March 29, 1971 $1.00 A McGraw-Hill Publication

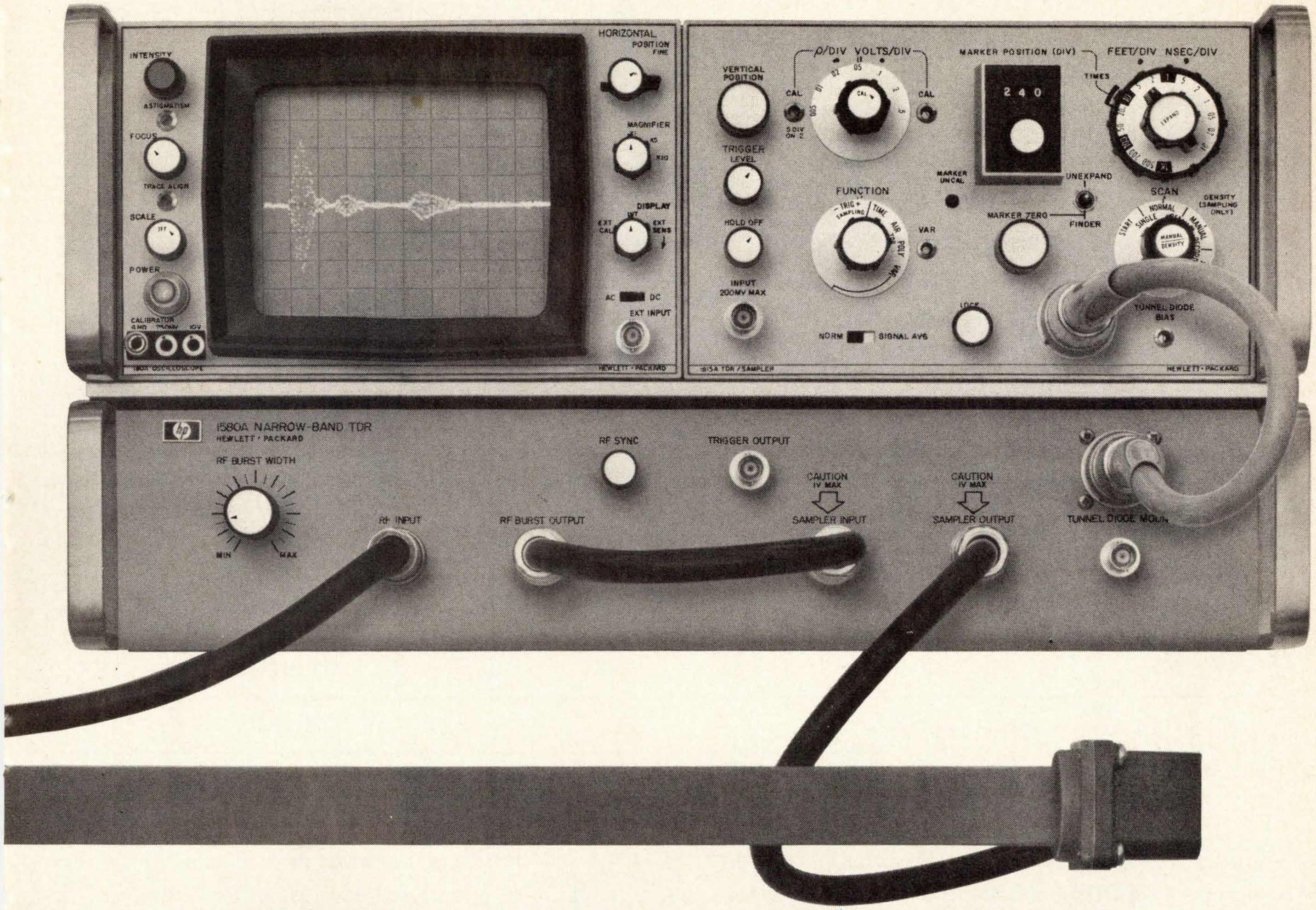
Electronics®

Special report:

CASHING IN ON THE CASHLESS SOCIETY

Circle 900 on reader service card

Stop beating your waveguides! HP's new Narrow-Band TDR system locates discontinuities the easy way!



Tired of banging on your waveguide "plumbing," or laborious segment-by-segment inspection? These are popular methods of trying to get rid of "hot spots," arcing, power losses and noise-producing, multipath-like phenomena – but, they are now passe!

Hewlett-Packard's new Narrow-Band Time Domain Reflectrometry system lets you locate problem-causing discontinuities accurately, at a glance! Design and maintenance become a matter of science, rather than trial-and-error—whether you're on a ship, in a plane, or at a relay station out in the middle of nowhere.

You thought TDR couldn't be used in waveguide work? You're right—it couldn't, until now. Most of a regular TDR system's wide-band energy just gets reflected out—or the reflections you get back are so weak and fuzzy that they're practically useless. But HP's new Model 1580A *Narrow-Band* TDR system gives you a fine-tuned burst of RF energy, rather than the conventional wide-band pulse.

The 1580A can be used with any CW microwave source whose output is in the tens of milliwatts, and can be tuned to any frequency between 3.5 and 12 GHz (1 GHz to 18 GHz available with minor modification). This lets you test any standard waveguide, in lengths up to several hundred feet. Also, most narrow-band coaxial transmission lines can be tested. Impedance differences as low as 1% can be detected, and discontinuities spaced less than 1 foot apart can be resolved.

The complete Narrow-Band TDR system costs only $6000. And for this price, you're getting not only the unique Narrow-Band TDR capabilities, but capabilities for wide-band TDR work, a regular oscilloscope, and sampling scope capabilities as well!

For further information on HP's new Narrow-Band TDR system, contact your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

Scopes are changing. Are you?

081/9A

HEWLETT hp PACKARD

Circle 1 on reader service card

No other transistor can make this statement:

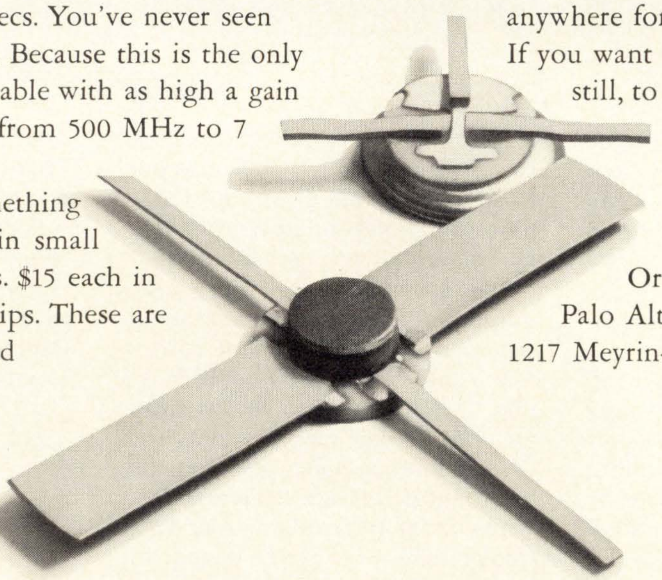
Frequency	Maximum Available Gain	Noise Figure	Power Output Amplifier And Oscillator Applications*
.5 GHz	22.5 dB	2.7 dB	27.5 dBm
1.0 GHz	16.8 dB	3.0 dB	27.5 dBm
2.0 GHz	11.3 dB	4.2 dB	26.0 dBm
4.0 GHz	5.6 dB	7.0 dB	22.0 dBm
7.0 GHz	3.5 dB	—	13.0 dBm
f max = 12 GHz.	*Figures are for Stripline package. Add 2.5 dB for chip performance.		

Just look at those specs. You've never seen anything like them before. Because this is the only production transistor available with as high a gain and as low a noise figure from 500 MHz to 7 GHz. At any price.

And our price is something else again. Just $19 each in small quantities for the packages. $15 each in small quantities for the chips. These are the lowest prices you'll find anywhere for this kind of performance.

If you want more information or, better still, to place an order either for evaluation quantities or your volume production requirements, call your local HP field engineer.

Or write us at Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.



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HEWLETT hp PACKARD

HP transistors: a small price to pay for performance.

Electronics

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Electronics

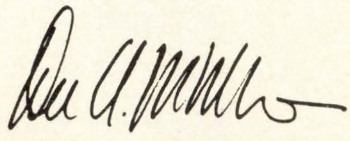
Publisher's letter

Mysteries—we had our share of them this issue. There was the Mysterious Case of the Optical Computer, which followed closely on the heels of the Sinister Case of the Disappearing Author. While we are, in a way, in the investigating game, the two mysteries so close together made us wish Sherlock Holmes were on the staff. Let's say right here, though, that we cleared up both—and found some interesting stories to pass on to you.

The optical computer yarn (see Probing the News, page 81) was the most mysterious case, because of its hints of industrial espionage and a level of security precautions that would have made a general proud. First came fascinating reports from Gerald Parkinson, McGraw-Hill World News correspondent in Los Angeles, about a laser-based computer—with specs that were almost too good to be true. But solid details about the machine, and the small West Coast company that was building it, were well guarded. Executive Editor Sam Weber collared the computer's developer, Frank Marchuk, after a seminar at the ISSCC and found out more about the plans of Computer General Inc. of Anaheim and Irvine, Calif. Then Larry Curran, our man on the spot, was put on the case. Although he uncovered a lot more information, he hit a stone wall when he tried to see the machine. Says Curran:

"Computer General will not permit plant visits by anyone other than bona fide customers or potential customers, and even then the visitor has to sign an agreement not to disclose anything he sees or hears. J. T. Martin, executive vice president, told me, 'All someone with some technical knowledge would have to see is the number of lasers we use, some details of our deflection system, and the recording medium, and we'd be giving away $1.8 million worth of information. Our only safeguard is our security.' They're hiring Pinkerton guards at all their facilities because of two or three break-ins, which they are convinced were attempts to photograph documents—industrial espionage."

The Case of the Disappearing Author was far tamer: no corporate spying or industrial intrigue. Yet there was no question about it: our author had vanished right as our industrial editor, Al Rosenblatt, was closing his article and needed some last-minute help. For days, James Pastoriza (see page 71) was not in the offices of Analog Devices Inc. or of its Pastoriza division. His home phone went unanswered. His associates said he was unreachable. James Brinton, manager of our Boston bureau, had interviewed him several times over the years. So Brinton, in checking with his industry contacts, remembered that Pastoriza is a ski buff—and tracked him down at a big New England ski championship. The transfer of data after that was a simple matter.



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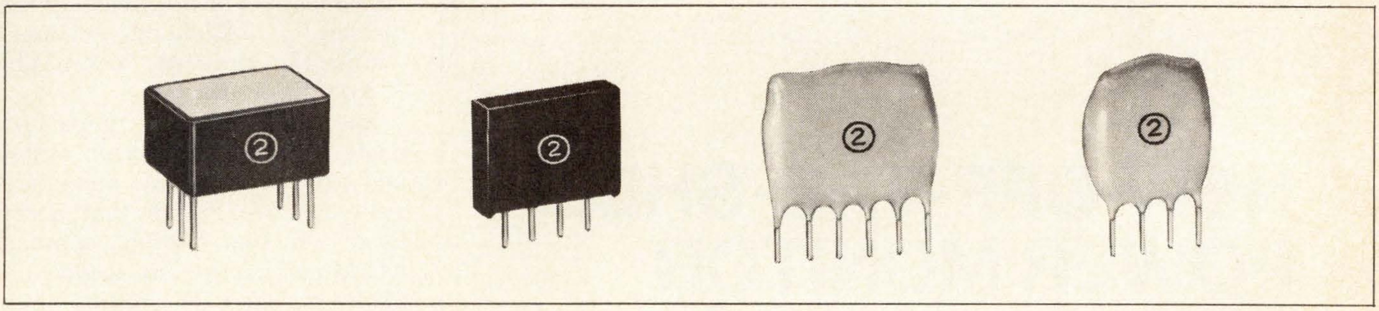
Your *custom* pulse transformer is a *standard* DST® transformer



Some of the case styles in which Sprague DST Pulse Transformers are available. Note the in-line leads.

You can select the transformer design you need from the new Sprague DST Family, a fully-characterized series of Designer Specified Transformers which Sprague Electric has pioneered. It's easy. Start with the two basic parameters dictated by your circuit requirements: primary (magnetizing) inductance and volt-second capacity.

New Sprague engineering data gives basic information from which all nominal sine wave parameters are derived. This data allows you to specify the one transformer from thousands of possibilities which will optimize performance in your application.

Design Style A minimizes magnetizing inductance change as a function of temperature. Typically it's $< \pm 10\%$ change from 0 to 60C; $< \pm 30\%$ from -55 to $+85$ C.

Design Style B and C give you broad bandpass characteristics, and still keep magnetizing inductance change $< \pm 15\%$ from 0 to 60 C.

Design Style D is *fast*. Associated leakage inductance and coupling capacitance are kept at a minimum. This style is just what you need for interstage and coupling devices in computer drive circuits.

The Sprague DST Series packs a lot of transformer into minimum volume packages— epoxy dipped for minimum cost, or pre-molded. The 100 mil in-line lead spacing is compatible with integrated circuit mounting dimensions on printed wiring boards.

To solve your pulse transformer design, start now. Write for Engineering Bulletin 40,350 to the Technical Literature Service, Sprague Electric Company, 35 Marshall St., North Adams, Massachusetts 01247.

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Readers comment

Four-channel broadcasts

To the Editor: The Dorren Quadraplex System by no stretch of the imagination can be described as "another contender for fm broadcast matrixing" [*Electronics*, March 1, p. 73]. On the contrary, it is a true four-channel multiplex system, fully compatible with existing two-channel systems. And unlike the matrixing and synthesizing systems, which seriously reduce channel separation, it does not degrade stereo reception. It is, moreover, the very thing that you say "no researcher has yet suggested"—a viable method of broadcasting four discrete, 15-kilohertz channels within the presently permissible 75-kHz deviation.

Spectrum analyzer comparisons made between the Dorren system and present monaural and stereo systems have shown that acceptance of the Dorren approach would not require any reallocation of the fm band. The results of the test broadcasts carried out over San Francisco's KIOI have shown that the change required in FCC regulations involves mainly wording or semantics, rather than anything affecting existing allocations. Thanks to the tests, KIOI has obtained the engineering informations necessary to file a formal petition for a decision on four-channel broadcasting in a few weeks.

The KIOI tests also fully confirmed the theoretical predictions and lab experiments which showed the system to be fully compatible with existing stereo and mono equipment. Separation between channels of at least 45 decibels at the transmitter and up to 40 dB at the receiver can be obtained; the full frequency response of 50 hertz to 15 kHz is realized on all four channels, and distortion and signal-to-noise figures are comparable to those of existing stereo systems.

Thomas M. Lott
Quadracast Systems Inc.
San Mateo, Calif.

▪ *Electronics* erred in calling the Dorren system "another contender for fm broadcast matrixing."

Meetings

Calendar

USNC/URSI IEEE Spring Meeting, Statler Hilton Hotel, Washington, **April 8-10.**

National Telemetering Conference, IEEE; Washington Hilton Hotel, **April 12-15.**

International Magnetics Conference (Intermag), IEEE; Denver Hilton, Denver, Colo., **April 13-16.**

Conference & Exposition on Electronics in Medicine, Electronics, Medical World News, Modern Hospital, Postgraduate Medicine; Sheraton-Boston Hotel and the John B. Hynes Civic Auditorium, **April 13-15.**

Offshore Technology Conference, IEEE, Houston, **April 18-21.**

International Geoscience Electronics Symposium, IEEE; Marriott Twin Bridges Motor Hotel, Washington, **April 18-23.**

Frequency Control Symposium, U.S. Army Electronics Command; Shelburne Hotel, Atlantic City, N.J., **April 26-28.**

Relay Conference, College of Engineering, Oklahoma State University Extension, National Association of Relay Manufacturers; Stillwater, Okla., **April 27-28.**

Southwestern IEEE Conference and Exhibition, Houston, Texas, **April 25-May 2.**

Symposium on Theory of Computing Association for Computing Machinery; Shaker Heights, Ohio, **May 3-5.**

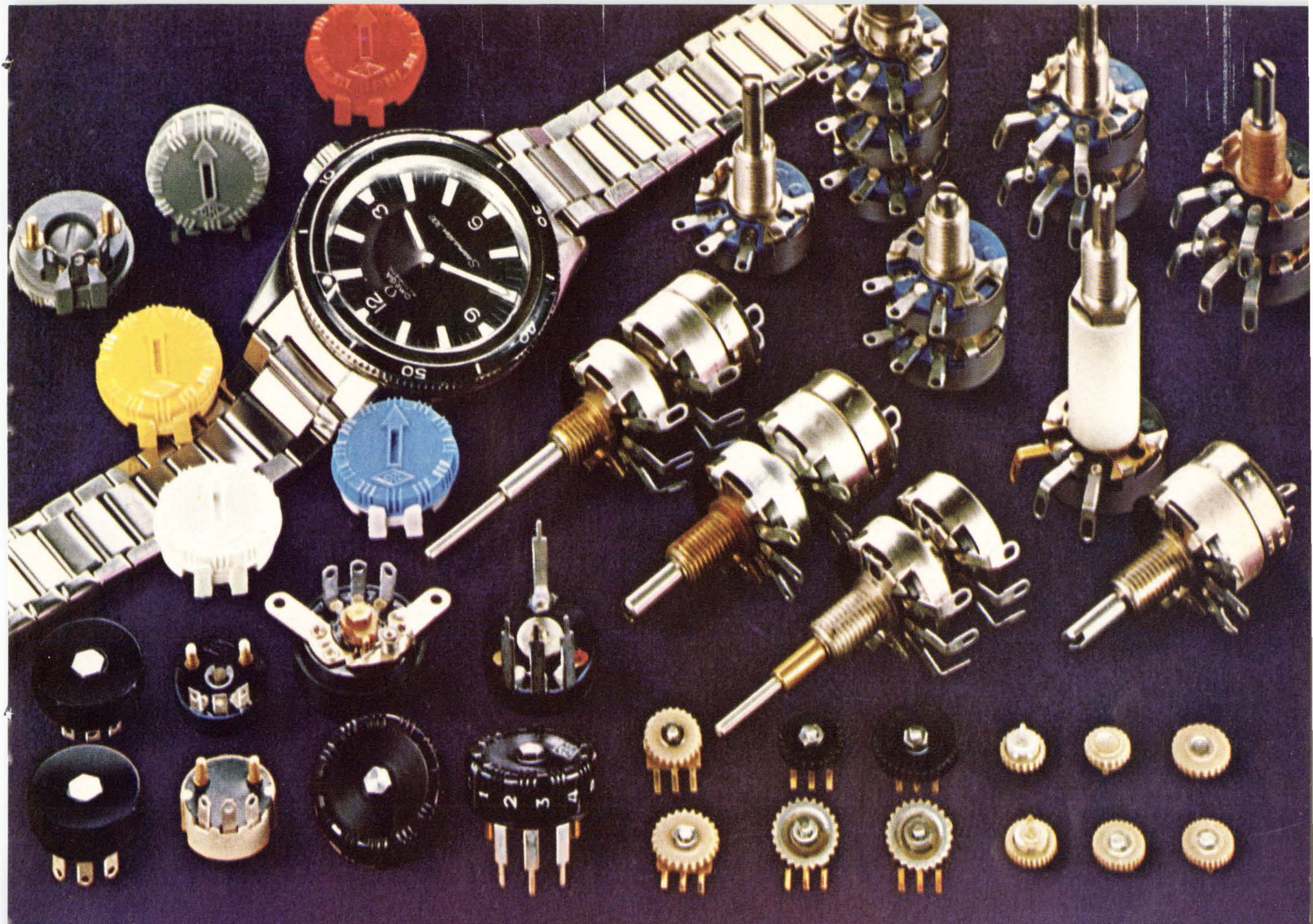
Society for Information Display International Symposium, Sheraton Hotel, Philadelphia, **May 4-6.**

Electronic Components Conference, IEEE; Statler-Hilton Hotel, Washington, **May 10-12.**

Electron, Ion, and Laser Beam Technology Conference, IEEE; University of Colorado, Boulder, **May 12-14.**

Call for papers

Geoscience Electronics Symposium, IEEE; Marriott Twin Bridges Motor Hotel, Washington, Aug. 25-27. **April 28** is deadline for submission of summaries to Mace T. Miyasacki, Applied Physics Laboratory, Johns Hopkins University, 8621 Georgia Ave., Silver Springs, Md. 20910.



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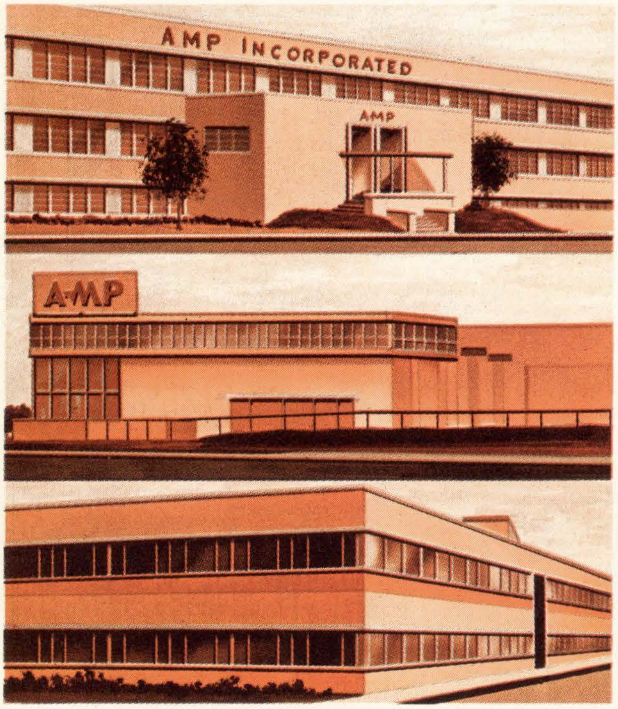

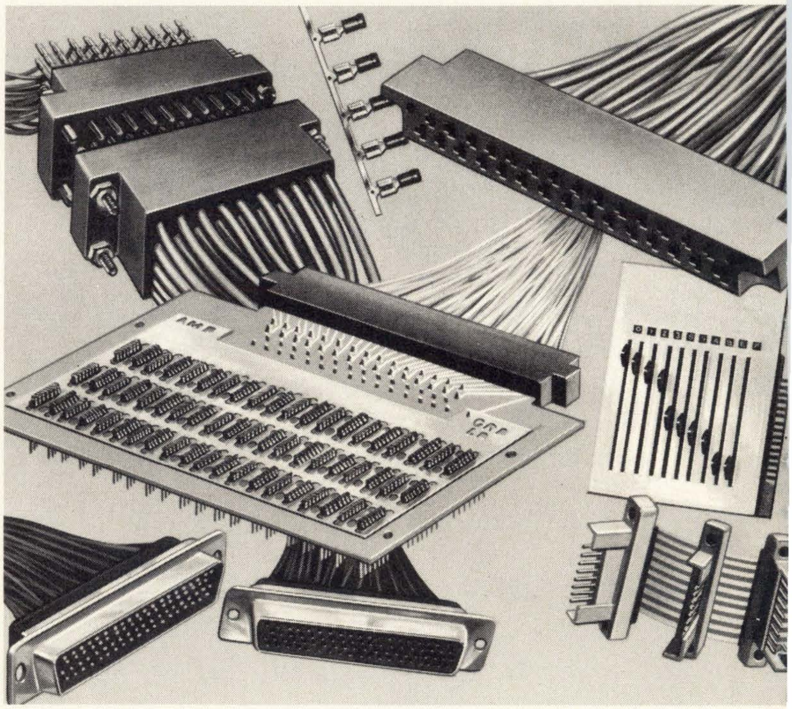

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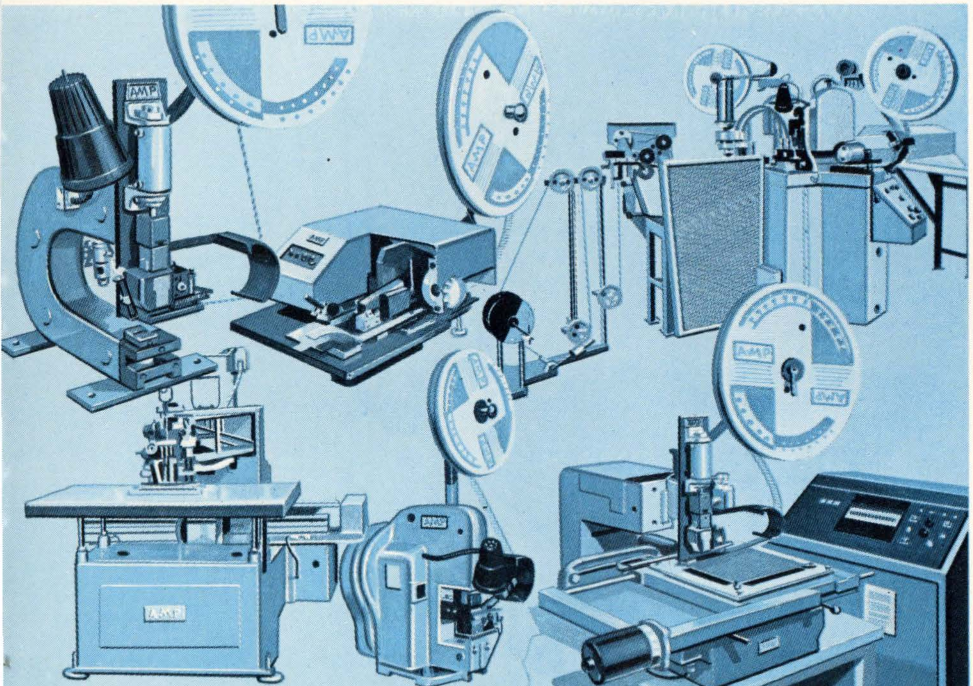

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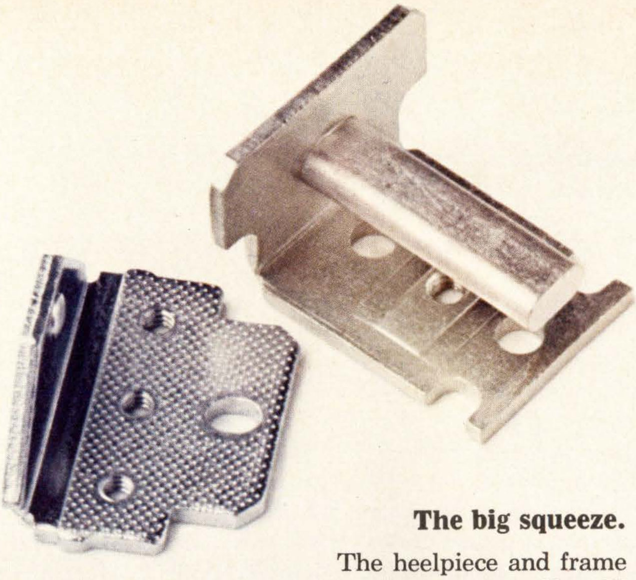
Circle 11 on reader service card

Reliability is 756 little dents and one big one.



The big squeeze.

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

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

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

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

A different kind of coil.

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

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

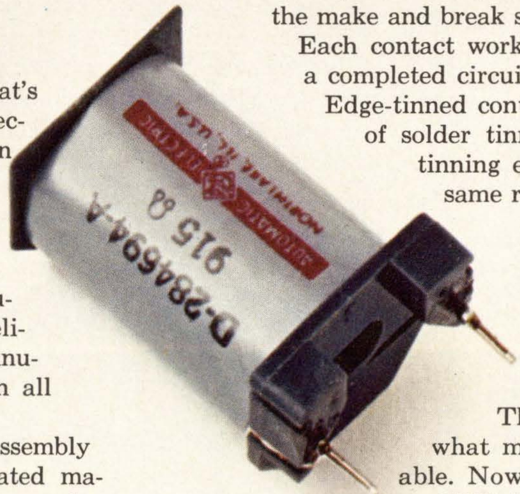
The coil is wound on the bobbin automatically. No chance of human error here.

We didn't forget the solder.

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

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

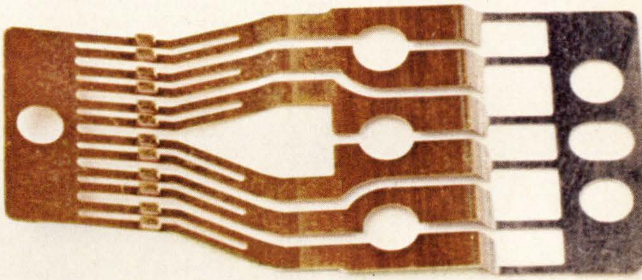
Finally, we wrap the whole assembly with extra-tough, mylar-laminated material. A cover is not really necessary here; but why take chances?



Springs and other things.

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

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



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

Two are better than one.

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

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

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

Etc. Etc. Etc.

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

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Circle 13 on reader service card

People

There's a woman in Gaithersburg, Md., who thinks of herself as a hyphen. What's more, the Government pays her $40,000 a year to act out her role.

Sounds like high-priced punctuation? It isn't if she does her job right. For as the Federal Government's top computer adviser and the self-described "hyphen between the customer and technology," Ruth Davis is in a position to save the government millions of dollars a year. In the process, she is expected to make decisions that will affect every element of the data processing industry.

Her powers as director of the National Bureau of Standards' Center for Computer Sciences and Technology are twofold. One is derived from the legislation that created her job: it makes her the chief technical adviser to the Office of Management and Budget and the General Services Administration, the duo charged with overseeing computer purchases. The other stems from her role as resident Federal computer expert. "He who has the information and desire to do something can make big changes," she says. "But if you're not careful, you won't have any impact at all." Despite this risk, however, it is this power that Ruth Davis finds most intriguing.

Accordingly, she plans to branch out into areas other than standards—the activity that absorbed most of her predecessor's time—as she works to make Federal computers cheaper and more effective.

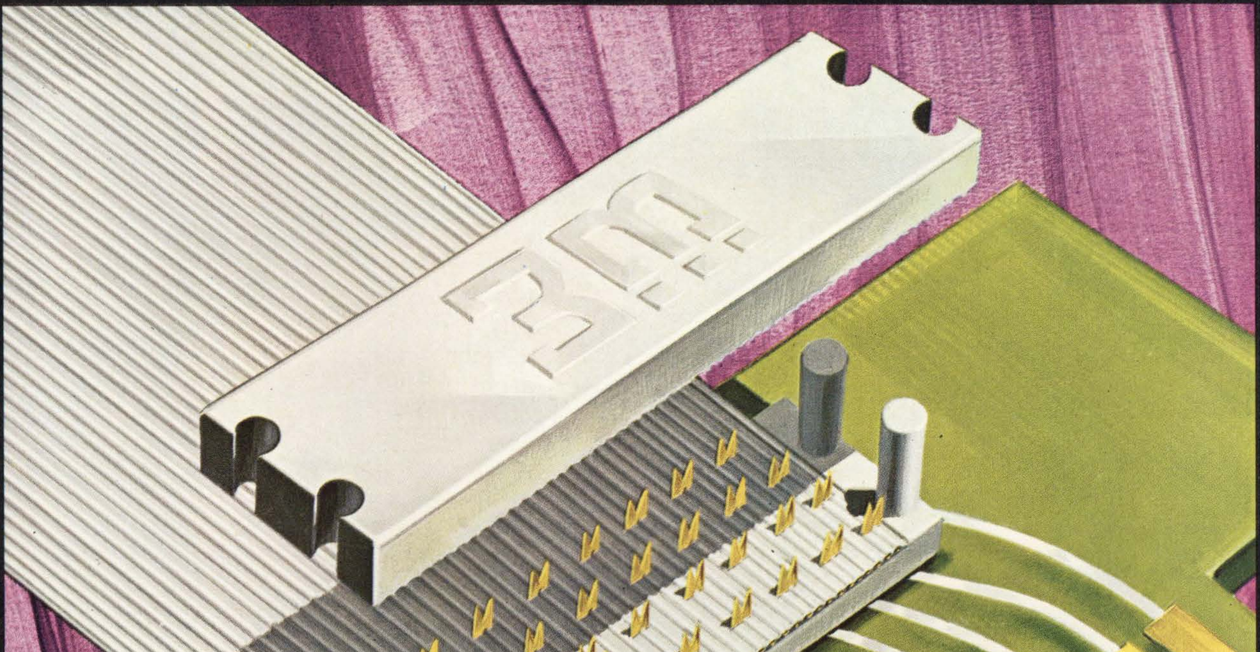
Any engineer who has to rely on third parties for test data is certain to feel frustrated. And when that engineer is a woman, and the tests are being run in the Antarctic, and the Navy forbids women to participate in Antarctic research efforts, the frustration could be total. Fortunately for Irene Peden, an associate professor of electrical engineering at the University of Washington, Seattle, the story has a happy ending: the Navy lifted its restriction. Mrs. Peden has just returned from the frozen continent where she did research on low-frequency waves in the ionosphere as a means of determing the sun's influence on that region.

For the first five years of the project, sponsored by the National Science Foundation, Mrs. Peden had to make do with data brought back to Seattle by three male colleagues and several graduate students. "But I knew the time would come," she says, "when, to be on top of the situation, I'd have to go myself." And go she did, to become one of the first two women—the Navy required that she have a female companion—to travel to the interior of the Antarctic.

The determined Mrs. Peden took Yoga and exercise classes before leaving Seattle—and they weren't wasted in Antarctica. At Longwire, the university's base camp 10 miles from Byrd Station, the researchers had to climb a 25-foot ladder to the surface just to begin work. Then, because one phase of her study involved measurement of the electrical properties of the ice sheet, Mrs. Peden had to spend six to 12 hours a day traveling over the ice.

"I didn't shovel snow," says the 5-foot 4-inch professor, but she made up for it by doing extra dishes.

Irene Peden



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Circle 15 on reader service card

Electronics Newsletter

March 29, 1971

GI, TI building 2,048-bit MOS RAMs

With most, if not all, computer mainframe makers hard at work on semiconductor memories, at least two companies—Texas Instruments and General Instrument—**are now delivering samples of new 2,048-bit MOS random access memories,** the first of this size chip.

Texas Instruments is about to introduce its RAM, with deliveries expected to begin in about two months. Access time is 280 nanoseconds. **At the same time, TI will introduce a low-power, low-speed version of the big RAM.** GI's silicon-gate RAM has a 256-nanosecond access time, a 500-nanosecond cycle time, and fits on a chip 140 mils on a side.

The largest monolithic MOS RAMs on the market are 1,024-bit devices, such as those produced by Intel, Mostek, and American Microsystems. Mostek, for one, has plans for a 2,048-bit or larger MOS RAM by early next year. **And TI expects to start sampling a 4,096-bit MOS RAM later this year.**

The greater packing density on the GI chip is achieved with a new memory cell technique employing only a single transistor per cell, compared with three used by Intel and others. It also uses a three-phase clock.

Lending competitive fire to the development of a 2,048-bit MOS RAM is Honeywell Inc., which has designed a similar unit and is seeking bids from major MOS houses to build it.

RCA delivering liquid-crystal display

Liquid crystal displays are being delivered by RCA to a commercial customer in preproduction evaluation quantities. While Ed Johnson, manager of the Optoelectronics group within the Solid State division, Somerville, N.J., declines to describe the nature of the display, **it's believed to be an animated advertisement.** Forty picture elements of the display are switched by hard-wired connections made to a slowly rotating drum, which resembles the one found in a music box. Contacts are made and broken sequentially as the drum rotates.

RCA apparently regards its liquid crystal effort as a solidly based technology well past the research phase. The 100-man optoelectronics operation is on the same profit-center-oriented level as, for example, the MOS group, **and RCA expects it to grow.** Another application RCA has in mind is for displays on electronic watches.

At the same time, another New Jersey liquid crystal house—Optel of Princeton—**is selling samples of its readouts to "practically every calculator maker in the world,"** says Edward Kornstein, vice president. Kornstein adds that he's working closely with two watchmakers—one Swiss, the other American. Sources outside Optel identify the American firm as Bulova.

DEC strips still more off naked minis

The trend to the so-called naked minicomputer appears to be growing [*Electronics,* March 15, p. 40]. **The latest stripped machine is Digital Equipment Corp.'s $800 PDP-16, designed to fill the gap between the smallest minis and digital controllers.** DEC's new machine needs no software because it's a hard-wired functional computer, rather than a general-purpose version.

The customer defines his problem with Chartware, a special flow-chart-oriented language; DEC feeds the Chartware program into a computer, which produces a list of functional TTL pc card modules together with wiring rules and other data necessary to put together a working system.

Like the company's previously announced modular minicomputers, the PDP-8/E and the PDP-11 [*Electronics,* Dec. 21, 1970, p. 47], the PDP-16 is bus-organized. **The $800 buys the smallest version, which includes a power supply and all accessories and suits applications requiring no memory.**

New display unit due from IBM

IBM will soon announce a CRT display unit capable also of producing a hard copy. **The unit will be a successor to IBM's venerable 2260 alphanumeric display,** and a graphic version replacing the 2250 may also be in the works.

Engineers who have been developing the unit at IBM's laboratories in Kingston, N.Y., have recently started a round-the-clock design wrapup and testing cycle, usually a sign that announcement isn't far off—possibly by this summer.

Bell transmits signals with LEDs

Gallium arsenide light-emitting diodes are being used at Bell Telephone Laboratories in Holmdel, N.J., to transmit signals at rates as high as 50 megabits per second. **While no field trials are planned, communications with LEDs is possible "a high percentage of time" in cities like New York City, Chicago, and Los Angeles,** where climates are not too severe. Though these LEDs are not lasers, they do give off an intense beam of infrared light when 200-milliamps pulses are driven transversely across the diode. Light emission takes place in an area 0.002 inch in diameter.

Bell researchers Bernard King, William Ortel, and Harry Schulte say that light from LEDs can carry information through the atmosphere for nearly two miles, but the beam must be amplified every 300 feet.

Air Force leans to austere CNI

The Air Force's Electronic Systems Division has issued two inquiries about communications, navigation, and identification equipment (CNI) and techniques. **One asks for letters of interest in a study of cost cutting,** the other for analysis of message flow and other characteristics of aircraft command and control.

The inquiries follow rumors that CNI is becoming more austere, even to the extent of leaving the communications role to ground stations rather than satellites as envisioned with U/CNI and I/CNI, and using fewer satellites as well.

Addenda

With fast dynamic LSI testers already being delivered or near delivery, Teledyne TAC of Woburn, Mass., has a probe station to match. The $8,900 PR-100 is said to be capable of probing more than 72,000 80-mil chips an hour, **not just for dc tests but for the ac tests that more makers demand;** what's more, the test rate gets higher, the bigger the chip. . . . Ampex Computer Products division will soon introduce a controller that makes seven disk drives, running simultaneously, a direct replacement for the Univac Fastrand drum memory. Ampex claims better performance —access time of 32 nanoseconds—makes disk storage cheaper than Fastrand drum.

Imaging technique makes its bow in line scanner

Bell's charge-coupled device can transmit printed page, may find way into camera as replacement for vidicon

Keeping its promise of a year ago when it revealed the concept of charge-coupled imaging [*Electronics*, May 11, 1970, p. 112], Bell Laboratories has built a charge-coupled device imaging system that is bound to have a major impact on information transmission and display technology. All forms of information processing could be affected, from line printers, which scan line by line for transmission over phone lines to hard copy terminals, to complex systems like Picturephone that use a space-imaging camera to produce real-time video transmission and display.

The camera used for Picturephone, like those being developed by a dozen or so companies in addition to Bell, uses silicon vidicon tubes. And it's no industry secret that vidicons have been a nightmare to make at yield levels that are commercially interesting—it's no picnic to build 600,000 good diodes in a single silicon chip. Besides, silicon vidicons require electron scanning along with all the high voltage, big size, and vacuum technology involved.

By contrast, a CCD imager would offer fabrication simplicity, consisting as it would of an array of metalized electrodes deposited on oxide over silicon. Only one diffusion is needed for these devices; it forms a small p-n junction connected to the output terminals. Most important, a CCD/imager would scan itself, requiring no external scanning apparatus. It would operate at low voltage, have good gray scale, and with luck could be fast enough for many picture transmission applications.

Bell's imaging device, although far from the complex array needed for vidicon applications, goes a long way toward achieving these goals. In fact, it's capable of imaging both words and pictures.

It consists of a linear array of 288 electrodes (10-micron-wide stripes, 2.5 microns apart) on a chip measuring 2 by 4.5 millimeters. Since three electrodes are used to process each bit of information, the device is a 96-bit, three-phase structure. The copy to be processed is placed on a revolving drum and imaged onto the electrode pattern; carriers produced by the image signal are stored under the middle electrode of each element. The image is then run off in standard CCD shift register fashion and a new line of the image is processed. Scanning is accomplished at 1 megahertz per bit with resolution as good as hard copy (facsimile) systems.

Although the system operating

Reading Electronics. Bell Labs' line scanner can transmit all kinds of printed matter. Left, section of device shows output diffusion; center, test transmission; right, developers Mike Tompsett and Walt Bertram display Electronics' logotype.

at Bell Labs' Murray Hill, N.J., center can handle only 2 or 3 inches at a time, an extension of the electrode line in the device to, say, 1,000 elements for reading an entire page width is not far off. What's required is smaller stripe geometry and, perhaps, slight improvement in transfer efficiency.

And even more promising than the line scanner is an area, or array, version that Bell is working on. An 8-by-8-bit device, which requires no movement of the image across it and could be the basis of a complex CCD camera device, it is divided into two sections—an 8-by-8 storage section whose last row is a 1-by-8 readout subsection with-output and gate diodes, and an 8-by-8 imaging section.

An image is focused on the imaging section and charge is collected under the storage electrodes; the entire charge pattern is then shifted to the storage section and read out line by line from the readout section. Thus, as in any camera TV tube, but unlike the line scanners, the image is not moved across the elements. Unlike silicon vidicon camera tubes, however, the CCD area imager is completely self-scanning, a process achieved through the simple manipulation of three clock voltages no more complex than shift registers.

Packaging

TI MOS goes plastic up to 40 pins

Texas Instruments in Houston is getting ready to offer plastic packages on all its standard ceramic dual in-line MOS ICs, up to and including 40-pin version. TI is the first big manufacturer to go all-plastic with 40 leads, according to Daniel Baudouin, MOS standard products program manager. The plastic units will be pin-for-pin replacements for ceramic devices at 25% lower cost, he says. Evaluation quantities of the devices are available now.

The molded packages include standard 14- and 16-lead packs with 300-mil row spacing, a new 18-pin, 300-mil version especially suited for memories, and 24-, 28-, and 40-pin packages on 600-mil spacings. TI had been expected to announce the smaller packages—in fact, TI claims to have produced over half the plastic bipolar ICs ever made. But the big 28- and 40-pin versions came as a surprise. Plastic replacements for many metal can parts also will be available.

Competitors' reaction to TI's move ran the gamut from much shrugging of shoulders on the West Coast to RCA's matter-of-fact comment that it's been epoxy-packaging 14- and 16-pin complementary MOS since last August. But there was some surprise that TI had gone all the way to the 40-pin configuration. As RCA's Elvet E. Moore, MOS IC manager, put it: "I'm sure we'll work on a 40-pin package in the near future. We just don't have the need at present."

Most of the discussion revolved around TI's choice of epoxy over silicone. For example, Electronic Arrays in Mountain View, Calif., will use silicone. Says Paul Flaskerud, manager of packaging technology: "It's our feeling that silicone is a cleaner material." And Pierrre Lamond, general manager at National Semiconductor in Santa Clara, Calif., seconds the motion. "We will have MOS in silicone shortly. I still feel it has advantages over epoxy and the Rome Air Development Center study backs this up." Signetics' George Vashel, manager of MOS manufacturing engineering, also says he feels that silicone is the way to go.

Looking into epoxy is American Microsystems Inc. of Santa Clara. James V. Barnett, packaging development manager, says that the material's main drawback is that it breaks down into harmful by-products—like hydrochloric acid, which attacks bonding pads.

The lead frames of the large cases are especially designed to hold very large chips, such as the 200-mil-square circuits used in some TI custom products and in its upcoming calculator on a chip.

With 40-pin ceramic packages costing over $1 in quantity, the big reason for going to plastic obviously is cost. However, reliability questions have held back the use of plastic for MOS even though it has been widely accepted in bipolars. But MOS ICs have two troublesome properties not shared with bipolar devices: high surface sensitivity to ionic contamination, and high pin count with mechanical strength a consequent problem.

TI reduced one major hangup—possible gate contamination from sodium ions—by passivating the devices with a quartz layer deposited by breaking down silane at high temperature.

The plastic itself was chosen after an 18-month study of more than 200 types. The final selection was an epoxy-based plastic that showed sufficient mechanical strength and moisture resistance, a suitable temperature coefficient, and low sodium content and transmission. Silicone plastics, such as those used in some bipolars, are porous to sodium; hence TI rejected their possible use in MOS.

After finding a suitable plastic, actual devices were subjected to extensive testing to verify their integrity; temperature cycling, thermal shock, and 85°C/85% relative humidity with reverse bias. Satisfactory results led to operating tests at 125°C with only one failure for 134,000 device hours (equivalent to 1.2 million hours mean time between failures at 25°C). Similarly, storage tests at 150°C produced one failure in 258,000 hours, equivalent to MTBF of 4.3 million at 25°C.

Smaller edge mount nudges ceramic DIP

Plastic is putting the pressure on ceramic dual in-line LSI packages from one side, and now pressure is coming from another source—a new, smaller version of the Coors edge-mount package, which was developed last year as a lower cost, but pluggable, alternative to the standard DIP format. The new package, developed by Metalized Ceramics Corp., Providence, R.I., is half the size of the previous package and promises to use lower-cost connectors, according to Frank Rydwansky, Metceram applications engineering manager.

The original edge mount had conductive patterns on only one side of the 1-by-2-inch ceramic substrate. Metceram's version uses double-sided metalization with conductive vias to reduce the size to about 1 by 0.75 inch. Present connectors would have to be split longitudinally to make isolated contact with edge fingers on each side of the package, but Rydwansky says such connectors can be easily modified to do this.

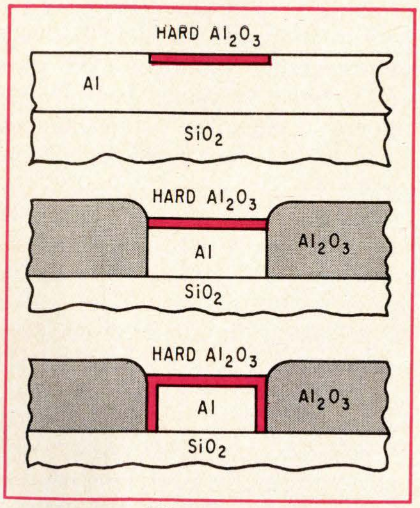
The Metceram package is made differently from the Coors version. Coors used a prefired substrate and metalized conductor patterns. It had a bonding pad in the same plane as the conductive pattern and thus had to use co-planar wire-bonding methods. Metceram will use two layers of ceramic tape laminated together and thus allow uphill bonding (users want uphill bonding to prevent shorts from occuring between the wire bonds and the edge of the chip).

