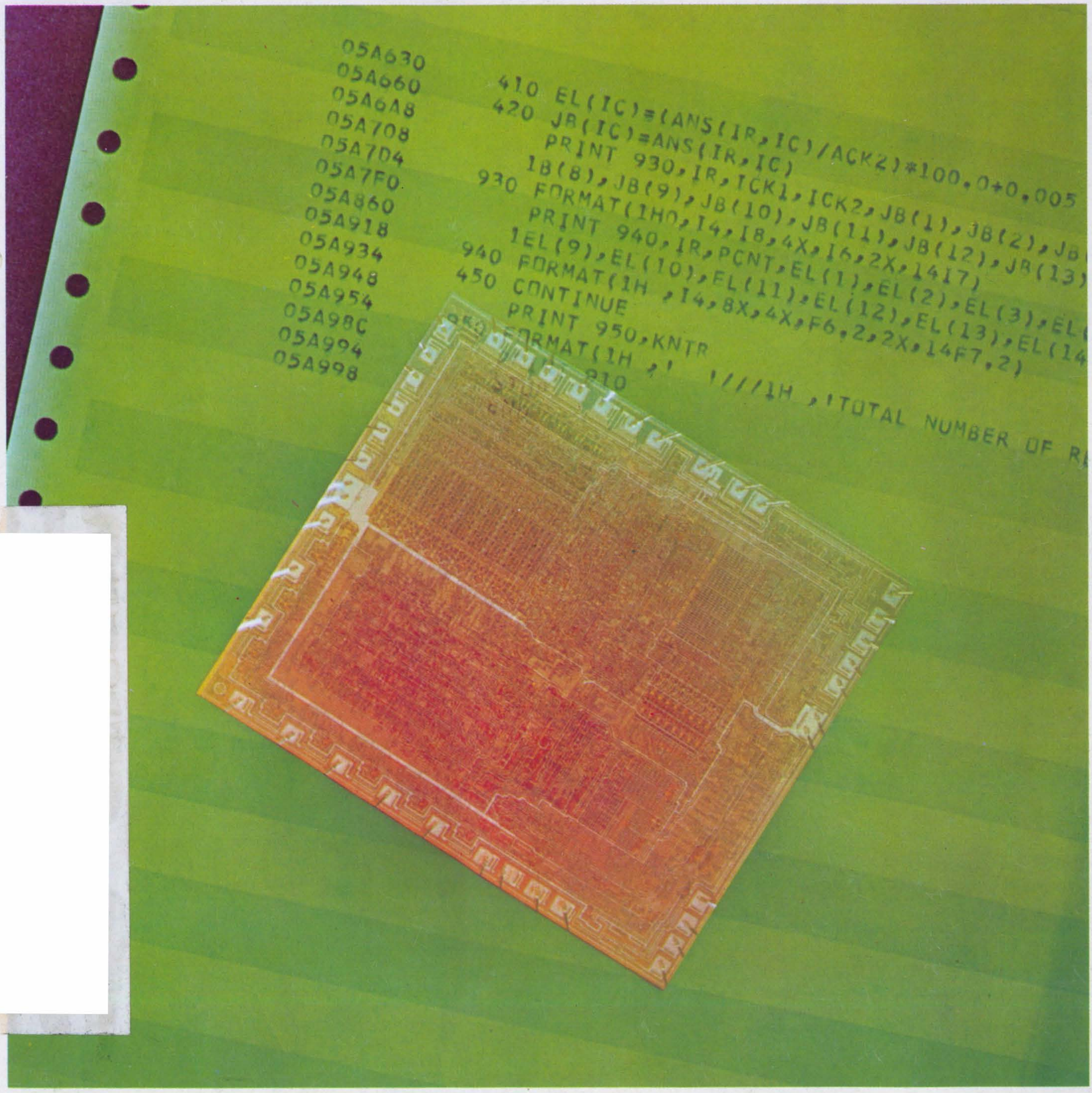
VOL. 22 NO. 18

Electronic Design®

FOR ENGINEERS AND ENGINEERING MANAGERS

SEPT. 1, 1974

Microprocessors: ICs with clout. They herald a new generation of improved logic designs. But to use these 'computers on a chip,' designers must think software as well as hardware. And products come in many forms, running the gamut from chips to boards to minis. What other hurdles are there? See Focus on page 52.

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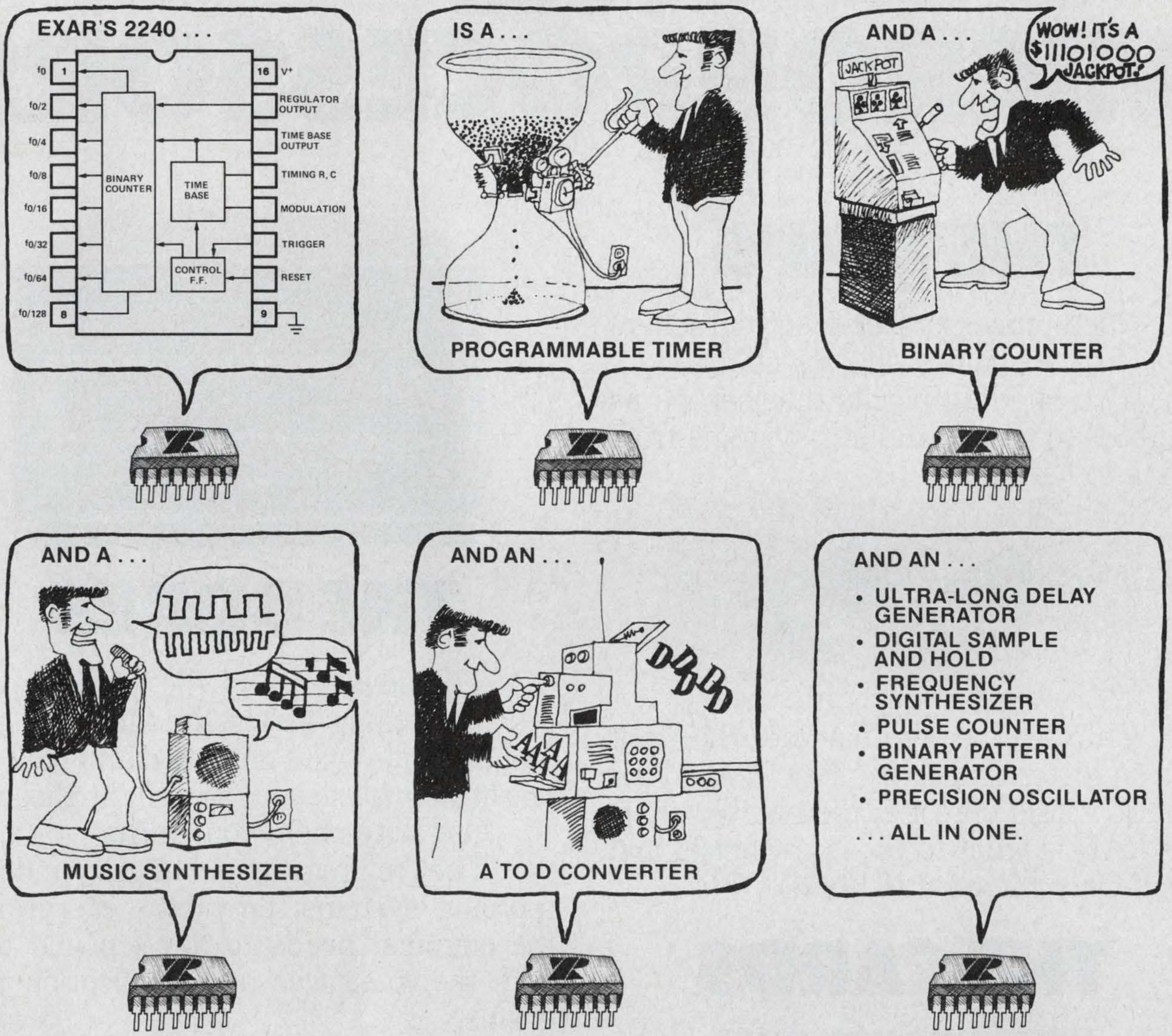
THE FIRST OF THE BIG COUNT TIMERS



Exar's new XR-2240 counter/programmable timer solves so many tough problems that designers will unanimously agree that it's really the universal timer.

With its unique combination of analog and digital timing methods, you can now replace inadequate and complex assemblages of monolithic and electromechanical timers with the much simpler XR-2240. As a bonus, you get greater flexibility, precision operation, and a reduction in components and costs for most applications.

Because of built-in programmability, you can also use the XR-2240 for frequency synthesis, electronic music synthesis, digital sample and hold, A to D conversion, binary counting and pattern generation, and more.

With a single XR-2240 you can now generate precision time delays programmable from 1RC to 255RC, a range of microseconds to 5 days. By cascading only two XR-2240 timers, you can extend the maximum delay by a factor of 2^N, where $N = 16$ bits, resulting in a total delay of 3 years!

The XR-2240 operates over a 4V to 15V supply range with an accuracy of 0.5% and an 80 ppm/°C temperature stability. It's available in either a 16-pin ceramic or plastic dual-in-line package for military or commercial applications. Prices start at $4.50 in 100 piece quantities.

For the more conventional timing applications, look to our other timers: the XR-320 timing circuit and the XR-2556 dual timers. Call or write Exar, the timer leader, for complete information.

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INFORMATION RETRIEVAL NUMBER 2

Electronic Design VOL. 22 NO. **18**

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Cover: Photo by Harry Meier, courtesy of Intel, Santa Clara, Calif. The manufacturer's Model 8080 microprocessor chip appears against a background listing in Fortran. Though compilers accepting Fortran are not yet available for processor chips, the listing symbolizes some of the rapid advances that have marked the microprocessor field.

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look at it, the gh speed RAM.

conditions. Just take advantage of the extremely low cenable capacitance (65 pF) low input level (4.0V) and high output current (1.2 mA) to minimize on-board delays. (For even faster speed, use the 2105-1 in a dynamic mode.)

2105 RAM FAMILY			
RAM	ACCESS TIME	CYCLE TIME	REFRESH MODE
2105	95 ns MAX	200 ns MIN	SYNCHRONOUS
2105-1	80 ns MAX	180 ns MIN	SYNCHRONOUS
2105-2	95 ns MAX	230 ns MIN	ASYNCHRONOUS

Quadrilevel supplies aren't needed either. A typical 4096 x 9-bit module with ECL interface operates on less than 5 watts from standard +5V, −5V, and +12V system supplies. Furthermore, you don't need special sense circuits since the output—1.2 mA at ground reference—is easily biased for TTL or ECL sensing.

THINGS TO COMPARE	OUR 2105	THEIR 7001
VERY FAST ACCESS	√	√
QUASI-STATIC OPERATION	√	√
FEW SUPPORT CIRCUITS	√	
LOW DRIVER LOADS	√	
EASILY SENSED OUTPUTS	√	
STANDARD SUPPLY LEVELS	√	
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SMALLER CHIP SIZE	√	
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READ MODIFY WRITE CYCLE	√	
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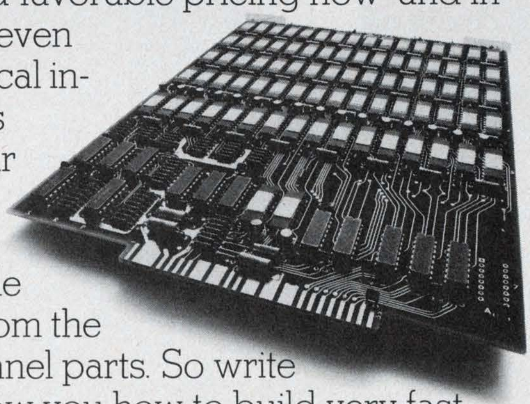
You save 30% to 40% on board area by using an 18-pin instead of a 22-pin package, and you save time and money by using standard supplies, 80% less drive and fewer support parts. Also, our smaller chip ensures volume availability and favorable pricing now and in the future. We even have economical interface circuits containing four address drivers and one clock driver per package (3210 for TTL inputs, 3211 for ECL.)



The RAMs and support circuits are available now, at Intel distributors or in OEM quantities from the factory that produces most of the world's n-channel parts. So write or call for a new 2105 application note. It will show you how to build very fast memories at low cost.

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across the desk

Here are correct specs for LR171E IC timer

The table in the article "Which IC Timer to Buy?" (ED No. 3, Feb. 1, 1974, p. 62) contains some errors. The supply voltage for the LR171E, made by Electrical Remote Control, is stated as a +6 to 45 V, whereas the supply can be +6 to 450 V. Also figures are given for variation in timing to changes in the supply voltages for the IC timers, and the LR171E is "'not specified." Yet the LR171E contains a 5-V shunt regulator and a 2.5-V regulator for the timing circuit. (The table does indicate that the LM122 is internally regulated.) The figure in the LR171E data sheet for timing accuracy to supply is given as timing to supply current; this is given as 0.1%/mA.

The accuracy of the XR2240 is stated as being 0.5% typical for a given RC. This figure is not specified for the LR171E because it has a calibration pin. A suitable trimming resistor can be used here to adjust the timing accuracy to any desired limit.

The LR171E has five TTL-compatible outputs, two of which are complementary. These two outputs can source or sink 20 mA, so they can drive loads without the need to interface. This seems to be a unique feature among the counter timers. Neither the XR2240 nor the Mostek MK5009 can source output current; the LR171E is the only counter timer at present that can. The two complementary outputs on the LR171E can be made to oscillate at a frequency independent of the timing oscillator and can be used to drive triacs and SCRs directly again; this is unique among IC timers.

I think that the only characteristic of the XR2240 that is unique is its high temperature stability compared with the MK5009 and LR171E. The LR171E seems to be more versatile than the XR2240.

J. K. Chuchla

Electrical Remote Control Co., Ltd.
P.O. Box No. 10, Bush Fair,
Harlow, Essex, CM18 6LZ
England

Article on multipliers is rated impressive

I've just read the article "Get High Voltage With Low-Cost Multipliers," (ED No. 13, June 21, 1974, p. 64), and I'm impressed with the encapsulating information given on p. 68. This type of material discussion should really help the project engineer, who is deeply concerned with actual circuit performance, not just circuit diagrams. As the author of this article recognizes, circuit performance must consider the interaction of the circuit with its on-the-job environment and with the insulating and packaging materials that protect it from that environment.

Philip K. Blumer, Supervisor
Marketing Communications

Dow Corning Corp.
Midland, Mich. 48640

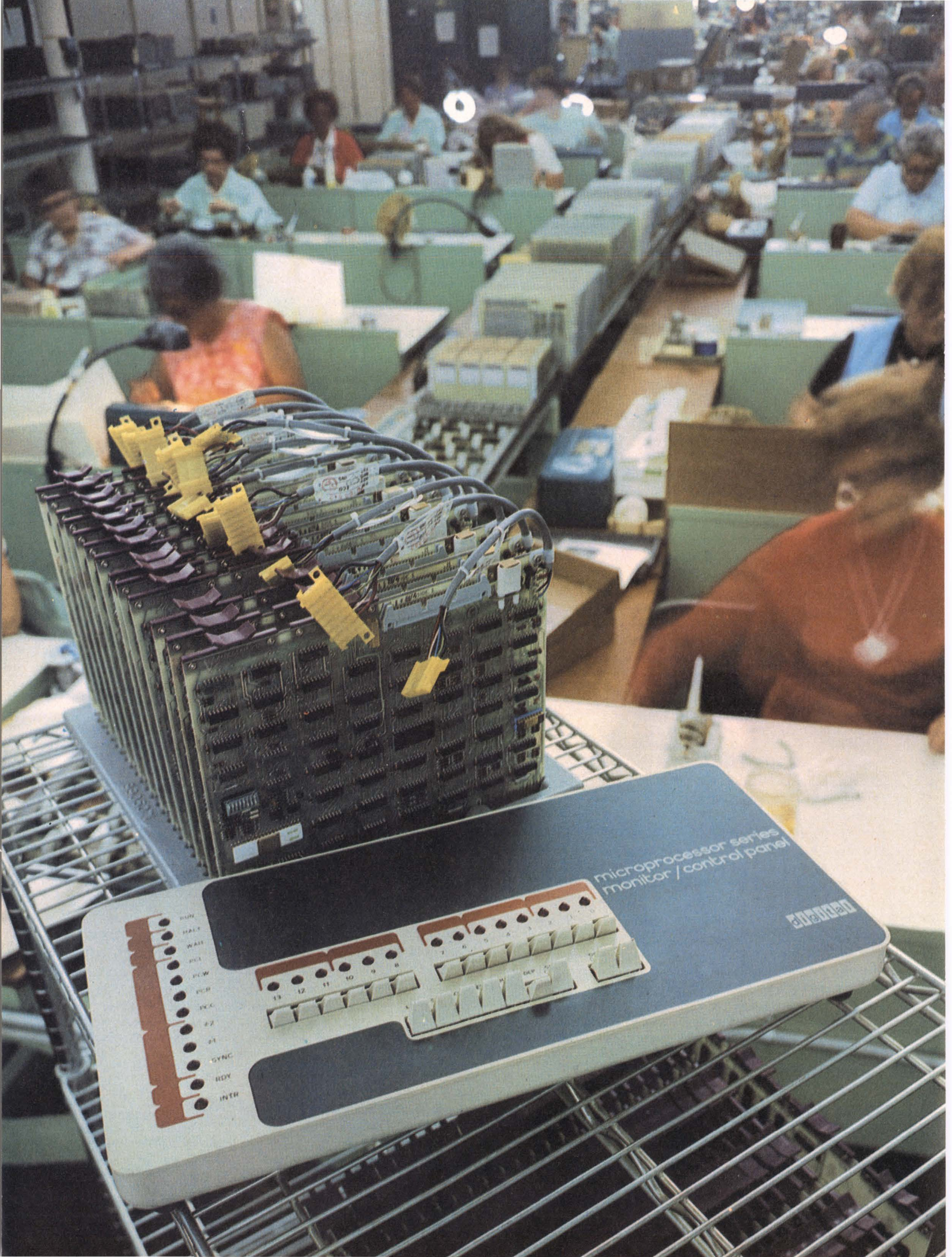
With piezo-crystals, the pressure counts

Regarding my article "Flints That Don't Wear Out" (ED No. 13, June 21, 1974, p. 88), I fear that the statement "It may then take as long as a minute or more to attain full voltage" may be misconstrued. Piezo materials are displacement-responsive rather than velocity-sensitive. Thus, in the subject application, the output voltage is directly dependent upon only the applied pressure.

Theoretically it doesn't matter how long it takes to get to the level

(continued on pg. 16)

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 50 Essex St. Rochelle Park, N.J. 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.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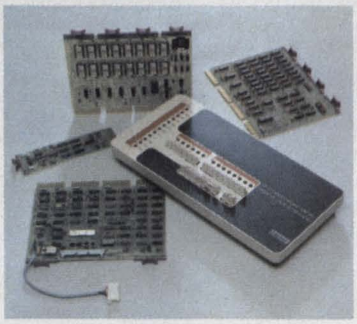

Plus, the MPS is easy to get up and going. Its external circuitry is TTL-compatible, which means you can interface to your computer or controller using Digital's broad line of standard logic modules.

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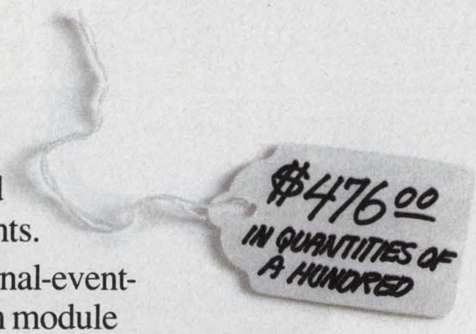

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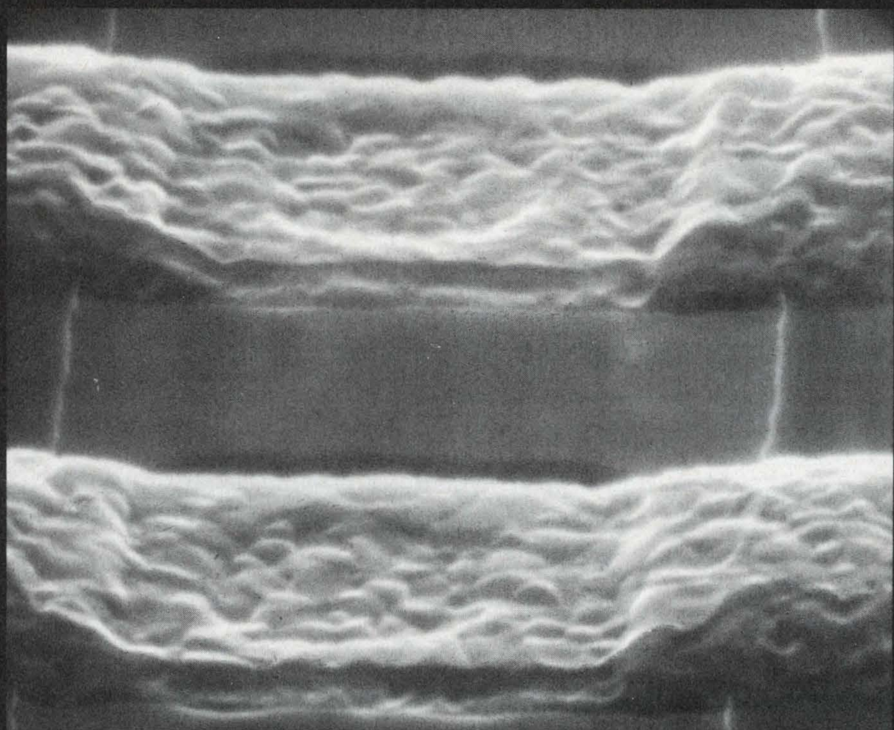

*AIM is Intersil's Avalanche-Induced Migration process, U.S. patent no. 3,742,592

AIM programing takes place entirely beneath the surface of the P/ROM. Compare the fully programed diode junction (top) with an unprogramed junction (bottom) in this unretouched 5000X photomicrograph of an Intersil IM5603A 1024-bit P/ROM. Note that there is no metal rupture or change of any kind in the appearance of the surface of the metal. Bit programing has taken place well below the surface, protected from any effect of environmental degradation.

100% reliable and faster to program.

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Programability

Intersil's Avalanche-Induced Migration technology gives superior reliability, faster programing and a better programing yield than fusible-link methods. AIM has been in use almost 4 years. It has created more than 1 billion memory bits without a single bit failure. And it lets you fully program a 2048-bit P/ROM in less than one second.

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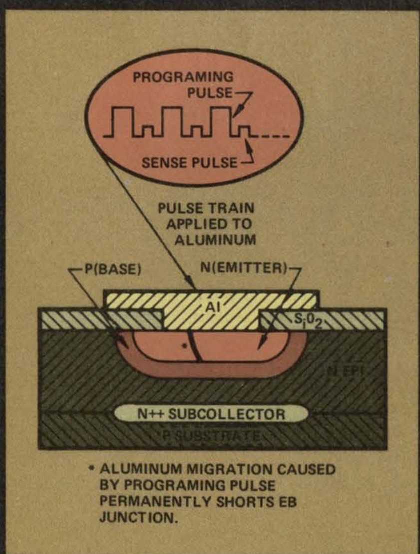
We apply a constant-current programing pulse to two back-to-back diodes. The reverse diode avalanches and shorts, leaving a single forward-biased diode. We then apply a sense pulse and determine the ohmic quality of the programed short; if it's not within specifications we immediately program it again until it is. Our pulse-sense programing sequence allows us to measure and control the quality of the programed short, whereas it's impossible to measure a programed "open" to a quality level that assures reliability.



Intersil P/ROMs in full volume production undergo a battery of static, dynamic and temperature checks before shipment to customers and distributors for off-the-shelf delivery.

Reliability

Once a short is formed, it's totally beneath the surface of the silicon, typically 1½ microns deep. It's covered by a natural passivation layer of silicon dioxide, aluminum and vapox — inherently hermetic and protected from any degrading effects of the environment. And there is no metallic debris to migrate or "grow back" with continued use of the memory at a later date.

Availability

Type	Capacity	Output	Access Time (Max)		Pd (mW)	Price (100-999)	
			Read (nSec)	C/S (nSec)		0 to +75°C	−55 to +125°C
IM5600	256 bit (32x8)	OC	50	50	350	$ 6.00	$ 9.50
IM5610	256 bit (32x8)	TS	50	50	350	6.00	9.50
IM5603A	1024 bit (256x4)	OC	60	30	450	22.00	44.00
IM5623A	1024 bit (256x4)	TS	60	30	450	22.00	44.00
IM5604	2048 bit (512x4)	OC	70	30	550	45.00	80.00
IM5624	2048 bit (512x4)	TS	70	30	550	45.00	80.00

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INFORMATION RETRIEVAL NUMBER 9

Another technical knockout

the first 900 MHz, 50 W RF chain

900 MHz radio is here now and Motorola is first with broadband devices for the entire range.

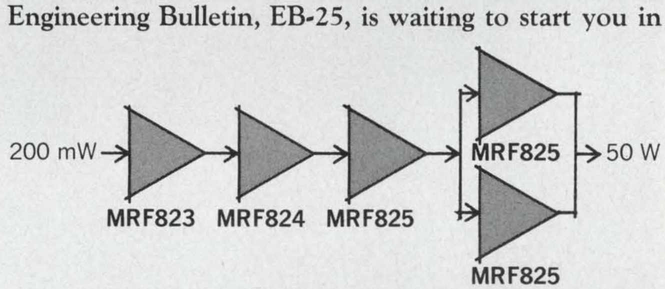
900 MHz TYPE	P_{out} W	G_{PE} (G_{PB})* dB Min	V_{cc} V
MRF816	0.75	10.0	12.5
MRF817	2.5	6.2	13.6
MRF818	8.0	5.05	13.6
MRF823	5.0	8.0	12.5
MRF824	12.0	5.0	12.5
MRF825	25.0	4.0*	12.5

*Common Base

Controlled Q† and mesh-overlay technologies are what did it. We combined all the best of land-mobile technology to develop the first lineup of common-emitter/common-base devices that meet the criteria of performance and cost.

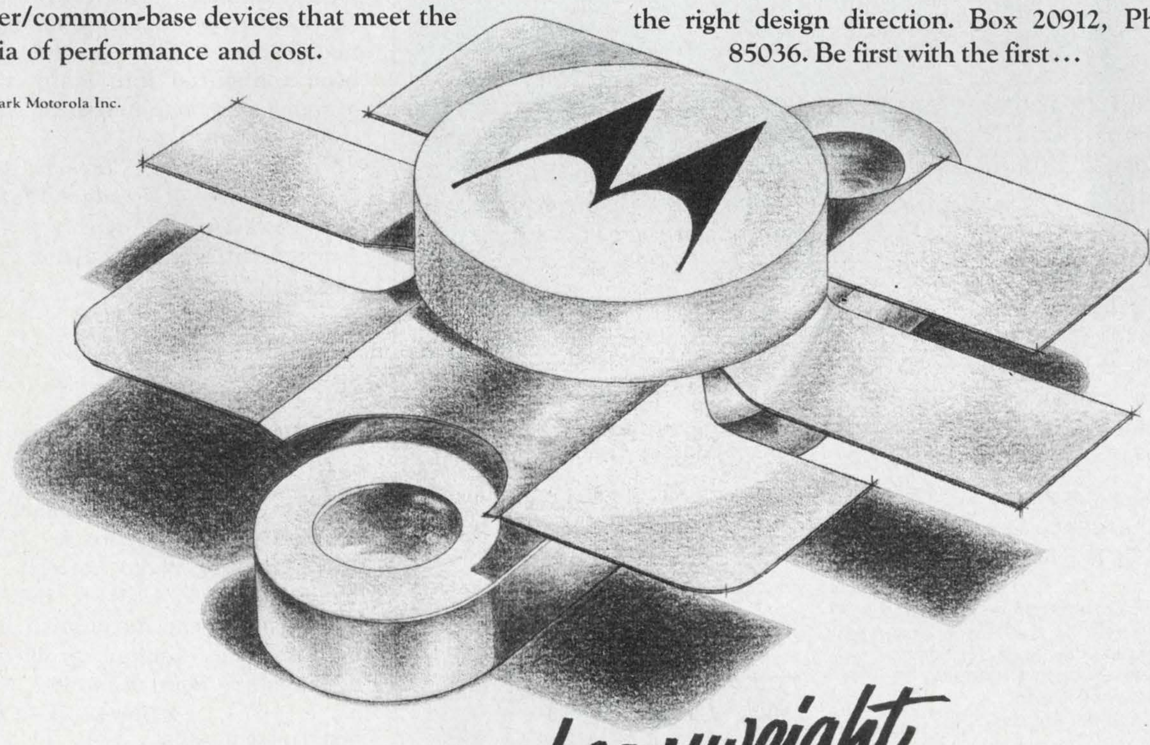
†Trademark Motorola Inc.

A complete line of 50 ohm PC board demonstration amplifiers to aid you in building your radio is available through your Motorola representative. And a new Engineering Bulletin, EB-25, is waiting to start you in



12.5 V, 806-821 MHz

the right design direction. Box 20912, Phoenix, AZ 85036. Be first with the first...



from Motorola, the heavyweight RF producer.

INFORMATION RETRIEVAL NUMBER 11

ACROSS THE DESK
(continued from pg. 7)

of strain to generate the required gap breakdown level. This may occur in milliseconds or minutes. In the case of a slowly applied excitation, leakage may be a problem, and this was the only intended meaning of the aforementioned statement—not that squeeze type excitation is inherently slow.

C. P. Germano
Vernitron Piezoelectric Div.
232 Forbes Rd.
Bedford, Ohio 44146

It was a 'fine' Focus, but don't forget ILC

"Focus on Data-Acquisition Equipment" in the June 7 issue was fine. But ILC Data Device Corp. was omitted from the rather complete listing of manufacturers.

ILC was founded approximately 10 years ago to produce discrete operational amplifiers. As we progressed, we entered the areas of d/a, a/d, synchro-to-digital and digital-to-synchro converters, plus the associated sample-and-hold and multiplexer modules. We presently have a complete line of data-acquisition modules, which are manufactured in both thick-film hybrids and discretes. These modules have been configured into many varied systems with our standard chassis configurations.

Jack R. Alford
Director of Product Planning
ILC Data Device Corp.
Airport International Plaza
Bohemia, N.Y. 11716

A call for ideas on acupuncture

I very much appreciated your circuit for alpha biofeedback (see "Simplified Biofeedback Circuit Detects Alpha-Wave Activity," ED No. 12, June 7, 1974, p. 154).

Do you intend to publish a circuit on the similar problem of acupuncture point locators?

Gerald W. Clarke
205 Driffill Blvd., #40
Oxnard, Calif. 93030

Ed. Note: If someone has an Idea for Design on acupuncture, we'll consider publishing it.

Discover how these auto-multimeters keep you out of trouble.

On the surface they may look like any well-designed digital multimeters.

Now look closer. What else do you see?

There... the Fluke name!

That indicates unusual performance.

