July 11, 1974

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Electronics

Pease Talks.

Wonderful World of V/F's.

Voltage to frequency converters are not new. You could always buy a good V/F converter in a big, rack-sized module. In fact, H-P and others made huge, monstrous things that cost a thousand dollars each. And they featured pretty good performance, considering.

Nowadays, we're talking about modern, small, reliable hybrid modules that don't cost you an arm and a leg. And don't need half-a-house worth of power to run. Say ±15 volts at a dozen or so mA. With the kind of linearity, 0.01%, and ultra-low TC you used to have to buy racks-worth for.

Why build it if you can't fly it?

Sure you could construct your own V/F converter. But the garden variety are usually pretty crummy. It's hard to get better than 1% linearity. And you just can't make a good V/F easily using the circuits you find in magazines today.

On the other hand, by putting together non-state-of-the-art components in a tricky circuit, we regularly succeed in producing a state-of-the-art V/F converter.

So I guess the big reason for buying and not doing it yourself is that you get more experience, more development, more of everything that makes it work. And less of the guesswork.

The one and only.

Our competitors in the V/F and F/V area are few and far between. A couple of guys offer one, maybe two versions of V/F converters. But linearity is not one of their strongest features. And that's being charitable.

We have a standard line and we've been making a lot of specials, too. And some of the specials we're trying to trade up to standards. Like micropower ones and ultra-low TC ones and all the way up to 10MHz and weird stuff like that.

We've got the 4701—a 0 to 10kHz V/F, the 4703—a 100kHz V/F, and the big gun—the 4705—a 1MHz V/F. Once we mastered the V/F, the other side of the coin—the F/V—was easy. So we've got the 4702 10kHz and the 4704 100kHz F/V.

We use a precision charge dispensing technique. Which means if you dump a certain value of charge from a capacitor, Q = CV, the frequency at which you do this determines the current and the amplifier sort of integrates this value and circles around the loop until you get the correct frequency. It's easy in theory, tricky in execution. Another standard approach is Q = IT which is a little more difficult and not nearly as good.

After you've got it what are you going to do with it?

We've got loads of standard applications literature on V/F and F/V use. In such areas as telemetry, tachometry, A/D converters, common-mode isolation, integration and how you can offset them or shift the full scale value or filter things. And how to work with different frequencies.

We discovered that several of our customers are using them in pollution monitoring where essentially you have to integrate for a long time without drift. There are some people in photospectrometry who integrate the area under a curve.

Voltage to frequency conversion and vice versa has been in use a long time. Our Teledyne Philbrick V/F Converters make it easier and less tricky to use V/F conversion in a lot of new ways.

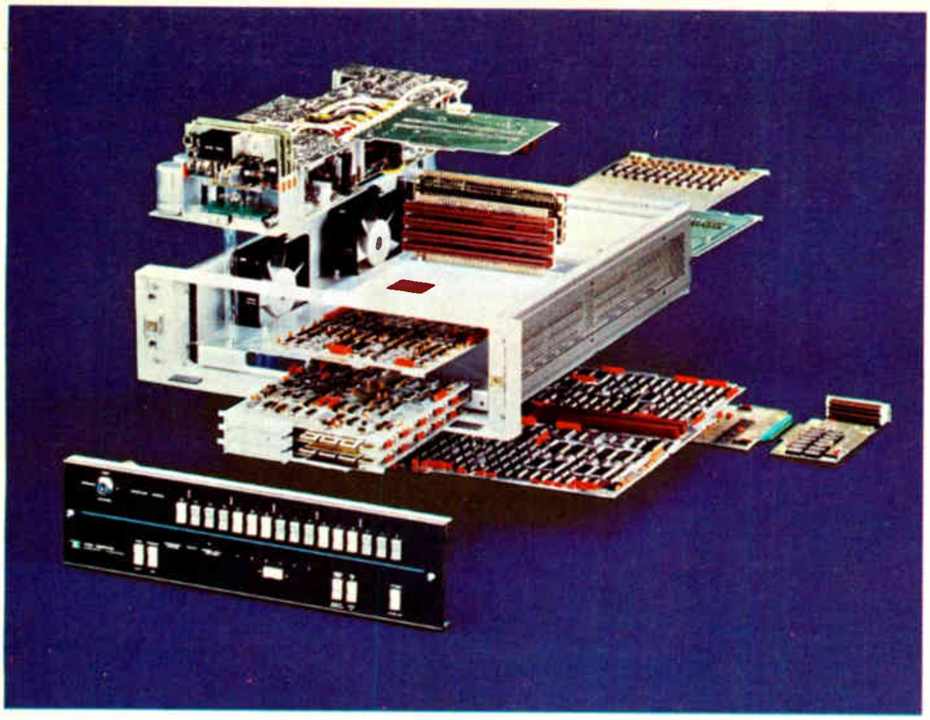
Don't be afraid, ask us.

If V/F or F/V sounds like it may answer your problem. Or if you don't know you have a problem, you really ought to get our Application Notes and spec sheets anyway. Just give us a call at (617) 329-1600. Or write us, Dedham, Massachusetts 02026. In Europe, Tel. 73.99.88, Telex: 25881. Or write, 1170 Brussels, Belgium.

TELEDYNE PHILBRICK

Robert A. Pease, Sr. Engineer

Circle 900 on reader service card



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Electronics

The International Magazine of Electronics Technology

Vol. 47, No. 14 • July 11, 1974

Highlights

Cover: Microprocessors start to roll, 81
Low-cost, versatile computer power on a chip—the revolutionary possibilities of microprocessors have designers in every electronics industry rushing to use them to upgrade current products and dreaming of altogether new applications. This special report explores the entire range of equipment being invaded by microprocessors, from industrial, communications, commercial, consumer, and instrumentation systems right through to computers themselves. Cover is by illustrator Everett Davidson.

Economic outlook: more 'realism' through 1975, 65
In the next six months tight money will cloud even the electronics industries' sunny prospects. But there's a silver lining—the scarcity of funds has halted inventory building, and lead times are easing.

Tester of complex logic boards is portable, 125
A special-purpose, microprogramed TTL microprocessor gives a new line of benchtop instruments over a hundred times the speed of minicomputer-controlled logic-board testers at less than a fifth of the price.

And in the next issue . . .
The problems of the overburdened FCC . . . designing logic boards for automatic testing . . . a look at high-performance analog-to-digital converters.

Electronics

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Publisher's letter

Microprocessors are entering the steep climb portion of their growth curve—now that industrial-equipment, communications-hardware, instrument, and even computer designers have turned on to the design innovations these mighty chips make possible.

We've rounded up all the current trends in microprocessor applications in the special report that starts on page 81. There, you'll find an in-depth report on how microprocessors are working their way into sophisticated hardware—at a pace that seems astonishing. Last year, microprocessor sales were about $10 million. In five years' time that figure should skyrocket to $800 million.

Yet that kind of growth is not so astonishing when you consider the level of sophistication that has been reached by the technology called large-scale integration. As Larry Altman, our Solid State Editor, points out in his introduction to the special report, "programable LSI circuits—the calculator was the first—combine the flexibility of custom design with the cost advantages of readily available standard products."

In our report on the blossoming of the microprocessor, you'll find sections on their application to industrial jobs (p. 83), communications (p. 88), consumer and commercial gear (p. 92), computers (p. 96), and instrumentation (p. 99). Then, too, there's a section on software tips and design aids (p. 100). And at the end of the special report, we've included an interesting review of the design advantages of microprocessor-based systems (p. 105), authored by William Davidow, manager of the microprocessor systems for Intel Corp.

Dan A. McMillan

July 11, 1974 Volume 47, Number 14
95,111 copies of this issue printed

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

Executive, editorial, circulation and advertising addresses: Electronics, McGraw-Hill Building, 1221 Avenue of the Americas, New York, N Y 10020 Telephone (212) 997-1221 Teletype TWX N Y 710-581-5234. Cable address: M C G R A W H I L L N Y

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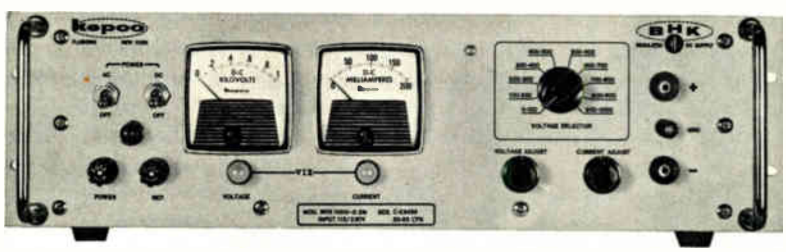

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Readers comment

Setting detector sensitivity

To the Editor: Regarding the product story on Innotech Corp.'s heterojunction photovoltaic detector, [*Electronics*, May 2, p. 137], Ray Pennoyer claims a sensitivity of 13 microamperes per milliwatt per square centimeter at 7,500 angstroms and then states that this figure is 70% higher than the output obtained from standard silicon units. His sensitivity number, as stated, equates to a quantum efficiency of 41%! UDT, Harshaw, RCA, EG&G, etc., have verified quantum efficiencies of 55% to 65% at this wavelength.

In point of fact, the Innotech device is 30% lower in sensitivity at 7,500 Å than "standard silicon units." Mr. Pennoyer further claims a sensitivity of 8 $\mu A/mW/cm^2$ at 5,000 Å, which equates to a quantum efficiency of 38%. He claims that "this is three to four times the sensitivity of a purely silicon detector." Again, in point of fact, this quantum efficiency is a factor of two lower than the published and verified quantum efficiency of devices manufactured by the aforementioned companies; i.e., 70% typical quantum efficiency.

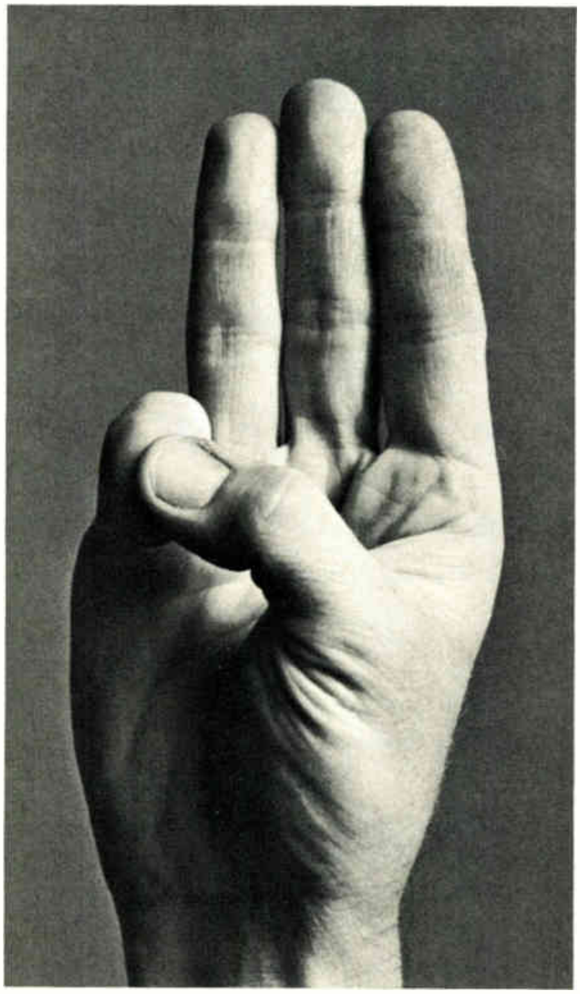
The higher quantum efficiency obtained by most manufacturers at 5,000 Å contradicts Pennoyer's statement that "in conventional photodetectors, these frequencies (blue-violet) are are absorbed before they reach the electron-emitting pn junction. . . ."

Using Pennoyer's own data to correct his relative spectral response curve to an absolute spectral response and comparing this absolute curve for PIN photodiodes will show the total spectral characteristics of the Innotech device to be inferior to those of the PIN photodiode. Based on Pennoyer's sensitivity statements and the absolute spectral response curve, it is inconceivable that the Innotech device could outperform any PIN silicon photodiode in the measurement of a 500-foot-candle source.

Edward L. Danahy
EG&G Inc.
Salem, Mass.

Mr. Pennoyer replies: The article did understate the response we obtain

TRW power Schottky SD-51



0.6V forward drop at 60 amps WITH a T_j of 125°C

On our honor. This power Schottky was developed with improved barrier formation techniques that make it possible to maintain 60 amp—0.6V forward drop at a T_j of 125°C.

We know there have been problems with power Schottkys when the T_j approached 100°C. This is simply not true with the TRW SD-51. Even at 125°C, the SD-51 has a 35V reverse leakage of 200mA, and a reverse recovery time of less than 10Ns in inverter circuits.

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Readers comment

in the visible range. Comparing our units to the "best" available referred to in Mr. Danahy's letter, we show the following results.

In the red region, measured at 700 nanometers, our absolute response is .46 A/W, about 25% higher. Our PVD090F has a sensitivity of 22 μA/mW/cm² at this wavelength. In the green region, measured at 550, our response is .40 A/W, about 55% higher. The PVD090F has a sensitivity of 18.8 μA/mW/cm² at this wavelength.

In the blue region, measured at 450 nm, our response is .31 A/W, which works out to be about 72% higher. The PVD090F has a sensitivity of 14.5 μA/mW/l² at this wavelength. In the violet region below 400 nm, the package itself affects the response, but as it stands, the response could conceivably be 100% higher.

All of this is available from a single unit with a pricing structure competitive to standard silicon units so that the designer can really do something with it. The data backing up our statement has been given to and reviewed with EG&G.

Calculating 10^y

To the Editor: Thank you for publishing David Rowland's collection of short-cut polynomial approximations for computing logarithmic and trigonometric functions on the four-function calculator [April 4, p. 145]. They are the answer to an engineer's prayer.

Although Rowland concluded that there is no easy way to compute 10^y or its equivalent, the antilogarithm of y, an approach is implicit in his collection of methods. Simply multiply the mantissa (fractional portion) of y by 2.303, converting it to a natural logarithm, and then use his procedure for computing e^x. Then point off decimal places in the answer according to the integer portion of y.

Incidentally, it should be made clear that the final step in the e^x procedure, "square twice," means "raise to the fourth power."

Peter W. Mitchell
Avco Everett Research Laboratory
Everett, Mass.

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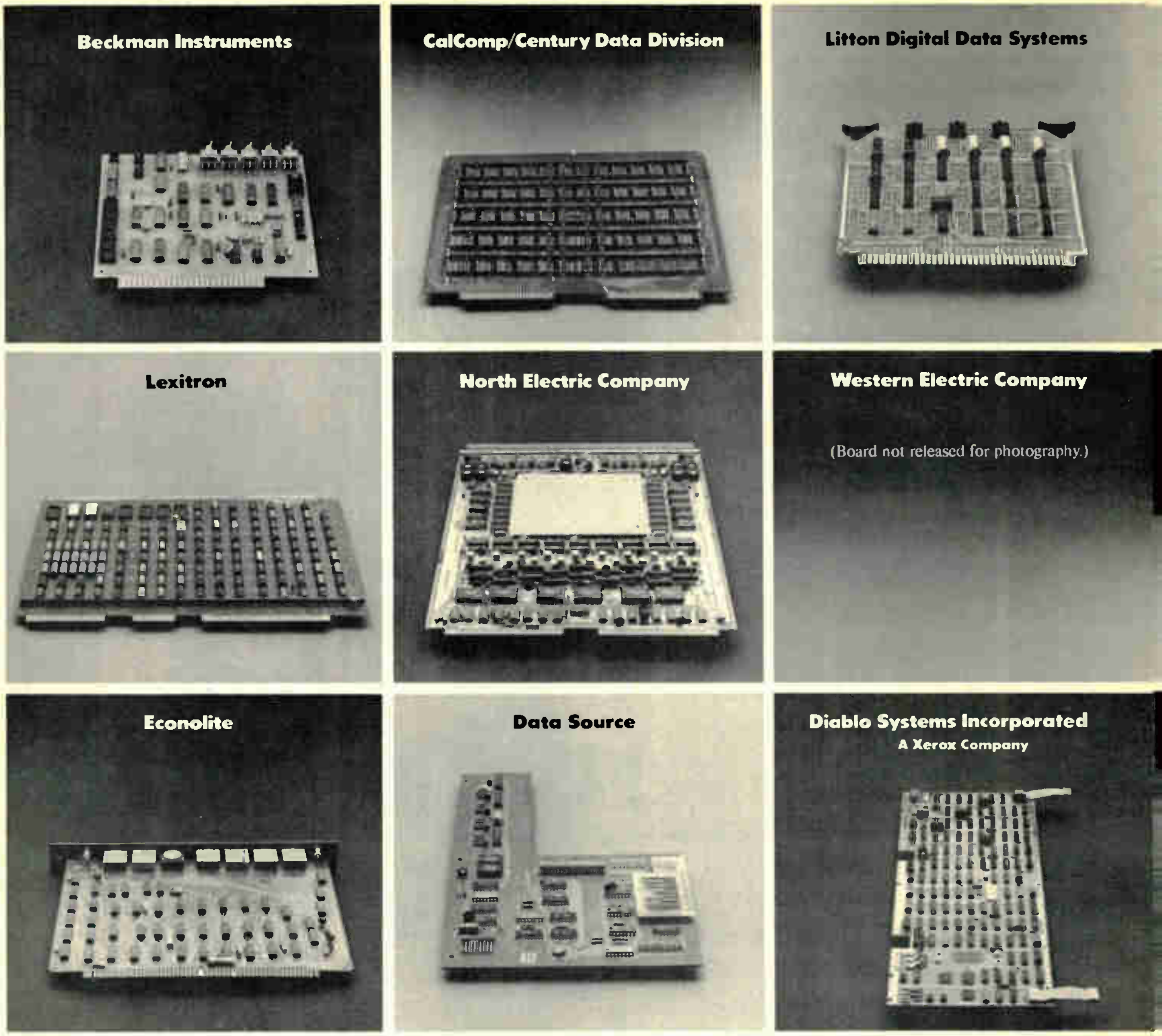

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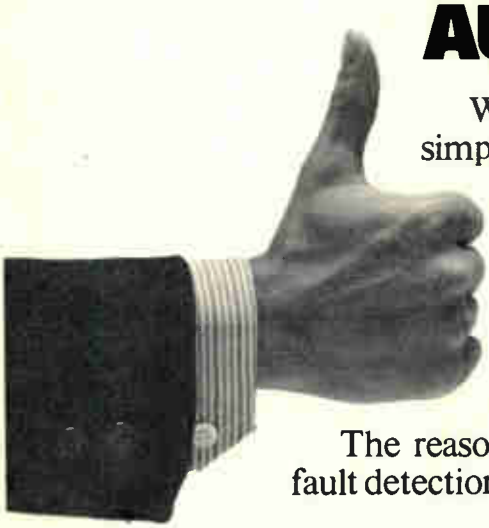

We've listed a few of our CAPABLE tester customers simply to point out something obvious. Companies like these don't buy sophisticated hardware just on the name. Which is a good thing because how many people have ever heard of the CAPABLE tester, anyway?

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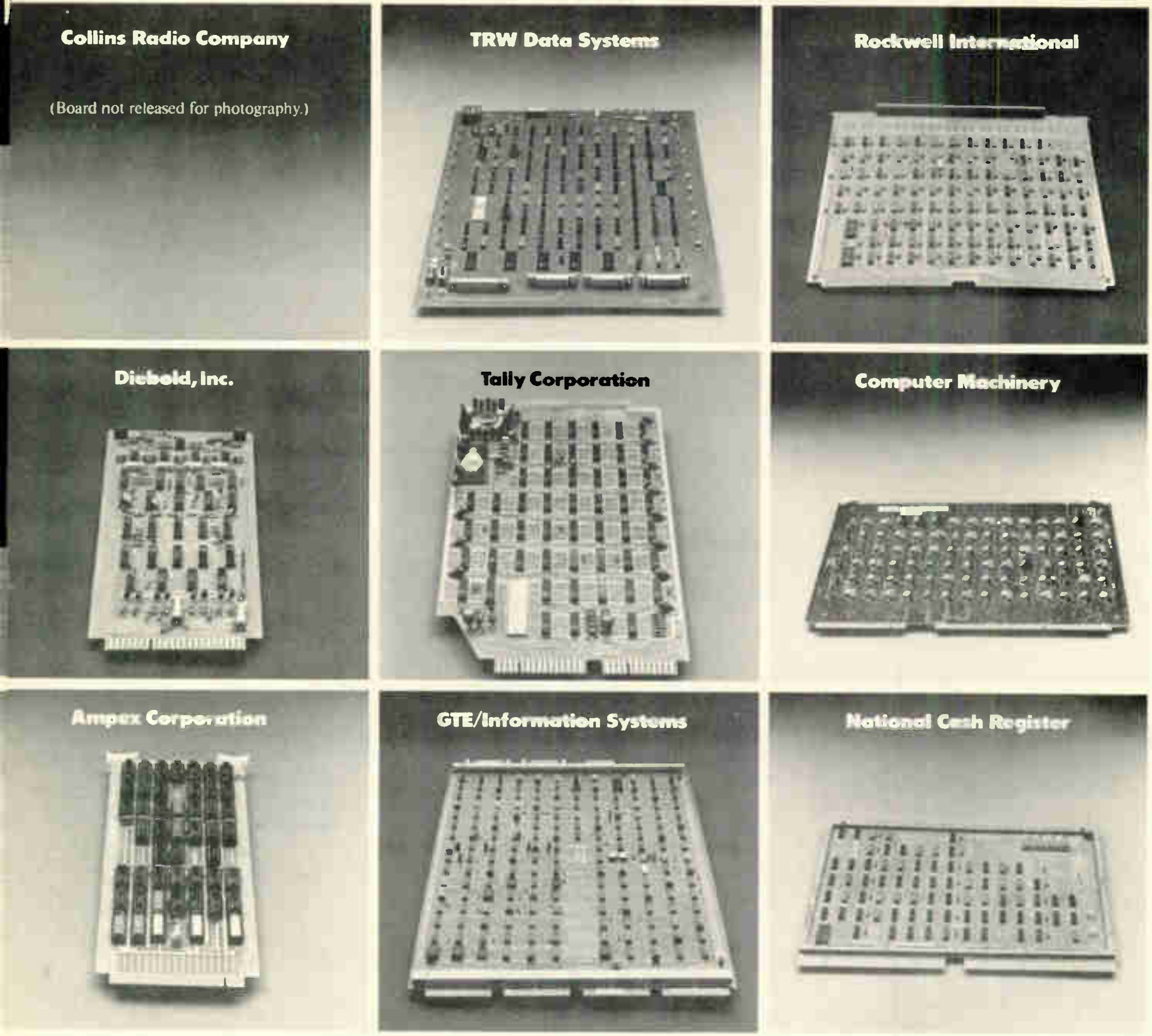

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People

Stern to expand IEEE's role

If Arthur P. Stern, the official nominee, becomes president in 1975 of the Institute of Electrical and Electronic Engineers, the organization is going to get a lot more involved in nontechnical activities. But Stern, vice president and general manager of the Magnavox Co. Advanced Products division, Torrance, Calif., hopes that members and critics will remember that the real goal is "to do something for our members—not just take a stand. Little would be gained by standing on the street corner and shouting slogans."

Next year IEEE presidential nominee Stern will seek more nontechnical activities.

Since a constitutional amendment late in 1972 permitted the IEEE to undertake nontechnical efforts, the institute has already become involved in several. These include congressional lobbying for improved pension-plan legislation and issuance of a recent report on the needs of young engineers. Stern feels such nontechnical activities will expand substantially in the coming years because "that's what the membership wants." Among the nontechnical activities Stern has in mind are lobbying for legislation of general importance to engineers, involvement in the ethics of the profession, and taking a greater interest in young engineers.

Stern was born in Hungary 48 years ago and has degrees from the Swiss Federal Institute of Technology in Zurich and Syracuse University. He attributes this desire for change partly to the upheavals in society: "Most of the problems in our society today—and their solutions—are related to technology. The engineer is aware of the central spot in which he sits, but he feels that he doesn't get recognition and compensation commensurate with his importance."

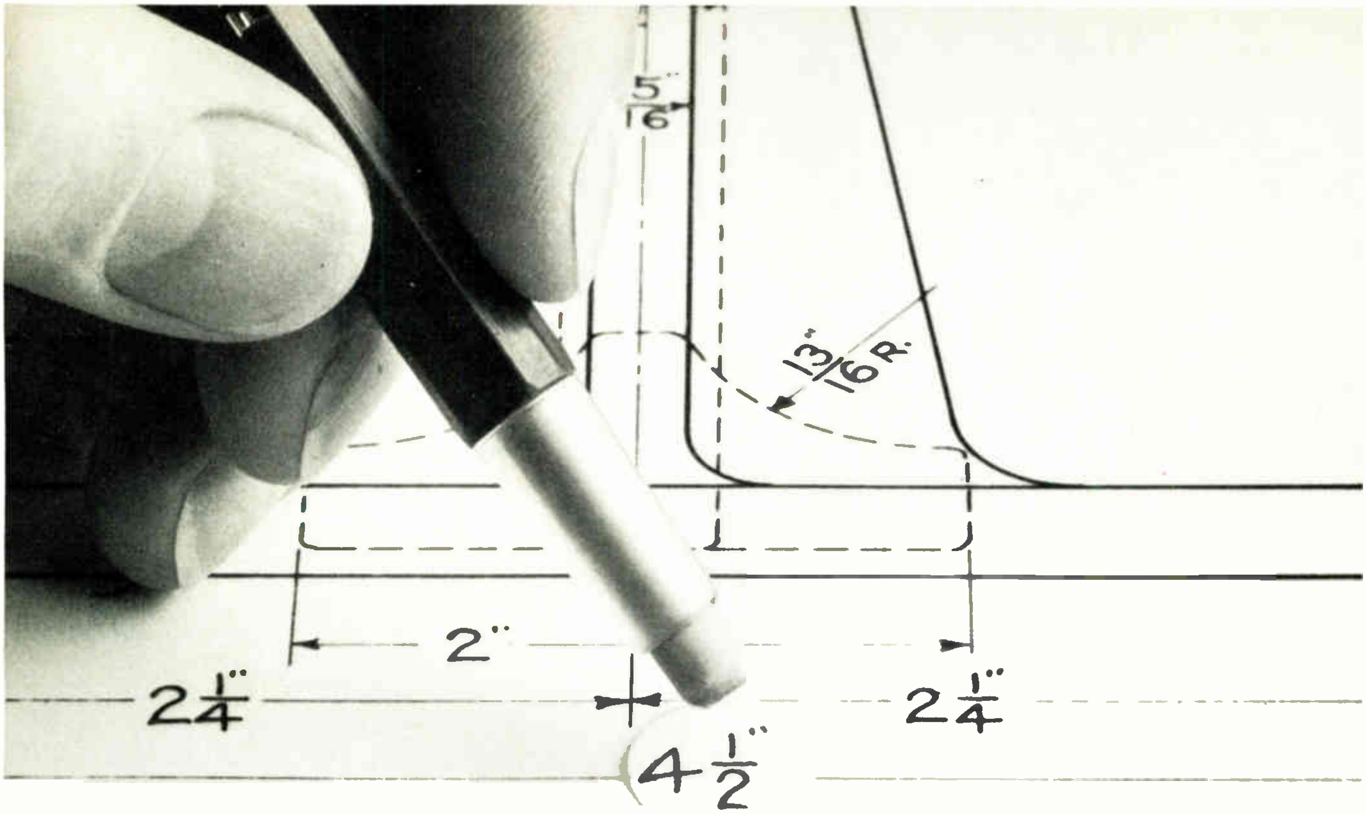
Stern doesn't see much of an interest in engineering unions, an often-discussed topic, but thinks that "portable" pension plans that engineers can take with them as they move from company to company will be demanded more and more by the mobile engineering profession. A fellow of the IEEE, Stern has served as secretary, treasurer, and, most recently, as vice president for regional activities of the 170,000 member organization.

Assuming Stern is elected by the membership, which seems highly likely, he will serve only one year as president, but he hopes to contribute something constructive in that time: "I think the institute has a tremendous challenge in giving direction to our new activities—while maintaining our traditional technical activities—to achieve worthwhile goals in a reasonable fashion."

Voiceprints move into medicine

Voiceprint identification, the still controversial method of identifying a person by the unique audio-frequency characteristics of his speech, has progressed far enough that its inventor is now adapting the acous-

Telltale voice. Lawrence G. Kersta is taking his voiceprints into the medical field.



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Kodak products for engineering data systems. Kodak tic technique to medical diagnosis. Lawrence G. Kersta visualized medical applications when he first developed the technique at Bell Laboratories in the early 1960s.

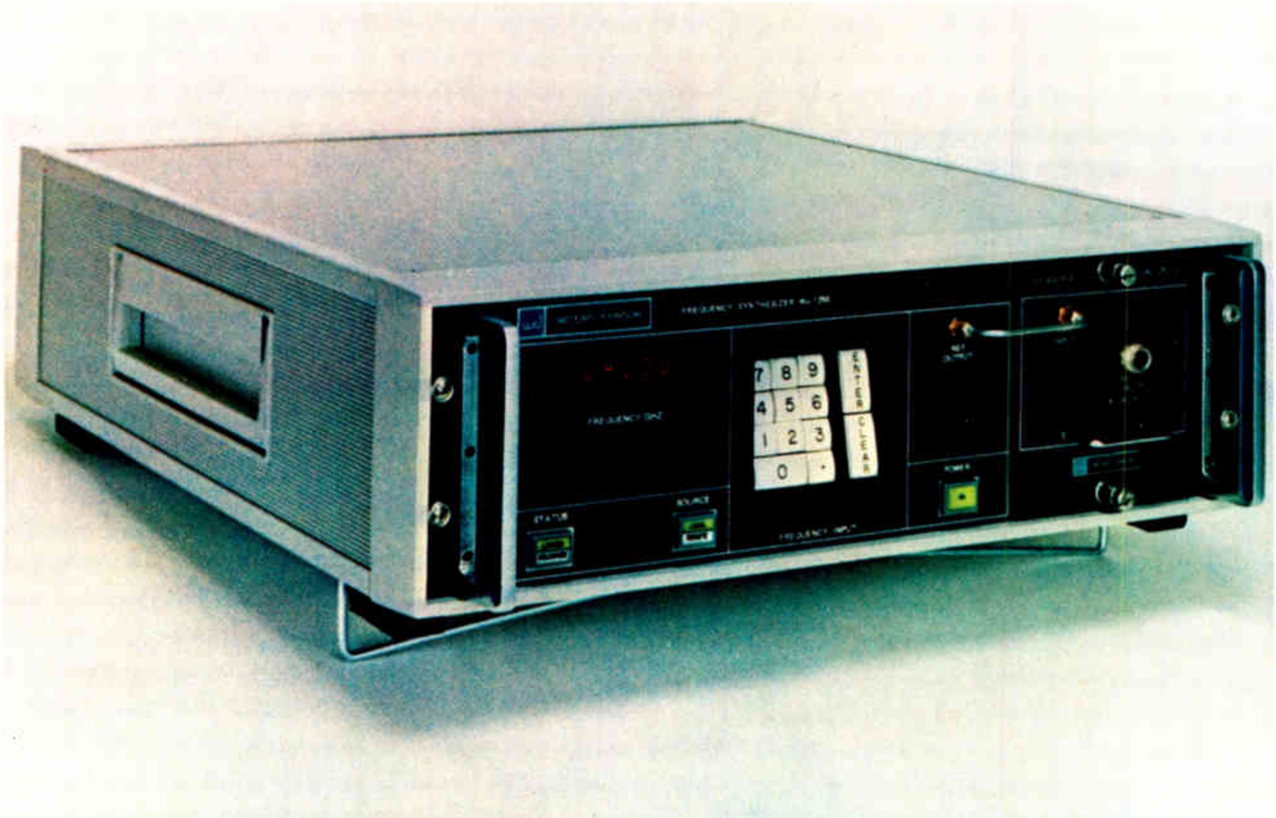
Kersta, working with Dr. Mortimer L. Schwartz, chief of cardiology at Bronx Lebanon Hospital, New York, aims at improving the acoustic diagnosis of a whole family of heart malfunctions. The audio "prints" are being used in conjunction with ultrasonic mapping techniques. Moreover, Kersta says, "the acoustic method should also be explored for monitoring fetal heart sounds, which are sometimes obscured by the mother's body sounds, and for looking at gastrointestinal sounds for ulcer conditions."

Supporting Kersta's medical work, which is in its very early stages, is Base Ten Systems Inc., Trenton, N.J., manufacturer of aerospace and aircraft telemetry. Base Ten has taken over the production and marketing of Kersta's system for voice-identification applications.

Although a recent decision in Federal District Court in Washington, D.C., ruled voiceprints as inadmissible as evidence [*Electronics*, June 27, p. 53], the technology's legal record is good. "We've had admissibility in more than 75 trials, with only four denials," Kersta points out.

Despite his brainchild's progress in law-enforcement circles, Kersta's own road recently has been rocky. His Voiceprint Laboratories, established the day he retired from Bell Labs in 1966 at 58 after 39 years on the research staff there, has been through bankruptcy proceedings twice. He salvaged the company the first time by buying it back from Farrington Manufacturing Co. when that supplier of credit-card readers and optical character-recognition gear folded in 1971. And last year, Kersta, who looks 10 years younger than his real age, went bankrupt on his own.

"The technology was sound, and widely accepted," Kersta says, "but I'm a scientist and apparently a business idiot. Base Ten, with no apologies, is very much profit-oriented," he continues. □



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If you're planning to attend AFCEA, you can see the WJ-1250 in the Watkins-Johnson suite at the Sheraton-Park Hotel. Otherwise, get the full story on W-J's frequency synthesizer product line and engineering capability by contacting the Watkins-Johnson Field Sales Office in your area or phoning Charles Foster in Palo Alto at (415) 493-4141, ext. 218.

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From the pages of Electronics, July, 1934

A mobile printer for police and aircraft radio

Two criticisms of present-day police radio systems are the lack of secrecy, and the lack of a permanent record to prove that the police car for which the message was intended actually received it. At a meeting of the Radio Club of America, first public disclosure of a simple automatic printer for this service was made by W. H. G. Finch.

The device of particular interest to police, or other mobile services, is a printer weighing 8 pounds, operating from the 6-volt automobile car battery, printing 35–40 words per minute on a tape. Thus the officer in the car need not worry about local audible interference; and his memory need not be taxed or handicapped by other local circumstances. This device, when properly actuated by the distant transmitter, will print out the message from headquarters and retain it as permanent proof that it was actually received in the car.

Teaching pilots 'blind flying'

A radically new method of teaching "blind" flying and radio-beam navigation now enables pilots to receive most of their training without leaving the ground. This novel device is in use training U.S. Army air mail pilots and others at Newark Airport, and because of its success is being adopted by the government for use in various locations. It consists of a dummy plane mounted on a pedestal equipped with complete blind flying instruments and radio, and a remote instructor's unit for the checking the student pilot in his "flight" inside the hangar.

The pilot is strapped in his plane in the usual manner and the cockpit is entirely enclosed by means of a hinged cover. By pressing a button the instructor places the plane in flight condition, and the pilot in the plane, using only the standard plane controls, must take off, "bank" and, in fact, make a complete "flight," without leaving the ground. The inventor is E. A. Link, a former manufacturer of player pianos.

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

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

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

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

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

Fifth Conference of the Canadian Medical and Biological Engineering Society, Queen Elizabeth Hotel, Montreal, Sept. 3-6.

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

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

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

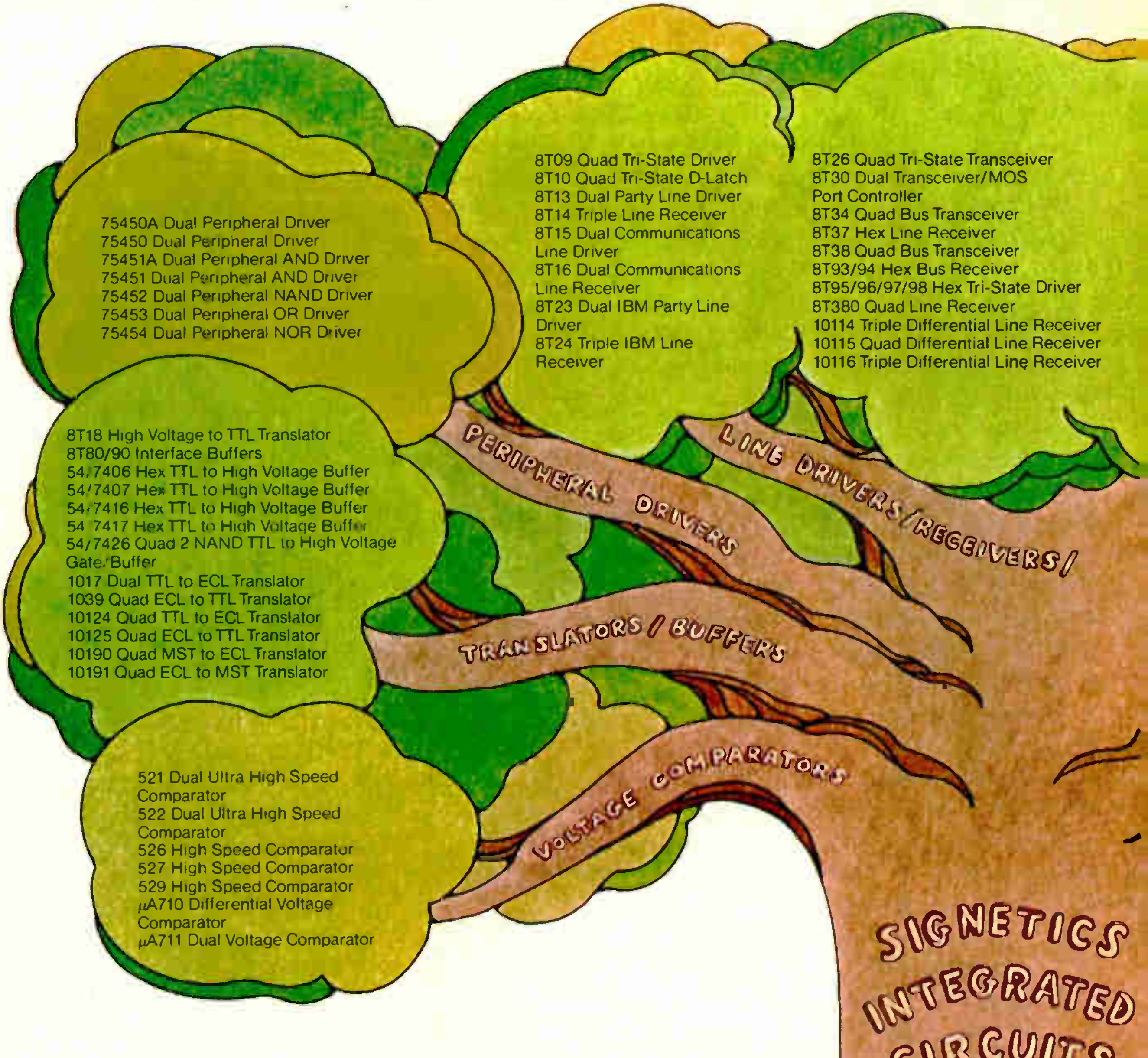
Western Electronic Show and Convention (Wescon), IEEE, Los Angeles, Sept. 10-13.

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

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

International Conference on the Technology and Applications of Charge Coupled Devices, University of Edinburgh, Centre for Industrial Consultancy and Liaison, et al., Edinburgh, Sept. 25-27.

SEE THE INTERFACE FOREST



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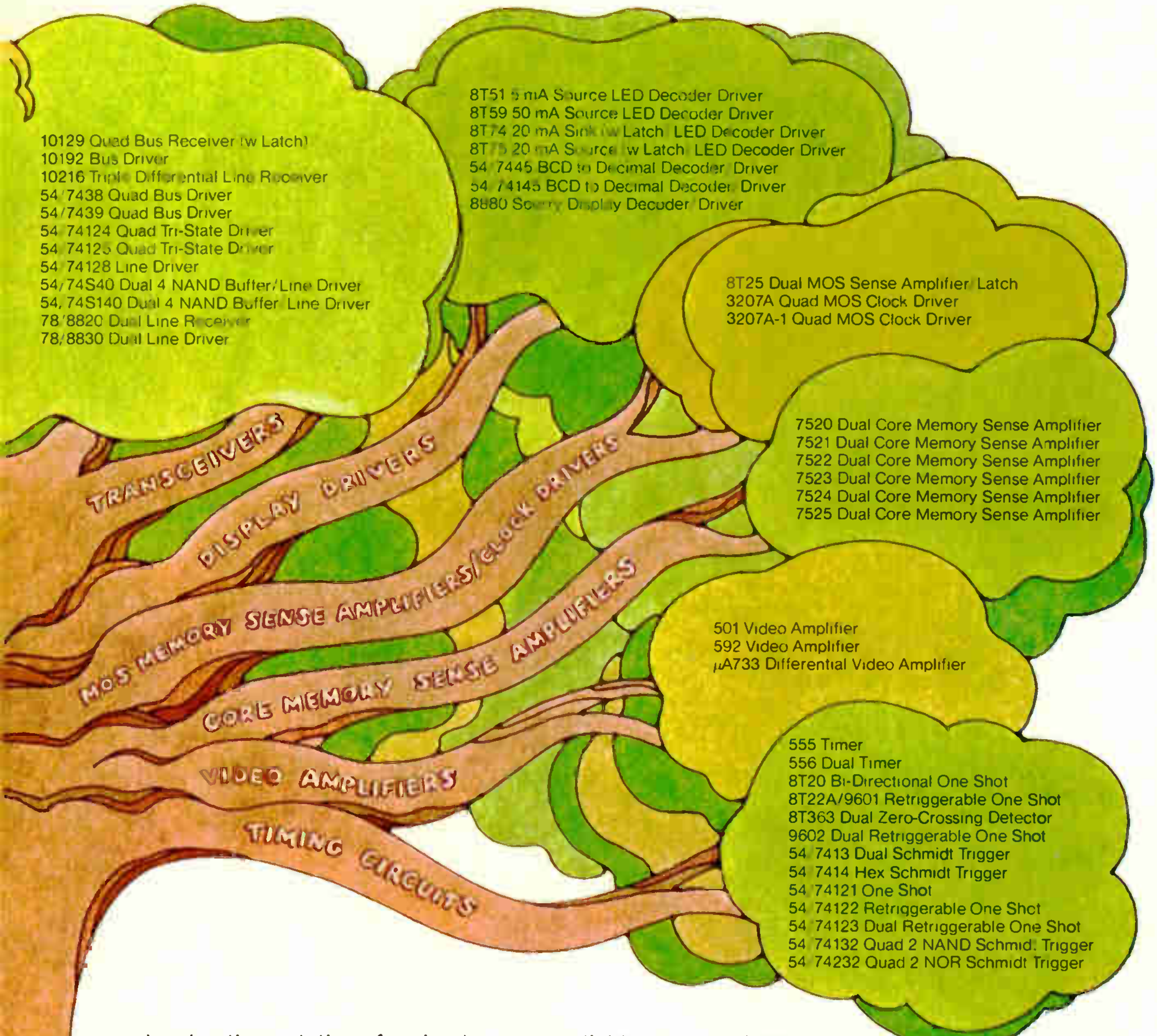

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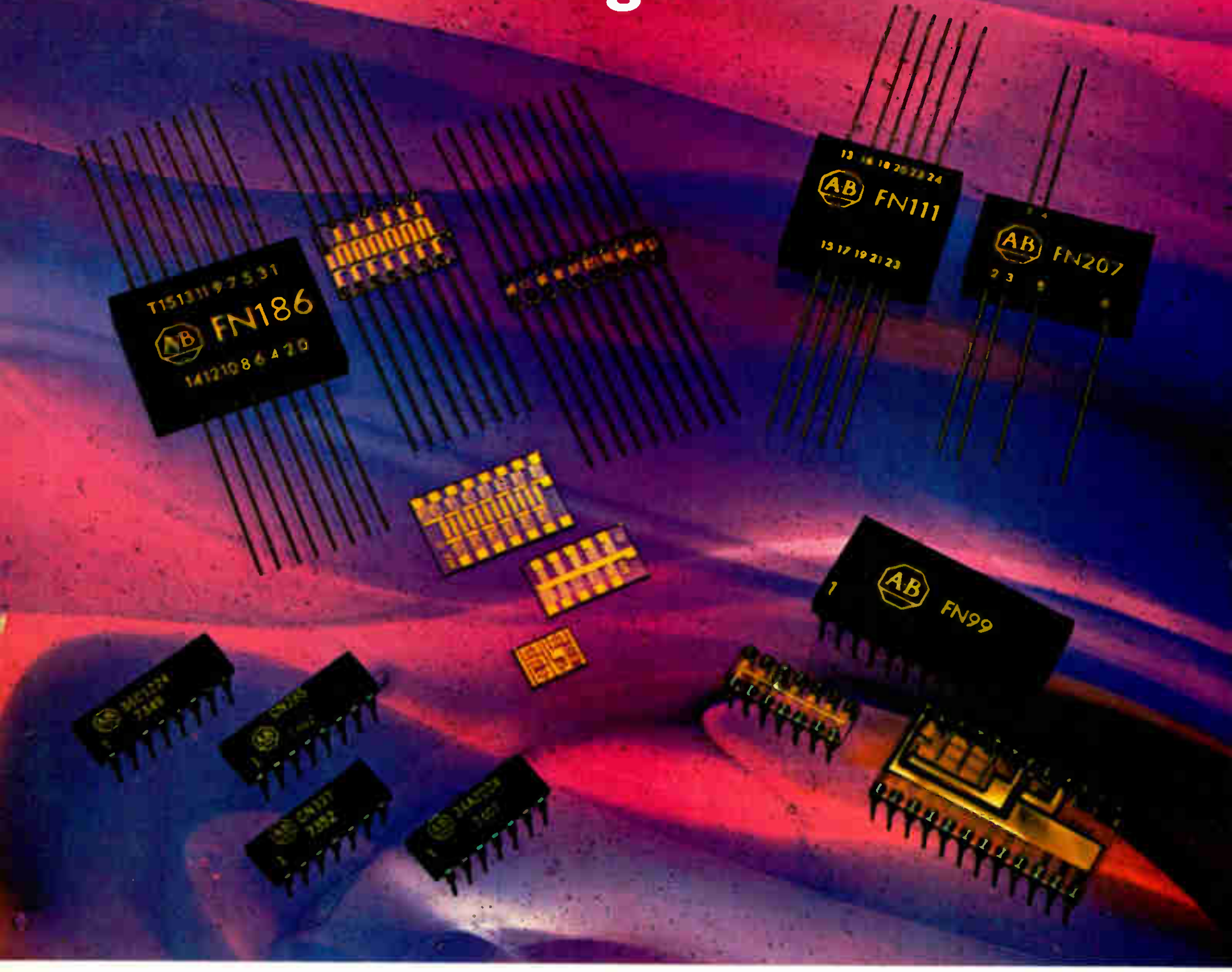

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Electronics newsletter

TI getting close to I²L watch, microprocessor . . .

Reports persist that Texas Instruments will unveil two products—a microprocessor and a circuit for a line of digital watches—using integrated injection logic. **Both product areas are well suited for implementation with injection logic**—the processor because I²L combines some of the speed of TTL with higher packaging density and lower power dissipation than MOS, and for watches, the technology offers the chance for high-speed circuits (4 megahertz and up), which are smaller and need smaller crystals than do equivalent MOS circuits. Also, I²L has high current outputs capable of driving LED displays directly, something MOS can't do.

. . . with products 2 to 6 months away

While TI isn't talking either way, some say those industry-first I²L products are only two to three months away—**but don't be surprised if they don't appear until the end of the year.** Nor will the company comment on any of its processor-design parameters, but I²L technology should be capable of achieving 100- to 200-nanosecond cycle times (compared to 2-microsecond n-channel speeds) in an 8-, 12-, or 16-bit parallel processing format with a large (greater than 75) instruction set.

TI's reluctance to discuss its high-performance microprocessor plans **may be related to its major position in TTL.** A device such as a bipolar processor would surely eat into the market for standard TTL, especially for faster minicomputers and general-purpose machines, not to mention data-communications and process-control applications.

Hamilton to offer women's Pulsar digital watch

The electronic watch market could really open this fall with **introduction of the first women's digital watch.** To be announced by Hamilton's Time Computer division, maker of the Pulsar LED watch, the new timepiece also will have a LED display and will sell for $250 and up.

The new watch will have about half the surface area of the men's Pulsar. It is this need to radically reduce size that has kept manufacturers from turning out a women's watch, but all that president John Bergey will say about the new Hamilton entry is that it was made possible by smaller components and changes in design and packaging.

MOS finds way into tone keyer for telephones

Suggesting a massive new market for MOS in telephones, engineers at Mostek Corp. are developing **a telephone tone-keying module that could shave about half the cost** from its electromechanical counterpart, the firm estimates. Instead of two coils with four windings each—which must be burned-in and tuned by hand—the Mostek approach uses an inexpensive, off-chip 3.58-megahertz crystal for reference, and divides down to obtain the audio frequencies standardized by the industry. On the chip, an op amp performs current-to-voltage conversion, as well as summing the two sine waves to get the tone pairs used. But besides the tone generator, the single C-MOS chip contains all the switching functions handled by the dual-contact, sliding-matrix keyboard now used, allowing touch pads of the calculator one-contact-per-key type.

Despite the high frequency, the chip will operate at voltages down to 3 V, and it boasts a low-impedance buffer capable of driving telephone lines. Samples will be available this year, with production in 1975.

IBM replaces Comsat's partners in satellite firm

The domestic-satellite business has become a whole new ball game with the entry of IBM. **The computer giant has replaced cash-hungry Lockheed Aircraft and MCI Communications as partners of Comsat General** in CML Satellite Corp. The deal involves payment of about $5 million for the one-third shares of Lockheed and MCI—$3.2 million from IBM, the rest from Comsat. Initially, the new company will be owned 55% by IBM, 45% by Comsat General. The purchase is subject to FCC approval.

Navy seeking solar plant

A 100-megawatt electrical-power plant **driven by solar energy has been proposed by the Naval Research Laboratory.** The plant might be located in the southwestern U.S. The NRL says it will accept proposals over the next six months and is emphasizing methods to hold down costs.

Datacom may add minicomputers

TRW Datacom International, an overseas representative with a unique difference—it buys equipment then resells it—is considering adding **additional data products to its line, including a minicomputer.** Datacom handles all marketing, export, and customer support, permitting a small- to medium-size firm to have an instant overseas operation with TRW appearing to be a large OEM.

Datacom, which has exclusive rights to sell Datapoint terminals overseas—it's been responsible for about half of that company's sales—**has also recently added TRW Data Systems' small terminals** and those made by the newly acquired Financial Data Systems subsidiary. Additionally, Datacom has new offices in Brazil, a joint venture in Australia, and has added to sales and service facilities in Switzerland and Canada.

Japanese develop multicopy thermal printing paper

Thermal paper that prints in duplicate—and in color—has been developed by Japan's Jujo Paper Co. in cooperation with the Musashino Electrical Communication Laboratory of Nippon Telegraph and Telephone Public Corp. and Oki Electric Manufacturing Co. Jujo, which calls the new paper Thermal Multi, says it expects to develop thermal paper that prints in triplicate. **The new paper uses the same basic thermal printing technology as conventional papers—two ingredients fused by heat.** The company, which has been licensed by NCR Corp. to make single-sheet heat-sensitive paper, has applied for patents on the improvements that make duplicate printing possible.

The price of the duplicate printing paper is about 10% more than two sheets of conventional paper of the same length. **The paper can be used in much of the equipment now on the market, although the power of the printing head probably will have to be increased by about 20%.** Colors available include black, blue, and red.

Eger leads list of OTP candidates

The leading candidate to succeed Clay T. Whitehead later this summer as director of the White House Office of Telecommunications Policy is John M. Eger. **He was just sworn in to fill the long-standing vacancy as Whitehead's deputy.** A 34-year-old attorney, Eger has been an assistant to Dean Burch, former chairman of the Federal Communications Commission and now special counsel to the President. Eger also is an alumnus of the Bell System, having spent five years with Illinois Bell.