Metceram is calling the new line of edge mounts Incert (for insertable ceramic technology.) Rydwansky says it's the first step toward multilayer circuits carrying beam-lead chips plugging into edge connectors, much the same as present printed circuit boards carrying several individually packaged integrated circuits.

Manufacturing

Anodized aluminum ends two-layer woes

One reason for the slow growth of the emitter-coupled-logic market is the need for a reliable two-layer metal system for interconnecting devices on the chip. According to Mike Shields, digital process development manager at Signetics Corp., Sunnyvale, Calif., plenty of time and money is spent on inspecting devices made with two-layer metal for metal cracking, oxide voids, and openings on the oxide step. However, Shields may have a solution.



Laying on. Signetics process: top, after hard anodization; center, field anodization; bottom, optional rehardening.

The old method consisted of depositing a passivation layer over the first metal run and then deposing the second-layer metal over it. This created a relatively high step that sometimes caused the top layer to crack.

Signetics says it has developed an anodic aluminum process for two-layer metal that eliminates most of such problems. In the Signetics process, an anodized aluminum layer is produced on top and on the sides of the bottom aluminum conductor. The anodized layer (alumina) is an insulator and so the top-layer metal can be deposited directly on it.

After the first aluminum layer is put down, a small area (the site of the crossover) on top of it is hard anodized. Then the complete surface is soft anodized, turning all of the aluminum into alumina except for the spot under the hard-anodized area, which remains plain aluminum. This yields a conductor surrounded by insulating material. The top layer of aluminum then can be deposited. The chip can be hard anodized in the last step, before the top layer is put down so that both the sides and the top of the lower conductor are surrounded by a hard layer. Shields says that this last step is not necessary; "It's just extra protection." For a feed-through, a hole is etched through the anodized layer to the aluminum.

Besides providing a better two-layer metal system, Shields says, the anodic aluminum process "provides more protection from electron migration within the semiconductor, it seals up pinholes and it produces a better [flatter] surface for chip passivation. It can be used with any process—it's not limited to ECL."

Shields notes that the process is not just a laboratory curiosity; Signetics is using it in a custom ECL circuit for a major computer manufacturer. The circuit is an eight-bit adder that contains some 1,000 transistors in 64 cells. On-chip speeds are on the order of 1.1 nanoseconds, and Shields hints that Signetics will have more ECL MSI to come. In fact, the company will evaluate Motorola's new 10,000-series ECL as a second-source candidate, and a proprietary Signetics ECL line hasn't been ruled out.

Integrated electronics

Motorola sees new ECL as standard for fast logic

The people who make the new MECL 10,000 logic series at Motorola's Semiconductor Products division in Phoenix [*Electronics,* Feb. 15, p. 25] aren't worried about losing ground in the market to Schottky-clamped transistor-transistor logic. In fact, they're making a strong case for MECL 10,000 becoming the high-speed logic standard of the future with its 2-nanosecond-per-gate propagation delay and low power dissipation (25 milliwatts per gate). And they still maintain that emitter-coupled logic and TTL will not compete head-to-head with each other in many systems applications.

To further its goal, Motorola has unveiled six standard functions to date in the MECL 10,000 line; by the year-end it will add 24 more, including 14 complex functions. One of the latter is the MC10181, a four-bit arithmetic/logic unit with up to 75 gates. Jon DeLaune, section manager of Motorola's ECL applications group, says it will do the arithmetic function in less than 20 nanoseconds with an average power dissipation per gate of just 8 mW.

DeLaune says power dissipation is about the same as that for the comparable non-Schottky series 74 TTL four-bit arithmetic function, but speed is four times greater than that of the TTL circuits. ECL users, he adds, have complained in the past about the lack of MSI and LSI complexity ranges. Before MECL 10,000 ECL circuits had been restricted to a maximum of about 32 gates per package because of their high power dissipation—MECL 2.5 circuits, for example, typically dissipate 60 mW per gate at a 2-nanosecond propagation delay.

"But now we can get a lot of logic into a package without thermally saturating it," DeLaune notes. Mike Lee, design section head for custom ECL, says MSI complexity in the standard MECL 10,000 family has been made possible by reducing the size of the transistor elements. Emitter lengths have been cut by one-third compared to those in the MECL 2.5 line, "and the base comes down right with the emitter," Lee adds.

He credits better overall process control for the line's high speed with low power dissipation. And better process control, in turn, led to reduced transistor geometries, he adds. Lee says Motorola now has a better handle on its diffusion depth and alignments. He points out that in previous custom and standard ECL designs, current switches operated at 40 mW because of a conservative approach to circuit design and processing. Now Motorola engineers have learned that propagation delay is almost constant over a wide switch power range. They've found that they can operate a current switch at 20 mW with only a very slight loss in propagation delay because of processing variations. And part of the delay is gained back by reducing parasitic capacitances through smaller transistor geometries.

Burns doesn't see Motorola knocking heads with Texas Instruments Inc.'s 74S Schottky TTL in systems competition. The newer large computers are in the under-3-nanosecond speed range, an untouchable area for TTL, Burns says. Moreover, "There are no indicated second sources for 74S and it's not easy to purchase off distributor shelves after being on the market for about a year. This seems like a small sort of effort for TI—an effort to extend the TTL life cycle which has reached saturation in new, large system prototype designs."

New RCA line signals MOS drive

When RCA earlier this month introduced a new line of low-voltage complementary MOS circuits, it served notice that it's determined to become a major factor at least in the silicon integrated circuit business. At stake is a share in MOS device sales, which are expected to zoom to $300 million by 1975; as much as a third of that amount could be spent on C/MOS circuitry, predicts RCA.

The new CD4000A line—23 circuits—can operate at supply voltages ranging from 15 volts down to 3 V, and even to 1.3V in custom units. The range on RCA's original CD4000 line, introduced last August, was 15 to 6 V. The low-voltage capability will permit direct interface with the more common bipolar transistor-transistor and diode-transistor logic types, as well as higher logic speeds.

A user will be able to select from among several output drivers and from several oscillator functions on the front end. Zener diodes to handle undesirable transients are built in.

In addition, RCA has promised to make available 18 more circuits, including a universal timing device aimed initially at the electronic watch market, by the end of the year.

To make the new line even more competitive RCA has also slashed prices—by as much as 50% for plastic-packaged units. The new line comes in flatpacks, 14- and 16-lead dual in-line ceramic and plastic packages, and in 12-lead TO-5 cans.

The low prices in the CD4000A line are possible because "yields are considerably better" than in the old line, says Elvet E. Moore, manager of MOS ICs for RCA's Solid State division, Somerville, N.J. This improvement was achieved through the changes in wafer chemistry that dropped operating voltage to 3 V, he says.

Moore emphasizes that the new line is "cost competitive on a system basis," because of greater circuit complexity compared with typical saturated logic. However, "We're not competing gate for gate when TTL gates cost 20 cents," he says. "In time, we could compete, but we're not interested right now." Per-gate prices in the CD-4000A line range from 90 cents to 50 cents.

The 41 different circuits to be introduced by the year-end include gates, flip-flops, buffers, logic-level converters, multiplexers, memories, and shift registers. They will satisfy about 50% of applications for C/MOS circuits, says William C. Hittinger, RCA vice president and general manager of the Solid State division. He hopes to see applications grow in such areas as automotive systems, industrial instrumentation and controls, watches and clocks, computers, calculators, and communications equipment.

One of the most imaginative of the new circuits may be the universal timing device, designated the TA 630. RCA will offer samples in early May. It is designed to meet "fast turnaround needs of a variety of customers," Moore says. With its 22 divider circuits in series, almost any frequency can be obtained from 2 megahertz down to 20 kilohertz. In addition, it will tolerate a very wide power supply range—from 1.3 V up to 18 or 20 V, he says.

Communications

FDA to install surveillance system

A computerized communications network, part of the Food and Drug Administration's attempt to identify and predict hazards in consumer products, is being readied for July 1 operation. Called the National Electronic Injury Surveillance System, the network connects the emergency rooms of 118 hospitals to a central FDA computer. The hospitals are statistically selected so that data on injuries can be projected on a national basis.

The system is so sensitive it can pick up changes in patterns of product-related injuries "before they reach epidemic proportions," says Robert D. Verhalen, chief of the epidemiology branch in FDA's Division of Consumer Product Safety. Verhalen foresees expansion of the system to include hospital in-patient injury reporting within 18 months to two years, and eventually to a statistical sample of individual physicians reporting minor cases handled in their offices.

The FDA designed the system, and wants to contract with Western Union for hardware and training. In that case, Western Union would provide its model 33 automatic send-receive teletype sets, which would be queried nightly by the FDA's in-House computer, an IBM 360/50 with an automatic calling unit. But the FDA is reluctant to discuss hardware, including costs; a senior official in its General Services division, which is responsible for providing the equipment, says that a request for proposals has not been published.

Verhalen expects reports on about 720,000 cases each year; about 9,000 cases, selected either by crude frequency of incidence or by a frequency/severity index the FDA uses, will be followed up by in-depth field investigations.

The system is the product of a marriage between a National Commission on Product Safety pilot system and the FAD's old National Injury Surveillance System, a 130-hospital network that reported to the FDA on mailed-in, two-page optical scan forms.

Variety's the spice of Domsat filings

If award of one of the potentially lucrative orbital slots for a domestic satellite system were based on system capacity alone, then Fairchild Hiller Corp.'s 120-channel proposal would win in a walk. But if variety and novelty of services are factored in, then RCA Global Communications Inc. would be ranked near the top with its plan to offer everything from motion picture distribution to switched digital service with three satellites comparable to Intelsat 4.

These are the conclusions being drawn from details of proposals filed with the Federal Communications Commission just prior to its mid-March deadline. Entry of the two companies, along with Western Telecommunications Inc., a regional microwave carrier that seeks to go nationwide with a North American Rockwell Corp. satellite, raises the number of competitors to eight [*Electronics,* March 15, p. 36].

Fairchild-Hiller's two-satellite system—with 120 channels of 34 megahertz each in both spacecraft —drawn heavily on the hardware of its NASA Applications Technology Satellite contract; it's clearly the most ambitious of the eight applications. It's also different in that it is the only system to use tightly focused beams to offer point-to-point service and to use 0.1-watt solid state power amplifiers instead of traveling-wave tubes. It's also one of the two proposals (MCI-Lockheed's is the other) that would use momentum wheel instead of spin stabilization.

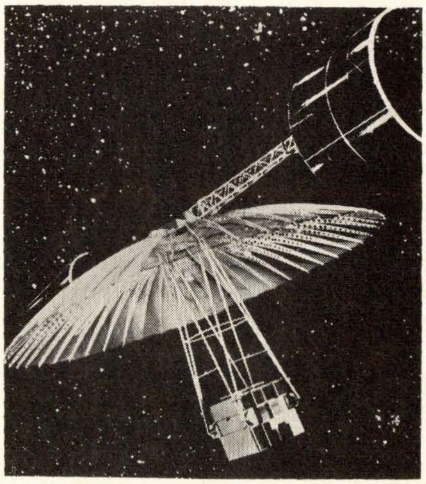
The Fairchild system's 30-foot self-erectable dish and a very accurate monobeam attitude-control system are the performance keys, says Mel E. Barmat, program manager for the firm. Together, they permit the satellite to send down a 0.6° beam at 4 gigahertz that will only be 200 miles wide when it hits the earth. Each spacecraft will be able to handle 96 point-to-point channels that will be sent up at 6 GHz and down at 4 GHz to New York, Los Angeles, Atlanta, Chicago, Dallas, and Seattle. And service will be extended to the Canal Zone, Hawaii, and Puerto Rico.

Thanks to high capability, Barmat says his firm can lease entire transponders for $340,000 a year in a one-satellite system and $235,000 a year in a three-satellite system. That's about one-third the cost Constant proposes in its coverage system.

Broad-beam coverage for TV distribution would be effected through 24 transponders located at the bottom of the spacecraft. Here again, Fairchild's proposal differs from the others in that it uses a 13-GHz uplink and a 7-GHz downlink to distribute the signals. The firm says it chose the 13 GHz uplink frequency because it can provide enough power on the ground to "burn through" virtually any kind of atmospheric disturbance.

Because RCA plans to use its

In the firmament. Each of the domestic communications satellites proposed by Fairchild Hiller Corp. will have a 30-foot-diameter antenna, will be about 25 feet high, and will weigh about 2,900 pounds in orbit. Vehicle will be Titan 3-C rocket.



satellite system to fill existing needs instead of breaking into the common-carrier market, its application reflects an approach similar to Western Union's and GT&E's. The system will use three Intelsat 4-like satellites scaled down in size so that they can be launched by the lower-cost Thor-Delta booster.

RCA also has added two new wrinkles to satellite communications services. After noting that the motion picture industry spends $50 million a year to print and distribute films to the nation's 15,000 movie theaters, RCA decided to propose a distribution system, says Leonard Tuft, Washington vice president for RCA Global Communications. The firm also is laying plans for an all-digital data service that would begin as a leased-line service and be expanded to include switching at a later date.

Electro-optics

Holocamera promises sharper pictures

Holography has been troubled by two thorny problems—the images are "speckled" or granular, and the systems usually are bulky. Scientists at the Hughes Research Laboratories, Malibu, Calif., have developed a prototype holographic camera that attacks both drawbacks

The so-called holocamera originally was developed to provide Apollo astronauts with greater resolution for their photographs of the lunar surface [*Electronics*, April 13, 1970, p. 84]; the laser along with most of its associated electronics are essentially the same as those used in the laser rangefinder Hughes produced for the M-60 tank. But while the instrument won't be used on later Apollo missions, Donald H. Close, a technical staffer at the laboratories, feels there are good prospects in nondestructive testing and for microscopically recording transient events in biological studies. Hughes already has applied holography to nondestructive testing of aircraft structures [*Electronics*, April 27, 1970, p. 44].

"There are a lot of holography systems using pulsed ruby lasers, but they are not small, portable instruments," Close says. The prototype holocamera measures 12 by 13 by 6.125 inches and weighs 17.4 pounds with film. The ruby laser, which is not Q-switched, has an output of approximately 20 millijoules. Four capacitors totaling 105 microfarads are charged from silver-zinc batteries with a cumulative 21 volts and 0.05 ampere-hour. The batteries are good for about 90 exposures before recharging.

Camera resolution is 4 microns for a single image. This compares with about 80 microns for the Apollo color stereo camera used for the lunar surface material, some of whose particles are smaller than 60 microns in diameter. The holocamera's higher resolution is critical here: investigators want to photograph these particles in an undisturbed state to learn how they are distributed and oriented and whether there is a surface coating on their top layers not present in other strata.

Coherence is necessary to obtain a hologram. However, coherence is also a disadvantage—light phase does not change during exposure, and there is a random scattering of light from the surface of the object being photographed. This causes the speckled or granular effect. The Hughes camera reduces speckling by taking four images of the same area in sequence with four different light-intensity distributions. The four images then are superimposed on each other so that their different light phases partially average out, cutting granularity by about 50%.

Different light phases are obtained by means of a wedge-shaped prism placed in the path of the illumination beam. The prism is automatically rotated 90° after each "shooting," which changes the angle of the beam a few tenths of a degree. The beam then passes through a ground-glass diffusing surface to give it a very rapid phase fluctuation.

Companies

Hughes MOS growth to have tighter rein

Jack M. Hirshon, the man who hoped to preside over the rebirth of Hughes Aircraft Co.'s semiconductor fortunes, isn't going to be at Newport Beach, Calif., if and when Hughes actually makes good on its second chance in ICs. Hirshon predicted the MOS division would have revenues between $5 million and $15 million by this year, after the operation was broken out into a separate division in late 1969 [*Electronics*, Dec. 8, 1969, p. 7].

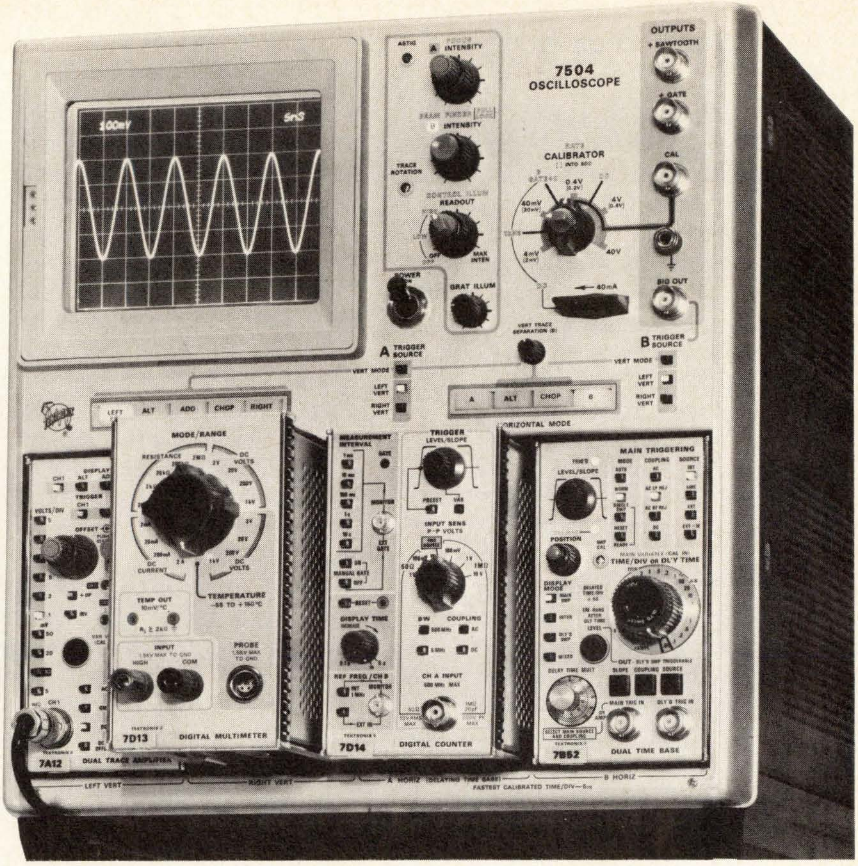
Hirshon has been kicked upstairs to a marketing job in the Hughes Industrial Electronics group, and the MOS operation's new manager is Richard Belardi. The operation itself has been folded back into the Microelectronic Products division. Hirshon was aware when he became MOS division manager that Hughes missed a golden opportunity to become dominant in bipolar semiconductors in the late 1950s. He was determined his division would change Hughes' reputation for strong technology and weak production.

But the MOS division was unprofitable last year on sales estimated at about $3 million, and Hirshon's successors apparently have a different view of how fast MOS business should grow.

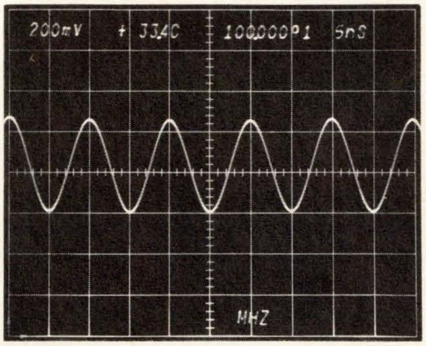
"Growth at any cost is not the philosophy here for either the short or long range," says William S. Eckess, marketing manager for the Microelectronic Products division. Eckess and Carroll Perkins, marketing manager for MOS operations in the division, admit that 1971 sales may grow very little, or remain flat, but they're determined that the MOS effort will be in the black this year.

With the MOS operation back in the Microelectronic Products division (which also includes hybrid circuit, frequency control device, special products and multiplex systems sections all with sepa-

push in the two center plug-ins and . . .



have an oscilloscope that digitally measures: frequency, resistance, current, voltage, and temperature. You still retain all normal scope features such as delaying sweep and dual trace. The CRT display at right is just one of many measurements possible with a scope/DMM/counter combination.



The output of an oscillator is displayed and its frequency is simultaneously correlated against changes in temperature.

The 7D13 Digital Multimeter has 3 1/2-digit readout. It measures DC voltages to 1000 V with an accuracy of ±0.1%, ±1 count; DC current to 2 A; resistance to 2 MΩ; and temperature from −55°C to +150°C.

The 7D13 input can be floated up to 1.5 kV above chassis potential. This allows considerable flexibility in measuring parameters that have a high common-mode voltage. A unique probe is supplied for measuring both voltage and temperature.

The 7D14 Digital Counter is *directly gated* to 525 MHz and has 8-digit readout. Both 50-Ω and 1-MΩ inputs are provided. Sensitivity is 100 mV P-P (35 mV RMS), about three times better than most counters. The signal connected to the vertical amplifier can also be routed to the 7D14 through the oscilloscope's trigger source switches. All 7000-Series vertical amplifier plug-ins (differential comparator, 10-μV differential, current amplifier, etc.) are available as signal conditioners for the counter.

The counter's Schmitt trigger circuit output can be displayed directly on the CRT. This gives a picture of the actual triggering point, thus, many signals that are difficult to trigger on with other counters are now measured with greater reliability.

The 7D14 will determine ratios from 0 to 10^5 and totalize from 0 to 10^8. The delayed sweep from the oscilloscope can drive the counter gate. By doing this, signals are displayed on the CRT with the ones being counted intensified.

For complete information on these exciting plug-ins, contact your nearby Tektronix field engineer or write: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.

Prices of instruments shown: 7504 90-MHz Oscilloscope $2000, 7A12 Dual-Trace Amplifier $850, 7B52 Dual Time Base $900, 7D13 Digital Multimeter $560, 7D14 Digital Counter $1400. The 7D13 and 7D14 are compatible with all 7000-Series mainframes except the new 7403N.

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rate profit-and-loss responsibility) Hughes is expected to become more competitive in the new MOS business it seeks. "A lot of our overhead costs have been eliminated," Eckess says, by eradicating duplication in such functions as accounting and shipping.

Perkins says almost 100% of MOS work will be custom, as is the trend at the more successful all-MOS firms such as American Microsystems Inc. and North American Rockwell Microelectronics Co. Under Hirshon, between 80% and 90% of business was custom.

Eckess insists that eliminating the MOS division doesn't mean Hughes will close it. "There's no way Hughes could get out of the MOS business. The bulk of our business is outside the company, but there's large usage of MOS inside Hughes," he says. As examples, he cites the McDonnell Douglas DC-10 multiplexed passenger services and entertainment system, the F-15, and the Airborne Warning and Control System.

Perkins adds that six major outside contracts are sustaining MOS operations now, plus a number of smaller agreements. Hughes officials won't confirm it, but one of those six pacts is with Timex to provide low-voltage complementary MOS circuits for an electronic watch.

Materials

Computer automates wafer production

To lower their overall costs, semiconductor companies have been turning to automation. However, the efforts have been applied mainly to device handling and packaging rather than actual manufacturing of the silicon die. But Applied Materials Technology Inc., Santa Clara, Calif., has teamed a new general-purpose control system with its epitaxial reactor to spawn an automatic epitaxial system.

"Most epi processes are completely manual and flow rates and time intervals are set manually," asserts Edward W. Onstead, manager of computer systems development at the company. This procedure, he says, not only leads to errors, but also wastes time. "With an automatic system," says Onstead, "there is no fixed time delay for the flow or temperature to stabilize, purge times can be reduced, and there is no manual setting of flow rate and temperatures."

Applied Materials chose a modular approach using Digital Equipment Corp.'s PDP-11 minicomputer. Each computer can run up to eight epi reactors. Onstead points out that this figure was arrived at through bulk storage constraints.

The system is card oriented. When a batch of wafers is started off, an IBM punched card goes with it. The card contains general information (lot number, date, etc.), the recipe (etch time, etch temperature, flow rate), and evaluation data parameters such as actual thickness and resistivity, which are taken after the processing is completed. When the wafers reach the epi stage, they are loaded in a tube and the card is inserted in a slot. The rest is automatic.

In addition to the reactor itself, the company designed the automatic flow controller, the automatic temperature controller, and the system interface. Onstead and his staff wrote the software package. Online peripherals include a teletype unit, an optional CRT terminal, and a 64,000-word disk memory. The disk stores recipes, reactor history, and, says Onstead, "It can be used to store digitized voice messages."

For the record

Bankruptcy. American Calculator Co. of Dallas has gone into bankruptcy, ending its attempt to market an American-made calculator using light-emitting-diode displays and Electronic Arrays' set of six MOS chips. However, Duke Ducote, former chief engineer at American Calculator, and other members of his engineering staff have been hired by the Computer Circuitry Co. of Grand Prairie, Texas, which in April will introduce two calculators much like those planned by American.

Layoff. Texas Instruments has announced a reduction of 432 in its work force in Sherman, Texas, 60 miles from Dallas. The action was necessary, says TI, "After a reduction in scheduled deliveries of a custom-designed integrated circuit produced in that location."

Big scope. Tektronix has announced a 500-megahertz real-time scope system with 1 gigahertz direct access. The system includes a 7904 mainframe ($2,900), a 7B92 dual time base ($1,400) and a 7A19 amplifier ($500). The mainframe also will accept other plug-ins from Tektronix' 700 series. System specifications include an 8-by-10-centimeter viewing area, a writing speed of 10 centimeters per nanosecond, and a 0.7 nanosecond rise time. Input sensitivity is 10 millivolts.

SST's relativity. A Congressional closing of the Department of Transportation's supersonic transport development accounts will injure avionics makers far less severely than it will the more severely depressed aircraft industry. But that is small comfort for Sperry Rand's Flight Systems division, Phoenix, by far the largest SST avionics supplier at this early stage.

Out. George Thiess, president and chairman of the board of Electro-Data, Garland, Texas, which is making the pulsar watch for Hamilton [*Electronics,* March 15, p. 14], has been ousted, apparently partly as a result of his opposition to the acquisition by Electro-Data of Care Electronics in Huntsville, Ala.

FCC separates. General Telephone & Electronics and Western Union probably will be forced to withdraw their data processing services as the result of a recent Federal Communications Commission decision. As predicted [*Electronics,* Feb. 1, p. 32], the FCC

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It's done with oscillographs. We have a bunch, but let's talk about these two. They can handle on-line or off-line test and measurement of any physical happening you might have in mind. From pulse flutters during surgery to whether or not you're refining that crude the same way today as last year.

The one on the bottom is the 5-134. It does everything but talk. It writes to 25,000 Hz. (But with all that speed, it has a data accuracy to $\pm$½%.) And can flip into any one of 10 different servo-controlled speeds.

It's modular, of course, with special refinements. Like the timer, servo control board and galvo all plug in. Individual input connectors as standard. An extremely quiet operation. That type of thing.

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And it's got a "jog" feature that allows you to move the paper short distances for initial set up—one hold-down button for on/off.

The smaller box is the 5-135. It weighs in at 35 pounds (a real portable) as compared to the other's 50 pounds. Both boxes share pretty much the same components. It's just that the 5-135 has broader application by more industries across the board because it's not quite so fancy (9 channels versus the 5-134's 18, for instance). Even though it's smaller, it doesn't skimp on performance. It has the largest range of input power options of anybody going. And all that at a lot less money. Not bad, huh?

And one more thing. Just in case you're building a system, we've got a range of other new goodies to complement these graphs: 1-172 amplifier, 8-114 bridge excitation/signal conditioner and the 23-111 paper processor.

If anything here piques your curiosity, you can get the full package of specs by writing Bell & Howell, Instruments Division, 360 Sierra Madre Villa, Pasadena, California 91109.

INSTRUMENTS DIVISION

BELL & HOWELL

ended its computer communications inquiry by ruling that all common carriers with data processing subsidiaries must maintain a strict wall of separation between their communications and data processing arms.

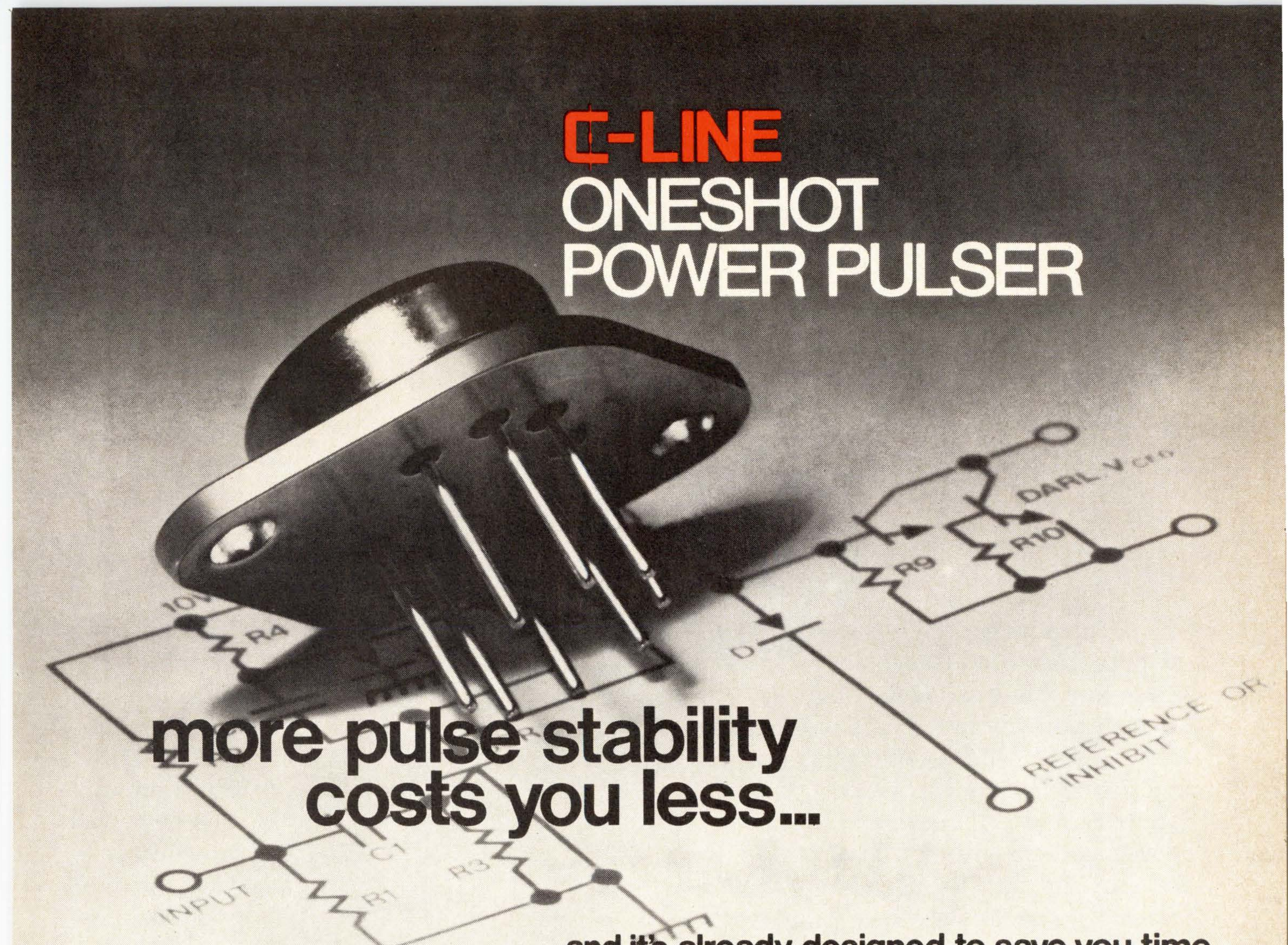
Suit shy. Laws now on the books, particularly liability statutes, are scaring electronics companies out of the medical market, says Oliver Schroeder, director of the Law-Medicine Center at Case Western Reserve University in Cleveland. Schroeder will urge a "vast reform movement in law" when he speaks at the Third National Conference on Electronics in Medicine in Boston (April 13-15).

Step. Control Data Corp., with shipments down 19% in 1970, has taken a giant step that it hopes will turn it firmly into the black. Its introduction of the Cyber 70 computer system is the company's first craft at commercial and business data processing.

The new series, now including models 72, 73, 74, and 76, is the first of CDC's products to emphasize character-oriented data addressing, in six- or eight-bit characters, as opposed to full-work addressing of as many as 60 bits at a time. The line replaces CDC's 6000 series and the 7600.

Another move. Singer Co. is dissolving its Electronics Products division Instrumentation activities are being consolidated in two California plants, and placed under Singer's Librascope division.

Plugging wire. Rejecting the assumption that "security is a mechanical flight control system," NASA is gearing up for a program designed to demonstrate the advantages of fly-by-wire aircraft controls. If all goes well, an LTV F-8C fighter will take off for its first test before the spring of 1972. As flight tests proceed, NASA hopes to prove that computers can provide more stability, less drag, and greater maneuverability than aerodynamic structures.



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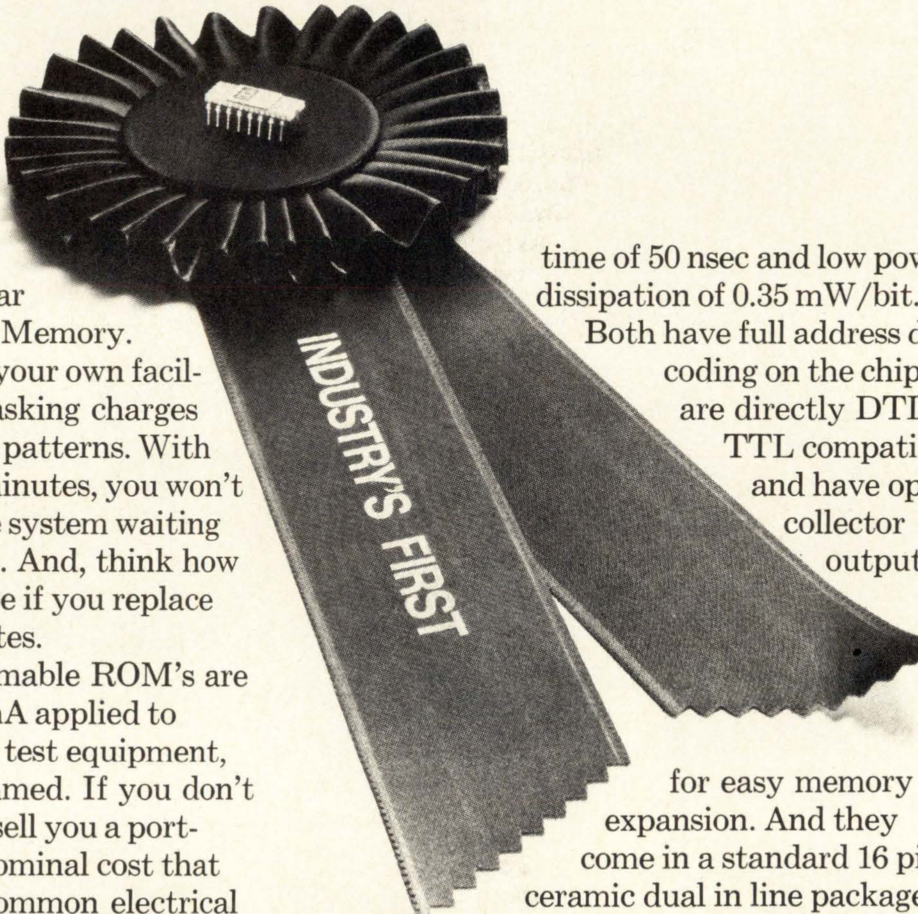

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Only *MMI* offers pin for pin compatibility and interchangeability between our 1024 programmable ROM (MM6300) and a 1024 bit mask-programmable ROM (MM6200). Both are bipolar; both organized as 256 words by 4 bits, have an access time of 50 nsec and low power dissipation of 0.35 mW/bit. Both have full address decoding on the chip, are directly DTL/TTL compatible and have open collector outputs for easy memory expansion. And they come in a standard 16 pin ceramic dual in line package.

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Washington Newsletter

March 29, 1971

U.S. plans tests of two more European missiles

As possible remedies for acknowledged shortcomings in the Army's low-altitude field air defenses, British Aircraft Corp.'s low-cost Rapier and the West German Nord combine's Roland will be evaluated in fiscal 1972 along with the French Crotale [*Electronics,* Dec. 21, 1970, p. 39]. The proposal is contained in John S. Foster's spending plans for his Directorate of Defense Research and Engineering.

Foster acknowledges that GE's Vulcan Gatling-gun system, Philco-Ford's Chaparral missile, a surface-to-air adaptation of Sidewinder, and General Dynamics' Redeye portable missile are all helping solve the Army's problem, but apparently not fast enough. "All three require improvement," he says.

USAF to replace hf gear with uhf satellite . . .

The Department of Defense will soon ask the Air Force to begin work on an ultra-high-frequency satellite system designed to take over from the high-frequency gear now employed by mobile users. Although the program is still in its formative stage, Louis deRosa, assistant to the Secretary of Defense for Telecommunications, says that **work on the system will most likely begin with fiscal year 1972 funds.**

The system would be used to provide reliable communications in a nuclear environment—a task beyond the reach of present hf equipment. According to deRosa, it will also have highly directive antennas, to enable mobile users equipped with small antennas to beam communications through the defense satellite communications system. **The Army and the Navy are also expected to share in developing ground-based equipment for the system.**

. . . as DOD pushes survivable unit

As work proceeds on the tactical uhf satellite system, the Pentagon plans to initiate work on an experimental survivable strategic communications satellite. John S. Foster, Director of Defense Research and Engineering, says its design and fabrication will start in fiscal year 1972. **Such a satellite would be capable of withstanding a number of nuclear effects and may include features that would protect it against a new family of Soviet killer satellites.**

New ATS-G laser may scrub five industry plans

A renewed space agency proposal, which would put a helium-neon laser communications experiment on board the G model of the Applications Technology Satellite, is now on the desk of Roy Jackson, chief of the Office of Advanced Research and Technology. If it gets headquarters approval, as expected, it will shoot down five industry proposals in another NASA shop, the Office of Space Science and Applications, whose contract with Aerojet-General Corp. for a 10.6-micron laser to fly on ATS-F was cancelled last year because it failed to meet specifications [*Electronics,* Dec. 21, 1970, p. 32].

This OART request to industry is for a He-Ne laser capable of transmitting a pseudo-random code at 35 megabits per second, and **its experiment "would be hard to turn down," says NASA sources, since it would eliminate any cost to OSSA.** The space science office's proposals to industry include requests for yttrium-aluminum-garnet and carbon-dioxide lasers.

Washington Newsletter

NASA instrument may replace test recorders

Flight tests of a small, low-cost unit that could be used to predict the lifetime of aircraft structures will soon begin at two Air Force bases. Developed by NASA's Langley Research Center, Hampton, Va., the unit measures how many times structural components such as wings and tails are stressed beyond a pre-set limit. Circuitry in the unit, which weighs 2½ pounds and costs about $400, is used to drive wire strain gauges. Returning pulses beyond certain voltages are then counted on a small electromechanical counter.

NASA sources say that the unit could be used to take the place of expensive continuous recording systems now used in many commercial planes. The unit will be tested on F-106 interceptors at Minot, N.D., and on A-37 attack planes at Wright Patterson AFB, Ohio.

Army moves to put Cheyenne into production

The Cheyenne may still get off the ground. The Army is requesting $13.2 million in fiscal 1972 funds for "advanced production engineering for [an] Advanced Attack Helicopter," which DOD sources admit is in fact Lockheed's troubled AH-56 helicopter gunship. Although the program was cancelled last year, more than $80 million in production and R&D accounts was left over—a sum that the service would also still like to spend on what Secretary Stanley Resor calls "the Army's number-one R&D priority."

Apart from technical difficulties, the program is threatened by USAF's attack experimental plane, the A-X [*Electronics,* Feb. 15, p. 114], which wants the role of close air support for ground troops. Congress may resolve that issue this year.

Pentagon to slash EDP buys 46%

Army, Navy and Air Force procurements of data processing hardware will drop 46% in the fiscal year beginning July 1, according to budget figures obtained from the Defense Department. The services' fiscal 1972 spending plans of $77.8 million are down from $114.2 million in the current year. At the same time, it's prepared to cut R&D for data processing more than $4.6 million to $114.7 million. Pentagon sources attribute much of the EDP procurement cutback to "an attractive price" negotiated with International Business Machines Corp., which led to larger than usual hardware buys this fiscal year.

Addenda

The final version of a General Accounting Office defense profit study uses the same figures as a first draft [*Electronics,* March 15, p. 44], but alters emphasis to support industry criticisms that commercial business is more profitable. . . . Teledyne Systems Co., Northridge, Calif., will test the feasibility of using Loran for vehicle location under a new $184,000 Transportation Department award, the first of three for urban vehicle location. . . . Communications and Industrial Electronics is the new name of EIA's Industrial Electronics division; it will oversee interconnection, data, satellite and broadband communications. . . . Watch for tougher scrutiny of medical device legislation now Rep. Paul Rogers (D. Fla.) is chairman of the public health and welfare subcommittee. . . . The Navy wants to go ahead with its Sanguine submarine communications system, reducing the power required by the extra-low-frequency transmitter; as a result, the stray electromagnetic fields generated will be considerably weaker.

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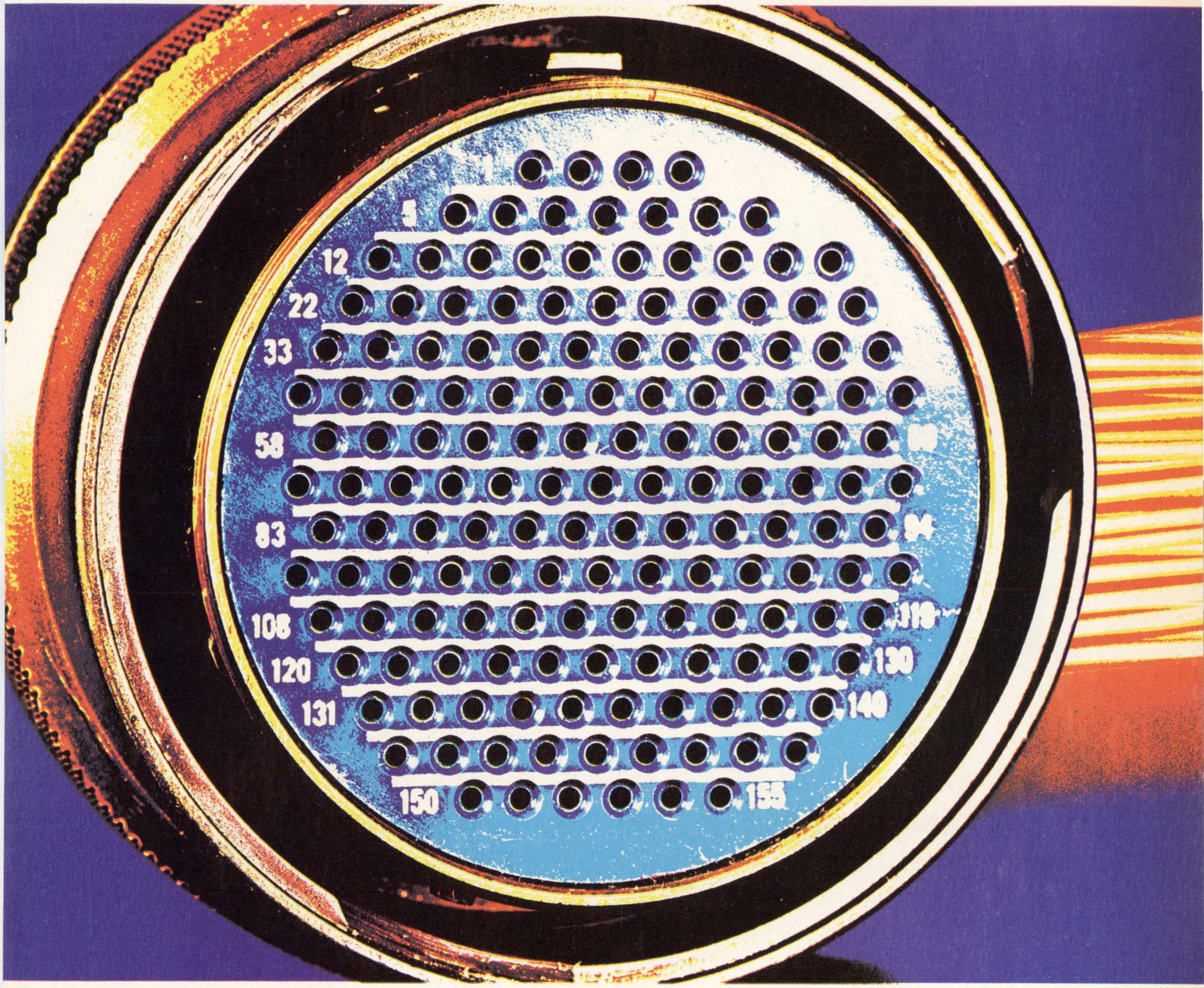

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MM4017/MM5017*	Dual 500/512 bit
MM4018/MM5018	Triple 64 bit
MM4100/MM5100	144/156 bit
MM4102/MM5102	Dual 71 bit
MM4105/MM5105	Quad 64 bit buffer memory
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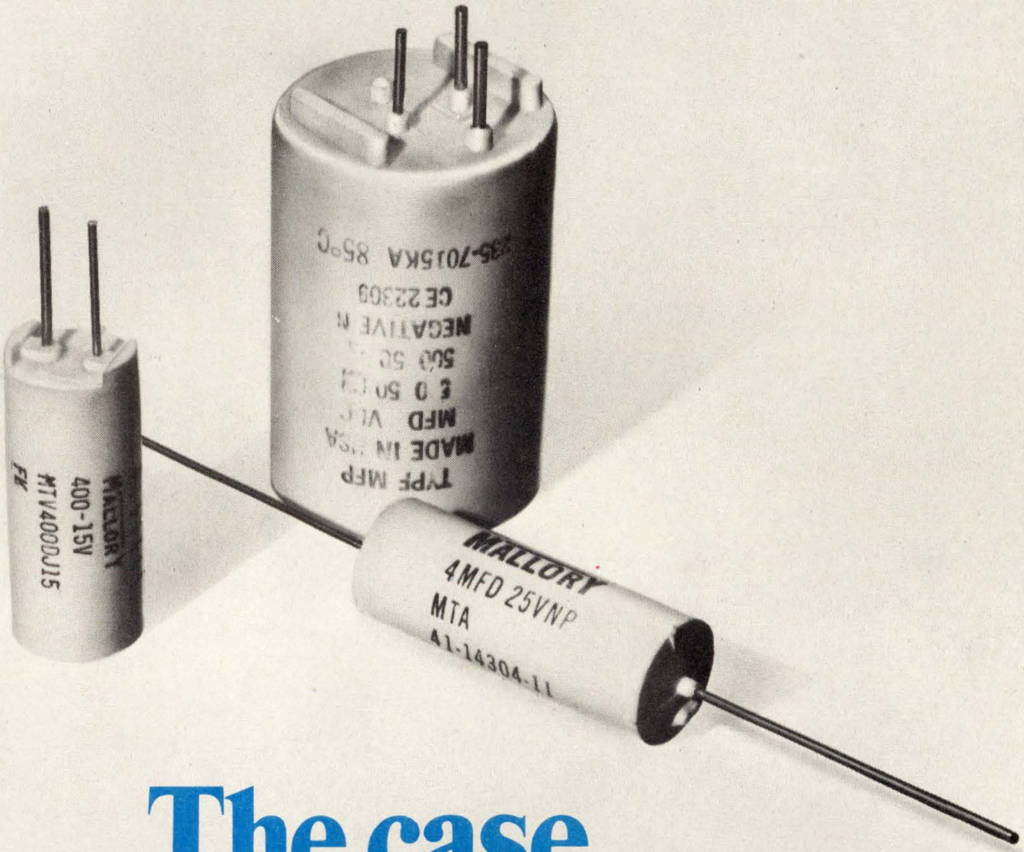

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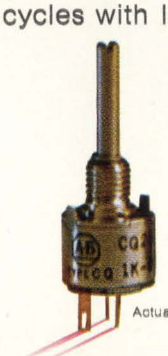

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Circle 40 on reader service card

Technical articles

Electronics firms to cash in on cashless society: page 42 (cover)

The greenback may end up as a novelty if, as predicted, a credit card terminal gets into every major retail establishment. To handle the awesome accounting and credit verification chores that must be faced by the end of the decade, electronics firms are designing a bagful of special equipment, including optical and magnetic card readers, "yes-no" terminals, and multipurpose keyboard-and-display units.