We designed both the Fluke 8600A and the 8800A with auto range, auto zero, and auto polarity. **And every parameter is fully protected.** This means you can accidentally overload the instrument with too much current... too much voltage... or too much resistance!!... and you're still okay.

Another way you stay out of trouble: MTBF on each instrument is a minimum of 10,000 hours.

Now, the specs.

The 26-range Fluke 8600A, $599. We packed this 20,000 count multimeter with five ranges of volts from 200 mV through 1200 V ac and dc. Five ranges of current, 200 μA to 2 A ac and dc. And six ranges of resistance from 200 ohms to 20 megohms.

Basic dc accuracy is a fully credible 0.02%. Options include built-in automatic rechargeable battery pack for up to 8 hours off-line operation. Digital output is also offered.

The 0.005% Fluke 8800A, $1099. This digital multimeter features five ranges of dc volts from ±200 mV to ±1200 V. Four ranges ac from 2 V to 1200 V. And six ranges of four terminal resistance from 200 ohms to 20 megohms. For complete isolation the input resistance is better than 1,000 megohms on lower ranges and 10 megohms on the higher ranges.

For critical resistance measurements the instrument provides completely isolated four terminal ohms with less than 4 volts open circuit from 200 ohms through 20 megohms.

So there are the specs.

Impressive? We think so. But remember—specs are one thing. That name on the panel, however ... It's what makes a Cadillac a Cadillac. And a Fluke a Fluke.

For details, call your nearest Fluke sales engineer. Or simply dial our hot line.

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FLUKE ®

INFORMATION RETRIEVAL NUMBER 123

FOR DEMONSTRATION, CIRCLE 124

Voice-recognition computer responds to virtually anyone

A computer voice-recognition system that understands a simple vocabulary of numbers and key words spoken by virtually anyone may permit credit-card verification to the company's computer over the phone. Or it may allow policemen to talk directly with a central crime computer via radio link.

The system, developed by Dialog Systems, Inc., Cambridge, Mass., is advanced over others in use, says Stephen L. Moshier, technical director. It recognizes the same words spoken by a wide range of different voices—virtually anyone who pronounces the words clearly. This is in contrast with systems in which the computer answers only to operators whom the system has been "trained" to recognize.

A major portion of the Dialog system is its software package, which controls a PDP-11 computer and special peripheral hardware. Among the peripherals is an a/d converter that converts voice to digital signals, a correlator that generates short-term autocorrelation functions of the voice and a high-speed array processor.

The recognition system, Moisher explains, is based on linear predictive coding that provides a compact way of stating meaningful characteristics of voice signals. The voice sounds that are accepted by the system are transformed, and the data are fed to a "maximum likelihood" processor which operates on the statistical properties of the sound transform. This processor selects the word with the highest likelihood of being the right one. If the word has a low probability, the system rejects the inputs and verbally requests a repeat. Digital recordings of the vocabulary suitable for the system are stored on discs with the PDP-11 system.

According to Moisher, the present system accepts 1000 different telephone messages with an average accuracy of 99%. A limitation of the system is that it cannot recognize words that are run into each other, as in normal speech. The machine only understands if the speaker pauses at the end of each word. This tells the system that one word is finished and the next is about to begin.

To increase recognition accuracy still further, the system repeats the message to the speaker and asks for verification. After the first message has been verified, the computer continually adjusts itself to understand the caller's voice quality better as it listen to subsequent messages.

Recycling gives U.S. copper self-sufficiency

Recycling of copper last year helped the United States push its self-sufficiency in the metal to a new high, reports the Copper Development Association, New York.

W. Stuart Lyman, the association's manager of technical and market services, points out that over the last 10 years the U.S. has been able to produce domestically over 91% of the copper and copper alloys it needs. The remainder is supplied principally by Canada.

The high point in copper self-sufficiency—95.1%—was reached last year principally because of a simple, low-cost copper recovery process. Recovery was responsible for 46% of the 1973 supply, or more than 1.6 million tons. This was close to the total U.S. mine production of copper; over 1.7 million tons, or 49% of the supply.

Consumption of copper and brass increased in the U.S. last year, with electrical and electronic products using 2.2 billion pounds—record 30% of the output. This represents an increase of 13.1% over the 1972 total.

Total domestic shipments of copper and copper alloys also reached a record level of close to 7.4 billion pounds, an increase of 10.3% over 1972.

Lyman believes that copper demand has slowed this year because of reductions in gross national products, orders in durable goods and building construction in the last two quarters.

Tough Army survey simplified by software

Keeping track of equipment in an elaborate Army communications center can cost as much as $20,000 and three months each time a survey is made. And surveys are needed frequently, because new equipment is constantly being added.

But with the help of a new computer program designated the Technical Control Facility Site Baseline Pilot Program, developed for the Army by Computer Sciences Corp. El Segundo, Calif., the time-consuming and expensive survey can be reduced to a routine operation. In addition the effects of changing different parts of the communications system can be simulated and studied beforehand.

This is important, a spokesman for Computer Sciences points out, because changing even one of the hundreds of message channels in one of these communications centers sets off a chain reaction of associated equipment changes that involve dozens of pieces of equipment in the center.

The new program, stored in an Army computer, records the effects of changes in circuits, message channels and new equipment. It also produces a list of circuit assignments that reflect the new layout of the facility. The detailed information provided by the computer makes it unnecessary for Army engineers to visit a facility to determine the changes required each time equipment is upgraded.

Communications personnel at each center log in a site-survey manual each month the changes in the center's operating configuration. The manual is returned to the

Army's Communications Electronics Engineering Installation Agency at Fort Huachuca, Ariz.

There the changes are entered into the computer, and each facility's status is updated automatically by the program. The computer then prints out a new set of current status records, which is sent to each site.

The data base developed for the program includes detailed engineering information on the communications circuits connected to each site, station equipment, power sources, air-conditioning and heating capacity, transmission interface equipment, signal conditioners, the location of cables and their connections, and a guide to the subscribers to receive service through the communiactions center.

Although complete records of only six communication centers are now stored in the computer, the data base for the program can handle all the records for every Army communications center in the world.

Although it was not designed for commercial applications, a Computer Sciences spokesman notes that the program can be used in civilian applications. He hastens to add, however, that these are limited to large companies, like Bell Telephone, or groups of communications companies.

Brain-wave system monitors meditation

An advanced electroencephalographic research system shows how "transcendental meditation causes the nervous system to become more flexible and stable," according to Paul Levine, chief scientist at Megatek Corp., of Point Loma, Calif., where the system was developed.

The core of the system is a 16-channel EEG Grass amplifier, which acquires signals from the brain. The 12-channel output of this amplifier is fed through an a/d converter to a Nova II minicomputer.

The computer takes the information, records it on magnetic tape and then does a real-time fast-Fourier transform on the brainwave. The output is a frequency-domain presentation that is displayed on a Megatek graphic interface. The interface provides a built-in memory with 50-Hz refresh to generate flicker-free displays.

The system reveals, Levine says, that transcendental meditation synchronizes electrical waves in the left and right cerebral hemisphere, bringing about concordance of phase.

"As a person meditates, his brain waves start out in the back with the Alpha rhythms, and these grow more intense as the meditation becomes deeper. Then these waves move forward toward the frontal lobes of the brain," explains Walter Foley, vice president at Megatek.

"By having the sensors in the 12 different positions, you can see on the screen in real-time the progress of the meditation; you can watch the synchronity between the halves of the brain."

The system can also be used for conventional brain-wave research.

Two OCR drawbacks reported overcome

Two basic drawbacks of computer optical character readers—the need to refer back to original documents to make error corrections and the rejection of all handwritten data or nonstandard OCR characters—have been circumvented in IBM's new low-cost optical character reader, the 3886.

According to an IBM spokesman l etters, numbers and even signatures that are normally unreadable and rejected by optical-scanning devices can now be captured, stored and visually displayed. The display appears on a modified IBM 3277 CRT console. The operator can observe and correct directly OCR errors, or he can enter nonstandard OCR data by keyboard. Reference back to the original document—normally done as a batch operation—is not required.

The key to the new system is a "video-collect" capability obtained through microprogramming. It transforms the output of the 3866 LED character reader—which may be in the form of OCR or non-OCR characters, handwritten text or even sketches—into a visual display. This feature allows the operator to supplement input data with written information.

The video capture function also permits users to display and verify visually critical OCR information. An important use that IBM sees for the video capture function is the creation of signature files to permit banks to display and verify depositors' signatures.

The video-collected data can be transferred by user written programs from the 3886 directly to a computer; or the data can be sent to an IBM 3410 magnetic tape unit for storage and later display. The stand-alone video-collect display is obtained by connection of a modified 3277 to a 3886.

The 3886 operates with virtual storage models of the IBM System-370 under DOS/VS, OS/VS1 or OS/VS2 programming.

The 3886 video-collect capability requires added data and instruction storage, depending upon user requirements. For a 24-month period, monthly rental of the 3886 ranges from $224 to $324, with purchase prices at $10,318 to $14,918.

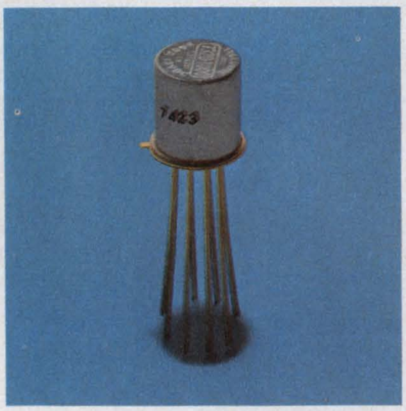
Beckman adds a line in process-control field

Introducing a new line of controllers, recorders, transmitters and computing modules, Beckman Instruments of Fullerton, Calif., has entered the process-control field.

Roy F. Brown, vice president and manager of the Process Instruments and Controls Group, says the new product line is the result of five years of research and development. Included is a pressure-sensitive-writing, dual-channel process indicator that can be read at up to 40 feet. Called the Model 8720, it uses two servo-driven tapes for each channel, to move the styli and provide a bar-like indicator of trend data.

All of the 8800 series feature an unusual "settling circuit" that eliminates the bumps—transients in the control signal—produced when control is transferred from automatic to manual, and remote to local, or when making gain or derivative changes.

RF switching to 500 MHz in a TO-5 package



RF circuit and packaging engineers are discovering that Teledyne TO-5 relays make excellent subminiature rf switches for frequency ranges up through UHF. Their reasons are: inherently low inter-contact capacitance and low loss contact circuit geometry. Typical rf performance: Isolation — 45db at 100 MHZ, 35db at 500 MHZ; Insertion Loss — 0.2db at 100 MHZ, 0.4db at 500 MHZ.

And Teledyne Relays offer the widest possible selection: MIL relays in SPDT & DPDT standard, sensitive, and maglatch types, all available with internal diodes; commercial models in DPDT standard and sensitive types, also available with internal diodes. All Teledyne TO-5 relays feature hermetic sealing, gold plated contacts, and all welded construction for high reliability.

For Transmit/receive switching in hand-held transceivers or any low power remote band switching application, Teledyne TO-5 relays are an excellent choice. No other relay offers this combination of rf performance, low coil power dissipation, and small package size.

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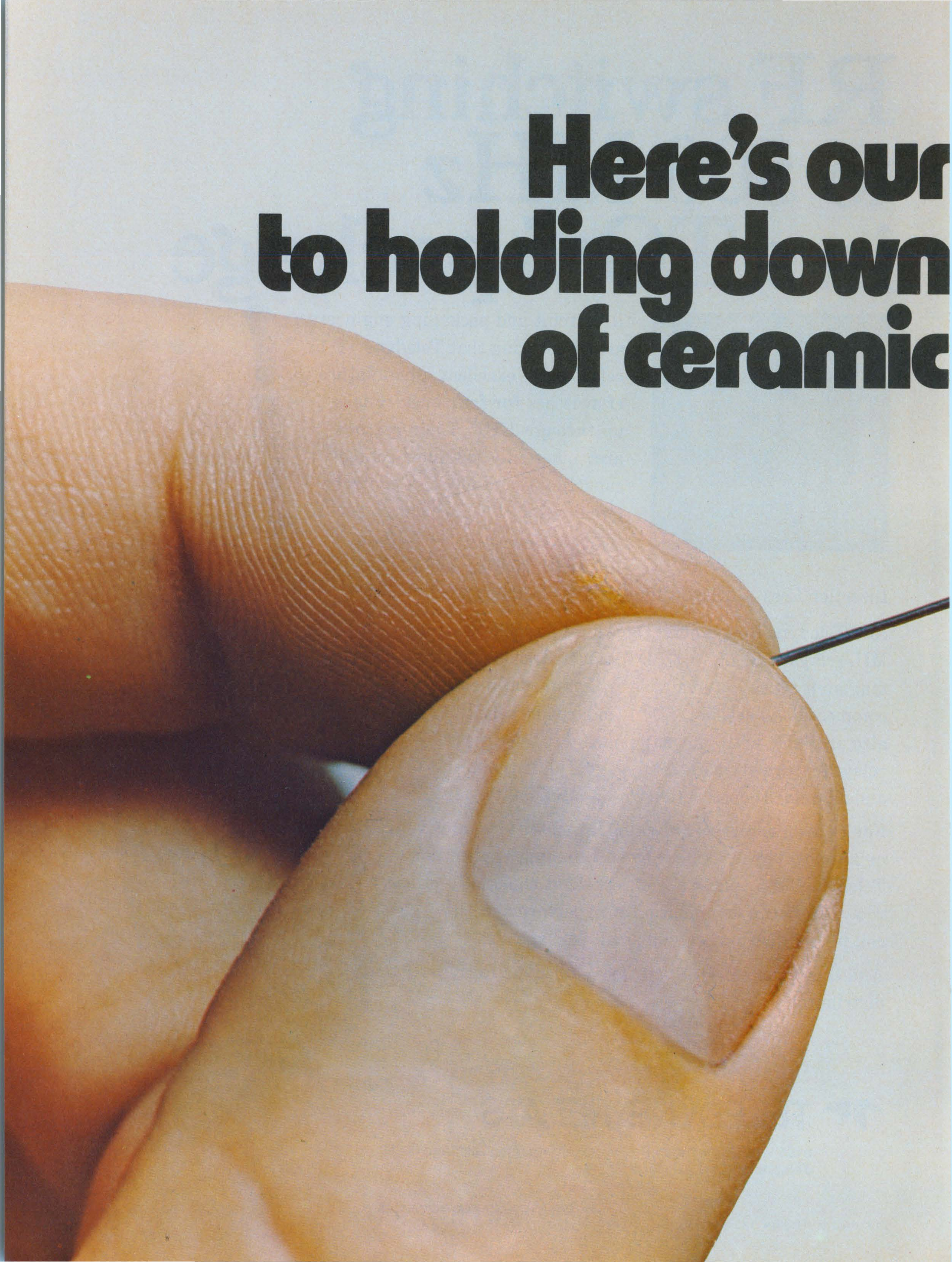
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INFORMATION RETRIEVAL NUMBER 17

A 1960s dream begins to come true under the seas

Remember back in the mid-1960s when there were predictions that people would one day be living in habitats on the ocean floor, raising fish, harvesting rich underwater crops and drilling for oil?

Why, providing the electronics for even one of those wet ventures would save an electronics company from the great defense budget drought that was looming.

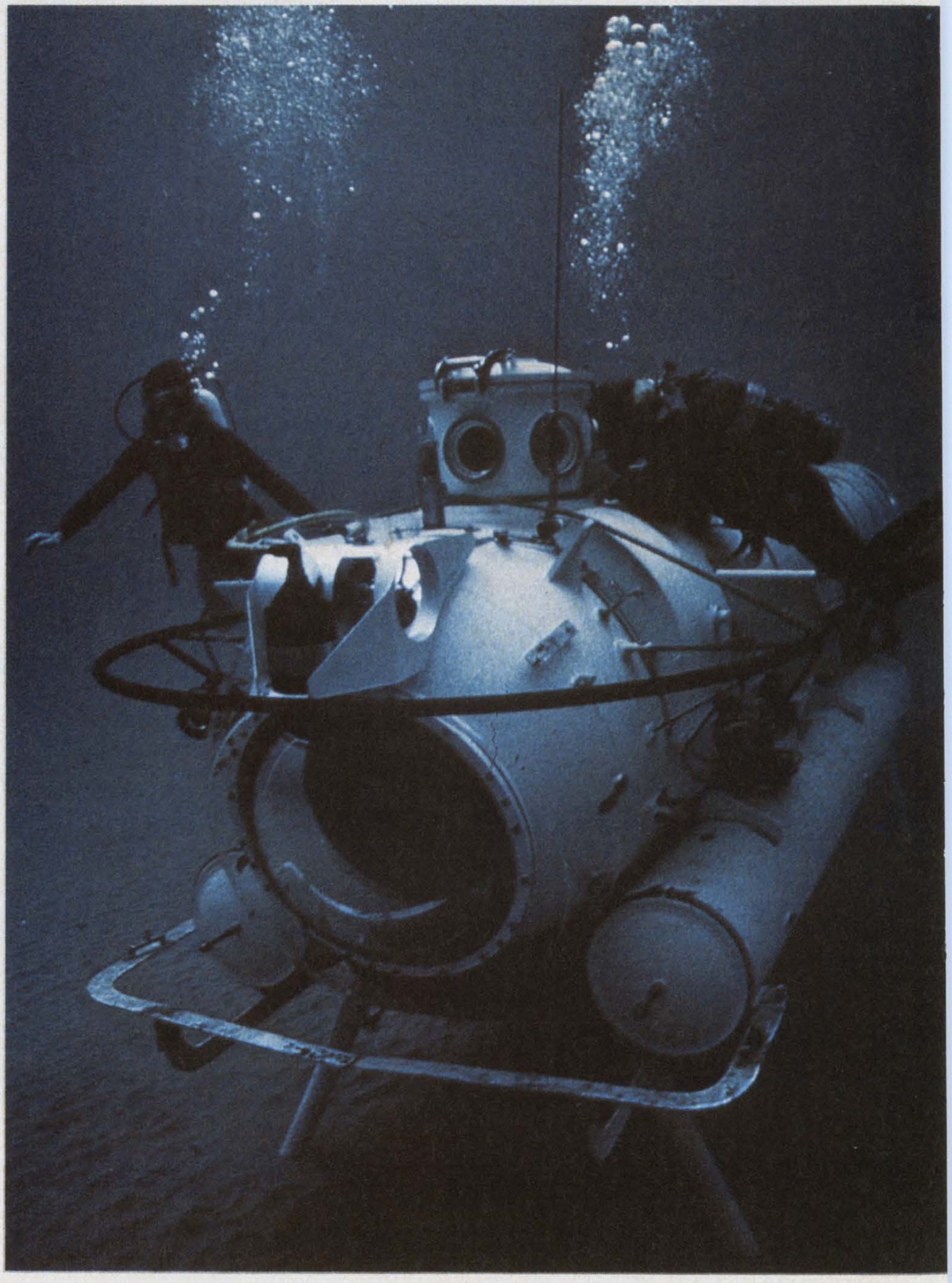
And those minerals that were going to be scooped up—the ferromanganese, the copper and nickel. And the diamonds. Yes, there really were diamonds lying on the ocean floor, just off the South African coast. And they're still there.

In fact, *all* the attractions of "inner space," as we used to call it, hoping to make it the financial bonanza that outer space was, are still there. The only difference between the mid-60s and now is that now it makes economic sense to go after them.

Oil companies are spending hundreds of millions of dollars preparing electronically controlled sea-floor drilling and production facilities. They're moving to the sea floor because they have to: The untapped oil deposits are farther out, in water too deep for platforms.

And it's now economically

John F. Mason
Associate Editor



Divers operate out of the small submersibles, like this Perry PC-15, which oil companies are buying to inspect pipe lines and oil rigs.

feasible: In the late sixties, the price of oil just didn't warrant the tremendous expense of undersea facilities, and now it does.

The new "wet oil fields" call for a sizable amount of auxiliary equipment and services. They require divers, submersibles and a whole new line of electronic devices and systems. Some of this equipment is available and some isn't even designed.

There still won't be any habitat cities on the ocean floor, but there are habitats on board the surface ships that attend diving operations. Pressurized at sea-bottom pressure, the shipboard habitat is home for the divers between trips in a transfer bell to the sea floor, where they swim out to work.

Scientific submersibles and surface ships will receive more emphasis as the need to exploit the oceans becomes more urgent.

Texas A & M's Oceanography Dept., for example, recently bought a submersible built by Perry Ocean Engineering, Riviera Beach, Fla., and now has a number of contracts with the Government and with industry. Among other studies, it is searching for natural gas bubbles in the Gulf of Mexico —an indicator of oil deposits below. The college is also studying the effects of pollution on coral reefs.

And Alvin, the Navy's deep submersible operated by the Woods Hole Oceanographic Institution, is again in the news. This time, Alvin, along with two French counterparts, is being used off the coast of the Azores in the Atlantic to check out the Mid-Ocean Ridge System, or more specifically the tectonic plates on the ocean floor—the rocks that move apart, allowing lava to gush forth and islands to form.

The Navy has a number of undersea efforts in progress for search and location, rescue and recovery, salvage and recovery, survey, environmental prediction and underwater construction.

Automated data buoys are being given more jobs—monitoring the weather and ocean state, among them. And these call for innovative design for sensors, power supplies data processing and telemetry.

Ocean mining is also ready to come into its own—what with the scarcity and high cost of metals and other materials. Take those diamonds lying in relatively shallow water off South Africa, for example. Howard Hughes is building a sea-going vacuum cleaner to sail out and suck them up. The ship will undoubtedly also attempt to harvest some of the ferromanganese nodules that lie in rich patches on deeper ocean floors. Other companies, including Tenneco's Deep Sea Ventures, Inc., and Kennecott, are also working toward the same end.

So electronics for ocean mining is also worth a realistic look. Ships need sea-bottom profiling equipment, sonar, underwater television, accurate depth measurement techniques, precise navigation systems and transducers to measure flow, pressure and the angle of the dredge pipe.

Oil fields on the ocean floor

Several subsea systems are being readied, some are wet and the

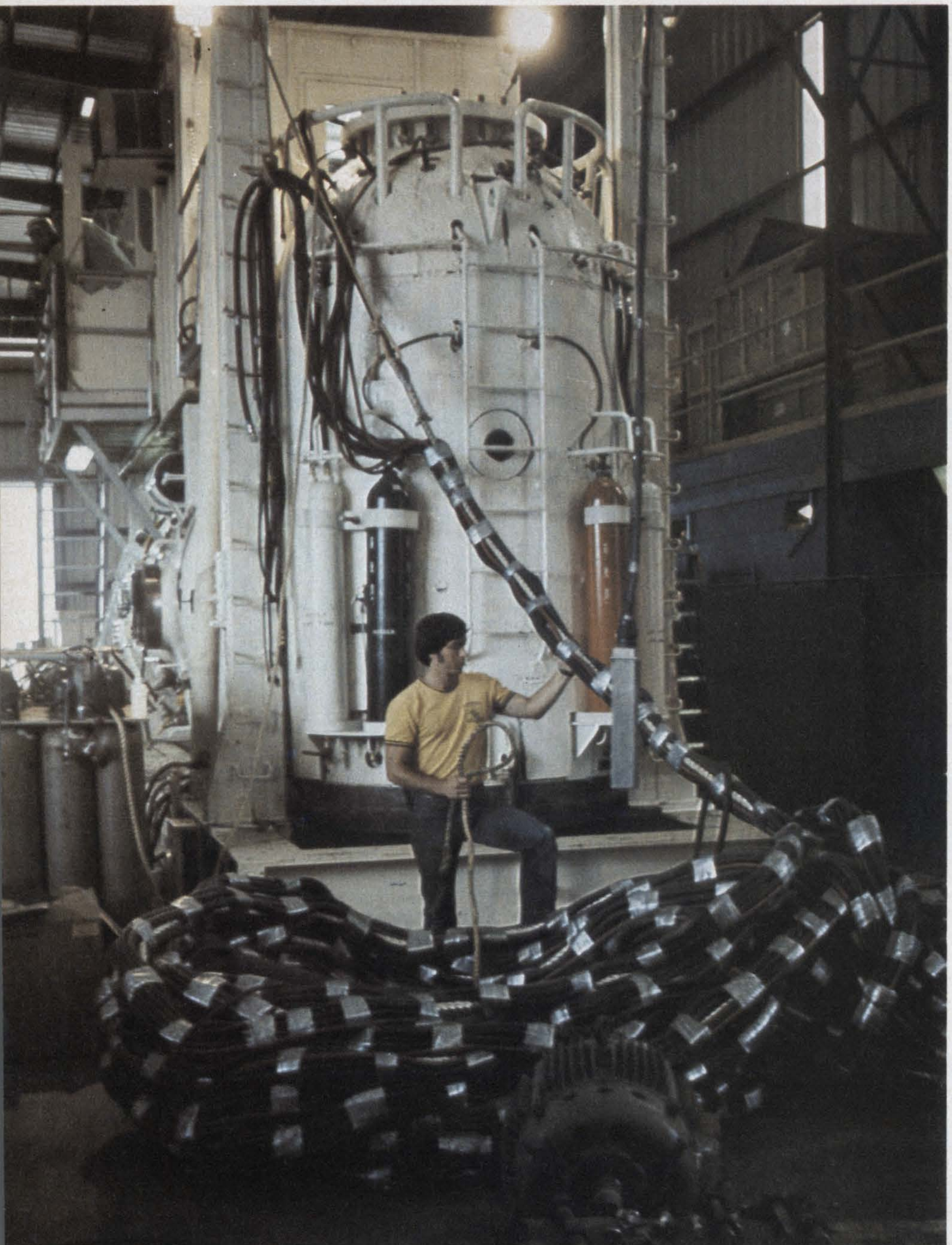


Photo by John F. Mason

Diving bells serve as elevators to carry Taylor divers to work on the ocean floor. The large umbilical cord carries power and communication.

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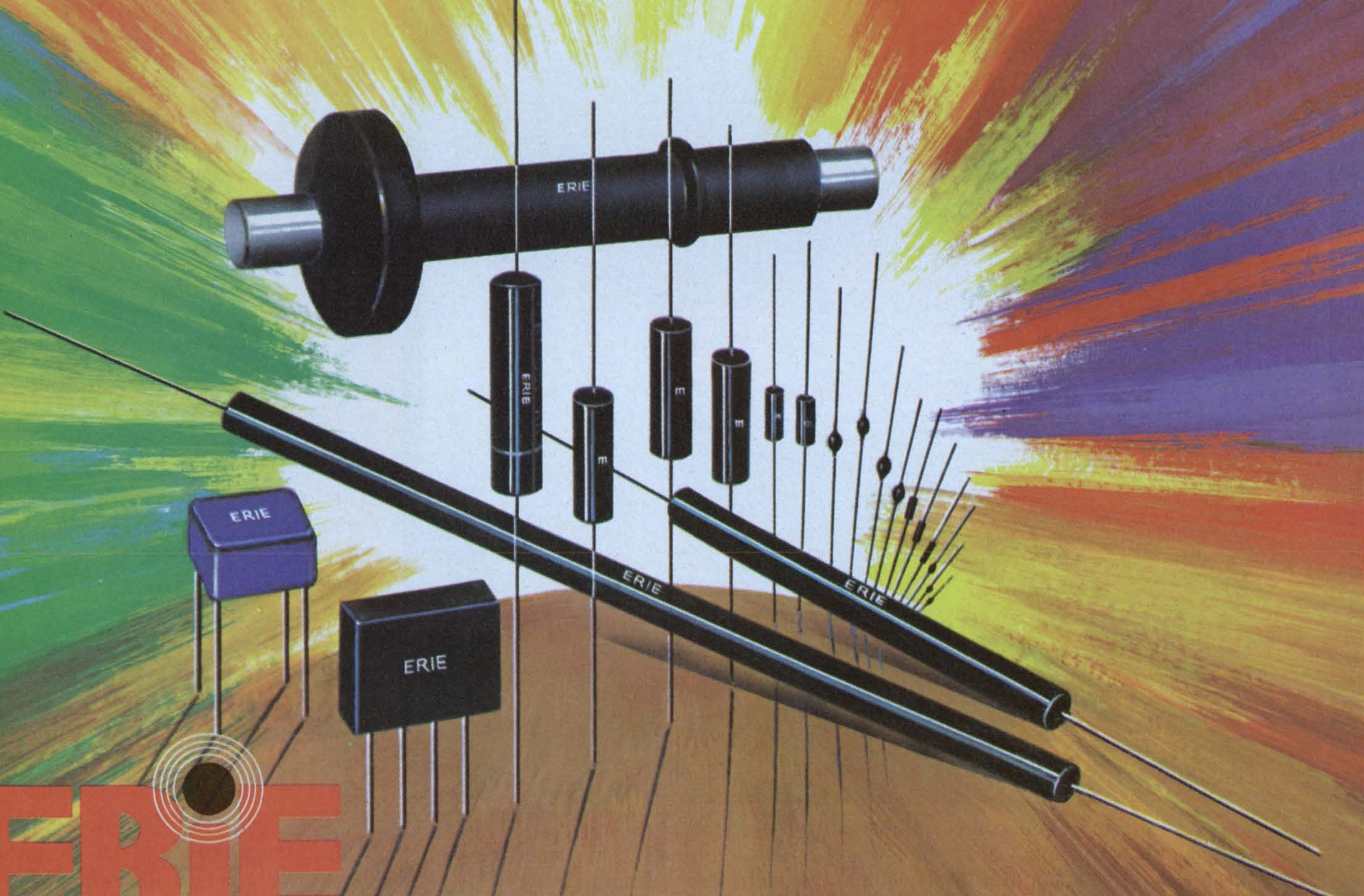

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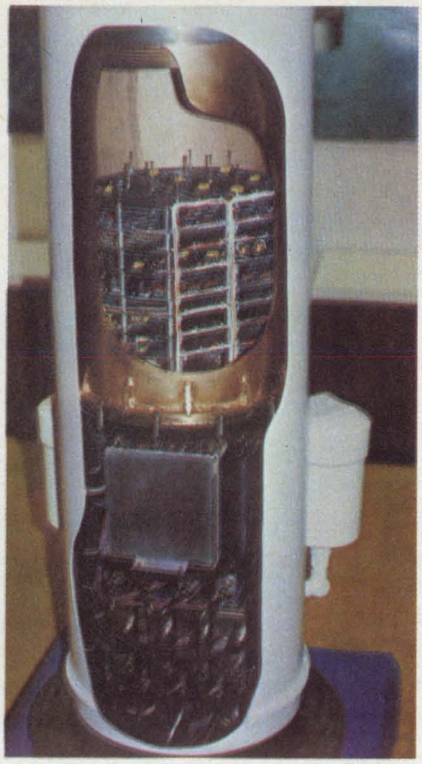
ERIE TECHNOLOGICAL PRODUCTS • Erie, Pennsylvania 16512 others are dry.

Two systems using the dry approach are being tested by Seal—or Sub-sea Equipment Associates Ltd.—in Houston, Tex. Seal is an international engineering services consortium jointly owned by Mobil Oil, Westinghouse Electric, British Petroleum, Compagnie Francaise de Petroles and Groupe Deep.

