June 27, 1974

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on U.S. technology

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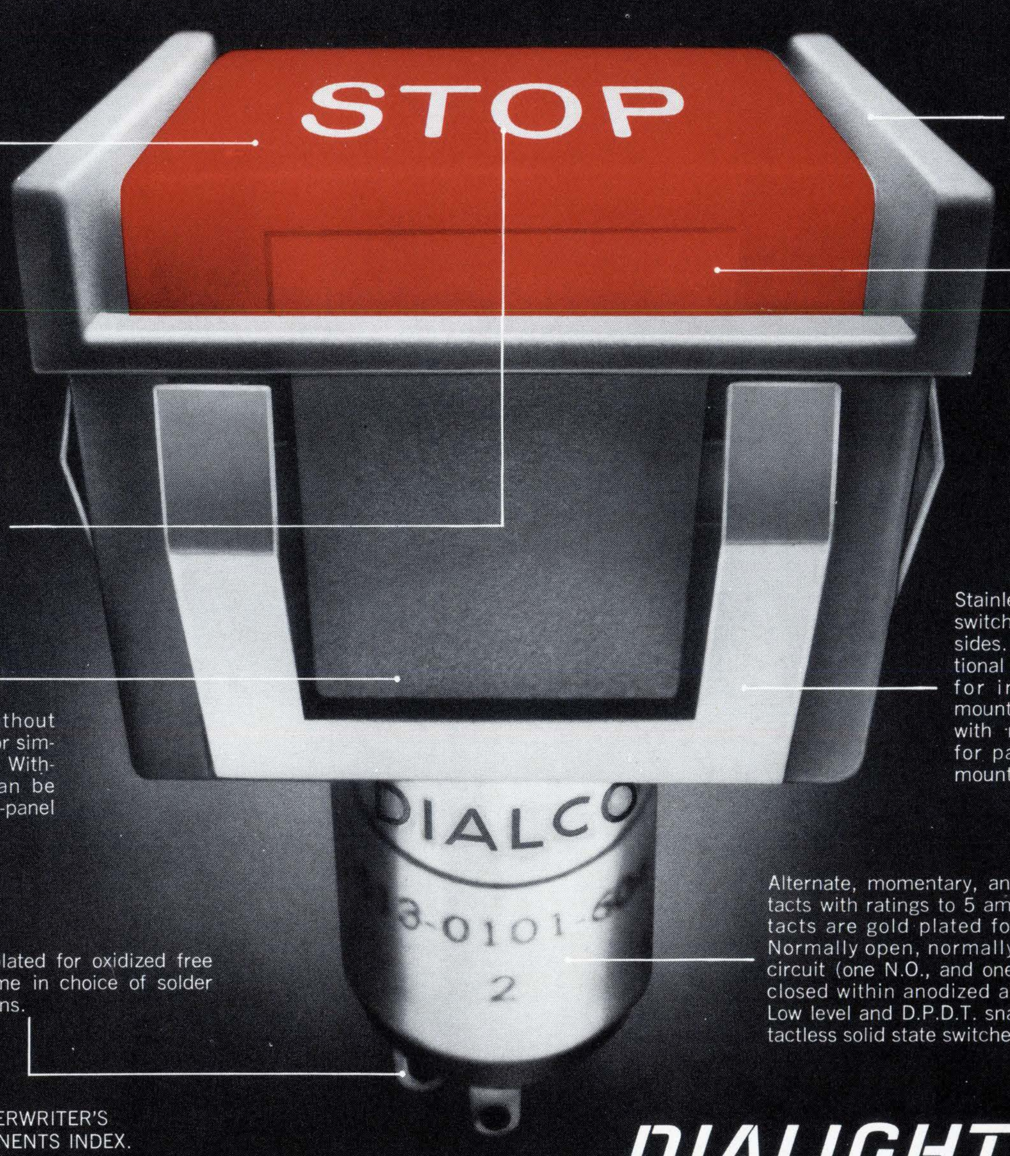

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Electronics

The International Magazine of Electronics Technology

Vol. 47, No. 13 • June 27, 1974

Highlights

Cover: Europe's EES face a changing world, 135
In Europe as in the U.S., electrical engineers worry about how soon to pick up on a new technology, the impact of microprocessors on job skills, and ways of improving communications between IC and system designers. So said eight European EEs who recently met in Amsterdam to give *Electronics* magazine their views. But one problem not found in the U.S. is language barriers.

Sales of electronic games sag temporarily, 69
Having passed their first spectacular growth period, all-electronic TV games no longer directly threaten the electromechanical equipment of the amusement arcade. But even that equipment may be up to 50% electronic today.

A-d converter fits on two chips, 93
Success in building the first monolithic analog-to-digital converter sprang partly from a new algorithm, which helped simplify the circuitry, but mainly from highly refined LSI linear processing, in which bipolar and MOS techniques are combined. Accuracy of the package is 0.05%.

PL/M eases microcomputer programing, 103
It's faster to program a microcomputer in the high-level language called PL/M than in assembly language. PL/M is also more efficient in its use of memory space for programs running 1,000 bytes and more.

And in the next issue . . .
Special report: microprocessor applications in industry, computers, instrumentation, communications, and consumer and commercial equipment.

Electronics

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Publisher's letter

The sun never sets on the electronics industries. The excitement, hard work, dumb luck, inspiration, and serendipity that makes electronics so challenging—and rewarding—has spread to the four corners of world. And our coverage goes there, too.

For example, in this issue alone you'll find a host of stories that have come from beyond the shores of the United States. First off, there's the cover story, a searching look at the European engineer today (see p. 135). As you read what eight contemporary EEs have to say about their profession, you'll find that engineers the world over face many of the same difficulties—and yet they have some problems, like language barriers, that you might not have been aware of.

Then, the Probing the News section this issue is chock-full of internationally oriented stories. One, by our Managing Editor, International, Art Erikson, reports on progress being made in reallocating maritime radio space (see p. 72). At the recent Geneva International Telecommunication Union meeting, 470-odd delegates from 90 member countries plowed through some 2,200 proposals for changes in existing regulations. But agreements were hammered out and will start to take effect in 1976. The story is important reading if you want to know what trends to watch for in communications gear.

Then, too, there's an article from our Tokyo bureau chief, Charlie Cohen, on the new crop of computers that have grown from the Japanese government's program of subsidies to computer makers (see p. 77), as well as a detailed look by our Frankfurt bureau chief, John Gosch, at who will produce what part for Spacelab, Europe's contribution to the U.S. post-Apollo manned space program (see p. 80).

And, there's a lot more international news in the Electronics Review section, as well as in the regular Electronics International and International Newsletter sections.

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Readers comment

Replicating ICs by X rays

To the Editor: Your article, "X-ray lithography highlights move to tiny IC patterns" [*Electronics*, May 30, p.29], does some injustice to our referenced conference presentation. Also it should have acknowledged that the original work on X-ray lithography was performed at Lincoln Laboratories.

The incorrect statements, such as "the X-ray technique appears to overcome some fundamental problems with electron-beam exposure of wafers," apparently resulted from a misunderstanding of our paper. We compare the X-ray technique to the parallel electron-image-projection technique. Electron-projection lithography does not use electron beams, but rather projects electron images onto the wafers.

On the other hand, direct electron-beam microfabrication will always be able to produce higher-resolution structures (about 0.05 micrometer), and for many applications, it is the most feasible technique. These two replication techniques complement direct device fabrication by electron beams by allowing batch production. The electron-beam systems are required to produce the high-resolution masks used for replication. In fact, we expect X-ray replication of device patterns will lag several years behind direct fabrication by scanning-electron-beam systems.

We would also like to clarify that we have not solved the problem of alignment, but have only proposed an approach that we believe can achieve an accuracy to 0.1 μm. Also, "the technique appears about to emerge from the laboratory," would seem to be overly optimistic.

Paul Sullivan
Hughes Research Laboratories
Malibu, Calif.

Converting solar energy

To the Editor: The article on solar energy [April 4, p.99] called photovoltaic devices the most simple and direct means of conversion known. This simplicity is of overriding value in space vehicles, but down here, the cost from sunbeam to power line is the important consideration.

Photovoltaic equipment does have a great future potential, especially for small to medium-size installations. For the real workhorse systems involving multi-megawatt stations, there are other means available for much lower-cost power. These systems use the energy as heat, rather than as photons.

The secret of high efficiency and low cost is in high-ratio concentration for power conversion at industrial-furnace temperatures. The technology is known, and materials are available for development of large conversion facilities. Such a plant would be environmentally clean and, of course, would not need the supply and processing of pellets. It appears that the cost could be as much as two to three times that of modern nuclear plants. However, this is at the beginning of the learning curve, and substantial reductions should be possible.

Warren M. Hubbard
Consultant
Chula Vista, Calif.

Renaming the author

To the Editor: There was a minor error in the article, "Computerized text-editing and typesetting make headlines" [May 30, p.111]. My first name is Robert, not "Albert." I can't really object too much, however; if there were no errors in typesetting, there would be much less need for our system.

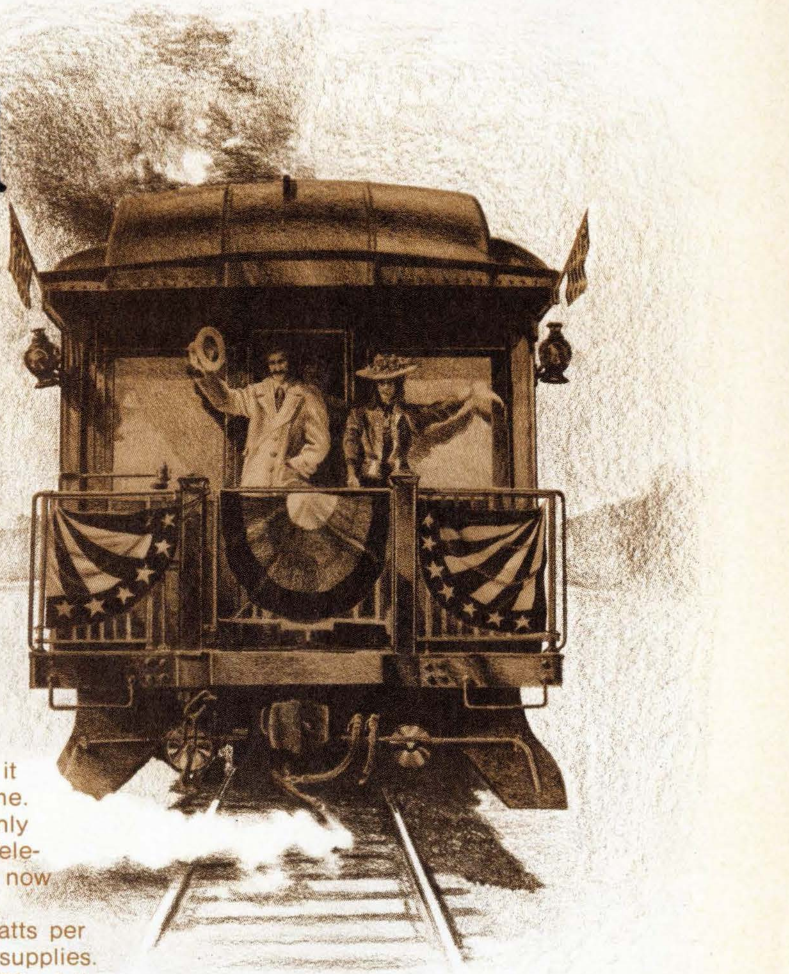
Robert L. Bushkoff
Xylogic Systems Inc.
Natick, Mass.

Automating by voice control

To the Editor: I'd like to clarify your Update column [May 30, p.18] regarding the use of voice-encoding systems manufactured by Threshold Technology Inc. for automatic baggage-handling. Although other airlines have shown an interest in this equipment, systems have been sold and are being used only by United Air Lines and TWA. Additional systems, however, have been sold for other materials-handling applications.

Marvin B. Herscher
Threshold Technology Inc.
Cinnaminson, N. J.

The last time someone announced 74C, it was a national campaign.



When we saw 74C coming down the tracks, we knew it would be the hottest and most logical CMOS line in a long time. Flags waved, bands played, and thousands of engineers suddenly found CMOS easier to design in. The only thing missing was Teledyne's big production volume and competitive pricing, and now you've got that too.

Here's what Teledyne 74C delivers: A mere 10 nanowatts per gate typical power dissipation. Operation on 3V to 15V power supplies. A big, guaranteed 1V noise margin. Typical noise immunity 45% of the supply voltage. Hefty outputs that drive MOS and bipolar logic (at least two LPTTL loads).

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40 years ago

From the pages of Electronics, June 1934

Electronic robot 'greeter'

At the main entrance of the magnificent new building of the Franklin Institute, Philadelphia, stands an electronic robot "greeter" garbed in the uniform of one of the museum attendants, who calls out a cheery message of welcome to each visitor who enters the building.

"This robot greeter is known around here as Egbert (for no reason at all)," explains James Stokley, associate director of the Franklin Institute, "and is operated by two photo-electric relays.

"A visitor coming in through the entrance door to the Museum interrupts a beam of deep red light which shines through gratings over the radiators in the vestibule. This sets off the mechanism in Egbert so that he raises his arm and salutes, and then an electrical phonograph connected with a loud speaker in his stomach says: 'How do you do. I'm very glad to see you. I hope you enjoy your visit' in a baritone voice.

"In order that Egbert will not greet people who are leaving, the second light beam is arranged so that visitors on the way out interrupt the second beam first. This operates another relay which disconnects the first one and so the welcoming mechanism does not function."

Court rules on 'feed-back'

On May 21, the United States Supreme Court declared that Lee de Forest, and not Major Armstrong, was the inventor of the regenerative or feed-back principle. It is believed that this decision will be final and that the economic waste that has been going on for many years in carrying on a contest that has given the decision first to one and then the other of the two claimants, will at last come to an end.

The amount of money that has gone in this fight must run to several millions of dollars; so far as the art was concerned, that money was wasted, gone to attorneys and patent lawyers instead of being reinvested in further research to the benefit of the art.

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People

Gould's new research lab helps the divisions

Basics. Gould's Carnahan is setting up research lab to back operating divisions.

Until recently, Gould Inc.'s electronic research centered on a couple of programs for ink-on-demand printing and semi-automatic transmissions for trucks. But the Chicago-based firm, which had $600 million in sales last year, is stepping up those activities as research director Robert D. Carnahan begins channeling a healthy chunk of the company's research, development and engineering budget into a new electrical and electronic research laboratory.

Nonexistent a year ago, the lab today commands part of a sprawling site in Rolling Meadows, Ill., that's destined to become the corporate headquarters for the electrical, electronic, and automotive conglomerate. Carnahan's long-range strategy is for his lab to support the firm's electrical and electronic products divisions "by extending into areas that they can't address at operating levels."

Carnahan has added enough staff to reach what he calls "a critical mass. We can now define needs, configure programs, and develop a strategy that we can carry out," he explains. "From this point on, staffing will be tied to programs." Within two years, he expects the lab to be housing 70 people.

Gould's work with Dana Corp. on the semi-automatic truck transmission, and further work on a fully automatic version, points to one of the firm's goals. "We'll probably get into the heavy-duty truck market with electronics as our entrée," he says. "The field is rife with the need for on-board, off-board diagnostics, warnings systems, sensors, detectors, logic and signal transmission."

Carnahan holds a bachelor of science in metallurgical engineering and a doctorate in materials science, and much of Gould's projected research will also be basic in nature. "Part of our emphasis will be in solid-state materials and device physics," he says. "And that emphasis will lead us quite naturally into sensor device development and display activities."

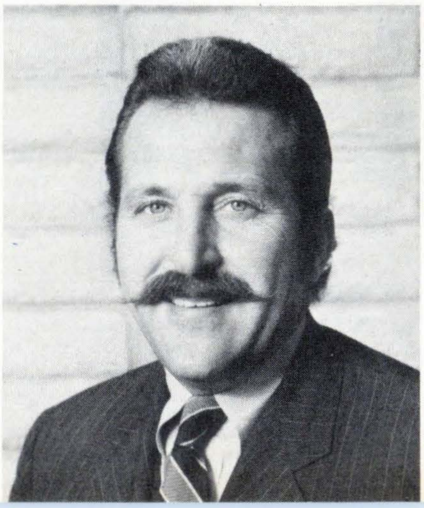
"There's a large opportunity in the general field of electronic ceramics for the development of thin-film devices using the kind of processes–vapor-phase vacuum deposition and sputtering–developed in the semiconductor industry," he points out.

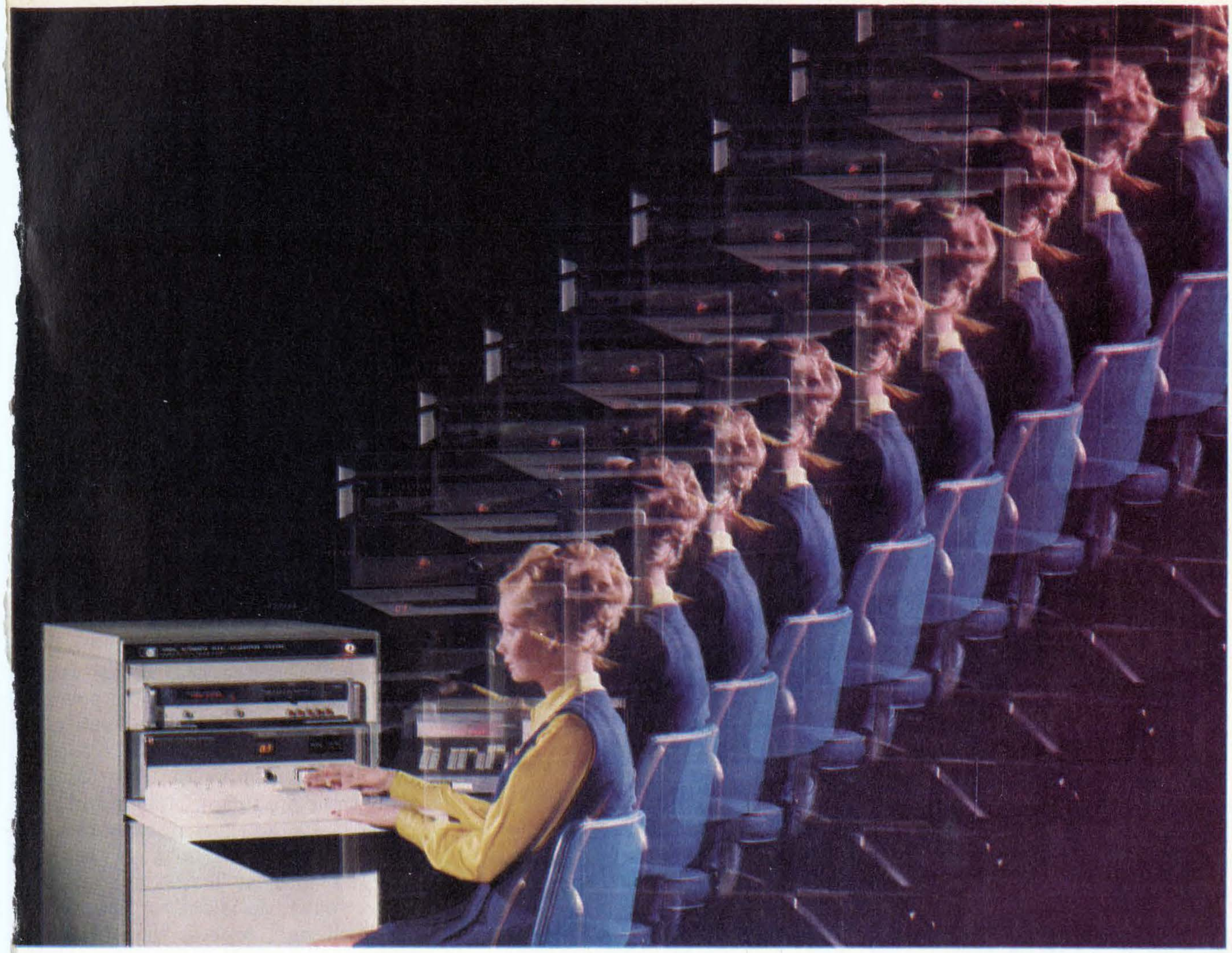
Cox streamlines for steep growth

It's been a year and a half since 38-year-old Marshall G. Cox became president and chief operating officer of Intersil Inc. But only now, after some sharp pruning of the corporate product tree and more than a dozen top-level personnel changes, does he believe the semiconductor firm is poised to penetrate the markets it's best suited to serve.

In the lead at the Cupertino,

Up, up and away. Intersil's Cox cuts product types, gears up for strong sales.





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Dry-reed relays and DVM resolution to 1 μV lets you monitor low-level transducer outputs as well as large AC signals and DC levels to 200V. Computational power of the 9820A calculator controller (or optional 9821A and 9830A) allows you to do calculations and data analysis, thus eliminating data reduction tasks. You can convert measurements to engineering or scientific units, linearize and compensate transducer outputs, calculate average values and standard deviation, perform design computations, and more... all automatically. And an optional page printer and X-Y plotter can save you hours preparing tabulated data and graphs.

Couple this capability with the system's operational simplicity—which lets you free skilled people for other tasks—and you can see why the 3050A is finding wide use in testing and data acquisition applications.

Contact your local HP field engineer for information on applying the 3050A to your testing situation. Or, write Hewlett-Packard.

094/48

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People

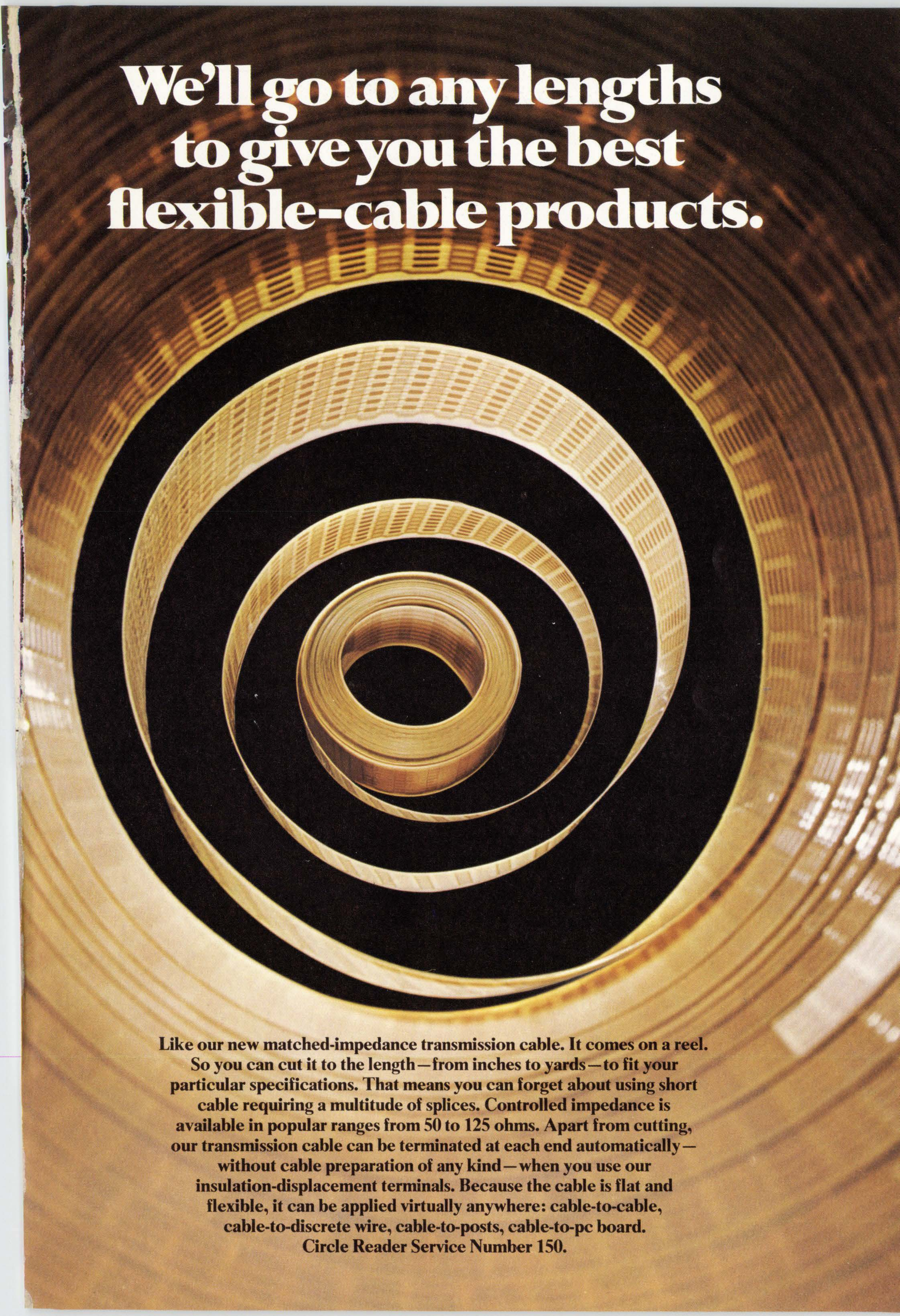
Calif. manufacturer will be many new faces recruited in recent months. Having served his own industry apprenticeship at Fairchild Semiconductor and Raytheon Semiconductor, Cox was not adverse to looking around for the people he wanted. From Litronix, for example, comes a new consumer product manager. From Fairchild, a senior process engineer now heads up pre-production R&D. The manager of microcomputer development is an old National Semiconductor hand, and so is the new manager of MOS process engineering, while the manager of bipolar process engineering is from Signetics.

Cox, who helped found Intersil Memory Systems (it merged in 1970 with its parent, Intersil), is concentrating on three product areas—precision analog devices, low-power consumer products, and memories. And he points out, for the record, that Intersil is now the only company to be producing bipolar and n-channel MOS and C-MOS memories.

Achieving this mix of technologies took at least one particularly hard decision—to abandon the p-channel process that Intersil had for long applied to random-access and read-only memories. But Cox is banking on the advantages of n-channel's higher speed.

The company last year doubled its sales to $24 million and quadrupled its earnings. This calendar year Cox expects sales to jump to about $40 million, next year to $60 million, and by 1976 to be averaging a robust $100 million. This is a far cry, indeed, from a company which as recently as 1972 Cox thinks could have been characterized as a small, high-technology company trying to serve too many market areas.

"We have situated ourselves very carefully in markets we believe will explode during the '70s and '80s," Cox says. "Semiconductor memories will average $700 million by 1977 and $1 billion by 1980. Precision analog circuits, now a $100-million-yearly market, has been growing at a 25% rate, and consumer products such as electronic watches will rival sales of hand-held calculators in a few years."


We'll go to any lengths to give you the best flexible-cable products.
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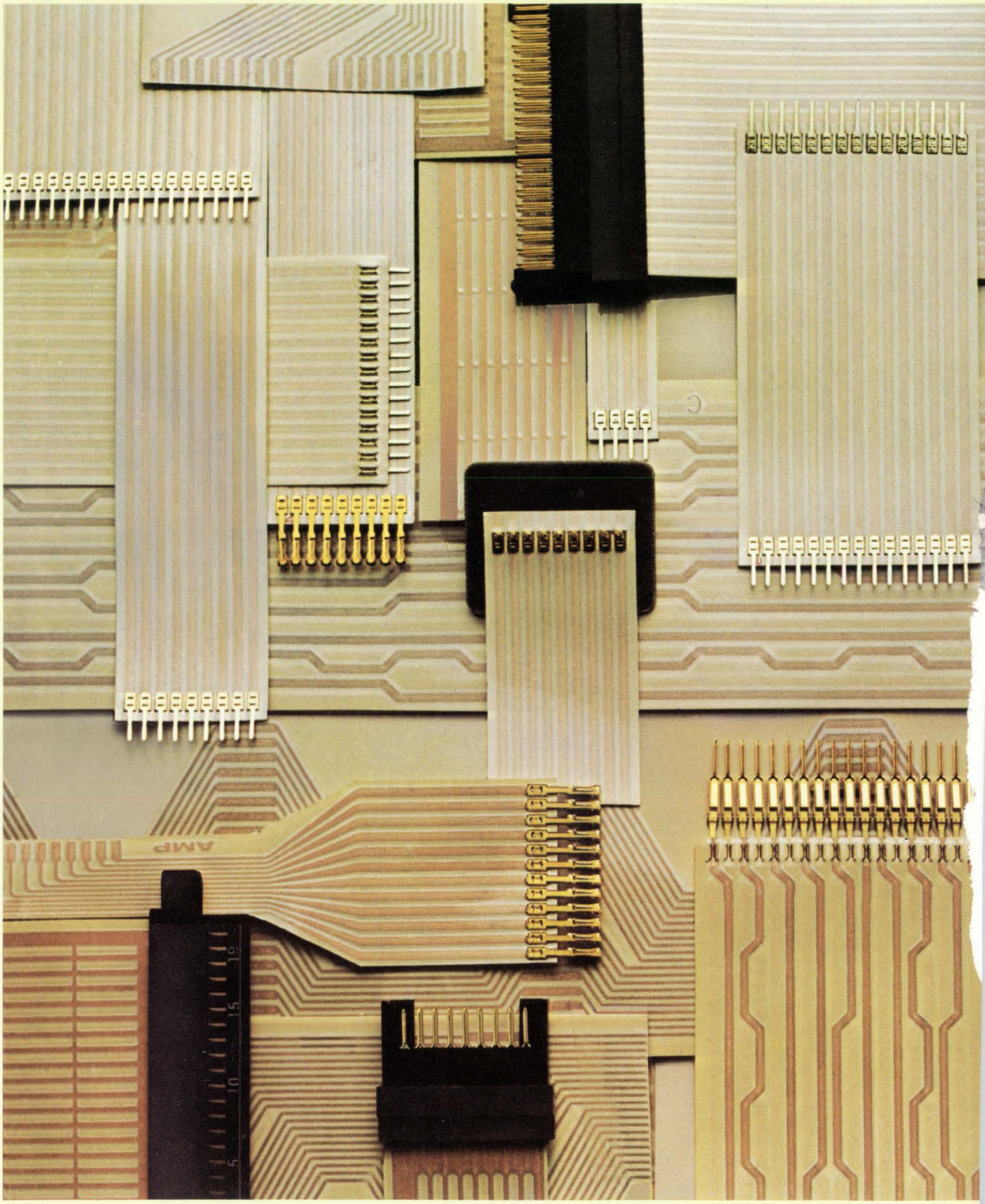

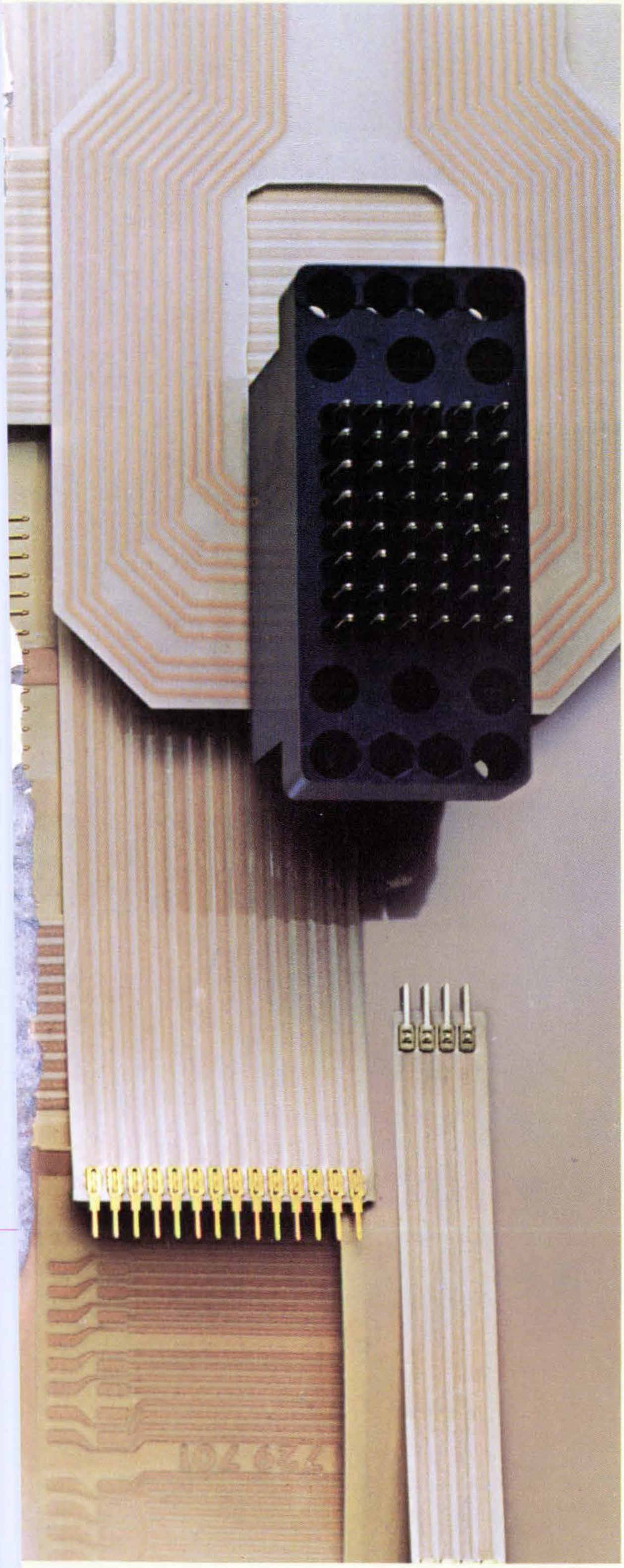

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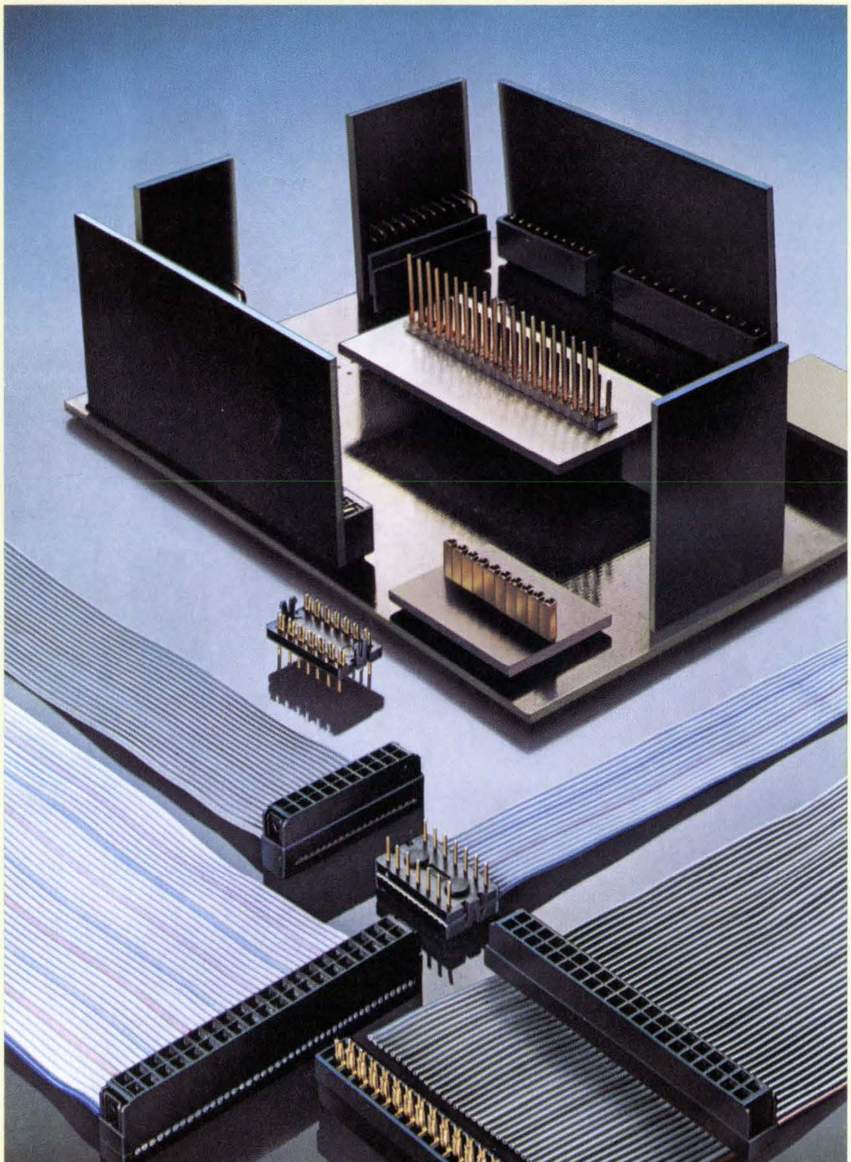

If you are, then it's time to be using AMP latch connectors. They let you terminate all leads simultaneously. Without pre-stripping or soldering.

These connectors are available in 10- to 60-position receptacles. And can mate with true .100 grid, two-row patterns of $.025^2$ posts. Inspection is simple—even during termination.

Our fork-type contacts provide redundancy and each locks into the cover for maximum point-of-contact pressure and cover retention.

Dual camming and latching beams on AMP contacts provide possible 4-point contact and positive locking for each connector cover.

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AMPMODU post headers are available to accommodate AMP latch connectors. Our complete line includes single- and double-row, straight-through and right angles on .100″, .125″ and .150″ center lines.

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Meetings

Precision Electromagnetic Measurements Conference, Royal Society, IEE, London, July 1–5.

Electromagnetic Compatibility Symposium, IEEE, San Francisco Hilton Hotel, San Francisco, July 16–18.

Circuit Theory and Design Conference, IEEE, IEE, London, England, July 23–26.

Summer Computer Simulation Conference, IEEE, Shamrock Hilton Hotel, Houston, Texas, July 24–26.

The Second Jerusalem Conference on Information Technology, The Jerusalem Economic Conference and its Computer Committee, Jerusalem, Israel, July 29–Aug. 1.

IFIP Congress, International Federation for Information Processing, IFIP, Stockholm, Aug. 5–8.

Computer Communications International Conference, IEEE, Stockholm, Sweden, Aug. 12–14.

National Electronics Conference of New Zealand (Nelcon), New Zealand Section, IEEE, University of Auckland, Auckland, Aug. 26–30.

International Congress on Data Processing, AMK, Congress Hall, West Berlin, Sept. 4–7.

International Switching Symposium 1974, VDE, Sheraton Hotel, Munich, Sept. 9–13.

Compcon Fall, IEEE, Mayflower Hotel, Washington, D. C., Sept. 10–12.

Western Electronic Show and Convention (Wescon), IEEE, Los Angeles, Sept. 10–13.

Fourth European Microwave Conference, Microwave Exhibitions and Publishers Ltd., Maison des Congres, Montreux, Switzerland, Sept. 10–13.

European Solid State Devices Res. Conference, Institute of Physics, IEEE, University of Nottingham, England, Sept. 16–19.

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Electronics newsletter

Intel broadens computer-chipline with bipolar LSI

Intel's drive to supply all segments of the LSI processor and computer-chip market by the end of the year is apparently on schedule. Two new chip designs are being planned for production—a more powerful version of Intel's 4004 microprocessor chip, software-compatible with the 4004, **and the firm's first bipolar-LSI computer chips,** a 6- or 7-chip set that is expandable by two-bit increments to cover the entire middle-level computer range.

Scheduled for entry in the fall, Intel's bipolar chips, are built with Schottky TTL technology. With cycle times as low as 70 nanoseconds, the new line is clearly capable of impacting the heart of the minicomputer market. Some chips in the set are: the microprogramed control unit; the arithmetic register unit; the carry and look-ahead chip; and a priority-interrupt chip.

Tau-Tron builds 1-GHz digital tester

Tau-Tron Inc., known for its high-speed test equipment, is pushing speed even higher with its new 1-gigahertz test set for measuring bit-error rate. Scheduled for production by the end of September, the set is aimed at digital satellite, coaxial cable, millimeter wave, laser/optical fiber, and microwave radio communications. **Most communications testers generally stop at 150 megahertz.** Although Takeda-Riken of Japan has sold some 1-GHz test sets in the U.S. for close to $50,000, Tau-Tron hopes to sell its set for less than $25,000.

To get the speed, the company says it has adapted old-hat technology, **using commercially available high-speed emitter-coupled logic.** The set contains the MN-2 pseudo-random data generator, which produces a pseudo-random sequence at bit rates from 200 MHz to 1 GHz and excites the system under test.

RCA to invest $27 million in Brazilian TV plants

Using $15 million in equity and $12 million to be raised on the local capital market, RCA Corp. is setting up television plants in Brazil, **The agreement calls for export of $380 million in products by January 1984.** The products involved include color and monochrome receivers for export and the local market, color modules and advanced solid-state assemblies for export, and black-and-white and color sets earmarked for other South American countries. Specific models and screen sizes have not been decided yet.

15 savings banks to set up funds exchange

Fifteen Washington State savings banks and savings and loan institutions have been given the go-ahead on a joint-venture pilot project **to set up an electronic banking center** at a Bellevue, Wash., shopping mall near Seattle. The center will be electronically equipped to handle all deposits, withdrawals, mortgage payments, and funds transfers for the 15 banks. Customers will use plastic cards issued by the sponsors.

Burroughs ARTS-2 bid $10 million below competitors'

Burroughs Corp.'s low bid of about $7.6 million for the FAA's Automated Radar Terminal System 2 (ARTS) is seen by competitors as notice that the company intends to "buy into" the market; **one industry source called the bid "astonishingly" low.** Lockheed's $19.7 million bid was the highest and the three largest manufacturers of complete control systems—Lockheed, Sperry Rand, and Cutler Hammer's AIL—each bid at least $18 million for the contract to make 73 terminals for medium-density airports.

Mostek sampling first micro chip

Mostek has been quietly sampling its first microprocessor, a p-channel ion-implanted depletion load device that the firm says is **at least as fast as the Intel 8080 in some applications.** Developed for a European terminal manufacturer and in production for the past six months, the chip's instruction set is organized for I/O applications—three classic accumulators on one chip offer two priorities of interrupts, and the I/O instructions use a ninth-bit flag so a peripheral can notify the processor that it's ready to accept output.

Congress to approve major U.S. purchases of computers

The Internal Revenue Service and the Veterans Administration plan computer purchases of $150 million and $45 million, respectively. **The purchase, plus other major government computer orders, will be submitted to Capitol Hill for prior approval**—a move calculated to cool congressional criticism of the General Service Administrations's EDP policies.

Univac bubbles get 16,000 bits on 150-mil chip

Sperry Univac's magnetic-bubble research project has succeeded in packing up to 16,000 bits on one chip approximately 150 by 150 mils. **This corresponds to 1.41 mil^2 per bit,** compared to 3.55 mil^2 for an experimental IBM MOS dynamic memory [*Electronics*, March 1, 1973, p. 38], 1.1 for an experimental IBM bipolar memory and 2.81 for the most recent bubble memory developed at Bell Laboratories.

William Doyle, manager of the project, sees a prospect within a couple of years of getting four times as many bits on a larger chip at the same density, using conventional photolithographic techniques to lay out the magnetic structure on top of the bubbly film. Eventually, predicts Doyle, **densities 36 times as great as those now attained will be achieved** with electron-beam lithography, or 25 bits/mil^2.

TI readies line of tin sockets

Designers bent on shaving precious pennies should look at a new line of tin-plated IC sockets to be introduced by TI in Attleboro, Mass. The latest version of TI's low-profile DIP sockets, **the new versions substitute tin for gold inlay on the contacts.** A 14-pin socket is priced at 8 cents in volume—about 25% less than gold-inlay sockets.

Addenda

The first mile-long section of millimeter waveguide tubing will be placed in position in northern New Jersey in August as part of the Bell System's super-capacity transmission system. The project eventually will transmit 230,000 phone calls simultaneously, **twice the capacity of the most advanced coaxial systems now operating.** The waveguide, a hollow 2.5-inch tube inside a protective sheath, will carry digitally coded voice, data, and TV at 40 to 110 gigahertz. . . . AII Systems of Moorestown, N.J., says its shipboard satellite communications terminal, Seacomm, has received L-band signals from ATS-6. **This is believed to be the first reception by a commercial shipboard terminal** from the NASA satellite.

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Video compression may help jam-proof RPV communications

Air Force Avionics Lab seeks acceptable TV pictures using one to two bits per picture element

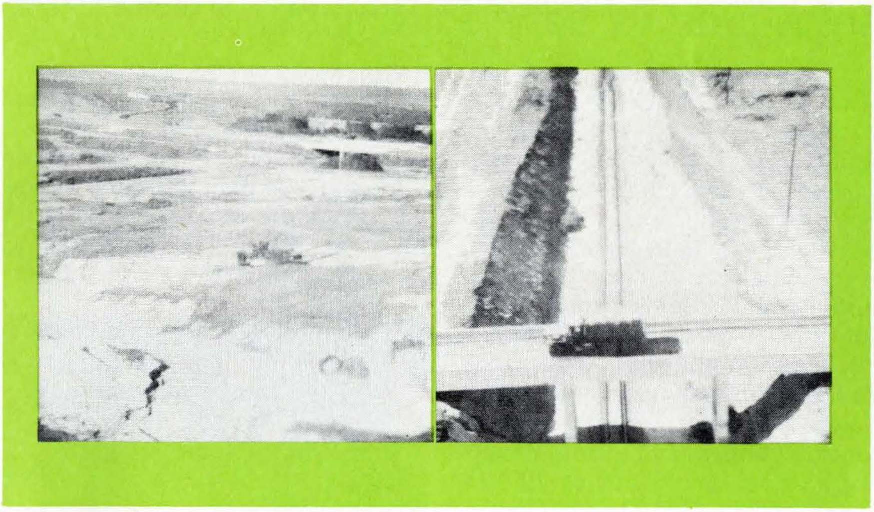
The Air Force wants anti-jam telemetry for airborne data links. And it is asking the Avionics Laboratory at Wright-Patterson Air Force Base, Ohio, to provide it. Early results have been encouraging, and the lab is building experimental hardware for bandwidth compression of TV video from remotely piloted vehicles. Most anti-jamming techniques are classed as spread-spectrum—increasing the bandwidth to force the opponent to distribute his power over a wider spectrum. But the bandwidth is usually compressed before being spread because the larger the difference between initial and spread bandwidths, the more jam-proof the transmission is.

The lab's effort resembles that directed at Picturephone-type digital imagery and satellite educational TV applications, except that it ignores the esthetics required for commercial pictures in favor of the minimum information needed to recognize and acquire RPV targets. Thus, by using spatial transforms, the information transmission branch of the laboratory's Systems Avionics division hopes to be able to represent each picture element in a 512-by-512-element video scan frame with only one or two bits. That's an important reduction from the six bits used in normal pulse-code-modulation techniques to describe each element with one of 64 different shades of gray. This adds up to 1.5 million bits per 512-by-512-element frame, and, since 30 frames per second are typically transmitted, PCM techniques use 48 to 50 megabits per second.

"Our goal is to get that down to one megabit per second," notes John S. Flatz, technical manager of the information transmission branch. And toward that end, his group is also trying to reduce frame rate. So far, indications are that eight frames a second may be adequate for a human monitoring the pictures to identify a target from the RPV's video transmission, says Capt. Stephen C. Noble, project engineer for video compression. "Frame rates slower than 16 per second, in any case, would require a memory to store and repeat frames to reduce flicker."

Each frame is divided into 4,096 subpictures of eight-by-eight picture elements each, and these are transformed by a computer that simulates a hardware processor, to be completed this fall. The transform hardware, which will process the pictures in real time, will use about 50 off-the-shelf chips, Noble estimates.

Video scan input from the RPV's TV camera would first go through an analog-to-digital converter module and be held for processing in memory—in the final hardware, possibly in six 4,096-bit RAMs. Since Noble is performing the transforms sequentially in the eight-by-eight-element subpictures, memory will be needed to store eight lines of picture information. The arithmetic logic unit in the hardware processor will be built out of Schottky transistor-transistor logic, and from there, the transformed picture information will be interfaced, perhaps through a buffer, to the RPV's communi-



Band squeeze. Working from digitized photos, the Air Force's experimental band-compression scheme shows promise for target acquisition. Targets are discernible even though photos have been transmitted with an average of only two bits per picture element.

cations equipment for relay.

The arithmetic logic unit is designed to perform two-dimensional, frequency-domain-type transforms using either Harr or Hadamard transforms, and it can be converted from one to the other by changing a read-only memory chip. Like the similar discrete Fourier transform, Harr and Hadamard versions change the information in the picture without significantly altering its meaning. But unlike the Fourier transform, they do not require multiplication during processing. This, Noble says, simplifies the ALU to an add-subtract module and reflects an effort to keep the on-board hardware for the pilotless planes to a minimum.

"Transform coding basically changes the elements into a new form, because that new form has some properties we want to exploit," Noble explains. "In this case, we know that there's redundant information in a picture, but it's hard to sort it out in the picture domain. Putting it into the transform domain allows us to eliminate redundancy." The 64 picture elements in each of the subpictures that make up a frame are transformed into 64 transform coefficients, only about half of which contain picture information. Efficiently assigning bits to the important coefficients is how the reduction in average bits per element, and therefore reduction in bandwidth, is achieved. □

Consumer electronics

MOS chip in remote-control unit helps tune TV set electronically

Most TV manufacturers admit the inevitability of all-electronic tuning. And most have several different schemes in the laboratory for doing away with such things as tuned circuits in the remote-control section, potentiometers in the tuner circuitry, and electromechanical channel displays on the front of the set. But Magnavox Co. has gotten to the market first with a top-of-the-line chassis that integrates most remote control, tuning, and display functions on a single 200-by-200-mil metal-oxide semiconductor chip.

Dubbed STAR—an acronym for silent tuning at random—the Magnavox system features a 6-inch-high channel number that appears on the TV screen, then shrinks to a point and disappears within three seconds, plus an ultrasonic-frequency remote-control transmitter that resembles a hand-held calculator. Two-digit channel numbers are punched on a 10-digit touch pad on the handset to give instantaneous access to all 82 vhf and uhf channels. Channels can be selected at random. In addition, function keys on the remote handset provide on-off, mute, and volume control and channel-display recall.

Discrimination among the ultrasonic tones is done digitally within the p-channel chip, which is supplied by Mostek Corp. "From a basic frequency, we synthesize 15 different frequencies spread between 38 and 45 kilohertz," says Robert Williams, manager of Magnavox' tuner and remote engineering section. "When we detect the presence of an ultrasonic signal from the transmitter, an amplifier feeds it into a countdown circuit on the LSI chip, which counts to that frequency."

Proprietary circuitry guards against false triggers—only a definite pulse duration and amplitude will activate the circuitry, thus differentiating the transmitted signals from the harmonics of the horizontal flyback transmitter or other signals in the horizontal section.

Each frequency is decoded immediately, and signals from the function keys are acted on immediately. "Because channel address is a two-digit entry, signals from the 10 numerical keys are stored for a second entry," adds Williams.

Volume-control signals are fed to an on-chip audio step-attenuator that produces stair-step voltages in 16 discrete steps. These are applied to a voltage-control-gain block that raises or lowers the volume.

"The tuning system is a birdie counting scheme for varactor tuning," Williams says. In essence, it's a modified frequency-synthesis technique. "A single oscillator generates

Electronic tuning. Channels are displayed right on the TV screen in Magnavox tuner that replaces electromechanical tuning devices with a portable hand-held remote control set.

a series of pulses at 6-megahertz harmonic intervals, and each pulse represents a particular channel. When a channel function is activated, the circuitry starts counting the birdies until it reaches the channel," he explains.

For channel display, Magnavox has designed a standard character generator onto the chip. When new channel information is detected, or when the channel-recall signal is received, the chip's display section generates the appropriate channel number and transforms it into video for display on the TV screen.

The chip still has some bugs to be ironed out. The layout has been revised, according to Williams, but to start production in late September a couple of external flip-flops are being added to take care of a mixup in the tuning and volume circuits. The sets, to be in production this fall, will retail from $995 to around $1,200. Industry officials put the premium paid for the system at between $65 and $85. □

Wariness greets new watch firm

There's certainly skepticism among the electronic-watchmaking fraternity over the $99 liquid-crystal-display watch made by tiny newcomer Princeton Material Sciences Corp. [*Electronics*, June 13, p. 35]. A retail price as low as that has many in the industry wondering how much, if any, profit the firm can be making.

"PMS could marginally make a profit, possibly by selling directly to a discount house, but it is impossible to make a profit under normal marketing conditions," comments Peter Stearns, marketing manager of Optel Corp., a company that's been delivering LCD watches retailing for about $175 for more than a year. Stearns is referring to the fact that Princeton Material's first products are going directly to Alexander's, a New York discount house, instead of to an established watchmaker who, in turn, would distribute them through his regular outlets.

Some even doubt whether low-priced LCD watches could be manufactured profitably by any company—including giant Timex, the leader in the low-priced-watch business, which has promised an $85 LCD watch for next fall [*Electronics*, May 16, p. 74]. Says a spokesman for American Microsystems Inc., a supplier of watch circuits: "Both Timex and PMS are taking a gamble. They are trying to create a market by foregoing profit. If they don't win, they could lose their shirts."

Then, too, others have accused Princeton Material of a one-shot attempt, using watch parts it was able to get hold of at a discount. This latter charge is vehemently denied by Princeton Material president Issai Lefkowitz, who formed the company in 1969 to manufacture liquid-crystal materials and displays. Lefkowitz points out that his company produced its first watch some time last year, and insists the firm now has the capability to "compete with Timex" in the low-priced digital electronic watch market.

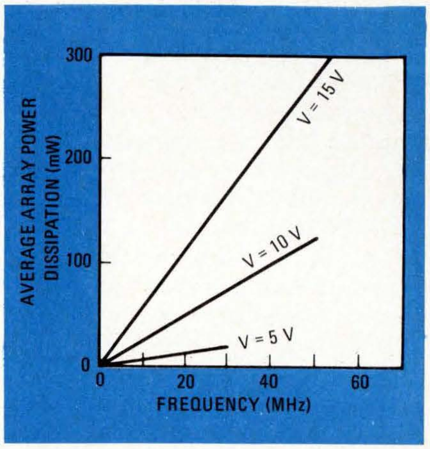
Watch components are bought from about 10 suppliers, including the complementary-MOS driver chip from Intel, the quartz crystal oscillator from Motorola, and discrete components from Sprague Electric. Sprague, incidentally, acquired a 40% interest in Princeton Material about a year ago.

Still, if Princeton Material is to compete, and compete successfully, it will have a lot of growing to do. It employs less than 40 people and has a modest 10,000 square feet of floor space, mostly for manufacturing. As for sales figures, Lefkowitz is reticent, admitting only to "under $5 million." □

Solid state

C-MOS on sapphire yields powerful logic

LSI-processor technology is becoming powerful enough to affect even the largest and highest-performance processing systems—those that have till now required the fastest transistor-transistor-logic packages. Evidence of this is the family of C-MOS-on-sapphire large-scale arithmetic logic circuits developed at RCA's Advanced Technology Laboratory in Camden, N.J.



Powerless. Dissipation is low in RCA's C-MOS-on-sapphire adder array—only 10 mW at 30 MHz at a 5-volt supply level.

Though earmarked under an Air Force Avionics Laboratory contract for an advanced signal-processing system, they have a commercial significance, too. The C-MOS-on-sapphire technology used to build these high-speed low-power large-scale integrated circuits for the military is quite similar to the process being used by the company for commercial circuits in pilot production at the Technology Center at RCA's Solid State division in Somerville, N.J. The company has already announced the development of commercial C-MOS-on-sapphire watch circuits, and, although RCA remains mum about future plans, this technology could well be transferred into a range of new microprocessor and other commercial LSI computer components.

The C-MOS-on-sapphire military circuits are extremely fast, low-power devices. An 8-by-8-bit multiplier array, containing 2,112 devices on a 210-by-214-mil chip, typically operates at data-throughput rates of 10 megahertz at power dissipations of less than 10 milliwatts—clearly equalling TTL speeds and as clearly bettering TTL packing density and power dissipation. What's more, the C-MOS-on-sapphire construction gives the device typically 40% noise immunity, as well as providing it with radiation hardness.

Another component, a C-MOS-on-sapphire adder, is optimized for 9-bit operation on a 134-by-92-mil chip containing 425 devices. It dissipates less than 10 mW.

Finally, a 4-by-5-bit multiplier hybrid assembly operates at the impressive throughput rate of 30 MHz, in the meantime dissipating less than 300 mW.

The multiplier array is made up entirely of combinational logic, which is static, and therefore needs no clock signals and less complex circuitry. On the chip are included all the different cell types necessary to perform the logic sequences, from AND and NAND gates, half adders, and full adders to round-off circuits. In addition, input-gate protection is provided on the chip for ease of handling.

If interface circuits are added, the multiplier array can be expanded to larger-size multipliers and/or complement-type multipliers for bigger systems. The longer strings of gate delays will, of course, make these slower—by about 30%—but they will dissipate no more power than the smaller circuits.

The adder array, which includes overflow protection, performs additions on binary numbers (one's or two's complement) or normal sign-magnitude formats with corresponding outputs. Also, the design of the adder itself resembles the multiplier design in that it can be expanded to accommodate larger input words simply by using more adder arrays. □

Beams, too, pack power on a chip

Sapphire-based C-MOS technology is one way of achieving high-performance LSI circuitry. As impressive is another method that combines Schottky TTL construction with a two-layer beam-lead metalization process to produce a 300-gate universal logic array suitable for computer processing applications.

Developed by Raytheon Co.'s Missile Systems division, Bedford, Mass., the array's gates operate at an unusual 7-nanosecond propagation delay, yielding gate-speed power products of only 40 picojoules—at least as good as standard Schottky small-scale- and medium-scale-integrated TTL packages. Indeed, this LSI performance permits the use of standard Schottky clock rates of 5 to 10 megahertz, which means that no sacrifice in operating speed is required in the space-saving LSI format.

The 300 gates fit on a modest 160-mil-square silicon chip containing 60 drivers capable of interfacing with external circuitry, 120 drivers capable of driving up to 10 internal loads, and 120 expansion elements to be used as logic AND or logic OR expander gates. Typically, the gates dissipate 5.5 to 6 milliwatts per driver and 1 mW per OR expander.

The chip layout is extremely simple. The gates have been arranged in blocks of 12 and 13 elements. And the layout was composed completely by computer through the stepping or mirroring of these basic blocks.

Thus, individual blocks can be interconnected as standard logic functions simply by calling the metalization layout of a function from a computer library. The functions include AND/OR and NAND/NOR gates, exclusive-OR and exclusive-NOR gates, flip-flops, four- and eight-bit selectors, four-bit adders, and four-bit arithmetic units.

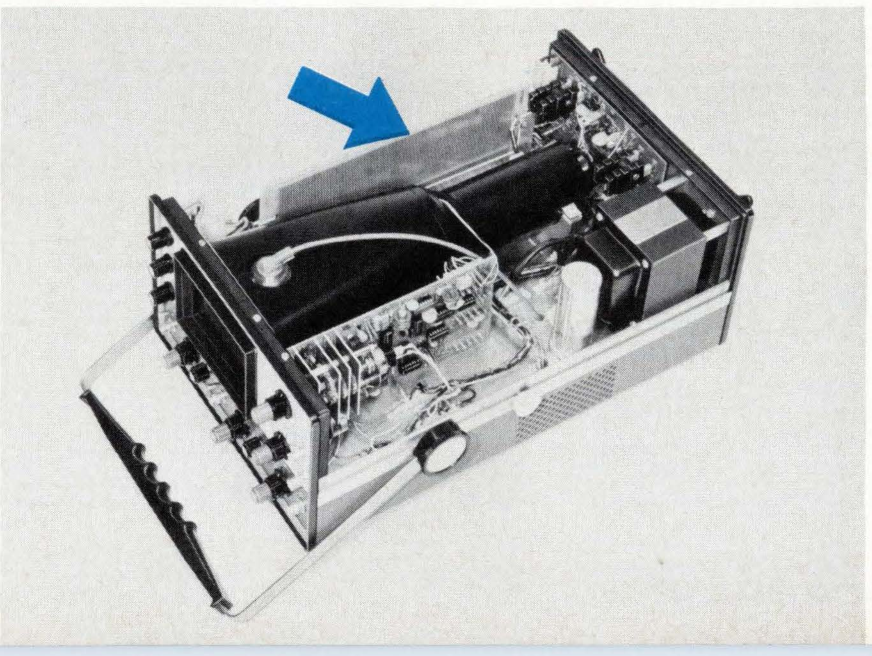
Raytheon has utilized, in a variety of programs, beam-lead master arrays of 40- and 60-gate complexity which were essentially based on Bell Laboratories' gold beam-lead technology with diffused underpasses for interconnection crossovers. But an improved low-capacitance beam-lead process, which provides two metal interconnection layers instead of one, has been developed by Raytheon for the 300-gate chips so that system speed and fan-out capability could be increased. □

Instruments

Delay line perks up low-cost dual scope

For $750, the Heath Co.'s latest entry in the assembled, portable, dual-trace oscilloscope competition is unusual enough to catch the eye of a lot of design, test and service engineers. To be sure, dual-trace scopes can be bought for several hundred dollars less, but these won't come equipped with a delay line and the high deflection sensitivity (1 millivolt per centimeter) that are in-

Dual traces. Combination of TTL and low-cost printed-circuit-type delay line (arrow) ensures that entire waveform will be displayed in $750 dual-trace oscilloscope from Heath.



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Faster spot response time results from the 3 MHz bandwidth of the X and Y channels (3 times the bandwidth of comparable crt displays). With the fast (1 div/μs) writing speed of the 605, even single-shot events are displayed as bright, easily viewed waveforms. The 605 has front panel controls and TTL compatible remote control inputs, a combination unique at such a low price. Real time monitoring applications are easy with the optional low cost time base $(125), another feature not offered on other variable persistence displays.

Applications for the 605 are many and varied. Bright, gray scale raster scan plots are obtained for ultrasound, thermographic, and nuclear scanning and for viewing scanning electron microscope images. Resolution is improved in spectrum analysis. Valuable trajectory information is provided for radar and sonar displays. With the time base option slow biophysical signals are easily monitored. In mechanical measurements flicker-free engine pressure/volume curves are readily plotted with no smear due to cycle-to-cycle variations. Uncluttered, single-shot vibration waveforms are easily displayed using the 1 div/μs writing speed.

For further information on how the 605 Variable Persistence Storage Monitor provides extra value in your display application contact your local Tektronix Field Engineer or write Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005. In Europe write Tektronix, Ltd., P. O. Box 36, Guernsey, Channel Islands, U. K.

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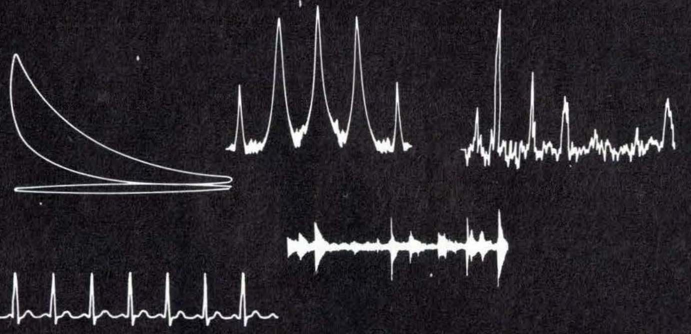
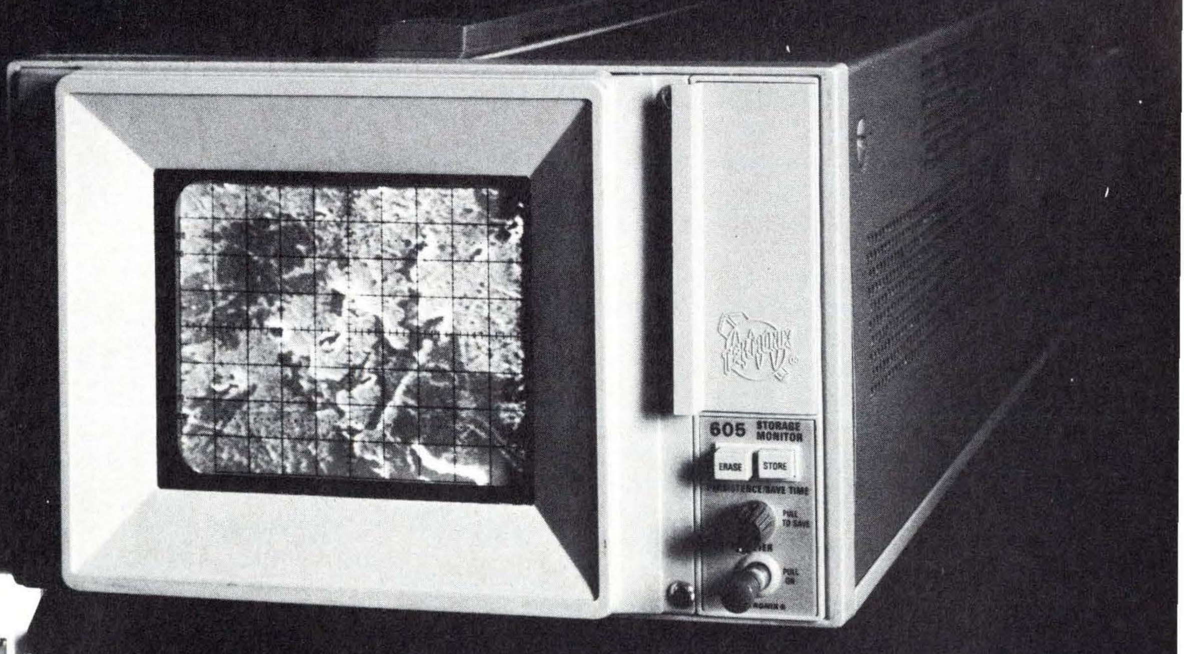
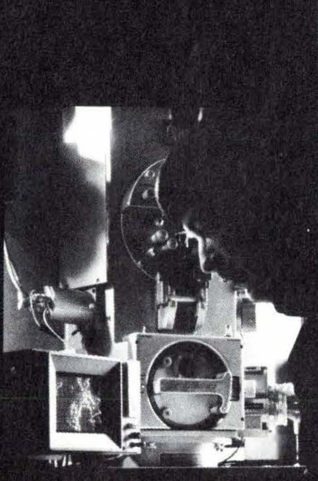






Gray scale capability and variable persistence storage of the 605 are used with a scanning electron microscope to study metal samples in a dental research laboratory.

For a demonstration circle 36 on reader service card.

Circle 37 on reader service card

cluded in Heath's model SO-4510.

The delay line gives the horizontal sweep a 20-nanosecond headstart before the waveform appears on the vertical plates. This assures the user of the scope that he is seeing the entire waveform at the left of the screen. Without a delay line, part of the leading edge of a fast signal may not be displayed.

The job of the delay line is to stall the vertical signal destined for the vertical plates so that the trigger signal, which has been picked off the vertical channel before the delay line's intervention, can unblank the trace and initiate the next horizontal sweep. But in earlier sweep circuits the process used up so many precious nanoseconds–from 300 to 600 ns–that relatively expensive coaxial delay lines were necessary, well out of reach of moderately priced scopes.

"TTL turned the trick for us," says design engineer Bob Ashton, "because it enabled us to build a sweep-triggering circuit which reduced the triggering time down to 140 ns. This meant we needed no more than a 160-ns delay line so we could turn to a relatively inexpensive printed-circuit-type delay line."

The model SO-4510 scope uses a cathode-ray tube with a 6-by-10-centimeter faceplate and a post-accelerator that improves trace brightness. However, it lacks the internal graticule necessary for parallax-free operation.