Logic design problems? See Alice: page 50

Attractive and easy to get along with, Alice is, in fact, a logic simulation program that lets the logic designer use the computer much as linear circuit engineers have been doing for years. The program permits breadboarding of logic circuit designs on a keyboard; the computer uncovers errors and analyzes performance.

Here come the minicomputer networks: maxicomputers, look out! page 56

If you're thinking about buying a big, expensive computer, asserts author Wallace B. Riley, you might want to consider whether a network of minicomputers could do the job just as well—and at a much lower cost. Of course, software and interconnection problems in minicomputer networks can be formidable, but the concept has great potential.

Help wanted: product-oriented engineers: page 63

With so many engineers out of work, it may come as a surprise to learn that there's a real need for people with product-design qualifications, says author Bernard M. Gordon. Many former defense and aerospace EEs could carve out a new career in industrial and consumer electronics, says Gordon—if they're ready to adapt to the philosophy and ideas of the marketplace.

Batteries live longer with low-power a-d converter: page 71

Remote sensing systems, such as environmental data-gathering networks, depend on battery power supplies that must last as long as possible. A real power-miser is a 12-bit a-d converter that turns off between conversions. And even when it's working, the unit's C/MOS logic is stingier with current than even low-power TTL. The result: the entire converter draws only 20 milliamperes at 5 kilohertz from a 12-volt battery.

And in the next issue . . .

The micropower movement in electronic wristwatches . . . molybdenum gates speed up MOS . . . laser IC tester gets inside circuits . . . multiplexing eases interconnection problems . . . new trends in LSI packaging.

Special report:

Cashless society means money in the bank for electronics firms

To provide foolproof credit authorization, designers are working on a variety of optical and magnetic card readers, 'yes-no' terminals, and keyboard-display units that encode sales slips and access credit records

by Gerald M. Walker, *Consumer editor*

☐ To banks, department stores, and other credit-granting institutions, the cashless society conjures vistas of swift, foolproof credit authorizations and simplified transactions, and mountains of checks and cash whittled down to a stock of credit cards. To many electronics companies, the cashless society's vistas evoke mountains of orders for point-of-sale terminals for card verification, authorizer terminals, communications modems, and central processing units.

Thanks to the widespread proliferation of credit cards, the groundwork for the cashless society already exists. So do plenty of headaches, including what card-encoding format will become standard and how to cope with fraud. But pitfalls or no, the new era will advance steadily over the next decade as more and more credit cards are issued. In fact, within the next five years, credit card terminals will be found at virtually every point of sale, including every store, bank, gas station, airline terminal, and restaurant—even doctors' offices and libraries. And because hospitals have begun to install their own systems and hardware, it's likely that an American will pay to enter and leave this world through a credit card terminal.

All of this may only be the beginning of a much larger consumer credit system. When a national system is in place, consumers may be able to shop at home via authorization terminals. One observer notes that "the technology is here, but before a nationwide credit approach can work, Ma Bell has to get the cost of communications down." "Maybe," adds a terminal manufacturer, "we can expect a Federal telecommunications network for credit verification."

Of immediate interest to electronics firms is the fact that the cashless society will not be a paperless society. While the all-in-one format of credit card statements will certainly reduce checking and cash volume at the point of sale, massive computerized networks will be required to handle the staggering accounting, transfer, and credit verification tasks that will be created.

The computer networks also will have to deal with the growing problems of credit card fraud and abuse of spending limits. A congressional investigation in 1969 found that as many as nine million cards are lost and stolen each year, of which about 1 million are used fraudulently. Estimates of losses range from $150 million to $1 billion a year, and with legislation recently enacted limiting the cardholder's liability in case of loss or theft, a premium will be put on foolproof credit verification, identification, and authorization systems.

Requirements proposed by the Federal Trade Commission also will accelerate the switch from basic mechanical point-of-sale procedures to electronic means and would definitely expand the computer's role at the billing end. The FTC has recommended that when a consumer disputes a single charge on a bill the entire balance must be held in a suspense ledger without credit charges until the dispute is settled. The agency also has proposed that all bills be submitted for payment in 21 days from the end of the billing period, eliminating the two- or three-month lag time sometimes allowed.

The role of electronics in the cashless society is evolving rapidly. Equipment already is available for encoding and reading cards, recording the location and purchases at the point of sale, identifying the card bearer, verifying credit status and authorizing conclusion of a purchase, and even for the high-speed embossing of the cards themselves. And backing up the point-of-sale terminals are communications modems and on-line or time-share computers to transmit and record transactions.

All of this hardware is needed to accommodate the explosive growth of credit cards. For example, in 1968 there were just 25 million bank credit cards in circulation representing less than 1% of retail debt. The figure two years later was 60 to 70 million bank cards accounting for 2% of retail debt. Master Charge and BankAmericard, the largest-issuing networks, have signed up 1.9 million retail outlets to accept their cards. And by 1975, banks alone will have handed out 90 million cards expected to be used in 20% to 30% of retail sales.

The hardware requirement alone represents an impressive profit potential, so much so that manufacturers are wary of numbers. Says the sales manager for a credit authorization system, "We have a good estimate of how much the market is worth, but it's so high that we don't want to talk about it." He estimates that about 50 to 60 companies are attempting to sell some form of hardware relating to credit cards, though actual sales are still slow.

On the technical side, the action is in the encoding systems and the terminals designed to read the cards; all other links in a verification system—communications and data processing—are technologically straightforward. The typical verification-authorization system begins way back at the choice of card embossing and encoding. At that point the decision to use mechanical, direct character reading, punched hole, optical, or magnetic format dictates the type of terminal to be used. It also influences the cost of the card itself, which can range from 2 cents to 50 cents.

The least expensive card format is simple mechanical embossing for optical character reading equipment, direct reading, or magnetic ink character-reading systems. There are several punch encoding choices such as Hollerith (a rectangular punched hole system), round and square holes, notches, and corner cuts. According to Bernard Van Emden, division manager, Identification Badge division, Datron Systems Inc., Mountain Lakes, N.J., there are 34 different ways to make hole-encoded cards.

More expensive are the optically encoded cards, on which the code is scanned by a reader device. These types include holographs (the most costly), fluorescent, and other spectrum dot techniques, highly reflective materials, and line or color optical codes.

Magnetic encoding has gained in prominence among credit card issuers, who are attracted by its combination of tamper resistance, cost, ease of reading, and high data density, though it may not be best in all of these categories. The passive magnetic code simply requires detecting the presence or absence of a magnetic material on the card. In the active approach a coded strip emits a field of polarity so that the card, similar to a computer tape, is read by a magnetic head.

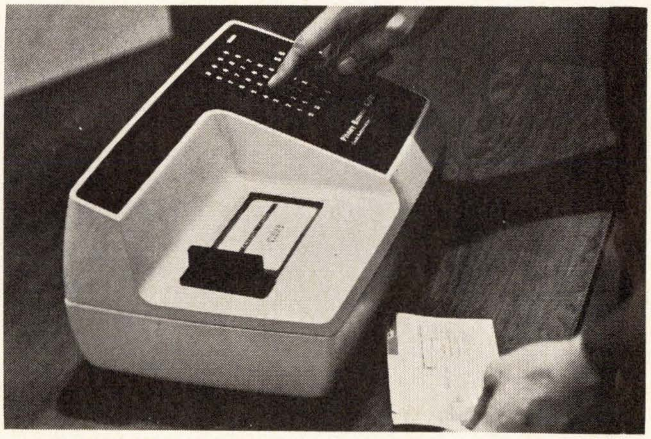
Each of these approaches has its partisans among issuers and equipment manufacturers. The OCR format still is top dog, but newer, electronic means of communicating transactions directly from point of sale to computer billing center are challenging the earlier systems. These terminals feature keyboard input of variable information and come in various models with automatic or manual card number input, with or without automatic sales slip imprinting from the credit card, and a variety of signal lights to direct sales personnel.

Though fairly simple, OCR systems can be slowed by unreadable transactions requiring human intervention. Slowups in billing, plus losses from machine and human error, have spurred investigations of the more expensive magnetic stripe and optical systems. The newer approaches offer speedy transmission by on-line techniques if necessary, faster automated billing in the back office, and, thanks to rapid communications between computer memory and point-of-sale terminal, a practical means of credit verification.

However, some roadblocks must be removed. The first is the large number of competing hardware systems along with a lack of standards. Only recently, after two years of labor, has the American National Standards Institute (ANSI) developed a proposal for card standardization (see panel, p. 46).

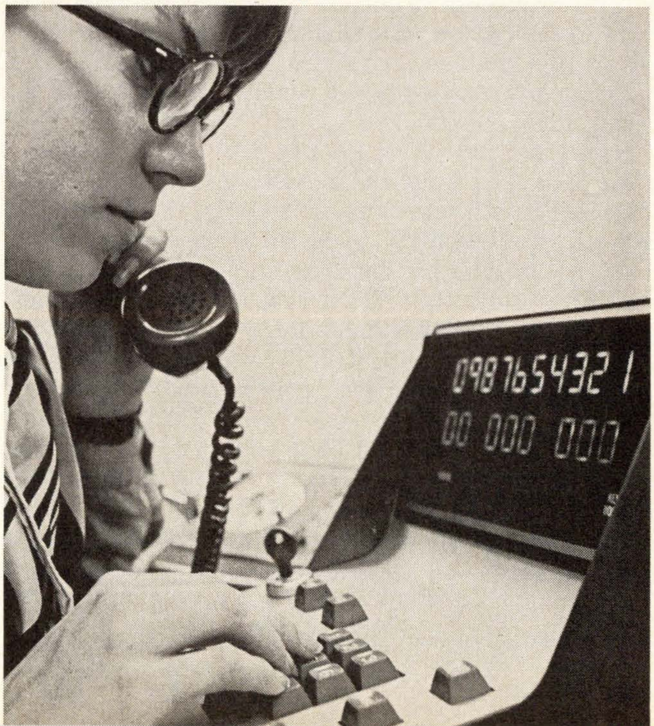
Though this standard set the physical specifications for cards, yet to be established are standards for the machine-readable part and the charge record form (sales slip). As for encoding systems, C. Thomas Deere of Data Card Corp., Minneapolis, Minn., who heads the ANSI card standards committee, points out that more than one technique probably will be accommodated in any future standard. Meetings will begin officially in April on international credit card standards, he adds.

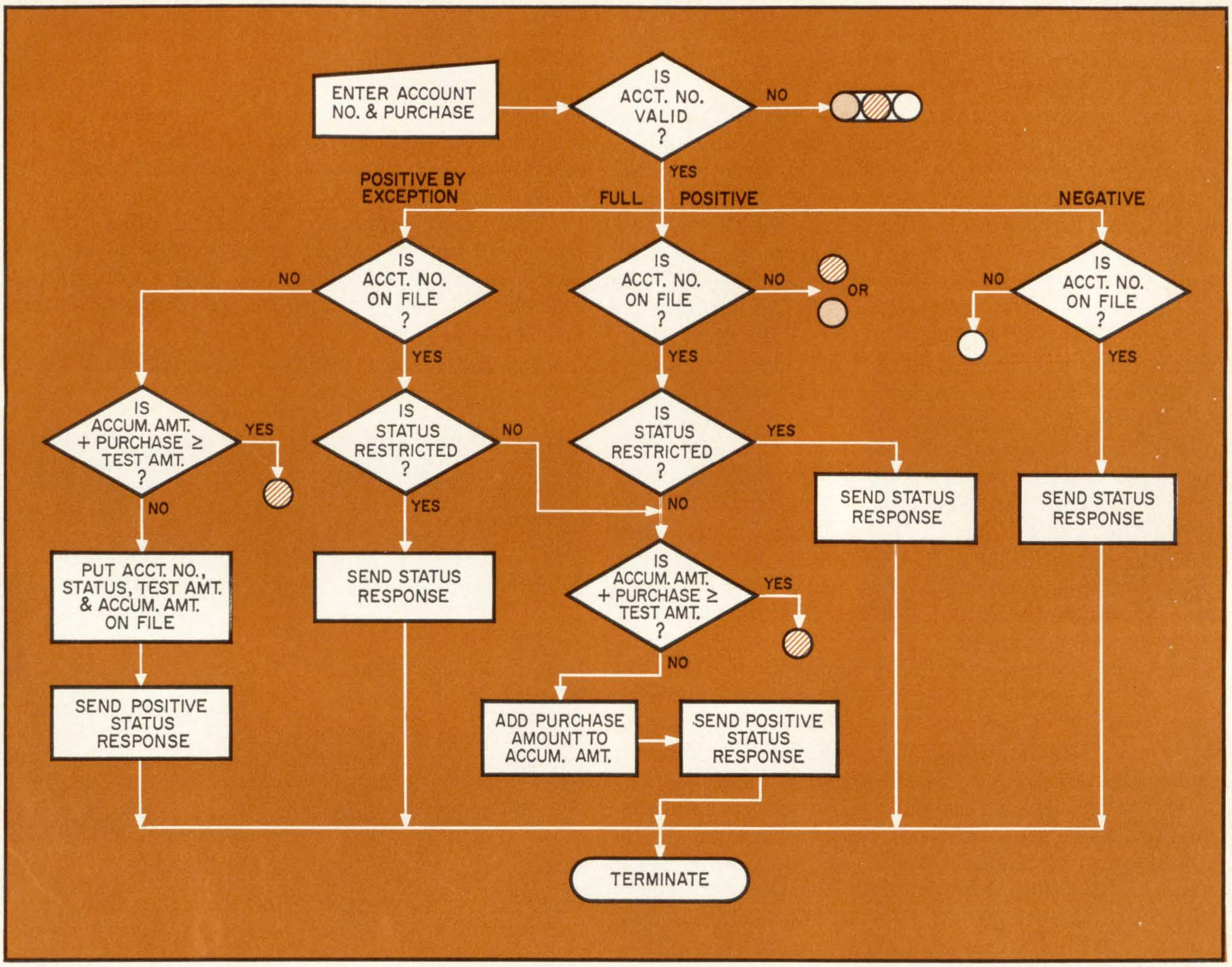
Aggravating the standardization problem is the lack



1. Fill 'er up. When used in a gas station, the Pitney-Bowes terminal will automatically read the encoded card and telephone a computer center to check credit status before completion of transaction.

2. Approved purchase. Generally located at central credit office, this TRW authorization terminal displays current account status when question arises, permitting immediate decision on granting credit.





3. Three checks. This flow chart compares the three types of credit verification that can be performed between a point-of-sale terminal and a central computer file by the TRW system.

of cooperation among credit card issuers. Retailers have always taken an independent line in business procedures, and in the case of card standards forced ANSI recognition of a smaller card than those issued by other credit grantors. On the other hand, the Air Transport Association of America has gone its own way in backing magnetic stripe encoding for airline cards, and American Express has lent its weight to the idea. The American Bankers Association also has thrown its support to magnetic stripe. Petroleum companies are not likely to be influenced by any of the other issuers either, because they are no longer interested in unprofitable interchange with other cards.

Another barrier is the cost of setting up credit verification systems, especially in an uncertain economy. Comments Paul T. Greer, general credit manager for Atlantic Richfield Co., New York, "The petroleum industry is interested [in electronic systems], but can't afford the price. Our changeover to unleaded gas came as an unexpected cost in 1970. But by 1973 telecommunications lines should be in use throughout the industry and by 1975 no service station will be without direct communication to a computer center."

Atlantic Richfield took a significant step in that direction in January when it signed a five-year agreement with National Data Corp., Atlanta, to take over full processing of its credit operation from account openings to collection. By next year NDC will manage the oil company's 4.5 million accounts under close supervision. The computer systems firm also will be evaluating and installing verification terminals throughout the Atlantic Richfield domain.

"We were on the verge of changing our entire system, but decided to let a systems house do the job instead," Greer explains. "If this works, most of the petroleum industry will probably go our way," he adds.

More impetus for sorting out the technology will come from the massive pressure of handling the hordes of credit card users expected in the future. Ironically, creditors have learned that the best type of card holder—from their point of view—is not the conscientious first-of-the-month billpayer, but the consumer who runs up monthly finance charges by not paying his bills on time. This customer also may be either a high risk or a valued big spender, putting a premium on a careful debt authorization system to sort out the complex interrelation between credit and risk. Likewise, interchange—or at least the ability to verify credit on several different cards from a single point of sale—will be essential.

The battle for supremacy in this promising market already is raging. Financial staying power during the next three to four years may make the difference among the score or more companies now competing. And service networks will be vital.

Three companies—Digital Data Systems Corp., Pennsauken, N.J., TRW Data Systems, Torrance, Calif., and Credit Systems Inc., Colmar, Pa.—have been competing in the difficult department store-chain store market with dedicated credit authorization systems. All three are moving into the other verification systems as well. They are also competing with the more elaborate point-of-sale electronic cash registers marketed by a dozen or more companies for department stores [*Electronics,* Nov. 23, 1970, p. 52].

Credit Systems has two basic Credit-Check systems: negative, which simply spots the "bad" cards, and a new positive authorization. The latter is designed for larger stores with computerized accounts receivable systems. Whereas the negative system, used by about 100 stores nationally, is limited to finding suspended accounts placed in computer memory, the positive verification can guard against multiple checks. For example, when the clerk uses a terminal keyboard to index the account number and amount of sales, the account number is first tested against negative accounts stored in the system. If there is no match, the dollar value is automatically added to the total sales since the last updating. This new total then is compared against the credit limit. If less than the limit, the credit sale is approved. The processor will prevent completion of transactions not meeting the credit rules and requires the clerk to seek authorization before completing overlimit purchases.

The processor, a new CSI-designed model, is hard wired and can handle approximately 4.5 transactions per second. The new Authorizer Display gives credit personnel immediate access to all account information. When a floor referral arrives, the authorization clerk uses this unit to retrieve account limit, amount of purchases or number of transactions since the last updating, and the assigned status code. This information is sufficient to decide to override the terminal. According to CSI, stores can verify every purchase for $20,000 to $30,000 a month, depending on the number of terminals and authorization stations.

Besides its own negative and positive networks, TRW Data Systems offers an in-between approach, called positive by exception. In this mode, the inputs to the processing unit are monthly lists of customers who will not be extended credit, risky customers with a specific 30 day credit limit, and valuable customers with high limits.

Early this year the company brought out a new terminal and cathode ray tube authorizer for its credit systems. The terminal features a light-emitting diode readout that displays the numbers entered on the keyboard by the sales clerk, and MOS shift registers capable of storing 32 digits at the terminal.

The LEDs replace the usual colored lights that signify the customer's credit status. Instead, the diodes are used in special sequences which will not tip off cardholders.

The shift registers provide full buffering, which simplifies the communications. With this arrangement, a two-wire system can be used for communicating with the central processor instead of the multiwire hookup required with a shared buffer. In use, the central processor polls the terminal on a nonpriority basis; the shift registers store data at the terminal until polled. When the processor hits a terminal with

Card coders are making out, too

While terminal manufacturers are scrambling for credit card authorization business, a handful of producers of equipment to emboss and encode cards are enjoying brisk sales. Interest in high-speed, low-cost production will intensify as more and more consumers enter credit systems. This will require more sophisticated electronic controls on the card coders, as well as the ability to accommodate whatever code types become dominant.

The Data Card Corp. of Minneapolis, Minn. has a Series 1500 that's just like a miniature processing plant. It embosses and encodes 1,500 cards per hour directly from magnetic tape, regardless of the number of lines or characters per line, the firm claims.

Models are available for up to six lines of embossing and up to 30 characters per line. Optional modules control magnetic stripe, punched hole, and optical bar coding. Also included are automatic parity checks of input from magnetic tape, checks on data into and out of memory, echo checking of embossed and punched data, and read-after-write of magnetic data for comparison with stored input information. Basic selling price is $78,000, depending on model and options; lease rate begins at $1,700 a month.

Another high-speed embosser has been developed by Dashew Business Machines Inc., Santa Monica, Calif. The model 500 Databosser reads data from magnetic tape into a process computer and controller. Decoding and driving systems actuate the embossing modules to put up to four lines of information on cards. Two-line cards, depending on software, can be embossed at approximately 1,500 per hour, according to the company. The machine can be programed for magnetic tape encoding and has a capability for control of write/read heads to magnetically encode cards. This system includes a console for access to the minicomputer module. Base price for the model 500 is $55,000, depending on configuration.

A simpler machine made by Datron Systems Inc., Mountain Lakes, N.J., punches Hollerith code into a card from a keyboard input at a rate exceeding five characters per second. Model 602 combines a card punch with a card reader to make cards from 70-column computer input cards. The company also operates a service bureau for punching out all hole configurations.

Polaroid Corp.'s Industrial Products division, Cambridge, Mass., makes cameras that are now snapping identification photos for cards in some 800 banks. By the end of 1971 the company expects 1,200 banks will be using snapshot credit cards.

Standards: who's doing what

At least four groups are working on standardizing or at least unifying aspects of credit cards and verification terminals. Here's the box score:

- American National Standards Institute is putting the final touches on standards covering dimensions, embossed character capacity, type style, material, and opacity of cards. In essence, all cards now circulating are acceptable and at least there is now very little chance of someone coming along with a triangular or disk-shaped credit card.
- American Bankers Association has just released a recommendation supporting magnetic stripe encoding for machine-readable cards. In addition, the ABA has promised to define minimum functional requirements for authorization and point-of-sale terminals to guide manufacturers.
- National Retail Merchants Association has a number of task groups working on various credit card recommendations. Included are groups for merchandise and customer identification, tag marking by manufacturers, and retail credit systems specifications.
- Air Transport Association of America has approved a front-of-the-card magnetic stripe encoding standard for airline use. (ABA's magnetic stripe will end up on the back.)

Though the disparity among approaches may appear confusing, the underlying theme is to have firm card specifications and leave equipment under a broad set of recommendations. This will permit electronics firms to use their design imagination competitively, provided that they build equipment that accommodates a standard credit card.

a transaction, that terminal receives priority interrupt, giving the clerk a reply in 1.6 seconds.

The CRT unit makes it possible for the authorizer to call up a complete past account record (up to nine months) from the store's main computer, the current purchase amount, the account number, and an up-to-the-minute accumulative purchase total.

The computer is TRW-designed and holds up to 200,000 16-bit accounts. Up to 10 processors can be paralleled to handle increases in business volume.

Digital Data Systems Corp. has three types of dedicated systems called CreditMaster in use in installations ranging from 400 terminals to 2,800 terminals. It's also getting set to market another terminal specially designed for verifying all credit cards at retail stores. These Veridex terminals are undergoing pilot tests at three locations and are scheduled to become available by midyear. The Veridex terminals won't cover airline or petroleum cards (a third terminal and system, Creditron, for petroleum company use, is planned for 1972), but their potential market is vast—the 1 million locations honoring bank, entertainment, and retail cards.

How issuing agencies will get together to share such a system is still a secret held by Digital Data Systems president Berdj C. Kalustyan, but some 47 banks are involved in sponsoring the Veridex pilots, he reports. The key to his approach, Kalustyan points out, is that the issuing firms do not have to accept a new card encoding system while still obtaining 100% verification in dedicated department store systems.

As in CreditMaster, the Veridex terminal uses telephone lines to transmit card identification and purchase amount to a computer for authorization. Also like CreditMaster, the central computer signals by lights at the terminal a "go" to complete imprinting of the charge slip, a hold to contact the authorizer, or a reject for "bad" cards. The Veridex terminal's self-scan numeric display repeats numbers keyed from the board and receives special code digits, such as a purchase authorization number, that cannot be signaled by the lights. It uses MOS digital and linear ICs.

Eugene Gertler, director of engineering, says that reliability and good service will be vital to the success of a terminal and related systems. Accordingly, the company's field engineers participate in design decisions. For example, at the insistence of servicemen, CreditMaster's countertop terminal was designed to be replaced by a nontechnical store employee simply and quickly.

"CreditMaster is a full-compliance system; that is, sales clerks are forced to use it to complete a purchase," Gertler explains. "This means that the terminals must be reliable and easily serviced or business comes to a halt." Thus, the decision to use a two-wire phone connection "meant more than just choosing the connector," he asserts. "Maintainability was part of the entire operation."

Reliability and ease of maintenance also figure prominantly in the entry of Pitney-Bowes Inc., Stamford, Conn. The stakes are especially high in P-B's proposed system because it uses a special fluorescent light to illuminate the terminal for reading the card. Undergoing trials in cooperation with National Data Corp., the terminals are designed to connect to the customer's own computerized account data bank by telephone lines.

To use the terminal, the sales person keys in the amount of purchase on the terminal keyboard and inserts the specially encoded card. The terminal automatically places a telephone call and, when the computer answers, the terminal transmits purchase amount and location, and credit card number. It then receives from the computer a credit authorization number or one of several other signals, which might indicate that the card is lost or stolen, instruct the clerk to seek more positive identification, or tell him to telephone a special number for further instructions.

The terminal is available in three configurations—a negative-only, light-signal type; a three-to-seven variable keyboard-and-light combination; and the keyboard-light combination with automatic sales slip imprinter. Typical terminal rental is $11 to $17 a month, not including telephone charges. A typical transaction takes 10 seconds to complete.

One of its unusual design features is an operational amplifier averaging circuit to assure maximum reliability regardless of the condition of the card.

To solve the problem of varying signal and background levels caused by dirt and grime on the card, the circuit produces a reference voltage against which the output of each channel is compared to determine the true signal. All channels are summed, divided by a factor, and added to a fixed bias, so when the comparison is made, the channel signal that exceeds the reference signal will be the correct output.

In addition, the readout has electromechanical counters using phase-lock loop filters that check the frequency pulses coming over the telephone line. This approach requires few parts too.

According to Frederic E. Zucker, assistant product manager for P-B's Authorization Systems branch, these features hold down costs without sacrificing reliability. Another cost saver: The ultraviolet light bulb used to read the code is automatically put in a standby mode when not in use to reduce heat.

Zucker points out that fluorescent spot card encoding will cost an issuing agency about 1 cent per card. The additional protection afforded by a tamper-proof, wear-resistant card justifies the extra expense, he maintains. As the code becomes part of the card laminate during encoding, it cannot be altered or degraded without destroying the card. "The only degradation of the card in tests of 15 contaminants, including gin and beer, was caused by the caustic action of acid," Zucker reveals.

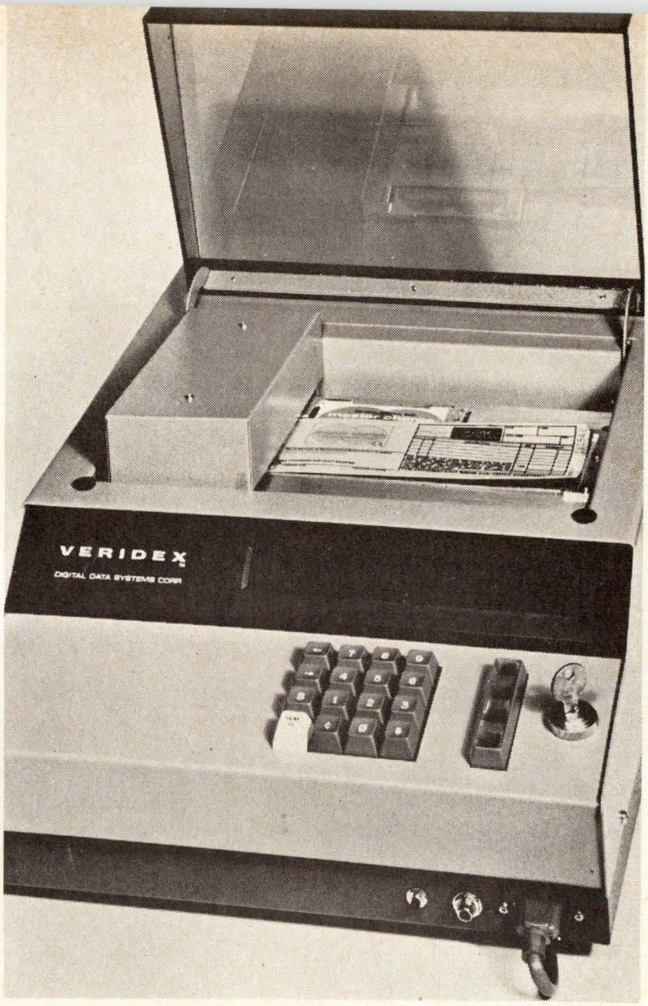
Pitney-Bowes offers complete, one-step service for card embossing, encoding on its equipment, and terminals. But to expedite acceptance of the fluorescent card, it will sell encoders to card-issuing concerns and will make its encoding process available to all other potential suppliers of authorization equipment.

Another special code system is undergoing field trial at American Express Co. using Act 1 automatic card terminal equipment supplied by Penril Data Communications, Rockville, Md. Act 1 will process magnetic stripe cards recently adopted by American Express as well as airline cards. Its configuration has a keyboard, digital readout, function indicating lights, and imprinter, as well as magnetic stripe read circuits and a built-in telecommunications modem.

The terminal reads and verifies account numbers from the magnetically encoded field before automatically dialing the American Express IBM 360 computers in New York. When processing nonmagnetic American Express cards, Act 1 accepts entry of the account number from the keyboard, then automatically dials the authorization system to verify the account. Approve, refer, and deny procedures are the same as in other verification terminals.

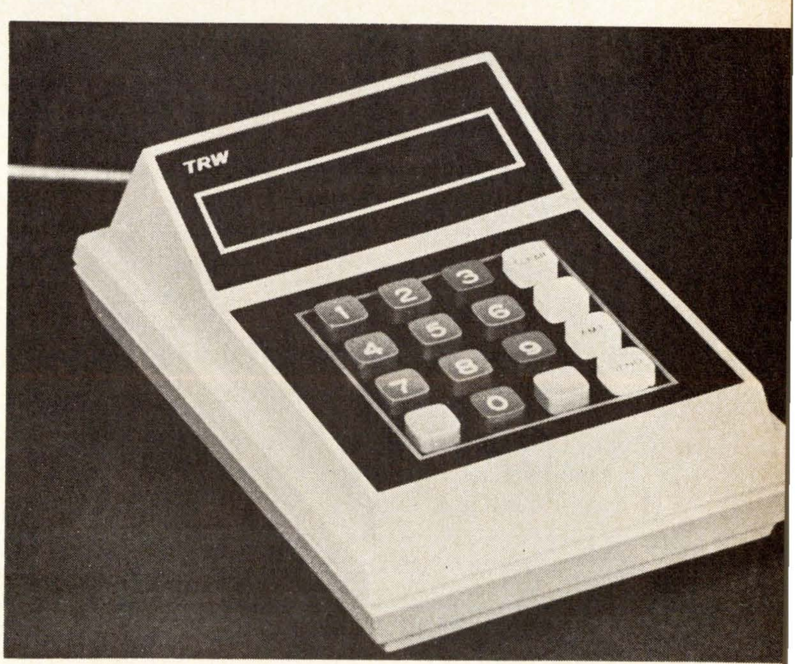
Penril's terminal is compatible with the magnetic stripe encoding approach recommended by the American Bankers Association's recent report on encoding specifications. Unlike the department stores, which prefer dedicated, packaged systems, the bank card issuers want to prepare their own systems and simply procure hardware to match the wide range of terminal needs from ski lodges to discount stores within their network.

Addressograph-Multigraph, Corp., Cleveland, the hands-down leader in document imprinters, by June expects to have a magnetic stripe authorization terminal that conforms to ABA card reading recommendations. IBM Corp. has also entered the competition with



4. Pick a card. Digital Data Systems Corp.'s Veridex terminal will verify all credit cards at retail stores, but not petroleum and air travel units.

5. Verifier. TRW Data Systems has just brought out this indicator terminal for point-of-sale credit check. It features LED display and an IC shift register for buffer storage.



Do-it-yourself airline tickets

Can consumers use self-service devices for credit purchases? This was one of the questions American Airlines and IBM attempted to answer in an automatic ticket vending experiment set up at Chicago's O'Hare International Airport.

A terminal in the lobby was set up to accept magnetic stripe-encoded American Express and Air Travel cards. After inserting the card, a passenger punched buttons for selecting destination, class of travel, and departure time. Then American Airlines' computer quickly verified the card, issued the ticket, and charged the account. IBM's Advance Systems Development division analyzed the trial and concluded that the experiment generally "was highly successful."

Copies of the complete study are available from the Air Transport Association of America, 1000 Connecticut Ave., N.W., Washington, D.C. 20032.

a magnetic reader terminal designed to this guideline and could have heavy impact on automated billing as well as authorization [*Electronics,* Mar. 15, p. 34].

A small firm, Interface Industries Inc., Central Islip, N.Y., will ship its first magnetic stripe readers to a bank in August and is planning a new fiber-optic bundle unit that will automatically read the embossed identification number on a card, rather than a magnetic code. Another company playing the encoding field in two directions, Automated Data Communication Corp., Burlington, Mass., has combined optical and magnetic approaches in its terminal line.

While most of the new terminals are basically digital and light code units, also available are voice-back audio models like the new IBM 2730 reader terminal. The recently announced Validier from Concord Computer Corp., Bedford, Mass., uses an inexpensive Touch Tone telephone equipped with voice-back speakers. A sales clerk punches one of the buttons on the telephone instrument to get a dial tone indicating a connection with the Validier concentrator office. Next, the clerk punches in the credit card number and amount of sale, triggering a credit file search from the concentrator to a central computer. If there are no restrictions, the clerk receives an authorization number from a synthesized voice message.

The synthesized voice also politely tells the clerk what to do in the event of a problem, but if human intervention is required for authorization, the clerk may use the handset instead of the voice box. Communications are via dedicated lines shared in geographic areas by users, according to the company.

One credit authorization terminal that's used by the consumer directly is the code-and-match system proposed by Rusco Electronic Systems, Los Angeles. The user's identification is encoded in the surface of a special card prepared by Rusco. Then the consumer memorizes his special number. At the point of sale, he hands his card to the clerk who inserts it into the terminal. Then the consumer punches in his secret code using a keyboard recessed out of the clerk's sight. The terminal compares the two inputs for identification and is not on-line to a computer or connected to telephone lines. The Veriformator also holds a derogatory credit file updated periodically and authorizes purchase, once again without connection to a computer.

Another off-line list storage system has been developed by ICV Inc., New York. The device, called Dataguard, searches a disk memory unit that's updated weekly. For $30 a month, a New England department store has been using the memory unit, keyboard terminal, and weekly update; it claims to have recovered 250 to 300 lost or stolen credit cards in six months.

ICV also has developed a means of embedding identification holograms into credit cards. Using a helium-neon laser operating at 2 milliwatts, a verification terminal in the works will compare the card hologram to a file of credit record holograms stored on a 3.5-inch-square film. The company expects to store up to two million separate accounts on each sheet [*Electronics,* Oct. 12, 1970, p. 52].

Companies that supply magnetic readers, modems, and CRT terminals to OEMs also have a heavy stake in the cashless society. However, the sales outlook in this sector is no less murky than for systems producers. Comments AMP Inc.'s Patrick Lannan, "We have to have flexibility designed into every unit in order to make proposals. So far, there's been a lot of proposing and not much marrying."

AMP, of Harrisburg, Pa., has developed a line including a remote input terminal for credit authorization, a magnetic card reader, and an inquiry terminal specifically for OEM sales. The input terminal consists of a reader/imprinter, variable data input slide switches as input devices, scanner Touch Tone oscillators, and an acoustical coupler to transmit data to a remote point.

For computer inquiries without reading cards, there's the AMP Syscom terminal featuring 12-position matrix slide switches, a matrix rotary switch, an automatic dialer, a scanner, a Touch Tone generator, a decoder, and light displays. It's coupled to a suitable direct-access arrangement by a two-wire line.

Athena Systems Inc., Bedford, Mass., is also an OEM supplier for credit card readers. The company has developed an unusual method of reading embossed cards with seven reading "fingers" arranged to sense alphanumeric characters from behind the credit card. It can record card information by mechanically pressing 18 character sensors into a magnetic tape put over these contacts. Reading and recording are mechanical, so the unit does not require electrical power.

The AS22T reader and recorder combination can be retrofitted to a standard card imprinter and sells for about $200 to $300, according to Eugene Garofalo, Athena's marketing director. At a gas station, for example, the reader would record a day's transactions on a built-in tape cassette and the station would send the tape to a processing center rather than over telephone lines. However, at the computer center, the cassette tape input must be transferred to a computer-compatible magnetic tape before processing. □

Half the length (11.5") of conventional cathode ray tubes, and operating up to 24 KV for improved visual and photographic writing speed, the Thomson-CSF F 8071 (right) requires no transmission line technique for operation up to 150 MHz at 0.2 dB.

Capable of high frequency (800 MHz), yet only 14" long, the OEE 1108 (left) utilizes the transmission line technique for operation up to 350 MHz bandwidth at 0.2 dB, with a sensitivity of 3.2 V/inch.

Type	Frequency Limit (MHz)	Bandwidth at 0.2 dB (MHz)	Y Deflection Factor (V/CM)	Useful Screen Area (Inch)	Length (Inch)
F 8071	300	150	4	4x2.5	11.5
OEE 1406	300	150	3	4x3.2	14
OEE 1108	800	350	1.3	4x3.2	14

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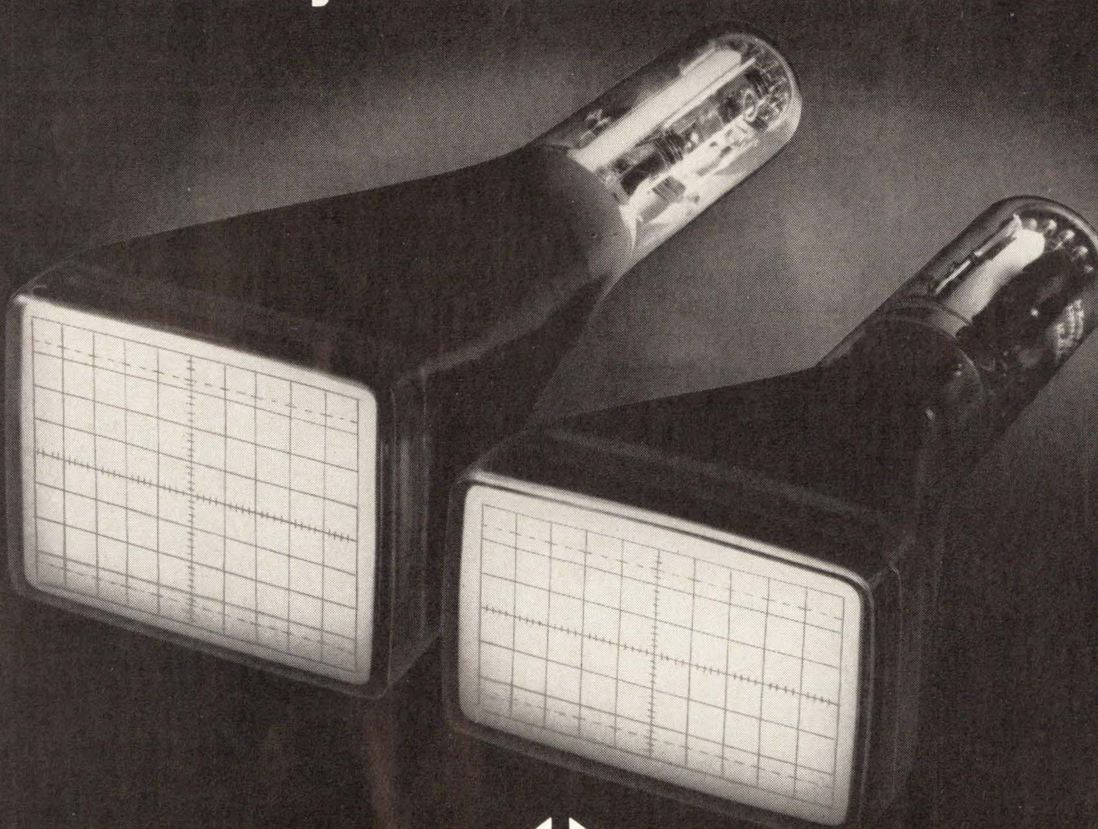

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Circle 49 on reader service card

Computers come to the aid of the logic designer, too

It's now possible to breadboard logic circuit designs on a keyboard and let the computer uncover errors and analyze performance; available software works at the gate level

by Richard J. Diephuis, *Applicon Inc., Burlington, Mass.*

☐ Linear circuit designers may have been the first to take advantage of a computer for simulating and analyzing circuits, but now it's the logic designers' turn. A computer can uncover many timing problems in digital designs that might have previously been found only by resorting to the breadboard, and thus can raise the chances for success when the design is finally committed to hardware.

Logic simulation programs, of which Alice is one example, parallel what a logic designer would do in using a breadboard as a design tool. (Alice is derived from "Applicon's logic simulator"; however, company dissatisfaction with the ALS acronym led to its phonetic counterpart.) The designer translates his paper design into computer input language, sets the initial states of various inputs, tells the computer which test points to monitor and how long the simulation should last, and hits the start button. The computer takes over, first pointing out any gross errors in the design—such as unconnected inputs—and then analyzing the circuit, printing out the states of various logic lines during the simulation run. If the program is interactive, as Alice is, the designer can stop the simulation at any time, slow it down or include extra test points to investigate problems as they occur.

In logic simulation, most available programs now work at the gate or logic-block level, rather than at either the circuit level, where individual transistors are modeled, or the subsystem level, where registers, arithmetic units, and the like are modeled. The logic-block level is most useful now because a circuit-level simulation would take too much computer time and a subsystem-level simulation probably would not tell enough about the circuit to be worthwhile. It's also difficult to simulate complete digital systems because such special elements as analog-to-digital converters are difficult to describe in a model.

At the logic-block level, programs use an idealized gate model, in which signal transitions are assumed to occur instantaneously rather than with finite rise and fall times (Fig. 1). Thus, the simulator cannot be used to determine noise immunity, since this requires simulation of voltage levels other than 0 and 1.

The logic simulation is time-quantized: signals are allowed to change only at integral time units, which should be chosen to be less than the shortest time period of interest to the designer. All rise and fall delays are specified in terms of these integral time units. Since zero rise and fall times are assumed, the signal is undefined at the switching time. To avoid this ambiguity in Alice, the value "at" a particular time is defined as the value just after that time (similar to the t_{0+} convention for step functions).

There are other limitations with all simulation programs, Alice included: they do not generally take into account such factors as change in delay with loading, delays associated with lead lengths, variations of parameters from logic block to logic block, and stray capacitance and other similar circuit properties.

There's also an upper limit on complexity. Simulation programs that are not time-shared can simulate about 2,000 to 5,000 gates if propagation delays are included. This number appears to be the limit with today's computer-memory capacities. If zero propagation delay is acceptable, then some simulators handle up to 10,000 gates. With a time-shared system, like Alice, about 1,000 to 2,000 gates with propagation delays can be simulated.

The first step in using the logic simulation program is to describe the network to be simulated. This description can be taken directly from the logic diagram. In Alice, the description for each logic element comprises the following information (Fig. 2): name of the logic element, the element type, the rise and fall delays, input designations, and the output designation. The logic element name is arbitrary, as are the designations for inputs and outputs. Selection of element types is limited by the program; Alice will work with AND, OR, NAND, and NOR gates and JK flip-flops. Each of these gates also can be modeled as clocked elements. (In a clocked gate, the output state is stored between clock pulses, a characteristic that is useful in such cases as multiphase MOS circuits.) Interconnections are described with names for the logic nets.

In addition, the user can define an element type and give it a name; Alice will enter it in its library and use it whenever called up. For example, a four-bit counter would be designed with standard logic blocks, described to the computer, and then given a name for later use as a single logic block.

One feature of Alice is that a manufacturer's standard logic circuits can be cataloged and used as element designations. The computer stores the model and the rise and fall delay times. For example, a four-input NAND gate could be described as:

GATENAME/ SN7420 IN1, IN2, IN3, IN4 OUT

Each use of a cataloged item is checked to insure that it has the proper number of inputs and outputs.

As an example of the use of Alice, consider the four-bit binary rate multiplier of Fig. 3. The computer-input description of the network is also shown in Fig. 3. Lines 2 through 5 describe the JK flip-flops. Note that each has a rise delay of 4 time units and a fall delay of 5, each has a clock input along with other inputs, and also note the naming of the outputs (FF4 has an unused Q output, shown by the asterisk).

The next several lines describe the NAND gates. Note that only one number appears in the position allocated for rise and fall delays, meaning that the two are equal (2 time units).

Lines 17 and 18 specify inputs and outputs, line 19 ends the circuit description and the final line tells the program to change from the edit mode (used for network description) to the simulation mode.

Before the computer does the simulation, the designer must describe the signal inputs, give commands to the computer about which signal lines to monitor and print out, and tell the computer how many time units to use for the simulation (Fig. 4a).