The dry approach means the entire control unit is housed in a pressure-tight container to maintain a sea-level environment, which enables normal oil-field electronic components to be used. Seal considers this an economy.

"We don't have to use the elaborate pressure-compensated devices that a wet system does," says the consortium's president A. T. Chatas in Houston.

The control unit must be installed by divers, but after that it can be repaired without manned intervention. A hook is lowered that picks up the entire control unit, brings it up and takes down a new one. This shouldn't be needed more than once every two years, according to Seal's Chatas.



Electronic control unit for submerged well, by TRW, locks onto template, receives commands from surface via cable, decodes them and carries out the commands.

Transducers are installed on the oil well's template to measure pressure, temperature, flow rates, level of bilge and status of valves—and to set off an alarm if needed. Data are telemetered to the platform control panel by multiplexed hardwire.

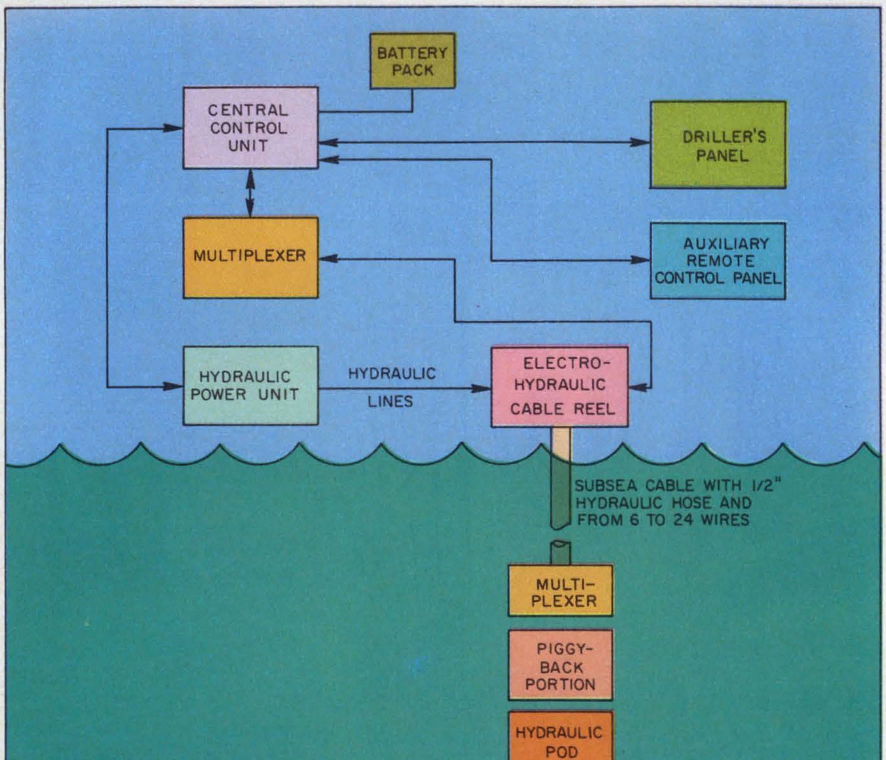
A problem is the power source. Now, power is generated on the platform and sent down by cable. The Japanese have experimented with a diesel generator in the water, and though it hasn't gone beyond the drawing-board stage, submerged nuclear generators will undoubtedly be available one day.

Exxon has taken the wet approach to subsea oil and gas production. The company will soon test its Submerged Production System in 170 feet of water in the Gulf of Mexico. The system is designed to operate at depths of 2000 feet, with future systems planned for considerably deeper waters. Exxon's aim was to design a system that would need virtually no manned intervention on the sea floor.

The remotely controlled system is operated by a cable running from the surface to the sea-floor template. Command messages to open and shut valves are sent through the cable by binary code. A safety unit monitors the wells and automatically shuts them if leaks or other critical malfunctions are detected.

When modules or valves need to be changed, a remotely controlled manipulator performs the operation upon command from the surface. A guide buoy is released from the template, and the manipulator hauls itself down and lands on a special cogged track. It then proceeds to the faulty module, replaces it with a new one and takes the old one to the surface. The manipulator finds the right place by monitoring its position on the cogged track through a computer at the surface and seven television cameras it carries. A diving bell is incorporated into the manipulator to allow a man to inspect the sea-floor installation and assume control of the manipulator's operation, if necessary.

Lockheed Petroleum Services Ltd. in Canada and in Houston is working toward development of a



Koomey multiplex electro-hydraulic control system, by Stewart & Stevenson, is designed for deep producing wells. The multiplex cable sends signals to the underwater multiplexer, which instructs the hydraulic pod.

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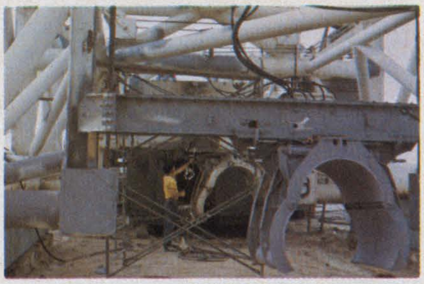


Welding habitats, such as Taylor's, are lowered to the ocean floor, where divers, monitored by transducers and TV, descend in bells to weld pipes.

complete ocean-floor oil field. To date, much of its work has been for Shell Oil and other oil companies in a large consortium, but Lockheed is also free to sell its system elsewhere.

Like Seal's, Lockheed's system is dry. But unlike Seal, which wishes to have as little manned intervention as possible, Lockheed is designing pressurized chambers where men, without divers' training, can work.

TRW Subsea Petroleum Systems in Houston, Tex., is producing subsea control units for a number of big oil companies. TRW's units are wet. All components operate at ambient pressure in an oil-filled, pressure-balanced package. Hydraulic systems are being left behind, because they're too slow, and multiplexed wire is moving in. Also, the number of functions that TRW's units can perform is growing. The present unit controls 126 functions, but one that will handle 256 is in the works.

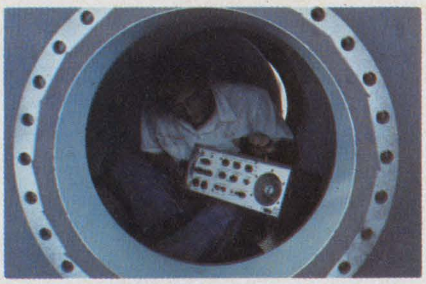
TRW's systems have a unique

Pressurized "elevators" to take divers to sea-floor welding habitats and deck-mounted chambers are in big demand at Perry Engineering.

technique for supplying power from the surface to the subsurface unit. Inductive couplers are used instead of pin connectors to input power and signals to the remote module. Pin connectors corrode in water and hence are prone to failure, while inductive couplers operate magnetically and are less subject to corrosion.

Stewart & Stevenson is another big producer of control units. "Because of the move to deep water, business is booming," says the company's Leroy H. Cook, an electronics engineer. "And everyone wants multiplexed wire."

S&S's newest unit is a multiplex



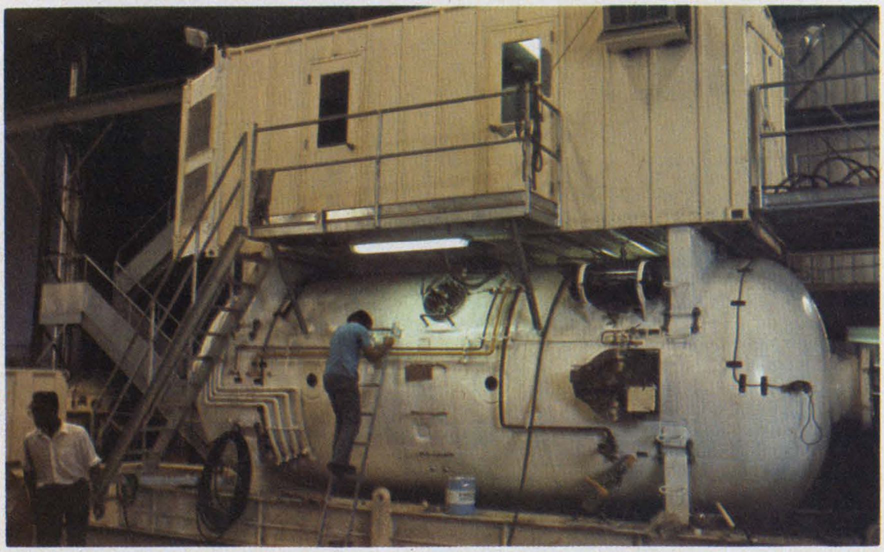
Helium speech unscrambler by Helle Engineering is brought out of a Perry Ocean Engineering personnel transfer bell for inspection.

electro-hydraulic system. Signals that normally would be sent to solenoids in the electro-hydraulic system are interpreted, assigned a time slot and then sent down on a command to the submerged unit. The submerged multiplexer then fires the solenoid.

S&S recently developed an automatic current-sensing device that examines the wire pairs that fire solenoids for current draw. Should a short be detected, the unit cuts off the current and sounds an alarm.

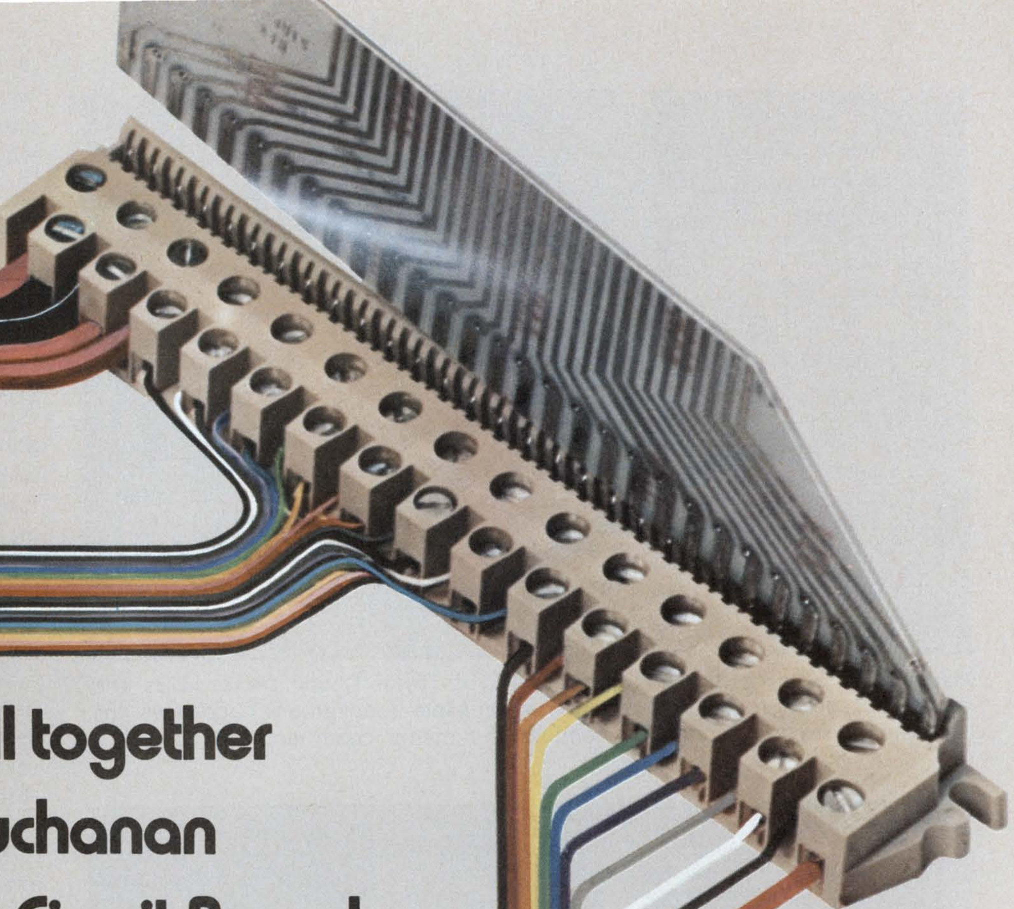
S&S feels its multiplexer is a particularly good design. It operates and monitors subsea functions over an eight-wire cable. It time-shares six control wires and uses two wires for power. Four of the six control wires are used for command and two for analog readback. The commands are sent, checked for authenticity and the solenoid is fired—all in less than a third of a second.

The multiplexer differs from



Environmental controls shack sits on top of Taylor's deck-mounted decompression chamber for divers. The men may stay in this chamber 30 days, leaving only for trips to the sea floor and back. The elaborate readouts in the control shack (above) are from transducers in the chamber that monitor the men.

INFORMATION RETRIEVAL NUMBER 21 ▶



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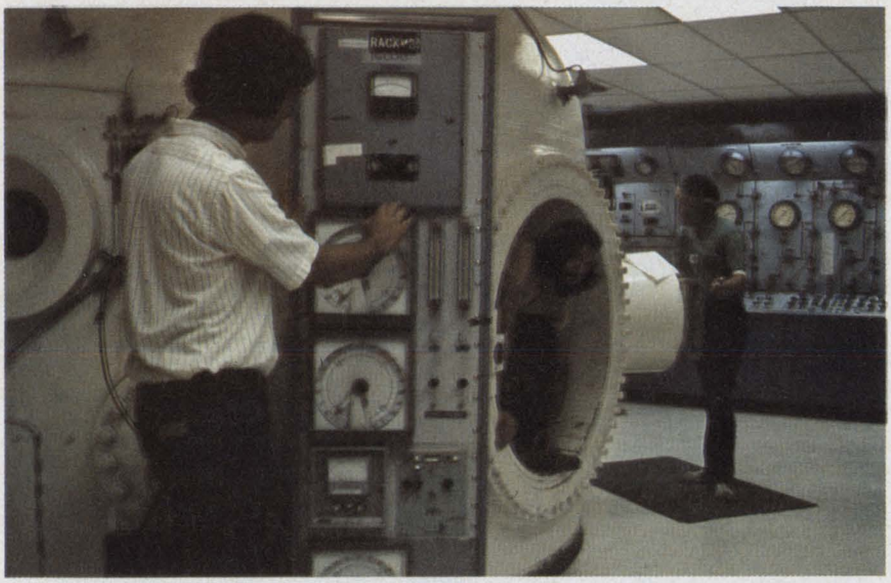
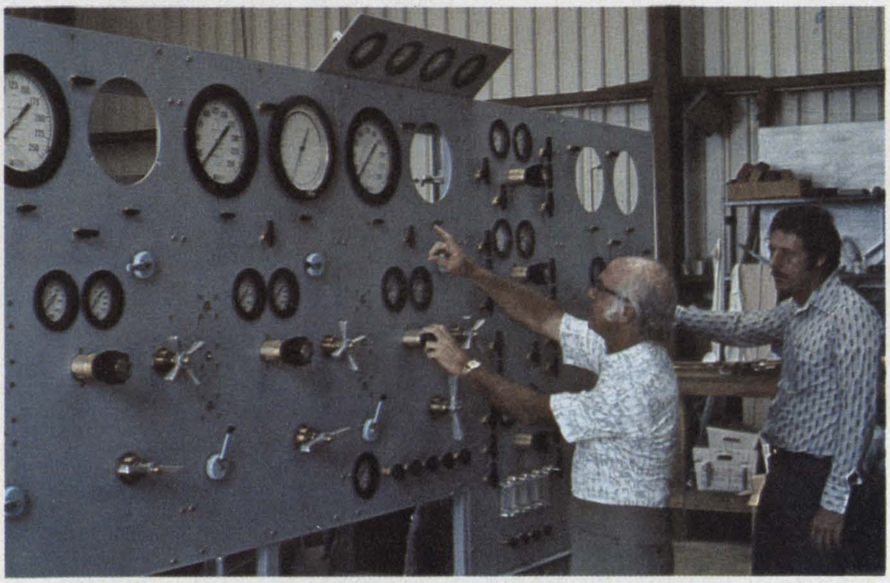


Hyperbaric research and training complex at Taylor Diving takes divers and equipment down to 2200 feet. Control console (background) indicates the intricate instrumentation that monitors the men's condition.



Control console, built by Perry, is used on the offshore platform or on board ship over a submerged well to monitor the diver saturation complex for diving bells and for the hyperbaric chamber on board ship.

our competitors use ordinary communication systems borrowed from the space program—a 10-bit-through-32-bit word serially sent through modems. We use a parallel command entry device; it is a true, synchronous multiplexer."

Divers are here to stay

In spite of the desire to fully automate submerged oil fields, divers are still needed and will be as fields move to deeper water, says Drew Michel, chief electrical engineer for Taylor Diving and Salvage Co. in Belle Chasse, La., just across the river from New Orleans.

"Up until recently, television wasn't trusted," he explains. "Now it's destined to become one of the most popular aids a diver can have."

But there are problems: Visibility through the minute, light-reflecting organisms in water must be improved, the vidicon must be protected from direct contact with the sun's rays, and the units must be better packaged.

One TV camera built by Edo Western, Salt Lake City, offers an automatic sun shutter that closes when the light gets too bright.

Building the minisubs

The small submersibles that the oil companies are now buying as fast, as they can be built are battery-powered and electronically controlled. Basically the minisubs carry sonar, a two-way sonar telephone, transponders on their outer walls for the mother ship to keep tabs on them, sensors for unhealthy air, and a pilot-control system. The buyer, of course, may further outfit them with television, sea-bottom survey equipment and a number of other devices.

"We're at the point now of trying to make maximum use of ICs, operational amplifiers and miniature parts," says Jon Newman, chief electrical engineer at Perry Ocean Engineering.

The big push at Perry is to get everything possible in epoxy and encapsulated. Solenoids that regulate motor speed have been successfully encased in plastic to protect them from hydrogen gas. The switch can be activated by simply moving a magnet over it.

A number of improvements have recently been made on submersible systems or are in the works:

- Plastic connectors deteriorate and permit leakage across the contacts. Perry has gone to rubber insert connectors.
- The sonar transducers fastened to the outside of the sub require a 2-1/2-in.-diameter penetration through the hull. Perry is working with Wesmar on a single coaxial multiplex system to reduce this opening.
- Sub-to-surface communication in the North Sea—where the action is nowadays—is difficult because of the sharp temperature gradient and the rough surface conditions. "The 27-kHz, upper-sideband system normally used doesn't penetrate too well," Newman reports. A dual-frequency system using military frequencies has worked better.
- The pilot's walk-around control box is too complicated. To prevent motor damage from a power drop when the submarine is suddenly switched from forward to reverse, the present system uses a multiplicity of cams and micro-

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Meet or exceed MIL-L-3661. Replaceable plug-in cartridges for 1.35-125V operation. Indicators mount as close as 1/2" centers; available with red, green, amber, blue, white translucent, light yellow or colorless lenses in wide range of lens shapes, legends and finishes. Off-the-shelf.

INCANDESCENT OR NEON SUB-MINIATURE INDICATORS

Meet or exceed MIL-L-3661. Mounts in 15/32", 1/2" or 17/32" clearance holes. Incandescent for 1.35-28V; neon has patented built-in current limiting resistor. Choice of cylindrical, faceted, convex, flat, square and round lens shapes, colors, finishes, legends. Off-the-shelf.

INFORMATION RETRIEVAL NUMBER 22

DIALIGHT

Dialight, A North American Philips Company
203 Harrison Place, Brooklyn, N. Y. 11237 (212) 497-7600

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switches to cause a protective time delay. A new unit that is being designed will replace all the cams, switches and time delays with operational amplifiers and a single command-sensing potentiometer.

The scientific research submersible Alvin, now tooling around at the bottom of the Atlantic, only needs a few new items, according to its pilot, Lawrence A. Shumaner, who is also manager of the Deep Submergence Engineering and Operations Section at Woods Hole. He says: "We need a solid-state circuit breaker that will carry 200 amps at 600 V dc that I can put in an oil-filled can and pressurize at 6000 pounds per square inch without changing the values of the components. Maybe then my problems in arcing in oil would go away, and the size and cost would come down.

"We want to put as much equipment outside the crowded submarine as possible. I don't see why the telephone can't be put in an oil can and stuck outside."

Exploration ships are becoming more elaborate. Gulf Oil's new Hollis Hedberg research and exploration ship is the only one, the company says, that is equipped with a complete on-board seismic data-processing capability. Since it can also process gravity and magnetic data, the new vessel enables its crew to obtain, on-site, a complete geophysical intepretation of the area.

Texas A&M has developed a new concept in oceanographic ships. The instrumentation is packaged in modules that can be installed or removed, according to the ship's particular mission. This permits one ship to carry out the jobs of many.

And the Glomar Challenger research ship used by colleges and Government agencies has achieved a believe-it-or-not capability that will undoubtedly come in very handy for ships and semisubmersibles drilling oil in very deep water. Many people thought it would be impossible to find a 10-1/2-inch hole in water 13,000 feet deep after the drilling bit was pulled out and replaced. But Edo Western found it. And the whole thing is relatively simple. It's done with acoustic reflectors on the re-entry cone over the hole and a sonar transceiver in a pipe being lowered. The scene is transmitted to the surface ship and displayed on a PPI scope until the new bit is successfully guided into the old hole. Edo Western says the system will work in 20,000 feet of water.

Alvin, the Navy's deep submersible operated by the Woods Hole Oceanographic Institution, is now diving in the mid-Atlantic to inspect rock formations.

The Navy is heavily engaged in underwater projects. Very advanced design has gone into the RUWS (remote unmanned work system), which will perform a variety of engineering and scientific work at depths of 20,000 feet.

The objective was to simulate man's senses in the cable-tethered system. A head-coupled TV camera on the vehicle follows the head motion of the operator some four miles above on a surface ship. Tension on the manipulator is fed up the cable to the operator so he can "feel" the weights and movements the claw is encountering. Integrated displays and controls allow the operator to control the remote vehicle with a minimum of learning and conscious thought.

Also under Navy development: Snoopy, a remote-controlled swimming television camera; SCAT, a submersible, cable-actuated teleoperator designed for undersea inspection and work tasks; and a navigation system that uses natural gravity and magnetic fields as aids.

Three candidates for transmitting data and power through a pressurized hull without penetrating it physically are being studied: electromagnetic coupling (split transformer halves), acoustic coupling—theoretically, efficiencies of up to 65 per cent are possible—and light coupling. Light systems have the potential for transmitting extremely wide-bandwidth information, the Navy says. The circuitry is relatively inexpensive and uncomplicated. And the method is particularly adaptable to transmitting digital data. ■■

COOL POWER FROM SEMTECH

SEMTECH NEWS

SILICON RECTIFIERS & ASSEMBLIES

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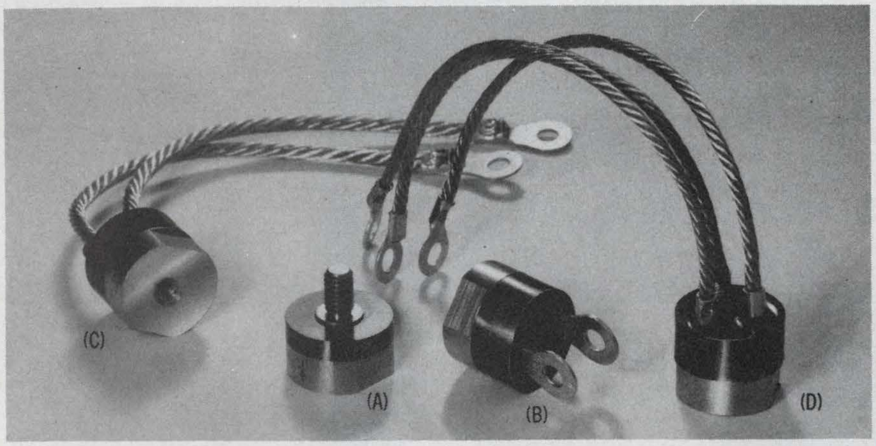
FAST RECOVERY POWER RECTIFIERS

Reverse Recovery(Trr) 200ns and 2μs



CUPAC 150

. . . the power house

CuPac 150 is specifically designed for high frequency-high power applications. CuPac 150 is capable of supplying up to 150 amperes with proper heat sinking. Available as half wave rectifier, doublers, center taps and three phase half wave bridge circuits.

Internally, CuPac 150 utilizes Semtech's Metoxilite rectifiers mounted on an (OFHC) oxygen-free hard copper insert base. Inherent rugged design and reliability enables the CuPac 150 to be used in stringent commercial, industrial, military and space applications.

Body Dimensions: 1.12" D x .70" H (+ stud)

FAST RECOVERY — (Trr) 200ns. (Fig. A)

Peak Inverse Voltage: 50, 100, 200 & 400V.

V_F (max.) (@ 100A): 1.40V, Tj @ 25°C; 1.35V, Tj @ 100°C.

Reverse Current (max.) @ PIV: 25μA @ 25°C; 1 MA @ 100°C.

MEDIUM RECOVERY (Trr) 2 μs.

PIV: 50, 100, 200, 400, & 600V.

V_F (max.) (@ 100A): 1.22V, Tj @ 25°C; 1.17V, Tj @ 100°C.

Reverse Current (max.) @ PIV: 25μA @ 25°C; 1mA @ 100°C.

• DOUBLERS & CENTER TAPS Figs. (B) & (C)

Body Dimensions: 1.12" D x .9" H (+ leads).

FAST RECOVERY (Trr) 200ns

PIV: 50, 100, 200 & 400V.

V_F (max.)(@ 50A): 1.40V @ 25°C; 1.35V @ 100°C.

Reverse Current, per leg (max.): 13 μA @ 25°C; 500 μA @ 100°C.

MEDIUM RECOVERY (Trr) 2 μs.

PIV: 50, 100, 200, 400 & 600V.

V_F (max.)(@ 50A): 1.22V @ 25°C; 1.17V @ 100°C.

Reverse Current, per leg (max.): 13 μA @ 100°C; 500 μA @ 100°C.

• 3 PHASE ½ WAVE BRIDGE Fig. (D)

Body Dimensions: 1.12" D x .9" H (+ leads).

FAST RECOVERY (Trr 200ns)

PIV, per leg: 50, 100, 200 & 400V.

V_F (max.) @ 33A: 1.40V, Tj @ 25°C; 1.35V, Tj @ 100°C.

Reverse Current, Per Leg @ PIV: 10 μA @ 25°C; 350 μA @ 100°C.

MEDIUM RECOVERY (Trr) 2 μs.

PIV, Per Leg: 50, 100, 200, 400 & 600V.

V_F (max.) @ 33A: 1.22V, Tj @ 25°C; 1.17V, Tj @ 100°C.

Reverse Current, Per Leg @ PIV: 10 μA @ 25°C; 350 μA @ 100°C.

CUPAC 150, LO-V_F

Peak Inverse Voltage: 30 & 50V.

Reverse Recovery: 85ns (typ.) & 100ns (max.)

• ½ WAVE RECTIFIER

	@ 25°C	@ 100°C	@ 150°C
V_F (typ.) @ 20A	.86V	.77V	.72V
V_F (typ.) @ 60A	.95V	.88V	.85V
V_F (typ.) @ 100A	1.02V	.97V	.93V

• DOUBLERS & CENTER TAPS

	@ 25°C	@ 100°C	@ 150°C
V_F (typ.) @ 10A	.86V	.77V	.72V
V_F (typ.) @ 30A	.95V	.88V	.85V
V_F (typ.) @ 50A	1.02V	.97V	.93V

• 3 PHASE ½ WAVE BRIDGE

	@ 25°C	@ 100°C	@ 150°C
V_F (typ.) @ 5A	.86V	.77V	.72V
V_F (typ.) @ 15A	.95V	.88V	.85V
V_F (typ.) @ 25A	1.02V	.97V	.93V

NEW "STUD"

. . . Super stud rectifier

Semtech Corporation introduces the DO-5 Stud, a new series of high current silicon stud rectifiers for high frequency applications. Capable of supplying up to 50 amperes with proper heat sinking, the DO-5 Stud has been specifically designed for industrial, military and space applications.

Metoxilite rectifiers are used internally, the base is a DO-5 configuration and terminals offer easy soldering properties.

Body Dimensions: .69" D x .45" H.

FAST RECOVERY (Trr) 150ns

IR (@ PIV), Per Leg: 13 μA @ 25°C; 500 μA @ 100°C.

V_F (max.)@ 50A: 1.40V @ 25°C; 1.35V @ 100°C.

MEDIUM RECOVERY (Trr) 2 μs.

PIV: 100, 200, 300, 400, & 600V.

IR (@ PIV), Per Leg: 13 μA @ 25°C; 500 μA @ 100°C.

V_F (max.)@ 50A: 1.22V @ 25°C; 1.17V @ 100°C.

LO-V_F "STUD"

. . . Low forward voltage drop.

LO-V_F stud rectifier is specifically designed for high frequency, high power applications.

VERY FAST RECOVERY (Trr) 100 ns.

Peak Inverse Voltage: 30V.

	@ 25°C	@ 100°C	@ 150°C
V_F (typ.) @ 10A	.86V	.77V	.72V
V_F (typ.) @ 30A	.95V	.88V	.85V
V_F (typ.) @ 50A	1.02V	.97V	.93V

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New laminar-flow electron gun promises brighter, better CRTs

Virtually every cathode-ray tube built since the 1930s—whether for oscilloscopes, television, radar or computer terminals—has used the same basic crossover electron gun. Watkins-Johnson Co. of Palo Alto, Calif., has developed an electron gun that uses a different operating principle—laminar flow.