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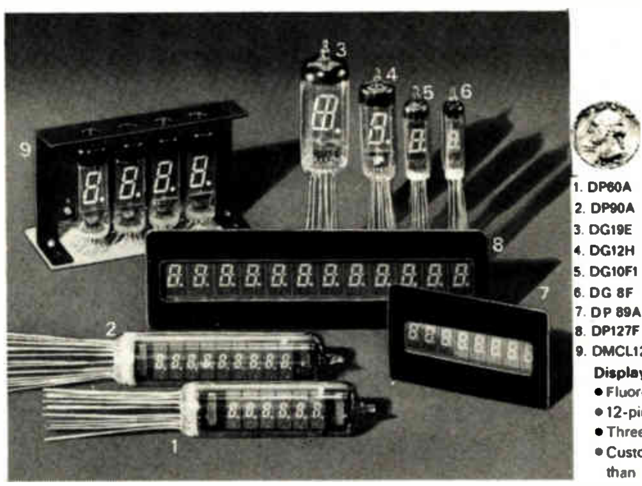

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Japanese develop nondestructive analog semiconductor memory

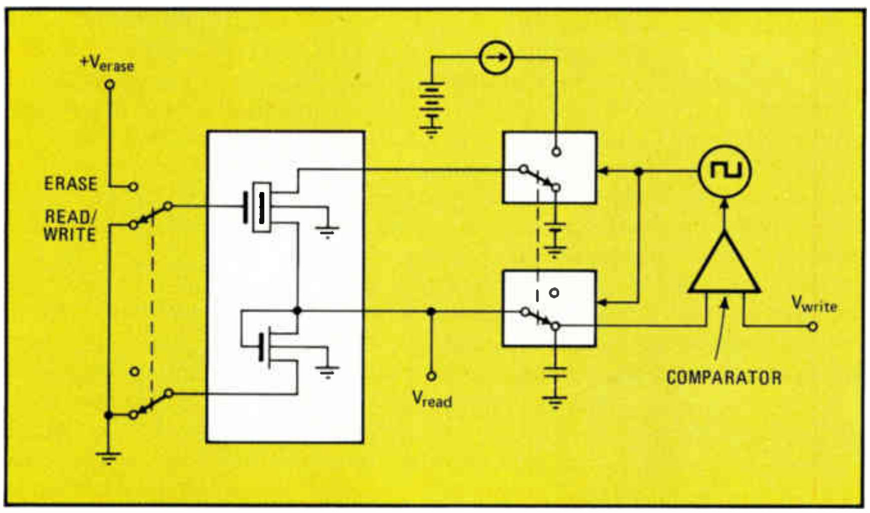
Government laboratory team stores data in a buried-gate of n-channel MOSFET

A semiconductor memory that stores analog, rather than digital, data has been developed at a Japanese government research laboratory. Among the applications envisioned for the memory are adaptive control systems, transient recorders, and zero-offset compensation when the device is included on the same IC chip as an operational amplifier. These applications then need no analog-to-digital conversion, digital memory, and conversion back to analog form that some systems require. However, advanced developments are usually not pursued by the Japanese government's research-oriented Electrotechnical Laboratory, where the device was developed. Head of the team is Yasuo Tarui, who first reported Schottky TTL devices and the diffusion self-aligned transistor, also called D-MOS. Yutaka Hayashi is responsible for most of the work on the analog memory.

In the device, the equivalent of a single memory cell directly becomes an analog memory that stores signal voltages—over the range of 0 to 4 volts, for example. Precision is within 0.25% ±2 millivolts initially, with a decay on the order of 0.5% to 1% per day. However, there are indications that storage life can be increased by several orders of magnitude by improvements in fabrication technology.

Structure. The basic memory device is a buried-gate n-channel MOS field-effect transistor. A floating gate of polycrystalline silicon is buried in the silicon-diode gate insulation, and a second gate of aluminum covers both the buried gate and the channel. Silicon-diode insulating layers—between the buried gate and the channel and between the second gate and the buried gate— are 50 to 100 nanometers thick.

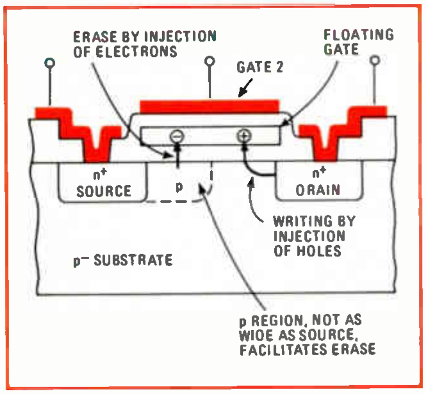
Information is stored as a charge on the buried gate, and readout is obtained by current flow from source to drain under control of the stored charge. And since the current flow does not affect the stored charge, readout is nondestructive. The addition of a controller using feedback-circuit techniques turns this device into a practical analog memory. The memory includes a constant-current power supply for writing, a comparator for comparing write and read voltages, and a square-wave generator, as well as switching circuits to facilitate writing. Erasure requires the addition of switches and of a low-voltage power supply.



Architecture. When the V_{write} voltage being measured exceeds the stored V_{read} voltage, the comparator-run square-wave generator causes stored voltage to increase in steps.

The Japanese device can be considered an improved version of the Famos structure designed to be electrically alterable [*Electronics*, May 10, 1971, p. 91]. Since it is a digital memory, there is no need to store a very precise charge on the buried gate — just enough so that the device is heavily biased on—for adequate discrimination from other cells that are not charged.

Other types of MOS devices are capable of operation in a linear mode, but linear operation of Famos-like devices is not easy because the gate potential cannot be either easily controlled or measured. However, the Japanese engineers solved that problem by utilizing



Afloat. By utilizing avalanche breakdown to inject holes or electrons, device offers control of charge on floating gate.

a feedback arrangement in the control circuit of the device.

Operation. The memory's read output is normally connected to one input of the comparator, and the other input accepts a write voltage. When the read output is zero and the write input has some value greater than zero, the comparator generates an output signal that turns on the square-wave generator. Period of the square wave is about 1.5 milliseconds.

On the first half-cycle of square-wave output, switching circuits both disconnect the read output from the comparator and switch the memory-transistor's drain from an operating power supply to a more powerful constant-current avalanche supply. During the period, a small charge is transferred to the memory-transistor's buried gate by avalanche breakdown at the drain. Transfer of charge is limited by the short time that avalanche current flows.

During the second square-wave half-cycle, the switching circuits are restored to their normal positions, and comparison is again performed. The write cycle is repeated 50 or so times until the read output equals the write input. Then, the square-wave generator is no longer enabled by the comparator, and the memory exhibits the stored analog voltage at its read terminal.

The comparator has two functions. It turns on the oscillator when there is a difference between read and write voltages. And it tapers down the avalanche current as the difference between read and write voltages becomes smaller.

Device current is converted to output voltage by an enhancement-type MOSFET load having geometry similar to the memory element and fabricated on the same chip. Voltage across the load is proportional to the square root of the memory current, resulting in a memory voltage linearly proportional to stored charge. The use of a load cancels errors from temperature changes.

Erasure is performed by opening the source connection of the memory element and, at the same time, applying positive voltages to gate two and the drain. This causes a high-field region at the surface of the p-diffusion, which in turn causes avalanche breakdown that injects high-energy electrons into the floating gate and erases the memory. □

Military electronics

Cylindrical phased-array antenna scans 360 degrees electronically

The great attractions of electronically scanned antenna arrays are that they remain stationary and have no moving or rotating parts. But because these antennas are generally built in a single plane, it's hard to obtain the all-around, 360° of coverage of even the simplest rotating antenna.

Motorola's Government Electronics division, however, has come up with a unique solution to the problem of a stationary antenna with 360° coverage—it has built an electronically scanned array in the shape of a cylinder. The result, for an airborne drone-control system, is a much simpler and more compact antenna installation than if one had used a rotating dish or a pair of arrays placed back to back.

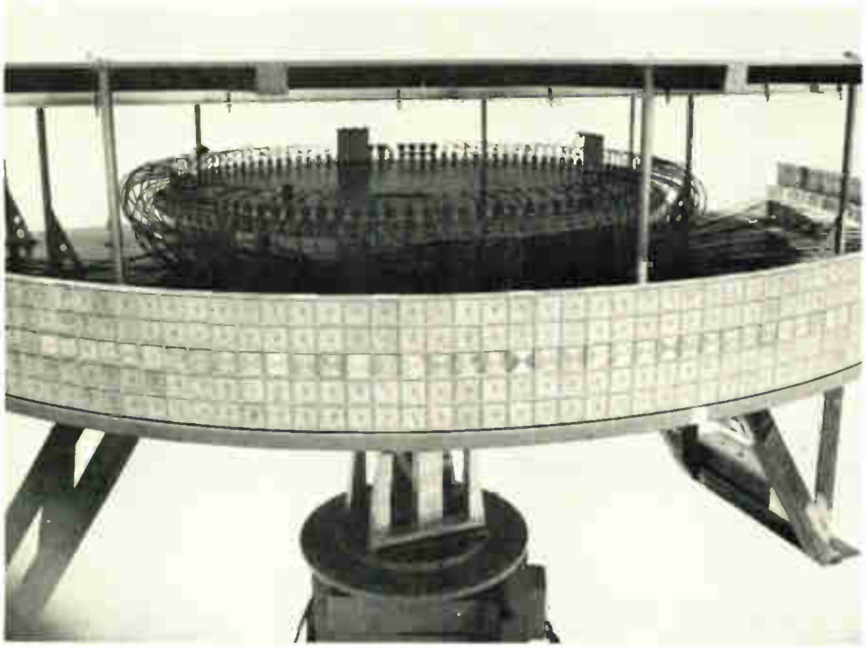
Five feet high and eight feet, 8 inches in diameter, the scanned cylindrical antenna fits into a seven-ft-high, 13-ft-wide, and 20-ft-long radome. In an operational system, the radome would be mounted atop a 14-ft pylon on a C-130 aircraft. The only moving parts of the antenna are for stabilization of its platform; the beam can be switched from any direction to any other in less than 100 microseconds under digital and rf control.

The antenna is being developed by the Scottsdale, Ariz., division under contract to the Naval Air Systems Command. A partial breadboard is being tested now, and the antenna is to be completed early in 1975. The first use could be for a system to control target drones by late 1975.

Drone application. The antenna is part of the AN/ASW-35 drone control system, an airborne version of the Motorola AN/TSW-10 ground-based drone-control complex. The cylindrical antenna replaces the eight-ft dish of the ground version. The ground antenna has better azimuth accuracy—less than 1 milliradian vs 4—largely because of the limitations of the airborne inertial guidance system used for heading reference. Range accuracy for both is 65 yards. Range to the drone is 150 nautical miles; as a relay, the airborne system could extend the range of a ground station to 400 miles. Transmitter output is 250 watts.

The antenna is not a phased-array in the conventional sense. Instead of relying on ferrite or diode phase shifters, which change the phase of energy applied to individual antenna radiating elements, and hence change its direction, the new antenna uses an electronic "lens" that maintains the proper phase relationships.

The lens—a flat, 52-inch-diameter cylinder concentric with the larger cylinder supporting the antenna elements—controls the microwave power going to the radiators. It does this through a complex arrangement of probes, to which the transmitter power is fed under the direction of



Round array. Scanning lens at center controls energy radiated by Motorola's partly built phased-array antenna. One set of horizontal radiators (in middle) is flanked by dummies.

high-power diode switches. These switches permit the antenna beam to scan or jump around as in other types of phased arrays. Coaxial cables carry power from the probes to each radiating element. Altogether, the system has 1,024 diode switches, each capable of handling 700 watts at 5 gigahertz.

The antenna has 216 radiating elements, each 30 in. high and consisting of 20 1.5-inch-square flat spiral antennas, arranged 20 high and one wide on the surface of the cylinder. Only 108 probes are in the system, but, by switching, they serve radiating elements on opposite sides of the structure. The probe spacings are chosen so that when the probes are energized, a flat wavefront is propagated.

Hurdles. All 20 segments of a radiating element may be selected for long range or only six for shorter range, but wider elevation coverage.

All of the switches, controlled by a minicomputer, are single-pole, double-throw devices. If each lens probe were selected in turn, 216 distinct directions would be possible. Motorola, however, uses proportional excitation of two adjacent probes to provide fine adjustment.

Aside from its complexity, a limitation in the antenna is a relatively low 24-decibels gain predicted for its aperture, caused partly by losses in the switching system. □

Solid State

Germans escalate C-MOS density

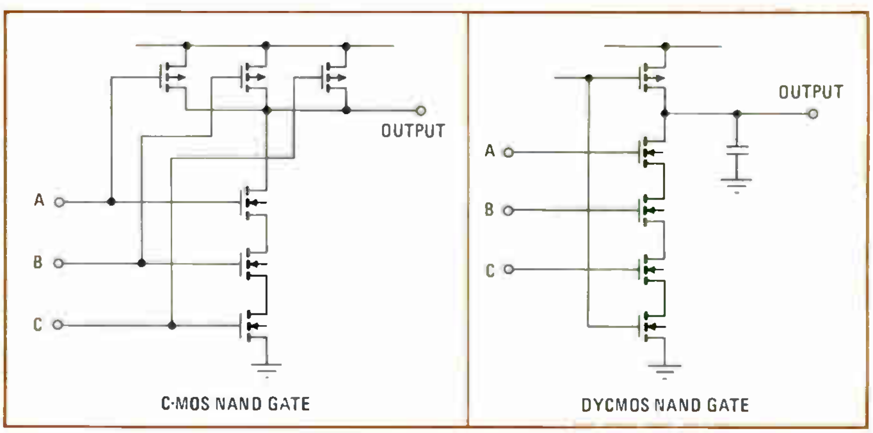
For all their advantages, complementary-MOS circuits have one shortcoming: they need more area than other MOS technologies. This drawback is attacked in a new circuit concept—Dycmos—developed at Valvo GmbH, the German components-producing subsidiary of Philips Gloeilampenfabrieken. Says Martin Kalthoff, head of the Valvo lab concerned with numerical-information engineering, "Preliminary estimates indicate that, compared with C-MOS, a savings of at least 30% can be obtained."

This saving in area with Dycmos—which stands for dynamic C-MOS—is achieved in two ways: by reducing the number of circuit elements needed for particular functions and by using a system layout in which a smaller area is taken up by the interconnections.

To change the output state in an ordinary C-MOS NAND gate, two transistors are needed for each input, or 10 transistors for a five-input gate. Each input is connected to p-channel devices connected in parallel between the voltage supply and the output and to n-channel transistors connected in series between the output line and ground.

Parts savings. The Dycmos NAND gate, on the other hand, can do with only one transistor per input—the series-connected n-channel unit—plus two charge-reversing transistors that are connected in series with the n-channel devices. One, a p-channel unit, is connected between the power supply and the output line. The other, an n-channel device, goes between the input transistors and ground. Finally, parasitic capacitance between elements in the structure is harnessed and used as if

Ground rules. The saving in chip real estate with Valvo's Dycmos technique even shows up in simple NAND gate, which requires five transistors, compared with six in standard C-MOS.



there were a capacitor between the output line and ground.

The gates of the two charge-reversing transistors are connected together, and if the clock input is connected to these gates and is at the 0 level, the parasitic capacitance is charged up via the p-channel transistor, giving a 1 at the output. During the readout phase, when the clock is at 1, the output goes to 0 only if all inputs are at 1. In any other case, the output of the circuit stays at 1.

Adder. The savings in elements is even more pronounced in such complex circuits as an adder. For example, 12-input C-MOS version has 24 transistors, but the Dycmos equivalent can do with only 14. Kalthoff says that similar components-saving techniques following roughly the same Valvo idea have been developed elsewhere, too—for example in C^2MOS that Japan's Toshiba is working on.

But what distinguishes Dycmos from other concepts is its special interconnection scheme. In Dycmos, a distinct division is made between the memory and switching functions. The memory elements are laid out in one row, with the switching elements arranged below that row in a matrix configuration. In this array, all switching transistors are placed for the best fit with the wiring scheme. In other words, the switching transistors are added after the interconnection grid is laid out, and distinct gate circuits in the new scheme can no longer be recognized as such.

More savings. This interconnection technique yields a saving of up to 50% in the area occupied by wiring alone. As a rule, the greater a circuit's wiring complexity, the more beneficial will be the switch from conventional connection techniques, Kalthoff points out. The new method is most effective in complex circuits, such as random-logic devices.

Using the concept, the Valvo engineers have already built some laboratory-type register-counters and programable logic arrays. Kalthoff expects commercial Dycmos devices will be available next year. They'll most likely be custom-designed circuits for use in complex digital systems. □

RCA begins making fast memories

RCA Corp. is moving briskly into the high-speed computer-memory market. The move underlines the division's general expansion mood—from linear and industrial digital-logic products into the high-performance mainstream of computer components.

In its biggest digital-product expansion since pioneering the complementary-MOS market five years ago, RCA is introducing three high-performance RAMs—the 7001, the popular, fast 1,024-bit RAM, and two C-MOS-on-sapphire RAMs of 256 and 1,024 bits. The technology for the 7001 was acquired from Advanced Memory Systems in a stock deal. RCA has already announced an 8-bit two-chip C-MOS microprocessor [*Electronics*, Feb. 21, p. 25].

Orders. Bernard V. Vonderschmitt, vice president and general manager of the Solid State division, says RCA is already taking orders for the 7001. The company, which is packaging the 7001s from AMS dice at its present IC-production facilities, will shortly move its production of all data-processing components—memories and microprocessors—to the site of its former Computer division in Palm Beach Park, Fla. There it will use the basic AMS process to manufacture 7001s, as well as its proprietary sapphire-based memories, scheduled for introduction by the end of the year.

In addition to the stock deal—RCA bought $2 million worth—AMS and RCA have signed a three-year, $750,000 agreement to exchange memory and microprocessor technology. AMS is making available its memory developments in exchange for RCA's C-MOS-on-sapphire technology, which includes the new line of RAMs. In effect, this gives both companies automatic second-source capability on all memory and processor products developed in the next three years.

Competitor. Indeed, the 7001 and the sapphire-based RAMs are intended to compete with today's bipolars. The 256-bit static C-MOS-on-sapphire part will have an access time of less than 50 nanoseconds, while the 1,024-bit static device can be accessed in less than 100 ns. In addition, RCA is developing its own version of low-power Schottky TTL for computer applications.

The division is also planning soon to open a manufacturing plant in Brazil, both to serve the growing South American market and act as an offshore IC feeder for its U.S. and other markets. General manager of the Brazil operation, called RCA Electronica, will be William A. Glaser, formerly director of the thyristor and rectifier departments at Solid-State in Somerville, N.J.

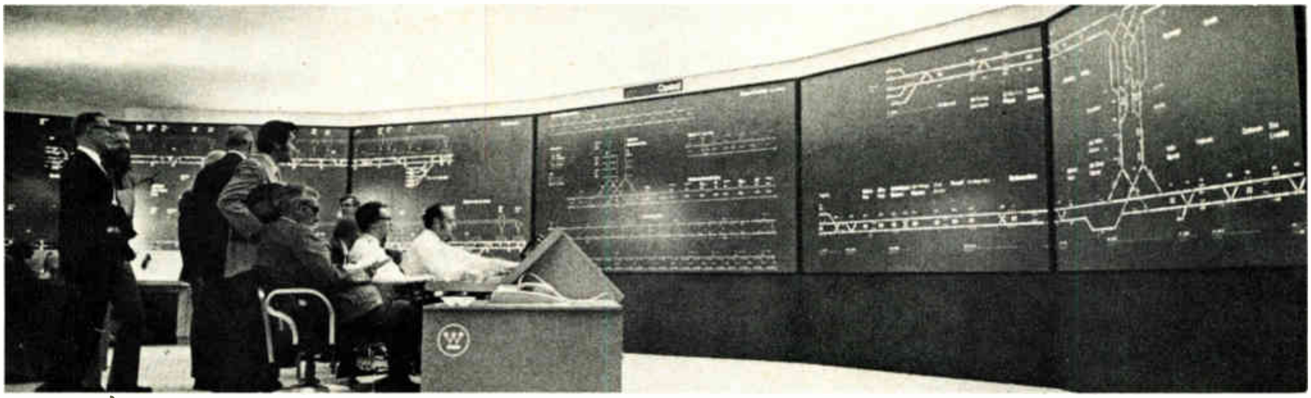
RCA is reported also to be evaluating production sites in Europe. All told, the Solid State division hopes to increase its sales by more than 40% this year, Vonderschmitt says. □

Transportation

BART is upgrading computer controls

The fix is going in for the San Francisco Bay Area Rapid Transit system. BART's control network may finally become reliable enough for completely automated operation of trains over the 75 miles of track in the mass-transit system. And there's hope that trains at last may be allowed to travel on the idle tracks under San Francisco Bay. State officials have forbidden operation through the bay tunnel because of the complexity of the track-merging system that trains must negotiate, and they doubt the capability of the control system to prevent disaster there.

Computer hardware and software will both have key roles in upgrading the system. The two Westinghouse Electric Corp. Prodac 250



Control center. Entire transportation complex of Bay Area Rapid Transit District shows up on display at headquarters in Oakland. This is the nerve center of the automatic train-control system that was designed by Westinghouse Electric and is presently being augmented.

computers, used for train-monitoring and sequencing chores, were reprogramed last month at BART headquarters in Oakland. Its new Computer Augmented Block System (CABS) backs up the original $36 million control system, designed by Westinghouse Electric.

BART officials hope that CABS will enable them to phase out the circa-19th-century control system required by the California Public Utilities Commission—flagmen at each station to keep trains at least two stations apart. The PUC, disturbed at the beginning by test results, ordered flagmen even before the system began operating in September 1972.

With CABS in place, BART will request permission from the utilities commission to reduce the two-station train separation, or headway, to only one station. This will considerably speed up service by reducing headway from 10 minutes to five.

Hardware, too. A new hardware system, Sequential Occupancy Release (SOR), is expected to reduce that all-important headway to 3⅓ minutes. This is still more than double the 1½-minute headway promised originally by Westinghouse. But it is, apparently, what BART will settle for. The processor system will ensure that one train has actually passed from one block to the next before allowing the next train to proceed. And the system will remember where each train is. It won't be fooled if a train-location signal fails because of circuit trouble or dirt buildup on the track, which carries the control signals.

"Once a train is detected in a block," says David S. Cochran, one of the two Hewlett-Packard Co. engineers called in to help BART get its system running properly, "the logic latches or locks the block behind it." This precludes the possibility of a rear-end collision if loss of detection occurs. The block is then unlocked, and the train progresses down the track, once the train ahead is checked out by the processors.

BART has already installed the SOR system at two of the 26 stations tnat will eventually have them. (There are 34 stations in all.) SOR is controlled by a pair of Computer Automation Inc. Alpha LSI digital processors to provide redundancy.

BART has been plagued with trouble since it began operation. The situation hit an all-time low in October 1972, when a train went off the end of the track in Fremont, Calif. Since then, an attendant rides alongside the brake in the front of each train. Fortunately, the cause of this accident was not the automated system. Rather, it was a faulty crystal-oscillator circuit that misinterpreted a command to stop, but instead accelerated the train. □

Government electronics

NOAA seeks funds for tornado net

Tornadoes whirling into the midwest in April caused widespread destruction, but timely warning by the National Oceanics and Atmospheric Administration's "weather wire" service prevented the deaths from being numbered in thousands.

So successful do NOAA officials regard the fm weather-warning transmitting system that they have sent a $20 million supplemental appropriation request to the White House Office of Management and Budget that would allow, in part, the net to be expanded to 300 transmitters blanketing the entire nation.

Gerald D. Petersen, NOAA director of meteorological and hydrological services, called the expansion of the transmitter system one of the most important recommendations to come out of the agency's study of operations during the tornado strikes. It will cost about $5 million. NOAA said thousands of persons would have been killed this spring if the existing warning net of weather radar and 64 fm transmitters had not been operating. The death toll reached 329.

Priorities. Other principal recommendations in the NOAA report include a one-year acceleration in radar procurement for the agency's national and local networks. In addition, there will be a similar speedup in NOAA's conversion of its network of teleprinter links for local radio and TV broadcasters to a high-speed digital system.

The report recommends accelerating long-range radar buys so that 24-hour-a-day surveillance of the entire country can be attained by 1975. The first contract for 56 long-range radar units for a national network was awarded to Enterprise

Electronics, Enterprise, Ala., in June. Each unit will cost about $100,000, NOAA said. Approximately 67 local weather radar units, at $50,000 each, also will be installed by the Alabama company by 1977 rather than 1978, if the report's recommendations are approved by OMB and Congress.

NOAA's proposed telecommunications plan also should be accelerated, the report recommends—the $35 million digital system should be completed in 1979 rather than 1980. NOAA has not yet issued a request for proposals on this new communications system.

Tone-alert. The fm radio network operates 24 hours a day at 162.55 and 162.4 kilohertz and has a "tone alert" that signals before an emergency weather prediction is broadcast. The NOAA report recommends that receivers, available for under $30 at commercial electronics dealers, should be placed in schools, hospitals, and local government buildings to give early warning of impending storms.

Although sources say OMB is unlikely to send the entire $20 million proposal to Congress—NOAA's total 1975 budget request was $49 million—they expect OMB to approve the appropriation request for the expanded radio network. It had not been part of NOAA's 1975 budget request, but was part of NOAA's long-range plans, Petersen said. □

System prints out courtroom notes

The price is almost right for a computer-based transcription system that can translate a court reporter's stenotype notes into a printed record of courtroom proceedings.

Last summer, when NCSC first opened bids for proposed systems, they were priced at least 20% higher than manual-transcription methods [*Electronics*, Aug. 30, 1973, p. 49]. Manual methods cost about $1 per page, while five companies had bid from $1.25 to $2.50 per automatically printed transcript page.

Helping to drive costs up were variations in court reporters' styles, which called for more complicated programs than had been previously available, says Michael Greenwood of the nonprofit National Center for State Courts, headquartered in Denver. But by designing more limited, though still flexible, software packages, NCSC has been able to negotiate the bid prices down; however Greenwood still won't say how much the reduction is.

What's more, to gain operating experience, as well as to help promote the technology, NCSC is helping to fund the installation of one of the first such systems in the Common Pleas Court in Philadelphia.

At least three additional systems will be installed elsewhere, with funding support expected from the Law Enforcement Assistance Administration. NCSC will advise the courts on the installation—at least 10 municipal courts are said to be interested—and help evaluate the systems' performance.

Feasible. A computerized transcription system is technically feasible for "perhaps every courtroom in the country," points out Greenwood. So far, however, the systems have been too expensive. But he predicts that they will become competitive with manual systems in two to four years, once development costs, particularly of software, have been amortized.

The Philadelphia system will be a fairly large one. It will serve 15 to 20 court reporters and have a computer system able to produce more than 100,000 pages of transcript annually, Greenwood says. Other systems to be installed under NCSC's guidance will accommodate only two or three court reporters and won't have the computer-print-out capability planned for the Philadelphia system.

Editing. The transcription system uses magnetic-tape cartridges or cassettes to take down the symbols struck by a court reporter as he operates his stenotype machine. These symbols are then decoded in a minicomputer-based system and displayed on cathode-ray tubes, where an operator can correct the computer translations of the notes. "Since each reporter has a different style, someone must make corrections before the print-out can be made," explains Greenwood.

For a large in-house system, such as the one planned for Philadelphia, a minicomputer might feed the coded transcript notes into a larger machine, and a bank of CRTs would be used for correction of reporters' notes. The total cost of the hardware needed for the Philadelphia prototype will be less than $250,000, Greenwood says.

Industry sources say that other potential applications for the systems include transcripts of corporate meetings and legislative hearings in all branches of government.

Five companies originally bid for the NCSC system, including Stenocomp, Inc., Bethesda, Md., Stentran Systems Co., Vienna, Va., and Stenographic Machines Inc., Skokie, Ill. □

Communications

Transceiver sends voice and data

It will be many years before the volume of digital data transmitted through telecommunications lines even approaches the amount of voice traffic. But, preparing for the future, scientists at consultant Arthur D. Little have designed a microwave-radio system that uses relatively inexpensive hardware to transmit both voice and digital data.

The result is a pulse-code-modulated, time-division-multiplexed digital microwave transceiver prototype that ADL says could be built for less than $5,000. The company is seeking licensees to manufacture it. ADL estimates the transceiver could be manufactured for approximately half the price of digital or analog transceivers. It was built mainly with off-the-shelf components, and Arthur H. Solomon, a staff member at the Cambridge, Mass. company, says that it can be manufactured in volume in hybrid form on printed-

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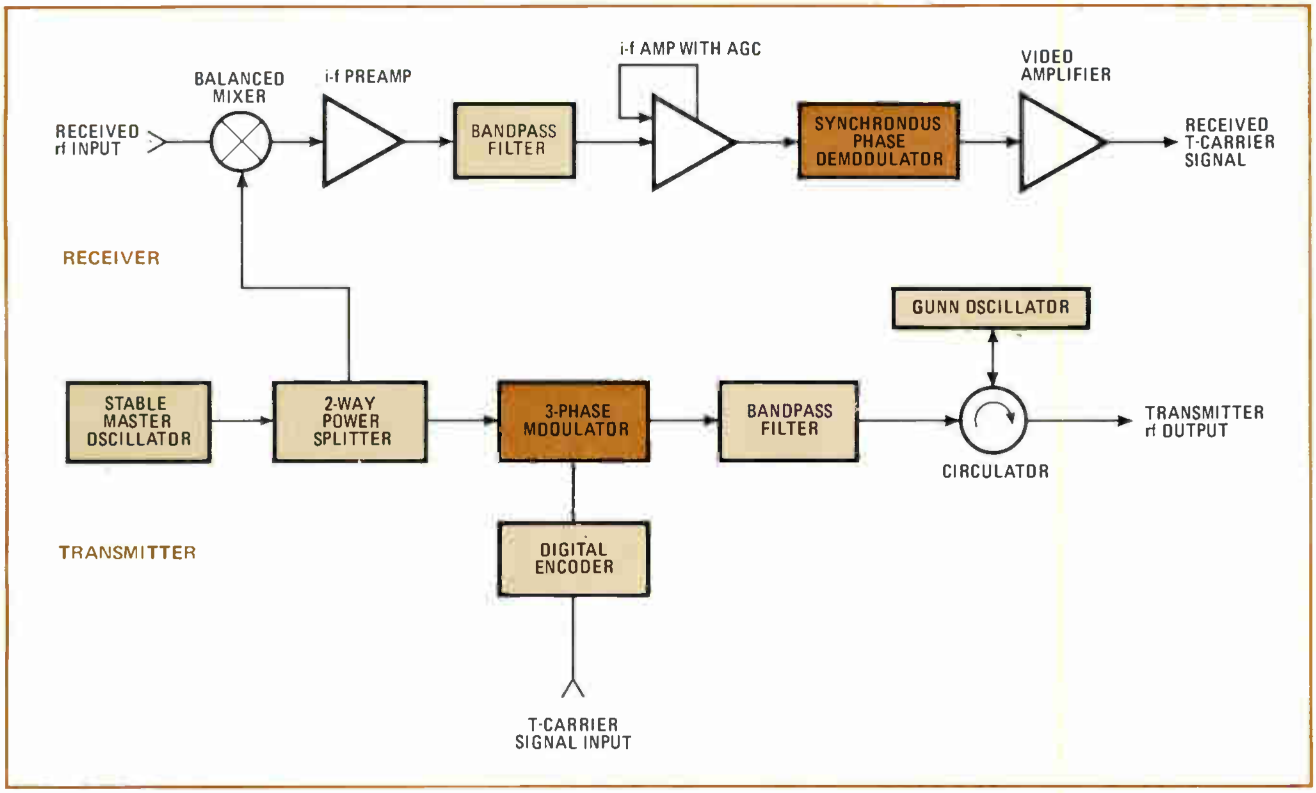

Combination. Arthur D. Little's digital-and-voice microwave transceiver uses a proprietary modulator, which produces 3 phases corresponding to the Bell System three-level T-carrier, and a demodulator, which reproduces the information from the phase-modulated signal.

circuit-board production lines.

The prototype system uses a private microwave frequency band at 12 gigahertz, but the transceiver could be designed for common-carrier bands operating at 11 or 18 to 23-GHz. Channel bandwidth of the 12-GHz system is 20 megahertz. The maximum data rate of 10 megabits per second is the equivalent of 150 single PCM-encoded voice channels, or 300 cross-polarized channels, and the bit-error rate is a maximum of 10^{-8}. The system has a useful range of approximately 10 miles, and it is designed for direct connection to a small parabolic dish antenna.

Design goals. At the outset, ADL assumed that most future digital microwave equipment would operate at bit rates corresponding to those of the Bell System's three-level T-carrier equipment for cable transmission of digitized voice traffic. There are two T-carrier transmission rates—T-1 at 1.544 megabits per second and T-2 at 6.33 Mb/s. The ADL transceiver accepts PCM signals conforming to the three-level T-carrier signal pattern.

However, most digital microwave-radio modulation formats have two, four, or more signal levels, which requires a digital encoder to translate the three-level T-carrier signal to a modulating signal. And the receiver needs a clock to synchronize and a decoder to sample the demodulated signal at the rate the bits are transmitted.

ADL was able to shave the cost of modulation-demodulation by using an inexpensive proprietary transmitter-modulator, made with standard Schottky mixer diodes, to produce three phases directly corresponding to the three amplitude states of the T-carrier signals.

And the receiver contains a proprietary synchronous phase-locked-loop demodulator to reproduce the three amplitude states directly from the phase-modulated signal. By transmitting a replica of the T-carrier signal, ADL eliminates the need for a preset timing circuit and decoder in the receiver.

Transparent. Using three-level modulation makes the transceiver completely "transparent" to the bit rate; the system can transmit and receive at any clock-rate between 4,800 b/s and 10 Mb/s. Conventional systems can transmit and receive at only one clock rate.

The system can transmit signals from T-1 and T-2 datasets, as well as nonstandard signals at higher or lower rates from a time-division multiplexer. Most conventional analog microwave radios use frequency-division multiplexing, which requires an expensive bandpass filter in each channel of the multiplexer. With TDM, there is no need to separate the signal by frequency, thus disposing of the need for narrowband filters, which lowers system cost still further. □

Trade

Puzzlement follows Soviet delegation

A USSR trade delegation visiting U.S. electronics companies during the first two weeks of July had everybody involved walking on eggs.

Not only did State and Commerce department officials refuse even to identify all of the companies on the delegation's itinerary, spokesmen at some of the companies were playing it cagey too. They either denied they were to be visited, or stressed that they didn't know what the Russians wanted and that the tour was undertaken at the Russians' instigation.

Semiconductors. But it was clear that the Russians seem particularly interested in semiconductors. On their very first day, they were at RCA's Solid State division, Somerville, N.J. Also scheduled were stops at ITT Semiconductor, West Palm Beach, Fla., and Fairchild Camera & Instrument Corp., Mountain View, Calif. A visit to General Instrument Corp., New York, included discussions with executives from the Microelectronics division, Hicksville, N.Y.

Still another on the visit list is Rockwell International in Anaheim, Calif., the location of that company's Microelectronics group. Other organizations hosting the Russians include RCA's Sarnoff Research Center, Princeton, N.J.; Control Data Corp., Minneapolis, Minn.; and Hewlett-Packard Co., Palo Alto, Calif.

Puzzle. What the Russians really have in mind, no one is saying. And the Russians themselves are not commenting. One source has it that they might be interested in turn-key semiconductor production plants to be set up within the Soviet Union.

However, the visit is important to the Russians, as can be measured by the high rank of the delegation members. The leader is V.G. Kolesnikov, vice minister of the Ministry of Electronic Industry. The other members are Y.V. Stetchichin, deputy director of the Import-Export department of the ministry, J.P. Dokuchaev, chief of research of the Semiconductor Research Institute, and P.P. Goidenko, manager of a large semiconductor plant.

But the secrecy of U.S. officials regarding the visit is puzzling. According to them, the Americans requested the visit originally and wanted it secret. "We could not publicize a commercial visit without

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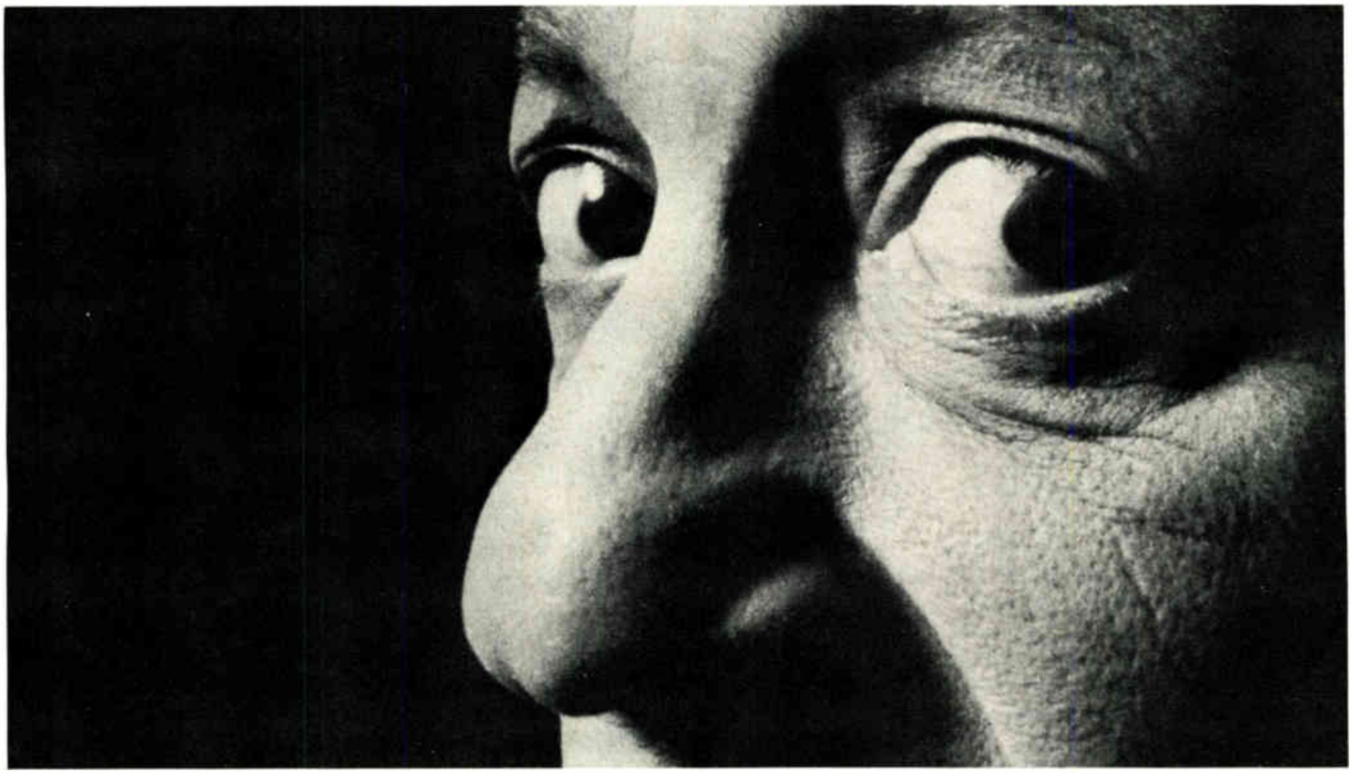

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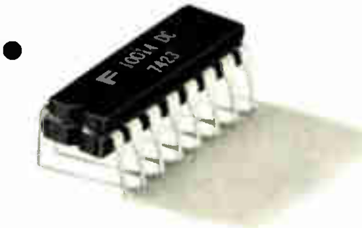

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Thanks to Fairchild's new F10014 monolithic active ECL terminators.

Each F10014 device provides a handy monolithic package containing 14 terminators—all useable over a wide range of impedance.

Of course, wherever carefully controlled impedances are maintained, matched passive resistor termination remains technically preferable.

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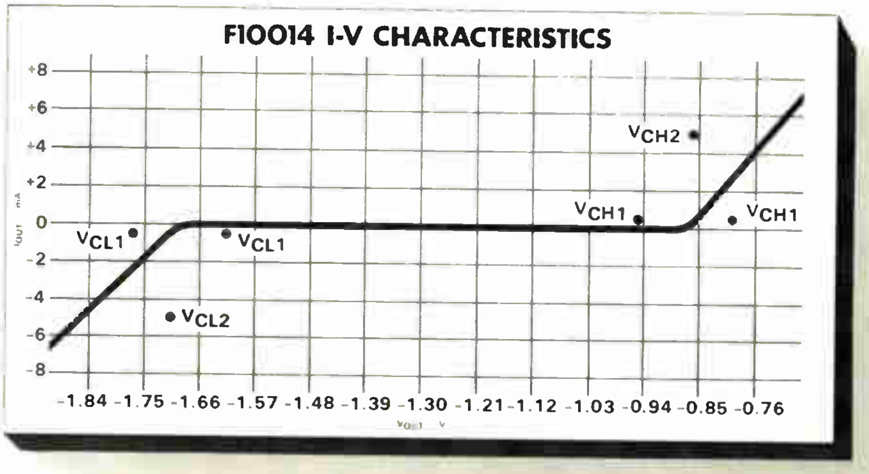

How Fairchild's remarkable new F10014 ECL active terminator works.

Looking at our F10014 characteristic curve you can see that the F10014 device exhibits a high impedance when the input signal is within normal ECL operating levels. But as soon as ringing or overshoot appear, the impedance drops.

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You can use the F10014 as the only termination. Or, in conjunction with passive termination as well.

Six key advantages.

Compared with diode clamps or conventional passive termination packages available, the new F10014 active terminator affords at least five or six worthwhile advantages.

1. The F10014 costs less per termination than other packages or diode clamps (see cost comparison table).
2. It has self-contained reference voltages. No external components or -2V supply required.
3. The F10014 can reduce your total system cost. And it can help you save money in other ways. Like allowing you to use more wire-wrap interconnects.
4. It uses low power—about 7.0 mW per termination.
5. The F10014 reduces design time. It successfully terminates the varying impedances to be expected on wire-wrap boards used in prototyping or with design modifications.
6. The F10014 is compatible with all ECL families. It avoids heavy drain on ECL families not rated for driving resistive terminations.

Comparative ECL Termination Costs.

Type	No. of Terminations	Price 100-999	Cost of Termination
Packaged Resistor Networks	10-12	0.74-2.25	.074-0.19
Clamping Diodes	1	1.00-2.00	1.00-2.00
F10014	14	**.98**	**.07**

permission from the hosts," a State official said.

More than competition is involved. Said a spokesman in the Commerce department: "The companies feel there is a whole range of opposition here to semiconductor trade with the Russians. There is concern that such components could be used by the military, and that American jobs, as well as technology, would be exported. The companies fear a backlash of resentment if it is publicized." □

News briefs

TI's new patent covers many miniature calculators

Texas Instruments, a leader in the hand-held calculator market, has been issued a patent that covers a large part of the field. "It is a basic patent and not restricted to any specific model or configuration," says a TI official. The patent is for "a miniature, battery-operated calculator with keyboard and display, with its main electronic circuitry in a single semiconductor-circuit array," as in the popular one-chip models.

First filed in September 1967, the patent application describes a four-function calculator, measuring 4¼ by 6⅛ by 1¾ inches, with an 18-button keyboard and a 12-digit thermal printer display—apparently a forerunner of the Canon Pocketronic, designed and built by TI. The firm intends soon to make licenses on the patent generally available to the industry. Bowmar, which received a patent, last December on a one-chip calculator, says its lawyers are investigating the development, while Rockwell International, another calculator manufacturer, says it is interested in the development but cannot comment because the company has not yet seen the TI patent.

Motorola Semiconductor pulls out of WEMA

"We're hoping they'll come back," says a spokesman at WEMA, referring to the pullout of Motorola Semiconductor Products division from the Palo Alto, Calif.-based association of electronics manufacturers. Motorola, in Phoenix, left because it felt that WEMA was too "West coast-oriented," said a spokesman. Particularly galling to Motorola was the formation of a semiconductor group without its being consulted.

Sylvania Service deception uncovered

An investigation by a northern New Jersey newspaper, the *Bergen Record*, charges that the Sylvania Service Corp., a subsidiary of GTE Sylvania, is engaged in unethical and deceptive TV-repair practices. Using the same color-TV set, the newspaper found, for example, that a repairman responding to a Sylvania Service Corp. call replaced tubes he had installed in his first stop, and another repairman urged that a set go to the shop for a wire replacement that could be accomplished in the home. A spokesman for Sylvania says the company is disturbed by the allegations and is launching its own investigation.

RCA's Hittinger adds new post

William C. Hittinger, RCA's Consumer and Solid State Electronics division executive vice president, has taken on the additional post of general manager of the company's Electronic Components group, primarily a manufacturer of electron tubes. At the same time, Roy H. Pollock will take over in a newly created post as vice president and general manager of the Consumer Electronics division in Indianapolis. He will report to Hittinger. Former head of Electronic Components, executive vice president John B. Farese will now handle special assignments for RCA president Anthony L. Conrad.

Comsat, Solarex settle dispute

Communications Satellite Corp., Washington, has agreed to license Solarex Corp., Rockville, Md., to make and market high efficiency "violet" solar cells. This settles a civil action brought by Comsat early this year to prohibit Solarex from making the cell. With a grant from The National Science Foundation, Solarex is trying to increase the cell's efficiency at converting light energy into electric power from 18% to 20%.

News update

German videophone fails to ring It made sense. Since West Germany is not due to get public videophone service until 1980, why not start producing instruments now for the nonpublic market and reap the benefits of being ready when the big market opens? That's what Siemens AG figured it would do [Aug. 30, p. 53] But it failed to reckon with federal communications authorities, who limited bandwidth availability and set high fees. The result: if a customer wants a set, he may buy one, Siemens says, but sales thus far are hardly worth mentioning.

Mitrix finding niche in computer nets Remember the wired city? The idea is still around, but nobody has started stringing wire yet. The result is that systems associated with that heady concept are finding uses elsewhere. One example is Mitre Corp.'s Mitrix, a full-duplex digital-communications interface for cable TV [Aug. 30, 1973, p. 29]. Originally thought of as a way to add versatility to a wired city's CATV, it's now being pitched for a role in computer networking. Mitre has received two contracts; the latest is from the University of Vermont hospital for a three-phase program of design, help in bidding for equipment, and installation and testing. Now Mitre plans to invest upwards of $250,000 in further development of computer-network technology and to make an in-house demonstration of Mitrix.

FAA still working on voice-response gear . . . It's going to be a while before your friendly airliner captain will hear voices telling him where to go. That is another way of saying that the FAA, not known for rushing pell-mell into change, is still developing a computer-controlled system for giving spoken advisory messages to pilots. The agency's National Aviation Facilities Experimental Center near Atlantic City, N.J., last year began testing Sperry Univac's fully digital response unit [Aug. 30, 1973, p. 32] because the FAA wants to automatically warn aircraft about other nearby planes, as well as fixed obstacles.

. . . as Univac proceeds with own R&D cash Sperry Univac, however, has decided to do some experimenting of its own while waiting to find out what the FAA decides. Using in-house R&D funds, the St. Paul company ran a test at the Minneapolis-St. Paul airport. Completed last month, the month-long experiment used a voice-response unit like the one delivered to Atlantic City to give pilots on the local control frequency a continually updated wind check. Results are encouraging. Now Univac says that the National Weather Service is interested in a similar system for commercial, navigation, and flight-service weather broadcasts.

Low-cost probe to be ready soon The low-cost meter for radiation hazards, developed by General Microwave Corp. [Aug. 30, 1973, p. 38], is going into production. Deliveries will start by late summer, says president Sherman Rinkel. In addition to a $475 wideband model (300 megahertz to 18 gigahertz) aimed at military and industrial users, there will be a $200 unit designed to detect radiation from microwave ovens. Also due in late 1974 is an isotropic probe with wideband sensitivity for detecting radiated power without regard for the orientation of the source. Its price, $750, is described by Rinkel as about half that of present comparable units. **—Howard Wolff**

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

Six things our salesmen are doing to ease the energy crisis.

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5. Making expediting calls on vendors in an attempt to keep vital supplies flowing.

6. Helping the Marketing Department to keep in closer touch with conditions and trends in the industries we serve.

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But add them up, and they can make a difference in our ability to serve our customers.

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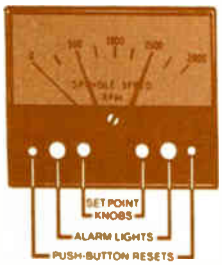

There's no need to mount extra alarm lights and reset buttons alongside this new GE meter relay. It instantly indicates and shuts off when over-limits occur. Restarts are made by simply pushing the button. Because everything is built in, you save panel space and extra mounting expense. Just one of many GE options.

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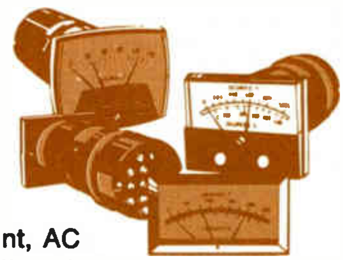

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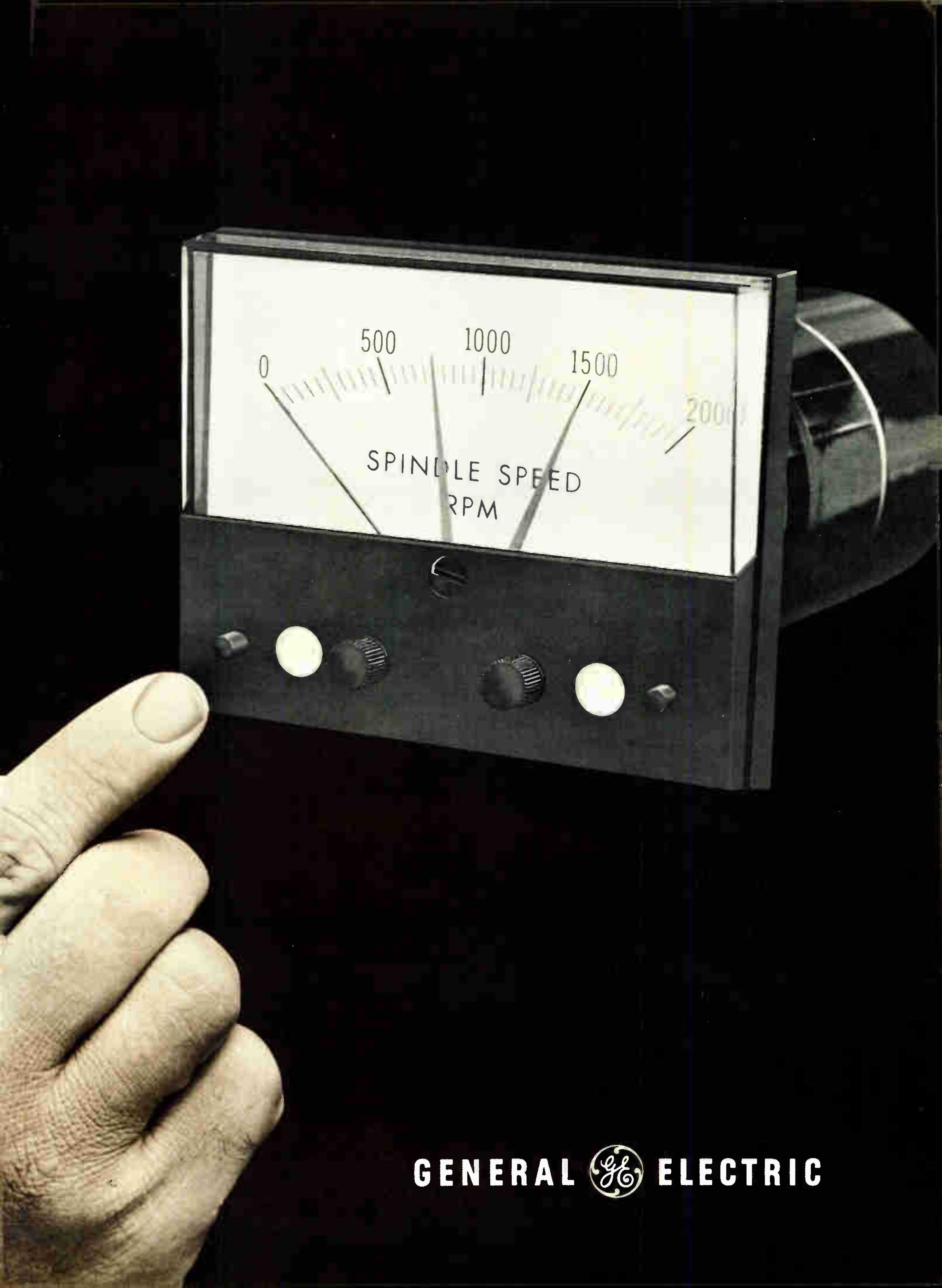
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SPINDLE SPEED
RPM
GENERAL ELECTRIC

New energy office wants $16 million national data net

A multimillion-dollar computer information service will soon be rented by the weeks-old Federal Energy Administration. The FEA has announced that a request for proposals would be out by July for a complete computer service. Hardware for the $4–6 million project would include two central-processing units, 2.9 million characters of main memory, 1.7 billion characters of mass storage, necessary peripherals, including 134 to 500 terminals, and a national telecommunications network. **An additional $10 million for various software systems is also in the works.**

The proposal will include training FEA personnel and a management contract, to cover 18 months, for operating the facility 24 hours a day, seven days a week. The FEA wants the proposed system to be fully operational by January 1975, but computer marketing experts indicate that it might take until January 1976 before such a system could be installed. **The system would be used for FEA's work in fuel allocation, price controls, weekly reports, international studies, refinery output projections, and internal bookkeeping.**

Air Force disputes criticism on Awacs jamming

The Air Force is countering congressional and General Accounting Office criticism that its Airborne Warning and Control System (Awacs) can be jammed by ground systems 200 miles away. A classified study, Saber Satin (Tactical) II, ordered by deputy defense secretary William P. Clements Jr., says that **ground-jamming of the radar side lobes can be countered by two Awacs aircraft working in tandem.** It also contends that high-power jamming of the main beam can be countered by such electronic countermeasures as frequency-hopping, blanking out the jammed frequency, or dropping below the jammer's radar horizon.