Triggering bandwidth is said to be two to three times the 15-megahertz vertical bandwidth in order to assure easy triggering on complex waveforms, and so no stability control is needed.

Though engineering accounts for the scope's performance, the Heath Co.'s unusual marketing structure can take much of the credit for the low price. "We don't have to load the price with the heavy sales overhead, as do some of our competitors, because we are essentially a direct-mail outfit," explains Charles Gilmore, marketing manager for the instrument line. "In fact, we are geared up to provide full customer services at much lower order values."

Deliveries will be made from the company's plant in Benton Harbor, Mich., beginning in early August. □

Materials

Low-energy beams alter materials

Producing thin films of materials by using low-energy bombardment ions has been found to cause some exotic alterations in the materials' properties. Researchers at Bell Laboratories, Murray Hill, N.J., who used ion beams to deposit films of various materials, have discovered that such films have radically different characteristics from the starting materials.

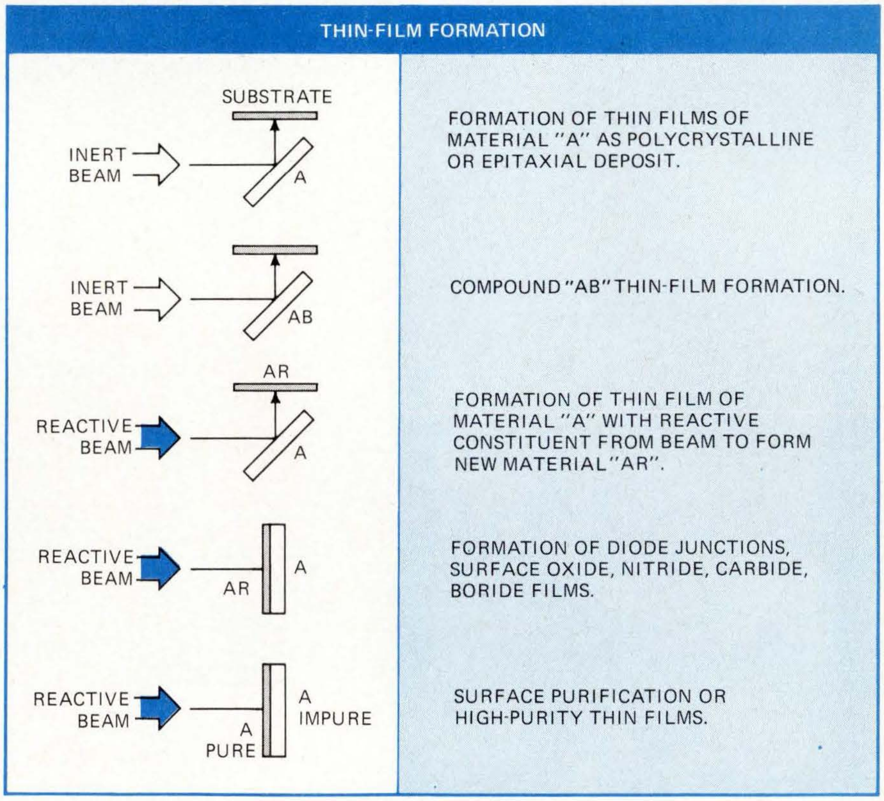
The deposition technique consists of bombarding a material with the ion beam, knocking off the atoms at or near the surface of the target, and then collecting these atoms on a substrate in a vacuum apparatus similar to that used for conventional sputtering and evaporation.

The results so far:

- Corrosion resistance of some materials increases greatly.
- Transition temperature of some superconductive materials rises considerably.
- Binary and ternary compounds, such as sapphire, can be formed from elemental materials.
- Materials heretofore requiring extraordinary heating prior to deposition can be deposited "cold" on virtually any substrate.

While much remains to be done before developmental work can be started, Bell researcher Paul H. Schmidt expects that the technique will be competitive with sputtering, but have three significant advantages: 1) surface smoothness is much greater; 2) adhesive quality is, often, much improved; and 3) vacuum requirements are less severe.

In addition, Schmidt believes the technique can be used to coat wires and metal foils to improve corrosion resistance, abrasive materials with hard surfaces, and biological materials so they can be examined with a



Formations. Films of various elemental and compound materials can be deposited by tailoring combinations of low-energy ions and reactive gases in experimental Bell technique.

scanning-electron microscope.

Schmidt and Edward G. Spencer, also a member of the technical staff at Bell, found that ion-beam-deposited films of copper and silver do not tarnish when exposed to air. And they expect to find similar corrosion-resistant properties in other metals and compounds.

In experiments with superconductors, too, they found that tungsten, which becomes superconductive at 0.012 kelvin, will become superconductive at 5 K when treated to the ion-beam technique. Likewise, molybdenum, which normally becomes superconductive at 0.9 K, becomes a superconductor at 7.5 K. And chromium, not previously known as a superconductor, was found to have a transition temperature of 1.52 K.

Refinements. Spencer and Schmidt also found that films can be made by direct bombardment of a compound or by the introduction into the ion beam of a reactive gas, which permits the oxide of the metal target to be formed directly. For instance sapphire (Al_2O_3) can be formed either by using an Al_2O_3 target or by bleeding oxygen over aluminum.

In addition to changing material properties, the ion-beam technique will deposit refractory metals on any substrate with a minimum amount of heating. This means that tungsten, for example, which melts at 3,000°C, could even be deposited on paper. Similarly, tantalum, niobium and other typically high-melting-point materials can be deposited on virtually any substrate.

In their experiments, Schmidt and Spencer used a low-energy (about 3,000 volts) ion-beam generator. This was basically a cold-cathode, hollow-anode glow discharge into which one of the noble gases was injected. As the gas ionized, ions aimed at the target knocked off atoms of target material. Ion energies can vary from about 10 electronvolts to the kilovolt range.

The reason there is no heating of the substrate is that there is no radiation or secondary-electron heating because the glow discharge is maintained outside of the vacuum apparatus. In the case of sputtering, which has a comparable deposition rate, the glow discharge is within the vacuum, and, even though it operates at about 2,000 V, radiates large amounts of heat on the target.

Four different noble gases were used—neon, argon, krypton, and xenon. Films were deposited at room temperature on soft glass, Al_2O_3, and acetate substrates. All targets consisted of ultra-pure materials (greater than 99.99%). A period (30 to 60 minutes) of target bombardment always preceded deposition to ensure that the target was clean. Deposition rates ranged from 50 to 300 angstroms per minute over an area of 2.5 cm^2 with ion source conditions of 6 kilovolts and 1 milliampere. Typical film thicknesses ranged from 1 to 5 micrometers. □

Communications

Circularly polarized TV signals getting Chicago tryout by ABC

The American Broadcasting Company has moved into a second phase—daytime tests—of its experiments with circularly polarized television transmissions from its Chicago station, WLS-TV. Off-hours test-pattern studies, completed in late April, indicated that circularly polarized waves will probably give better reception in cities because of fewer problems with reflections from large buildings. If the daytime tests confirm this, ABC will ask the Federal Communications Commission for permission to adopt the technique as a permanent method of transmission.

Up to now, all television transmissions have used horizontally polarized signals, where the electric field vector is restricted to the horizontal plane. When reflected, the vector remains in the horizontal plane, so that antennas cannot discriminate between direct and reflected waves. Although circular polarization was known to the early TV antenna designers, horizontally polarized transmitting antennas were better developed, and once the trend was started, horizontal polarization became a way of life in TV transmitting.

To take maximum advantage of the interference reduction provided by circularly polarized signals, set owners will have to buy new antennas. However, these should not be significantly more costly than present antennas, since they are simply an assembly of metal rods placed in both horizontal and vertical orientations. Present antennas, it should be pointed out, will also receive the circularly polarized signals, but determining how well they perform is one of the subjects of the present tests.

Although nearly all frequency-modulation radio stations in the U.S. now use circularly polarized transmitting antennas, ABC's tests are the first for television transmissions, says Fred Zellner, ABC's manager for allocations and rf systems. ABC chose Chicago for the tests because interference grew rapidly during construction of the 100-story John Hancock building.

ABC, together with RCA Corp., designed an antenna assembly comprising a horizontally and a circularly polarized antenna. Regularly scheduled programs now are being transmitted alternately from the antennas—one or two days on one antenna, and a similar period on the other. Engineers from the Washington, D. C., telecommunications consulting firm of Smith and Powstenko are measuring picture quality. ABC also has hired a public-opinion consultant to poll viewers for their comments on how the pictures from the two antennas compare.

In circular polarization, the field vectors rotate as the wave propagates, so that a rod antenna's orientation is unimportant. Thus, for example, simple rabbit-ear antennas

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electronic arrays

Circle 41 on reader service card

should give equal reception in all orientations. More importantly, when a circularly polarized signal is reflected from, for instance, a building, it changes the direction of polarization—say, from clockwise to counterclockwise—and a specially designed receiving antenna would reject the reflected wave and accept only the directly transmitted wave. Also, a signal striking the antenna from the aft direction would be rejected. This would help improve reception in fringe areas, where there may be two stations transmitting in opposite directions on the same channel (so-called co-channel interference). □

Communications

Phone add-on fight opens in New York

If the storm of protest over telephone-company interconnection fees breaks through the defenses manned by the New York Telephone Co., the market for both new and old types of telephone add-on equipment can be expected to broaden. At a public hearing last week on interconnect devices at the New York Public Service Commission's offices in New York City, a stream of witnesses— including city and state officials, as well as consumer groups and individual subscribers—challenged the telephone company to present evidence that add-on devices without the protective couplers for connecting such equipment to telephones have degraded telephone service.

If these groups win out in New York, a national precedent could be set for modifying, if not eliminating, the coupler requirement—or, at least, lowering phone-company fees. New York Telephone's opening statement was simply that the present tariffs (approved by the PSC in 1972) are designed to protect the network. A more definitive case for retention of such tariffs will be filed by the telephone company by Aug. 1, along with direct presentations

News briefs

MIT sees color TV reliability up . . .
Thanks to increased reliability and resultant savings in service charges, the total life cycle cost of color TV sets has declined in constant dollars from over $1,200 in 1964 to about $800 in 1972, according to a study just released by the Massachusetts Institute of Technology Center for Policy Alternatives. The 330-page report, covering color receivers and refrigerators, concludes that design changes to enhance reliability bring down the total cost of these appliances more effectively than attempts to improve the productivity of service organizations. Eventually, MIT expects to develop procedures to show manufacturers and Federal agencies how to design for minimum life-cycle costs.

. . . but TV sales slump
The softening in TV sales for 1974 predicted at the beginning of the year [*Electronics*, Jan. 10, 1974, p. 103] appears to be continuing, according to midyear figures disclosed by marketing executives at a panel held at the Consumer Electronics Show in Chicago. The panel heard that between 8.5 and 9 million color sets and about 6.5 black-and-white sets will be sold by the end of the year. Last year the total was slightly over 9 million color and just under 7 million black-and-white sets.

GTE Sylvania to study data link problems
Eyeing problems in high-frequency line-of-sight, troposcatter, and satellite tactical data links, the U.S. Navy has awarded a $20,000 contract to GTE Sylvania Inc.'s Communications Systems division to evaluate low- and medium-frequency radio waves for short-range data links for the Marine corps. Sylvania will specifically analyze the propagation and noise characteristics of ground and sky waves in the 200-to-500-kilohertz radio band, and will investigate modulation error control and signal-processing techniques for the links. In addition, the company will design, on paper at least, a typical data-link system.

Univac innovates in its 90/30
The third and latest model in Sperry Univac's new 90 series of computers, the 90/30, is a small-to-medium-scale unit that's intended to replace the seven-year-old Univac 9200 and 9300 computers. It not only makes major use of microprogramed logic, but the controllers for communication lines, magnetic-disk storage units, and other peripherals are integrated with the mainframe due to the use of MSI and LSI techniques.

House grants NASA $3.3 billion
The House of Representatives, acting on a compromise bill with the Senate, voted to authorize a maximum of nearly $3.3 billion in spending by the National Aeronautics and Space Administration during the fiscal year beginning July 1. Major items include $805 million for the space shuttle, $313.3 million for space flight operations, $250 million for tracking and data acquisition, and $266 million for lunar and planetary exploration. The total is about $19 million less than NASA requested. Of the reduction, $10 million was made in the space-flight operations program. Actual expenditures will be set later by appropriations legislation.

Navy to look for Sanguine site
The U.S. Navy says it will start looking in 1976 for Federally owned land suitable for its Sanguine submarine communications system [*Electronics*, May 2, p. 38]. Development work was suspended about two months ago, but the Navy has said it hopes to resume the project in the 1975 fiscal year starting July 1, if Congress approves. The proposed system, involving installation of a vast below-ground network of wires, has been fought by environmentalists and others. Because of such opposition, the Navy turned away from proposed sites in Wisconsin, Texas, and Michigan.

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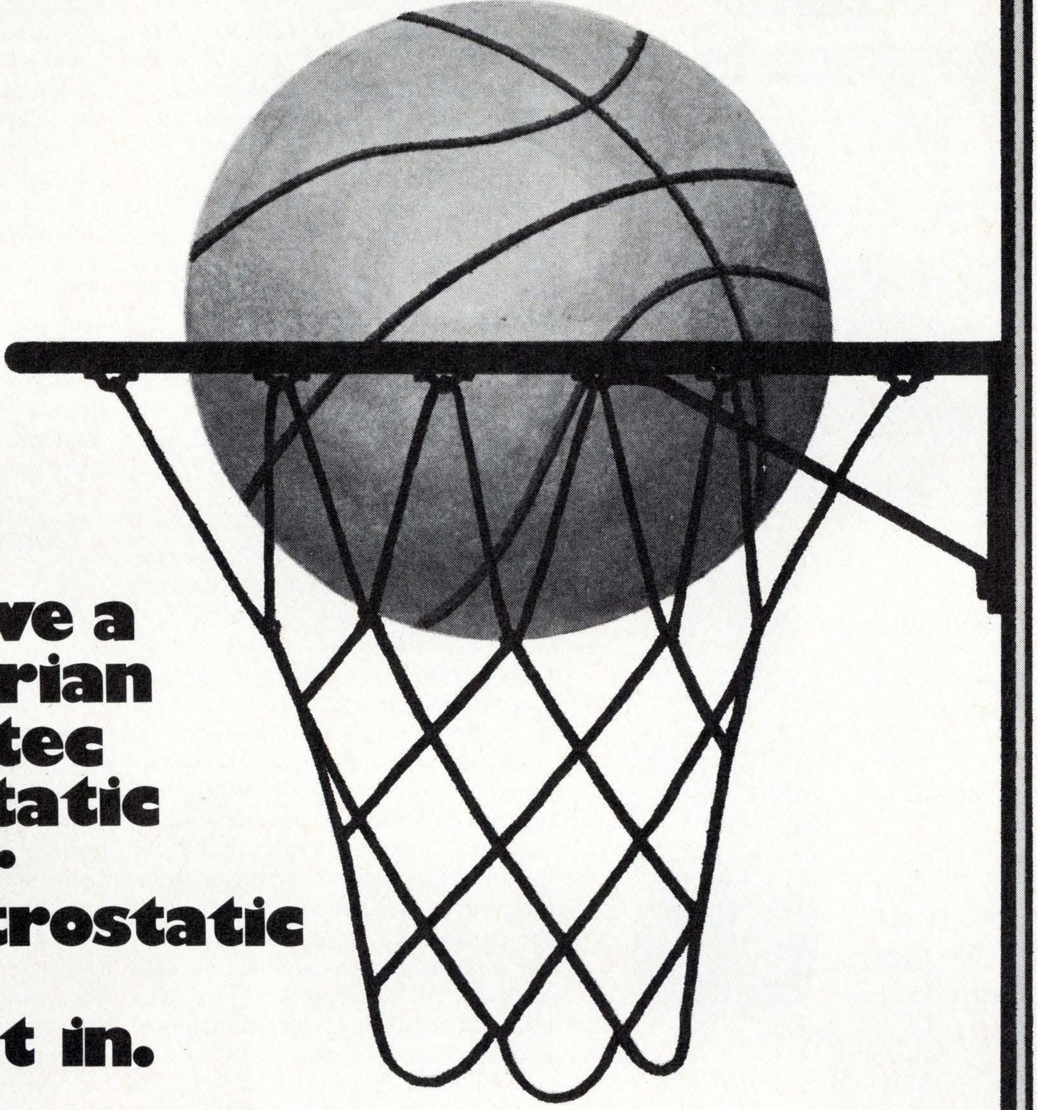

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from the manufacturers of the well-established telephone answering devices. But waiting in the wings for the interconnect charges to drop are the manufacturers of the relatively new add-ons, which include such things as automatic answering machines and dialers, intercom units, and even small private branch exchanges (PABXs).

Harry Newton, a New York City telecommunications consultant, testified that there are now at least 400,000 phone answering devices in use nationwide which are made by about 20 independent manufacturers. In addition, there are 65,000 phone-answering devices made by the Bell System in use. And the market is growing fast—by 50% to 60% a year, says Newton.

Newton says that if phone company tariffs—rules specifying not only fees but equipment requirements as well—for add-on equipment are disallowed the business would follow the course of pocket calculators with radical reduction in the size and cost of equipment.

Certification. The crucial questions are, of course, whether the protective devices are needed and, if they are, how can standards be established so that non-Bell System manufacturers can build them into the equipment. Several witnesses at the hearing suggested that the PSC itself set up a laboratory to determine the safety of add-on equipment and issue certification to approved manufacturers. But because of the cost involved, it appears that the Federal Communications Commission may be the only agency with the know-how, funds, and authority to conduct such tests.

When the FCC allowed the interconnection of customer-provided equipment to the telephone in the Carterfone decision of 1968, two regulatory systems were suggested, as pointed out by Commissioner of New York City's Department of Consumer Affairs, Elinor Guggenheimer. One proposal would ignore how customer-owned equipment is designed but would require that it be connected to the telephone system through a standard interconnecting device—the much-maligned coupler. The other—and the one she favors—would be to establish standards for the electronic design of the add-ons and to institute a procedure for certifying them as sound. With this approach, the coupler might be omitted entirely from the telephone system.

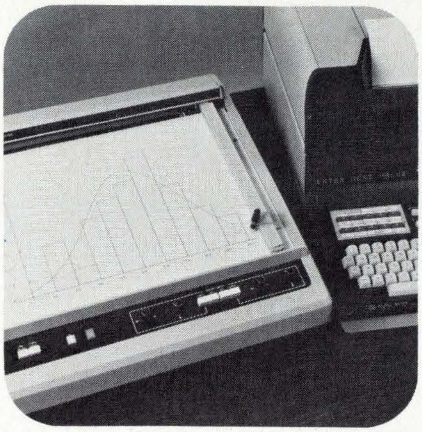
Telephone subscribers also complained about the fees they're paying for couplers. In the New York City area, these include a $46 installation fee plus a $5.86 monthly charge, which means, pointed out one subscriber, that the telephone company may collect more than the cost of the added equipment in less than a year. One telephone-answering unit, Phone-Mate, for example, costs less than $100. □

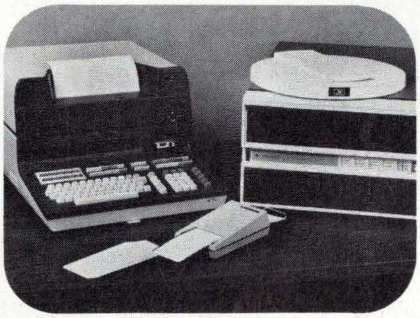
Commercial electronics

Micro chips aid design changes

Many digital engineers are discovering the advantages of putting their logic in the form of software and using one of the new single-chip microprocessors as a major component in their designs. But few companies have taken this approach as far as Digi-log Systems Inc., of Horsham, Pa., a designer and builder of special-purpose and custom-designed computer terminals.

Heretofore, the company had relied on hard-wired logic for a variety of terminal products. Included were two units displaying 16 lines of 40 and 80 characters, respectively, and each with a keyboard and an acoustic coupler for use with a telephone handset. There are also a terminal for use by travel agents that gives them direct access to an airline's computerized reservations system (still being tested by the airline); a CRT terminal with an attached tape-cassette drive, for use by insurance brokers; and a terminal for use in a chain of restaurants catering to motorists, enabling them to receive telephone messages while on the road by interrogating a central message center. [*Electronics*,





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May 10, 1973, p. 31].

But the necessity for a new design to build each individual product turned out to be too expensive when it came to a terminal earmarked for users of Western Union's Mailgram service—until Digi-log designed the terminal around Intel's 8008 microprocessor. Digi-log has now shipped several hundred units made in that configuration to Xonics Corp., the contractor building the terminals for Western Union. Digi-log has also used the same idea in designs for other customers.

Basically, its entire design approach has been reduced to a set of printed-circuit boards: three kinds of read-only memory, a read/write memory, synchronous and asynchronous input/output cards, a set of display drivers, a keyboard module that can generate any 8-bit code from any of 110 keys, and, last but not least, a processor board, called Microterm, which uses either the 8008 or the faster version of it, the 8008-1.

"We have no standard product," says Marvin Pollock, director of product applications, "but we use the Microterm to emulate any other product we want to." He cites one Digi-log customer who uses a single terminal design for three different applications, each of which is programed for the Microterm and its microprocessor.

Perhaps the most effective use of the Microterm is in a program-development center built by Digi-log for its own use. Here the Microterm runs in three modes: to load a new program into a read/write memory; to emulate the processor while debugging that program; and finally to transfer the program into a reprogramable read-only memory (ReProm). For the last, it uses Intel 1702 memories, which can be erased under ultraviolet light. It can also copy the contents of a known ReProm into a new one, thus doubling as a low-volume production unit. For larger volumes, the box can also drive a paper-tape punch to generate the data for the program mask of an Intel 1302, the mask-programed equivalent to the 1702 memory. □

News update

France delays signing of space-agency pact A little slippage can be expected in the timetable for setting up any new international agency. So no one was particularly surprised when the April 1, 1974 target date for signing the convention establishing the European Space Agency [Aug. 16, 1973, p. 69] was pushed back until this month. And now the agency's birth doesn't look likely until autumn. The official reason was France's request for a delay so that the new Giscard d'Estaing government could take another look at the proposition. But equally important is the inability of the French and the West Germans to agree on whether a Frenchman or a German should head ESA. Meanwhile, European space programs are continuing smoothly under the direction of ESRO, one of the two organizations ESA will supplant (see p. 80).

LED display panel cost reduced The problem a year ago with Litton's light-emitting-diode display panel [Aug. 16, 1973, p. 34] was to reduce the cost from $1 a point to 10 cents a point. At the time, it was felt that the display, another possible flat-screen replacement for TV, wouldn't get down to the dime level until 1980 or so. But now Litton's Data Systems division in Van Nuys, Calif., says that it has not only solved the cost problem, but has managed to overcome heat and power handicaps. It has a contract from the U.S. Army Electronics Command to build a 6-by-6-inch panel, using low-power, off-the-shelf medium-scale ICs rather than custom LSI.

Microprocessor chip too complex A British maker of peripherals last year breadboarded a microprocessor chip that it said would put a minicomputer with roughly the power of a Digital Equipment Corp. PDP-11 onto a single 10-by-14-inch board. But IC makers approached by the company, Computer Electronics Ltd. [Aug. 16, 1973, p. 59], couldn't manufacture the chips in quantity. "We've shelved the project until the technology can catch up," says an official of the firm, explaining that IC makers "didn't feel they could give us a high enough yield for the complex chip." Among advances required to produce the 300-mil chip: larger slices of purer silicon which "in a year might be available," he says.

Fairchild says yes to 200 X 200 CCD imager A 200-by-200 CCD imaging array can be built. That's what the feasibility study performed by Fairchild Camera & Instrument for the Navy under an $800,000-plus contract shows, says the company. The study, due to be completed next month for the Navy's Electronic Systems Command [May 10, 1973, p. 25] is aimed at the development of large-area CCD arrays. The next phase is development, and Fairchild says it's hopeful that it can win the award. The phase of the program just completed called for fabrication of prototype cameras with emphasis on anti-blooming and on-chip amplification techniques. The ultimate goal is development of low-light-level cameras for all three services.

Smart video camera getting around A broad range of industries is using the smart video camera introduced by Reticon Corp. of Mountain View, Calif. [July 5, 1973, p. 32]. The camera, which can perform such tasks as inspecting parts on a production line, preparing production records, or printing inventory lists, is now being used by companies in the drug industry, plywood and plastic laminates manufacturing, and the diamond industry, among others. All told, says Reticon, several dozen units have been sold since they became available several months ago. Reticon also has improved the microcomputer control unit and has increased the array to 1,024 diodes from 512.

A-m radio chip selling well While Signetics Corp. has not yet captured the a-m radio market with its monolithic front end [Aug. 16, 1973, p. 40], it reports that its chip is selling well—mostly to General Motors' Delco subsidiary. Another good customer, says Signetics, is a Japanese radio manufacturer that supplies Volkswagen, and Signetics hopes to increase sales in Japan when that nation's consumer market opens up once again. The chip itself is designed to replace only the transistors and the interstage resistor-capacitor networks directly between the transistors.

Big pay-TV test runs into problems The question a year ago was: Would viewers accept pay television? While programing had begun in California, Pennsylvania, and Virginia, the big test was coming up: the attempt to crack a big, tough market—New York City—by Sterling Manhattan Cable [Aug. 2, 1973, p. 71]. Installation, scheduled for last fall, is still scheduled, but sterling—and all pay TV operators—have run into a shortage of capital, a well-financed anti-pay TV campaign by the National Association of Broadcasters, lack of good programs and new movies, and trouble arranging sports pickups. Insiders predict that the whole affair will have to wind up in the lap of the FCC.

—**Howard Wolff**

Intended to bring *Electronics* readers up to date on news stories of the past months.

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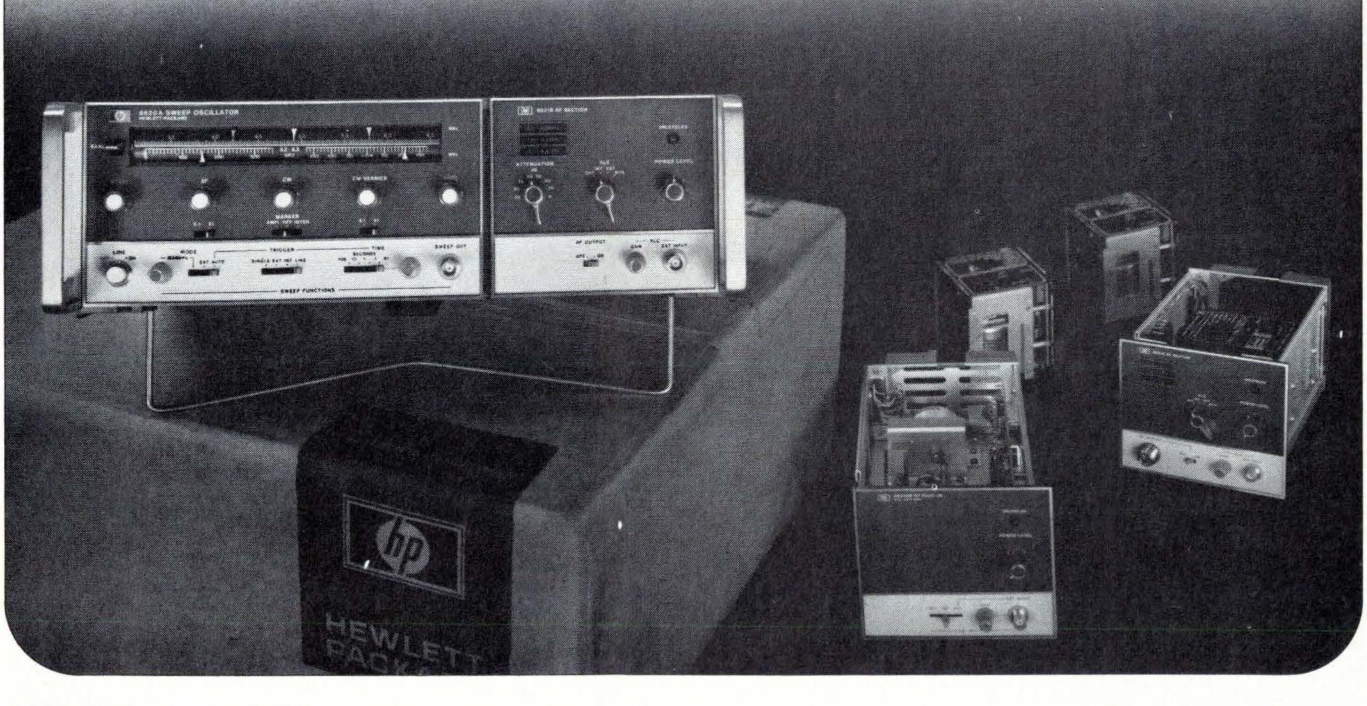

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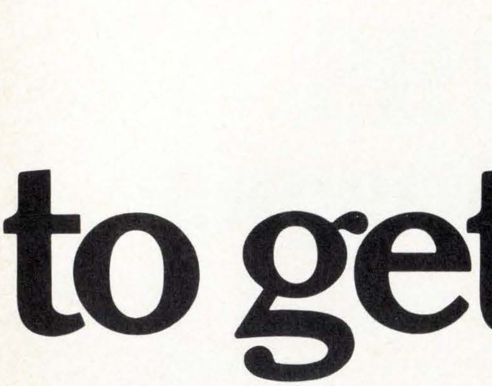

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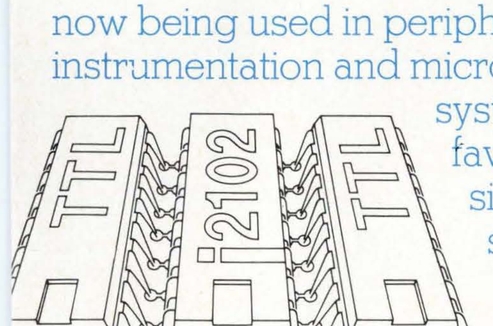

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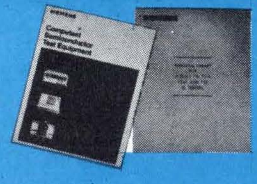

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Circle 52 on reader service card

Washington newsletter

Laser safety standard at last sees the light

Within the week, after nearly three years of discussion and dispute between laser manufacturers and the Government, **the Bureau of Radiological Health will publish a revised Federal standard for laser safety.** Alexander M. Schmidt, commissioner of the Food and Drug Administration which oversees the bureau, contends that the new standard is much improved over the one first proposed last December.

But agreement seems unlikely on the hazards of Class II systems—lasers with outputs of between 1 and 5 milliwatts. The first bureau definition, restricting Class II lasers to 1 mW, was labeled "ultraconservative" and "overzealous" by the Electronic Industries Association. Notes Allen M. Wilson, EIA's chief engineer, **1-mW lasers would be useless to the construction industry, which accounts for 75% of civilian laser dollar sales.** And, though no one admits it officially, **manufacturers expect to go on selling 1-5-mW lasers** but only to the construction industry.

Inflation relief urged for aerospace fixed-price awards

The Department of Defense is giving sympathetic consideration to **a plan by the aerospace industry for economic relief from the pressures of fixed-price contracts** in a period of soaring inflation—even though the request is generating some initial suspicion in a Congress disturbed by rising weapons costs. William B. Bergen, president of Rockwell International's North American Aerospace group and a leader of the appeal, wants **wider use of price adjustment clauses in Government contracts, more phased procurements using shorter-term contracts, and improved means of measuring inflation on individual programs.**

Assistant secretary of defense Arthur Mendolia is encouraging DOD contract officers to make greater use of adjustment clauses and shorter-term awards to overcome company reluctance to bid on new contracts. But Bergen notes that Federal economic indices often reflect primarily commercial markets, and are not very relevant to aerospace.

House action on a-m radios unlikely despite Senate OK

Despite the Senate's passage in mid-June of **legislation that will require all consumer radios retailing for more than $15 to receive fm as well as a-m signals,** chances for approval by the House of Representatives are poor, say congressional insiders. **No House action is scheduled on the bill, which slipped through the Senate on a 44-42 vote.** Most of the support for the bill comes from fm broadcasters anxious to reach the auto radio market, but the **radio manufacturers represented by the Electronic Industries Association have opposed it.** And EIA staff vice president for consumer products, Jack Wayman, says the association will testify against it when it comes up for consideration by the Interstate and Foreign Commerce Committee's communications subcommittee.

U.S. court rules against voiceprints

The prospects for the voiceprint as a new application of electronics to law enforcement have been dimmed by a June ruling of the U.S. Court of Appeals in Washington that **the technique is inadmissible as evidence, since it's "not sufficiently accepted by the scientific community as a whole."** While the ruling is applicable only to Federal courts under the Washington-based appeals court's jurisdiction, it is expected to influence other courts as well. Some state courts and the U.S. Military Court of Appeals now accept voiceprint evidence.

Mass transit derailed

"If we can get men to the moon and back, why can't we get people from one side of town to the other?" That question by one congressman is being posed with increasing frequency to embarrassed electronics and aerospace systems companies, which once viewed urban mass transit as the perfect vehicle for the transfer of high technology from space and defense programs to the nation's cities.

For years that dream of a long straight track toward a new major market was encouraged by the Department of Transportation through its Urban Mass Transportation Administration and its steadily increasing budget. Now, however, the dream has turned into a technological nightmare following a couple of badly engineered but expensive efforts, San Francisco's Bay Area Rapid Transit system [*Electronics*, Dec. 4, 1972, p. 47] and the Morgantown, W. Va., demonstration program of personal rapid transit.

UMTA's Watergate

The more recent disaster–at Morgantown's system for linking the University of West Virginia's downtown campus with another on the little city's fringe–is proving to be UMTA's Watergate. Problems with the Morgantown experiment began not long after DOT took over the program in 1971. Despite its widely publicized dedication in October, 1972, just prior to the presidential election, the system won't begin operating until early next year. Even then it is unlikely to be completed. And it may never be if a disenchanted Congress cuts off funds.

The price tag for the three-station, 45-car system that runs no more than 2.2 miles is now $64 million. If it is ever extended to the six stations and more than 70 cars originally planned, the cost will nearly double to $125 million. Those figures far exceed what the university originally had in mind–$13 million for a little system of small electric vehicles on a lightweight, elevated guideway.

What happened? First, DOT decided it needed a more substantial system designed to serve as a national prototype, not engineered simply to meet the needs of a small college town. Thus were the little cars proposed by Alden Self-Transit Systems Corp. of Milford, Mass., dropped in favor of far larger vehicles designed by Boeing Co. Of course, this meant enlarging the guideway into a cumbersome structure of steel and concrete.

Then an image-conscious White House entered the act, demanding an accelerated schedule for the sake of a national political campaign. That further muddied the technological waters. UMTA was obliged to turn to concurrent design and production, that stumbling block of so many military projects in the past. The guideway builder, for example, was called upon to begin work before the new vehicle specifications were fixed.

The penalties

The economic and engineering consequences of these judgments are history now. But the penalties are only beginning to be paid. Not only is Congress turned off on new technology for transportation, but so are many of the nation's city administrators.

Money for UMTA programs is coming hard in Congress this year. For example, the House Appropriations Committee's transportation panel has already eliminated $18.1 million for the agency's fiscal 1975 budget request, wiping out two significant programs. One is a $7.5-million dual-mode demonstration system that could handle vehicles adaptable to both automated guideway operation and conventional street driving. The other, priced at $10.6 million for initial design and development, involved an improved personal rapid transit system to be built near Denver.

Another loser in the aftermath of Morgantown was Robert A. Hemmes, whose recent departure as UMTA R&D chief was never officially linked to the project's failure though no one in the agency disputes the connection.

UMTA's lost appropriations and Hemmes' lost job after Morgantown are but symptoms of the program's problems. Their roots lie in the apparent compulsion of DOT's administrators, abetted by anxious contractors, to overdesign new systems for competitive civilian markets as though they were going to the moon.

Back to busing

Few people are surprised now that UMTA has retreated to playing it safe with the "proven technology" of Detroit's buses. UMTA's administrators know their jobs are secure when they smilingly acknowledge they "can give you money for all the buses you want." Of course, the record shows they are right. In one week in June, grants for buses included $10 million to Honolulu, $2.4 million to Kansas City, $2.5 million to Tucson, and $7 million to Cleveland.

It is enough to make Detroit comfortable with its conviction that electronics and aerospace technologies must first come down to earth before they can begin to challenge the bus. **–Ray Connolly**

Electronics international

Significant developments in technology and business

Sony starts converting bipolar devices to new structure for higher performance

A novel transistor technology developed by two Sony Corp. engineers seems to defy conventional design rules, yet it gives superior device performance and higher production yield than standard double-diffused devices. Hajime Yagi and Tadaharu Tsuyuki design their devices with low emitter-doping concentrations (LECs)—typically an order of magnitude or two below those in the base, rather than several orders of magnitude higher.

Sony has been producing LECs for about three months and expects to convert all bipolar-device production, including integrated circuits, to the new structure over a five-year period. The Sony engineers emphasize that only the configuration is changed, and all device processing remains conventional. Furthermore, the features of the devices include two-dimensional, rather than three-dimensional, current flow, which is especially helpful in computer-aided design of ICs.

Basics. In the new technology, an electrical barrier in the emitter reflects the minority carriers injected into it, preventing them from becoming a component of the emitter current. A necessary, but easily met, condition is that minority-carrier lifetime in the portion of the emitter with low doping concentration should be high enough to make recombination current negligible.

The most usual barrier used in these devices is a low-doping/high-doping junction (n^+/n or p^+/p) barrier. Also useful are a p/n junction barrier, and less commonly, MIS barrier and heterojunction barrier. A big difference in the new approach is that the base doping profile of transistors is unaffected by the emitter-doping conditions.

Transistor-current gain is a linear function of ion-implantation dosage in the base. Therefore, current gains in the order of 10,000 are possible in a single transistor, rather than requiring a Darlington connection of two transistors.

Devices produced by this process include power transistors, low-noise transistors, symmetrical transistors, high-current-gain transistors, high-frequency transistors, phototransistors, junction-gate-controlled transistors, MIS gate-controlled transistors, and thyristors—including those with gate turn-off characteristics.

An important reason for the improved performance is a self-ballasting effect in the LEC region, which makes current flow throughout the device more uniform and eliminates hot spots. However, saturation resistance is still a low 0.1 ohm, measured at collector current of 8 A and base current of 1 A. □

Switzerland

Microprocessor operates data-ray meter to gage plating thickness

To help its customers make sure they were not wasting money by plating on overly thick gold layers, Geneva-based Oxy Metal Industries (Suisse) SA decided to develop a highly sensitive thickness meter. And, since their design called for computing capacity, Oxy engineers built the meter around Intel's MCS-4 microprocessor system.

All this occurred back in 1972, when anyone designing a microprocessor into hardware was pioneering. The development model was ready in November of that year. It has since been refined, and the first production units are scheduled for delivery toward the end of June. But the new device, called the mc Betameter 100, is not the only piece of microprocessor hardware that Oxy has readied for the market. "We have sold a dozen RALs already," says Georges Matile, head of the company's electronics laboratories. In Oxy's lexicon, a RAL is a random-access loader, built around an MCS-4 for automated plating.

Oxy's Betameter, priced at $5,000, works on the same basic principle as other nondestructive plating-thickness gages. The sample is bombarded with beta rays, and the resulting backscatter is picked up by a geiger tube. The count from the tube is converted into micrometers of thickness by means of a calibration curve that takes into account the plating material, the base metal, and the radioactive source of the beta rays. This beta-ray technique also works for determining percentages of the metals making up an alloy.

The Oxy instrument has eight different calibration curves stored in a pair of 256-word, 8-bit programable read-only memories. A similar pair of PROMs is reserved for eight additional special curves if the customer wants them. Mainly because of these curves, the instrument shows an accuracy to better than 5%, in most cases, over a range of 0 to 100 micrometers.

Along with making possible calibration curves that match the measurement, the microprocessor improves the instrument's accuracy in two other main ways. It averages out the initial calibration readings, and it checks constantly to make sure the measurement attempted is within the limits of the instrument's setup. Warning lights show when conditions are poor or actually impossible. And, of course, there's a big plus in operating ease because the sequence of steps during a measurement is programmed into the instrument via seven PROMs.

To take a reading of a plating thickness, the user sets the test duration—1 second is the minimum, but the usual time is between 5 and 15 seconds—and inserts a plastic "key" in the front panel to switch in the appropriate curve. Then the instrument has to be calibrated against two standards, themselves accurate to 40 atoms.

For each calibration—one for the low end, and one for the high end—the system actually takes a series of five readings, stores them, then discards the low and high ones, and finally averages out the remaining three.

Actual thickness readings can be based on a single measurement or the average of five, as for the calibration. Readout is a direct three-digit display of the thickness in micrometers. A sorting option indicates the condition of the plating on a sample. □

Japan

Black matrix, dots yield storage tube

Engineers at Tokyo Shibaura Electric Co. have developed a new storage oscilloscope tube using black-matrix technology and aimed it at the engineer's bench. Toshiba hopes for a sales spurt because the new tube costs a tenth as much as previous models.

Toshiba designers say that the utility of memory oscilloscopes with storage tubes should make for large demand, but the $1,800 for the CRT alone tends to price these oscilloscopes beyond the budgets of most users. Toshiba's price tag of less than $360 for a rectangular, 6-inch diagonal, direct-view storage tube is expected to open the way for less expensive equipment.

Price of the 10-megahertz scope is only $1,800, compared with prices that range from $2,900 to more than $3,600 for competitive brands in Japan. Maximum memory writing rate is 0.25 kilometer per second for single events.

The phosphor dots in the new tube are able to provide memory action, as well as acting as fluorescent phosphor in the usual manner. This ability eliminates the usual storage mesh, which is extremely difficult to fabricate and the major factor in the high price of storage tubes. The phosphor dots can provide storage because they have the two characteristics needed—they have good dielectric qualities, and they are efficient emitters of secondary electrons. The black matrix provides a conductive path to a transparent, tin oxide conductive coating on the faceplate and allows collection of secondary electrons.

Construction. Fabrication of the tube faceplate starts with deposition of the tin-oxide coating on the inside surface. This is followed by the black matrix and then the phosphor dots, much like making color-TV tubes. Dot spacing is 0.2 millimeter, about half that used in the average 16-inch color picture tube. This spacing gives a total of more than 200,000 phosphor dots.

Just behind the faceplate is a so-called hybrid mesh, which both repels ions that might otherwise damage the screen and collects some of the secondary electrons emitted from the screen. The hybrid mesh can also be used to produce an electrical signal corresponding to the waveform stored on the screen. The mesh is similar to the ion-repeller mesh in conventional storage tubes.

When the tube is used for display of repetitive signals, it operates in the same manner as an ordinary cathode-ray tube. Transparency of the screen is about 60%, and decreased brightness is compensated for by improved contrast. □

Around the world

Computer puts "map" of harbor on screen

When the Swedish 255,000-ton supertanker Sea Soldier recently sailed into Rotterdam, bridge officers had a new navigation aid helping them: a computerized system that pictures the channel ahead directly on the main radar screen. The system—a joint effort by the Kockums shipyards of Sweden and Selenia of Italy—was on its maiden run, and, according to Kockums engineers, it was a great success.

Until now, similar systems—made by Sperry—have required a special screen, separate from the main radar screen. The Kockums-Selenia system integrates the ship's radar, made by Selenia, with the system for presenting the lines of the shipping lane, so that the bridge gets it on one screen.

A moving map of the shipping channel is displayed on the screen, enabling the navigator to see his own ship's position in relation to the channel limits as well as to other ships and obstacles. As the ship moves, the lines on the screen also move.

The system makes use of an anti-collision computer, made by Selenia, linked to the normal on-board SM-3 navigation computer, which is made by Kongsberg of Norway. The Selenia computer, linked to the radar screen, presents vectors and speeds of other ships that the anti-collision radar system picks up, while the Kongsberg computer presents the channel map.

The map is programmed into the computer by means of punched tape or by keyboarding. The ship can keep a library of tapes for the ports that it sails to and the channels it passes. When a ship enters a stretch for which there is no tape, the data can be put directly into the computer by keyboarding the local latitudes and longitudes, which are taken off a standard chart.

Other details—such as water depths—can also be programmed to appear on the screen. The system also provides an automatic alarm signal, through the collision-avoidance system, if the ship crosses a boundary line.

The system provides a motion picture as the ship moves ahead—"like moving on a map," says Nils-Eric Thorell, a Kockums engineer. "You see your own ship in relation to other ships and to the limits. You can get an idea of where the other ships will be sailing." Initially, the system will be installed in ships built at Kockums in Malmoe, Sweden.

'Read-mostly' mass memory stores bits optically on glass

France's Laboratoires d'Electronique et de Physique Appliquée has been experimenting with a promising candidate for low-cost "read-mostly" mass memories–**semiconductor-glass disks that can be read by a modified video-disk player.** LEP, a unit in the Philips group, uses metastable germanium-tellurium disks 8 centimeters in diameter to store bits optically as transparent spots 1 micrometer in diameter in the translucent glass.

Bits are recorded by a low-power laser at a scanning rate of 1 megahertz. Only 2 nanojoules of energy per micrometer square are needed to restore the glass to its stable state. **Packing density runs between 10^6 and 10^7 bits per square centimeter, about 10 times the capacity of magnetic disks.** The glass disks can be erased by heating them to 140°C. LEP's work so far indicates that the disks can survive five to 10 erasures.

German, U. S. firms team to form auto semiconductor firm

VDO Adolf Schindling AG, west German vehicle-instrument maker, and Solid State Scientific Inc., of Montgomeryville, Pa., have agreed to form a joint semiconductor-manufacturing company. This move is apparently in anticipation of increasing use of solid-state devices in automotive accessories. **VDO owns 60% and Solid State 40% of the company, which is tentatively called VDO Elektronik and will probably be located in Switzerland.** Operations are scheduled to start in 1976.

The new facility's production targets are set quite high–"about 50 million integrated circuits a year, once the plant becomes fully operational with 300 to 400 people," says VDO. **The company's output, for VDO's own use and probably also for outside customers, will initially be complementary-MOS circuits only, but other types may be added later.** The German firm will provide the capitalization for the new venture, and Solid State's contribution will be its research and development potential, plus its production knowhow.

Electronic watches slated by firms in Japan, France

Two new producers of electronic watches with liquid-crystal displays will hit the market in Japan and Europe within the next few months. **Casio Computer Co. of Japan, the consumer-calculator maker, plans to have its watch ready in August.** In France, television manufacturer Marcel Pizon has spun off a new independent company, Electronique Marcel Pizon, to make solid-state clocks and watches. The clocks went into production this month, and a line of watches is due out in the fall. **Pizon's first big target is to supply Swiss watchmakers with electronic movements, which he says they still fear "because the quartz doesn't go tick-tock."**

ITT cranks up in UK for worldwide boom in capacitors

The ITT Capacitor division in the United Kingdom will more than double its production by early 1976 under plans that seek to exploit rising worldwide demand and include contesting tantalum technology in the Japanese marketplace. **Production for all types is targeted for 7 million per week from the current approximately 3 million, of which about 30% is exported.**

Japan, where the UK operation now ships 200,000 tantalum capacitors per week, is a primary target. **The company believes it has gotten**

ahead of the Japanese companies in that technology, and "we want to beat them on their home ground," says one top executive, who adds that ITT also is eyeing Hong Kong and Taiwan. Over-all export sales have been rising 1% a month. ITT's UK operation contributes $130 million to the corporation's $450 million annual revenue for its European components group.

Nippon Electric expands capacity for its computers

To meet anticipated demand for its System 100 small computer and also for its ACOS series 77 computers, developed jointly with Tokyo Shibaura Electric Co. (see p. 77), Nippon Electric Co. is rushing to completion a computer plant in neighboring Ibaraki prefecture. **NEC is also enlarging its present computer plant on the outskirts of Tokyo.** The new plant is set up as a subsidiary, Nippon Electric Ibaraki Ltd.

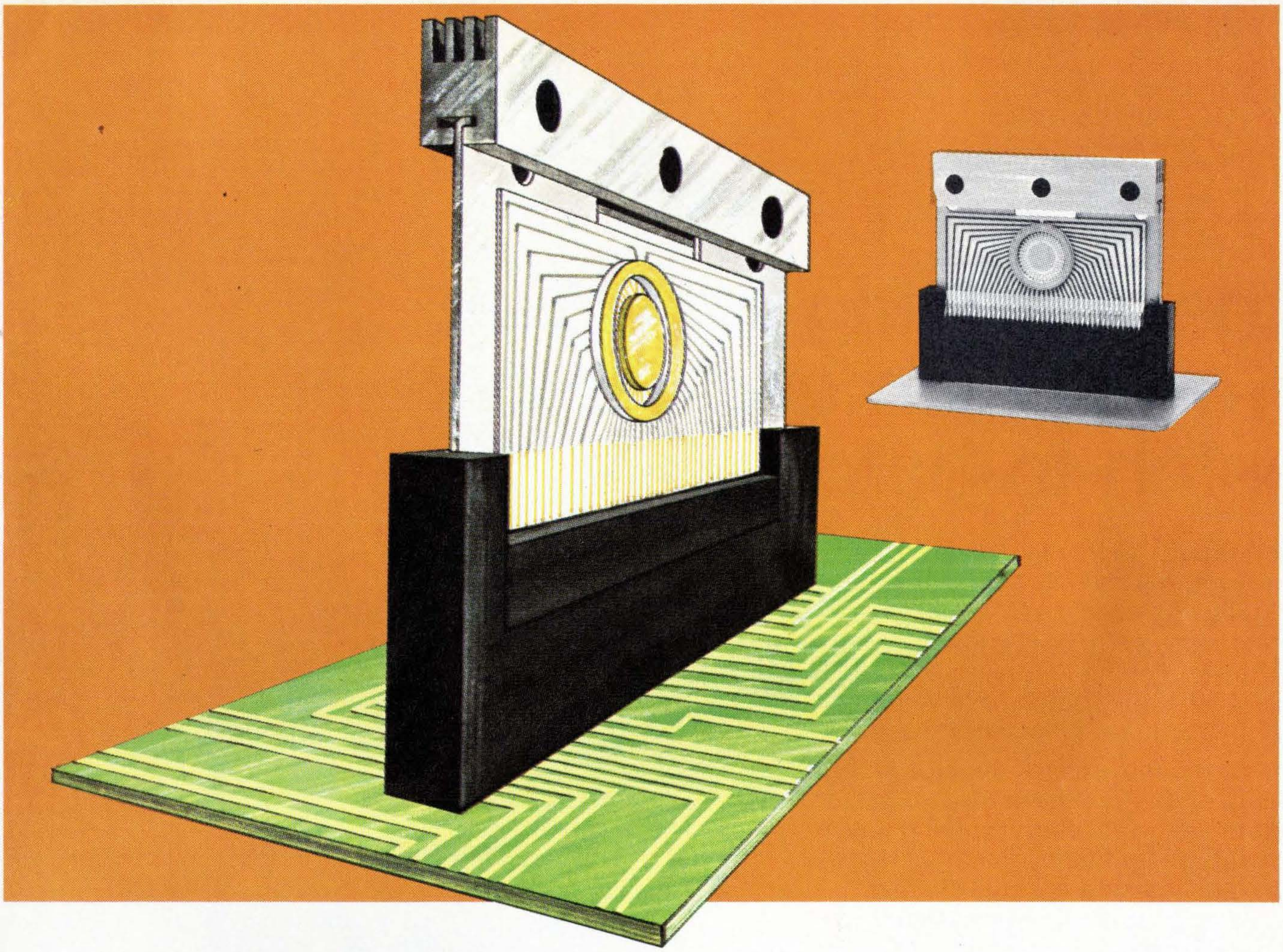
The Ibaraki plant will assemble CPUs for NEC's computers. At the start of operations next April, NEC plans to have more than 200 people working in almost 50,000 square feet of floor space. Production for fiscal 1975 is expected to reach more than $88 million. By the second half of fiscal 1976, the company plans to have more than 1,000 people at work in more than 215,000 square feet of space and production of more than $176 million. The capital investment through the end of fiscal 1976 is expected to reach more than $21 million.

Japanese agree to limit color-TV exports to Britain

The Japanese television industry is expected to limit exports to Great Britain of color receivers to about 100,000 sets for the second half of this year. In a meeting between Japanese and British industry representatives held in Tokyo last week, the British maintained that total color sales would be 500,000 to 600,000 fewer sets than the 2.8 million sold last year. **The Japanese say they don't think business will be all that bad, but agreed in principle to limit exports to the neighborhood of last year's 275,000 sets.** Exports to Britain for the first half of this year are expected to reach the 160,000 sets agreed upon by Japanese and British industries last November.

Addenda

Philips Data Systems division has strengthened its stance in the OEM market with a new minicomputer built around a general-purpose bus and a one-board LSI central processor. **The new P852m machine comes with standard memory modules of 4,096, 8,192, or 16,384 bits that have 1.2-microsecond access time. . . .** France is slowly building up an automatic automobile-telephone network. **The radio-link exchange at Lille, first city after Paris to get the new service, went on the air in mid-June with a start-up quota of 75 lines, slated to be increased to 200 next year.** Paris will get its third exchange soon, pushing the total there to more than 600 lines. Thomson-CSF is the kingpin supplier of the sets, which operate in the 150-megahertz band with 10 watts of emitter power. . . . West Germany's federal railways have introduced direct computer control of signaling and train-switching. **Controlled by a remotely installed computer supplied by Siemens AG are four signaling and switching stations along the Hanover-Bremen railroad line.** The computer, a model 304 process-control machine, uses a fixed program to check the routing of each train according to stored time schedules and then sets the track switches and the signaling gear.



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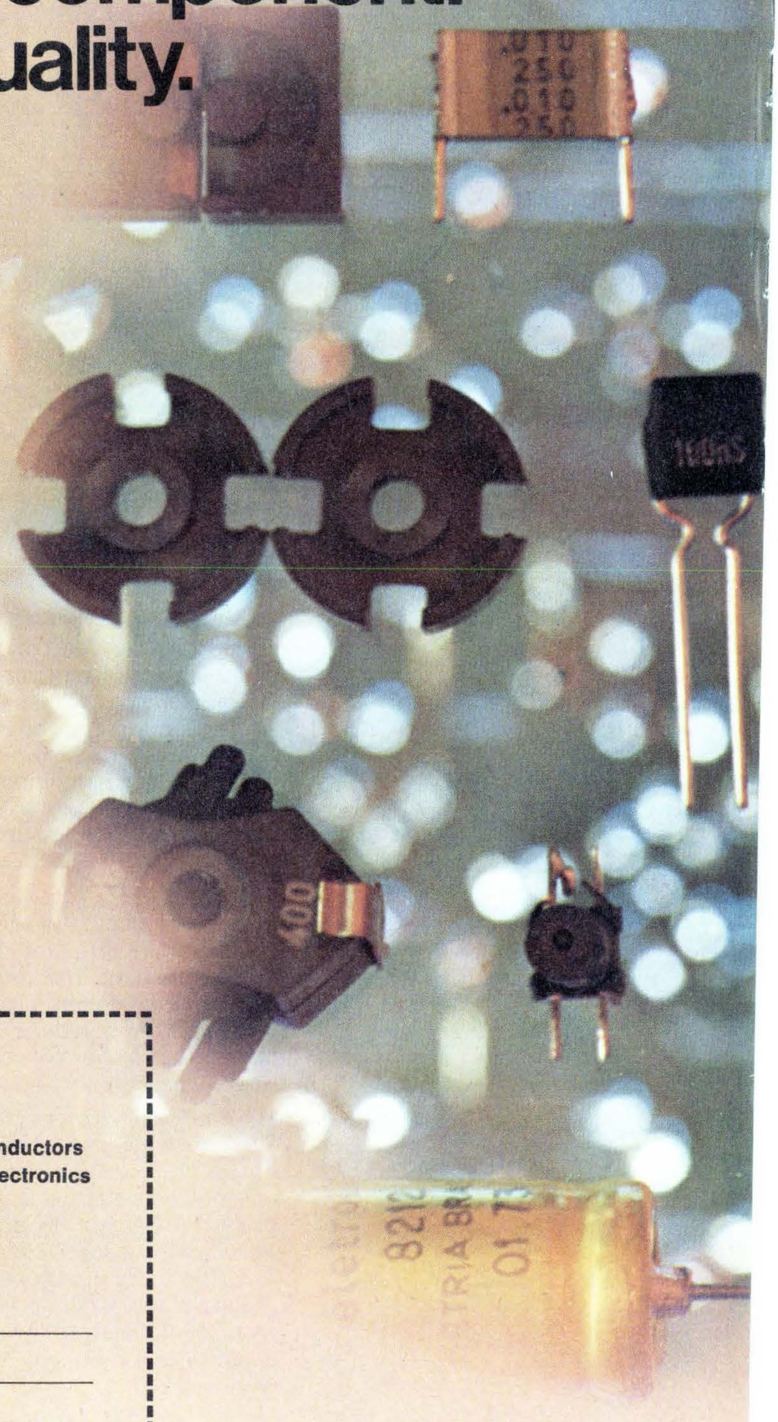
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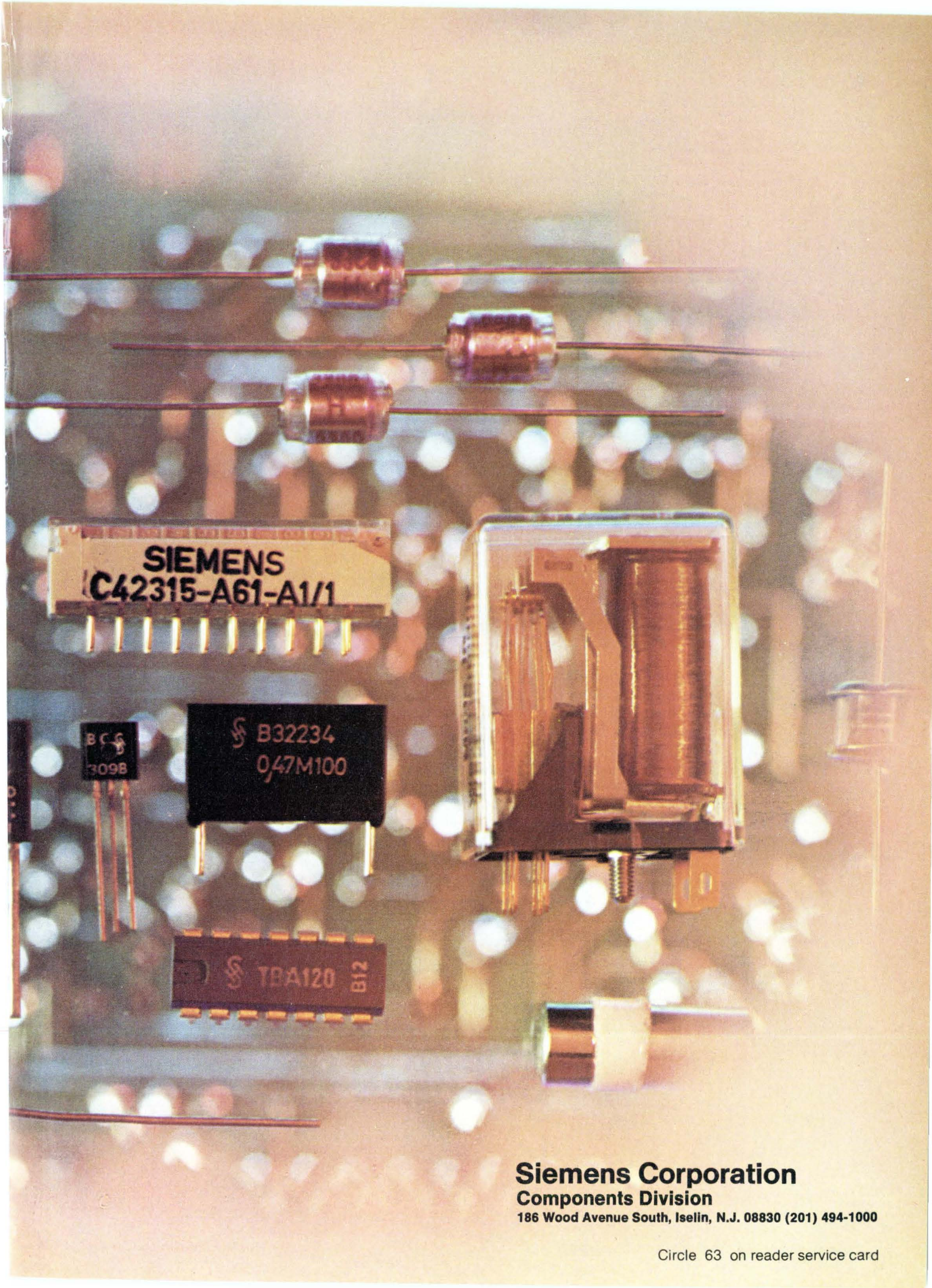
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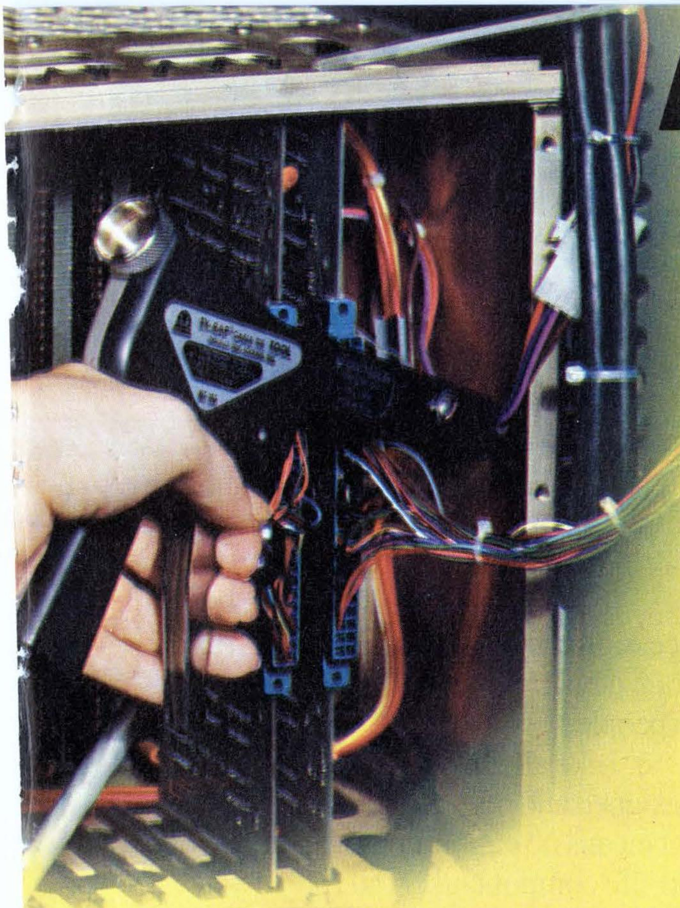

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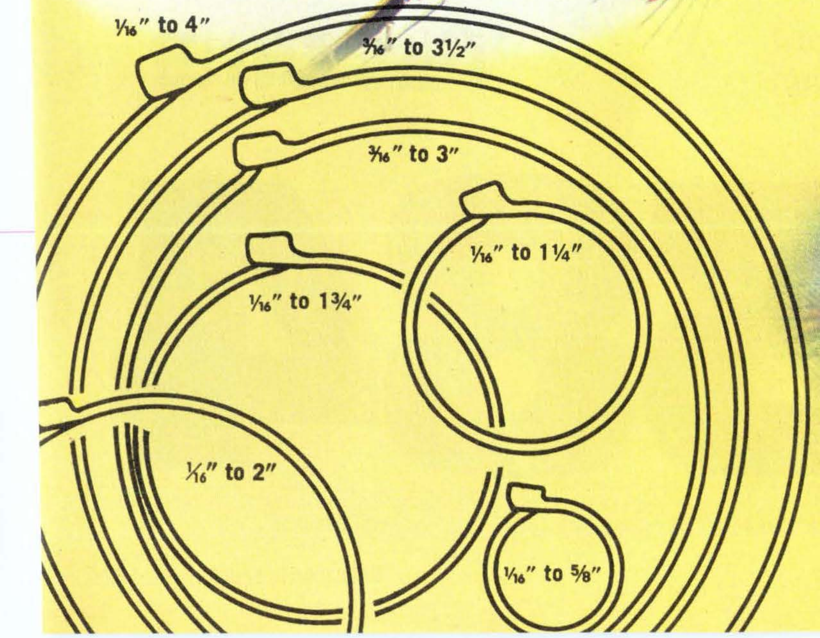

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A whole new game

Makers of electronic amusements find soaring growth rate slowing amid shakeout

by Bernard C. Cole, San Francisco bureau manager

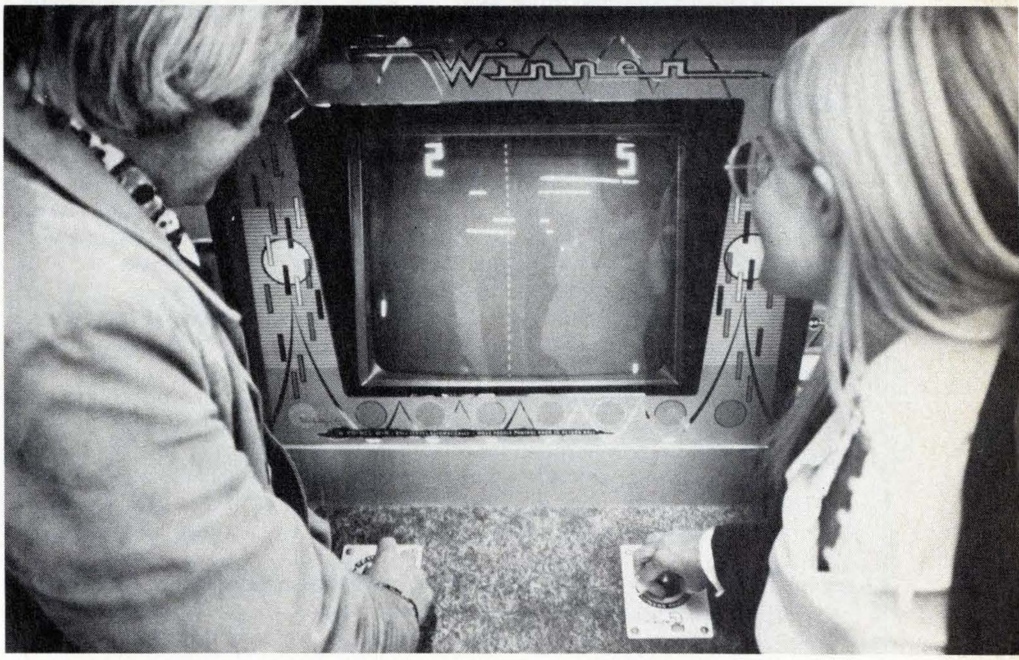
Six months ago, it seemed that electronics was going to take over yet another electromechanical stronghold—amusement games. But that's not going to occur quite yet because the market, perhaps approaching saturation, has slowed. After an interval of consolidation and intensive research, a period of impressive growth appears to be coming, but it won't be quite as spectacular as that of the last two years.

Although the traditional Chicago giants of the $120-million-a-year amusement industry—Bally Corp., Gottlieb Inc., Williams Electronics, and Chicago Coin—are not as interested as they once were in the new technology, significant changes have taken place. Where there once were just pinball machines, now there are also the so-called Pong games, played by two persons who try to "hit" an electronic ball back and forth on a cathode-ray tube. Consisting mostly of the display, a TTL circuit board, and a cabinet, the electronic games made it possible for a lot of small companies—located mostly in San Francisco's Silicon Valley—to enter the field.