The first line defines the clock:

```
S>>DS CLOCK 0 (25,5);
```

The S>> is typed by the computer to request a simulation-mode command. The user then types DS for define signal, CLOCK for the name of the signal, 0 the initial value, and (25,5) shows that it is at 0 for 25 time units and at 1 for 5 units and the parentheses show that the signal is periodic.

The CLOCK signal just defined is then connected to all points labeled CLK in the circuit description:

```
S>>CPI CLK=CLOCK;
```

The next line defines a set of signals, called a vector, for parallel input:

```
S>>DV IV A,B,C,D;
```

where the DV means define vector, the IV is the name of this vector and the ABCD refers to nets A, B, C, and D in the original circuit description.

The initial value of vector IV is then set to 0000 with a set vector (SV) command. The direct clear net (DC), the reset input, is set to 1:

```
S>>SV IV 0000;
S>>SN1 DC;
```

The net DC thus will be held at 1 until the user gives an SN0 command (set net to 0) for DC.

Now the print commands, shown in Fig. 4b, are given.

The first line tells the computer to print out, or trace (T), values for the listed nets.

```
S>>T A,B,C,D,,CLK,,-Q4N,
          Q3,Q2,Q1,,OUT;
```

The next line tells when to print out these values. The print change command (PC) orders printout of the quantities when the clock changes state.

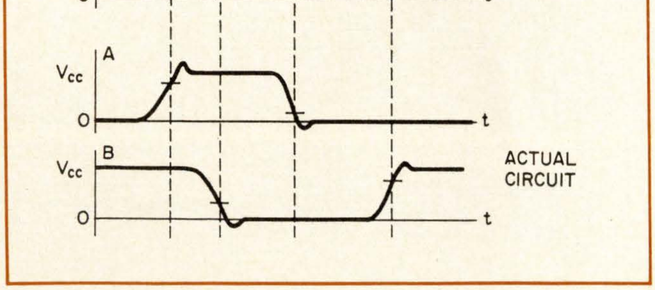
Then an additional print instruction is given; the computer is to also print the values after the first stable state (PFS)—that is, the values following each transition, after all delays have taken effect.

```
S>>PFS;
```

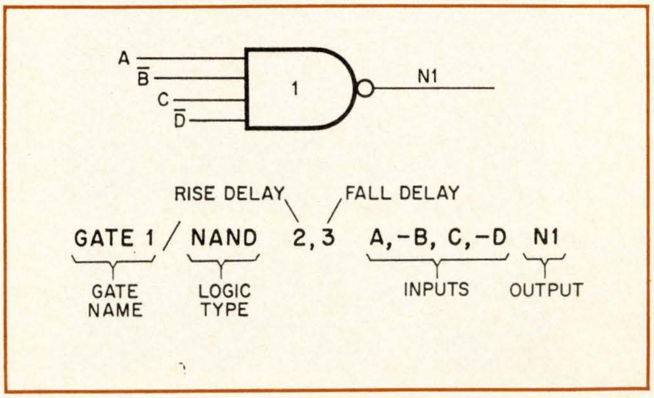
Finally, PE (print at every time unit) is disabled and a start-stop command is given;

```
S>>XPE;
S>>SPT 15;
```

The computer will print the network name, the



1. Defining delays. Present simulation programs do not account for finite rise and fall time, but only for signal delays through logic elements. Sketches show how rise and fall delays are defined.



2. On the line. Each logic element in Alice is described on one line: name of gate element, type, rise and fall delays, inputs and outputs.

date and time, and the name of each signal being traced (signal names are printed vertically over their respective columns). The simulation is to run for 15 time units.

Now the computer can do the simulation; it prints out the values of the assigned signals as shown in Fig. 4c. In this example, only two signal traces are printed in the 15 time units (the first because of the clock change and the second because of reaching the first stable state). Note that all initial states that were undefined, X, are now reset to 1.

After resetting the network, the user begins his simulation by giving the indicated commands:

He sets the net DC to 0:

```
S>>SN0 DC;
```

He defines new initial values for vector IV:

```
S>>SV IV 0101;
```

He then tells the computer to simulate for 150 time units, using the previously specified print commands from SPT:

```
S>>S 150;
```

The computer proceeds to simulate for 150 time units, taking up where it left off at time unit 15. From this printout the designer can check circuit operation.

Alice also detects two types of timing problems: hazards and spikes. A hazard is defined as a situation in which a slight difference in the arrival times of two or more inputs to a particular gate might cause an anomaly in the output of the gate. A spike is an attempt to change the output of a logic element faster than its inherent propagation delay time.

An example of how one designer used this feature in simulating the action of the circuit of Fig. 2 is shown in Fig. 5.

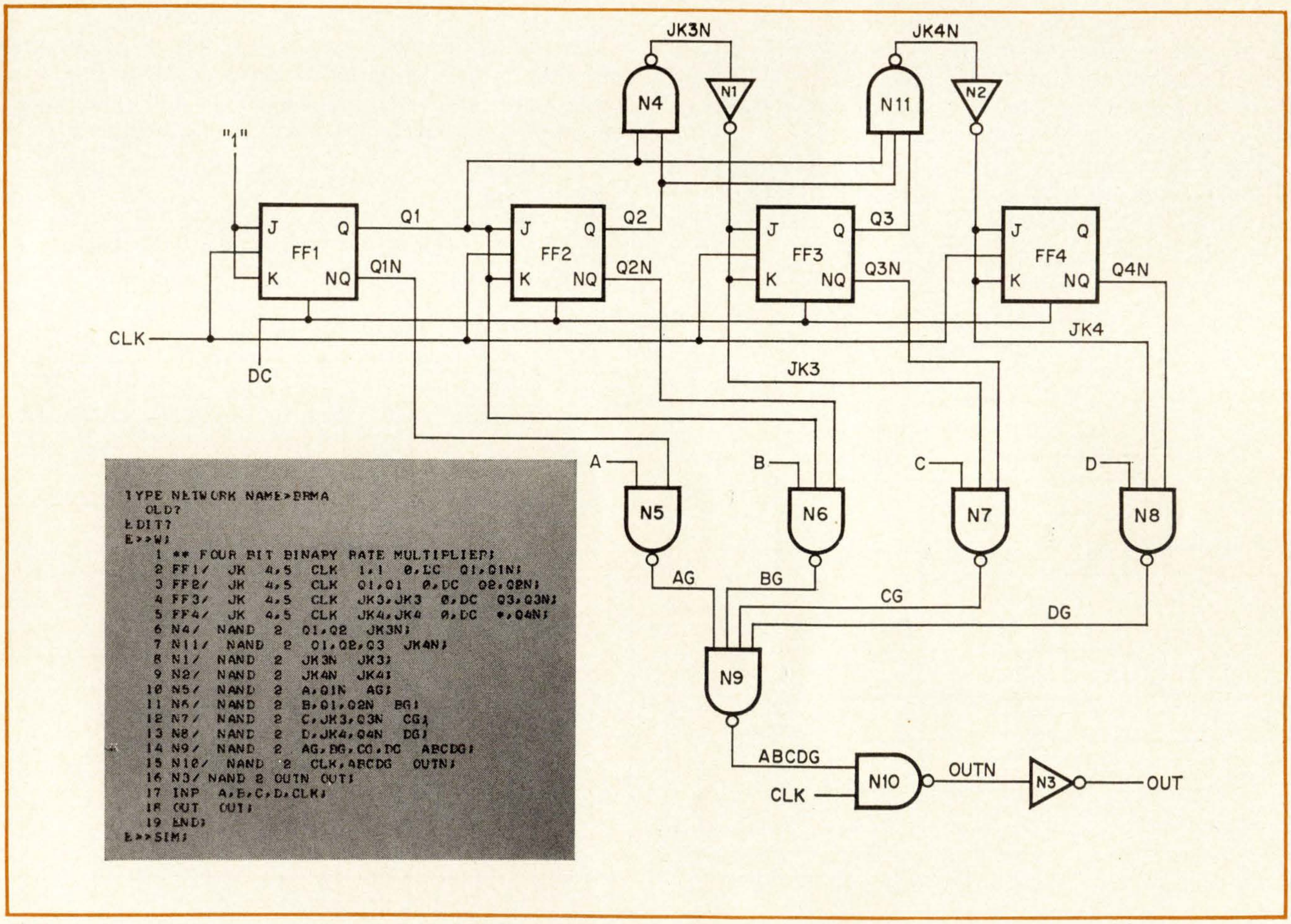
First the computer is commanded to get into this mode (HAZ covers both hazards and spikes):

```
S>>HAZ;
```

The simulator is still set up to print out the information as in the example., The designer tells it to work for another 150 time intervals:

```
S>>S 150;
```

In this example, no hazards are detected, but at time 186, it senses two spikes:




```
TYPE NETWORK NAME>BRMA
  OLD?
EDIT?
E>>W;
   1 ** FOUR BIT BINARY RATE MULTIPLIER;
   2 FF1/  JK  4,5  CLK  1,1  0,DC  Q1,Q1N;
   3 FF2/  JK  4,5  CLK  Q1,Q1  0,DC  Q2,Q2N;
   4 FF3/  JK  4,5  CLK  JK3,JK3  0,DC  Q3,Q3N;
   5 FF4/  JK  4,5  CLK  JK4,JK4  0,DC  *,Q4N;
   6 N4/  NAND  2  Q1,Q2  JK3N;
   7 N11/  NAND  2  Q1,Q2,Q3  JK4N;
   8 N1/  NAND  2  JK3N  JK3;
   9 N2/  NAND  2  JK4N  JK4;
  10 N5/  NAND  2  A,Q1N  AG;
  11 N6/  NAND  2  B,Q1,Q2N  BG;
  12 N7/  NAND  2  C,JK3,Q3N  CG;
  13 N8/  NAND  2  D,JK4,Q4N  DG;
  14 N9/  NAND  2  AG,BG,CG,DG  ABCDG;
  15 N10/  NAND  2  CLK,ABCDG  OUTN;
  16 N3/ NAND 2 OUTN OUT;
  17 INP  A,B,C,D,CLK;
  18 OUT  OUT;
  19 END;
E>>SIM;
```

3. Set an example. Four-bit binary rate multiplier serves as example for use of program. Designations of logic elements and interconnecting lines (nets) are arbitrary. Printout shows computer description of circuit.

```
SPIKE FROM 1
GATE  N11, OUTPUT CONNECTS
                    TO NET   JK4N
TIME= 186
SPIKE FROM 1
GATE  N4, OUTPUT CONNECTS
                    TO NET   JK3N
TIME= 186
```

The spike occurs when gates N4 and N11 are in the 1 state (SPIKE FROM 1). The output information is an aid in locating the gates, which in this simple example is not as difficult as it would be in an actual, more complex network.

In analyzing the circuit, the designer would see that a spike occurs on gate N4 when the states of flip-flops FF1 and FF2 in Fig. 2a change from 01 to 10. Because of the unequal rise and fall delays of FF1 and FF2, their state is 11 for one time unit between the states 01 and 10, causing N4 to attempt to produce a negative output pulse of length 1. Because the delay time of N4 is 2, a spike occurs. Similar conditions cause spikes on gates N6 and N11.

The simulation then resumes until time 241 when another spike occurs, after which the simulation continues until completing its assigned 150 time units.

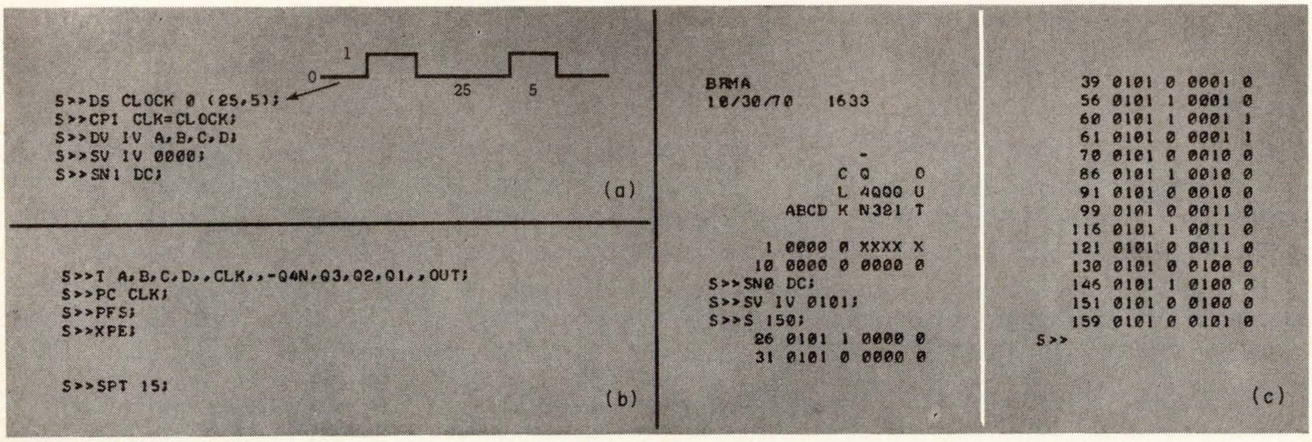
An interactive logic simulator allows a designer to step through a design, tracing a level change as it propagates through the system. For example, suppose the designer wanted to analyze the operation of the circuit in Fig. 2 to determine those signals causing net ABCDG to change from 0 to 1. The simulation is shown in Fig. 6.

The first command is to define a halt condition (DH) when the net ABCDG changes from 0 to 1. This halt is given the name HLT1:

```
S>>DH HLT1 ABCDG =0-1;
```

The computer then is told to simulate. It's still operating under the previous print conditions, printing after each stable state and when the clock changes state. At some point after time 961, the change in ABCDG occurs, and the computer stops. However, the user cannot be sure just when it stopped; all that he knows is that it stopped after the last print time, 961. He therefore asks for the printout of the last time unit, which turns out to be time 969.

```
S>>PT;
    969 0010 0 0000 0
```



4. Follow instructions. Simulation of the four-bit binary rate multiplier requires clock signal definition (a) and printing instructions (b). Computer then delivers printout of states of chosen nets of prescribed time units (c).

```
S>>HAZ;
S>>S 150;
    176 0101 1 0101 0
    180 0101 1 0101 1
    181 0101 0 0101 1

SPIKE FROM 1
GATE  N4, OUTPUT CONNECTS
 TO NET   JK3N
TIME= 186

SPIKE FROM 1
GATE  N11, OUTPUT CONNECTS
 TO NET   JK4N
TIME= 186

    190 0101 0 0110 0
    206 0101 1 0110 0
    211 0101 0 0110 0
    223 0101 0 0111 0
    236 0101 1 0111 0
    240 0101 1 0111 1
    241 0101 0 0111 1

SPIKE FROM 1
GATE  N6, OUTPUT CONNECTS
 TO NET   BG
TIME= 246

    250 0101 0 1000 0
    266 0101 1 1000 0
    271 0101 0 1000 0
    279 0101 0 1001 0
    296 0101 1 1001 0
    300 0101 1 1001 1
    301 0101 0 1001 1
```

5. Bad news. Timing problems in the circuit design are automatically detected by Alice. Here, the user discovers that binary rate multiplier produces spikes under three conditions.

Logic simulation competition grows

Several logic simulation programs have appeared on the scene during the past couple of years. Such programs have been of two basic types: batch-mode programs used by many semiconductor houses for custom design of LSI chips (Fairchild's Fairsim and Motorola's Simul-8 are two examples) and interactive programs, which are available to customers of time-sharing services. Alice, the subject of this article, is available on two time-sharing networks: Applied Logic's Al/Com and the Multicomp network. Other time-shared logic simulation programs are Rapidata's Logic, Tymshare's Logsim and Digilog, and General Electric's Logic$.

On the subject of cost, author Diephuis points out that it's difficult to give a simple quote, since cost depends on the complexity of the network being analyzed and the amount of interaction by the user. In an actual problem, simulating a 450-gate circuit for 80,000 time units costs about $90. Depending on the user's familiarity with Alice, this simulation might take one to three hours of computer connect time.

The table shows the time-sharing services that offer interactive logic simulation programs, along with the number of standard logic element types (ranging from basic AND, OR, and the like to clocked gates, one-shot multivibrators, etc.) and the total number of elements each program will handle. These numbers, of course, are not the only measure of usefulness of any of the programs. Other user convenience features are often more important; unfortunately, they do not lend themselves to simple tabulation.

	Program	No. of different logic elements*	Total no. of elements
Applied Logic Corp. 1 Palmer Sq. Princeton, N.J. 08540 609-924-7800	Alice	23	1,000–2,000
Multicomp Inc. 36 Washington St. Wellesley Hills, Mass. 02181 617-237-2910	Alice	23	1,000–2,000
General Electric Co. Information Services Dept. 7735 Old Georgetown Road Bethesda, Md. 20014 301-654-9360	Logic$	27	500
Rapidata Inc. 200 New Dutch Lane Fairfield, N.J. 07006 201-227-0035	Logic	27	500
Tymshare Inc. 525 University Ave. Palo Alto, Calif. 94301 415-328-5990	Logsim Digilog	29 18	250 400

*These numbers may include extra blocks that have no circuit counterparts but are needed for machine control. Programs also differ in ease of defining nonstandard blocks. Such blocks increase the number of available elements.

```
S>>DH HLT1 ABCDG =0-1;
S>>S;
    926 0010 1 1110 0
    931 0010 0 1110 0
    939 0010 0 1111 0
    956 0010 1 1111 0
    961 0010 0 1111 0
S>>PT;

    969 0010 0 0000 0

S>>PN ABCDG;

ABCDG=1

S>>PN AG,BG,CG,DG;
```

```
AG=1
BG=1
CG=0
DG=1
S>>PN C,JK3,Q3N;
C=1
JK3=1
Q3N=1
S>>PN JK3N;
JK3N=1
S>>PE;
S>>S 1;
    970 0010 0 0000 0
```

```
S>>PN JK3;
JK3=0
S>>S 2;
    971 0010 0 0000 0
    972 0010 0 0000 0
S>>PN CG;
CG=1
S>>S 2;
    973 0010 0 0000 0
    974 0010 0 0000 0
S>>PN ABCDG;
ABCDG=0
S>>
```

6. Slow down. Alice is interactive, allowing designer to step one time interval at a time through a simulation, checking logic level changes after each interval. This printout shows how the designer traces signals leading up to a change in ABCDG.

He then checks to see if ABCDG is indeed 1 at this time:

```
S>>PN ABCDG;
ABCDG=1
```

Now the designer decides to look at each of the signals leading up to ABCDG:

```
S>>PN AG,BG,CG,DG;
```

Noting that CG is 0, he traces back through this gate (C, JK3, Q3N) and looks at JK3N. He decides to let the circuit step one more time unit, so he gives a print-every-time-unit command (PE) and tells the computer to simulate one time unit and stop.

After the results of time unit 970 are printed out, he again asks for the value of JK3. He goes two more time units, asks for CG, goes another two time units, and finally checks the value of ABCDG, noting that it now has changed back to zero. □

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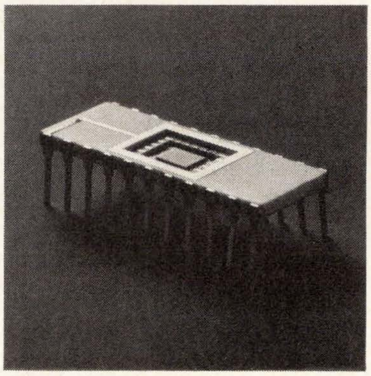

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Minicomputer networks—a challenge to maxicomputers?

Groups of minicomputers, variously interconnected and with special software, can take over certain kinds of large-scale jobs from a big machine—and at less cost

by Wallace B. Riley, *Computers editor*

☐ For many applications, a network of interconnected minicomputers may be as effective as a single large computer—and much less expensive. Today individual minicomputers are available for only a few thousand dollars, yet they execute instructions at respectable speeds and handle 16-bit numbers.

According to one very rough estimate, for instance, eight 16-bit machines with 1-microsecond cycle times and costing $10,000 each might for some purposes give as good a performance, when suitably interconnected, as a machine in the $1 million class, with 64-bit words and a 500-nanosecond cycle time.

Or, to quote a real-life example, one consultant tells of an oil company that approached him to find out how to reduce the oppressive cost of a set of three IBM System 360 model 50s, with which it was processing seismic data. He found that the same job could have been handled by about 10 minicomputers at a much lower cost.

Of course, it's not really that simple. The methods of interconnection range from the straightforward but limited to the complex but flexible, and the software needed can get hairy. Both factors add to the price of a system. But the fact remains that a minicomputer network has great capabilities that are only just beginning to be explored.

One way of building such a network that's just coming into vogue is the modular computer concept [*Electronics,* Oct. 12, 1970, p. 121]. Another is to have the computers transmit data to one another through their input-output channels, so that each computer behaves as if the others were just so many paper-tape readers or card punches. A third way is to group processors around a multiport memory, so that each has access to any part of the memory—though some people would define this as a multiprocessor rather than a network. Naturally, any of these networks would require varying amounts of special software.

A proponent of the minicomputer interconnection idea is Frank Heart, of Bolt, Beranek and Newman Inc., Cambridge, Mass. He is in charge of the interface message producer, or Imp, which BB&N is building for the Advanced Research Projects Agency of the Department of Defense, and which is part of ARPA's vast transcontinental computer network [*Electronics,* Sept. 30, 1968, p. 131]. In that system, which will have many of the advantages of minicomputer networks, only on a much larger scale, one Imp stands between every computer in the network and the network itself.

Heart says, "Look at the similarities and differences between the large and small computers we have today. The raw speeds of both kinds are limited by the memory bandwidth; and both kinds gain in the same way from advances in memory technology. Both have similar memory access times. So how do they differ? Large machines have more hardware—they have longer words, more instructions, complex input-output controllers, and sophisticated facilities for indexing. If we can get the complexity of the large machine some other way than by adding hardware, we can save money. One way to obtain this complexity is to put it in software; the speed penalty often encountered in software is avoided by executing it in stacked-up minicomputers."

"In this way," he continues, "you can get the power of a very large machine at very low hardware cost. Furthermore, you give the actual user of the system a chance to get his hands on the machine—a chance he rarely gets with large machines, which are surrounded by machine operators, operating system programs, and the like. With this hands-on experience, the user gets a better feel for the computer's handling of his problem—although the computer's efficiency may suffer from his hands-on operation of it."

For calculations involving a large data base, a large processor is most efficient, according to Don Murphy, data communications marketing manager at Digital Equipment Corp., Maynard, Mass. He adds that the larger the number of people who have access to this data base, the less its cost per bit. On the other hand, says Murphy, a small computer is more efficient in control functions, where decision-making can be automatic but where the actual computation is limited. One control function in which a small computer shines is in improving the communication between Man and Large Machine. It can easily handle the trivial tasks that otherwise would tend to load up the big machine with overhead—tasks like data preparation, editing, and format checking.

Murphy proposes extending this concept to several levels. He suggests that a Digital Equipment PDP-11 computer works very well as a front end for a larger machine such as a PDP-10, where it can monitor and consolidate signals arriving from a remote computer such as the PDP-8/E. These in turn can act as "intelligent terminals" that coordinate the communication paths between simple source terminals such as cathode-ray tube displays, with keyboards, data collection devices, and so on. Murphy feels that eventually even the simple alphanumeric CRT unit will be a small computer.

(Murphy, of course, likes to mention his own company's products as typical installations at each of these levels. His concept, however, applies to other hierarchies of computers, including some that are mixtures of several manufacturer's products.)

Eventually, says Murphy, data communication networks will charge their users on the basis of the data transmitted, not on the length of time the connection is maintained. When this kind of network is built, minicomputers will be almost indispensable at the network's nodes to compress the data and revise its format for maximum efficiency.

Other advantages of the network concept, adds Roger Cady, engineering manager for the PDP-11 computer at Digital Equipment Corp., are that it permits the system to be tailored closely to the particular job, and it offers fail-soft operation. Job tailoring is done by equipping each individual processor in the network with the particular hardware features and software packages that adapt it to a specific part of the job to be done. Fail-soft operation means that, if any one processor in the network fails, the network as a whole can continue to operate with a somewhat degraded level of performance, instead of grinding to a complete halt.

As for the number of machines in a network, Heart insists that hooking up three or four wouldn't accomplish much—he'd rather see lots interconnected in a vast network. "If you have many times the memory capacity, many times the bandwidth, with many memory accesses simultaneously, then a whole bunch of problems becomes accessible at a much lower cost than on one large computer."

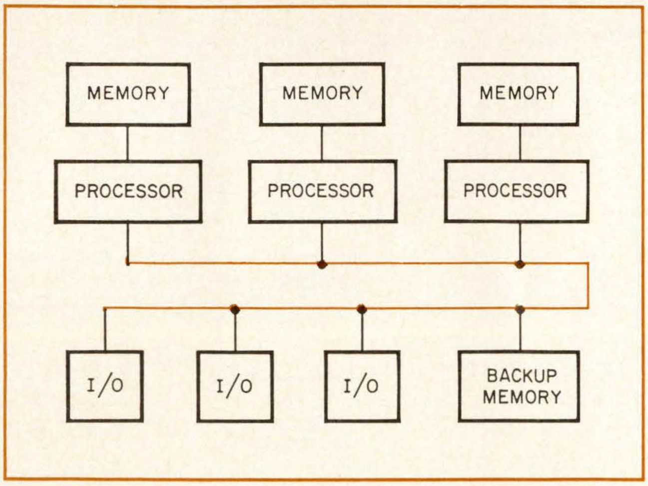
This view meets with the agreement, in principle at least, of C. Gordon Bell, professor of electrical engineering and computer science at Carnegie-Mellon University, Pittsburgh, Pa. But he warns that the software problems are "fierce." Only when the software task can be broken up to match the individual pieces of hardware does the network approach look attractive, says Bell. Otherwise, in some cases the software costs might exceed the savings in hardware.

Opinions differ about the difficulty of writing the software for a network of minicomputers. Heart claims it wouldn't be an overwhelming job. "Big machines always come with blankets of software," he says. "But people always have to write their own software for little machines. A guy who really wants to try this approach will be able to do it more easily than he suspects."

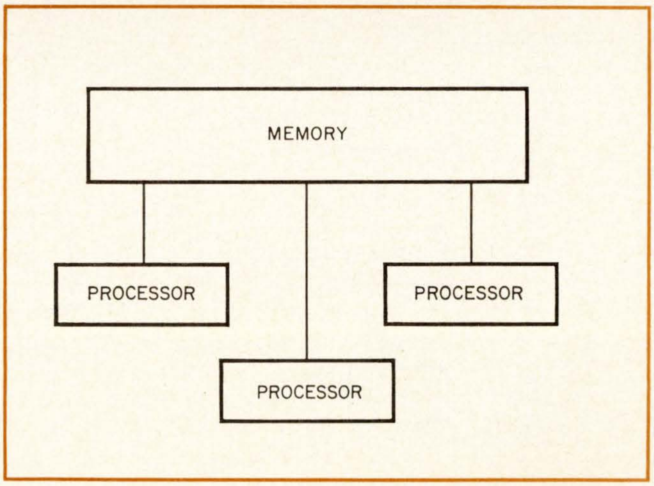
The main characteristic of software for a network of minicomputers would be its division into segments for the individual computers, as Bell pointed out. Most minicomputer programs aren't segmented because neither the machines nor their problems requires it. But segments occur naturally in software prepared for large machines and, except when actually in use reside on disk files instead of taking up space in the main memory.

Because the big-machine programs already have these segments, incorporating them into a program for a network of minicomputers wouldn't be too difficult, maintains Heart. "Besides," he says, "if the network has one large multiport memory for the use of all the processors—as would be characteristic of one form of network—segmentation won't be necessary, or at least it won't be as severe as it would be otherwise."

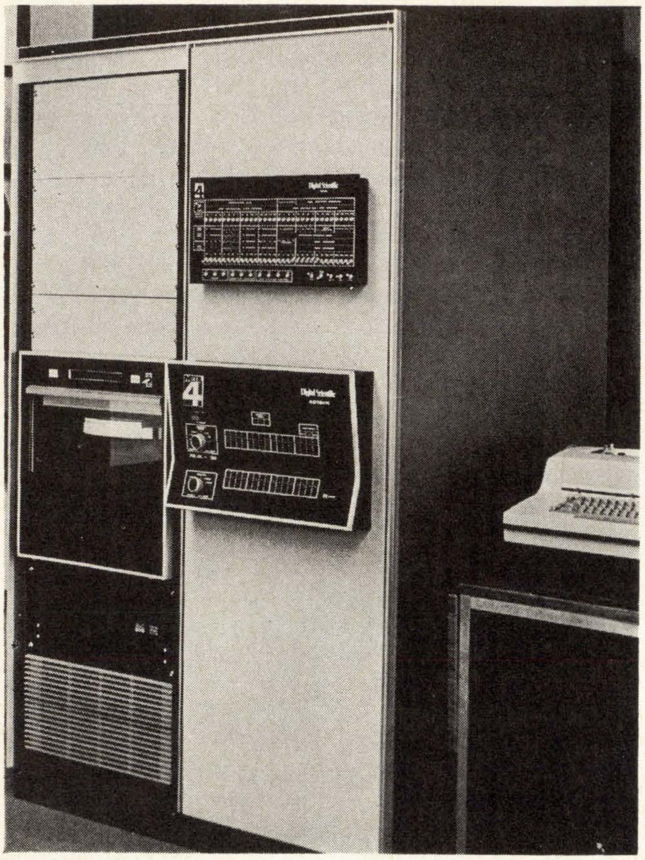
However, one of the designers of Data General Corp.'s Supernova computer, Larry Seligman, disagrees with Heart. He says designing the hardware to interconnect the computers is easy, but the real problem is in the software. "Figuring out how to



1. Input-output bus. One way of linking minicomputers into a network that boosts their total performance is through the bus along which the individual computer's input-output equipment communicates with the processor.



2. Multiport. Another possible interconnection is to permit each processor to have direct access to a large common memory that's independent of the processors, as shown here, or to one another's individual memories.



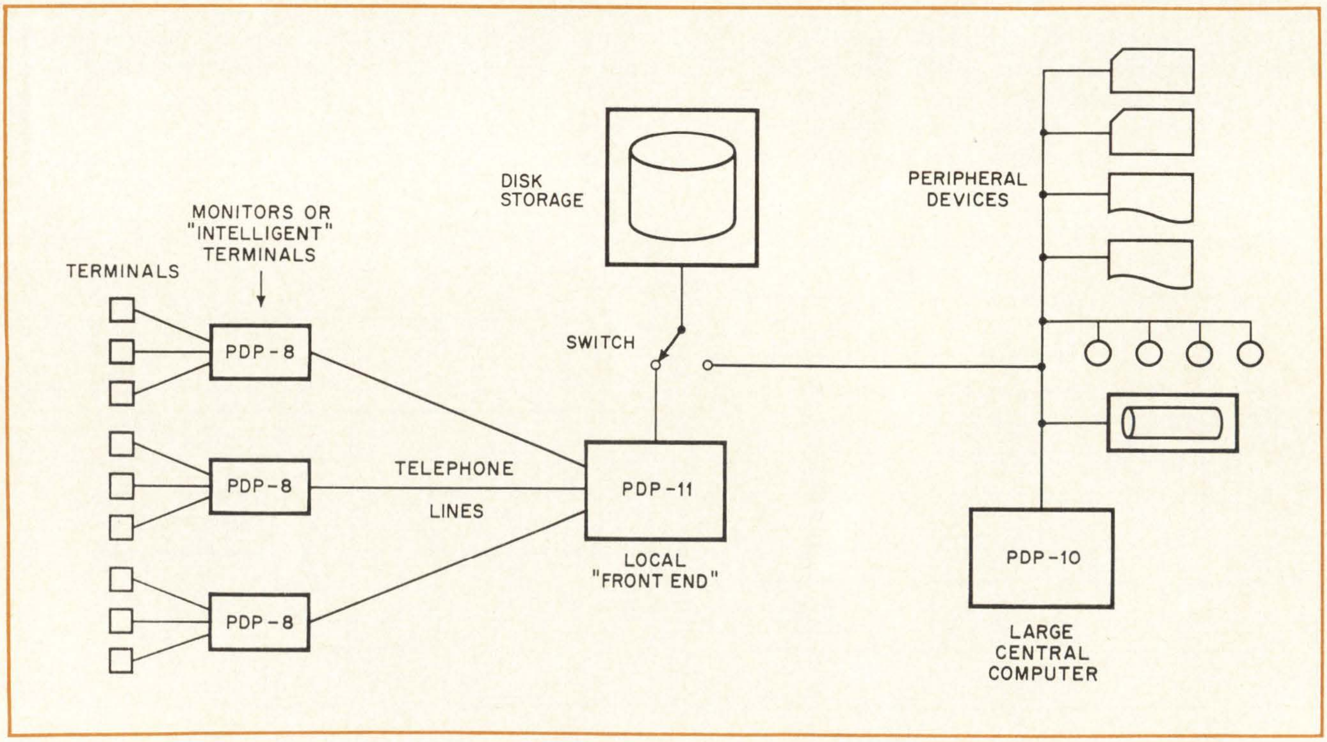
3. **Meta 4.** This computer, shown here in a configuration that emulates the IBM 1130, has a multiport memory.

break up the job is likely to be pretty tough," he says, but admits that "people are putting things together. Some of our customers are trying it, and we build some stuff on special order for them, as well as offering them our multiprocessor communications adapter, or MCA. I think their interest indicates an important new trend; but that doesn't decrease the difficulty of the job."

Nonetheless, some jobs break up naturally—for example, monitoring a data communication network, which involves input, computation, arranging to a format, and output. In fact, it's hard to handle these jobs on one machine because the machine's time has to be segmented, and that requires a big operating system. "Big operating systems are big headaches," says Seligman.

Cady of DEC believes the day is coming when people will compare a large computer system having "blankets of software" (Frank Heart's term) with a task-oriented network of minicomputers working under special-purpose software—the large system will be found wanting.

"Look at the big operating system that comes with the IBM System 360," says Cady. "Its latest version requires 262,000 bytes of main storage. While that much software can do just about anything for anybody, the fact remains that on many tasks a lot of it is just deadwood, and a smaller computer with simpler software would be a lot more efficient—especially in real-time jobs." While the operating system never actually occupies 262,000 bytes—chunks of it are continually passing back and forth between main



4. **Common buffer.** A variation on the input-output bus interconnection (Fig. 1), good particularly when the interconnections are measured in miles instead of feet, uses a disk storage unit shared by both a minicomputer and a large central computer.

storage and disk storage—it occasionally would overflow the next smaller standard level of main memory, 131,000 bytes, that IBM offers with its computers.

Some programs written for big computers can be run on smaller ones if the job can be divided up to fit the machine. If it's not easily subdivided, the big number-crunching computer is the only way to tackle it. An example of such a job is processing an extremely large matrix of floating-point numbers—suitable for machines on the scale of Illiac 4.

The actual interconnection in a network of minicomputers can be done in several ways. One is to link several processors, each with its own memory, through their input-output channels to a ring-shaped or open-ended bus, to which one or more backup memory modules and several input-output controllers are also linked (Fig. 1).

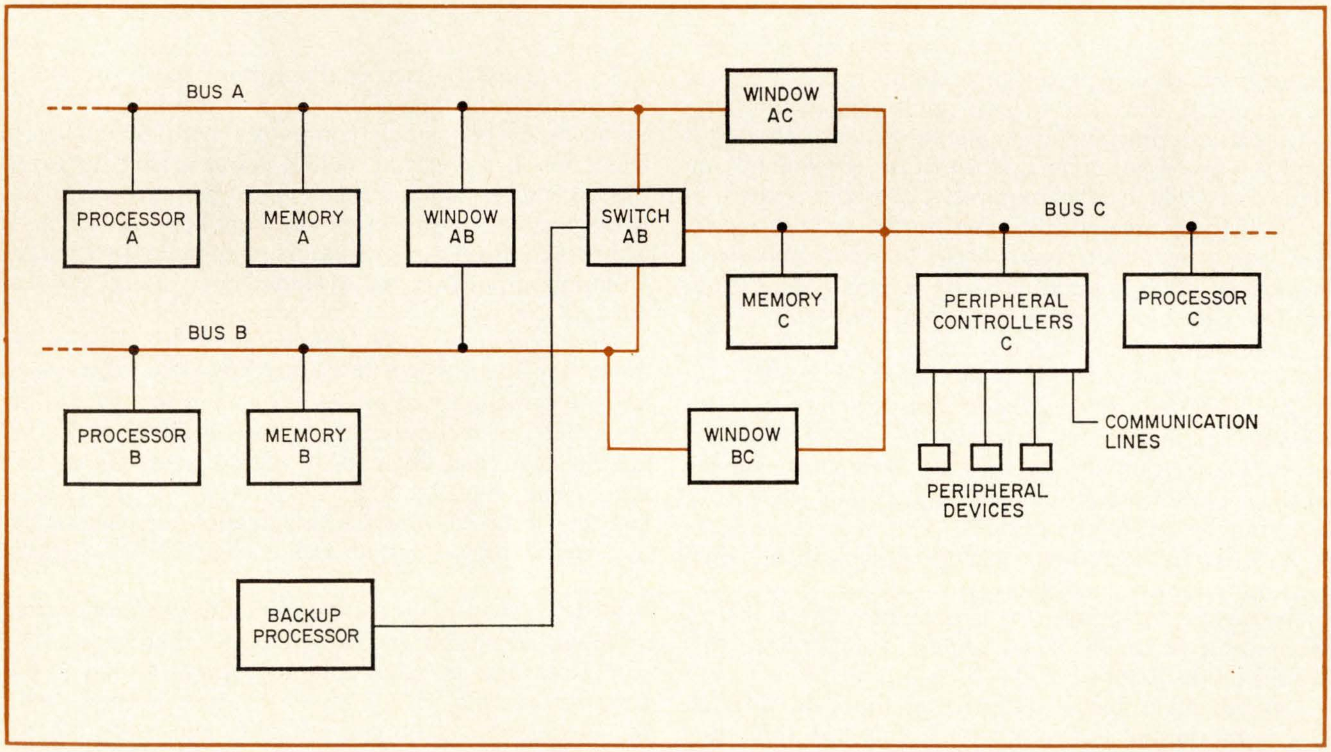
BB&N's Heart, however, doesn't think a connection through the input-output channels is adequate for the performance he's considering. It involves too much overhead, he says. First, each of the two minicomputers involved has to use one memory cycle to transfer data from the memory of one to that of the other, and then the second minicomputer needs another cycle to get the data out for its own use. "It would be much better," says Heart, "if every machine had direct access to the appropriate point in one large common memory, independently of access by other machines. Such a multiport memory [see Fig. 2] would be costly, but not nearly as expensive as a Goliath computer."

The memory of the Meta 4 computer, shown in Fig. 3, is similar to what Heart has in mind. The Meta 4, which is built by the Digital Scientific Corp. in San Diego, Calif., has a memory with four ports, which make it accessible by four processors or other units independently.

However, any attempt to discuss the tradeoffs between input-output bus interconnection and multiport interconnection makes Gordon Bell of Carnegie-Mellon University very indignant. In his lexicon, a computer is a processor plus a memory; a multiprocessor is many processors and one memory; and a network is many processors and many memories. Therefore, since the multiport approach effectively makes a system with one big memory, regardless of the number of individual modules, this design, to him, is a multiprocessor.

Is the distinction more than merely semantic? Bell says it is, because there are two different ways of designing an array of minicomputers: as a pipeline, or as a parallel machine. In a pipeline each processor does part of the job and passes its result on to the next. In a parallel system all the components are working simultaneously on some aspect of the problem, while transferring intermediate results, subroutines, and so on between one another. A multiprocessor, Bell says, can easily be organized as a parallel system; but a network, which doesn't have a multiport memory, such an organization is quite difficult.

Nonetheless, Seligman of Data General does compare the input-output bus and the multiport interconnections. Unlike Heart, he feels their relative merits depend on the specific job that the minicom-



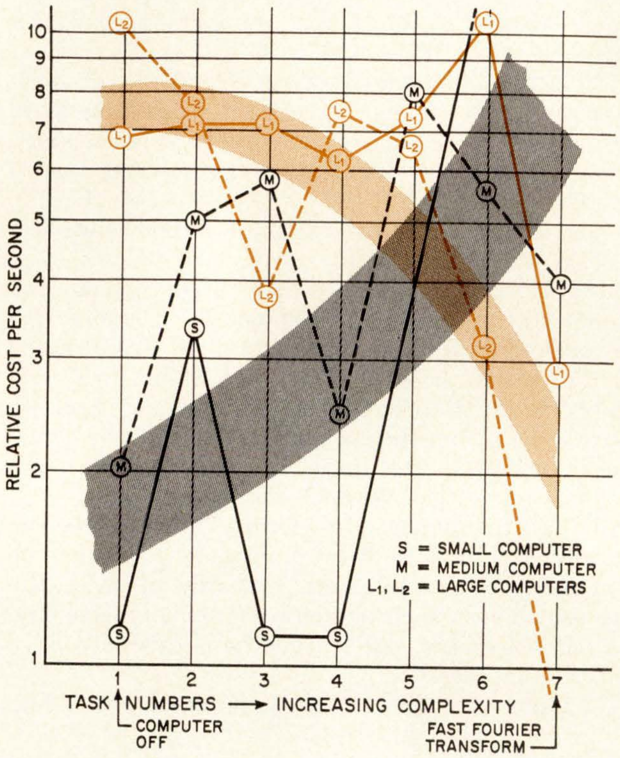
5. Unified-bus network. This approach has the ability to handle input-output operations efficiently. Switches can be set to transmit an unlimited number of words. Protected by "window-shade" logic, windows transmit only one word by cycle-stealing. Other equipment may be attached to any bus.

The irreplaceable maxi

The idea that a network can always equal the performance of a large machine is wrong, says Bell of Carnegie-Mellon University. He has worked out a comparison of various kinds of processors applied to various kinds of tasks, and charted the results, as shown at right.

The costs and relative performance levels in the chart were obtained from a line of reasoning similar to the following simplified example: to buy a CDC 6600 would cost about $3 million, and the machine is capable of adding roughly 3 million pairs of numbers each second, whether they are fixed-point or floating-point numbers. On the other hand, the Digital Equipment Corp. PDP-8, a small machine, costs only $10,000 or so; it can do 300,000 fixed-point additions per second, or 3,000 floating-point additions. Thus it costs two and a half orders of magnitude less than the 6600, but it adds fixed-point numbers only one order of magnitude more slowly. Therefore in an application involving only the addition of fixed-point numbers, a battery of PDP-8s is much more economical than one 6600. But very few applications are that simple. Other applications that require the use of more complex instructions, of which the floating-point addition is an extreme example—it's three orders of magnitude slower—would be rather poorly served by a PDP-8 network.

The black lines in the chart represent costs for typical small computers; the colored lines correspond to big machines. More important than the specific points plotted are the tendencies for the black lines to curve upward to the right, and for the colored lines to curve downward. Thus, as one would suspect, a simple job costs less to do on a simple machine than on a large machine; but a complex problem, such as frequency analysis using the fast Fourier transform, is likely to be more expensive on a small computer than on a machine like the Control Data 6600.



puter network is expected to perform.

He points out that a large multiport memory requires a crossbar switch or its equivalent between it and the processor connected to it. An equivalent configuration, which also requires a crossbar switch, is an individual memory for each processor with means for each processor to gain access to other processors' memories. This switch may be a stand-alone unit, or it may be built into the individual memories' access circuits; either way, it is expensive, and it affects the speed of access. "It can cost almost as much as a whole additional minicomputer," says Seligman. "But its cost is almost independent of the size of the memories it interconnects, so in large systems it can be, and is, employed economically. In small systems it may not be worth the cost."

And Seligman points out that the crossbar switch also adds an extra hundred nanoseconds or so to the memory's access time. In a machine with a 300-ns computing cycle, like Data General's Supernova, this would be disastrous.

On the other hand, transferring the data through the input-output bus costs time, too—but this time penalty is isolated by the channel structure from the basic machine cycle, which therefore doesn't suffer from it. Obviously, too, it's avoided as long as a given processor can work with data in its own memory.

To compare the two configurations more precisely, the extent of the delays they impose can be calculated in terms of two small computers with 800-ns core memories. If a crossbar switch is interposed between the two processors and their respective memories, the average cycle per processor can vary between 450 and 675 ns; but if the two processors communicate through an input-output bus, the average time varies between 400 and 800 ns.

These estimates take into account the amount of delay, the distribution of data in the two memories, and the probability of interference—and the last factor is crucial. For if the two computers interfere with one another less than about 30% of the time, the input-output bus connection can be shown to result in less lost time. Since in practice the amount of interference in a well designed system is less than 1%, the input-output bus connection is clearly at an advantage.

Cady, however, would qualify this preference for an input-output design. He points out that such a design loses time in interrupt processing as well as in transferring data. Every time a transfer is requested, the processor has to put aside its own program to handle that request. The time lost can be reduced by incorporating additional hardware, and different manufacturers have done this at various levels of sophistication. But adding interrupt-processing hardware to a minicomputer tends to turn it into a maxicomputer.

Transfers along the input-output bus are also complicated when bona fide input-output operations are time-dependent and therefore can't themselves be interrupted. Cady feels that this linkup is best when input-output rates are low and not time-dependent.

Murphy, also of DEC, is more actively in favor of the input-output interconnection. He sees the device that serves as an interface between the network and the computer as a useful buffer that doesn't tie up the main computer. There are alternative ways of handling this buffering process: either by connecting the minicomputer directly to the main computer as a front end, with the transmission lines going out from it; or by using conventional input-output equipment with switching apparatus that makes it accessible to either the central computer or the minicomputer. Murphy predicts the latter is the coming trend.

When the input-output switch is used in the latter kind of system, the minicomputer receives messages from a telephone line, adjusts their format for the central computer, and then sends them through the switch to a disk or drum storage unit, as shown in Fig. 4. When the entire message has been stored, the unit interrupts the central computer, which can respond and pick up the message at its leisure. Its reply goes onto the disk, and is picked up from there by the minicomputer and retransmitted to the remote device.

Despite the extra step of disk or drum storage this approach is flexible and efficient enough to permit real-time use, and it makes better use of the central computer's time. But it doesn't permit direct communication between two remote stations. They must transmit to the central office and let it retransmit. A direct connection would be very expensive, Murphy says, and would also present certain problems in bandwidth and loss of flexibility.

All communications beyond the data concentrator are over telephone lines, using modems connected to the concentrator-computer. This is the best way to set up these networks, even if all the "remote" terminals are in the same building with the central, because hardware and software for the telephone-line connection are standardized.

But all these configurations, Cady points out, ignore input-output. In a system that does a lot of number-crunching, they are all reasonable configurations; but the performance of the great majority of installed systems is limited by the performance of the input-output equipment, which makes fancy ways to interconnect processors and memories only academic.