Long delayed and always controversial, **Awacs is scheduled to move to production in fiscal 1975 with a $550 million procurement request for 12 planes,** plus $220 million in RDT&E. Successful passage of the procurement appropriation in the Senate could well **depend on how effective the Air Force study is in persuading skeptical senators concerned about the sensitive jamming issue.** The study will also be used by the Defense Department in its year-end review of the program, and the results will be delivered to congressional armed services committees.

NASA appeal of Seasat, LST cuts is chancy . . .

A NASA appeal to the Senate to restore $8 million for its Seasat oceanographic satellite and $6.2 million for its Large Space Telescope in its fiscal 1975 budget is given "less than a 50-50 chance" by one knowledgeable staffer, following elimination of the funds from the $2.34 billion appropriation passed by the House at the end of June. The House also failed to appropriate the $16 million authorized earlier to begin work on a third Earth Resources Technology Satellite, known as ERTS-C. But since the space agency had not requested these funds in its budget, it is not including them in its appeal. If the Senate acts, then the funding differences between its appropriation and that of the House will be ironed out in a conference.

NASA's Seasat appeal will be based on its argument that **its proposed 1978 launch of the satellite with a surplus Air Force rocket will cost nearly $3 million less than a 1980s launch using the Space Shuttle,** which is scheduled to be operational at that time. Appealing the LST cut will be more difficult since congressional opposition is based on the project's high total cost, estimated to run as high as $300–500 million.

. . . but it moves ahead with solar-run craft

NASA is moving cautiously, but deliberately, forward with its **Solar Electric Propulsion Stage spacecraft, awarding parallel studies of $330,144 to Boeing Aerospace Co. and $347,500 to Rockwell International** for SEPS' "evolutionary concept definition and systems analysis." The contracts, scheduled for completion in January, 1975, should provide a base for the preliminary design phase of the program's development schedule next year. The SEPS idea is based on using high-power solar arrays and electric thrusters for primary spacecraft propulsion. **Initially, the concept would start with a 15-kilowatt SEPS building block** that would be capable of being upgraded to 25 kilowatts of thrust-subsystem power on planetary and earth-orbital missions.

Computer group asks splitting of FCC, breakup of AT&T

Division of the Federal Communications Commission into two regulatory agencies—one for broadcasting and the other for telecommunications—and the breaking up of AT&T has been urged on the Senate by the California-based Computer Industry Association. The association of 38 companies, mostly peripheral-equipment makers, has told the Senate Antitrust and Monopoly subcommittee in testimony that **splitting up the FCC "would allow equal emphasis" on regulation of broadcasting and telecommunications, rather than allowing continuation of broadcasting's dominance of commission activities.**

As for AT&T, the association wants it placed under jurisdiction of the Public Utility Holding Company Act, now applicable to gas and electric companies. **The association also seeks to split the telephone company into local operating companies, a company for interstate transmission, and one or more equipment companies.** The testimony came in connection with hearings on the Industrial Reorganization Act (S-1167), introduced by subcommittee chairman Philip A. Hart (D., Mich.) and designed to limit concentration of industrial power in major U.S. industries such as communications and transportation.

Passage of the act is most unlikely, say knowledgeable congressional observers, although one staffer says the hearings "have AT&T and the others worried with the publicity they are getting and are producing interesting testimony never heard before." AT&T is scheduled to respond to criticisms with testimony of its own later this summer.

Interior to get high-performing cloud-tracking radar

Interior Department officials believe they will be getting a new standard for radar reliability and data quality in a mobile cloud-tracking radar unit to be built by Enterprise Electronics Corp., Enterprise, Ala. The company, a manufacturer of meteorological radar, will build the $315,000 prototype for use by the Bureau of Reclamation in tracking atmospheric events inside clouds. The system will be a complete, self-contained unit with a digital video integration processor to insure accuracy and reliability from complex signal inputs. A hardwired data compiler will interface with the department's new IBM computer in Denver. Government radar experts are predicting that the new unit "will become a benchmark for comparison of reliability and data quality." **The unit's price is about twice that of less accurate radar models used by television stations and the National Weather Service.**

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Circle No. 51

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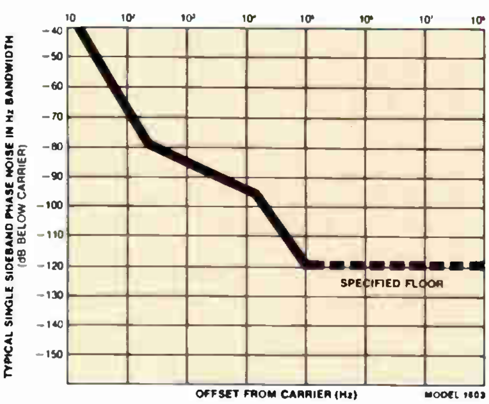

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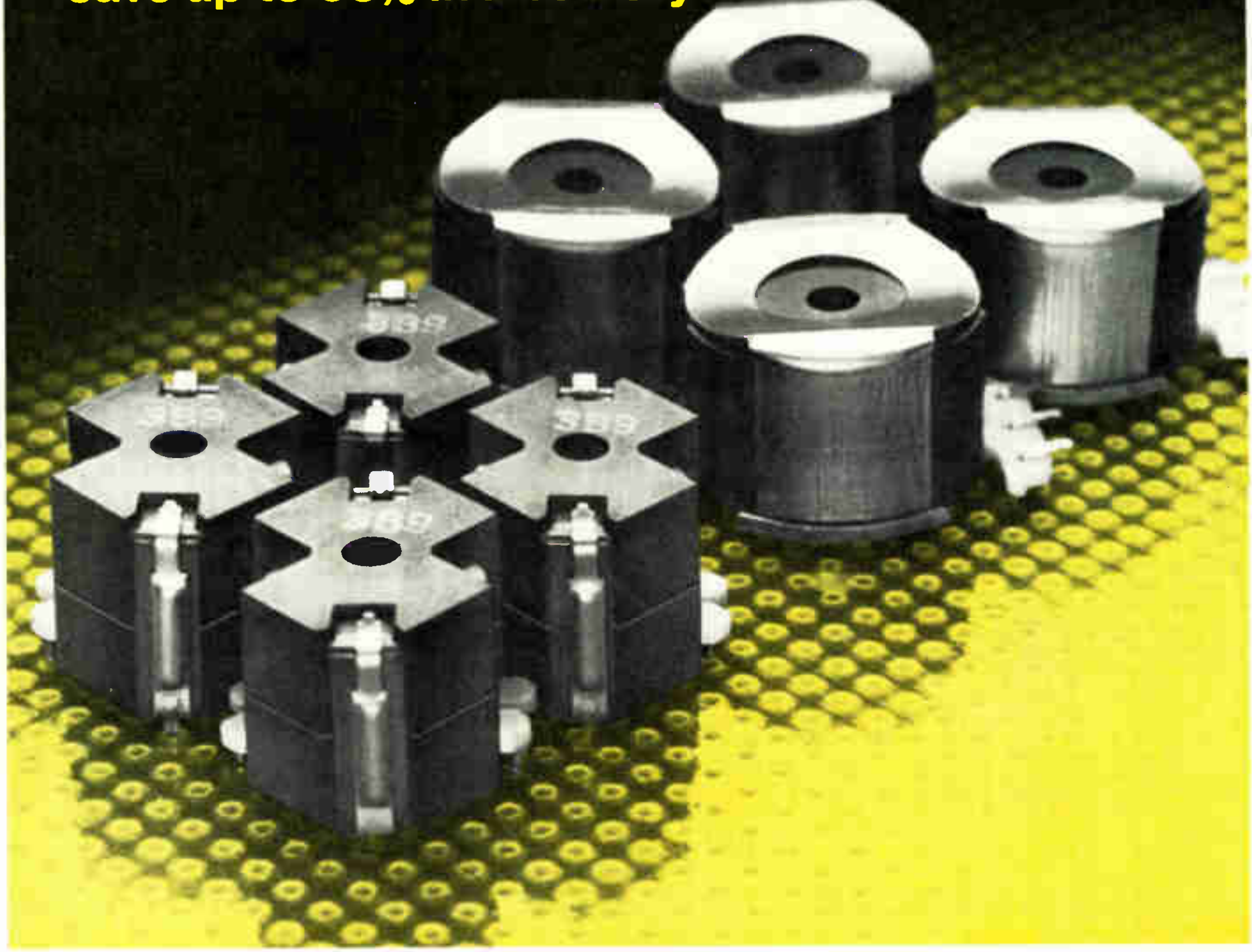

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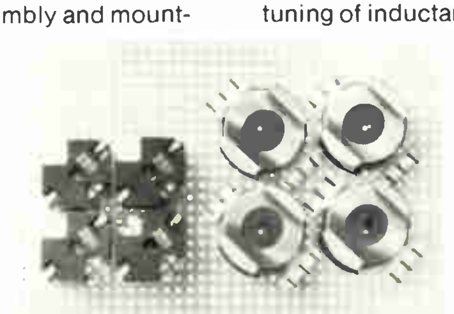

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Circle 52 on reader service card

LED display shines through substrate

Resembling a semiconductor upside-down cake, a numerical display from Japan's Hitachi Ltd. is based on monolithic gallium phosphide light-emitting diodes. The device's front plane with the pn junction segments faces the substrate upon which the individual digits are assembled. Light from the segments travels through the chip and exits from the polished back plane, which faces the observer.

This configuration offers a number of advantages, not the least of which is the ability to use flip-chip techniques for bonding the chip to the substrate, eliminating individual wire bonding of each segment. The device was developed by Masahiro Kitada and coworkers at Hitachi's Central Research Laboratory.

Gallium phosphide has the rather large index of refraction of 3.37, which means that all light rays striking a surface at angles greater than 17° undergo total internal reflection. This characteristic prevents broadening, or spreading, of the apparent source of the light emitted by the segments. At the same time, light output and contrast are reasonably constant over an extremely wide range of viewing angles.

What's more, there is no hole in the center of the light emitter—the metal ohmic contacts do not block the center as do the wire bonds of conventional units. Furthermore, the metal contacts reflect light back towards the observer, enhancing the brightness of the display.

The segment diodes are fabricated by selective masked diffusion rather than by the overall double epitaxial layer and mesa etch often used for monolithic displays. Starting material is an n-type gallium phosphide wafer with an epitaxial layer. Two types have been used, an 80-micrometer thick vapor-phase epitaxial layer and a liquid-phase epitaxial layer 30 micrometers thick. Either way the wafers contain nitrogen doping to produce green color and sulfur doping to give n-type conductivity. Carrier concentration is about 5×10^{16} per cubic centimeter.

Diffusion is performed using a mask of Al_2O_3 or Si_3N_4. Chemical vapor deposition of the mask and photoetching are conventional processes. Zinc diffusion through mask windows to form the p regions of the light-emitting pn junctions is from a ZnP_2 source. The zinc is the dopant and phosphorus is required to keep the partial vapor pressure of phosphorus at a value high enough to prevent loss of phosphorus from the wafer.

Diffusion is followed by metalization over the entire surface of the chip on top of the mask layer. The pattern of metalized segments is fabricated by photo etching. Each metal segment contacts the p region of the individual diodes that make up one light-emitting segment through the windows in the mask layer, which forms part of the passivation of the completed device.

Contact to the substrate of the chips is made by gold-germanium eutectic metalization through windows opened in the two open areas in the display pattern.

Then comes fabrication of solder bumps for face-down bonding of chips on a substrate with appropriate wiring pattern. The last step is to mirror polish the back side of the wafer— the side that faces the observer—and to dice into individual chips. □

Around the world

Philips develops large-screen TV projector

In looking for a replacement for its veteran large-screen TV projector, the Eidophor, Philips Gloeilampenfabrieken has turned to ferroelectric crystals. One of its French affiliates, Laboratories d'Electronique et de Physique Appliquée has put together a demonstration color-TV system that projects a light flux of some 2,500 lumens, enough for a full-fledged cinema screen.

LEP officials think their new hardware could be sold for about one third the $80,000 or so that the Eidophor projectors cost. What's more, they say the next system does not need as much care as does the Eidophor, which uses a thin film of oil to modulate the projected light. LEP's system is based on a special tube called Titus, which has as its modulating element a slab of ferroelectric crystal. For color-TV projection, LEP uses three Titus tubes to modulate a focused beam from a 4.5-kilowatt xenon lamp.

System automates blood-flow analysis

A hospital research team in London has turned to electronics to build an automated blood-flow measurement system. With it, the measurement takes seconds, which means that the device holds promise for mass screening of patients. With Autopleth, all a clinician need do is attach a limb-encircling pressure cuff. The tabletop system then automatically inflates the cuff to the desired pressure, runs through four measurements and deflates the cuff when the process is done.

To build the system, researchers at Guy's Hospital put together a U.S.-made strain-gauge cuff from Parks Laboratories and an automatic digitally programmed dual-chamber cuff inflator built in-house around National Semiconductor silicon strain-gauge integrated circuits. A Fluke digital multimeter to measure the strain-gauge resistance, a small calculator and memory to perform the flow calculations, and a chart recorder complete the system. The Guy's group estimates that the units would commercially cost about $15,000. The prototype will be part of a three-year trial sponsored by drug company Servier Ltd. [*Electronics*, June 13, p. 44].

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EEC seeks to brace computer industry against U.S. firms

The European Economic Community's Council of Ministers, seeking to make the community's computer industry more competitive with U.S. firms, **last week approved a plan to provide subsidies for European projects in data and systems applications among computer users.** The plan, a brainchild of the EEC commission, includes giving financial aid for such joint international industry projects as software and peripherals.

The program will coordinate public purchases of computer software and hardware, plus attempt to set common standards, including a single computer language. No specific projects have been defined by the council, but the commission is to submit implementing proposals, including probable budget requirements, by the end of the year. The program seeks to encourage joint actions where possible among such computer users as national administrations, on the one hand, and hardware and software producers on the other.

The commission eventually wants to combine efforts on mainframe technology and finally merge various production facilities. This would ultimately mean strengthening the present Unidata link between CII, Philips, and Siemens, which commission experts privately say is inadequate to stand up against U.S. rivals. While there is a strong European-only bias in the program as originally outlined, some European computer makers favor U.S. links. **Who will participate in community-funded projects will be decided on a "case-by-case" basis, says a commission official.**

Membrain expected to supply testers for UK phone-switching

Membrain Ltd. is expected to supply most of the automatic test equipment used by manufacturers of electronic switching equipment for the British Post Office's vast TXE-4 electronic telephone-switching project. **The fast-growing company has the inside track over General Radio Co. and Teradyne Inc. for Plessey Telecommunications Ltd.'s portion of the switching project.** Plessey already has garnered part of the TXE program shared with ITT's Standard Telephones and Cables. **The Plessey contract with Membrain, expected to be signed by September, will be worth $2.5 million, which could grow as Plessey's portion increases.** TXE-4 could account for $2 billion in business by 1985.

Plessey also is negotiating contracts worth up to $2.5 million with Hughes and Teradyne for automatic back-plane testers to check out wiring at the rear of switching racks. **The fully automatic Hughes system, for which STC also is negotiating, seemingly is favored over the operator-controlled Teradyne equipment, although the checkout decisions in both are performed automatically.**

Low-frequency hybrid filters use tantalum as base

Siemens AG is about to introduce a line of low-frequency hybrid active filters based on tantalum thin film. The German company says the main applications will be in communications equipment—for example in data transmission and pulse-code-modulation systems—and in test, measuring, and control equipment. Basic to the development have been determining circuit parameters by computer. Components are trimmed by lasers, and the operational amplifiers required for the filters are built onto the substrate.

The result of a five-year development effort, the new devices have a quality factor of 100 for frequencies between 100 and 1,000 hertz and a Q of 50 for frequencies as high as to 10 kilohertz. By using tantalum-nitride resistors and beta-tantalum capacitors, almost ideal temperature compensation is achieved for the frequency and stability-determining RC product. Values of 40×10^{-6} per °K are attained by the filters, says Erich Gelder, marketing manager for integrated circuits. Samples of the new devices will soon be available, and volume deliveries will start within six months, Gelder says. **A second-degree filter— one with two frequency-determining components and measuring only 47 by 18 by 3 millimeters—will sell for roughly $10 apiece in large quantities.**

Sweden to begin regular stereo radio broadcasts

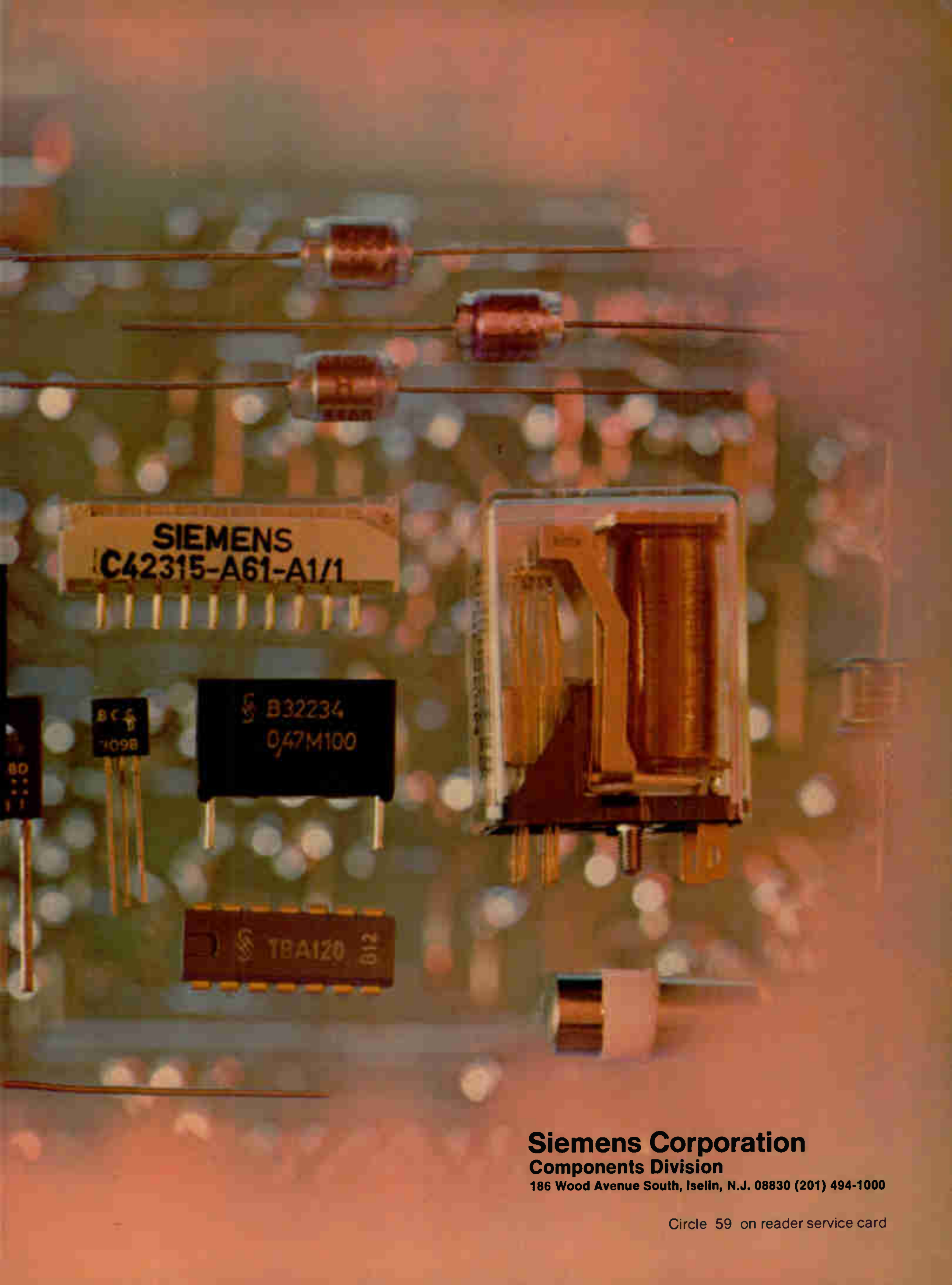
After at least a decade of discussion, studies, debate, and testing, Sweden is on the way to getting regular stereo radio transmissions. The Swedish telecommunications authority and the Swedish Broadcasting Corp. have requested funding—almost $3 million—from the government to start stereo transmissions in 1976. Until now, test transmissions have been made once or twice a week on the "good-music" program. Under the proposal, stereo broadcasting will be started on programs 2 and 3 (good music and light music), and by 1979, program 1 (news and talk) will also have stereo. **Sweden's start of regular stereo broadcasts was delayed by a proposal that a special Swedish-developed "channel-splitting" system be used. However, the final decision is to use the standard pilot-tone system.**

Three firms invest in Korean plants to export components

Philips Gloeilampenfabrieken is the largest of three international electronics companies about to set up shop in Korea. **The Dutch giant plans to invest $6.6 million in a plant with an annual production capacity for export of 500 million resistors, 500 million capacitors, and 15 million potentiometers.** Also, Magnetic Media Korea will get a $1.14 million loan from the U.S. company known as Panasia Investors Inc. to develop an annual production capacity for export of 1.6 million reels of cassette tapes, 395,000 reels of other tapes, 6 million cassettes, and 600,000 cartridges. At the same time, Fuji Denki Seizo of Japan is investing $675,000 for a 45% share of a joint venture with three Koreans to produce magnetic switches and other electronic parts, of which 36% will be for export.

Addenda

The Japanese government has decided to place quotas on exports to France of tape recorders, phonographs, and record players starting July 8. Although France's production of the items covered by the quota is a small percentage of the total demand and Japanese imports are a small percentage of the total market, Japan decided to act before movements underway to restrict exports of Japanese electronics to Europe gained more steam. . . . An estimated cost of $40 million has killed the proposed world's largest radio telescope, at Jodrell Bank. The UK's Science Research Council told the University of Manchester that it wouldn't support the 375-foot dish.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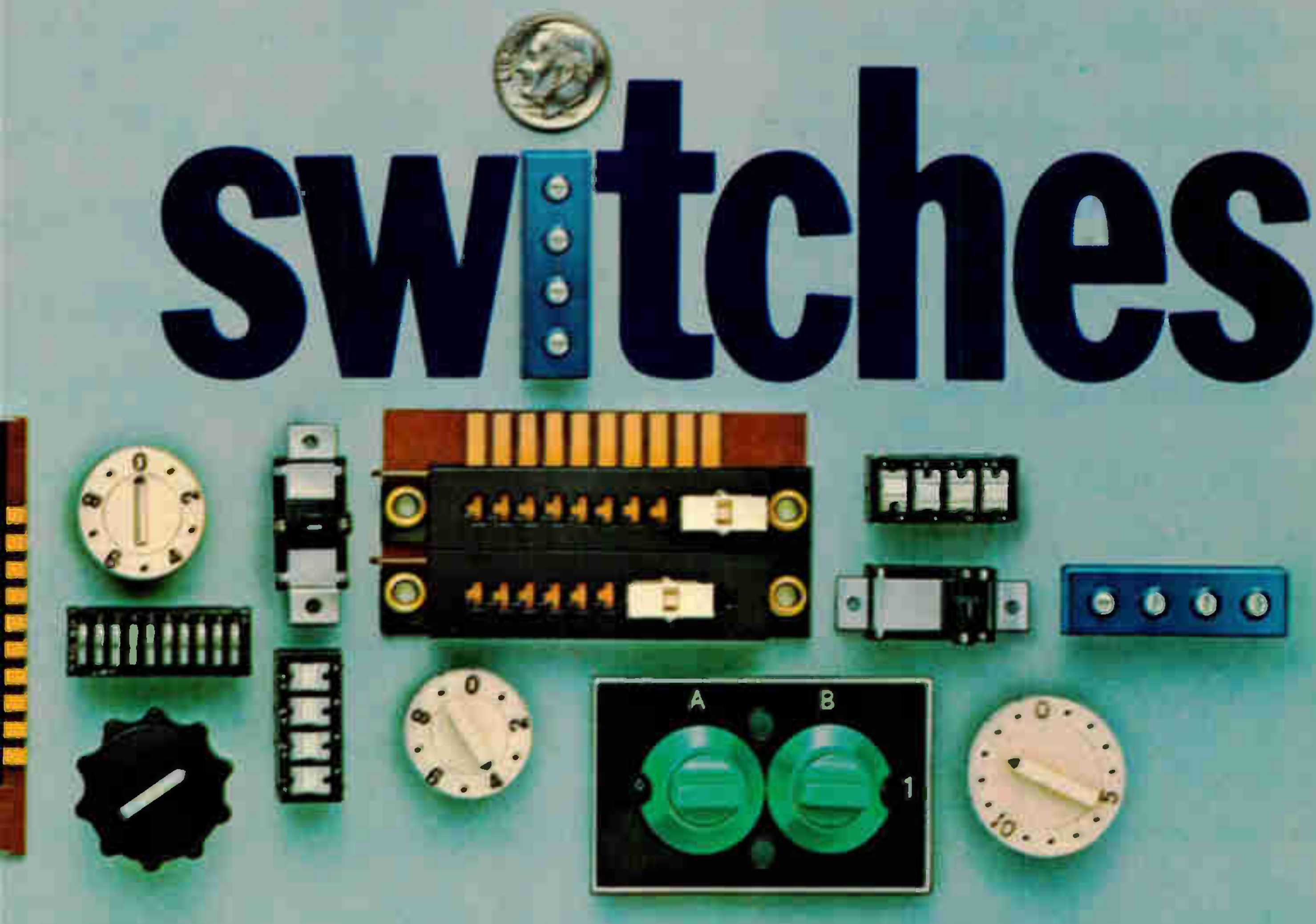

Circle 61 on reader service card

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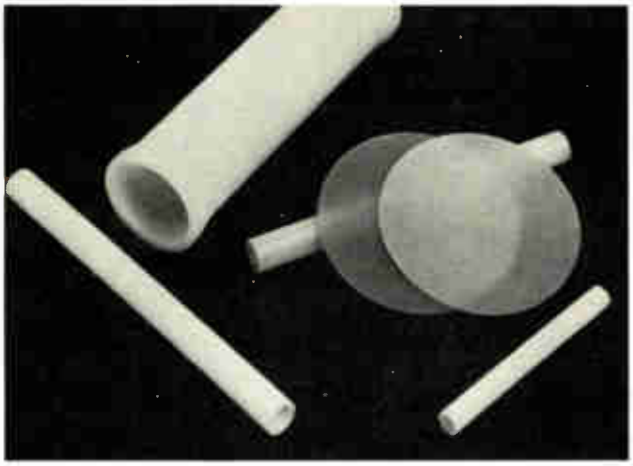

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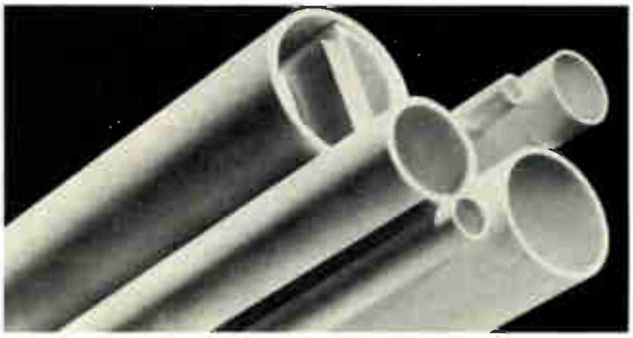

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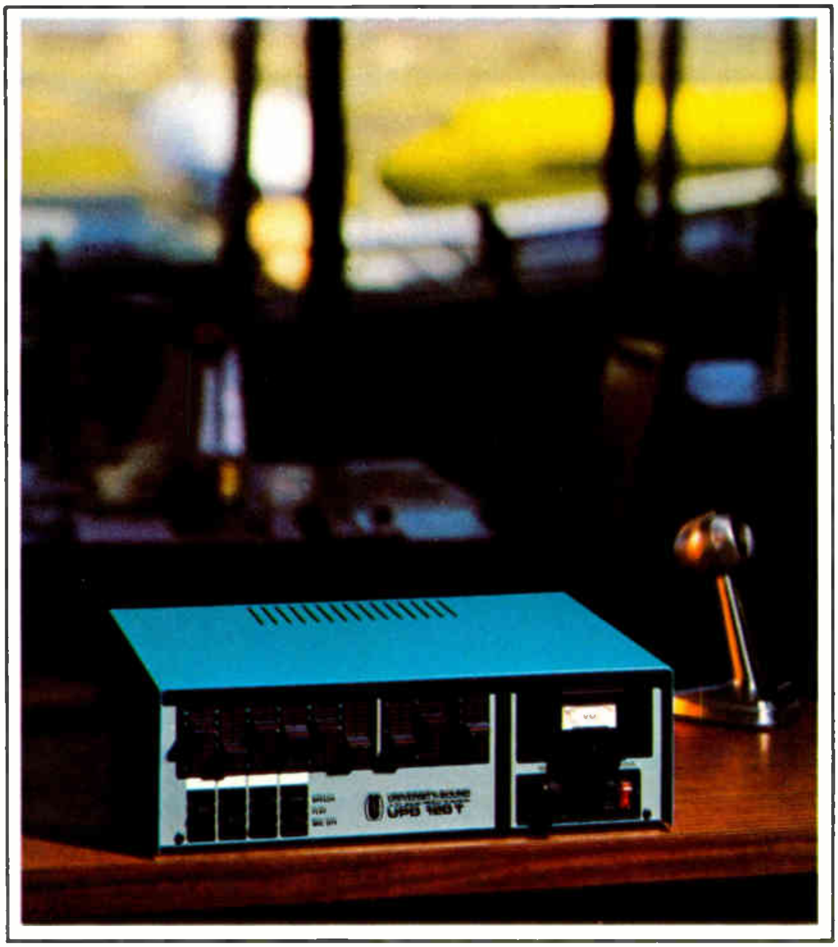

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Money worries cloud bright picture

Electronics industries find high interest rates and inflation are making their blue skies just a little less bright

by Howard Wolff, Associate Editor

They're saying that business is great—and should stay that way in the second half of 1974—but electronics executives are just a bit worried about two clouds in their blue skies: high interest rates and inflation.

Perhaps Richard Reisinger of Tektronix expresses it best when he says: "We'd been thinking there would be a slowdown, but we don't see that in our order rate. By no means do we expect a downturn." However, the manager of corporate development puts his finger on the money squeeze when he adds: "But our business depends on companies' ability to expand, and many small companies can't get the money."

This thread of concern runs pretty steadily, except for occasional bursts of optimism like "We're ahead of plans all along the line" from Hewlett-Packard's Ed Van Brokhorst, vice president and treasurer.

But, ironically, it's inflation that has had a major positive effect on one big problem of six months ago: shortages. Because of tight money, buyers are reluctant to build big inventories. This, coupled with general easing of material shortages, has seen delivery lead times shorten considerably. Finally, all this has added up to more realistic booking-to-billing ratios. As explained by Charles Clough, vice president for semiconductor marketing at Texas Instruments:

"Throughout late 1972 to early 1974, booking-to-billing ratios were very very high. Now, bookings are more realistic when compared to billings. That's because lead times are coming in for all products except diodes, and as lead times come in, people don't need to place 18-month orders. Buys are now covering a shorter delivery period—about eight to 12 months."

At Allen-Bradley's Electronics division, lead times are shortening on fixed resistor products. This, says Stanley Kukawka, vice president and general manager, is due partly to increased capacity, but also to slightly lower bookings.

At another components house, TRW Electronic Components division, marketing director Keith Myers says, "It's impossible to equal last year." Still, says Myers, 1974 looks good. "We'll finish 1974 at a little stronger pace than we thought at the beginning of the year." Myers says that his division "sees the problem being the high cost of money. Our customers are looking very closely at their inventories."

Color sets. In the consumer area, color-TV production, as predicted, is down 5% to 10% from last year's record of 9.3 million sets. But sales are up for the industry leaders—at RCA, officials are considering raising their prediction of in-

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dustry-wide production of color sets in 1974 to 8.8 million from 8.6 million. "And I wouldn't be surprised if the industry goes over 9 million," says David J. McCarty, manager of market development. "The seasonally adjusted rate for the first 21 weeks was 9.05 million, and for the last four weeks, we've been running at 9.7 million. Right now, sales to dealers are 5.5% behind last year, though that figure was as high as 7% earlier." However, any decrease in unit sales should be wiped out by increased prices.

Sales up. As for dollars, the two leaders in market share—Zenith and RCA, in that order—confirm that their sales are up over 1973. RCA isn't saying by how much, but Zenith president John J. Nevin said in May that his company's sales increased 4.3% over a comparable 1973 period in color, 5.7% in monochrome.

All this should bode well for semiconductor makers because the color-TV industry is now running about 59% solid state, compared to 35% at this time last year. However, Bernard V. Vondershmitt, vice president and general manager of RCA's Solid State division, sees a general softening in TV components, a condition that some in the industry attribute to double ordering.

Another consumer area, calculators, is expected to experience a shakeout. There are over 50 brands on the market now, says S.F. Accardo, a vice president of New York Stock Exchange member William D. Witter Inc., and eventually, "only those companies with a high degree of vertical integration, including expertise in semiconductor production, are likely to survive." He believes domestic demand for all types of calculators should rise in 1974 by 50%, to 13 million to 14 million units, with 40% to 42% of the sales in the fourth quarter. Scientific calculators will account for 20% of that total, compared to a negligible number last year.

Big and strong. In the computer market, TI's Clough sees strength at the large manufacturers' and inventory imbalances only at the smaller houses. David Methvin,

Looking 'em over. A Manhattan store tells the world about its stock of Hewlett-Packard calculators (left) while a passing citizen stops to inspect the array of cases and key boards.

president of Computer Automation Inc., the Irvine, Calif., minicomputer maker, also notes that some customers are stretching out deliveries to keep inventory down. Methvin also points to high interest rates and inflation as major problems. Minicomputer sales, says Methvin, should grow to nearly 50% more than in 1973.

For semiconductor makers, aside from the money crunch, the year looks good—although not up to the levels of 1973. Fairchild's Richard deJ. Osborne, executive vice president for finance and business development, characterizes 1974 as a "good year" in view of its slightly slower growth rate of 20%. "The essence of what's happening," notes Osborne, "is an adjustment of inventory levels." Fairchild, he says, has adjusted its numbers because "we don't have to carry a large inventory" any more. And, he adds, "our customers, as they find things more available, are doing the same sort of thing."

Osborne says there is no evidence that shipments are slowing down on customers' end products. He does say, however, that since more products are better available, bookings will begin to drop, and thus backlogs will also. "The ultimate usage of semiconductors," he says, "is not diminishing. We are seeing some kind of adjustment" in the backlog area, he says. "We just can't sustain the kinds of backlogs of last year."

One of the sectors affected during this new adjustment period, says Osborne, is TTL. "This is one of the areas where availability has improved," but he says that it does not signify a softening in the TTL market. Such changes, he says, "happen by evolution, rather than quickly."

Pentagon is back. One interesting development is detected by TI's Clough. He says that the military is turning into a good market for the semiconductor manufacturers: "The Pentagon has increased funding for electronic systems by 5%; for R&D, 12%," he points out. "The military market's showing solid strength for the first time in three years. Because of our inability to supply custom products, the military was forced to use a standard product, and that will continue." □

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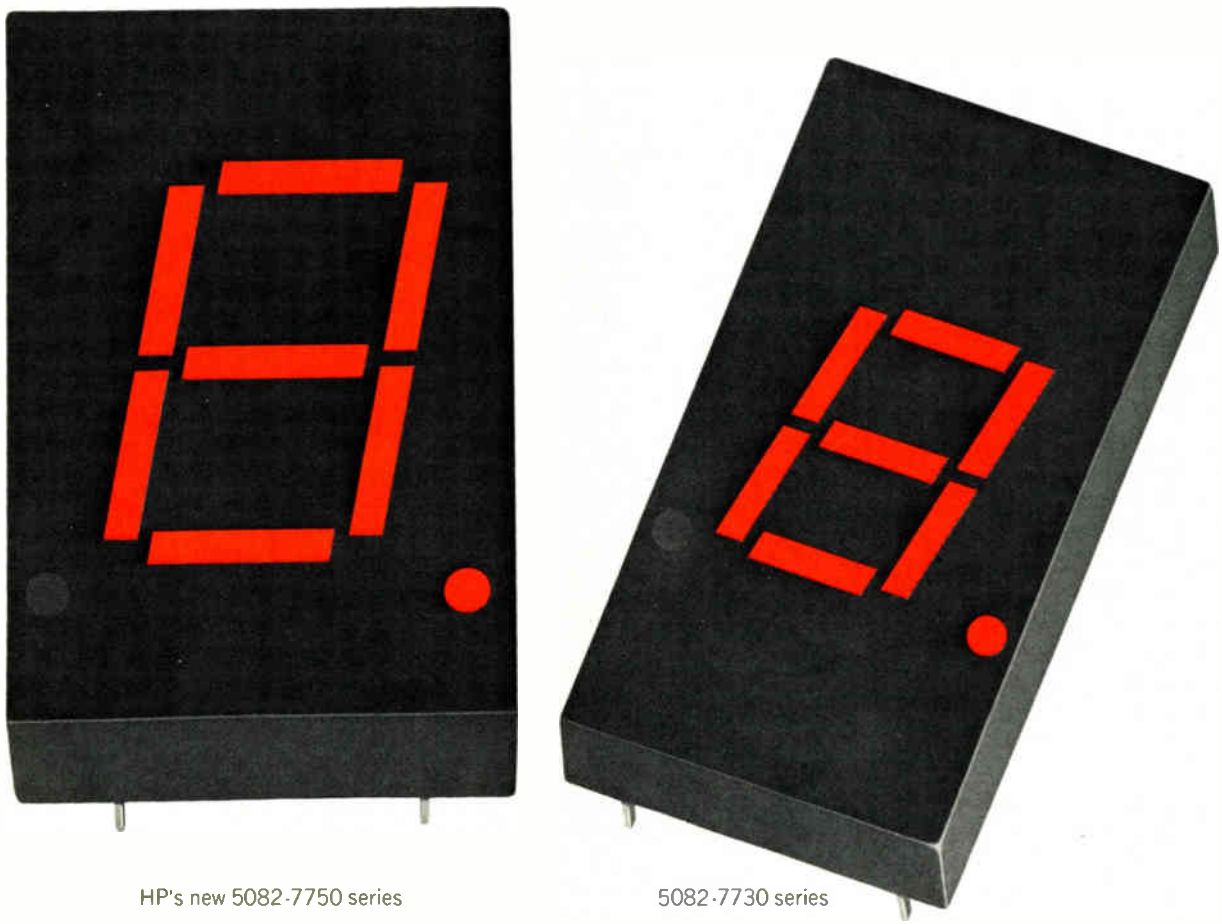

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Communications

Germans to start nationwide paging

Eurobeep paging system can be expanded to cover Europe; France prepares own system next year, Austria waits in wings

by John Gosch, Frankfurt bureau

Most people have heard an electronic pager—that series of beeps triggered by a central transmitter from a small receiver carried by the person being summoned. These systems have a short range—within a hospital, say, or for a dozen or so city blocks. But a service about to start in West Germany, France, and Sweden promise nationwide, or even Europe-wide, paging.

The German version, called the European Radio Call Service—or Eurobeep—will send number-coded messages to a receiver that can be removed from its installation in a car and be carried about. The caller simply sends the code over regular phone lines to a radio center where it is converted for transmission. At the receiver, the signals trigger a beeper and one of four signal lights that direct the person to take a particular action.

"The hardware for such service was ready some time ago," says Günter Strunz, in charge of land-mobile services and microwave systems at West Germany's post office-run Telecommunication Engineering Center in Darmstadt. "But there were some problems relating to interference with radio stations, signal-shadow regions, transmitter-siting, and the like that had to be ironed out first." With these problems now out of the way, West Germany is moving to provide the nationwide service.

France, which already has city-wide radio-call services in Paris and Lyons, is also expected to start going nationwide next year, Strunz says. Several other countries, among them Austria, are very much interested in the service and are watching to see how West Germany will fare.

In Sweden, a system using fm bands is due to go into operation in 1976. [*Electronics*, May 24, 1973, p. 57]. The telecommunications board is designing transmission equipment and taking bids on a first batch of 1,500 paging units. System details will be given to companies that want to make and sell receivers. Interestingly, the authority rejected a paging system developed by Martin-Marietta because it couldn't handle 300,000 subscribers.

The Swedish service will have a unique feature. The caller will dial the number of a pager, then dial in the number that should be called back. The subscriber will get a buzz on his receiver and call a central number, where a computer-synthesized voice will tell him that number.

The subscriber fee will be about $50 a year, plus around a nickel a call. It's hoped that each paging unit will sell for less than $250.

The German plans provide for three call regions across the country. Each will have its own radio center with a number of transmitters tied to it. One is already on the air. The $8 million network, which calls for a total of 22 transmitters, is scheduled for completion by the end of 1976.

Hardware. The hardware for the network comes from the Nürnberg firm of TeKaDe Felten & Guilleaume Fernmeldeanlagen GmbH and from Rohde & Schwarz, the big communications and measuring-equipment maker in Munich. TeKaDe, half-owned by Philips Gloei-

Taking it along. Subscriber to Eurobeep leaves his car, taking receiver with him. It is mounted beneath dashboard, much like tape deck, for easy access and removal. One transmitter is already operating.

Within reach. Motorist stopping for lunch at one of rest areas along the Autobahn has his receiver handy. The devices can handle four messages phoned to a central transmitter and then digitized.

lampenfabrieken of the Netherlands, was also the first company to develop a post office-approved receiver for the new call service.

Sending a message from a telephone is simple. The caller dials the number of the radio center, then the code—also termed the radio call number—assigned to the receiver he or she wants to address. At the center, the six digits of the radio call number are temporarily stored and then converted into a form suitable for transmission.

The basic receiver version is designed for only one call number, but other versions can handle as many as four. These numbers differ only in their last digit, and each represents a specific message. For example, 452386 may stand for "Call the office," 452387 for "Return to company headquarters," and 452388 for something else. In the receiver, the number-coded signals trigger a buzzer and light up one of four lamps, each denoting a different message.

Strunz is confident that the new service will be welcomed, especially by people who spend much time on the road—traveling salesmen, journalists, country doctors, appliance repairmen, and the like. A conservative post office forecast puts the number of subscribers in West Germany at 10,000 within the next three years. Another pegs it between 20,000 and 30,000 after five years, a projection based partly on the growing popularity of mobile-communications systems—automobile-telephone systems, for instance—for which demand has been rising at about 24% annually during the last few years.

Charges. For the subscriber to Eurobeep, there's a post office charge of roughly $20 a month for a single-code receiver. For each additional code that his receiver can handle, the fee goes up another $20 so that a four-code unit costs about $80 a month. The monthly charge for an internationally used call number is $30.

These fees sound high until they are compared with the charges for a conventional automobile telephone. In West Germany, that comes to nearly five times as much—about $109 a month. The same ratio applies to the hardware—roughly $800 for the TeKaDe receiver versus $4,000 for an automobile phone system.

For communications authorities, the big advantage of the new service is frequency economy. While regular mobile telephone systems tie up a radio-frequency channel for the duration of the two-way call, the transmission of a complete call number, including the "free-line" signal, takes only 800 milliseconds. Thus, Eurobeep occupies a channel for less than one second.

The TeKaDe-developed receiver, designated E11-2, resembles a small transistor radio. It can be purchased or rented. Besides producing and selling the receiver itself, TeKaDe also supplies it to AEG-Telefunken which sells the unit under its label.

Beeper. Receiver used in Eurobeep paging system was developed by TeKaDe and is sold by AEG-Telefunken.

The network's vhf transmitters, from Rohde & Schwarz, are controlled from the radio centers and operate between 87.0 and 87.5 megahertz. Their output power is either 0.2 or 2 kilowatts, depending on local requirements. Assigned to each call region are three carrier frequencies, onto which the audio-frequency-coded call signals are amplitude modulated.

Each receiver in use is assigned a certain combination of six audio-frequency pulses corresponding to the six digits of the call number. These pulses, between 470.8 and 979.8 hertz, are sequentially and continuously transmitted and evaluated in the receiver's decoder. All receivers in a call region pick up this pulse train, but only the receiver whose address-pulse combination agrees with that of the one transmitted will be able to respond.

A special receiver feature is that it automatically monitors signal-field strength. The receiver sets off an alarm when the signal strength falls below a certain level, as can happen under bridges or in valleys. This alarm tells the user to either switch to another channel or to move on to a better location.

The alarm is first given by an optical indication that flashes at 1-second intervals for 20 seconds. After that there's also an acoustical alarm that sounds at 1-second intervals and also lasts for 20 seconds. Both alarms are turned off 3 seconds after the signal strength has reached the proper level.

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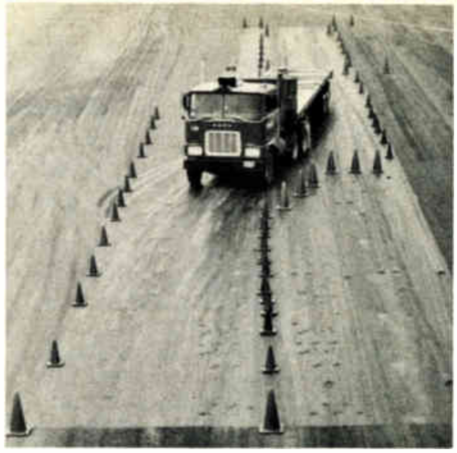


Straight and narrow. Truck at left skids and jackknifes when entering lane on wet pavement. But equipped with electronic antiskid controls, truck at right stays within the 12-foot lane.

Automotive electronics

Truck operators fear electronics

Fight to put off use of antiskid controls until devices can be road-tested; assurances that systems will work leave them unimpressed

"Keep on truckin'," insists the legend emblazoned on T-shirts, sweatshirts, bumper stickers. It's almost as though the people who came up with the motto have a message about electronic antiskid controls for the operators of America's heavy-duty trucks, a potential market of $100 million a year.

Those truckers are trying to hold off implementation of new safety regulations for trucks equipped with air brakes that would in effect require electronic controls to prevent locking of brakes and skidding. The American Trucking Association has been authorized by its executive board to go to court to seek a delay if current negotiations with the National Highway Traffic Safety Administration (NHTSA) don't work out. The ATA is bargaining for more time in which to test production models of new trucks. Partly motivating the association is, of course, the higher price tags on the trucks (electronic antiskid would add an estimated $100 per axle to the cost; total cost of all new safety requirements would be $500 to $1,500 per truck). But the overriding consideration is fear that the electronics won't work.

The new regulations, embodied in Motor Vehicle Safety Standard 121, and due to take effect March 1, set minimum stopping distances and require trucks to stop within a 12-foot-wide lane. This means much larger brakes—so large that Standard 121, although it never mentions electronics, makes electronic antiskid controls mandatory. An electromagnetic pickup on each wheel senses speed, a computer determines whether safe operating conditions are being met, and a controller opens or closes the brake's air line.

The ATA's position is one of wariness about electronics. Assurances from the half-dozen or so companies making axles that the new system is safe leave the group less than assured. "We have had that kind of thing before, and the product hasn't come through," says Lew Kibbee, the ATA's director of automotive engineering. Kibbee hastens to explain that the ATA is not against Standard 121. "We've been an advocate of 121 safety requirements for a long time. The association doesn't want to delay safety regulations—just take the bugs out."

Kibbee emphasizes that without electronic controls for the new, big front brakes, the ATA would have been against 121. It's just that prototypes didn't work to the satisfaction of the association and that members would be buying " a pig in a poke" if it purchased 121-equipped trucks without first testing them.

Kibbee and his group suggest that if all models come out equipped for 121 compliance, the ATA be allowed to modify (for "modify" read "disconnect") all electronics until the units have been road-tested by ATA personnel and users. The alternative, fears Kibbee, is that the electronic controls would be "mothered" by manufacturers' engineers to prove their efficacy.

Jitters. Meanwhile, truck manufacturers White, Ford, and General Motors have been telling truckers about what they see as the dangers inherent in 121, including failure of electronics. "Ford got out a film [on antiskid] that scared the bejesus out of our truckers," says Kibbee.

Meanwhile, in Washington, the NHTSA, a part of the Department of Transportation, calls the ATA's position the result of a "misconception" about the reliability of the brake systems. The administration's Sid Williams says the position is based on performance of prototypes that failed "because of people and design errors. The systems were added to existing wheels and axles" and consequently were exposed to weather and abnormal wear. "Production systems will be reliable," he says, because they will be designed into the truck, rather than be added on."

Confident. Williams admits that it would be possible for the agency to postpone compliance or "offer concessions" to truck makers if the systems were proved unreliable. However, he adds, "I don't see that happening. I think they are reliable." The last postponement of the regulation—from September 1974 [*Electronics*, May 10, 1973, p. 70]—was due to shortages of axle materials.

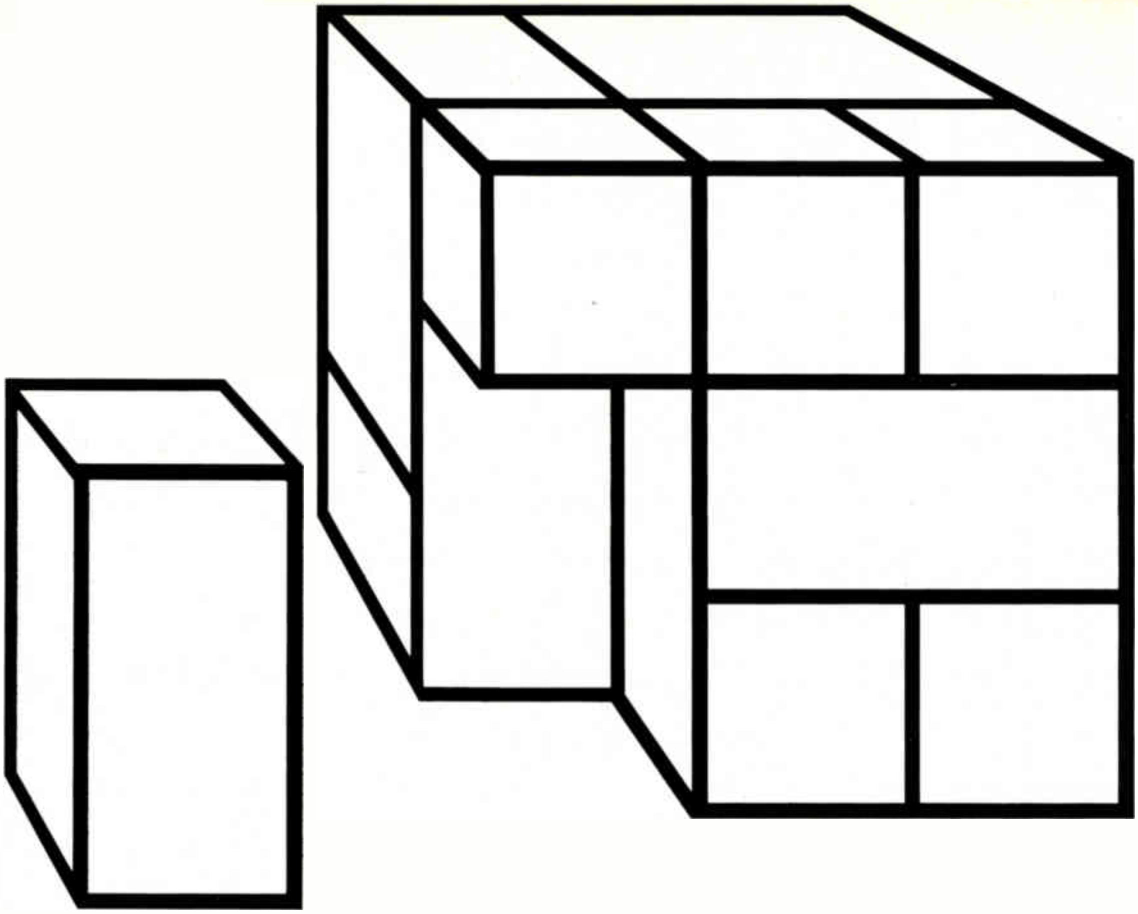
What about the manufacturers of the axles? The Rockwell-Standard division of Rockwell International, which claims to make 70% of the axles installed on the big trucks, is adamant. Beginning this November, says a spokesman, Rockwell won't even make axles that don't conform to 121—that's how convinced the company is that the electronic controls will do the job and do it well.