These newer companies really didn't need much capital to get started because the games were much easier to manufacture than their electromechanical counterparts and even easier to change—merely by replacing their logic boards—a helpful factor in a business where a game is old after three or four months.

Six months after the introduction of the first such video-electronic game in early 1972 by Nutting Associates of Mountain View, Calif., and the founding of Atari Inc. of Los Gatos, Calif., an industry leader, sales started climbing at an astounding rate, and 20 or so similar companies burst into existence. By the end of last year total sales of video games had risen to $20 million a year. By the end of this year, sales are expected to reach about $50 million for the year.

Bouncing light. "Flim-Flam" game by Meadows Electronics has three paddle sizes and player can vary speed of ball after it's hit. Video "Winner" game is basically a copy of Pong games. Made by Midway, it has only one size paddle that moves vertically.



However, by last January, the curve started to flatten; most of the sales for the fiscal year had been chalked up in the first six or eight months. The market appeared to have been saturated, and many of the companies that had copied Atari's Pong before it was patented had disappeared. That left Atari, Nutting, and a half-dozen companies that had come up with original game designs and who had learned the ins and outs of the amusement business. As a result, most industry sources speculate that TV games will gross no more than $30 million in sales in the next fiscal year.

Appeal fades. This sag has left the makers of traditional games with the feeling that, while there's a niche for electronics, the TV games won't drive their electromechanical cousins into the sea. "TV games had a great year in 1973, but now the market has been saturated," says

Ross Scheer, director of marketing for Bally. "Maybe applications of some electronics will be used somewhere, but not in a TV version."

Adds Frank Bracha, Bally's assistant vice president for engineering: "In paddle games such as Pong, we have seen a tremendous fall-off in game appeal. There are quite a few people manufacturing those games, and some of them will make a substantial amount of money this year. But while our sales of flipper [pinball] games are increasing, there seems to be degradation in the sales of TV games."

In agreement is David Marofsky, manufacturing vice president at Midway Manufacturing Co., a subsidiary of Bally in Schiller Park, Ill. He says there is no question but that sales of TV games are dropping. "There is still a market out there, but it is nowhere as large as it once was," he says. "It will be limited to a few large manufacturers with new twists." Midway, which sold around 12,000 TV games in 1973-74, is projecting sales of 3,000 to 5,000 in 1974-75.

But the use of electronics is slowly penetrating traditional games in other ways. Arcade games—gun, driving, and bowling games, for example—are beginning to incorporate electronics for sound packages, timing devices, photocells, and speed controls on dc motors. "Midway is mixing electronics with stepper-type systems in almost all our arcade games," says Marofsky. "We began using electronics for sound systems in 1968 and then began using tape decks and electronics for speed variations and programing."

Midway sells a table-tennis wall game that Marofsky estimates is about 50% electronic. It has a transceiver for remote control and logic for varying the speed of the reflected light "ball," depending on how it is hit and the number of hits. "It still uses a lot of light sockets, and scoring is done mechanically; but without electronics, the game is nothing," he says. "We are constantly blending electronics into our arcade line. And we have had very good experience with reliability. We have repair-and-return modular packages, and most of our distributors are stocking certain cards that they are getting a turnaround on."

Combinations. Some manufacturers are turning out mechanical arcade games that they could not have built without electronics. A new regulation bowling/scoring game—Bally Alley—is built around an Intel 4004 microprocessor. "It gives us computer control of the game," says Bally's Bracha, "for station-keeping, monitoring players, monitoring free games and credits, and monitoring the condition of the game. The whole design is based on utilization of microprocessor technology."

Adds Bally's Scheer: "Its cost is comparable to traditional bowling games, but its size is much smaller than the traditional 17 to 30 feet. And since it has remote control, we can hang it on the wall if we have to."

But the other electromechanical game manufacturers, such as Chicago Coin, are approaching electronics with caution. "Sure we are moving more and more into solid state, but very slowly and very carefully," says Jerry Koci, chief engineer at Chicago Coin. "Not too many of the servicemen understand and can repair solid state."

In fact, in an attempt to gain a marketing edge over similar games from competitors that use electronics, Chicago Coin has gone backward into electromechanical technology for a new driving game called Speed Shift. "Maybe electronics will eventually give us more reliability and longer life," says Bracha. "But we don't have enough history on games in the field." □

Learning the business

While makers of traditional games are proceeding cautiously with electronics, the manufacturers of video games—the people who started the furor—have learned their lesson. Since public interest peaks and falls off quickly, the newer companies now realize that they must constantly introduce new games. They are now hitting the market with a whole new generation.

Atari has eight new games on the market; Ramtech of Sunnyvale, Calif., has five; Kee of Santa Clara has four; and Nutting has two. Two newcomers have come out with new innovative games also—Exidy Inc. of Palo Alto and Meadows Electronics of Sunnyvale.

Many of these games can be characterized as having gone beyond the primitive paddleboard concept plus TTL logic to a second and even third generation of games with much more sophisticated electronic innards: LSI, thick-film hybrids, custom MOS chips, ROMs, RAMs, and shift registers.

"The important thing in the amusement-game business," says Nolan Bushnell, the 30-year-old chairman of Atari, "is novelty and fast turnaround in production. The public likes new games and will play anthing—electromechanical or electronic—as long as it is different and challenging.

"With an electronic game, you can design faster, produce it faster, and get it on the market faster. Because of its smaller size and relative quietness, it can be fitted into more locations. And electronic logic has more flexibility. You can do more things with it to produce an exciting, challenging, and entertaining game. And as the cost of components comes down in the future, it can be done much more cheaply."

With total industry volume down from about 50,000 units last year to about 40,000 this year, Bushnell believes that this development, although temporary, is all to the good. To him, it means the disappearance of the game copiers that saturated the market with low-quality games. The solid ones who are left are doing quite well, he says.

Atari manufacturing vice president Richard Mobilio estimates that the company's newest entry, Grand Trak 10, a racing game, will gross $12 million on a 10,000-unit run this year. And other games are in the works, he says.

And what of the third generation? Bushnell, for one, is looking at microprocessors—not the 4-bit kind being used in the electromechanical games, but the 8- and 16-bit high-speed models. As soon as more are available, he is planning to design a whole line of games around them. H. R. (Pete) Kaufman, president of Exidy, concurs: "My God! When you think of some of the things you can do with microprocessors, it will be fantastic."

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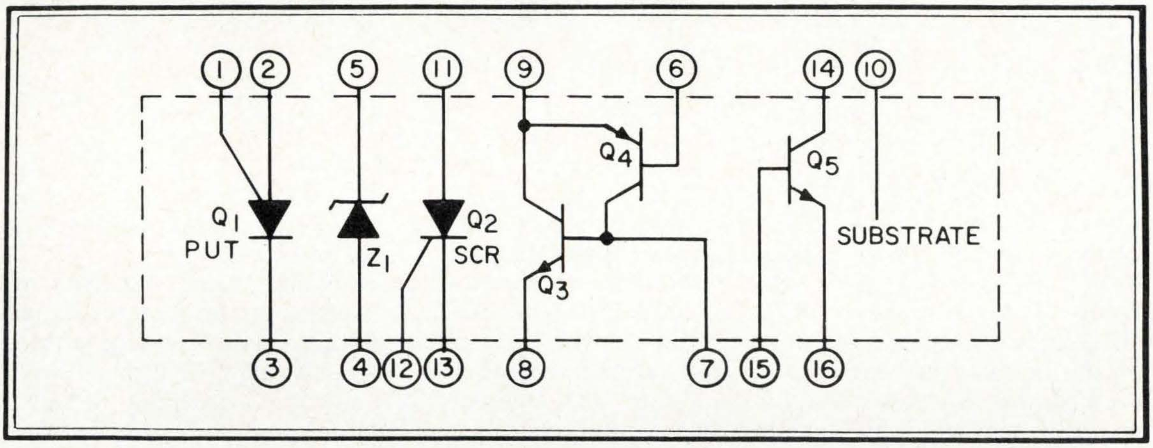

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Communications

Maritime radio space reallocated

470 delegates to ITU conference manage to agree on changes in regulations that will start to take effect in 1976

by Arthur Erikson, Managing Editor, International

"It's like trying to put a quart of water into a pint jar," says FCC commissioner Robert E. Lee. The jar Lee has in mind is the overtaxed portion of frequency spectrum set aside worldwide for maritime mobile radiotelephone communications. The pouring—far too sloppy in Lee's view—was done early this month in Geneva during a seven-week meeting of the International Telecommunication Union. And Lee was there as head of the U.S. delegation.

At the meeting, officially called the World Administrative Radio Conference for Maritime Mobile Telecommunications, 90 ITU member countries painfully reworked the radio regulations for all kinds of ships' radio services, from on-board communications by walkie-talkie to international distress frequencies. The 470-odd delegates had to cope with mountains of paper to do the job: some 2,200 proposals for changes to the existing regulations were tabled at the conference.

By far the thorniest task was working out new allotments for the 176 channels reserved for maritime mobile radiotelephone services in the hf bands of 4, 6, 8, 12, 16 and 22 MHz. But the conference also hammered out agreements covering dozens of other services, including selective calling, narrow-band teletypewriter transmission, distress frequencies, and satellite transmission. Largely untouched, though, were the frequency plans for broad-band telegraph transmission and oceanographic work.

The reworked regulations won't start going into effect until 1976 and won't be fully phased in until the 1980s. But upcoming changes portend important new business for makers of communications gear. A lot of hardware aboard some 60,000 ships and at nearly 3,000 coastal stations will be affected.

To be more specific, the hardware changes aboard ships at sea, once the new regulations start going into effect, will include:

- The number of ships carrying extensive vhf gear will undoubtedly increase, since the 156.8-MHz distress frequency used in the U.S. has been generalized and ships' movements allocations have been set for vhf maritime mobile bands.
- Ship-shore teletypewriter traffic should spurt, since the number of pairs of hf frequencies for narrow-band, direct-printing services will go from 112 channels to more than 250. Also, the conference blocked out a tariff scheme for Telex calls between regular subscribers and ships.
- Higher-quality receivers will be needed at sea, since, along with the closer channel spacing in hf bands, a new calling concept was adopted: instead of sweeping through whole bands to pick up calls, operators will use just two narrow-band spot call frequencies in each band.
- Portable two-way radios will become more common on large tankers and cargo ships, since six channels in the 450-MHz band were tagged for use by on-board uhf portables worldwide.

High time. It's easy to see why ITU decided it was high time to rework the regulations covering communications on the high seas. The first exclusively maritime conference was held way back in 1967. But in the last seven years, there have been some radical changes in world shipping. For one, the number of passenger ships has dropped drastically while the number of cargo ships and tankers has climbed. Also, there's been a spurt in the growth of fishing

Conferees. Top trio of the U.S. delegation was, from left, L.R. Raish of White House Office of Telecommunications Policy, Robert E. Lee of FCC, and Gordon L. Huffcutt of State Department's Office of Telecommunications.

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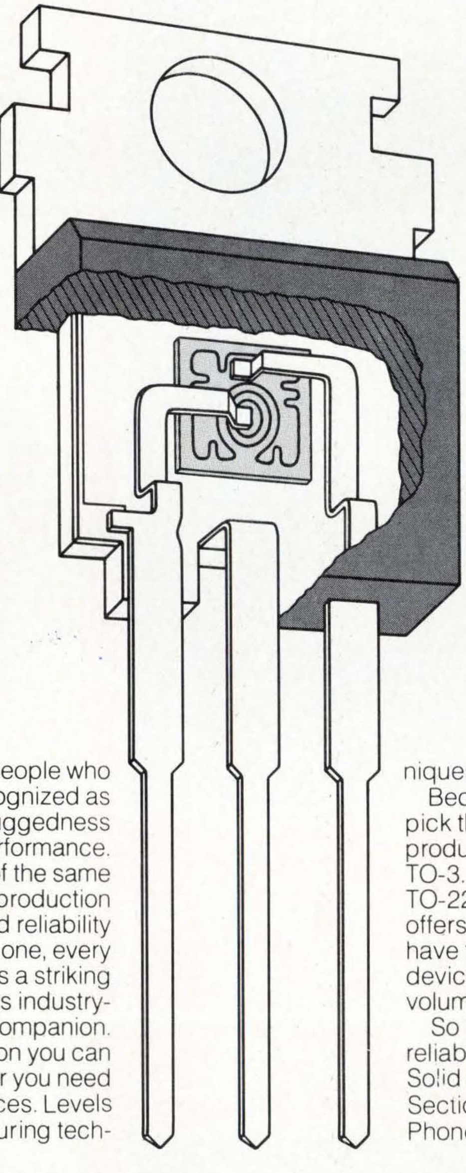

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fleets. Above all, ITU has come under strong pressure from developing countries that want space in the spectrum, if only for prestige.

A lot of "have-not" countries came to the conference convinced that the switch to single-sideband for hf radiotelephony decreed at the 1967 conference would mean enough new channels to accommodate everybody when the changeover is completed at the end of 1977. But that's not the case, even though the 1974 conference did manage to squeeze out an additional 37 channels for radiotelephony from the maritime mobile spectrum. Ten were picked up by shifting channels currently assigned to telegraphy. The other 27 came as the conference adopted a 3.1-kilohertz carrier spacing between hf channels. Right now, the standard is 3.2 kHz in some bands, 3.5 in others.

At the very least, there will be a lot of crystal changing to do when the new hf radiotelephony frequency plan—Appendix 25 to the radio regulations—goes into force on Jan. 1, 1978. And many shipowners then will need more expensive receivers—with frequency synthesizers and sharper filters, for example—than they can get by with now. But it's not technical difficulties that trouble U.S. telecommunications officials and their counterparts in some of the other major maritime countries. To fit in some 40 new countries and take care of nations that felt they had received short shrift in the existing allocations, a whole new hf plan was patched together. "It was eyeball engineering," maintains L. R. "Bob" Raish, a consultant to the White House's Office of Telecommunications Policy and vice-chairman of the U.S. delegation at the conference. The new plan, he goes on, "will create chaos in the coastal radiotelephone business. It puts 25 years of working out natural sharing arrangements into the scrap heap."

Not everyone from the "have" countries was quite that vehement. Johannes Kuppers, the top West German negotiator, terms the Appendix 25 revision as "not really good but not so bad that you cannot work with it." The Germans wanted allocations shared on the basis of expected traffic.

The Japanese contingent, however, left Geneva apprehensive about the Appendix 25 reworking. Its chief, Masso Hirano of the Radio Regulatory Bureau of Japan's Ministry of Posts and Telecommunications, is convinced that "it will take the greatest effort to implement it."

Wait and see. As for the conference chairman, Reginald N. Billington, he feels that it's very difficult to assess the full impact of the new allocation plan because it doesn't go into effect for another three and a half years, and no one knows yet what the traffic will be like then. But Billington, an official of the United Kingdom's post office, characterizes as "premature" a second important decision reached at Geneva, one that provides for two different selective calling systems. The idea is for ships to have automatic receivers that respond when a shore station has a message for the ship. Along with individual codes for ships there is provision for codes that alert all ships that are equipped with automatic receivers.

The existing system, the brainchild of engineers at Siemens AG and the West German post office, was introduced into the radio regulations in 1967. Since then, some 1,000 ships—mainly German and Dutch—have been fitted with automatic receivers. The German system, known as SSFC (for sequence signaling frequency code), so far has worked well. But it does have its drawbacks, admit Kuppers and other SSFC supporters. It requires a bandwidth of 3,000 hertz for the five frequencies that make up the signaling code. An even greater handicap is the fact that the five-frequency code allows only up to 10,000 call numbers compared to the capacity of at least a million call numbers that's wanted.

To that end, the U.S., Japan, and the Netherlands, primarily, have pushed development of digital selective calling systems. In fact, the CCIR, ITU's radio standards body, has worked up a tentative recommendation based on a signal format having a seven-bit code plus three checking bits. There's also a packing scheme for decimal numbers that covers literally millions of call-number possibilities. The study group that worked out the format hopes to get final approval by the CCIR at a July meeting. In that case, digital selective calling could start appearing aboard ships sailing the oceans of the world in about a year, some optimists think.

Like Billington, however, Kuppers feels that would be far too early. "We fear interference in other channels because of the pulse transmission of digital systems."

Other important changes or additions to the radio regulations were less controversial. "For maritime satellites, we worked in some minimum provisions to allow implementation of them," says Raish. Essentially, the conference agreed on services where satellite channels can and cannot be used and established regulations for shipboard terminal operations. □

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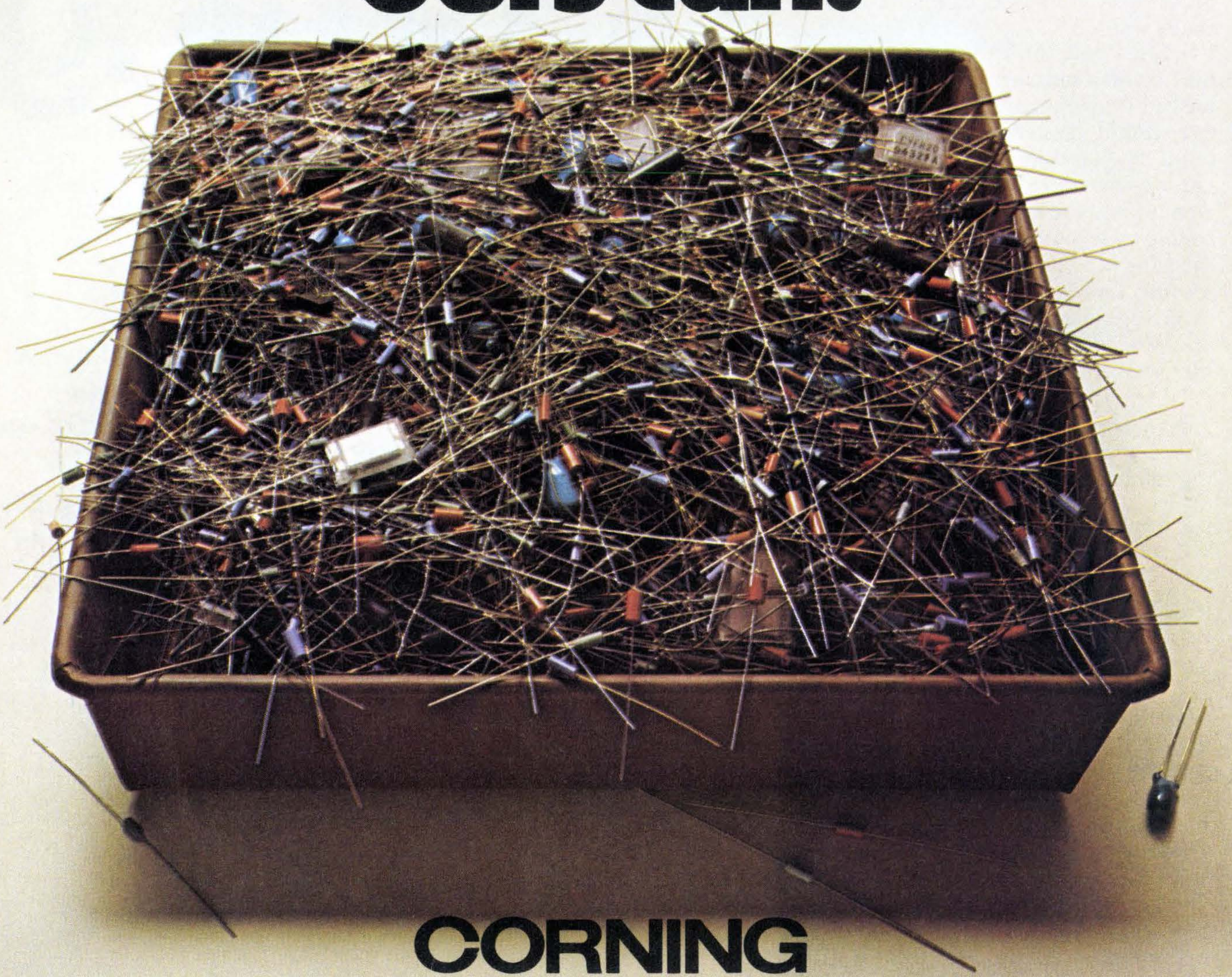


CORNING
ELECTRONICS

Computers

Japan prepares for new invasion

First machines in government-subsidized effort to deal with lifting of import rules are announced by two groups

by Charles L. Cohen, Tokyo bureau

The wraps are off the first computers to emerge from a massive Japanese development effort. Government subsidized, it's aimed at keeping domestic computer manufacturers competitive when remaining import restrictions are lifted in 1975. With two of the three specially formed groups announcing their first models, the Japanese are serving notice that they're not going to give up any part of their home market share without a fight. And it's possible that they'll add to that share.

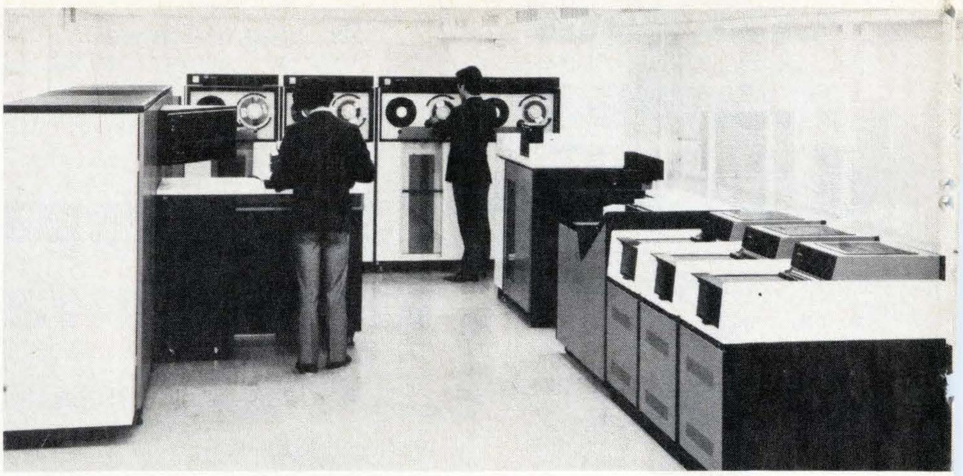
But any optimism must be viewed in light of the Japanese government's motives for offering subsidies to the three combines. Observers point out that the Tokyo regime would not be liberalizing its computer restrictions if the United States had not applied almost unbearable pressure. Following that line of reasoning, the subsidies can be interpreted as a means of merely coping with an anticipated wave of American imports, rather than as a market-domination tool; if the Japanese computer companies just hold their own, then the plan would be judged a success.

However, another school of thought sees the Japanese companies, with broadened and more competitive lines, actually increasing their shares of market. As can be expected, the makers themselves are enrolled in this school. Nippon Electric Co. predicts that its partnership with Tokyo Shibaura Electric Co. (Toshiba) will increase its market share over the next three years to 23% from the present 18%. In any event, about the only thing that appears certain is that the Japanese companies should manage to increase sales, if not market share, each year.

So far, Nippon-Toshiba has an-

Contender. This is the Cosmo-700, built by Mitsubishi-Oki. It's designed to compete with IBM's 370/45 and also with a new machine due from the Nippon-Toshiba duo.

Additions. Two more new computers are in the Nippon-Toshiba ACOS series 77. They are, at top, the 400, a medium-size model, and the 300, also in the medium class.



nounced three computers [*Electronics*, June 13, p. 65]. They are the ACOS series 77 model 200 small computer, and 300 and 400 medium size models. Designed to compete with IBM's 370/115, 125, and 135, they will start shipping in October. Still to come are five models.

The Mitsubishi Electric Corp.-Oki Electric Industry Co. group has unveiled its Cosmo-700, with deliveries scheduled to start in December. The group will develop three more new machines. In line with Mitsubishi's strategy of not competing with IBM where the American giant is solidly entrenched, none of the group's computers will be large machines. Also, Mitsubishi has 20% of the market in small machines.

The third group, Fujitsu-Hitachi, says it's developing seven systems in its series, but refuses to say whether any will definitely be announced this year. However, since this combine has a larger market share than the other two, it can be expected to come out with entries in all sizes to compete across the board with Nippon-Toshiba and with IBM.

Higher languages. The Nippon-Toshiba machines, with virtual memory and ring protection, are oriented to higher level languages than previous models, including Fortran, Cobol, and PL-1. The operating system is mainly firmware. The main memory is all n-MOS, 1,024-bit chips at present, with 4,096-bit chips due in about a year. Logic is TTL. Memory speed for the 300 and 400 is read time of 1 microsecond and write of 1.35μs. The 200 will rent for about $5,000 to $12,400; the 300 for $10,000 to $20,000, and the 400 for $12,400 to $28,000. The group has ambitious sales targets for its new machines: for the 200, the five-year plan calls for 2,000 systems to be installed; for the other two models, the aim is more than 800.

The Cosmo-700 from Mitsubishi-Oki is designed to compete with IBM's 370/45, which also pits it against the still-to-be announced Nippon-Toshiba System 500. It's the first in a series of four: the 300, 500, and 900 are still to come.

The Cosmos are software-compatible with the former Xerox Data Systems Sigma 5 and 7 control computers, made under license by Mitsubishi. This, says Mitsubishi, gives them general-purpose capability. Among the features of the new computers is an option of core or semiconductor memory. The reason, says Mitsubishi, is that many customers will use the machines for control applications, and core offers the advantage of nonvolatility. Another feature is the use of a color-TV picture tube and keyboard console, rather than the typewriter console used by most other computer makers. The console can display up to 2,000 alphanumeric or Japanese symbols and has a memory. The computer's main memory in its semiconductor configuration uses 1,096-bit n-MOS RAMs with expansion to 4,096-bit chips due in a year. Logic is TTL.

Although most of Mitsubishi's computer business is now control and scientific, it has its eye on sales of general-purpose machines to the Mitsubishi group of companies. No wonder, because that group claims to account for 10% of Japan's gross national product and an even larger percentage of Japan's computer use. The companies use mostly IBM computers, but Mitsubishi is hopeful because it says it now has the beginnings of a line that is broad enough to interest members of the group.

It wants to sell its new line on the basis of bringing the computer to the user. The company figures that it can push the concept of a distributed computer system, rather than one large computer in a center. It reasons that most centers keep getting bigger, and that there is always the threat that any problem shutting down the center can bring a company's computer activity to a complete halt. Mitsubishi maintains that even with decentralization of this sort, the new computers would be powerful enough for most jobs because their use of virtual memory gives each user up to 16 megabytes of memory. And there is almost no limit to the number of users.

Option. In cases where a local computer can't do the job, there would still be recourse to a larger center because the communications processor is improved; Mitsubishi has developed software for this purpose, and the on-line data-management system has been developed.

Mitsubishi says it figures that systems using its computer should have a monthly rental of $12,400 to $35,000. This is based on the company's figure of $28,000 to $53,000 for equivalent IBM 370/145 installations. □

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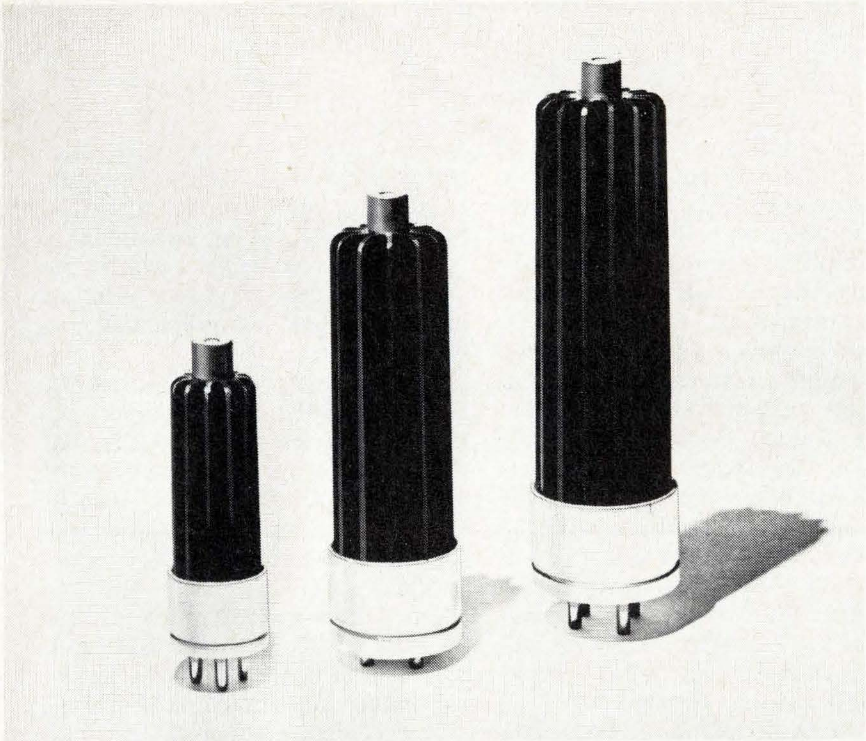

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STR6808	1.5	6.4	2
STR6894	20	2.5	2
STR6895	20	2.5	2
STR7018	2	2.5	1
STR7019	1	6.4	2
STR7454	25	6.5	1
STR7789	15	0.4	2
STR7790	20	1.0	2
STR7792	25	2.0	2
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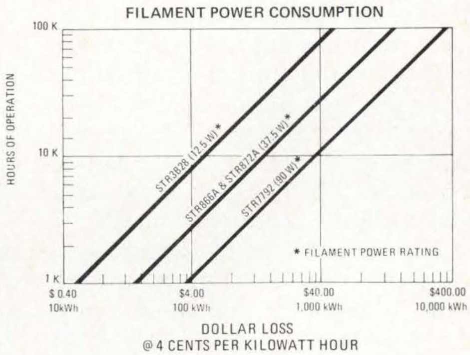

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Space electronics

Europe starts ambitious venture

With green light from ESRO, design work begins on Spacelab, Europe's part in the U.S. post-Apollo program

by John Gosch, Frankfurt bureau

Hardly was the ink dry on the contract from the European Space Research Organization in Paris before some 120 specialists at West Germany's ERNO Raumfahrttechnik GmbH got busy on the design of Europe's contribution to the U.S. Space Shuttle venture: Spacelab.

Spacelab will be developed by a consortium of West European companies, with Bremen-based ERNO the consortium leader. The project, in which eventually thousands of engineers and workers will be involved, is part of the $5.5 billion Apollo follow-up program that provides for putting manned laboratories into space during the next decade.

What's more, Spacelab represents Western Europe's biggest single space project to date. It also marks the first entry into manned space flight by non-American or non-Russian astronauts or cosmonauts. The project's design and development cost is presently pegged at close to $240 million, "but it could eventually run as high as $400 million as a result of as yet unforeseen follow-up expenses or inflation," an ERNO spokesman says.

Participating in the Spacelab's development are 15 firms in nine European countries–Belgium, Denmark, France, Great Britain, Italy, The Netherlands, Spain, Switzerland, and West Germany, with the last footing 54.1% of the bill. The first Spacelab version is to be completed by 1979 and ready for launch a year later. "We are 99% sure that a contract to build a second one will come shortly," an ERNO project leader confides. Beyond that, he says, as many as four or even eight more may follow, so that during the 1980s there will be a fleet of up to 10 Spacelabs available.

The Spacelab's transport system, the U.S.-developed Space Shuttle, consists of a lower stage for propulsion and a reusable upper stage, the orbiter. This stage, an airplane-like, rocket-propelled vehicle, will be designed to carry payloads into an earth orbit and to return them to ground.

The lab itself, which is roughly 12 feet in diameter by 42 ft long and weighs more than 2,100 pounds, will be housed in the orbiter and serves as a workplace for a crew of up to four people. The work they will perform will involve experiments in astronomy, physics, earth observations, navigation, materials research, biology, and medicine. The orbiter stage will serve as the astronauts' household and bedroom.

According to Hans-Joerg Pospieszczyk, in charge of the Spacelab's electrical/electronics systems design at ERNO, close to 40% of the vehicle's total design and development costs will be spent for electronic hardware and software, and a number of European firms active in this field can expect substantial business to come from the project.

Most of the Spacelab's electronic hardware is integrated into its control and data-management system (CDMS). Its prime purpose is to collect, process, display and record all data generated by the lab's experiments and its various flight subsystems, such as attitude-control equipment, and other gear like power-distribution units and environment-control equipment.

Responsible for the CDMS devel-

Model. This mock-up of the Space Lab shows Europe's role—the project might run as high as $400 million out of the $5.5 billion to be spent—in post-Apollo.

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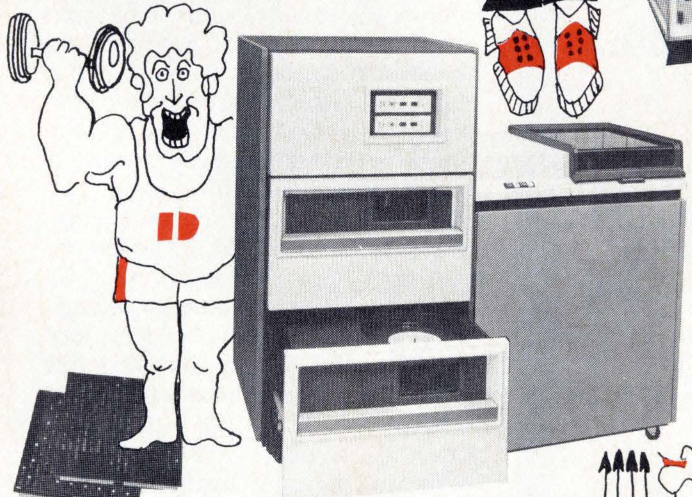

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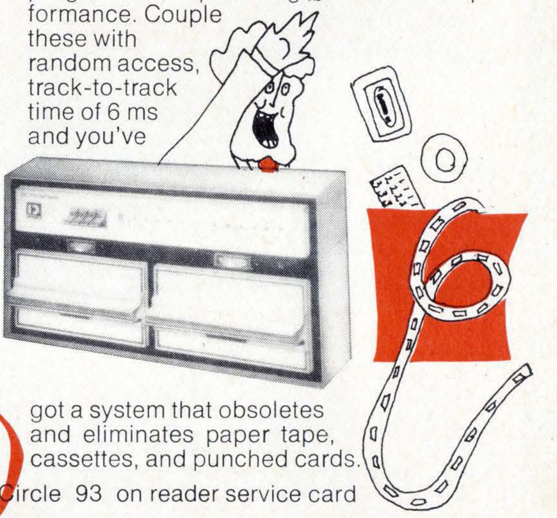

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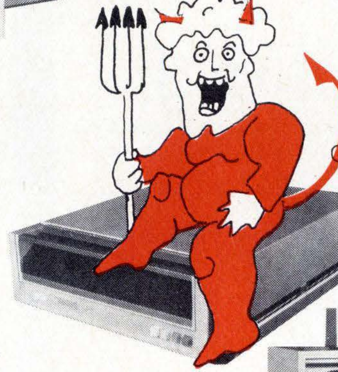

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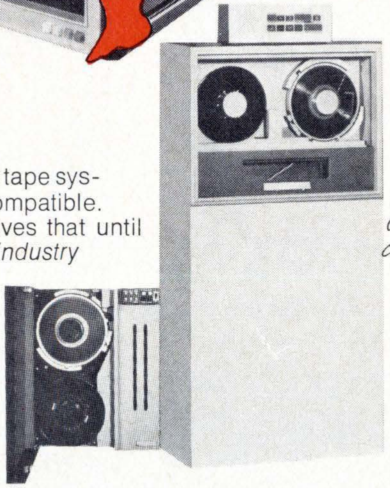

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opment effort is France's Engins Matra, a company which ERNO has worked with on other projects during the past eight years or so. Cooperating with Matra are the French electronics firms Thomson-CSF and Electronique Marcel Dassault; West Germany's AEG-Telefunken, Dornier System GmbH, and ITT subsidiary Standard Elektrik Lorenz AG; and Odetics Inc. of Anaheim, Calif.

At the heart of the CDMS will be three identical computers, the type M182E developed by Dassault for launcher programs but specifically repackaged for the Spacelab project. One of the three controls the acquisition of data from the experiments. Another handles all data from the flight subsystems, while the third serves as a back-up for subsystem and experiment data-processing.

The computers, which essentially prepare the data for telemetry, display, and for monitoring and checkout, are 16-bit machines with 32 kilowords of core memory, extendable to 64 kilowords. They feature a cycle time of 1.2 microseconds, and additions and multiplications can be performed in 2 and 7.5 microseconds, respectively. Data flow is over input/output channels capable of handling 550 kilowords per second. The computer software will come from West Germany's Dornier and from the German-Dutch VFW-Fokker combine which is ERNO's parent company.

Data acquisition and command distribution is by 14 SEL-supplied remote-acquisition units, which have standardized input interfaces for analog, discrete, and digital channels. Other Spacelab equipment will be wideband digital and analog signal units for down-link transfer of experiment data via transmitters in the orbiter.

Belgium's contribution to the Spacelab project is the ground support equipment, which will come from that country's Bell Telephone Manufacturing Co., another ITT subsidiary. Prime function of that equipment will be automatic checkout and simulation of Spacelab conditions during the various test and system integration phases prior to launch. □

Microcomputers

Service houses offer applications aid

Buyers of microprocessors are paying for the system support that's part of the price of higher computers but which chip makers don't provide

It's happened before and it will happen again—a new semiconductor technology has spawned a new semiconductor-related business. The technology in this case is the microprocessor; the business is the applications house.

There are about 10 of these small but active companies around the country. Most are less than a year old, but some approach the venerable age of two years. They exist because of the economics of the microprocessor. While a customer acquiring a full-sized- or mini-computer system expects a certain amount of system support for his money, he neither expects nor gets much when he purchases a $300 micro from a semiconductor manufacturer. Enter the applications house.

Any list of these companies has to be incomplete because of the ease with which one can be started—and the speed with which it can close its doors. But they generally tend to cluster around industrial or semiconductor centers, or where their organizers have been working in other jobs. They often are started by two persons who are either hardware designers or programers or both. And the new entrepreneurs more often than not harbor dreams of growing larger by expanding into other areas.

Take, as a case in point, a relative old-timer that's been designing since the fall of 1972. Applied Computing Technology of Irvine, Calif., has workers from computer, telemetry, and minicomputer firms, among them NCR, General Automation, and aerospace companies—what might be called the California mix—and its programers total 25 years' experience. A good deal of the firm's work has been in the automotive field with headlight aligning and antiskid systems. But now the company, which currently has annual sales of about $750,000, would like to find a product niche to exploit, preferably in an industry with an annual volume of at least $10 million.

Another "old" company, established about 18 months ago, is Prolog Corp. of Monterey, Calif. Its founders, Edwin Lee, president, and Matt Biewer, vice president and chief engineer, have worked together for about 10 years, most recently at MSI Data Corp., a builder of supermarket terminals that Lee helped found. "Initially the designs for MSI terminals were basically hard-wired logic," says Lee. "Then we discovered microprocessors. Matt took the Intel 4004 and redesigned most of MSI's designs in less than five months. And 12 weeks after he started the redesign work, MSI had 10 prototypes in the field." That showed the men the potential of microprocessors and led them to found Prolog.

Coming from the computer industry are Dale V. Schmidt and G. Graham Murray, founders of Data/Ware Development Corp. of San Diego. Says Schmidt: "We concentrated on minicomputers, but we quickly saw that microcomputers would serve the purpose in many applications." For example, in a test system for Sony (see p. 177) "the mini was overkill. It was a competitive bid, and our competition proposed minis, but we did it with a micro."

The men who founded Varitel Inc. in Beverly Hills, Calif., in February 1973 again represent that necessary combination of software and hardware experience. Bruce Gladstone spent most of his professional life in aerospace systems instrumentation, and Meir Niv has spent about a decade doing machine-language programing and logic design. Varitel, which wants to stay small, is currently working on a display system for a maker of cable TV gear. It's also involved in a data-acquisition system for Aerospace Corp., a machine-tool controller, a computer tape-test system, and the medical instrumentation field. Gladstone projects results by September 1975 of "somewhere around the $300,000 mark, including shipments and royalties." □

Doing their bits

"We see the potential of microprocessors a bit differently than most people," says Edwin Lee, president of Prolog Corp. Instead of going after the data-processing and computer systems/hardware markets with high-speed 8- and 16-bit machines, assemblers, and high-level languages, Lee sees "90% of future business in dedicated controller applications" like traffic lights. These jobs won't be done by the high-speed, sophisticated 8- and 16-bit machines, he says, but by a simple and inexpensive one "that a machine-design engineer used to hard-wired logic will understand and put to work immediately." The answer, says Lee, is Intel Corp.'s 4-bit microprocessor, the 4004.

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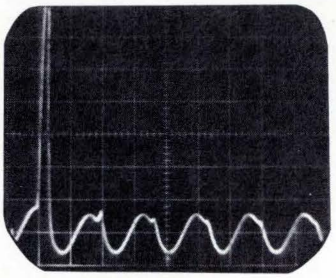

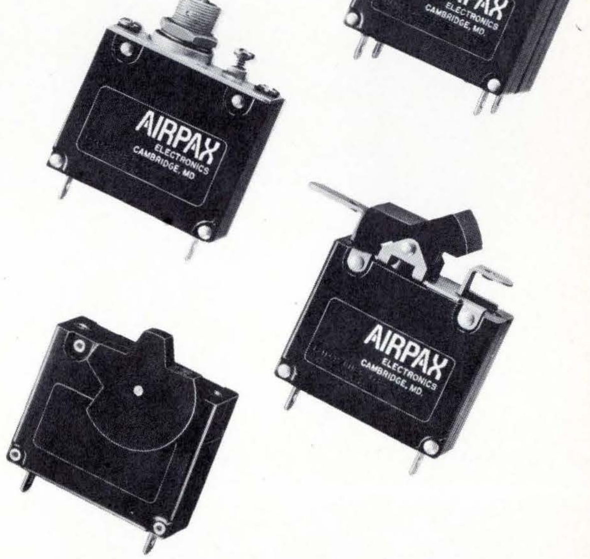

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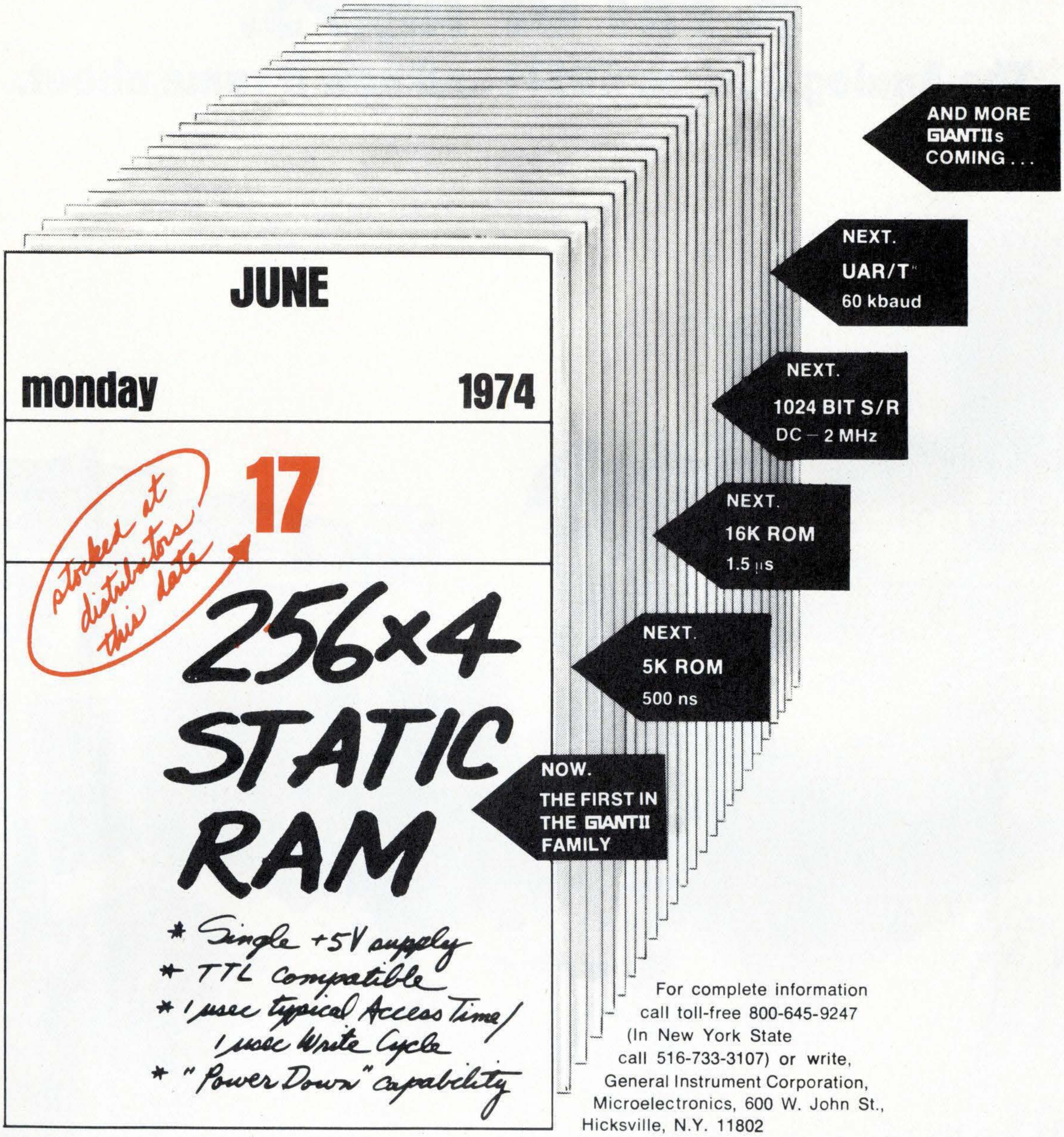

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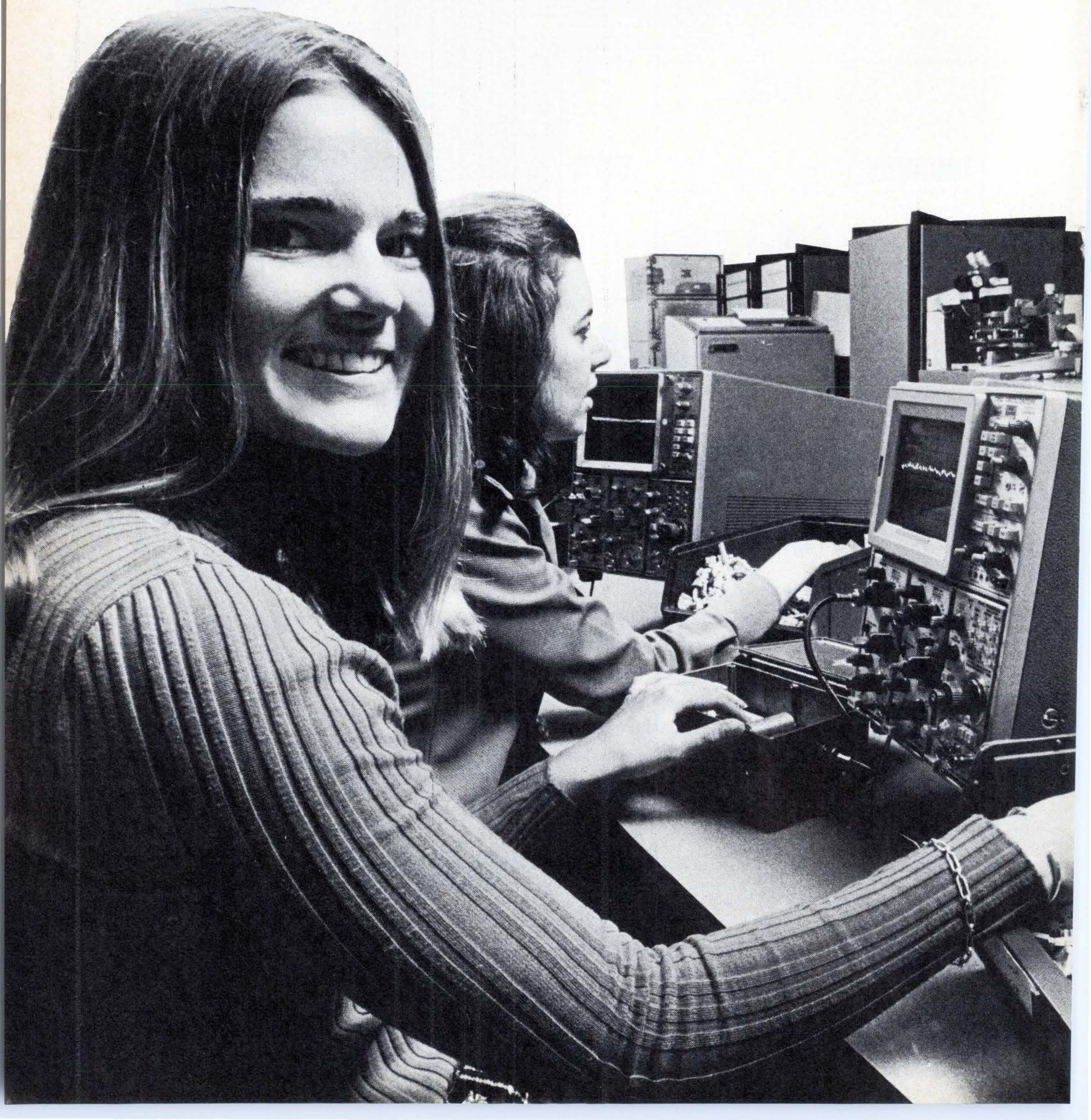

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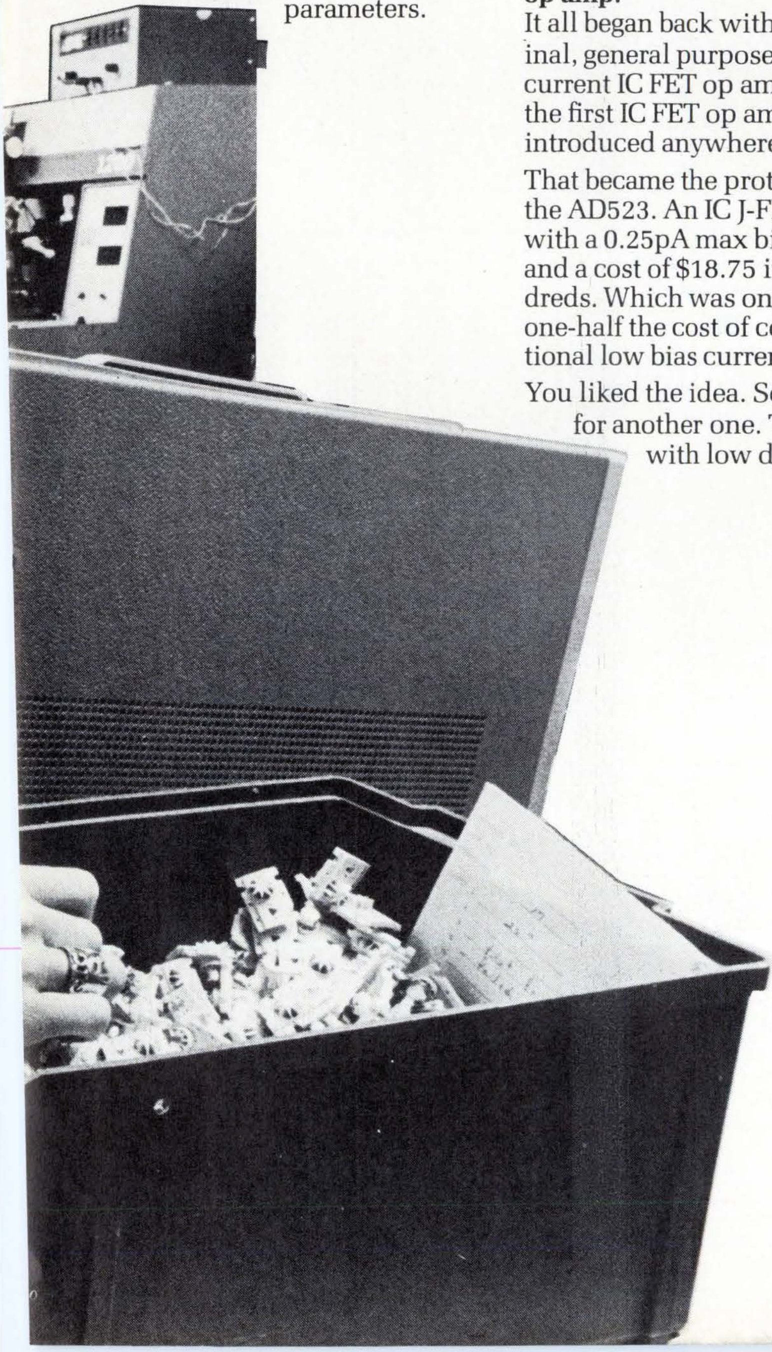

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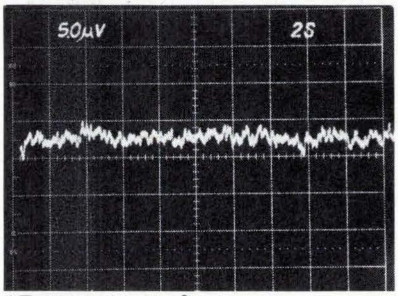

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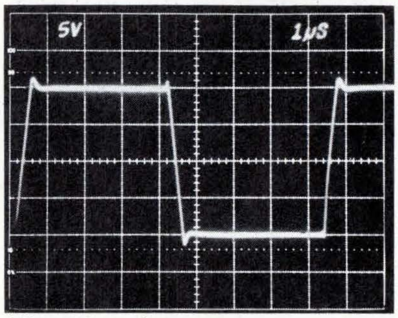

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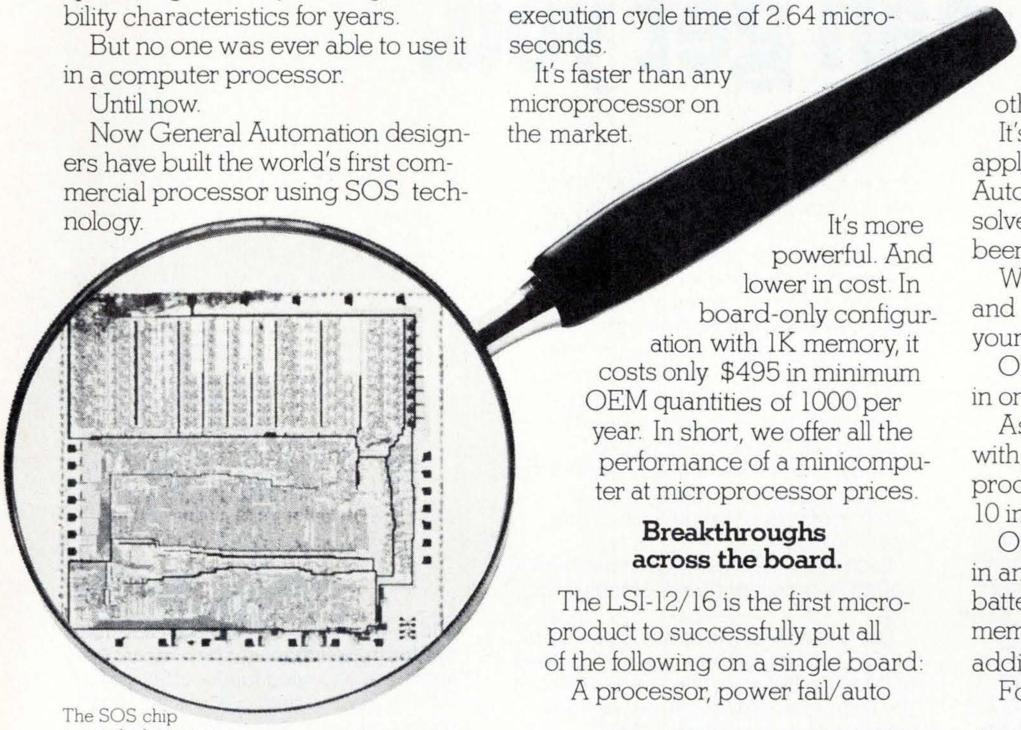

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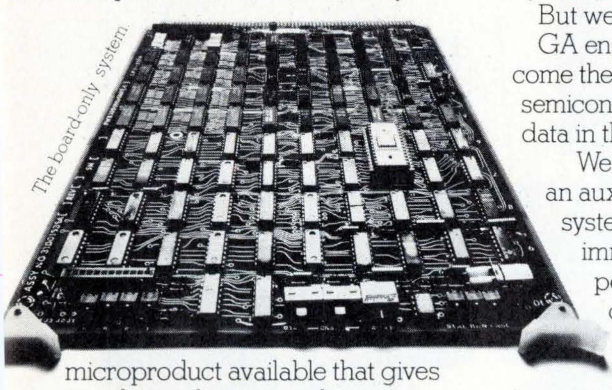

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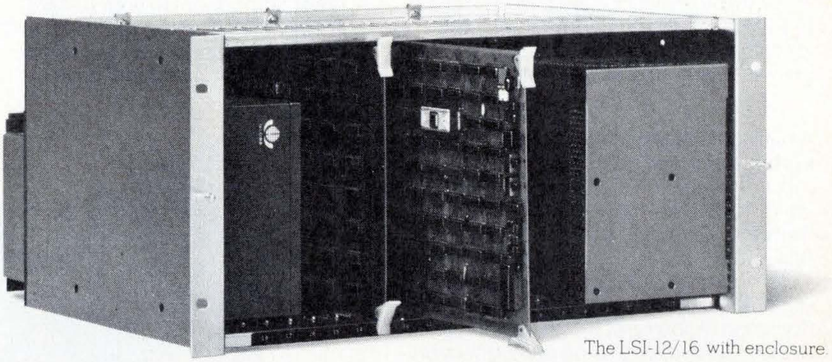

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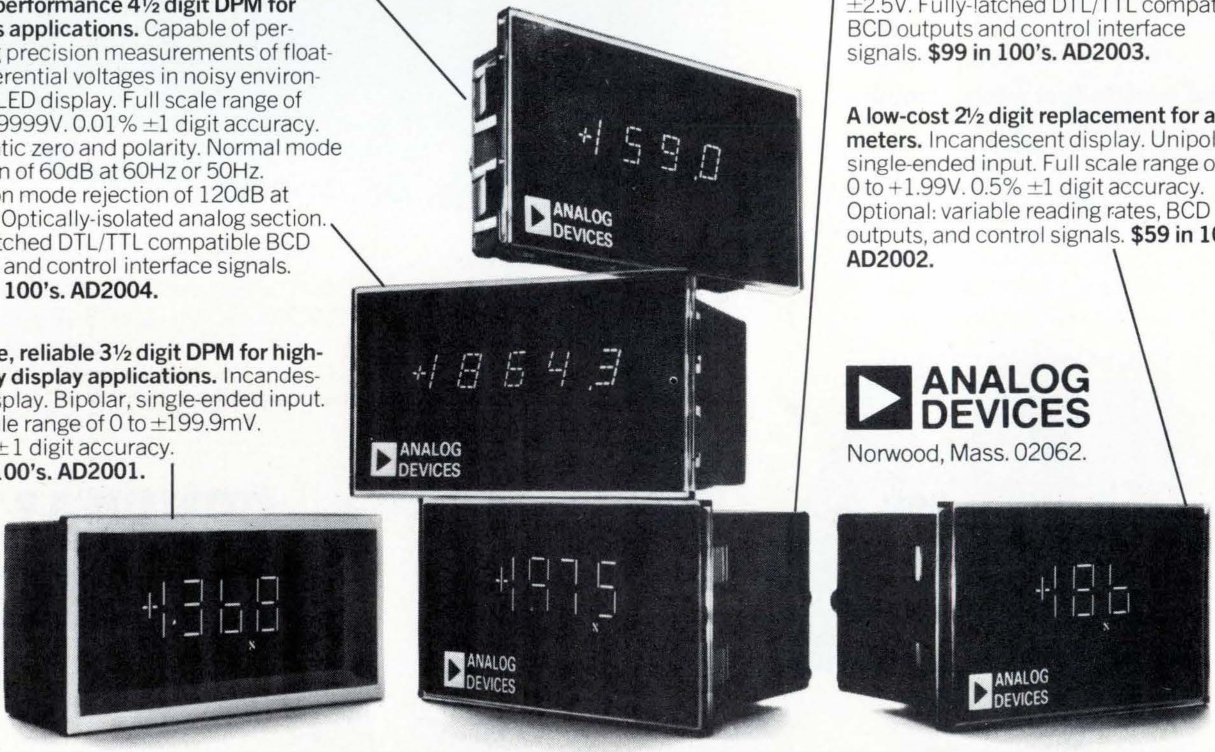

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Improved linear processing packs a-d converter onto two IC chips

Sophistication in mixing bipolar and MOS devices on the same chips, plus simplification of the circuitry by a new algorithm, has made the monolithic analog-to-digital converter a reality; the flexible package has many uses

by Gary Grandbois, *Siliconix Inc., Santa Clara, Calif.*

☐ The technique of combining metal-oxide-semiconductor and bipolar processes on a common substrate, having been successfully applied to analog switches, is repeating that success with another linear-circuit design—an analog-to-digital converter system. This converter, which is capable of accuracy to 0.05%, is significant on two counts.

First, a new conversion algorithm greatly reduces the number of circuit elements. Second, and more important, improved large-scale-integration linear processing further condenses the conversion circuitry so that it all fits onto just two ICs. At last, the accuracy and stability requirements of the a-d converter are attainable in monolithic form.

The chip pair was originally intended to serve as a 3½-digit a-d converter for digital display systems, but it can also be used in a host of other converter applications. Examples include digital frequency meters, digital thermometers, optically isolated panel meters, and of course, the basic DVM, which can incorporate ac-voltage, current, and resistance-measuring converters to complete the digital-multimeter function.

The array of technologies used to put everything on two chips (LD110/111) is impressive. The mainly analog processing chip (LD111) packs p-channel MOSFETs, npn and pnp bipolar transistors, and Schottky diodes into a 75-by-102-mil area. Between them, these elements provide a bipolar integrator, a bipolar comparator, two MOSFET-input unity-gain amplifiers, several p-channel MOS analog switches, and the level-shifting drivers that allow the analog and digital processors to interface directly. Bias-current matching has been improved and chip size kept small by using p-channel MOSFETs as constant-current bias elements in place of much larger resistive loads.

On the digital LD110 processor, low-threshold metal-gate p-channel MOS processing yields maximum density. The 1,400 transistors contained on the 128-by-129-mil chip combine the counting, storage, and data-multiplexing functions with the necessary control random logic.

Part 1 of this two-part article discusses the chip's design, its performance characteristics, component selection, and error considerations for the two chips. Part 2 describes the many jobs these devices can perform in a system.

Part 1: The converter's design

One of the keys to integrating the a-d-converter function onto two low-cost chips is the new algorithm. This associates an automatic-zeroing circuit with a simplified conversion technique that's similar to dual-slope and voltage-to-frequency conversion schemes.

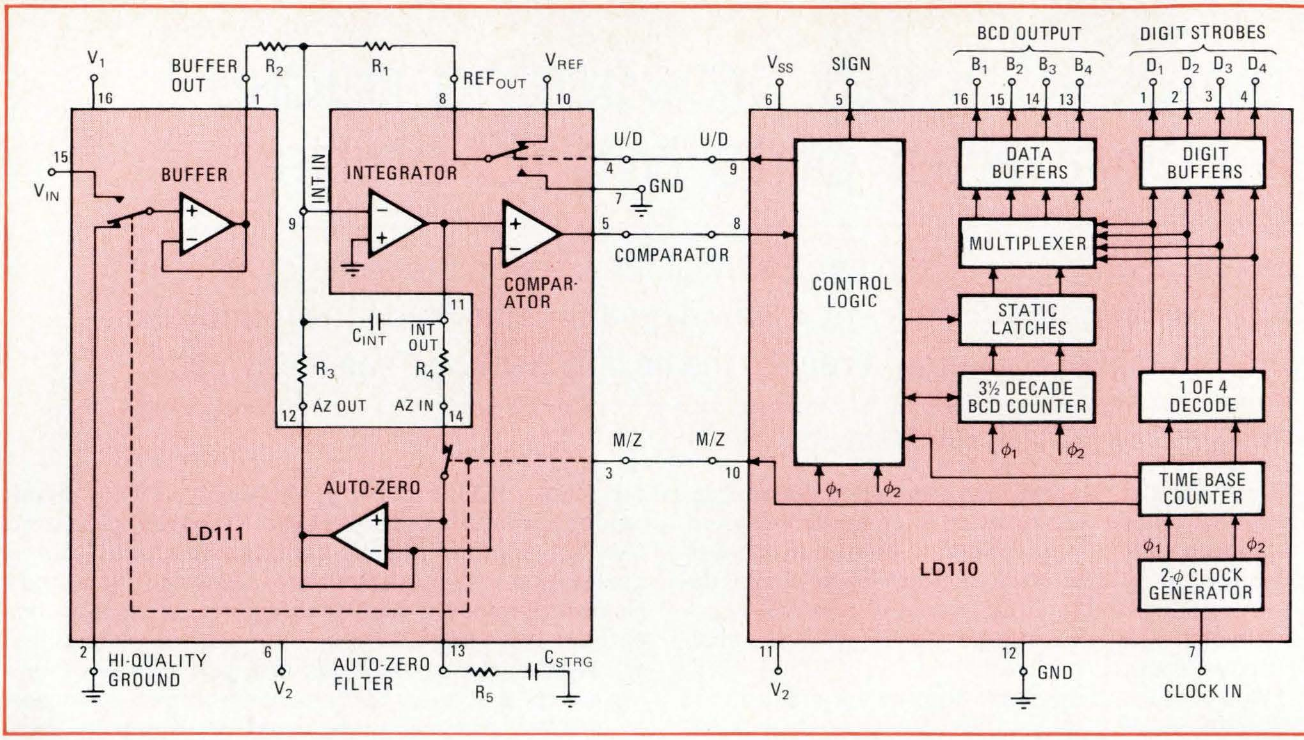
The auto-zero circuit does more than just eliminate the effects of offset and drift by automatically establishing the zero. For one thing, it allows use of a single reference voltage and full-scale calibration to measure bipolar analog inputs over two voltage ranges (2,000 volts and 200.0 millivolts). For another, it permits tolerances for external components to be relaxed pretty far, with no effect on the specified accuracy of 0.05% (of reading)—a change of 1 in the count for every 0.05% deviation.

Third, the p-channel MOSFET input buffer amplifier can only provide a high input impedance (10,000 megohms) and low input-bias current (4 picoamperes at 25°C) because the auto-zero circuitry eliminates most of the high differential offset voltage associated with a MOSFET differential input.

The conversion technique, as the block diagram in Fig. 1 shows, makes use of standard linear-circuit blocks. An input signal V_{IN} is switched through a buffer circuit to an integrator, the output of which goes both to the automatic-zeroing circuit and to the comparator. To correct for input-current and voltage-offset errors, the auto-zero output is then fed back through the input switch to the input.

Digitization of the analog signal is accomplished by a closed-loop discrete data-control system in which the sampled state of the comparator determines which of two discrete pulse widths the reference current can take. The control-logic module allows a BCD counter to accumulate counts during this process to produce the desired digital conversion. These counts are derived from the external clock signal by means of a two-phase clock-generator and time-base counter. The external clock signal may be of MOS or TTL levels.