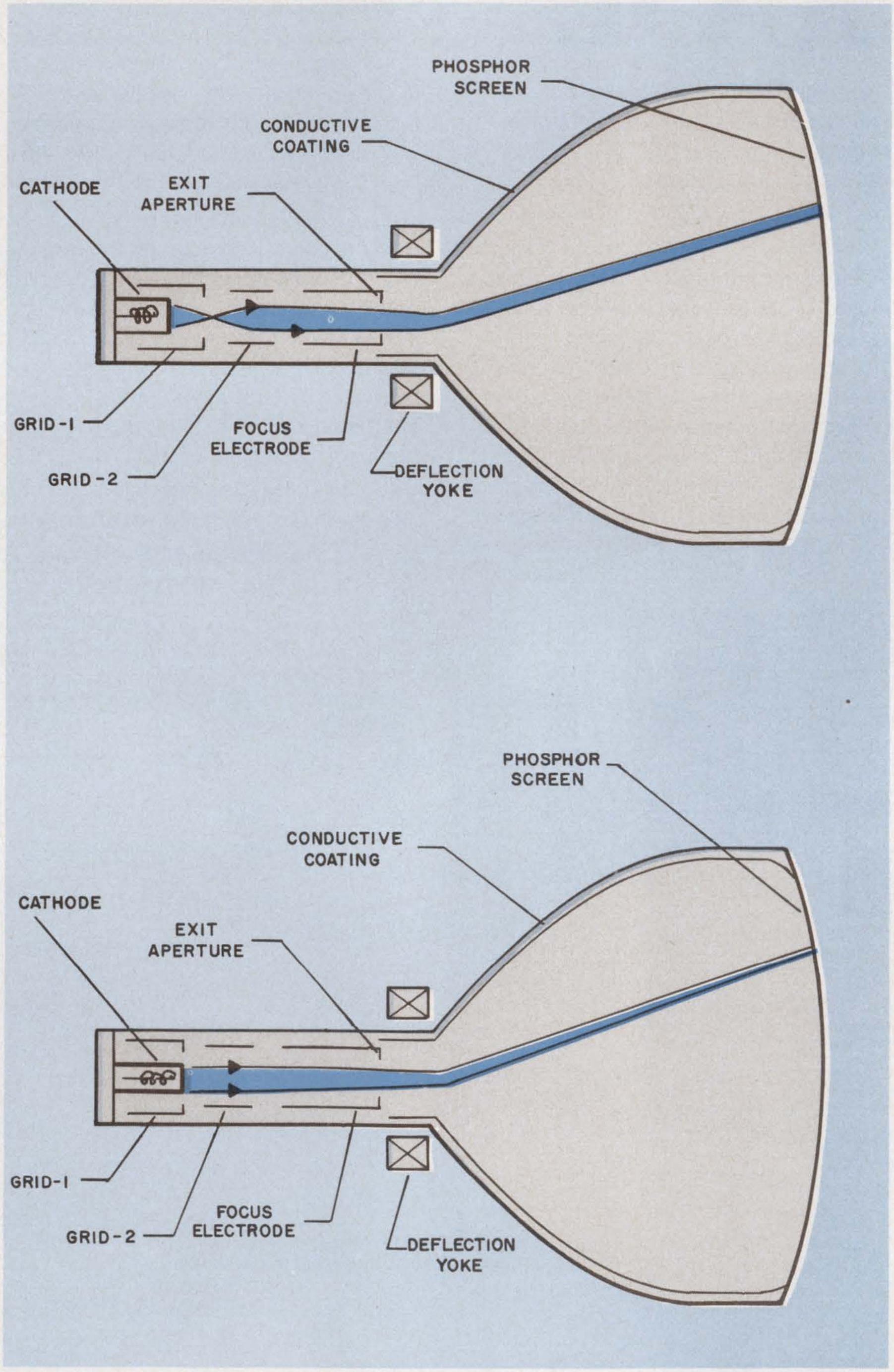
The technique promises brighter CRT displays with smaller spot size, better resolution and lower drive requirements, the company says.

Although the superiority of the laminar-flow CRT has not yet been demonstrated in all applications, research indicates several theoretical advantages for tubes using the new gun:

- Up to a 30% reduction in spot size.
- Up to double the current density in the electron spot at the screen.
- Up to twice the peak line brightness without loss of resolution (when not limited by phosphor characteristics).
- Reduced grid drive for the same brightness, or a brighter image with the same signal.

By focusing the image of an intense source of electrons, any electron gun is designed to produce a small intense spot of controlled brightness on the phosphor screen of a CRT. The crossover electron gun can be compared to an optical system that produces a focused image of a small, bright point source. In the case of the crossover-gun CRT, the intense electron source is provided when the electric field in the gun is shaped so that the emitted electrons converge to a crossover almost immediately after leaving

Northe K. Osbrink
Western Editor



Electrons emitted from the cathode of the laminar flow gun (bottom) travel in a nearly parallel path beam until they converge to a focus at the viewing screen. This contrasts with the electron beam trajectory for the standard crossover type cathode-ray tube.

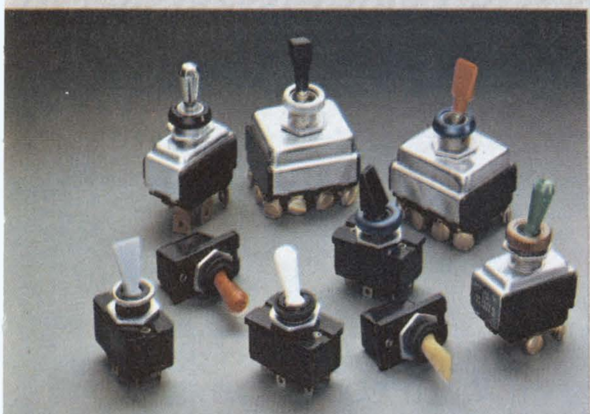
The first color-capped industrial toggle.

Introducing our new heavy-duty Designer Line switches with up to 20 amp, 2 hp, A-c and D-c ratings. Now you can color-code almost any function or simply use color to improve overall equipment appearance.

Select from nine distinctive lever styles, nine standard colors, two bushing lengths, as well as eleven color-coordinated decorator facenuts in two types.

You also choose from five switch bases, screw or plug-in terminals, single and double poles, plus a variety of circuit configurations.

The first color-capped industrial toggle switch gives you the new colorful choice for your heavy-duty applications. Contact your Cutler-Hammer Sales Office or Switch Distributor.



Designer Line—the broadest line of commercial toggle switches, ratings up to 8 amps, A-c and D-c, and 15 amps A-c. A rainbow of colors! Virtually unlimited combinations of toggle styles, circuits, colors.

CONTROL

CUTLER-HAMMER

SPECIALTY PRODUCTS DIVISION, Milwaukee, Wis. 53201

Switch to No.1

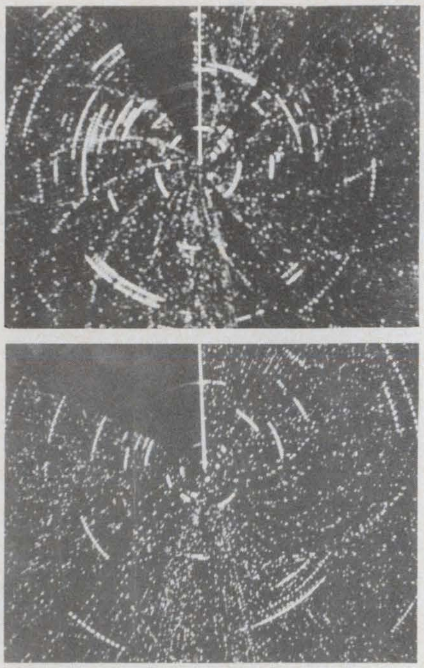
INFORMATION RETRIEVAL NUMBER 26

the cathode. It is this crossover point that serves as the object that is projected onto the phosphor screen.

For a circular cathode, this crossover does not produce the ideal bright sphere, but approximates a cone. The electron distribution is highest at the center of the cone and is surrounded by a region of decreasing electron density. The resulting spot on the screen, therefore, has an intense center surrounded by a ring of decreasing intensity. Passing the electron beam through a circular aperture, which masks the outermost portion of the beam, improves the uniformity of the spot. Normally this requires more grid drive to the electron gun, to compensate for a loss in brightness.

Watkins-Johnson's laminar-flow electron gun can be compared to the magnifying glass that focuses parallel rays of light from the sun to a bright point. The electrons emitted from the cathode of the laminar-flow gun travel in a nearly parallel beam that is gradually compressed into a focal point at the CRT screen. Because the circular cathode has an even distribution of electrons emitted across its surface, the spot on the screen tends to have virtually a constant brightness.

There are a number of operational differences between the two types of electron guns. To produce the crossover, it's necessary to make the electric field of the crossover gun very strong at the center of the cathode. This field strength falls off rapidly toward the edges. Conversely the electric field across the surface of the cathode in the laminar-flow gun is uniform. This provides more electrons from a given cathode configuration.



Improved resolution is evident in photo comparison of new laminar flow gun CRT display (bottom) and standard crossover CRT display in a PPI radar system. Actual size of each display is 10 in. in diameter.

Another difference is that the optical analog of the crossover-gun CRT is a short-focal-length lens, which tends to exhibit more abberations (failures to produce point-to-point correspondence between object and image) than the longer-focal-length analog of the laminar-flow CRT.

Also, the high electron density at the crossover point in a crossover CRT produces a space charge that causes electrons in the beam to repel one another, thereby blurring the spot image—a problem not found in the laminar—flow CRT.

According to Norman Lehrer, staff scientist at Watkins-Johnson, tradeoffs are required to optimize each of the parameter advantages in the new tube, and they may not all be available in one CRT.

Lehrer feels that response to the new tubes has been very satisfactory. "In general, our customers have been impressed with the improved brightness and resolution evident in our laminar-flow CRTs," he reports, "In particular, designers of high-resolution CRT computer terminals are not only pleased with the improved clarity but find the reduced video drive requirements advantageous in simplifying circuitry and reducing production costs."

So far only a few laminar-flow CRTs have been produced, and for the forseeable future production is to be limited to custom orders so the technology can be observed in critical applications.

Lehrer notes that electron guns using laminar flow can be applied to practically any CRT configuration, electromagnetic or electrostatic, and if produced in quantity, should not be significantly more expensive than crossover CRT counterparts. ■■

Plastic protects components at 800 F

Waveguides, circuit boards, structural members and heat-shield packages that can withstand 800 F are envisioned with a new plastic developed by Hughes Aircraft. The new class of polyimide, designated HR-600, is reported stable at 700 F and able to endure 800 F.

Dr. Norman Bilow, senior scientist at Hughes in Culver City, Calif., notes that although electronic components will not work at these temperature extremes, printed circuit-boards sometimes are subjected to them, with resulting damage.

Bilow says that laminates of the new plastic with graphite fiber can be used to make a low-weight, strong waveguide for space applications. Such a waveguide could withstand better than twice the temperature extremes encountered by current epoxy-graphite waveguides.

HR-600 laminates with graphite fiber even show an increase in flexural strength as the temperature increases, Bilow reports. ■■

ELECTRONIC DESIGN'S GOLD BOOK CONTEST

Want to win a $5.00 certificate toward purchase of Hayden technical books plus a chance for a week's Windjammer cruise for two in the blue Caribbean? Turn to p. 134 this issue for details.

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New, Low-Cost Cermet Trimming Potentiometer outperforms the other "small-change" models!

Bourns super cermet performance delivers again. Our new Model 3352 trimming potentiometer handles more power . . . takes more shock and vibration . . . has a lower CRV . . . and is easier to set than, for example, the "Model 91". Naturally, Bourns super cermet performance is comparably priced. You can depend on it.

The 3352 is a ⅜" diameter, single-turn device with an easy (but stable) three-way thumbwheel adjust. It can be wave-soldered, and withstands board washing processes with minimal (1%) TR shift. The 3352 is available TODAY in a variety of pin styles to suit your requirements.

Compare performance . . . specify Bourns Model 3352. For complete details, contact your local Bourns representative . . . or the factory direct.

COMPARE PERFORMANCE

	Model 3352	Beckman Model 91
Power	.75 watts at 40°C	.5 watts at 40°C
Electrical Angle	230°	180°
Adjustability	±0.05%	±0.05%
Torque	5 oz.-in. max.	6 oz.-in.
Shock	100G's max. ±2% VRS	50G's no VRS spec.
Vibration	30G's max. ±2% VRS	10G's no VRS spec.
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INFORMATION RETRIEVAL NUMBER 27

VACTEC Couplers
For putting it together, VACTEC is second only to RODIN*.
Vactec Optical Couplers (T.M. Vactrols) put together incandescent lamps, neon lamps or LEDs with photoconductors or phototransistors in a wide variety of packages and capabilities.
Couplers using photoconductive cells are useful for isolation where speed requirements are in the order of milliseconds. Applications include noiseless switching, noiseless potentiometers, signal modulators for audio, triac firing, and low cost RMS regulators.
Couplers using LEDs and phototransistors or photodarlingtons provide higher speed for output sensing, input driving, interfacing and coupling, solid state relays, and switching.
VACTEC really does put them together—we make our own photoconductive cells, phototransistors and photodarlingtons and do the assembly at our only factory near St. Louis. Write for all Vactrol bulletins.
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washington report

President Ford: A strong supporter of technology

Since becoming Vice President on December 6, 1973, Mr. Ford has walked a tightrope supporting the views and policies of President Nixon while carefully refraining from crossing swords with Congress. Then at high noon, August 9, 1974, it became a new ball game. Where does the new President stand on issues vital to the electronics industry?

Any changes from the Nixon administration's legislative programs, most observers believe, are likely to come in areas other than defense and space. President Ford has said he is a strong supporter of the space program, specifically because of the technological spinoffs, which he says have benefited the nation in national defense and the domestic economy. "These benefits justify the expenditures we have made," he said recently.

In 1973, for example, he voted against attempts to cut funds for the Space Shuttle. He supported the continuation of the supersonic transport program and the Lockheed loan guarantee.

While there may be trims, the defense budget will largely remain intact. President Ford said last spring he thought the nation was fully prepared to meet any challenge, but that the U.S. didn't have the military superiority it once enjoyed and it worried him. He's concerned about military sufficiency in the next five to ten years. "We cannot afford to neglect adequate procurement as well as adequate research and development." President Ford's first task, and a continuing one, will be dampening down inflation. At the same time he is expected to rebuild and modernize the defense forces, and he will probably give top priority to new technology for solving the energy situation. In summary, technology of all types and in all areas is likely to regain its old prominence. President Ford, by all accounts, has a better grasp and appreciation for science and technology than Mr. Nixon.

Pension protection for engineers nears reality

Highly mobile engineers appear likely to become eligible soon for a pension plan. After several years of legislative debate, many complications and disheartening delays, Senate and House conferees have finally agreed on a joint bill, and it is expected to be signed by the President. Nearly 35-million workers would be affected by this legislation.

One of the most important provisions is the mobility factor: Employees would be able to take vested pension benefits from employer to employer when changing jobs. Job-changing among engineers has become so prevalent that under present setups, many retired employees never get a penny in pensions.

The Federal bill would ensure against default in case of cessation of an employer's business. Self-employed engineers could deduct up to $7500 for retirement, and employees of companies without pension plans could deduct up to $1500. The bill places a $45,000 ceiling on annual benefits and limits tax-deductible contributions in profit-sharing plans. The Government procurement clause for engineers is expected to be included in the final legislation. This requires companies that have Government contracts to participate in the pension plan to protect engineers.

The switch from inches to centimeters: Side-tracked

Legislation to convert to the metric system is dead this year, according to Congressional spokesmen. The reason: There's too much to do, and too little time. The House voted to kill the measure (H.R. 11035) when the proposal reached the floor under a rule preventing amendment. This legislation would have created a 21-member National Metric Conversion Board to plan and coordinate a 10-year voluntary conversion process in the nation. Labor forces and small-business interests wanted the bill changed to include provisions for Federal subsidies for worker retraining, tool replacement and conversion-cost assistance. But opponents, who favored "letting the chips fall where they may," insisted on a parlimentary procedure that insulated the measure against amendment during debate. Some observers feel that the decisive 240-153 vote against the bill reflected resentment over the "no-amendment" rule rather than the bill's merits.

Engineers call for better Federal use of technology

A strong case for Federal support of technology was made by some of the country's leading scientists and engineers at recent hearings on the subject by the House Science and Astronautics Committee.

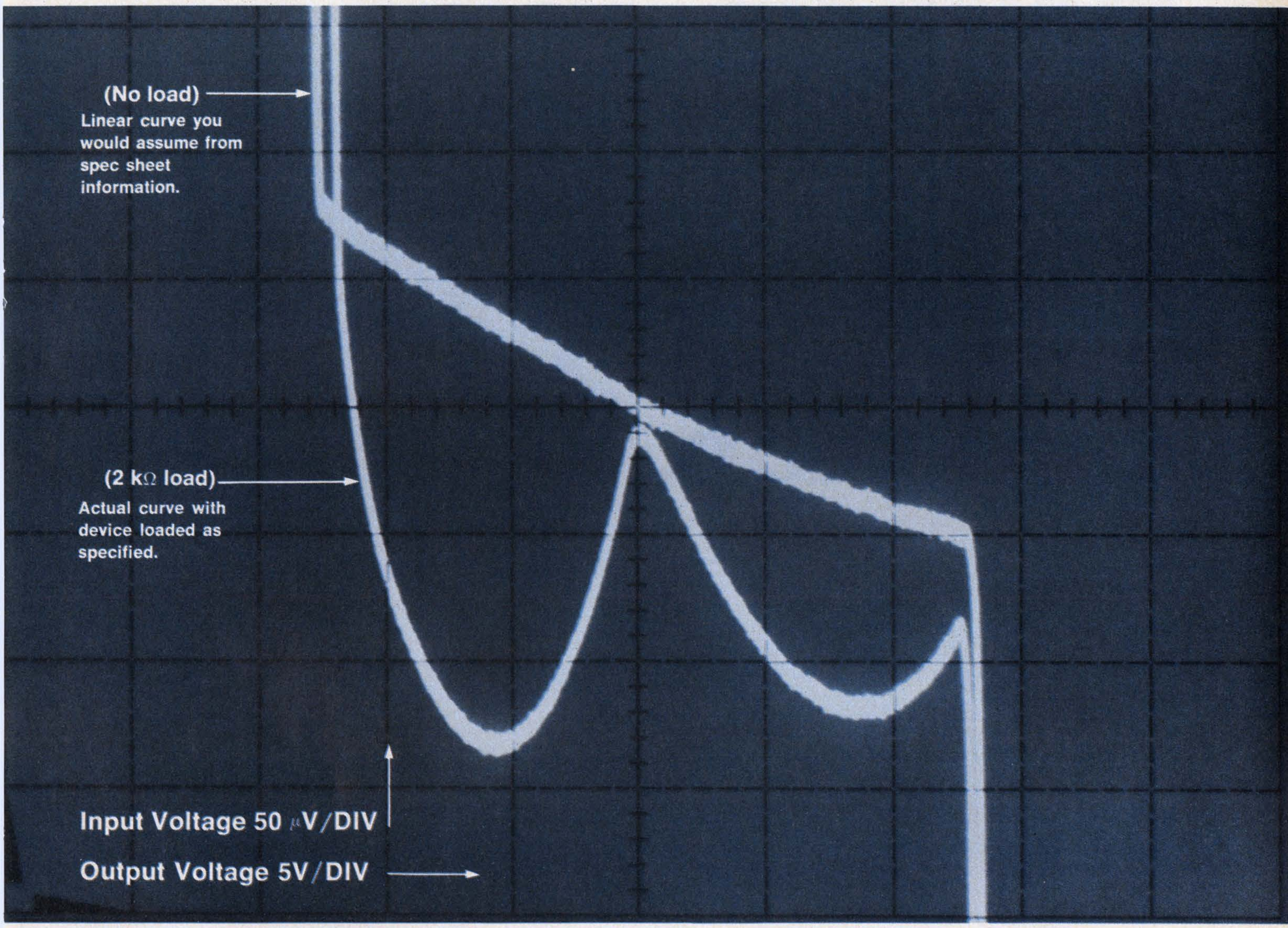
Patrick Haggerty, chairman of the board of Texas Instruments, suggested a National Development Act of 1976 in conjunction with the celebration of the nation's Bicentennial. The act would foster growth in science and technology that are vital to continued economic and social growth in the U.S.

Senator Edward Kennedy (D-Mass.), who opened the hearings, pointed out that the Government's attitude and its support of science and technology had declined in recent years and that a re-examination of the role of science and technology in society was needed.

Commercial Avionics industry reports growth

Avionics systems executives have expressed optimism at the continuing growth of their industry. At a meeting of the Airline Electronic Engineering Committee more than 300 officials from the U.S. and overseas agreed that the avionics market for the air-transport industry and general aviation was very good. One boost to the growth of avionics is the Airport Development Aid Program of the Federal Aviation Administration. More than $1-billion has been allocated under the program for airport development in the last four years. Funds have been approved for 1955 projects, of which 1355 were at airports serving airline users and 600 at airports handling general-aviation aircraft only. The FAA program operates on a matching fund basis with state and local sponsors contributing to over-all project costs.

The spec sheets tell you what should happen.



The 577 shows you what did.

When you're designing circuits using linear IC's, you count on spec sheets for the information you need. Generally, gain, CMRR and power supply rejection ratio are given as the ratios of voltage changes measured between discrete points. You assume a "linear" integrated circuit has a linear gain curve (a straight line) with no spurious excursions. But an actual device operating in real-life conditions isn't always linear. Often it produces very irregular curves that may make a big difference in your finished circuit.

These irregular curves are hidden from meters, digital read-outs and go no-go indicators. In fact, a Curve Tracer with its CRT display is the only way to see what is actually happening across the entire operating range of the device you're testing.

The Tektronix 577/178 Curve Tracer will measure and display gain. Offset voltage. Input bias current. Common-mode rejection ratio. And power supply rejection ratio. In addition, the 577/178 displays thermal effects. Popcorn (or flicker) noise. And parameter nonlinearities. And the 577/178 has a storage display to retain curves for comparison or detailed evaluation. Yet it costs only $3100.

INFORMATION RETRIEVAL NUMBER 121
FOR DEMONSTRATION, CIRCLE 122

To learn about the pitfalls of linear IC performance and measurements write to Tektronix for pamphlet No. A3040, A3061. Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005. Or call your local field engineer.

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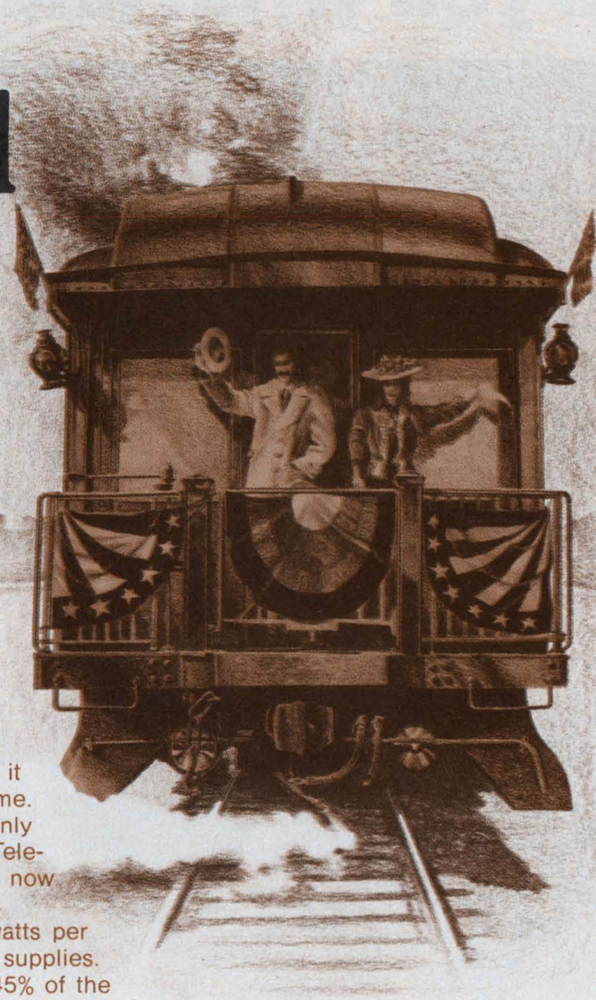
The last time someone announced 74C, it was a national campaign.



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

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

And 74C really simplifies design. 74C logic functions, pinouts and even numbers are identical to 7400 TTL, and every 74C device is compatible with every other 74C device. I/O specs are consistent (no interpreting a pile of data sheets to calculate what's compatible with what). Not to mention drastic cuts in the need for supply regulation, bypass capacitors and noise filtering.

The first batch is available now.

MM74C00	Quad 2-Input NAND Gate	MM74C107	Dual J-K Master-Slave Flip-Flop
MM74C04	Hex Inverter	MM74C160	Synchronous Decade Counter
MM74C20	Dual 4-Input NAND Gate	MM74C161	Synchronous 4-Bit Binary Counter
MM74C42	BCD-to-Decimal Decoder	MM74C192	Synchronous Up/Down Decade Counter
MM74C74	Dual D Flip-Flop	MM74C195	4-Bit Parallel-Access Shift Register

That's our national platform for 74C. But Teledyne's CMOS campaign has just begun. We'll soon be speaking softly about big values in proprietary devices compatible with 74C and custom CMOS for linear and digital applications. All with ultra-low power dissipation and high noise immunity.

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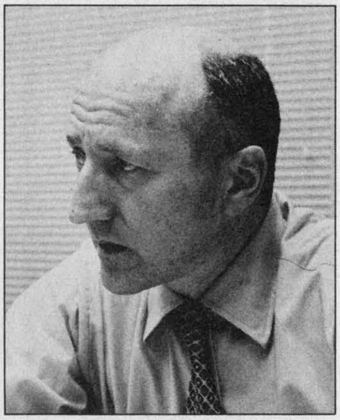
editorial

The front-runner



Engineers throughout the world have traditionally viewed American engineers as the root of most progress in electronics. And with good cause. For, in fact, American engineers have been leaders in many areas of technology for a variety of historic and economic reasons.

I became particularly conscious of this on two separate recent occasions. First, I was studying comments from hundreds of readers polled for a "profile" study of ELECTRONIC DESIGN's 11,000 European subscribers, all of whom receive ELECTRONIC DESIGN's GOLD BOOK. Almost to a man these people stated, among other things, that they read ELECTRONIC DESIGN because it keeps them up to date on design techniques, products and technical developments in the United States.

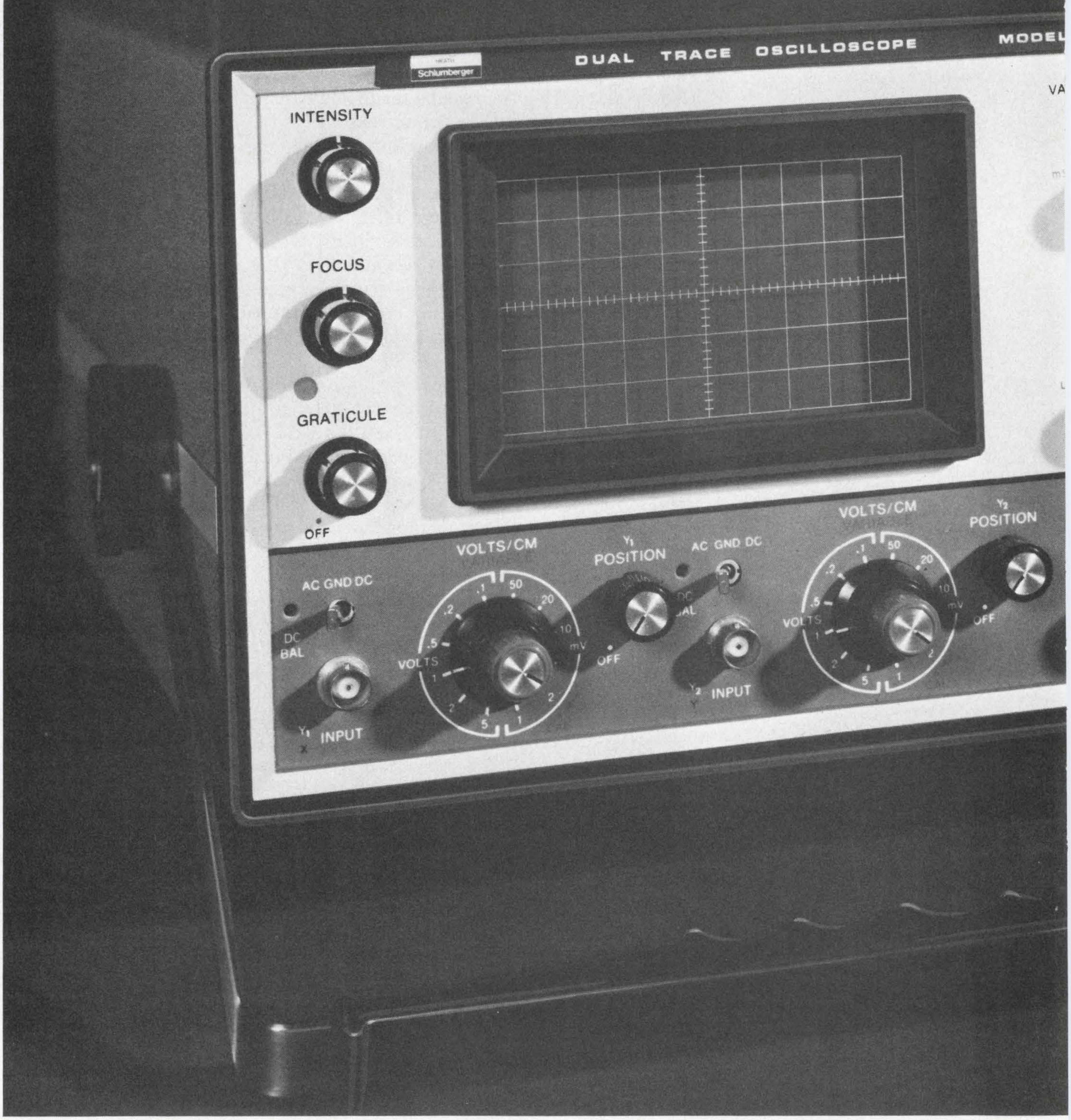
Just a few days later, our circulation director showed me checks and purchase orders from an additional 2200 people outside the U.S.A. who wanted copies of ELECTRONIC DESIGN's GOLD BOOK. And that was just the beginning. I wasn't surprised to find additional orders from the major countries in Western Europe, where ELECTRONIC DESIGN has heavy circulation. But I was amazed to find that the list looked like an index to a World Atlas, with orders pouring in from every continent but Antarctica and almost every country you could name.

Since the products and manufacturers listed in the GOLD BOOK are predominately American and since the GOLD BOOK is the most extensive compilation of such products in the world, the message from these people is clear. Throughout the world engineers still feel that they must find out what's available in the United States. They still feel the U.S. is at the forefront.

Will such leadership continue forever? I suspect not. Engineers in Europe and Asia, particularly, see themselves in a race with American engineers. They see the American as a front-runner and they want to catch up and pass him. But the American engineer isn't looking back; he doesn't know he's being chased. He may be surprised one day to find himself watching the heels of a fellow he didn't know was following him.

GEORGE ROSTKY
Editor-in-Chief

A low-cost scope offer more than a low

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FOCUS on Microprocessors

Digital designers faced with the many performance claims for new LSI microprocessors might conclude that one of these little, low-cost marvels could solve all their system problems. After all, if a small IC offers the processing of a computer, replaces scores of standard logic circuits and has a seemingly endless list of applications, who needs to design with anything else?

Closer examination of the burgeoning application literature for a "computer on a chip" reveals a different picture. A large-scale integration processor, for example, does perform many of the functions of the central processing unit in conventional computers. But to use the circuit, many more ICs may be needed to interface with peripheral devices, data-communication lines and even its own memory.

And that low price tag on the LSI processor—typically, well under $100 for 4-bit word-length units and under $400 for 8-bit units—is low compared with the thousands of dollars needed for a general-purpose minicomputer. However, to build a full-fledged microcomputer, you need memory, and the cost of that can easily exceed the price of the processor.

Moreover, if you add up the cost of all the necessary hardware components, you may find the total exceeding the less-than-$1000 level of "stripped down" minicomputers available on PC boards.