Another big maker, Kelsey-Hayes Corp., won't even discuss the controversy. But some indications of its position may be gathered by noting that a year ago, Kelsey-Hayes already had some 5,000 of its Computer Brake Control axle sets installed as optional equipment.

In addition to Rockwell-Standard and Kelsey-Hayes, companies with a stake in the adaptive-braking business are Bendix-Westinghouse's Air Brake division, Eaton Corp.'s Brake division, Wagner Electric Corp.'s Automotive Products division, and B.F. Goodrich Co. In Europe, there is activity at Fiat, Daimler-Benz, and Robert Bosch.

Rockwell's system, Skid-Trol, is all digital and uses MOS large-scale integration. Other systems range from all-analog (Eaton) to Bendix' combination analog-digital. Truck manufacturers like the analog approach because they say it will be easier to modify over the first few years of use. Rockwell, however, points out that its system can be changed as easily, simply by altering the programing of the MOS chip's read-only memory.

But truckers couldn't care less if their braking systems are analog, digital, MOS, or whatever. Their concern is about what happens when the electronics stops working—not "if" but "when"—because they have heard, seen, or read the scare stories. As one observer who is close to the trucking industry points out: "It isn't enough to say that a front-axle failure of the braking systems simply returns control to the driver as before. With these big, new brakes, the driver won't be able to control his truck if he has to put his foot in the hole." □



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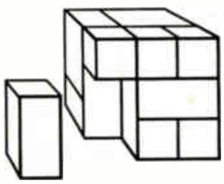

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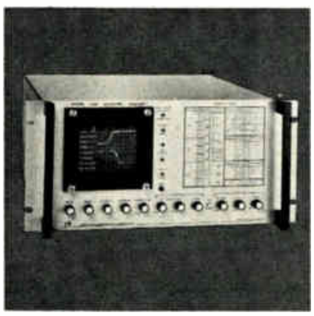

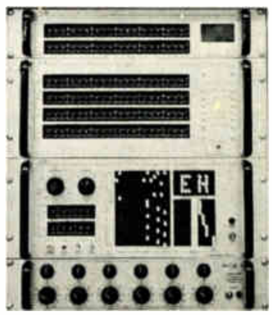

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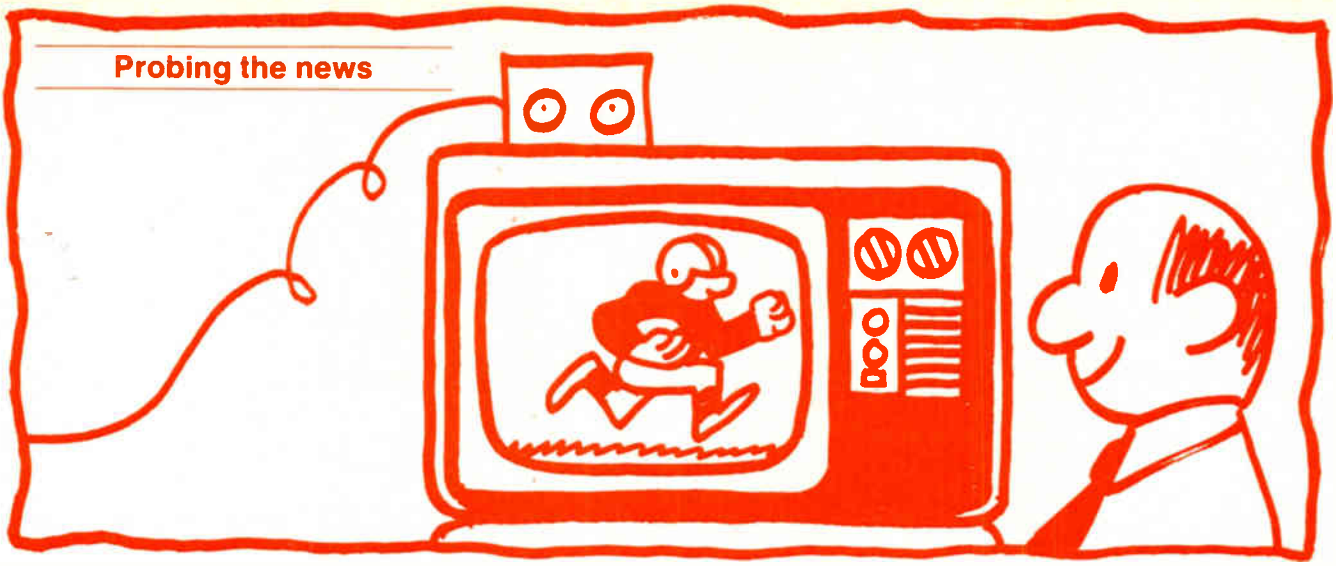


Consumer electronics

See the cable adapter on the TV set?

Well, you may not need one within two or three years because an EIA panel has written standards for cable-compatible receivers

by Ray Connolly, Washington bureau manager

The adapter atop the TV set that hooks it to the cable may become a memory—as will the cost of installing and maintaining it—if a new set of standards is adopted. The standards, for cable-compatible receivers, are close to approval by the Electronic Industries Association's Cable Television Systems Committee. TVs would cost $21 to $28 more to receive 28 channels.

While the proposed standards have a long and possibly tortuous road to travel before final specifications are adopted by the Federal Communications Commission, the EIA committee proposal represents the first step toward evolution of a national standard for a cable-compatible receiver. The CTSC is a joint undertaking of two EIA entities: the Consumer Electronics Group, made up principally of TV-receiver and components manufacturers, and the Communications division's broadband communications section, representing CATV-equipment makers and cable-system operators. Committee chairman is Howard Head of A. D. Ring & Associates, Washington-based consulting engineers and representatives of the Association of Maximum Service Telecasters.

Penetration of new cable-compatible receiver models "could begin within two years," Head's committee estimates. But that's only if industry review of the proposal and FCC approval is achieved in one to two years and manufacturers develop and promote new models in one to five years. That's "too optimistic," say several industry sources, who forecast a lead time of at least three years.

To get air and cable broadcasting on the same tuner, the EIA committee proposes to get 28 channels by allocating vhf channels 2 through 13 to air and/or general-purpose cable, by restricting uhf channels 14 through 83 to over-the-air broadcasting, and then, as channels 2 through 13 are filled, by giving cablecasters the midband channels 84 through 91 and superband 92 through 99. "This plan," the draft proposal points out, "permits a maximum of 28 general-purpose CATV channels per cable, but places no restraints on other cable services added by any means." The FCC order calls for a minimum of 20 cable channels in the top 100 U.S. markets.

The proposal is likely to be modified in the process of adoption by the members of the EIA's Consumer division and broadband section later this year, even though the committee includes representatives of the leading cable operators and makers of sets and tuners. But the committee contends that assigning the midband and superband channels to cable should eliminate the problems created for cable operators by the need for a cable-system converter for each receiver.

Redesign. Of the "substantial problems" confronting the Head committee in developing its specifications, the chairman called for the development of a means of "minimizing on-channel interference in the presence of strong signals off the air." The most practical way of doing this—providing a shield of the cable drop to the chassis of the receiver tuner—is complicated by the problems associated with small receivers. Some 65% of the 17 million sets sold annually are those with 19-inch or smaller screens, and these are line-connected models where the chassis is at a 60-hertz ac potential with respect to ground.

Chairman Head says the committee believes this problem can be resolved by "a redesign of the receiver power supply to incorporate a transformer." Shifting the power supply to a transformer design, the committee notes, adds to complexity and cost.

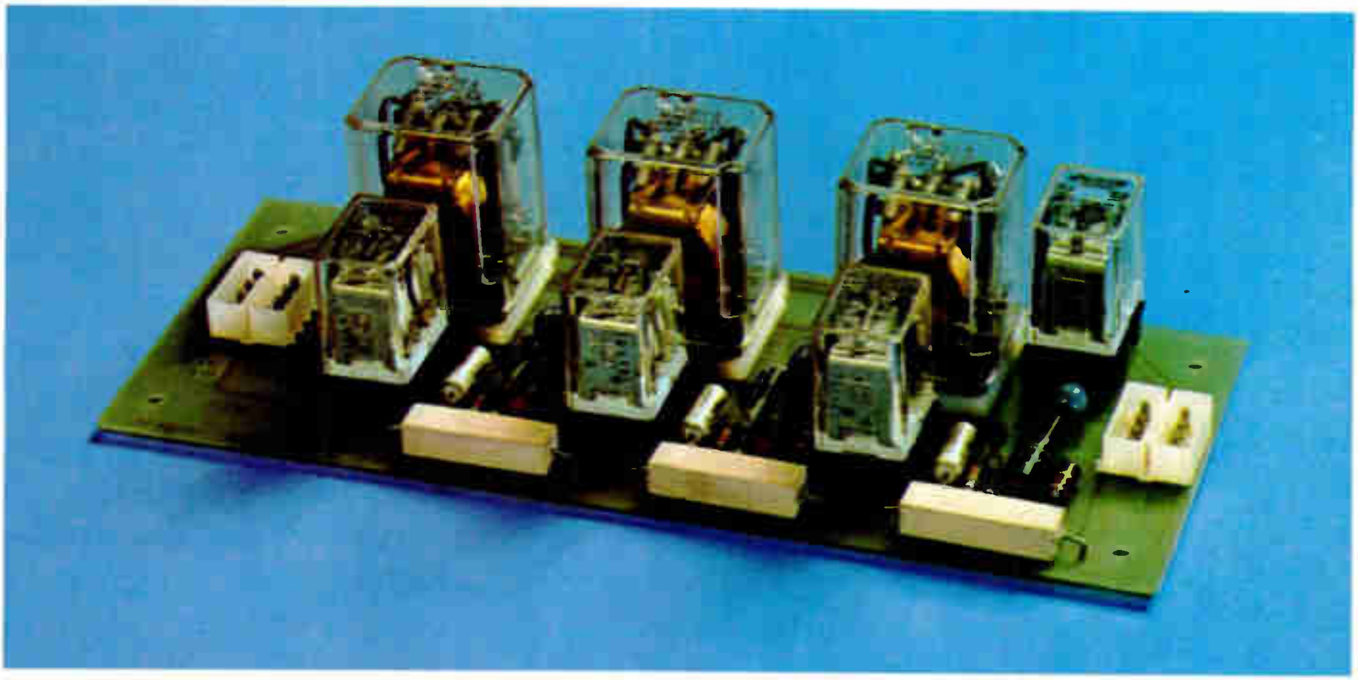
The many other engineering problems required tradeoffs in several areas, according to the committee draft. Key problem areas identified by the committee and its comments on them include the following:

■ **Other interference.** The frequency bands used for cable by nonbroadcast carriage make a receiver susceptible to local-oscillator leakage from other receivers connected to the cable. This energy leakage interferes with the image and must be limited at the receiver's cable-input terminal. The isolation between cable drops must also be adequate, and receiver image rejection must be high, while cable systems must limit signal levels at image frequencies.

■ **Tuners.** The size limitations of electromechanical vhf tuners—which account for about 90% of the market—become a problem as soon as their capability is increased beyond the 12 vhf channels. Not only is cost increased, but cabinets of smaller receivers set a practical limit of 20 channels, the minimum required by the FCC. The committee uses up this leeway by adding eight midband cable channels to the tuner. As for the remaining eight superband channels, the committee proposes that addition of these be optional with each receiver manufacturer. However, all these eight are "general-purpose" cable channels, as distinguished from "special-purpose" channels.

Why did the EIA committee limit itself to electromechanical tuners, rather than the more modern varactor tuner? It concedes that the size of a varactor tuner would not be radically affected by expanded CATV-channel coverage. But it notes that for coverage beyond 20 vhf channels, there is a need for "increasing the present two-band vhf varactor to a three-band concept." And three-band varactor tuning is not yet available. □

The $100,000 control sub-assembly!

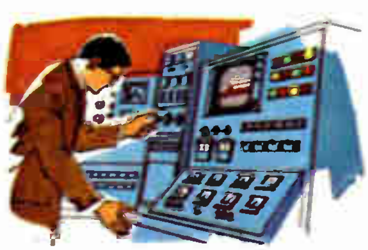


A case for conducting your own "make or buy" analysis.

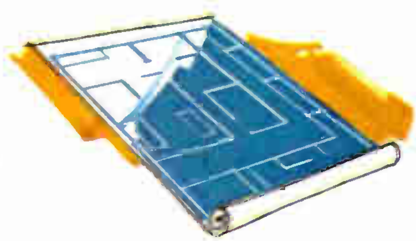
Initially, there may be no question about producing the control assemblies for your products in-house.

However, a careful "make or buy" analysis could save your company thousands of dollars.

Personnel—training, supervision, FICA, Workmen's Compensation, and many other contingent expenses—can contribute substantially to the cost of each unit you produce.



Special test equipment, jigs, fixtures, and machinery can represent a sizable capital investment. The extra costs of procuring, warehousing and controlling an extra inventory of parts and materials should be a part of your cost analysis. Floor space, too, is a very important consideration. When all costs are included, you could have $100,000 invested before you produce that first assembly.



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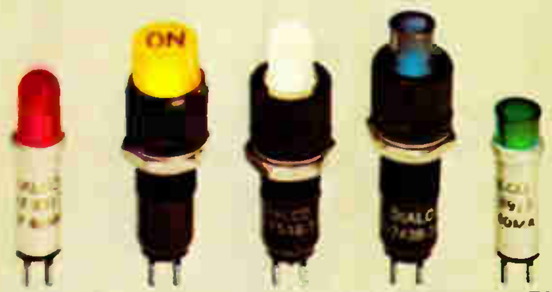

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SEND ME FREE INDICATOR LIGHT PRODUCT SELECTOR GUIDE.

Diverse industry users clamber aboard the microprocessor bandwagon

LSI processors are not only expanding capabilities of traditional products —from instruments to consumer wares— they're also creating completely new markets

CONTENTS:

☐ Industrial-equipment designers like them because they can be tailored economically to bring computer capability to jobs where minicomputers represent overkill.

Communications-gear designers are enthusiastic because their flexibility can solve problems presented by the ever-changing multiplex and modem specifications.

Instrument designers are looking forward to making them the basis of families of "smart" instruments that can evaluate data and react accordingly, without boosting instrument costs significantly. And even computer manufacturers are eyeing them as perfect companions to their TTL-based central-processor modules.

It's no wonder, then, that microprocessors are engaging the attention of equipment designers of all persuasions and manufacturers from a wide variety of industries. As a result, the growth of microprocessors is projected to leap from last year's $10 million to $800 million in the next five years. More dramatic yet will be the increase in the value of new end equipment built around LSI processors, expected to exceed a staggering $10 to $15 billion a year by the end of the same period.

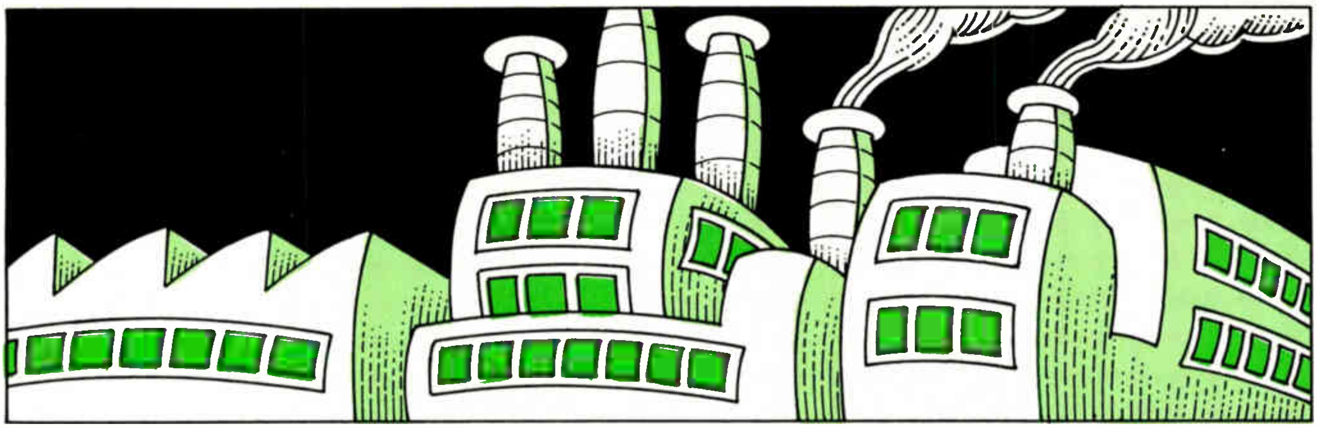
What has caused the sudden microprocessor boom? Simply stated, LSI technology has reached the level of sophistication where it can provide the logic and memory performance needed to perform a growing number of computer functions at low cost. Programable LSI circuits—the calculator was the first—combine the flexibility of custom design with the cost advantages of readily available standard products. The user can change his design or add features to it merely by changing a program in a read-only memory. No mask changes are needed. And he is saving money by replacing many dozens of logic packages with a few LSI chips.

Impressive as today's microprocessors are, they are only the most visible aspect of what is clearly becoming an LSI-processor revolution that will completely change computer and computer-control design. Today's LSI processors are at the capability level of the small and not-so-small computer. But more powerful LSI-processor and computer-component chips that are now starting to appear far exceed the requirements of today's microcomputer applications.

Built with bipolar and improved MOS techniques, these faster and more complex components go to the heart of minicomputer-based systems, nourishing more and more equipment-design applications. These are the LSI programable chips computer manufacturers themselves have been waiting for. At last, the full benefits of LSI programable technology can be applied to the large computer, ushering in a new era of high-performance computer control at lower cost.

These articles bring together the experiences of the first microprocessor users—the promises and problems of designing with this powerful technique. The entire range of electronic-equipment designs has been researched—industrial, communications, consumer, commercial, instrumentation, and computer technology. Included are details on such varied systems as process and numerical controllers, word processors, data loggers, communications controllers, intelligent terminals, point-of-sale systems, games, toys, advanced calculators, self-calibrating instruments, automobile controls, and all the rest.

Also included is a section that contains tips on software and design aids. Finally, Bill Davidow, manager of microcomputer systems for Intel Corp., adds up the design advantages of microprocessor-based systems to show their impact where it counts most—on the bottom line. —Laurence Altman, Senior Editor



Industrial
Automatic control proliferates

by Alfred I. Rosenblatt, Associate Editor

"The microprocessor is going to set the industrial-equipment marketplace on its ear. The technology will never be the same again." That opinion was expressed by a market planner at a semiconductor house developing a microprocessor-chip set for one of the manufacturers of process-control instrumentation. The prediction is borne out by developments in the industrial marketplace. What's more, prospects for dramatic improvements are as bright for piece-parts manufacturing as for process control.

Although less than three years old, microprocessors are already finding their way into a host of new industrial equipment—factory-automation systems, machine-tool control, data-acquisition systems for such jobs as monitoring apportionment of meat for hamburgers, electronic scales, control of conveyor lines, numerical control, robot manipulation of piece parts, data-sensing, and component-insertion. They are also being used for environmental monitoring and phototypesetting.

These microprocessor-based systems offer the flexibility to adapt manufacturing systems to changing demands and upgrade them as production expands. All that is necessary is for chips containing new instructions to be inserted when peripherals are changed, equipment is added, or the system itself is modified. Changes and modifications are much more difficult when conventional hard-wired circuitry must be replaced.

What's more, manufacturers are happy about decreases in manufacturing costs that result when a relatively few microprocessor chips replace tens of discrete SSI and MSI circuits. Not only are fewer components required, but the microprocessor obviates the necessity to fabricate many more components manually into hard-wired logic arrays and insert these boards into the control systems. However, where speed is critical, hard-wired designs may do better for some time to come.

As the capabilities of microprocessors are expanded, they are taking over many of the tasks—at a pleasant reduction of costs—previously performed by minicomputers, but for which a considerable amount of the power of minicomputers is wasted. Replacing the purchased minicomputers may also increase the amount of value added for a manufacturer in his final product with a consequent increase in profits.

Taking over the factory

The availability of powerful low-cost microprocessors is also hastening the transition to the efficient distribution of computer power through employment of hierarchical computer systems in factories. The microprocessors and microcomputers perform dedicated tasks under the control of minicomputers, and the entire complex is tied in to large central computer systems.

What's more, the microprocessor is making it possible for manufacturers of process-control equipment and systems virtually to go into computer-manufacturing. Bruce H. Baldridge, director of corporate marketing and product planning at Foxboro Corp., Foxboro, Mass., points out that microprocessors are going to seriously influence the make-or-buy decision so that "a company like Foxboro could buy a micro chip, put it on a board, and it would be putting us in the computer-manufacturing business without the expense of getting deeply involved in the technology."

The importance of the microprocessor to industry is summed up by Edwin Lee, president of Pro-Log Corp., a Monterey, Calif., systems-design firm that also offers a line of microprocessor modules, "Within 12 to 18 months, anyone who hasn't incorporated a microprocessor in his design will either be serving a very special application or he's going to be very uncompetitive, as far as hardware is concerned."

Another consultant calls this "an explosive situation—anything that's cheap and reasonably powerful changes things. Anyone doing anything with hard-wired electronics who doesn't look at and consider microprocessors is making a big mistake."

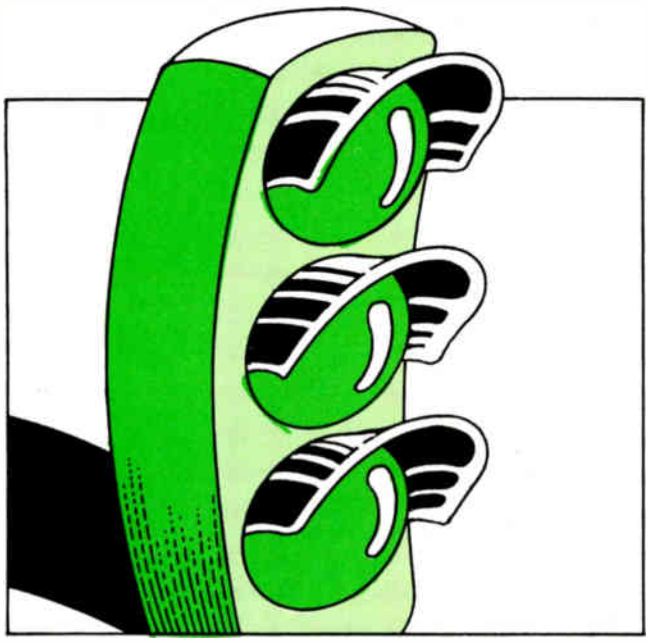
A recently completed study on factory automation by Quantum Science Corp., a New York-based industrial-research company, estimates that by 1984, industry will

APPLICATION OF MICROCOMPUTERS TO FACTORY AUTOMATION					
	Machine tool control (units/year)	Robots (units/year)	Product testing (units/year)	Facilities monitoring (units/year)	Total cost
1974	300	10	300	150	760 @ $1,000 each avg.
1979	3,400	2,850	500	300	7,050 @ $400 each avg.
1984	7,800	14,000	1,000	600	23,400 @ $300 each avg.
	Estimates courtesy of Quantum Science Corp.				

be buying 27,300 microcomputers a year at an average price of $300 each. Accumulated over the years, these numbers will have an incredible effect on the factory's operation, increasing the efficiency and cost-effectiveness of production. The average unit price today is $1,000 according to the Quantum Science study.

Perhaps most unusual is Quantum's prediction that programable manipulators, or robots, will mushroom with the aid of microcomputers from 10 units installed in 1974 to 14,000 a year by 1984. About half that many—7,800 a year—are expected to be used for machine-tool control, a mammoth increase from the present base of 300 a year. And about 3,900 new microprocessors a year are predicted to handle communications between the various tools and computers in another 10 years, whereas now only 50 units a year are now being sold for that purpose. Product-testing is expected to account for 1,000 units per year by 1984—more than a three fold increase—and facilities-monitoring will rise to 600 a year—a four fold increase.

Perhaps the earliest to recognize the potential of the new microprocessors were manufacturers of industrial-control equipment. For example, Comstar Corp., Minneapolis, first started using microprocessors two and a half years ago, and now it has more than 700 microcomputers installed. Applications include assembly-machine control, automatic weighing and batching systems, materials-handling systems, remote monitoring and control, data entry, and automobile-traffic control.



One particularly strong market for the microprocessors is in materials-handling. For Beatrice Foods' new frozen-food warehouse in Chicago, for example, Comstar has installed six microprocessor systems. Each controls 50 motors in a network of more than 300 conveyors that transport boxes from the freezer to trucks. On the way, they go through sorters, convergers, divergers, and conveyor-belt changes, but the controller keeps track of every box for its entire trip.

"In earlier warehouses, Beatrice used electromechanical-relay control, with limit switches for actuation," says Tom Walstrom, regional sales manager for Comstar. "Something like our system could have been designed and built with relays, but it might never have worked. It would have been too complex to be practical and much too large to maintain."

Numerical controllers gain

For several reasons, microprocessors also have an excellent potential for being built into stand-alone numerical controllers for machine tools, which are now fabricated with hard-wired logic. Microprocessors can sharply reduce the component count in the controllers while offering easy modifications of programs and functions, which are now possible only with much more expensive systems built around minicomputers.

Although the major N/C suppliers like Allen-Bradley Co., Bendix Corp., and Cincinnati Milacron Co. aren't saying much about their interest in microprocessors, smaller companies and even newcomers to the field, with little or no product base and inventory to worry about, may jump in. General Electric Co., the largest N/C supplier, only last month announced that it had begun using a microprocessor in one of its numerical controllers.

One newcomer is Cambridge Thermionic Corp., Cambridge, Mass., a manufacturer of IC sockets and terminals. But rather than compete head-on with the giants, Cambion's recently introduced PMC-1 microcomputer numerical control is aimed at applications that may have been too expensive for N/C until now, says Lyndon Wilkes of the N/C marketing group. The PMC-1, which operates point to point, rather than on a continuous path, is aimed at simple positioning for such applications as insertion, wire-wrapping, and machines for drilling printed-circuit boards. In its open-loop configuration, it can position a tool to within .001 inch.

Price of the unit is less than $4,000, including the controller, which is built around the Intel 4-bit MCS-4 microprocessor set, plus a two-axis motor drive and a stepping power supply. The price is about $1,000 less than the lowest-priced hard-wired controller available, asserts Wilkes.

Manipulating the controls

As indicated in the block diagram, the control and arithmetic units in the Intel 4004 chip allow the CPU to acquire and manipulate control logic and data from the memory sections of the microcomputer and generate the outputs called for in the parts-making program.

Control programs containing the logic which, in conventional N/Cs is hard-wired, is stored in read-only memory. The ROM controls interfacing for a maximum of 32 inputs and outputs. In addition, the ROM section contains the microprograms and data tables that the central processor must execute to control the tool. The unit can accommodate a maximum of six ROMs, each containing 256 by 8 bits, or programable ROMs, if field programability is desired.

A random-access memory—there can be a maximum of four devices, each containing 256 by 8 bits—serves as a scratchpad for the central processor. The RAM temporarily stores and releases data and instructions needed on a priority basis by the CPU as it executes the control programs stored in ROM. The parts-making programs themselves are written by the user, just as for a hard-wired controller. Then they're entered into the controller via punched-paper tape. For production runs, however, these programs could also be stored in a programable ROM.

Likewise, the ROM output interface controls the dispatch of signals to the X- and Y-axis motor drivers and the display readouts. RAM storage controls output to the tools and tape-reader motor. An automatic reset clears the CPU and RAM, resetting the system back to microprogram step one. A two-phase clock circuit provides the timing signals needed by the CPU.

Other components of the system include a ROM input-control interface that monitors inputs from control-panel switches, a paper-tape reader, tool feedback, and an X-Y jog-select mode.

All active components in the control section are contained on a single plug-in printed-circuit board—a decided advantage for maintenance and trouble-shooting, points out applications engineer Howard Atwood. Moreover, because the control has fewer parts, Atwood says the company can deliver a unit in one month or even two weeks, as opposed to the three to six months it would take to put a hard-wired control together.

Bending metal

A microprocessor-based system also controls a metal-stretching and bending press designed by Varitel Inc., Beverly Hills, Calif. About as large as a good-sized room, these giant machines have generally not been amenable to control by off-the-shelf numerical controllers, as have other machine tools, because of the great differences in their design caused by the spread in the size and type of parts they are called upon to fabricate. Hard-wired logic systems are generally used, and each press requires a custom-designed controller.

Although custom designing is still a problem, Varitel president Bruce Gladstone estimates that use of microprocessors can cut design time to a third or even a quarter of the time required to program a hard-wired system. To program the National Semiconductor IMP-16 card used by Varitel, the operator first bends the metal by manual controls. Two angular and two linear multiplexed analog-to-digital converters transmit to a tape cassette the amount of stretch and other factors involved in making the bend. The operator can edit the information as he goes.

When the information on the cassette proves to be accurate, it is transferred to the IMP-16's on-board erasable RAM. The RAM's capacity of 256 by 16 bits is adequate to provide 12-bit accuracy, achieved through two digital-to-analog converters that drive linear servos. As an added benefit, Varitel provides a small panel that plugs into one of the IMP-16 slots for servicing and troubleshooting. The panel contains its own memory.

The new microprocessors could also affect the design of programable controllers, which are themselves solid-state replacements for hard-wired banks of electromechanical relay logic. The present solid-state designs are also hard-wired and hence would be excellent candidates to be replaced by microprocessors.

But because of the many inputs derived from the assembly-line machines being controlled, present CPU speeds are generally too slow, says senior systems engineer Ronald D. Malcolm at Modicon Corp., Andover, Mass. Hard-wired designs will offer as fast or faster processing speeds for some time to come, but the microprocessors could allow more features to be added at lower cost, says Malcolm.

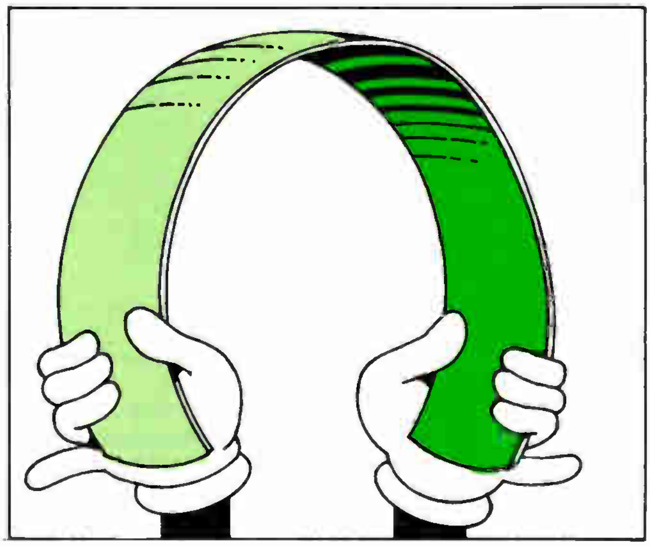
In addition, the microprocessors shorten design time "a great deal," he adds, as well as reduce the physical size, power-supply requirements, and cost. However, for use in its larger controllers, Modicon is considering a 16-bit bipolar monolithic microprocessor with a 150-nanosecond microinstruction time that is being sampled by Monolithic Memories.

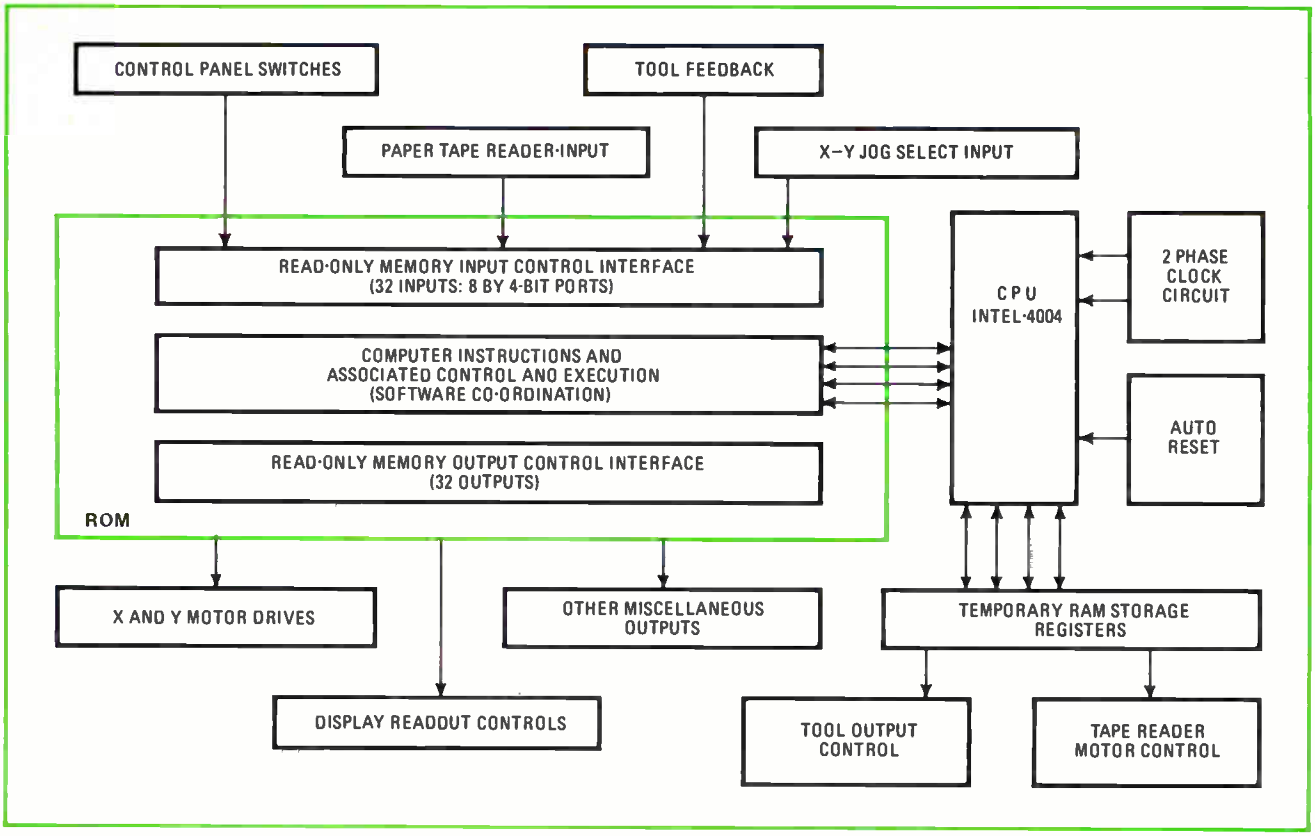
And Modicon, a pioneer in programable controllers, has already applied microprocessor technology to peripheral products. For example, Intel's MCS-4 set is designed into the P-500 impact printer introduced last winter, as well as the manually operated programing panel for its smallest controller, thereby speeding up the panel's response time.

Controlling traffic

One of the greatest potential applications of microprocessors is to control street traffic. Indeed, Multisonics Corp. of San Ramon, Calif., with 10 years of experience in this application, predicts that intersection-control systems constitute the wave of the future for microprocessors.

Tom Seabury, chief engineer, points out that controllers can be designed for each intersection's needs.





1. Numerical control. An Intel 4004 microprocessor chip is at the center of the PMC-1 point-to-point numerical-control system introduced by Cambridge Thermionic Corp., Cambridge, Md. Programs can be changed simply by plugging in new read-only-memory chips.

"Some traffic schemes, for example, require that all vehicles stop while pedestrians cross in a 'scramble' fashion," he says. "The conventional random-logic controllers need wiring changes to allow this, while with the microprocessor, all we have to do is plug in a different ROM package."

Seabury says the microprocessor is ideal for the stand-alone intelligent intersection controller. Minicomputers, the other alternative to hard-wiring, provide power that is wasted in such a dedicated application, and they are unable to withstand the severe environmental conditions without major design modifications.

The switch to microprocessors is coming at a time when hard-wired controllers had begun to supersede electromechanical controllers, which have synchronous motors that turn switch drums to operate the signal lights. Now, in replacing the hard-wired controllers, the number of ICs has been reduced by at least 60%—from between 500 and 600 to about 100. The company's model 901 controller uses only 50 watts of input power, weighs only 41 pounds, and measures only 17 by 17 by 9 inches. Standard hard-wired models use about 200 W, weigh about 80 pounds, and are twice as big.

The model 901 uses the Intel 8008 as its CPU. Multisonics designers first built their systems with the Intel 4004 microprocessor chip as a substitute for drift-prone analog timing circuits. But this 4-bit chip was small, had limited memory capability, and had no instruction-interrupt or capability for single-step instructions. When the 8008 became available, the designers shifted to it.

Also making traffic-signal controls, Comstar is teaming with TRW Systems, Houston, on a contract for 1,000 microcomputers for the city of Baltimore.

Microprocessors are also providing information to help humans improve the quality of the earth's environment. In one application, microprocessors are being installed in remote data-gathering stations that are keeping tabs on such conditions as water and air quality at sites proposed for nuclear-power plants.

Watching the environment

By preprocessing data and determining right at the remote site whether or not it falls within certain preset limits, "we can economize greatly on data-transmission costs because we send back only important data," explains Melvin Couchman, director of marketing and planning for NUS Corp., Rockville, Md. Ordinarily, as many as a half dozen remote stations are tied to a central data-gathering station via telephone lines. In addition to screening out unnecessary and redundant data, the microprocessor-based systems can also run calibration and diagnostic tests of the remote instrumentation to determine whether or not it's functioning properly, a task that might otherwise have to be handled from the central site.

The new systems, built around Computer Automation's LSI-2 unit, also cost less than if they'd been built with hard-wired logic, Couchman points out. But even more important is the capability of programing the microprocessor to tailor the operation of each remote station to specific requirements. "We just change the programable ROM in the field with a new program, or we put in a read/write memory and use the same basic physical hardware," says Couchman. "It would be much more complicated to change hard-wired logic."

Other types of data-acquisition systems are also feeling the effect of microprocessors. Quindar Electronics Corp., Springfield, N.J., has expanded the capabilities of its system, which is designed to monitor the operation of utilities, partially process the data, and send necessary information to the central computer [*Electronics*, May 30, p. 34]. Process Computer Systems Corp., Ann Arbor, Mich., has designed a system that monitors torque applied to fasteners on an auto assembly line [*Electronics*, June 13, p. 42].

Another company, Doric Scientific Corp., San Diego, Calif., has introduced a new data-monitoring system that not only sharply expands the number of monitored points—to as many as 1,000, an order of magnitude increase over the capacity of an earlier hard-wired unit—but also increases the kinds of parameters that can be monitored. Doric's new microprocessor-based Digitrend 220 monitors and records dc voltages and currents, as well as thermocouple outputs, in such diverse areas as the textile, petrochemical and pulp and paper industries.

The system handles as many as six different types of functional ranges at a time— double the capacity of Doric's hard-wired Digitrend 210. Moreover, with room for plug-in interfaces, it can send this data out to as many as four separate peripheral recording or transmission devices, such as magnetic-tape recorders or teletypewriters. In contrast, the Digitrend 210 handles but a single peripheral.

Doric relies on an Intel 8008, with as many as three PROMS, four ROMS, and two RAMS in a bus-organized structure. The memories contain input instructions for handling data, coefficients for linearizing the nonlinear thermocouple inputs, for scaling, for reading out measurements directly in both the fahrenheit and celsius scales, for limiting alarms, and scratchpad memory for aiding in linearization and formatting.

The new unit was designed to do more than its hard-wired predecessor, but comparable configurations would cost 25% more, admits chief engineer Freeman Rose. However, it performs all its functions in just about the same space as its predecessor.

Moreover, the microprocessor approach is "quite a bit" cheaper than if Doric had gone to a minicomputer, Rose continues. At any rate, Doric did not want to "boggle the mind of the customer" with a mini and the software that would be needed. With the microprocessor, changes are made by simply plugging in a new memory, rather than substituting a hard-wired logic board. Doric is looking at such new n-channel microprocessors as the 8080 to expand the capability of its system still further by offering such operations as trend analysis and averaging.

Typesetting makes headlines

For typesetting, a typical microprocessor-based system would consist of a module containing all the processing and memory functions. One module, built by Varityper division, Addressograph Multigraph Corp., East Hanover, N.J., contains the Intel 8008, which offers the large instruction capability required by phototypesetting equipment, plus the required programable ROM,

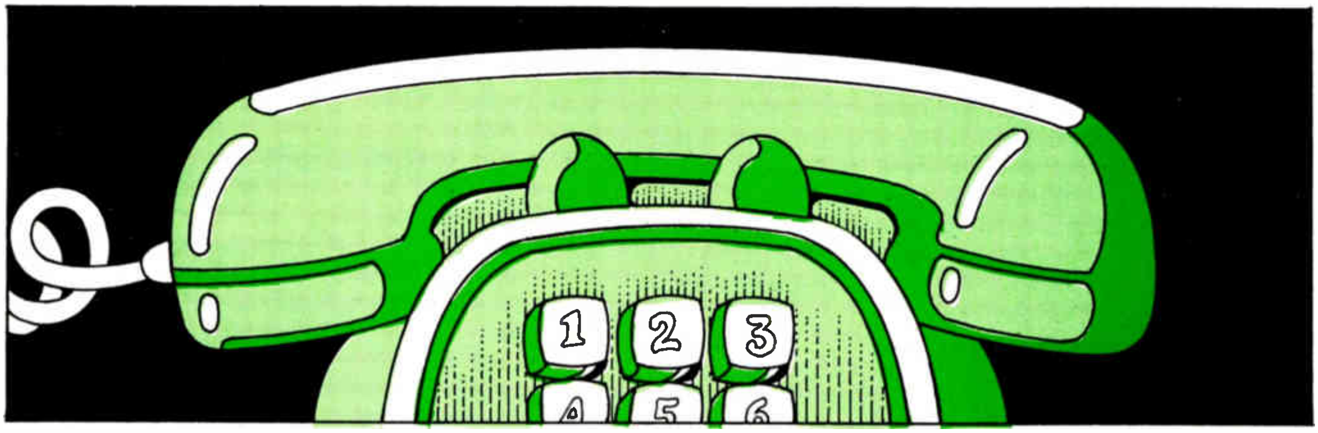
ROM, and RAM, an input bus, and printer and teletypewriter interfaces.

Not only is Varityper able to add processing capabilities to its top-of-the-line phototypesetter that sells for some $15,500, but processing can be included in lower-end products as well. In the past year, the company has introduced a phototypesetting controller called the Amtrol, built around the Intel 8008. The results couldn't have made management happier. Varityper engineers have built a family of 16 standard plug-in modules that they can just about pull off the shelf and apply to new products as they're needed.

This summer, for example, the company will introduce a composition machine that will sell for less than $10,000, yet have decision-making capability. This could never have been accomplished at such a low price with the special-purpose minicomputer that Varityper had been buying since 1969. The old mini was "markedly" more expensive than even the full Amtrol controller, and the modular family enables Varityper to tailor the processing power to each application.

Other advantages abound. The new processor is far more compact and reliable, and its plug-in design makes it easy to troubleshoot and service in the field. Moreover, customers seem to prefer the microprocessor design to hard-wired logic, says Joseph A. Verderber, of the office of product management, because it's easier to upgrade the system by adding features through a plug-in read-only memory.

Microprocessors have already begun to have a tremendous impact on many industries that have repetitive processes to be controlled. In the future, their application is likely to be limited solely by the imagination of the design engineer. Although cheap now, microprocessor prices will come down still further. Within a decade, an entire microcomputer with 4 kilobits of memory could cost less than $150, predicts a market consultant at Quantum Science Corp. That price earmarks the device for an ubiquity similar to that enjoyed by today's hand-held calculator.



Communications
Data-handling gains flexibility

by Stephen E. Scrupski, Communications & Microwave Editor

A strong tide is running in favor of replacing analog communications with digital methods. Microprocessors are accelerating this trend, bringing on a new wave of "intelligent" digital communications equipment. Multiplexers, code converters, error checkers, input/output controllers—all are natural applications for microprocessors. However, their full impact is yet to be felt; most communications-equipment suppliers are still in the feasibility-model and prototyping stages, while the speed limitations of present-day microprocessors are still inhibiting their wider usage.

As in other industries, communications designers like the flexibility and the low costs offered by microcomputers. Custom routines for individual tasks can be quickly changed simply by changing the contents of the programable read-only memories that hold the programs. This is particularly useful in digital communications, where many different codes and message protocols are in use and where the processing chores do not require the capabilities nor justify the cost of minicomputers.

Microcomputer hardware and software can be designed in parallel. While the printed-circuit boards are being laid out to accommodate the almost standard parts of the microprocessor complement, software design can proceed independently, and the two designs can be merged late in the product's development cycle, allowing for system optimization in a minimum of design time. What's more, when a microcomputer breaks down in a communications system, recovery time should be substantially less than in any other kind of system. Service technicians can carry standard circuit modules that are compatible with any of their company's equipment, requiring only new programing to take the place of a failed unit.

Micro teams with mini

An example of how a microprocessor and a minicomputer can be teamed up is in the message-switching units (Fig. 1) being developed by Action Communication Systems Inc., Dallas, Texas, in which microprocessors serve as front ends for Data General Corp. Nova minicomputers. The switchers are used in networks of private terminals, such as those employed by police departments to access records in a state capital or the National Crime Information Center in Washington, D.C. The company has installed several such systems. In the Texas network, for example, more than 500 terminals are located in police headquarters throughout the state.

These switchers, now in the prototype stage, will speed up the switching action and allow higher data rates. They will do this by relieving the minicomputers of certain standard operations—the "dirty work" that must be performed on all messages, such as converting them to the proper code for processing by the Nova and scanning the incoming character strings to identify different control sequences.

"What we're trying to do is eliminate any character-by-character handling by the Nova and allow it to handle only blocks of data," says Action design engineer Michael Fannin. By allowing the minicomputer to do the more complex tasks while the microprocessor handles the menial chores, he predicts that this configuration will raise the processing speed by about an order of magnitude, from the 1,000 or 2,000 characters per second to 10,000 or 20,000 characters per second.

Action is using National Semiconductor's IMP-16C processor for this application "because of its powerful instruction set," says Fannin. "Although it has a slower cycle time than some of its competition," he adds, "it does more with its instructions."

In the system (Fig. 1), circuit controllers interface with the communications circuits and perform serial assembly and disassembly of the characters at data rates as high as 19,200 bits per second. The microprocessors interface with the controllers and perform four functions:

- Convert character codes.
- Scan messages for key characters.

- Edit message headers and text.
- Check character calculations.

One microprocessor can handle the 19,200-b/s rate. It also interfaces with the 64,000-character semiconductor random-access memory, which buffers message blocks between the microprocessor and the central minicomputer.

In such applications, the microprocessor serves primarily as a piece of hardware, since the custom features still reside in the minicomputer's program. In effect, Action is using the microprocessor as a low-cost way to achieve large-scale integration. Many communications designers consider that this is the primary benefit of the microprocessor.

Arliss Whiteside, senior department consultant (essentially a senior scientist) in information processing at the Bendix Research Laboratories in Southfield, Mich., says, "A microprocessor is just another component—and a few too many people consider it something magic. I think they're oversold."

Whiteside goes on to explain that the microprocessor, in his view, is simply a way to cash in on the benefits of large-scale integration—lower costs through fewer packages—without entering a multi-thousand-dollar program to develop custom LSI. "I call it standard LSI," he adds, "LSI that is standardized, flexible, and built by the manufacturer in the quantities that are necessary to justify the design costs for an LSI chip."

Handling the full load

Such a viewpoint is supported in applications where the microprocessor assists a minicomputer. But in others, microprocessors shoulder the full load of data processing. Collins Radio Corp. in Dallas, for example plans to use microprocessors in an intelligent repeater for a private microwave data-transmission system now being built.

In the system, several data links surround a central-hub repeater terminal that switches one link to another upon request. The data signal carries address information that is decoded by the microprocessor, which then routes the message through the hub repeater to the proper receiving terminal. Although this is still an experimental project, according to Collins, the experiments have nothing to do with the microprocessors—the unknown factors are in the radio communications.

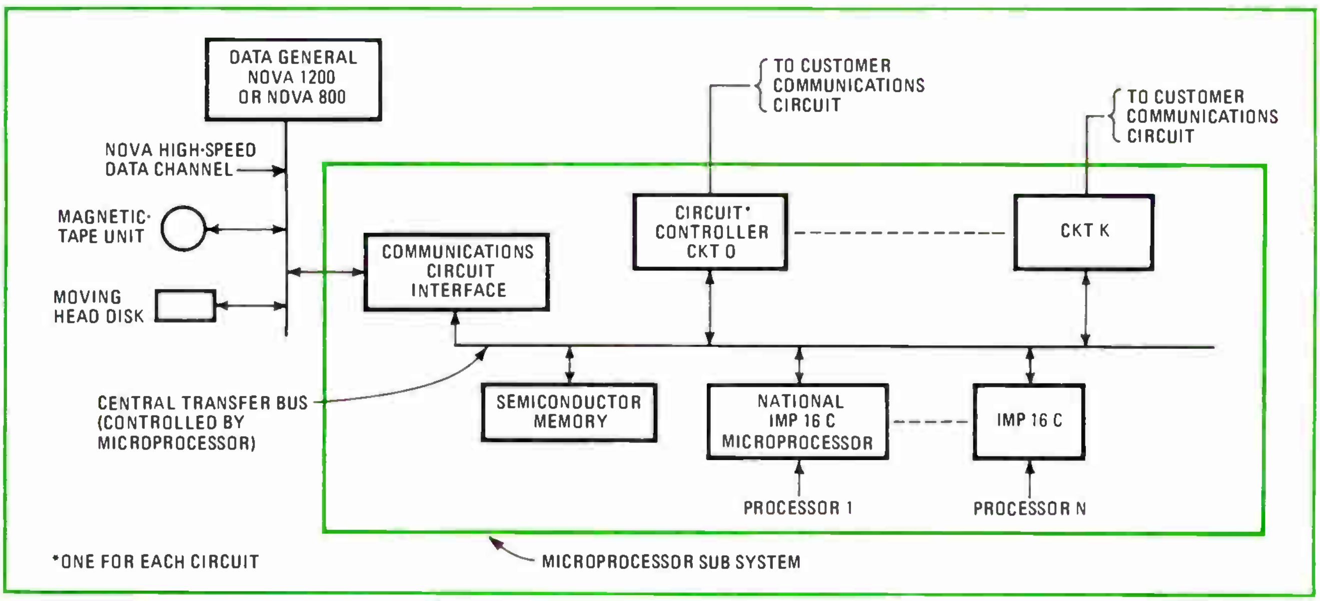
In this instance, the microcomputer's small size helps it beat out a minicomputer for the application—the repeaters have to be man-transportable and battery-powered. To further reduce the power drain, Collins engineers are replacing the TTL circuits recommended by the microcomputer manufacturer with complementary-MOS circuits. To conserve battery power, Collins is also using C-MOS chips for the random-access memory and programable read-only memory. However, the use of C-MOS instead of TTL slows down the system from the microprocessor's basic 1.4-microsecond cycle time to about 4 μs.