Two intervals are required—one interval for the automatic-zeroing circuit (called the auto-zero interval) and one interval for digital conversion of the analog signal



1. Convertible pair. On the analog chip (left), the input V_{IN} is switched through a buffer to an integrator and automatic-zeroing-correction circuit. Meanwhile, on the digital chip, the measuring interval is determined by the combination clock generator time and base-counter.

(called the measurement interval). Consequently, the clock frequency is divided into two sampling intervals, totaling 6,144 pulses and made up 4,096 pulses for the measurement interval, plus 2,048 pulses for the auto-zero interval.

Building a converter system

Application of the LD110/111 two-chip a-d converter should begin with the selection of power supplies and clock frequency. The recommended supply voltages are V_1 = 12 V ±10%, V_2 = −12 V ±10%, and V_{SS} = 5 V ±10%.

More latitude is allowed in the choice of clock frequency (f_{IN}), 2 to 75 kilohertz being the recommended range. The sampling rate is 1/6,144 of the clock frequency (or sampling rate = f_{IN}/6,144).

As with other integrating conversion schemes, line-frequency interference may be minimized by the selection of a particular clock frequency. If the auto-zero and measurement periods are integral multiples of the line-frequency (f_L) period, line-frequency rejection will be maximized:

$$\Delta t_{ZERO} = 2{,}048/f_{IN}, \text{ where } \Delta t_{MEASURE} = 2\Delta t_{ZERO}$$
$$2{,}048/f_{IN} = n/f_L, \text{ where } n = 1, 2, 3, \ldots 51$$

then

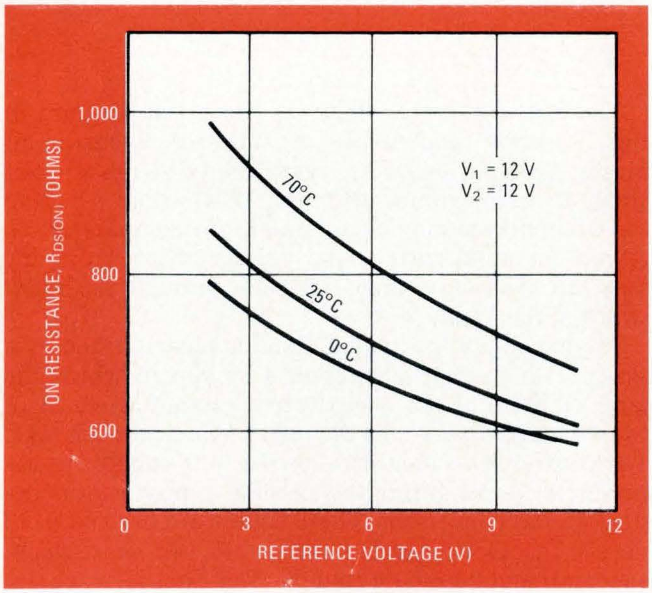
$$f_{IN} = 2{,}048\, f_L/n$$

Once the clock frequency is chosen, the proper values for the external RC components may be determined. When a full-scale voltage range, V_{IN} F.S., is chosen, the relationship between the ratio R_1/R_2 and the reference voltage V_{REF} is:

$$R_1/R_2 = (2{,}000/V_{IN}\ F.S.)(V_{REF}/8{,}192)$$

It also should be pointed out that R_1, R_2, and V_{REF} are basically the only temperature-sensitive elements in the system. This is because the auto-zero interval makes the system essentially independent of changes, either in the amplifiers' offset voltages or in the values of the integrator capacitor, the storage capacitor, or resistors R_3, R_4, and R_5.

Because of such considerations as temperature coefficients and availability, it is usually more convenient to select the reference voltage before assigning resistance values. This voltage should be greater than 5 V but less



2. Compensating for the effects of temperature. The changes of switch resistance with temperature and reference voltage can cause errors. A large reference voltage will minimize the effects of the temperature—dependent on—resistance of the switch.

How the circuitry works

Two-chip analog-to-digital conversion circuitry operation depends on the synchronous action of the three interconnecting circuits—the analog comparator, which conveys data on the integrator state; the up/down logic, which controls the pulse-width modulation of the reference voltage, determined by the comparator state; and the measure/zero logic, which controls the timing of the measurement and auto-zero intervals.

The analog circuitry is shown in the auto-zero (AZ) mode in Fig. 1, p. 94. When the buffer input is switched to ground, thus starting the auto-zero interval, it supplies the integrator input summing node (node 9 in the figure) with a current equal to the input buffer-offset voltage divided by the resistance of resistor R_2 (V_{OS}/R_2). The auto-zero interval allows the effects of temperature and drift to be impressed on the auto-zero storage voltage, V_{STRG}, maintained as a reference by the storage capacitor, C_{STRG}. Therefore, during the succeeding measurement interval, these effects will be balanced out.

In addition, the storage voltage acquires a voltage component, available at the auto-zero amplifier output, which provides a current through resistor R_3. This current derives from the reference voltage, V_{REF}, and the reference resistor, R_1, and is equal to $-\frac{1}{2}V_{REF}/R_1$—the ½ resulting from the 50% duty cycle of the up/down switch. Consequently, the net current provided to the integrator summing node is $\pm\frac{1}{2}V_{REF}/R_1$, depending on the state of the up/down switch.

The output of the integrator during the auto-zero interval is shown in the timing diagram of Fig. A, along with the pertinent timing points. At the beginning of this interval, there is a brief override period, during which the 50% duty cycle of the up/down logic is inhibited while the integrator output is brought to the storage voltage.

At the start of the measurement interval, the measure/zero logic switches the analog input voltage into the input buffer amplifier. This amplifier acts as a voltage-to-current converter. The additional current it now sends to the integrator summing node disrupts the balance achieved in the auto-zero interval, driving the integrator output away from the auto-zero equilibrium voltage.

The sense of this deviation is transmitted by the comparator to the control logic, which then attempts to return the integrator output to the storage voltage by using one of the two duty cycles available during the measure interval. For a high comparator output in the clock cycle preceding a set of eight cycles, the up/down logic is high for one clock cycle, low for seven—the pattern called duty cycle 1 in Fig. B. With a low comparator output in the last clock cycle of the set, the up/down logic will be high for seven cycles and low for one in the following duty cycle—labeled 2 in Fig. B. It can be seen from the figure that the high state of the up/down logic drives the integrator output voltage up. Therefore, the synchronous up/down BCD counter adds one count for each clock pulse when the up/down logic is high and subtracts one count for each clock pulse when the up/down logic is low.

It can be shown that:

$$\text{Net count} = V_{IN}(R_1/R_2)(8{,}192/V_{REF})$$

The measure of the input voltage is therefore a ratio of the reference voltage, and, significantly, the integral or time constant has no influence on accuracy.

Having digitized the analog input, this data must now be brought out to the display. The BCD counter is put on hold, and its contents are loaded into the latches along with underrange information decoded from the counter contents (5% of full scale). The counter is then cleared. The contents of the static latches are multiplexed to the push-pull data output buffers in BCD format.

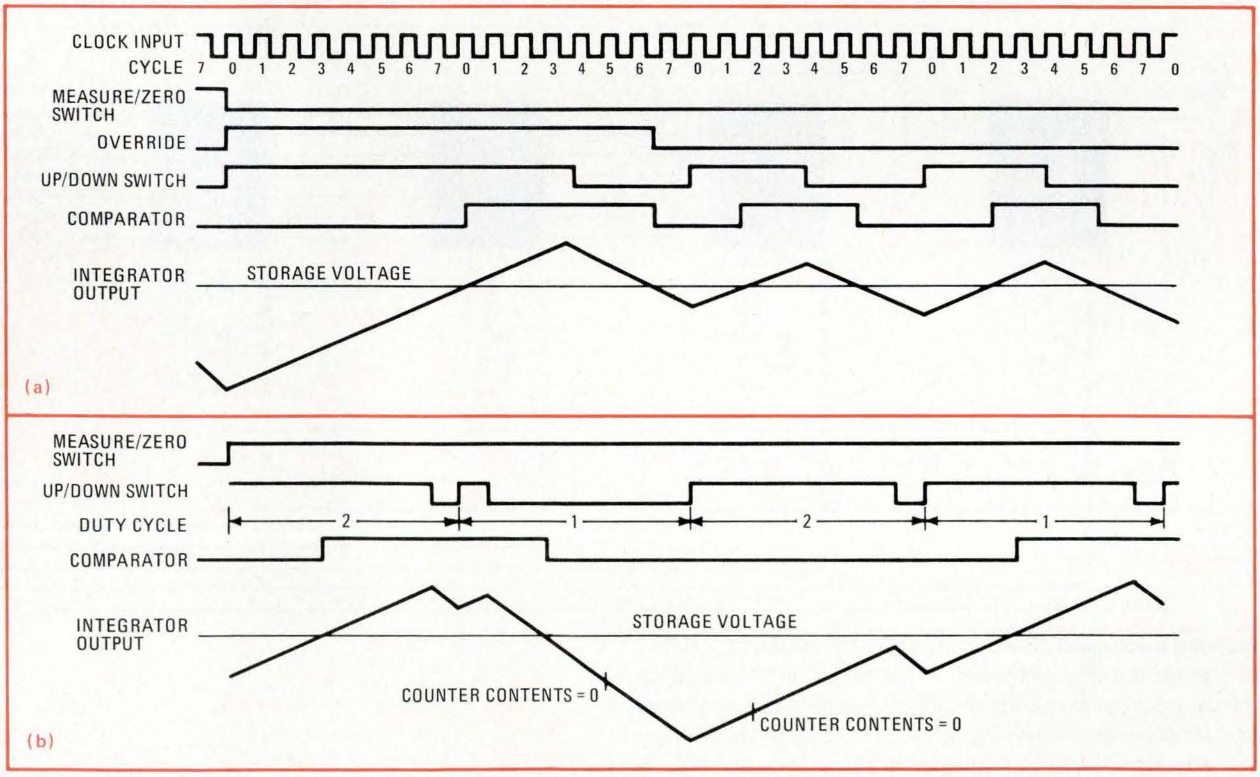


TABLE 1: VALUES FOR COMPONENTS OF THE AUTO-ZERO FILTER				
Input frequency (kHz)	Integrator capacitor (μF)	Storage capacitor (μF)	R_4 (kΩ)	R_5 (kΩ)
2 – 10	0.1	1.0	68	15
10 – 20	0.039	0.1	240	47
20 – 40	0.022	0.1	120	33
40 – 75	0.01	0.1	82	18

than V_1. As V_{REF} is increased, the up/down switch's on resistance decreases (Fig. 2), but simultaneously the resistance of reference resistor R_1 increases and reduces the proportion of the total resistance provided by R_1 and switch. Consequently, a large reference voltage minimizes the effects of this switch's temperature-dependent on resistance.

In any case, it is very important for the reference voltage itself to have a low temperature coefficient to minimize drift and, thus, count error. The following equation quantizes the change in count that occurs for a fractional change in reference voltage:

$$\Delta count = -2{,}000\,(V_{IN}/V_{IN}F.S.)(\Delta V_{REF}/V_{REF})$$

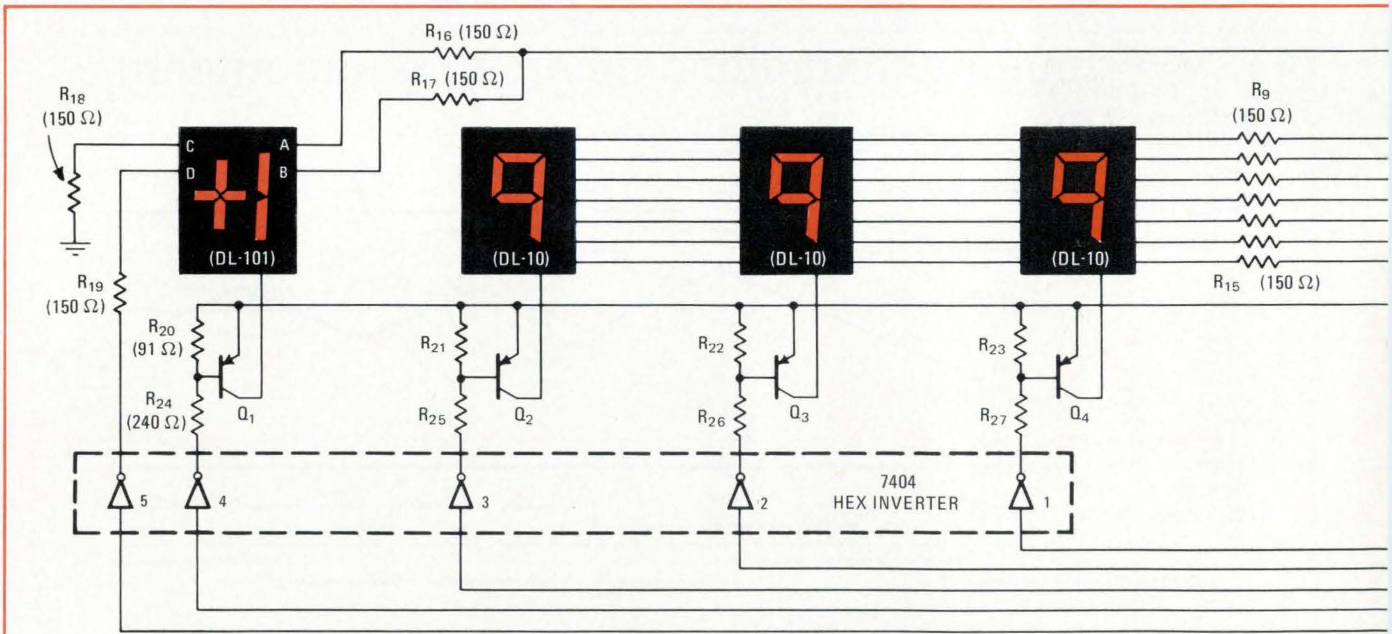
In other words, the count decreases by 1 for each +0.05% change in the reference voltage.

As for external resistors, R_2 should be chosen to supply a full-scale current of 20 microamperes into the integrator summing node (100 kilohms for 2,000 V, and 10 kilohms for 200.0 mV). R_1, the reference resistor, can then be determined from the next-to-last equation.

Remember, however, that the temperature-dependent on resistance of the up/down switch, which has a temperature coefficient of about 0.2%/°C, counts as part of the total resistance of R_1. And the error in count resulting from a change in this total resistance R_1 parallels that of V_{REF}, being:

$$\Delta\, count = -2{,}000\,(V_{IN}/V_{IN}\,F.S.)(\Delta R_1/R_1)$$

Now the net count is proportional to the ratio R_1/R_2 (see "How the circuitry works," p. 95), so equal temperature coefficients for these resistors should allow this ratio (and the count) to be maintained, even with a change in the ambient temperature. It is desirable, how-



3. Building a voltmeter. The primary application of the LD110/111 converter set is digital voltmeters. In this typical +2.000-V digital voltmeter, the clock frequency of 24.5 kHz yields a sampling range of four samples per second. Capacitor C_5 is adjusted for true zero output, after which it can be replaced with a fixed-value component. After this the only calibration required is from trimmer R_6.

ever, to use resistors with low temperature coefficients for R_1 and R_2 to reduce any errors resulting from the differences in these coefficients.

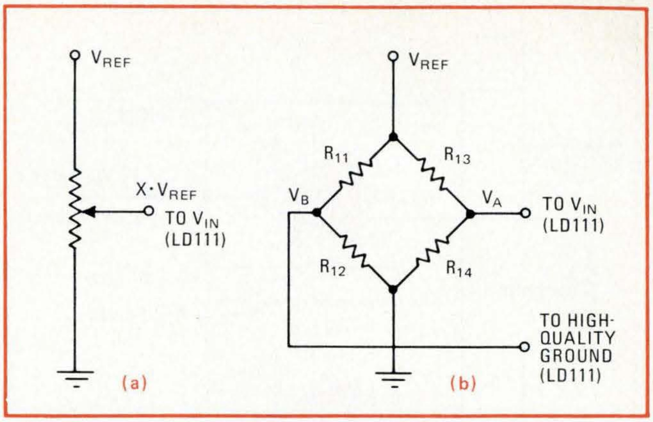
Maintaining accuracy

The specified accuracy of the a-d converter will be maintained if the integrator capacitor (C_{INT}) is chosen to hold the voltage swing of the integrator within 0.75 V of the storage voltage. This apparently arbitrary value results from two conflicting considerations. The first is the need to maintain a small integrator swing to reduce the error that can occur during the override interval. The second is the need for an integrator swing large enough to keep the error arising from a comparator offset to less than 0.1 of the least significant bit. To minimize these possible sources of error, the value of the integrator capacitor should approximately equal 570 μF-Hz/f_{IN}.

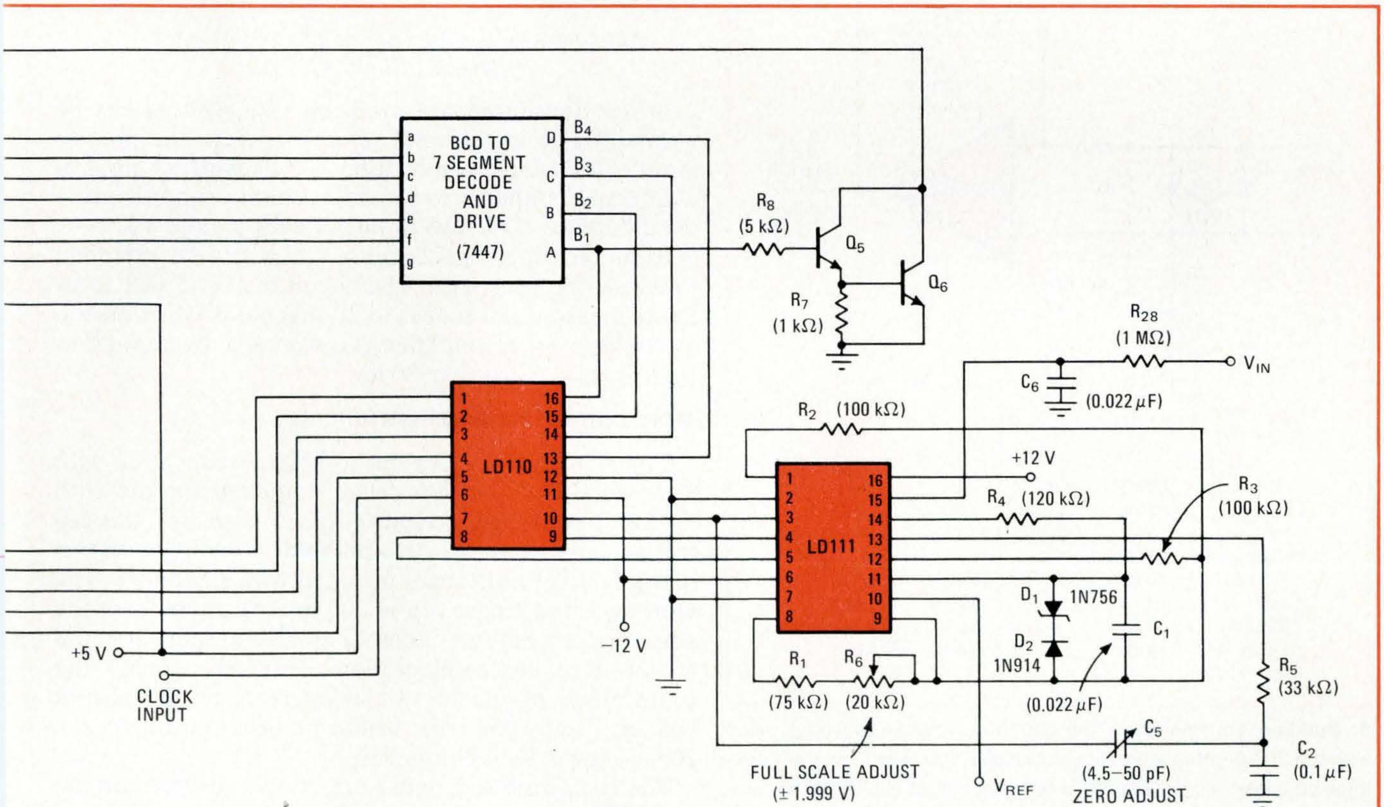
The storage voltage (V_{STRG}) should be maintained between -2 V and -5 V for normal operation. The on resistance of the auto-zero switch is typically 11 kilohms at a storage voltage of -4 V (V_2 = -12 V) and will increase significantly with an increasingly negative storage voltage. Resistor R_3 can be selected to produce the desired V_{STRG}, provided ground is at zero potential, by the equation:

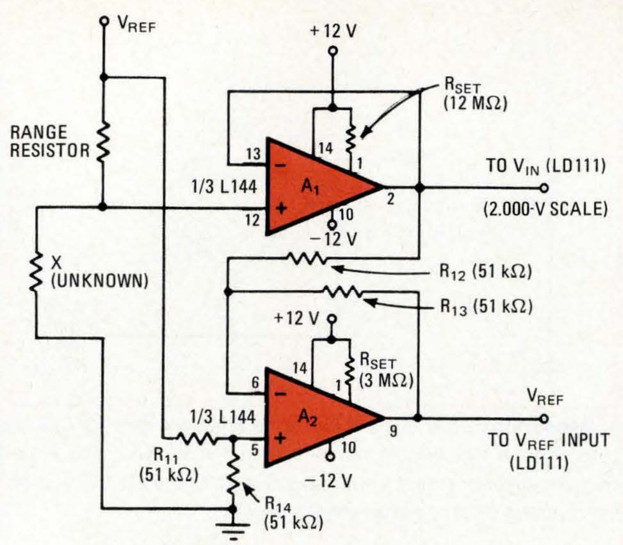
$$V_{STRG} = -\tfrac{1}{2}V_{REF}(R_3/R_1)$$

Several tradeoffs must be made in selecting RC components for the auto-zero filter circuit (R_4, R_5, and storage capacitor C_{STRG}). Various component values for different clock-frequency ranges are presented in the table on p. 96, along with the recommended values for the integrator capacitor.



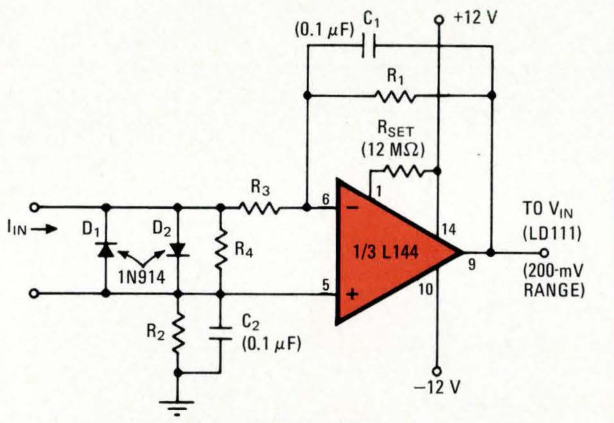
4. Measuring ratios. The a-d converter chips are ideal for ratio measurements. A typical potentiometer circuit is shown in (a), while for bridge measurements (b), the ground input of the LD 111 is used as the inverting input of a differential amplifier.





RANGE TO:	RANGE RESISTOR
200 Ω	819.2 Ω
2 kΩ	8.192 kΩ
20 kΩ	81.92 kΩ
200 kΩ	830 kΩ
2 MΩ	8.51 MΩ
20 MΩ	163 MΩ

5. Measuring resistance. This circuit, combined with the converter pair, will measure resistance values accurately to 20 megohms. The buffer amplifier A_1 should have a low input-bias current—less than 20 nanoamperes—for best accuracy.



CURRENT RANGE TO:	R_1	R_2	R_3	R_4
200 nA	500 kΩ	500 kΩ	0	∞
2 µA	50 kΩ	50 kΩ	0	∞
20 µA	5 kΩ	5 kΩ	0	∞
200 µA	1 kΩ	0	0	∞
2 mA	50 kΩ	0	5.0 kΩ	10.0 Ω
20 mA	50 kΩ	0	5.0 kΩ	1.0 Ω
200 mA	50 kΩ	0	5.0 kΩ	0.1 Ω
2 A	50 kΩ	0	5.0 kΩ	0.01 Ω

6. Building an ammeter. This current-to-voltage converter, used with the 200.0-mV range of a typical digital voltmeter, has eight decades of current range. The more sensitive ranges (up to 200 µA) use the amplifier in the differential mode.

Part 2: The converter's uses

Since the user of the LD110/111 two-chip a-d converter can choose from a wide range of external components, the a-d system is very flexible and can be adapted to a variety of digitizing applications.

The circuit in Fig. 3 presents the chip set in a typical ±2,000-v digital-voltmeter application. The clock frequency of 24.5 kHz yields a sampling rate of four samples a second. Capacitor C_5 is adjusted for 0000 output with zero input and can be replaced by one of fixed value, once the proper value for the circuit board being used has been determined. The only calibration required after that is trimmer resistor R_6. R_1 and R_2 should be 5% metal-film resistors. All other resistors may be of 10% tolerance—an illustration of how this conversion technique reduces component cost, as well as count.

The LD110/111 analog-to-digital converter automatically measures input voltage as a ratio. (See "How the circuitry works," p. 95, which summarizes the fact that the count is proportional to the ratio of the input voltage and the reference voltage in the equation: Net count = V_{IN} $(R_1/R_2)(8{,}192/V_{REF})$.) Obviously, therefore, the system can easily handle ratio-measurement applications. Ratio measurements that use the excitation voltage of the ratio device as their reference voltage are independent of variations in the excitation voltage.

Figure 4 shows some typical ratio-measuring circuits. The output of the potentiometer in Fig. 4a, which can represent position, level, etc., can be substituted in the equation quoted in parentheses above to demonstrate this capability:

$$\begin{aligned} \text{Net count} &= XV_{REF}\,(R_1/R_2)(8{,}192/V_{REF}) \\ &= (R_1/R_2)(8{,}192X) \end{aligned}$$

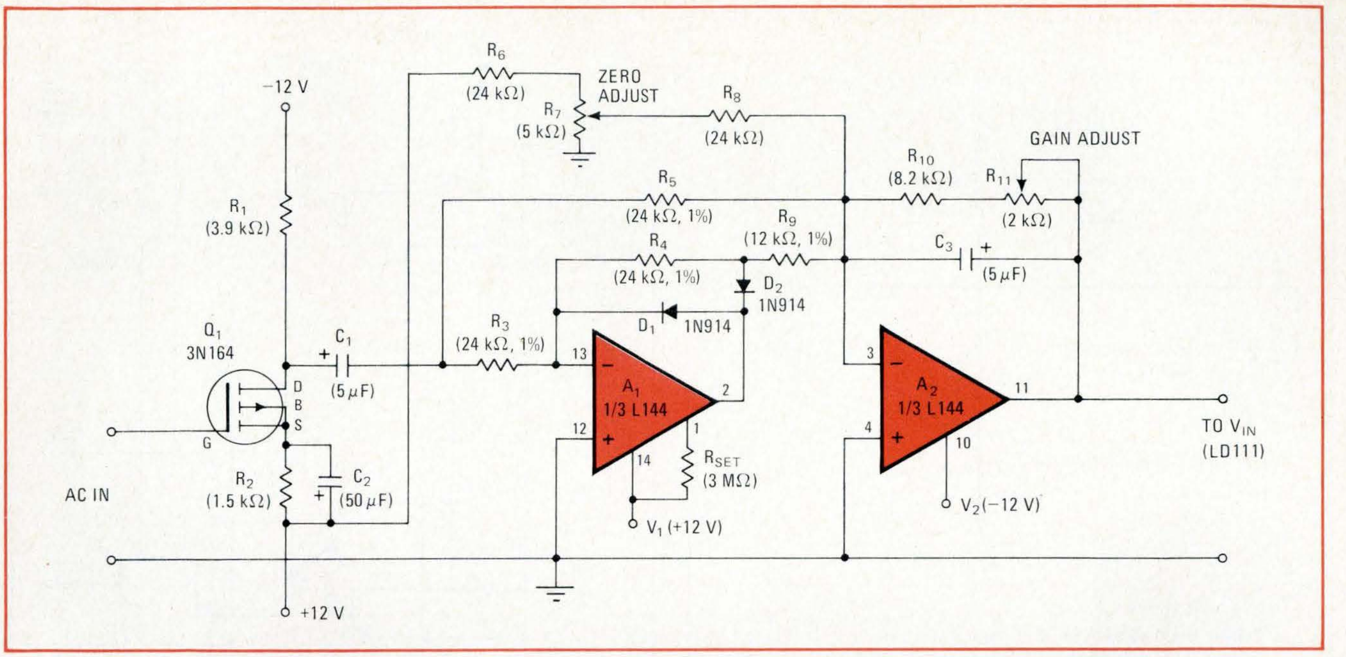
Bridge transducer measurements (Fig. 4b) can also be normalized to an external reference. Here the ground input of the LD111 can be used as the inverting input of a difference amplifier to provide a count proportional to the difference of the two input voltages V_A and V_B.

Ratio-measurement techniques can also be extended to measuring resistance. The circuit in Fig. 5 will accurately measure resistances to 20 megohms when associated with a buffer amplifier (A_1) having a low input bias current (I_{IN}) of less than 30 nA.

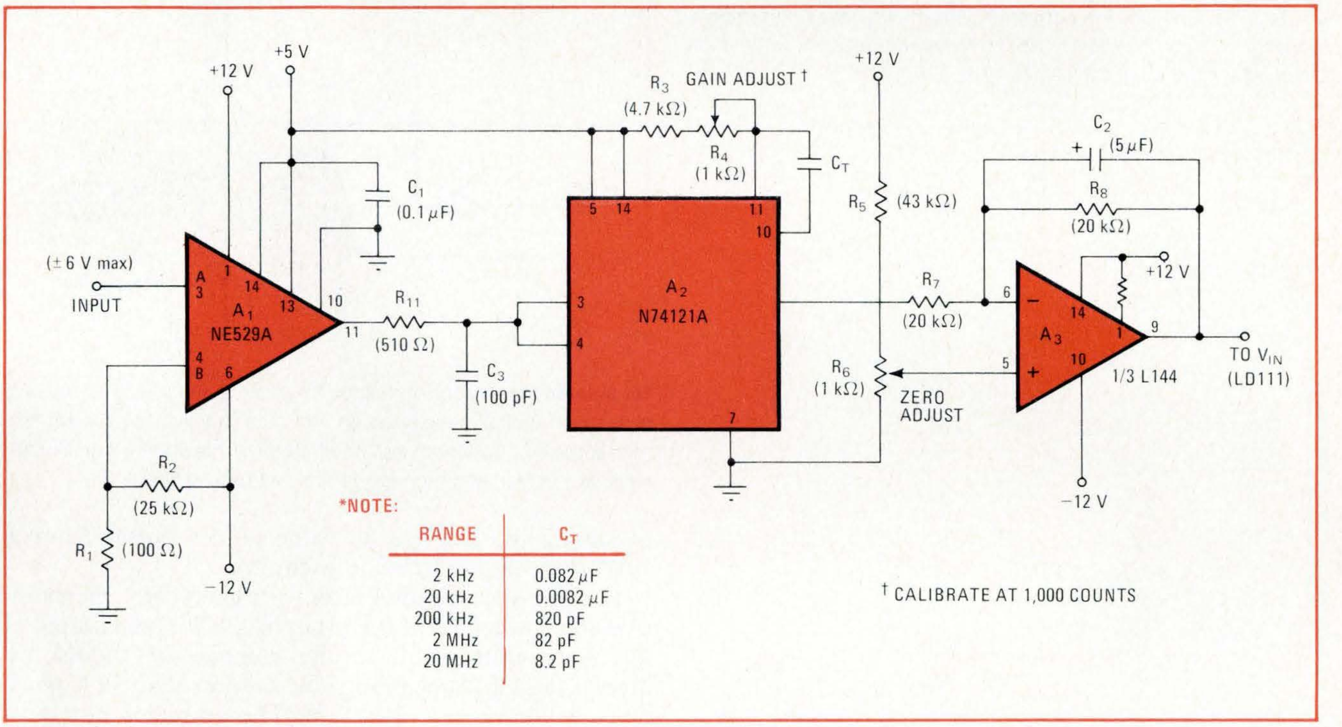
More converters and instruments

Figure 6 shows a current-to-voltage converter with eight decades of current range. Intended for use with the 200.0-mV range of typical digital voltmeter, this circuit actually comprises two different circuits, as shown in the table of resistances included with the figure. The more sensitive ranges (up to 200 microamperes) use the amplifier in a differential mode to give an output equal to $-2I_{IN}R_1$. This configuration effectively cancels the contribution of the input-bias currents to the output voltage. (Since this error would be insignificant on the 200-µA range, R_2 is eliminated.)

The less sensitive ranges (2 mA to 2 amperes) use the amplifier in an inverting configuration to provide an



7. Ac-dc. Using the converter pair as an ac-to-dc converter requires keeping the input impedance and input bias currents at about the same value as those of the LD111 input, buffer amplifier. The circuit includes a p-channel enhancement-mode MOSFET input buffer amplifier.



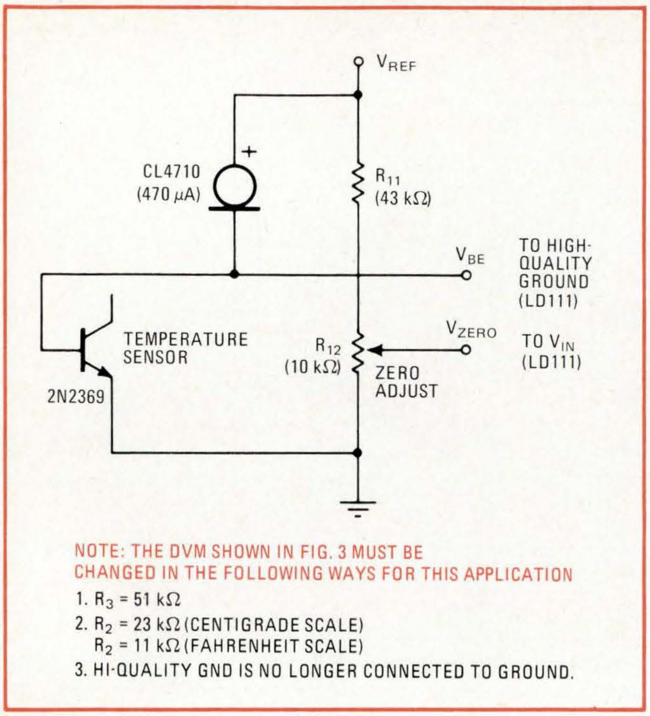
8. Measure frequency digitally. The basic 2-V digital-voltmeter circuit can be used to measure frequency when used with 74121-type monostable multivibrator. Here, frequency is converted to voltage by taking the average dc value of the one-shot's pulses.

output equal to $-I_{IN}R_4R_1/R_3$. Input protection is provided by diodes D_1 and D_2.

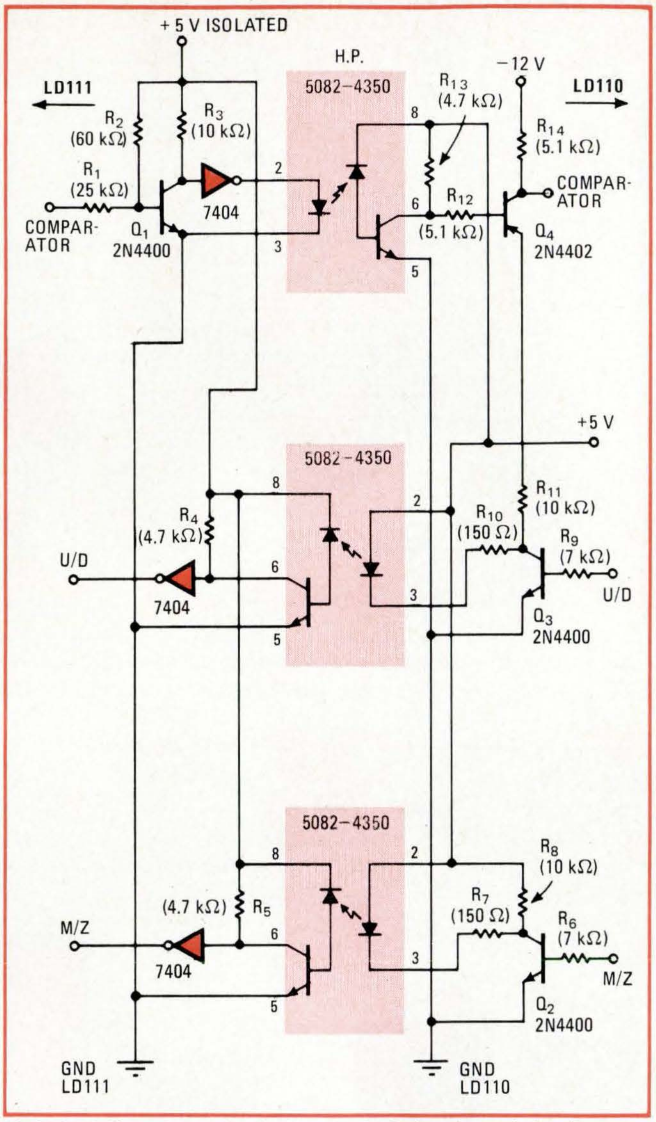
When an ac-to-dc converter is designed with the LD110/111 converter set, the input impedance and input-bias currents should approximate those of the LD111 input-buffer amplifier. This is particularly necessary if the digital-voltmeter circuit of Fig. 3 is used, so that the same range resistors can be employed for both ac and dc measurements.

The ac-to-dc converter shown in Fig. 7 fulfills these requirements. The circuit includes a p-channel MOS enhancement-mode FET-input buffer amplifier, coupled to a classical absolute-value circuit, which essentially eliminates the effect of the forward-voltage drop across diodes D_1 and D_2. A filter removes the dc component of the rectified ac, which is then scaled to rms. The output is linear from 40 hertz to 10 kHz.

A digital frequency meter can be fashioned from the basic 2-V digital-voltmeter circuit by using the circuit shown in Fig. 8. Here, frequency is converted to voltage



9. Digital thermometer. By changing the forward voltage drop across a pn junction, the converter system, will measure temperature as a voltage change across the temperature-sensitive junction. The temperature coefficient typically is –2.3 mV/°C.



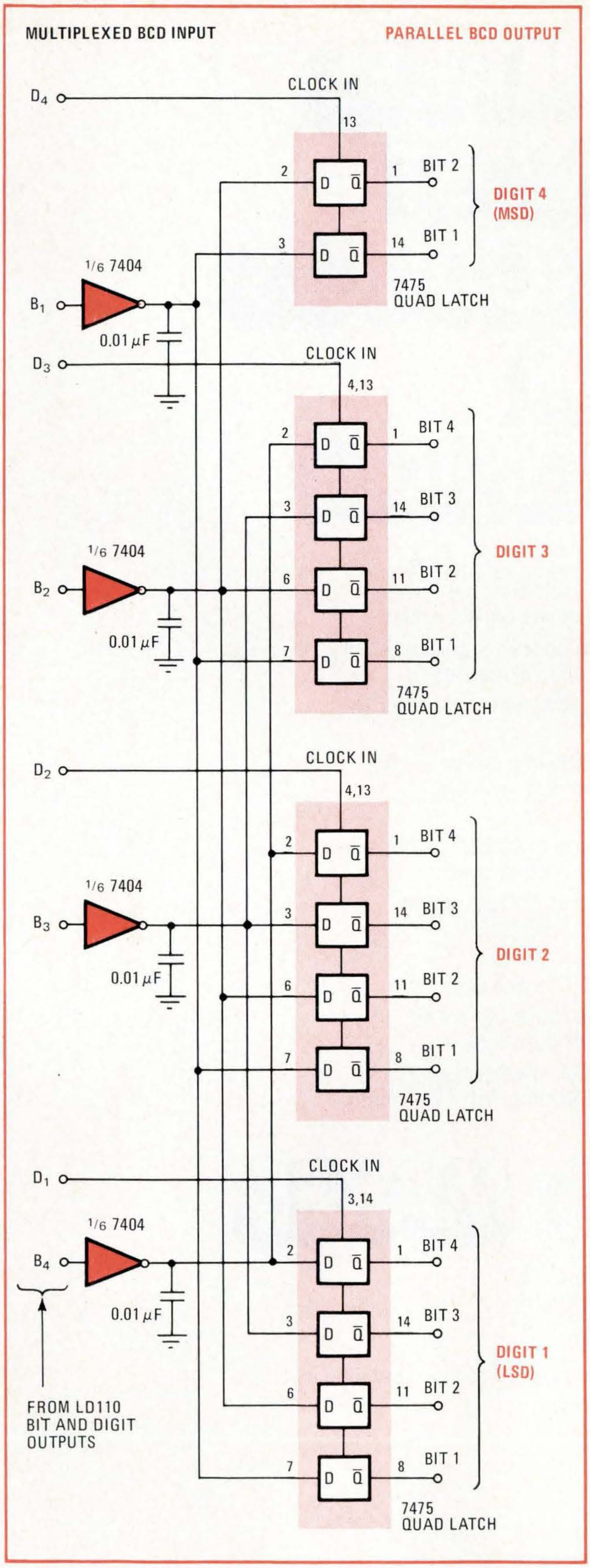
10. In isolation. A good technique for isolating the a-d circuit uses a high-speed optical coupler as an interface to the three a-d signals (measure zero, up/down, and comparator). This system is useful for medical, nuclear, and process-control instrumentation.

by taking the average dc value of the pulses from a 74121-type monostable multivibrator.

The one-shot multivibrator is triggered by the positive-going ac signal at the input of a 529-type comparator. The input signal to the comparator should be greater than 0.1 V peak to peak and less than 12 V peak to peak for proper operation. The amplifier not only acts as a dc filter, but it also provides zeroing. This circuit will maintain an accuracy to 2% over a range of five decades.

The converter system can also be used to construct a digital thermometer by using the change in forward-voltage drop across a pn junction as the temperature-sensitive element in the circuit (Fig. 9). This change is typically –2.3 mV/°C. The circuit has the base-emitter junction of a bipolar transistor biased with a 470-μA current source.

With this element, the junction voltage V_{BE} is applied to the input buffer amplifier of the analog processor, which functions as a differential amplifier. The buffer



11. Parallel output. For those jobs where the BCD data for all four digits should be available in a parallel format—for example, as printer inputs—this multiplexed-BCD-to-parallel-BCD converter has four quad bistable latches activated by LD110 output.

resistor R_2 is scaled to give a count proportional to temperature, as shown by the equation:

$$Count = 1{,}000\,A\,[V_{ZERO} - V_{BE}\,(t)]$$

Gain A must be approximately 5 for the Celsius scale, 9 for the Fahrenheit scale.

Some other ideas

The isolation circuit of Fig. 10 provides a floating analog processor for measurement of off-ground signals, like those found in medical, nuclear, and process-control instrumentation.

The three analog-to-digital interface signals (measure/zero, up/down, and comparator) are isolated by high-speed optical couplers with a 2,500-v insulation. The TTL-level drive capability needed to interface the optical couplers with the LD110/111-system signals is provided by transistors Q_1, Q_2, and Q_3. The isolators in the measure/zero and up/down channels are used in the noninverting mode, while the isolator in the comparator interface is used in the inverting mode. Transistor Q_4 shifts the TTL-level signal to the MOS-level required at the LD110 comparator input.

Although the isolators tend to shorten the pulse width of the LD110/111-system signals, the unique conversion technique of the system automatically compensates for this. No additional adjustments are necessary.

The multiplexed BCD output of the converter is useful for digital displays, but there are other applications, such as printer inputs, in which the BCD data for all four digits should be available in a parallel format. The multiplexed-BCD-to-parallel-BCD converter of Fig. 11 will provide the proper interface for these jobs.

The converter consists of four quad bistable latches activated in the proper sequence by the digit strobe output of the LD110. The complemented outputs ($\bar{Q}$) of the quad latch set will reflect the state of the bit outputs when the digit strobe goes high and will maintain this state when the digit strobe goes low. The latches will be updated with the next digit strobe.

Consequently, this parallel BCD output will not be affected by the blinking off of the digit strobes when the count exceeds 1,999 (overrange), and it can therefore be used to drive a non-blinking display up to a full-scale of 3,000 counts. The parallel BCD output can be put in a hold state if all digit strobes are clamped to ground to prevent the updating of the latches.

What the future holds

The preceding examples indicate the multiplicity of uses possible for the scaling, ratio-measurement, and differential-input capabilities of the LD110/111. The next evolutionary step is to single-chip monolithic a-d converters, a prospect that grows more attractive as linear LSI processing becomes more powerful. First to arrive will undoubtedly be a low-speed a-d converter resembling the LD110/111 and aimed specifically at the market in high-performance digital multimeters. This will probably incorporate the various digital-multimeter functions into the linear front end. Medium- and high-speed a-d converters for control applications, although not in the range of today's single-chip technology, will surely become a reality in the not-so-distant future. □

High-level language simplifies microcomputer programing

Just as Fortran and Basic sharply reduce the time and effort required to program large computers, so Intel's PL/M eases the programing of systems based on LSI microprocessors; here are step-by-step directions

by Gary A. Kildall,
Naval Postgraduate School, Monterey, Calif.

☐ The microcomputer is being applied to more and more tasks that are not economically feasible for a minicomputer, with its larger instruction set and higher speed and cost. Although the microprocessor is slower than the central processor of a minicomputer, it can easily perform many tasks that are complex enough to require extensive digital processing.

What's more, microprocessors, which serve as central processors of microcomputers and are generally made with MOS large-scale integration, are constantly attaining higher speeds and higher circuit density per chip. As the capabilities of microcomputers are being ever extended, programing aids are being developed to simplify their use, while minimizing design and development time. These aids sometimes require use of a larger computer; when this is the case, they can be used either on commercial time-sharing networks or on a user's own large in-house computer.

The microcomputer may be viewed as a ROM-driven LSI logic chip because the microcomputer can execute complicated sequences of instructions stored in an external memory. Thus, the microcomputer chip connected to a read-only memory containing the proper data can appear to be a single custom chip. In this way, the system designer can substitute microcomputer programing for traditional hard-wired logic design or custom chip fabrication, gaining advantages in reduced development time, ease of design change, and reduced production costs.

The application of microcomputers points up the common ground between software and hardware designers. While software-system designers can use microcomputers most effectively when they are aware of the hardware environment, the hardware designer is well advised to learn the basic techniques of the programer.

These techniques include how to use assemblers, compilers, and processor simulators, which are effective tools in developing and debugging large and small microcomputer programs. This article introduces these programing tools to the hardware designer and specifically examines the advantages of the PL/M language, which make possible rapid design of systems around the MCS-8 microcomputer, made by Intel Corp.

The MCS-8 is based on the 8008 microprocessor, one of a new class of devices being offered by several manu-

1. Symbolic. This simple program for choosing the larger of two numbers takes nine lines of code in symbolic or assembly language, but typically only one line in a higher-level language, such as PL/M.

LABEL	INSTRUCTION	COMMENT
TEST	SHL B	LOAD ADDRESS OF B
	LAM	LOAD B INTO ACCUM
	SHL A	LOAD ADDRESS OF A
	CPM	COMPARE B WITH A
	JFC L1	JUMP TO L1 IF B ≤ A
	LAM	LOAD A INTO ACCUM
L1	SHL C	LOAD ADDRESS OF C
	LMA	STORE ACCUM INTO C
	END	END OF PROGRAM

Closing the loop

Readers who would like to discuss the PL/M language with Mr. Kildall may call him at (408) 646-2240 during the week of July 15, between the hours of 9 a.m. and 12 noon, Pacific Daylight Time.

facturers as a result of recent advances in semiconductor electronics. The PL/M programing aid is a good example of the service that these manufacturers can offer to simplify the use of their products.

Minimizing software costs

Like other programing tools, the PL/M approach automates the production of programs to counteract the rapidly increasing cost of software production at a time when hardware costs are decreasing. And, in addition to rapid production turnaround, the programs can be fully checked out early in the design process. What's more, the self-documentation of PL/M programs enables one programer to readily understand the work of another, which dramatically reduces program-maintenance costs and provides transportability of software between programers and to other Intel processors as they are introduced.

Additional cost reductions will also result from standardization of parts and modules, and alterability of the final program often outweighs benefits of random-logic designs or custom-chip fabrication.

The PL/M compiler, which is another program, translates the PL/M program into machine language. This compiler, which can be run on a medium- or large-scale computer, is available from several nationwide time-sharing services.

Last but not least, PL/M programs can be recompiled as improved optimizing versions of the compiler are released, as Intel has recently done. A recent revision of the PL/M compiler, for example, makes possible reduction of generated code by about 15%.

Although PL/M requires a cross-compiler—one that runs only on a larger machine—a resident compiler that uses the microcomputer itself to produce its programs is technically feasible with the advanced state of microcomputer development and today's inexpensive peripherals. Such a compiler would require several passes to reduce a PL/M source program to machine language, using the developmental system itself, and eliminating the need for large-system support.

A program for the Intel 8008 microprocessor is a sequence of instructions from its normal instruction set (see "Hardware for PL/M," p. 105) that performs a particular task. Given no programing aids, the designer must determine the machine codes that represent each of the instructions in his program and store these codes into program memory. This approach to programing quickly becomes unwieldy in all but the most trivial projects.

Nearly all manufacturers of microprocessors (and mini- and maxicomputers as well) provide symbolic assemblers—programs that ease the programing task by eliminating the need to translate instructions manually into machine-readable form. The designer can express his program in terms of mnemonics, which are abbreviations that suggest individual instructions. Then the assembler translates each mnemonic instruction into its binary representation.

Symbolic addresses

In addition, the programer can refer to memory locations by symbolic name, rather than actual numeric address; the assembler translates these, as well as the instructions. The assembler usually runs on a larger computer, although both Intel Corp. and National Semiconductor Corp. have assemblers that run directly on their microcomputer-based development systems, and symbolic programs for Rockwell microcomputers can be assembled on a machine built around that unit by Applied Computer Technology Inc. The assembler requires significantly less development and check-out time than manual translation, and there are fewer coding errors.

STATEMENT

```
DECLARE MESSAGE DATA ('WALLA WALLA WASH'),
    (CHAR, I, J, SENDBIT) BYTE;

/* SEND EACH CHARACTER FROM MESSAGE VECTOR TO TELEPRINTER */
    DO I = 0 TO LAST(MESSAGE);
    CHAR = MESSAGE(I);
    SENDBIT = 0;

    /* SEND EACH BIT FROM CHAR TO TELEPRINTER */
        DO J = 1 TO 11;
        OUTPUT(0) = SENDBIT:
        CALL TIME (91); /* WATTS 9.1 MS */
        SENDBIT = CHAR AND 1;
        /* ROTATE CHAR FOR NEXT ITERATION */
        CHAR = ROR (CHAR OR 1, 1);
        END;
    END;
```

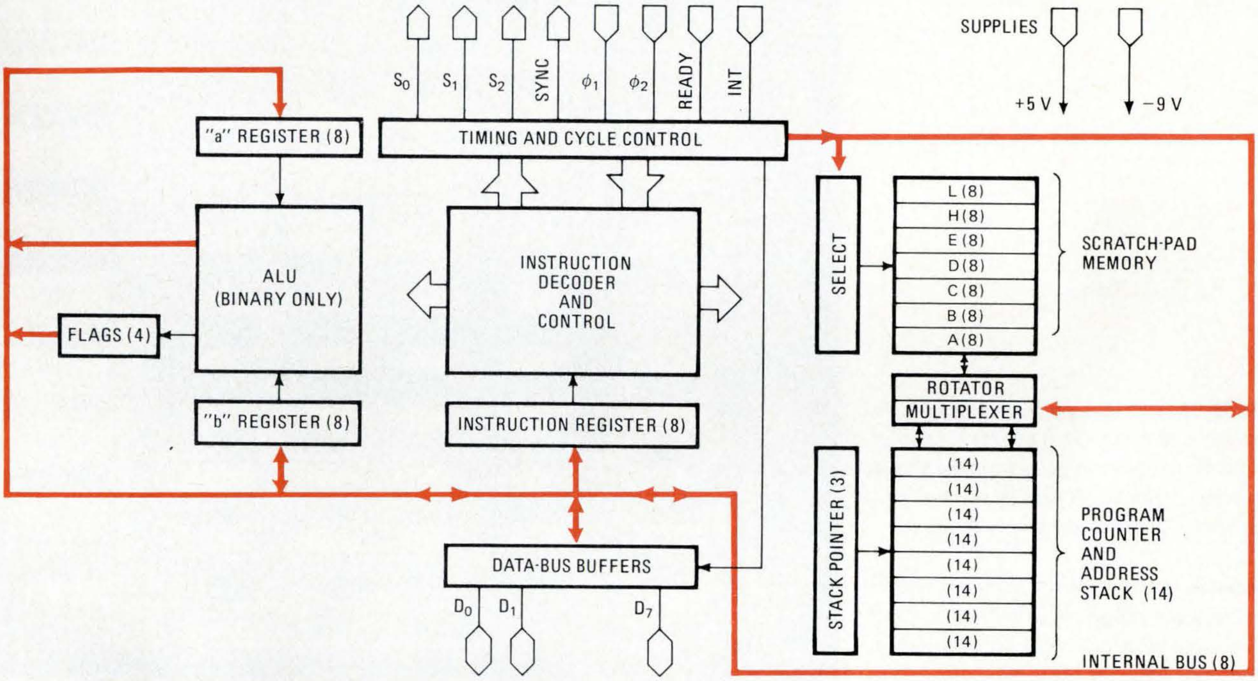
2. Serial sender. To print a short message on a Teletype, this routine in PL/M transmits 11 pulses at 9.1-millisecond intervals for each character in the message, stopping after the last one. The pulse train consists of one start pulse, eight data pulses, and two stop pulses.

Hardware for PL/M

The Intel MCS-8 microcomputer consists of the 8008 microprocessor plus a collection of standard read/write and read-only memories and shift registers. The 8008 is a single-chip MOS device with

- 8-bit parallel word size
- Seven 8-bit general-purpose registers
- 16,384-word address capability, in either read-only or read/write memory
- Up to 32 8-bit latched input and output ports

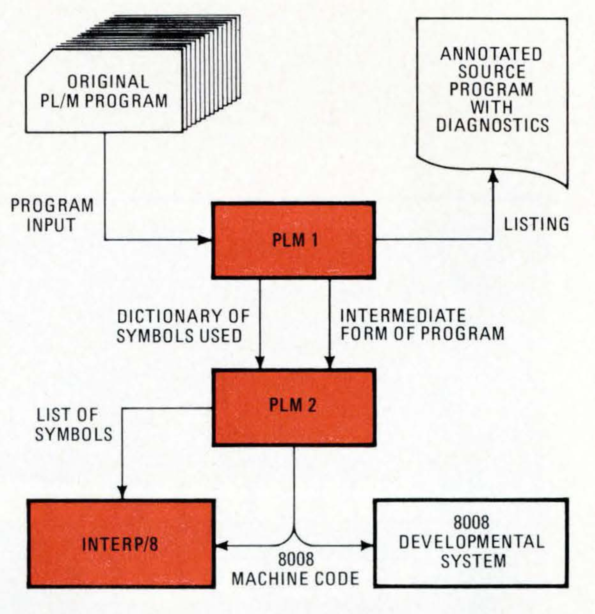
The MCS-8 instruction set includes register-to-register, register-to-memory, and memory-to-register transfers, along with arithmetic, logic, and comparison instructions. Conditional and unconditional transfers and subroutine calls are also provided. Input and output instructions read data from input ports and set data into output-port latches. Each of these instructions is represented in program memory by a sequence of one, two, or three 8-bit words.



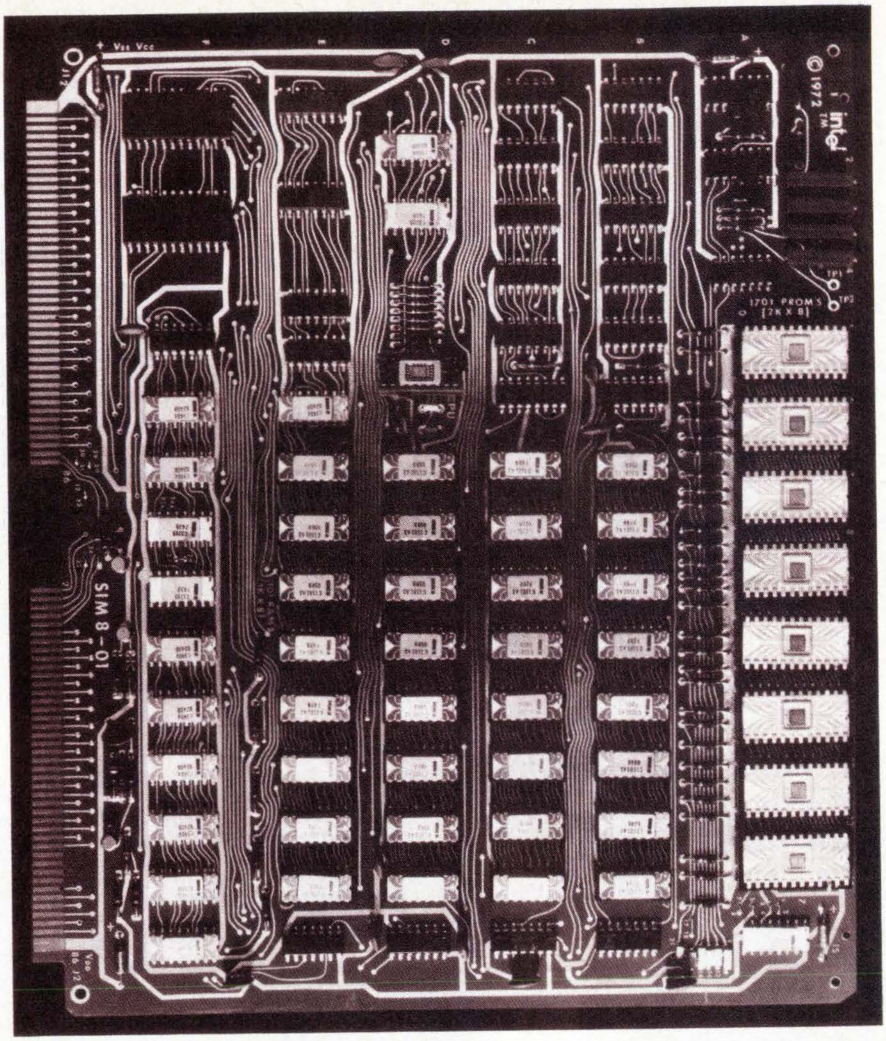
Assembly-language programing, however, is necessarily closely related to the machine architecture because instructions in symbolic code have a one-to-one correspondence with those in machine code. As a result, the programer must spend much more time keeping track of the location of data elements and proper register usage than actually conceptualizing the solution to his problem.

On large-scale computers, high-level languages have been developed to provide important facilities independently of particular machine architectures, while eliminating the trivialities of assembly languages. These facilities include program-control structures, data types, and primitive operations suitable for concise expressions of programs in particular problem environments. For example, a problem environment may be one of numerical computation, in which application-oriented programing languages like Basic and Fortran are appropriate. Or the environment may be the control of a particular class of computer and all its functions, for which system languages, which are necessarily closely related to the machine architecture, are useful.

In a system language, program statements generally correspond directly with machine-level instructions, and conversely, every machine operation is reflected in a high-level language statement. Because of this corre-

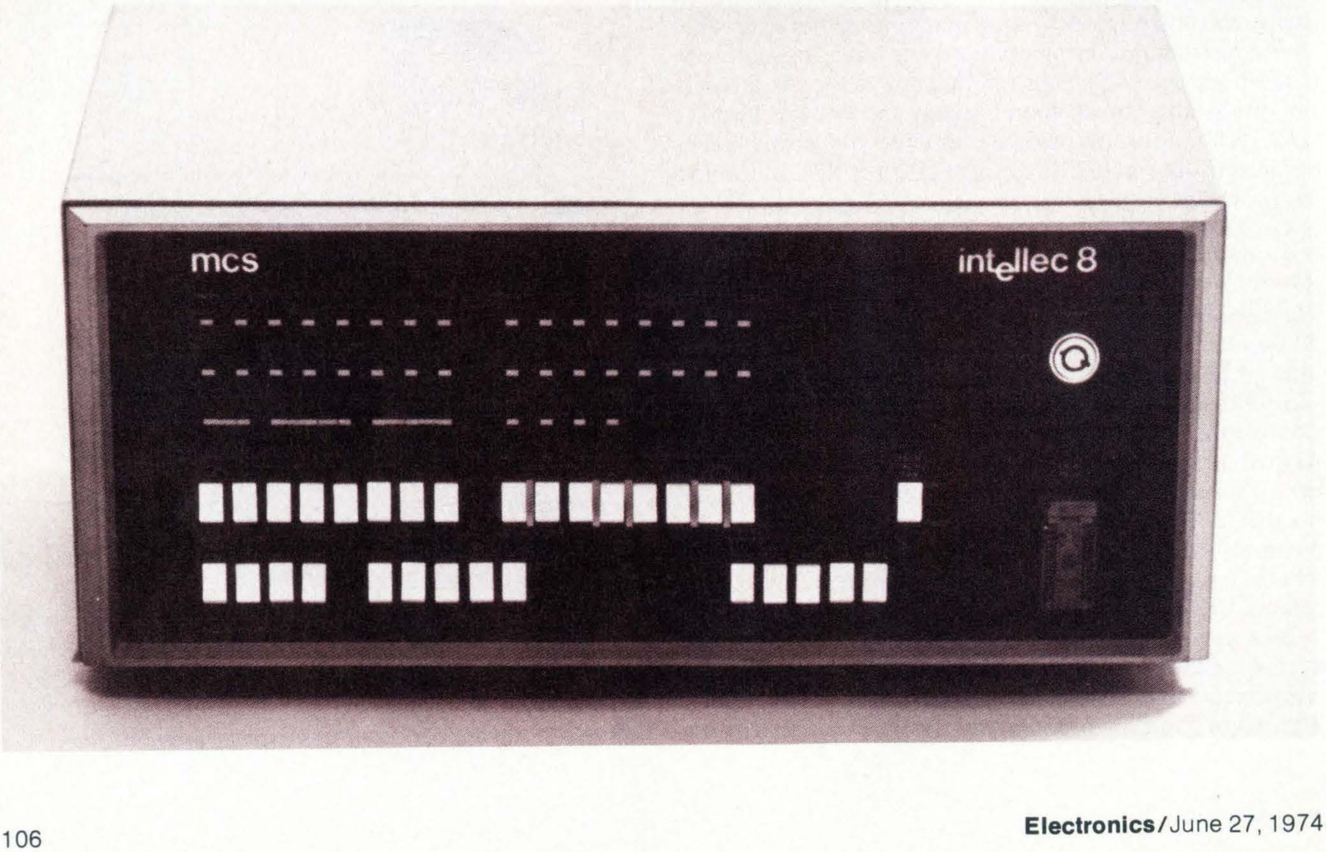


3. Compiler. Translating PL/M programs into machine language takes two passes with programs called PLM1 and PLM2, run by a larger machine. A third pass, with Interp/8, simulates the microprocessor on the big machine to check out the program.



4. SIM8-01. This Intel product checks out a program written in MCS-8 machine code or compiled into machine code from the PL/M language. Erasable ROMs store the program, and a Teletype gives input/output.

5. Intellec 8. This developmental system can check out programs written in PL/M. It also serves as a prototype for production systems based on the MCS-8.



spondence, system-language programs usually translate efficiently to the machine-language level, and the programer finds all the machine's facilities directly available to him. PL/M, an example of such a language, was designed for use with the 8008 microprocessor, and is also usable with Intel's newer 8080 microprocessor [*Electronics*, April 18, p. 95], which has more useful machine-level instructions and a considerably faster instruction cycle than its predecessor.

Nevertheless, some hardware designers, particularly those newly introduced to software systems, may prefer to work at a comfortable level, which may mean programing in absolute machine code initially and then moving to assembly language as more capability is required. Similarly, they can easily make the transition to a high-level language when programing in assembly-language becomes tedious.

In any case, the designer soon becomes familiar with various programing levels. One of these levels can then be intelligently selected as most appropriate for a given application. Each level has its own advantages. For example, a program in PL/M that compiles into about 500 bytes of memory space when using the 8008's instruction set might require perhaps as much as 30% less space if it were coded directly in assembly language. But larger programs running 1,000 bytes or more usually turn out to be more compact when written in PL/M than in assembly language because the compiler can keep track more easily of memory-reference areas, registers, and other resources. The amount of machine code generated in assembly language or PL/M varies, of course, with program complexity and style. Thus, an absolute comparison between the two is not possible.

Simple coding

The PL/M language consists of a number of basic statement types in which complicated arithmetic, logical, and character operations on 8-bit and 16-bit quantities can be expressed in a form resembling usual algebraic notation. Relational tests can be expressed in a natural way to control conditional branching throughout the PL/M program.

For example, to move the larger of two numbers in locations A and B into the location called C, either the PL/M statement,

```
IF A > B, THEN C=A; ELSE C=B
```

or the nine-instruction assembly-language program shown in Fig. 1 can be used. The statement reads, "If the value of A is greater than the value of B, then set C to equal A; otherwise set C to equal B."

Additional language structures provide iteration control to permit program segments to be "looped," or executed repeatedly a prescribed number of times. Subroutine facilities include mechanisms that are useful for modular programing and construction of subroutine libraries.

The over-all structure of the PL/M language is most easily demonstrated by a simple example. Suppose a teleprinter is connected to the least-significant bit of an output port of the Intel 8008. A PL/M program that sends a short message to the teleprinter is shown in Fig. 2; it individually times the transmission of the bits through the output port. This program can be translated into machine code loaded into the memory of the MCS-8, and then it is executed.

The program begins with a data declaration that defines a string of Ascii characters—the words "Walla Walla Wash" as shown in line 1. The 16 individual characters of this string are labeled from 0 to 15 so that they can be addressed by the program (spaces are characters, too). Four variables, or 8-bit memory locations, CHAR, I, J, and SENDBIT, are defined on line 2.

Any names

These designations are wholly arbitrary; the programer may use any names he wants, so long as he defines them before he uses them. CHAR holds each character of the message in succession for transmission, I identifies the position of the character in the message, and J controls the position of the bit in the character. The right-most bit of location SENDBIT is the next bit to be transmitted.

Since the instructions between lines 5 and 17 are executed repetitively, they are collectively called a loop. Before each repetition, the variable I is incremented until its value indicates the position of the last character in MESSAGE—in this case, 15.

First, the value of all bits in SENDBIT is set to 0 on line 7 to send a start pulse as the first bit (line 11). Then the individual bits of the selected character are sent in the inner loop between lines 10 and 16. This loop is executed 11 times, corresponding to the start pulse, 8 data bits, and 2 stop pulses, during each passage through the outer loop, beginning on line 5.

Each successive bit is sent on line 11, followed by a 9.1-millisecond time-out. This time delay is a standard feature in PL/M; the compiler implements it by inserting a wait loop in the program. The wait loop stores an appropriate number in a counter, decrements it once each processor cycle, and allows the program to continue when the counter reaches zero.

On each inner-loop iteration, the right-most bit of CHAR is selected on line 13 by the AND function, and it is stored in SENDBIT. The operation on line 15 places a 1 in the right-most position of CHAR and then rotates the result one step to the right. This step gradually fills CHAR with 1s, working from left to right in each iteration, so that two stop pulses, which are 1s, are sent properly on the 10th and 11th iterations.