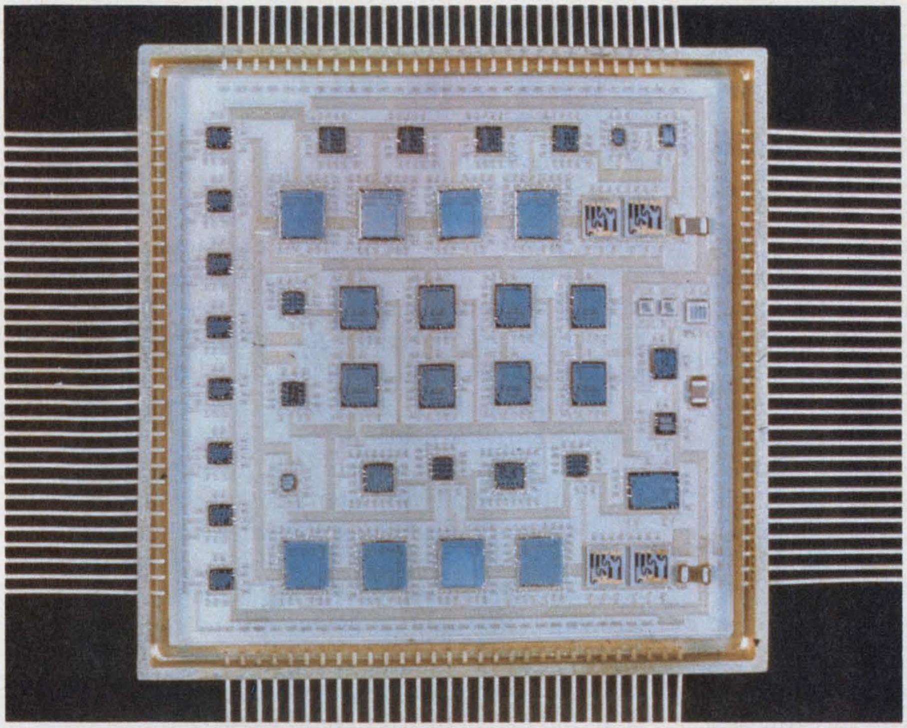
Combine an LSI microprocessor with associated circuitry and memory, and you obtain a microcomputer. In the foreground are LSI circuits and prototype systems offered by Rockwell International. The manufacturer's line includes 4 and 8-bit microprocessor chip sets.

Programming—unfamiliar demands

A decision to use an LSI processor opens up a whole new design ball game. Not only must a digital designer contend with the relatively familiar requirements of any logic system. The designer must also grapple with the relatively unfamiliar demands of programming. And software development, usually involving assembly language (only one step up from a computer's inherent machine language of ONEs and ZEROs), represents by far the major design effort and cost.

In addition microprocessors don't lend themselves to the traditional "learning curve" for new

Edward A. Torrero
Associate Editor



Dice mounted on a substrate form a microprocessor system. This unique packaging approach is used by Teledyne Semiconductor. Other vendors typically mount DIPs on PC boards.

components. Previously the experience gained in the use of one component could be transferred to a similar component from another manufacturer. But different microprocessors generally don't have alternate sources. And the chips come with different software capabilities, hardware requirements and design aids. Hence a completed design, using one LSI processor, might have to be scrapped totally if you decide to turn to another vendor's unit.

Still, there are major benefits. Microprocessors are unique among ICs in that they can be programmed like computers. As a result, they permit a tradeoff of software for hardware to achieve a dazzling increase in system capability and versatility.

They can be used economically to replace or upgrade random-logic designs, involving scores of standard ICs, when many functions must be performed. And they use less circuitry than hardwired logic in applications emphasizing random collection and routing of data.

Of course, for some applications microprocessors are not the sole LSI alternative. Complex logic decisions might be handled just as well with circuitry using programmable logic arrays. And arithmetic computations are performed by arithmetic logic units or by calculator chips—from which a number of microprocessors have evolved. Custom LSI chips provide yet another alternative.

Nevertheless microprocessors are filling the gap between special-purpose LSI circuits and conventional minicomputers. They are currently finding their greatest use as decentralized, cheaper minis in remote, programmable controllers.

There's a wide product range

The many advantages of microprocessors are creating a demand that manufacturers are meeting in a variety of ways. Designers can choose from among single or multichip processors, chip sets or PC-board assemblies, and from among a wide range of technologies.

The most common technology is silicon-gate, p-channel MOS (PMOS). But manufacturers are also using n-channel MOS (NMOS) and silicon-on-sapphire MOS (SOS/MOS) to achieve speeds that are higher than those possible with PMOS. Bipolar processes are employed for the highest speeds—about 200-ns cycle vs 2 μs for NMOS types. Complementary MOS (CMOS) is used for the lowest power dissipations—microwatt-range chip dissipation vs milliwatt range for other types.

Standard LSI-processor products in various configurations handle data in 4, 8 and 16-bit word lengths, and modular multichip microprocessors can be used to achieve even longer word-length processing. The available configurations, with their major features, consist of the following:

- Microprocessor chip sets, including special interface ICs and sometimes special memories, to simplify designs of minimum-hardware systems for specific applications.
- Microprocessor-based logic boards to eliminate the need to test, assemble and interconnect

processor chips, peripheral circuits and memory for a variety of applications.

- General-purpose—n o n d e d ic a t e d—microcomputers, on cards or in boxes, to permit system design, development and testing. These are offered by component manufacturers, as well as, a growing number of other vendors.
- Microprocessor-based minicomputers offering, as a result of their traditional mini features, maximum flexibility and capability when compared with MOS microcomputers. Offered by minicomputer manufacturers, these units generally use custom MOS processors.

The cost of each configuration increases with a unit's complexity. At the minicomputer level, hardware cost might be the highest. But available software support is the most extensive. Designers tend to feel that the number of units determines the major tradeoff in a choice between a micro and minicomputer. A small number of units—as for an end-user application—can best be served by a mini, which can minimize software development costs. But for large quantities—as for an OEM application—a microcomputer can minimize hardware costs.

Chip sets improve early versions

Due to increasing availability of special interface circuits and improvements in processor-chip architecture, fewer additional circuits are needed for the newest microprocessors than for earlier versions. First-generation 8-bit processors, for example, typically needed about 20 additional standard-TTL circuits to make them work.

The extra ICs include the following: registers to address memory, either ROM or RAM; decoders to interface with memories; other ICs to handle processor information and to synchronize the operation of the processor and circuits; clock circuits, and a variable amount of interface ICs, depending on the application. For example, in a multichannel data-communications application each channel requires an asynchronous receiver/transmitter and associated interface ICs.

But even with newer processors, applications still can require additional circuitry to obtain one or more of the following: clock generation and timing, memory and I/O control, data and address buffering, multiplexed inputs, interrupt control, refresh for dynamic memories and additional supply voltages.

And some microprocessors are offered only as part of complete chip sets or with the purchase of the associated memory from the same IC manufacturer. This may not bé a problem if you plan to buy all your components from the same source, but it does stop you from shopping around for the lowest price and precludes the use of core memory—which most processors can accept just as well as semiconductor types. Also, if you purchase a chip set, you must design around the circuits offered.

Specs don't tell all

Unlike the less-complicated ICs, microprocessors cannot be completely characterized on a simple data sheet. Moreover different vendors use different parameters to measure a processor's capabilities. This makes any comparison of processors—not to mention selection of the best one—a difficult task. And there's no trend in sight toward standardization.

A microprocessor's computing speed is a case in point. Frequently manufacturers use a basic cycle time, or period—sometimes called a microcycle—to denote speed. But many microcomputer operations require several such cycles to be performed. This applies especially to the execution of the more powerful instructions. Hence a critical instruction may require more time than that indicated by the basic cycle.

In addition a microprocessor's maximum clock rate can be misleading, if taken for a measure of speed. It's possible for one microprocessor to perform basic operations—like register-to-register add—faster than a unit using a higher clock rate. Differences in microprocessor architecture and chip design tend to minimize the importance of the clock-rate spec.

Other specs given to indicate speed include minimum instruction time, interrupt response time, and time to add two numbers—which may already reside in the processor. Like cycle time and clock rate, these numbers don't measure such critical times as the over-all time needed to perform important routines. Excluded are additional delays, such as those needed to obtain data from memory. The solution is to use benchmark programs tailored to your application as a basis for selection of one microprocessor over another.

Use of benchmark programs can determine the power of the instruction set, thus circumventing one of the most abused specs—the number of instructions. Microprocessor comparisons based on this number abound, although such comparisons have serious flaws.

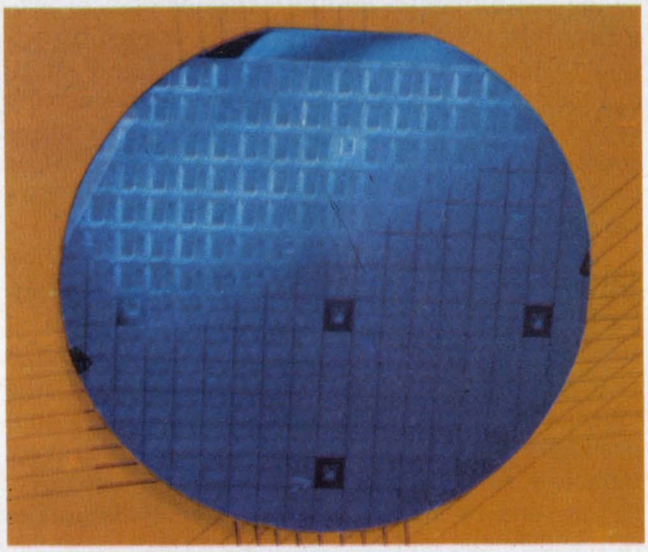
For example, a simple number doesn't reveal what instructions are available for data movement and manipulation, for decision and control and for input/output operations. Some microprocessors have far more I/O instructions than others; they are tailored for a specific class of applications. And missing instructions can always be performed by routines, although with a sacrifice in speed.

Also, the number of instructions claimed for the same microprocessor can increase from one page of a reference manual to another. One reason is that instructions that move data have been multiplied by the number of addressing modes.

Common addressing modes include direct, immediate and indirect. In the immediate mode, the instruction includes data, while in the indirect mode, an address preloaded into a register increases the address bits in an instruction. Variations and extensions of these modes are also available, so a basic instruction can be multiplied several times.

Other factors that inflate the number of instructions may be the number of registers—in, say, a load-to-register operation—or the number of conditions—for example, those on which a branch may occur.

Of course, improved instruction sets are obtained with longer word-length microprocessors and advanced versions of smaller units. For example, 16-bit microprocessors have instructions for multiply and divide—functions that require



They're not "computers on a chip"—yet. But LSI microprocessors, symbolized by this wafer from Intel, perform many of the functions of central-processing units in conventional computers.

software routines in 8-bit models.

And advanced microprocessors feature more powerful instructions as well as the original set of a predecessor. However, this "software compatibility" doesn't allow routine upgrading of systems by chip replacement. In general, expect to redesign to employ the new hardware/software tradeoffs efficiently.

For virtually all models, data sheets claim TTL compatibility. But don't expect many MOS processors to drive TTL loads; most don't. The term primarily refers to the fact that both microprocessor and TTL circuit can use a common 5-V supply. Newer models list a maximum TTL-drive capability of only one standard load, and many models require external components to achieve the interface levels needed for logic compatibility.

Watch architectural claims, too

Many computer-like features of microprocessors are frequently cited, including the number and function of registers, the type and depth of stack, interrupt capability and direct-memory access (DMA). However, there isn't as much architectural diversity as there is with minicomputers. IC manufacturers are constrained by technology limitations, so that comparable microprocessors tend to perform similarly. For example, preliminary benchmark programs run by several manufacturers for their 8-bit, single-chip NMOS processors often show comparable execution times.

Data sheets frequently boast several working registers. But only a single register, the accumulator, is essential. An accumulator, however, must have access to memory, and available instructions should permit immediate addressing and data manipulation between the accumulator and memory. If indirect addressing is available, even the function of special index registers can be accomplished with memory.

The major significance of additional registers lies in access time and the bit efficiency of instruction words. It takes far fewer bits to specify one of several previously defined working registers than a memory location. And a faster execution time can be obtained with registers that are separate from memory. They can be accessed without excessive memory-cycle delays. Otherwise it doesn't matter whether these registers are in an external memory or in the processor, so long as they can be referenced efficiently.

Some data sheets might seem to imply that the quantity of registers is more significant than their quality. It isn't. Not all registers can be incremented and tested for zero, even though they are described as "general-purpose." Those that can may be used for counting and program-loop control. In general, not all registers can be used for indexed addressing. Nor can they be loaded directly from memory—rather than only from the accumulator—or used as a source or destination for arithmetic logic operations.

Microprocessors employ stack-oriented registers that can be accessed only in a last-in-first-out basis—the so-called LIFO, or push-down, stack. These are used for subroutine nesting, interrupts and for temporary storage of data. They can be either on the chip (a hardware stack) or external to the processor in memory (a software, or pointer, stack). The hardware stack permits higher-speed operation, but it has limited size. The size of the software stack may be as large as available memory space permits, but the stack must be maintained by the program.

An interrupt capability is an absolute must for applications that involve asynchronous or unpredictable events. All microprocessors claim some type of interrupt handling ability, but the extent can vary from one unit to another. With older processors, you have to design the means to save the contents of the processor just prior to the interrupt, and then restore the information after the interrupt is serviced.

Those means may involve reservation of registers on the chip, use of external registers or use of another microprocessor. Any of these methods can store the essential contents of the processing unit. Software control, involving special routines, must also be provided to complete the design. The complexity of these techniques tends to discourage designers from attempting to handle even a single interrupt.

Newer microprocessors can accommodate single-line, multilevel and vectored interrupts, and they save essential registers automatically. A complete saving must be programmed. In one single-line interrupt system, device-interrupt requests are ORed together to form one request line. The program identifies the device and resolves priority. A multilevel scheme employs several single-level sense lines to handle additional interrupts. For very fast response, the vectored interrupt directly branches to a memory location that corresponds to a specific interrupt.

Another feature that depends on the unit is DMA capability. For some units, a "direct" access of memory must be performed indirectly through the microprocessor's usual word-by-word transfer procedure. This may not be a problem if you don't mind the processor's idle time, but it does limit data-transfer efficiency.

And don't expect I/O data throughput rates always to include the time needed to sense for a device or to respond to an interrupt. When these times are included, the actual throughput can be significantly less than expected.

Fixed instruction vs microprogram

Most microprocessors come with fixed instruction sets, around which software must be developed for an application. For some units, however, the option exists for microprogramming, the ability to alter or totally change the original instruction set. In essence, you program the microprocessor's internal microinstructions to obtain a macroinstruction set that is tailored to the application.

The advantages of microprogramming include increased speed, since microinstructions are executed considerably faster than macroinstructions are. Also, the technique allows a more detailed level of control that can be used to reduce hardware; the program controls more functions.

Because of the hardware savings, vendors expect microprogramming to find its greatest use in large-volume applications—in excess of tens of thousands of units. Alternatively, microprogramming represents the logical choice for an emulation of another computing system or for the speedy execution of critical, short routines.

The exceptional skills required for microprogramming constitute its major disadvantage. A microprogrammer must deal with the specific timing relationships of the internal architecture. And since each application requires a separate microprogram, each has its own instruction set that can't be transferred easily to another application. Nor can software design aids, geared toward the fixed instruction set, be applied to the changed set.

Design aids speed development

Much of the start-up, or development, effort in the design of a microcomputer system is linked to the coding phase. Coding converts system programs into instructions that can be loaded directly into the memory. However, the basic design-aid tools themselves are programs that generally require the use of time-sharing services or other computer facilities. And like the LSI processors they support, design-aid features can differ from vendor to vendor.

Assemblers are a case in point. All assemblers convert a program into the basic machine language in a process that usually involves several steps. Essentially the assembler reads a so-called source tape—with statements written in the mnemonic, or symbolic, assembly language—and produces a so-called object tape, with binary numbers suitable for the processor's memory. Errors due to misuse of the assembly language can be detected and pointed out by the assembler.

But some manufacturers offer single-pass assemblers, thereby reducing the steps needed to obtain the binary instructions for memory. Or they may provide the option of loading the assembler into ROMs and pROMs so that the microcomputer itself, rather than a host computer, executes the program. These are called hardware assemblers.

Another type, called a macro-assembler, simplifies coding when similar sections of code are used repeatedly, but variations preclude the use of conventional subroutine techniques. With a macro-assembler, a single instruction yields the necessary expansion.

Editors, available on time-sharing services, allow designers to prepare the original assembly-language programs and to change or correct them with simple commands. They can add documentation and store, combine and retrieve programs. And they can readily output programs onto paper

MICROPROCESSOR SCORECARD®

μP Scorecard®	Classification	Technology	Parts Family: Clock Driver	Parts Family: I/O Interface	Parts Family: UART/USRT	Parts Family: RAM	Parts Family: ROM/PROM	Parts Family: Interface	Features: Interrupts	Features: Integrated CPU	Features: Microprogrammed	Features: Accessible Stack	Features: DMA Ability	Features: BCD Arithmetic	Word Size (Data/Program)	Address Capacity (Program Words)	Clock (kHz/Phases)	Register Add Time (μsec per Data Word)	Number of CPU Registers: ALU	Number of CPU Registers: XR	Number of CPU Registers: GP	Return-Stack Size (NR x Bits)	Voltages Required	Power Dissipation (Watts)	Operating Temperature Range (°C)	Package Sizes (DIP Pins)	Price Range (approx.; CPU only; Quantity 100)	Status	Remarks
BURROUGHS MINI-D	One-chip CPU with ROM	PMOS								√					8/12	256	1000/1	9	3	—	1		−12, +5			16	$ 60	Custom	
FAIRCHILD PPS-25	Calculator-oriented	PMOS		√		√	√							√	4x25/12		400/2	62.5	1	—	—	4x12	−10, +5	.6	0, +70	16, 18 24, 40	$ 60	Delivered	
INTEL MCS-4/4004	Calculator-oriented	PMOS		√		√	√	√		√				√	4/8	4K	740/2	10.8	1	—	16	4x12	−10, +5	1.0	0, +70	16	$ 30	Stocked	
INTEL 4014	Calculator-oriented	PMOS		√		√	√	√	√	√				√	4/8	8K	740/2	10.8	1	—	24	8x12	−10, +5	1.0	0, +70	16, 24		Rumored	
INTEL MCS-8/8008	One-chip CPU	PMOS							√						8/8	16K	500/2	20	1	—	6	8x14	−9, +5	1.0	0, +70	18	$100	Stocked	
INTEL 8008-1	One-chip CPU	PMOS							√						8/8	16K	800/2	12.5	1	—	6	8x14	−9, +5	1.0	0, +70	18	$130	Stocked	
INTEL 8080	One-chip CPU	NMOS	√	√	√	√	√	√	√	√		√	√	√	8/8	64K	2083/2	2	1	—	6	(RAM)	−5, +5, +12	1.0	0, +70	40	$200	Delivered	
INTERSIL ISD-8	One-chip CPU	CMOS							√	√					12/12	4K	2000/1	6	1	—	—	Modifies Program	5	.002	−55, +125	40		Announced	DEC PDP-8 Code
MOTOROLA 6800	One-chip CPU	NMOS		√	√	√	√		√	√				√	8/8	64K	1000/2	2	2	1	—	(RAM)	5	.25	0, +70	24, 40	$150	Samples	
NATIONAL GPC/P	4-bit Slice	PMOS									√	√	√		4N/23	100	715/4	1.4	8	—	—	16x4N	−12, +5	.7	0, +70	22, 24	$150	Delivered	1 ≤ N 5 6
NATIONAL IMP-4	3-chip CPU	PMOS						√	√		√	√		√	4/4	64K	500/4	12	4	—	—	7x12	−12, +5	1.0	0, +70	22, 24	$150	Samples	16x4 Data Stack
NATIONAL IMP-8	3-chip CPU	PMOS							√		√	√	√		8/8	64K	715/4	4.6	3	1	—	16x8	−12, +5	1.0	0, +70	22, 24	$230	Delivered	
NATIONAL IMP-16	5-chip CPU	PMOS							√		√	√	√		16/16	64K	715/4	4.6	2	2	—	16x16	−12, +5	1.4	0, +70	22, 24	$310	Delivered	
RAYTHEON RP-1600	4-bit Slice	Bipolar									√				4N/48	64K	5000/1	1	j	k	—							Announced	(j + k) ≤ 8
RCA COSMAC	2-chip CPU	CMOS							√				√	√	8/8	64K	667/1	6	p	q	—	rx16	12	.01	−55, +125	40		Announced	(p + r + 2q) ≤ 15
ROCKWELL PPS-4	Calculator-oriented	PMOS	√	√		√	√			√		√	√	√	4/8	4K	200/2	5	1	—	1	3x12	17	.225	0, +70	42	$ 40	Delivered	
ROCKWELL PPS-8	One-chip CPU	PMOS	√	√		√	√		√	√		√	√	√	8/8	16K	256/2	12	1	1	2	2x14	17	.3	0, +70	42		Announced	
SIGNETICS 2650	One-chip CPU	NMOS							√	√				√	8/8	32K	1200/1	4.8	s	t	—	8x15	5	.5	0, +70	40	$100	Announced	(s + t) ≤ 6
TOSHIBA TLCS-12	One-chip CPU	NMOS		√		√	√		√	√	√				12/12	4K	1000/3	13	1	—	—	(RAM)	−5, +5	.8	−20, +80	16, 24 26, 42		Announced	Multiply Instruction

July 1, 1974

A tabulation of representative LSI microprocessors reflects the product range: from calculator-oriented, 4-bit units using PMOS technology to newer 16-bit multichip bipolar processors. Note that the table, reprinted from "New Logic Notebook" by Microcomputer Techniques, compares push-down stacks—called return stacks—in terms of number of registers (NR) and the bit size of each. Also processor registers are divided into accumulators (ALU), index registers (XR) and remaining registers (GP) for general use.

tape as well as printers.

A number of loaders are available to complete the coding process. With these, which can be stored in ROMs, assembled programs are loaded into read-only memory. They can also be loaded into RAMs, in which case a bootstrap type is used. A so-called relocating loader automatically adjusts program addresses and loads the resulting instructions. And some loaders have linking capability that lets you use routines with undefined labels. These types supply the missing cross-references between separate routines.

Several manufacturers also offer compilers, which allow programs to be written in a high-level language. The benefits are many: A short readable compiler statement corresponds to many symbolic assembly-language statements. Compilers eliminate the need to write detailed codes to control loops, to access complex data structures or to program formulas and functions. And since programming details are lessened, errors are reduced.

But while high-level language programs are compact, easy to read and much easier to write, the net result could be excessive storage space and slower execution, when compared with an assembly-language program. Generally a choice between the two approaches depends on the degree of optimization required and the design time allowable.

In addition to these design aids, test programs —such as simulators—are virtually mandatory to track down the various subtle errors that may remain. Similarly hardware prototype units are essential to the development of the final product. Prototype units generally involve expanded memory capability, teletypewriter or card-reader interface, power supply, chassis and control panel —in addition to a microcomputer.

Besides boosting initial development costs for the designer, the wide range of hardware/software support requires a major investment by the semiconductor manufacturers. This investment is in addition to that needed to produce the LSI chips. In fact, one indication of a vendor's seriousness in marketing a particular microprocessor is the availability of hardware/software support for the product.

Still, ever more manufacturers are entering the field because of the high potential payoff. Various sources predict that the microcomputer market—valued at under $50-million last year—should reach at least $500-million in four years. In the process, a sizable chunk of the TTL market could be replaced. Major microprocessor-chip vendors—such as Intel, National Semiconductor and Rockwell International—are meeting the challenge in a variety of ways.

The Components

By any standard, the recognized leader in microprocessors is Intel, which introduced the product in 1971. Benefiting from its early, one-to-two-year lead over competitors, Intel reportedly captured as much as three-quarters of last year's microcomputer market. Moreover each of its processor chips has been a first of its kind, beginning with a 4-bit unit, the 4004, and leading to an 8-bit PMOS model, the 8008, and the latest advance, an 8-bit NMOS microprocessor—the 8080.

Among the Intel products, the 8080 sets the pace for increased speed and improved instructions. The silicon-gate processor has a 2-μs instruction cycle and 74 basic instructions, which include the 48 instructions of the earlier 8008. The additional 30 instructions and a 6:1 faster execution rate provide up to a 10:1 speed advantage over the 8008. Moreover the improved performance of the 8080 is obtained with a typical power dissipation of only 600 mW, the same as that of the 8008.

The 8080 can address up to 65-k bytes of memory without need for an external address register. This compares with 16-k bytes of memory and an external register for the 8008. The 8080 requires only six peripheral ICs, as contrasted with the 20 needed with the 8008. The NMOS 8080 comes in a 40-pin package and operates from +12 and ±5-V supplies.

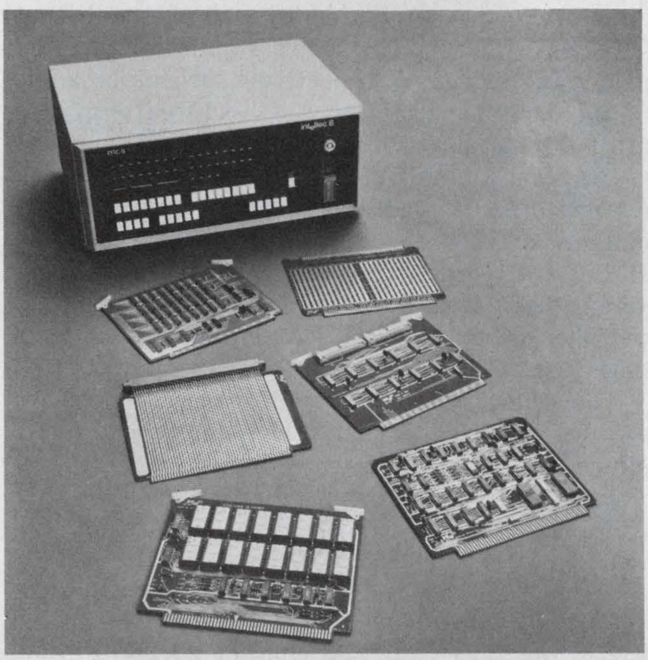
A number of architectural differences account for the improved performance of the 8080. For example, it contains a 16-bit stack pointer (to operate the external LIFO stack) and a 16-bit program counter (to indicate the next instruction), instead of an address storage stack with eight 14-bit locations. A portion of the external memory can be used as a last-in, first-out stack, addressed by the stack pointer upon the execution of a Call, Return or Restart instruction.

Moreover not only the program counter but also the data register, the accumulator and the flags (bits that are set to indicate various conditions) can be saved in the external push-down stack. As a result, multiple interrupts can be handled more easily with the 8080.

The 8080 can perform BCD and binary arithmetic. It also has capability for double-precision arithmetic involving two 16-bit numbers. The NMOS processor can handle up to 256 input ports and a similar range of outputs.

Intel offers several hardware and software design aids for the development of microcomputer systems with its processors. The aids include the Intellec series, consisting of expandable, modular systems that come complete with microprocessor, memory, power supplies and circuitry for teletypewriter interface and clock generation. Each Intellec system is housed in a compact cabinet that features a control and display panel for immediate system monitoring and debugging. All program storage can be accomplished with RAMs, rather than ROMs, for easier program loading and modification. After a program is firm, it can be loaded into ROM.

The standard software package for the Intellec



Most manufacturers offer design aids to simplify development of microcomputer systems. Intel's aids include the Intellec series, which comes complete with memory, supplies and clock and interface circuitry.

series includes a system monitor, contained in pROMs, resident assembler and text editor. A programming module provides the timing and level shifting to program pROMs. Additional support is provided by a cross-assembler and simulator written in Fortran IV and by a PL/M compiler available on time-sharing terminals.

The use of PL/M, derived from IBM's PL/1 language, permits sample programs to be written in a fraction of the time needed to write the same program in assembly language. PL/M offers a far simpler means of programming, compared with assembly language. And the debugging and checkout times of a PL/M program are less, because the structure of the language allows the compiler to detect error conditions that would not be spotted by an assembler.

Recent additions to the Intel product line include several ICs, intended to simplify system design and expansion, and an advanced version of the company's 4-bit microprocessor. The additional circuits include a 4-k-bit dynamic RAM (the 8107), a 2048 × 8-bit ROM (the 8316), a 512 × 8-bit pROM (the 8604), and several peripheral circuits. The latter interface communications lines, handle increased loads and replace IC packages now required.

Intel's new 4-bit microprocessor, the 4014, features software compatibility with the earlier 4004. Additional instructions permit logic operations, such as AND and OR. The 4014 also allows storage capacity of 8-k bytes of memory, increased from the 4-k bytes for the 4004. Other capabilities include improved single-interrupt handling and a single-step mode of operation to simplify testing and debugging.

IMP series—chips, cards and 'boxes'

National Semiconductor offers a broad line of PMOS microprocessor products. They consist of 4, 8 and 16-bit parallel processors that are available in chip form, on card subsystems and in complete microcomputer boxes. Each microprocessor features downward software compatibility —it's compatible with a microprocessor having a shorter word length, but not one with a longer word length. And the fixed instruction set of each can be altered or changed through microprogramming techniques.

The National microprocessors are built around two building-block chips: a Register and Arithmetic Logic Unit (RALU) and a Control Read-Only Memory (CROM). The RALU is a 4-bit "slice"; four are used with one or two CROMs to obtain the 16-bit system, and eight RALUs with two CROMs can be used to form a 32-bit system. The CROM provides storage for the manufacturer's fixed instruction set and the control logic for up to eight RALUs.

The IMP-16C, National Semiconductor's 16-bit microprocessor system, comes on an 8-1/2 × 11-in. PC board. It consists of the processor, clock system, I/O bus drivers, 256 words of RAM and provisions for 512 words of ROM or pROM memory.

The IMP-16C uses a basic 43-instruction set and an expanded 17-instruction set provided by a second CROM. The additional 17 speed processing with instructions that include divide, multiply and double-precision add and subtract. The basic microcycle, or machine cycle, is 1.4 μs. Several microcycles are needed to execute a typical instruction. Two 16-bit numbers can be multiplied for a 32-bit result in a speedy 150 μs.

Each RALU supplies the IMP-16C with an accumulator and a push-down stack. A total of four accumulators improve the bit efficiency of instruction words by cutting down memory-cycle delays. The hardware stack permits rapid nesting of subroutines and interrupts, and its limited depth can be extended—for, say, overflow conditions—by use of main memory.

The microprocessor also features vectored as well as slower, single-line interrupts. With a single-line interrupt, the total overhead time to get to the service routine can be as high as 34.85 μs, since it depends on the number of peripheral devices, and these might number 16. But with a vectored interrupt, the total overhead is only 4.55 μs, a figure that doesn't change with the number of devices.

Several software design aids are offered with each microprocessor. Programs are available for cross and self-assembling, source editing, debugging, and absolute and relocate loading. Also, driver/utility and diagnostic aids are offered. Hardware design aids using assembly language come as complete microcomputers and prototype systems. For the 16-bit system, these are the IMP-16L and 16P boxes. Both units contain a 16-bit microprocessor card.

The IMP-16L has a front-panel display, which provides access to memory and microprocessor registers. The box comes with 4-k, 16-bit words, expandable to 65-k words. Also, a high-speed asynchronous bus permits direct-memory access by peripheral devices without the need to go through the RALUs.

The IMP-16P can interface with a teletypewriter for application software development. This prototyping tool comes complete with chassis, control panel, power supplies and one or more 4-k, 16-bit-word read/write memory modules. National Semiconductor says the IMP-16P is the box to start with to begin a 16-bit design.