Considering tradeoffs

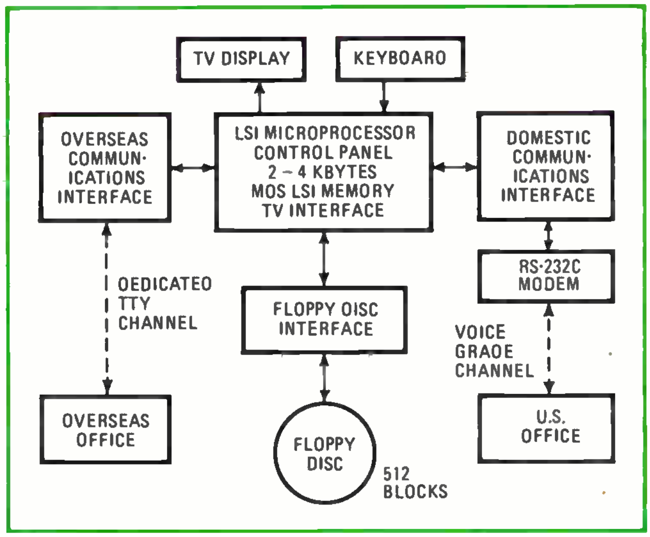
The reduced speed affects the architecture of the system, since extra memory is required to compensate for it. As the message is received in the processor at the hub repeater, it is stored in a buffer memory, and the microprocessor goes right to work processing the information. By the time the message is completely received, the microprocessor has extracted the processing and routing information, and the message is ready to be retransmitted to its destination.

The reduced speed also prevents Collins engineers from using the microprocessor for what should be a natural function—error-checking. The expected maximum data speed of 500 kilobits per second is just too fast for today's microprocessors. Error-checking therefore is done by hard-wired logic. However, if the transmission speed were lower—say, in the range of 50 kilobits per second—the microprocessors could be used to perform error-checking, says Collins design engineer Dale Walls.

Or, if the microprocessor could be operated at its design cycle speed of 1.4 μs, Walls says it would be "aw-



1. Nova helper. In message-switching units built by Action Communication, a National Semiconductor IMP-16 microprocessor handles character-by-character decoding so that Nova minicomputer can concentrate on handling full blocks of data, increasing system speed.



2. Interpreter. A microprocessor handles conversions of codes and speeds to allow a domestic data processor to communicate with an overseas network via the RCA Global Communications system. Easily changed software helps customize system.

fully close to being applicable for error-checking." The limiting speed of today's microprocessors however, will soon be overcome by a new generation of faster devices built with bipolar or sapphire-based MOS technologies, while 4-bit processor slices capable of instruction times of 10 to 50 ns are expected to be available by the end of the year.

Interfacing between nations

A microprocessor is the sole computing component in a programable controller built to handle international leased-data channels. Developed jointly by RCA Laboratories, Princeton N.J., and RCA Global Communications Inc., New York, the controller connects RCA's Cosmac, a two-chip C-MOS microprocessor and associated semiconductor RAMs, to a floppy-disk drive for mass storage of messages.

The combination of the microcomputer with a floppy-disk drive allows RCA to cut the cost of the controller below that of either a system combining magnetic tape with a minicomputer or hard-wired logic. The single basic design, easily customized by software, meets a variety of different customer needs, while at the same time offering improved maintainability.

The microprocessor's job is to provide all the conversions necessary to interface a domestic communications network with an overseas network (Fig. 2). Signals, codes, speeds, character formats—all must be often reconciled to allow the two networks to communicate with one another. And, since each private user who leases a channel from RCA has his own unique combination of such parameters, use of hard-wired logic would require long development times and an abundance of specialized equipment that would have to be maintained.

Minicomputers, although they offer programability, are simply too expensive to be considered for this application, according to RCA, since they have too much computing power for the few lines that must be controlled. Another tangential problem, RCA claims, is that often the customer has only partial knowledge of his own needs, and the microprocessor programability offers RCA engineers an easy means to add needed features at later stages.

Helping the police

In another police-oriented application, Motorola's Communications division, Schaumburg, Ill., is using a microprocessor in a computerized mobile terminal system, first installed for the Atlantic City, N.J., police in 1973. Each squad car carries a light-weight terminal with a full keyboard and plasma alphanumeric display. Using the terminal, a policeman can access files at his local station, at the state headquarters, or even at the National Crime Information Center.

An 8-bit microprocessor is built into the base-station unit, says Jerry Schloemer, manager for command and control products at Motorola. The microprocessor acts as a communications interface to the computer at the next higher echelon, controlling the coding on the radio channel and performing a reduced store-and-forward function in both directions.

"We hope that the cost of microprocessor devices will come down with increasing volumes," Schloemer says. "If so, we're planning to put microprocessors in the next-generation car unit—it gives us a little extra power to be able to offer more features. We hope that their use will reduce our product-introduction cycle," he adds, "but we've seen no evidence of that yet."

Even voice signals, once they are converted to digital form, as in a pulse-code-modulation system, may offer opportunities for microprocessors. Presently, telephone voice signals in a 4-kilohertz bandwidth are sampled in a "channel bank" at an 8-kHz rate, and each sample is encoded into 8 bits; thus the 4-kHz voice signal is sent at a rate of 64 kilobits per second, which is extremely wasteful of bandwidths, says David Trask, manager of the communications system laboratory of the Raytheon Equipment division in Wayland, Mass.

Simplifying the phone system

He points out that telephone engineers have given much thought to ways to reduce the bit rate necessary

Calling all cars. Microprocessor in Atlantic City, N. J., police station controls message-coding for keyboard terminals used in squad cars.

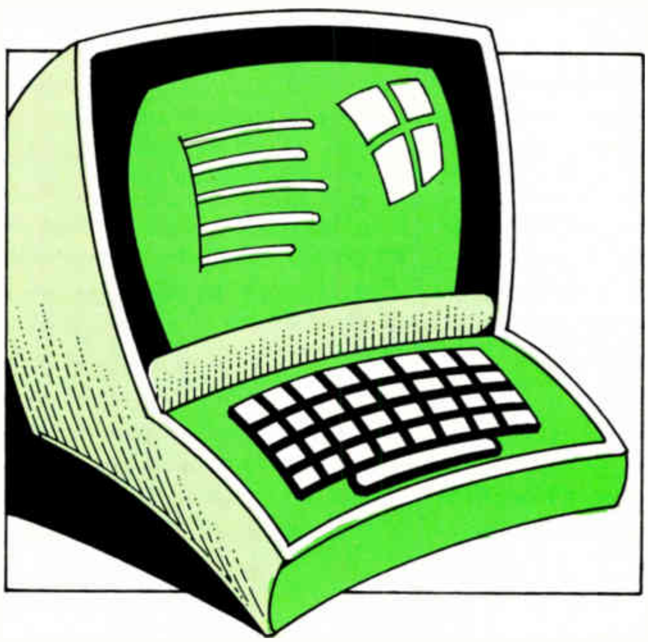
for each voice signal and thus to expand the capabilities of the transmission system. For example, many algorithms have been proposed for a processor that would note an instantaneous value of the voice signal and predict the value during the next sampling period. Then, when the next sample actually appears, the processor would transmit only the difference between the actual and predicted values.

If the algorithm is effective, it would only require a few bits, rather than the full 8 bits presently used. An identically programed microprocessor at the receiving end would then reconstruct the full voice signal. In fact, he envisions a telephone set that has the sampling and microprocessor circuitry built right into the back so that digital signals are sent to the telephone central office directly from the set itself.

Microprocessors are being designed into a somewhat similar system at Harris Electronic Systems, Melbourne, Fla. Harris is building encryption devices for secure digital-communications systems and, says Ray Glenn, associate principal engineer at Harris, the microprocessor makes a good pseudo-random noise generator. One microprocessor can be programed to encode a digital signal, and an identical microprocessor at the receiving end can decode the signal.

If fabricated with medium-scale integration, such a system might require up to about 75 packages, but a microprocessor would cut the count to only 10 to 15 packages, Glenn estimates. He points out that microprocessors are being used at Harris to control the output-power levels of radio-frequency transmitters throughout the day. Temperature changes, Glenn says, cause the power level to drift, but a simple 4-bit microprocessor can store a control algorithm that enables the microprocessor, when presented with digital information on the output level, to bring the level back to the desired point.

It is clear that microprocessors are taking over many of the routine applications in communications equipment. And regardless of whether the designer views a microprocessor as merely another component—a way to get standard LSI— or as a radical new component that offers small-scale programing, nearly all analog, as well as digital, communications gear will benefit from its impact.



Consumer/commercial
Microprocessors go public

by Gerald M. Walker, Consumer Editor

Manufacturers of commercial and consumer products have for some time taken the lead in applying advanced semiconductor technology. Their adoption of microprocessors is no exception. In a sense, microprocessors are accelerating the timetable for equipment and systems already deemed feasible in both the commercial and consumer markets.

In addition, development of totally new products not yet identified will sweep these markets in the same way that the personal electronic calculators came from nowhere into international prominence. Thus, microprocessors are having it both ways—enhancing present-day equipment while promising completely new products for offices, stores, households, and entertainment centers.

Included in commmercial equipment containing microprocessors now on the market are terminals for point-of-sale and supermarket checkout, scales, terminals for investment houses and the finance industry, automated back tellers, processors for business-inventory control, equipment for supermarket in-store packaging, and portable data terminals.

Among the products using microprocessors in the comsumer and related markets or on the drawing board for the near future are sophisticated games, gambling equipment, cable-television transmission hardware, do-it-yourself instrument kits, and photographic-film developers. Further down the pike are automobile on-board processors that perform such tasks as controlling combustion timing (Fig. 1), exhaust emission, transmission operation, and anti-skid and diagnostic systems.

It's in the household that the explosive new product—the home computer—is expected to emerge. The most obvious door into the home is the television set, which can make good use of a data-communications processor. By then, microprocessors will have to be quite different from today's products, not only in bit capacity, but also in basic environmental configuration and price.

In the entertainment world, the microprocessor offers the simulation of games at a level of sophistication until now reserved for military and space projects. In its civilian format, simulation makes games realistic by the capability to cram programing, memory, feedback, and real-time processing onto a single chip. Certainly Disney's "Land" and "World" are proving the wide attraction of family fantasy via simulation. The subject of a movie spoof about a year ago, an adult fantasyland designed around simulation techniques is now more than science fiction.

In general, the advantages of microprocessors to commercial/consumer-equipment designers boil down to the tradeoffs between hard-wired and programable logic. For instance, point-of-sale cash registers built with hard-wired packages have performed both as stand-alone units and minicomputer-controlled terminals. By changing to microprocessors, POS-equipment manufacturers gain the important advantage of adapting their basic equipment through programing to the needs of individual stores.

On the other hand, the problem most frequently mentioned by manufacturers of commercial/consumer equipment using microprocessors is the difficulty of refining the very software that they also say is the microprocessor's major advantage over hard-wired circuits. Equipment makers feel that microprocessor suppliers are not equal to the task of providing software support, forcing users to become immersed in programing.

Some of the commercial-consumer products using microprocessors are hardly a generation removed from electromechanical design. Yet the totally different requirements of the technology have made the switchover from hard-wired logic to microprocessors as traumatic for designers as the original change from an electromechanical to an electronic approach.

As C.W. Kessler, vice president of corporate engineering and advanced development for NCR Corp., Dayton, Ohio, points out, engineers familiar with Boolean equations and logic families, which were adequate for the design of hard-wired equipment, must now add complex instruction sets to their repertoires for microprocessors. They must be prepared to live with the sequential operation of microprocessors, which is slower than the parallel operation of chips using standard logic like TTL.

In addition, Kessler suggests, "There is a horde of new problems in choosing the right microprocessor, and these have become corporate-level decisions. After all, you're tied to one supplier, once work is completed on hardware and software. There's a lot hanging on the source selection, since you don't have a second source."

POS-terminal producers took different routes to arrive at use of microprocessors. For example, National Semiconductor's Systems division began applying them as a direct result of its ties to development by the semiconductor operation. Because of the close relationship, programs presented little problem. However, the main challenge was to teach test personnel to debug semiconductor chips the way programers debug a computer. This conversion required training because microprocessor faults are much more difficult to isolate and correct than failures on a standard LSI chip.

At American Regitel Corp., San Carlos, Calif., application of a microprocessor made it possible to design a terminal combining stand-alone "intelligence" and peripheral-communications capability. Such mechanical attributes as communications routines are specified in read-only memory, while the logical attributes at the human and exterior interfaces are specified by instructions residing in random-access memory. The former are concerned with fixed procedures, while the latter must be variable to permit application of a wide range of sequences, tax tables, and keyboard checks.

Most of the jobs assigned to the controller are performed at the speed of the terminal operator, and the program responsible for driving the printer has a throughput of only 30 to 100 characters per second. Because the arithmetic is not a major difficulty, and transactions are done at human speeds (communications functions require logic throughput of 200 to 300 characters per second), a general-purpose microprocessor that could fetch in 3 to 10 microseconds was adequate, putting the task well within the capacity of 4-bit processors.

NCR presently employs Intel MCS-4 microprocessors in two products—a bank-teller terminal and a point-of-sale terminal—and will soon introduce four others that use microprocessors. Their functions are quite different.

Inside the NCR 279 financial terminal, for instance, microprocessors control the keyboard, printer, and credit-card reader, do the teller's arithmetic, transfer data, and act as computer-interrupt. In the NCR 255 supermarket register, the microprocessor is essentially a back-up element to provide the terminal stand-alone capability, should the remote computer-controller fail. The microprocessor makes it possible to do away with dual minicomputers to control terminals unless the customer wants the redundancy.

Another teller terminal using microprocessors has been built by Financial Data Science Inc., Orlando, Fla., and about 100 are presently in the field. The model 108 contains three MCS-4s—one for printer control, one to provide stand-alone processing in the event of communications failure to the central computer, and one to control the keyboard and perform calculations.

Microprocessor knowhow

Not only are microprocessors changing the design of equipment, they are also changing the demands on the designers who use them. A list of the skills and tools needed for the new generation of microprocessor applications engineers, recently drawn up by Herman Schmid of General Electric, is awesome.

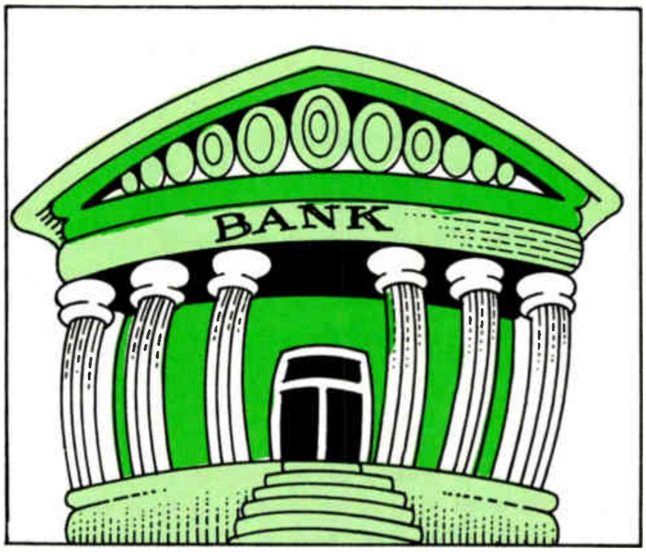
He states that engineers must thoroughly comprehend the organization, operation, and performance of the processor's CPU; control of input/output; the organization and operation of RAMs, ROMs, and programable ROMs, plus such interface circuits as analog-to-digital and digital-to-analog converters; operation of peripheral equipment; the operation of multilevel priority-interrupt systems; the operation of control-panel circuits; and the operation of such various logic families as TTL, p-MOS, n-MOS, and C-MOS.

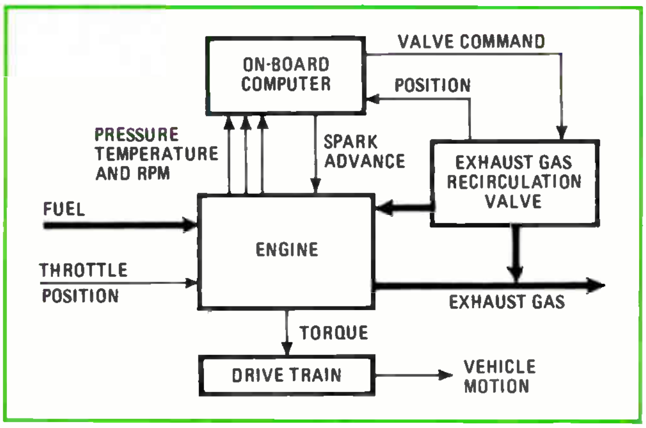
But that's not all. For designing firmware, this same engineer must also have extensive knowledge of programing. This designer needs to be an expert in software for machine-level, micro-level, and assembler-language programing. Finally, the microprocessor engineer must be familiar with such interface operations as the performance of converters and signal-conditioning.

The first and third applications could have been performed by hard-wired logic, but stand-alone processing backup would have required a minicomputer. By applying the microprocessor to the keyboard, total package count was reduced 30%, and total cost was lowered to slightly less than what hard-wired logic would have been. In addition to the 108, which is meant for savings-and-loan institutions, the model 151 is also available for full-service automated bank tellers. It uses one microprocessor, essentially as a calculator.

Automating inventory

The manufacturer that probably has the most units containing microprocessors in the field is MSI Data Corp., Costa Mesa, Calif. This firm has delivered about 10,000 portable data terminals for use in taking and recording inventory or other data at remote locations.





1. Economy car. One microprocessor will be used in an automobile for spark-ignition timing and exhaust-gas recirculation-valve control.

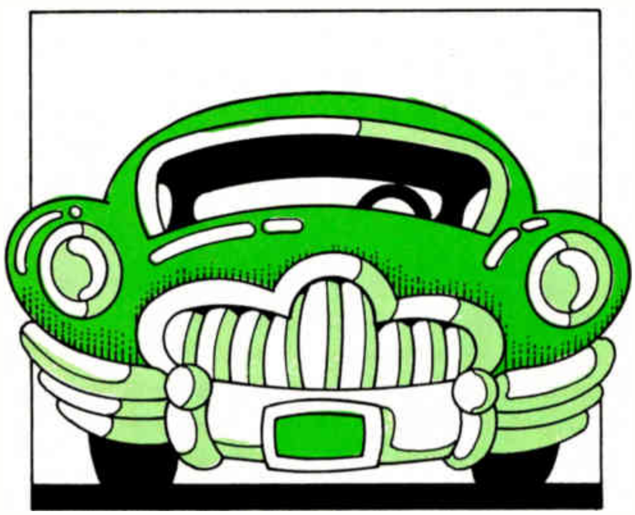
Each terminal contains one MCS-4 microprocessor.

The MSI battery-powered model 1100, which has semiconductor memory, and the model 2100, which has a magnetic-tape cassette, look like plump hand-held calculators, except that the keyboards have special symbols, and just below the LED displays are function switches for transferring data to telephone modems. Data such as supermarket inventory or warehouse stockroom supplies is entered through the keyboard and recorded either on a tape cassette or in solid-state memory, depending on which of the two models is used.

Afterwards, this data is communicated by telephone to a MSI receiver at some control location. Depending on the model used, 7,000 to 20,000 characters of information can be transmitted in less than three minutes, eliminating several data-handling steps required in manual or even punch-card procedures.

MSI originally designed these terminals with TTL to control the displays, computations, and interface circuits. Later models were converted to complementary-MOS chips to reduce battery-power dissipation. But the need for flexibility to meet a variety of uses for remote terminals made microprocessors attractive replacements for the control logic. At the same time, delays in delivery of standard chips made the change to microprocessors even more attractive.

Larry Hendricks, manager of the Electronic Engineering department for MSI, points out that previous experience in designing a minicomputer controller for data terminals was valuable in learning how to design with microprocessors. In fact, MSI now uses a minicomputer that it designed and built to serve as a communications controller to write the microprograms.



Hendricks complains that microprocessors are still difficult for many designers to learn to use because there's no easy applications track; hardware-oriented engineers stumble on the software, while software-oriented programers get confused by LSI technology.

He also cites three other current problems. First, he would like microprocessor manufacturers to stick with one device long enough to establish an industry standard such as the 1103 chip. Second, Hendricks is uncomfortable with single-source purchasing, particularly since MSI is now buying microprocessors in relatively large quantities to support production of about 1,000 portable data terminals a day. The third problem is the need for a more sophisticated system that nonprogramers can use for microprograming.

While microprocessors are essentially used for what Hendricks calls "bit-banging," that is, simple and slow processing chores, he believes that there's a danger of trying to apply them for too many functions. "It may seem possible to substitute a microprocessor for every minicomputer," he says, "but you have to watch out that you're not sending a boy to do a man's job."

Singer patterns its own

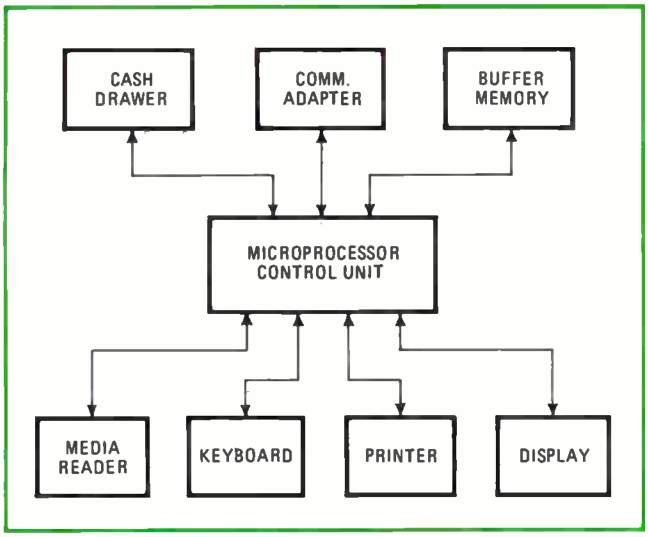
Although most microprocessor users, especially commercial manufacturers, have been concerned with dependence on sole-source purchasing, Singer Corp., New York, has alleviated this situation by designing its own microprocessor at the firm's research laboratory in Fairfield, N.J. At least three semiconductor houses are qualified to use Singer's masks to produce the chip. In fact, one of the design constraints was to be conservative enough to keep producibility within the capability of at least two suppliers—not an easy task.

The result is the Advanced Byte-Oriented (ABO) microcomputer, an 8-bit, n-channel MOS processor measuring 191 by 202 mils. The 40-pin unit is designed for a variety of Singer products, including point-of-sale terminals built by the Business Machines division in San Leandro, Calif. It's microprogramed internally from a 6,000-bit ROM, rather than from separate chips.

One reason Singer designed its own microcomputer was to follow the course of its electronic end products into what the firm calls "distributed computing," that is, loading each piece of equipment with as much processing capability as possible. Thus, in a Singer POS terminal, the ABO is heavy on processing capability and light on arithmetic-calculation functions.

Microcomputers from semiconductor suppliers need both capabilities, whereas a custom design could downgrade the less important attribute. Of a total of 256 instruction codes, 50 are basic, and the instruction time is typically 10 microseconds. According to Singer, prototypes of its microprocessor are now being manufactured by two sources.

The Business Machines division presently has a terminal with a single microprocessor also of Singer de-



2. POS microprocessor. In a stand-alone point-of-sale terminal, the control unit carries out microinstructions stored in a ROM.

sign. However, unlike the ABO, this unit has five 12-kilobit ROMs outboarded to instruct the microprocessor. The function of the microprocessor-control unit (Fig. 2) is to direct the flow of data between the I/O devices and the buffer memory and to perform arithmetic chores. All data transfers within the microprocessor and between it and the I/O devices are accomplished by means of a source-destination bus, consisting of a 5-bit source address, a 5-bit destination address, and a 6-bit data bus. Because each register inside the microprocessor and in the I/O devices is addressable, it can act as either the source or the destination in a data transfer. However, intercommunications are minimized, and interface requirements for the I/O devices are simple because the terminal is bus-oriented.

Steering for Detroit

An example of what an automobile-microprocessor system might look like is a Ford Motor Co. advanced development. Figure 1 shows the bare bones of a digital control system, designed to maximize fuel economy. It is being road-tested, but it won't be ready for a standard car for some time. This system uses two microprocessors and other custom-LSI devices to control timing of spark ignition and position the exhaust-gas-recirculation (EGR) valve by using several engine inputs.

Ford engineers decided to use a microprocessor because attempting to compensate an analog programable spark-timing controller over the worst-case of auto temperatures turned out to be more expensive than a digital control system. The microcomputer made it easier to program changes in engine design than to use hard-wired logic. Ford uses a 12-bit microprocessor with the program and associated coefficients, which describe the engine-control algorithm stored in a ROM.

The present engine-control software is contained in about 1,500 12-bit words. The system also includes an 8-bit analog-to-digital converter with an eight-channel multiplexer under CPU control to measure the outputs of engine and EGR-valve transducers. The key reason for using a microprocessor for this application is to be able to design the same hardware for all engine and transmission variations in several different models, changing only the software to match each car.

Actually the idea for computer-like management of timing, combustion control, emission control and transmission control has been considered by the advanced engineering departments of the auto Big Three for some time. There is also a possibility for microprocessors to handle such safety functions such as antiskid braking and on-board diagnostic systems.

The game's the thing

A unique, but significant, application of microprocessors to games is exemplified by a bowling game Bally Manufacturing Corp., Chicago, has been marketing since last October. Sold to distributors for $1,600, about 85 of the electronic game, Bally Alley, are now installed. Each contains one Intel 4004 CPU, four programable ROMs, a RAM, and one 1,024-bit ROM, in addition to some 250 discrete power transistors and silicon-controlled rectifiers.

The electronics package in Bally Alley is vital to give players the right "feel," not only in the scoring, but in the fall of the "pins," the roll of the "ball," and posting the odds normally associated with making various shots. None of this could have been done in the size and cost required of an arcade game without the microprocessor.

The microprocessor monitors the placement of the ball when it is sent down the lane by a player (one to four can play at any one time), keeps tabs on the pins, and metes out free games and credits. In controlling the scoring, the microcomputer tracks pin patterns. A player can decide at what place along the bottom of the lane to let go of the simulated ball, and the microprocessor calculates from program instructions how many balls have been used before recording the score on an incandescent-lamp display. Bally is now looking at microprocessors in 8-bit configurations for other games, as well as gambling equipment it builds.

Computers

Peripherals now, mainframes later

by Wallace B. Riley, Computers Editor

Although much of the shouting about microprocessors has been about consumer and industrial applications, these programable large-scale integrated circuits are also impinging on the way computer manufacturers themselves are designing data-processing systems.

For manufacturers of large mainframes, the impact is mainly in peripheral and control equipment because today's microprocessors are generally too slow and limited to perform large-scale processing. For minicomputer manufacturers, however, the low-cost versatile LSI processor goes to the very heart of their designs and promises to open up a whole range of higher-performance capabilities at lower costs.

A major advantage of microprocessors is the smoother design iterations that can be wholly or partially achieved by reprograming a microprocessor instead of rewiring a major part of a prototype design. These design iterations are necessary in almost any development cycle because the original specifications have to be modified as development proceeds. The goal is a design that meets the original specifications to some degree while being both manufacturable and marketable. In conventional designs, iterations often take the form of building and rebuilding a succession of prototypes—an expensive and time-consuming process.

The main use of microprocessors with the large mainframes has been in peripheral equipment and controllers. Their application inside the computers themselves has been like only a distant rumble of thunder because until now they have been too slow. However, a new generation of chips now on the drawing board promises to overcome that shortcoming.

Microprocessors have thus far proved of value primarily in low-cost, low-speed equipment, such as cathode-ray-tube terminals and magnetic-tape cassette drives. Their main benefits have been to facilitate customization and addition of power at a lower cost than previous designs and to increase the processing capabilities of remote terminals.

Makers of punched-card machines, floppy-disk-storage units, and devices of similar complexity say they may use microprocessors in their next design cycles. However, they have thus far found the LSI chips too slow or too limited in some other functions. These companies are expressing great interest in such microprocessors as Intel's new 8080 [*Electronics*, April 18, p. 95], mainly because of its expanded instruction set and the order-of-magnitude increase in speed.

Microprocessors cut costs and reduce system complexity while simplifying customization of otherwise standard designs. For example, Beehive Medical Electronics Inc. of Salt Lake City, Utah, can adapt its Superbee terminal easily to a variety of applications because it uses the Intel 8008-1 chip. And, although the microprocessor replaces only some of the circuitry of the company's earlier model, it adds new functions and adapts easily to each customer's application.

A trend changes

Significantly, the burgeoning interest in microprocessors reverses one important trend that has been shaping up during the past few years—the execution in hardware of many functions traditionally left to the software. This tradition was established in the early days of computers, when gates cost $100 apiece and programers were paid clerical wages. These rates made the minimization of hardware imperative and the proliferation of software initially unimportant.

But since then, costs of hardware and software have moved inexorably in opposite directions. Today, some functions that would have cost astronomical amounts for 1954 hardware can be implemented now for little more than pocket money, while software has grown to almost unmanageable proportions in the form of operating systems, time-sharing, and so on—all in the name of efficient use of hardware.

The low cost of hardware has made microprocessors possible—simple enough not to require software of the complexity remotely resembling an operating system and cheap enough for inefficient use without adding significantly to the cost. As a result, some new functions can be implemented in software that considerably simplifies design and alteration—without the headaches associated with large software systems.

Peripherals and controllers benefit

In the peripheral devices themselves, microprocessors take a substantial load from a controller or central processor. For example, Digi-log Systems Inc., Horsham, Pa., uses microprocessors to control a display's refresh memory, its communications interface, its editing functions (inserting and deleting words, phrases, and paragraphs, and rearranging them as directed from the keyboard), as well as other display characteristics.

A variety of optional capabilities is available with the basic models. Customers select the capabilities they want, and modules programed to perform the desired tasks under software control are shipped with the system. In most other terminals, these functions are performed by hard-wired logic, which can be added or removed from a system only with difficulty.

However, some designers who have tried the Intel 8008 for these functions have criticized it as not being fast enough and not having a large enough instruction set to do an adequate job. Again, the 8080 chip is viewed as a substantial improvement, although it's still too new for users to have accumulated much experience with it.

The Beehive and Digi-log terminals illustrate one of two trends in the computer-terminal market—their microprocessor-based units offer greater power and a higher level of customization, yet at lower cost. The other trend is to the "dumb" terminal under control of the central computer, which provides a simple way to "look into" a computer to see what's going on. "There'll always be a market for a dumb terminal," says Richard Kaufman, director of marketing at Applied Digital Data Systems Inc., Hauppauge, N.Y. Because of these two extreme requirements, the intermediate terminal that has only a small amount of logic capability will disappear. But the best way for designers to keep up with the trend toward smarter and smarter terminals is to use microprocessors to provide the "smartness."

Building controllers

Builders of mechanical peripheral equipment that contains minimal electronic circuitry have no need for microprocessors. However, builders of controllers for this equipment, as well as the manufacturers that build both the mechanical devices and their electronic controls, are more enthusiastic about microprocessors for

Microprocessor aids the mini

Perhaps partly because of a certain degree of overselling by microprocessor manufacturers and partly because of misunderstandings of what a microprocessor is and what it can do, there has been some speculation that the advent of microprocessors means the end of the smaller minicomputers. This is most emphatically not true. On the contrary, by enhancing the capability of the minicomputer, the microprocessor opens a whole new range of applications for the minicomputer that it couldn't touch economically before.

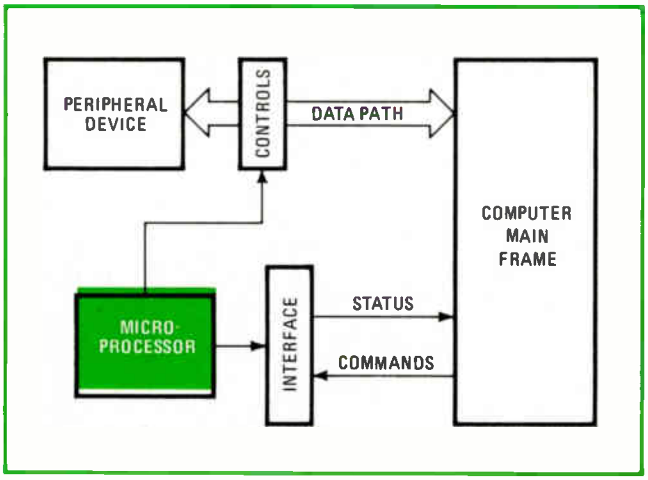
In many of the new applications, the capabilities of microprocessors and minicomputers have been combined to increase the effectiveness of the entire system at only a small increase in cost. For example, David Methvin, president of Computer Automation Inc., describes attempts to drive a series of remote terminals from a single minicomputer. "It didn't work very well," says Methvin, "because the minicomputer's speed and short word length are generally adequate to drive no more than two or three terminals."

But by designing into each terminal a microprocessor to handle some local processing and relieve the control minicomputer of the drudgery, it can easily do the higher-level work for the entire network. "In this way," concludes Methvin, "the advent of the microprocessor creates a new market, not only for itself, but also for the minicomputer, which previously had to yield to something bigger and costlier."

Microdata Corp., Irvine, Calif., a leading producer of microprogramed minicomputers, has not yet begun using the single-chip p-channel-MOS microprocessors in any of its computers. However, Richard Vahlstrom, technical director, foresees a possible utilization of the devices in peripheral equipment whenever they become cost-effective. Meanwhile, Microdata has introduced its Micro-One, a one-board bipolar processor that is both software- and firmware-compatible with the company's older 800 and 1600 series minicomputers and with their peripherals [*Electronics*, May 30, p. 142].

Digital Equipment Corp. and General Automation Inc. have already recognized this trend, as shown by their recent product announcements. General Automation now has two minicomputers based on silicon-on-sapphire microprocessors, while DEC's microprocessor module, an extension of its long-standing line of logic modules, is based on Intel's 8008 microprocessor—one of some 53 circuits on the card. The PDP-8/A is the company's latest version of the line with which it more or less invented the minicomputer market back in 1965. The original PDP-8 was a discrete-component computer in a big box 34 inches high and almost two feet square. But now the complete set of 79 PDP-8 instructions can be executed by an assembly of components on a single printed-circuit board measuring 15¾ by 8½ inches, not including the memory.

The PDP-8/A makes extensive use of LSI, but none of the circuits is a microprocessor. Future versions of this and other DEC computers may include circuits that would be called microprocessors today. William Hogan, marketing manager for logic products in DEC's components group, describes the microprocessor module as the first of a series of products that will use any appropriate semiconductor chips with the right combination of cost and performance.

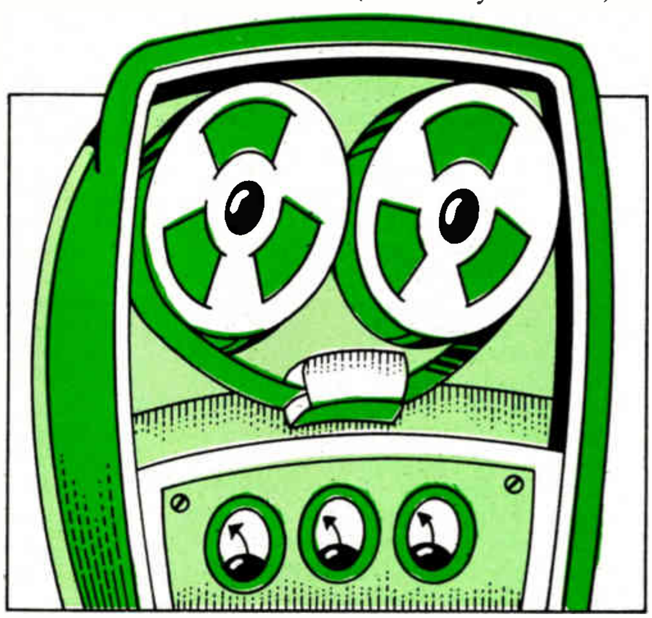


1. Interface and control. Today's microprocessors are applied in computer systems primarily where they do not affect data flow, but that limitation will only last until their performance improves.

use in the interface and control sections of their machines (see Fig. 1). The interface section responds to signals from the central processor and generates status signals to it. The control section sets up the device controller for a particular task. But neither of these functions is concerned with the actual passage of data through the controller, which may involve such steps as serial-to-parallel conversion, assembly of words from bytes, and error detection and correction.

Although the enthusiasm of controller designers, like that of terminal designers, is tempered by the performance level of presently available microprocessors, they look forward to a new generation of microprocessors now on the drawing board. The higher performance of the new microprocessors will enable them to graduate to full use in the data path as well.

New single-chip processors made with silicon-on-sapphire and bipolar technologies are expected to promote such a graduation by reducing the typical execution time to the range of 50 to 500 nanoseconds (from today's 2 to 20 microseconds) and increasing the number of instructions toward 200 (from today's 40 to 75).



Specifically, Intel is reported to be working on a bipolar microprocessor that can execute instructions in as little as 500 nanoseconds. In MOS, Rockwell's Microelectronics Group, one of the earliest to exploit sapphire technology, is developing more powerful processor chips. They already supply devices to General Automation for their LSI microcomputer line. Also, Inselek Corp., Princeton, N.J., has proposed a C-MOS-on-sapphire microprocessor that could handle a data rate of 3 megabits per second with its cycle time of 300 ns. Inselek says the device will be available early in 1975.

For its paper-tape emulator, Remex, a unit of Ex-Cell-O Corp., Santa Ana, Calif., chose the Intel MCS-4, a chip set that includes the 4004 4-bit microprocessor. The emulator is a magnetic-tape cassette drive that works with a minicomputer like a paper-tape reader.

Currently, the programs for the emulator are stored in programable read-only memories—the kind that can be erased under ultraviolet light. Program bugs turned up by the first few customers can be easily corrected. Later, when change activity has died down somewhat, Remex plans to switch, perhaps first to fused-link ROMs, which can be updated but not erased, and eventually to masked ROMs that can't be changed in the field at all, except by physically exchanging one part for another.

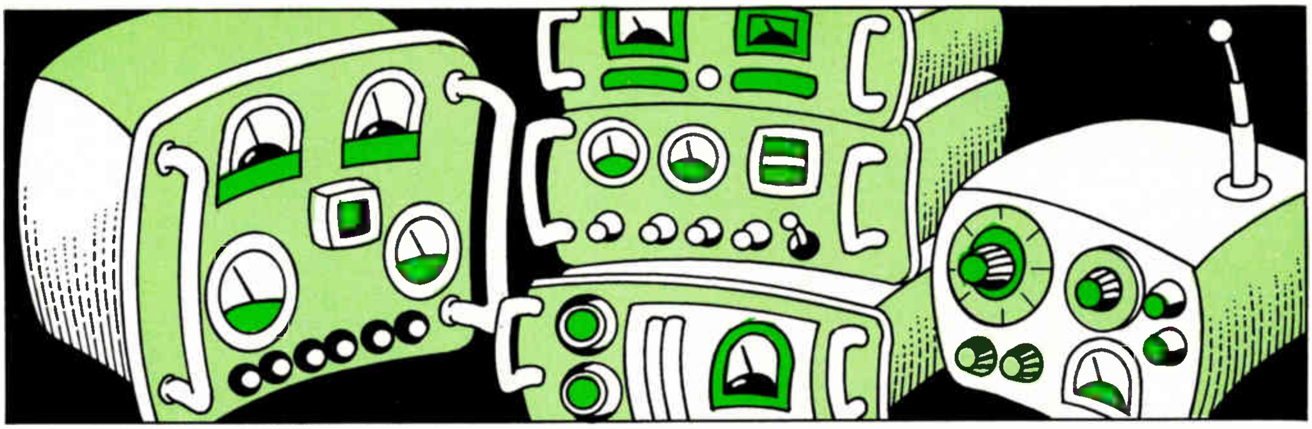
Stamp out logic monsters

Decision Data Corp., also of Horsham, Pa., indicates great interest in microprocessors—particularly in data recorders. In these peripherals, a few microprocessors replace a multitude of interconnected integrated circuits. The company manufactures a line of punched-card machines—both the old standard 80-column type and the newer, smaller 96-column equipment for IBM's System/3 and similar computers. The line includes a data recorder, which is a sort of combination keypunch, card reader, card punch, and printer, with various other outputs available and usable either on line with a computer or as a stand-alone device.

"Data recorders are monsters in logic," says Thomas Richardson, vice president for engineering, referring to the multitudinous functions that the machines perform. Present designs, he says, use 700 to 800 small-scale integrated-circuit packages, plus as many as 400 signal lines to interconnected equipment—clearly a prime territory for an invasion by microprocessors. Richardson indicates that the company will begin to move in this direction before the end of 1974, initially with its own design implemented with medium-scale ICs and later graduating to bona fide LSI microprocessors.

Despite the advances already made, development of faster, more powerful microprocessors is continuing. Although today's microprocessors have word lengths of 4 to 8 bits and instruction-cycle times of 2 to 20 microseconds, at least one 12-bit unit has already been developed in Japan [*Electronics*, March 21, p. 111]. And semiconductor manufacturers in the U.S. are working feverishly to increase speeds.

What's more, LSI processors being made with bipolar and SOS technologies are yielding processor chips that blur the distinctions between the capabilities of the microprocessor and the small minicomputer. Indeed, the LSI miniprocessor is already on the design bench.



Instruments
Systems are getting 'smarter'

by Michael J. Riezenman, Industrial Editor

Anyone who has ever twiddled the controls of a pulse generator, wasted a couple of hours trying to recall how to use a scope's delayed-sweep feature, or laboriously calculated the standard deviation of a set of measurements knows that it takes detailed knowledge and refined techniques to use a complex modern instrument properly and efficiently. But soon, microprocessors will bring about a new generation of "intelligent" instruments that will automatically relieve the operator of routine procedures. And most of these "smarter" instruments will be cheaper than the ones they replace.

Instruments can be made less costly because, in many cases, the software techniques used with microprocessors will be cheaper than the hard-wired logic and mechanical switches they replace. Probably multi-instrument systems can benefit even more because microcomputers should replace minicomputers or programable calculators in small systems and do much of the repetitious work so that much cheaper minicomputers or calculators can be designed into larger systems.

Many cost-related benefits can be expected from a whole new class of small computer-controlled instrument systems that would be too expensive if built with minicomputers or even programable calculators. And for large systems that need minicomputers as controllers, microprocessors may be able to make significant reductions in the costs of the computers by using them as preprocessors in the instruments that are controlled by, and are feeding data to, the minicomputers.

These reductions should be significant. The intelligent application of, say, $400 worth of microcomputer components in each of five or six instruments may make it possible to replace a Digital Equipment Corp. PDP-11/45 minicomputer that costs about $16,000 to $18,000 in an appropriate configuration, with a PDP-11/40 at a cost of about $12,000.

The straight bench instrument that can probably realize the greatest cost reduction by use of a microprocessor is the frequency synthesizer. A high-resolution synthesizer uses a large number of expensive electromechanical switches and a great deal of complex logic circuitry simply to tell the frequency-generating circuitry what to do. Replacing these switches with simpler, cheaper ones or with a keyboard and replacing the logic circuitry with a microprocessor will, in most cases, justify the cost of the microprocessor, even if it brings no other benefits.

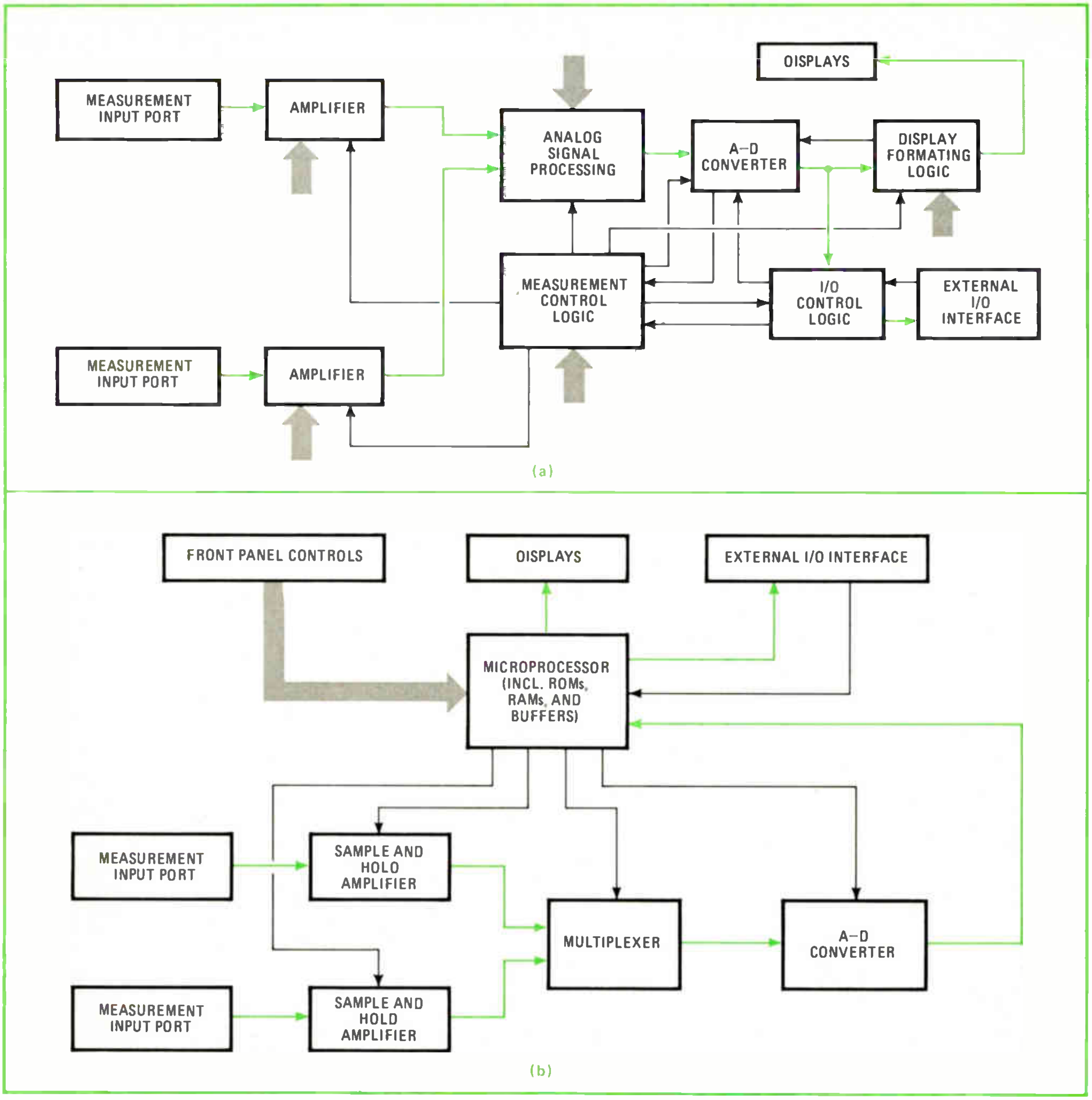
Of course, microprocessors will provide a whole host of such other benefits as data-formatting for the instrument's input/output interface. Moreover, the microprocessor will enhance accuracy and reliability through the use of special routines for self-diagnosis and the elimination of systematic errors.

Automating testers

Already several manufacturers have introduced microprocessor-controlled instruments. Among them are the in-circuit IC testers built by Testline Inc., Titusville, Fla.; the model 76A automatic capacitance bridge made by Boonton Electrics Corp., Parsippany, N.J.; the Qualifier 901 IC tester made by Fairchild Systems Technology, Palo Alto, Calif.; the Digitrend 220 recorder made by Doric Scientific Corp., San Diego, Calif.; and the interfacing circuitry used by Tektronix Inc., Beaverton, Ore., to marry the digital processing oscilloscope with the company's model 31 programable calculator.

Most of these pioneering applications use the microprocessor more as a manipulator of bit patterns than as a number-cruncher. The microprocessors are used more to set up tests, perform interfacing chores, and control other subsystems than to process the data that the instruments have acquired.

The IC testers are perhaps the best examples of this emphasis, since, strictly speaking, these instruments acquire no numerical data at all. They use the microprocessors for the quick and easy setup of complex input-bit patterns and comparison of actual and expected output-bit patterns without resorting to either expensive minicomputers or so-called performance



1. Generalized instrument. Typical digital-readout instrument is really an analog machine with a lot of digital control and display circuitry tacked onto it (a). In particular, signal processing is performed by conventional analog means. With microprocessor, a-d converter is moved up front so that most processing can be done digitally (b). In both diagrams, signal paths are shown in color, and control lines are in black.

boards. One of the additional benefits of the Qualifier 901 is a thorough self-test routine. Under control of the microprocessor, the machine checks itself out every time a program is loaded into it.

While they use the microprocessors largely for control, the Boonton capacitance bridge and the Doric recorder also exploit the processor's ability to do a bit of numerical calculation, as well. The capacitance bridge directly measures only capacitance and conductance. It then processes these numbers to find such quantities as equivalent series resistance, equivalent parallel resistance, Q, dissipation factor, and percentage of deviation from a preset reference.

The Doric Digitrend 220 recorder is programed with a set of linearizing equations for various thermocouples. Instead of using different linearizing networks for each of the six common thermocouples (types J, K, T, E, S, and R), the instrument does it all with software. (See p. 87 for more details on this instrument.)

A generalized microprocessor-controlled instrument and its conventional digital counterpart are shown in Fig. 1. The exact nature of the instrument is not specified, but it may either be a two-channel voltmeter or a wattmeter.

The main point is that the conventional version of the generalized instrument (Fig. 1a) does all of its processing, which may include such difficult operations as multiplication and linearization before the output is digitized. Also, the conventional instrument needs lots of logic circuitry to control the making of the measurement, to format the digital display, and to handle the I/O interface with any other equipment to which it may be connected in a system.

The microprocessor-controlled instrument, on the other hand, (Fig. 1b) converts the data into digital form as close to the front end as possible and does all of its signal processing digitally. Its potential for cost reduction comes from the capability of a single microprocessor to do the signal processing and also handle all of the interfacing and formatting chores that would require literally hundreds of TTL packages.

Getting 'smart'

The most dramatic impact of microprocessors on instrumentation will be in the creation of new "smart" instruments for a host of new applications. A smart instrument is one that performs a significant amount of internal arithmetic processing. From a number of inputs (either signals or switch positions), it calculates an output to display and/or performs additional processing.

Indeed, smart instruments, like people, may be expected to come with a wide range of intelligence. At the low end of the spectrum may be a digital voltmeter for communications applications that can be programed to make, say, 1,000 measurements and then display their mean and standard deviation. For this, the microprocessor, together with associated control memory and I/O circuitry, would perform all the logic-management functions.

Assuming that very fast measurement times aren't needed, such a system could be built of one of today's 8-bit n-channel microprocessors, together with, say, eight 1-kilobit random-access memories to supply 8,000 bits of main memory and the associated read-only memory for control, plus I/Os. The entire system could be implemented with fewer than 20 LSI packages—only a tenth of the more than 200 standard TTL circuits that would be needed.

A somewhat smarter instrument might modify its own behavior as a result of its calculations. An example of such an instrument already exists—it is Hewlett-Packard Co.'s model 3805A distance meter. This surveyor's tool measures distances by measuring the time required for an infrared beam to travel from the instrument to a reflector and back.

Since atmospheric perturbations can affect the readings, the meter is programed to make 3,000 measurements and to calculate their mean and standard deviation. Then, if the standard deviation is within a specified limit, the mean is displayed as an accurate reading. If the standard deviation is out of spec, the meter makes as many additional measurements as are necessary to get it within spec. If, after it has made 32,000 measurements, the instrument still fails to get a sufficiently good standard deviation, it displays the mean in flashing numerals to tell the operator that the measurement conditions are less than ideal.

The next level of instrument made possible by microprocessors could, by today's standards, be called geniuses. These instruments will probably be most noteworthy for their high degree of human engineering. Their value may best be appreciated by considering the hairy problems that one may encounter when using a complex pulse generator or oscilloscope. Highly skilled engineers, not to mention technicians and service personnel, can easily waste several hours refamiliarizing themselves with instruments that they haven't used for several months. Even an instrument that one has used every day can present problems if someone else borrows and returns it with some small, seldom-used, control out of its usual position.

Building 'geniuses'

Microprocessors can and will be used to generate a "genius" class of instruments, but how it will be done is uncertain. One can imagine an oscilloscope that has had most of the knobs and switches replaced by a keyboard through which one punches in such parameters as the sweep speeds, vertical sensitivities, and triggering modes needed for any particular application.