The operation of the PL/M compiler and its PLM1 and PLM2 subdivisions is shown graphically in Fig. 3. PLM1 accepts a PL/M source program from a card reader, time-sharing console, or other input device. This first pass produces a listing of the source program, along with any error diagnostics, and analyzes the program structure. An intermediate file that contains a linearized version of the original program is written, and the symbols used in it are listed.

Although the linearized version does not resemble either an assembly language or PL/M, it has been reduced to a highly simplified form of the original program. PLM2 uses this intermediate file as input and generates machine code for the 8008 microcomputer.

A PL/M program can often be checked out by simulating the 8008 microcomputer's actions on a larger ma-

```
STRING COMPARISON PROGRAM
TYPE SOURCE STRING:  A  B  C  D
TYPE TEST STRING:
  A  B  C  D
*  *  *  *
TYPE SOURCE STRING:  666 666 666
TYPE TEST STRING:  6
666 666 666
*** *** ***
TYPE SOURCE STRING:  AAAAAAAABABABA
TYPE TEST STRING: AB
AAAAAAAABABABA
       * * *
TYPE SOURCE STRING:  XXXXXXX$
TYPE TEST STRING:  XXXX
XXXXXXX
****
TYPE SOURCE STRING:  WALLA WALLA WASH
TYPE TEST STRING:  WALLA$
WALLA WALLA WASH
*     *
```

6. Test run. Sample PL/M program produced this printout. Manually entered data is in color, and machine output is in black. Technique is valuable debugging tool.

chine. A third program, called Interp/8, is available for this purpose. The three programs PLM1, PLM2, and Interp/8 are written in ANSI standard Fortran IV, and will run on most larger computer systems.

A new version of the PL/M compiler is available for use with the extended instruction set of the 8080. Consisting of sections PLM81 and PLM82, it is accompanied by a new simulator called Interp/80. New coding is not required for the 8080. Working with old PL/M programs written for the 8008, the compiler can produce binary code requiring 10% to 20% less storage than the 8008 requires, and having the advantages of new interrupt and decimal-arithmetic capabilities.

Experience with PL/M will enable designers of future Intel microprocessors to incorporate new machine-level instructions that will make more efficient use of the PL/M language. Furthermore, if Intel so chooses, it can alter its processor architecture in future designs, as it did between the 8008 and 8080, without affecting the user of PL/M at all, except possibly to improve the performance of this application.

A number of microcomputer manufacturers are considering the use of high-level languages to augment their assembly-language products, although none have been announced yet. Several minicomputer producers, however, offer high-level applications languages, and at least one minicomputer company, Microdata Corp., provides a systems language. In fact, Microdata's MPL language [*Electronics*, Feb. 15, 1973, p. 95] closely resembles PL/M; both of them, in fact, were essentially derived from the same basic system language.

Once the PL/M program is written and checked out, the machine code is punched on paper tape (Fig. 3) and loaded into memory of a microcomputer developmental system. Again, the program is verified, and all real-time and environmental considerations are checked out. Final production systems can then be developed from this prototype. The production system, for example, may use read-only memory for the program when the developmental system's memory is read/write.

How to go on the air

Given a PL/M program and an MCS-8 microcomputer, how does a programer actually go through the compilation and execution process? As mentioned previously, the PL/M compiler is available from several nationwide time sharing services. These are the General Electric, Tymshare, National CSS, Applied Logic Corp., and United Computing Services facilities. Documentation for general programing is available from Intel Corp., and the time-sharing services provide system-dependent operating instructions.

Once the programer has a contract with the commercial service, he is assigned a work area in the host system in which he can store PL/M programs. These programs are created on line by using the time-sharing service's editor, which allows the programer to enter and alter program files. When a particular program is created, it is saved in a permanent file for subsequent compilation.

In the compilation process, PLM1 is executed first, using the saved PL/M program as input. Any diagnostic messages are printed at the time-sharing console. If no program errors are detected during the PLM1 pass, then the programer can call for PLM2. This second pass leaves code in MCS-8 machine language, which corresponds to the original program in the user's work area.

With this code, the programer may execute the Interp/8 program, which reads the machine code and simulates the actions of the MCS-8, as previously discussed. If execution errors appear during simulation, the programer can alter the original PL/M program and repeat the compilation and simulation process. When the programer is convinced the program is correct, he can punch the machine language on paper tape or other medium at his local console.

Programing at home

When a large amount of development work is to be done, the user may find it feasible to purchase the PL/M compiler and CPU simulator directly from Intel and run them on an in-house computer system. The user, at his option, can program either in batch or time-sharing mode.

The machine code produced by the compiler can be executed in several different ways. The easiest method is with a developmental system, such as the Intel SIM8-01 or Intellec 8 (Figs. 4 and 5) or equivalent prototyping hardware. These systems include hardware and software for Teletype, as well as facilities for loading and checking out programs.

The machine code is loaded into the SIM8-01 from the Teletype into erasable read-only memories. These chips are then inserted into sockets on the prototype board, and the program is executed. With the Intellec 8 developmental system, the machine code is entered from the Teletype into read/write memory, where the program can be subsequently executed and tested. Both approaches bypass the simulation stage.

After testing the program on a developmental system, a production model making use of MCS-8 and a mixture of read-only and read/write memory can be tailored closely to the final application. Although the hardware is minimized in the production system to reduce costs, the programs remain the same as in the prototype.

Developing systems

Intel Corp. has completed a number of projects using PL/M, including an assembler that runs on the Intellec 8 developmental system. This assembler's characteristics show the effectiveness of the PL/M approach to system development. For example, it has full macro capabilities, which means that a programer can define special pseudo-instructions that cause the assembler to insert sequences of instructions in the main program during the assembly process. Macros are like subroutines, except that the main program executes them as it comes to them, instead of branching out of the main stream and then returning, as it does with subroutines.

The assembler is also capable of conditional assembly, which means that it can react to such external signals as the positions of console switches at the time of assembly. Such signals indicate conditions that are not necessarily known to the programer at the time he writes the code—such as the availability of particular output equipment to which the assembler's results are to be sent.

Another useful characteristic of the assembler is evaluation of expressions at assembly time, which permits the programer to specify certain parameters algebraically instead of numerically or symbolically. Then when a program is assembled, the assembler evaluates the algebraic expressions and inserts the correct values in the machine-language program. The process requires the variables to be specified ahead of time, but it permits the programer to alter these variables by changing their specification only once, rather than every time they are used in the program. It's a great time-saver and bug-killer.

While these characteristics are not uncommon in advanced assembly languages, high-level languages that can handle them are quite rare. Yet by using PL/M, the assembler was coded in approximately 100 man-hours, and it requires 6,000 bytes of program storage—equivalent to 3,000 words on a minicomputer with a 16-bit word size. Intel estimates that the project would have taken five times as long to code and debug directly in assembly language, with little or no reduction in program-memory space. The resulting assembler is easy to maintain and alter, and, equally important, it can be recompiled for Intel's new 8080 microprocessor without alteration.

A practical example

PL/M permits many programing shortcuts, such as dividing a complex task into individual subtasks, or procedures, that are called upon when needed to simplify the job of writing the program itself. These procedures are conceptually simple and therefore easy to formulate and express in PL/M, as well as easy to check out before being incorporated in a larger program.

For example, consider a simple program for character manipulation—one that might be part of the work of a more comprehensive word-processing system. The function is relatively simple: the program asks the keyboard for two input-character strings, scans the first string for all occurrences of the second, echoes the first string, and types an asterisk under the starting position in the first string of each occurrence of the second string. A sample interaction with this program is shown in Fig. 6; all lines typed by the operator are in color.

Stated in this way, this example may seem to have little or no practical value. But it is almost identical to a program needed to fetch the strings from two different data-entry devices and do something more sophisticated than printing an asterisk when it finds a match.

This suggests a practical application—a teleprinter to check out a routine before it is embedded in a larger program. When all the bugs are out of the routine, the procedures that transfer data to and from the teleprinter can be replaced with other procedures that, for example, check sensors and turn indicators on and off. The new procedures, of course, have to be checked out in a real environment, but that's much easier when the main routine is known to be bug-free. □

Electronic combination lock offers double protection

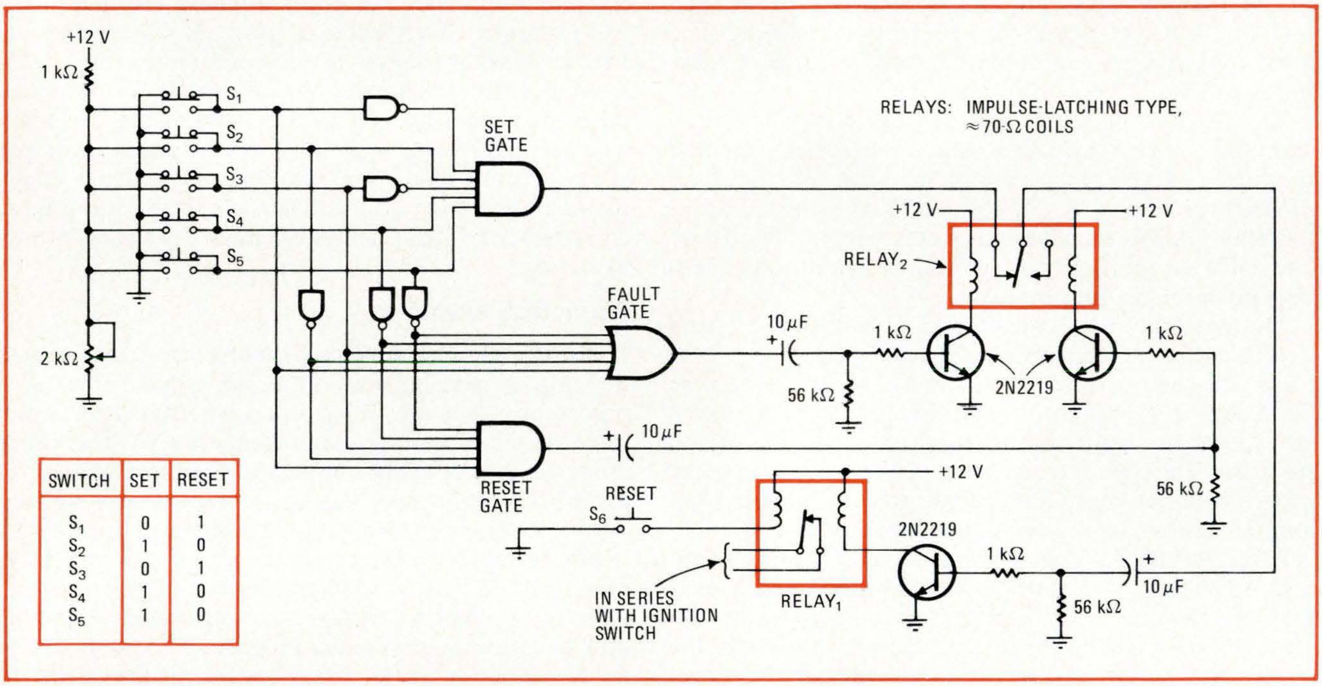
by Louis F. Caso
Bethpage, N.Y.

If you need a doubly safe lock, try the electronic combination lock shown here. It will not unlock unless the correct combination of switches is depressed, and if the wrong combination is chosen, the lock will not open until it is reset with another combination.

The circuit in the figure is intended for installation in an automobile, but it can be easily modified for other applications. When the correct combination of switches S_1 through S_5 is depressed, the output of the SET gate goes to logic 1, closing the contacts of $RELAY_1$. When the car's ignition is turned off, this relay should be reset (contacts opened) by using switch S_6.

To open (set) the lock, switches S_2, S_4, and S_5 are depressed simultaneously. If an error is made, the output of the FAULT gate goes to logic 1, and the contacts of $RELAY_2$ will open. When this happens, the lock must be reset before the opening combination can be used again. Switches S_1 and S_3 are depressed simultaneously to reset the lock.

Any secret combination of push buttons can be selected by arranging the switches as desired. For most applications, the multiple-input logic gates can be obtained by interconnecting standard dual-input gates. □



SWITCH	SET	RESET
S_1	0	1
S_2	1	0
S_3	0	1
S_4	1	0
S_5	1	0

Safe and sound. To open this electronic combination lock, depress the correct combination of switches S_1 through S_5. But if an error is made, the lock must be reset with another switch combination before it can be opened again (The switches are depressed simultaneously.) The circuit shown here is for locking an automobile ignition, but it can be readily adapted for other uses.

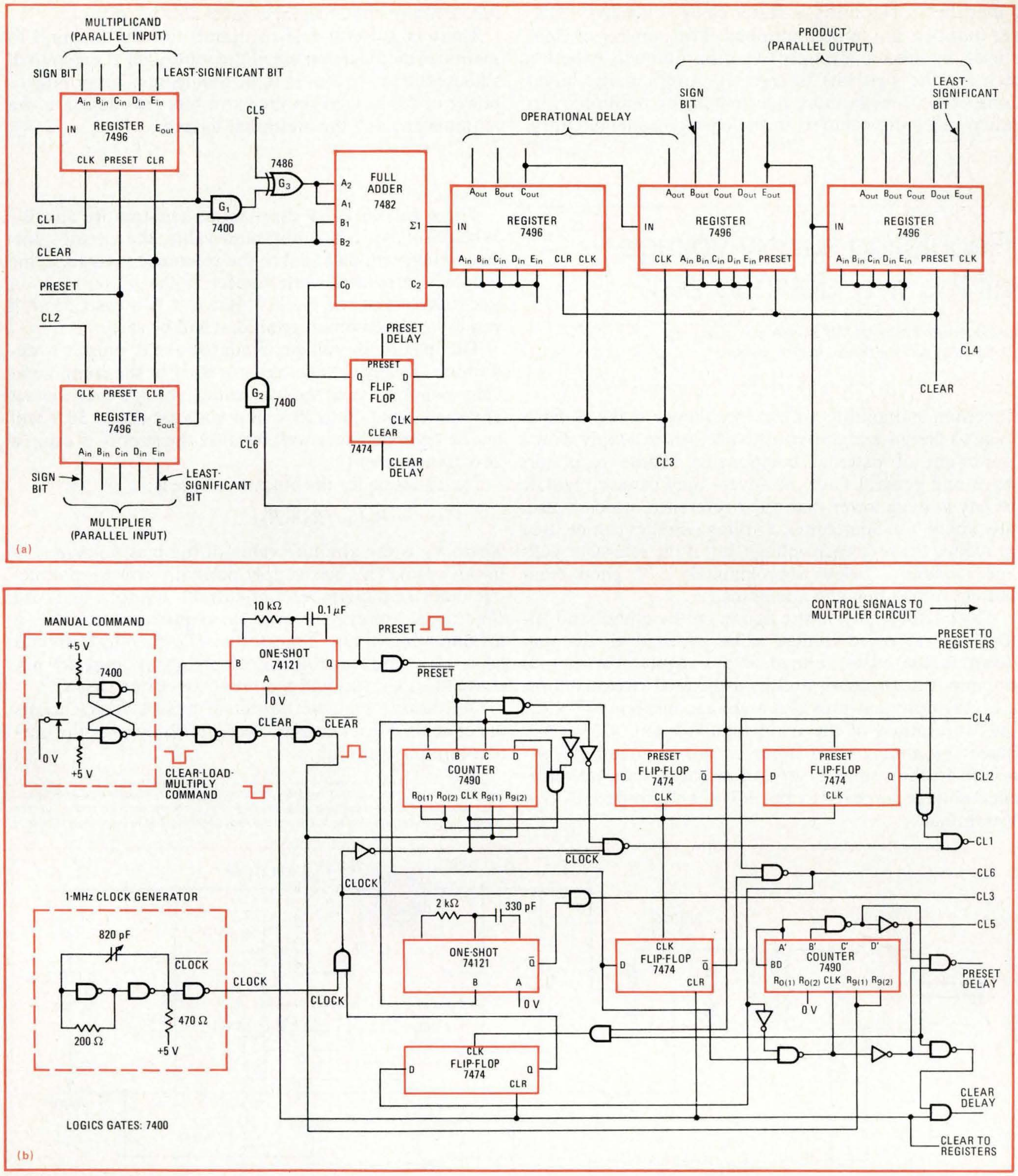
Serial digital multiplier handles two five-bit numbers

by T.K. Tawfig and H.L. Hvims
Allerod, Denmark

Because of the fast operating speeds of today's digital circuits, the serial type of digital multiplier can be regarded as a practical alternative to the parallel or serial/parallel type in many applications. The serial approach can mean a large savings in the number of ICs required to do the job.

The circuit shown is an expandable serial digital multiplier that can accept two 5-bit numbers in two's-complement form. It is useful in such applications as digital filters, signal correlators, and other digital systems that employ two's-complement notation. The multiplier circuitry is shown in (a), while the circuitry used to get the necessary control signals is shown in (b).

The multiplication process is started by a CLEAR-LOAD-MULTIPLY command, which is generated by a manual latch, and stops automatically upon completion. When this start command initiates the control sig-



Serial multiplication. The number of ICs needed to build this digital multiplier is minimized because the circuit performs the multiplication serially. The two 5-bit two's-complement input numbers, however, as well as the output number, are in parallel form. The multiplier circuitry is given in (a), and the control-signal circuitry in (b). The system is easily expanded to accommodate larger numbers.

nals, the two numbers to be multiplied—the multiplicand and the multiplier—are loaded into their respective registers.

Each bit of the multiplicand is gated by each bit of the multiplier through gate G_1. To obtain the final product, the partial sums are added to the partial products. Gate G_2 passes the partial sums, and gate G_3 provides an inversion when the flip-flop delay is preset. This inversion causes the multiplicand to be subtracted when it is gated by the sign bit of the multiplier. An additional shift register provides an OPERATIONAL DELAY for spreading the sign bit. The final product is available in parallel form from the two output registers.

The basic clock frequency for the multiplier circuit is

1 megahertz. Naturally, a faster clock is needed if bigger numbers are to be multiplied. The number of clock pulses required to multiply two n-bit numbers (where n includes the sign bit) is 2n(n–1). Additionally, larger numbers will mean more registers in the multiplier circuitry and more counters in the control-signal circuitry. (Some minor circuit changes must also be made.)

There is a useful rule of thumb to keep in mind to minimize modification when the multiplier is expanded. Choose the factor 2(n–1) to be the nearest larger integer power of 2 and then set the extra bits introduced in the multiplicand and the multiplier to zero. □

Regulating supply voltage all the way down to zero

by Brother Thomas McGahee
Don Bosco Technical School, Boston, Mass.

Precision monolithic voltage regulators make it fairly easy to design a high-performance power supply with a minimum of external components. These regulators have one general fault, however—they cannot regulate to any voltage lower than their reference, which is usually about 7 V. Sometimes, a voltage divider can be used to reduce the reference voltage, but if the reference voltage is reduced below approximately 2 V, good regulation can no longer be maintained.

The circuit shown in the figure, on the other hand, allows the reference voltage to be adjusted all the way down to the offset voltage of the regulator's internal op amp. $REGULATOR_1$ and its associated circuitry form a bias supply that provides a voltage of about -7 V for the V^- terminal of the main regulator ($REGULATOR_2$). Since the noninverting input of this regulator is connected to the common ground of the circuit, its reference voltage appears to be +7 V with respect to this V^- terminal.

There will be a 7-V drop across resistors R_2 and R_3. When R_1 is set to its minimum value, the circuit's output voltage will be equal to the reference voltage. If the output is measured with respect to the V^- terminal of $REGULATOR_2$, it will be 7 V. But if it is measured with respect to the common ground, it will be zero.

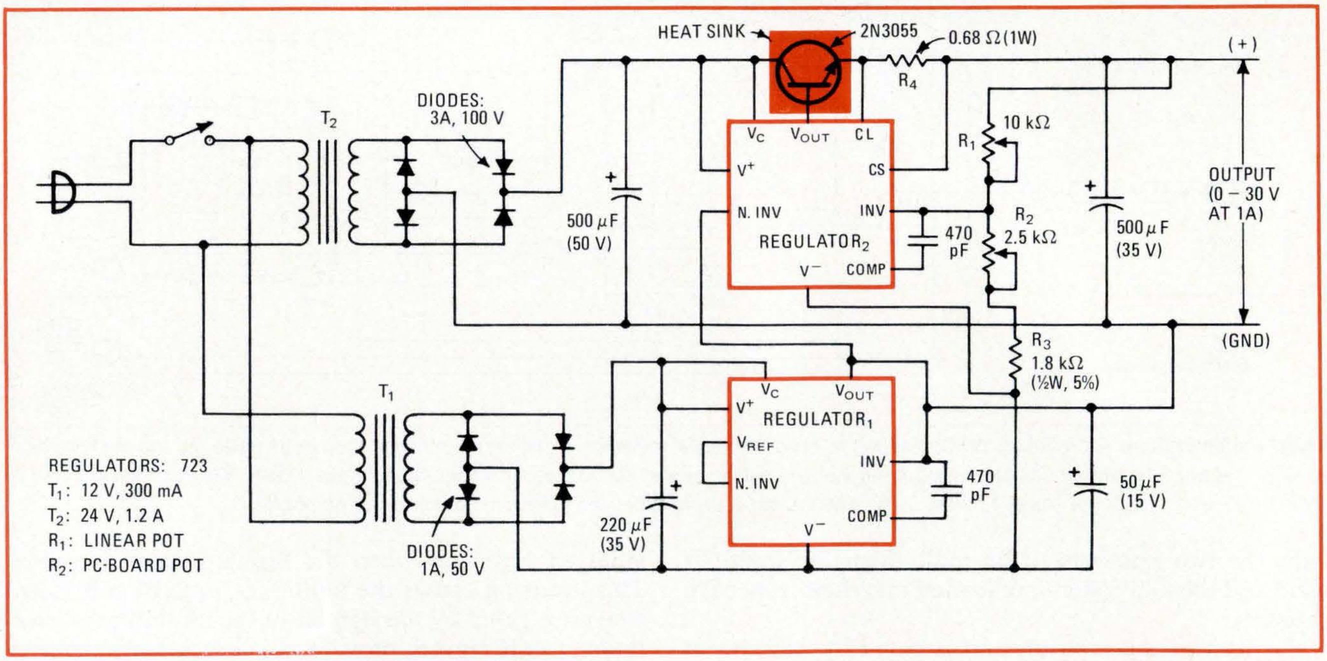
The maximum voltage available at the output is determined by the value of resistor R_2. For the component values shown here, the maximum voltage may be set anywhere from 16 to 39 V. But voltages above 30 V will not be regulated very well because the supply is using a 24-V transformer (T_2).

The equation for the output voltage is:

$$V_{OUT} = R_1 V_B/(R_2+R_3)$$

where V_B is the absolute value of the bias voltage (7 V in this case). The bias supply normally will be producing about 12 milliamperes of current. Under worst-case conditions, however, it may be required to provide a maximum of 40 mA. Transformer T_1, therefore, should be a 12-V unit capable of supplying at least 50 mA (since $REGULATOR_1$ will require some current itself).

The transistor at the output of $REGULATOR_2$ boosts the circuit's output current. Resistor R_4 acts as the current-limiting resistor. □



Variable supply. This power supply, which employs two IC voltage regulators, produces a regulated output voltage of between 0 and 30 V. $REGULATOR_1$ provides the bias voltage for $REGULATOR_2$ so that the latter device can operate with respect to a common ground. The lowest regulated output voltage, then, is approximately zero, rather than the reference voltage of $REGULATOR_2$.

THERMAL DESIGN PART 8

Heat exchangers cool hot plug-in pc boards

When device power levels and packing densities rise, the thermal deficiencies of printed-circuit boards must be compensated by efficient heat exchangers

by Benjamin Shelpuk, *RCA Corp., Camden, N.J.*

☐ On most counts, the plug-in printed-circuit board deserves its status as today's unofficial industry-wide standard. Mounting vertically in an equipment case, it can easily be withdrawn when replacement is necessary. Yet it is well protected from shock and vibration, being held rigidly in place by card slides.

Thermally, however, the plug-in printed-circuit board is much less impressive. Neither epoxy-glass nor paper-based boards are good heat conductors. Also, the thermal paths from hot devices on the boards to the outside world are often long and hinder cooling.

Proof of the board's inadequacy as a heat conductor is that a temperature gradient of 707°C is required to drive just 1 watt of heat through a piece of epoxy-glass board only 1 inch square and 20 mils thick. This determination was made from an equation that enables the designer to calculate thermal gradient whenever heat flow can be considered unidirectional. The equation is:

$$\Delta T_{max} = QL/8Ktw$$

where

ΔT_{max} = temperature gradient to the hottest spot in the board, in degrees centigrade

Q = heat transfer by conduction along the board, in watts

L = span of the board between card guides, in inches

K = thermal conductivity of the board, in watts per inch°C

t = board thickness, in inches

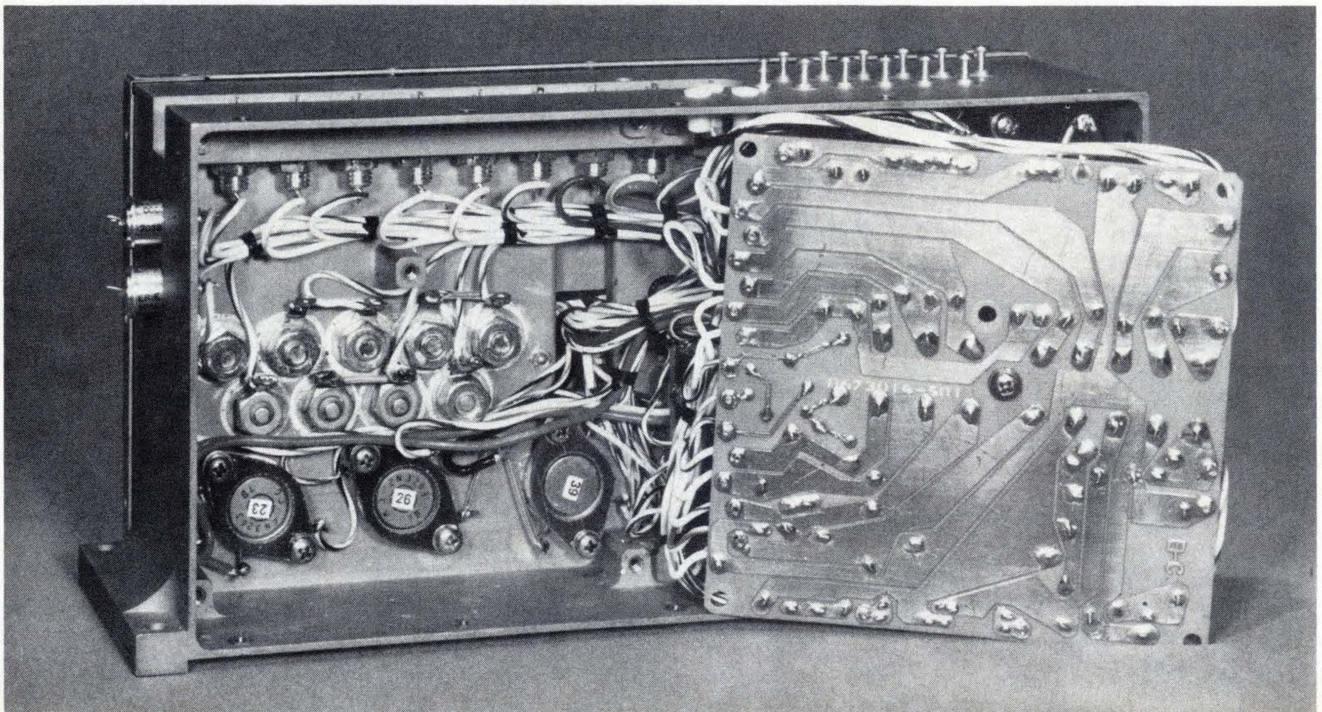
w = length of each interface between board and card guide, in inches.

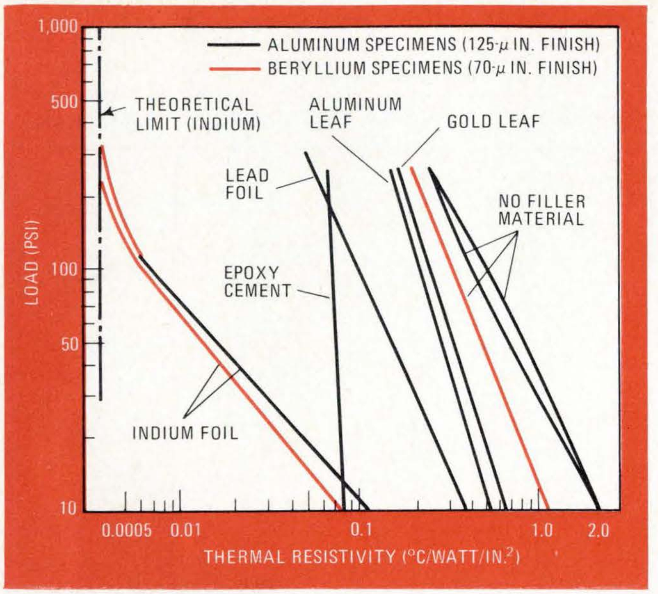
The equation assumes uniform power dissipation over the surface of the board and is realistic if the designer has optimized both heat spreading and component location on the board's surface.

One way to improve heat flow through a board is to use the copper conductors on its surface to transfer heat. Being a fine thermal conductor, the copper lowers thermal resistance significantly—though precisely how much it is lowered is difficult to calculate because the pattern etched into the conductor markedly reduces heat transfer. For instance, if just 10% of the copper is removed from a fully-clad board, thermal resistance of the overall board can increase by a factor of 17.[1]

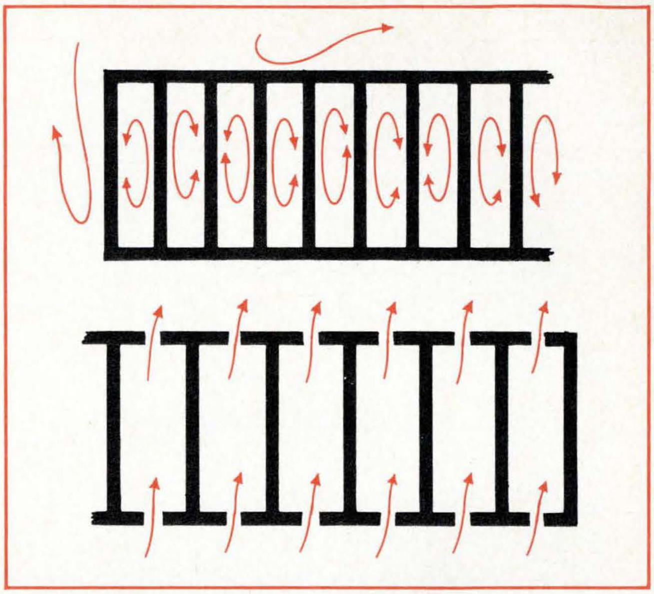
Materials other than epoxy-glass can be used for pc-board construction to upgrade their heat-transfer char-

1. Destined for the moon. Rarefied atmospheres deny package designers the advantage of convective cooling. This assembly, part of a radar system carried on the Apollo 17, employs a highly conductive frame to absorb heat from the printed-circuit board.





2. Beware of the boundary. Fillers between printed-circuit boards and the card slide, and high-compression forces aid heat flow across the interface. Data is based on research performed by MIT Instrumentation Laboratory.



3. Alternatives. Closed convective system shown in (a) prevents contaminants from being swept in by a moving air stream. But switching to an open system (b) boosts cooling capability per unit volume tenfold—10 watts/in.³ versus 1 watt/in.³

acteristics. But generally they fail to improve heat transfer enough to compensate for the electrical constraints they impose. Instead, it is frequently better to switch to a heat-conducting frame to support the pc board.

The heat-conducting frame

This technique was used to good effect for the Apollo 17, in a pc-board assembly that was part of the coherent synthetic aperture radar (CSAR). Figure 1 shows details of that assembly. Effective conductive cooling is a must in space, where the lack of atmosphere robs the designer of convective cooling. In the CSAR assembly, heat flowed from the board to the housing through the threaded bosses on which the board was mounted. Maximum temperature rise was kept low because the thermal path to a boss from any heat-producing component was kept short.

The Standard Hardware Program (SHP) developed by the U.S. Navy also utilizes heat-conducting frames to guarantee adequate heat transfer from its modules.[2]

However, only a poor thermal path from board to frame is provided by the usual card slides. The problem is that ease of maintainability and accessibility demands boards that slip easily in and out of card slides—but the thermal interface between such boards and slides is not good. Fortunately, card slides can often be modified to provide a large positive area of contact that will optimize heat flow across the interface.

Figure 2 summarizes the results of some interface resistivity studies.[3] It shows that various filler materials can be used to lower the thermal resistivity of board/slide interfaces. Note also the negative slope of the plots, which denotes that high compressive forces along the interface also lower thermal resistivity.

Enter the ambient

Regardless of how effectively such conduction paths are enhanced, convective transfer to the ambient fluid (usually air) often emerges as the principal heat-transfer mode in electronic equipment.

Two geometries are common in convective transfer. Figure 3a illustrates a closed system in which transfer is in effect a two-step process. Heat is moved from the board surfaces to the surrounding air by natural or forced convection, and the air is then cooled by natural- or forced-convection transfer to the equipment case.

In the open system shown in Fig. 3b, the air is not entrapped, but enters the enclosure, sweeps across the pc boards, and then exits carrying the heat to the environment. There is no intermediate transfer to and from the equipment case. But such a system is often unacceptable because it can transport moisture and other harmful contaminants.

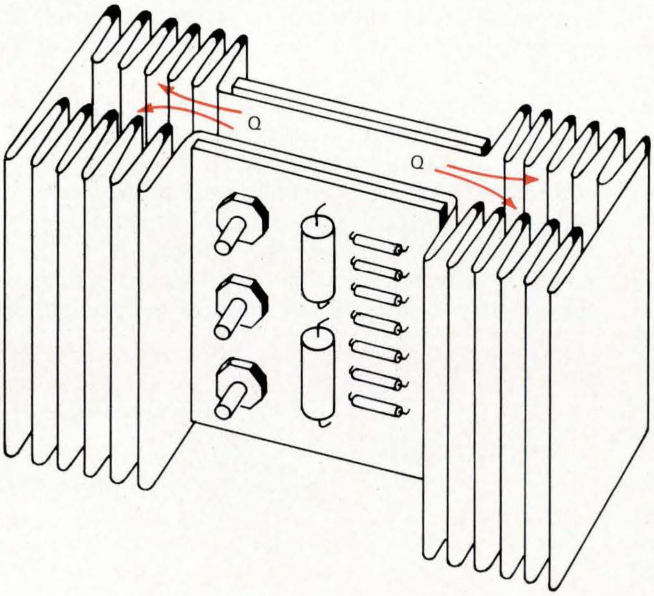
In either type of convective system, orientation and spacing of the boards play an important role in determining component temperatures. So do the flow rate and temperature of the cooling medium. Table 1 lists the range of typical heat-transfer rates for both open and closed plug-in pc-board designs. Note that the power density for a well-designed closed system where the exterior cooling is by natural convection ranges

TABLE 1: HOW COOLING MODE AFFECTS POWER DISSIPATION

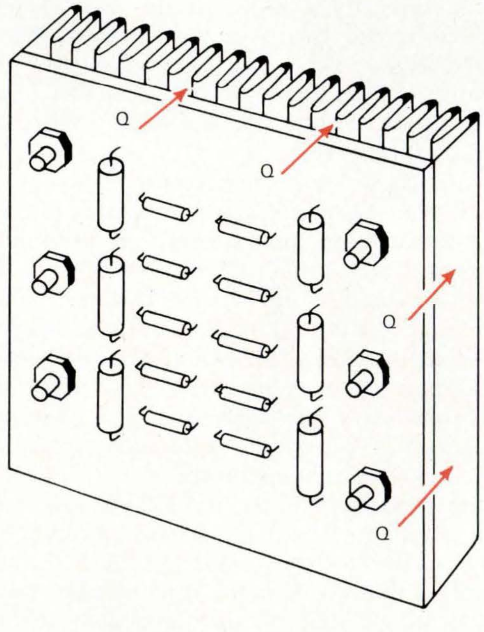
System type	Internal cooling mode	Exterior cooling mode	
		Natural convection (W/in.³)	Forced convection (W/in.³)
Open		0.5 – 1	5 – 10
Closed	Natural convection	0.1 – 0.25	0.2 – 1.0
Closed	Forced convection	0.2 – 0.8	0.5 – 3.0
Closed	Conduction	0.4 – 1.5	2.0 – 4.0

	RESISTANCE (°C / W)		ΔT°C	
	IN-LINE	COPLANAR	IN-LINE	COPLANAR
CONDUCTIVE RESISTANCES				
R_{TJ} DEVICE-JUNCTION TO CASE	2.5	2.5	27.5	27.5
R_{T1} DEVICE-INTERFACE	1.12	1.12	12.3	12.3
R_{T2} THERMAL SPREADING RESISTANCE	0.65	0.65	7.1	7.1
R_{T3} BASEPLATE RESISTANCE (VERTICAL)	4.83	4.83	3.4	3.1
R_{T4} BASEPLATE RESISTANCE (HORIZONTAL)	1.97	–	39.8	0
CONVECTIVE RESISTANCES				
$T_{SO} - T_{SI}$ COOLING AIR TEMPERATURE RISE				26.3
1 / hA CONVECTION TRANSFER RESISTANCE	–	0.53	–	29.0*
TOTAL TEMPERATURE RISE °C			90.1	79.0

* INCLUDES $T_{SO} - T_{SI}$



(a)



(b)

4. Go coplanar. The in-line construction (a) accounts for the large temperature rise—90.1°C. By contrast, the heat-transfer path in the coplanar structure (b) is very short, and temperature rise is significantly less—66.1°C.

from 0.10 W/in.[3] to 1.5 W/in.[3]. Also, for the internal forced-air cooling modes, total volume must not be so large that the space consumed by blowers and ducting becomes a significant fraction of the total volume. Otherwise, the listed values become invalid.

Looking at one design

Assume that a designer attempts to house a 100-watt uhf radio transmitter-receiver combination in a standard cabinet designed to mount printed-circuit boards. Detailed analysis of a particular design reveals that the maximum power dissipation that can be rejected in such a cabinet (4.87 in. wide by 7.62 in. high by 19.56 in. deep) is limited to 56 W at sea level and to 28 W if the equipment is operated at high altitude, where there is little convective cooling. Clearly, plug-in pc-board construction would not be appropriate for this equipment.

The power dissipation of the equipment, broken down by its component modules, is given in Table 2. Checking the power densities of each module against the criteria of Table 1 indicates that forced-air convection is necessary in two modules—the transmitter and the power supply. Since the equipment is intended for the military, however, an open system with forced-air convection directly over the circuit cards would be unacceptable because of possible contamination. So a closed-system, forced-air cold plate is a likely alternative.

Forced-air cooling differs from natural convection in that the driving force circulating the air is a mechanical pump rather than natural buoyancy induced by temperature gradients. This significantly increases the value of the parameter known as film coefficient (h), thereby upgrading the effectiveness of the surface area (A) of the heat-exchanging structure.

The basic relationship for convective transfer across a boundary is:

$$Q = hA\Delta T$$

where

Q = power, in watts

h = film coefficient, in W/ft^2-°C

A = area, in square feet

ΔT = temperature gradient, in degrees centigrade.

It turns out that the film coefficient is about an order of magnitude higher in forced convective transfer than it is in natural convection—2.6 to 7.9 W/ft^2-°C compared with 0.2 to 0.4 W/ft^2-°C.

But this improvement has to be traded off against the energy that must be expended on forcing air past the surface that needs to be cooled. This usually translates as electric power driving a fan or blower and can be defined as:

$$P_f = KvH \qquad (1)$$

where

P_f = fan power required to deliver the necessary air velocity, in watts

K = a constant of 0.023 W-minute/ft-lb

v = air flow rate, in ft^3/minute

H = frictional air pressure loss, in pounds/ft^2.

Thus design optimization comes down to the task of maximizing the heat transfer required in terms of Q and P_f.

TABLE 2:
THERMAL BUDGET FOR A 100-WATT TRANSMITTER-RECEIVER

Module	Peak power Transmit (W)	Peak power Receive (W)	Average power 50% duty cycle (W)	Power density (W/in.^{3})
Guard receiver	1.8	1.8	1.8	0.09
Frequency/control	18.9	18.3	18.6	0.19
Main receiver	4.8	4.8	4.8	0.05
Transmitter	272.0	25.9	149	2.72
Power supply	98.5	35.2	66.5	0.76
Totals	396	86	241.7	0.96

As if this were not enough, the designer must usually restrict the physical size of the heat-exchanging structure to the smallest volume possible. In the case of the uhf transmitter-receiver, the space available for the rf power output stages, which dissipate 250 W, is 100 cubic inches, or roughly 8¾ by 5¾ by 2 in. The task requires that the junction temperatures of the rf power transistors be cooled to within safe limits.

Cold-plate considerations

Two cold-plate configurations were analyzed to determine the temperature fields which develop in each. Figure 4a is a straightforward variation of the plug-in printed-circuit board; the transistors are stud-mounted on an aluminum plate 90 mils thick that has integral heat sinks at both ends. Figure 4b shows how the board and the heat exchanger can be repackaged so that they become coplanar. The coplanar structure proved to be superior because it considerably shortened the conduction paths between each transistor and the heat exchanger.

The assumptions and design constraints used in the analysis of these two configurations are:

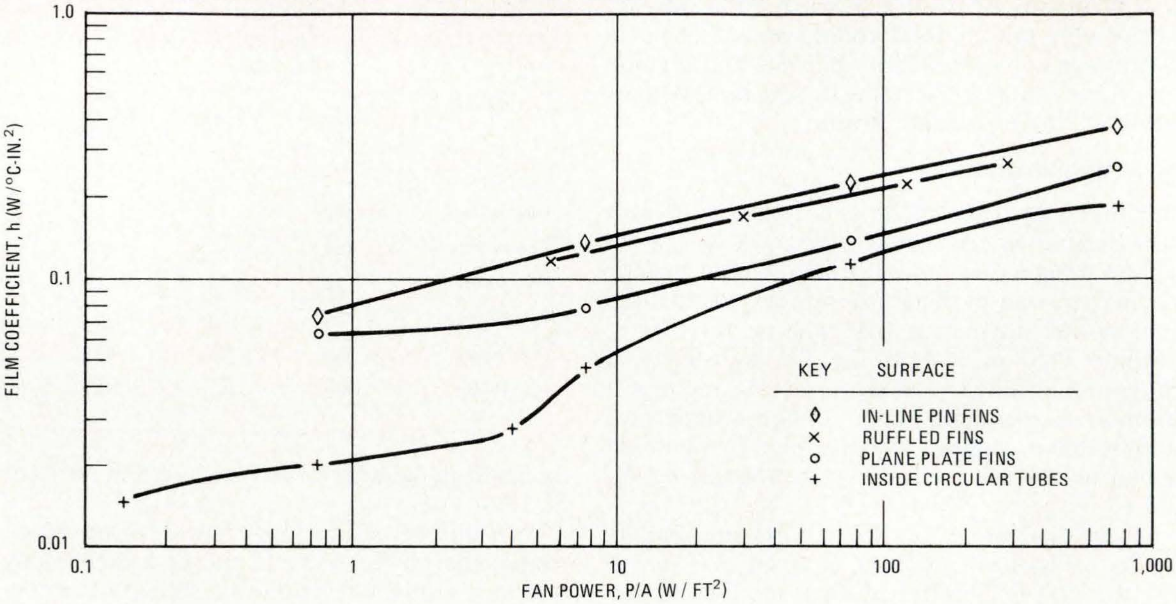
- Each transistor dissipates 11 W.
- Power is dissipated uniformly on the pc board at 2.3 W/in.^{2}.
- The equipment chassis is 90-mil-thick aluminum, with a thermal conductivity, K, of 4.4 W/in.-°C.
- Maximum transistor junction temperature is 150°C.
- Operating environmental temperature is 71°C.

The results of the analysis are listed in the table of Fig. 4. The critical ΔT, which is the temperature rise from the ambient to each device junction, can be expressed as:

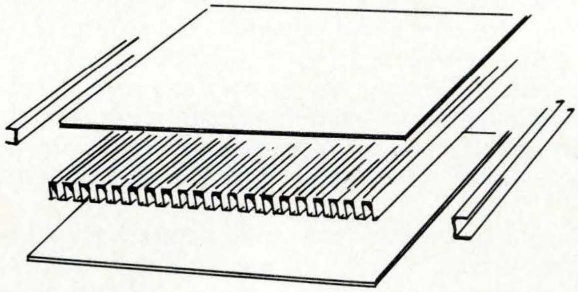
$$T_J - T_A = Q(R_{TJ} + R_{T1} + R_{T2} + R_{T3} + R_{T4} + 1/hA)$$

The values and definitions of the thermal resistances are in Fig. 4. The subscripts represent thermal resistances which are conductive paths. The quantity 1/hA is the thermal resistance across the convective interface of the heat-exchanger surface.

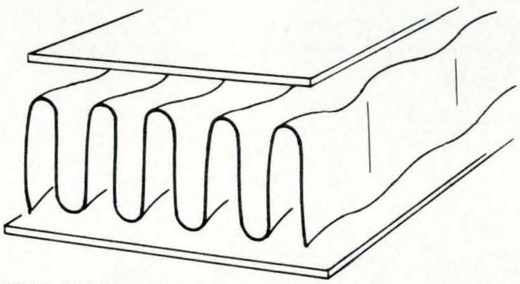
If the conductive resistances are assumed to be known, then the design goal is to assure that the value of 1/hA will be small enough to hold T_J below 150°C. The film coefficient h is determined by the fluid dynam-



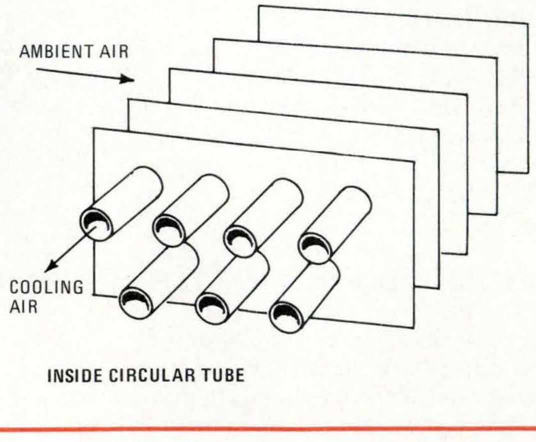
5. Different geometries, equal areas. In-line pin fin is the most effective convective surface, according to these plots of film coefficient, h, versus fan power.



PLANE PLATE FIN



RUFFLED FIN



INSIDE CIRCULAR TUBE

ics of the system and is largely a function of fan input power. The heat-transfer surface area (A) is a function of heat exchanger type and volume. Thus the required value of 1/hA can be achieved by proper selection of heat exchanger type and size, and adequate fan power.

The analysis demonstrates that the in-line configurations of Fig. 4a won't do the job. If the in-line construction were selected, the 90.1°C rise would boost the junction temperature to 161.1°C, above the design limit of 150°C. Just how big this rise would be in actuality would depend on the value of 1/hA, because 1/hA has been assumed to be zero in the in-line case. But it really doesn't matter because the allowable gradient budget has been consumed in conduction drops. It is therefore impossible to maintain the desired temperature, regardless of the heat exchanger selected.

The horizontal baseplate resistance (R_{t4}) with a resistance of 1.97°C/W is the major contributor to the temperature rise. If a designer wants to stick with the in-line design he might reduce this resistance by using a thick chassis.

However, the coplanar design will certainly do the job. Here a value of 0.53°C/W is required for 1/hA, to maintain the hottest transistor below the maximum allowable temperature of 150°C. There is obviously a tradeoff between supplying more air to the heat exchanger and providing more heat exchange surface so that the exchange can make a closer approach to the exit air temperature.

Once the basic packaging structure has been selected, the next step in the design is to select a forced-air heat exchanger.

Exchanging heat

The heat exchanger enables heat to cross the boundary from a conductive region to a moving fluid such as air. Since its design is a major engineering challenge, it is worth summarizing the factors that go into a design analysis and to establish a design selection sequence.[4,5]

The prime considerations are the size and geometry of the heat exchanger structure. Heat transfer through the exchanger is expressed as:

$$Q = hA(T_H - T_S)$$

where

h = film coefficient of heat transfer, in W/in.^{2}-°C

A = area, in square inches

T_H = heat exchanger temperature

T_S = cooling air temperature.

As has been shown in the example, the designer wishes to maximize both h and A so as to minimize the temperature gradient ($T_H - T_A$).

The relationship which determines the air temperature rise in the heat exchanger is expressed in the equation:

$$Q = mc_p (T_{SO} - T_{SI})$$

where

m = mass flow rate, in pounds per second

c_p = specific heat of the fluid at constant pressure, in W-sec/lb-°C

T_{SO} = cooling air temperature at the exchanger outlet, in °C

T_{SI} = cooling air temperature at the exchanger inlet, in °C.

The design goal here is to maximize the air flow rate (m) so as to minimize the temperature drop to be provided by the exchanger. However, a price is paid in electrical power required to energize the fan as can be seen from Eq. 1. In this case, air flow rate, v, as well as the air pressure drop, h, must be minimized for minimum fan power consumption.

The key variables in this group of equations—h, H and v—are interrelated for a given type of heat-exchanger surface. By carefully evaluating these variables, it is possible to tailor a heat-exchange system to a given application.[4,5]

Surface considerations

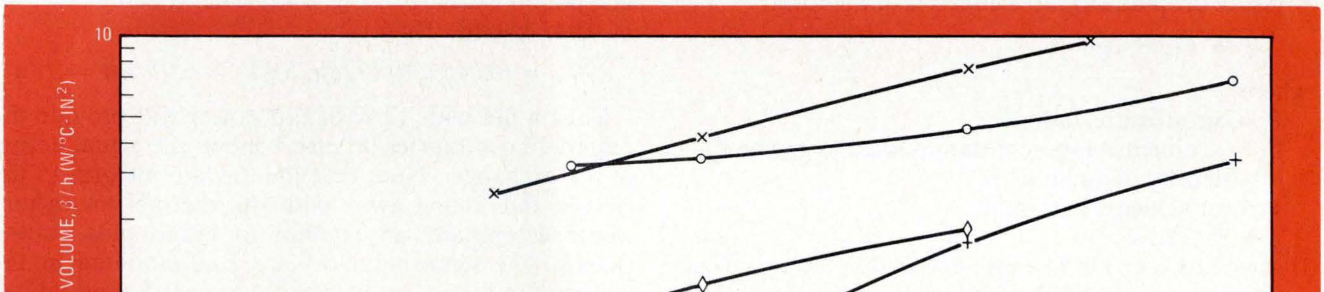
There is a considerable variation in the performance of various heat-exchanging surfaces. The value of h versus air power per unit cross-sectional area is plotted for a number of surfaces in Fig. 5. Note that the pin-fin exchanger delivers a value of h that is three and a half to four and a half times higher than the value of competing structures.

A useful figure of merit for evaluating a heat-exchanging surface is defined as the amount of heat exchanger surface contained in a unit volume or A/V. It is assigned the symbol β. From the standpoint of maximum βh, the ruffled fin provides the most heat transfer per unit of volume and thus offers the designer a very compact exchanger.

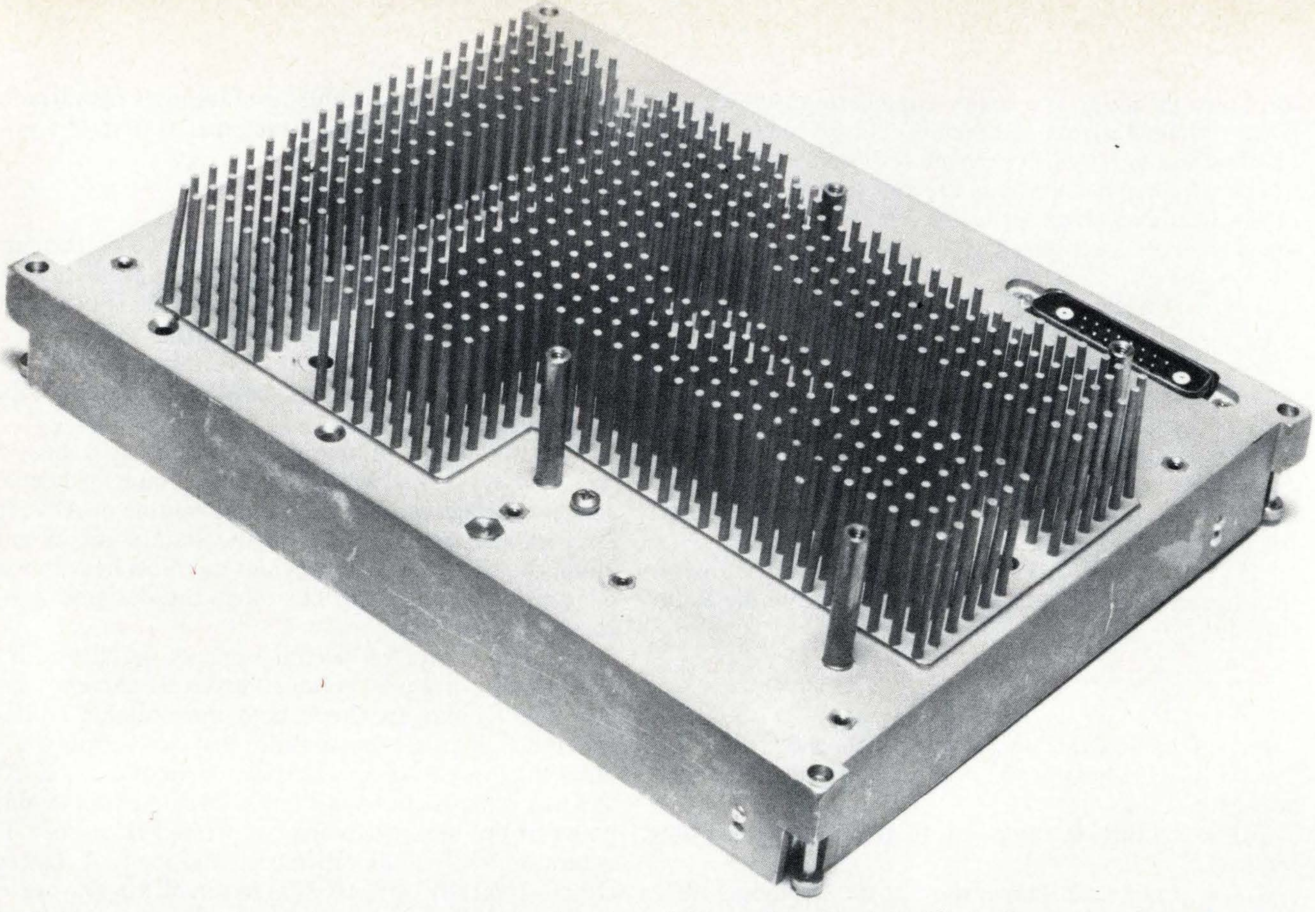
Figure 6 compares several surfaces on the basis of heat transfer per unit volume versus air friction power per unit volume. In effect, both the ordinate and abscissa in Fig. 5 have been multiplied by β. Thus the ordinate h becomes hA/V, expressed in W/in.^{3}-°C. The abscissa is the frictional air power per unit volume dissipated in the heat exchanger, expressed in W/in.^{3}. The values do not include other frictional losses or fan efficiency—typically 15% to 30% in small air-moving devices.

If the designer wants to include these losses, he can multiply the abscissa values by a number ranging from 7 to 13 to determine the approximate fan power. In the usual design operating range, this type of exchanger can reject 1.50 to 3.00 W/°C in.^{3} with a fan power requirement of 300 to 750 W/in.^{3}.

The form factor, which is the width-to-height ratio of a forced-air heat exchanger, depends heavily on the quantity of air passing through a given cross section. A



6. Equal volumes. By multiplying β (heat-exchanger surface area per unit volume) by the film coefficient and fan power, heat-exchanger surfaces can be compared on an equal volume basis. The ruffled-fin exchanger comes out on top.



7. Pin-fin exchanger. Die-cast heat exchanger safely dissipates 100 watts of power and fits into a volume of just 50 cubic inches. Stud-mounted transistors are in valleys between pins.

high-performance heat exchanger will generally require a large cross section to minimize air temperature rise and acoustic noise.

Pressure drops can build up quickly if there are long narrow ducts and many turns in the path or if there are expansions and contractions in the cross section. The pressure drop due to these effects is of the form:

$$P = k_1 \rho v^2 / 2g$$

where

P = air pressure, in lb
k_1 = a dimensionless constant related to geometry
ρ = density of air, in lb/ft^3
v = air velocity, in ft/min
g = 32.2 ft/s^2.

It is wise to keep air flow rate low so that the air velocity (v) does not exceed 500 to 800 ft to limit pressure-drop losses. A good value for air flow often used in military systems and a good starting point in any design is 4 lb/min/kW.

To return to the coplanar exchanger of Fig. 4b, a thermal budget for convective transfer can be calculated. The quantity 1/hA had a calculated value of 0.53°C/W for each transistor. If the exchanger contains 12 transistors, the total heat transfer requirement is 12 × 1/0.53 = 22.6W/°C. If the available volume for the exchanger is 50 in.,^{3} the required heat transfer per unit volume (βh) is 0.45 W/°C-in.^{3}. This value of h is well within the capability of the heat exchangers shown in Fig. 6. Pin fins are selected because they can easily be integrated into the module enclosure. Pins spaced at 5.35 per lineal inch facilitate die-casting the exchanger.

To determine the fan power required, the following relationship can be used:

$$P_{fan} = (\beta P/A)(V r_p)$$

where (βP/A) is the power required per cubic foot, plotted as the abscissa in Fig. 6; V is the volume of the heat exchanger in cubic feet; and r_p is the ratio of fan power to core friction, assumed in this case to be 13. Since the required βh is 0.45 W/°C-in.^{3}, then for the in-line pin fin exchanger, Fig. 6 indicates a value of βP/A of 0.045 kW/ft^3. Then:

$$P_{fan} = (0.045)(50/1728)(13)kW = 0.017kW = 17W$$

Thus a fan with 17 W of fan power will provide the required heat transfer. Figure 7 shows the actual design of the exchanger. Note that the fins are integral to the chassis, thus doing away with the thermal losses that would accompany an attempt to fasten pins on the chassis. The semiconductors are stud-mounted in the two rows in the spaces between the pins. A thermal test program has confirmed the validity of the predicted temperature profile.

By applying such design principles from the very beginning of a packaging design, equipment designers can avoid the compromises in reliability and power output which have plagued designs in the past. □

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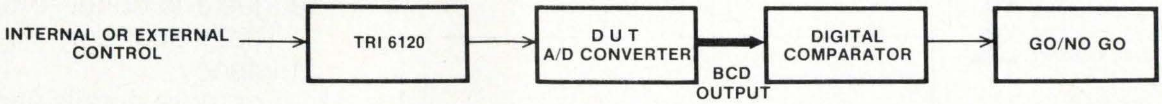

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Capacitance-coupled logic fills unusual jobs

by Stephen R. Pareles
Cook College of Environmental Science, New Brunswick, N.J.

Capacitively coupling logic signals may prove to be a simple way to do several not-so-simple jobs. For instance, capacitive coupling can make short work of bidirectional pulse-edge detection, as well as comparison of an analog signal and a digital signal.

With the circuit of Fig. 1 and a single-trace oscilloscope, an analog signal and a digital signal can be displayed at the same time, allowing the two signals to be compared or synchronized. The circuit's output is the analog signal with superimposed digital cursors.

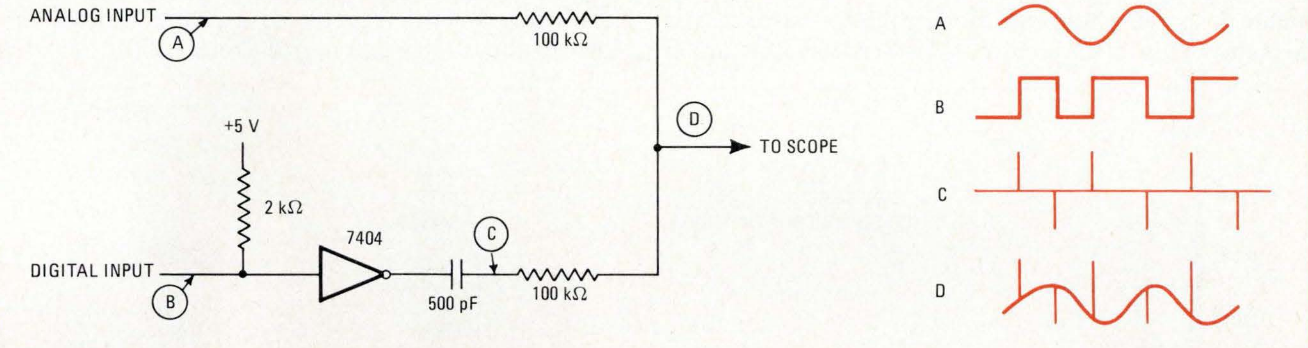
The capacitor serves as a bidirectional edge-detector for the buffered arbitrary logic train. Analog-level transients are produced by the capacitor from this input logic train. They are positive for leading pulse edges and negative for trailing pulse edges.

These transients are then cross-coupled with the analog signal through resistors that provide cross-current isolation (100-kilohm resistors are sufficient for most applications). A capacitance of 500 picofarads is ideal for slow horizontal sweep rates of up to about 100 hertz. Smaller capacitance values should be used for faster sweep rates to prevent the trailing edges of the transients from becoming observable.

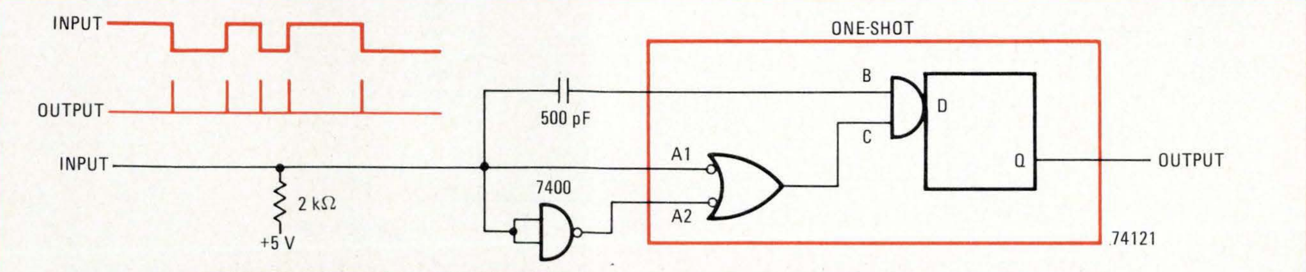
Capacitive coupling can also be used to perform bidirectional edge-detection when a logic-level output is desired. The detector circuit, which is drawn in Fig. 2, can even handle variable pulse widths.

Normally, a 74121-type one-shot is only triggered by a positive transition at point D, following a low condition at points D and Q. When the input first goes high, point A1 goes high. Since point A2 is still high, point C momentarily remains low. When A2 goes low and C high, the one-shot is triggered by the positive edge at D. Point B is kept high throughout.

When the input goes low, A1 goes low before A2 goes high, so that C remains high. Point B, however, is momentarily low. When B goes high again, the one-shot is triggered by the positive edge at C, as before. The tables in Fig. 2 detail the circuit's operation at key points. □



1. Two-signal display. A capacitor simplifies the task of observing two signals on a single-trace oscilloscope. The circuit's output becomes the analog input with superimposed digital timing cursors. The two 100-kilohm resistors provide the necessary cross-current isolation.



CIRCUIT OPERATION

TIME	POSITIVE INPUT TRANSITION							NEGATIVE INPUT TRANSITION						
	INPUT	A1	A2	C	B	D	Q	INPUT	A1	A2	C	B	D	Q
t_n	0	0	1	1	1	1	0	1	1	0	1	1	1	0
TRANSITION	1	1	1	0	1	0	0	0	0	0	1	0	0	0
t_{n+1}	1	1	0	1	1	1	ONE-SHOT	0	0	1	1	1	1	ONE-SHOT

2. Dual edge-detection. Both the leading and trailing edges of the input-pulse train are detected by this capacitively coupled circuit.

Test circuit checks optical isolators

by D. Bruce Johnson
Tullahoma, Tenn.

When you add your own voltmeter to this test circuit, you can accurately measure the current-transfer efficiency of an optically coupled isolator that has a phototransistor output. The test circuit also enables you to evaluate the current gain (h_{FE}) of the coupler's phototransistor. Both parameters, which are measured to within ±3%, can be read directly from the voltmeter's display over the useful current range of most couplers.

The test circuit employs an operational amplifier (A_1) as a voltage-to-current converter to supply a maximum drive current of 10 milliamperes for the coupler's input light-emitting diode for the transfer-efficiency test. A pnp transistor is also wired as a voltage-to-current converter for providing a maximum base current of 10 microamperes to the coupler's phototransistor for the h_{FE} measurement. Another op amp (A_2) acts as a current-to-voltage converter during both tests.

The coupler's transfer efficiency can be defined as:

$$efficiency = \left| (I_C/I_D) \times 100\% \right|_{I_B=0}$$

where I_C is the phototransistor's collector current, and I_D is the LED's forward current. The transfer function of the voltage-to-current converter is expressed by:

$$I_D = E_i/100$$

and the transfer function of the current-to-voltage converter is:

$$E_o = I_C R_{FB}$$

The coupler's transfer efficiency can now be written as:

$$efficiency = (100E_o/E_i R_{FB}) \times 100\%$$

For the circuit to provide direct reading, a ganged switch is used to control both voltage E_i and resistance R_{FB}. The product of E_i and R_{FB} is always 100, regardless of switch position. The transfer efficiency, therefore, simply becomes $E_o \times 100\%$—so that a 1-volt output indicates an efficiency of 100%.