With the unified bus concept, says Cady, input-output equipment can be added indefinitely. Not surprisingly, the unified bus concept is the principal design feature of DEC's PDP-11 computer [*Electronics*, Dec. 21, 1970, p. 47]. And indeed, Digital Equipment Corp. is building several modular networks on special order, all based on the PDP-11 and all essentially minicomputer networks. Basically each system contains four processors—one master, one task processor, one communications unit, and one backup for use in case one of the others fails at a critical moment (Fig. 5). All the buses in the various individual computers are interconnected, and every device on every bus has only a single port into that bus. Devices with two or more ports are also possible.

The unified-bus approach to networks is much neater than anything else, Cady thinks. For example, short of using multiport memories, the bus allows a single memory or other unit to be shared by two or more processors, with a switch connected to the unit and to the buses. A comparison of this arrangement and the traditional input-output bus connection is shown in Fig. 6. Obviously the traditional scheme is more complex and troublesome than the unified bus. Furthermore, in the traditional scheme, the switching necessary to add a third memory, shown in the diagram, and to permit an input-output unit to have access to it, not shown, is incredibly messy.

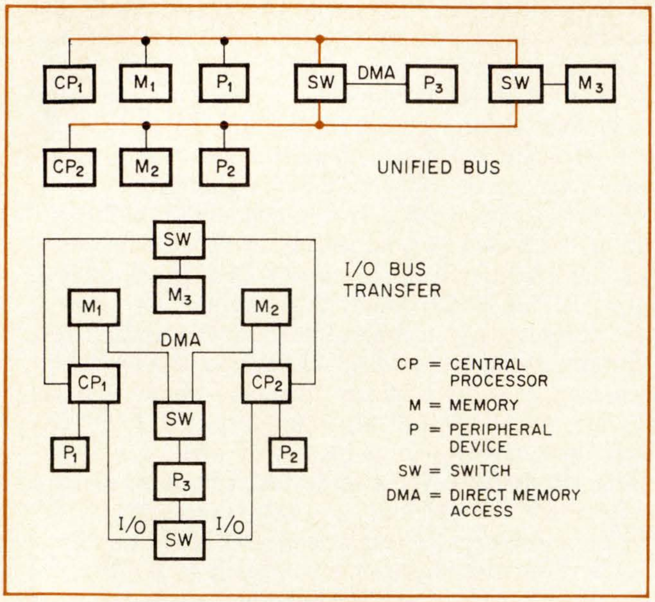
Any job suitable for a large fast computer but too complex for a small one is worth examining to see whether a network of small computer could handle it. The fundamental requirement is for it to be divisible into several parts that the individual computers can handle. Typesetting is divisible in this way—hyphenation and justification for one computer, layout for another, photosetting for a third, and so on.

Because these tasks occur in a well defined order for every paragraph of copy, there is little interference between computers, and the job could be done readily with a network connected through an input-output bus. On the other hand, seismic analysis or other operations that involve a large data base would require a crossbar switch, because the amount of cross-referencing between memories would be very high.

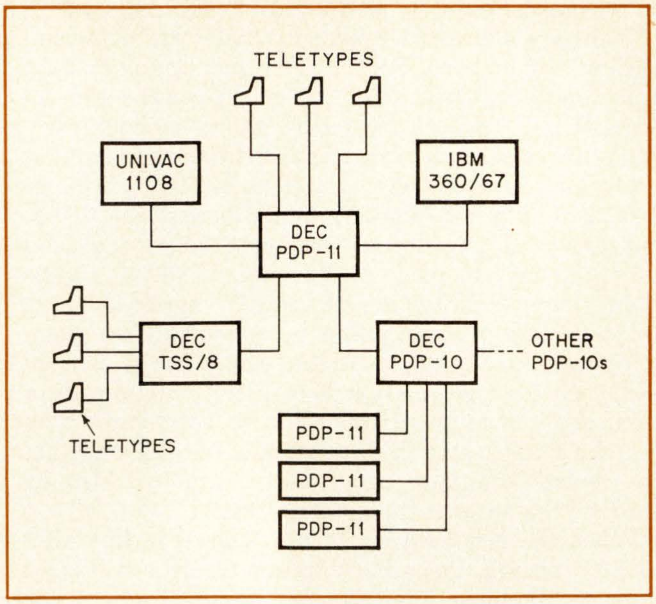
Speech processing is a good example of an application for a pipeline network. At Carnegie-Mellon University, Raj Reddy, a colleague of Gordon Bell, is working on a speech-processing machine using a pipeline of minicomputers. Eventually he hopes to have a computer to which anyone can speak freely, via telephone or simliar input device, with few restrictions on vocabulary or syntax. But there are several years of research facing him, with material for many doctoral theses by graduate students at CMU and elsewhere.

Reddy's qualifications for developing such a system are impressive. Before coming to CMU he developed a system at Stanford University using a big computer with a big program. His network at CMU won't be a simple pipeline, which implies a direct hierarchy, but will have complex interconnections between each processor and others in the system, both fore and aft. Both feedback and feedforward would be involved. Reddy visualizes implementing it through what Bell would call a multiprocessor—a big memory containing a common data base used by all processors.

Reddy sees a host of problems to be overcome before his system's physical implementation can begin. For example, ways to interlock the various processors must be developed, the data for each one must be continuously updated, and a protocol must be established for those occasions when two or more processors try to gain access to the same data. No software or programing language exists to tackle these problems, while the hardware that can do the job is expensive. Reddy is thinking in terms of PDP-11s or



6. Neatness vs mess. Proponents of the unified-bus approach to a network point out that it permits new equipment to be added to an existing network much more easily than when the connection is made through the conventional input-output bus.



7. Projected network. At Carnegie-Mellon University this configuration is envisioned for the eventual use of graduate and undergraduate students. Among other things it will enable research to proceed on the tradeoffs between minis and maxis.

machines of similar size and capability.

Bell agrees that speech processing in one application for minicomputers in a pipeline network. But he thinks the task also requires a big machine somewhere in the mix—for example, a syntax dictionary. Just hanging a big backup memory on the network won't be sufficient for such problems, he feels. Parallel networks of minicomputers can also be useful. Bell points to the management of Control Data's Star computer [*Electronics*, March 30, 1970, p. 52] as an example. The processors in a truly parallel network execute different instruction streams and also process different data banks, their work being correlated by a central supervisory computer. This is different from another kind of network, also sometimes called "parallel," in which all the processors execute the same instructions on different data banks.

Interconnecting small computers without careful designing can lead to trouble, Bell warns. He cites one commercially available product made of three small computers of two different types and a disk storage unit. One minicomputer is a data concentrator, another controls the disk, and the third is the main processor. This particular product, Bell says, contains no provision for failure of one processor, and insufficient computation capability for big problems, and it is quite expensive.

Meanwhile at CMU a network is being constructed that involves several small computers and a few large ones. It represents an expansion of the university's computation center, which students use for course work and research. Already installed are one Univac 1108, one IBM System 360 model 67, one Digital Equipment PDP-10, and one TSS-8—the last a version of DEC's PDP-8 with hardware and software added for time-sharing. More PDP-10s have been ordered. Eventually the network may have a configuration like that shown in Fig. 7. In that network students will use remote terminals to gain access to the PDP-8; when that computer's capabilities are exceeded, the overflow will go first to the PDP-11 and then to the 360.

In Florida the Data General Corp. is installing a hospital information system comprising three Nova 800 computers with the MCA option. One of the three maintains a large data base containing a variety of hospital records. Each of the other two is connected to 16 interactive remote terminals, preprocessing their inputs before forwarding to the data-base computer. Both updatings and inquiries are processed through the 32 terminals. A wide variety of peripheral equipment is also connected to the data-base computer, which is kept very busy juggling everything. Nevertheless, the whole system is much less expensive than the 360/50 that was originally envisioned for the job.

Data General is also bidding on a reservation system for an international airline. The system would involve six Nova 800 computers connected to an IBM 360. Four of the six would preprocess messages arriving from 64 remote terminals each, a total of 256 terminals. The other two, one of which is redundant, would carry out further processing, and would interface the system with the 360.

At CMU Bell and his colleagues are thinking about building a minicomputer multiprocessor, but without the crossbar switch. He thinks there should be a better way to attain this configuration and level of capability. The details and the corresponding software will keep a lot of doctoral students busy, but Bell feels that once these problems have been overcome, his approach is the way to build really great computers. □

WANTED:
product-oriented EEs

Engineers who've lost their defense or aerospace jobs can enjoy a new career in industrial and consumer electronics—but only if they're prepared to grasp the economics of the marketplace

by Bernard M. Gordon, *Gordon Engineering Co., Wakefield, Mass.*

☐ Paradoxically, at a time when many electronics engineers are unemployed, there's a shortage of people with their technical qualifications and also with adequate electronic product experience. In industrial process control and measurement, automatic machine tool control, communications, test equipment, pollution control, scientific and analytical instrumentation and similar fields, electronics engineers are urgently needed who are capable of conceiving, designing and putting into production competitive and useful products.

And there's the rub. As both the would-be employer and the unemployed engineer often find to their dismay in the course of an interview, a mismatch exists between the attitudes of those who have worked in an academic, military or aerospace environment and the requirements of competitive, product-oriented industry. This mismatch is based partly on the reality of the differences between the two kinds of activity and partly on the lack of understanding of those differences.

It hasn't always existed. As recently as twenty years ago a well educated electronics engineer was expected to be able to tackle any problem that was presented to him. Jobs were scarce, salaries were low, and engineering budgets were very tight. Any engineer—and particularly any electronics engineer—was expected to be capable of assessing a present or potential need and developing and putting into production a new product that could satisfy it.

In contrast, the military-oriented management philosophy of many companies today assigns the engineer to a small part of the overall development task, and trains him to a high degree of specialized competency in a small, restricted segment of the field. It derives its rationale from Government contracting and fiscal procedures that base the return to a company primarily on how well it can prove its need for the large variety and number of engineers it puts on its payroll.

However, there appears to be no reason why a competent engineer, even after spending a working lifetime in the aerospace or academic fields, cannot convert to a useful and leading role in commercial, industrial activities. But to do so the engineer must understand that certain fundamental economic rules, incontrovertible as the basic laws of physics, govern any assessment of his usefulness and productivity within a successful company.

When such an engineer is hired by an old line company, two major problems arise. Many engineers don't understand the increment of accomplishment required for each level of success in a commercial environment, and at the same time many company managements don't know how to indoctrinate, orient, and motivate those engineers.

To understand the attitudes of the managers in competitive, product-oriented companies, the distribution of funds in such a company has to be grasped (see Table 1 on page 65).

The product-oriented company exists primarily to make a profit. Without it a company cannot grow, and if a company does not grow in its field it will generally die. A typically well run company should try to earn about 17% before taxes.

Many engineers with a research or aerospace background are surprised to find that a typical sales and marketing expense constitutes about 20% of a product company's operating budget, while only about 8% of sales may be allocated for product development, including tooling and learning. Moreover, product development includes more than just the mere building of a prototype or demonstration model—it also

A mismatch exists between the attitudes . . . in an academic, military, or aerospace environment, and the requirements of competitive, product-oriented industry.

A case history from computers

The first computers, such as the original Univac and the ERA series, were designed by a small handful of men who conceived the machines, designed the circuits, tested the computers, put them into production, built the test equipment, and, in short, carried out the entire program. In those days, budgets were very tight and designers had to be right the first time. However, from the late 1950s and through the 1960s the philosophy of the military-oriented company has taken hold, and as many as several hundred people, most of them engineers, may be assigned to the development of a single computer, the design evolving through a series of decisions, each vetoed in turn, and with eventual reliability achieved only through a series of abortive errors and reworks.

I remember when in the late 1950s I was the president of a data systems company and was invited to the plant of a large military contractor which was involved in the design and production of three models of a single "fire control computer". In our company we were designing and building dozens of large-scale systems, varying from air traffic control systems to stabilization control systems to PCM telemetry systems. It was our practice never to put more than one engineer on such a project or to support him with more than a handful of men.

When I arrived at the airport I was met by an executive of the company and driven to their plant. Since I was familiar with the program being carried out I was amazed when I estimated that their facility contained about 100,000 square feet and that, from the size of their parking lot, there ought to be about 500 people within. My host, however, informed me that I was wrong, that it was actually a 300,000-square-foot plant, with almost 3,000 employees.

I expressed my wonder and, in an effort to impress him, commented that from my understanding of the technical content of the system they were developing, my relatively small company could have done the job in less than one year with two engineers. He turned to me and said, "Yes, I know you could, and you probably would have delivered the three systems for about $1,000,000. But we are getting $300,000,000 so tell me who's smarter?"

It hardly needs saying, but we each had our own opinion on that.

covers the design of production test equipment, manufacturing drawings, incoming inspection, assembly and test, and a myriad of other details—so that the amount allocated to real development is more typically 5% than the 8% shown in the table.

Factory cost is the cost of manufacturing the product and generally includes cost of materials and direct assembly and test labor, typically multiplied by a factor of 2.5 to cover factory overhead. Service and warranty of units shipped might run over the range from 1% to 3% with about 2% being typical. General and administrative expenses include such factors as officers' salaries, accounting and payroll costs, interest, and incidental expenses. This generally runs from 6% to 10% with about 8% being typical.

A successful product-oriented company must have budget allocations for each of these areas. The specific amounts may vary from company to company, of course, depending on the nature of the product line and the size of the company; but the percentages in Table 1 are typical of a medium-sized electronics company or a division in a much larger company.

From an understanding of the factors shown in the table, the engineer may derive at least two significant points. First, only about 5% of the company's sales can be spent in actual product development. It is an obvious corollary that each engineer must produce in terms of sales dollars no less than twenty times what he is allowed to spend for development. Secondly, products must be sold for about two and a half times what they cost to make, and, again, it obviously follows that a product must be designed to be manufactured for about 40% of its selling price. Surprisingly, many engineers have found these two points hard to accept.

Each engineer must produce in terms of sales dollars no less than twenty times what he is allowed to spend for development.

Moreover, in determining how much can be spent to develop a competitive product one must take into account two other factors: the likely lifetime of the product, and the total dollar income likely to be achieved from its sale during that lifetime. In the semiconductor field the state of the art of component and manufacturing processes is changing very rapidly, many new devices appear on the market weekly, and the probable design obsolescence of a product is nine months to a year. This means its sales life is unlikely to be much longer than two to three years (see Fig. 1).

Also, if it takes about six months to one year to develop a product it's obvious that nearly every device being put into production will be "designwise" technologically obsolescent by the time it gets there. Therefore, for this reason alone, it is clear that time is of the essence. However, if the product is destined to become obsolete over a two- or three-year period, with sales typically building up during the first year, peaking out in the second year, and beginning to tail off in the third year, it becomes easy to understand the limitations that must be placed on the total time and funds allotted to developing a particular product.

Table 2 shows the typical make-up of a product

The would-be product project engineer... must accept as reality that he has settled on no less than a $1-million-a-year responsibility to earn his keep.

engineering team within my own company. It is based on our experience in designing products varying from X-ray machines to desk calculators, from digital computers to gas chromatograph analyzers and from communication receivers to high-resolution, electron microscopes. Generally, a single project engineer is responsible for designing everything to do with a product, with the full-time help of an engineering assistant, a wireman one-half time, an industrial and/or mechanical designer one-quarter time, and the equivalent of a full-time printed-circuit designer and documentation draftsman.

This may seem like a meager crew to turn out a complex product—until their expenditures are taken into account. Table 2 shows that the direct salaries alone for that group for one year will approximate $50,000. Assuming an engineering overhead of 100%, for that group just to be on the payroll will cost the company $100,000. To this must be added provision for expendable material, such as component parts, printed-circuit masters, prototype metalwork, engineering tooling, all of which may add up to $20,000 per year. Thus a typical productive product engineering group must spend about $120,000 annually, or about $10,000 per month.

Therefore, if expenditures are distributed as in Table 1, if the life cycle of a product is estimated at two to three years, and engineering salaries and overhead are reasonably in accord with Table 2, the time and effort that can be allowed to go into the development of a competitive product can now be deduced. Inversely, it's possible to calculate the product value that must be put into production each year by each product project engineer.

The required productivity in dollar volume of sales per year of a product project engineer supported by the support group indicated above is given by the equation:

$$P = \frac{E \times 100}{S} \times \frac{1}{Y}$$

where

P = product dollar volume in sales per year

E = number of dollars expended by engineering group

S = percent of sales allocated to product development

Y = anticipated product life in years.

If E = $120,000, Y = 2 years and S is 5% of annual sales, then $1,200,000 in sales must incrementally result from the engineer's efforts each year.

TABLE 1

Distribution of funds in a product-based electronics company

Area of expenditure	**Low**	**Range Typical**	**High**
Profit goal before taxes	10%	17%	25%
Sales and marketing expense	15%	20%	25%
Product development including tooling and learning	6%	8%	10%
Factory cost	35%	45%	55%
Service and warranty	1%	2%	3%
General and administrative expense	6%	8%	10%
		100%	

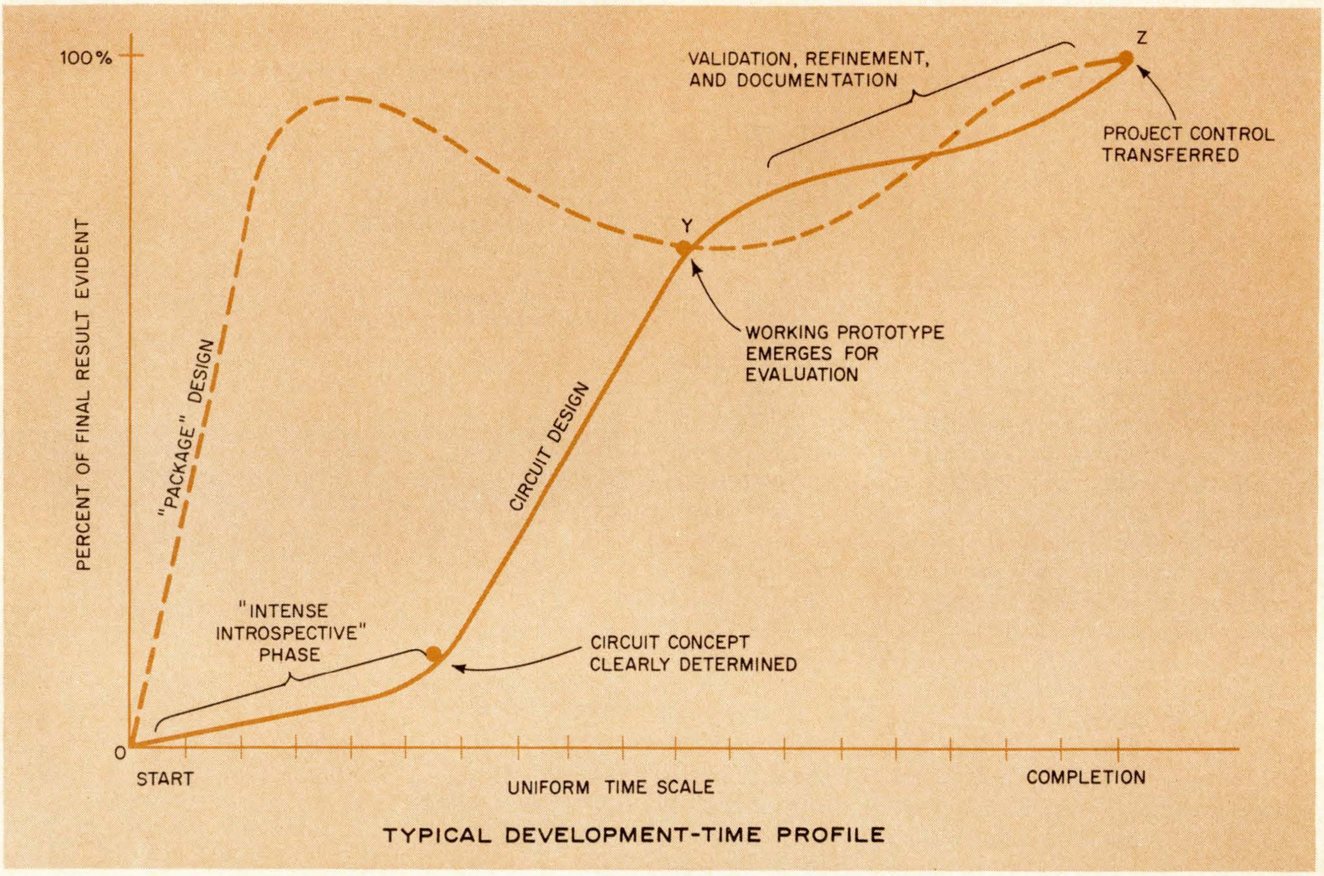
TABLE 2

Typical cost of a project including and supporting one product project engineer

Staff function	**Annual-salary range**	**Time spent on project**	**Average annual expense**
Product project engineer	$17,000-27,000	Full time	$22,000
Engineering assistant or technician	8,500-12,500	Full time	10,500
Wireman	7,000- 9,000	Half time	4,000
Mechanical designer	10,000-14,000	Quarter time	3,000
Printed circuit designer and draftsman	8,500-12,500	Full time	10,500
			$50,000
Average product expenditure per year			$ 50,000
100% overhead			50,000
Expendable material (parts, pc masters, other engineering, tooling, etc.)			20,000
Total			$120,000
Average project team cost = $10,000 per month			

Although the details may vary from product to product and from company to company, any calculation based on any reasonable set of assumptions results in this order of magnitude for design effort versus product return. Typically, one finds that a $5-million company has about five development engineers and a $100-million company has around 100 development engineers. Thus, the would-be product

The engineer must understand that certain fundamental economic rules, incontrovertible as the basic laws of physics, govern any assessment of his usefulness and productivity.



1. Product development. In the product-oriented company the project engineer must keep the end product in view from the start, thus refining the package design before he has even a rough idea of the circuitry it will contain.

project engineer, coming from a Government, academic, or avionics background, must accept as reality that he has settled on no less than a $1-million-a-year responsibility to earn his keep.

Not only must the product engineer produce new and imaginative products, but they must be competitive. He can also find better, cleverer, lower-cost ways of making established products.

Figure 1 shows how a product is developed. Marketing techniques must be used to help characterize it and establish price/performance trade-offs. The competition must be assessed. The customer's technological alternatives to buying the potential product must be weighed. The contributing technologies and their likely status a year or two hence must be considered. Will the useful life of the design be too short for reasonable profit potential? Who are likely to enter the market in the next two years, and what are they likely to offer?

Highly conceptual engineers from an academic or military background frequently confuse a usable technique with a product.

Only after the engineer, together with marketing personnel, has characterized a predictable, competitive product should the physical design effort be intensified. It's the only way to be confident that development money will be utilized wisely.

At the beginning of a project it is usually wise to go slowly, to make sure that what is to be designed is really going to be a product and not merely a technique demonstration. Highly conceptual engineers from an academic or military background frequently confuse a usable technique with a product. They may have previously worked under a management that thought it would get a commercial product as a fallout from some military development. This is almost never so, because most military developments are aimed at specific and narrow end uses, and a commercial product must be designed to be used by a wide variety of potential users.

Next, experience has shown that at the very beginning of a project the package design should be aimed immediately at the final result. Surprisingly, the packaging may be even more important in a commercial than in a military project. For instance, temperature and humidity requirements are sometimes more stringent, and reliability, too, may be more significant in a steel mill than in a fighter plane. The project engineer is responsible for this package even though he may have available the services of competent industrial and mechanical designers. He must pin down size, form-factor, human interfaces, accessibility, weight, color and finish, before circuits and even block diagrams have been determined. This is necessary because the end use of the equipment must govern all other design efforts.

While the package is evolving, the project engineer must proceed alone to design circuits, engaging in an intensive first-round effort and seeking the lowest-cost, simplest, most direct route to a design that fits the specifications and fits the proposed package. He may have to spend as much as 20% to 30% of his project schedule before he really knows what that product design is going to be. But then he can proceed with confidence that the product will be a reality.

At this point, he must be prepared to move very fast, bringing everything to bear to complete the project. Circuits must be designed, laid out and documented. Priced bills of material must be developed. Incoming inspection procedures must be generated. Reliability check points and test equipment must be developed. There is a great deal of work to be done, and it is the project engineer who must do it.

Throughout the life of the project, moreover, two constraints must be imposed and superimposed: the design must be both easy and inexpensive to manufacture. Quite clearly, the project engineer must be right on top of parts costs, and he must become intimately familiar with manufacturing procedures.

Thus the product project engineer in a competitive product company must learn to become quite a man. He must have a profound and broad technical background. He must tackle nearly every aspect of the design himself and be responsible for it. He must know economics and manufacturing. He must have a handle on the competitors, for it is his project. It will fail or succeed based on him and on no one else. Thus, unlike his military counterparts, the commercial project engineer must acknowledge it's all up to him. A failure is his failure, but a success is his success.

Naturally the transition from a military-oriented background is not easy. A major difficulty has frequently been the newcomer's feeling of "superiority" to those who have always been practical product types. After working for years in an atmosphere where deference has been paid to degrees rather than diligence, mathematics rather than manufacturing, reports rather than results, and ego rather than economics he may go through some shattering experiences. The defense-oriented engineer may reach the traumatic conclusion that his counterparts, who have been under the gun of economic scheduling and marketing pressures for years, may have produced more inventions, circuits, and equipment than he had imagined possible. He may also be surprised to find that they have been enjoying their jobs all this time, both materially and emotionally, as a result of the satisfactions arising from a sense of real achievement.

> *Unlike his military counterparts, the commercial project engineer must acknowledge [that] a failure is his failure, but a success is his success.*

> *The defense-oriented engineer may reach the traumatic conclusion that his counterparts . . . may have produced more inventions, circuits and equipment than he had imagined possible.*

But the speed with which the displaced engineer makes his adjustment is also partly up to the management of his new company. For the management of a company to bring out the best in its engineers, it cannot treat them like hired hands. If the engineer is to be the goose that lays the golden egg, he must be regarded as a very valuable asset and both a member and pillar of the company. It should be obvious, but often it is not, that a successful project engineer is spending a lot of money and that his salary and the cost of equipment necessary to support him are secondary considerations. We have generally found it good, both psychologically and by real financial reward, to indicate to an engineer that if his product succeeds he will get a return from it.

Unfortunately some managements, particularly in industrial-product companies with vested interests in the past, are not yet willing to gamble on new technologies and new ideas. Here, of course, the project engineer must be a salesman as well and be able to sell his ideas to the management.

All this is not to imply that there have not been significant and spectacular engineering accomplishments and technical advances in Government-sponsored and Government-oriented laboratories. Many of them have been made, however, with huge expenditures and without taxing the capabilities of most of the people involved in carrying out the task.

The achievement of a product-oriented company is measured by quite different criteria and requires a quite different approach from the electronics engineer. If he wants to make a success of his transition from defense and aerospace programs to the competitive world of industrial and commercial product development, he need only follow the long established tenets of practical product realization.

Who knows, he may even discover the work stimulating and enjoyable. □

Designer's casebook

Any voltmeter reads electronic thermometer

Robert J. Battes
Delta-Pacific Electronics, Prospect Heights, Ill.

A silicon-diode probe and an operational amplifier with an unusual gain adjustment are the key elements in an electronic thermometer that gives a readout, in degrees, on an ordinary voltmeter. The sensing circuit's voltage variations can be adjusted to align with a temperature scale. For instance, a 10- or 100-millivolt reading can represent 1°C at one setting or 1°F at another setting of the amplifier.

The op amp is connected as a differential amplifier. An input that varies with the temperature of probe D_1 is obtained through resistor R_1 and part of R_2. Zener diode D_2 and R_3 provide a reference voltage; offset is adjusted by R_4. R_2 is the gain adjustment, but it is not entirely within the feedback path as shown on the diagram of the conventional differential amplifier. In the location used, R_2 helps to make the output both linear and scalable.

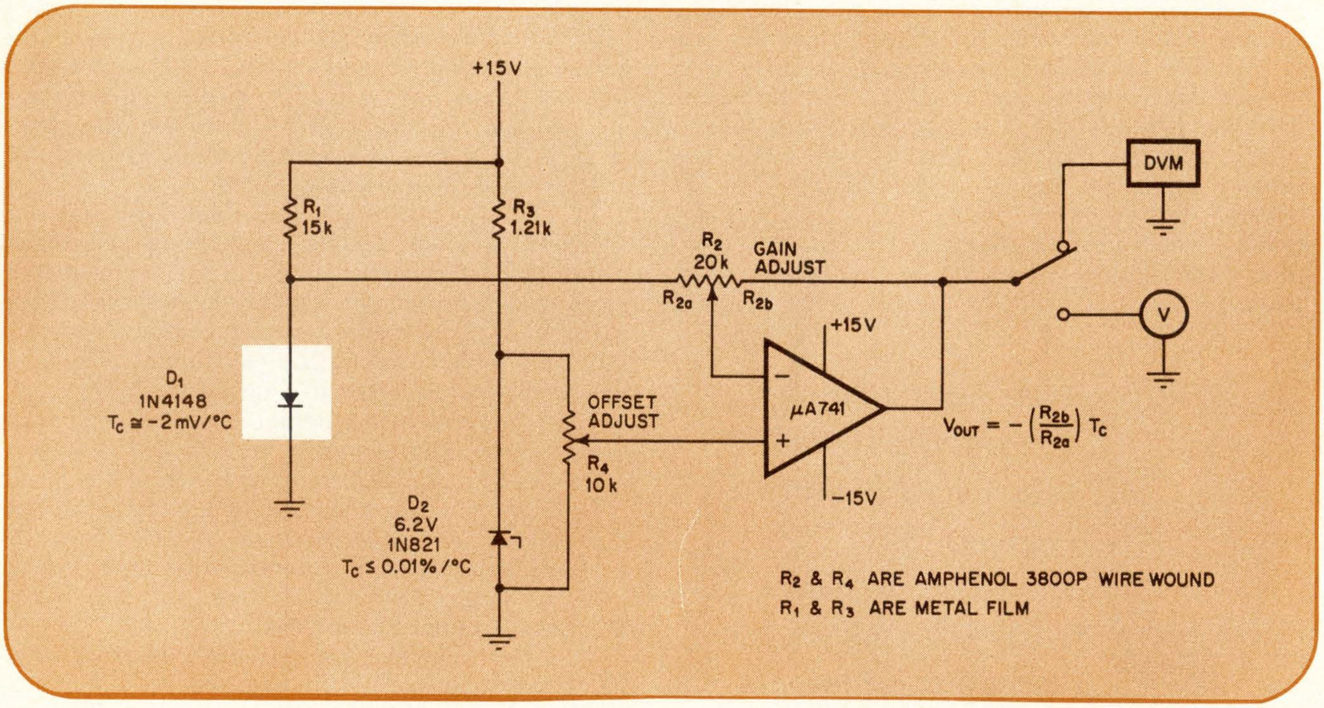
The values of R_1, R_3 and R_4 do not significantly affect the gain of the amplifier. The low impedance of the zener diodes, about 25 ohms, swamps out the presence of R_1 and R_3, and the high impedance of the amplifier masks the presence of R_4, which is much lower in value. The output voltage can be expressed in terms of R_2 and the temperature coefficient, T_c, of D_1.

$$V_{out} = -(R_{2b}/R_{2a})\,T_c$$

After potentiometer R_2 in the actual circuit is adjusted to bring the output within a suitable range on the voltmeter, potentiometer R_4 is used to adjust offset. This aligns V_{out} with the desired temperature scale so that the reading corresponds to degrees without further conversion. The instrument is calibrated by setting R_4 with the probe at a known temperature to calibrate the instrument.

Metal film resistors, wirewound potentiometers, and the small temperature coefficient of the temperature-compensated zener diode give the circuit excellent temperature stability. Minor variations in supply voltages do not significantly affect accuracy. Since the dynamic impedances of the two silicon diodes are matched closely, supply voltage changes result in a common-mode input signal that is greatly attenuated by the amplifier.

Volts by degrees. Amplifier adjustments allow the temperature of probe D_1 to be read on the voltmeter without further scaling or conversion factors. The output is scaled with R_2, which is located to simplify scaling by contributing to R_1. Adjusting offset with R_4 allows voltage to represent degrees F or C.



Low-voltage feedback loop controls high-voltage supply

By Roy J. Krusberg,
University of Georgia, Athens, Ga.

Considerable savings in size, cost, and complexity can be achieved by limiting the current in the primary winding of a high-voltage power supply's transformer, instead of controlling the output from the secondary winding. Much of the regulation circuitry can be built with low-voltage components, reducing cost and bulk, and eliminating sticky decoupling problems.

This approach is illustrated by a photomultiplier tube supply whose output ranges from 500 volts to 3.5 kilovolts, at currents up to 1 milliampere. Regulation can be as tight as 0.001%.

Q_1, a power transistor suitable for 117-volt operation, is located in the direct-current arms of a full-wave rectifier between isolation transformer T_1 and high-voltage transformer T_2. A feedback current through two low-voltage operational amplifiers, A_1 and A_2, varies Q_1's gain. Current through the primary winding drops when the output voltage rises above a level selected with the taps on resistors R_1 through R_{17}, or rises when V_{out} drops below the selected level.

As A_2 drives Q_1 toward saturation or cutoff, T_2's output fluctuates about the desired output. Diodes D_5 and D_6 rectify the controlled high voltage ac signal while L_1 and C_1 filter the ripple to provide a smooth dc voltage output. The series-parallel resonant circuit filters better than a pi-section filter alone.

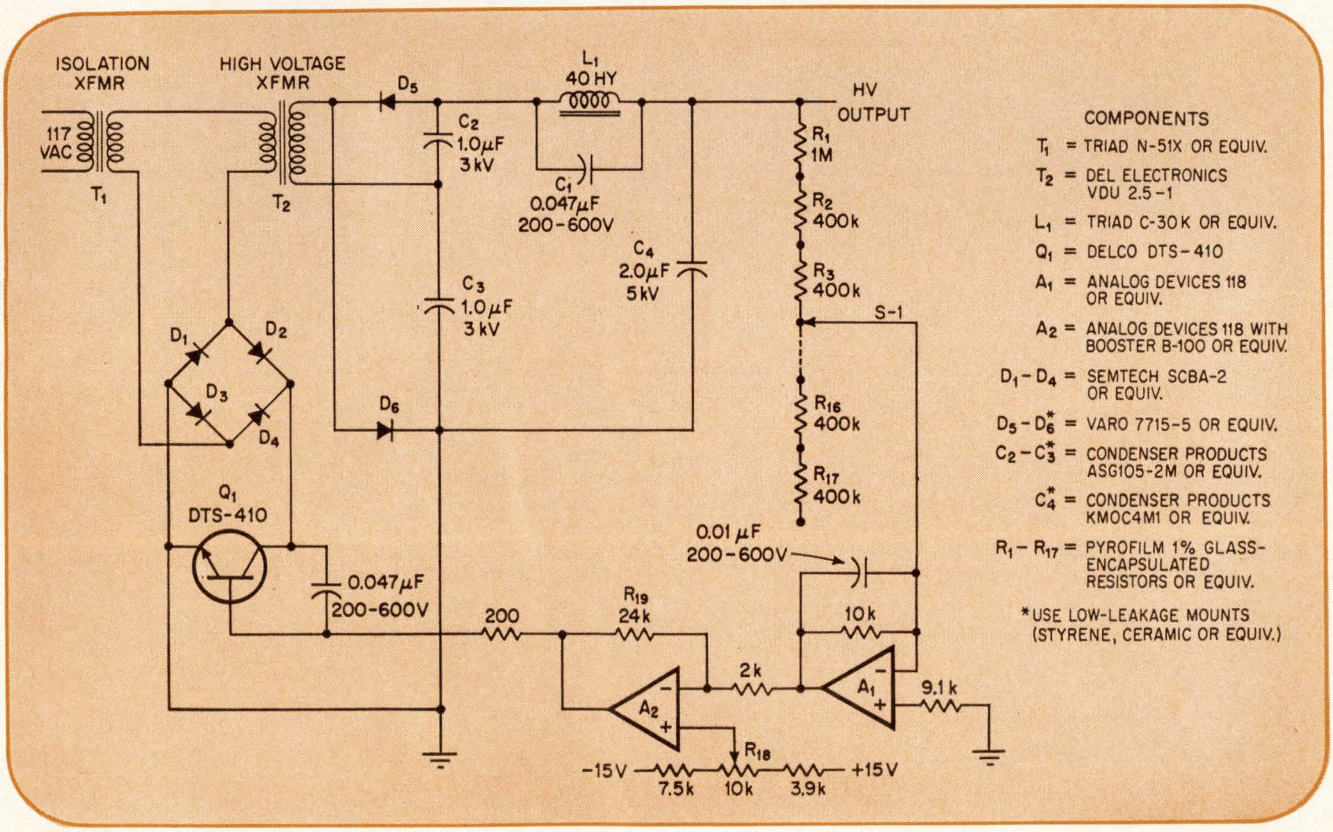
An offset voltage is injected into A_2's noninverting input to initially bias Q_1; current sources are the op amp power supplies and R_{18}. A_2's gain is set by feedback resistor R_{19} and is trimmed by R_{18} to give the desired output range in combination with the taps on R_1 through R_{17}.

After startup, the current sample obtained from R_1 through R_{17} feeds into A_1's inverting input. A_1 is connected as an inverting current amplifier; its output varies to hold the potential at the input summing point at zero. Since A_1's output is coupled into A_2's inverting input, the latter's polarity is suitable for driving Q_1.

If component values are changed, the standoffs must be adequate to isolate the low-voltage devices from ground. C_1 should be selected to resonate at 120 hertz with L_1. Tap resistors should be high-voltage glass-encapsulated types.

Because of its simplicity and reduced noise, a power transistor is preferred over a Triac and phase-control circuit for low-power regulation. Also, Triacs seem to have an erratic firing point, which degrades short-term regulation.

Volts control kilovolts. Current samples taken from the high-voltage output of power transformer T_2 are fed back through operational amplifiers A_1 and A_2 to control conduction in power transistor Q_1. The feedback limits the current in the transformer primary to regulate the secondary voltage, which is then filtered by L_1C_1.



Op amp's current booster ends crossover distortion

By J. Rodney Cox
U.S. Naval Ordnance Station, Louisville, Ky.

A high-performance operational amplifier's linearity usually suffers when output current is boosted. Adding a conventional power amplifier stage also adds crossover distortion for a fast changing signal. This can be prevented by adding a complementary power stage that conducts before a fast-changing signal crosses zero voltage. This booster stage also can improve slew rate.

The booster's two diodes, D_1 and D_2, establish a voltage offset that enables transistors Q_1 and Q_2 to go into conduction early. Q_1 starts boosting positive-going amplifier outputs as they drop near zero; Q_2 does the same for negative-going signals approaching zero. The booster output thus follows the signal waveform without the usual push-pull delays.

The transistors are biased to maintain small collector currents. On the Q_1 side, bias current comes in through resistor R_1 and splits between D_1 and Q_1. Q_2's complementary current flows out through R_2. The diodes provide a voltage offset so that no crossover is necessary before Q_1 and Q_2 conduct. Capacitors C_1 and C_2 preserve waveform integrity during fast signal transitions. Emitter resistors R_3 and R_4 prevent thermal runaway of the transistors.

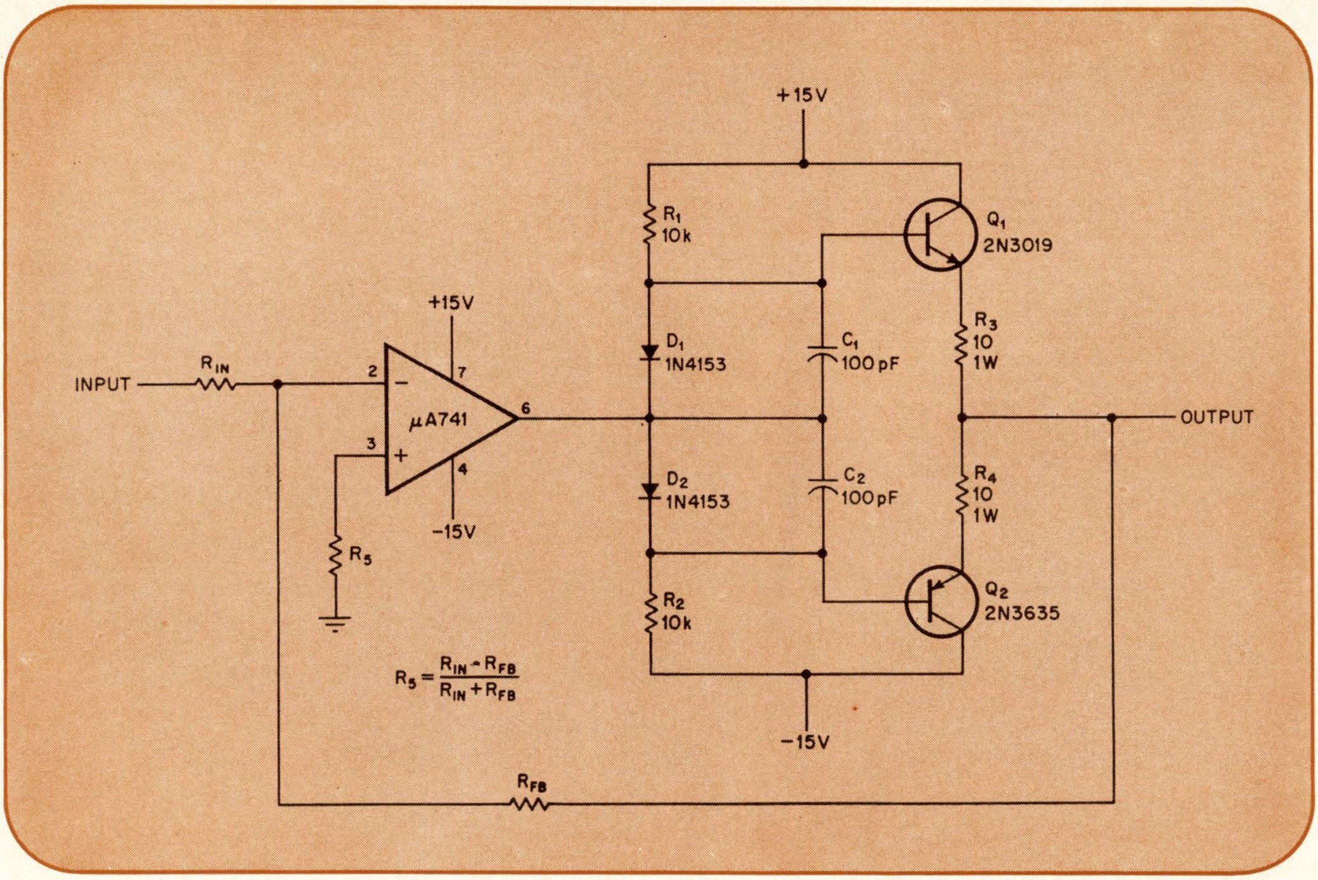
Feedback is taken from the booster output to maintain the waveform through both stages. When accomplished through a conventional booster, it accentuates the distortion. Here, it doesn't.

The presence of the power stage in the feedback path increases slew rate. A monolithic op amp's slew rate is limited primarily by the fact that the amplifier's own output stage delivers current with internal negative feedback. Using the external power stage virtually eliminates capacitive feedback, speeding up the monolithic circuit's response.

The booster shown presents an output load of slightly less than 5 kilohms to the op amp. Minimum current gain of the transistors is 30. Output current rating of a typical high-performance amplifier such as the μA741 is 25 milliamperes. The booster increases this to about 500 mA; currents up to 300 mA undistorted were measured using the μA741.

Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas and solutions to design problems. Descriptions should be brief. We'll pay $50 for each item published.

High current, low distortion. Booster eliminates output crossover distortion by placing its transistors in conduction before the signal voltages cross zero. The diodes maintain a voltage offset so that a small current flows through the transistors. Also, the external booster minimizes capacitive feedback from the amplifier output, which raises the op amp slew rate.



Low-power a-d converter is a battery life-saver

Built for remote sensing applications, unit turns off between conversions, using just the quiescent current supplied to its C/MOS logic section; total drain is only 20 mA from 12-V supply

by Robert D. Moore, *University of California, San Diego*
and James J. Pastoriza, *PDL Corp., Newton Upper Falls, Mass.*

☐ Remote environmental data-gathering systems have an environmental problem of their own: minimizing the drain on battery power supplies. One workable solution is an analog-to-digital converter designed so that its analog section is switched off when no data is converted. And even when it's operating, it uses complementary MOS logic that's more miserly with current than even low-power transistor-transistor logic —and less costly to boot.

The overall result: the complete converter draws only 20 milliamperes maximum from a 12-volt supply at a 5-kilohertz conversion rate and less than 1 mA at 100 hertz. This is less power than is consumed by the logic section alone of a low-power TTL converter.

In its environmental milieu, the converter doesn't have to be fast, because data taken from ocean buoys, space probes, and radiation monitors usually varies slowly with time. However, over a long period of time the data taken may vary widely, so a broad dynamic range is essential. The coverter satisfies this requirement handsomely: its 12-bit resolution permits accuracy of one part in 4,096. Thus, in taking atmospheric readings, for example, where variations of ± 10,000 microbars per week are common, the converter can resolve a 5-microbar change.

A block diagram of the converter, showing the logic and switchable power supply portion of the analog section, is illustrated in Fig. 1.

The low power consumption of the complete unit depends on the conversion rate, R, and the time to make a conversion, T. The power consumption figures were corroborated by empirical measurements. For 1, 10 and 100 conversions per second, the average current drawn is approximately 24, 60 and 420 microamperes, respectively. These values are at least two two orders of magnitude lower than those attainable with conventional TTL. And at the more commonly used conversion rate of 5 kHz the average current drain of 20 mA is about an order of magnitude below that of a device made with low-power TTL.