Seldom-changed controls might be automatically set to preprogramed states from which they could be changed, via the keyboard, if desired. The status of the machine could be presented on the cathode-ray tube by a character-generator similar to the one already available on Tektronix' 7000 series scopes. In addition to simply presenting the machine's status, the CRT readout could also warn of incompatible instructions or of valid, but unusual, measurement conditions.

In a sense, oscilloscopes and other measurement tools aren't difficult to deal with because they present the user with displays, which, if abnormal, warn that corrective action is needed. The myriad possibilities for error in setting up signal generators, synthesizers, and other signal sources, on the other hand, can drive an engineer to a psychiatrist. Few users of pulse-generators can claim that they have never set the pulse width to a duration longer than the period defined by the selected repetition rate. And on some complex two-channel pulsers

Who invented the microprocessor?

Intel Corp. certainly deserves the credit for exploiting the microprocessor concept and was the first to market microprocessors, although much credit must also go to the many companies and individuals who contributed in some way to the development of large-scale integration.

Remember Viatron? In 1968, the Burlington, Mass., firm startled the world by announcing its intention to build a data-handling system that would rent for $40 a month in its basic configuration. [*Electronics*, Oct. 14, 1968, p. 193]. Heart of the Viatron unit was an 8-bit microprocessor run by a primitive program in a read-only memory. But the company encountered serious financial and management problems, and it went bankrupt after about two years.

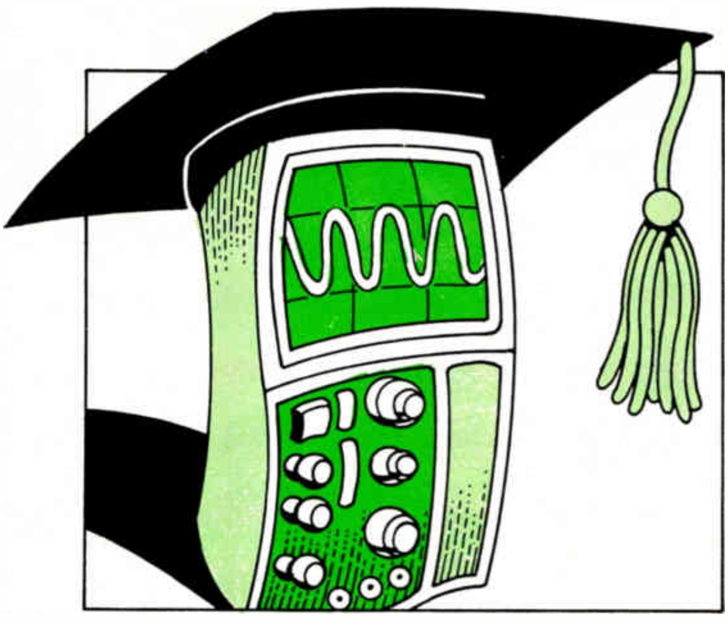
Meanwhile, General Electric Co. found itself designing integrated logic circuits for some of its terminals, duplicating much of the work from project to project, but not generating enough volume on any one of them to justify the use of custom-designed LSI—until somebody thought of a customized *programable* LSI circuit. GE then developed an eight-chip basic logic unit, or BLU, that could be used without change with different programs in many different terminal designs—essentially what is done today with microprocessors.

that have separate controls for such settings as amplitude, offset, delay, pulse width, and trigger mode, the fact that these highly interactive controls have been set wrong is not always obvious.

The microprocessor can unravel that complexity. If all of the instrument's operating information is fed in through a small keyboard-controlled processor, the instrument could simply refuse to accept an input that is incompatible with earlier instructions. Alternatively, electronic stops could be programed into the machines, and a small light-emitting-diode display could be positioned above a vernier pulse-width control. As the control is rotated to increase the pulse width, the display would reflect its position, so long as the pulse width did not conflict with any other control settings.

If such a conflict arises, the machine might be programed to ignore the control setting and to set only the maximum pulse width that could be accommodated. The LED display would keep the operator informed of what is happening by always showing the actual pulse width being generated, regardless of the front-panel control setting.

Although each of the ways in which a microprocessor might be used in an instrument has been discussed as a separate idea, it should be clear that, at least until their prices are reduced considerably, the devices will be used primarily in applications where they can perform several functions.



Most industry sources agree that an instrument would have to sell for at least $2,000 to $3,000 to justify the inclusion of a microprocessor. There is no upper limit to the size of instrumentation systems in which microprocessors could be included, since even systems large, complex, and costly enough to justify the use of a minicomputer may benefit from the inclusion of microprocessors as preprocessors.

Peak picker

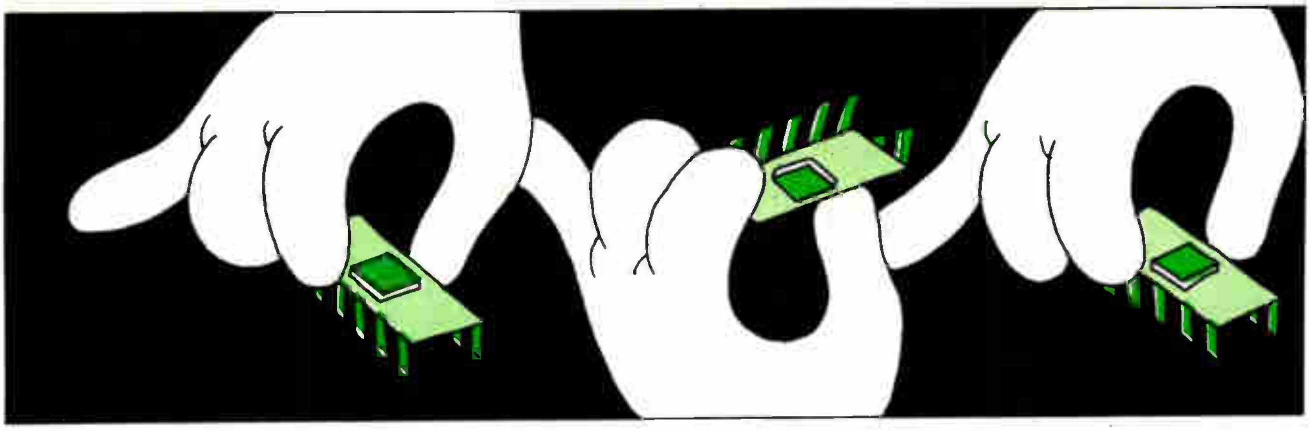
Such an application might be in an analytical chemistry laboratory, where a single, fairly small minicomputer could control, say, two or three mass spectrometers and a dozen gas chromatographs if each of them were equipped with a microprocessor programed to act as a peak-picker. The outputs of these analytical instruments, if drawn by a chart recorder, are typically a series of peaks separated by nulls. Unfortunately, closely spaced peaks tend to blend into each other, which makes it difficult to decide exactly where the peaks are.

An experienced human operator can locate the peaks by eye, but it takes a fairly complex computer program to do the job. If the computer is to do all the peak-picking, it would have to be an extremely fast machine with a lot of memory. Adding the microprocessors brings the task well within the capabilities of a minicomputer of modest size.

Improvements are imminent

Thus far, only a handful of commercially available instruments contain microprocessors. But this state of affairs in no way indicates a lack of interest in them by the major instrument houses. Quite the contrary.

Although details are not yet available, it is clear that microprocessors are responsible for previously unavailable or unaffordable capabilities that will be offered in several new meters, counters, signal sources, and oscilloscopes before this year is out. The designers of these instruments speak of "totally new approaches to the making of measurements" but, understandably, they refuse to elaborate on what that means right now. However, the next six months promise plenty of excitement for the makers and users of electronic instrumentation.



Design
Blending hardware and software

by Wallace B. Riley, Computers Editor

It's a whole new world, but it's really not all that different from what the engineer is accustomed to. Supposedly, EEs experienced in the conventional approach to design—flip-flops and gates—might expect to encounter difficulty expressing their design ideas in term of software. But, although the end result of a software development effort looks different on paper from the traditional logic diagram, it is basically identical.

An engineer's usual approach begins with a set of functional specifications, which he translates into a block diagram and then reduces to the level of individual gates. The completed design is assembled on a breadboard, built into a prototype, and then, with a series of tests and redesigns, reduced to a form that can be manufactured in volume and sold at a profit. Meanwhile, it may be undergoing simulation on a computer as part of the design refinement.

Likewise, software design begins with functional specifications, but it is translated into a sequence of instructions, rather than into an array of gates. The paper design usually involves a flow chart, which shows events graphically in the proper order, together with conditions that can cause the order of events to change. The first step can be a high-level flow chart, which closely resembles the block diagram. This is broken down into a form in which each block in the flow chart represents a single instruction in the program. Standardized shapes of blocks in the flow diagram have evolved (Fig. 1) so that one person can more easily follow the logic of another person's work. [For an example of applying a flow chart to either the hardware or software implementation of a specific design, see *Electronics*, Oct. 11, 1973, p.97.]

For some individuals, software is a problem until they get the hang of it. At some companies, teaching engineers how to program and programers the limits of hardware has turned out to be a great enlightenment on both sides. But the highly motivated people who undertook the project knew that understanding microprocessor software would be essential sooner or later, and they have managed to overcome any obstacles to understanding. Still other companies have assigned the task to younger engineers who had no previous strong commitment to either hardware or software designs, and who, therefore, made the transition easily.

In the last analysis, any intelligent person who can lay out a procedure accurately one step at a time can learn to write a program for a microprocessor.

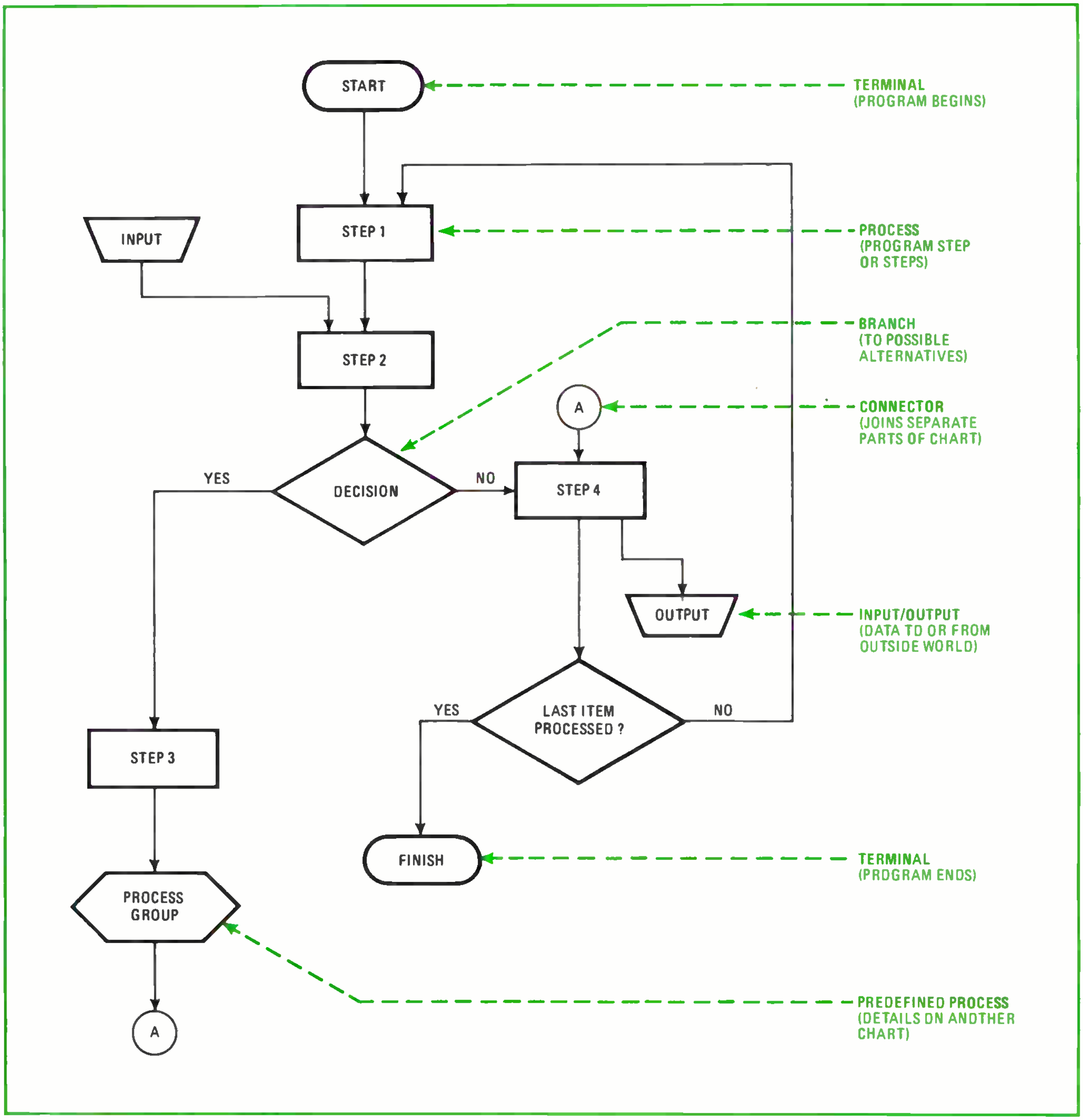
Support is essential

Some users and potential users of microprocessors express concern about the level of software support from the manufacturer. Since microprocessors come from semiconductor houses, those users fear the vendors don't have the capacity to offer the assistance that is expected from the IBMs or the DECs.

The concern is largely unfounded because the need for software support, compared to the requirements of large computers, is small indeed. But to the extent that microprocessor users have had no previous exposure to computers, they may need to be led through thickets of unfamiliar concepts to get their applications working.

Support for a large general-purpose computer is significantly different from support for a minicomputer, and it differs even more from the kind of support that a microprocessor user will need. And since a general-purpose computer is likely to cost its user hundreds of dollars an hour, he doesn't want to shut it down even momentarily if he can avoid it—not even to load new programs into it. To protect him from unnecessary expense, manufacturers offer operating systems, which are software packages designed to keep the machine running under all but the most catastrophic conditions, as well as various aids that simplify the task of writing programs for the large computer.

But a minicomputer is likely to be operated in a dedicated application so that a single program runs over and over indefinitely. Furthermore, it's sufficiently inexpensive that its occasional stopping between jobs or when an error occurs is only an inconvenience, not a major expense. Minimakers also offer support, in the



1. Flow-diagram conventions. These are among standard shapes that simplify communications via flow charts. Also often used are specific input/output functions, such as a torn sheet of paper for a printout, a tape reel for magnetic tape, or a cylinder for a disk or drum.

form of some kinds of programing aids and perhaps a relatively low-level time-sharing system. Of course, there's maintenance of the hardware, but this is far short of the support that is expected from the manufacturer of a general-purpose computer.

None of this kind of support applies in any way to microprocessors, except possibly in the form of higher-level programing languages like PL/M [*Electronics*, June 27, p. 103]. Like the average passenger automobile, a microprocessor remains economically feasible, even though it may be "parked" 90% of the time. Its program is likely to be wholly in a read-only memory, making it even more dedicated than a dedicated mini. It doesn't even need hardware maintenance, because it can't be patched the way a board or chassis can.

For users wholly unacquainted with the art and science of computer application, extensive support from the vendor will be necessary. By and large, this support is available now—in the form of users' manuals, programing manuals, application notes, and similar documentation—and it shows no signs of abating. But in all probability, using microprocessors won't be a wholly new experience for most people. Many engineers have already used minicomputers in some form or have enlisted the aid of various computer-aided-design programs. And, as indicated previously, most of those who have already tried microprocessors haven't found the software a serious problem.

Processors and product costs

How microprocessors boost profits

by William Davidow, Intel Corp., Santa Clara, Calif.

When the first single-chip microprocessors were introduced two years ago, few designers or project managers could foresee how massively these devices would influence creation of new products and services. To most, the microprocessor was merely another interesting LSI device to be evaluated and built with some memory and interface chips into prototype equipment.

But as designers became familiar with the early microprocessors and equipment began to benefit from them, respect grew for their capability and versatility. Rapidly there arose an awareness throughout the electronics industries that the microprocessor was indeed a significant extension of computer technology. Suddenly, the concept of distributed computer power became a reality, applicable to a host of new equipment.

There are compelling and fundamental reasons for the dramatic success of today's microprocessors:

- Manufacturing costs of products can be significantly reduced by designing around microprocessors.
- Development costs and time are reduced.
- Products can be rushed to the market faster, which enables a company to seize advantages in sales and market share.
- Product capabilities are enhanced, and manufacturers can economically add features that boost profits.
- Product reliability is increased, leading to a corresponding reduction in both the cost of service and warranties.

Microprocessors enable designers to replace hardware with software. Using programed logic, they can

TABLE 1: NUMBER OF ICs REPLACED BY A READ-ONLY MEMORY

ROM size (bits)	Gates replaced	ICs replaced
2,048	128 – 256	13 – 25
4,096	256 – 512	25 – 50
8,192	512 – 1,024	50 – 100
16,384	1,024 – 2,048	100 – 200

now substitute a handful of ICs for a large number of conventional random-logic networks. In such a system, the information about logical sequences and the output responses provided from input signals are stored in a few memory chips instead of in relatively expensive interconnect patterns on printed-circuit cards.

Use of microprocessors saves money and time at every stage of the product's life cycle. These savings are passed on to the customer in products with greater capabilities and higher reliability than has ever before been attainable. Microprocessors are not only improving the performance of established products, they are bringing about completely new products. They are beginning to permeate every walk of life.

Memory replaces random logic

If microprocessors were fast enough with their programable techniques, they could replace all hard-wired logic. But as the speed of new generations of microprocessors is increased, they will move into more and more designs now implemented with conventional ICs. And although each new application has its unique structure, it's possible to estimate the package reduction that accrues when hard-wired random logic is replaced by programable techniques.

Again, the microprocessor replaces logic by storing program sequences in memory, rather than implementing these sequences with gates and flip-flops. While it is impossible to prove quantitatively, designers use a rough rule that they can replace one gate by using 8 to 16 bits of memory. Therefore, if the average hard-wired logic circuit contains on the order of 10 gates, Table 1 indicates that a single 4,096-bit read-only-memory can replace 50 MSI packages. Each new 16,384-bit ROM save as many as 200 IC packages in every design. No wonder system designers are being so quickly convinced of the capability of microprocessors to reduce IC complexity.

Reducing manufacturing costs

Clearly, reduced IC complexity translates directly into reduced product costs. Table 2, which presents a detailed analysis of the sources of these surprisingly high costs, shows that the average sale price of an integrated circuit today is approximately 50 cents. Incoming inspection and testing cost an average of 5 cents more.

Many companies are now buying aged and tested circuits for their applications to increase system reliability, and this adds about 15 cents to unit costs. A simple printed-circuit card may cost as little as 25 cents for each IC position, but the average cost in most applications for high-quality cards is closer to 50 cents. (In some systems, costs of sophisticated multilayer cards can go as high as $1 per location, and if wire-wrap assemblies are used, the cost per IC position can reach the $2 mark.)

TABLE 2: SYSTEM MANUFACTURING COSTS PER IC

IC	$ .50
Incoming inspection	.05
Pc card	.50
Fabrication	.05
Board test and rework	.10
Connector	.05
Discretes	.05
Wiring	.10
Power	.10
Cabinetry, fans, etc.	.10
Total	**$ 1.60**

Next, board test and rework add another dime to system cost, while the cost of a connector, divided by the number of ICs per printed-circuit card, frequently exceeds 5 cents. Then the system requires such components as resistors, capacitors, and power-bus bars, which add another 5 cents per IC.

Systems frequently average one wire or more per IC position, and the wires—even those installed by automatic equipment—frequently cost more than 10 cents each. Finally, the cost of power supplies and mechanical packaging add another 20 cents. Altogether, the minimum system cost approaches $2 per IC.

Table 3 shows the potential system saving in manufacturing costs that can be achieved by using a microprocessor. The savings are derived by assuming that the typical manufacturer can save $1.50 to $3 by displacing a single IC, after which the cost of implementing an equivalent system with a microprocessor is taken into account. In moderate volumes, a system such as the MCS-4, made up of 16,384 bits of ROM, a processor, and a minimal amount of RAM, can be purchased for less than $100. This system has the potential of displacing $150 to $600 of manufacturing cost in a system.

Reducing development time

Use of microprocessors simplifies nearly every phase of product development. Because of the extensive design aids and support supplied with microprocessors, it

TABLE 3: SAVINGS IN USING PROGRAMED LOGIC

ROM size (bits)	IC replaced	Savings
2,048	13 – 25	$19.50 – $78
4,096	25 – 50	$37.50 – $150
8,192	50 – 100	$75.00 – $300
16,384	100 – 200	$150.00 – $600

TABLE 4: HOW MICROPROCESSORS REDUCE DEVELOPMENT TIME AND COST

	Conventional system	Programed logic
Product definition		Simplified because of ease of incorporating features
System and logic design	Done with logic diagrams	Can be programed with design aids (compilers, assemblers, editors)
Debug	Done with conventional lab instrumentation	Software and hardware aids reduce time
Pc card layout		Fewer cards to lay out
Documentation		Less hardware to document
Cooling and packaging		Reduced system size and power consumption eases job
Power distribution		Less power to distribute
Engineering changes	Done with yellow wire	Change program in PROM

is relatively easy to develop applications programs that tailor the devices to the systems and then implement these systems in very short turn-around times. Indeed, a principal reason for the increasing popularity of microprocessors is the speed with which products can be developed, designed, and rushed to the market. Discussions with system designers indicate development cycles have frequently been shortened by as much as six to 12 months to only a few weeks.

Table 4 tabulates a number of the steps in a system-development cycle and the effects of the microprocessor on the design-cycle time—designing becomes easier, faster and less costly. Surprisingly, product definition is frequently speeded up as soon as the decision is made to use a microprocessor because the incremental cost for adding features to the system is usually small and can be easily estimated.

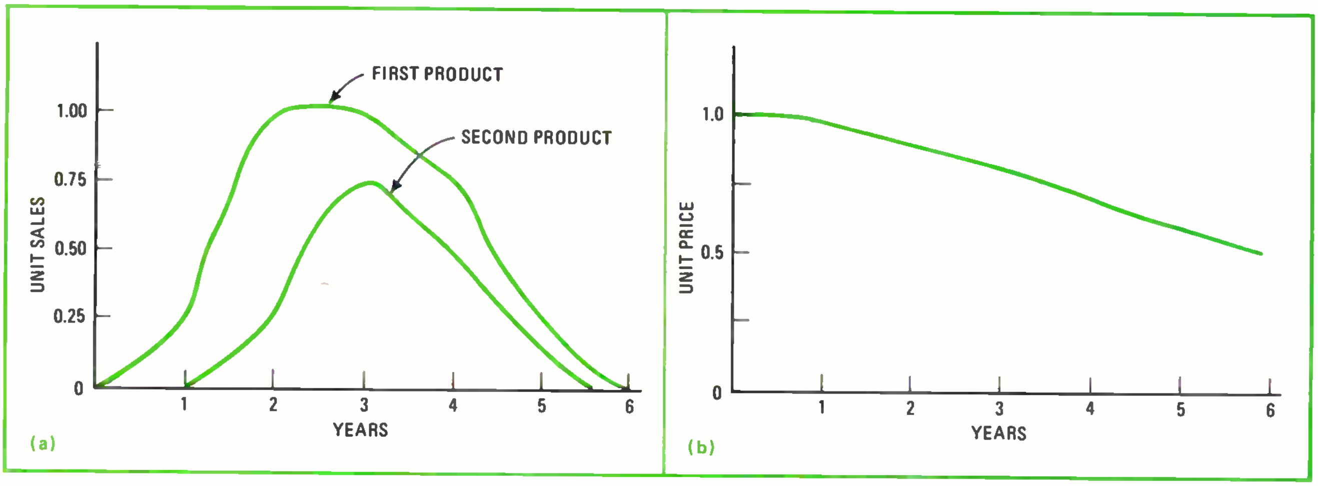
For example, adding such features as automatic tax-computation to an electronic cash register may require only the addition of a single ROM, which has a minimal effect on total system cost, power dissipation, and packaging requirements. But adding the same function by means of IC logic might require two or three fairly large pc cards filled with SSI and MSI logic packages.

Building around microprocessors also reduces the time needed for system design. When the engineer decides to use a microprocessor, he designs by programing—potentially a more organized and faster way to design than by using logic diagrams. What's more, the ready availability of extensive software aids, such as simulators, assemblers, editors, compilers, and monitors, reduces the cost of program development. These aids also reduce the time needed for system debugging. Pc-card layout time is reduced simply because fewer cards need to be laid out.

Getting to market fast

When product-design cycles can be shortened, obviously new products can be rushed to the market faster. This permits companies to either beat out the competition or effectively respond to competitive moves. Figure 1 shows what typically happens in a competitive program when one company beats another to the market. Assuming that both companies have about the same marketing capability, the company that introduces the product first usually can gain a greater share of the market (Fig. 1a) and reach a mature sales volume more quickly.

Figure 1(b) shows the price erosion characteristic of most products during their life cycles. This erosion means that the company introducing the product first will not only sell more but will sell at a higher price. In



1. Market jump. Microprocessor design helps get equipment to the market fast, resulting in a greater share of market than second entry (a) as product matures. What's more, first product shows a slower rate of price erosion (b).

TABLE 5:
PROJECTED INCOME FROM FIRST AND SECOND PRODUCT

FIRST PRODUCT			
Year	Price	Unit sales	Income
1	$ 1.00	.25	$ .25
2	.90	1.00	.90
3	.80	1.00	.80
4	.70	.75	.52
5	.60	.25	.16
		Total	$ 2.63

SECOND PRODUCT			
Year	Price	Unit sales	Income
1	$ 1.00	0	$ .00
2	.90	.25	.23
3	.80	.75	.60
4	.70	.50	.35
5	.60	.10	.06
		Total	$ 1.24

TABLE 6:
HOW MICROCOMPUTERS AFFECT CORPORATE PROFITS

	Without microcomputers	With microcomputers
Sales	100%	100%
Cost of goods sold	−55	−45
Gross margin	45%	55%
Development		
Engineering	8 %	6%
Documentation	1.5	1
Warranty	1.5	1
Marketing	20	20
G & A	3	3
Engineering and marketing costs	34%	31%
Before-tax profit	11%	24%

this hypothetical example, the first product to the market generates about twice the total income that the second product does (Table 5). As a result, the advantage gained by application of a microprocessor to achieve early product introduction can have a much greater impact than merely reducing manufacturing costs.

Again, since product features can be added to equipment built around microprocessors simply by adding more program storage, many manufacturers are taking advantage of this characteristic to increase the value of their products. For instance, makers of point-of-sale-equipment are adding automatic tax-computation to cash registers by merely increasing the ROM size. Instrument makers are adding automatic calibration to their instruments. Makers of vehicular-traffic-light controllers are adding automatic sensing of traffic loads to their basic equipment and adjusting the duration of the signals. From a profitability point of view, these optional features, many of which are requested by the customer, are frequently sold at 10 to 20 times the cost of adding them. Some companies have been able to earn sizable profits from marginal products and services through the application of microcomputers.

Because the danger of their failure is eliminated by replacing many ICs, the use of a microprocessor can significantly increase system reliability. A digital system fails most frequently because interconnects fail. The use of a typical 16-pin IC will introduce approximately 36 interconnections in a system (16 interconnections from the chip to the lead frame, 16 from the lead frame to the pc card, two interconnections from the pc card to the back plane, and two interconnections from back-plane point to back-plane point).

If one ROM eliminates 50 ICs, then it eliminates approximately 1,800 interconnections. While little data exists to prove the point, it is believed that the reliability of the electronic portion of a system can be increased by a factor of 5 to 10 by use of microprocessors.

Finally, consider the bottom line. Table 6 presents a comparison based on information from users of the profit-and-loss statements of a hypothetical product line before and after the use of microprocessors. The product using the microcomputer has a smaller final cost because the manufacturing costs of systems containing microcomputers are generally lower than those built with conventional ICs, and the enhanced capability of many microprocessor-system products enables manufacturers to charge more for their equipment.

In addition, the shortening of development cycles and the elimination of much documentation can save a company another 2.5%. Warranty and service costs, such as those associated with stocking spare parts and training service engineers, can also be greatly reduced. The net effects of all these savings can frequently increase product-line profits by 10% to 20%.

The challenge is here. The design and cost advantages of putting computation and decision-making into equipment are clear messages to product-planning managers for all kinds of manufacturers, many of whom have been outside of the orbit of the electronics industries. These technical managers are finding that the use of microprocessors can affect such basic ingredients of corporate success and failure as manufacturing costs, market share, development costs, time, system reliability, and serviceability. The advantages of microprocessors have been demonstrated already. The challenge now is to use them wisely. □

Want to learn more about microprocessors?

Here are some additional articles on microprocessors that have been published in *Electronics*:

Kildall, Gary, "High-level language simplifies microcomputer programing," June 27, p.103.

Altman, Laurence, "Single-chip microprocessors open up new world of applications," April 18, p.81.

Shima, Masatoshi, and Faggin, Federico, "In switch to n-MOS, microprocessor gets a 2-μs cycle time," April 18, p.95.

Young, Link, Bennett, Tom, and Lavell, Jeff, "N-channel MOS technology yields new generation of microprocessors," April 18, p.88.

Tarui, Tadaaki, Namimoto, Keiji, and Takahashi, Yukiharu, "Twelve-bit microprocessor nears minicomputer's performance level," March 21, p. 111.

Electronics staff, "The minicomputer comes on," Oct. 25, 1973, p.98.

Gladstone, Bruce, "Designing with microprocessors instead of wired logic asks more of designers," Oct. 11, 1973, p.91.

Continuing biasing improves clamping amplifier

by Jerry Graeme
Burr-Brown Research Corp., Tucson, Ariz.

A clamping amplifier can be made faster and more accurate by biasing its zener clamping element so that it is always on. This biasing technique also results in reduced clamp capacitance, sharper turn-on, broader bandwidth, and lower thermal drift.

Clamping amplifiers or feedback limiters are frequently used to provide amplitude limiting for signal clipping, signal squaring, or overload protection. One of the simplest clamping elements for these applications is a zener diode.

A zener diode connected across the feedback resistor of an operational amplifier will conduct when the op-amp output level reaches the zener voltage. The zener overrides the feedback resistor and limits the op-amp output swing at the zener voltage. To obtain bipolar amplitude limiting, two zener diodes are generally connected, in series-opposing fashion, across the feedback resistor, as shown in (a).

Zener diodes used in this way, however, impose serious limitations on the clamp because of their large capacitance, insufficiently sharp turn-on characteristic, high leakage current, and undesirable thermal drift.

Zener parasitic capacitance, which is typically a comparatively high 700 picofarads, can result in a long turn-on time for the clamp, as well as restricted signal bandwidth. For the zener to turn on, its capacitance must be charged through resistor R_1, which is often a large value, to preserve the circuit's input resistance. Signal bandwidth is limited because resistor R_2 is capacitively shunted by the zener.

When the zener conducts, it goes from a high-resistance state to a low one. But since this transition is not abrupt, sharp limiting cannot be achieved, and the clamping is rounded. Even in its high-resistance state, the zener, through its leakage current, introduces error into the amplifier's summing junction. Furthermore, when the zener is on, the clamp level it sets is subject to thermal drift since the zener will probably not be held at its zero-temperature-coefficient current.

All of these limitations can be overcome to a significant extent with the biased zener clamp of (b). Here, the zener is continuously biased on so that it does not limit the op-amp output swing until the diode bridge places the zener in the feedback path.

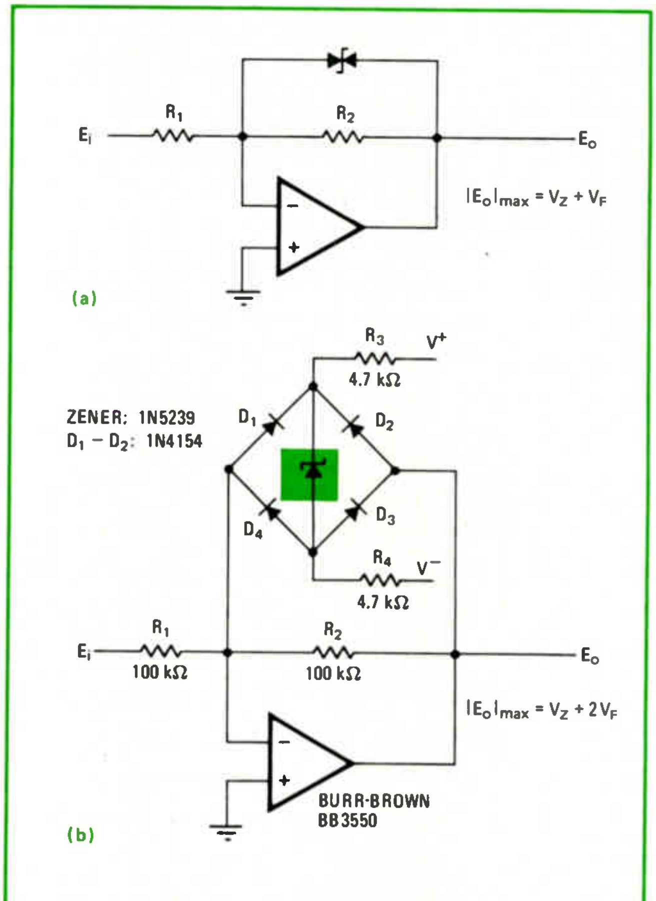
Clamping occurs when the voltage across resistor R_2 can support the zener voltage as well as forward-bias two of the bridge diodes. Positive-polarity signals are clamped when diodes D_1 and D_3 conduct, connecting the zener across the feedback path. When diodes D_2 and D_4 conduct, the zener limits signals of the opposite polarity. Since the same zener is used for both signal polarities, the output clamping will be symmetrical.

The continuous zener bias dramatically reduces the clamp's shunt capacitance, sharpens the clamping response, and often means lower thermal drift. To reduce thermal drift, resistor R_3 is chosen to produce a zener thermal variation that is canceled by that of two bridge diodes. When the clamp is on, the zener current is approximately:

$$I_Z = (V^+ + V_F)/R_3 \text{ or } (-V^- + V_F)/R_3$$

where V_F is the forward voltage of a junction diode, and V^+ and V^- are the supply voltages. (This equation neglects the signal current from resistor R_1, which is generally small compared to the zener current.)

Sharper clamping is achieved by avoiding the zener turn-on characteristic and leakage current. The clamping circuit is now turned on by the bridge diodes, and the sharper turn-on of these junction diodes improves



Whetting sharpness of zener clamp. Standard zener-type clamping amplifier (a) can be slow and sloppy because of large zener capacitance and zener leakage. But a dramatically faster and crisper response can be obtained by adding a bridge of junction diodes to keep the zener always biased on, no matter the input signal polarity. The improved clamp (b) also provides more bandwidth and less drift.

clamping sharpness by around 8:1. Zener leakage current no longer reduces signal current as the clamping level is approached. Leakage to the amplifier summing junction is now the much smaller leakage of junction diodes D_1 and D_4.

Additionally, the capacitance of the clamping circuit is reduced by avoiding the charging and discharging of the zener capacitance. Only small voltage changes, the ones produced by signal current flow in the continuously biased zener, occur across the zener capacitance. Large voltage changes are restricted to the junction diodes, which have a far lower capacitance than the zener. The equivalent clamp capacitance that must now be charged through resistor R_1 is merely the combined capacitances of diodes D_1 and D_4. Typically, this represents a 100:1 reduction from the basic zener clamp capacitance so that turn-on time is faster.

And lastly, the bandwidth-limiting capacitive shunt on resistor R_2 is reduced by more than 100:1. Amplifier signals that do not turn the clamp on are not even affected by the small bridge-diode capacitance. When the bridge diodes are off, fixed voltages are established at one end of diodes D_1 and D_4 by the zener and its bias resistors. The only signal swing on these two input shunting diodes, then, is the very small summing junction signal. The equivalent capacitive shunt of resistor R_2 is reduced to $2C_F/A$, where C_F is the forward capacitance of a junction diode, and A is the open-loop gain of the op amp. (This capacitance is negligible compared to other parasitic capacitances.)

For the components shown in the figure, large- and small-signal bandwidths are boosted from 3 kilohertz to 400 kHz; clamping sharpness error is reduced from 0.8 volt to 0.1 V; clamp leakage current is decreased from 400 nanoamperes to 7 nA; and clamp-level thermal drift is brought down from 7 mV/°C to 0.6 mV/°C. □

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G. Tobey, J. Graeme, and L. Huelsman, "Operational Amplifiers—Design and Applications," McGraw-Hill, 1971.

LED display shows beat frequency

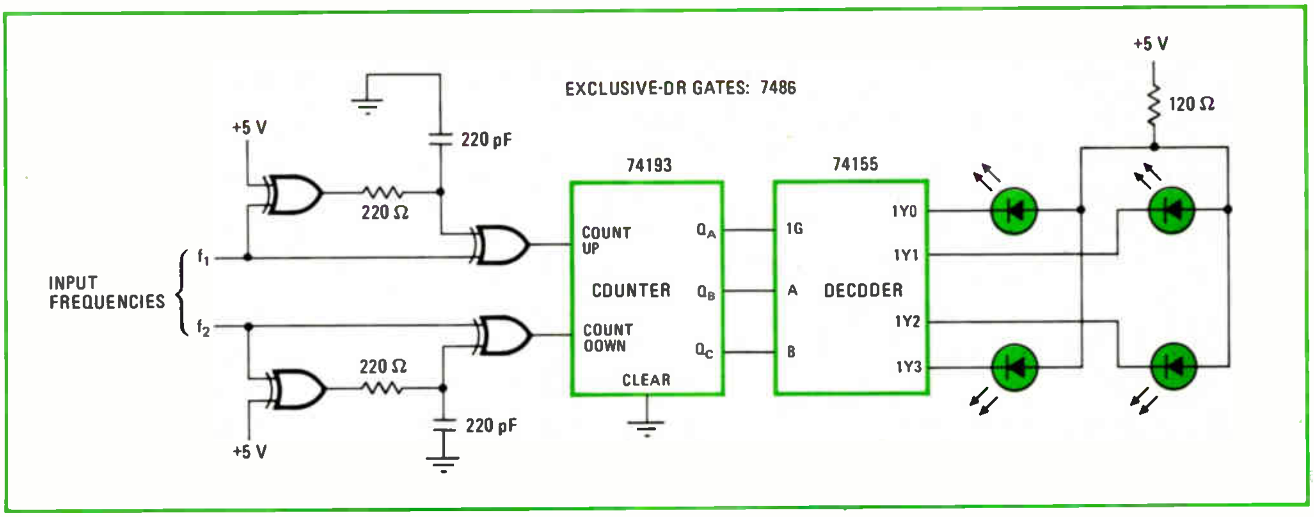
by Sergio Franco
Oberlin College, Oberlin, Ohio

A simple, easy-to-use beat-frequency indicator can be built at a cost of only about $5. The circuit, which employs four light-emitting diodes as its display, can be used in a variety of applications, but is particularly suited to the tuning of musical instruments.

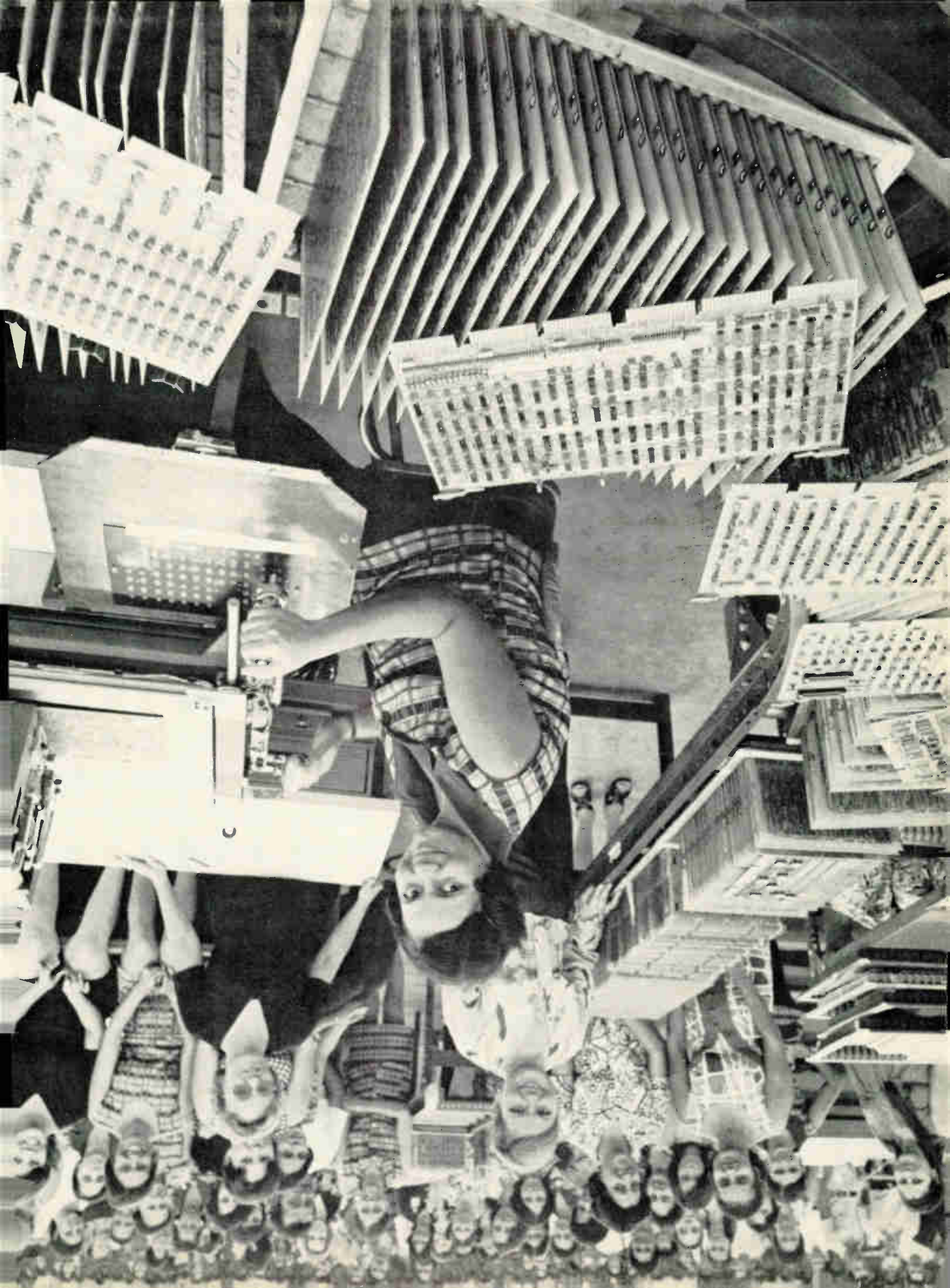
The heart of the circuit is a 4-bit synchronous up/down binary counter. After undergoing proper shaping by exclusive-OR gates, input frequencies f_1 and f_2 are applied, respectively, to the count-up and count-down terminals of the counter. The net count, therefore, will be in either the up or the down direction, depending on whether f_1 is greater than or less than f_2. When f_1 equals f_2, the counter alternates between two consecutive states, producing a net count of zero.

These three input conditions can be easily displayed by means of four LEDs arranged in a circle. (A decoder is used to drive the LEDs from the counter output lines.) Only one LED is on at a time. Therefore, when f_1 is greater than f_2, a dot of light is produced that rotates clockwise; when f_1 is less than f_2, the dot rotates counterclockwise; and when f_1 equals f_2, there is no rotation.

Furthermore, since the exclusive-OR shaping network produces a sharp negative pulse for each transition of the two inputs, the dot of light moves one step for every beat. The rate of apparent rotation of the dot, then, is an exact indication of the beat frequency. □



LEDs show the beat. Economical circuit displays the difference frequency between its two inputs, as well as indicating their relative magnitude. Since only one LED conducts at a time, what is displayed is a dot of light. The dot rotates clockwise when f_1 is greater than f_2 and counterclockwise when f_1 is smaller. The rate of rotation is the beat frequency. When f_1 equals f_2, the dot remains stationary.



Dc differential voltmeter resolves 1 microvolt

by James Williams
Massachusetts Institute of Technology, Cambridge, Mass.

If you're dissatisfied with the choice of commercially available dc differential voltmeters, here's a high-performance unit that you can build yourself for about $800. Besides functioning as a high-resolution differential voltmeter, this instrument can serve as a picoammeter or an an adjustable voltage-reference source. It affords good stability, an absolute five-place accuracy of ±0.001%, and a resolution of 1 microvolt. It also provides an output for a ground-referenced stripchart recorder and overload protection for its nullmeter.

The voltmeter is intended for use with standard cells, temperature-compensated zener diodes, and other precision low-voltage sources. Its input voltage range is 0 to 10 V, and its operating temperature range is 20°C to 30°C.

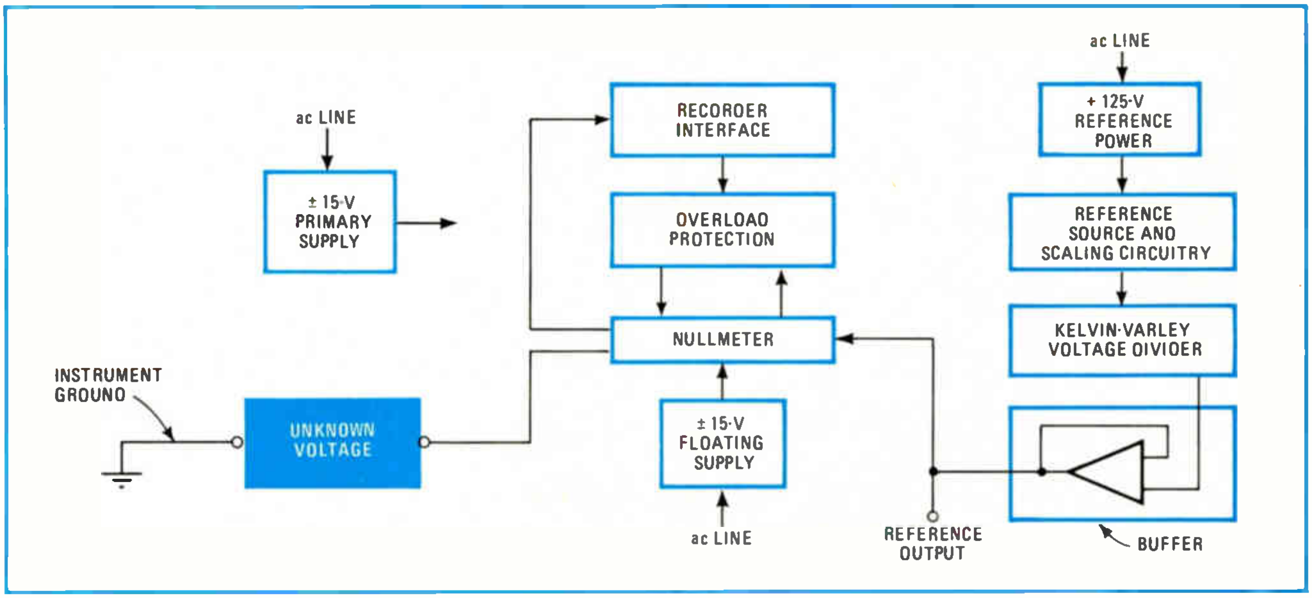
In general, a high-resolution differential voltmeter makes a measurement in a classical potentiometric way. A stable voltage reference is placed across a variable voltage divider, whose output is applied to one input of a high-sensitivity voltmeter. The voltage to be measured is applied to the other input of the voltmeter. When the divider is adjusted to the same potential as the unknown voltage, the voltmeter will read zero. Since no current flows through the voltmeter during null, the unknown voltage sees an infinite impedance.

The block diagram of the voltmeter is given in Fig. 1. The instrument includes a high-stability solid-state voltage-reference source and a nullmeter having a full-scale resolution as fine as 5 μV. Since the input impedance of the nullmeter is known, the unit can also function as a highly accurate picoammeter for determining low-level offset and bias currents. If the meter goes off scale, there are indicators to show which way to bring the meter back on scale.

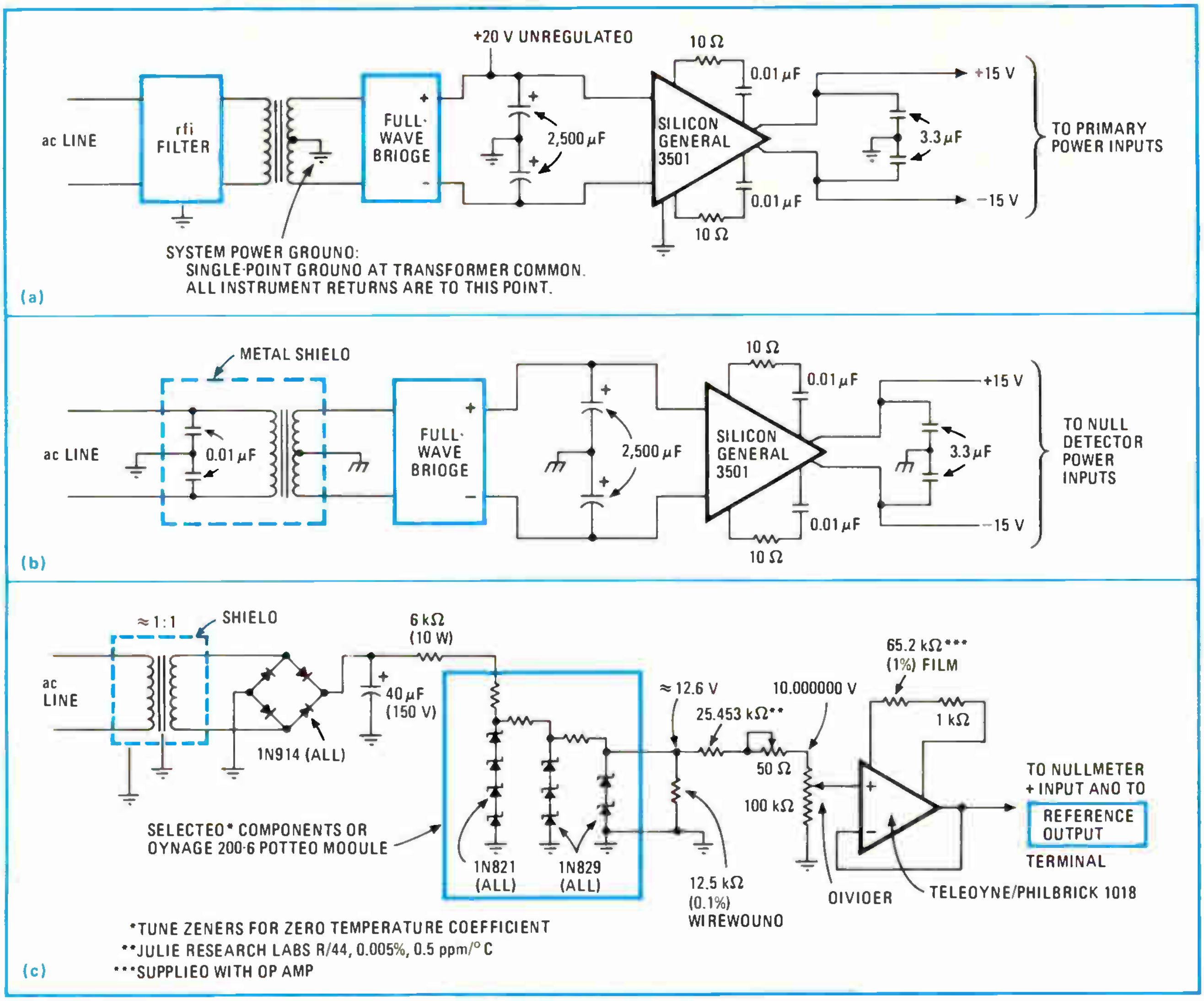
The output for the ground-referenced stripchart recorder is derived from the floating nullmeter without introducing leakage across either the voltage divider or the voltage to be measured. The buffer amplifier connected to the divider permits the voltmeter to be used as a variable voltage-reference source that can be set to within ±0.001%.