A similar relationship exists for phototransistor h_{FE}, which is defined as:

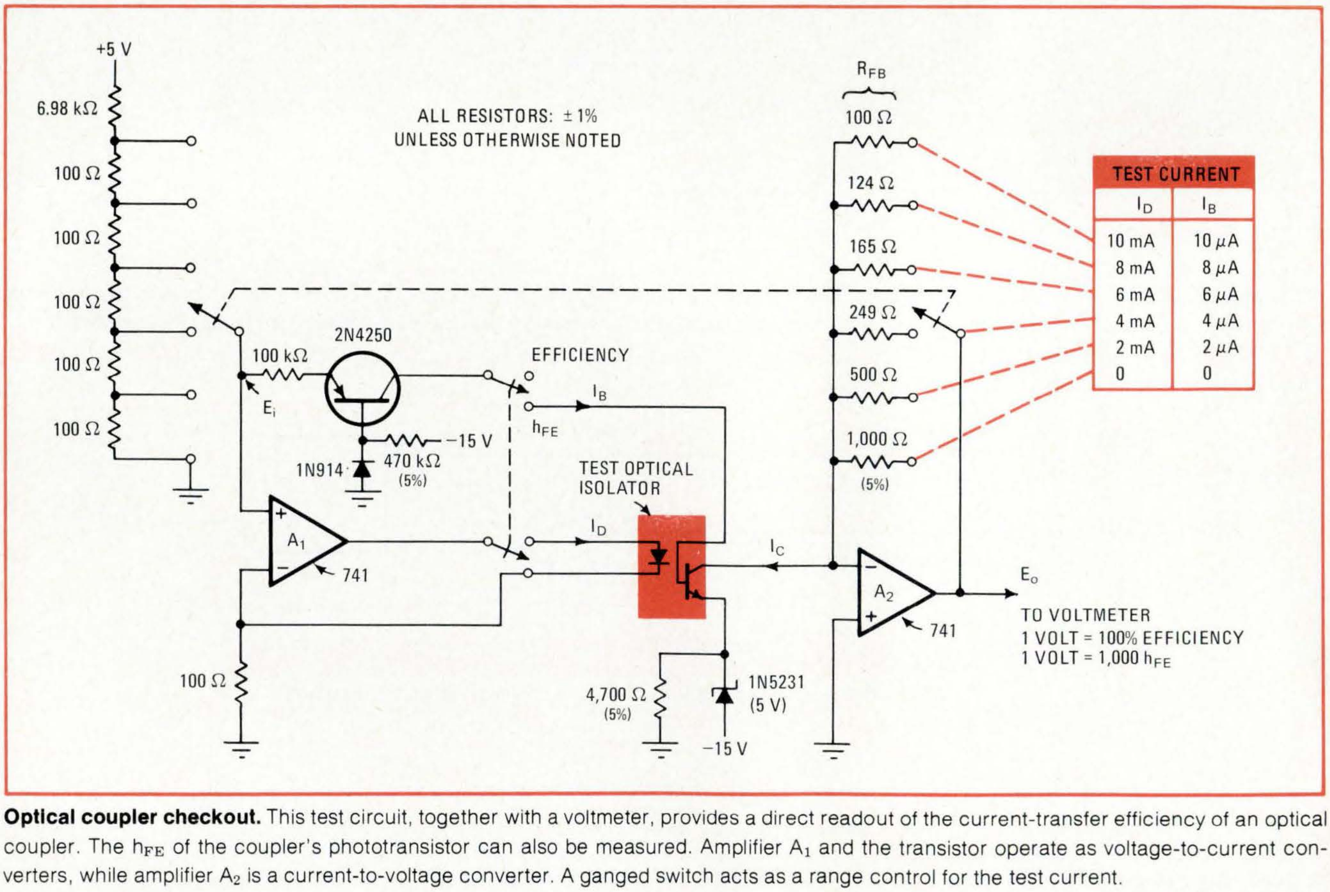
$$h_{FE} = \left| I_C/I_B \right|_{I_D=0}$$

where I_B is the phototransistor's base current. In terms of the transfer functions of the test circuit, phototransistor h_{FE} can be written as:

$$h_{FE} = E_o(10^5)/E_i R_{FB}$$

Since the product of E_i and R_{FB} is 100, then h_{FE} equals $1{,}000E_i$—so that a 1-V output corresponds to an h_{FE} of 1,000.

If you use general-purpose 741-type op amps in the test circuit, you will be able to measure transfer efficiency to about 300% and h_{FE} to about 3,000. □



Optical coupler checkout. This test circuit, together with a voltmeter, provides a direct readout of the current-transfer efficiency of an optical coupler. The h_{FE} of the coupler's phototransistor can also be measured. Amplifier A_1 and the transistor operate as voltage-to-current converters, while amplifier A_2 is a current-to-voltage converter. A ganged switch acts as a range control for the test current.

Examining worst-case fan-out of standard C-MOS buffers

by Rob Walker
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Complementary-MOS buffers are normally used when an interface is needed between C-MOS and TTL circuitry. There are two more or less standard types of buffers that are generally employed—the inverting type 4049 device and the noninverting type 4050 device. Both are available from a variety of semiconductor manufacturers.

A cursory analysis of the data sheet for these buffers will lead many designers to believe that the maximum TTL fan-out of the buffers is less than two under worst-case conditions. Naturally, a buffer fan-out of only one increases component count and system cost. But if the tracking effects between TTL and C-MOS devices are taken into account, the true worst-case fan-out can be regarded as two TTL loads.

Table 1 shows the usual worst-case specifications given for the 4049 and 4050 buffers for a low-level output voltage. The available output current decreases with rising temperature, but increases for a higher supply voltage. Since one standard TTL load is normally assumed to be 1.6 milliamperes, the natural conclusion is that the type 4049 or type 4050 C-MOS buffer can't possibly drive two TTL loads under worst-case conditions.

However, a closer look at the true worst-case operating conditions shows this conclusion to be inaccurate—the worst-case fan-out of a C-MOS buffer can safely be taken as equal to two when the following factors are taken into consideration:

- Commercial-grade TTL is only specified to +75°C, permitting the maximum C-MOS temperature to be regarded as +75°C.
- The maximum low-level output voltage of 0.4 V for TTL is rather arbitrary. For example, Schottky TTL and low-power Schottky TTL, which are both certainly TTL-compatible, have a low-level output voltage that is less than or equal to 0.5 V.
- Commercial TTL is specified over a V_{CC} supply range of 4.75 to 5.25 V. It is only reasonable to assume the C-MOS buffers will be using the same supply.
- The maximum 1.6-mA low-level input current required by a TTL device is specified at a drive voltage of only 0.4 V and a supply voltage of 5.25 V. This required input current drops when the drive voltage is increased to 0.5 V and/or the supply voltage is reduced.

Table 2 is a summary of these true worst-case conditions—for a low-level output of 0.5 V, the C-MOS buffer fan-out is two, which represents a potential 50% components savings. What's more, if low-power Schottky-TTL devices are used instead of standard TTL devices, the C-MOS buffer fan-out jumps to more than nine. □

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.

TABLE 1

SPECIFIED WORST-CASE CONDITIONS

TEMPERATURE	−40°C	+25°C	+85°C
V_{OL} = 0.4 V, V_{DD} = 4.5 V	I_{OL} = 3.1 mA	I_{OL} = 2.6 mA	I_{OL} = 2.1 mA
V_{OL} = 0.4 V, V_{DD} = 5 V	I_{OL} = 3.6 mA	I_{OL} = 3 mA	I_{OL} = 2.5 mA

V_{OL} = Low-level output drive voltage I_{OL} = Low-level output drive current V_{DD} = Supply voltage

TABLE 2

PRACTICAL WORST-CASE LIMITS

PARAMETER (T_A = 0 − 75°C)	V_{CC} = V_{DD} = 4.75 V		V_{CC} = V_{DD} = 5.25 V	
	V_{OL} = 0.4 V	V_{OL} = 0.5 V	V_{OL} = 0.4 V	V_{OL} = 0.5 V
I_{IL} (TTL)	1.402 mA	1.363 mA	1.6 mA	1.56 mA
I_{OL} (C-MOS)	2.39 mA	2.94 mA	2.85 mA	3.41 mA
FANOUT	1.70 mA	2.16 mA	1.74 mA	2.18 mA

V_{OL} = Low-level output drive voltage
I_{OL} = Low-level output drive current
I_{IL} = Low-level input current
V_{CC} = TTL supply voltage
V_{DD} = C-MOS supply voltage
Fanout = I_{OL} / I_{IL}
T_A = Absolute temperature

Engineer's newsletter

Faster 1103 is also easier to use than the original

Despite the hullabaloo over new faster and bigger random-access memories, **users' love affairs with the old 1103 may get even stronger as manufacturers quietly introduce better designs at the old prices.** Joining others on the market, the latest are from the 1103 inventor—Intel's A models—three new designs that use a single clock instead of three, have faster access (down to 145 ns, compared to the former 300 ns), and dissipate nearly a third less standby power. **Designers can now upgrade memory boards to meet 200-ns applications without having to turn to more expensive n-channel products.**

LED shows faults in circuit boards

Are you using on-card power-supply regulation? **If so, a fault indicator for every circuit board in your system can be had almost for free by simply placing a light-emitting diode and its series current-limiting resistor across the IC regulator's input and output terminals.** *Voilà*! You have built what's called a BITE (Built-In Test Equipment) indicator, observes Stephen F. Moore, an engineer at Resdel Engineering Corp. in Arcadia, Calif. The LED will light if there's a fault in the regulator's output, but it uses little power when there is no fault.

When a circuit fault occurs, the regulator's output voltage rises, increasing the voltage difference across its input and output terminals so that the LED conducts. **The current-limiting resistor determines the point at which the LED becomes visible.** To control the LED turn-on point more closely, you can place a zener diode in series with the LED.

Center helps you get reliability in microcircuits

The next time you need help on a microcircuit-reliability problem, consider enlisting the aid of the Reliability Analysis Center at Rome Air Development Center, Griffis Air Force Base, N.Y. The RAC, operated for RADC by the Illinois Institute of Technology Research Institute, **offers, at a fee, consulting services and special studies, either in support of your own investigation or by taking over your problem.**

One useful RAC service, in view of the growing complexity of LSI components, is device selection—**reviewing device construction, quality status, reliability history, failure modes, and so on, of components you are considering.** The RAC quarterly newsletter can be obtained by writing Lee Mirth, RAC project engineer, or calling (315) 330-4151.

We know it can add, but can it sing?

Supporting the trend by calculator manufacturers of adding features to their product lines is this observation by Homer Potts, a Ph.D. at Chautauqua Laboratories, 915 E. Walnut, Pasadena, Calif., who writes: "Is calculator music next? I have noticed that **the HP-35 calculator emits a signal that can be picked up by a-m radio. The main signal comes from the display, but signals are also emitted during calculation.** The tone appears to vary as the battery voltage changes, and **it can, in fact, be an indication of battery strength.**"

—Laurence Altman

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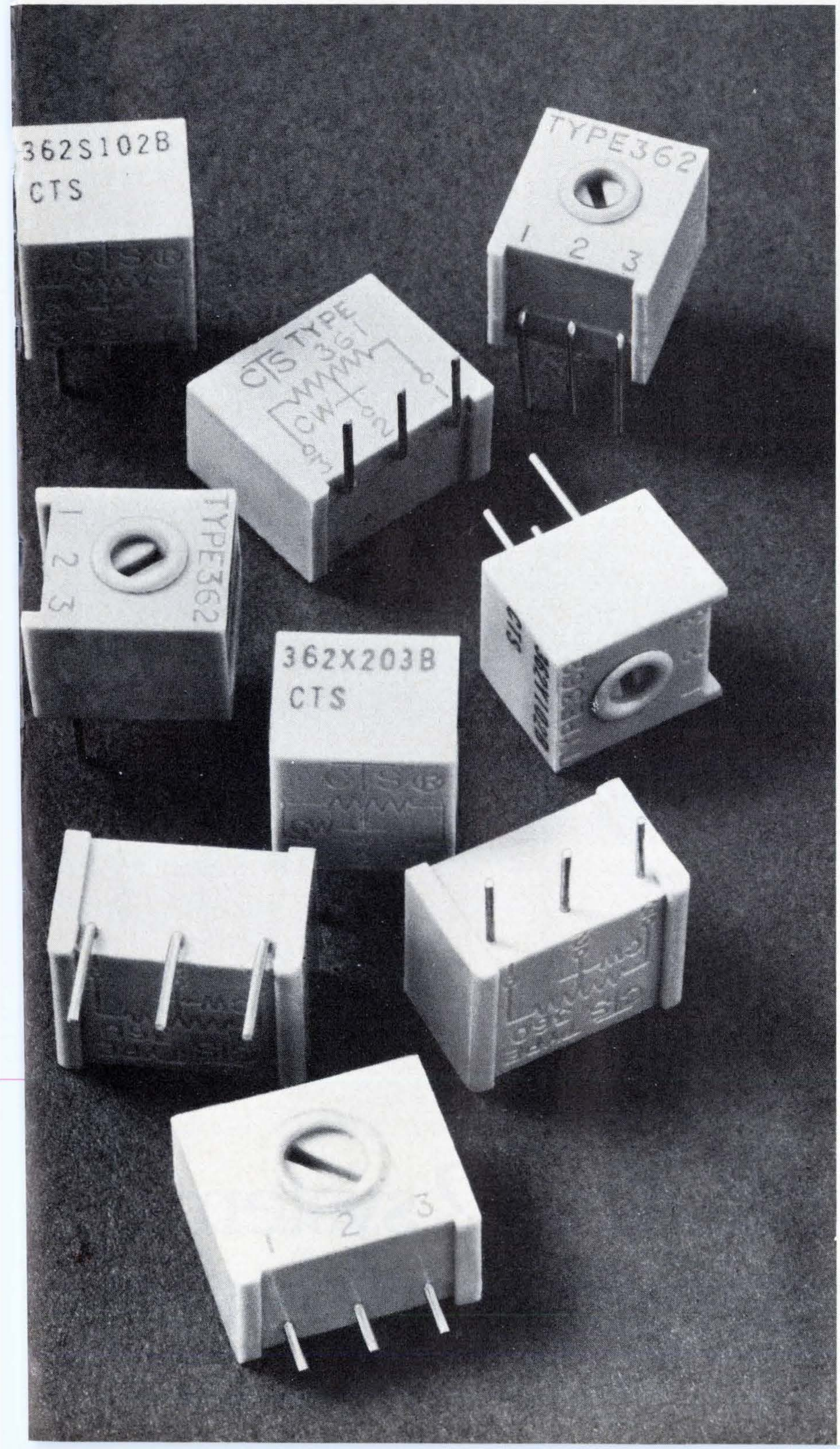

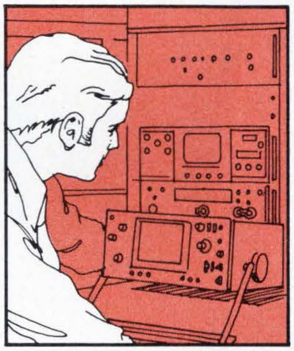

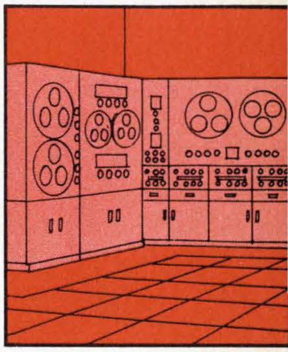

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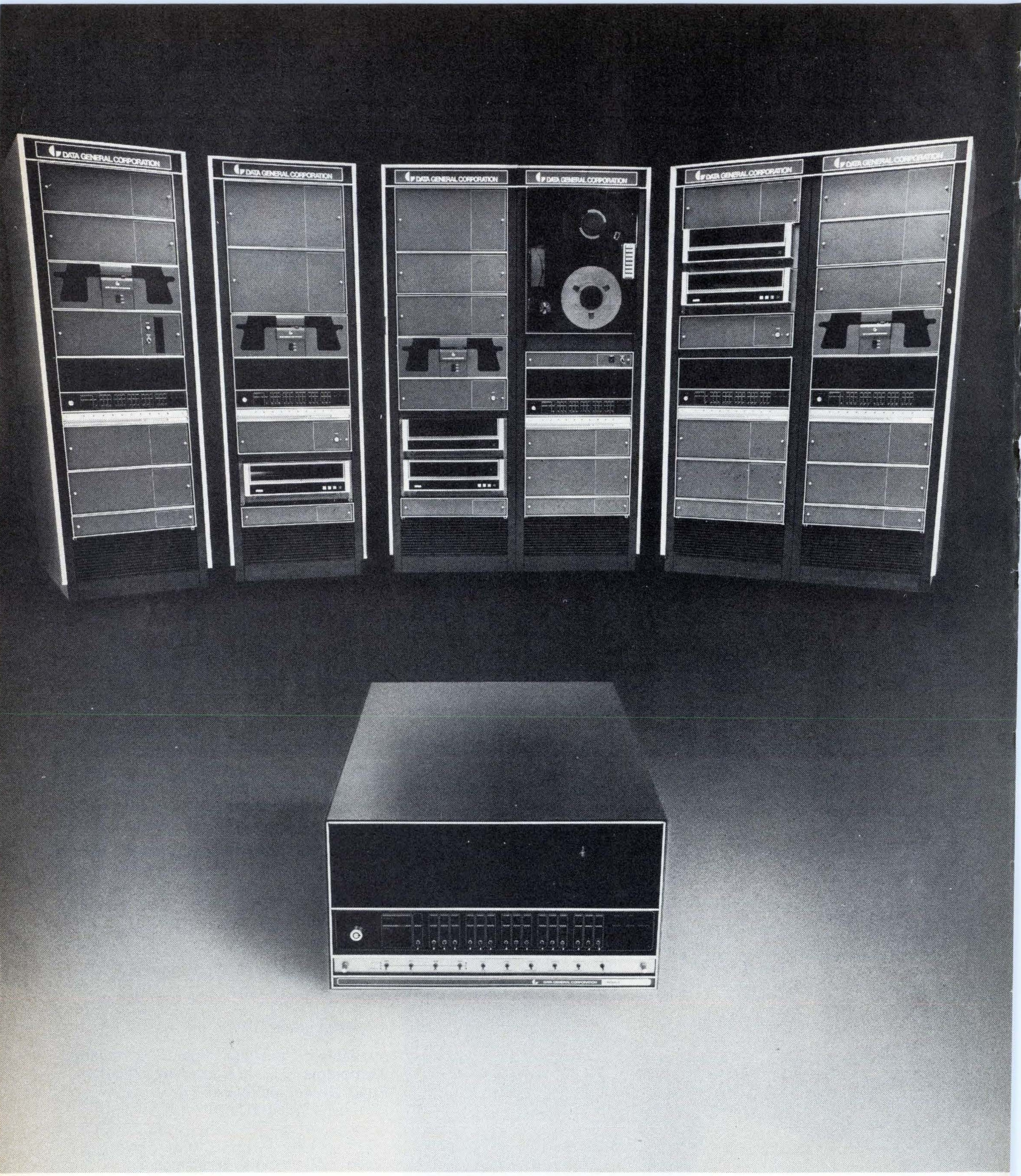

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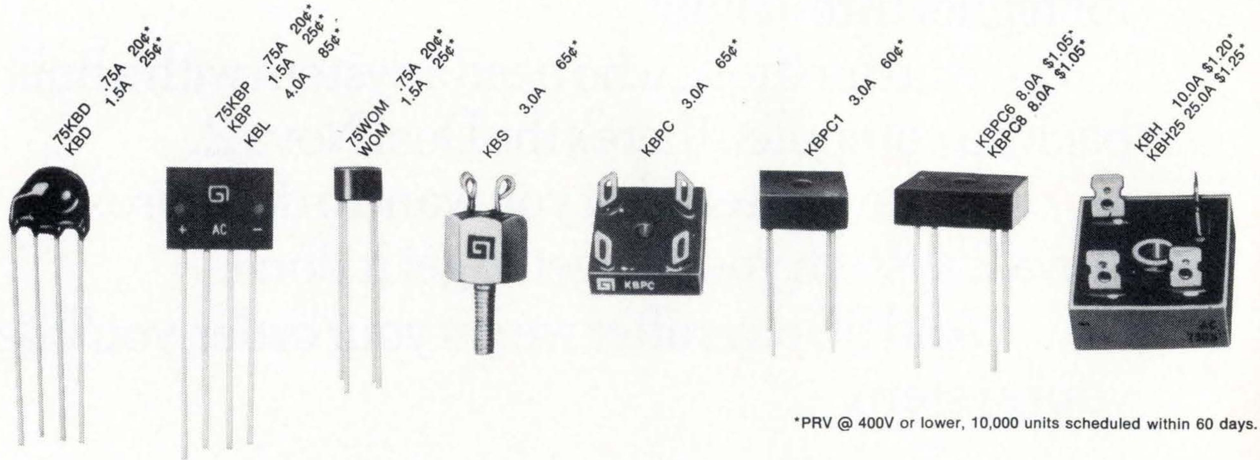

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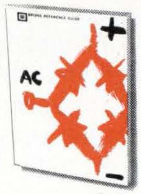

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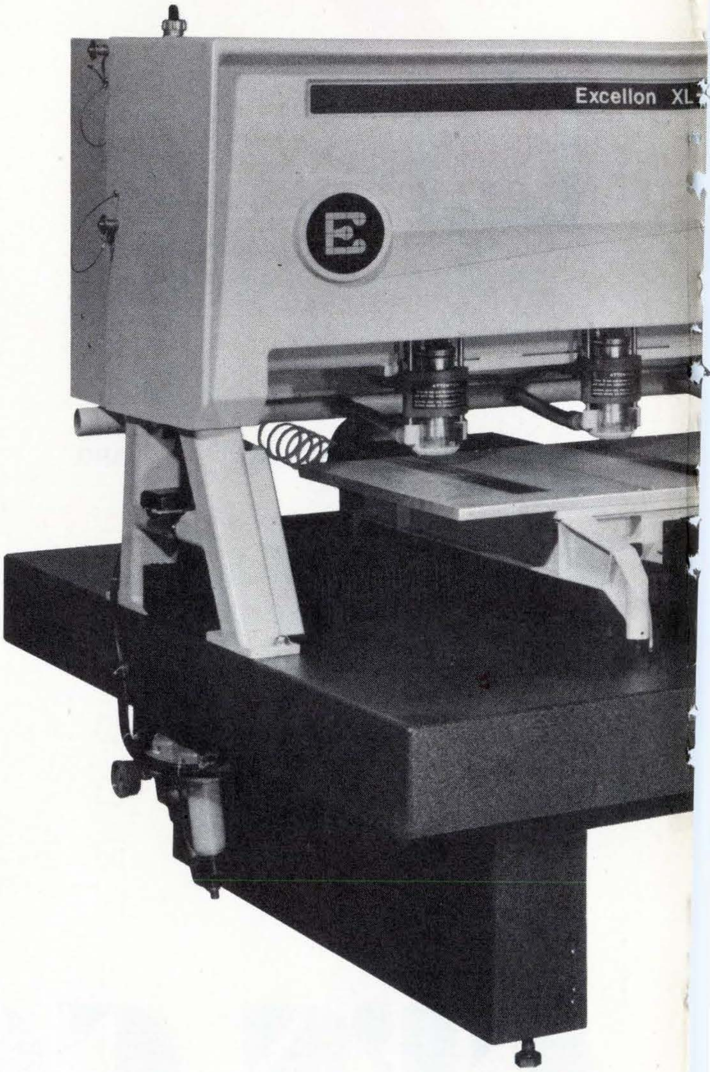

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Model A, 1-spindle.

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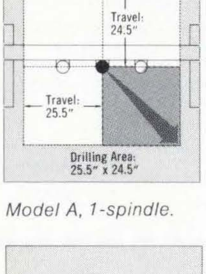
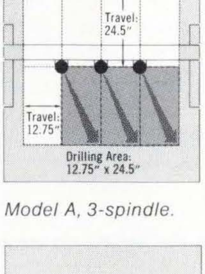


Model B, 1-spindle.



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shoes virtually friction free. High torque, low inertia DC servo motors drive the table up to 400 ipm on each axis. Absolute positioning accuracy: ±.0002". Repeatable positioning accuracy: ±.0001".

The illustrations (at left) show the drilling areas using one, two or three spindles.

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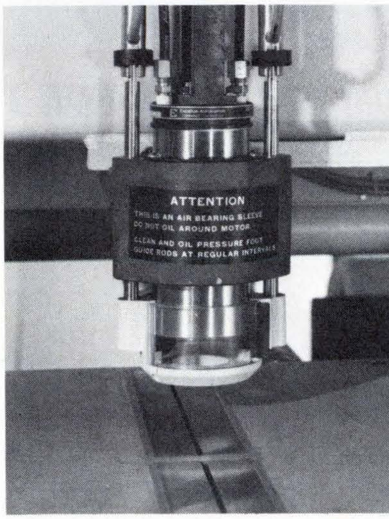

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European EE roundtable reflects universality of design problems

Like their U. S. counterparts, Europe's EEs are preoccupied with microprocessors, the system/component-design interface, and shortages; but some concerns are unique to each country

by Arthur Erikson, *Managing Editor, International*

"You can make new products using the same technology . . . . But there comes a day when you have to change."

☐ *There is no such thing as a typical European electronics engineer; rather, there are British, French, Dutch, Italian, Belgian, and German engineers—each with a characteristic background and outlook. Nevertheless to get some insight into what concerns EEs in Europe these days,* Electronics *convened a meeting with eight of them from six countries for a long spring-afternoon's talk (see "Editing the tapes," p. 137).*

Soon after the eight panelists settled into their places in a screened-off corner of the elegant breakfast room of the Hotel Victoria in downtown Amsterdam, the talk turned to the day-to-day problems EEs have to cope with, especially those caused by new components and new technologies. All the equipment designers nodded in agreement when Alain Quéau, the oscilloscope man from Schlumberger, remarked that one almost needs a crystal ball to pick the right IC technology. And nobody demurred when Henk Bremer, who heads the voltmeter/multimeter design effort at Philips Gloeilampenfabrieken, insisted that it's as much a matter of when as of what. But sides formed when Robert Carey, who is in charge of developing numerical-control systems at Philips, contested the contention of Quéau and Olivetti's Alfredo Olivei that it helps a lot if your company manufactures ICs, as well as equipment. Here's what was said:

Quéau. If your ICs are standardized, it's very difficult to change from one family to another. We need almost a crystal ball to know which semiconductor processes will turn out to be the most economical. It's easier for companies like Philips, which can manage its own production of ICs.

Carey. The point is that Philips manufactures ICs mainly for the mass market—television sets, radios, and so forth. In the industrial sector, where we work, the impact is minimal, and we have exactly the same problem as you have in deciding which techniques to apply. For example, we are just going over from TTL to C-MOS, and it was very difficult to decide where to apply C-MOS and where to apply TTL.

Quéau. And which C-MOS.

Bremer. Not only which C-MOS. There comes a moment when you have to change over from one family of instruments to a new one. Of course, you can make new products using the same technology and even with the same TTL sockets. But there comes a day that you have to change. You have to change to new mechanical designs, you have to look for new electronics, and then there is an enormous change of technology. But I think one of the most important things is to know *when* to change to a new technology and, of course, which one.

Olivei. Yes. The point of choice for big firms probably is overemphasized because big firms have available instruments like technological assessments and forecasts. They can know with some degree of certitude what will be in the near future the winning technology. The problems are immense for medium and small companies, which cannot make these assessments satisfactorily because it costs too much.

Quéau. But sometimes Philips has the same problem we have because if they use C-MOS and this C-MOS is used only by Philips, it will cost quite a lot.

Carey. We are in exactly the same position as small companies or medium-size companies, except that we operate within the framework of a larger company. Our larger company does make integrated circuits, that's true, but we have to choose the optimum techniques for our problems, and maybe they are not supplied by our own company. And that's not just the case with Philips, but with every large company.

Bremer's point that timing is as important as choice when changing technology was reiterated often by, among others, Marcel Nollet, who leads a group of engineers developing tracking and communications systems for satellites and earth stations at Bell Telephone Manufacturing Co., an ITT subsidiary based in Antwerp, Belgium.

Nollet. There is a continuous evolution in technology for electronic components, and the main point we have to consider is when there will be the highest demand for a piece of equipment. Then we have to move quickly and do the design with the technology that exists.

Quéau. You have to be very careful. We made a bit of a mistake once because we were a little bit too fast in technology. It was an oscilloscope in 1962. We had the first 100-MHz scope with transistors in the world, so we lost two or three years in the shift to ICs because we were already working with transistors.

Carey. Sometimes you are forced to change. We are being forced in our readouts for machine tools to go over to C-MOS because we have to offer a digital readout that has to fit in a very, very small box, has to be mounted in a machine-tool plant, and has to give off absolutely no heat. We had to change over to a low-power solution.

Quéau. That's a technical point of view—not an economic point of view.

Carey. It also has to do with economy because we have to have a low price. So we have the problem of what to do. Do we make a tradeoff between Schottky TTL or do we go to C-MOS? With C-MOS, we have lower cost in the power supplies, higher cost in the ICs. And then you need the crystal ball again. What's C-MOS going to be like in 1975?

Microprocessors magnify the problem

Like most American EEs, all the hardware designers on the panel had microprocessors on their minds. Tonio Frühauf, leader of a group developing frequency synthesizers and related instruments at Rohde & Schwarz, in Munich, hit common ground when he emphasized the troubles that hardware people have with software, a problem most U.S. designers have shared. Giancarlo Monti, who does research in digital satellite-communications systems for the Italian SIT-Siemens, added some nuances to Frühauf's viewpoint, and so did Carey, Quéau, and Olivei.

Frühauf. We work with microprocessors, and the biggest problem so far is that, on one side, there's hardware

Editing the tapes

To make this report as clear and concise as possible, the transcripts of the recording tapes made at the *Electronics* roundtable had to be edited thoroughly to weed out repetitions, interruptions, and confusing statements that cropped up during these lengthy conversations. This was especially important because the native language of six of the eight panelists was not English.

Rather than attempt a word-for-word rendition, which would ramble, the dialogues are constructed from fair paraphrases, albeit using the panelists' actual words as much as possible. These dialogues do not strictly follow the chronological order of the transcript, but were paraphrased from statements made at different times during the taping. Moreover, a few company names have been cut out in spots where panelists were critical of products of certain manufacturers, and there was no one from these companies to respond to the criticism.

All eight of the electrical/electronics engineers who sat in on *Electronics'* roundtable in Amsterdam have solid design experience. And all have enough active career ahead of them that they're forced to keep on top of the changes in technology, in business conditions, and in society.

Although the panelists come from six different countries, they're not exactly representative of Europe's electronics industries. For instance, none is directly involved in entertainment electronics, a dominant market, but one in which American technology is no real threat. The Amsterdam panelists, by contrast, work in sectors that are very much affected by technological advances in the United States. That's why what these engineers have on their minds—as individuals and not as expounders of company views—is particularly pertinent. The panelists were:

■ Henk Bremer, who is Dutch, started to work for N.V. Philips in 1953, two years after he had won a degree in electrical engineering from the Groningen Technical College. He also holds a bachelor's degree in electronic engineering from Eindhoven Technical College. Bremer started as a development engineer for scientific instruments at Philips, then worked as a service engineer for test and measuring instruments. Now he's the technical-development manager for voltmeters and systems.

■ Robert Carey started his career at the National Engineering Laboratory in Glasgow, Scotland. While working there, he took a bachelor's degree at Strathclyde University. Later he moved to the Birnie Hill Institute to learn advanced machine-tool and control technology. Meanwhile, he completed requirements for a master of science degree at Strathclyde. Since early 1970, Carey has been working at Philips in Eindhoven, the Netherlands, where he is now manager of the Numerical Control department.

■ Patricia Foster is a senior communications engineer at British Aircraft Corp. in Great Britain. She is mainly involved in international spacecraft projects. Before signing on at BAC, Ms. Foster was a senior antenna engineer at Marconi Ltd., led a radioastronomy group at the University of Aberdeen, and worked at the Royal Radar Establishment. She did her undergraduate work at Edinburgh and holds a doctorate from the Cavendish Laboratory at Cambridge.

■ Tonio Frühauf studied first at the Darmstadt, then at the Munich technical college in Germany. After winning a Diplom-Ingenieur degree, he joined Rohde & Schwarz, where he now leads a group that designs frequency synthesizers and related instruments.

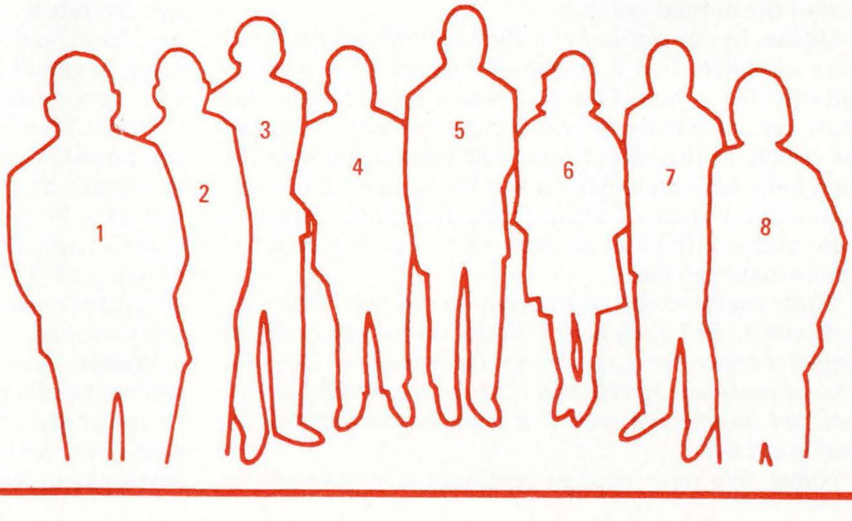
■ Giancarlo Monti has specialized in digital satellite-communications systems since graduation from the University of Bologna in 1968. He's now a project manager in the digital techniques laboratory at SIT-Siemens, which, despite its name, is a thoroughly Italian company.

■ Marcel Nollet of Belgium heads a tracking and communications group of the Line and Radio Transmission division of Bell Telephone Manufacturing Co., an ITT subsidiary based in Antwerp. Nollet participated in the design of tracking equipment for several earth stations, including the ELDO guidance station at Gove, Australia. He's a graduate of the technical college in Ostend.

■ Alfredo Olivei, another Italian, has done R&D in a variety of sectors—nonimpact printers, memory systems, and circuits—for Olivetti S.p.A. Now he's assistant to the corporate manager for advanced technologies. Olivei holds doctoral or postdoctoral degrees from the Universities of Grenoble, Pisa, and Rome.

■ Alain Quéau is the lead engineer for oscilloscope development at Schlumberger Instruments and Systems in France. Before joining SIS, Quéau did a stint as a junior research engineer in the U.S. with Tektronix and has done research in underwater warfare for the French navy. He holds a Ph.D. in electronics from the Ecole Nationale Supérieure d'Electrotechnique, d'Electronique, d'Informatique, et d'Hydraulique at Toulouse.

1. Marcel Nollet, Bell Telephone Mfg. Co. (Antwerp)
2. Tonio Frühauf, Rohde & Schwarz (Munich)
3. Alfredo Olivei, Olivetti (Ivrea)
4. Giancarlo Monti, SIT-Siemens (Milan)
5. Henk Bremer, Philips (Almelo)
6. Patricia Foster, British Aircraft Corp. (Filton)
7. Robert Carey, Philips (Eindhoven)
8. Alain Quéau, Schlumberger (St. Etienne)



"We have two tendencies—the younger engineers using too much software, the older ones too much logical hardware."

designing, and on the other side, there is doing the software. The software specialist normally doesn't know anything about hardware, so the engineer who wants to integrate a microprocessor into equipment has to know both. You don't have standard interfaces always, and there are many cases where you can think about solutions by hardware logic or by adding computer programs.

I've seen often that engineers say software is very, very complicated and they're afraid to work with it—especially older engineers. I try to explain to them that developing software is only a special way of developing digital-logic circuits. But it is very difficult to persuade them.

Monti. We have noted that the older engineers don't use software and prefer to use hardware logic, while the younger ones tend to use software, even when there is no necessity. So we have two tendencies—the younger engineers using too much software and the older ones too much logical hardware.

Carey. I haven't had a problem with older people. The average age in my group is about 26, and they are all hardware designers, basically. But we've had some experience finding software people and teaching them numerical control. It doesn't work. The best way to do it is to take your hardware people and teach them programing. You're best out of it that way. Unless there's a speed problem, it is always cheaper to use a software solution.

Olivei. An electrical engineer—a hardware engineer—cannot afford any longer not to know software. With microprocessors, it's a matter of knowing firmware—just what part hardware must play in a system and what part software has to play. It is antihistoric not to accept software. I studied at the University of Grenoble in 1964, and they were already teaching the rudiments of software at the IMAG [Institut de Mathématiques Appliquées de Grenoble].

Carey. In my bachelor's course in 1965, we were doing assembly language for English Electric computers, and in 1966, we were learning on-going Fortran as part of the normal syllabus.

Quéau. In our company in 1967 or 1968, all the hardware designers had a course of four hours a week in software for a year. Our case was a bit particular because one of our departments does nuclear work, and the people in that department had been using software for a long, long time. Also, it was the beginning of automatic test systems—Camac [computer-aided measurement and control] and all that—so we had the opportunity to make the move.

These engineers are no strangers to computer-aided design, either. Bell Telephone's Nollet turned out to be the biggest booster for CAD among the panelists. Everyone who commented agreed that CAD is a powerful design tool, but no one considers it a panacea, particularly for analog circuits.

Nollet. We have enough computer terminals in our company that engineers can use them like a slide rule. For systems design, we even use them as peripherals for our test equipment. We format outputs so we can interface them digitally with the terminal, which calculates distributions and the like. CAD is especially valid for designing filters.

Carey. We have the same facility, but we don't use it very much—maybe because our work doesn't lend itself very well. We do simulations of systems; but once we have done the simulations, it's finished. We don't do detailed designs. We have tried computer design for printed-circuit-board layout—not the artwork—and we've had some problems. Now, we do most of our layouts by hand and then do the artwork by numerical control.

Bremer. Some of the engineers in my group use CAD for developing custom LSIs—for voltmeters, especially. But we do not use it, say, for analog circuits. At the moment, they are calculated by hand.

Quéau. We have a program for analog circuits, but we check it out by hand. There are lots of things that can interact in analog circuits, so you have to check. But what is nice with CAD is the number of parameters you can change and see the circuit's reaction. But the program has to be done by an intelligent person; you have to remember that the computer can only repeat, only repeat. The problem is to find the actual model.

Olivei. In our company, we do a lot of computer design for mechanical parts and for analog and digital circuits. For minimizing the area of chips, though, the computer gives just a first idea, and a person has to check for the final reduction.

Designing circuits

As users of ICs and microprocessors, the panelists inevitably got around to the interplay between circuit men at IC houses and equipment builders. Again, there was a parallel with the situation in the United States, as Carey points out.

Carey. We have a problem in Europe, as someone was saying, that circuit designers are really disappearing. Everybody is a systems designer today. We're getting fewer and fewer circuit designers, and they're all going to circuit manufacturers. Certainly, in the digital area, nobody designs flip-flops anymore.

Quéau. You have the same problem in measurement equipment. You have to know how people make measurements. You can make the apparatus as accurate as you want, but the fellow using it will operate it with 10% or 20% error. If the design engineer doesn't know this, he will goof. That's why the designer must not be at the integrated-circuit company, he must be at an instrument company.

Bremer. Do you think that it is possible to have an instrument-development group here, say, and work with an integrated-circuits factory 200 kilometers or more away? We would specify the IC here, they would do the development work and make the circuit, and then send

"You have to have the instrument designer and the designer of the IC—digital and analog—on the same floor."

it back to the instrument maker.

Quéau. We have tried that, and it does not work at all. We hired someone [a digital IC designer] from an IC manufacturer, and he asked us, "What is the process?" We answered him, "What are the problems you will have?" It was funny—this fellow had never heard about the variation of V_{BE} with temperature—something analog people know very well. You need to have both on the same team.

Bremer. I agree. Our experience is that you have to have the instrument designer and the designer of the IC—digital and analog—on the same floor.

Olivei. Olivetti doesn't produce ICs itself and relies on outsiders like Philips and the U.S. producers. But there are Olivetti people stationed in the U.S. who do the liaison between Olivetti and the circuit makers. So we don't deal directly with the company, but with the Olivetti man. If we didn't have all these people in the U.S., we would have a lot of problems.

As they talked about relations with IC suppliers, the Amsterdam panelists evoked their concern about second sources and shortages of all kinds of components and materials. Toward the end of this train of thought, Patricia Foster, a senior engineer for telecommunications at British Aircraft Corp., hit upon a problem that does not affect Americans when she reported coming across shortages of key materials created by political considerations, as well as shortages caused by supply and demand.

Olivei. You have to have a guarantee that if your first supplier has a strike or a production problem, you don't have to stop your own production. You need a second supplier, probably not with the same volume of production, but enough to allow you to continue production. We usually try to have a second source, even for cost analysis.

Quéau. So you have to pay for two development contracts.

Olivei. Not necessarily, because the first supplier can pass on the knowledge developed to prepare the circuit for another. It is difficult, but it has happened.

Quéau. But only when the characteristics you want are well below what is possible with the technology. If you give a custom design that is very difficult to achieve to one producer, say, Plessey, they will give you a circuit that they can manufacture. If you then send the layout to, say, Philips, their process will be slightly different, and it won't work. So you have to pay for two contracts.

Frühauf. Another problem is that most of the new devices come from America. You get samples, but you don't know if the manufacturer will still be producing the part a year from now. And if he stops making a special device that's designed into your equipment, you stop manufacturing your own instrument. It's very, very difficult. For microprocessors, you can get only one manufacturer [for identical chip sets], but they are so important now that you buy them, in spite of the fact that you don't have a second manufacturer.

Carey. There is always a risk inherent in large-scale ICs. But everybody has to take a risk; otherwise, you would stand still. We took a risk, for example, using a read-only memory which has a format of 512 by 10 bits. We hoped a second source would come along, but it took two years before one appeared. If the first company had gone *kaput*, we would have had to redesign using someone else's ROM with another format. That is something every engineer must be able to do—make a tradeoff study to see whether he wishes to accept this risk.

Frühauf. I still think it is more dangerous if we are dependent on American manufacturers than if we would be dependent only on European manufacturers.

Carey. If America stops supplying these solid-state devices, you'll find very quickly that the semiconductor houses of Europe will be buying engineers in America to manufacture the things here.

Quéau. What is dangerous is when the device design is good, but no one but you wants to use it. Then the manufacturer in the U.S. won't manufacture for a thousand pieces a year, or else you pay a lot for it.

Foster. Have any of you come across blanket refusals by American companies to deliver certain items? There's one particular kind of mesh for antennas that's made by about three firms in the States and nowhere else. This has suddenly become unavailable to Europeans. What our designers do is to make sure that someone in Europe is making it, even if we have to pay them to do it. And this is just one example of national political policies hindering supply.

Quéau. That's the problem; you have to have a source in the country where you need it. And that's why, many times, you give contracts to develop some things that already exist. In France we have been embargoed on Polaroid 10,000 film because we have been building atomic bombs for a long time, and this film can be used to take pictures of the explosions.

The active hardware designers among the panelists all showed keen awareness of "natural" shortages—present and future. They are designing with that in mind, but as Quéau replied when asked how one can design without wire, "It's impossible."

Carey. You find a lot of large electronic equipment is going over to aluminum power lines because the long-term shortage of copper was taken into account by the equipment designer. That is what we've been doing— trying to find out what's happening with prices of materials and what do we have for a second source of supply. I think designers generally work with shortages of materials in mind, but not in the electronics sense—purely in the mechanical sense.

Quéau. But what about wire? You have a lot of plastic around the metal, and there's a shortage of wire because there's a shortage of oil to make plastics with.

Carey. That is not something a

"There is no such thing as a European engineer; there are British engineers, French engineers, Belgian engineers."

designer can take into his criteria. We had to do some very quick redesign recently because a company was unable to supply connectors to us for a year, also due to this plastic problem. But the designer couldn't foresee in the first instance that the connector would not be available.

Europeans search for a style

Amsterdam has a distinctive architectural style, and it was fitting that the panelists in Amsterdam got around to talk of the style of their designs. It uncovered conflicting views. Henk Bremer of Philips maintained that an international style has started to evolve, at least for the faces of instruments. The other panelists generally hewed to the line that the national outlooks of the designers and national differences in markets work against finding a "European" style.

Nollet. A few years ago, instruments designed in Europe started to take on more and more an American look, and finally all the instruments came to have the same look on the outside. By doing this, European instrument makers came up. This is still so, more or less.

Bremer. I don't agree. Now, you tend to see that we have our own faces, which reflects the mix of the different people involved in the design. It's very important—not only for Philips, but for Europe—to find a style.

Olivei. From the long experience we have had with cathedrals, it is very difficult for Europeans to find a style.

Carey. It is a question of education and national background. There is no such thing as a European engineer; there are British engineers, French engineers, Belgian engineers—all with different characteristics and techniques. Dutch and German engineers are very much tied in with standards; they like to work with them. Italians say the standards are useless and design it their own way. I pointed out something to an Italian engineer that was against ISO standards, and he said. "Well, the standard is stupid; change it." If you go to Germany, they go too far; they have standards for everything you can imagine.

Olivei. Young and inexperienced engineers probably have different approaches in different countries, but experienced engineers—whether French, German, or Italian—have the same kind of approach to problems. Individual differences probably count more than national or academic backgrounds.

Bremer. No. Can you imagine the Citroën DS being developed by Germans or the Volvo by Spaniards?

Carey. And a Fiat 125 is surely not at all like a Volkswagen.

Frühauf. It's wrong to say the Citroën is built in France because the engineer is French. The real reason is that the French engineer has developed something for French customers, and if a German engineer had to develop a car for French customers, then I hope he would also build something like a Citroën. It's not the character of the engineer that determines the product, but the character of the market.

Foster. I don't think your argument is valid. I have seen two antennas with the same electrical specifications, built for the same customer—one built by an Italian firm, the other by a British firm. There is no getting away from the fact that the waveguide parts of the Italian one were much more elegant than the British one; both were made for a battleship.

Frühauf. If you design for the world market, you develop an instrument. Then you see another one almost like it from a European competitor, and you find that in America, somebody has thought just the same way as you because it's built for the same customer.

Bremer. For a company that makes and sells instruments all over the world, it is very difficult to find the right styling. It must not be Dutch styling, it must not be German styling, not European or American styling—it must be world styling. We have seen at Philips that this is a main problem for the conception of our instruments. Philips

"You have to keep a firm grip on the industrial designers and try to instill some cost-consciousness into them."

has a styling-design center in Eindhoven with more than a hundred people from all over the world—Chinese and so on—just to find a middle styling, the middle of the taste of everybody.

But whether the look is national or stateless, it's important, the group agreed. And so are the controls that occupy the panels of instruments.

Carey. For some instruments, you have to keep a firm grip on the industrial designers and try to instill some cost-consciousness into them. But looks are important. A sewage-pump manufacturer—and a sewage pump is something you never see—told me their sales of the pump went up 400% after they called in an industrial designer and made it beautiful. We have a power supply with a beautiful face that's generally stuck in a cupboard, but it is important.

Bremer. When you buy it, you see it.

Quéau. It makes the only difference in the choice when you want to sell something, and two or three instruments have the same performance characteristics.

Nollet. One of the most important considerations for the user is the controls, knobs, indicators, and adjustments that you have to make. Five or 10 years ago, there were so many calibrations and adjustments to make. There has been a lot of improvement.

Carey. Well, for instruments, you have electronics engineers designing for electronics. In numerical control, we are designing for people who operate machine tools. Every time I get a new man in my group, I put him in the factory, working with numerical controls for a few weeks so he learns the problems these guys have pressing all those buttons and touching all those knobs. And maybe when he designs a control he remembers the time he had to walk 10 feet down the machine to turn a knob and thinks about how you operate this and not just how economical it is. That is something that five or 10 years ago was not considered by the engineer—certainly not in Europe. Also I think in America. I've worked with some American instruments that were terrible things to operate just because of the knobs on the panel.

Far from the soldering iron

Perhaps the most distinguishing difference between EEs in Europe and their counterparts in the U.S. is the stability and job security of the Europeans. Young engineers in Europe may switch companies once or twice, but generally stay with the same firm after that. However, once an engineer has settled into his career, his company can't fire him easily and sometimes not at all. Nevertheless, an EE in Europe has many of the same problems as an American engineer does if design—and not management or marketing—is his career goal.

Nollet. European engineers normally make their careers in the first or second company they work for. They also have to live and work in their national environment, so they don't have much job flexibility outside their own company and have to learn to develop themselves within it.

So you have to give development engineers tasks that broaden their use to the company. You can give them total responsibility for part of a project. After developing the technical and cost proposal, they can work with the customer and learn that customer satisfaction is a prime goal of the company, along with profit. That way, you develop engineers that can function as marketing men, production men, or quality-control men. So you can avoid a crisis for engineers who have to move out of design work.

Foster. That doesn't solve the problem because you haven't enough of this sort of job for all the engineers you've got.

Bremer. The question is: is there 100% matching between the number of engineers who are going from designing to marketing or applications?

Nollet. There is never 100% matching, but if you give the design engineers other responsibilities, they

"Some managements are changing theories very fast about the differences between managers and technical people."

stay motivated. And for smaller projects, they can stay close to design.

Quéau. He is right, and the engineer will do a better job when he has the responsibility for the whole project, knowing the kinds of customers and the marketing. When there is a problem, he has to go out there and see what it is. So he is responsible from the beginning to the end, but not responsible for policy. That is a management thing.

Frühauf. We say in Germany that your salary grows quadratically with your distance from the soldering iron. If you are only happy doing technical things and you are a really good design engineer, even so, you have to move away from the soldering iron to get the money you need as you grow older. It's a bad situation: There are no old design engineers.

Olivei. Some managements are changing theories very fast about the differences between managers and technical people. Engineers do knowledge work, and for knowledge work, planning and doing are the same thing. So I don't see as much difference as in the past between a management career and a designer's career.

Bremer. The problem is: what is your intention—to grow and grow and grow so far that you cannot do the work you want to do? Then you are unhappy, and maybe the company becomes unhappy with your work. I believe there is a big job for the managers of the company to have a good policy for job guidance or job rotation. It would be a good idea to have several people in the factory to guide technical people to the right place.

Carey. That was right about a quadratic rule for the soldering iron, but you can stay in design engineering at a lower salary. In Europe, most people have individual contracts with their companies, and these contracts are hard to break. The engineer's salary curve, of course, saturates at a lower level than a manager's.

Bremer. There's a trend in Europe—at least in Holland—that some, not many, but part of the people in electronics don't want to become managers. You know, they say to themselves, "as an electronics engineer, I work 40 or 45 hours a week, and then I go home to my wife and children every night, and weekends I can go sailing and so on." Well a manager works, let's say 60 or 70 hours a week—sometimes more. And the difference in salary—in effective salary after taxes—well, the difference is decreasing. Ten or 15 years ago, the goal of most people was to be a manager, but now, I don't think that's so.

Quéau. Quite right. A lot of engineers I know would rather stay in St. Etienne—out in the country—than go to Paris and become a manager. In the country, you can ski, fish, do what you want to do, and more people want to do that.

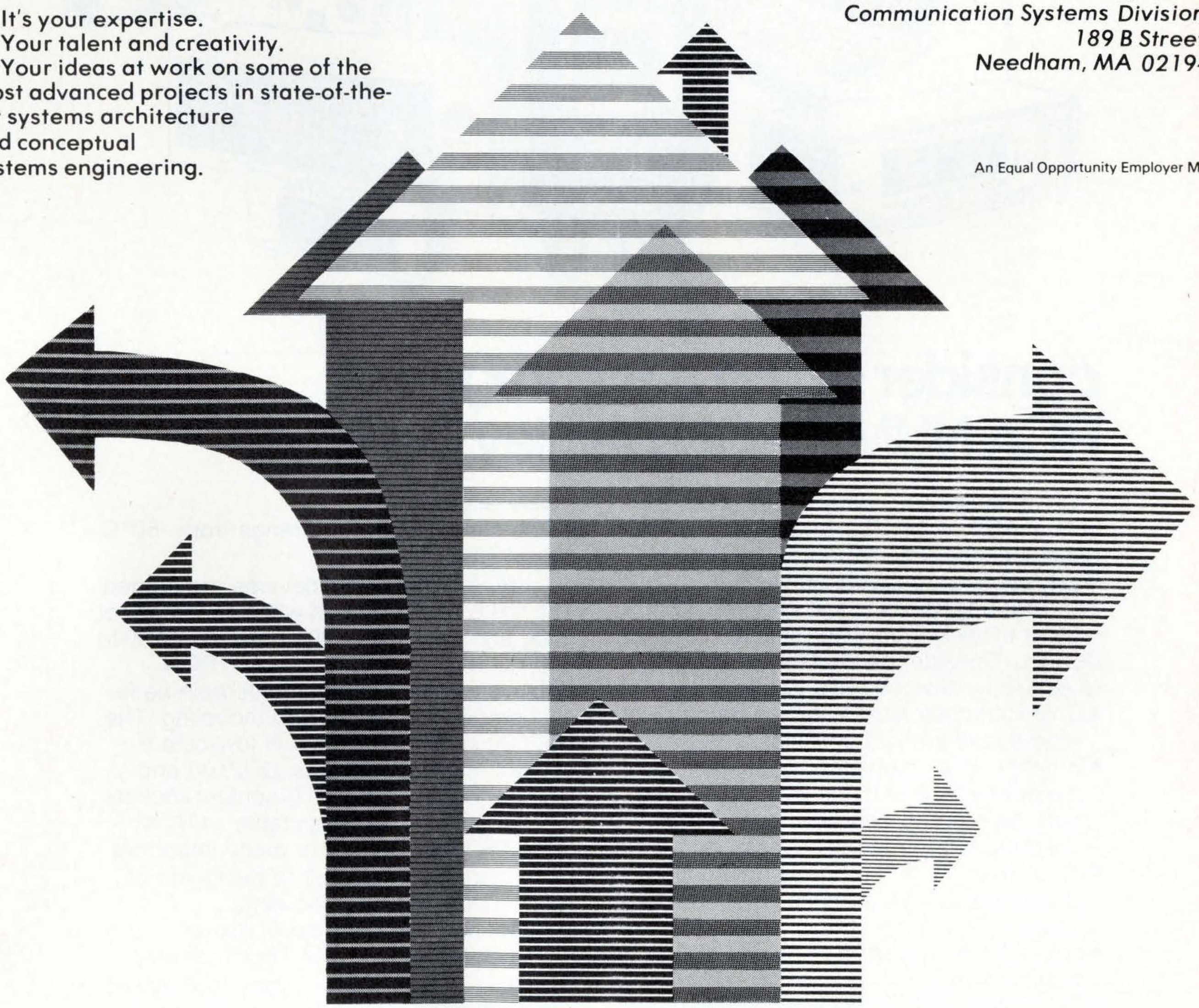
Olivei. But you have a responsibility towards your firm to try to undertake more important tasks and to search for more responsibility. Not just to have a better car, but morally.

Monti. But a technical career involves responsibility because it's so difficult to keep acquiring the new techniques you need to plan the work. I don't think it's an easy life.

Vive la différence (sometimes)

Throughout the Amsterdam tapes, comparisons between American and European EEs pop up fairly often. Except for job security, the group felt that most of the advantages were on the other side of the Atlantic. For starters, Rohde & Schwarz's Tonio Frühauf remarked early in the afternoon that, since most new devices come from U.S. semiconductor makers, American EEs learn about them sooner. And Frühauf had other concerns.

Frühauf. I think European engineers must do the same work as American engineers with less money and with less time because companies can spend only 10% to 15% of their turnover for R&D. And the market for European manufacturers is rather smaller. The USA itself is



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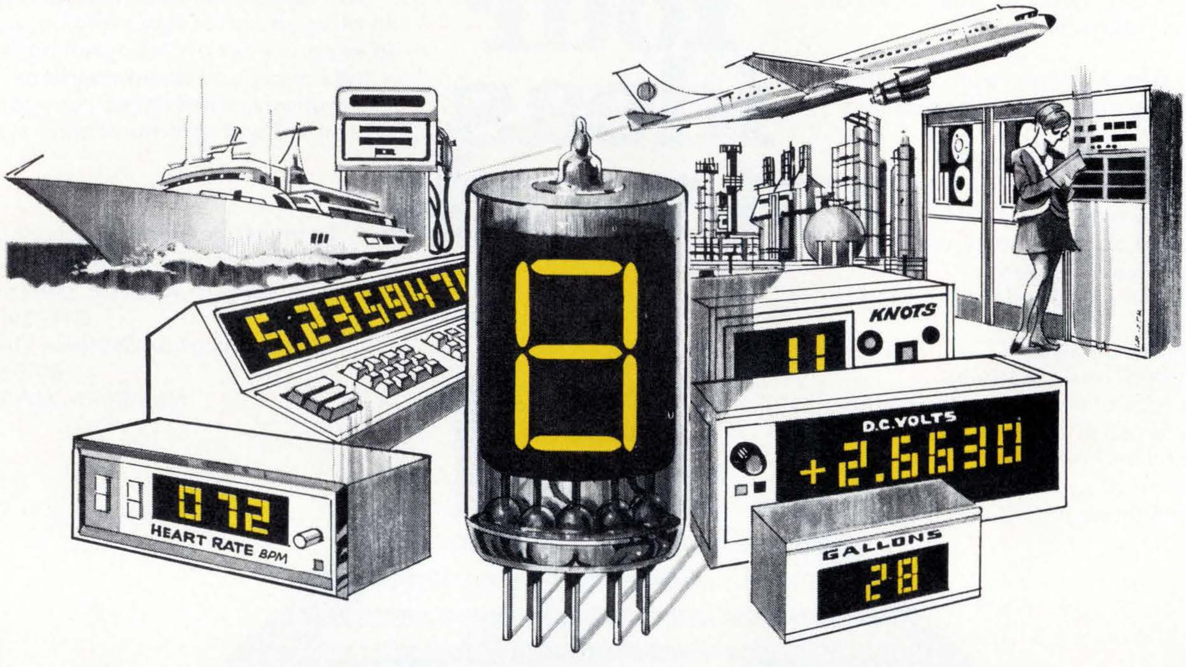

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"The different languages in Europe cost us a lot of money —I can't guess what part of the GNP, but it's a lot."

much bigger, and there's the Buy American Act, so Americans buy American products. But we in Europe don't have this nationalistic feeling—anyway, not in Germany—so the Americans can deliver their equipment here without difficulties. But we must compete in the world market, so our equipment must be as good as American equipment, even though we have less money to work with and fewer people.

Quéau. There's a good answer for that. Since we can't spend as much for R&D, we put in fewer components, and with less parts, our equipment can only be more reliable. But if you want to be competitive in the American market, your instrument must be cheaper because of the trade act.

Besides small R&D budgets, language barriers are a disadvantage to EEs in Europe, even though English has become the lingua franca *for technology.*

Nollet. In Europe, there is a problem for international projects. There's egoism and nationalism, and the work is split up inefficiently. There's also a lack of good communications because of the language problem.

Quéau. That is true maybe for governmental projects, but not for us, a multinational company. At Schlumberger, everybody had to learn English, and at Solartron [a Schlumberger company in the UK] everybody had to learn French. So both speak French and English—not very well, but they make the effort.

Foster. Sometimes I think it is safer for people to speak in their own language. Occasionally, we have had Telexes come from the Continent in English, and it has been very unclear what they meant.

Bremer. I agree that it's a good thing to learn English and other languages so there will be no barriers between countries. But the barriers exist, and they dissipate a lot of energy. It is more or less a fiction that you don't find in the U.S. because every man in the U.S. speaks English. The different languages in Europe cost us a lot of money—I can't guess what part of the GNP, but it's a lot.

The general topic of communications—written, as well as oral—had a further airing as the discussion turned to paperwork. Again, there was a comparison with American engineering.

Foster. I think we have too much paperwork in Europe; every new development is preceded by lengthy theoretical studies, where perhaps an American firm would just go out and manufacture it—have a bash at it.

Carey. That's not true. It's just the other way around. In Europe, people jump into manufacturing and don't do the paperwork first. In NASA and Minuteman projects in America, they started with systems management, which involves writing the specifications before you start to produce. In the past in Europe, people made something and then wrote the specifications. They haven't said, first of all, the market wants this; but this is the specification, let's make it.

Quéau. That is what you have to do first—do the paperwork. But not just any kind of paperwork—paperwork that covers the progression of a project.

Nollet. Objective-oriented paperwork.

Quéau. In my own experience, I have seen that the Americans start from the beginning because they believe they don't have the background. We believe we have the background, and so we start somewhere about the middle of the project because we think we know. I think their approach is better than ours, for sometimes we have to start over and see how it really works.

The EE's burden

The majority of the engineers at the roundtable had come to Amsterdam to sit in on Eurocon '74, organized by the Convention of National Societies of Electrical Engineers of Western Europe, together with the Institute of Electrical and Electronics Engineers' Region 8. Eurocon '74's theme was "The Engineer in Society," and the panelists had a short exchange on the topic. The tapes indicate, though, that the preoccupation with day-to-day design problems outweighs concern for the sociological import of the equipment in question. Yet, as in the U.S., social consciousness is awakening as Tonio Frühauf and Robert Carey attest.

Frühauf. Sometimes when we build automatic instruments, we think, but only a little bit, how they're related to society. Because of the shortage of workers, you think of the people who will use these instruments—the operators—and you try to make them simple to use. And then you think there will be a need for only very stupid people because your instruments are so easy to operate that people don't have to think. But this is only theoretical; it is not necessary for getting turnover.

Carey. We do something a little bit more practical. We make controls to replace the man who turns the wheels on machine tools, and we've been trying to study exactly what we've done. We've put in control features that you could say are redundant—cathode-ray tubes with nice displays so you can see what the control is doing, the possibility to talk with it through a keyboard. These things are redundant, but they are put in, really, to help the operator pass his day and keep him a little bit interested in what he's doing. It costs money, but it seems to be worth it.

Otherwise, plant managers find that operators stay out sick, and the machines can't run because you need a man to push the start button and put in the metal workpieces. But after he's put in the punched tape and pushed the start button, there's nothing for him to do but twiddle his thumbs until the piece is finished.

Frühauf. You think about saving money, you think about saving time, and so on, of course; but nobody thinks about sociological fallout. When engineers design television sets, nobody thinks about whether this is good or bad for their families. □

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Fast 8-bit microprocessor is versatile

Rockwell's p-channel system comes with CPU chip, 256-by-8 RAM, direct-memory-access controller, and enlarged input/output chip

by Laurence Altman, Solid State Editor

The first microprocessor available as a standard product is less than two years old. But already, semiconductor manufacturers are introducing second-generation models with enlarged instruction capacities, higher speeds, and greater flexibility for an ever-expanding range of applications.

Intel and Motorola have already announced n-channel 8-bit additions to their microprocessor family [*Electronics*, April 18, p. 81]. Now, Rockwell International's Microelectronic Device division, Anaheim, Calif., joins the club by adding an 8-bit system to its 4-bit version, already on the market. Built with p-channel technology, the PPS-8 offers more than 90 instructions, can directly address more than 16,384 bytes of read-only memory, plus a like amount of random-access memory. Complete instruction time is 4 microseconds.

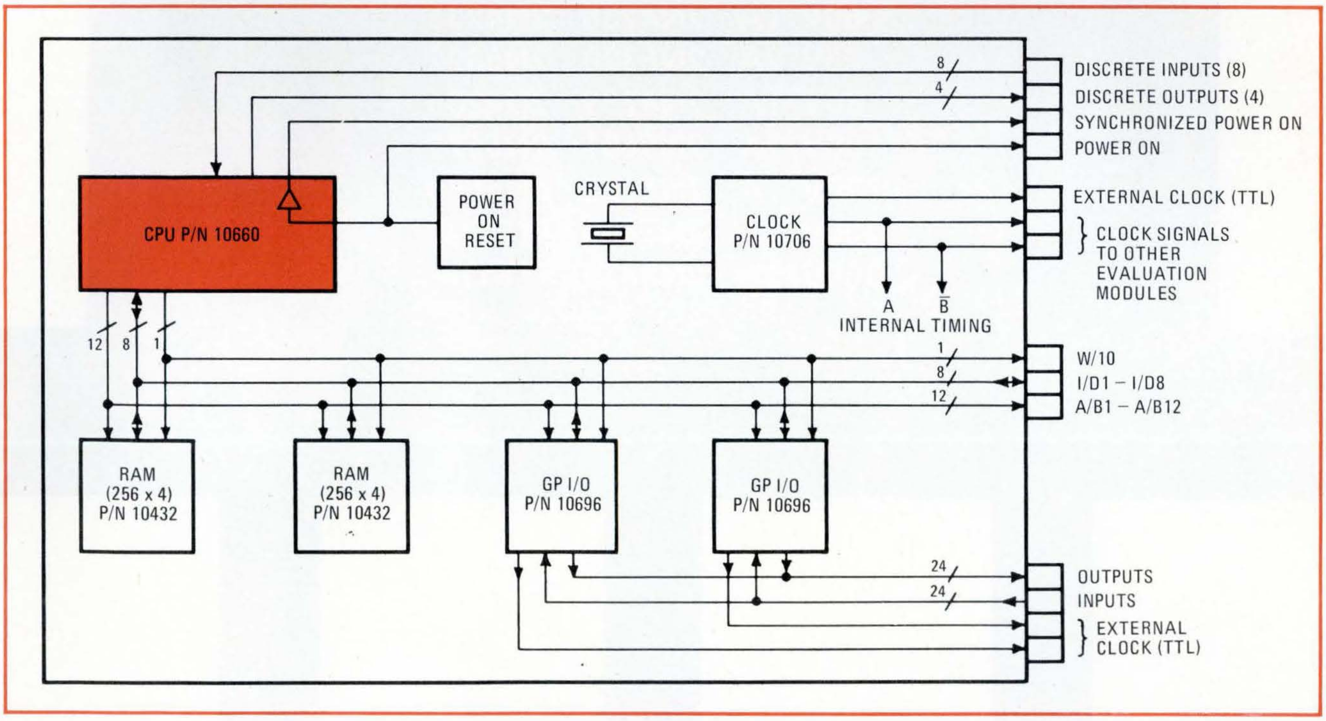
The peripheral devices available are the RAM (a full 256 by 8 bits), the direct-memory-access controller (DMAC), and an expanded input/output chip, called the GPIO #2.

The microprocessor chip has somewhat the same organization as the 4-bit CPU in Rockwell's PPS-4, except that, instead of having save registers, the addresses were put directly into the first 32 addresses of RAM. This implements a 32-deep first-in, last-out stack.

Michel Ebertin, director of new-product development at the division, points out that the PPS-8 follow-on system is constructed exactly like the PPS-4 system so the same memories and simulators can be used with both systems to give the user "instant system-upgrading." Says Ebertin, "We've kept the same bus system and the same timing, so that the same ROMs can be used with both systems; the same system simulators or assembler boxes can be used." In addition, all the input/outputs that were developed for the 4-bit system can be used in the 8-bit system because of a special instruction, called the IO4, which allows the 8-bit system to read in or out with only 4 bits.

Flexibility. Ebertin also points out

One version. Typical 8-bit parallel processing system includes microprocessor (in color), RAMs, and input/output and clock circuits.



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80V/1A	2N4239	2N4236
100V/1A	2N5681	2N5679
120V/1A	2N5682	2N5680
200V/1A	2N3440	FT5415
300V/1A	2N3439	FT5416

that the 8-bit system is designed so that most of its 90 basic instructions are modifiable for maximum flexibility. Says Ebertin, "We've included the capability for packed binary [-coded] decimal logic, so that in a sophisticated high-speed decimal machine, the speed of calculations can be doubled because now, one add-time calculates two digits, rather than one." What's more, the system has three levels of priority built in, as well as, via the new I/O devices, a daisy-chain priority group that allows the user to generate an additional eight levels of instruction on the third-level priority. And the DMAC is so constituted that burst data can be transferred in and out of the memory chips at the full clock rate.

Responsible for the high throughput rate is a multiplexing system. While the memory-access time in each case is 2 μs and an instruction cycle takes 4 μs, a full decimal addition or subtraction requires only three instruction cycles, or 12 μs. Byte manipulation—moving a byte from one spot to another—also takes only 12 μs, and a table search takes 12 μs. Burst data is transferred at the full clock rate of 4 μs per byte.

The new I/O circuitry, the GPIO #2, was developed to work directly with the CPU chip. The GPIO #2 actually does a lot of preprocessing. It has two 10-bit-port receiver/drivers, which, when +5 and -12-volt supplies are used, become fully TTL-compatible. The GPIO #2 receives commands from the CPU, which are stored in two function registers. These command the input/output ports, telling the device whether to copy and send the commands to the CPU, send them out either in parallel form or in serial form, or store the data in the CPU registers.