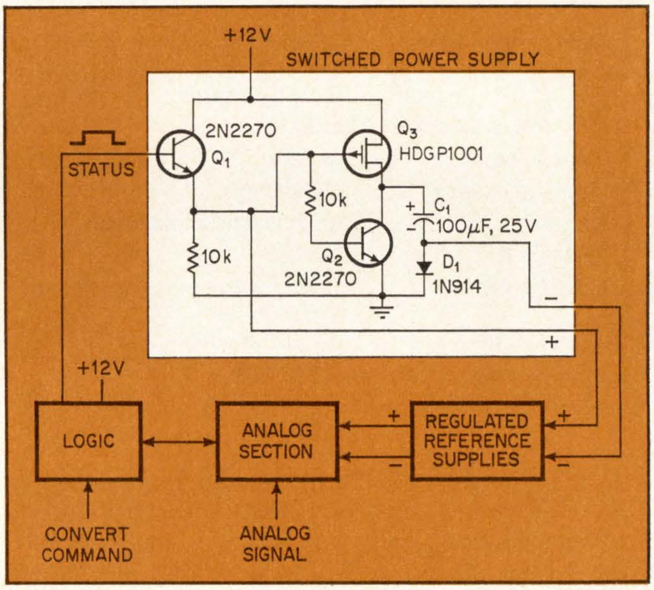
From such measurements (with T = 100 microseconds), it was possible to develop an equation, which plots as a straight line, relating the average supply current I_S in mA, and the conversion rate, in conversions per second:

$$I_S = 0.02 + 40\,RT$$

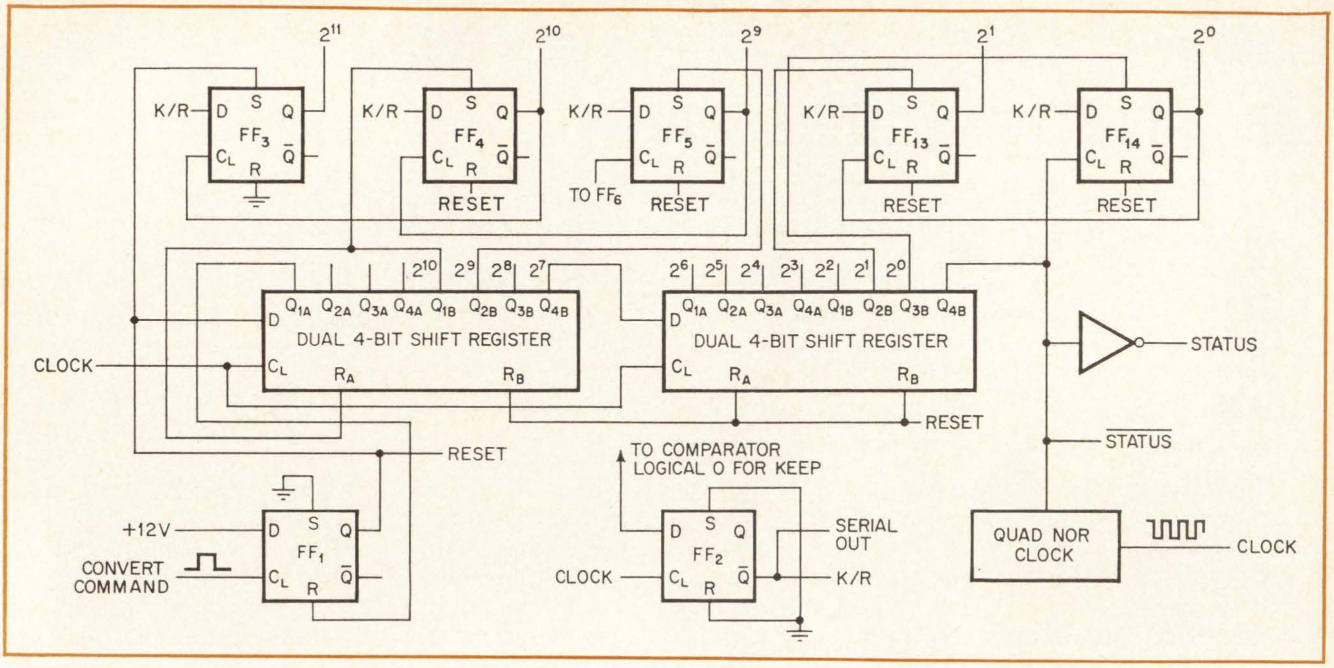
where the quiescent current drawn by the logic between conversions is 0.02 mA.

Conversion time is 70 μs, a moderate speed for a 12-bit converter. However an additional 30 μs is needed to assure that all elements in the switchable power supply reach a steady state following a conversion. Clock rate is 4.4 μs per bit. The first 17.5 μs of a conversion cycle is taken up by the turn-on and settling time of the voltage regulator, comparator, and the rest of the analog circuitry; the remaining 52.5 μs is used for converting the analog input signal to 12-bit resolution. Performance specifications for the unit are shown in the table on page 72.

The analog section uses off-the-shelf circuits from



1. Switchable. Power drain in the a-d converter is kept low by switching off power to the analog section when the unit is not converting an input signal. Power is turned on after a STATUS pulse from the logic section indicates that a conversion is to be made. When no STATUS pulse is present, C_1 charges to +12 volts through Q_3 and D_1. When a STATUS pulse is received, Q_3 turns off, and Q_1 and Q_2 conduct. A positive voltage then is available at the emitter of Q_1; and equal but negative voltage is present at C_1.



2. Complementary design. Fabricated with RCA's C/MOS circuits, the logic section of the a-d converter draws a maximum of only about 1 mA. Seven flip-flops, two dual four-bit shift registers, and a quad NOR fit on a single 2-by-4-inch printed circuit board.

TABLE 1
A-d converter specifications

Power supply	logic: +9 to +15 V analog: +12 to +15 V
Total current drain	at 5-kHz conversion rate: 20 mA
Conversion time	70 μs + 30 μs for switchable supply to settle
Max. conversion rate	10 kHz
Input voltage	±10 V
Input impedance	10 kilohms
Accuracy	± ½ least significant bit
Resolution	12 bits
Input trigger	1 μs positive pulse at 70% of logic voltage
Output signal	MOS compatible
Power supply sensitivity	12 to 15 V ± 1 bit

TABLE 2
Cost/power comparisons

Logic	Cost*	Power
TTL	$29	350 mA @ 5 V
Low-power TTL	$63	30 mA @ 5 V
C/MOS	$53	20 μA @ 12 V

*As of Jan. 1, 1971 in 100-unit quantities

Analog Devices Inc.: three AD550 quad monolithic μDAC switches and an AD850 precision thin film resistor network. Each quad current switch rests on a monolithic silicon substrate, providing temperature tracking among its switches and insuring monotonic outputs for all code combinations.

Tracking among the three quads themselves, which are in the same temperature environment anyway, is less important. This because the effect on the current in the ladder resistors of the analog section is reduced as the switches are used further down the ladder. For example, the effect of the fifth switch in the second μDAC unit is reduced by a factor of 1/16 ($1/2^4$); the ninth switch in the third unit by a factor of 1/256 ($1/2^8$). Although these units are designed to operate from a +15-volt supply, they will perform satisfactorily from the +12 to +15 volts available in the buoy.

The comparator section is an LM306 from National Semiconductor Corp. The switchable power supply and the regulated supplies use discrete components packaged on printed circuit cards. The power supplies furnish the +5 V required by the μDAC switches and +6.4-V reference needed to insure sufficient current levels in the resistor networks.

The converter is switched off between conversions of the voltage supplied to the analog section; the low-level quiescent current needed by the logic suffices to keep the converter circuitry alert to the start of the next conversion cycle. When it begins, the power to the analog section is switched back on.

This type of switching allows the positive and negative voltage required by the analog portion of the a-d converter to be generated from a single +12-V lead-acid battery. This is done by charging a capacitor from a positive voltage between conversions. Then its positive terminal is effectively grounded, providing a symmetrical negative voltage on the other terminal. With only 70 μs needed to complete a conversion cycle, the capacitor retains its charge without any significant droop.

In the schematic of the switched power supply shown in Fig. 1, the +12-V source supplies continuous power to the logic. However, unless the STATUS line is high (as it is only during a conversion cycle) the 12-V level is not applied to the analog section because transistor Q_1 is turned off. When the STATUS line goes positive, Q_1 conducts, applying the positive voltage to the analog circuitry. Moreover, during the quiescent period between conversions, when no STATUS pulse is present, capacitor C_1 has charged to nearly 12 V through MOSFET Q_3 and diode D_1. This charge is maintained—the emitter of Q_1 is low during this time so that Q_3 is turned on and Q_2 is off.

Using MOSFET Q_3 instead of a resistor prevents the charge on the capacitor from leaking off. A resistor's value would have to be quite low to assure complete charging of C_1 between conversions, especially at high conversion rates. However, when the unit is converting, this low resistance would quickly discharge the capacitor. Q_3's high off resistance (about 10^9 ohms) and low on resistance (about 30 ohms) provides an effective solution to quickly charging the capacitor and preventing it from discharging during cycles.

When the STATUS pulse is applied again and Q_1 conducts, Q_2 turns on hard and Q_3 turns off. Thus, during conversions, the positive end of C_1 is brought near ground, providing a negative voltage at the point indicated. This scheme has the further advantage that the power supply lines to the analog section are well decoupled from the logic during conversion.

The converter's logic portion uses low-power C/MOS circuitry, which draws only a few microamperes under quiescent conditions. The C/MOS logic uses power only when making transitions from one state to another. And even at high conversion rates, the logic alone for the 12-bit successive approximation converter, including a clock, as shown in Fig. 2, requires a maximum of only about 1 mA.

Three types of RCA circuits were used for the converter's logic: a CD4015D dual four-bit shift register; a CD4013D dual flip-flop; and a CD4011D quad NOR used as the clock. Altogether, there are 10 packages; they fit on a single 2-by-4-inch p-c card.

Thanks to the C/MOS circuits, the logic can operate over a wide range of supply voltages—anywhere from +6 to +15 volts. This range easily accommodates both overcharging and power dropoffs encountered in batteries used in remote locations. This high level also means the C/MOS logic has far better immunity to noise than TTL or diode-transistor logic, which operate around a +5-V level, thus allowing a variation of only about $\pm$1.5V.

Another C/MOS advantage is greater fan out and fan in: the D inputs on all 12 flip-flops in the data register are driven from a single flip-flop output. TTL circuitry, for example, would have required two separate driver circuits to handle them.

Some simplifications were also made possible in the layout of the logic by using C/MOS circuits. This is because with MOS technology, more circuits can fit into a single package than with conventional bipolar designs. For example, at present there is nothing available in TTL that's comparable to RCA's C/MOS dual four-bit shift register. Instead of using two dual packages, four separate TTL four-bit shift registers would have to be used.

A conversion of an analog input level to digital form is begun in the logic section as a result of a signal generated outside of the converter. This square-wave signal is applied to the CONVERT COMMAND input of the logic section. It clocks flip-flop FF1, driving the reset line to a 1, setting FF3, and resetting FF4 through FF14. FF3 through FF14 constitute the data register portion of the unit. At the end of a conversion they contain the binary-number equivalent of the input signal voltage level.

At the beginning of a conversion this register is set to 100000000000. (Input signal voltage to the converter range is $\pm$10 V, with a 12-bit binary output code in which -10 V = 000000000000; 0 V = 100000000000; and +10 V = 111111111111. With a 12-bit converter, such an input voltage range is resolved to about 5 mV.)

The RESET line also resets the last 12 bits of the 16-bit shift register. This causes the $\overline{\text{STATUS}}$ line (STATUS is an output pulse, a 1 during a conversion) to go to 0, starting the clock. The first positive-going clock transition then clocks a 1 into the Q_{1A} bit of the first shift register, which resets FF1.

When STATUS goes to 1, the power supply for the analog section is switched on. The most-significant-bit flip-flop (FF3) is left set through the first four clock pulses so that the analog section has enough time to settle down. By the time the bit in the shift register has reached the 2^{10} position, the comparator output will have settled to a level that depends on two factors: the relative magnitude of the feedback current generated by the position of the most significant bit and the current in the resistor ladder network produced by the input voltage.

If the sampled analog signal level is large enough so that the most significant bit can be retained, the comparator output will be a 0; if not, a 1. This level controls the state into which FF2 is clocked. FF2's $\overline{Q}$ output controls the KEEP/REJECT line, which in turn controls the data inputs of all the flip-flops in the data register.

When the shift register changes state to the 2^{10} position, FF4 is set, clocking FF3 which will be reset if the KEEP/REJECT line is low and left set if the line is high. One clock period later the bit is shifted to the 2^9 position. This sets FF5, which clocks FF4. This process continues until one clock period after FF14 is set. The next positive-going clock transition shifts the bit to the last position in the shift register. This clocks FF14, drives STATUS low, and stops the clock, completing the conversion. □

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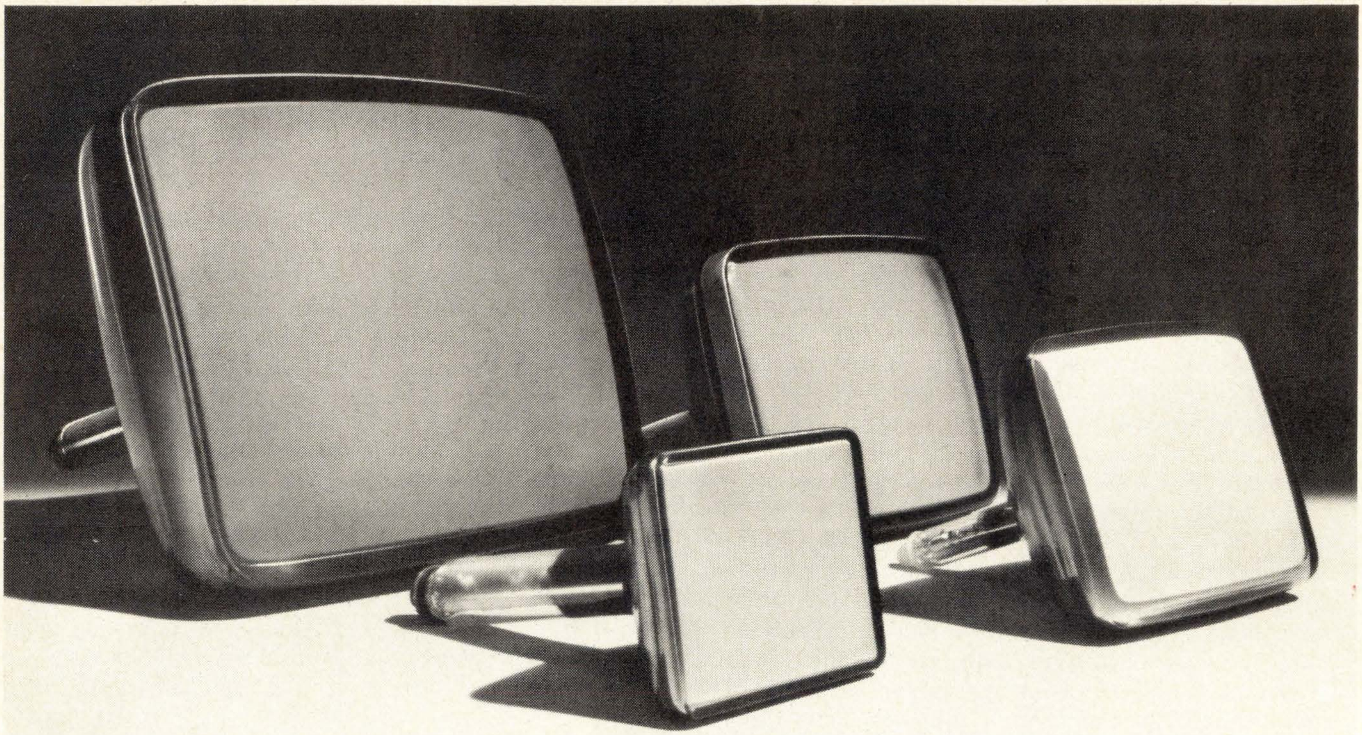

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Resolution	Phosphor	P4					P39										
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	"B" (at the edge) mm (inch) •	0.16 (0.0062)	0.19 (0.0074)	0.26 (0.0102)	0.26 (0.0102)	0.23 (0.0092)	0.11 (0.0043)	0.12 (0.0047)	0.22 (0.0088)	0.12 (0.0047)	0.14 (0.0055)	0.14 (0.0055)	0.19 (0.0076)	0.14 (0.0055)	0.14 (0.0055)	0.14 (0.0055)	0.15 (0.0059)

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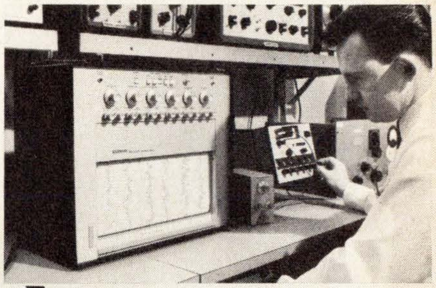

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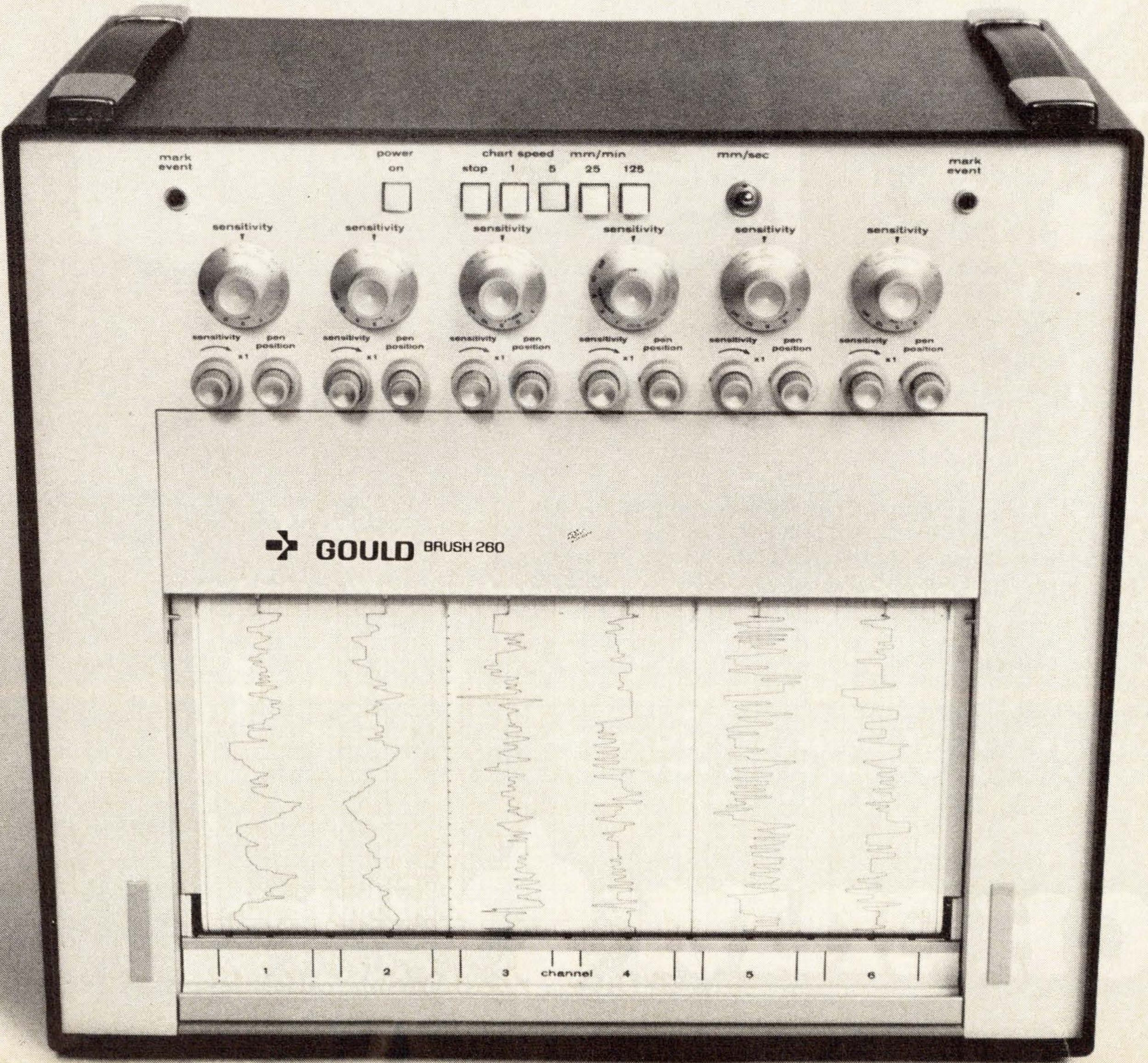

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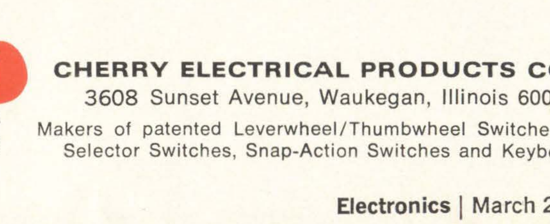

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EE job market is changing

Hard times toughen job qualifications and put premium on profit-oriented skills; college recruitment sags

The employment situation for electrical engineers was so bad last year that EEs thought it couldn't get any worse. But worsen it did—one source calls it "the longest sustained period of unemployment for technical people we have seen in 20 years"—and the severity and duration of hard times are shifting patterns in recruitment, college placements, retraining, and corporate personnel policy.

The glut of labor in the engineering market has put a premium on experience that can be directly related to corporate profits, as well as on impressive educational and vocational backgrounds. Some engineers with marketable experience—in linear and digital circuit design, or bipolar and MOS processing, for example—are finding jobs. But companies admit that they're looking for "highly sophisticated engineers" to get the most for their money. Likewise, some companies, notably in the semiconductor industry, say they haven't cut back and are hiring new engineers, although again, standards are far higher. And a few of the prestige engineering schools say they haven't experienced significant cutbacks in campus recruiting.

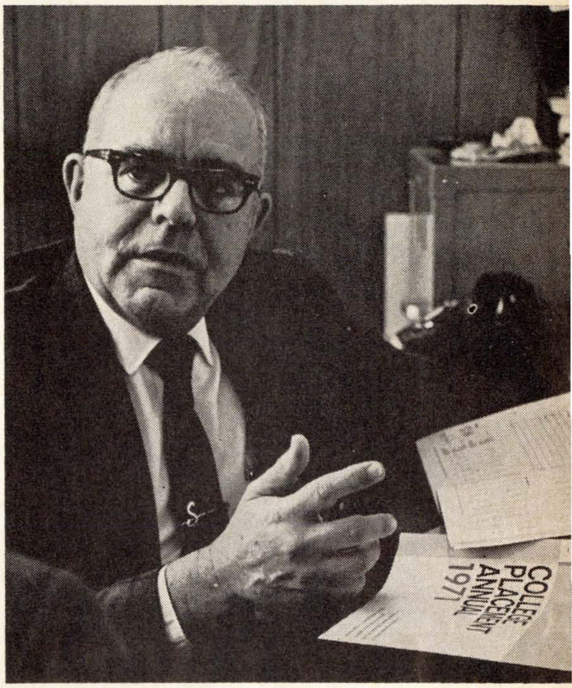
Though jobs are hard to come by, several companies have openings for a few EEs. On the West Coast, Philco-Ford's Western Development Laboratories division is looking for communications engineers. National Semiconductor and Fairchild Semiconductor both are seeking engineers who know linear, digital, or MOS circuit design. Hughes Aircraft Co. in Culver City, Calif., needs circuit, logic and microwave component designers. In Florida, Harris Semiconductor is seeking engineers with photomask or MOS process development experience, and Martin Marietta's Orlando division needs a few radar and fire control engineers. And in Chicago, Motorola has openings for 300 experienced and inexperienced engineers, most of them in electronics and electrical engineering.

On the other hand, jobless aerospace engineers find little cause for optimism. "Commercial industry doesn't seem to want to absorb them," observes Paul Anderson, counselor for technical placement at Drake Associates, a Chicago employment agency. They must be retrained, and industry can find what it needs in its own ranks, he says.

Most companies don't expect to cut their already-depleted engineering staffs any further. Some are hoping to avoid further layoffs by cutting the work week. A case in point is the Fairchild Semiconductor division, Mountain View, Calif., which reduced working hours and salaries for most of its engineers by 10% during a four-month period ending March 1.

Policies on rehiring laid-off engineers, or reassigning them instead of letting them go, vary from company to company. "If we come up with new requirements, we go to our layoffs first," says Peter Perry, employment manager for Martin Marietta Corp.'s Orlando, Fla., division.

Hughes Aircraft Co., Culver City, Calif., maintains a computerized tabulation of all laid-off engineers; the primary rehiring consideration is seniority. It also has a free-transfer policy for employees, and continuous training and education programs, according to Robert A. Martin, head of employment. "We don't discard employes like squeezed lemons," he notes.

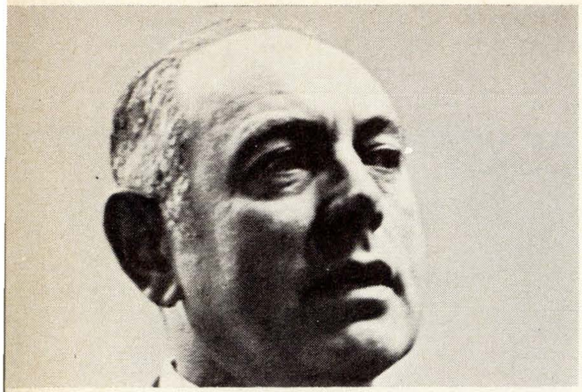


Dropouts. Illinois Tech's Smith says two-thirds of recruiters cancelled.

Some companies, however, find it difficult to reassign engineers because of their functional setups and appear less anxious to rehire laid-off EEs. At Dana Laboratories in Irvine, Calif., the professional engineering staff is split up into project teams; when they finish one project they move on as a group to another, making it difficult to shift individuals.

National Semiconductor Corp., Santa Clara, Calif., says it never rehires EEs. And reassigning or retraining an employee depends on his individual situation. For example, the company says it would not retrain a program manager who has been earning $30,000 a year with 10 years of specialized experience. But it would consider retraining someone at the systems level, earning, say, $15,000 a year with three to four years of work in more general areas.

A few companies, such as the Harris Semiconductor division in Melbourne, Fla., report they haven't laid off EEs in the past year and don't plan to in the future. In fact, says Harris Semiconductor personnel man Jack Nostrand, the



Silver lining. Bunker-Ramo's Goodyear says weak market will help him to lure new EE grads.

present level of 150 engineers represents a 16% increase over last year's.

Other companies haven't changed their employment force significantly but don't plan any new hiring, either. At the Defense Communications division of International Telephone and Telegraph Corp., Nutley, N.J., a spokesman asserts that "we've done reasonably well in a bad time, but we're not growing."

Less affected than most are EEs working for the Government. "The number of Federal EEs always remains relatively stable," states Harry Clark, manpower forecaster for the Civil Service Commission. He notes a very slight increase in a few departments, such as the Navy. According to the commission's latest figures—as of June 30, 1969—there were 16,816 electronics engineers in Federal service. "These positions are quite solid in the Government," says Clark. "When you cut back on your contractors, you must rely on your in-house engineers."

The Department of Defense's general hiring freeze is expected to continue for the balance of the 1971 fiscal year. But DOD spokesmen explain that if Congress accepts the Administration's proposed fiscal 1972 defense budget, the situation for EEs should improve.

Though it's still too early in the year to get final figures on campus recruitment of EEs, reports from colleges indicate drastic reductions in the number of companies making visits. At the Illinois Institute of Technology in Chicago, William Smith, director of placement, reports that about two-thirds of the firms that were expected to recruit all types of engineers have cancelled, and he guesses that the percentage among firms seeking EEs is even higher. And at Northwestern University in Evanston, Ill., Frances Brown, placement assistant in engineering and science, reports that the number of recruiters seeking EEs dropped by about 25% and, in contrast to the trend at most schools, starting salaries were a bit lower.

Georgia Institute of Technology, Atlanta, reports that beginning salaries are up, but by a negligible amount compared to the 6% to 7% rise recorded each year during the mid- to late-1960s and the 4% rise last year. B. D. Pickel, director of placement, reports that students are receiving fewer job offers; he feels the overall job market is worsening. Recently, he relates, Pratt & Whitney Aircraft put out 48 job offers to graduates, and 45 accepted. Then the company withdrew all of them and is laying off 4,100 people on top of that.

In spite of the grim job picture, however, Pickel says there has been no slackening in the number of undergraduates selecting an electrical engineering major, and most college officials agree with him.

At Massachusetts Institute of Technology, Cambridge, 164 companies visited the campus this year, against 198 last year. "This is better than I had expected," says Robert K. Weatherall, director of placement. He reports that one Boston-area firm was even disappointed that it saw so few students.

Harris Semiconductor's Nostrand notes that one reason for reduced college recruitment is that "the requirements we presently have are for experienced-type personnel. The marketplace being what it is, we find there are experienced people available who sometimes cost very little more than the fellow right off the campus. A June graduate's salary has not increased in the last 12 months. For maybe $1,000 or $2,000 more, we can get a man with experience and make him productive immediately."

On the other hand, W. Frederick Goodyear, vice president of Bunker-Ramo Corp.'s Business and Industry division, Trumbull, Conn., feels the poor employment situation will help his division's college recruitment efforts. "We like to pull in about 10 or 12 new grads every year," he says. "This has been tough to do because, being 100% commercial, we haven't been able to offer the draft deferments that military and aerospace contractors can." But with the weak market for EEs in the military/aerospace sector, Goodyear is sure he will have less trouble now. □

Reporting on this article were Larry Armstrong, Washington; Gail Farrell, Boston; Paul Fransen, Dallas; Stephen Wm. Fields, Marilyn Howey, and Roberta Schwartz, San Francisco; Alfred Rosenblatt, New York; and McGraw-Hill World News correspondents Stan Fisher and Rose Raskin, Atlanta; Judy Phelps, Los Angeles; and Jane Shaw, Chicago.

Graduate students: wary

Undergraduate enrollments in electrical engineering courses apparently aren't falling off, according to colleges and universities. But fewer students are going on to pursue graduate EE degrees, says Bill Cooke of Miami, Fla. Cooke expects to earn his master's in communications and electromagnetic theory this June from Georgia Tech.

He feels the doctorate is losing some of its allure as a terminal degree. And there's a change at the master's level, too, he says: three or four of his friends are considering taking their degrees in electrical engineering and then switching over to industrial management for a second MS as a cushion against a future economic downturn. Cooke, who also is considering this alternative, stresses that he and most of his friends, if freed from worrying about their job futures, would prefer to go into research.

Another phenomenon, he notes, is that some Ph.D.s are switching over to medical degrees, or, in a variation, EE graduate students at the master's level are picking up medical courses at the nearby Emory University School of Medicine. The reason, Cooke says, is the apparent demand for the EE-medicine combination in bioengineering. **—Stan Fisher**

Solid state

Isoplanar process stirs IC houses

Originally aimed at fabrication of dense bipolar ICs, Fairchild's method shows promise for high-frequency transistors and diodes—even MOS devices

by Robert Henkel, Managing Editor, News, and Stephen Wm. Fields, San Francisco bureau manager

Soft sell in the hotly competitive semiconductor industry is about as incongruous as a McGovern button on President Nixon's lapel. But in a business where "advances in the state of the art" are announced weekly, Fairchild Semiconductor's disclosure last month of its Isoplanar oxidized isolation process for making bipolar ICs was conspicuously conservative—it even made a point of noting that "there's no assurance that its commercial exploitation would be profitable."

Nonetheless, IC makers feel that Isoplanar is a significant development, and their excitement over oxide isolation for bipolar circuit fabrication is reflected by the growing amount of development work. Many agree that Isoplanar promises more circuit-packing density and higher yields, which could lead to reduced costs. And not only could the process make bipolar more cost-competitive with MOS, but ironically, it also looks very promising for MOS fabrication itself (see panel).

"If anything, Fairchild is being too modest with Isoplanar," declares a top IC circuit designer for RCA. A major West Coast semiconductor maker says that Isoplanar "as a technology, is top-notch. It will do all Fairchild says it will—if they can make it." He calls it "close to the ultimate" in bipolar fabrication.

P. T. Panousis, member of the technical staff at Bell Laboratories' semiconductor device lab in Murray Hill, N.J., says the Fairchild work is "very interesting. It should have a bright future in ICs," he predicts, adding that oxide isolation is "one of the things we are quite hot on now." He maintains no new bipolar process has the potential to compete with oxide isolation structures in packing density.

In the Fairchild approach [*Electronics*, March 1, p. 53], a passive insulator-oxide ring provides isolation between adjacent devices, replacing the active p-type diffusions that isolate conventional bipolar devices. Since the isolation serves as an insulator, the isolation region doesn't have to be separated from the transistor base.

One of the biggest advantages of Isoplanar is that, except for the oxide step, it's processed conventionally, says Panousis. "This is important because most performance-improving devices—emitter-coupled logic for example—require tricky, expensive processing," he notes.

Panousis concurs with predictions of improved yields. As Fairchild has pointed out, with a deep oxide covering much of the silicon, pinholes and defects in the silicon are not as serious as they are in conventional bipolar circuits. In fact, one Fairchild official says it's possible that yields could double.

Another big advantage that's widely acknowledged is improved circuit density, a major factor in lowering costs. "We've tried Isoplanar and it works in saving space between devices," says Sven Simonsen, director of bipolar technology at Advanced Micro Devices Inc., Sunnyvale, Calif. "You can save almost half in some geometries," he adds.

First assessments of the Isoplanar process obtained from other device makers often focused on one problem: growing the thick oxide layers. The length of time required at high temperatures to grow the oxide layers can be a real pitfall, says an official at one top western semiconductor house. However, Doug Peltzer, an Isoplanar devel-

All this and MOS too

Fairchild's goal in its hard push on Isoplanar development was to improve bipolar fabrication so it could compete with MOS in density—and thus in price. However, Fairchild now admits that the new process also can be applied to MOS devices. And indeed, other semiconductor companies are interested in Isoplanar or the older, two-step Planox oxide isolation method for their own MOS circuits.

"I think the Isoplanar process is a good one for both bipolar and MOS circuits," says Kenneth Moyle, director of MOS operations at Intersil Memory Corp. It can eliminate an oxide step in MOS, and because it also reduces sidewall capacitance, "we get faster MOS devices." He says Intersil has made devices with the process.

The Hughes Microelectronic Products division, Newport Beach, Calif., has been doing R&D on the Planox process for about a year; it expects first applications to be in new types of high-density complementary MOS circuits. Another top semiconductor maker, which isn't interested in Isoplanar because it says it has its own process, is producing MOS circuits with cells measuring just 6 square mils, and it already has shrunk MOS cell size in the lab to just 1.5 square mils.

oper, replies simply that the diffusion is not done at high temperatures, "so this is not a problem."

Another headache mentioned was the process's thin (1 to 2 microns) epitaxial layers. These require very close control to prevent emitter-collector shorts—the diffusion "pipe" problem. But again, Peltzer says this is not a problem because the base diffusion itself is not thin. Another possible source of trouble is inversion in the base region. "If the base is too lightly doped, it won't get the proper inversion under it," comments Bell Labs' Panousis. Fairchild got around this by putting the collector in the middle, but this cost space.

While Fairchild may have been cautious in announcing Isoplanar, it's moving ahead on products faster than some in industry realize. The first Isoplanar device, scheduled for introduction in June, will be a 256-bit RAM. Next step will be a 1,024-bit RAM, which will occupy the same chip area as a conventional 256-bit bipolar RAM.

C. Lester Hogan, president of parent Fairchild Camera & Instrument Corp, is brimming with enthusiasm: he likens Isoplanar's impact on bipolar technology to the silicon gate on MOS. He predicts that by next year, silicon gate MOS shipments will pass metal gates.

Primary target for Isoplanar is memories and complex functions at the MSI and LSI level, but there are other potential areas of interest for Isoplanar. For example, Bell Labs' Panousis says the Fairchild process can be applied to very-high-frequency discrete transistors as well as ICs. He feels it can be used to attain a frequency above X band, but won't pinpoint it. The high frequency is possible because the oxide isolation technique reduces sidewall capacitance—and low capacitance means higher-frequency operation. Other circuit elements, such as diodes, can be made simply by encircling a piece of p-type material with oxide.

Fairchild also admits that Isoplanar is "more amenable" to combining MOS and bipolar devices on the same wafer in simultaneous diffusion. And another application it already is examining is radiation-resistant circuits. □

Computers

Optical computer reads like a dream . . .

. . . but competitors are skeptical that controversial Frank Marchuk can really deliver a 10-trillion-bit, 20-nanosecond system in May for $1.2 million

by Samuel Weber, Executive Editor, and Gerald Parkinson, McGraw-Hill World News

"Either he's much smarter than anyone else, or he's kidding himself."

"If he has what he says he has, he's a candidate for the Nobel Prize."

The target of such epithets is mystery man Frank Marchuk, stocky, dapper president of Computer General Inc. of Anaheim, Calif., and Phoenix, Ariz. He says he has an optical computer that, if it lives up to his claims, could well make the conventional computer obsolete.

Slated for delivery in May to an unidentified bank, says Marchuk, is the company's first operating commercial system, the CG-100. And the dazzling specifications announced for the CG-100 are commanding the skeptical attention of engineers at the big systems manufacturers like IBM and RCA. For openers, the CG-100 is said to have a main storage of 10 trillion bits with a read/write cycle time of 20 nanoseconds. The rest of the system specifications read like a computer designer's vision of perfection: data nonvolatility guaranteed for 25 years, storage cost of 10^{-7} cent per bit, less than 1 error in 10^9 bits, associative memory organization, an arithmetic execution time and rate that "far exceeds any computer system," no moving parts in the main memory, automatic error control and correction, and plug-to-plug compatibility with standard IBM peripherals.

What's more, the CG-100 is claimed to operate with a mix of different communication lines and transmission rates, a variety of remote terminal types, any number of minicomputer controller units, and any kind of peripheral device.

All this is supposed to sell for the unheard of price of only $1.2 million. By contrast, IBM's 360/195, with a 32.5-million-bit memory, costs $12 million; its 370/165, with 24-million-bit storage, costs $4.4 million. And Marchuk reports that a second model, the CG-500, is being developed and will be available in the first quarter of 1972. He says it will have a 50-trillion-bit memory with 100 nanosecond full cycle time and will cost $2.4 million. Marchuk claims to have received 42 letters of intent to purchase CG-100s and 10 for the CG-500.

Although the big computer makers are tracking Marchuk closely, they don't appear to be worried. As one IBM development engineer puts it, "So far, everything he has said he can do can be done—in the lab. But making a product that you can sell, that's another story."

One cause of skepticism in the computer industry is Marchuk's unwillingness to release more than a few details about his system. Recently, for example, he was invited to participate with optical memory experts in a panel discussion at the International Solid State Circuits Conference in Philadelphia. He spent most of his time parrying incisive technical questions by claiming the information sought was proprietary. To date, he has published nothing, nor has he delivered technical papers, on the CG-100. But he says he will file for 30 patents in April, at which time he'll release more information.

Meanwhile the technical community is particularly intrigued by the computer's heart—a memory system that uses a laser for writing data either in digital form or as a holographic image. The recording medium, which can be written on and erased without damage, is a special chemical composition film deposited in seven layers, each approximately 2,000 angstroms thick, on a Teflon film backing. The Teflon itself is backed with a Mylar sheet; the backing is about 0.5-inch thick. A single 4-by-4-foot plane makes up the 10-trillion-bit store.

Marchuk won't identify the film material. There is also some confusion on whether the deposition is done in one piece, or in sections; Marchuk has mentioned both approaches on separate occasions. But thin-film experts point out that the problems of controlling homogeneity and thickness over a 16-square-foot area are formidable.

Though Marchuk is holding back many of the computer's details, he has provided a sketchy outline of the machine's operation in recent interviews. Incoming digital data first goes through a control unit that provides all programing, timing, and sequencing of operations. The controller is a subnano-

Enigma. Can Frank Marchuk deliver?

second logic system, says Marchuk.

How the laser beam is deflected for writing information in the memory remains a mystery. But Marchuk says data is modulated acousto-optically onto the beam.

The memory plane is divided into many areas, or "pages." The operator selects a page and instructs the system to write data in that page. When the write function begins, the data is given a code, and a laser starts writing at the selected location in that page by changing the state of the chemical memory film. Simultaneously, another laser beam that is slaved to the first one records the code and data address in a register.

Data is stored sequentially in a gray line or grayscale pattern. As Marchuk explains it, the laser writes what appears to be a single dot, less than a micron across, in one location, but the dot actually is a series of lines, or bits. This is what gives the memory its high density. The sequence in which the lines are written determines the pattern—each line's intensity is slightly different than that of its neighbors. The CG-100 will have a density of five bits at one location.

When data is accessed, the appropriate code is fed into the computer, and information on the location of that data is obtained from the address register. The logic system then directs a scanner beam to that spot for readout.

The scanner beam is a high-intensity light source, deflected by an optical system. As it scans, the light is diffused by the sequential pattern of the stored data; this diffusion pattern is picked up by an array of 10 light cells.

Computer General is trying to lease or buy three buildings in Phoenix and in May expects to have 60,000 square feet of manufacturing facilities, says executive vice president J. T. Martin. It will maintain one research and development facility in Irvine, Calif. but will move the other from Anaheim to San Diego. The company won't permit plant visits by anyone except customers or potential customers and makes everyone sign an agreement not to disclose anything. "Our only safeguard is security," says Martin. □

Military electronics

S-3A moves ahead—step by step

By avoiding technology pitfalls, Navy and Lockheed hope to keep antisubmarine warfare aircraft on schedule toward a $2-billion production decision in '72

by Ray Connolly, Washington bureau manager

"No technological breakthroughs" are required for development of the Navy's S-3A antisubmarine warfare aircraft. That's the point that S-3A project manager Capt. Fred H. Baughman likes to emphasize—and it's right in line with the Pentagon's dictum that new systems should evolve from existing hardware wherever possible. And Baughman knows he is expected to deliver at a time when technological hangups have led to numerous Washington horror stories about weapons systems contractors whose costs have escalated while performance and delivery schedules have slipped.

The aircraft, being developed by Lockheed-California Co., Burbank, will contain "a lot of new hardware not identical with any other hardware," says the soft-spoken, 46-year-old Baughman (pronounced Boffman). "We are doing more with things that have been done before, trying to squeeze a little more on packaging, but there are no technological breakthroughs on the avionics." That's why Baughman is convinced that he can keep the $2-billion-plus production program, its prime contractor, and 16 avionics subs on time and meet cost and performance schedules. Though Lockheed has admitted it will slip its target date, it will come in under the contract ceiling at some cost to its development program profits. [*Electronics*, Jan. 18, p. 51]. And though Lockheed was rumored to be encountering some technological problems, Baughman says he has no complaints about the company's performance thus far.

An important management tool available to Baughman is the Defense Department's "milestones" concept where the contractor must demonstrate specific performance milestones in his development program before he can proceed to the next phase. The first S-3A milestone was "to build up the avionics system, piece by piece, subsystem by subsystem, in the laboratory," Baughman explains. "The second thing was to deliver a P-3 airframe—and that was delivered in January—to build up as a flying testbed for the full avionics systems," he adds.

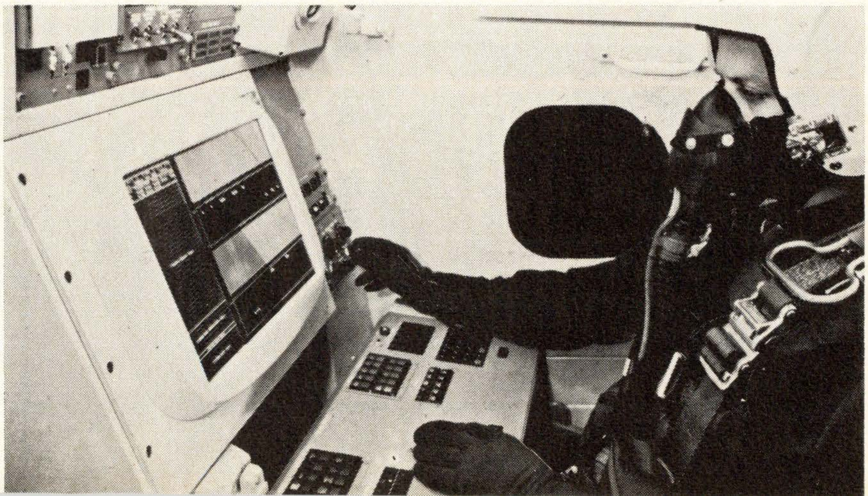
The P-3, also built by Lockheed and operating as the Navy's land-based ASW counterpart to the carrier-based S-3, is scheduled to begin its testbed flights on Aug. 31 at Lockheed's Burbank facility. "An evaluation of that aircraft becomes the next year's avionics milestone" prior to going ahead with a production decision, Baughman says. He's hopeful that these first avionics testbed flights will be completed and the milestone met to permit a first production lot go-ahead on April 1, 1972, a lead time on the Oct. 1 deadline that should suffice "to give us some gravy if necessary before the contract becomes a real problem," he adds.

The S-3A's maiden flight itself will represent another milestone, says Baughman, "and we're hoping to have that in January even though it's keyed to the same milestone" as the avionics. "Obviously, we're going to be very cautious about the first and second flights," he asserts. A Naval preliminary evaluation of the airplane will follow a year later. It "will take place essentially concurrently with the flying testbed demonstration," says Baughman; those two events "are the contract milestones for that year."

The Pentagon wants $207 million in fiscal 1972 to complete most of the S-3A development plus $373 million for the first 13 production aircraft "if flight testing shows that the aircraft is ready." As these will be in addition to the six prototypes in the development contract, it's clear DOD wants to get the aircraft into the fleet now that the U.S. has decided not to try and match the Soviet Union's nearly 390 submarines on a boat-for-boat basis.

The first S-3A milestone amounts to the key ASW avionics—the Uni-

Top man. The S-3A's tactical coordinator directs the antisubmarine warfare mission from his seat behind the co-pilot.



vac computer, the Loral Corp. tactical displays, the Sanders Associates acoustic data processors, and Hartman Systems Co.'s integrated control panels. "These are the principal things that have to be demonstrated together, operating under software control to specific qualitative, measurable values," says the project chief.

Even if milestones fall behind the October 1 decision, dates for each production lot beginning in 1972 and continuing each year to 1975 can be slipped up to six months to meet a requirement.

Avionics costs will account for roughly 50% of the S-3A program outlays when the aircraft enters production, at a cost "in excess of $2 billion" for 199 planes, says Baughman. As for unit cost of the planes, Baughman says the figures "sound like $10 million per plane, but unit cost is a slippery thing. If you're talking about flyaway cost, that's one thing; if you're talking about total taxpayer investment, that's another number," he adds. "You could probably make this airplane cost $5 million to $6 million"—as he expects it will in volume production—"or three times that number, depending on what you included."

Counting total development funds, including weapons stores and sensors such as sonobuoys, plus other outlays for Government-furnished equipment under separate contract, the price more nearly approximates the higher figure. Defense Department data shows the target cost for the 199 planes to be $2.891 billion with an absolute ceiling of $3.2 billion.

For that money the Navy expects to give its carriers a four-man, subsonic twin-jet, with 4,000 lb of avionics, that can stay on station for up to eight hours and range up to 1,000 miles from its carrier base. And as the concept of merging carrier missions to eliminate the sharp division between attack ships and antisubmarine warfare carriers begins to take hold in the Navy, the S-3A is likely to find a new role—giving attack groups a self-contained ASW capability. □

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Computers

Where is XDS going?