Briefly, here's how the instrument works. The ac line furnishes power to both the 125-V unregulated supply and the two ±15-V supplies, one of which is floating. The 125-V supply acts as a pseudo-current source while driving the voltage-reference source. The output of the reference, which is approximately 12.6 V, is resistively scaled to 10.000000 V (at 25°C) across the Kelvin-Varley voltage divider. The divider's output is buffered by an ultra-stable unity-gain amplifier that provides the REFERENCE OUTPUT terminal for the instrument. When the output from the divider equals the unknown voltage, the nullmeter will read zero so that the unknown is then equal to the divider setting.

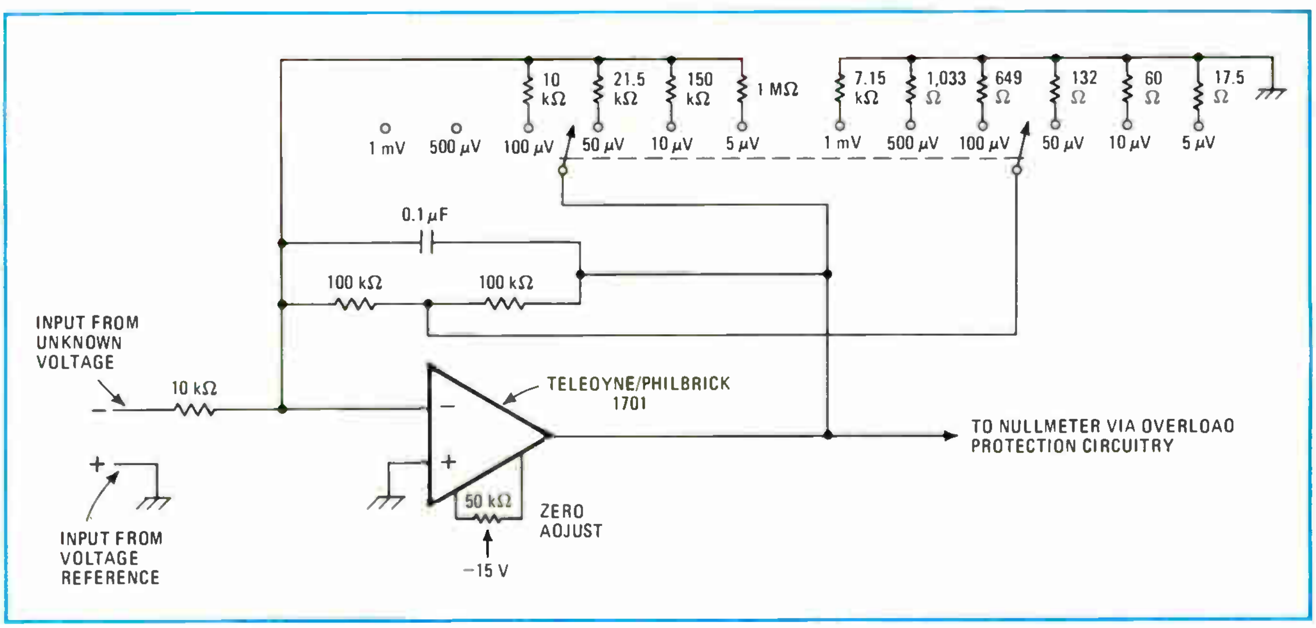
For the ±15-V primary power supply (Fig. 2a), a monolithic tracking voltage regulator is wired in its standard configuration. The two 10-ohm resistors provide overload sensing, and the capacitors smooth out and prevent spurious oscillations. System ground is at



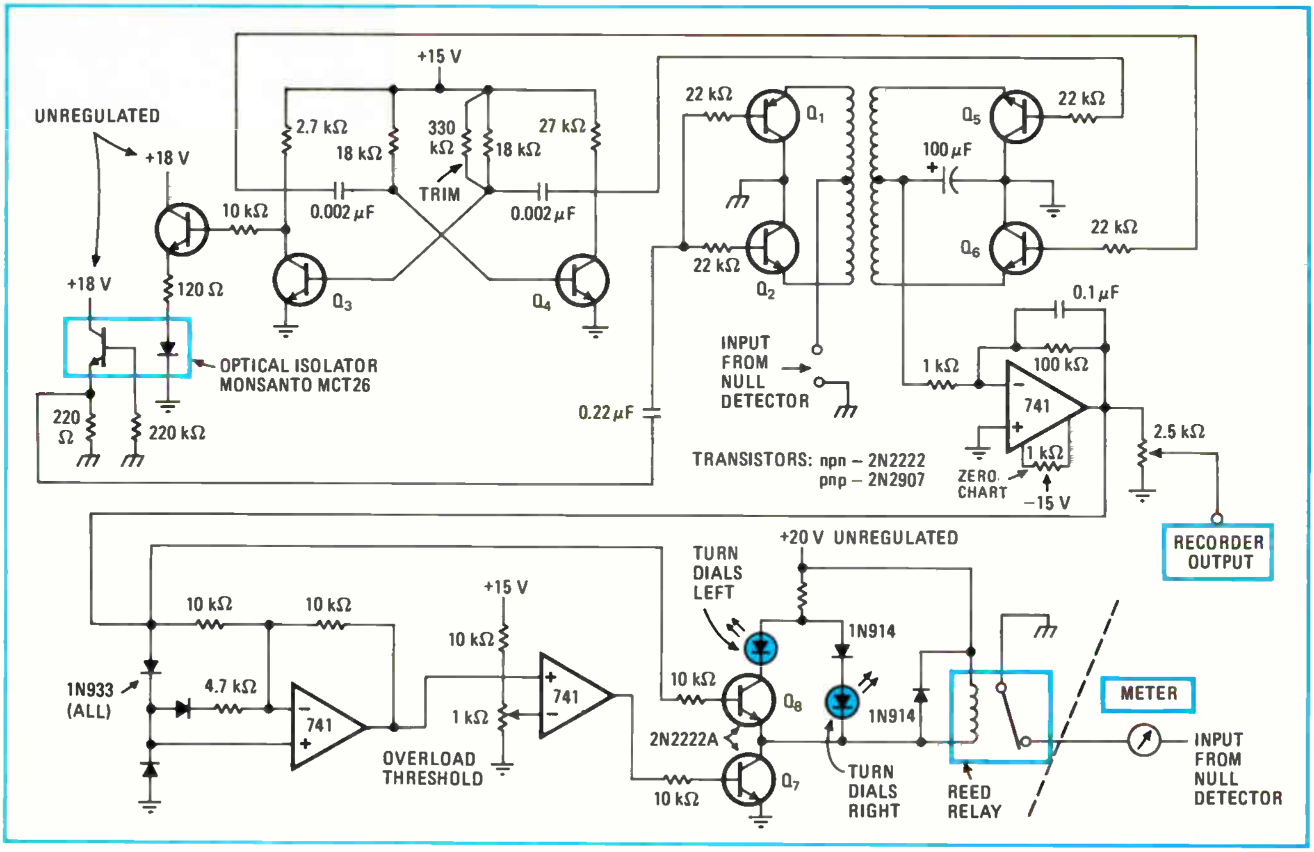
1. Performance plus trimmings. This high-resolution differential voltmeter takes advantage of modern solid-state technology to provide both accuracy and stability at reasonable cost. Its floating nullmeter, which is protected against overloads, assures a true differential measurement. The instrument also has a settable voltage-reference output, as well as a ground-referenced output for a stripchart recorder.



2. The voltage sources. The voltmeter's primary ±15-V supply (a) is ground-referenced, but the ±15-V supply (b) for its null detector is floating. The ultra-stable reference source (c), which is used to match the unknown voltage, contains an array of specially selected zeners.



3. Precision null detector. A chopper-stabilized amplifier is at the heart of the instrument's null detector. A T-type feedback network, which is used to set amplifier gain, minimizes leakage problems and keeps the sizes of the feedback resistances at practical levels.



4. The outputs. A ground-referenced output for a stripchart recorder is developed from the null-detector's output by isolating the floating detector with an optical coupler. LED indicators show which way to null the meter. The reed relay disconnects the meter during overloads.

the transformer common, and all common power returns are brought to this point. There are no common power bus lines in the instrument—a precaution that must be taken to avoid corrupted grounds. Moreover, an rfi filter is used to block spikes from the ac line. A similar circuit, (Fig. 2b), but one with a floating ground, is used for supplying the instrument's null detector.

The voltage-reference source (Fig. 2c) is powered by the voltage derived from the transformer and its rectification components. The cascaded temperature-compensated zener diodes are specially selected for optimum matched parameters and are aged to produce stabilities greater than those of unsaturated standard cells. But a commercially available module can be used instead, if desired.

The reference output is scaled to 10 V across the divider. An ultra-stable, low-bias-current op amp buffers the output of the divider for the instrument's nullmeter input and its REFERENCE OUTPUT terminal. The output current for the voltage reference can range from 0 to 3.5 milliamperes. Its stability is ±1 ppm for a 10% shift in line voltage, ±2 ppm for a 1°C change in operating temperature, and ±5 μV maximum over a 24-hour period.

The instrument's null detector (Fig. 3) is designed around a chopper-stabilized amplifier. Since it is powered by a floating supply, this amplifier sees a true differential signal at its inputs. The power common line is used as one of the inputs, but the power and signal common returns are separated to minimize grounding loops and noise. A T-type feedback network sets amplifier gain, helps to hold feedback resistances to practical levels, and avoids leakage problems.

Overload protection for the meter movement and the output for a stripchart recorder are provided by the circuit of Fig. 4. The ground-referenced recorder output preserves the integrity of the nullmeter's true floating ground and simplifies the interfacing of the recording device.

The input for this circuit, which is the output from the null detector, drives the pulse-amplitude modulator formed by the transformer and transistors Q_1 and Q_2. The signal is chopped at the frequency set by the multivibrator made up of transistors Q_3 and Q_4. The chopping drive signal must be fed through an optical isolator because the multivibrator, which is the source of the chopping signal, is instrument-grounded. The signal that appears at the transformer secondary is demodulated synchronously by transistors Q_5 and Q_6. The multivibrator's trim resistor is selected to give a symmetrical swing about zero at the demodulated output. This output is then amplified for the recorder hookup.

The input for the overload protection circuit is taken from the signal developed for the stripchart recorder. The first stage of this circuit takes the absolute value of the recorder output. When the meter is overloaded, transistor Q_7 conducts. If the base voltage of transistor Q_8 is high, the meter is off scale in its plus zone, and the TURN DIALS LEFT indicator will light. If Q_8's base is low, the meter is off scale in its minus zone, and the TURN DIALS RIGHT indicator will come on. In either case, the reed relay disconnects the meter during an overload. □

Bucket-brigade shift register generates constant phase delay

by F.E. Hinkle
University of Texas, Applied Research Laboratories, Austin, Texas

A digitally programable constant-phase-delay network makes an interesting application for a bucket-brigade analog shift register. The circuit generates a phase delay, in degrees, that is independent of the frequency of the signal to be phase-shifted.

The analog shift register works in conjunction with a phase-locked loop so that the input frequency forms the time delay needed for a constant phase delay. The register delays the input by:

$$\tau = M/2f_v$$

where M is the number of register-delay elements or bits, and f_v is the frequency of the bit shift (biphase clock).

Since the frequency for shifting the analog bits is a function of the input frequency, the delay time will also be a function of input frequency. A phase-locked loop is used as a frequency multiplier, with a divide-by-N network in its feedback path. During lock, the frequency of the phase-locked loop will be an integral multiple of the input signal being applied to the shift register:

$$f_v = Nf_{in}$$

where N is the divide-by integer in the phase-locked loop, and f_{in} is the input frequency. When the frequency of the phase-locked loop is applied to the shift register as the bit-shift frequency, the new time delay of the register is:

$$\tau = M/2Nf_{in}$$

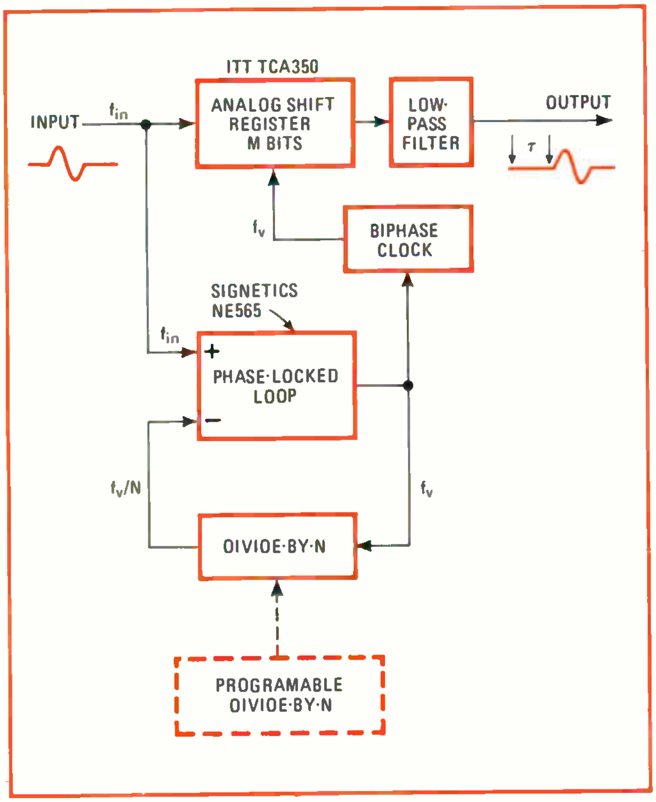
The delay time-to-angle conversion for the input sine wave can be defined as:

$$\textit{delay angle} = (\tau/T_{in}) \times 360° = (\tau f_{in}) \times 360°$$

where T_{in} is the period of the input waveform. Substituting for τ in this equation yields:

$$\textit{delay angle} = (M/2N) \times 360°$$

The delay angle of the input waveform, therefore, is independent of that waveform's frequency. By using a programable divide-by-N circuit, the amount of the delay angle can be adjusted in the desired increments. For this circuit, when M = N = 185, the delay angle is 180° for all frequencies within the range of the phase-locked loop. The circuit's major limitation is the lock-on range of the phase-locked loop. □



Controlled phase shift. Bucket-brigade analog shift register and a phase-locked loop provide a constant phase delay that is independent of the input frequency. The phase-locked loop determines the bit-shift frequency of the register, and a divide-by-N circuit sets the frequency of the phase-locked loop. The delay can be made variable by adding a programable divide-by-N circuit as indicated.

The analog shift register

Not too long ago, *Electronics* reported on the MOS bucket-brigade approach to building a charge-transfer device [Dec. 6, 1971, pp.86–91, and Feb. 28, 1972, pp.62–71]. One of the practical hardware functions of the bucket-brigade technology is an analog shift register [Nov. 22, 1971, pp.112–114]. Such a device is a rather unusual circuit that will store bits of analog data and delay them as a function of the input clock frequency.

The register used here, in the constant-phase-delay network, is made by ITT Semiconductors in Palm Beach, Fla. It will delay the input waveform by 185 stages. All that is required is a biphase clock, which can be as fast as 500 kilohertz, plus a low-pass filter at the output to remove the clocking waveforms. The register's output waveform will be an accurate sampled replica of the input, delayed by 185 clock pulses.

Since the shift register runs from negative voltages, some form of voltage-level conversion is necessary when TTL digital circuits are used to generate the biphase symmetrical clock signals. Another method of clock generation is to use C-MOS integrated circuits with the drain supply tied to ground and the source supply connected to a negative voltage. (A C-MOS decade counter can then be wired as a divide-by-four circuit and two of its outputs taken for the biphase clock.) The clock circuitry can be used to drive a number of registers simultaneously.

The type TCA350 shift register employed in the phase-shift network is housed in a TO-77-metal can. It costs less than $10.

Crucial EE pension clause encounters snag in House

Just when the pension reform bill, H.R. 2, giving engineers and other professionals a more liberal set of pension regulations looked like a sure thing in the House of Representatives, **one of the key measures concerning EEs suddenly ran into trouble. The item dealt with an automatic provision to include rights for engineers working for Government contractors to transfer and retain pension funds.** At the last minute, this clause was sent to the Department of Labor for "further study"—tantamount to sweeping it under a bureaucratic rug. Having crowed prematurely about the pension legislation, the IEEE is hopping mad, and **a letter-writing campaign to congressmen is being considered.**

Ge diodes do better at temperature compensation

An inexpensive germanium diode—to be specific, the venerable type 1N198—makes an excellent temperature-compensation device for the base-emitter junction of a general-purpose silicon transistor, says Dale Hileman of Sphygmetrics Inc. in Woodland Hills, Calif. **Normally silicon junctions are used, but they're tough to bias,** requiring several hundred millivolts before they'll conduct. Not so with germanium. **The lower forward-barrier of a germanium diode's junction makes it possible to compensate a silicon transistor simply by connecting the diode in series with the ground-return path of the transistor's base circuit** (the diode's cathode faces ground). And the 1N198 device has just the right forward-voltage-versus-temperature characteristic for the job.

Two tapes tell all about metrication

For many designers **the question is no longer whether to go metric, but how to make the change.** Honeywell's Process Control division, Fort Washington, Pa., has an answer—two video tapes and some supplementary worksheets. The hour-long tape provides **a thorough discussion of metrication for engineers, technicians, and shop personnel.** The second is an 18-minute job (without buzzes) aimed principally at clerical personnel; its main emphasis is on spelling and the proper use of upper- and lower-case letters in abbreviations. **Cost of the engineering tape and worksheets is $500; the other package goes for $250.**

When to fuse a dc power supply

The outputs of dc power supplies are not usually protected by fuses nowadays because **modern power supplies almost invariably include current-limiting circuitry of the "foldback" type.** What some users of these supplies don't realize, however, is that **operation of the current-limiting circuitry can be seriously compromised if the supply is being used to power a largely reactive load.** In this situation, the wise designer **puts a fuse into the output circuit,** current-limited or not.

An easy way to breadboard that third pcb layer

Here's some welcome **help for prototype breadboarding of those troublesome three-layer circuit boards** —a job that usually takes an expensive full-scale design. Circuit-Stik Inc., Torrance, Calif., which makes circuit-board patterns on very thin adhesive-backed fiberglass for prototyping conventional boards, has now developed **sheets of adhesive-backed fiberglass that make nifty three-layer boards when combined with existing patterns, copper tape, and boards.** The material comes in two sizes: 3 by 4 inches, and 5 by 6 in. **—Laurence Altman**

TYPE - 256 x 1 Static SOS/CMOS Ram
NUMBER - INS4200
READ CYCLE TIME - 180 nS
WRITE CYCLE TIME - 140 nS
QUIESCENT POWER DISSIPATION - 40 µW @ 10 V
INPUT CAPACITANCE - 6.5 pF
SUPPLY VOLTAGES - 5 to 15 volts
OUTPUT - Three-state TTL compatible, full address decoding and bipolar compatible pin-outs.
PACKAGE - 16 pin dual-in-line
PRICE - Mil Range (100-999) $38.00
Comm. Range (100-999) $21.00

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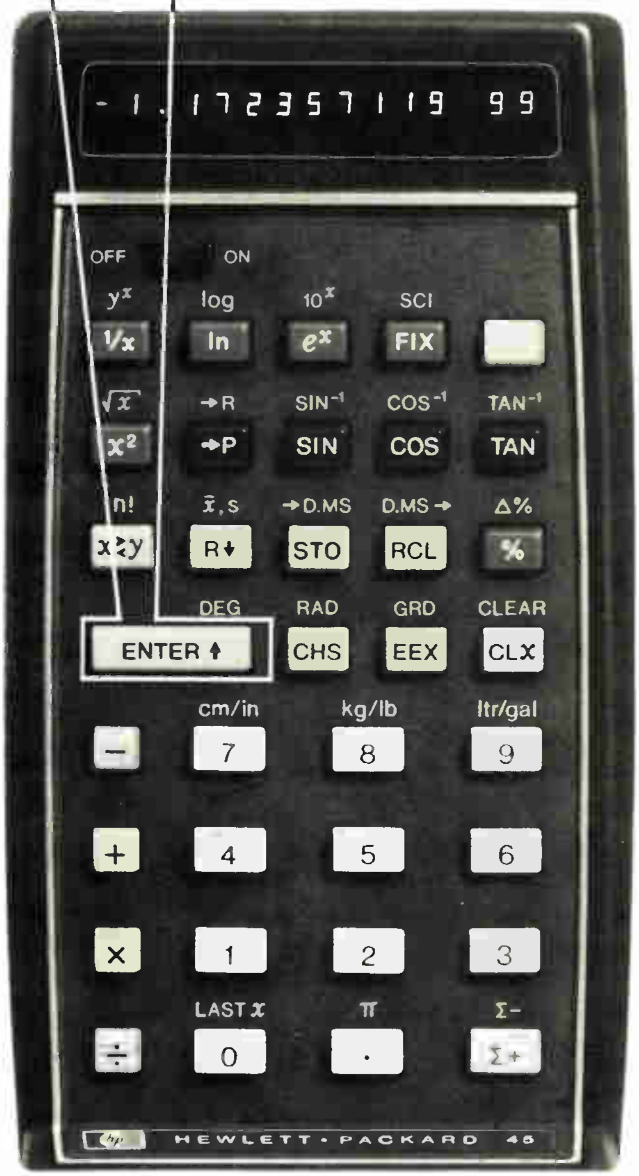


In 1928 a Polish mathematician, Dr. Jan Lukasiewicz, invented a parenthesis-free but unambiguous language. As it's evolved over the years it's come to be known as Reverse Polish Notation (RPN), and it's become a standard language of computer science.

Today, it's the only language that allows you to "speak" with total consistency to a pocket-sized calculator. And the only pocket-sized calculators that use it are Hewlett-Packard's.

[ENTER↑] is the key to RPN because it enables you to load data into a 4-Register Operational Stack with the following consequences:

1. You can *always* enter data the same way, i.e. from left to right, the natural way to read any expression.

2. You can *always* proceed through your problem the same way. Once you've entered a number you ask: "Can I operate?" If yes, you perform the operation. If no, you press [ENTER↑] and key in the next number.

3. You can see *all* intermediate data anytime, so you can check the progress of your calculations *as you go.*

4. You almost never have to re-enter intermediate answers—a real time-saver, especially when your data have eight or nine digits each.

5. You don't have to think your problem all the way through beforehand to determine the best method of approach.

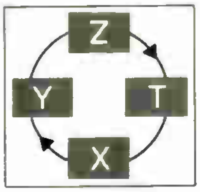
6. You can easily recover from errors since each operation is performed sequentially, immediately after pressing the appropriate key, and all data stored in the calculator can be easily reviewed.

7. You can communicate with your calculator efficiently, consistently and without ambiguity. You always proceed one way, no matter what the problem.

The HP-45 uses RPN.

That's one reason it's the most powerful pre-programmed pocket-sized scientific calculator. Here are 8 others:

1. It's pre-programmed to handle 44 arithmetic, trigonometric and logarithmic functions and data manipulation operations beyond the basic four (+, −, ×, ÷).

2. 

It offers a 4-Register Operational Stack that saves intermediate answers and automatically retrieves them when they are required in the calculation.

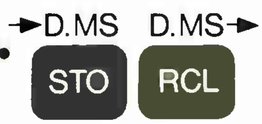
3. 

It lets you store up to nine separate constants in its nine Addressable Memory Registers.

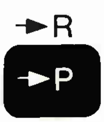
4. It gives you a "Last X" Register for error correction or multiple operations on the same number. If you get stuck midway through a problem, you can use the "Last X" Register to unravel what you've done.

5. 

It displays up to 10 significant digits in either fixed-decimal or scientific notation and automatically positions the decimal point throughout its 200-decade range.

6. 

It converts angles from decimal degrees, radians or grads to degrees/minutes/seconds and back again.

7. 

It converts polar coordinates to rectangular coordinates...or vice-versa. In seconds.

8. 

Its Gold "Shift" Key doubles the functions of 24 keys which increases the HP-45's capability without increasing its size.

The HP-35 uses RPN too.

If the HP-45 is the world's most powerful pre-programmed pocket-sized scientific calculator, the HP-35 is runner-up. It handles 22 functions, has a 4-Register Stack, one Addressable Memory Register and also displays up to 10 digits in either fixed-decimal or scientific notation.

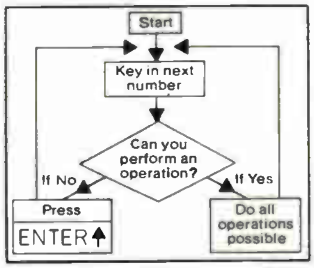
*Domestic U.S.A. prices, not including applicable state and local taxes.

New low prices.

HP-45: $325* HP-35: $225*

Now the exceptional value of these exceptional instruments is even more apparent, because we've cut their prices by $70.* You can now own the world's most powerful pocket-sized pre-programmed scientific calculator, the HP-45, for only $325.* The HP-35 now costs just $225.*

Send for our booklet "ENTER vs. EQUALS."



It demonstrates the superiority of Dr. Lukasiewicz' language by comparing it to other calculators' systems on a problem-by-problem basis, and it explains the algorithm shown above which lets you evaluate any expression on a calculator that uses RPN and an Operational Stack. This booklet is must reading for anyone seriously interested in owning a powerful pocket-sized calculator.

The coupon gets you detailed specifications of either the HP-45 or the HP-35 plus the booklet.

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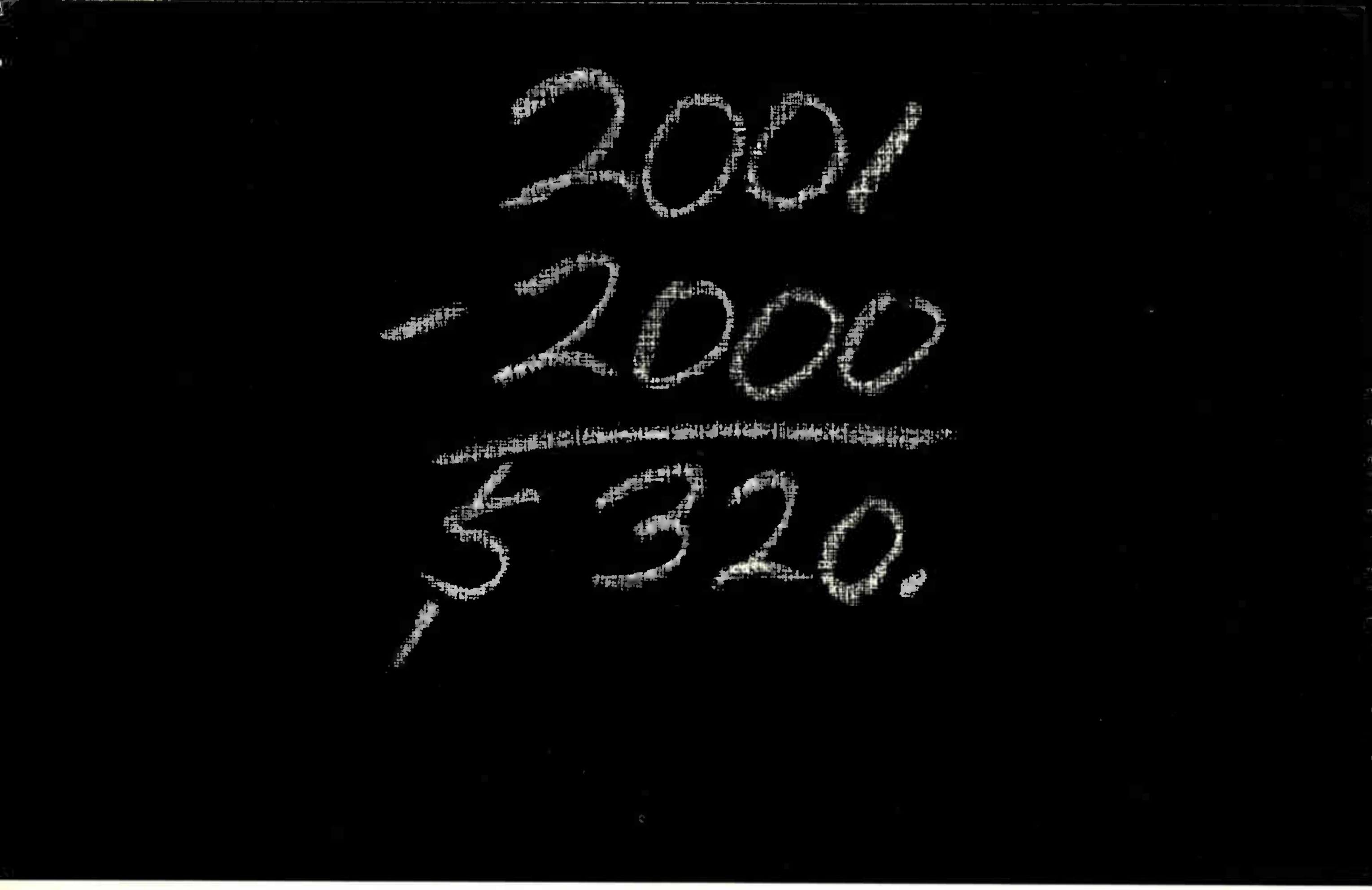
Circle 123 on reader service card



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In addition, its frequency, bandwidth, and output level are programmable, making it ideal for production test and systems use as well as in the design laboratory. If you're still not sure which sweeper we built for you, send for more information. Just circle the reader service number or give us a call.

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Circle 124 on reader service card

Portable tester checks complex logic

Low-cost unit with capabilities of minicomputer-controlled systems combines both programed and pseudorandom test patterns

by Paul Franson, Los Angeles bureau manager

Best known for its test software capabilities, Mirco Inc. set up a hardware subsidiary about a year ago. And now the subsidiary, called Mirco Systems Inc., is announcing a line of benchtop logic-board testers that sell for a base price between $6,000 and $12,000, yet are said to have the test capability and flexibility of minicomputer-controlled systems costing five to 10 times more.

The extremely low price of the testers, called the Mirco 500 series, is expected to make automatic testing practical for in-house and field-service applications, and also reduce board inventory substantially. Moreover, the compact 50–60 pound systems are capable of testing large and complex logic-circuit boards.

Mirco Systems marketing vice president Robert E. Anderson, attributes much of the testers' cost and performance advantages to a special-purpose microprogramed TTL test processor with a 200-nanosecond cycle time, 10 times faster than a typical minicomputer. Other design innovations include a technique for compressing test programs into a minimum amount of memory, the separation of test functions from programing functions, and a custom monolithic pin-driver/sensor for each of the input/output pins of the board under test.

Loading test program. Magnetic-tape cassette is one of four vehicles for loading test program into logic-board tester.

The units test boards with up to 223 pins at clock and pin-change rates of 500 kilohertz to 700 kHz, very much faster than the 500-hertz-to-5-kHz rates of minicomputer-controlled testers. This speed is especially important in large memory-filled boards, where tens of thousands of steps may be required for adequate testing.

The testers also permit both pseudorandom (fixed-sequence) and programed stimuli/response patterns, each most suitable for certain types of boards. The programing capability can be used to initialize boards, for example, followed by up to 10^{12} steps chosen from 255 difference sequences, applied at 400 kHz.

Programing variety. Several approaches can be taken to programing the testers for specific boards. Easiest and least expensive for a customer with relatively few complex boards, says Anderson, is to buy the programs from Mirco, ready to run on the machine. Programs can also be prepared using software available on the General Electric Mark III time-sharing system, or with the Mirco Flash software plus an existing minicomputer system. Finally, for approximately $15,000, users with heavy programing loads can buy Mirco's model 620 programing station. This station plus a tester costs less, incidentally, than a full computer-controlled test system with programing capability and permits the user to buy additional testers minus their usual programing capability.

Mirco also has test programs to convert programs written for General Radio, Teradyne, Computer Automation, and Membrain test systems to the test language required. Possible fault-isolation procedures include fault dictionaries generated by the Flash software and logic-probing guides.

An important factor in

price and size in a tester is the pin electronics, which provides the drivers to the inputs and the sensors for the outputs of the board under test. Mirco uses a custom monolithic circuit compatible with TTL (space is provided for special adapter circuitry to other levels if required). Driver high-level is 4.3 volts with a 10-milliampere source-current limit, and low-level is 0.5 V at 50-mA sink. Slew rate is 100 V per microsecond. Sensor threshold is 1.4 V at 100-kilohms/100-picofarads input impedance. Sixty-four pins are standard, with expansion by sets of 32 to 224 (with one for the probe). Power supply to the logic board is 6 A at 5 V, adjustable from 3.5 to 5.5 V for testing performance at limits.

Four models are made by Mirco. The 510 uses programable ROMs for program storage and entry. Up to 12,288 bytes of erasable storage hold five to 10 programs that can be selected with a thumbwheel switch. The other three models use up to 8 kilobytes of random-access memory (4 kilobytes is standard), which Anderson claims is three times the capacity of conventional minicomputer-system storage because of the efficient programing and organization. The 520 uses magnetic-tape cassettes for program entry, with 160 kilobytes on one tape accessible at 1,000 bytes per second, and the 530 uses paper tape at 100 bytes per second. An accessory to the 530 is the 610 tape-cassette unit/ROM programer and data link.

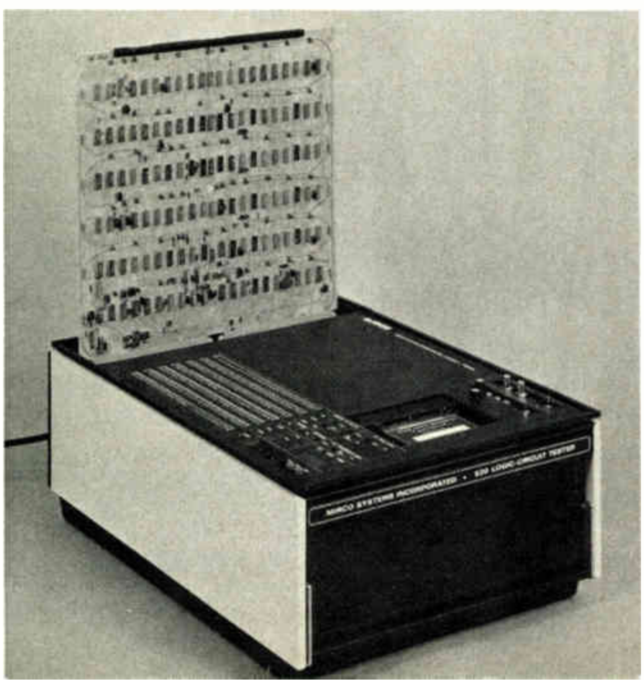
The other model in the series is the 540, with a data link to the EIA RS-232 channel for entry from the Mirco 620 programing station or another suitable minicomputer.

Mirco can supply programing for specific boards in PROM, cassette, or paper tape.

The testers will be available for delivery in October. They operate on 117 or 234 V at 300 watts. They measure 9 by 23 by 16 inches, so can fit under an airplane seat. The editor and assembler software for a suitable computer configuration is supplied.

Mirco Systems Inc., 2106 West Peoria Ave., Phoenix, Ariz. 85029 [338]

Complicated test. The model 520 logic-circuit tester is shown checking out a complex board belonging to a popular minicomputer.



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When you need reliable rectifiers, take your lead from ITT. The latest technology makes our products both reliable and cost-competitive. For example, consider the leads on our 1-amp glass-passivated device. They're weldable, bendable, and they pass tough pull tests with ease. You can specify our 1-amp rectifiers with confidence for the cut-and-bend operations of automated insertion equipment. Our technology results in high reliability for 400 mA and 1A glass as well as 1A and 3A plastic. For a good deal, go with the reliable people who hold all the cards—including zeners, diode arrays, silicon transistors and silicon, germanium and tuner diodes. Write today for our handy cross-reference guide.

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semiconductors

ITT Semiconductors is a division of International Telephone and Telegraph Corporation, 500 Broadway, Lawrence, Mass. 08142 Phone 617-688-1881. Factories in West Palm Beach, Florida • Lawrence, Massachusetts • Footscray, England • Colmar, France • Freiburg, Germany • Cascais, Portugal • Taipei, Taiwan • Sydney, Australia

ITT

Circle 127 on reader service card

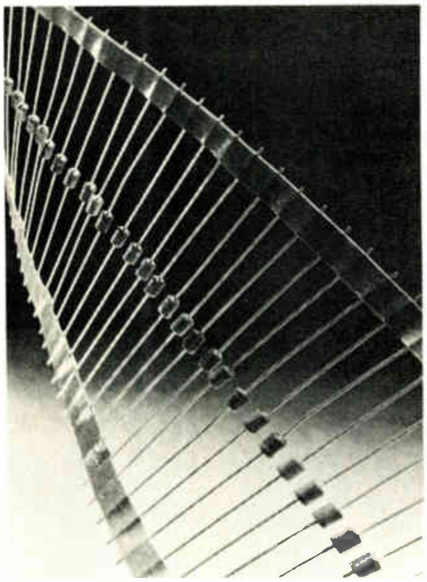
Components

Capacitors use zener technology

Semiconductor-type bonding means greater stability for glass-encased ceramic chips

Glass-to-metal bonding, long a successful technique in the production of zener diodes, is now being applied to glass-encased ceramic capacitors. The result is a rugged high-stability axial-lead monolithic capacitor that retains the economy of its high-K ceramic dielectric.

Two companies are producing the new capacitors—USCC/Centralab in Burbank, Calif., and the capacitor division of ITT Components Group Europe, in Devon, England. Centralab introduced its Monoglass capacitor line a few months ago, and ITT Europe—with the U.S. as its prime marketing target—is now producing 20,000 per week and plans to increase that to 100,000 a week in September (see photo).



The hermetic capacitors are ideal for automatic insertion by the same equipment that is suitable for resistors and diodes. The glass is bonded to the metal at the interface between each axial lead and the glass body. This construction results in a highly stable capacitor over a wide range of operating conditions. The new capacitors are principally intended for such high-volume applications as computers, telecommunications, and process-control equipment.

The Centralab units are available in four sizes; 0.200 by 0.100 inch, 0.250 by 0.100 in., 0.300 by 0.150 in., and 0.400 by 0.150 in. Working voltage rating can be either 50 V or 100 V dc over a capacitance range of 0.01 to 1.0 microfarad.

The ITT capacitors also can be supplied with either a 50-V or 100-V rating, but the capacitance range is somewhat smaller—220 to 10,000 picofarads, which will be extended to 33,000 pF in the next six months. The operating temperature range for these units is -55°C to +125°C. To manufacture the devices, ITT stacks the ceramic dielectric and metal electrodes alternatively and then fires them.

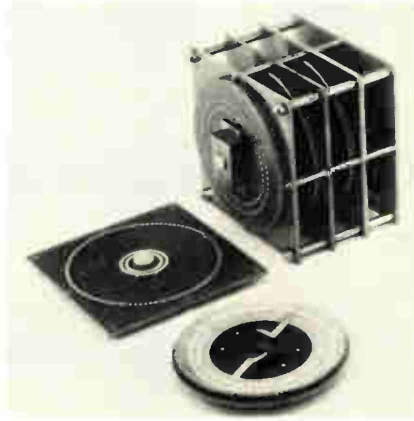
Prices, of course, depend on capacitor specifications and the size of the order. The devices are expected to sell between the prices of conventional axial-lead monolithic ceramic capacitors and disk-type ceramic capacitors.

USCC/Centralab, Electronics Division, Globe-Union Inc., 2151 N. Lincoln St., Burbank, Calif. 91504 [341]

ITT Components Group Europe, Capacitor Division, Brixham Rd., Paignton, Devon, England [339]

Switch comes in paralleling or progressive-shorting type

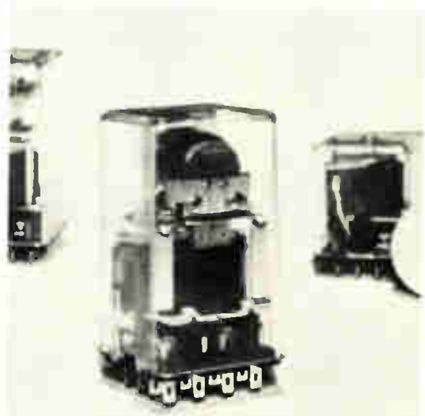
An instrument-quality switch, in its paralleling form, shorts all its positions together as it rotates, except for one position that's isolated from the rest on the same deck. Such a design is useful for multiple-circuit cable testing, both for continuity and voltage breakdown, and for solid-state testing where it is desirable to connect all circuits in common, except the one being tested, to eliminate transients causing errors. The unit can be modified to fit various applications that require paralleling of circuits, such as notch or



tab homing. It can also be used for binary coding or position selection, minimizing the amount of interconnecting circuitry needed for remote control. The switch is also available in a progressive-shorting form, which connects a new contact to all preceding contacts each time the switch is rotated by one position.
Langevin, 2030 Placentia Ave., Costa Mesa, Calif. 92627 [343]

Industrial relay controls 10-ampere resistive loads

Mechanical latching and electrical reset are features of the model 455 relay for 10-ampere applications. The relay also has four-pole, double-throw load-handling contacts capable of controlling ⅓-hp motor loads or 10-A resistive loads at 120 volts ac. After the operate coil is energized, the contacts remain transferred, even if power fails, until reset. For test or maintenance purposes, manual actuators are available as a specified option



Why Parylene works where other microelectronic protection fails:

Crevice penetration in hybrids

This beam lead has a 0.3 mil parylene coating all the way to the weld. Parylene penetrates deep within small crevices, maintaining clearance while putting a coherent coating under beam leaded chips and air bridges. No area is left unprotected, preventing shorts and allowing the designer great latitude in component spacing and sizing. And parylene secures loose debris while preventing breakoff of pigtails during shock and vibration loadings.

Controlled conformality

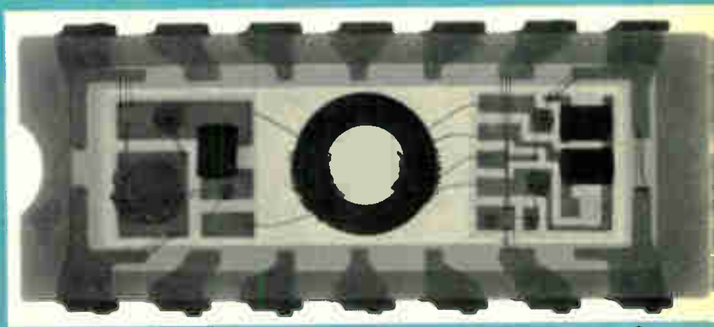
There's a uniform coating of parylene all the way around the half-mil tip of this phonograph needle. That's true conformality, and only parylene gives it, in precisely controlled thicknesses from .002 to 3 mils, in one step. Unlike spray or dip coatings, parylene won't bridge or puddle, or thin out at sharp edges, creating potential failure points. The parylene coating is completely uniform, no matter how dense or intricate the module. And because it's applied at room temperature, there's no component discomfort.

Lead Strengthening

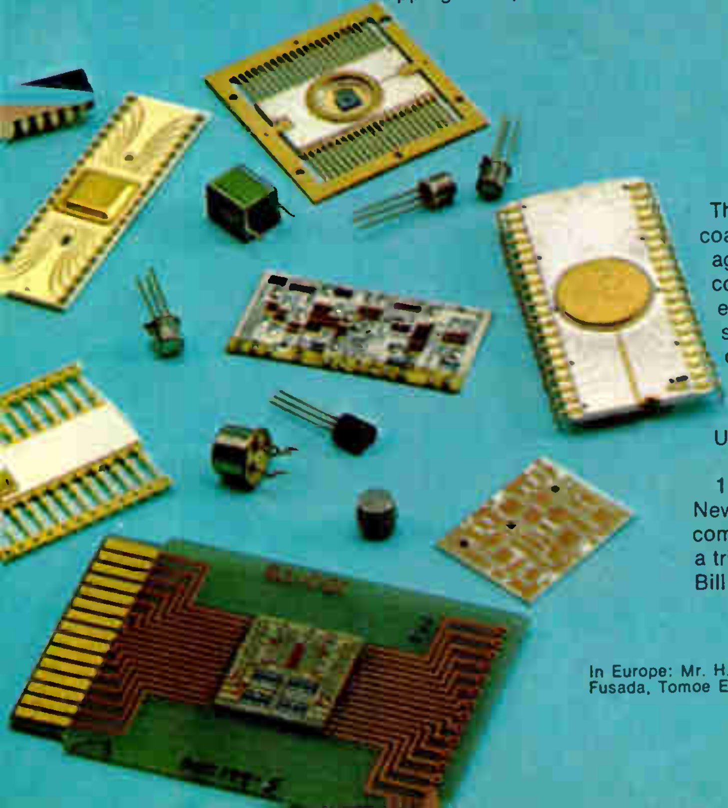
It took up to 75 grams pull to break these 1 mil wires. Bare 1 mil aluminum wires, for instance, exhibit bond strengths of 3-5.5 grams; coated with 1 mil of parylene, pull strength increases by 60-70 grams. So wire and bond are stronger, and sideward shorts and loop collapse during extreme g-loads are prevented. Parylene coatings will penetrate the less than 1 mil clearance between beam lead bonded chips and the substrate, giving such strong coating coverage that the chip cannot be lifted without destroying it.

△200 C thermal shock protection

This hybrid microelectronics relay has undergone 200 45-minute cycles from −120 to 80°C, simulating earth-orbiting conditions. This X-ray shows all leads remain intact. Parylene protection was at work, on the transformer core and then the whole assembly before packaging (TO-116). There was no appearance of corona up to 5000 V_{dc}; leakage was reduced from 10μA to <.001μA at 1000V. RTV encapsulation suffered dimensional mismatch, straining and snapping leads, with 500 V/mil bulk breakdown.



X-ray courtesy NASA Lewis Research Center and Sterer Eng. & Mfg. Co.



Broad cost effectiveness

These are some of the circuit modules now being protected with a conformal coating of parylene. Because nothing else offers parylene's combined protection against thermal cycling, shock, vibration, humidity, solvents, radiation, ionic contamination. Better barrier protection than liquid coatings like silicones, epoxies, and urethanes. On hybrids you can combine parylene with a hermetic seal for optimum environmental protection . . . and parylene alone will often do the job, and at less cost than hermetic seals. Parylene is compatible with active devices, and meets the tough requirements of MIL-I-46058C. For long term reliability, parylene provides a cost-effective solution.

Union Carbide invented the parylene system. Various patents apply; commercial use of the patented technology is licensed. Write for our 16-page brochure: Union Carbide Corp., 270 Park Avenue, Dept. RFB-65, New York, N.Y. 10017. For instant communication, and information about a trial run at reasonable cost, call Bill Loeb at (212) 551-6071.

UNION CARBIDE PARYLENE

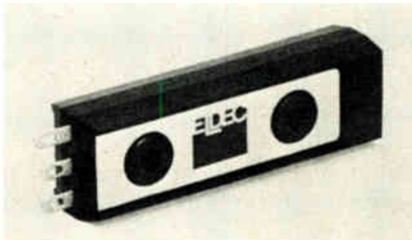
In Europe: Mr. H. Torre, Union Carbide Europe S.A., 5 Rue Pedro-Meylan, 1211 Geneva 17. In Japan: Mr. N. Fusada, Tomoe Engineering Co. Ltd., Shin Shin Kai Bldg., 14-1 Nihonbashi 3-Chome, Chuo-Ku, Tokyo.

Circle 131 on reader service card

for both operate and reset. Voltages for the reset and operate coils are 6 to 240 V ac, or 6 to 125 V dc.
Struthers-Dunn Inc., Lambs Rd., Pitman, N.J. 08071 [345]

Industrial proximity switch responds in 3 milliseconds

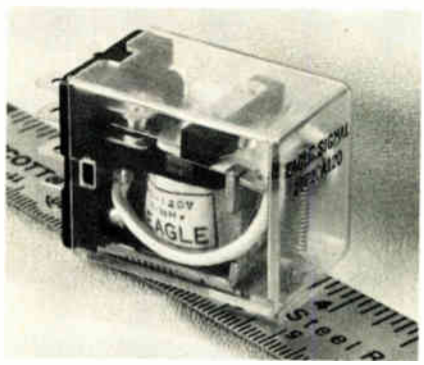
An all-metal-sensing solid-state proximity switch for industrial applications is called the model 8-210. The miniaturized unit features re-



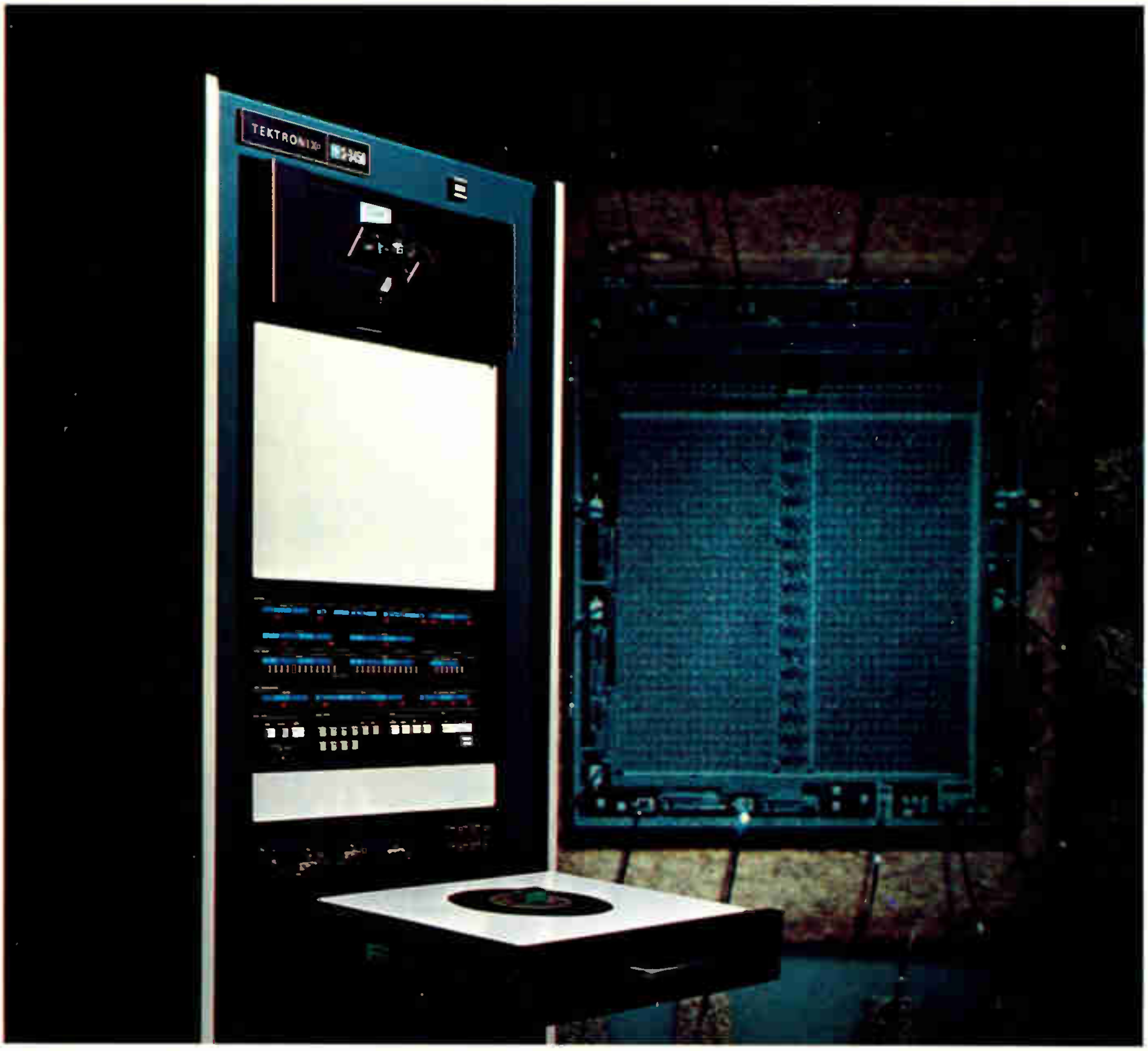
peatability of ±10% over a range of -65°F to +180°F, response time of 3 milliseconds, and numerous output options for various systems configurations. One of a family of switches, the 8-210 offers a sensing distance of ¼ inch, standard version; or 1/10 inch, precision version.
Eldec Corp., 16700 13th Ave. W., Lynnwood, Wash. 98036 [344]

Small 10-ampere relay is priced at $2.50

A 10-ampere, double-pole, double-throw enclosed relay is said to be half the size and cost of models with similar capabilities. Price is $2.50 in quantities over 100. Designated the 14-series relay, the device controls



TEKTRONIX HAS A NEW LINE TO TEST YOUR MEMORY



Meet the latest additions to the growing lines of TEKTRONIX Automated Test Equipment, the S-3400 Series of Semiconductor Memory Test Systems. These S-3400 systems are modularly constructed, fully programmable, stand alone semiconductor memory testers; capable of performing dc parametric, and functional tests on semiconductor memory devices.