This flexibility is advantageous, for instance, in a point-of-sale terminal, where, as part of the operating sequences, one looks for a unique key depression or 8-bit character. Normally, this operation would have to be done in software and interleaved with other parts of the program. Now, with the GPIO #2, the user can detect it right in the I/O device, which will ignore all codes coming in except the one that matches. Once the detection is made, an interrupt is sent to the CPU, which then takes up the remaining task. This allows the device to accommodate more functions than were possible in the 4-bit system.

The DMAC circuit operates on command from the I/O device that emits a signal freezing the CPU; that is, all of its drivers on the data line and on the address line float, which puts the CPU in a "halt" mode. Then the DMAC's RAM address lines become active, and the I/O devices can start sending or receiving information at full clock rate into and out of the memory.

Coming. Other peripheral devices at the conceptual stage for the PPS-8 system are a floppy-disk controller, a CRT controller, and a programable I/O device. The programable I/O points to a complete processing system—RAM, ROM, CPU, clock, and I/O—on one chip. By allowing the I/O device to be microprogramed, the I/O function can be reduced to a one-chip device, and each customer could generate his own microprograms for it. But Ebertin says the p-channel process would have to be shelved because its devices are too large to accommodate this design, so a programable I/O device will probably be fabricated on a sapphire substrate. But Ebertin predicts that the programable I/O will be available by the early spring of 1975.

As for design aids, Ebertin points out: "Rockwell is on the General Electric and Tymshare systems, which allow full assembly simulators. This lets a user do his own program-generation and program-verification in basic machine language. In addition, we have some evaluation modules for the 4-bit system already available."

Also being designed is a new ROM loader, to be used with an electrically alterable ROM. These devices are scheduled to be available in the fall of 1974.

Microelectronic Device Division, Rockwell International, P.O. Box 3669, 3430 Miraloma Ave., Anaheim, Calif. 92803 [338]

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Semiconductors

Drivers offer more protection

Standard interface circuits' breakdown voltage is nearly tripled at 80 volts

Since its introduction several years ago by Texas Instruments, the 7545 family of interface-driver circuits has been an industry standard, produced by several manufacturers. Now, as the initial step of expanding its efforts in interface circuits, National Semiconductor Corp. has developed a high-voltage version, called the LM3611-3614 dual peripheral driver. This device will be followed by at least eight new interface product lines, says Stephen Fields, interface-marketing manager at National.

The principal difference between new driver circuit and the TI version is its breakdown voltage–80 volts, compared to 30 V for the standard 7545 models–thus providing added voltage protection against on-line spikes. The advantages of the 7545 series are high speed–25 to 30 nanoseconds–and a high sink-current capability–up to 300 milliamperes on each output.

The circuitry is simple: two gates drive two power transistors. The four models in the series are for the AND, NAND, NOR, and OR logic on the gate. The output emitters are tied to ground so that through either one of the two collectors it is possible to sink up to 300 mA.

The speed of the devices makes them useful as drivers in data processing and in memory devices, but other applications soon became apparent. Since they are so compact and have output breakdown voltages of about 30 V, it was found that these interface circuits can drive lamps, solenoids and relays.

But designers soon found out–and users did, too–that if a relay or solenoid were driven by one of these devices, there were often unpredictable inductive spikes, or kicks, higher than 30 V that would latch up and blow the outputs.

In addition, the high speeds of the device often complicated the designs for slow-speed applications, such as in relays and lamps, which don't operate well when driven with a 20-nanosecond edge. After about a year of design and production work, National is introducing the LM3611 series, designed for those applications where a higher breakdown voltage is required than that provided by its LM75451 series. To achieve the high voltage breakdown, National has applied the linear process that it uses with its high-voltage display-driver circuits. Characteristics of this process include high epitaxial resistance and substitution of another metal for gold.

"In essence, we have traded speed for an increase in output voltage breakdown," says Fields. "The breakdown voltage at 80 V is almost triple that of the earlier series." All other specifications are the same, except that the LM3611 series is slower by design, at 120 to 130 nanoseconds.

"They are pin-for-pin compatible with the 7545 series, with the same output sink capability of 300 mA," he adds. The price of the LM3611 series is $1.90 each in quantities of 100, compared to $1 each for the LM75451 series in similar quantities. In volume quantities, says Fields, the price is significantly lower for the LM3611. "One reason for the higher price is that this device needs a much more complex process to get the higher breakdown voltages," he adds.

National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, Calif. 95051 [411]

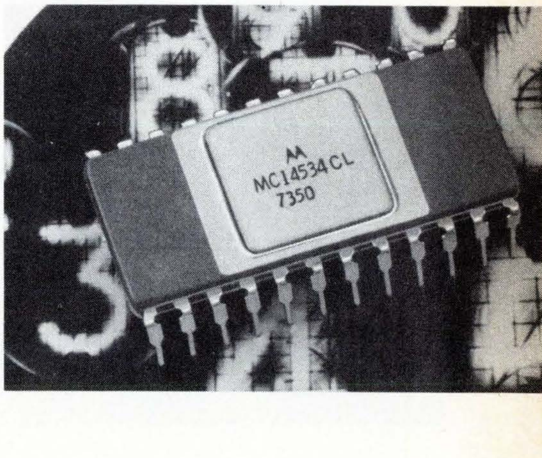
Stabistor diodes come in miniature glass packages

A line of 50 stabistors–diffused-silicon zener diodes with controlled forward-voltage characteristics–are packaged in subminiature glass housings. They are designed for a broad range of circuits where stable, low-voltage references are required, including voltage-regulation, voltage-sensing, meter and relay protection, and computer circuits. The diodes are manufactured in double-plug packages, with silicon dice bonded to the ends of the plugs. Reference voltages are from 0.560 V to 3.700 V, and tolerances are typically ±5%. Prices for the units, which come in DO-35 glass packages, start at 10 cents each in quantities of 25,000.

American Power Devices Inc., 7 Andover St., Andover, Mass. 01810 [414]

Counter and timer circuits added to C-MOS products

A flexible 24-stage binary timer and a real-time five-decade counter have been added to the Motorola C-MOS family. Capable of counting from 1 to 2^{24}, the MC14536 programable timer consists of 24 counters, the last six stages of which are selectable by a 4-bit code. Varying the timer's input clock frequency provides a wide variety of intervals, while additional versatility is achieved with an on-chip oscillator, a monostable multivibrator output, and an internal clock-conditioning circuit with long rise and fall times. The second addition to the line, a decade counter designated the MC14534, counts events in real time and can be used to update multiplexed displays. The MC14534 contains five decade counters that have their outputs time-multiplexed by an internal scanner. The counters and scanner can be reset independently. The

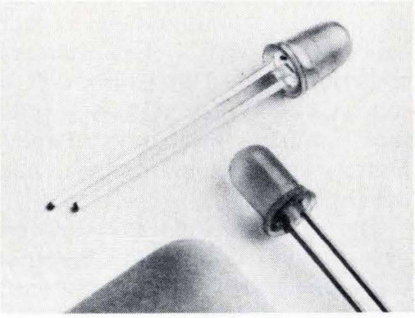


New products

MC14534 can be used for continuous-counting displays or as an event counter in industrial control. Model CL, with a temperature specification of -40° to +85°C, is priced at $21.83 each in 100-lots; and type L, -55° to +125°C, at $39.29 each.
Motorola Semiconductor Products Inc., Box 20912, Phoenix, Ariz. 85036 [415]

Green LEDs dissipate 112 milliwatts of power

For designers requiring a light-emitting-diode lamp for panel lighting, film-annotation, circuit-status indication, alphanumeric display or visual indication, the 521-9206 series



provides axial leads flexible enough for bending and rigid enough for direct mounting to a printed-circuit board. Moreover, the lamp also provides a wide viewing angle, life measured in years, and low power consumption, making it compatible with integrated circuits. Maximum ratings for the lamp include: power dissipation of 112 mW, linear derating from 25°C at 1.49 mW/°C, continuous forward current of 40 mA, peak pulse current of 1 A at 1 μs pulse and 1% duty cycle, and peak reverse voltage of 5 V. Price is 55 cents each in 100-lots.
Dialight, 203 Harrison Pl., Brooklyn, N.Y. 11237 [416]

Diodes rated at 8–12 kV are small in size, cost

A manufacturing technique that permits the molding of 8- to 12-kilovolt miniaturized silicon diodes with

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35 CMOS types ready for shipment by August

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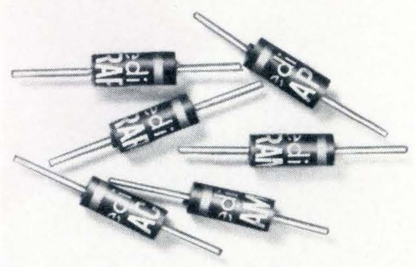
SILTEK

Circle 155 on reader service card

short silver leads also permits them to be sold for a relatively low price—$1.70 each in quantities of 1,000. Electrical ratings of the new line are: model AM, 8 kv peak inverse voltage, 125 milliamperes; model AP, 10 kv, 100 mA; and model AR, 12 kv, 80 mA. Standard and fast-recovery types are available. The units

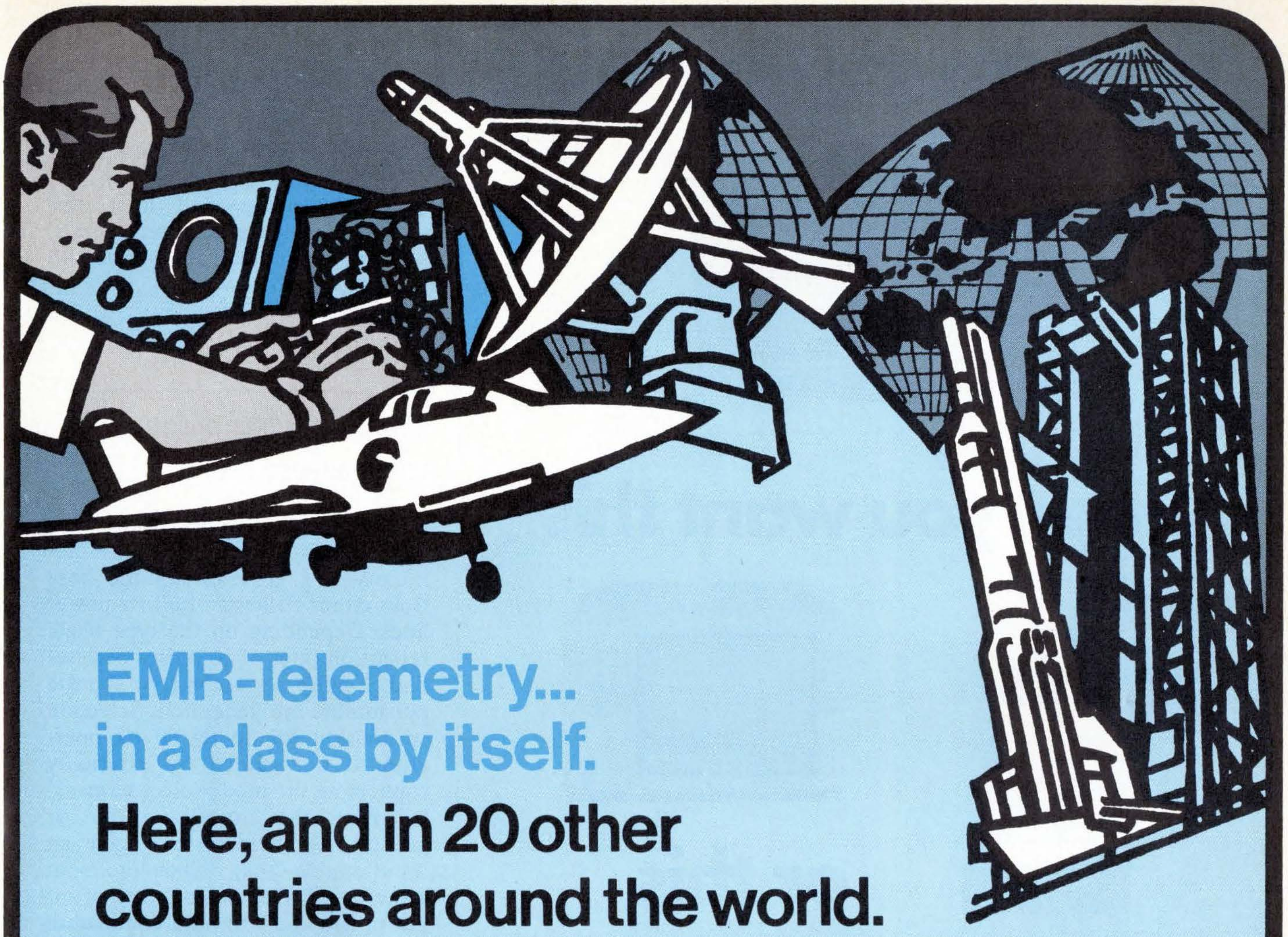


measure 0.380 inch long by 0.160 in. in diameter, with leads 0.030 in. in diameter that are 0.375 in. long. The diode junctions are said to display avalanche characteristics, high surge capabilities, and low leakage. Delivery is from stock.

Electrical Devices Inc., 21 Gray Oaks Ave., Yonkers, N.Y. 10710 [417]

Dual-channel opto-isolator permits high densities

A pair of inverting optically isolated gates, each with a light-emitting diode and a integrated detector, is now available in a single package. This dual-channel configuration makes higher-density packaging possible. The photons are collected in the detector by a photodiode, then amplified by a high-gain linear amplifier that drives a Schottky-clamped open-collector output transistor. Delay times of 50 nanoseconds can be obtained with this high-speed integrated photon detector. Maximum dc and ac circuit-isolation between each input and output is maintained while DTL/TTL compatibility is achieved. The model 5082-4364 dual isolator is designed for use in high-speed digital applications where common-mode signals must be rejected. Typical applications include use as a line receiver and digital programing of



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Japan Space Program . . .

By 1976, the Japanese National Space Development Agency expects to launch a variety of communication and scientific satellites. EMR will supply both frequency and time division multiplex ground stations for use at several stages of the program: for experimenters to check out their scientific and communications packages; for functional tests of each stage of the rocket boosters; and for a complete checkout and monitoring system in the blockhouse at the launch site.

India Aircraft Flight Test Program . . .

The India Aeronautical Development Establishment is using an EMR ground telemetry Data Readout Station consisting of a quick-look, van-mounted, checkout system coupled with a large FM-PAM/PDM and PCM computerized telemetry system. Real-time flight testing of aircraft will be accomplished with this facility.

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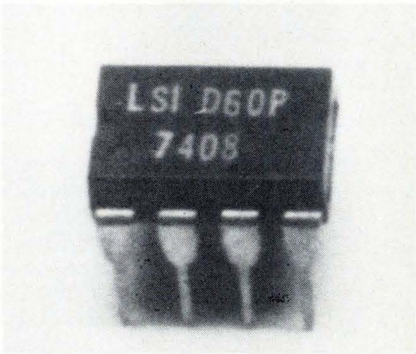
floating power supplies, motors, and machine-control systems. Ground loops between system interfaces, such as a computer and peripherals, can be eliminated. Price is $9.90 each in 100-lots.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [418]

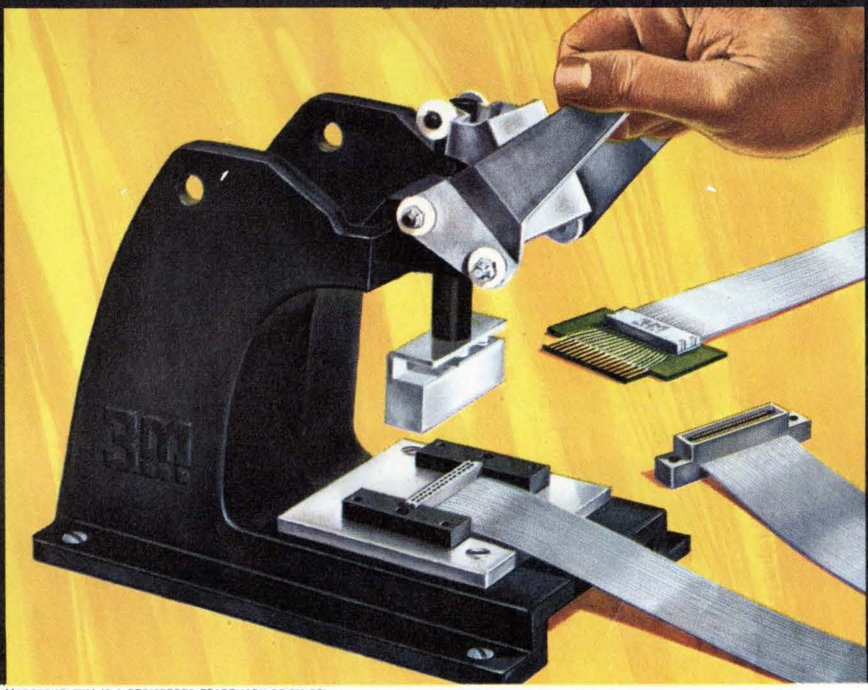
C-MOS dividers produce time base from line

Three C-MOS dividers, called the RED Series, provide high noise immunity and generate a time base from either 50-hertz or 60-Hz power lines. Depending on the type used, repetition rates of 10 pulses per second, 1 pulse per second, or 1 pulse per minute are generated. Selection of division for 50 Hz/60 Hz operation is determined by externally connecting the mode-select terminal to either the supply voltage or ground. All divider types have an input-enable that, when held at ground, will disable counting of input pulses and will hold count until input-enable is returned to the supply voltage. Applying a positive voltage to the reset input will clear all divider stages to zero count. The dividers are typically used where line-frequency accuracy is adequate for generating pulses for use in time-keeping circuits, i.e. digital or analog clocks. They can also be used where timing pulses are required for controlling instruments, time-delay circuits, counters, and general-purpose industrial controls. Price is $5.90 in 100-lots.



LSI Computer Systems Inc., 22 Cain Dr., Plainview, N.Y. 11803 [420]

"Scotchflex" Flat Cable Connector System makes 50 connections at a time.



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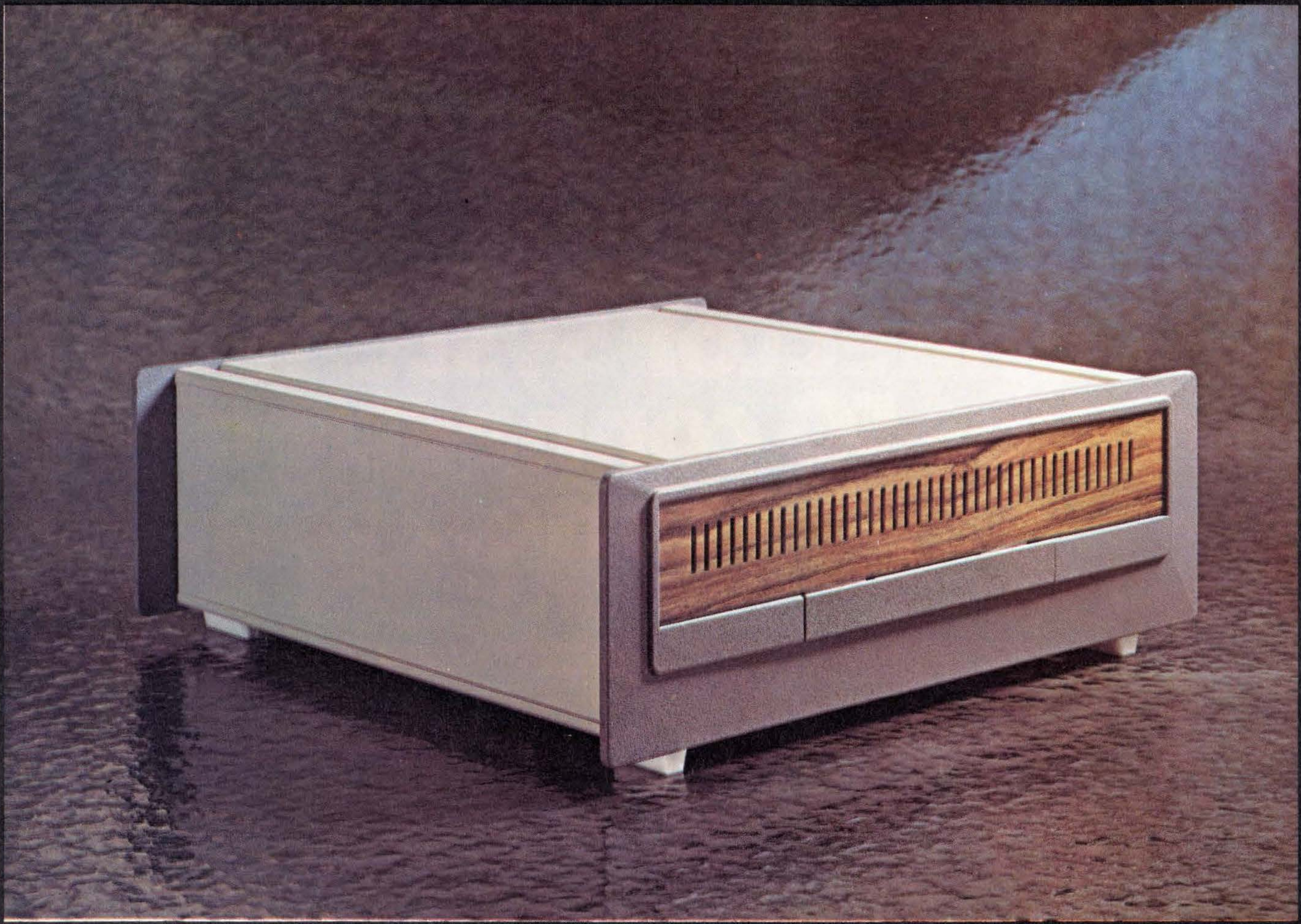

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Instruments

Pulser aims at high-speed logic

Generator offers risetime variable down to 1 ns; is near-perfect 50-ohm source

Putting emitter-coupled logic to work has top priority with engineers seeking faster switching times, but testing such circuits—with transition times of about a nanosecond—challenges the state of the art in waveform sources. So Hewlett-Packard's variable-transition pulse generator, with rise times in the 1-ns vicinity and repetition rates as high as 250 megahertz, is a welcome arrival.

What makes a variable-transition-time pulse generator so valuable is the fact that the propagation delay of an ECL device depends on transition time of the driving pulse. So it is important to apply pulses with specified transition times to check performance. Secondly, it is frequently necessary to measure component behavior within a circuit. With rise and fall times variable from 1 ns to 0.5 millisecond, the H-P 8082A can deliver the necessary pulse with the shape and transition times required. Pulse linearity is 5% or better for transition times of 5 ns or more.

Equally important to pulse shape and transition time is the source impedance. The 8082A is an excellent 50-ohm source, so that it may be connected directly to ECL circuits without a terminating resistor and with little degradation of the pulse shape. Since the reflection coefficient is a mere 2%, the generator absorbs 98% of any reflected wave.

Two BNC connectors provide complementary outputs. Two companion switches invert the outputs at the ports and switch signal excursions positive or negative. Both amplitudes and offsets at the output ports are variable, however, but setting the amplitude controls to ECL defeats the various controls and produces standard ECL voltage levels, -0.9 V and -1.7 V. Dc offset may be varied over ±2 V, pulse delay from 2 ns to 0.5 ms, and pulse width from 2 ns to 0.5 ms. Pulse period, delay, and width jitter is less than 0.1% of setting plus 50 picoseconds.

H-P engineers have simplified panel layout by placing pulse period, width and delay slide controls one above the other so as to avoid incompatible settings. The user need do no more than keep the width and delay controls to the left of the period control to assure meaningful settings.

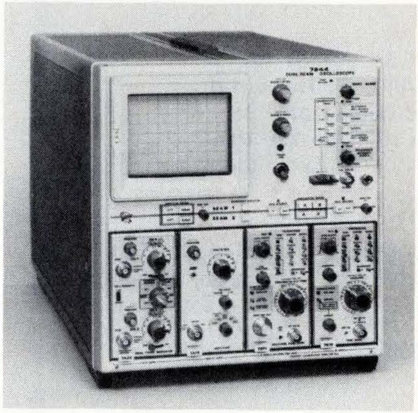
An unusual feature is a copper heat pipe which conducts heat from heat-producing components to a heat sink at the rear of the cabinet. Thus no forced-air moving device is necessary, the acoustic noise is gone, and so too are the narrow power-line frequency constraints imposed by a forced-air cooling device. Thus the pulse generator operates over an unusually broad power-line frequency range—48 to 440 hertz. Line voltage source levels are switch-selectable—100, 120, 220 and 240 volts.

The model 8082A generator is priced at $3,355 in the U.S.

Inquiries Manager, Hewlett-Packard Co., 1501 Rage Oill Rd., Ralo Clto, Cclif. [351†

Dual-beam oscilloscope offers 400-MHz bandwidth

A 400-MHz bandwidth, dual-beam oscilloscope is designed for analyzing simultaneous, fast, single-shot events or fast events occurring at very slow repetition rates. Called the 7844, the unit is essentially two oscilloscopes in one; both independently and simultaneously use the same cathode-ray-tube display. A second version, the R7844, is functionally identical to the 7844 but is installed in a 7-inch-high rackmount cabinet. The 7844 and R7844 have four compartments from which the user can select from more than 30 plug-ins to suit special requirements. The 7844/R7844 can also be combined with a wide range of input amplifiers to give varied bandwidths. The 7844 dual-beam mainframe sells for $5,900, and the rack-mounted R7844 sells for $6,000.



Tektronix, Box 500, Beaverton, Ore. 97005 [354]

Infrared thermometer checks board components

A portable, digital infrared thermometer, called the Heat Spy DHS series, provides instant non-contact surface-temperature measurements of circuit-board components as

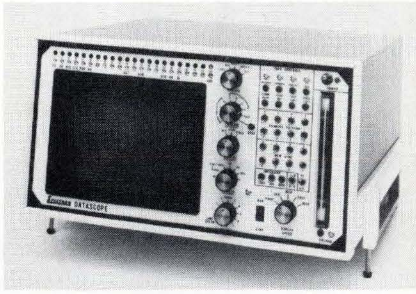
New products

small as 0.1 inch in diameter over a range of 0 to 600°F. Good for use during breadboarding, troubleshooting, and testing, the unit also measures the temperature of high-voltage components without contact, where conventional contact methods are impractical and dangerous. The exact target being measured is defined by a light beam, which shines precisely on the component under observation.

William Wahl Corp., 12908 Panama St., Los Angeles, Calif. 90066 [356]

Data monitor-tester checks line, equipment

Designated the Datascope, a portable test instrument for troubleshooting and monitoring data-com-



munications channels provides both a CRT display and a magnetic-tape recording of all line traffic at the business-machine (EIA RS-232-C) interface of any standard modem. The unit pinpoints problems in system hardware and software by showing what is sent and received. Errors caused by equipment malfunctions, incorrect programs-or

Our engineers have a way of dealing with supply shortages: Design around them.

Like everyone else, the wire and cable industry is feeling the crunch of short supply these days. Wire stranding and drawing capacity and petrochemical feed stocks have become common phrases.

It's one of the reasons we started our company-wide "Yes We Can" program. Asking all our employees to help minimize customer inconvenience. We think it's paying off for you.

Take the Product Engineering Department, for example. Our engineers are treating shortages as a challenge to their ingenuity. They've worked out alternate designs — shield constructions that save copper is just one example. Or they've recommended substitute insulations — available materials to replace hard-to-procure compounds. Without significantly changing product performance. With a relatively small increase — sometimes even a reduction — in original cost.

They've involved our Purchasing Department by asking them to locate new sources of supply. Searching throughout the world, if necessary, to find additional qualified and dependable vendors. And working closely with our long-term suppliers to insure their meeting our production needs.

Our engineers have kept in close contact with their customer counterparts. Keeping them informed of materials to be avoided because of scarcity, or suggesting possible substitutes. Helping them to write new wire and cable specs around available materials so that the products can be delivered in a reasonable time.

All told, we think our engineers are meeting the challenge. But then, so are our other employees who say, "Yes we can." That's the goal. We think their efforts are helping you. And we think they've made us a better company.

Brand-Rex Yes we can.

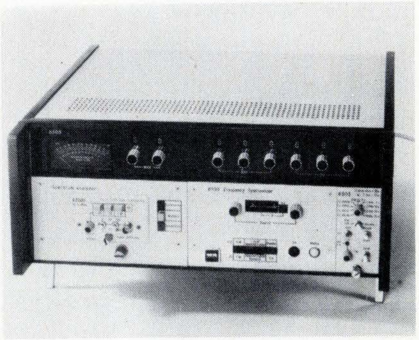
Willimantic, Conn. 06226

BRAND-REX CO. A PART OF Akzona INCORPORATED line trouble are visible, and little time is needed for isolating system problems. The Datascope may be left on line indefinitely to record and display data. Using an endless-loop tape, the last 40 minutes of traffic, at 2,400 bits/s is always maintained. During on-line operation, data is delivered simultaneously to the display and tape unit.

Spectron Corp., Moorestown, N.J. [357]

Spectrum analyzer doubles as frequency synthesizer

A spectrum analyzer, called the series 6000, is also designed to double as a frequency synthesizer. As a spectrum analyzer, it has fre-



quency ranges of 0 to 11 MHz and 10 to 110 MHz, with dynamic ranges of better than 120 dB and 100 dB, respectively. With the substitution of plug-in modules, the unit becomes an eight-digit, programable frequency synthesizer with a range of 10 kHz to 110 MHz and a resolution of 1 Hz (0.01 Hz optional). Accessory-function plug-ins provide a-m/fm-input provisions, sweeps and markers, and phase/frequency comparison, for example.

Adret Corp., 1887 Lititz Pike, Lancaster, Pa. 17601 [358]

Counter/printer works with positioning systems

A series of digital counter/printers, designed for use with positioning systems, coordinate-measuring machines, and plotting systems, features bidirectional counters for each

the price for moving up to a sweep/function generator just came down to $149.50

Circle 165 on reader service card

Exact now offers a laboratory-quality sweep/function generator at a price you'd pay for less-useful sine-square oscillators. And you'll get so much more out of the new Model 195 than traditional audio test equipment, such as sine, square, triangle and swept waveforms . . . even pulses.

This new 2 Hz to 200 kHz instrument is the practical answer to many of your signal source needs, whether you're checking audio equipment, testing bread-boarded circuits or teaching at the high school or college level.

An internal sweep generator lets you sweep, either linearly or logarithmically, the entire audio range of amplifiers or speakers without changing ranges or even touching a knob. The Model 195 has three 1000:1 sweep ranges for frequency sweeping plus high and low level sine outputs with amplitude control. Or you can control the frequency by an external voltage (VCF).

The Model 195 is completely portable, operated by a 9-volt transistor battery, so you can forget 60-Hertz hum problems altogether. An optional rechargeable power supply and charger permits continuous operation from Ni-Cad battery power.

This is a true instrument . . . developed by by one of the world's leading designers and manufacturers of laboratory function generators and frequency synthesizers. Find out what the Model 195 can do on *your* bench, and move up to a better source of signals.

Price: Model 195 $149.50
Optional rechargeable power supply, complete with battery and charger $25.00 f.o.b. Hillsboro, Oregon. Instruments stocked in 36 locations across the United States.

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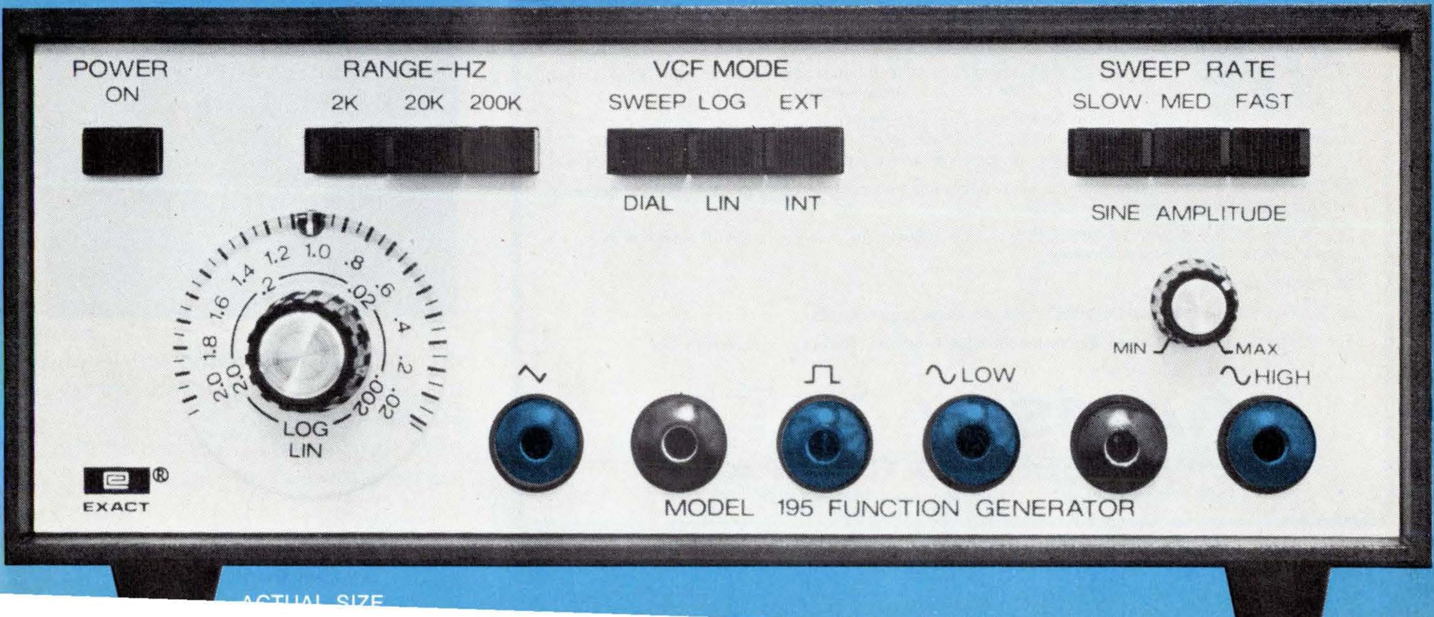
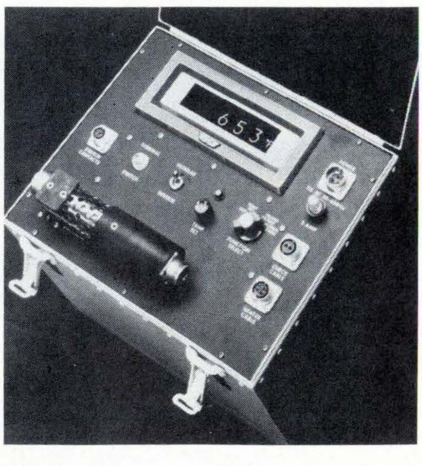


axis and the printer to read the data for each axis. The buffered outputs of each bidirectional counter are applied in parallel to the printer for all three axes (in a three-axis system). The printer contains circuitry to multiplex all three axes and to print them out, one underneath the other, with the appropriate axis symbol. It also features a three-digit presettable "item-sequence-number counter." This counter can be preset to some number other than zero. At the end of every print cycle, this counter is updated by one count. Price is $2,000.

Keltron Corp., 225 Crescent St., Waltham, Mass. 02154 [359]

Portable tester checks thermal sensors, systems

Thermal switches, thermocouples, and continuous-wire fire-detection systems can all be checked with the H262C Tempcal 2 thermal-sensor-tester. This portable unit saves time by testing and troubleshooting thermal sensors in their normal operating locations. The H262C uses a heater for up to 1650°F. This temperature is preset, and thereafter the probe is automatically controlled and monitored by solid-state, digital-indicator circuitry. For bench-type operation, the thermocouple or



thermal switch is connected to and its operation monitored on the H262C.

Howell Instruments, 3479 W. Vickery Blvd., Fort Worth, Texas 76107 [360]

If you're testing 1K RAM's or 4K RAM's without an MD-100 or MD-104...

YOU'RE KIDDING YOURSELF!

Reliability—With more than 300 stand-alone MD-100/104 systems in use throughout the world today, Macrodata has set the industry standards for memory testers—and these two systems still provide the only way you can test memories effectively and obtain valid data.

Pattern Sensitivity—If one of those "it's no problem" guys has been telling you that a few hardwired patterns are all you need to test RAM's, watch out! They have decided that RAM's aren't really pattern sensitive, so they don't bother to fully explore worst-case pattern conditions for these devices. They say that it's not necessary, but you know better.

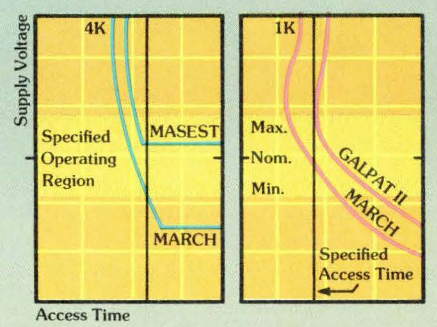
Pattern Sensitivity Tests

The adjacent curves are plots of individual device access times at different supply voltages. Each curve represents a different test pattern. Over the specified operating regions of the devices, these shmoo plots show the pattern sensitivities of the 1K and 4K RAMS. For example, while MARCH would make one think that the 4K device is operational, notice that the chip does not work during a portion of its MASEST curve. A MARCH test also indicates that the 1K device passes its access time specification at nominal voltage, but a GALPAT II test demonstrates much slower access time characteristics and that the 1K chip does not really pass at nominal voltage.

Here's Why You Need MD-100/104 Capability

Example #1: In a recent test, six devices from separate lots from the same manufacturer all failed under different unique patterns with identical set-up conditions of voltage, timing, etc.

Example #2: In another test, one device passed on all patterns for approximately 10 seconds and then failed due to heating problems. After being rehabilitated by coolant spray, the device again ran and passed until heat produced failure.



Example #3: For typical pattern sensitivity of 1K and 4K RAM's, see the chart of V. vs. Access Time.

Let's Make A Deal—If someone tells you that your semiconductor memory is not pattern sensitive and all you need are fixed patterns to solve your test problems, send your device to us for the moment of truth. If we're right, aren't you just kidding yourself until you get an MD-100/104 on line? For action, call or send for a free brochure today.

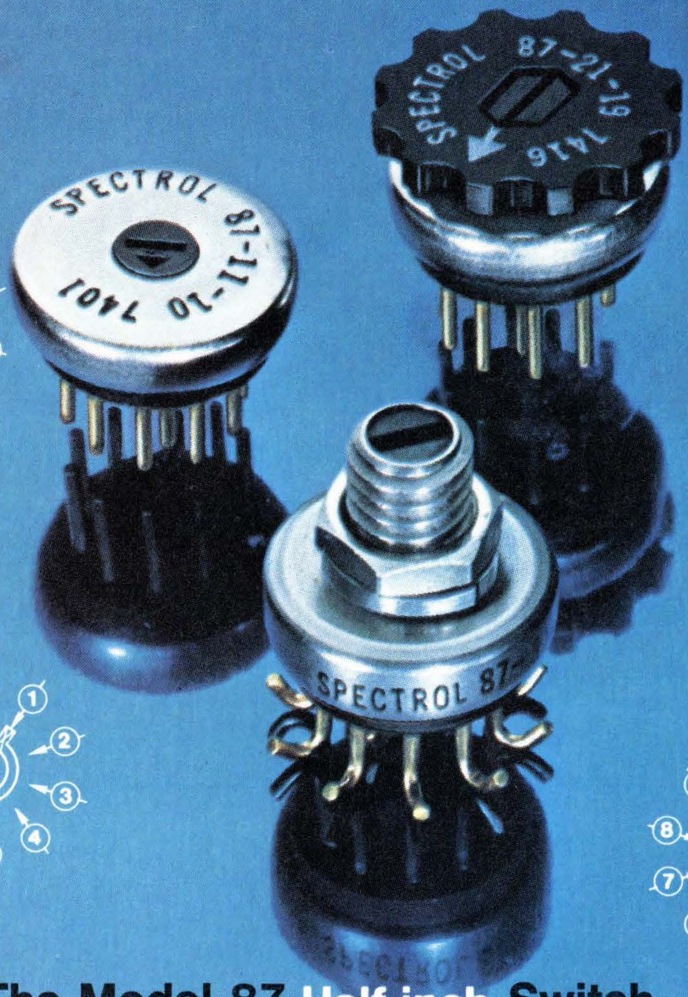
Macrodata

Macrodata Corporation, 6203 Variel Avenue, Woodland Hills, California 91364, Phone: (213) 887-5550, Telex: 65-1345

Sales Offices: *Northern California Area* Tel. (408) 735-9560 • *Scottsdale* Tel. (602) 966-2179 • *Minneapolis Area* Tel. (612) 454-2034 • *Chicago Area* Tel. (312) 297-8746 • *Cleveland Area* Tel. (216) 461-8333 • *Dayton Area* Tel. (513) 293-3145 • *East Coast* Tel. (516) 543-8600 **International:** *West Germany — Munich* Tel. (0811) 34 56 00 Telex: (841) 521-5969 • *Milan, Italy* Tel. 871-988/899-248 Telex: (843) 34314 • *Sweden and Norway — Stockholm* Tel. (08)-380-370 • *Tel Aviv, Israel* Tel. 25 55 69 • *Tokyo, Japan* Tel. (03) 985-5266 Telex: (781) 272-2171 • *Buckinghamshire, England* Tel. High Wycombe (0494) 36 3 81 Telex: (851) 837236

Circle 167 on reader service card

Christmas could come early for designers using this versatile switch from Spectrol...



The Model 87 Half-inch Switch

• Up to 3 poles and up to 10 positions — a total of 18 switching combinations to choose from • Mounts directly on a printed circuit board • Design versatility permits unlimited applications and many cost saving benefits: logic switching, internal switching device for optional equipment add-ons, test point switching, adapting main-frame computers to peripheral equipment, standardizing printed circuit boards, selecting operational voltages, selecting calibration resistors, etc. Send for literature, and ask about free samples.

Spectrol

SPECTROL ELECTRONICS GROUP

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UNITED KINGDOM Spectrol Reliance Ltd. Drakes Way, Swindon, Wiltshire, England • Swindon 21351 • TELEX: 44692

ITALY SP Elettronica spa Via Carlo Pisacane 7, 20016 Pero (Milan) Italy • 35 30 241 • TELEX: 36091

Circle 168 on reader service card

Data handling

CRT terminal is low-priced

Unit to sell for $900 in 100-lots; hard-copy output is optional

The computer industry's lowest-priced cathode-ray-tube terminal is the first new product from Digital Equipment Corp's new Components group [*Electronics*, June 13, p. 52)].

It's the VT-50 DECscope, priced at less than $900 each in quantities of 100. The terminal will also be offered in small quantities, but only by one of DEC's previous groups, since the Components group will deal only with large-volume customers. Small unit prices have not yet been determined, but judging from the quantity prices, the VT-50 will sell for about 10% less than any equivalent terminal now on the market.

The terminal, which has an ANSI standard keyboard, displays 12 lines of 80 characters each, from the 64-character standard Ascii set. It can be connected to communications lines operating as fast as 9,600 bits per second, at that rate, the screen fills completely in less than one second.

The key to the terminal's low cost is in DEC's approach to building it. CRT terminals are usually put together from subassemblies, such as TV monitors, keyboards, and so on, purchased from various suppliers. But DEC has designed the VT-50 to be assembled from basic electronic and mechanical components as simply and with as little labor as possible.

For example, component density is so low that insertion is easy, and heat is dissipated through normal air convection without fans. Besides reducing cost, lack of fans also reduces the amount of power drawn by the terminal and makes it practically noiseless while in use. Furthermore, the enclosure is injection-molded plastic; although this requires expensive tooling, it is cheap in large volumes.

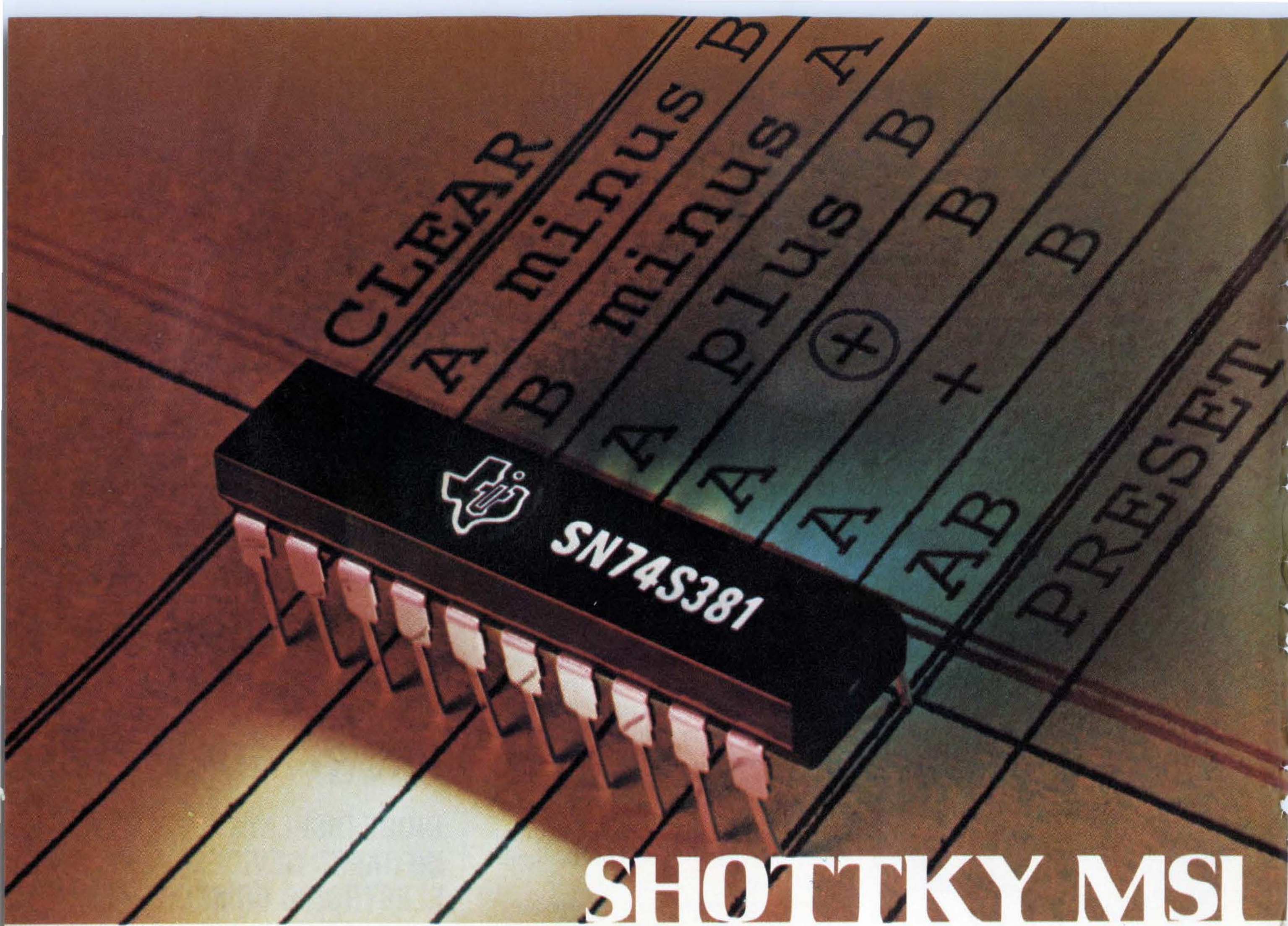
An optional copier, integral with the terminal, can produce hard copy of the data displayed at any time. The electrolytic printer has a raised helical ridge on a rotating drum that scans the width of a strip of special paper. An electric arc, controlled by the displayed data, darkens the paper to form characters in a 5-by-7 matrix.

The principle is the same as that used in many types of facsimile machines.

Digital Equipment Corp., Components Group, 1 Iron Way, Marlboro, Mass. 01752 (After July 1) [361]

Tape eraser handles reels, cartridges, cassettes

Designed for erasing magnetic tape, including digital-cassette type up to ¼-inch wide, a universal hand-held



A mini-ALU.

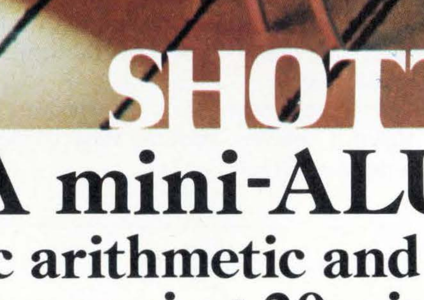
Delivering basic arithmetic and a little Boolean. ...in a space-saving 20-pin package.

TI's new SN74S381 4-bit binary ALU gives you the most useful arithmetic/logic functions in a compact 20-pin, 300-mil-wide plastic package – offering up to a 58% reduction in p-c board area when compared to current 24-pin functions.

And, the 74S381's versatile three-port architecture features full-carry look-ahead. This makes it a basic building block for high density, high performance digital processors in any multiple of 4-bits.

Arithmetic operations include addition and subtraction, (A minus B) and (B minus A) without external manipulation of operands.

Logic operations are: AND. OR. Exclusive OR. Also,



CLEAR (set to minimum) and PRESET (set to maximum).

Couple this functional versatility with a 16-bit typical add time of 25 ns (using a 74S182 look-ahead), a 100-999 piece price of $4.40, and you have efficiency plus economy.

The SN74S381N is available from your local authorized TI distributor or from TI directly. For data sheets indicate by type number and write: Texas Instruments Incorporated, P. O. Box 5012, M/S 308, Dallas, Texas 75222.

TEXAS INSTRUMENTS
INCORPORATED

83064

bulk eraser, called the model R24017, can be used for reel-to-reel, cassette and eight-track cartridge tapes, and for computer and other professional applications using up to ¼ in. tape. A handle permits moving the eraser across the reel or cartridge, obliterating the recording in a matter of seconds without having to rewind tape. Background noise is reduced below normal erase-head level. Operation is at 110–120 V, 4 A, 50-60 Hz ac. The model R24017 measures only 4 by 2¼ inches. It is priced at $26.50.

Robins Industries Corp., 75 Austin Blvd., Commack, N.Y. 11725 [364]

Miniature tape drive uses 3M cartridge

The model 600 digital tape drive, which occupies 3⅛ by 7 inches of panel space and which may be

mounted in any plane, uses the 3M data cartridge as the tape medium. Moreover, the tape drive is compatible with proposed ANSI and ECMA specifications. Designed to meet both OEM needs and end-user applications, the 600 is offered both with and without the electronics. Digital data is recorded on ¼-inch tape in up to four tracks, written at a density of 1,600 bits/inch, phase-encoded, at 30 inches/second. This results in a data-transfer rate of 48,000 bits/s. The 600 operates at 90 in./s in bidirectional high-speed search. Price starts at less than $300.

Quantex, 200 Terminal Dr., Plainview, N.Y. 11803 [363]

Tablet/cursor's resolution is 1,000 lines per inch

The model 200 graphics-input table is provided as a separate package, along with a cursor, for converting drawings, maps, and other data into digital signals for input to a display, memory, or CPU for processing. The package is designed for use with digitizing electronics. The tablet features resolutions up to 1,000 lines per inch, and holds errors to ±0.005 inch. The model 200 tablets are available in sizes from 11 by 11 in. to 36 by 48 in. Prices range from $2,000 to $6,500.

Electrak Corp., 16634 Oakmont Ave., Gaithersburg, Md. 20760 [366]

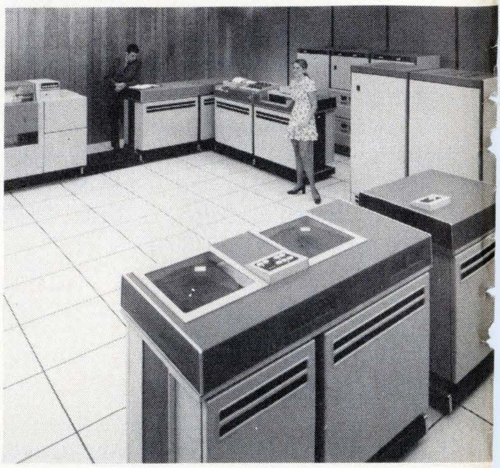
Tape reader operates to 300 characters/second

A medium-speed photoelectric tape reader, called the model R2000, offers bidirectional reading speeds to 300 characters per second continuously, and up to 200 characters per second asynchronously. The R2000 uses a deep-socket reading technique that reads tapes with up to 60% transmissivity. This technique also allows read-head exposure to ambient light with no effect on the reading. The unit reads 5-, 7- and 8-level tapes interchangeably. A direct-drive sprocket capstan also minimizes edge guidance, tape drag, skew, and wear problems. Prices in a single quantity start at $546.

Tally Corp., 8301 S. 180th St., Kent, Wash. 98031 [367]

Two computer systems added to Century line

Two new members of the Century series computers are the Century 151, a low-cost, high-performance computer with MOS memory, and the Century 201, a high-performance on-line system with multiprograming capabilities and large-capacity files. The 151 offers full hardware and software compatibility with larger Century computers. The basic Century 151 has a 32,000-



word memory which can be expanded to 128,000 words. Cycle time is 750 nanoseconds, with each cycle reading or writing up to three bytes of data. Price is $133,695, and rental is $2,675 a month on a five-year contract. The Century 201, which offers multiprograming and a memory-access time of 650 nanoseconds is priced at $300,000 or can be rented for $5,525 per month.

The National Cash Register Co., Dayton, Ohio 45479 [365]

Graphic data digitizer can use ordinary pen

The model E241 graphic-data digitizer is designed so that the user places graphic source material, such as a strip chart, map or photograph, on the Orthoplex sensor, then pressure from a ball point pen or any similar stylus causes the instrument to generate the X and Y coordinates of the contact point. Other features include a seven-segment digital display for the X-Y coordinate values and slanted working surface for easy access to the coordinate positions. The model E241 can be used as a stand-alone digitizer with independently selectable X-Y zero and scale

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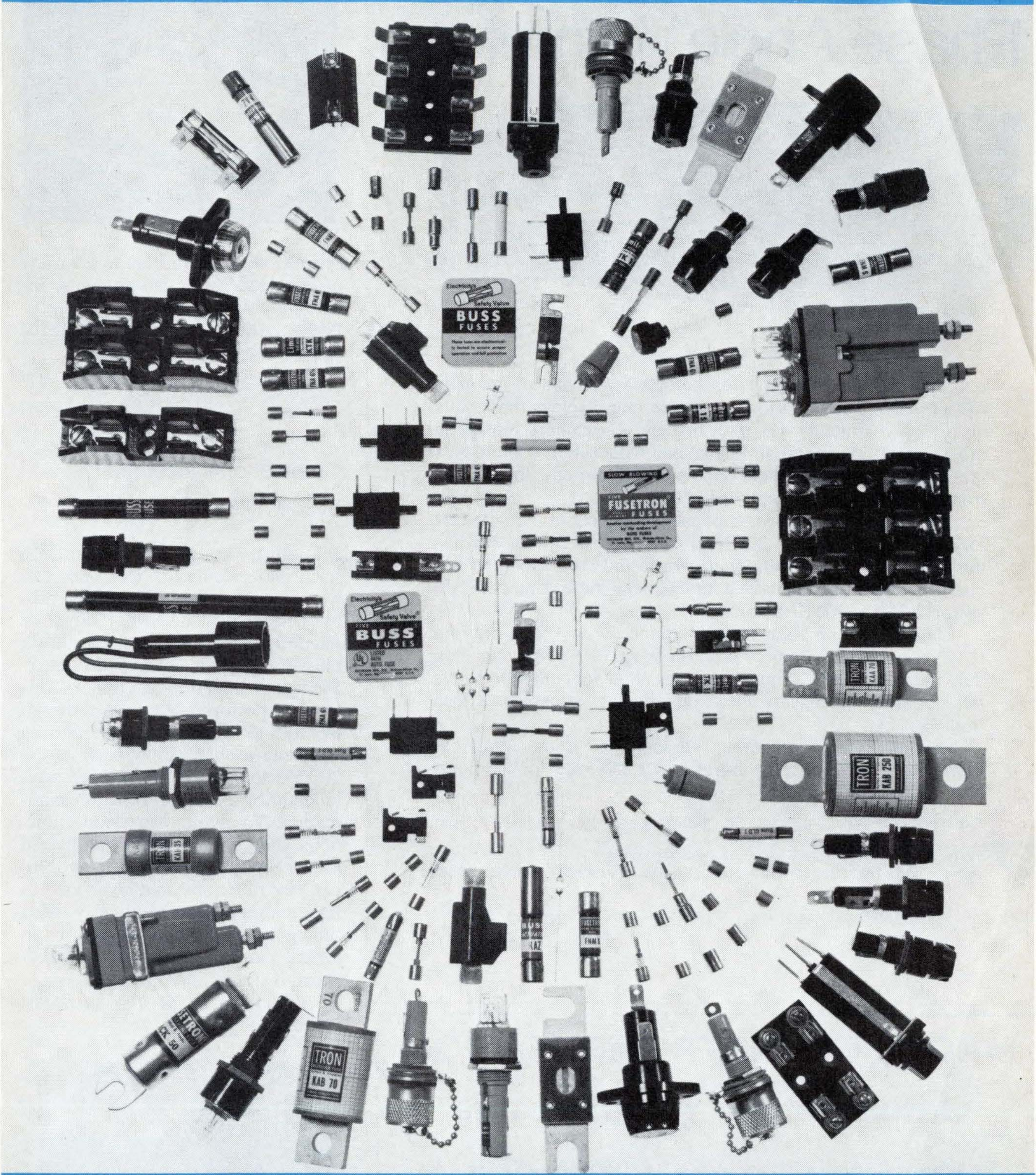

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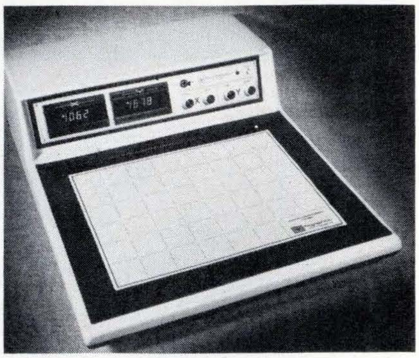


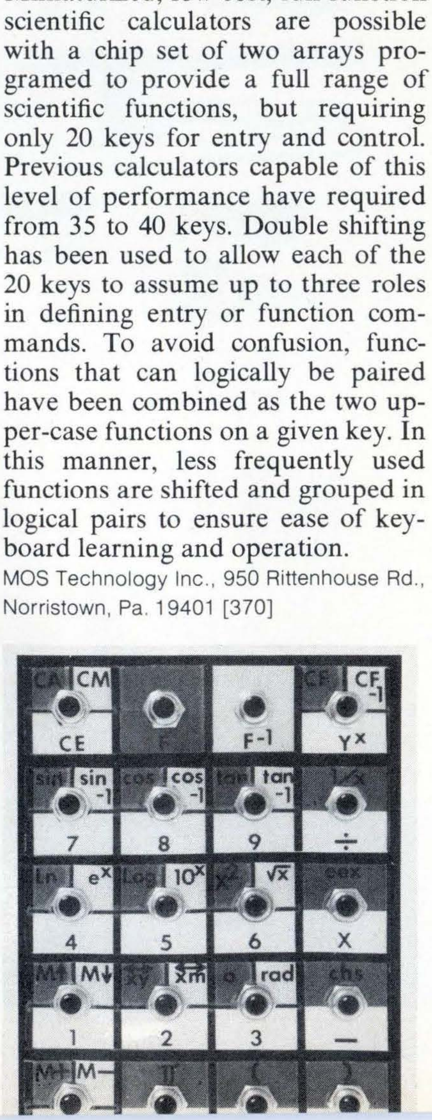
settings, or be connected to a variety of data-processing instruments, including several widely used calculators. Additional interface cards can be inserted.

Elographics Inc., 1976 Oak Ridge Turnpike, Oak Ridge, Tenn. 37830 [368]

Chip set cuts size, cost of scientific calculator

Miniaturized, low cost, full-function scientific calculators are possible with a chip set of two arrays programed to provide a full range of scientific functions, but requiring only 20 keys for entry and control. Previous calculators capable of this level of performance have required from 35 to 40 keys. Double shifting has been used to allow each of the 20 keys to assume up to three roles in defining entry or function commands. To avoid confusion, functions that can logically be paired have been combined as the two upper-case functions on a given key. In this manner, less frequently used functions are shifted and grouped in logical pairs to ensure ease of keyboard learning and operation.

MOS Technology Inc., 950 Rittenhouse Rd., Norristown, Pa. 19401 [370]



A flexcircuit for the "Silent 700."

We did it for Texas Instruments.

The "Silent 700.*" A powerful improvement over data terminals using conventional paper tape and noisy impact printers.

To help keep the Model 733 ASR teletypewriter silent, Texas Instruments needed a way to provide 42 conductors between the thermal print head and its electronics. And to do it without using a bulky, stiff, relatively heavy 42-conductor cable.

A Schjeldahl flexcircuit was the answer.

Dynamic characteristics of this application dictate a requirement for one million flexes without conductor failure. This called for conductors, insulation and adhesive to be something more than ordinary materials.

For improved reflow soldering of closely spaced connections, pad areas are electrolytically plated. And the flexcircuit had to be producible in volume.

An almost continuously flexing flexcircuit. Schjeldahl did it for Texas Instruments.

Schjeldahl Company
Electrical Products Division
Northfield, Minnesota 55057
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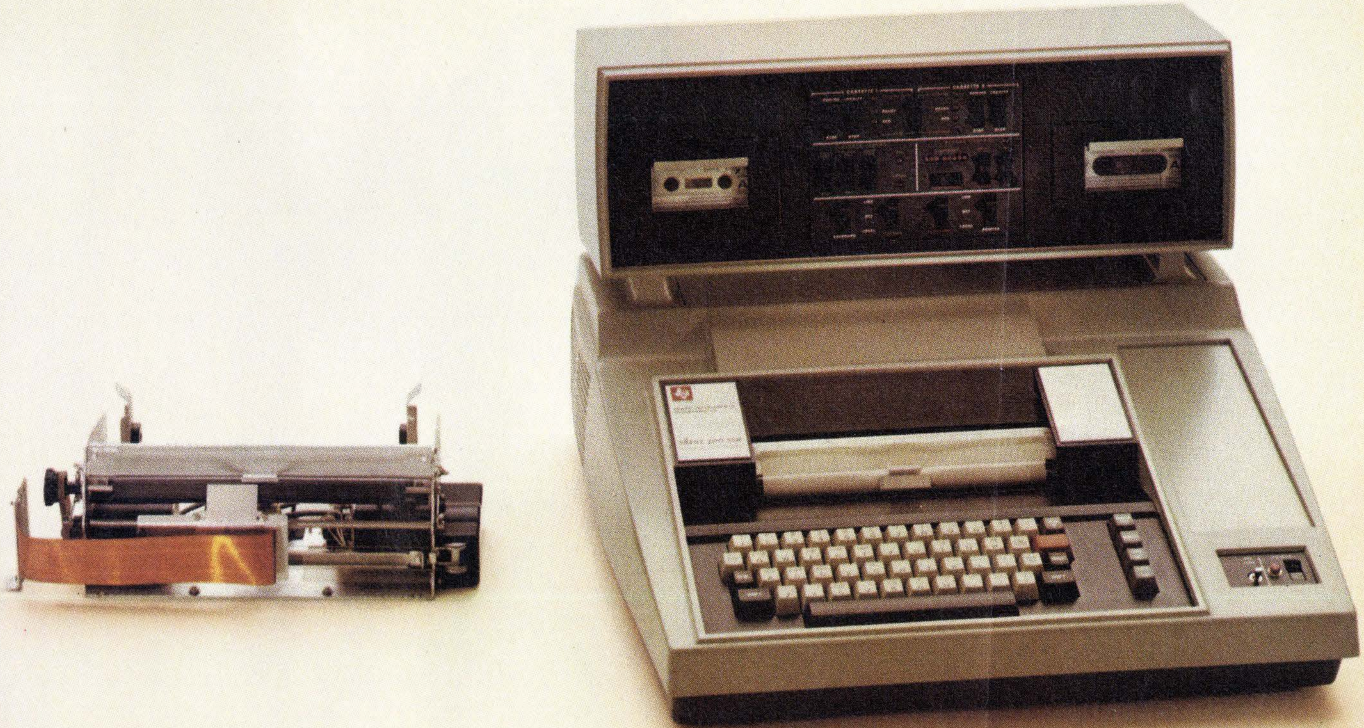
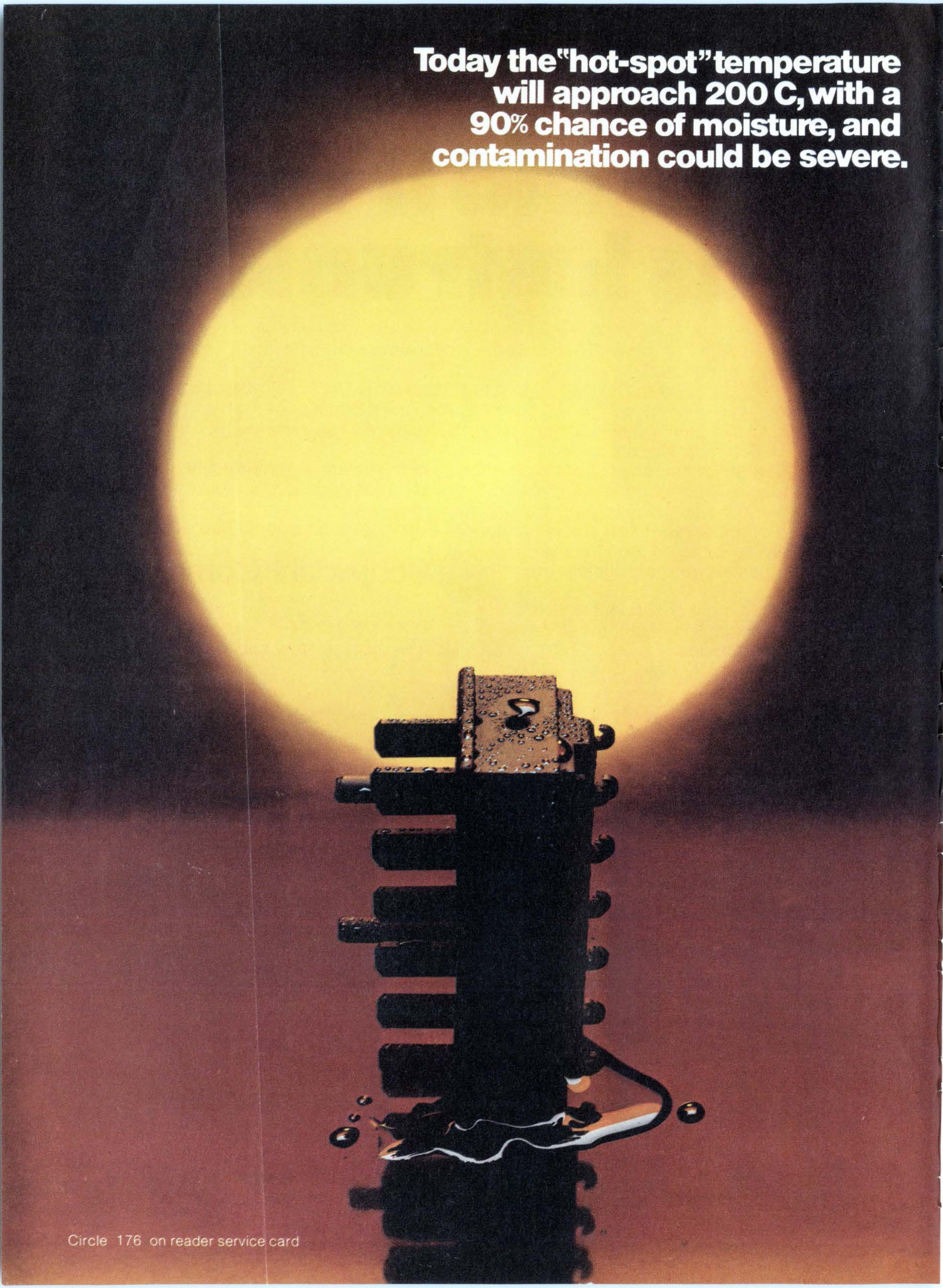
The state of the art people in volume flexible circuits



And we can do it for you.