The once free-wheeling Xerox division takes aim at commercial and 'selective' business EDP markets

by Lawrence Curran, Los Angeles bureau manager

Helmsman. William F. Glavin is steering XDS toward business systems.

When he took over as president of Xerox Data Systems last October following the abrupt resignation of Dan McGurk [*Electronics*, Nov. 9, 1970, p. 45], William F. Glavin inherited the reins of a company in transition, if not in retreat. After enjoying a steady 25% to 30% annual increase in revenue almost since its predecessor company was founded in late 1961, the Xerox Corp. division was beginning to take its lumps. In fact, it was hit even harder than most other computer manufacturers in the slump that started last year. Sales in 1970 dipped under $100 million from the approximately $125-million level in 1969, and profits disappeared.

Glavin is predicting another year without profit [*Electronics*, March 1, p. 18], mainly because he doesn't foresee a quick turnaround in the computer industry. But some say that the company, founded by Max Palevsky as Scientific Data Systems, had already started to go downhill by the time Xerox bought it in May 1969. "Palevsky was lucky to sell a dead horse before it hit the ground," comments one former XDS employee.

But with all its resources, Xerox Corp. doesn't intend to let its computer capability falter. Glavin says the parent company bought the digital computer company to give it the complete data processing and retrieval capability it seeks to equip the office of the future—from copiers to computers to printers.

But the biggest transition is the change from the free-wheeling, product-oriented, Palevsky days to a company more closely attuned to corporate market goals. The data systems division is bidding with two other Xerox units on two commercial systems jobs now worth about $7 million; more of this kind of teaming can be expected.

Toward that end, Xerox Corp., which reportedly was surprised by the lack of research and development capability it uncovered when it bought Scientific Data Systems, hiked XDS development outlays 50% last year and will maintain that level through 1971. This accounts in part for the lack of profits: the hikes were made at a time when orders were falling off, and Glavin doesn't expect them to pick up significantly until at least October.

Most of the development money increase will be spent on expanding XDS's software capability. This will be a requirement as the company shifts its emphasis to the business data processing market, albeit on a very selective basis. Glavin says that Xerox at one time discussed challenging IBM head-on, but it was decided that "it wasn't the thing for us to do." As Xerox president C. Peter McColough put it "our strategy will clearly be not to go after IBM across the board. We don't intend to play IBM's game. We don't have their resources. We will go after selective markets."

The El Segundo, Calif., division is getting a helping hand from its parent company, which is making more of its R&D expertise available through a laboratory opened in Palo Alto, Calif., last year. The lab will be more research oriented but will concentrate heavily in computer-related work.

The Rochester technology group is putting together "the digital and imaging needs of the office of the future," Glavin says. "They're taking a hard look at nonimpact printers, and we're looking at them, too." XDS would have total product manufacturing responsibility for such a line, although it's still to be determined whether XDS or Xerox would market the product. "It could be used in the XDS peripheral equipment line, or as a stand-alone product," Glavin adds.

However, it appears that the data systems division is pulling in its own horns on mainframe hardware development for the present with software and peripheral equipment getting the emphasis. In fact, XDS dropped a development program in plated-wire memories late last year—just when some sources close to the company and to the memory business said it had led to a viable memory. These sources say the division dropped all internal memory development in an economy move. Glavin emphatically denies this, adding that emphasis has shifted to semiconductor memories, which were found to be progressing faster then expected.

XDS customers can expect to see essentially the "same range of computers we offer today over the next couple of years," Glavin says. Nor does XDS intend to get into the minicomputer business, he adds, except by purchasing minicomputers for its systems division, which was a bright spot in 1970. □

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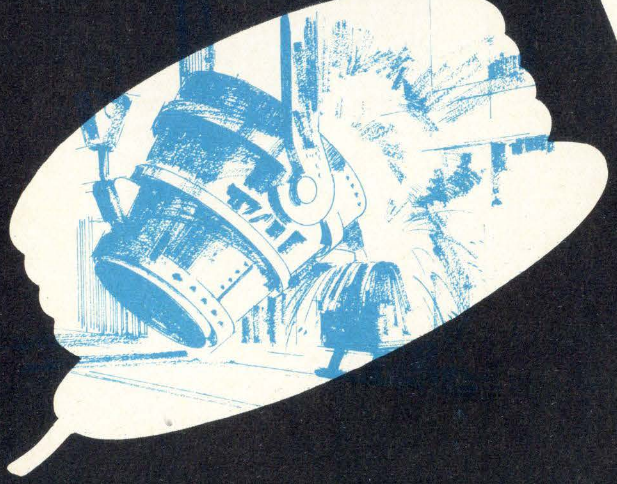
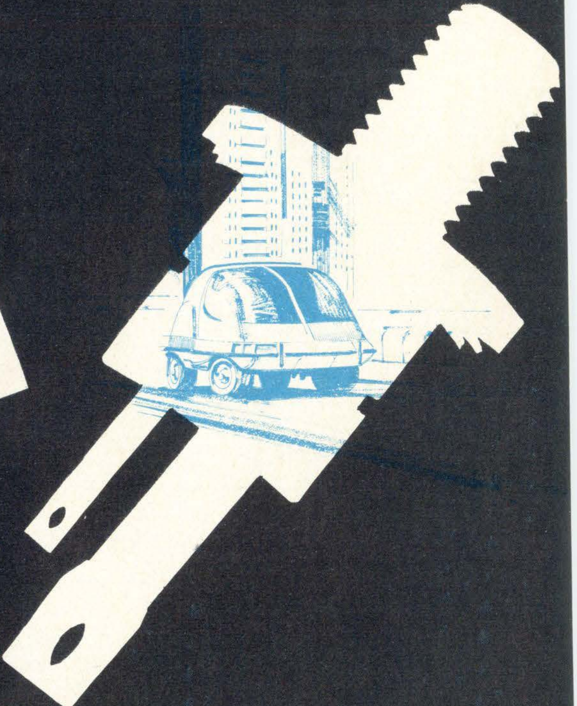




Circle 88 on reader service card

Next generation of instruments trims size, cost

H-P turns to LSI circuits, solid state displays in 500-MHz counter and rms voltmeter

Instrument design has been in ferment for some time—with LSI circuits and LED readouts as essential ingredients in a brew that promises smaller, less expensive products. Thanks to large-scale integration, designers are now able to pack most of an instrument's circuitry onto a few chips. With the diodes, displays can be made much smaller and driven with a power supply that delivers a few, and not a few hundred, volts.

One of the first instrument companies to design the two technologies into a product is Hewlett-Packard Co. The Palo Alto giant is introducing two instruments, a counter and a digital voltmeter, which the company is already calling the first of a new breed.

The counter, labeled the 5300A measurement system, is a six-digit instrument with a range of 500 megahertz. It measures 3½ by 6¼ by 9¾ inches and sells for as low as $520 in the 10-MHz version. Among its custom internal circuits are two metal-oxide semiconductor LSI circuits: the counting decades and the time base.

The voltmeter too has an MOS/LSI counting circuit. The dvm relies also on some other custom ICs, including a thin film input amplifier. Called the 3403A, the instrument measures rms values and decibels as well as dc voltage. It's a 3½-digit instrument, 4½ by 7¾ by 9½ inches in size, with price ranging from $1,400 to $2,225.

Displays for both instruments are custom units, each on a single substrate. The digits are 7-by-4 matrices; to cut power requirements the digits are operated on a time-shared basis.

For the counter, H-P uses a "plug-on" module joined to the underside of a mainframe by a 50-pin connector. The plug-ons available now are about the same size as the mainframe.

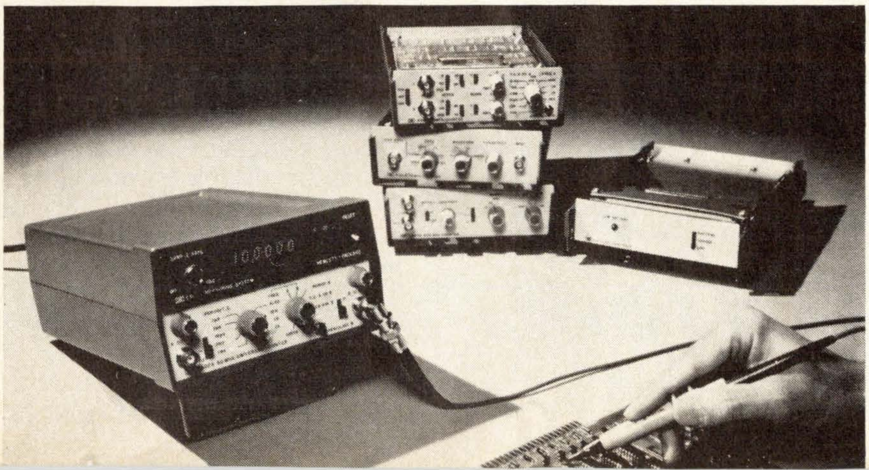
Although this arrangement sounds similar to what goes on in traditional plug-in instruments, H-P engineers argue that there's a difference. Normally a mainframe is either a complete instrument itself or very close to being one, and the plug-ins do specific, limited jobs, such as extending range or increasing accuracy. In the 5300A, however, the mainframe, which sells for $395, contains counting and timing circuits, the display, and a reference oscillator. But it's the plug-on that actually determines what measurements the total instrument will make, or what function it will perform.

H-P has four plug-ons available now:

- The 5301A, which allows the instrument to count to 10 MHz, sells for $125.
- The 5302A, which turns the instrument into a 50-MHz counter/timer capable of measuring period and ratio and which has a totalizing capability, costs $250.
- The 5303A, which makes the instrument a 500-MHz counter, costs $750.
- The 5304A, a counter/timer plug-on that gives the instrument a 10-MHz range and 100-nanosecond resolution, sells for $300.

Others are planned. "We're already starting to design a new group of plug-on modules for the 5300A," reports product manager Bernard Belkin. "And these will offer nontraditional counter functions."

Plug-ons don't necessarily have



New breed. Counter (left) and rms voltmeter feature LED display and large-scale integration.

to be mainframe size, nor is there any reason why only one mainframe can be used. All the major circuits, such as the time base and display, are accessible through the mainframe connector. Therefore a user could, for example, just use the display, or send a signal into the mainframe to be counted, remove the measurement for processing, and then feed back that result for display.

Printed-circuit cards could be made up to program special tests. And H-P itself is thinking along these lines—a $75 plug-on that runs a diagnostic test on the counter is already available.

A battery pack, which fits between the mainframe and plug-on like bologna in a sandwich and which runs the instrument up to 8 hours, sells for $175.

The 3403A voltmeter measures dc over full-scale ranges from 10 millivolts to 1,000 volts with an accuracy of 0.2% of reading, and with autoranging.

It has five decibel ranges, which cover a span of -60 to $+60$ dB. A front-panel adjustment allows the user to pick the reference level. Accuracy is ± 0.1 dB. Autoranging on the dB scale is optional.

H-P engineers consider the rms capability the instrument's most important feature since it measures what's often called "true" rms, and does it over a range of 1 hertz to 100 MHz. In "true" measurements the ac signal is converted, usually by a thermal device, into a dc signal directly proportional to the input's value—the instrument doesn't simply measure the peak of the input and apply a conversion factor. The advantage is that ac inputs of almost any shape, including multiplexed signals and noise, can be measured.

The voltmeter's display portion is self-contained; it has its own clock along with the instrument's analog-to-digital converter. H-P is selling the display portion alone as a panel meter. Delivery of both the counter and the voltmeter will begin in late spring.

Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif. 94304 **[338]**

New products

Communications

Tester handles 350-megabit rate

by James Brinton, Boston bureau manager

Checkout system for communication links uses maximum-length register to generate bit stream

Before the end of the decade, the Bell System and independent carriers will be operating data links with capacities of 300 megabits or more. But before the equipment and the systems can be built and maintained, a new generation of test equipment has to emerge. Perhaps the first of this generation is the system 1000/1100 communications test set from Tau-tron Inc. In fact, the 1000/1100 grew out of the custom requirements of Bell Laboratories and an order for a system, presumably for work on the 300-megabit T-5 carrier system now in development.

The market is just now developing, Tau-tron says, and user needs differ from set to set, particularly in synchronization.

The tester can check anything through which data passes, from a modem to an intercity transmission link, at rates from 240 to 350 megabits per second. Other Tau-tron models test at lower rates.

Both the transmitter and receiver use maximum-length shift registers: devices with specially connected feedback loops around them. Output is a pseudorandom bit stream. In standard 1000/1100's the stream, or period, runs to 37,767 bits, and is repetitive. Much longer streams are available.

A test system consists of a transmitter (a 1000) and a receiver (an 1100); in both, identically wired maximum-length shift registers are the code generators.

To reach 350-megabit speeds, says Yohan Cho, president, the systems were mapped out conventionally. Individual parts then were designed to take advantage of emitter-coupled logic (MECL 2.5 and 3) and Tau-tron's Univer tunnel diode logic. This required special power supply and power distribution designs, and special attention to MECL fan-in and fan-out, heat dissipation, and packaging of the fast logic. It also meant use of coaxial cable instead of single wires; strip-line circuit boards instead of boards without constant-impedance transmission lines; impedance matching between the circuit boards, components, and transmission line; and finally, line terminations with low reflection back into the system.

The philosophy behind the test approach is that pseudorandom streams of data are best for functional and dynamic excitation of the full passband of a data channel, and so are better than simple nonrandom streams of alternating 0s and 1s. The 1-0-1-0 . . . . pattern is easier to generate but its spectral characteristics differ, synchronization can be less certain, and error injection is said to be less meaningful than in a pseudorandom scheme like Tau-tron's.

Operation is simple: since both code generators are wired alike, their outputs will be identical. The receiver uses a comparator to spot differences between the incoming bit stream and that produced by its own code generator. Any difference is an error, and a pulse is transmitted to a front panel output jack.

Responding to custom orders, as Tau-tron does, is sometimes complex. The length of the period needed often exceeds the standard 37,767 bits, perhaps yielding megabit-long pseudorandom bit streams. Also, rearrangement of feedback loops within the shift register changes the spectral and statistical characteristics of the output.

Often the transmitter's excitation circuitry is specialized, too. Some users must provide for a programable data source, or for the optional insertion of word indent or preamble data. Also, since the system must keep track of each period and the position of the transmitter shift register's output within a period, there's a code generator output to a sync countdown circuit. This, in turn, feeds sync acquisition logic and excitation circuitry in the receiver.

Synchronization is the major problem in receiver design, according to Tau-tron vice president John Connolly. "It can be a messy problem if only because of the high data rates involved," he asserts. To solve the problems, Tau-tron uses a variety of crosscorrelation sync techniques.

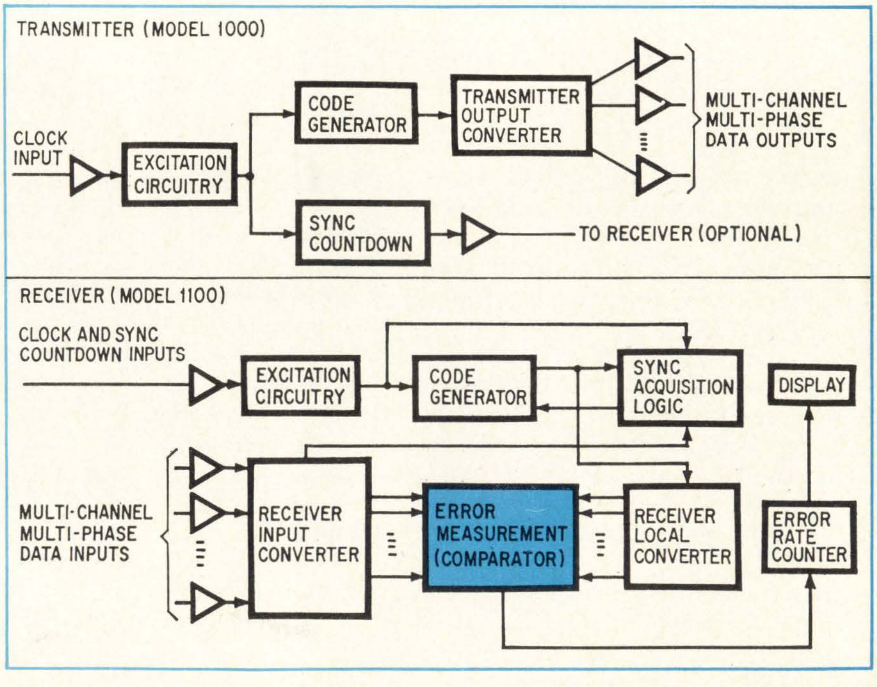
One method uses the receiver's shift register and its comparator to find a match between the incoming bit stream and that coming out of the receiver shift register. "We view the output of the comparator for one period," says Connolly; "if there's no match we slip the receiver's bit pattern by one bit and look again, repeating until we have a match." Though this sounds like a cumbersome process, in practice it takes only from 1 microsecond to 10 milliseconds to reach synchronism: "It's 1 millisecond or less than that on the average," says Connolly. Once synchronism is reached, the only output from the comparator, which uses exclusive-OR circuitry, will be the error pulses that are passed to the error output jack and may then be displayed.

The 1000 can be had with a transmitter output converter, essentially a serial-to-parallel converter that allows output of up to 16 channels of multiple phase data. The companion unit in the 1100 is called the receiver local converter; it takes input from the code generator and feeds it into the comparator.

The system is priced at $14,600 in basic form, and delivery time is three to four months.

Tau-tron Inc., 685 Lawrence St., Lowell, Mass. 01852 **[339]**

High-speed testing. In receiver portion, a comparator detects differences between incoming bit stream and that produced by the system's code generator.



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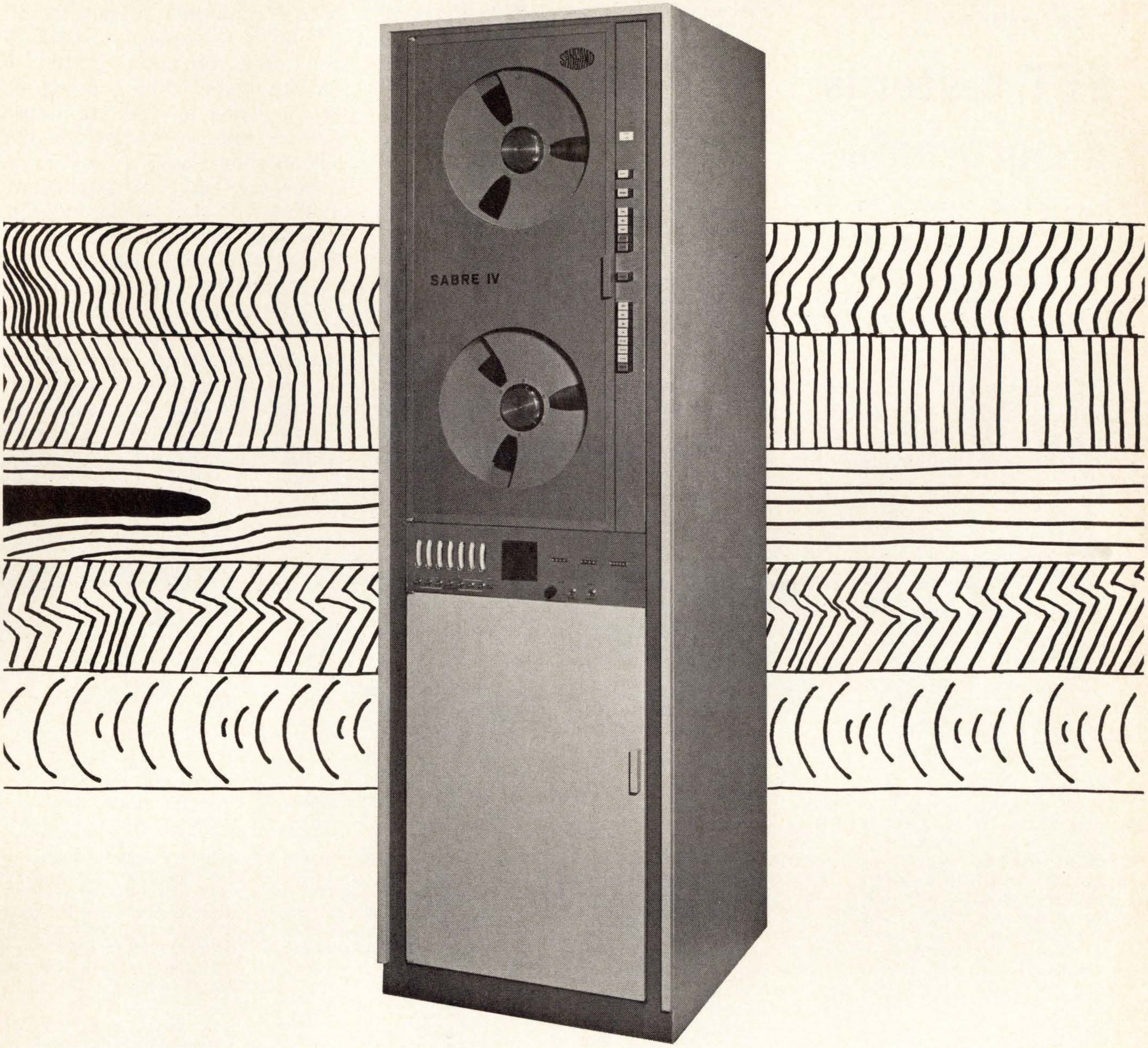

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DS706

Circle 93 on reader service card

Instruments

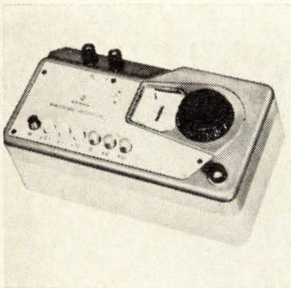
FET tester is programable

Automatic unit can do incoming inspection, wafer probing, classification

While the volume of transistor business in general is declining, one segment—field effect devices—is experiencing a substantial growth. With more devices filling more applications for more users, says John Day, vice president of International Production Technology Inc., "there was a need for an automatic FET tester that could be used with a computer or by itself, and one that would be easy to program." IPT's model 9000 fills that bill, Day says.

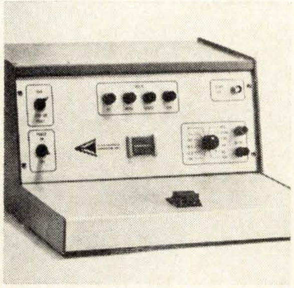
The IPT-9000 is a completely self-contained go/no-go multiple classification test system for incoming inspection, wafer probing, and final production classification of FETs. All testing and classification is controlled by programs stored in the memory, or by a single set of panel digit-switches. Memory capacity is 16, 32, or 64 tests, on up to 16 classifications. The unit has a lighted, front-panel display for monitoring programs stored in memory; a special programing feature facilitates interrupting preprogramed sequences to perform special tests unrelated to any stored in memory, and without changing anything in the memory. Single tests may be called from memory by front-panel switches.

The memory is programed from a single set of digit switches, or can be loaded by means of a card reader, tape reader, or computer. Once a program is in the memory, the IPT-9000 does all testing without any peripheral equipment. While conducting tests from a

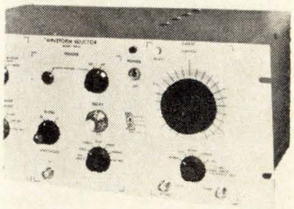


Wheatstone bridge type 1802-30301 measures resistance from 0.08 ohm to 120 megohms in nine ranges. Six pushbutton multipliers and single-dial reading are used to select the ranges which are indicated on a sensitive mirror scale galvanometer. Unit measures 8½ x 4½ x 5 in. and weighs 5 lb. Price is $205. Freed Transformer Co., 1718 Weirfield St., Brooklyn, N.Y. 11227 [361]

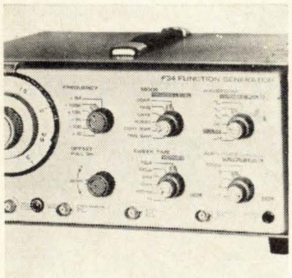
Digital panel meters series 35 are precision, low-cost 3½-digit replacements for pointer-and-scale instruments for monitoring any physical or chemical phenomenon that can be represented by a dc voltage or current analog. Standard units are available in a choice of five voltage ranges, 100 mV to 1,000 V full scale. Gralex Industries, 155 Marine St., Farmingdale, N.Y. 11735 [362]



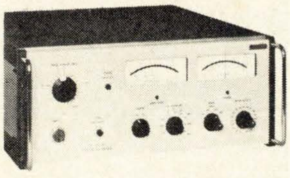
Automatic IC tester model 7000 is designed to operate at production line rates. It handles TTL, DTL and RTL in DIP, flat-pack or TO-5 packages with a maximum of 16 pins. Test results are displayed on the test set panel by means of Pass/Fail lights and four fault analysis lights. Price is $1,400. Electrodata Concepts Inc., 69 Connecticut Ave., Norwalk, Conn. 06854 [363]



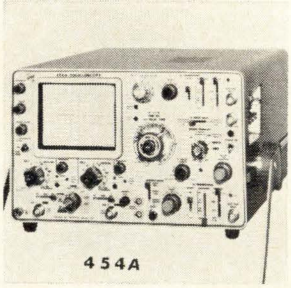
Waveform Eductor TDH-8 is a 50-channel signal averager that reconstructs periodic waveforms obscured by high ambient noise levels, and offers fast sweep times with resolution to 1 μs. A built-in variable delay circuit permits reconstruction of waveforms occurring from 10 μs to 11 s after receipt of a trigger signal. Princeton Applied Research Corp., Box 565, Princeton, N.J. [364]



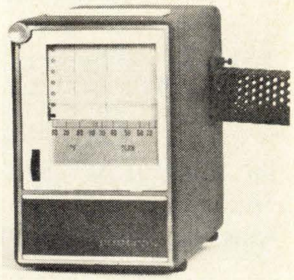
Function generator model F34 features sweep and burst and foolproof calibrated sweep width control, preventing improper or unacceptable settings and visually indicating sweep limits directly on tuning controls. The instrument's frequency analog output facilitates display of frequency response test results. Interstate Electronics Corp., P.O. Box 3117, Anaheim, Calif. 92803 [365]



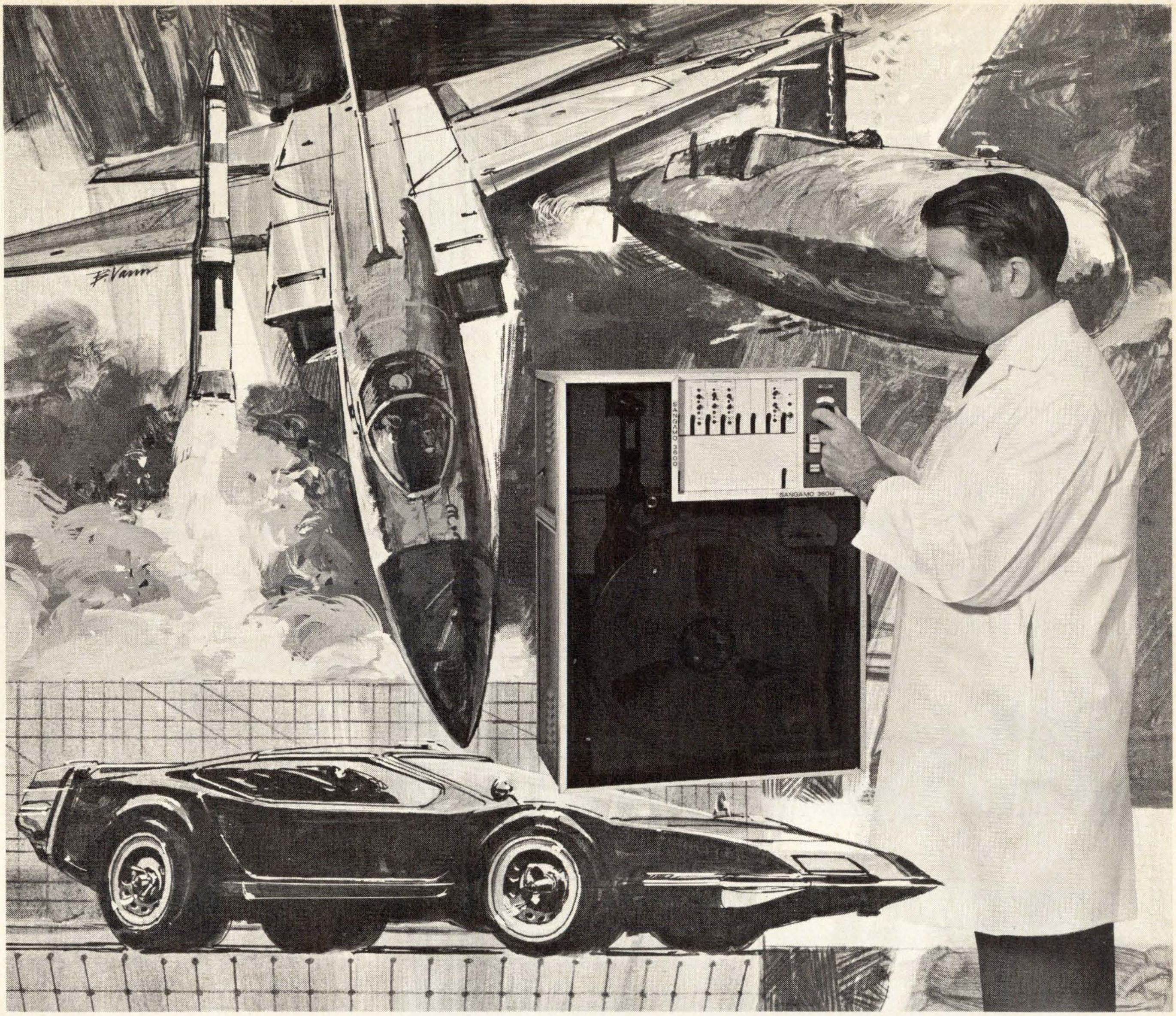
Vector voltmeter type 2020 accurately measures the amplitudes and phase relationship of two signals in the 1.5 MHz to 2.4 GHz range. Dynamic range is 80 dB. Advantages over similar instruments include elimination of large mismatch errors through low VSWR, 50-ohm inputs and extended frequency range. PRD Electronics Inc., Prospect Ave., Westbury, N.Y. [366]



Portable laboratory oscilloscope 454A is a dual-trace instrument. Deflection factors and bandwidth are 2 mV/division at 50 MHz, increasing to 100 MHz at 5 mV/div and 150 MHz at 20 mV/div to 10 V/div. Channel 1 and 2 amplifiers can be cascaded to obtain approximately 400 μV/div at 33 MHz, single trace. Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97005 [367]



Relative humidity/temperature recorder model 225 has a 9-week chart capability. Temperature range is 60° to 90° F. RH readings are measured from 10% to 90% with an accuracy of ±4% RH at 77° F. The unit samples either RH or temperature once every 4 seconds. Rustrak Instruments division of Gulton Industries Inc., Manchester, N.H. [368]



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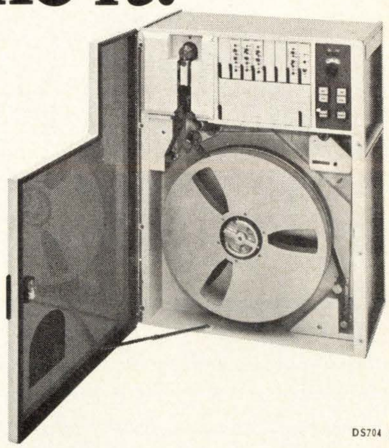


DS704 R

The innovators in tape instrumentation

Circle 95 on reader service card

memory program on one unit, the peripheral equipment may be used to load additional testers.

The manually programable tester may be purchased first, and peripheral equipment can be added.

Prices range from $20,000 to $30,000 depending on the number of tests, the number of classifications, and options.

International Production Technology, Inc., 185 Evelyn Ave., Mountain View, Calif. 94040 **[369]**

Light diodes put into ready-made displays

Packagers are getting their hands on light-emitting diodes. Until now an engineer wanting a solid state display would have had to buy LEDs from a diode maker, get the other necessary parts, and build the display himself. The packager wants to take over these jobs.

One of the first to offer its services is The Dialight Corp., a longtime maker of displays and indicators. Dialight is introducing five LED products—two lamps, two lamps packaged in a plastic cartridge, and an ⅛-inch numeric readout. They're first of a LED line that vice president for marketing, Richard Lakin, predicts will soon number between 500 and 1,000.

Although Dialight expects to be successful in selling these five new products, it expects also that they'll attract custom business.

The ⅛-inch numeric is called the 745. It's a 6-by-8 diode matrix which can be driven directly from DTL and TTL circuits. Power dissipation is 20 milliwatts, and operating voltage is 3 volts. Sales engineer Chet Dombroski says his company can deliver LED readouts as high as 1 inch.

The lamps packed in cartridges are the 249 and a smaller version called the Datalamp. Both are intended as front-panel indicators. They're available in three colors—red, amber, and yellow. The other two lamps are LEDs in encapsulated packages.

The Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237 **[370]**

Data handling

Bipolar ICs run minicomputer

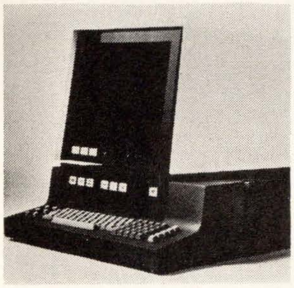
Semiconductor array replaces diode matrix for faster, denser read-only memory

Bipolar semiconductor memories that have the density and speed needed for microprograming [*Electronics,* Feb. 15, p. 39] are beginning to show up in minicomputer designs. Microdata Corp. includes a bipolar microprogram in its Micro 1600, described as a "big brother" to earlier computers in which the control logic was stored in a diode matrix.

The company says the micro command step (cycle time) requires 200 nanoseconds in the new model, compared to 220 nanoseconds in the earlier 800 series. The 1600 also provides up to 16,384 words of control or micromemory, vs 1,024 words for the 800 series.

The memory is made with bipolar read-only or random access storage components. It can incorporate a fixed, a programable, or an alterable ROM. The customer who wants to write a control firmware program probably will use the system's software simulator to familiarize himself with the program, then load it into an alterable ROM version of the machine. The AROM is made up of bipolar random access memory components, and is useful for program debugging because it can be changed at will, but gives the user a true online system checkout.

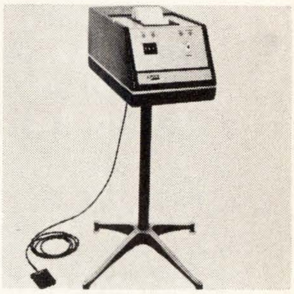
Once the user is satisfied with the program, he probably would transfer the data pattern into a programable ROM, which consists of bipolar ROMs with fusible links that are blown to store 0s if all 1s



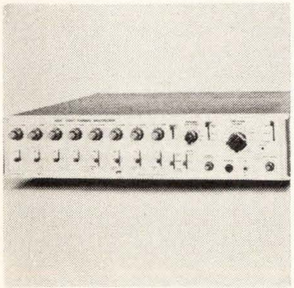
Graphic display terminal called the Conographic/10 uses conic sections to produce curvilinear drawings, general purpose graphics, alphanumerics, and symbols. Making the technique possible is a generator that features data compression of 10 to 100 times, and high-speed image transmission. Price is less than $9,000. Conographic Corp., 380 Green St., Cambridge, Mass. [401]

Digital scanner model K10-5055A allows a single printer to record digital data from as many as six sources. Data sources can be electronic counters, digital voltmeters, computers, and other devices that have parallel BCD digital outputs. Each channel of the scanner accepts up to 10 columns of BCD information. Hewlett-Packard Co., 1601 California Ave., Palo Alto, Calif. [402]

Portable printer model 720 is for time-sharing and communications applications. It has a built-in acoustic or hardwire coupler self-contained in the case. The printer operates at switched speeds of 10, 15, and 30 characters/s using a non-impact thermal print head that renders the unit virtually silent. Price is $3,395. Data Access Systems Inc., Route 10, Dover, N.J. 07801 [403]

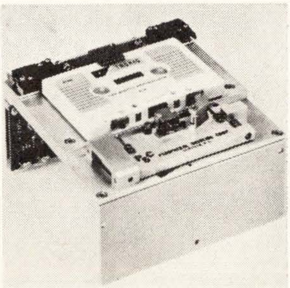


Lightweight printer is a 21-column unit that records readings from PICOMM coordinate measuring machines and other equipment. Designed to produce a hard copy printout of the XYZ coordinate locations displayed on the digital readout, it accepts data in a 4-bit format and outputs it upon depression of pushbutton or foot pedal. Potter Instrument Co., Plainview, N.Y. [404]

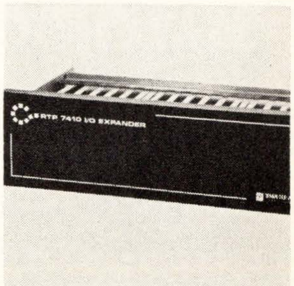


Eight-channel multiplexer model 4701 can be used with most XYZ storage or nonstorage CRT displays. Each channel has differential inputs with a 1-megohm, 20-picofarad input impedance and common mode rejection ratio is better than 100:1. The bandwidth is 1 MHz. Price is $1,500; availability, 2nd quarter of the year. Tektronix Inc., P.O. Box 500, Beaverton, Ore. [405]

Digital-to-analog converter DAC-59 incorporates the latest in thick-film technology in one completely self-contained, compact plastic case, measuring a total of 1.6 cu in. It will accept a 3-digit BCD word and convert it to an analog voltage (9.99 V) in less than 25 μs. It has an overall accuracy of ±0.1%. Price is $59. Varadyne Systems, 1020 Turnpike St., Canton, Mass. [406]



Digital cassette transport model 702A offers the customer the flexibility of changing the tape speed to tailor fit his needs. Overall size is less than 5¼ x 5¼ x 4 in. The system is DTL/TTL compatible. Recording density is up to 1,600 b/in. Tape speed is 3-12 in./s adjustable. Rewind speed is 25 in./s. Peripheral Systems Corp., Little Falls Rd., Fairfield, N.J. [407]



Universal I/O expander and interface controller series RTP 7410 offers a modern approach to real-time systems implementation. It is plug-in compatible with all of the popular minicomputers on the market. Unit quantity prices are from $800 to $1,200 depending on the selected computer. Delivery is from 45 days ARO. Computer Products, 1400 N.W. 70th St., Ft. Lauderdale, Fla. [408]

had been coded into the arrays. This would be the usual procedure if the system customer is buying small quantities that don't justify the masking charge for a fixed ROM pattern.

But if the user's anticipated needs call for large numbers of systems doing the same repetitive task, he would probably freeze the data pattern when the ROM is manufactured and use what Microdata calls the BROM (for bipolar read-only memory) version of the Micro 1600. The BROM contains a fixed, unalterable program.

The Micro 1600 comes with an 8,192-word, eight-bit core memory that has a 1-microsecond full cycle time. Further comparison of the machine with the 800 series shows that it has 31 general-purpose file registers vs 15 for the 800. The 1600 also comes with a dual-processor provision that will allow two microprogramed cpu's to be connected to a common core memory. One of the processors could be dedicated as an input-output processor and coupled to another that was microprogramed to emulate a general-purpose processor.

Kenneth Allen, president, believes the Micro 1600's firmware architecture makes it more flexible than many competitive minicomputers that have a fixed architecture. "Some of them can't control the register organization of the machine as we can," he points out. That's the function of the BROM, if the user needs the larger quantities of machines that would justify the fixed-program BROM. "The machine is programed much the same way as any computer," Allen notes, "but the BROM can control whether the file registers are accumulators or index registers, for example."

He predicts the Micro 1600 will be used for such applications as batch terminal and machine tool control, character recognition, and medical instrumentation operation.

The machine will sell for "less than $5,500," Allen says. Limited quantities will be ready in June.

Microdata Corp., 644 East Young St., Santa Ana, Calif. 92705 **[409]**

MOS memory system built for peripherals cycles in 2 μs

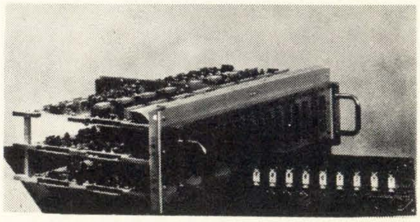
Though a manufacturer can assemble a memory system from many available semiconductor circuits, the user who wants to buy a complete IC memory system finds few to choose from, according to Control Technology, Inc. That's why the company decided to market its 1100 series of complete semiconductor random access memory systems, designed for peripheral equipment.

Robert B. McJohnson, vice president of engineering, says that CTI—up to now a custom design and assembly house—needed a memory for communications terminals, but was unable to find low-cost packages that were suited to the application. So CTI designed its own, and is now offering it for other users.

The memories are complete systems with 2-microsecond cycle times. Minimum size is 256 words by one bit, and the systems are modularly expandable in increments of 256 words by one bit up to 4,096 words of 36 bits. The storage chips are Intel 1101 silicon gate MOS circuits, but inputs and outputs are TTL compatible.

McJohnson sees the major users as systems companies that prefer to buy a tested memory rather than develop their own. The 1100 series is designed for peripherals where core systems would be too expensive because of the small size. In CTI's communications terminal, for example, four memories are used; one is only 512 words by eight bits. Other uses McJohnson anticipates are supervisory control, ancillary memories such as lookup

Modular. Memory for peripherals is expandable to 4k words by 36 bits.



tables, and in terminals.

In addition to size, several features of the memories are optional: serial or parallel input and output, address counters, package, and power supplies. In addition, memory-system-select inputs simplify expansion.

Delivery and price depend on size and configuration, but McJohnson says that the memory modules are in stock, and that cost, including registers, packaging and power supply for a typical memory would be about 10 cents per bit.

Control Technology Inc., 520 Easy St., Garland, Texas 75040 **[410]**

Analog-digital converter resolves 7 bits at 30 MHz

Because radars and nuclear instrumentation need analog signals quantized at very high speeds, faster operation at higher resolutions is constantly being looked for in analog-to-digital converters. Until recently, probably the fastest commercially available a-d converters provided six-bit resolution at 30 megahertz.

But the AD3000-7 from American Astrionics, Inc., Hollywood, Calif., doubles this, providing seven-bit resolution at 30 MHz. Roy Colombe, American Astrionics' general manager, says the AD3000-7 uses the same feed-forward parallel detection subranging as in the firm's earlier a-d converters, but it's modified for greater speed.

With conventional feed-forward parallel subranging techniques, a converter processes the most significant bits of the data before it processes the least significant bits, so that half the unit is idle half the time. American Astrionics uses dual track-and-hold amplifiers in the input to the AD3000-7, and they are multiplexed so that part of the machine is working on the most significant bits while the other part is processing the least significant bits. Then double buffering of the output logic enables the user to see one conversion every 33 nanoseconds.

Colombe knows of no other commercially available a-d converter that has a multiplexed front end. He says the track-and-hold amplifiers have traditionally been difficult to build, and it's even tougher to make two that track each other. These amplifiers have a bandwidth of 110 MHz, a typical aperture time of 50 picoseconds, and a VSWR of less than 1.2.

"The aperture time is what controls the dynamic accuracy of the machine—its accuracy on a moving signal," Colombe points out. The fast aperture time (75 ns maximum) techniques employed in the track-and-hold amplifier to allow it to settle quickly, and use of the discrete threshold detectors combine to provide the seven-bit accuracy at high speeds. "We don't use integrated circuit threshold detectors," Colombe says, "because we can't find any with good enough stability to give us seven-bit accuracy, so we build our own discrete detectors."

He says the AD3000-7 can be used in high-speed sampling of radar signals, including laser radars, in video processing, and in transient analysis, such as that requiring high data rates from short-term events like nuclear tests.

The unit can be rack-mounted in a 19-by-3½-by-13-inch enclosure. It sells for $13,900 and delivery time is six weeks. A six-bit version is available for $11,200.

American Astrionics Inc., a subsidiary of Technicolor Inc., 855 North Cahuenga Blvd., Hollywood, Calif. 90038 **[411]**

Modified key-disk-tape station is remote, on-line terminal

In most data entry systems that require an editing capability, the keyboard terminal has a cathode ray tube. But not the terminal developed by General Computer Systems, which is nearly as fast as a CRT station but uses no CRT and produces a hard-copy printout. In addition, the unit can serve as a data-input device for a pooled keyboard-to-tape system.

The terminal is a new version of the keyboard entry unit that is part of the company's established keyboard-to-disk-to-tape system. On the market since 1969, that system accumulates data from as many as 31 keyboards on a magnetic disk that serves as a buffer and on which the data can be edited, reformatted, or otherwise processed before being written on a magnetic tape. The keyboards on the older system also use the hard-copy printer as a means of verifying the data being entered.

But in that system data is transmitted from the keyboard over a 14-wire cable, which isn't practical for a remote terminal. In the new product, electronic circuits have been added to the existing keyboard to serialize the data and transmit it to a remote location over a telephone line.

In the full-duplex mode, which is ideal for remote operation, the 2103 prints a record of what the distant system has received and entered, rather than what was sent. The machine can also operate conventionally, with the terminal displaying what is keyed locally.

For the printout, which takes place at up to 35 characters per second, a horizontal strip of impact-sensitive paper is used. This format, while not convenient for lengthy copy, is suitable for credit and account verification and for reservations systems.

As a remote terminal, the 2103 can be used with any computer or modem since it operates with standard ASCII input. In fact, GCS is offering the 2103 to the general terminal market where batch capability isn't required.

The dual functions are also valuable in such applications as branch banking. The on-line function can be used for credit or account verification, and after banking hours the batch capability can be used for other business. Any of three keyboard layouts can be selected—the 029 keyboard, the typewriter, or the 10-key adding machine.

The 2103 sells for $3,500 to $5,000, depending on options.

General Computer Systems, 12011 Coit Road, Dallas, Texas 75230 **[412]**

Industrial electronics

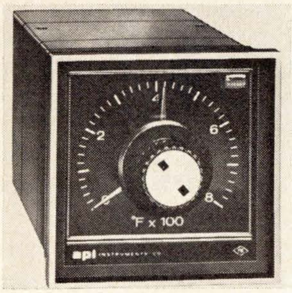
Hall-effect tachometer

Gear-tooth pickup unit measures to zero velocity; one type tells direction, too

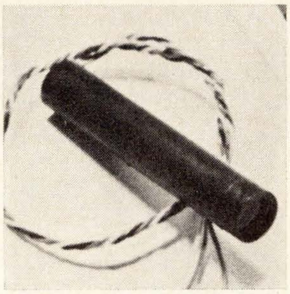
A common method of measuring the speed of rotating machinery is to count the teeth in the gears that drive it. Conventional electromagnetic speed pickups, however, cannot measure speeds down to zero —which is one of the achievements of a tooth-sensing transducer from Airpax Electronics that uses a Hall-effect sensor.