The S-3400 systems have been designed and built to give you a system that can completely and effectively test all semiconductor memories. With interfaces available for wafer probers and automatic device handlers, a total package may be configured to supply you with a complete solution for your semiconductor memory testing requirements.

The S-3400 series joins with our S-3100 series and S-3260 Automated Test Systems to bring to you a wide range of test and measurement solutions. For more information contact the Systems Applications Engineer nearest you listed on the opposite page, circle the reader service card or write Box 500 A, Beaverton, OR 97005

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10-ampere or 1/10-horsepower loads at 120 V ac and 10 A at 24 V dc. The relay is also available in models for 6, 12, 48, 110 V dc and 6, 12, 24, and 48 V ac. All types measure ⅞ by 1 7/16 by 1 1/8 inches and weigh 1¼ ounces.
Eagle Signal, Industrial Controls Division, 736 Federal St., Davenport, Iowa 52803 [346]

Sintered aluminum capacitors range from 0.1 to 22 μF

The performance of tantalum capacitors is combined with the low cost and compactness of aluminum types in the Alsicon series of solid aluminum capacitors. Made by a sintering process, the Alsicon is suitable for a range of applications, including radio, television, stereo equipment and tape recorders, electronic calculators, computers and measuring instruments. The capacitance range is 0.1 to 22 microfarads. The operating temperature range is −25° to +85° C. The capacitors have a low leakage current and a maximum dissipation factor of 0.12.
Guest International Ltd., Redlands, Coulsdon, Surrey, England [347]

Rotary reed switch offers one to 10 positions

The GRS series rotary reed switch measures 1 inch in diameter and 1 in. in height (excluding control shaft) and weighs less than 1 ounce. The flatted anodized-aluminum shaft is approximately ¾ in. long and ¼ in. in diameter, for use with standard control knobs. The hermetically sealed reed switches that make up the assembly are mounted in protective slots around the periphery of a filled-nylon body and replace conventional contacts—the reeds provide Form A precious-metal contacts, actuated by a permanent magnet mounted within the body on the central control shaft. The contact arrangement is break-before-make, and one to 10 contact positions can be supplied.

Gordos Corp., 250 Glenwood Ave., Bloomfield, N.J. 07003 [349]

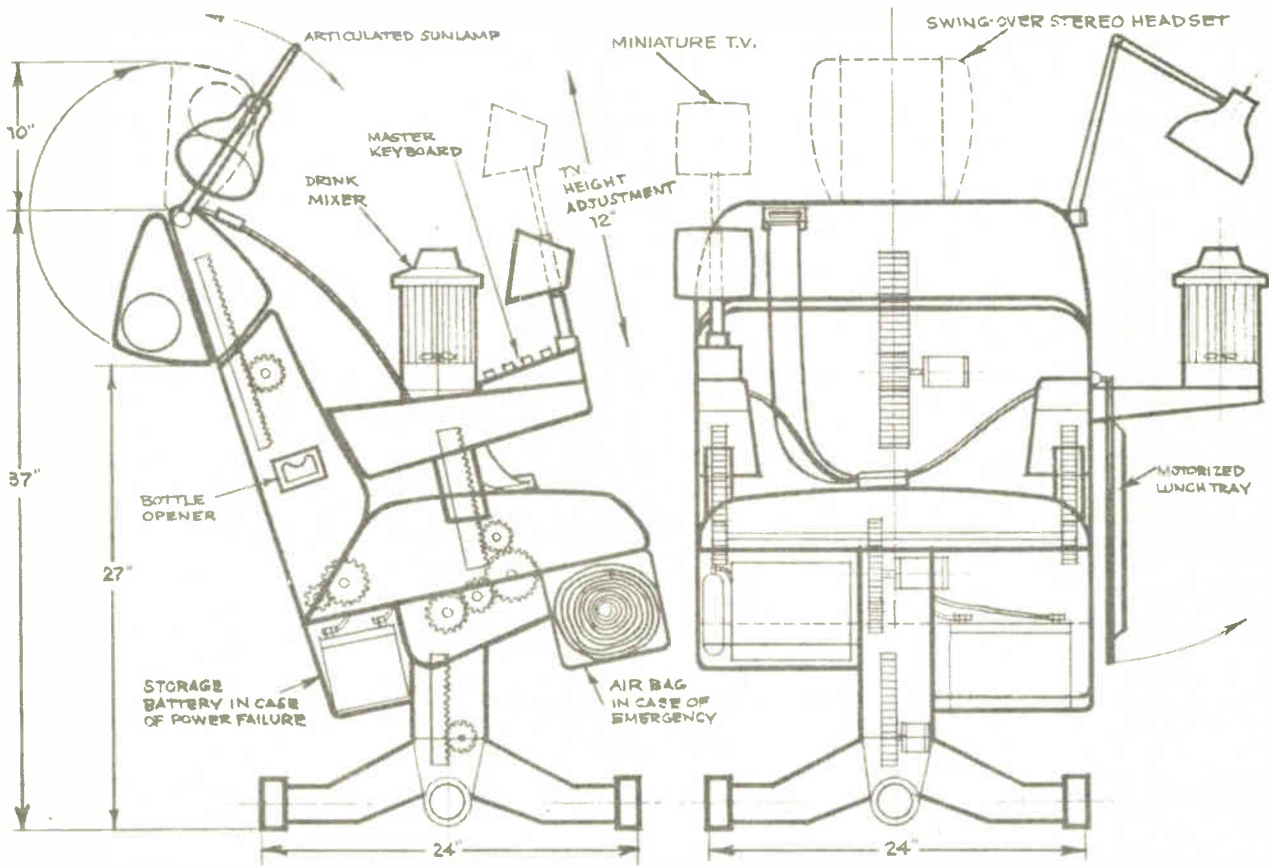
Color CRT produces a picture in 4–6 seconds

A color cathode-ray tube, which produces a picture in 4 to 6 seconds, incorporates a newly designed cathode/heater assembly that lets the tube heat up fast without its life being shortened. The company has also developed and is testing a cathode coating, which extends the life of conventional tubes. This cathode coating will also be used in the new tube, called the Faston CRT. Samples of 25-volt, 90° negative guard-band and 25-V, 110° standard tubes are available for test and evaluation.
Westinghouse Electric Corp., Westinghouse Bldg., Gateway Center, Pittsburgh, Pa. 15222 [348]

Voltage-transient suppressor offers ac and dc protection

A silicon bipolar transient suppressor provides voltage-transient protection symmetrically. Applications are where large voltage transients can permanently damage voltage-sensitive components, such as transistors, integrated circuits, MOS devices, hybrids, and many other voltage-sensitive components. Specifications of the suppressor include: a breakdown voltage of 10 to 110 volts (±10%), peak pulse power of 500 watts, response time of 1×10^{-12} seconds, and a dynamic impedance of 1.5 to 70 ohms.
Semtech Corp., 652 Mitchell Rd., Newbury Park, Calif. 91320 [350]

You tried a stock mini motor and added a bunch of detail parts, but it's a mess of assemblies. Now what do you do?



Good time to call TRW/Globe. We can build a "motion package" that will cost less than your cheap motor with a lot of kluge hung onto it.

TRW/Globe motion packages combine multiple functions to save space, simplify purchasing, eliminate assembly and interfacing costs, and reduce inventory problems.

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We're the largest builder of precision miniature motors that will do that for you.

For more information about our "motion packages" **write for our free booklet: "The Simplifiers".** TRW/Globe Motors, an Electronic Components Division of TRW Inc., Dayton, Ohio 45404 (513-228-3171).

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TRW GLOBE MOTORS

Instruments

Generator has wide range

Low-priced unit produces sine, square and triangular waves from 0.1 Hz to 1 MHz

Although not the first function generator to carry a price tag under $150, a compact instrument developed by Heath/Schlumberger also offers an unusually broad frequency range and 50-decibel calibrated attenuation. The model SG-1271, which is priced at $140 assembled, delivers a signal over a range from 0.1 hertz to 1 megahertz, so it can cover the audio as well as radio-frequency bands—well into the broadcast band. Its calibrated attenuator is accurate to within ±1 dB.

Sine, square and triangular waves are available at the BNC output connector, and output is 10 volts peak to peak. The calibrated attenuator provides stepped 50-dB attenuation in 10-dB increments, accurate to within ±1 dB. The instrument's variable attenuator provides up to 20-dB attenuation at each step.

The output level of the SG-1271 is flat within 1.5 dB over the entire tuning range. Its frequency-control dial has a 100:1 tuning range and is accurate within 3% of full scale. Waveform symmetry is within 10% of any 50% duty cycle. The function generator may be powered by 105-130 or 210-260 volts, 50-60 Hz, selectable by positioning a chassis-mounted switch and using the appropriate fuse. Power consumption is a maximum of 15 watts. All operating specifications apply over the full temperature range of the instrument, which is 0°C to 40°C.

Measuring 7¼ inches wide by 3 in. high by 8⅞ in. deep (excluding the handle), the SG-1271 weighs 4.2 pounds. It is also available in kit form. The kit version, called the IG-1271, is priced at $99.95.

Heath/Schlumberger Instruments, Benton Harbor, Mich. 49022 [351]

Plug-in scope provides 5-megahertz bandwidth

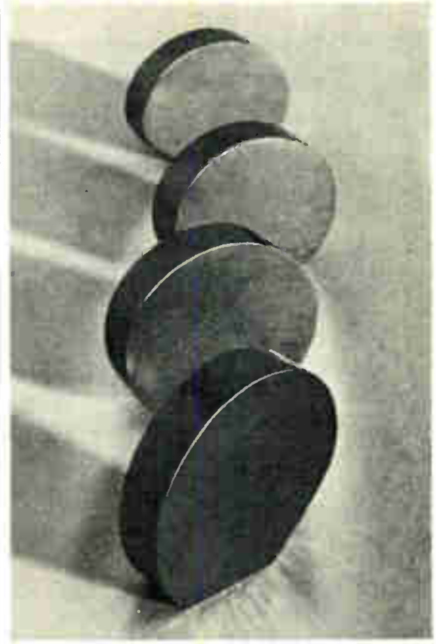
The model SC 501 oscilloscope, the first plug-in module scope in the Tektronix TM 500 series of multi-functional instruments, has a bandwidth of 5 MHz and a calibrated vertical deflection range from 10 mV/division to 1 V/div., selectable in decade steps. A variable control

extends this to at least 10 V/div., and a 2.5-inch CRT provides bright displays at sweep rates to 200 ns/div. Calibrated sweep rates are selected by pushbutton logic in decade steps from 1 μs/div. to 100 μs/div., and from 1 ms/div. to 100 ms/div. A variable control extends the slowest sweep rate to at least 1 s/div. Price is $650.

Tektronix Inc., Box 500, Beaverton, Ore. 97005 [353]

Digital measurement adds precision to power sources

The 446 line of rf power sources with wide frequency range (plug-in heads from 10 kHz to 2500 MHz),



New products

and up to 50 watts cw of power, incorporates a counter-type frequency meter, which permits direct reading of generated frequency to within 0.002%. An integrated-circuit, crystal-based counter, using a basic chip with associated circuitry, is built into the 446 main-frame, and a line of complementary plug-in cavity oscillator heads is available. For heads with frequency generation capabilities above 50 megahertz, a prescaler is incorporated into the head so that

direct reading of frequency is possible up to 1,000 MHz. Above 1,000 MHz where IC prescalers are not yet available, a dc control voltage plus a-d converter provides digital frequency readout, to within 0.2%. The design will permit retrofit of high-frequency prescalers, according to the company.

Ailtech, 19535 E. Walnut Dr., City of Industry, Calif. 91748 [355]

Battery-operated recorder consumes 5 watts

A portable dc recorder, designated the model R1-5DC, consumes 5 watts and operates for up to 10 hours typically before battery-recharge. Input sensitivity is 100, 200, 500, 1,000 and 2,000 millivolts per centimeter, selectable from a five-position switch on the front panel, with 2 to 1 vernier control on a dual concentric shaft. Other features are a differential input configuration

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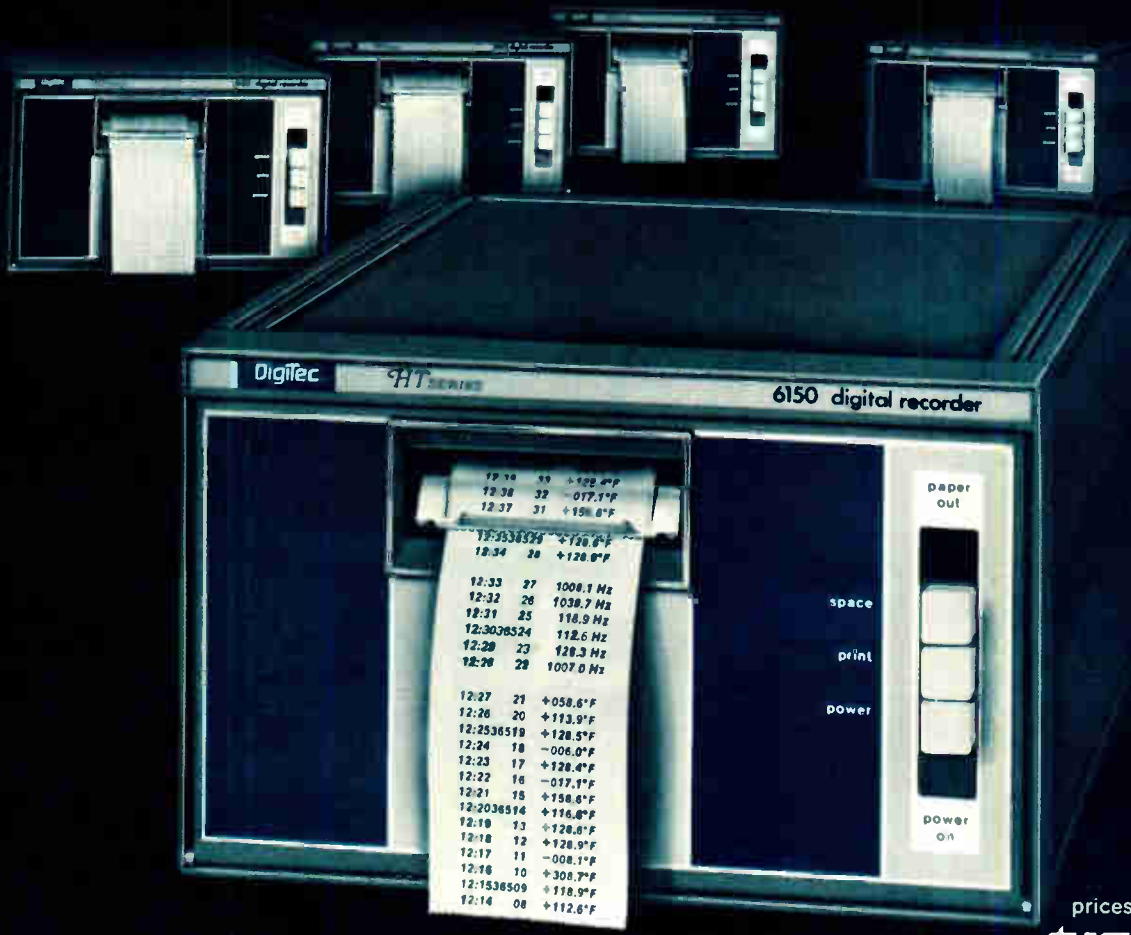

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with third lead brought out as signal ground, a linearity within 1% and a chart-speed accuracy to within ±2%.

General Scanning Inc., 150 Coolidge Ave., Watertown, Mass. 02172 [358]

Simplified logic speeds frequency counting

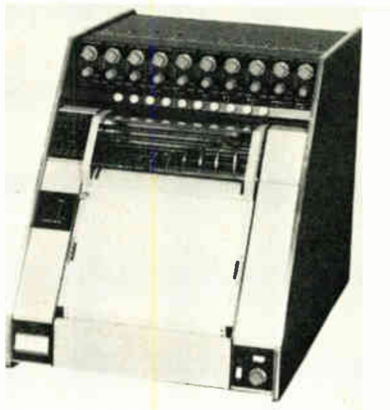
Designated Cimron DMC 45, a digital multimeter/counter uses a simplified simulation of a two-speed clock logic to integrate signals for 100 milliseconds, while providing infinite noise rejection at 10 Hz and multiples. The frequency-counting phase-lock circuitry, enabling a direct counting function, also eliminates the 10-second time base below 100 Hz, so that measurements can be made five to 10 times faster at these low frequencies. The 4-¾-digit meter offers six measurement functions and 32 ranges: dc volts from 10 microvolts to 1,000 volts in five ranges; ac volts from 10 μV to 750 V in five ranges; dc and ac current from 100 microamperes to 4 A in

five ranges; resistance from 0.4 kilohms to 40 megohms in six ranges, and frequency from 10 Hz to 20 MHz in six ranges. The DMC 45 is priced at $695 without options.

California Instruments Co., 5150 Convoy St., San Diego, Calif. 92111 [354]

10 single-pen recorders are built into one chassis

The model B-X6 recorder consists of 10 single-pen recorders built into one chassis, with all pens overlapping and writing the full 10-inch chart width at speeds better than ½ second full scale. Each pen has its own 11-step attenuator with inputs of 10 millivolts to 20 volts (1 mV span is optional). The recorder has



24 chart speeds, 200% zero adjustment on each of the 10 pens, and damping and gain adjustments on all channels. Each pen writes in a different color ink, using a replaceable Teflon tip.

Soltec Corp., 10747 Chandler Blvd., North Hollywood, Calif. 91601 [357]

Digital data delay unit handles 8 analog signals

The model DDD-1 digital data delay provides up to several seconds delay of up to eight analog signals. The instrument can be used to replace endless-tape-loop systems for the study of non-predictable transient signals. Analog signals are digitized, stored in a shift register, and then converted back to analog form for strip-chart or tape recording. The recorder can be activated after an event occurs and record several seconds of data prior to the event. Since the DDD-1 operates continuously, there is no limit on total record length. Price starts at $650.

Nimbus Instruments, 2791 Del Monte St., W. Sacramento, Calif. 95691 [359]

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Circle 142 on reader service card

Semiconductors

Static RAMs are fast

Access times of two models are 145 and 260 ns; they require three supplies

There's a gap in the semiconductor memory market between the 500-nanosecond, 2102-type static random-access memory and the very fast (70-nanosecond) 7001-type n-channel MOS RAM.

Electronic Memories seems to be aiming at filling this gap with two 1,024-bit n-channel metal-gate MOS devices. The parts, developed and made at the firm's Phoenix subsidiary, have been used in Microram 3000N systems built by Electronic Memories, but were not expected on the market so soon.

The Semi 1216 and Semi 1217 are static memories, but are apparently faster than most. They are not plug-compatible with any other products now on the market, but are compatible with each other. The RAMs are organized as 1,024 words by 1 bit and can easily be expanded for larger systems. Electronic Memories expects to have a second source soon.

Static memories such as the popular 2102 are easier to use than the dynamic 1103, but 2102's and similar parts on the market typically exhibit access times of 500 nanoseconds and above, though a recently announced 9102 from advanced micro devices claims 400 ns. The Semi parts, however, have maximum access times of 145 ns (1217) and 260 ns (1216). A faster version is in development.

There is a tradeoff in using the Semi 1216 and 1217 in that they require three power supplies rather than the single +5 volts of the 2102. The 1216/7 requires +5 volts, +15 volts and -4.4 volts. Cycle time is 260 ns or 375 ns.

Two tri-state data outputs are provided, positive and its complement, and either can drive a TTL load. Slightly higher speed (10 to 15 ns) is possible by driving a differential amplifier with both outputs. All inputs and outputs, in fact, are TTL-compatible except chip-select, which requires +15 volts.

Bryan W. Rickard, marketing manager for semiconductor memory components, expects the 1216/7 to find a market where the 7001 is too cumbersome, and the 2102 is too slow. Prime candidates are controllers and point-of-sale terminals.

The RAMs are supplied in 22-pin ceramic dual in-line packages. The 1216 is priced at $11 each in quantities of 100 to 999, and the 1217 will follow this month at $13.

Electronic Memories, a division of Electronic Memories and Magnetics Corp., 12621 Chadron Ave., Hawthorne, Calif. 90250 [411]

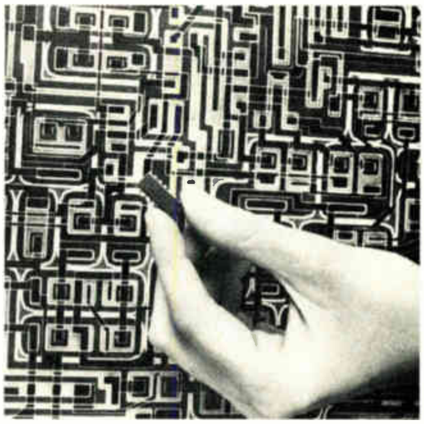
SCRs provide blocking voltages to 1,200 V

A series of 210-ampere-rms hockey puk silicon controlled rectifiers features an accelerated cathode-excitation design for high-frequency inverter applications. The 125 PM, 125 PL, 125 PLB series offer blocking voltages to 1,200 volts, and a maximum turn-off time of 20 microseconds for the 125 PM, 30 μs for the 125PL, and 40 μs for the 125 PLB series. Price for the 125PL50 in 1-9 quantities is $68.27 each, and delivery time for all units is four weeks after receipt of order.

Semiconductor division, International Rectifier Corp., 233 Kansas St., El Segundo, Calif. 90245 [414]

IC eliminates most tuned circuits in fm radio

Fm receivers for cars, hi-fi systems, and industrial communications equipment can be made smaller and less expensive with an integrated circuit called a frequency-modulated intermediate-frequency strip. Selling for $2.55 each in lots of 100, the circuit is said to replace most of



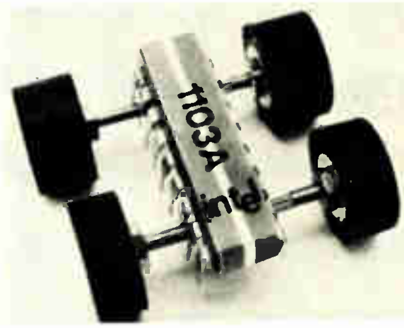
the tuned circuits that are now used in fm receivers—more than $20 worth of parts and wiring. Designated the model NE563, the IC is an advanced phase-locked loop circuit, incorporating a double-conversion technique that provides a radio with higher frequency response, better sensitivity, and lower distortion than is possible with other components. The NE563 was specifically designed to minimize alignment procedures and requires measurement of only 1 dc volt for low distortion.

Signetics Corp., Consumer Products Dept., 811 E. Argues Ave., Sunnyvale, Calif. 94086 [413]

RAMs are single-clocked, high-speed versions of 1103

A 1,024-bit p-channel MOS dynamic RAM is available in three versions called the 1103A, 1103A-1, and 1103A-2. Unlike the original 1103 design developed by Intel, the new RAMs are single-clocked, operate with faster access times, and dissipate less power. The 1103A, 1103A-1, or 1103A-2 may either upgrade existing system designs or become the basis of new, low-cost, higher-performance memory systems with access times of about 200 nanoseconds or less. In addition, precharge timing is generated on the chip from the chip-enable clock. And, despite shorter access times, the new RAMs operate at lower power in typical systems. Typical standby power is 2 microwatts per bit. Prices of the new memories

New products



range from $7.80 to $13.50.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051 [415]

2-watt fm sound system housed in single IC package

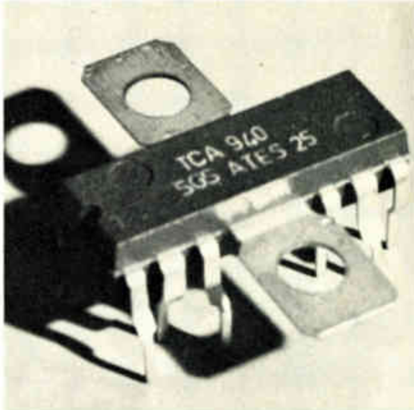
A complete 2-watt fm sound system in a single integrated circuit package, designated type ITT3701, minimizes the external components needed to provide the complete sound function for a TV set, fm radio, and other fm-receiver applications. The 3701 includes a high-gain limiter i-f/limiter, a quadrature-type fm detector, a dc-operated volume control, and an internally compensated 2-watt audio amplifier. The circuit is packaged in a modified 14-pin plastic DIP with an integral heat-sink bracket. For applications requiring a different heat-sink configuration, the device can be supplied without the bracket and with a tinned mounting surface for external heat-sink attachment. Price is $2.20 each for 100-999.

ITT Semiconductors, 3301 Electronics Way, W. Palm Beach, Fla. 33407 [418]

Audio amplifier circuit provides 7-watt output

The TCA 940 monolithic audio amplifier, with both thermal shut-down and a new, power-limiting, short-circuit protection system, offers 7 watts of output power at 1% distortion (with an 18-volt supply and a 4-ohm load). Supply voltage range is 6 to 24 V and the 45-decibel ripple rejection helps simplify power supply design. The unit, which offers an

New products

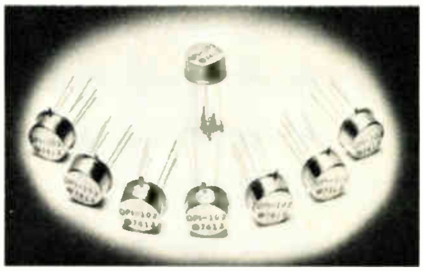


open-loop voltage gain of 75 dB, operates from 40 hertz to 20 kHz, has a 3-dB bandwidth and 65% efficiency at 5-watts output power.

SGS-ATES Semiconductor Corp., 436 Newtonville Ave., Newtonville, Mass. 02160 [417]

Optical coupler provides 1,500-volt isolation

Offering an isolation voltage of 1,500 volts, believed to be among the highest available in a TO-5 package, the OPI 102 isolator consists of of a gallium-arsenide infrared emitter coupled with a silicon phototransistor. Typical current transfer ratio is 60%, with an input of 10 milliamperes for input/out compatibility with integrated circuits. Input/output resistance and capacitance are typically 10^{12} ohms and 2.5 picofarads, respectively. When used as a replacement for pulse transformers or mechanical relays, the unit helps eliminate common-mode noise rejection, ground loops, and voltage-level translation. Price is $3.25 in 100-lots.



Optron Inc., 1201 Tappan Circle, Carrollton, Texas 75006 [419]

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useful area: 11.5 x 307mm

for Oscilloscope

size: 3"
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useful area: 69.8mm

size: 5"
neck O.D. 41mm
useful area: 114.3mm

size: 3"
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useful area: 69.8mm

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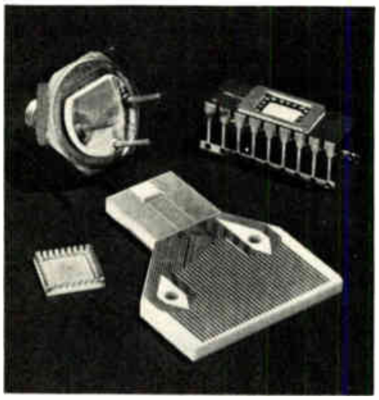

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Circle 149 on reader service card

Packaging & production

Test system checks out FETs

Optional equipment permits measurement of matching parameters on dual devices

Because it's costly and difficult to match parameters in the manufacture of dual field-effect transistors, Teradyne has included optional multiplexed test stations in its new computer-operated system designed basically for testing single FETs. The option, according to the company, brings onto the production line a feature previously available only on laboratory-type test and measurement equipment.

The test system, designated the T349, is offered with either of two software packages—the T349A for on-line classification, data logging, and automatic distribution analyses on recorded values; and the T349B, primarily for burn-in and life-test applications.

Both the A and B models measure leakage currents from 10 picoamperes to 1 milliampere at voltages up to 411 volts. Breakdown voltages from 0 to 400 V are measured at currents between 1 microampere and 1 mA. Conducting measurements are made in either a dc or a pulsed mode.

The $7,500 option for measuring dual devices can match voltages to within a 1-millivolt resolution, and it can match transconductance to within 10%, the company says.

The system is available with a maximum of four test stations, or three manual stations and one automatic handler, or two automatic handlers. Each manual station can handle between 500 and 1,000 three- or four-lead devices in an hour, and each automatic handler can test approximately 5,000 devices per hour. Where the test program for a wafer is relatively simple, up to 30,000 devices per hour can be tested.

Both models come with a central processor, the T349A with a 12,288-bit memory and the T349B with a 16,384-bit memory. In addition, the model A has a Teletype terminal, a four-tape magnetic-tape unit and starter pack, and classification and inspection software, including summary sheets, data-logged parameter values, and automatic distribution analysis. The model B test system includes a display/keyboard terminal, an 80-column line printer, a two-tape magnetic-tape unit and starter pack, a multijob go/no-go capability, data-logging, an end-of-life analysis program, and an off-line automatic-distribution-curve-analysis program.

Other options available, besides the multiplexed stations for dual devices, include 4-kilobit memory extensions, several line printers, terminals, tape files, and extra test stations.

Price of the T349A is $57,000 and price of the T349B is $71,500, without options. Deliveries will start in the third quarter and will take 16 weeks.

Teradyne Inc., 183 Essex St., Boston, Mass. 02111 [391]

Heat dissipator permits mixing seven packages

A heat dissipator that permits mixing or matching pairs of seven different semiconductor case configu-

rations is designated the HP3-350. It uses a dual universal-hole pattern that accepts two of any combination of devices in TO-3, TO-66, and TO-36 cases, ¼- and 10/32-inch stud mounts, plus Power Pac and Power Tab plastic packages. The dissipator, which has a staggered-finger design for creating turbulence in moving air, is said to be particularly good for thermal-matching of Darlington amplifiers. Price is 76 cents in quantities of 1,000 for an unplated version.

International Electronic Research Corp., 135 W. Magnolia Blvd., Burbank, Calif. 91502 [395]

Wave solderer accepts 10 DIPs in a lead frame

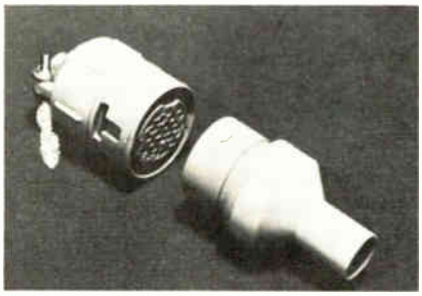
Helping to overcome the problem of tinning dual in-line package leads at mass-production speeds, a wave-soldering machine accepts up to 10

DIPs in a lead frame. Before the frame is loaded onto the machine's conveyor, the leads of each DIP are bent downward into their final position. The operator then manually feeds the lead frames onto the conveyor at intervals as close as 1.5 inches. The pusher-type conveyor moves successive lead frames over fluxing, preheating, and wave-tinning stations at conveyor speeds of up to 15 feet per minute, while the entire lead frame moves across the crest of the solder wave.

Hollis Engineering Inc., Nashua, N.H. 03060 [398]

Circular connectors offer shock resistance to 50 g

The Thorkom series of lightweight polycarbonate circular connectors



are designed for computer, automotive, test and measuring equipment, and medical instrumentation applications. Priced from $2 a mated pair (depending on configuration of connector and strain relief), the series features 0.085-inch high-density contact arrangements, shock resistance up to 50 g, and removable gold-plated contacts.

Viking Industries Inc., 8324 Topanga Canyon Blvd., Chatsworth, Calif. 91311 [396]

Snap-in guide kit permits varied card-spacings

A snap-in guide kit, which provides several different card-spacings within the same frame, uses an embossed spacing strip with guides instead of tube spacers. The guides have a molded foot at each end that allows them to be positioned over any of the embossments along the length of the spacing strip. Spacing is at multiples of 0.2 inch, with 0.4 in. being the minimum distance between cards.

Vero Electronics Inc., 171 Bridge Rd., Hauppauge, N.Y. 11787 [397]

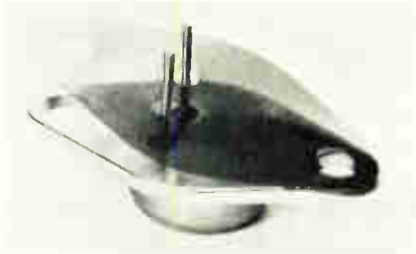
DIP lead frames offered with no tooling charge

Stamped 24- and 28-pin DIP lead frames, designed for LSI, MOS and bipolar integrated circuits used in electronic calculators and programmable computers, are produced from open tooling, and there is no tooling charge. The 0.010 inch Alloy 42 stamped frames can be supplied in continuous coils or shipped in strips, complete with over-all or spot gold-plating compatible with Mil Spec 883. Both the 24- and 28-pin lead frames are available with either a 0.200-by-0.200-inch center pad or a 0.340-by-0.230-in.-center pad. Other features, such as a rigidized pad support and improved dam bar facilitate plastic molding techniques.

Buckbee-Mears Precision Stamping Inc., 1818 Touhy Ave., Elk Grove Village, Ill. 60007 [400]

Insulator can withstand case temperatures to 125°C

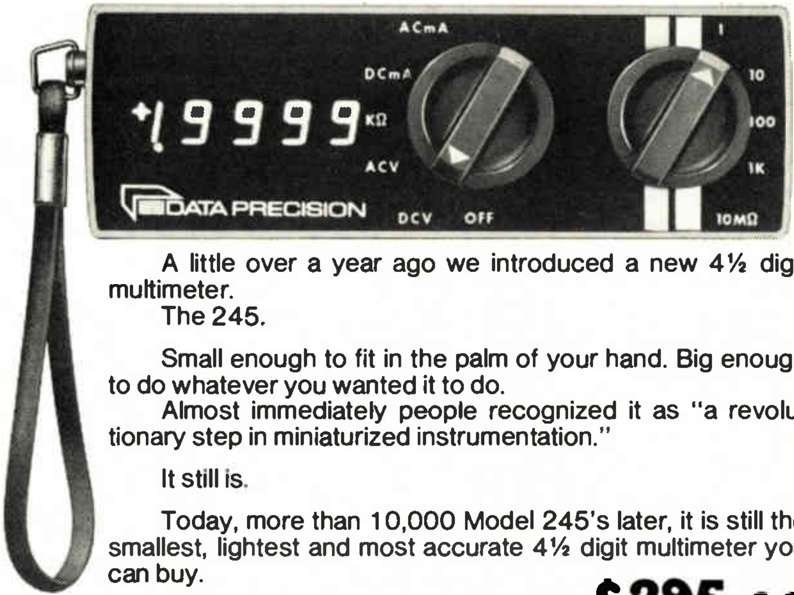
An insulator, designed for use with most semiconductor packages and called Thermalfilm II, is 2 mils thick. It is available for TO-3, TO-66, TO-5, TO-18 and plastic-packaged devices. The dielectric strength of the material is 7,000 volts per mil, and it may be used in any appli-



cation involving case temperatures up to 125°C. The insulator is bright green so that it is readily identifiable on the production line. Price is 1.5 cents in 1,000-lots.

Thermalloy, 2021 W. Valley View Lane, Dallas, Texas 75234 [399]

10,000 meters later...



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New products/materials

A flexible masking compound has been formulated to protect and then be easily stripped from molds, lead wires, printed-circuit boards, and potting forms. Called Flexible Mask, it doesn't corrode precious metals. The material, which can be applied by automatic dip, brush, or flow methods, is nontoxic and nonflammable. It stops solder from flowing onto contacts, terminals, and screw heads, and prevents contamination during assembly operations. It also withstands temperatures up to 500°F.

Techform Laboratories, 215 W. 131st St., Los Angeles, Calif. 90061 [476]

TechniGold 18K, 16K, and 14K are low-karat gold-alloy plating solutions, which are said to cut plating costs from 38% to 56%. And even a duplex plating system, using a lower-karat alloy underneath and a 24K solution on the surface can effect savings from 28% to 42%, the company says. The hard gold solutions are tarnish-resistant and exhibit the properties of pure gold. TechniGold 18K is 75% gold, while TechniGold 16K is 67% gold and TechniGold 14K is 58% gold. The solutions are capable of plating 100 millionths of an inch at 10 amperes per square foot in 4½ minutes or 100 millionths at 15 amperes in 3½ minutes. All solutions yield a 240- to 280-knoop hardness.

Technic Inc., Box 965, Providence, R.I. 02901 [380]

New aluminum-alloy evaporation materials, which include aluminum-silicon, aluminum-copper, and aluminum-silicon-copper alloys, are specifically designed to alleviate the problems of silicon diffusion and electro-migration in integrated circuits and discrete devices. Three purity grades, four standard diameters of wire and rod, and eight standard sizes of discrete charges are available. Grade C is the most commonly used priority level and assures high-yield metalization on both bipolar and MOS devices.

Cominco American Inc., Spokane Industrial Park, Spokane, Wash. 99216 [477]

Three gold-epoxy pastes, for use in

"Augat's interconnection system appeared to have more advantages for use in the AN/TPX-42A Air Traffic Control System.

"Our extensive testing confirmed it."

Robert A. Mesard, Group Leader
Transportation Systems Division
A.I.L. Division of Cutler Hammer.

Robert A. Mesard

"When work began on the AN/TPX-42A, we started looking for an interconnection system that offered high reliability and design flexibility, without sacrificing lower initial costs or low field maintenance.

"Our program staff ran detailed reliability and cost analyses of the four basic interconnection systems under consideration: P.C. boards, multilayering, welded wire-stitching, and wire-wrapped plug-in panels.

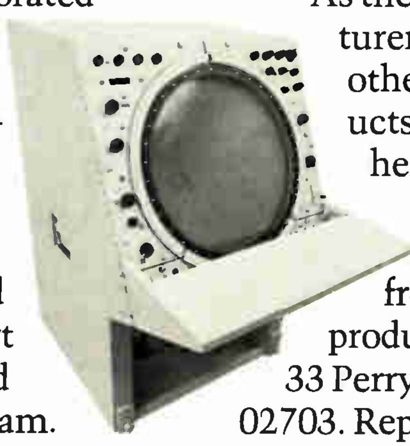
"The system meeting all of our requirements was wire-wrapped plug-in panels. We compared several manufacturers of socket panels and selected the Augat panel based on overall quality, range of products, and their willingness to respond to our needs.

"Our findings were incorporated into our proposal to the Air Force. But as the wire-wrapped plug-in panel concept was comparatively untried in U.S.A.F. equipment, they requested additional testing. So we ran a series of in-depth reliability and stability studies and tests as part of our systems qualification and reliability demonstration program.

"After 13,200 test hours, we experienced no mechanical failure or intermittence with the Augat system.

"Electronic Systems Division of U.S.A.F. accepted these findings and approved the Augat system.

"We now have used substantial production quantities of Augat panels without a single contact failure."



The AN/TPX-42A

Augat first pioneered the socket-panel concept in 1965, and the exclusive precision-machined tapered-entry contact has made Augat the reliability standard for the plug-in interconnection industry.

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Europe—Augat International, Inc., Boulevard A. Reyers, 103, 1040 Brussels, Belgium, Tel. (02) 36-93-99.
Japan—Kyokuto Boeki Kaisha Ltd., New Otemachi Bldg., 2-1, 2-Chome Otemachi, Chiyoda-Ku, Tokyo 100-91, Japan, Tel. (03) 244-3788.

contact applications, provide thermo-setting gold for conductive ohmic bonding. The gold pastes can be applied manually or by machine-dispensing or screen-printing and are cured with relatively low applied heat in bonding operations. The material bonds well to alumina-ceramic substrates, phenolic circuit boards, and transistor headers. It is useful in a variety of applications in solid-state and hybrid circuits. Type GE-10 is the most economical to use, since it is a one-part system. Types GE-20 and GE-30, both two-part systems, cure more rapidly and at lower temperatures. Prices of the pastes depend on the market value of gold.

Transene Co. Inc., Route 1, Rowley, Mass. 01969 [478]

A flame-resistant, unclad paper-base laminate, for use in terminal strips and high-voltage components, is designated Synthene FR-2. The material meets military specification LP-509 (grade FR-2), and Underwriters' Laboratories' flammability classification 94 V-O. As a paper-base phenolic-resin laminate, it has good punching characteristics and good electrical properties even in high humidities. Synthene FR-2 is for use in terminal strips and such high-voltage components as yokes for TV sets, appliance switches, and various radio parts. The material is available in 48-by-48-inch sheets, with thickness ranging from 0.032 in. to 0.125 in. Price for 1/16-inch-thick material is $1.54 per pound in production quantities.

Synthane-Taylor Corp., Box 835, Valley Forge, Pa. 19482 [479]

A new epitaxial process yields a gallium-phosphide slice to which the customer adds only metal contacts to produce a green light-emitting diode. Optimum wavelength at 20 milliamperes is 556 nanometers. The liquid-phase epitaxial process forms the basic pn junction during the process, so that a diffusion step is eliminated for the customer. Price is expected to be less than $100 per square inch.

Texas Materials Laboratories Inc., 2714 National Circle, Garland, Texas 75041 [480]

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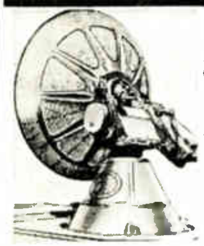

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New literature

C-MOS handbook. Motorola Inc., Semiconductor Products division, 5005 E. McDowell Rd., Box 20912, Phoenix, Ariz. 85036. Entitled the McMOS Handbook, a revised edition of a publication on C-MOS products and circuitry includes chapters on system design, computer applications, fundamental logic configurations, technology, reliability, and analog basic circuits. Circle 421 on reader service card.

Low-pass filters. Bulletin 2999, from Microwave Filter Co. Inc., 6743 Kinne St., E. Syracuse, N.Y. 13057, describes a line of low-pass filters for the 0-to-400-megahertz range. The brochure also shows performance characteristics of special models to 2,000 watts. [422]

Data communications maintenance. Atlantic Research Corp., 5390 Cherokee Ave., Alexandria Va. 22314, is offering a catalog outlining a product line of data-communications maintenance and signal-interface equipment. [423]

Connectors. Describing hermetically sealed connectors, a brochure from Detoronics Corp., 10660 E. Rush St., S. El Monte, Calif. 91733, illustrates various configurations using glass-to-metal bonding. [424]

Thermal effects. Engineers concerned with thermal effects on semiconductor performance and reliability will be interested in a 22-page reference book from International Electronic Research Corp., 135 W. Magnolia Blvd., Burbank, Calif. 91502, called "Guidelines to Semiconductor Thermal Management." [425]

Microwave tuning diodes. Raytheon Co., Special Microwave Devices Operation, 130 Second Ave., Waltham, Mass. 02154. Microwave tuning diodes form the subject of a product bulletin that discusses the tuning of Gunn, Impatt or transistor oscillators where high Q is required. [426]

FET analog switches. Siliconix Inc., 2201 Laurelwood Rd., Santa Clara,

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New literature

Calif. 95054. An application note describing the use of FET analog switches in several sample-and-hold circuits is intended to eliminate the cut-and-try methods used by many designers. The brochure presents design criteria and in particular examines current-handling and offset characteristics, charge-transfer characteristics, and inverting and noninverting designs. [427]

Power resistors. A revised handbook on power wirewound resistors is available from RCL Electronics, 700 S. 21st St., Irvington, N.J. 07111. Included are an ordering guide and cross-reference chart. [428]

Optoelectronics. A catalog from Vactec Inc., 2423 Northline Industrial Blvd., Maryland Heights, Mo. 63043, describes a line of optoelectronic products, which includes cadmium sulfide and cadmium selenide photoconductive cells, silicon solar cells, npn phototransistors, and opto-isolators. [429]

Computer graphics. The PDS-1G minicomputer-based interactive graphics display system, which provides both on-line and stand-alone capability, is described in a bulletin from Imlac Corp., 150 A St., Needham, Mass. 02194 [430]

Power tubes. RCA Electronic Components, 415 S. Fifth St., Harrison, N.J. 07029, is offering a wall chart tabulating power tubes by power level and application. The chart catalogs various services by frequency from 500 kHz to 1450 MHz and cross-references tube recommendations against power levels from 10 W to 250 kW. [431]

Calculator handbook. For $10, users of the H-P 35 scientific calculator can buy a handbook giving the most efficient keystroke sequences for solving commonly encountered mathematical problems. The book is available from Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [432]

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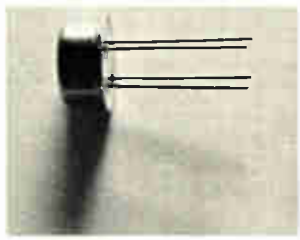

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Inc., 32 Lincoln Ave., Orange, N.J. 07050. A 370-page reference to more than 25,000 currently produced power semiconductors called the Power Semiconductor D.A.T.A. Book, presents the electrical and physical characteristics of power rectifiers, transistors, SCRs, and triacs in 13 applications-oriented sections. Price is $37.50 until July 26 for a one-year two-edition subscription. After July 26, the price will be $47.50. [433]

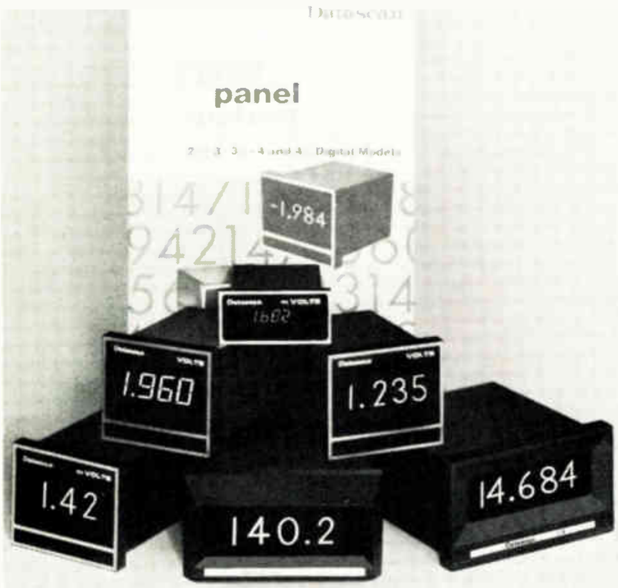
Minicomputer disks. System Industries, 535 Del Rey Ave., Sunnyvale, Calif. 94086, has issued a brochure that describes the line of disk storage systems for the most popular minicomputers. Storage specifications are listed both for the series 3500/4500 lines, which use the Diablo disk drives, and for the series 9500 system, which uses the CDC 9760/62 disk drives. [434]

Power supplies. ACDC Electronics Inc., Oceanside Industrial Center, Oceanside Calif. 92054, is offering a six-page reference to OEM power supplies. The brochure contains basic specs and prices of more than 100 standard models ranging from 1,200 milliwatts to 500 watts. [435]

IBM peripherals. Saving money on IBM peripherals is the major topic discussed in a brochure available from Computer Hardware Inc., Suite 80, 2424 Arden Way, Sacramento, Calif. 95825. [436]

Memory tester. A memory and microprocessor chip tester, the model MD-104M is described in a two-page brochure from Macrodata Corp., 6203 Variel Ave., Woodland Hills, Calif. 91364. Block diagrams, specifications, and ordering information are included. [437]

Image intensifiers. A four-page brochure from ITT, Electro-Optical Products division, 7635 Plantation Rd., Box 7065, Roanoke, Va. 24019, describes 18-mm microchannel wafers for image pickup applications under low light or infrared ambient light conditions. A list of tube types is included. [438]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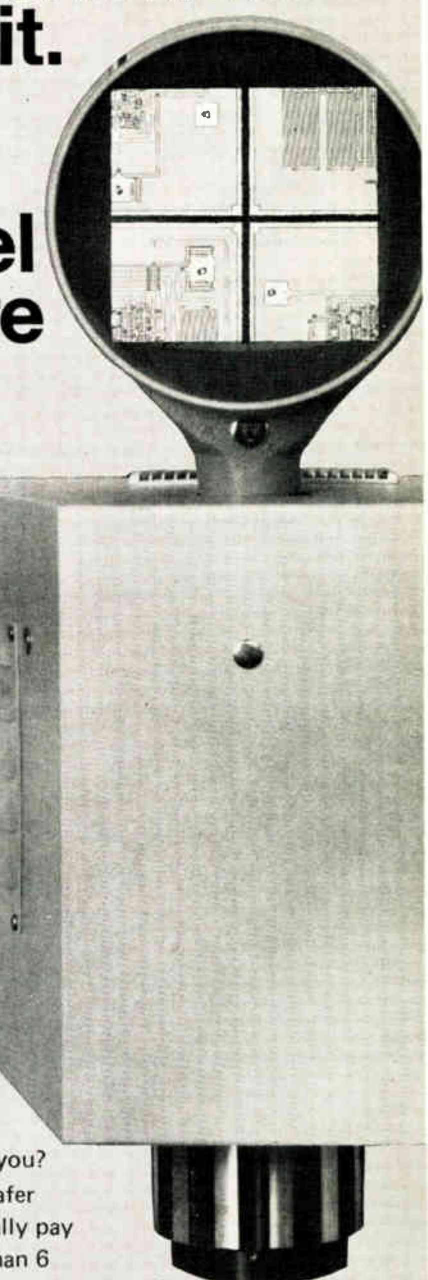

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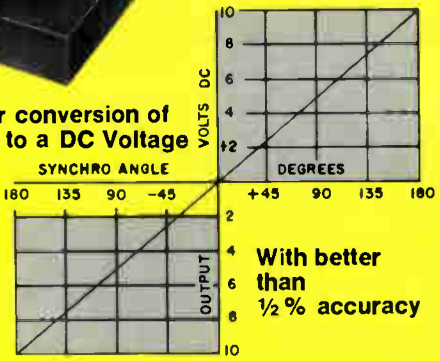

With better than ½% accuracy

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Reference: 26V ±10% 400HZ (Unit can be altered to accommodate 115V if available at no extra cost)
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- ***Isolation between input and output***

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Load: 0 to 40ma
Total Regulation: +0.1%
Distortion: 0.5% maximum rms
Temperature Range: —55°C to +125°C
Size: 2.0″ x 1.8″ x 0.5″

Other units are available at different power and voltage levels as well as wider temperature ranges. Information will be furnished upon request.

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This new encapsulated circuit converts a 3 wire synchro input to a pair of dc outputs proportional to the sine and cosine of the synchro angle independent of a-c line fluctuations.

- Complete solid state construction.
- Operates over a wide temperature range.
- Independent of reference line fluctuations.
- Conversion accuracy — 6 minutes.
- Reference and synchro inputs isolated from ground.

Specifications Model DMD 1508-2

Accuracy: Overall conversion accuracy 6 minutes. Absolute value of sine and cosine outputs accurate to ±30MV

Temperature Range:
Operating —40°C to +85°C
Storage —55°C to +125°C

Synchro Input: 90V RMS ±5%LL 400Hz ±5%

DC Power: ±15V DC ±10% @ 50MA

Reference: 115VRMS ±5% 400Hz ±5%

Output: 10V DC full scale output on either channel @ 5ma load

Temperature coefficient of accuracy:
±15 seconds/°C avg. on conversion accuracy
±1 MV/ °C on absolute output voltages

Size: 2.0″ x 1.5″ x 2.5″

Units are available with wider temperature ranges and 11.8V LL, 26V reference synchro inputs. Information will be supplied upon request.

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DC x DC = DC OUTPUT

#MCM 1478-1

Product Accuracy is ±½% of all theoretical product output readings over Full Temperature Range of −55°C to +125°C.

Maximum Output Error for Either
X = 0, Y = 10V
Y = 0, X = 10V
X = 0, Y = 0
would be ±2 MV over Entire Temperature Range.

Specifications Include:

Transfer Equation: E = XY/10
X & Y Input Signal Ranges: 0 to ±10V peak
Maximum Static and Dynamic Product Error: ½% of point or 2MV, whichever is greater, over entire temperature range
Input Impedance: X = 10K, Y = 10K
Full Scale Output: ±10V peak
Minimum Load for Full Scale Output: 2000 ohms
Output Impedance: Less than 10 ohms
Bandwidth: 1000Hz
DC Power: ±15V, unless otherwise required, at 20ma
Size: 1.3″ x 1.8″ x 0.5″
Output is short circuit protected

Circle 901 on reader service card

There is No Substitute for Reliability

GENERAL MAGNETICS • INC
135 Bloomfield Ave., Bloomfield, New Jersey 07003 - Tel. (201) 743-2700