*Trademark of Texas Instruments Incorporated

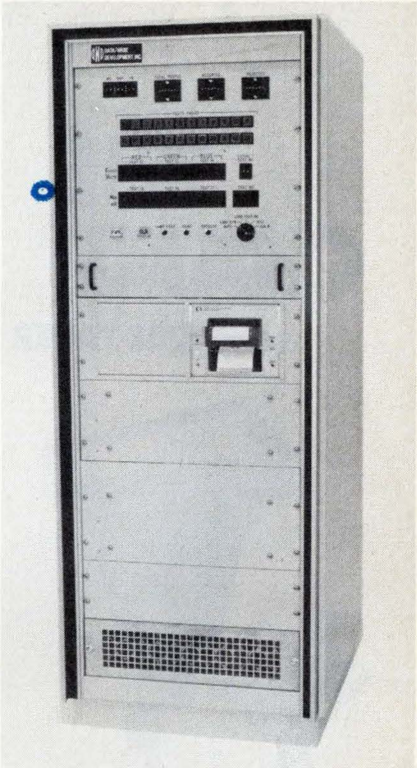
Circle 175 on reader service card


Today the "hot-spot" temperature will approach 200 C, with a 90% chance of moisture, and contamination could be severe.
Circle 176 on reader service card

Packaging & production

Microprocessor controls tester

Chip set can program system to check out virtually any device



Because they are much lower in cost and complexity than minicomputers, microprocessors are spurring the development of reasonably priced automatic test systems. One of the latest is a system, the model 400, developed by Data/Ware Development Corp. for in-factory tests. The company has delivered one to Sony Corp. of America for testing color-TV tubes, and the system, which is completely automatic, has many other uses, particularly in checkout of devices.

The test is organized in a familiar manner for automated checkout. An Intel MCS-4 microprocessor chip set controls the input/output buffer, which, in turn, programs and controls power supplies, measuring instruments and a relay matrix. To the MCS-4 are added both read-only and random-access memory. Both fixed and programable sources can be used; the filament voltage for the tubes can be fixed, for example.

This system provides for programing the points at which forcing voltages are applied to the unit under test, the voltage values, the measurement points, and the measurement-current scale. Proper selection of these parameters adopts the model 400 to almost any device to be tested, says Data/Ware vice president Dale V. Schmidt.

In checking color-TV tubes, each gets more than 20 different tests, results are compared to preselected limits, and go/no-go indication is provided. Results for the test are printed, along with the serial number of the tube tested.

The model 400 can contain multiple power supplies, providing maximum outputs of 1,000 volts and power of 100 watts. Measurements are made by a programable digital ammeter that is accurate to within 0.1% and has ranges of 1 microampere to 2 amperes, full scale. The relay matrix uses 32 double-pole, double-throw, telephone-type relays.

Go/no-go signals, LED digital readouts, audible alarm, and a 10-column printer are among the outputs. Programs are stored in ROMs, each containing 4,096 words, which can be changed as desired.

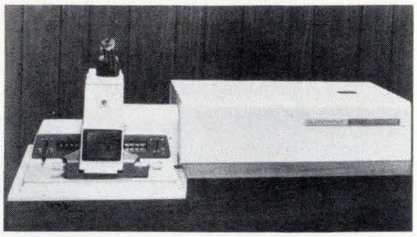
Price and availability of the system depend on the specific capabilities required.

Data/Ware Development Corp., 11585 Sorrento Valley Rd., San Diego, Calif. 92121 [391]

Laser scribing system runs at 48 strokes/minute

A semiautomatic scribing machine, which uses a laser to create accurately edged kerfs, is called the Laserscribe Mini. It scribes silicon, germanium, gallium arsenide, gallium phosphide and related semiconductor materials. The mechanical/electrical components of a dia-

New products



mond-scribing machine and viewing and focusing optics are also offered. The Laserscribe Mini can scribe a 2.0-mil depth at maximum speed with a typical kerf width of 1 mil; scribing speed is typically 48 strokes per minute. The Laserscribe Mini costs $15,750 when the user provides his own Tempress Model 1713C Diamond Scribe, or $19,750 if the unit must be supplied.

Quantronix, 225 Engineers Rd., Smithtown, New York 11787 [393]

Circuit board checker handles 250,000 tests/s

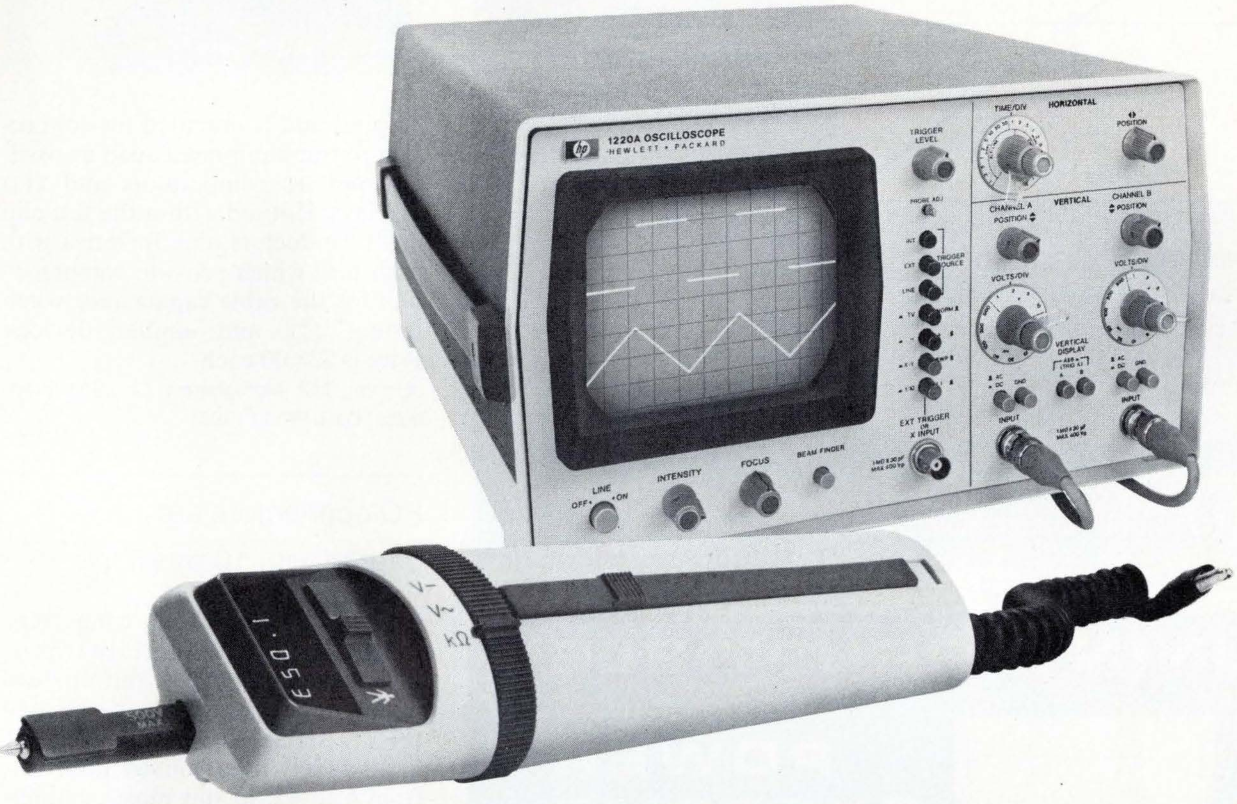
Designed for low-volume production operation, the Datatester 4400 computer-controlled, semi-automatic circuit board test system can also be used as a trouble-shooting and repair station. The system's processor provides a stored program, which permits the testing of boards, devices, and entire modules with the patterns and timing needed for functional tests, in addition to testing of LSI boards and devices, and sequential logic boards. The system handles all sequential functional testing by outputs of any digital logic circuit having up to 1,000 inputs. It performs 250,000 tests per second and requires a maximum of five seconds per output for test count response. Price is $6,475, and delivery time is 60 days.

Data Test Corp., 2450 Whitman Rd., Concord, Calif. 94518 [394]

Test clip works with 16-pin IC packages

The A23-2115 test clip, combined with one meter of 16-core cable is suitable for IC packages with up to

Get Less For Your Money.



Get a pair of HP basic test instruments that give you less—less measurement hassle because they're so easy to use. Less downtime because they're all solid-state. Less weight and bulk because this scope and probe multimeter were designed to be part of your lightweight travel kit.

Imagine a 3½-digit probe multimeter that is completely self contained, weighs only seven ounces, fits in the palm of your hand—and so advanced it AUTO ranges, AUTO zeros, and has AUTO polarity. It's practically foolproof. Completely portable. And it's absolutely unique—there's nothing else like it anywhere. At any price. And it's just $310*. That's a surprisingly low price for a state-of-the-art instrument built to HP's most exacting standards.

Or get our bright, full 5-inch diagonal display oscilloscope that gives you a whole lot less of those squinting, guessing, knob-tweaking measurements you'd just as soon do without. It's a dual channel, 15 MHz lightweight (only 15 pounds) with the sensitivity, accuracy, and big-scope conveniences most troubleshooters are likely to need. And best of all, it sells for only $695*.

There you are, a top-quality scope and probe multimeter for a lot less money. They're backed by HP's reputation and worldwide service and support facilities. So why gamble? There's less chance of error when you get your measurement instruments from the measurement leader. To get the full story on our 970A probe multimeter or the 1220A oscilloscope, just fill out and return the coupon.

*Domestic U.S.A. prices only.

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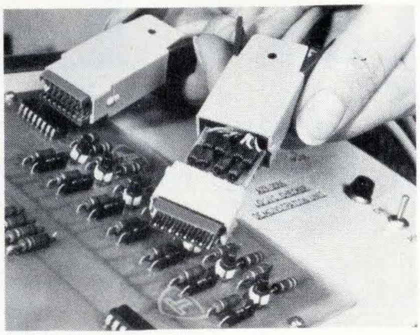

16 pins, and is intended for connection to test equipment such as oscilloscopes, IC comparators and LED displays. Housed within the test clip are 16 inductors, one in series with each pin, which provide compensation for the cable capacitance when testing TTL and similar devices. Price is $38.00 each.

Jermyn, 712 Montgomery St., San Francisco, Calif. 94111 [395]

PC connectors are offered with 10 positions

A line of printed-circuit connectors, featuring solder terminations, folded ribbon contacts and tin/lead plating (as an option) is designated the 117 series. The unit is available in 10 widely used contact positions, from 6 to 43, to suit most commercial requirements. The solder-termination feature provides for flush installation on printed-circuit boards measuring from 0.054- to 0.071-in. thick.

Amphenol Industrial division, 1830 South 54th Ave., Chicago, Illinois 60650 [396]

IC pattern board built for rugged environments

Designated the modular universal integrated-circuit pattern board, Series 11, a pluggable wire-wrap circuit board offers low profile, high-density design and hard-mounted pin connectors, which make it suitable for difficult environments, including military applications. The board also offers up to 150 IC positions and 120 input-output connectors. It is suitable for use in any size

If your printed wiring can't stand the heat, switch to Norplex G-30.

Ordinary laminates just can't take the extreme temperatures generated by high density electronic systems.

But Norplex G-30 is no ordinary copper-clad laminate/ prepreg material. It's a woven glass impregnated with polyimide resin, which assures you an outstanding combination of processing and operating characteristics.

For example, its exceptional heat resistance permits continuous operating temperatures in the 400°-500° F. range. G-30 gives you unexcelled dimensional stability, flexural strength and processability. In multilayer applications, it also eliminates the smearing of resin during hole drilling, and minimizes cracking of plated-through holes.

Thus, Norplex G-30 performs with unequalled excellence in such demanding applications as aerospace electronics, computers, and communications equipment.

Send coupon for our brochure on G-30 glass-polyimide, a new breakthrough in circuit technology. Or phone: 608/784-6070.

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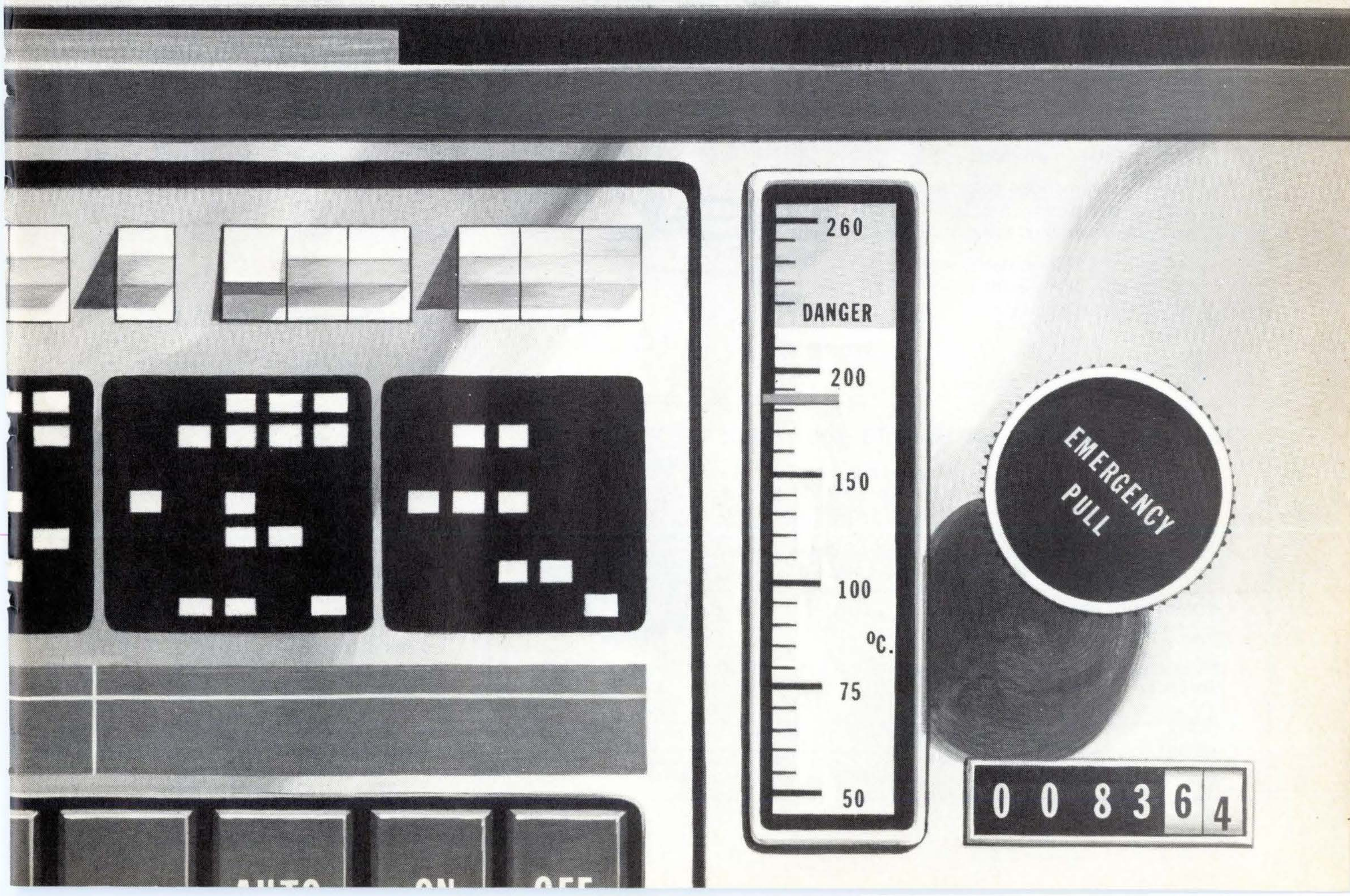
Title____________________

Company____________________

Address____________________

City__________ State________ Zip________

Circle 181 on reader service card

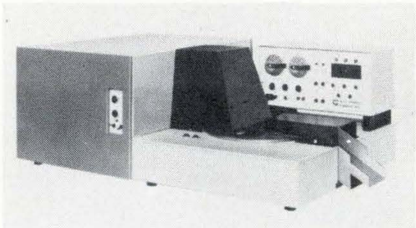


production-run from breadboarding to manufacture of thousands of units.

Garry Manufacturing Company, 1010 Jersey Avenue, New Brunswick, N.J. 08901 [397]

Thick-film trimmer also tests, sorts in one operation

An automatic abrasive thick-film trimmer, designated Model MT-200 Auto Trimmer, tests, trims and sorts in one operation. After initial setup, all the operator need do is load the machine, the rest is automatically done at rates from 2,000 to 2,500 trims per hour. The Auto Trimmer first tests for resistance value, resis-

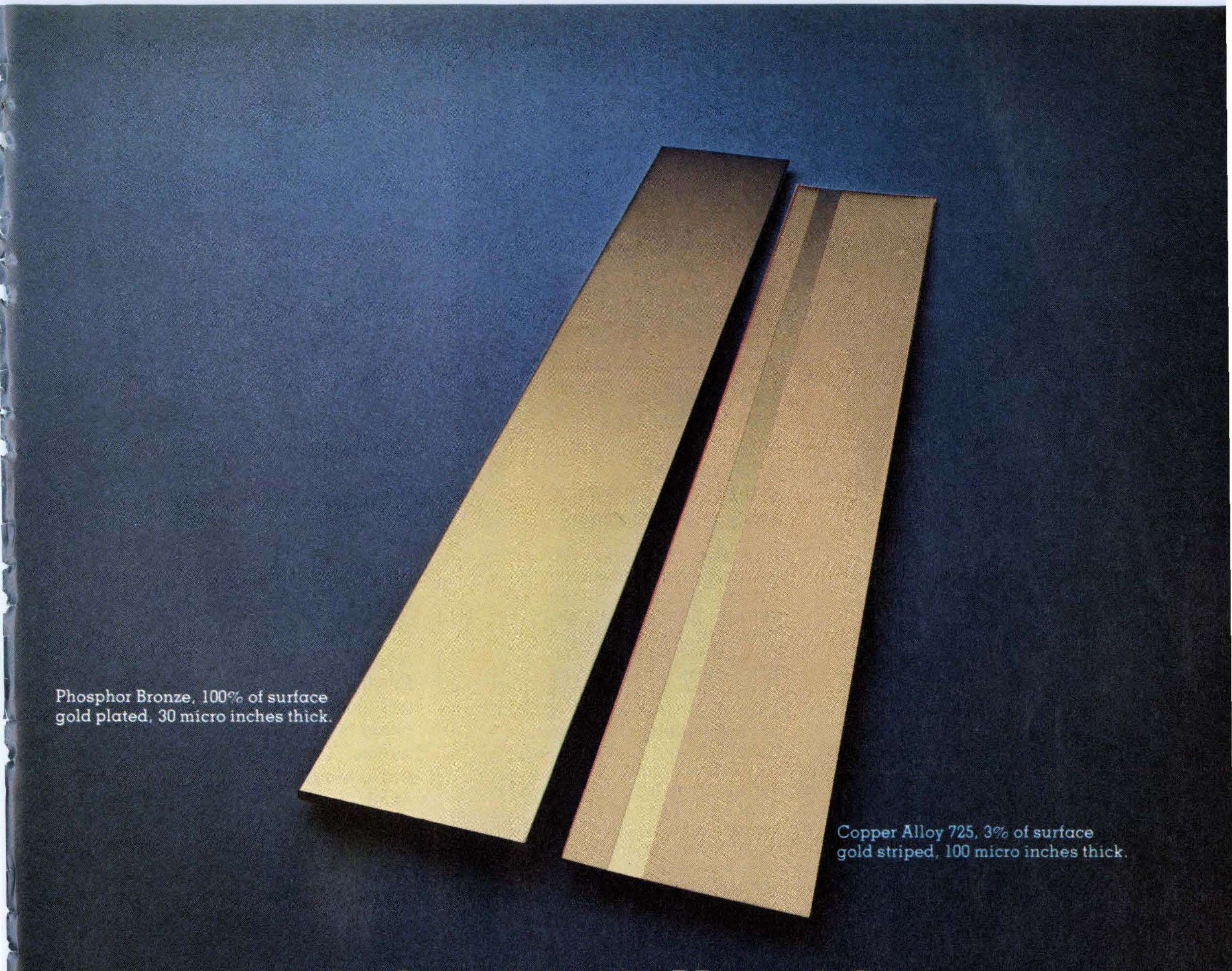


tors above or below predetermined values are rejected, and then it trims the acceptable resistors to 0.1% of specified value. The substrates are then off-loaded automatically down either a "reject" or "good" chute. Price is $10,400.

Comco Inc., 9421 Telfair Ave., Sun Valley, Calif. 91352 [398]

Ceramic caster produces 6-inch tape continuously

The model 103 ceramic caster is developed primarily for casting thin sheets of ceramic for multilayer-ceramic capacitor manufacture. From an organic slurry, the model 103 continuously casts 3- to 6-inch-wide tape on a polyethylene or polypropylene carrier at speeds of up to 30 feet per minute. Ceramic thicknesses range from 0.0005 to 0.005 inch. The ceramic/binder slurry dries as it winds through a self-contained 30-foot spiral path onto a central take-up reel. The model 103



Cut gold plating 90% on contact springs with CA-725.

CA-725 is the copper-base spring alloy that is rapidly becoming the standard of the electronics industry. Bare CA-725 has outstanding wrap-resistance stability. It's easy to solder and has good corrosion resistance without gold plating. Some gold is still used for resistance stability in critical circuits. But can be concentrated only where you need it... at the contact points.

That means proven cost reductions: Actual experience has confirmed CA-725's ability to cut gold plating by 90%. This substantially reduces the cost of the finished part even with increased gold thickness at the contact points. One main frame-connector user reports bare CA-725 connector springs with heavier gold at the contact points outlasted former springs by 10 times in wear tests.

Stay ahead of your competition: Copper Alloy 725 is rapidly gaining acceptance with the largest electronic component users. You should know more about it. It is available from your regular brass and copper suppliers. Gold-striped material is available from composite metal producers. Call them today. Or write to Dept. 7173, The International Nickel Company, Inc., One New York Plaza, New York, N.Y. 10004.

The amount of gold you save depends on your design. Here is our calculation for an average-size connector spring:

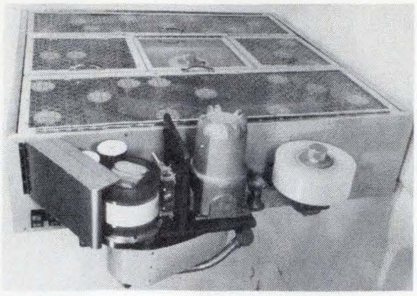
Design	Spring Alloy	Gold Plating Thickness Micro Inches At Contact	Overall	Relative Amount of Gold Required
Overall plating	CA-510 (Phosphor Bronze)	30	30	10
Stripe	CA-725	100	Bare	1

INCO

THE INTERNATIONAL NICKEL COMPANY, INC. ONE NEW YORK PLAZA, NEW YORK, N.Y. 10004

Circle 183 on reader service card

New products

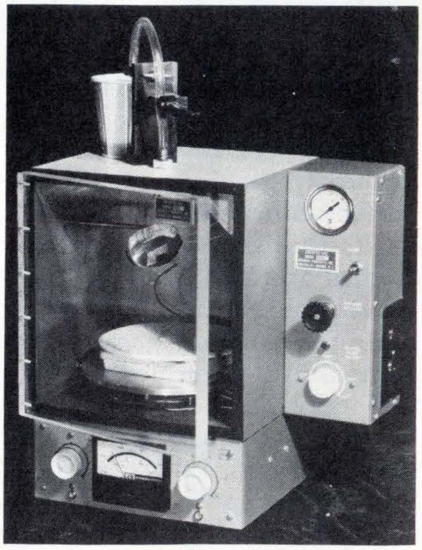


is priced at $18,000 to $20,000, depending on options.

Cladan Inc., 11404 Sorrento Valley Rd., San Diego, California 92121 [399]

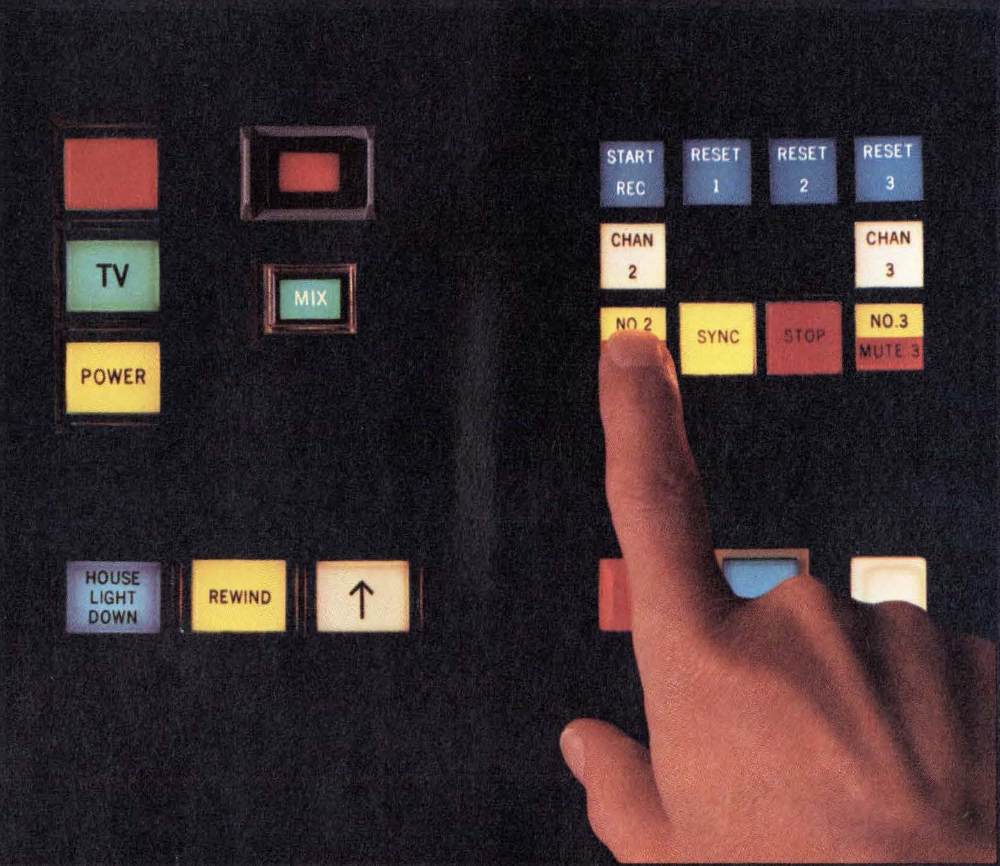
Encapsulators offer heater plate, vibration

A line of vacuum encapsulators, the Encapsu-Vac 4010 series, specifically designed for curing epoxies, offers both heat and vibration techniques. The heater plate, which is SCR-controlled, permits heating the mold to allow curing of the plastic inside the chamber. The encapsulator also has a vacuum oven that maintains temperatures of 125°C maximum continuously. In addition, a vibration capability operates when epoxies are poured into the mold cavities. The amplitude of vibration has a separate SCR-controlled adjustment. Three models are price at from $1,425 to $2,225.



Aremco Products, Inc., P.O. Box 429 Ossining, New York 10562 [400]

Industrial designers like the way they look. Engineers like the way they work.



MAIN PHOTO:
Series 3 (right) and Series 4 (left)

LOWER PHOTO:
Series 4, (left) lowest cost, all three energy levels, snap-in mount.

Series 2, (back) with modular design, up to 4 lamps and 4 poles, military versions.

Series 1, (right) with bushing mount, panel seal, military versions.

Series 3, (front) the smallest in our line, with snap-in or matrix mount.

If you've got a particular idea about what a lighted pushbutton should look like, we've got four important numbers for you: Series 1, 2, 3 and 4.

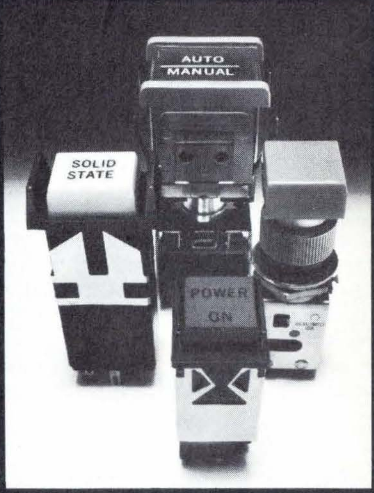
They represent one of the biggest selections of lighted pushbuttons in the world.

So you get to choose from a long list of options, depending upon the switch you select. Like buttons available in popular, highly consistent colors. Either transmitted or projected. Legending includes hot stamp, engraved or film insert, with an optional hidden legend available. Barriers and housings come in a choice of colors. Lighting is single or multiple lamp. Mounting either single unit, strip or matrix. You can also choose between round or square configurations, and most of them offer front-of-panel relamping without tools.

But your choice doesn't end at the front of the panel. In back of the button, there are three energy levels available—solid-state, low-energy and power. You can choose among solder, quick-connect, P.C. board mount or screw terminals. They're all U.L. and C.S.A. listed, with military-listed variations available. Circuitry can be single-pole, single-throw through four-pole, double-throw. With momentary or alternate action.

And, even though each of the four Series has its own particular advantages, they all have one thing in common: the kind of reliability you'd expect from the company that pioneered lighted pushbutton switches.

If you'd like more information on any or all of the MICRO SWITCH lighted pushbuttons, call toll-free 800/645-9200 (in N. Y. 516/294-0990, collect) for the name of your nearest Branch Office or Authorized Distributor.



MICRO SWITCH

FREEPORT, ILLINOIS 61032

A DIVISION OF HONEYWELL

MICRO SWITCH products are available worldwide through Honeywell International.

Circle 185 on reader service card

Subassemblies

Converters give high resolution

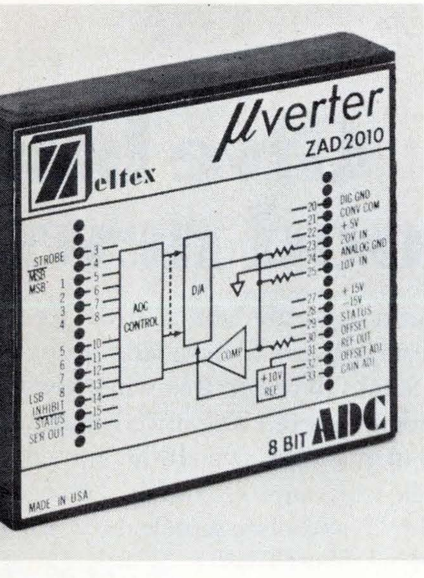
Analog-to-digital units also offer fast conversion time at low prices

In analog-to-digital converters, high resolution and speed don't usually go along with low prices, but such is the case with two families of devices developed by Zeltex Inc.

One family is the 3000 series, with 13- and 14-bit resolution and with speeds up to 40 kilohertz. The other is the 2000 series of eight-bit devices with a full-conversion time of 8 microseconds.

Both groups use thick-film resistor networks and also make use of digital large-scale-integration technology in a novel circuit configuration that incorporates the successive-approximation technique of conversion.

The model ZAD3014 is a 14-bit, 35-microsecond device that is accurate to within 0.005% and sells for $249 for a single unit. The ZAD3013, which is pin-compatible, offers 13-bit resolution, a conversion time of 25 microseconds, and accuracy to within 0.01%. This model is priced at $229. Both of these models in the 3000 series offer four user-selectable input voltage ranges (0 to +5, 0 to +10, ±10, and −10 volts) and three codes (binary, offset binary and 2s complement). The units are packaged in DIP-compatible modules that measure 1.98 by 3.6 by 0.4 inches.



In the 2000 series, the ZAD2010 is a fully militarized model offering eight-bit resolution and an 8-microsecond conversion time over the range from −55°C to +125°C. The ZAD2000 is a commercial version of the same device and is intended for applications where small size and low price are required. Both models in the series are housed in the Zeltex μverter package that measures 1.76 by 1.98 by 0.4 in.

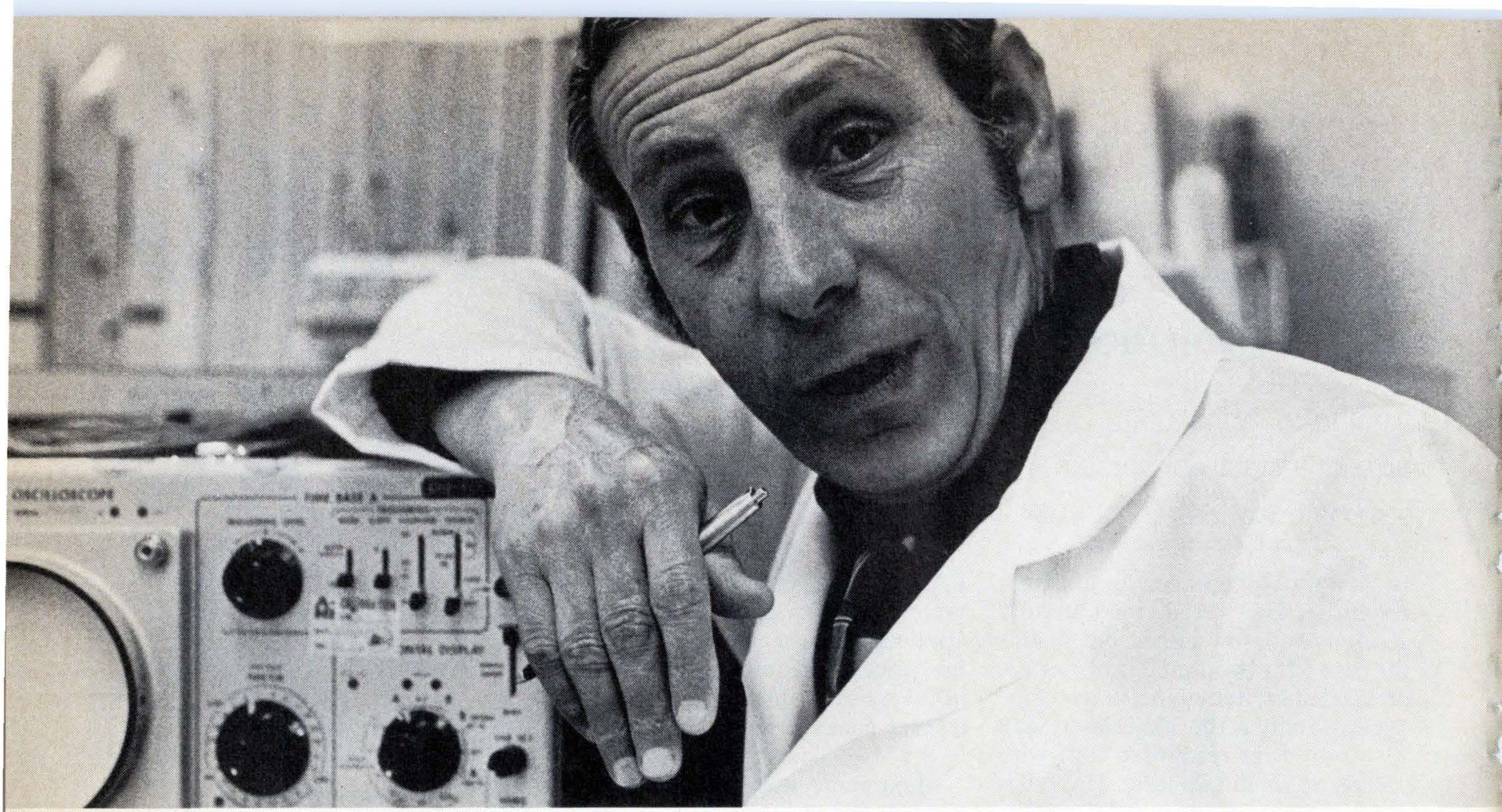
Maximum user flexibility has been designed into the 2000 series, the company says. Four input ranges are built in and are selected by external jumpers. The units are DIP-compatible and can be mounted into sockets or on printed-circuit boards. The commercial model sells for $59 in single units, and the military version for $95. Delivery time for both is two weeks.

Zeltex Inc., 1000 Chalomar Rd., Concord, Calif. 94520 [391]

Thin-film resistor networks put in dual in-line housings

Allen-Bradley Co., Milwaukee, has extended its thin-film resistor technology into a standard line of precision thin-film resistor networks in dual-in-line packages. Previously available in flat pack and chip circuits, the networks are built from integrated films of chromium cobalt vacuum-deposited on glass substrates. Interconnections are metal film, and the lead frame provides a mechanical and soldered junction.

Package configurations include standard 14-, 16-, 20-, and 24-pin DIPs, with package widths of 0.300, 0.600, and 0.900 inch. Resistance range of the network is from 1,000 ohms to 10 megohms standard, with 10 Ω to 50 MΩ available on special order. Resistor tolerances are as low as ± 0.01%, and resistance matching



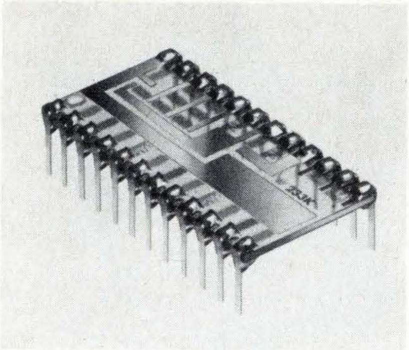
"Okay, okay. You tell me where we can find twenty thousand RAMs a week for that much less than the 2102 and I'll tell you where to find the Easter bunny."

Give him the good news:

You can find all the 1K RAMs you need right now—right here at AMI. We have 4006, 4008 and 4008-9 RAMs ready for immediate delivery. They're pin-for-pin with Mostek's. But you can get more of ours—faster. (Stands to reason that when you have larger production facilities you can produce more.) The price is right, too. For example, the 4008-9 is yours for just $3.50 in quantities over 1000. You get the advantages of a 2102 system, while saving a bundle with our 4006 family. You can get an application note on how to do it, and a free sample, by writing to Frank Rittiman, AMI, 3800 Homestead Road, Santa Clara, CA 95051. Phone: (408) 255-3651. Or ask your distributor.

AMI®
AMERICAN MICROSYSTEMS, INC.

Circle 188 on reader service card



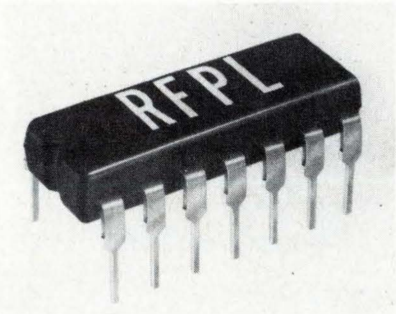
is as low as ± 0.005% at 25°C. Temperature coefficient of resistance is ±25 ppm/°C, or as low as ±5 ppm/°C; TCR tracking is ±5 ppm/°C standard.

In addition, power rating is 50 milliwatts per resistor, although the firm will provide up to 250 mw per resistor on custom orders. Delivery on standard networks is less than 6 weeks; custom orders take 8-10 weeks. Prices of the resistor networks range from $5 to $50, depending on specifications.

Allen-Bradley Co., 1201 S. Second St., Milwaukee, Wis. 53204. [382]

Signal processors are available in DIP form

A family of rf signal processing components, housed in 14-pin dual in-line packages, are compatible with standard DIP devices used in logic and dc circuitry. Four units, priced at $9.50 each for 10 to 49 pieces, are offered. The devices are the model FD-1 series wideband miniature frequency doubler, the

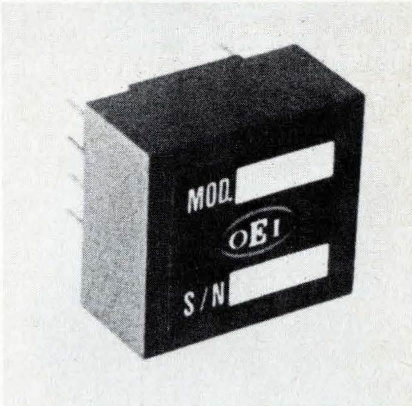


DBM-14 double balanced mixer, the 2PD-5 miniature broadband rf power divider/combiner, and the DC-14 series miniature broadband bidirectional coupler. The FD-1 for example, offers a 5-to-500-megahertz input frequency range and a 10- to 1,000-MHz output frequency range. Input power is + 10 dBm.

Rf Power Labs Inc., 11013 118th Place, N.E. Kirkland, Wash. 98033 [383]

Op amp settles to 0.1% in less than 50 nanoseconds

The model 9823 op amp provides a settling time to 0.1% in less than 50 nanoseconds. The 9823 is intended for use with current-output devices such as digital-to-analog converters, photodiodes, ion gauges and photomultiplier tubes. Further, the 9823 features fully differential input and may also be used in general-purpose wide-band applications in non-in-



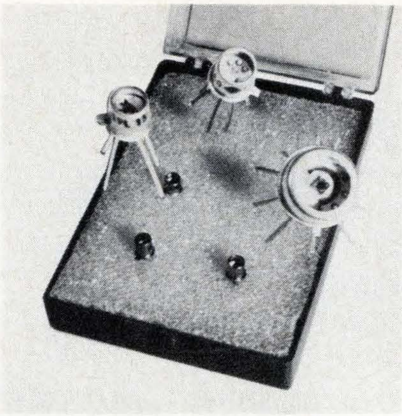
verting, inverting and differential circuits. Other features include a minimum slewing rate of 30 volts per microsecond and a 75-megahertz minimum gain-bandwidth product. Price is $66 each for 1-2, $59.50 each for 3-9, and $54 each for 10-29 pieces.

Optical Electronics Inc., Box 11140, Tucson, Ariz. 85734. [385]

Design kit provides opto-electronic aids

An opto-electronic design kit intended to aid designers of devices for industrial control, instrumentation, monitoring, inspection, and gaging, consists of six opto-elec-

New products



tronic switches and other devices, together with a 96-page illustrated circuit design handbook on how to use them in a diverse range of applications. The six solid-state devices combine advanced photosensitive silicon elements (both LED- and filament-responsive) with C-MOS technology, to provide integrated buffer amplifiers, adjustable-threshold triggers and light-to-frequency converters. Price is $75.

Integrated Photomatrix Inc., 1101 Bristol Rd., Mountainside, N.J. 07092 [386]

Dual delay module provides delays of 10 to 1,000 ns

An ECL/TTL-compatible, pc-board-mounted programable dual delay module provides output pulses within 1 ns of digitally-selected nominal times in a range of 10 ns to 1,000 ns after trigger. The unit is designed to trigger on ECL/TTL positive or negative edges, and programing is accomplished by three decades of remotely generated BCD inputs for the control of each of two independently timed ECL/TTL outputs.

Technitrol Inc., 1952 E. Allegheny Ave., Philadelphia, Pa. 19134 [389]

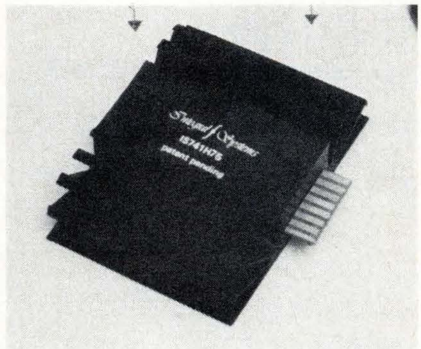
Power-supply modules allow variable design

Expanding the SM series sub-modular power supply line, 10 new low-voltage models incorporate a "building block" concept, which is said to combine the benefits of multiple-output design and single-output modularity. The basic building block is a sub-modular power supply with built-in rectifier, filter, regulator, protective circuits and exclusive logic-inhibit function. Other building blocks include an ac transformer, heat sink assemblies and protective thermostats. The new models, designated -050, cover the range of 4.20 V to 4.75 V or 0.16 A to 75 A and are for use in low-voltage applications such as memories, solid-state optical devices, and emitter-coupled logic. The new units, which range in price from $10 to $175, require no external components for adjustments.

Powertec Inc., 9168 DeSoto Ave., Chatsworth, Calif. 91311 [388]

Op amp handles audio and servo applications

The IS741H75 operational amplifier with a 75-watt output is designed for audio and servo power applications. The unit is a cast hybrid, thermally compensated true differential amplifier joioed to a heat sink. Continuous rms currents of 5 amperes can be maintained at the output, and loads as low as 1.0 ohm can be safely driven. The power supply pins are rated ±45 volts. In addition, output short-circuit protection, a 3 MHz unity-gain bandwidth, 60 db open-loop gain, and single-supply compatibility are also

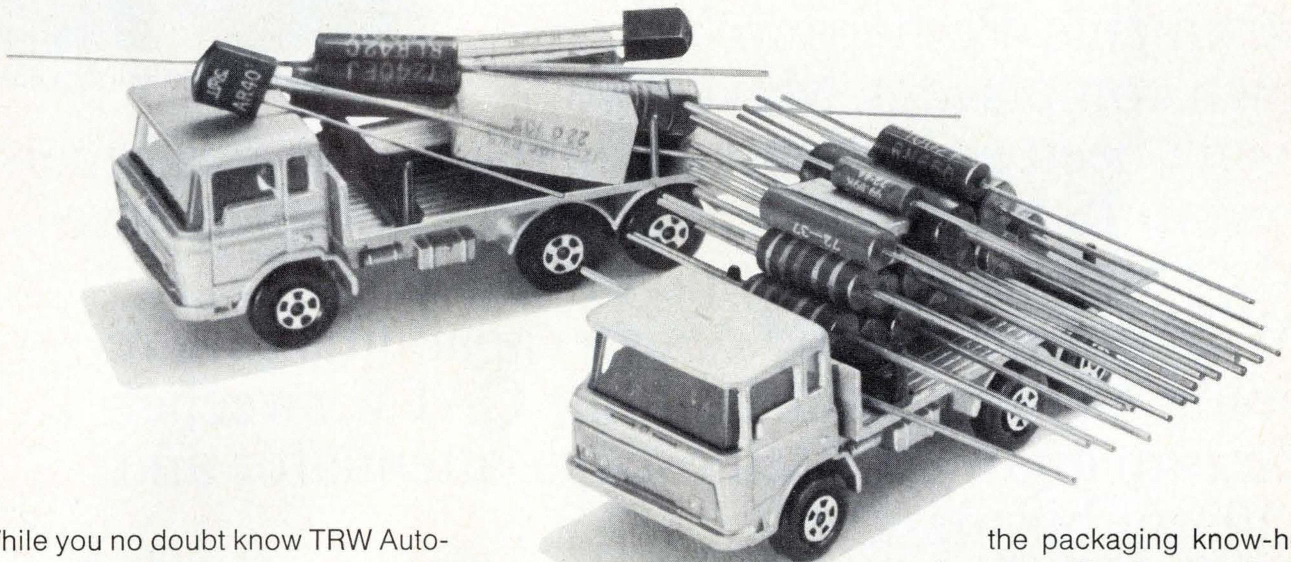


features. Price is $25 each in 100-lots

Integral Systems, 500 Walthan St., N. Wilmington, Mass. 01887 [387]

You know TRW for chassis and engine parts.

But do you know our resistor capability?



While you no doubt know TRW Automotive Worldwide, you may *not* know TRW/IRC—the resistor branch of the family.

TRW/IRC offers the broadest line of fixed resistors in the business—used by the *billions* in consumer, industrial, and military applications. This is a total resistor technology: carbon comp.'s, Metal Glaze™, wirewound, thin-film, networks, strips, and resistive functions for specific applications. We can give you *any* of the proven technologies, at reliability levels to meet automotive demands.

In fact, our resistors are already designed into automotive safety devices, electronic controls, ignition systems, fuel injection, adaptive brake systems and, of course, AM and FM radios, and mobile communications equipment.

TRW/IRC offers a high-volume, multi-source (four domestic plants) production capability. *Plus* the packaging know-how for cost-effective interfacing with your assembly equipment. So get to know us. Send for the TRW/IRC Resistors Catalog. TRW/IRC Resistors, an Electronic Components Division of TRW, Inc., Greenway Road, Boone, N.C. 28607. (704) 264-8861.

TRW/IRC Fixed Resistors
Greenway Rd., Boone, N.C. 28607

Please send your latest catalog on TRW/IRC Resistors for Automotive Applications

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Company ______

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TRW® IRC RESISTORS

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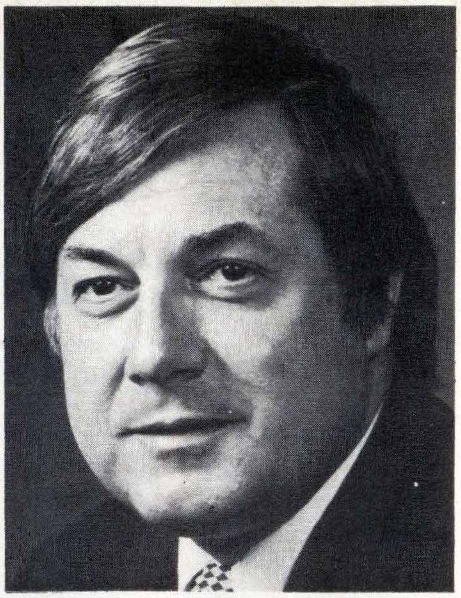

Carl Pehlke, President and Chairman

In fact, we've got a lot of great instruments. Perhaps we've grown complacent. Maybe we haven't been ardent enough in telling our customers Texscan IS the world leader, with a complete line and a single source that no other has.

With our design and design capabilities, we're coming on even stronger in the CATV, sweeper, spectrum analyzer, oscilloscope, attenuator and oscillator business.

We'll be telling you more later. For now, though, why is Texscan *the* leading supplier? For openers, take a look at the chart below:

	Number of Models		
PRODUCT	**TEXSCAN**	**TELONIC**	**WAVETEK**
Laboratory Sweep Generators	26	8	7
Spectrum Analyzers	6	0	0
Display Oscilloscopes	3	3	1
Attenuators	83	18	8
Oscillators	149	0	0
Filter types	8	6	0

Based on latest catalog information

Texscan

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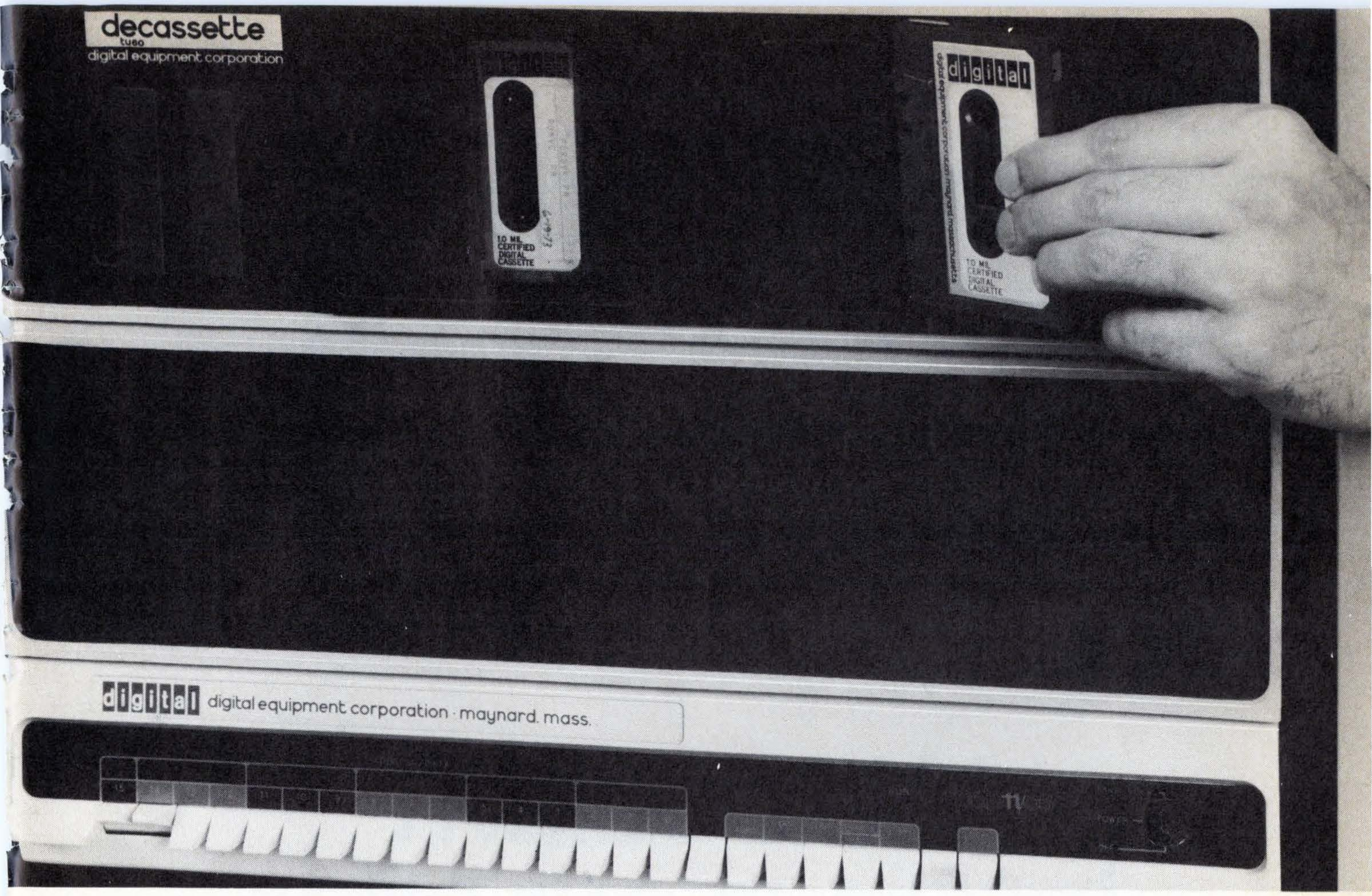

Wherever Digital computers are, Digital cassettes are going.

Digital's dual magnetic tape cassettes aren't everywhere yet. But wherever Digital PDP-8 and PDP-11's are used, DECcassettes are rolling.

That's because DECcassettes are the first truly reliable alternative to paper tape. Digital's own 1 mil tape with heavy mylar backing guards against tape failure. A special reel-to-reel drive design extends the life of tape performance. And single track recording coupled with error checking circuits protects against intrusion of noisy external signals.

Yet, with all these features, a DECcassette costs less than paper tape. And 15% less than other cassette-type systems. The single-unit price before liberal OEM quantity discounts is only $2990.

Every DECcassette is also supported with the diagnostics and systems software you need to get your research, development, monitoring, data communications and other applications running in a minimum amount of time.

For stand-alone systems, CAPS-8 and CAPS-11 give you the convenience of a magnetic tape resident programming system and the adaptability of a paper tape system.

Editor, relocating assembler, linker, debugger and file utility routines, combined with a concise, easy-to-use command language and a standard cassette file structure, enables easy extension of the system, too.

Operating systems software such as DOS/BATCH-11, RT-11 and OS-8 come complete with handlers that support the DECcassette. COMTEX-11 communications executive and other types of applications software are available on cassettes, thus eliminating the need for other more costly input devices.

Now you know why wherever Digital computers are, Digital cassettes are going.

Check into one yourself, whether you need a total system or just the drive itself.

Once you do, you'll be rolling, too. Delivery 30 days after receipt of order.

Call or write for complete information, Digital Equipment Corporation, Maynard, Mass. 01754. (617) 897-5111, Ext. 2949. European headquarters: 81 route de l'Aire, 1211 Geneva 26. Tel: 42 79 50. Digital Equipment of Canada Ltd., P.O. Box 11500 Ottawa, Ontario, K2H 8K8 (613) 592-5111.

digital

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We improved our micro resist.

New KODAK Micro Resist 747 is the purest, most stringently controlled resist we've ever made.

It's filtered to a value of 0.5 micrometer, and there are less than 10 parts per million of metal ions. (Less than three parts per million each of sodium, lithium, potassium, tin, or gold.) Viscosity and solids are also closely controlled.

And there are processing solutions of equally high quality: KODAK Micro Resist Developer, Thinner, and Rinse. All of which help you get more uniform coatings and better process reliability. And *that* means economy.

There's convenience, as well. This negative-working resist comes in four ready-to-use viscosity grades: 30, 45, 60, and 110 centistokes.

We couldn't improve our offer.

Technical assistance.

We'd be pleased to share our experience in microelectronics with you. As a start, why not send for the comprehensive six-page data sheet on KODAK Micro Resist 747? Or have a representative demonstrate it for you. Either way, just use the coupon.

Kodak

Eastman Kodak Company PHF
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☐ Please have a representative demonstrate KODAK Micro Resist 747.

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For information on sales outside the U.S. and Canada, contact the International Photographic Division, Eastman Kodak Company, Rochester, N.Y. 14650, U.S.A.

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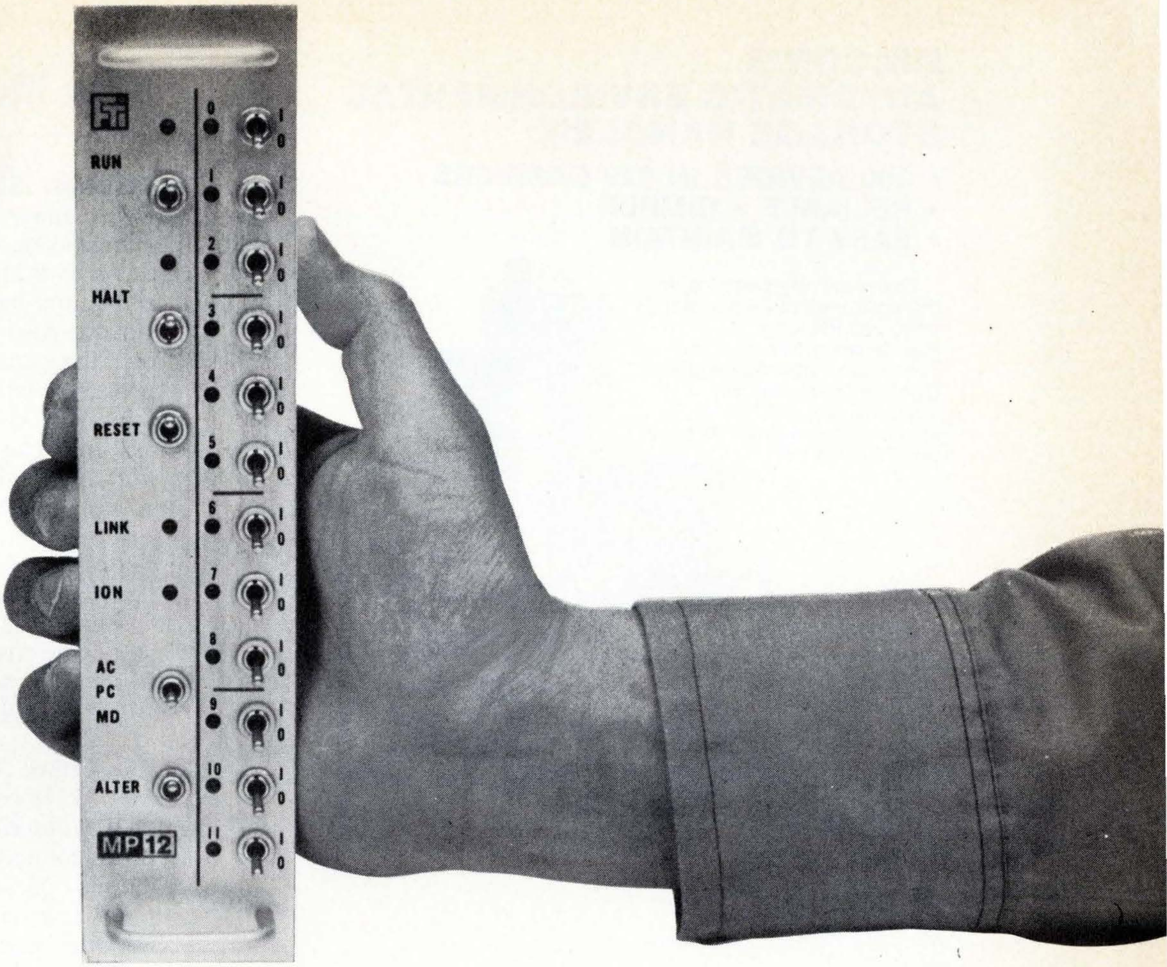

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It's the MP12 . . . Fabri-Tek's new microprocessor that performs like a minicomputer. The MP12 helps you get your application system up and running faster, easier and with more capability than ever before. No MOS microprocessor can match its performance in data acquisition, automated assembly, point-of-sale and other dedicated digital control applications.

Completely Operational—The MP12 CPU is a completely self-contained operational unit. All the digital electronics you need are built in along with 4K of reliable core memory, an operating console, power fail-auto restart and more. Everything comes in a compact 2.0" x 9.5" x 15.0" package.

Supporting Software—You also get all the software you need to develop and check out your own application programs. MP12 supplied programs are completely documented and include assembler, debug, loaders, 360/370 cross-assembler, source edit utility, processor diagnostic and utility sub-routines. Instruction set is PDP-8 compatible.

Easy Interfacing—You never had a processor so easy to interface. In fact, it's plug-in easy. The MP12 comes with all the timing and control necessary to interface with almost any peripheral. And it has enough power to drive up to 64 peripherals . . . printers, teletypes, CRT's, card equipment, on and off-line storage devices.

Quick Delivery, Low Price—There's a lot more you'll like about Fabri-Tek's MP12. Delivery and price, for instance. It's available for off-the-shelf delivery for as little as $990 in quantities of 100. It can actually help you cut your overall manufacturing costs.

The MP12 could be the most useful component you've ever seen. For complete specifications and option information just write to MP12 at the address below.

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New literature

Resistors. Electro-Science Laboratories Inc., 1601 Sherman Ave., Pennsauken, N.J. 08110. Product bulletin #31-74 covers a low-cost, ruthenium-based, low-firing resistor system. Also discussed are complementing conductive, dielectric, and protective-coating compositions for thick-film circuits, multilayer MSI, and LSI arrays using low-cost soda-lime-glass substrates. Circle 421 on reader service card.

Socket hand tool. A hand tool for inserting sockets into electronic circuit boards is described in a bulletin available from Garry Manufacturing Co., 1010 Jersey Ave., New Brunswick, N.J. 08901. [422]

Connectors. A catalog from Malco, 5150 W. Roosevelt Rd., Chicago, Ill. 60650, describes high-density cylindrical connectors called the MARC-43 and -53 series. General descriptions, test data, descriptions of accessories, and modifications are also provided in the 21-page booklet. [423]

Power supplies. Optical Radiation Corp., 1090 Lousons Rd., Union, N.J. 07083. Xenon point-source lamps and power supplies are discussed in a brochure containing mechanical and electrical data, polar plots, brightness-distribution information, and spectral-irradiation charts. [424]

Temperature controllers. Thermo Electric, Saddle Brook, N.J. 07662, has published a catalog on solid-state output relays to switch 2, 10, 25, and 40 amperes at 240 volts ac with the Half-Size 100 and 100 series temperature controllers. [425]

Variable-resistance components. An updated short-form catalog from Bourns Inc., 1200 Columbia Ave., Riverside, Calif. 92505, contains information on the Trimpot product line, which includes potentiometers, controls, and variable resistors. [426]

Thermoplastic polyester. General Electric Plastics Business Department, 1 Plastics Ave., Pittsfield, Mass. 01201. A 16-page brochure

describes insulating and packaging capabilities of Valox resin, a thermoplastic polyester for connectors and integrated circuits. [427]

Photosensitive devices. Hamamatsu Corp., 120 Wood Ave., Middlesex, N.J. 08846. A brochure provides detailed specifications on more than 100 types of photosensitive devices, such as photomultipliers, phototubes, photoconductive cells, light sources, memory tubes, and video equipment. [428]

Interconnecting. An expanded series of interconnecting leads and hermetic connectors for high-voltage applications is described in catalog #73-218 from AMP's Capitron division, Elizabethtown, Pa. [429]

Access control. The line of Identi-Logic electronic access-control systems is described in a 16-page catalog from Eaton Corp., Box 25288, Charlotte, N.C. 28212. These control systems provide security at building-access points. [423]

Diamond-scribing. A 68-page manual from American Coldset Corp., Semiconductor Tool division, 529 Fifth Ave., New York, N.Y. 10017, describes diamond-scribing tools and processes for use with semiconductor wafers. [431]

Memory chip. Nortec Electronics Corp., 3697 Tahoe Way, Santa Clara, Calif. 95051, has issued a brochure giving information on seven random-access memories, two read-only memories and four shift registers. Photographs and specifications are provided. [432]

Photomultiplier. A 36-page publication from Emitronics Inc., Gencom division, 80 Express St., Plainview, N.Y. 11803, gives drawings and specifications on more than 70 photomultiplier tubes. [433]

Frequency multiplexing. Frequency-multiplexing electronics to expand tape-recorder capability is described in a bulletin from Tri-Com Inc., 12216 Parklawn Dr., Rockville, Md. 20852 [434]


What you can't see can hurt you.
Unless you have mass, atomic-absorption, infrared and X-ray spectrographs, scanning and transmission-electron microscopes, scanning electron microprobes, X-ray fluorescence. Or us.
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18.0	2.1	3.3	6.0	8.0	13.0	18.0	26.0	40.0
24.0	1.5	2.8	4.2	7.0	11.0	15.0	21.0	33.0
28.0	1.4	2.4	4.0	6.3	9.0	14.0	20.0	29.0
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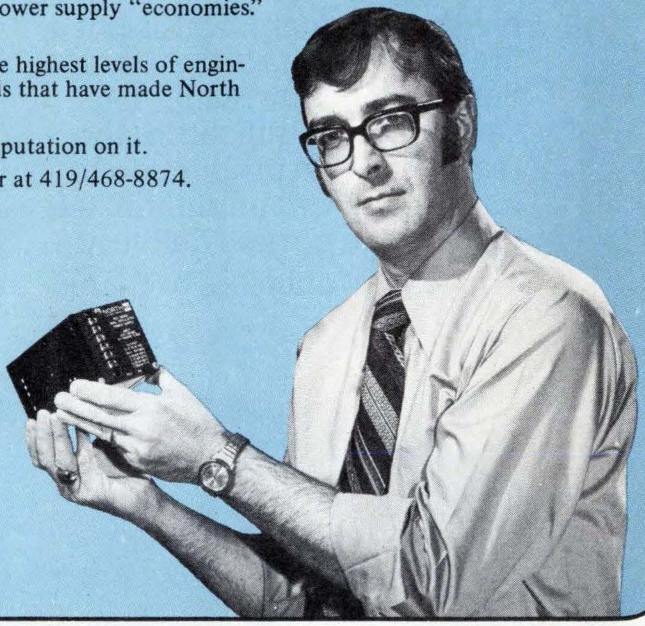

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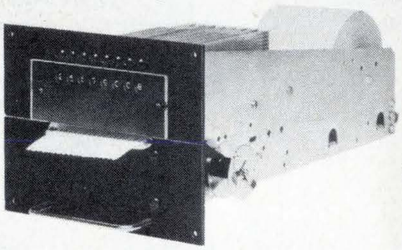

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