This zero-speed ability makes it possible to take measurements while a machine is starting up and stopping, and it also provides accurate low-speed tachometry. A possible application is on a production line, to provide a total count of piece parts; another is to measure the length of product that has passed a given point.

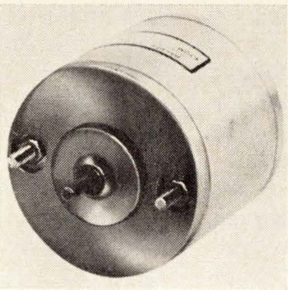
The sensing device, the model 4-0001 zero-velocity gear-tooth transducer, contains its own signal-conditioning circuitry on a 1-by-½-inch pc card to provide a positive 5-volt output pulse whenever there's a discontinuity in the material making up the gear. Each time a gear tooth, which must be made of a ferrous material, passes the transducer, the magnetic field in the Hall device is affected, changing the device's output. This change, in the form of a millivolt-level sine wave, is passed to an operational amplifier arranged with positive feedback to lock either full on or full off. A rotating gear produces a train of pulses ranging between 0 and 5 V. This output is much more compatible with digital instrumentation than the dc



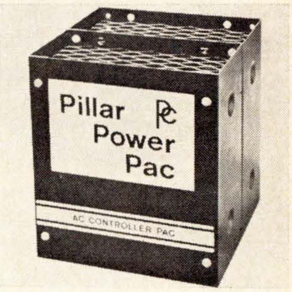
Controller model 232-F shuts off heat and sounds an alarm when a process is endangered because a set point temperature is exceeded. It is available in both indicating and nonindicating versions. It offers on/off output through a relay with contact rating of 5 amperes. It measures less than 4 in.² by 6 in. deep. API Instruments Co., Chesterland, Ohio 44026 [421]



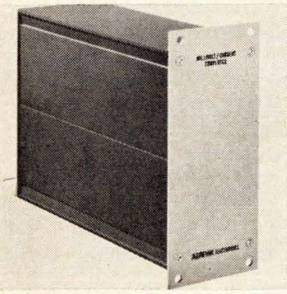
Infrared sensing device model IR-10 senses IR rays reflected into its lens and produces a common +5 to +15-V signal. This output can then be used directly in other standard DTL or TTL logic circuits for a variety of applications. Uses are for counting, alarms, and control systems. Price is $75. Kolt Engineering, 16550 Shady View Lane, Los Gatos, Calif. 95030 [422]



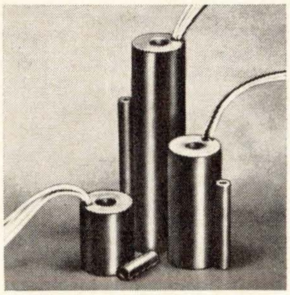
Speed regulated, permanent magnet, commercial dc motor type CYQM has a built-in brushless tachometer generator that permits multiple or variable speed settings. Speed is adjusted while the motor is running for maximum accuracy. Typical performance is 1 to 6 oz-in. at 1,800 rpm. Uses include magnetic tape player drives. Barber-Colman Co., Rockford, Ill. [423]



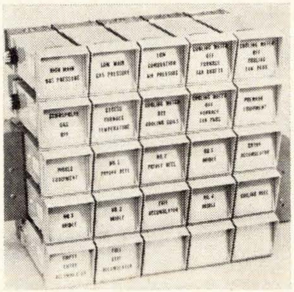
Solid state ac power controllers are ruggedly designed, versatile, phase control units with output ratings up to 50 amperes at 240 volts. Input control signal may be derived by means of a simple relay closure, a potentiometer setting, or an isolated low-level dc control signal. Applications include on-off switching. Pillar Corp., 823 S. 70th St., West Allis, Wis. 53214 [424]



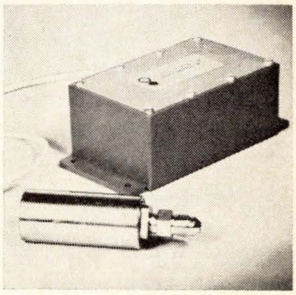
Industrial telemetering amplifier model 582 provides dc millivolt to current conversion for process control. It accepts input from thermocouples, strain gauges, etc. Output is a proportional constant current of 1 to 5, 4 to 20, or 10 to 50 mA dc. It has two isolated inputs of 2,000 ohms and 200 kilohms. Airpax Electronics, P.O. Box 8488, Ft. Lauderdale, Fla. 33310 [425]



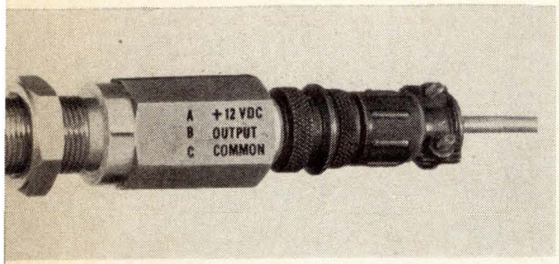
High-reliability, linear position transducers, designated the series 225, provide high output and infinite resolution. They are being offered in three models covering the full scale ranges of ±0.05, ±0.125 and ±0.300 in. to meet a variety of application requirements. Price ranges from $3.50 to $15. Robinson-Halpern Co., 5 Union Hill Rd., West Conshohocken, Pa. 19428 [426]



Modular annunciators series CR-150J are designed for continuous monitoring of vital points within a system, operation or process. They allow an operator to keep a close watch on any number of monitoring points and determine, through several audible and visual signals, whether or not all elements are operating correctly. General Electric Co., P.O. Box 913, Bloomington, Ill. [427]



Pressure alarm and control systems series CPDC-200 provide an interface with N/C and computer devices, or simply controlled electrical or mechanical systems. They give warning of impending failure and/or control in all military, industrial, and manufacturing processes. Price is $55 each in 1,000 lots. Columbia Research Laboratories Inc., Woodlyn, Pa. 19094 [428]



Speed meter. Hall-effect device in gear tooth transducer senses speeds down to zero, produces digital output signals.

levels, corresponding to speed, produced by conventional devices.

Conventional transducers have trouble at low speeds because they are basically velocity-sensing devices, Airpax says. Their operation depends on ferrous-metal gear teeth altering the flux set up by a magnet in the transducer.

This, in turn, induces a voltage pulse in the transducer's pickup coil. The difficult part is that the voltage generated in the coil depends on the speed with which flux lines are cut; as speed decreases, so does the amplitude of the voltage pulse. "Generally this voltage gets too low to handle when the speed goes below 10 cycles per second," says Dudley Nye, director of research at Airpax Controls. For a commonly used 60-tooth gear, this 10 hertz corresponds to a speed of 10 rpm.

The Airpax transducer, however, depends for its operation on the presence, or position, of a gear tooth; the tooth's speed is unimportant. Hence the device—about 1 inch in diameter and 3⁵⁄₁₆ inches long—can measure down to zero velocity. Upper frequency limit of the transducer, which requires a 12-volt dc source, is above 100 kilohertz, corresponding to 100,000 rpm with a 60-tooth gear.

A second version of the transducer, model 4-0002, senses not only speed but direction of rotation. This is accomplished by adding a second Hall device together with some logic circuitry. Rotation direction shows up as a difference in phase between pulse outputs of the two Hall probes. And these pulses are used to clock a D flip-flop whose outputs indicate the direction of rotation.

Price of the model 4-0001 is $49, less connector, in quantities of one to four. Delivery takes three weeks. The model 4-0002 costs $89 in small quantities, with four- to five-week delivery.

Airpax Electronics, Controls division, P.O. Box 8488, Ft. Lauderdale, Fla. 33310 **[429]**

Keyboard with CRT display programs industrial controller

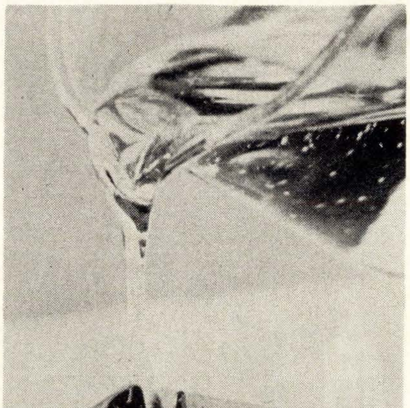
A keyboard-cathode ray tube display unit for the first time is working with a programable controller—the stored-program replacement for hard-wired relay sequencing controls that's finding increasing use on manufacturing and process lines [*Electronics*, March 15, p. 107].

The new AutoMate 33 controller, developed by Reliance Electric Co., can be programed from the CRT keyboard with the standard symbols used in conventional relay ladder diagrams, says Reliance. The CRT unit is plugged into the controller. And the ladder diagram symbols—for such functions as normally open and normally closed contacts, and series and parallel circuits—can be displayed and manipulated easily.

Plug-in programing consoles using ladder-diagram symbols have been available before, but without CRT displays. And other units must be programed with a minicomputer, using a special language.

The basic AutoMate 33 consists of a main sequence control unit, containing a 16-bit core memory, plus as many as 128 rack-mounted input and output modules. The input units, which can accept signals from pushbuttons, limit and selector switches, etc., can be added in groups of eight. Output modules which drive devices such as motor starters, solenoids, and contactors, can be added one at a time. They provide power at 120 volts ac and

New materials



Syntactic foam casting resin, called Stycast 36DD, has a 24-hour water absorption rating of less than 0.1% and a dielectric strength greater than 300 volts/mil. It is strong and rugged. With a dielectric constant of 1.7 and a dissipation factor of less than 0.0009 from 60 to 10^{10} Hz, the designer can expect minimum degradation of Q for his encapsulated component or filled high-frequency cavity. Where Stycast 36DD is applied as a transmission line dielectric in coaxial lines or waveguides, the low dielectric constant and loss factor assure minimum dielectric and transmission losses. Price is $45 per gallon. Emerson & Cuming Inc., Canton, Mass. 02021 **[436]**

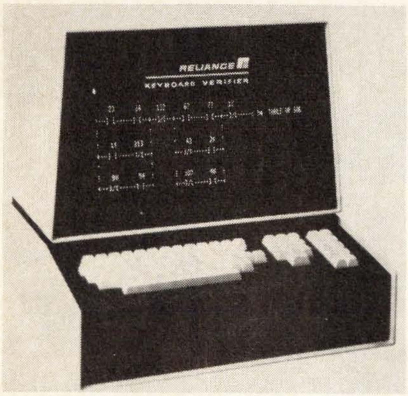
A new line of soldering materials is designed to solve critical joining and cleaning problems in the manufacture of hybrid and other ICs. Included are Microcreams, micropastes, IC grade Vaculoy solder, conductive inks, microfluxes, microcleaners and a microdryer. Alpha Metals Inc., 56 Water St., Jersey City, N.J. 07304 **[437]**

Ultrahigh temperature epoxy system HDT is a two-component epoxy that can operate at 1,000°F for short periods and well over 550°F for continuous use, with little loss of bond strength. It has proven to be an excellent adhesive for bonding Teflon and other fluorocarbons to metalic substrates. It is suitable as an adhesive, electronic potting and encapsulating compound and a casting resin, for short run, high-temperature molds used primarily in injection molding applications. HDT is of medium viscosity and well suited for production applications in meter-mix dispense equipment. Allaco Products Inc., 130 Wood Rd., Braintree, Mass. **[438]**

dc. The core memory is supplied with from 1,000 to 4,000 words depending on the size of the control system.

A system that could replace 80 to 90 relays costs about $8,000, says Reliance. To this may be added the below-$4,000 price of the CRT unit, called a keyboard-verifier by Reliance. Because it's detachable, one such unit with its 1,000-word MOS memory can serve any number of basic AutoMates. Reliance also says it will preprogram its controller from a customer's own relay ladder diagram so that the keyboard-verifier may not be needed.

Another option is a $1,000 tape cassette unit that can be plugged into the controller to record whatever sequence is stored in memory. This recorded tape then can be sent to Reliance, which will produce from it a hard-copy diagram showing the entire relay sequence.



Logic view. Instructions for controller are entered at CRT terminal, using ordinary relay symbols.

The basic controller is about 24 inches wide, 20 inches deep and 24 inches high. It's protected in a NEMA-12 enclosure. Power-conditioning modules in a separate input/output rack could occupy an enclosure of about the same size. The keyboard verifier is about the size of a portable television, and the cassette recorder is about the size of a "box of golf balls," says Reliance.

Industrial Drives Group, Reliance Electric Co., 24701 Euclid Ave., Cleveland, Ohio 44117 **[430]**

New literature

Terminal junction system. Appleton Electric Co., 1701 Wellington Ave., Chicago 60657. A 12-page brochure announces the MIL-T-81714 terminal junction system for electronic applications. Circle **446** on reader service card

Reed relays. Guardian Electric Mfg. Co. of California Inc., 5755 Camille Ave., Culver City, Calif. 90230. Six new series of reed relays ranging in size from miniature to standard and power types are described in a brochure. **[447]**

Microwave devices. Texas Instruments Inc., P.O. Box 5012, M/S 16, Dallas 75222, has available a 17-by-22-in. wall chart for microwave integrated circuits and discrete devices. **[448]**

Bipolar transistors. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. A bipolar transistor reliability report discusses reliability processing options, JAN-TX preconditioning tests, JAN-TX burn-in, and HTRB test results. **[449]**

Disk drive controller. KDI Interactive Data Systems, 17785 Sky Park Cir., Irvine, Calif. The DC-16 disk drive controller that enables minicomputers to provide greatly expanded data bases is described in a six-page brochure. **[450]**

Servo control systems. Randtronics Inc., 465 Convention Way, Redwood City, Calif. 94063. Brochure C370 describes the company's full range of products and services in the area of dc electric-motor control equipment and related engineering activities. **[451]**

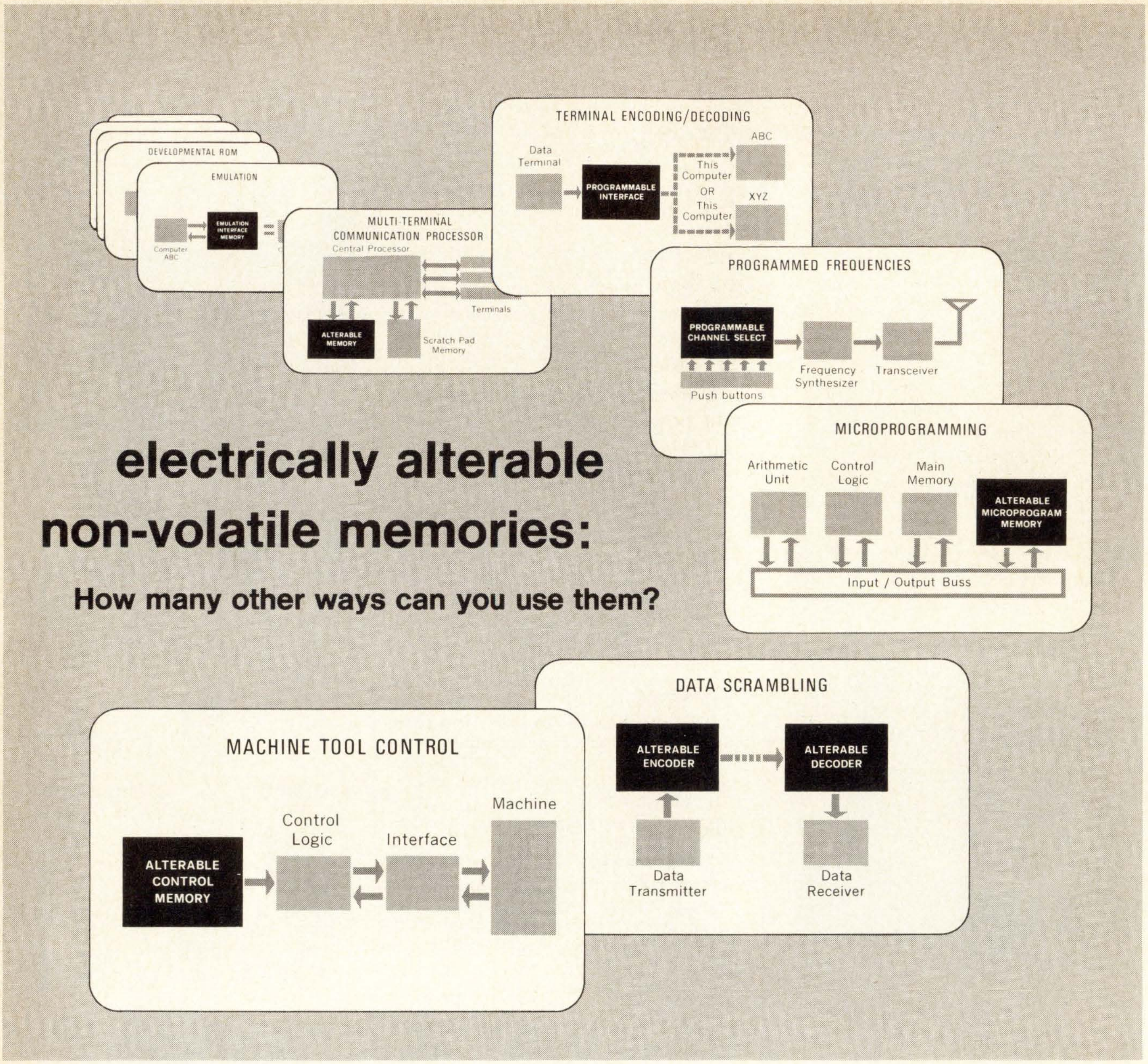
Low-profile trimmers. Beckman Instruments Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634. Low-profile, rectangular cermet trimming potentiometers series 89 are featured in a catalog sheet. **[452]**

Power supplies. Abbott Transistor Laboratories Inc., 5200 W. Jefferson Blvd., Los Angeles 90016. Over 3,000 models of power supplies are listed with prices and application photos in the 72-page catalog for 1971. **[453]**

Synchro-to-digital converters. North Atlantic Industries Inc., Terminal Drive, Plainview, N.Y. 11803. A four-page application note reviews the pros and cons of tracking-versus-sampling principles for digitizing resolver and synchro forms of shaft angle data. **[454]**

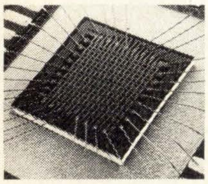
Satellite printers. Data Products Corp., 6219 DeSoto Ave., Woodland Hills, Calif. 91364. A six-page brochure describes how satellite off-line printing can save money while providing high print quality and high printing volume for computer users in all industries. **[455]**

Circle 103 on reader service card



electrically alterable non-volatile memories:

How many other ways can you use them?



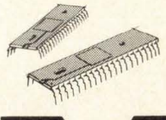
Up until now you've had to settle for non-volatility *or* electrical alterability in a semiconductor memory system. One or the other; not both together.

Today, we're glad to say, you can have your cake and eat it too. Because the best of both have now been combined in a single device: our new 256-bit Read-Mostly Memories (RMM).

Key to their unique characteristics is the use of amorphous and silicon semiconductors integrated in a 16x16 matrix on a monolithic chip, with a diode-isolated Ovonic Memory Switch (OMS) at each cross-point. What makes them alterable and non-volatile, too, is the fact that the OMSs are, in essence, bistable resistors. They can be reversibly switched between their high resistance (300k Ω) and low resistance (500 Ω) states by the application of controlled current-time pulses. And they're also capable of remaining in either state indefinitely, even when power is removed.

Add to these exclusive features non-destructive readout plus read speeds of 150 nsec access and 200 nsec cycle time (including decoding delay) and you've got yourself a versatile memory element that's readily adaptable to a host of applications beyond those diagrammed above.

Availability? Off-the-shelf! At prices ranging from $120 each in quantities of 1 to 9, $75 each from 10 to 99, and $60 each for 100 or more. Application engineering assistance is available upon request without obligation. Write or call for complete information today.



OVONIC RMM

Energy Conversion Devices, Inc.
1675 WEST MAPLE ROAD • TROY, MICHIGAN 48084 • 313/549-7300

International Newsletter

March 29, 1971

East Germans show their TTL ICs

East Germany's electronics industry finally has gotten a leg up in IC production, though large-volume output problems apparently remain. Displayed at the Leipzig Spring Fair were various types of transistor-transistor logic devices, roughly equivalent to the 7400 series. Using planar epitaxial technology, the devices are intended for applications in data processing, numerical control systems, and other industrial gear. **One TTL series shown features a per-gate power loss of only 10 milliwatts, a static signal-to-noise ratio of 1 volt, and fan-out of up to 30 for certain power gates.**

Judging from the packaging used, West German and British observers deduced **that much of East Germany's IC production equipment is outmoded by Western standards.** And the relatively high device costs quoted point to low yields; outdated manufacturing machines are held partly responsible, though diffusion and test equipment seemed more up to date, the observers say. On the other hand, East German discrete components were rated by Western fairgoers as "not bad at all."

West Germany tries out long-haul videophone link

Long-distance videophone transmission debuted in West Germany as the country's first experimental link between Darmstadt and Munich went into trial operations. The 240-mile link connects several subscribers at the German post office research center in Darmstadt and several subscribers at Munich-based Siemens AG, the system's developer. **Though postal officials plan to expand the trial link to include Bonn, West Germany's capital, they do not expect videophone transmissions to go public before 1980.** The experimental link uses regular telephone cables within the two cities and 4- and 6-gigahertz microwave links between them. Video bandwidth is 1 megahertz and frame frequency is 25 per second. The 4-by-4.3-inch picture format uses about 225 lines.

Siemens has been pressing the post office to get other postal authorities to adopt its videophone norms on an international basis. These call for a line frequency of 8 kilohertz, frame frequency of 30 per second, bandwidth of 1 MHz, and a picture format of about 5 by 6 inches with 267 lines. **Siemens says that its standards have a good chance of being adopted worldwide,** especially since postal officials in other countries already have worked out similar proposals.

IBM will sign new license pact with Japanese firms

IBM is about to sign a new five-year computer license agreement with 15 Japanese computer and peripherals companies—**with royalties set about 40% lower than the present 1% for basic technology and 5% for nonbasic technology.** One reason for the reduction is said to be an increased flow of patent licenses in the reverse direction. The agreement was expedited because IBM dropped its demand for access to patents owned jointly by Japanese licensees and others. However, there's an apparent gentlemen's agreement that the Japanese firms will do their best to expedite granting of licenses to IBM case by case.

IBM's agreement with the 15 companies and its license for IBM Japan to use IBM patents both expired at the end of 1970. IBM Japan needs government approval for every new computer it builds in Japan. **It's anxious to start production of the 370/135,** and permission was not likely to be granted until the pact was out of the way.

International Newsletter

CGE plans to sell Continental Edison

Continental Edison, the ailing consumer electronics arm of France's CGE, will be sold to Thomson-Brandt, the nation's biggest electronics group. The latter will buy 75% of Continental Edison for one franc (18 cents) and then will invest $5.4 million in new working capital; CGE will invest another $1.8 million and will retain 25% of the shares. CGE pumped some $5 million into Continental Edison in recent months, **but the subsidiary continued to lose a lot of money.**

Thomson-Brandt agreed to buy the firm in 1969 as part of a general agreement for CGE to specialize in electrical equipment and Thomson-Brandt to absorb CGE's electronics business. But Thomson-Brandt later backed out of the Continental Edison purchase. CGE reportedly was negotiating with Holland's Philips and with American and British firms to sell the ailing subsidiary. **But the French government blocked them and apparently lured Thomson-Brandt with official financing.**

Ferranti using Bell's CDI process to make big bipolar RAMs

Ferranti Ltd. is picking up Bell Laboratories' collector diffusion isolation process for fabricating bipolar integrated circuits [*Electronics*, August 31, 1970, p. 87] to make large random access memory chips. Currently, fast bipolar RAMs are limited to 256 bits by power dissipation problems, **but Ferranti researchers say their experiments indicate they will be able to get much higher bit densities and access times of 50 nanoseconds without dissipation problems.**

The optimism centers about two developments: a processing breakthrough that raises breakdown voltage sufficiently to make the chips TTL compatible, and a circuit configuration that is said to make beneficial use of the high inverse current gain and the high collector junction capacitance that normally are snags of CDI transistors. If plans work out, **samples will be available by the year-end.**

Japanese competition hurting French component sales

French passive component makers are complaining that Japanese competition is squeezing them out of their "traditional" European markets, particularly West Germany and Italy. The current slowdown in the German economy, added to this Japanese competition, is compounding the damage, the French firms say. **The most affected area is condensers, say the French; they suspect Japanese firms are dumping the devices.**

France's electronics trade association, FNIE, has held talks aimed at persuading Japanese makers to limit their condenser exports to Europe, but with no results so far. FNIE has an agreement with Japan's electronics trade organization limiting Japanese components exports to France, but other European countries don't.

Addenda

Motorola sources in Japan say the company expects to obtain Japanese government permission to form a joint-venture semiconductor operation this summer . . . A Japanese researcher claims to have developed **a low-temperature (500°C) process for depositing protective nitride coatings on silicon semiconductors** . . . Swedish hi-fi equipment maker Sonab AB is investing about $1 million to expand output of its omnidirectional stereo speakers [*Electronics*, Nov. 9, 1970, p. 153] and to start up production of vhf land mobile communications systems . . . The new V-12 engine in the Jaguar E-type sports car uses an electronic ignition system, made by Joseph Lucas Ltd., as standard equipment.

Liquid crystal displays bring flat TV closer

Ferroelectric ceramic layer in experimental displays solves crosstalk problem while providing storage capability

The elusive low-power, flat-screen television could be several steps closer to reality if experiments with liquid crystal displays at West Germany's Siemens AG bear fruit. The most promising element in the Siemens work is a ferroelectric ceramic layer that circumvents some of the problems of addressing a liquid crystal display, while adding a storage capability.

In a simple liquid crystal matrix display, a thin layer of nematic liquid crystal is sandwiched between two glass plates with parallel conductor electrodes on their surface. The plates are placed so that the electrodes form an X-Y matrix of intersections.

To address an element, a voltage is applied to the appropriate X and Y electrode, and the element gets the full voltage. This voltage induces the dynamic scattering that is the basis of liquid crystal operation. But shunting in the matrix sends part of the voltage to surrounding display elements, which also go into the dynamic scattering mode. These parasitic currents cause crosstalk, or lack of contrast in the display.

Another problem for TV applications is the long response time to induce scattering—generally several milliseconds. But if, for example, a television display with half a million elements is to be addressed 24 times a second, the addressing pulses must be applied for a period that's considerably longer than the scanning time per element to induce dynamic scattering. Thus, the display elements must be capable of storing the signals that contain brightness information.

In the Siemens approach, crosstalk is suppressed by exploiting the lead zirconate-lead titanate ceramic's nonlinear properties. These properties assure that the voltage applied to a particular element is much higher than the threshold voltage required to induce the scattering action in surrounding elements. What's more, the ceramic itself can store information in the form of polarization states.

The Siemens research team, headed by Josef G. Grabmaier, has developed two basic versions of experimental liquid crystal displays. The simpler version, without the ceramic storage capability, is suitable for fast dynamic displays with several thousand elements. The X and Y electrodes are on opposite sides of the 100-micron-thick ceramic layer; the 10-micron liquid crystal film lies between ceramic layer and the Y conductors. If an ac voltage pulse is applied to such a double-layer arrangement, the voltage will effectively encounter a nonlinear and a linear capacitance in series. With suitable capacitances in both layers, the voltage across the liquid crystal can be made to increase very rapidly compared with the total voltage applied across both layers. This assures that the only element that is activated into dynamic scattering is the one to which the voltage is applied; the voltage at adjacent elements is far below the value that would activate them, thereby eliminating crosstalk. The capacitances of the liquid crystal and ceramic layers are matched by using different widths for the X and Y electrodes.

The other display version also has X and Y electrodes on opposite sides of the ceramic layer. However, to achieve storage, there's a small readout electrode at the Y conductor side of each intersection. It is isolated from that electrode but is capacitively coupled to it by the ceramic material. Opposite to the readout electrode, on the back face of the liquid crystal layer, is a corresponding but larger electrode. On the other side of that layer is a very large transparent front electrode.

In this version, video signals, for example, can be stored as polarization states in the ceramic material. That portion of the material at the X and Y conductor intersection forms the ceramic storage element. If the ceramic elements initially are at the upper remanence point of the ceramic's hysteresis loop, a negative voltage pulse applied to the matrix will kick these elements into the lower remanence state, thereby inversely polarizing them. This process takes about 1 microsecond. Thus, the image information first is converted into a polarization pattern stored in the ceramic. This pattern then is turned into a visible image on the liquid crystal film by applying a 1-millisecond readout pulse simultaneously across all X electrodes and across the big front electrode. All elements then return to the initial polarization state.

Sweden

Oscilloscope stores one trace while displaying seven more

Patient monitoring setups in hospitals may have to do double duty—continuously keeping track of electrocardiograms or electroencephalograms and also storing unusual curves for later analysis. A new eight-channel oscilloscope with its own MOS memory performs both chores and is more flexible than conventional approaches, says its maker, Elema-Schonander of Stockholm. The Swedish electronics firm is a subsidiary of West Germany's Siemens AG.

The scope, which has been tested at several Swedish institutions and a Danish hospital, has eight presentation channels. Seven are used to monitor seven patients simultaneously, while the eighth is left free to present a captured curve for further study. When an attendant observes an abnormal curve, he pushes a "freeze" button that displays the questionable trace on the reserve channel while the other channels continue to present fresh incoming curves. By contrast, graph recorders don't discriminate against normal data; delay-loop tapes are bulky and sometimes unreliable, and storage scopes interrupt the flow of new information while they put data into storage.

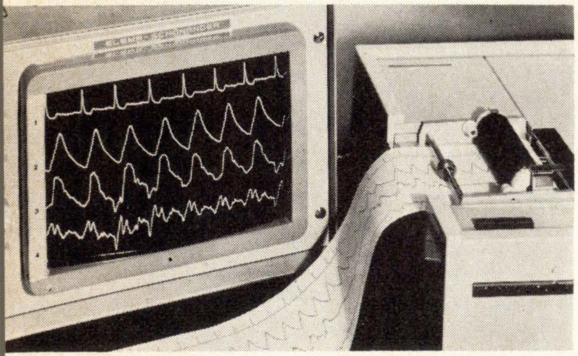
What's more, when connected to a recorder, the oscilloscope orders the peripheral to store only that part of the curve that's displayed on the frozen channel. Thus, the scope's "freeze" button acts as an on-off switch for the recorder.

In operation, the signal from the patient enters an analog-to-digital converter, and then goes into a memory made up of 64 512-bit MOS shift registers. The memory is normally designed for 7.5 seconds of operation, but can be used from 2 to 15 seconds. The signal goes out through a digital-to-analog converter for presentation on the screen and also for feeding to a recorder.

The curve, which travels from right to left, is presented on the screen at constant speed; light intensity is the same over the face of the screen. The curve at the screen's right-hand edge represents actual time while that at the left has been stored 5 to 15 seconds.

Elema-Schonander envisions the biggest use of the oscilloscope in intensive-care coronary units, but the maker also will market them for use in catherization laboratories to monitor blood pressure. The unit is priced at about $8,000.

Track record. Prototype of eight-trace scope handles four channels.



Switzerland

Medex exhibitors zero in on heartbeats, blood counts

There's no doubt that there's a burgeoning market for medical electronics in Europe although no one is quite sure when it will burst into full blossom. When the flowering finally comes, though, it looks like American companies will be gathering a good part of the bouquets.

That's the impression made by Medex 71, the first major international medical electronics exposition held on the Continent. At Medex, held in mid-March at Basel, the hardware that drew clumps of showgoers generally turned out to be carrying a U.S. brand name. To be sure, the two European heavyweights in the field, Holland's Philips Gloeilampenfabrieken and West Germany's Siemens AG, weren't on hand for Medex. But strong as these two are, the American competition looks formidable.

Still, the market holds so much promise that many European companies, large and small, are taking a crack at it. And here and there at Medex front-running European technology turned up.

Hoffmann-La Roche Bioelectronics division, for example, has readied for obstetricians an instrument that monitors a baby's heart action during birth. Fetal heartbeats can be heard through the mother's abdomen using a stethoscope, but it's hard to distinguish them from the mother's.

La Roche's hardware gives a direct indication. As soon as the baby's head starts to emerge, an electrocardiogram electrode centered in a vacuum cup is clapped onto it. At the same time, a pressure-sensing catheter is inserted into the mother's amniotic pouch. The instrument then displays, side by side on a chart recorder, the pressure changes during the mother's birth-giving contractions and the changes in the baby's heartbeat.

Normally, the beat slows during a contraction, then picks up again. If the heartbeat isn't right, the obstetrician knows it right away from the shape of the side-by-side curves. He can then decide if a Caesarian birth is necessary. Hoffmann-La Roche is based in Basel, but this instrument was developed by its newly acquired French subsidiary, the former medical electronics division of aircraft maker Avions Dassault.

Another noteworthy item of monitoring equipment turned up on the stand of OTE/Galileo, a division of the Italian company Montedel. OTE's equipment does what other monitoring equipment does—keeps tabs on heart action, respiratory action, blood pressure, and other vital functions. However, OTE has gone about as far as you can go in modular monitoring.

There's a central control unit

that can handle up to 20 bedside units, each monitoring a number of morphological parameters. Both the central control and bedside units are built up of standard modules that provide just about any conceivable monitoring function from electrocardiogram amplifiers to multichannel telemetry systems. Anywhere from two to 28 modules can be combined to make up one "instrument." All have digital outputs that can be fed directly to a computer for statistical processing.

Smaller companies, too, turned up with technological advances. Elemicrodata of Zurich, for one, has a better way of counting blood corpuscles. Its hardware, like other blood-particle counters, determines the count by accurately measuring the changes of resistance of an electrolyte—a solution with the blood sample diluted in it. However, instead of a capillary tube, Elemicrodata's counter uses a precision-drilled ruby—with a passage as small as 1 micron—to control the flow of the electrolyte. It's much faster, claims Elemicrodata.

The tiny changes in resistance caused by the corpuscles as they pass through the ruby show up as current variations, which are amplified by an operational amplifier, with a gain of 7,000, and a proprietary input network matched to the ruby's characteristics. The amplifier's output is fed to an up-down counter, whose range can be set to count particles of a given size only. The ruby size, too, can be changed to adapt the instrument for counting impurities in water.

Another small company with technology to talk about is Biviator SA of Geneva. The company has developed an isotope-powered pacemaker battery that delivers 300 microwatts into loads as large as 4,000 ohms. The battery will power a pacemaker developed by France's atomic energy commissariat.

Another Biviator innovation is an ultraviolet meter based on a proprietary photocell. The spectrum covered by the cell is from 290 to 400 nanometers, but there's a version sensitive only to wavelengths from 300 to 325 nanometers, the range where sunburns come from. Biviator sees a potentially big market for these meters among users of suntan lamps. The price will be right, about $5.

Rise and shine, it's wake-up-by-computer time

Despite the obvious surplus of alarm clocks in Switzerland, the working day at telephone exchanges in that country's main cities starts with a round of calls to subscribers who've requested an early-morning ringup from the wakeup service. Now the girls who make the calls are about to be replaced by electronic hardware. After successful trials in Solothurn, a town about 30 miles south of Basel, the automatic waking equipment is going into Zurich exchanges. And the Swiss Post Office, which runs the phone system, has ordered sets for its 17 major telephone districts.

Autophon ATG, the Solothurn-based telecommunications company that developed the system, maintains it's the first of its kind. Along with its big backyard client, Autophon has picked up telephone-system customers in Finland and the Near East. The company also has signed up its first buyers for a smaller, hotel-sized waking system. Autophon's equipment made its debut this month at INEL, the biennial Swiss industrial electronics show.

The basic set of telephone-exchange wakeup equipment does the work of 10 fast-dialing operators—it can put out 200 calls in 10 minutes. When the early riser picks up his phone in answer to the call, the wakeup equipment switches him onto the exchange's 24-hour time-service answering machine. But if the subscriber doesn't answer his call after 10 rings, it's transferred to the next 10-minute cycle for a second, and final, effort.

To book a wakeup call, Swiss subscribers first dial the three-digit number assigned to the wakeup service. This gets the subscriber into the equipment, which replies with a recording telling him to dial his number (a wakeup call can be booked only from the phone for which the call is requested). If the dialing transient impulses check out, the number is fed into a core memory and is stored temporarily in a number register. Some of the more advanced Swiss exchanges have automatic subscriber identification; in that case, the caller's number feeds directly into the register as soon as the wakeup service number is dialed.

Once the caller's number is in the register, the answering machine asks the caller to dial in the wakeup time—for example 6:30 a.m. would be dialed in as 0630. These four digits go into the time register. Then the memory circuits search for a free location in the main store and transfer all the booking data to it. After that, the answering machine tells the caller that he'll be phoned on time. Meanwhile, the message-unit recorder for his line is pinged with a wakeup charge.

The main store for a set has six core-memory units with a capacity of 30 kilobits, enough to store 560 calls. In the morning, the store is interrogated once every 10 minutes and all calls due to come up during that period are transferred to working stores. There are 10 of these, each with an outgoing line assigned to it and an output set to generate dialing impulses.

Canada

STOL spells take-off for Canadian avionics

Canadian aerospace firms expect substantial government funding for short-take-off-and-landing aircraft and their associated avionics and ground equipment. The hopes follow the recent Science Council of Canada report that urged the development of STOL planes as a major element of Canada's air transport system and as a major entry in the export market.

When funds are allocated, Ottawa will probably accord first priority to de Havilland Aircraft Co.'s DHC-7, a 48-passenger STOL intended to meet the needs of the intercity travel market at home and abroad. The DHC-7 is funded until October, when the design will have been completed. Then, about $75 million will be needed to get through to aircraft certification. Some of the money is likely to come from the government, on the grounds that de Havilland's STOL expertise is a valuable national resource.

For more than two years the Canadian government has been promoting the aerospace industry through an "Airports for Export" program, under which its Department of Industry, Trade, and Commerce acts as an unpaid commercial agent, through its foreign consulates. The Canadian share of the $800-million-per-year worldwide airport construction market is quite small but growing, and as it increases so do orders for the associated instrumentation—radars, communications, lighting systems, ILS, and the like—that may comprise from 5% to 10% of the airports' cost.

A far larger potential market, though, is for STOL aircraft—planes that could provide service from city center to city center along the 350-mile average flight length that is typical today. The Canadians are convinced that STOL service will go through an evolutionary development from today's 17-passenger commuter-type aircraft, such as de Havilland's Twin Otter, to planes carrying 40-50 passengers, and on to 150-passenger aircraft.

As now envisioned, Canada's STOL program would require about $150 million over the next five years, of which $50 million would be for avionics development. Dudley Taylor, president of Aviation Electric, a Montreal-based subsidiary of the Bendix Corporation, and chairman of the Stolports and Subsystems group of the Air Industries Association of Canada, says that existing technology will be used wherever possible. "Although the program's focus will be Canadian, it would be wasteful to re-invent existing equipment simply because it wasn't home-grown. Where appropriate, licensing agreements can sharpen the expertise of Canadian avionics manufacturers, while conserving program resources."

The classes of equipment involved include VOR, ILS, DME, area-navigation, air traffic control, communications, beacon transponders, and enroute and airport surveillance radars. Only the instrument-landing—because of the great precision needed for city-center operations—and area-navigation systems—because of the relatively steep landing approaches of STOL planes—are expected to require major new work.

Japan

Two digital control systems aimed at Japan's factories

The Japanese economy has slowed down a bit and some capital investment programs are being stretched out. Yet the country, built on low labor costs, is deep in a labor-saving and automation kick because, slowdown or no, there appears to be an absolute shortage of labor. Two new electronic industrial control systems that have just hit the market fit into that labor-saving trend—and may help promote it. Together the two—a microprogrammer from Mitsubishi and a sequence controller from Shindengen —fill in the range below the minicomputer level. And both reflect their makers' confidence that there is a need for relatively simple digital hardware to replace relay systems and to perform tasks for which minicomputers are overqualified and thus too costly.

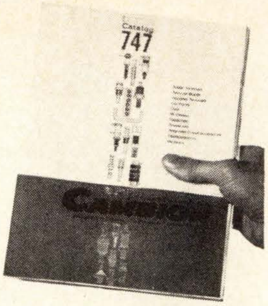
Shindengen, in developing its sequence controller, was concerned not just with labor saving, but with the shortage of technically trained people. The controller is designed for applications where many copies of the same programing are required, such as for running injection molding machines. These are jobs conventionally performed by relay sequence controls. What's more, it can be used for a larger number of steps than relay systems and for additional functions. A typical system, with a total of 64 input and output channels, is priced in the neighborhood of $2,000. No peripheral equipment is needed for programing.

Mitsubishi Electric's microcontroller system is a step up in sophistication. It provides the control logic of a minicomputer at much lower cost and complexity. Originally developed for a radar application, it is now being offered to the industrial control market because the potential demand there is growing fast. Mitsubishi figures that the processor should open up a new control field that has been too complex for wired or relay logic but for which minicomputers have been too expensive.

The price is kept low and the microcontroller adapted to an industrial environment by the elimination of computer-type language and peripherals for programing. The processor is designed with memory read capability only. Two types of memory are available—a read-write memory for initial programing and debugging, and a read only memory for long-term use. Both have a capacity of 256 words. Since the processor itself has only read capability, the read-write memory is programed in a separate unit.

Shindengen's sequence processor eliminates the rewiring and debugging headaches of changeovers in relay-type sequencer systems. It uses the standard hardware configuration and programed control concepts of digital computers. Both control logic and decoders of its diode read only memory use standard types of medium and small scale integration transistor-transistor logic. Word length is 10 bits.

The read only memory modules that define the programs are the only components that differ in individual systems. Programing—by inserting diodes into boards—can be done either by Shindengen or the user and is changed in the field merely by interchanging boards. Each memory printed circuit board contains 64 program steps, and up to 16 boards can be used for a maximum of 1,024 steps.



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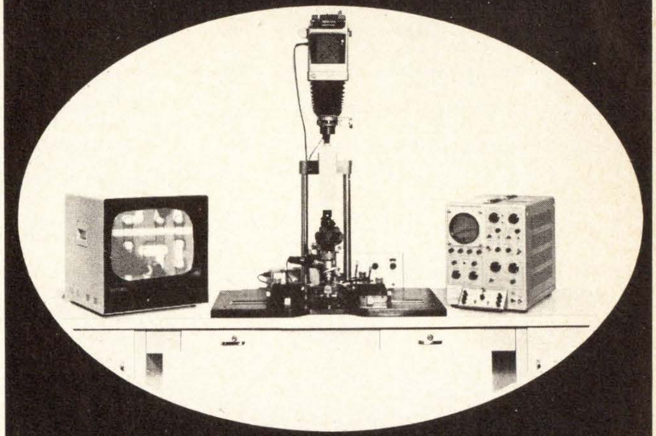

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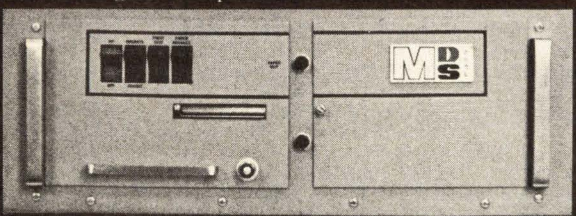

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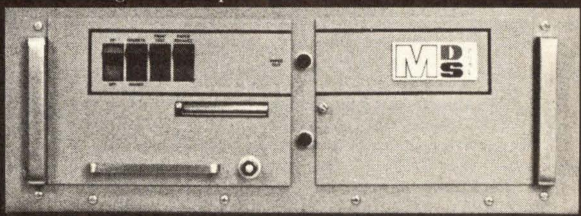

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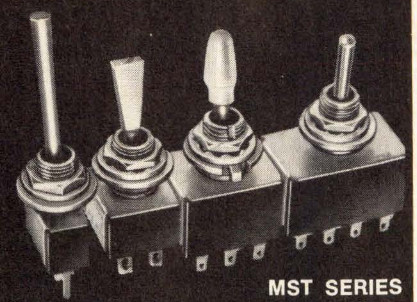

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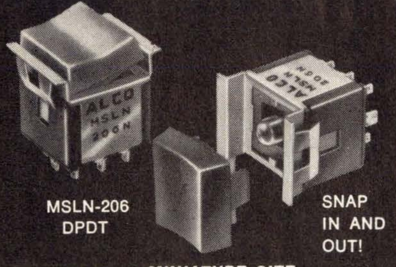

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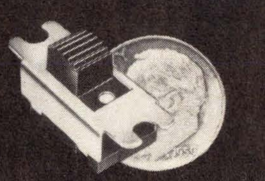

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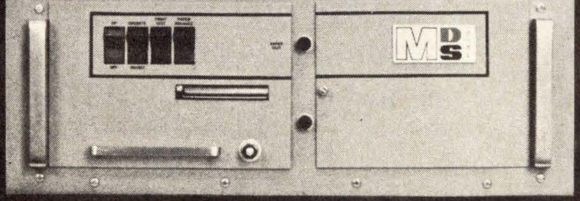

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Circle 140 on reader service card

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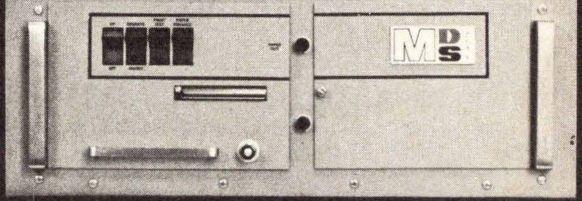

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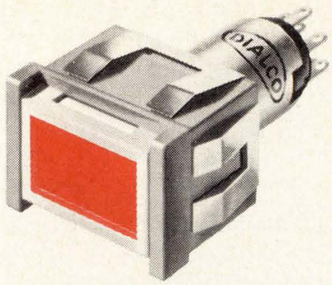
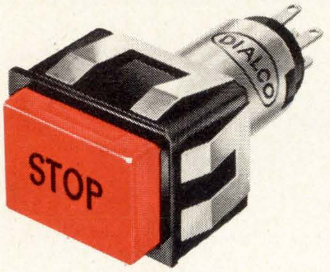


and a

legend presentation that's positive (like this one) or negative (like the one below) or just plain (like the one above) . . . one that's white when "off" and red, green, yellow (amber), blue or light yellow when "on" . . . or colored both "on" and "off."



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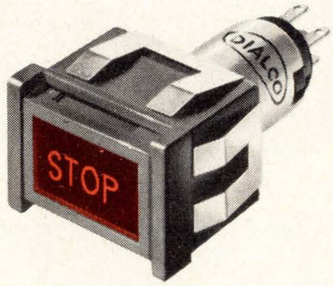

etc.
etc.
etc.

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