Recent additions to National Semiconductor's line are an advanced 4-bit microprocessor system and a microprogramming tool to help designers alter or change the fixed instruction set. The 4-bit system performs BCD arithmetic and uses one CROM, one RALU and a Four-bit Interface Logic Unit, called FILU. The interface unit combines the functions of a number of standard-TTL peripheral circuits.

The microprogramming tool, called Field-Alterable Control Element (FACE), makes use of the fact that a change of CROMs changes the fixed instruction set. FACE, which comes on a card, replaces the CROM on a microprocessor board to form what mainframe designers call writable-control store. Microprocessor control logic now becomes accessible to external ROM or RAM for development of a tailored microprogram. The final result can be stored in a custom-masked CROM or a bipolar pROM. The increased speed of the bipolar memory can reduce delays incurred through connection of external, off-the-board circuitry.

PPS family provides chip sets

Aiming to reduce the number of additional components often needed with single-chip microprocessors, the Microelectronics Div. of Rockwell International offers chip sets for both 4 and 8-bit systems. The sets come complete with processor, clock circuit, memory and input/output ICs. For additional flexibility, you can get a combination ROM and RAM chip or you can select from a growing number of interface and peripheral circuits.

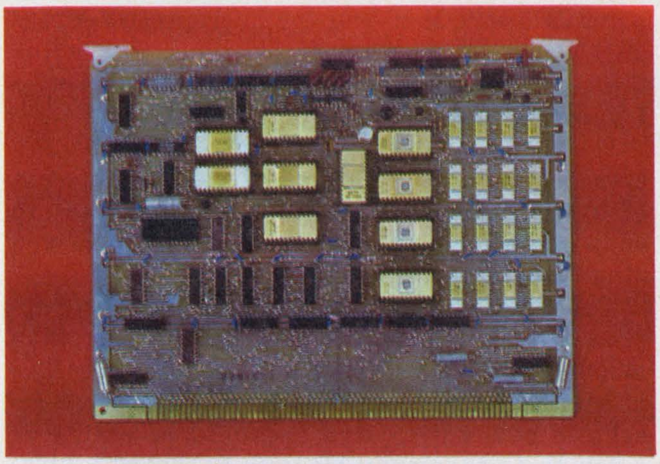
Rockwell estimates that up to 30 peripheral circuits can be eliminated by use of the PPS-4 or PPS-8 chip sets. These are 4 and 8-bit parallel processing systems, respectively. Moreover some of the special circuits in the Rockwell chip sets are not generally available with competing processors. For example, a nonvolatile RAM is being developed for the PPS-4 set. And a controller circuit, in an advanced development stage, for the PPS-8 will permit direct memory access. Rockwell is also developing other circuits for use with peripherals such as CRTs, printers and floppy discs.

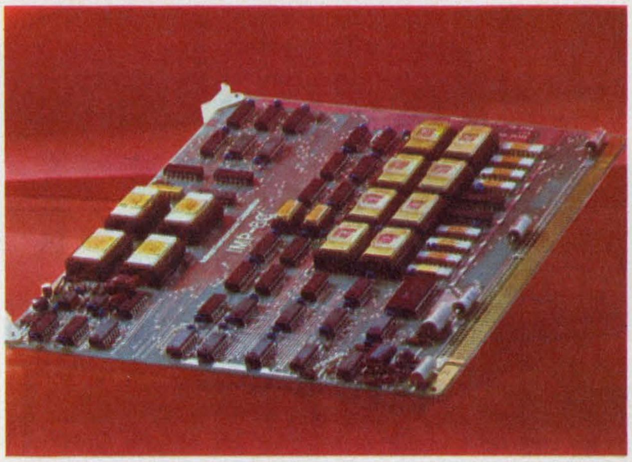
The PPS-8 features over 90 instructions, with capabilities for decimal and binary arithmetic single-byte subroutine call and digit/byte manipulation. A complete instruction cycle can be executed in 4 μs, and decimal addition or subtraction is performed at 12 μs per digit. Among 4-bit microprocessors, the PPS-4 sets the pace for speed, with an instruction cycle of 5 μs and a register-to-register add time of 2.5 μs. The 50 instructions for the PPS-4 contain logic and conditional and unconditional data-transfer operations.

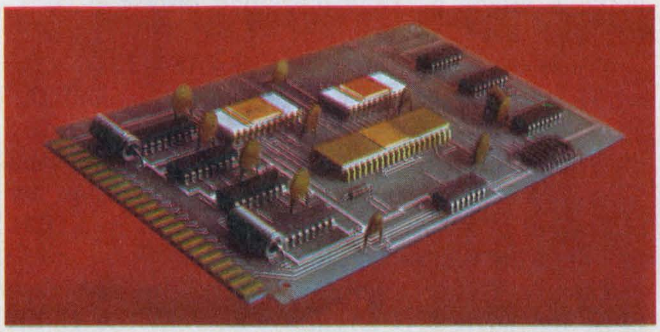
The PPS chip sets use a relatively slow clock, typically 200 kHz. However, signals internal to the system are handled at four times that rate. The clock generator provides the processor with two synchronized signals, which are then divided logically into four phases, thus boosting the speed.

Bus lines transfer data during the second and fourth time intervals. In the alternate intervals, address and data-bus lines are automatically cleared to zero. This interface timing scheme permits direct connection of an extensive number of circuits. For the PPS-4, up to 30 circuits can share the bus without need for additional buffering or drive circuitry.

Also, the control logic within the processor allows arithmetic or logic instructions to be carried out in one cycle time. Addition of two decimal digits requires six instructions, or six cycle times. Hence for the 5-μs cycle of the PPS-4, two decimal







Processor cards provide an assembled and tested microprocessor system, complete with memory. Clockwise from the top left are National Semiconductor's 16, 8 and 4-bit models (the IMP-16C/300, 8C/200 and IMP-4, respectively). National units also feature a microprogramming option that can be used to alter or change the fixed instruction set.

digits can be added or subtracted in 30 μs.

Software aids consist of cross-assemblers and simulators available on time-shared services. The aids may also be purchased for use on in-house computers. Hardware aids range from Assemulators (developed by Applied Computing Technology) to evaluation boards, containing microprocessors, RAMs, I/O circuits and clocks.

Micro Systems

Aiming to shorten the usual development time for a microcomputer design, some manufacturers are offering systems that constitute full-fledged microcomputers and complete prototype units. These vendors use chips supplied by Intel, National Semiconductor or Rockwell International.

Product forms range from consoles with circuitry on conventional PC boards to LSI dice mounted on a single substrate. Besides providing the necessary components for a host of applications, these products also feature additional circuitry that helps extend the capabilities of the internal LSI microprocessor.

An early microcomputer entry is the Micral series from R2E (Realisations Etudes Electroniques, based in France). Micral systems, built around Intel's 8-bit microprocessors, come in three processing speeds: 12 μs (basic model), 6 μs (Micral G) and 2 μs (Micral S).

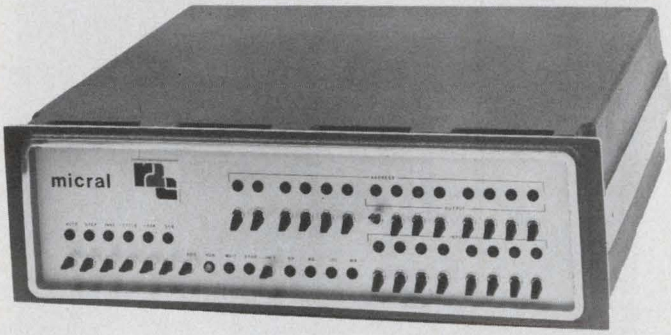
Although Micral uses the 8008, it has several instructions beyond those available with the 8008. The additional instructions permit improved handling of interrupts and allow register saves. Interrupt-driven I/O channels can be operated at a maximum throughput of 56-Mbyte/sec. Also, the Micral G (and S) includes five added instructions for data manipulation.

Software support includes a two-pass assembler, keyboard editor and diagnostics for peripherals and I/O interfaces supplied with the microcomputer. In addition R2E offers a high-level control language to simplify prototype development.

Micral units have a memory capacity of 16-k bytes, and this can be increased to 64 k. The direct addressing capacity of peripherals is a hefty 1792 bytes at the input and 23 at the output. Up to seven I/O channels can be operated.

Applied Computing Technology provides a series of Assemulators—short for assemblers/simulators—for the Intel and Rockwell 4-bit processors. Assemulators, which can interface directly with a teletypewriter, reduce the development phase of microcomputer designs.

In a typical development phase, a designer specifies and interconnects the I/O circuitry, which is then interfaced to the Assemulator. Programs are written and assembled in the Assemulator, which holds the utility system in ROM



Complete microcomputers extend the capabilities of the basic microprocessor used. R2E's Micral system, for example, provides additional instructions for interrupt handling and data manipulation. R2E uses Intel chips.

and the assembled program in a special emulation ROM. As a result, testing of programs involves simple manipulation of Assemulator console switches or the teletypewriter, so that program debugging can be reduced to a fraction of that normally required. And because the unit contains a resident assembler, costly time-sharing changes can be eliminated.

Both the CBC-4, the Assemulator for the Intel chip, and the PPS-4MP, which is used for Rockwell's model, are similar. However, the CBC-4 features a single-pass assembler for simplified assembly. For both units, the corrected program can be recorded in pROMs, which are then inserted into the microcomputer to complete the design.

Pro-Log features the PLS-400 family of microcomputers on 4-1/2 × 6-1/2-in. PC cards. Built around Intel's 4-bit processor, the 4004, the PLS-400 also contains Intel's 4002 RAMs and 1702A erasable pROMS. A minimum system consists of a single card with 1024 bytes of memory and 32 TTL I/O lines. For expanded capability, a three-card system contains 4096 bytes of memory and 128 TTL I/O lines.

Also available from Pro-Log is the MPS-800 family of 8-bit microcomputers for data processing. The family consists of three-card and five-card systems. Both units come with 256 words of pROM and 1024 words of RAM data/instruction memory. The memory can be expanded to 16-k words.

Process Computer Systems offers a microcomputer built around Intel's 8080 microprocessor. Called the Series 2000 Micro CPU, the system aims for such industrial applications as torque monitoring and control and also engine testing.

Plug-in modules allow the Series 2000 to control a variety of processes. The I/O modules include a 12-bit a/d converter, 16-bit digital input interface and modules for relay outputs. These units communicate with the system's memory and microprocessor through a common backplane data bus. Moreover the microprocessor sees all I/O devices as memory locations, precluding the need for special—and possibly less efficient—I/O instructions.

Process Computer Systems also offers plug-in breadboard cards, which allow the development of special analog and digital I/O modules. In addition assembler, compiler, debugging and other programs are available.

Teledyne Systems takes a unique packaging approach for its microcomputers. Rather than mount DIPs on PC boards, it mounts IC dice on ceramic substrates. The hybrid approach results in reduced size and improved reliability at prices that are comparable with PC-board equivalents. A single package measures only 2 × 2 × 0.2-in.

Teledyne's microcomputers are the TDY-52A, which uses Intel's 4004 microprocessor, and the TDY-52B, which uses National Semiconductor's dice to form a 16-bit unit. Instructions for the TDY-52A can be tailored to an application by alteration of the control microprogram in ROMs mounted on the substrate.

The TDY-52A requires external power supplies and some I/O circuitry, as does the 16-bit unit. In addition the TDY-52B requires an external clock (5.7 MHz square wave) and memory (ROM, RAM or combinations of both). Memory configurations are available in hybrid packages identical to those of the microcomputers.

New LSI Processors

At various stages of introduction—from chip development to some product delivery—are a multitude of LSI processors, all of which are expected to be available in quantity by about the middle of next year. The great majority use NMOS technology, handle 8-bit word lengths and have a basic cycle of about 2 μs, as does Intel's 8080. And most of these are being offered with special peripheral circuits and memories to minimize the circuitry otherwise needed.

In addition to these circuits, manufacturers are developing 12-bit processors that employ CMOS technology and emulate popular minis. And bipolar/LSI processors, featuring high-density techniques, promise to close the speed gap between microcomputers and conventional minis.

Five ICs comprise the basic microcomputer chip set promised by Motorola in its M6800 family. The heart of the set is the microprocessing unit, or MPU—an 8-bit parallel processor. The MPU lists 72 instructions and seven addressing modes, with one mode reserved for two 8-bit accumulators on the chip. It also uses 16-bit memory addressing, allowing memory size up to 65-k addresses.

The MPU shares data and address buses with special byte-organized memories—1024 × 8-bit ROMs and static 128 × 8-bit RAMs—and two programmable I/O circuits, the Peripheral Interface Adapter (PIA) and the Asynchronous Communications Interface Adapter (ACIA). The special I/O circuits permit reduced interface circuitry.

All five silicon-gate NMOS chips operate from a single 5-V supply. A total of 10 circuits of the M6800 family can be interconnected on the bus without reduction of the maximum clock rate of 1 MHz, which must be supplied by an external clock.

The interface circuits look like memory locations to the MPU. Hence the MPU can use the same instructions for, say, peripherals, connected to the PIA that it uses with RAM; special I/O instructions are not needed. The PIA controls and transfers data and status information to and from peripheral devices or, possibly, other microprocessors.

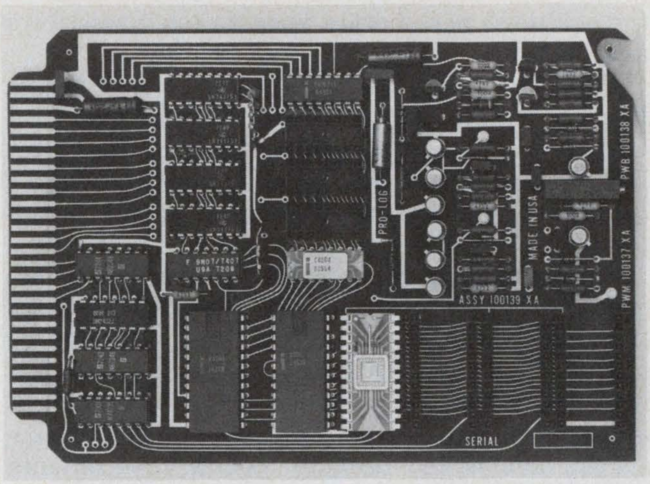
Much of the control logic for peripherals can be handled by the PIA. In an application described by Motorola, for example, a PIA replaces the 16 to 20 standard MSI logic circuits usually required to control popular OEM printers. The complete interface consists of the PIA, peripheral drivers and comparators. The latter provide TTL-compatible logic levels in the face of inductive surges from the printer.

Similarly the ACIA performs all the functions of a standard universal asynchronous receiver/transmitter. It relieves the MPU of many of the timing and control functions of asynchronous data communications. And it can interface directly with standard modems, including a special modem IC planned for the M6800 family.

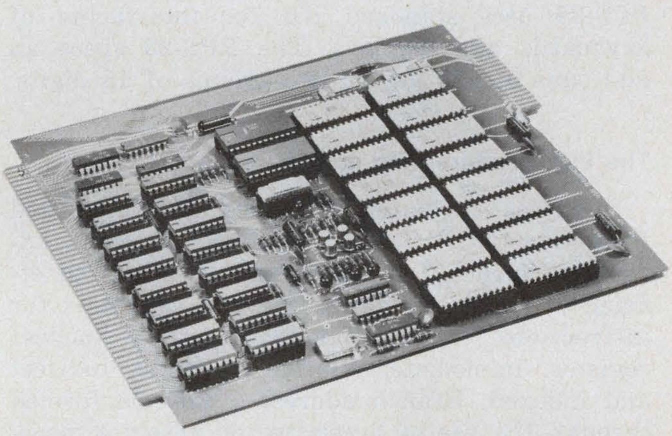
The MPU features decimal and binary arithmetic capabilities, variable-length instructions and double-byte operations. Addressing modes include extended, indexed, implied and relative, as well as immediate and direct. The minimum execution time, as for the Add instruction, is 2 μs. The maximum time reaches 12 μs in the case of a Software Interrupt instruction.

A special feature of Electronic Arrays' 8-bit NMOS parallel processor is string or series capability. Up to 16 bytes of data can be entered from memory or from an I/O device, and stored in the chip's multiregister accumulator for processing. And the 16-byte data transfer can be accomplished with a single instruction.

Moreover the chip contains a 24-byte RAM, called the Program-Address Storage (PAS). It can be used as a push-down stack, for interrupt



Microcomputers on PC boards are offered by Pro-Log, Models available include a 4-bit system for dedicated-controller applications and an 8-bit model for data processing. Both systems use Intel chips.



Prototype systems help cut development time. Applied Computing Technology calls its systems Assemulators, or combination assemblers/simulators. The vendor supplies prototype units for microprocessors offered by Intel and Rockwell International.

vectors, for program-call storage, or for a combination of these functions. For expanded capability, the PAS can be extended into external RAM.

The 8-bit processor has about 66 instructions and addresses up to 65-k bytes of memory. The four addressing modes are direct, immediate, indexed and extended. Memory can be ROMs or RAMs of various speeds in any combination.

Other circuits planned by Electronic Arrays for the microprocessor consist of the following: a 1024 × 8-bit ROM, 256 × 4-bit RAM and an I/O controller. The I/O chip is intended to be a general-purpose, programmable logic design for any interface.

Fairchild Semiconductor plans to offer the F8 chip set, consisting of an 8-bit NMOS Isoplanar microprocessor, a memory interface chip, an 8-k bit ROM and a custom RAM. The system features a basic cycle of 2 μs and has internal clock and interface circuitry. Direct-drive capability exists for standard peripherals, such as teletypewriters and printers.

Fairchild estimates that improvements in the F8 family can reduce the amount of peripheral circuits by 10 to 30%, compared with other 8-bit NMOS processors. Also, preliminary benchmark programs indicate speed improvements by a factor of 1-1/2 to 3.

Software support includes a compiler to accept the PL/M language and a special conversational utility system that requires an interface module. The system allows a program to proceed in slow motion, so designers can debug a program with paper tape or cassette. The utility system avoids the need to modify the contents of a pROM each time a correction is required.

An earlier microprocessor from Fairchild is the PPS-25 system, a 4-bit chip set. Intended for scientific calculators and control systems, the PPS-25 uses standard ICs for interfacing of keyboards and displays. The PPS-25 specs an add time of 125 μs for two groups of 16 digits.

The PIP: 8 addressing modes

Signetics' upcoming Programmable Integrated Processor (PIP) allows the use of eight addressing modes, for increased flexibility and efficiency in programming. Operand addresses for instructions can be defined in these modes: register, immediate, relative, absolute, indirect and indexed. Branch addresses may be formed through the use of a relative or absolute mode, and each may be direct or indirect.

The PIP responds to over 64 instructions, the most complex of which are executed in less than 10 μs. Instructions feature variable lengths for improved bit efficiency; they may be 1, 2 or 3 bytes long. Also each of the chip's four general-purpose registers may be used as an accumulator. Hence processing bottlenecks that result from having only a single accumulator are eliminated.

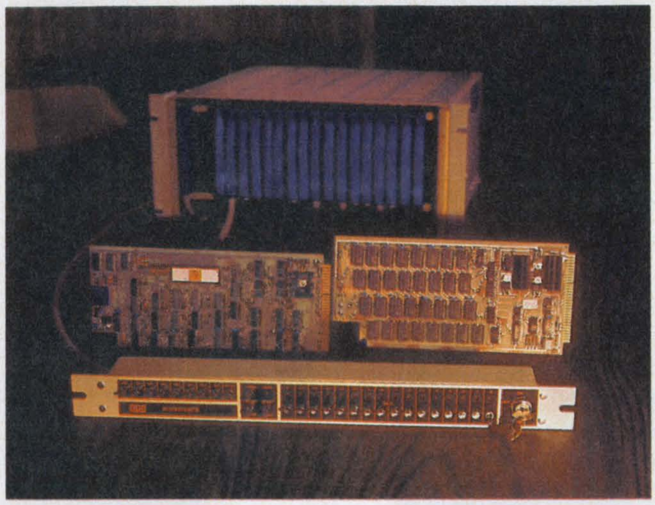
The Signetics' chip operates from a single 5-V supply. Its input clock frequency is variable down to dc; externally the PIP resembles a static IC. The processor's address lines allow direct addressing for up to 32-k bytes of memory. And PIP's vectored-interrupt capability allows indirect branching to any location in memory.

A full range of design aids is planned for the PIP, including a cross-assembler written in Fortran II rather than the more common but advanced Fortran IV. The use of the more basic language permits the assembler program to be run on a wide range of computers, from mainframes to minicomputers.

In a rare example of microprocessor alternate sourcing, Microsystems International Ltd. offers the 8008, the 8-bit PMOS processor introduced by Intel. MIL provides the microprocessor, as well as the various components needed to make an 8-bit microcomputer, on seven basic boards. Each board measures 4-1/2 × 6-in. and uses a standard dual 22-way edge connector.

On the MOD8-1 board, for example, are the microprocessor, clock generators and state-decoding and bus-switching control logic. An I/O board, the MOD8-2, contains teletypewriter interface and reader-control and system-restart logic. Other boards provide ROM, RAM, buffer and I/O circuitry.

MIL's design aids include the Monitor-8 software package, which allows interactive debugging of designers' programs entered in assembly language from a teletypewriter. In



Microcomputers aim for industrial applications such as engine testing and torque control. Process Computer System's Series 2000 Micro CPU features a common backplane data bus on which interface modules communicate with the microprocessor and memory.

addition the company offers a similar applications package for a series of boards that will use a proprietary 4-bit microprocessor expected shortly. The 4-bit system is called the MOD4 series.

Proving that PMOS is still around for 8-bit units, Mostek is sampling an 8-bit p-channel, parallel processor called the MK5065. Compared with first-generation units, the MK5065 expands the number of instructions and slashes the number of peripheral circuits. Also, the chip's architecture is three-leveled for rapid handling of interrupts. One or two of the chip's three program counters and three accumulators, for example, can be reserved for immediate servicing of interrupts.

Bipolar processors emerge

The first general-purpose bipolar/LSI microprocessor has just been announced by Raytheon

Semiconductor. A seven-chip processor called the RP16, the 16-bit unit surpasses MOS microprocessors in speed through the use of bipolar technology, increased addressing modes and an improved instruction set. Two versions of the RP16 are slated. Model A emphasizes arithmetic capabilities, while Model B stresses byte handling (see product feature; p. 109 this issue).

While most microprocessor chips are intended for random-logic designers, a Schottky-TTL processor from Monolithic Memories is aimed at the computer architect. The special-purpose microprocessor, dubbed the Model 6701 microcontroller, can be used to emulate conventional computers and replace scores of packages at reduced power. A single 6701 can perform the function of 25 TTL MSI packages while saving about 6 W.

The 6701 consists of four 4-bit controllers and associated ROMs and shift registers. None of the ROMs is used to decode the processor's 36 instructions, which are at the fundamental level of arithmetic logic units. As a result, microprogramming techniques can be employed to apply the IC.

A single cycle takes about 200 ns. But within this period the 6701 can execute such functions as subtract, shift and store. The bipolar speeds assure a precise emulation of conventional machines, which use standard-bipolar circuits. Moreover the 6701 can be expanded in increments of 4 bits, so that other than 16-bit systems can be designed without significant reductions in speed. Other applications foreseen for the 6701 include high-speed peripheral controllers and point-of-sale systems.

12-bit models fill a gap

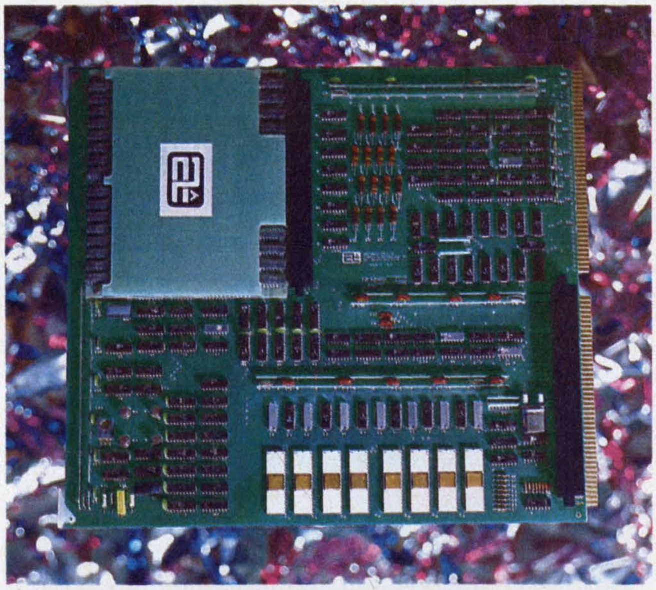
Although much of the current microprocessor activity involves 8 and 16-bit units, two manufacturers—Intersil and Toshiba—are filling the gap with 12-bit models. The Intersil processor is designed to be a CMOS/LSI equivalent of Digital Equipment Corp.'s popular PDP-8 minicomputer. The Toshiba processor (the TLCS-12) is a proprietary PMOS design, with such component-saving features as a timing generator on the chip.

Preliminary data for the Toshiba chip indicate add and subtract times of about 10 μs. And multiply and divide functions reportedly can be executed in 30 to 60 μs. The chip operates from $\pm$5-V supplies and dissipates 0.8 W.

Intersil's CMOS microprocessor benefits from the sizable software support that exists for the PDP-8. And the many designers familiar with the mini should be able to transfer that experience to the CMOS processor. However the unit's repertoire of eight basic memory-reference instructions tends to limit the range of applications.

Still a multitude of applications uses the PDP-8. Noting this fact Intersil plans to develop a full set of circuitry and memory, all using CMOS, to operate with the processor. Conceivably, the end result could be a pocket-sized, portable PDP-8.

RCA, the leading CMOS manufacturer, also has a CMOS microprocessor. Called COSMAC, it is an 8-bit, two-chip set that emphasizes low-power dissipation and I/O interface capabilities in a proprietary design. Each chip dissipates only 100 μW. And the I/O can be controlled



A complete mini, except for power supply, comes on this PC board. Computer Automation's Naked Mini/LSI-1 uses four custom LSI chips, each a 4-bit slice, and programmable logic arrays—rather than ROMs—to form the mini's central processing unit.

with up to 16 commands and a total of 23 lines, including a bidirectional data bus.

COSMAC is built around a 16 $\times$ 16-bit scratchpad register, from which references to memory are made. The microprocessor can address up to 65-k bytes of memory, and it uses a simple two-step fetch-and-execute sequence.

The processor cycle, consisting of eight clock pulses, ranges from 3 to 10 μs. With the faster speed, and using a RAM with a 1-μs cycle, a 6-μs fetch-and-execute time can be obtained for any instruction. Response to interrupts, allowed only after complete instruction cycles, ranges from 3 to 9 μs.

In the wings, RCA has a single-chip COSMAC. In addition the company is developing silicon-on-sapphire processors, with multichip units for military applications initially scheduled.

(continued on next page)

Micro-based Minis

Not to be undone by the emergence of component manufacturers into the microcomputer area, minicomputer makers have also embraced LSI microprocessors. Generally using custom MOS chips, they offer models aimed at high-volume applications—as are microcomputers—with large-quantity unit prices hovering about the \$500 level. This undercuts the price of many micros.

Micro-based minis are promoted as low-end

Custom silicon-on-sapphire LSI processors are the basis for General Automation's LSI 12/16, an 8-bit system. The mini maker also uses SOS chips for a 16-bit system, the LSI 16, that is a functional equivalent of the company's SPC-16 mini.

models complementing an established line. The new units benefit from the impressive software support—including extensive application programs—available with the rest of the line. Moreover the units offer traditional mini hardware/software features, which results in unique and versatile capability. At present Computer Automation, General Automation and DEC are incorporating microprocessors into their newer models. However, most industry observers expect that list to grow.

Computer Automation calls its microprocessor-based minicomputer the Naked Mini/LSI-1—an allusion to the fact that the mini comes complete, except for power supply, on a 15 × 17-in. PC board. The LSI-1 uses space-saving MOS programmable logic arrays, rather than ROMs, to contain the unit's control logic. Four more MOS/LSI chips, each a 4-bit slice, make up the rest of the central processing unit for the 16-bit machine.

Standard features include direct-memory addressing and four other I/O systems. The unit also has hardware multiply and divide, multilevel indirect addressing, and up to 256 vectored priority interrupts. Memory can range from 1-k to 262-k 16-bit words, and may consist of core or semiconductor types in any combination. The basic processor cycle time is 1.6 μs; an add-memory-to-register operation, involving 16 bits, takes 9.2 μs.

A special feature of the machine's architecture is its ability to organize memory automatically. If memory modules of different size and type are mixed or rearranged on the bus, the computer assigns addresses without any reference to software.

The processor board contains slots for optional hardware functions. These include power-fail/restart, teletypewriter/CRT interface and real-time clock. In addition various plug-in options are available for additional buffers, drivers, interfaces and expanded memory.

Moreover the LSI-1 has an impressive 168 basic instructions. And most of these require only one memory location in contrast with the two or more locations usually needed in other minis.

The instruction set contains 29 memory-reference instructions—which simplify operations involving many pieces of data stored in memory. And conditional jumps can be performed with 63 instructions, each of which causes both the test and the jump. Other features of the instruction set include memory scan, three-way compare, word and byte addressing and full shift capability.

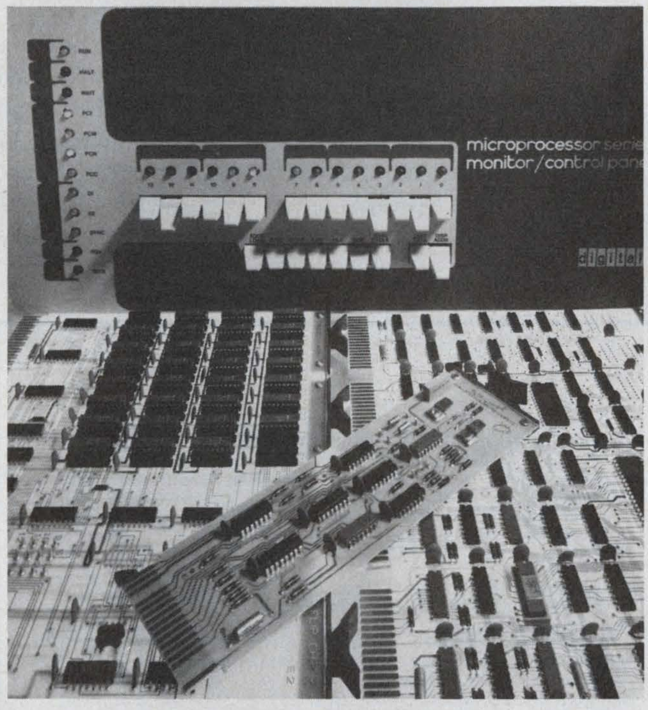
Among the various design aids available, Computer Automation offers several advanced software packages. These include Advanced BASIC, which can run with only 4 k of memory, Extended BASIC, using 8 k of memory, and FORTRAN. Standard packages include assemblers, loaders and debug and utility programs.

Mini turns to SOS

LSI processors employing silicon-on-sapphire techniques are used by General Automation in an 8-bit microcomputer—the LSI-12/16—and an expanded 16-bit model—the LSI 16. The SOS chips, developed for General Automation by Rockwell International, permit operation at speeds comparable with more conventional minis that use bipolar circuits.

The 8-bit unit, featuring 1 to 32-k words of semiconductor memory and an instruction execution cycle of 2.64 μs, comes with a low price tag of \$495 in 1000-unit quantities. It can be obtained on a 7-3/4 × 10-in. PC board and in an enclosed system that contains power supply, battery backup for volatile memory and card slots for additional I/O boards.

For designers who want to retrofit new instructions in a ROM, the 8-bit LSI-12/16 provides a ROM "patch" system in addition to main memory. The patch elminates the need to change ROMs when similar, but not identical, ROM programs are required. In addition the architecture of the LSI-12/16 has a shared-byte feature, allowing a two-byte instruction to be stored in a single-byte of memory. General Automation estimates that this architectural feature could reduce the amount of program memory otherwise required by about a third.



A building-block approach to microcomputer designs is offered by Digital Equipment Corp. The modules, using Intel's 8008 PMOS processor, contain the peripheral circuitry usually needed to operate the microprocessor.

The LSI-12/16 uses 12-bit parallel addressing, which permits direct addressing of 4-k words of memory without paging techniques. It also provides eight 12-bit hardware registers, 52 basic commands, a processor-controlled priority-interrupt system and a teletypewriter interface. Standard control features include a relative time clock, external priority interrupt, 16-bit parallel I/O bus, integral console and a ROM-based console program. Several fail-safe features also protect against power transients and interruptions, component failures and program errors.

Software development can be minimized through the use of a complete cross-program generation system on the company's SPC-16 minicomputer. The disc-based system provides assembly, editing and debugging. Other aids offered include a device-independent, real-time executive program and a conversational assembly system.

While the LSI-12/16 microcomputer can replace the company's somewhat slower SPC-12 minicomputer, General Automation's 16-bit unit is billed as the functional equivalent of the company's slightly faster SPC-16 mini. Furthermore the LSI-16 and expanded memory offers on two small boards the performance of the SPC-16 on six larger boards. The basic LSI-16 unit comes on a 7-3/4 × 11-in. PC board, containing 1-k words of memory and an SOS microprocessor chip set. The two chips consist of an arithmetic logic unit and a control read-only memory, which stores the control logic for the ALU.

A second "micromemory" board of the same size provides a 32-k-word × 18-bit (16 bits plus parity) memory system. The high density is achieved through the use of hybrid packaging. General Automation mounts eight 1103A (1-k bit RAM) memory chips onto a common ceramic substrate and plugs the substrates into vertical connectors on the board. A conventional approach, involving individual DIPs, would have resulted in a maximum board density of 16-k bits. In addition it will be possible to obtain a 120-k micromemory by replacement of the 1-k bit chips with 4-k bit RAMs, when they later become widely available.

Together with the micromemory board, the LSI-16 offers an average cycle time of 1.8 μs. Standard features of the LSI-16 board include power-fail/restart capability, real-time clock, operation-monitor alarm, cold-start capability and an asynchronous memory interface. An additional PC board for options can be obtained with parity and hardware memory protection, teletypewriter controller, operator's console and a piggyback read-only memory board that can accommodate up to 4-k 16-bit words of memory.

MPS modules ease interfacing

A microprocessor module set is the initial entry into the microcomputer field by Digital Equipment Corp. The mini maker expects the modules, which use Intel's 8-bit PMOS processor, to be used as building blocks for dedicated controllers. Called MPS, the series can perform decision-making functions, add intelligence to data terminals and replace hard-wired logic systems. Moreover the units come complete with much of the peripheral circuitry usually needed to operate the microprocessor; hence interface

(continued on next page)

problems are reduced.

Five modules constitute the series. The CPU module contains the processor and complete instruction decode and control circuitry. Other modules provide 1-k to 4-k words of read/write memory and 256 to 4-k words of programmable read-only memory. A detection module can be used to obtain priority interrupts, while a monitor/control-panel unit can serve as a diagnostic checkout.

Software aids needed to program the MPS come in paper-tape format. The aids, offered in a special kit, consist of editors, assemblers, pROM programmer, debug software, duplicator and loader. Programs are prepared in conjunction with a PDP-8 with 4-k words of memory.

TTL/MSI processors are offered, too

Still other microprocessor products use medium-scale-integration (MSI) standard-TTL circuits. These TTL/MSI processors, like their LSI cousins, can be programmed for a host of high-volume applications.

Complete TTL/MSI processors come on PC boards or in compact modules, and they sell for about \$1000 in single-unit quantities. They operate at faster speeds than their MOS counterparts, and they are offered by established vendors in the minicomputer business.

For example, 12-bit TTL/MSI units have been introduced by DEC, Fabri-Tek and Microdata The DEC model, called the PDP-8/A Miniprocessor, is a two-module, MSI version of the company's widely used PDP-8 mini.

Fabri-Tek's MP12 processor includes 4-k words of core memory in a 2 × 15 × 9.5-in. module, and it requires only one 5-V, 40-W supply. And Microdata's Micro-One unit, on a single 8-1/2 × 11-in. board, can be microprogrammed to emulate general or special-purpose computers.

The TTL/MSI processors use circuits that are widely alternate-sourced, in contrast with LSI units, which are virtually sole-sourced. But that picture could change dramatically in the next 12 months. Several manufacturers—Advanced Micro Devices, for example—are reportedly on the verge of following Microsystems International's

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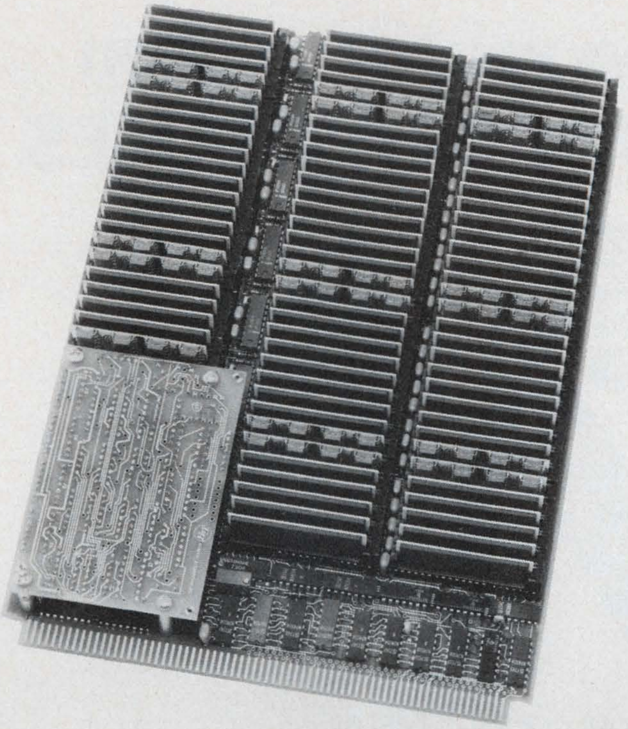

Hybrid packaging yields a 32-k × 18-bit 'micromemory' on a single board. General Automation offers the unit for use with the company's LSI-16 system.

lead in alternate-sourcing Intel's 8008 processor, or possibly producing Intel's 8080 chip. Aiming at more recent models, American Microsystems has plans to alternate-source Motorola's microprocessor chips. Furthermore a number of primary processor-chip suppliers are seeking other sources for their proprietary circuits.

Also expected are more bipolar/LSI microprocessors. For example, Texas Instruments—though tight-lipped officially—is said to be developing a biploar unit that uses integrated-injection-logic (I^{2}L) for increased density. I^{2}L maintains the high speeds of bipolar circuits while achieving densities comparable with MOS (see "Integrated Injection Logic Shaping Up as Strong Bipolar Challenge to MOS," ED 6, March 15, 1974, p. 28). Most observers consider a high-density process, such as I^{2}L, absolutely essential to achieve the high functions per chip needed for bipolar/LSI.

The strong emergence of bipolar/LSI microprocessors could have far-reaching effects. At present processor-chip vendors, who are the hardware experts, are increasing their software support, while mini makers, who excel in software, are stripping down to "bare-bones" models.

However, direct competition of products generally is limited because of the speed gap between most micros, which use MOS, and bipolar mini models. Bipolar/LSI processors could bridge the speed gap, thereby sparking a historic confrontation between chip vendors and mini makers. ■■

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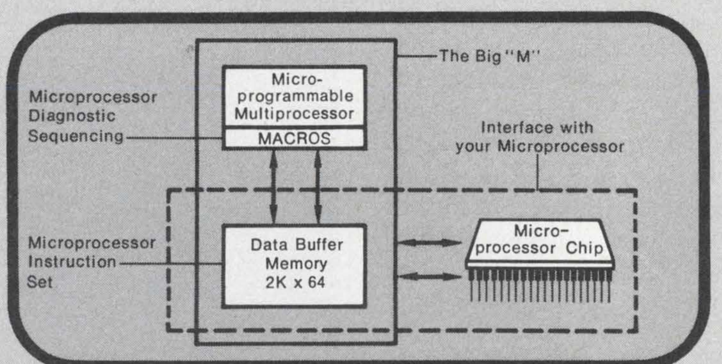

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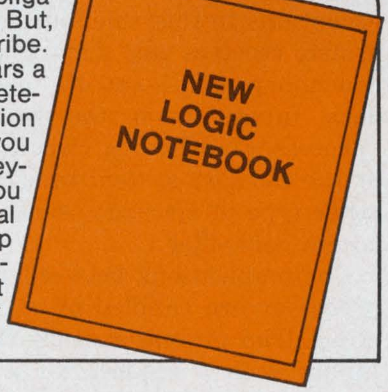

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INFORMATION RETRIEVAL NUMBER 33

Give flexibility to memory systems

with an asynchronous design. You can use any type of memory chip, including the newer 4-k dynamic RAMs.

Increasingly, asynchronous designs are being used in memory systems to boost versatility and capability. Among other benefits, an asynchronous system permits the use of virtually any speed memory element—up to certain processor limitations—and either dynamic or static types. The advantages result from the asynchronous method's well-defined, but flexible, interface.

Systems become flexible enough to be upgraded, as required, with larger, faster or cheaper memories. This flexibility is especially important, now that IC manufacturers are offering a variety of 4-k dynamic RAM chips. With an asynchronous system, designers need not be locked into one vendor's product. They can switch to other units, depending on the availability of alternate sources —or just plain availability.

Moreover the design of an asynchronous system need not be cumbersome if you break it down into these phases:

- Define the interface specifications.
- Select the memory chip.
- Design the control logic.
- Provide interface elements for compatibility.

What is an asynchronous system?

An asynchronous memory system operates independently of the processor timing. There are exceptions to this rule, but generally the memory system receives only a start command—to initiate a memory cycle—and the necessary address and data inputs from the processor. (The term "processor" indicates circuitry on the other side of the memory-system interface. It may be some other type of circuitry, such as a direct-memory-access controller.)

Communications between the memory and the processor are handled by a "hand-shaking" technique. The processor sends the address and data inputs with a request for a memory cycle. The memory system acknowledges the cycle request. If the cycle is an access from the memory, the memory system sends data back to the interface along with a signal to indicate that data are available. When the memory can receive requests for a cycle from more than one source, the sources will have some sort of priority control of the memory. This priority circuitry is often contained in the control section of the memory system.

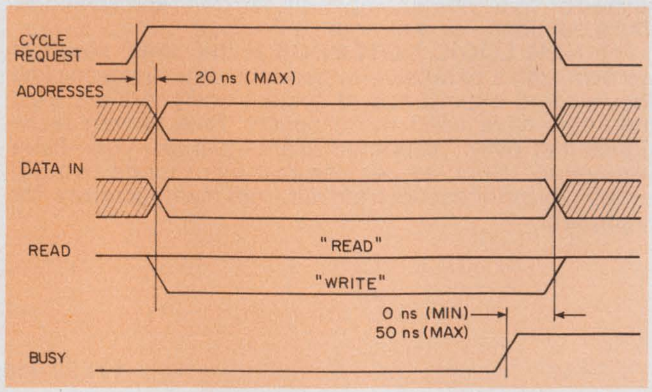
In addition to any priority logic, the control section contains the logic required to take the system interface commands and generate the signals for the internal operations of the memory system.

An asynchronous system also has two other major elements: interface circuitry and the storage matrix. The matrix consists of the memory chips, placed in a compact layout with power-supply decoupling, and any special signal conditioning elements—such as pull-up resistors.

System interface requirements

Several questions must be answered to determine the memory-system interface requirements. What is the timing for the control signals that the processor sends to the system interface? How are the data and address signals related to these control signals? Does the processor have any access or cycle-time limits?

To aid in the memory-circuit selection, the various cycle types—such as read, write, read-modify-write and write-verify-read—must be specified. This involves specification of control



1. **An asynchronous design begins** with specification of the system interface signals to the memory system.

Bob Cook, Manager, MOS Memory Design, Mostek Corp., 1215 W. Crosby Rd., Carrollton, Tex. 75006.

signals from the processor and their timing.

For example, a typical memory cycle begins with a Cycle Request signal from the processor (Fig. 1). The cycle type—read or write—is determined by the Read signal. The diagram shows that the Address, Data In and cycle type signals must be available no later than 20 ns after Cycle Request.

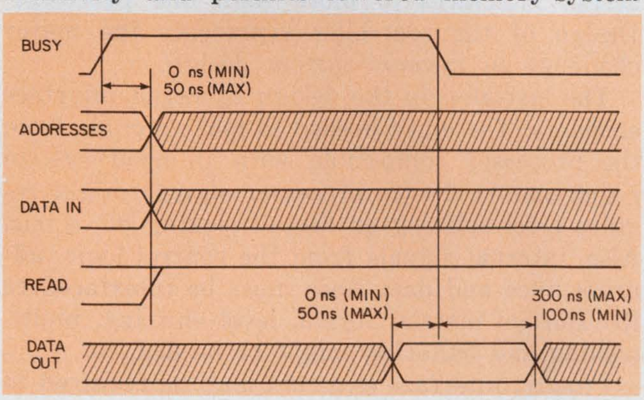
The Busy signal comes from the memory system. From Fig. 1, information from the processor remains valid at the interface until 0 to 50 ns after Busy occurs.

Other questions relate to the control and data signals that the memory system sends back to the processor. How does the memory acknowledge the start of a cycle? How should valid output data be specified for memory access? How long should this output data be valid at the interface?

In a typical case—for a read cycle, for example—the Busy signal indicates that output data are at the interface (Fig. 2). The diagram shows that data must appear no sooner than 50 ns before Busy, but before the Busy signal fades. Data remain valid for 100 to 300 ns. A further interface requirement might be that no cycle requests can occur until after Busy returns to logic ZERO.

Save memory-system power

Another possible control signal at the interface indicates long periods of intended memory inactivity and permits lowered memory-system



2. **These control and data signals are sent back** to the processor by the memory system.

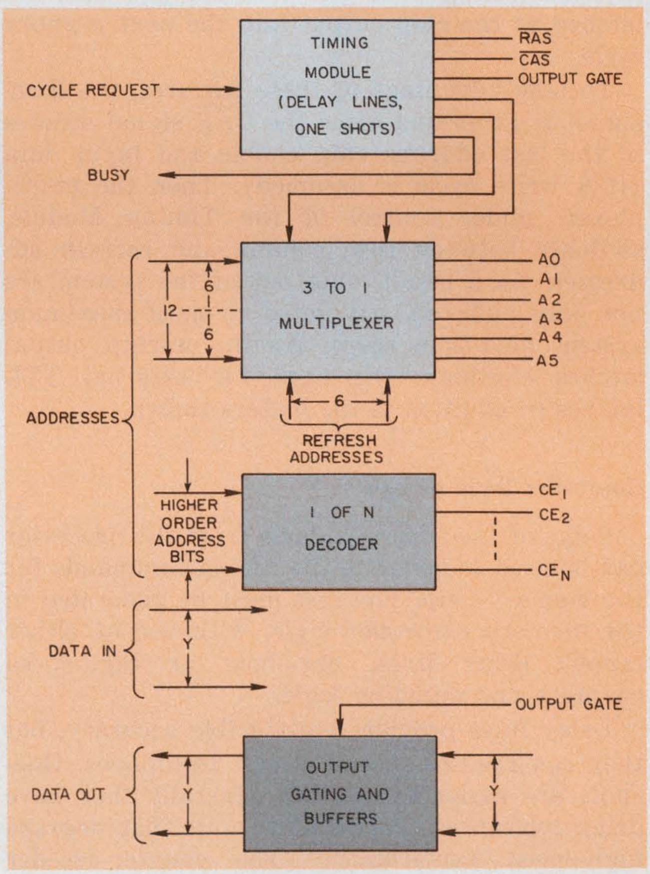
4-k RAMs: New and efficient

The advance of memory chips to ever higher densities has culminated in 4096 × 1-bit dynamic RAMs (see "4096-Bit RAMs Making the Scene as an Alternative to Core—Finally," ED No. 3, Feb. 1, 1974, p. 40). But these chips not only provide the largest storage density. Additional features on the chip allow increased efficiency for memory-system designs.

A 12-bit address selects one of 4096 memory locations, for which data are either read or written. Generally the RAM chips receive the 12 bits in parallel and latch them on the chip. One RAM comes in a package with only 16 pins. The 12 address bits multiplex into the chip on six address pins and in two steps, requiring two clocks. Other parallel-address RAMs use a single clock.

And 4-k RAMs usually include a chip-select input, allowing modules of greater than 4-k words to be built. All have read/write control circuitry, which determines whether data are written into or out of the IC.

Data into the chips are often latched, just like addresses. Output latches, a less common feature, are also available. For all of the new RAMs, inputs feature TTL-compatibility.



3. **Interface circuitry for a memory system** assumes the use of Mostek's 4-k dynamic RAM, the MK4096.

dissipation. This control signal is especially useful when memory systems are designed with circuits that have a standby mode or when system support circuitry must be powered down.

The memory circuits selected must, above all, be able to provide the timing and cycle types dictated by interface specifications. Further criteria are the memory's size and modularity, if any. For example, if a memory system has to be expanded in, say, 2-k-word sections, a 4-k-word-by-1-bit chip isn't the most efficient choice.

Price and availability are other important factors to consider in selection. And the easier a memory circuit is to design into a system, the shorter the development cycle and possibly the lower the system cost.

Newer memory chips offer several features that simplify their design into a system. These features include latches for addresses and input/output data, direct TTL compatibility, static operation and standby modes. The special features of Mostek's 4-k dynamic RAM (the MK4096), for example, allow use of the interface circuitry in Fig. 3. Buffering, needed to drive the memory array, is not shown.

The RAM, which comes in a 16-pin DIP, latches input addresses, chip enable and data as TTL signals. Two TTL clock signals (terminals $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$) control the multiplexing of the 12-bit address onto the chip, which uses six pins for addressing. In addition the output data are latched at the chip output into the next memory cycle.

To take advantage of these features, the Busy signal is generated after the $\overline{\text{CAS}}$ signal strobes in the last address, chip enable and input data (if a write cycle is assumed). Then the multiplexer, under control of the Timing Module, switches between row, column and refresh addresses. As a result, data out of the system are not only buffered, but gated to meet maximum system hold-time specs. Again, on-chip output latches eliminate the need for external TTL latches in addition to the buffers shown.

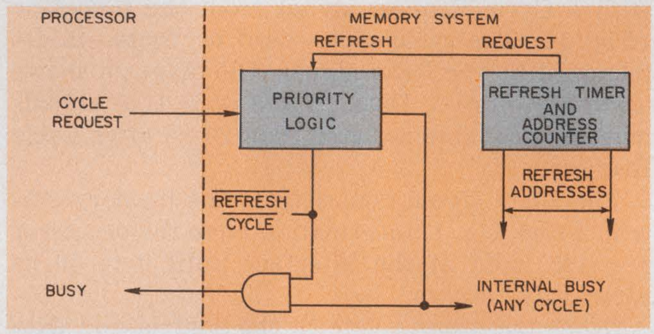
Controller logic design

Some of the control signals from the processor can be used to generate the timing commands for the memory chip. The rest must be generated in the memory controller logic, with use of either tapped delay lines, one-shots or high-speed counters and decoding logic.

Delay lines provide reproducible accuracy, but they can require special circuit techniques. One-shots are easier to use, but generally they have delay tolerances from unit to unit that degrade high-speed performance. The counter-decoder scheme requires an accurate, high-frequency clock.

Generation of the memory-chip timing solves only part of the problem. The memory controller must also generate the output signals from the system. Here again, care must be taken to adhere to the system interface specs. The "output valid" signal has to be generated, and data from the memory must be supplied to the interface at the proper time. If an "end of cycle" command is required, it, too, must come from the memory controller.

The controller also contains priority logic to permit refresh cycles for dynamic memories. This logic provides the refresh interval, advances the refresh address counter and gains control of the system to perform the refresh.



4. **The controller section of an asynchronous design** can include refresh-cycle interrupt logic needed for dynamic semiconductor memories.

The logic in Fig. 4 shows how a refresh cycle prevents the system from placing a Busy signal on the interface. If we assume still that Busy acknowledges Cycle Request, the priority logic must not interrupt a regular cycle once it has begun. But as soon as a normal cycle is completed, the refresh circuitry can take command of the system. If a regular cycle is requested during a refresh cycle, the priority logic ignores the request until the refresh cycle is completed.

Interface several processors

Also contained in some of the control logic might be the circuitry to achieve direct-memory access interfaces to more than one processor. Design of the controller represents the major challenge in memory-system design.

The last step in the design concerns interface elements. These are needed to make signals from the processor compatible with internal system requirements. Hence processor signals might require level shifting or demultiplexing off a bus. Also, internal signals from the control logic, address lines and data lines must be interfaced to the storage matrix. Again, level shifting, multiplexing and buffering might be needed.

Finally, interface elements may be required to achieve output voltage and current compatibility with other systems. ■■

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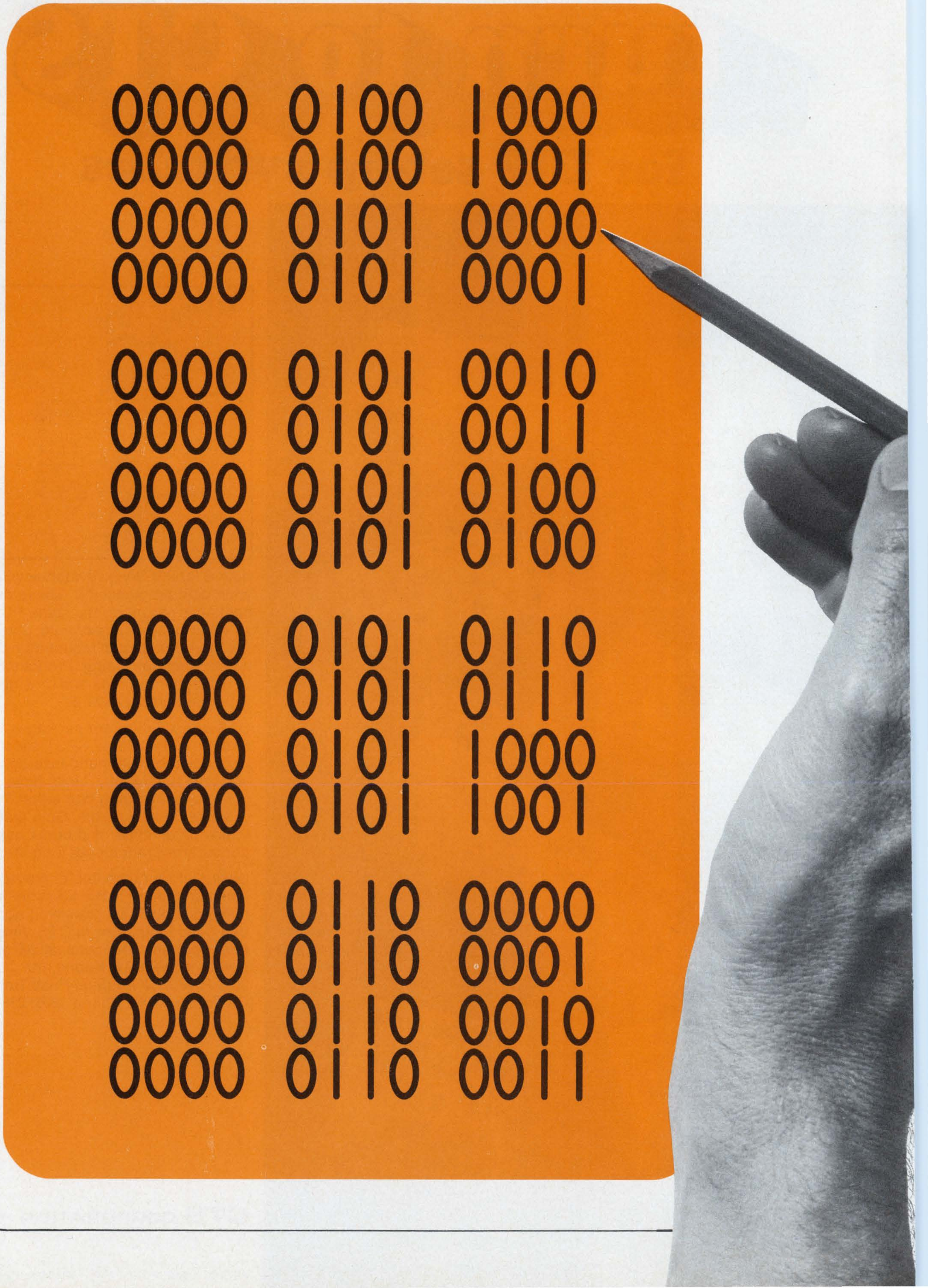

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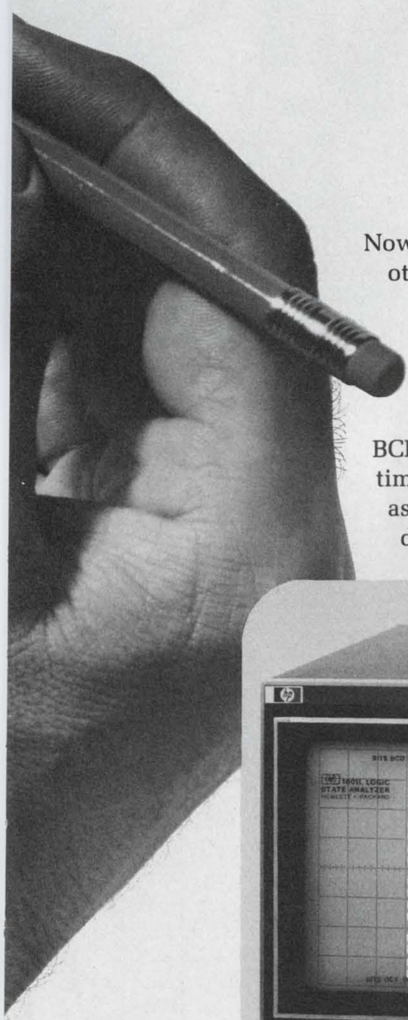

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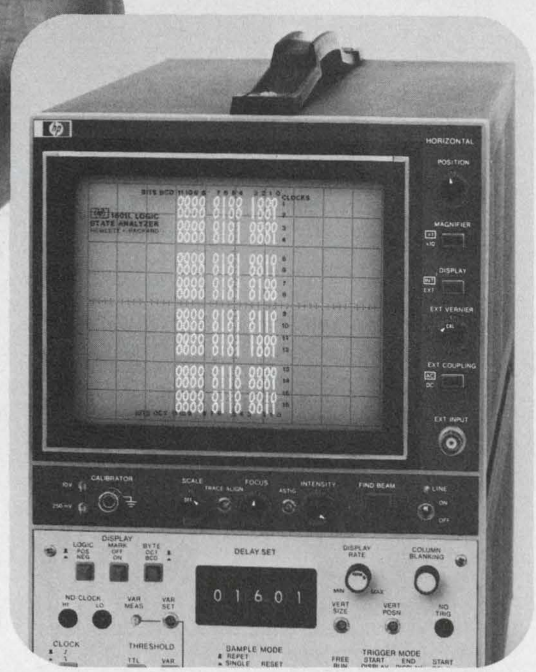

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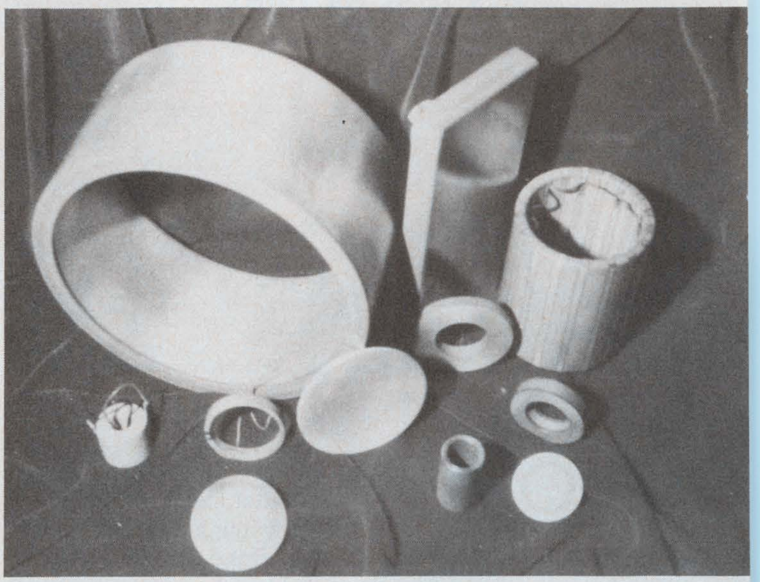
Piezoelectric ceramic transducers:

Learn to use these energy transformers as a connecting link between mechanical equipment and electronic circuits.

Ceramic piezoelectric transducers—energy transformers—provide a sturdy bridge between mechanical processes and electronic circuits. The devices can work as linear translators, acoustic transmitters and receivers, dynamic strain gauges, storage devices, accelerometers and delay lines.

Ceramic transducers, of course, have both mechanical and electrical specifications. Electronics engineers recognize them as voltage generators; mechanical engineers see them as mechanical motors. In the last ten years, with the availability of more uniform materials, such as lead zirconate titanate instead of barium titanate, and with higher dielectric constants, applications have expanded from the simple phonograph cartridge to acoustic "X-ray" machines.



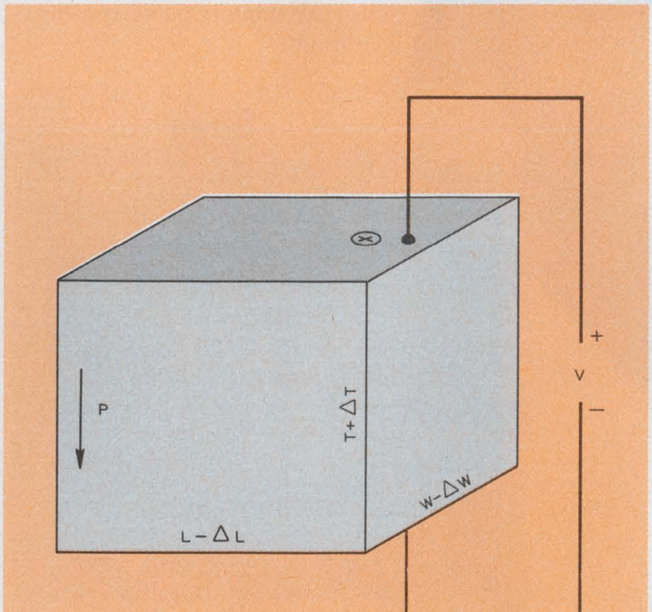
1. **Piezoelectric ceramic materials** are available in many shapes and sizes.

Making a piezoelectric transducer

Piezoelectric devices are composed of a high-dielectric-constant polycrystalline material, which can be formed into many shapes and sizes (Fig. 1). The piezoelectric ceramics don't exist in the free state. To produce piezoelectric properties, the dielectric material must be subjected to a process known as polarization. A strong electric field is placed across the dielectric (Fig. 2). This distorts the physical shape and electrical properties of the crystallites and creates a permanent, net electric polar moment. This process is similar to the creation of magnetic dipoles or the aligning of domains in magnetic materials.

Since the poling process distorts the piezoelectric material, the physical and electrical characteristics in the poling direction differ from the properties perpendicular to the poling axis—that is, the material becomes anisotropic.

To simplify the identification of the different ceramic parameters, the following standard notations are used: d_{ij}, g_{ij}, k_{ij}, y_{ij} and K_i. The "i" subscript identifies the direction of the electrical field associated with the applied voltage or charge



2. **The electric fields** required to pole the ceramic material are often as high as 100 V/mil.

Charles Edmiston, Field Engineering Manager, Gulton Industries, Piezo Products Div., P.O. Box 4300, Fullerton, Calif. 92634.

produced. The "j" subscript represents the direction of stress or strain. The numerical value of the subscript identifies the axis or direction in the ceramic material.

To identify directions in the ceramic, three axes are drawn on an imaginary unit cube of the material (Fig. 3). As shown in Fig. 3a, the 1 and 2 axes are perpendicular to the poling axis. The 3 axis is parallel to the poling axis. Since two of the axes are perpendicular to the poling direction, their properties are identical. Thus their subscripts (2) are usually omitted. When the mechanical stress or strain is shear in the mode, the applied stress is parallel to the direction of polarization and the mechanical subscript is designated as 5 (Fig. 3b).

Coefficients are important

The piezoelectric charge coefficient, designated d_{ij}, and the voltage coefficient, g_{ij}, describe the electrical and mechanical parameters of piezoelectric ceramics.

The coefficients d_{33}, d_{31} and d_{15} are the ratios of the electric charge generated per unit area to the force applied per unit area. The d_{33} term applies when the force is in the 3 direction (along the polarization axis, Fig. 4a), and the force is impressed on the same surface on which the charge is collected.

Coefficient d_{31} applies when the charge is collected on the same surface as before but with the force applied at right angles to the polarization axis (Fig. 4b). Subscript 15 indicates that the charge is collected on the electrodes that are at right angles to the original poling electrodes and that the applied mechanical stress is shear (Fig. 4c).

The units for the d_{ij} coefficients are commonly expressed as coulombs/meter^2 per newton/meter^2. When the area of the electrode on which the charge is collected equals the area on which the force is applied, the areas cancel and the coefficient is expressed as coulombs/newton.

The d_{ij} terms also represent the mechanical strain produced when the ceramic is used as a motor device. The units are then usually expressed as meters/volt.

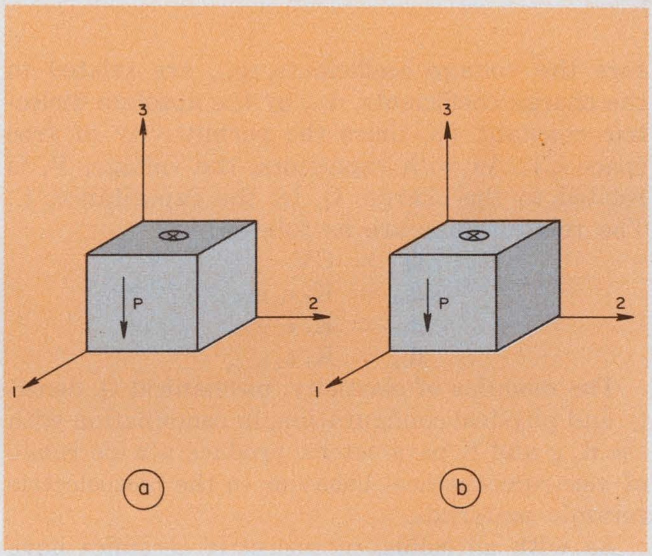
Piezoelectric voltage coefficients g_{33}, g_{31} and g_{15} represent ratios of the electrical field produced to the applied mechanical stress in an open-circuited condition. Units are usually expressed in volt-meters/newton.

The ceramic materials are essentially dielectrics with unusually high relative dielectric constants. The constants have typical values that range from 500 to more than 3000. Ordinary dielectrics such as mica, glass or plastic have relative dielectric constants that might range from 2 to 10.

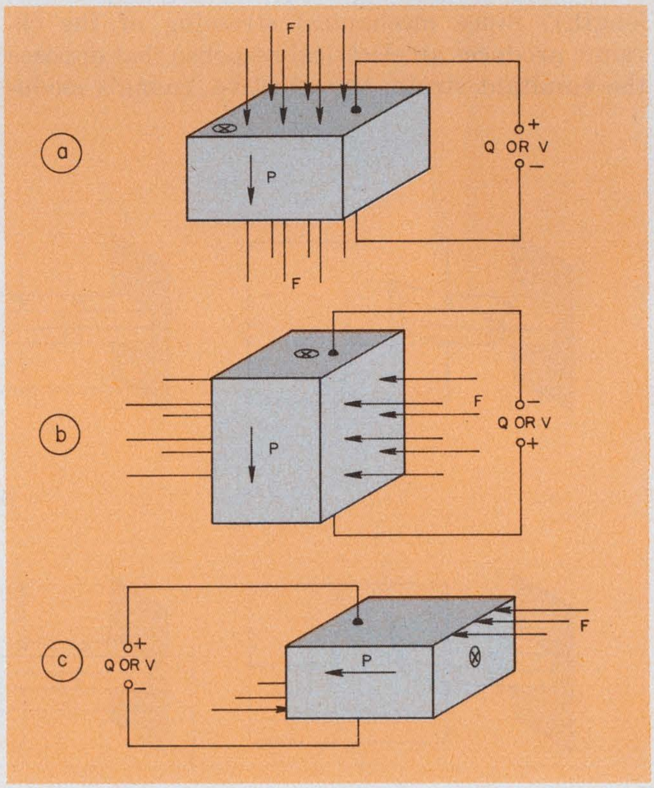
Relative dielectric constant is designated by the symbol K. Since no mechanical parameters are associated with K, the mechanical subscript is omitted. The symbol K_3 describes the relative dielectric constant in the direction of poling. And K_1 is the constant perpendicular to the poling axis.

The coefficients work together

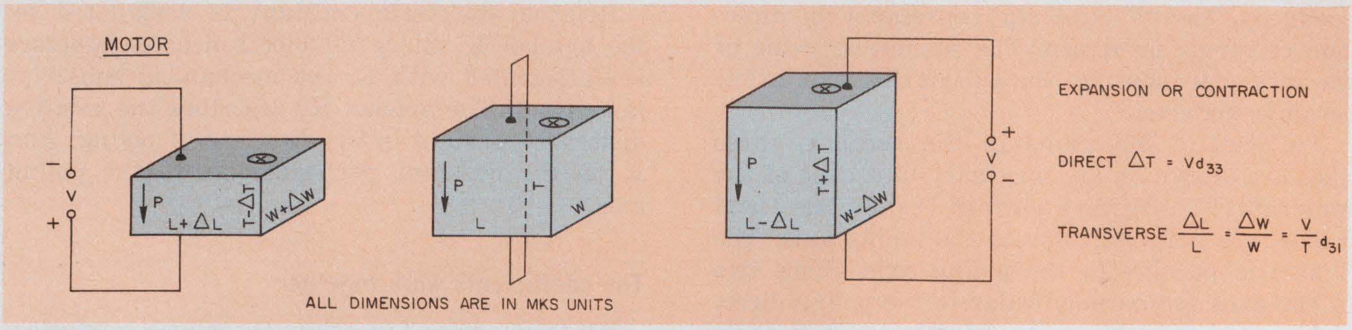
At frequencies far below resonance, piezoelectric devices are fundamentally capacitors. There-



3. A unit cube of the ceramic material is set up as a three-dimensional solid for easy analysis.



4. A polarized piece of ceramic has different characteristics when it is stressed in different directions.



5. **Motor applications of the ceramic** let the material expand or contract when voltage is applied. Be careful when you do computations—all dimensions should be in the MKS-units system.

fore the voltage coefficients, g_{ij}, are related to the charge coefficients, d_{ij}, by the absolute dielectric constant (K times the permittivity of free space ϵ_0). As with capacitors, the voltage, V, is related to the charge, Q, by the capacitance, C. The relationships are as follows:

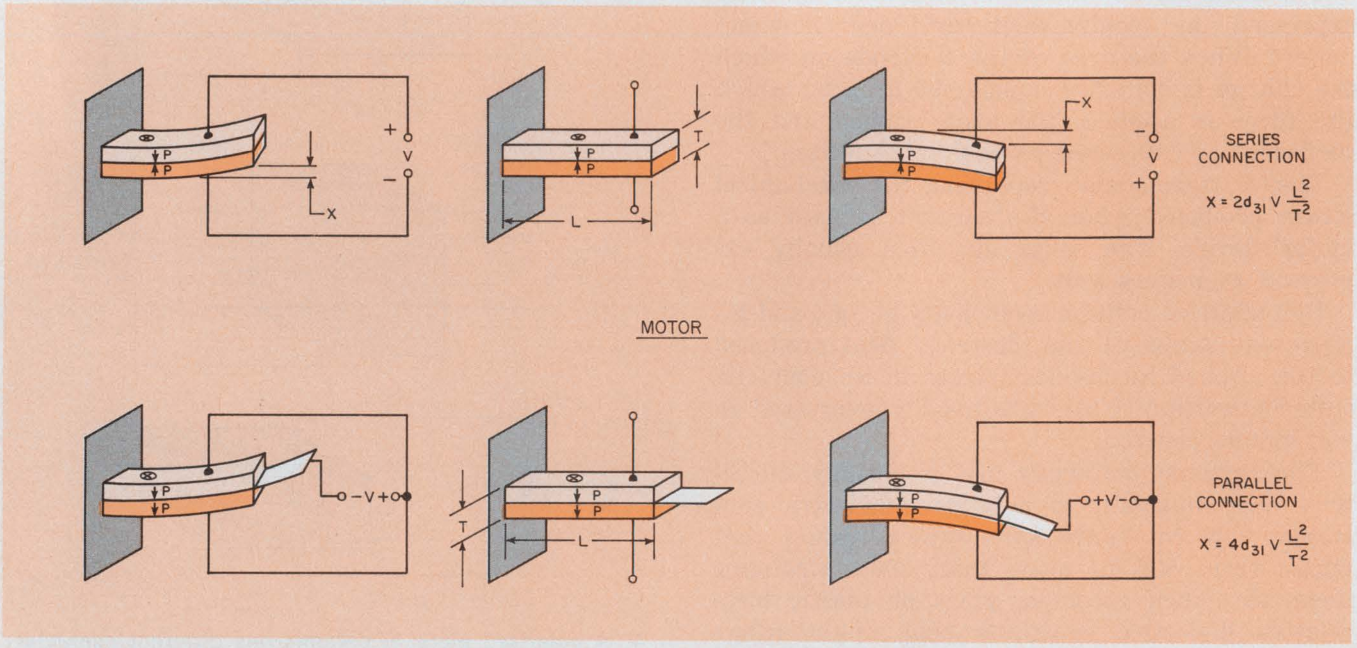
$$Q = CV$$
$$d_{33} = K_3\, \epsilon_0\, g_{33}$$
$$d_{31} = K_3\, \epsilon_0\, g_{31}$$
$$d_{15} = K_1\, \epsilon_0\, g_{15}.$$

The modulus of elasticity, mechanical Q, density and physical configuration, in combination with the d, g and K parameters, produce a wide range of electromechanical behavior in the piezoelectric ceramic materials.

As with all solids, piezoelectric ceramics have mechanical stiffness described in terms of Young's modulus—the ratio of stress (force per unit area) to strain (change in length per unit length). Since mechanical stressing of the ceramic produces an electrical response that opposes the resultant strain, the effective Young's modulus with the electrodes shorted together is lower than with the electrodes open. Furthermore the stiffness is different in the 3 direction than in the 1 and 2 directions.

Thus when expressing such quantities, you must specify both direction and electrical or mechanical conditions. The term Y_{33}^E is the ratio of stress to strain in the 3 direction when the electric field is held constant (electrodes shorted). Y_{33}^D is the equivalent under a constant strain with the electrodes open. Y_{11}^D and Y_{11}^E are the moduli in the 1 and 2 directions, and Y_{55}^E and Y_{55}^D are the ratios of shear stress to shear strain. Units for the terms in Young's modulus are expressed as newtons/meter^2.

Since the ceramics are semimechanical devices, they have resonant frequencies—frequencies at which displacements (when driven electrically) or voltage outputs (when driven mechanically) will exhibit marked changes. The ratio of displacement or voltage output at resonance to the low frequency value is defined by the mechanical



6. **Simple motor-bender applications** use a piezoelectric ceramic bonded to piezoceramic substrates.

quality factor Q_m. The finite value of Q_m results from internal losses or damping that is inherent in the material.

Electromechanical coupling coefficients combine all physical and electrical parameters at the same time. Somewhat analogous to the beta of a transistor—the conversion ratio for base current and collector current—electromechanical coupling coefficients k_{33}, k_{31}, k_{15} and k_p describe the conversion of energy by the piezoelectric ceramic from electrical to mechanical form, or vice versa.

The square of the coupling coefficient is the fraction of input energy of one kind stored in the piezoelectric ceramic. Subscripts denote the relative directions of electrical and mechanical quantities and the type of motion involved. The subscripts can be associated with the vibratory modes of certain ideal mechanical designs, and since they represent energy ratios, they are dimensionless.

Applying piezoelectric materials

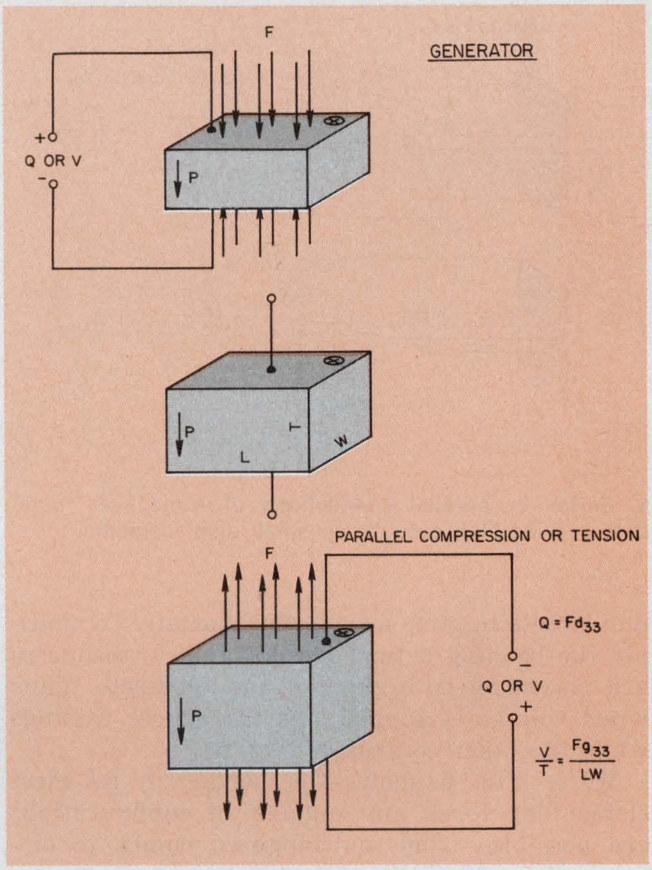
Many applications require that the ceramic material be used with other materials that optimize a particular characteristic. In these cases mechanical amplifiers, mass loads, resonant horns and housings are usually part of the transducer. Let's look first at applications that use the motor properties below resonance.

The formula in Fig. 5 describes the displacement for the 33 orientation when a field is applied. Thus if 1 V is placed across the electrodes of a 2-mm-thick piece of ceramic, it will produce as much displacement as another transducer that is 2 cm thick. This motor characteristic, along with the fact that these materials can be connected in series mechanically and in parallel electrically, makes the transducers ideal for linear translators, micropositioners, wide-band, off-resonance acoustic projectors and many other applications.

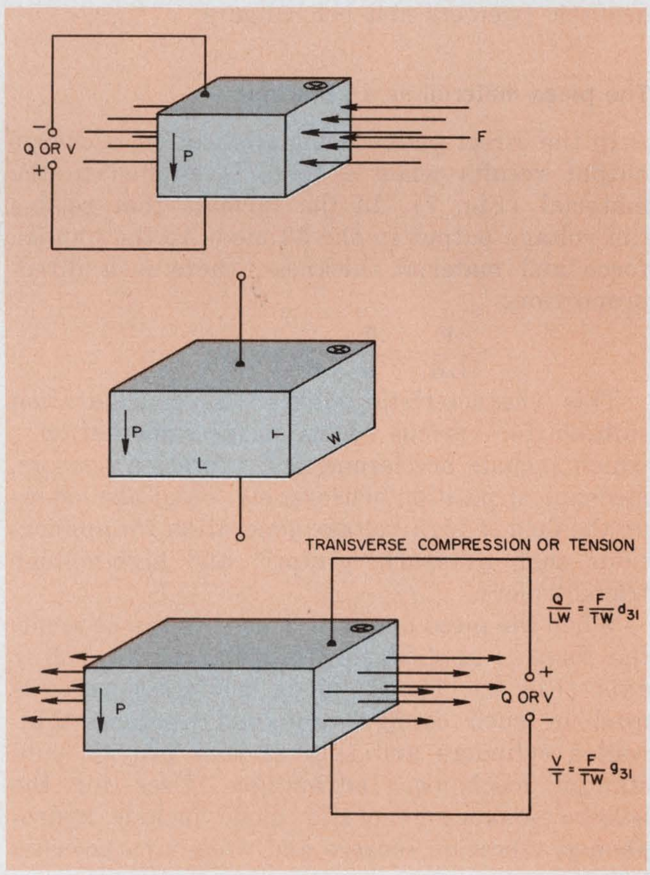
When a voltage is applied across the electrodes in the 33 direction, the piezo material not only changes its physical dimension in the vertical direction but also in the length and depth (Fig. 5). In the formula that describes transverse movement, displacement is not only a function of the applied voltage but also of the physical dimensions of the transducer. This characteristic opens up applications in a different operating mode—known as bender or bimorph.

A piezoelectric ceramic bender takes advantage of the transverse expansion and contraction when voltages are applied in the 33 direction. If one of the electrode surfaces of a long thin piece of ceramic is bonded to a thin substrate so one surface is free and the other restricted, the transducer will bend when voltage is applied.

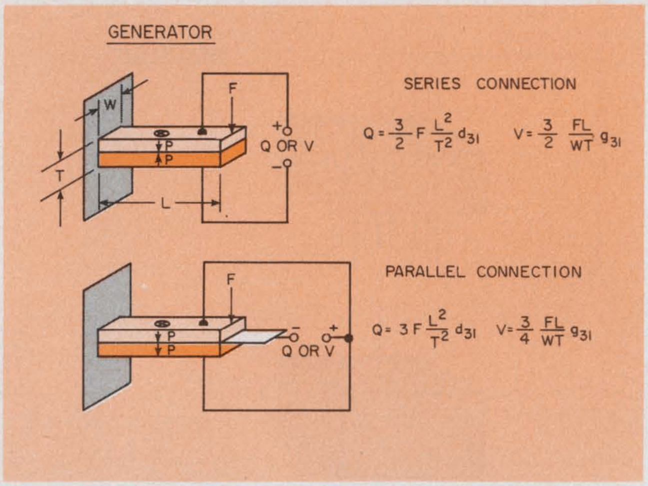
The bending motion is analogous to the curve



7. **Direct generator applications** make use of a charge output from the transducer under mechanical stress.



8. **Forces applied perpendicular to the poling axis** also produce usable electrical outputs.



9. **Series or parallel connections** of transducer materials provide high outputs for small displacements.

in a bimetallic strip used in thermostats. To multiply the bending action, piezoceramic transducers are placed on both sides of the substrate. Thus when voltage is applied, one transducer expands while the other contracts (Fig. 6).

While Fig. 6 shows the bender in its most elementary form, any number of configurations are possible—from multifingered combs to circular discs. Motor benders are used where relatively large displacements and low forces are required—as in linear translators, micropositioners, clock-drive motors, tactile pressure sensors, acoustic tweeters and bell ringers.

The piezo material as a generator

In the direct piezoelectric application, a charge output results when a force is applied to the material (Fig. 7). In the formula that relates the voltage output in the 33 mode to the applied force and material thickness, there is a direct proportion:

$$\frac{F}{LW} = \frac{F}{a} = \text{pressure.}$$

This characteristic makes the configuration suitable for various forms of instrumentation—which include accelerometers, vibration sensors, mechanical position sensors, etc.—and also opens up the field of high-voltage generation for applications such as spark ignitors[1] and high-voltage transformers.

When the piezo material is used in the 31 mode, the force is applied perpendicular to the poling axis (Fig. 8). The 31 mode below resonance is used in such configurations as benders, thin-walled cylinders and spheres that provide substantial mechanical advantages. Uses for the below-resonance generator mode include hydrophones, vibration sensors and wide-band acoustic receivers.

The piezoelectric ceramic-generator bender construction is identical to the motor bender described earlier (Fig. 9). But in this configuration the generator, or 31, mode provides substantial voltage outputs from small displacement inputs, because of the mechanical gain of the bending motion. Applications for these devices include phonograph cartridges, microphones, hydrophones and strain gauges.

Resonance has its uses, too

At frequencies far below resonance, the transducer responds in phase and proportionately to the applied input. A transducer will hold its mechanical displacement as long as the dc voltage is applied. However, the charge produced by the dc potential will leak off at a rate determined by the RC time constant of the transducer in combination with the external circuit. The leakage limits the frequency response of piezoelectric transducers that operate in the direct mode.

When the transducer is driven electrically, its motions are small at low frequencies. The material can be considered a reactive element (a capacitor).

As the resonant frequency is approached, the displacements are amplified, and the mechanical characteristics significantly affect the impedance seen by the electrical signal source (an oscillator).

In the vicinity of resonance the self-capacitance of the transducer is shunted by a series-resonant circuit that consists of the electrical equivalents of the effective mass, the compliance (stiffness) and the losses. At resonance, the shunting arm becomes resistive and acts as a low impedance in parallel with the self-capacitance.

By dipping to a minimum value, the impedance curve would show a marked change at the resonant frequency. At a frequency slightly above the resonant value, the series-resonant circuit becomes inductive. And a parallel resonance is created between the inductance and self-capacitance of the transducer. The parallel resonance represents a peak in the impedance-vs-frequency curve (anti-resonance).

Applications of the resonant properties include ultrasonic cleaners, fetal heart monitors, liquid atomizers, burglar alarms, delay lines and resonant audio speakers. ■■

Bibliography

Mason, Warren P., "Physical Acoustics, Principles and Methods," Vol. I, Part A, Academic Press, 1964.

Heuter, Theodor and Bolt, Richard, "Sonics," John Wiley and Sons, Inc., 1955.

Glennite Catalog, Gulton Industries, Fullerton, Calif., February, 1974.

References

1. Germano, Carmen, "Flints That Don't Wear Out," *Electronic Design*, No. 13, June 21, 1974, pp. 88-90.

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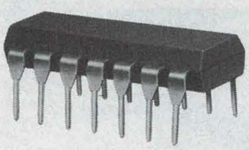

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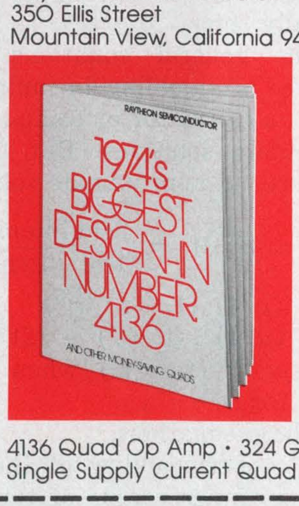

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Shape foil into a magnetic shield

with scissors. Permeability, thickness and the layers needed are determined by simple formulas and measurements.

Many magnetic shielding problems can be solved with a pair of scissors and a sheet of magnetic foil. The thickness of the shield and the number of layers required are determined first by simple formulas. The foil is then hand-trimmed to the required outline and fitted around the structure to be shielded (Fig. 1). Measurements then tell whether refinements are needed.

If you have only a few shields to worry about, the job is done. If you have thousands to make, this is still a good initial design procedure.

Satisfactory ductile foil material, ranging from 0.002 to 0.01-in. thick, is available in a variety of permeabilities. It may be best to start with 0.004 or 0.006-in. thickness. Adhesive tape can hold the shield in place.

Low-permeability foils are usually 0.004-in. thick, and high-permeability foils can be obtained as thin as 0.002 in. Several widths are available.

1. A pair of scissors and a roll or two of foil magnetic-alloy material are all you need to fabricate a practical magnetic shield.

Mathematical approach provides insights

What are the best materials to use, the most efficient geometries and the degree of shielding attainable? You can find out by trial and error, but that's time-consuming and imprecise. On the other hand, a purely mathematical approach can be very complex, and because of the many simplifications and assumptions that must be generally made to simplify calculations, the results can be unreliable unless the engineer makes some measurements. An approach that combines the insights of a mathematical analysis and practical trial and error, produces the best results.

The mathematical analysis of magnetic shielding is an ancient subject.[1] One of the first conclusions drawn by investigators was that multiple, concentric shields are more effective than increased thicknesses of a single magnetic material shell. Beyond a certain thickness, it has been found, much greater shielding can be obtained if the shell is divided into several layers of alternate magnetic and nonmagnetic material. For a sphere or long cylinder, when the radii of the layers are large compared with their thickness, best results are obtained when the alternate magnetic-nonmagnetic layers are approximately equally thick.

The general equations for calculating the degree of shielding in multilayer shells are complex; a calculator or computer is usually required to obtain solutions. But for a single-layer enclosure, an approximate solution is:

$$g_1 = H_o/H_i = \frac{\text{field intensity outside the shield}}{\text{field intensity inside the shield}}$$

$$= (\mu/4)\ (1 - r_i^2/r_o^2)$$

$$= (\mu/4)\ [(t^2/r_o^2) - (2t/r_o)] \qquad (1)$$

$$\cong \mu t/2r_o (t << r_o), \text{ when } (r_o - t) \text{ is substituted for } r_i.$$

In these equations,

μ = permeability of the magnetic material,
r_i = inner radius of the shield,
r_o = outer radius of the shield,
t = thickness of magnetic material.

Richard D. Vance, President, Ad-Vance Magnetics, Inc., Rochester, Ind. 46975.

These equations are valid for spherical shields or for cylindrical when the length-to-diameter ratio is 4 or more.

For multilayer shields, each additional magnetic-material layer around the first layer multiplies the attenuation by roughly

$$g_{ij} = \mu t^2/r_o^2. \tag{2}$$

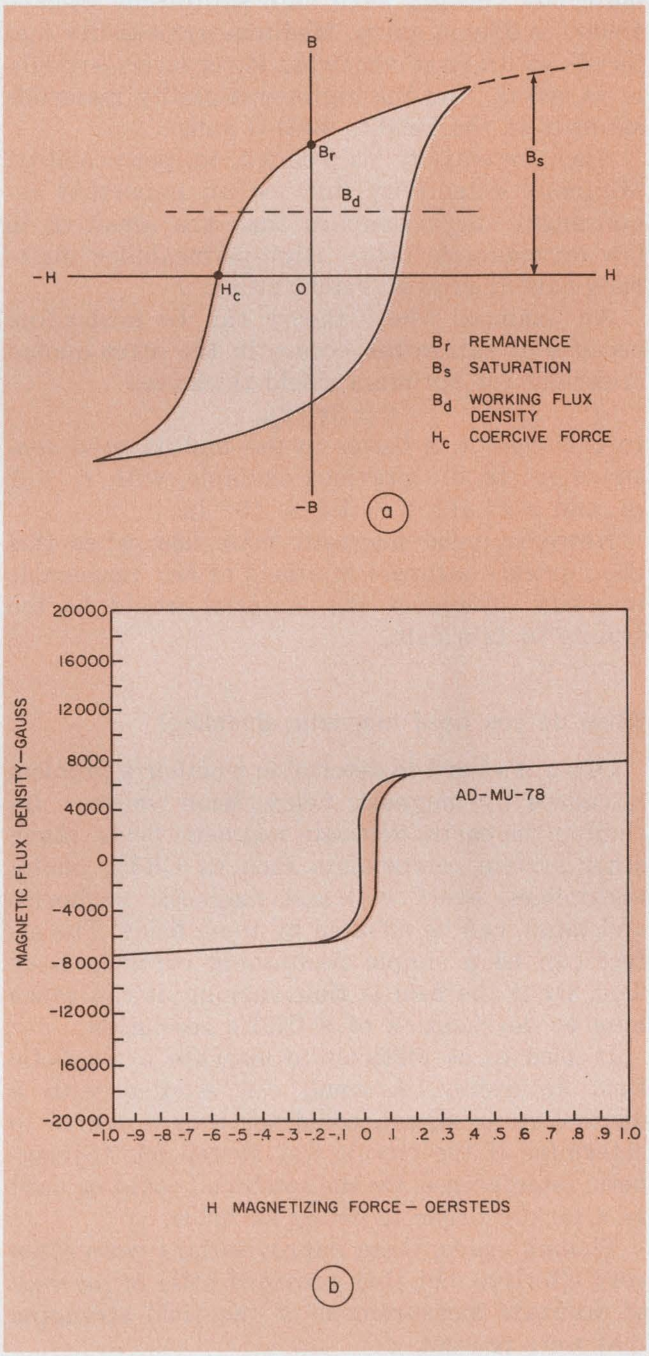
As an example, assume that a shield is in the form of a long cylinder with an OD of 2 in. and wall thickness of 0.02 in. and that the shield material has $\mu = 10^5$. Then the shield can produce attenuation of $0.02 \times 10^5/2 \times 1 = 1000$. Doubling the thickness of the material would only double the attenuation. But if a second 0.02-in.-thick magnetic layer, about 0.02-in. away, surrounds the first, the attenuation is 40 times greater, or 40,000. The space between the two magnetic layers must be occupied by nonmagnetic material, such as copper, aluminum or any dielectric material.

Magnetic materials saturate

Eqs. 1 and 2 are approximations. But even with use of a fully expanded equation,[2] the results are still approximate. This is because all mathematical analyses assume that the magnetic material behaves linearly—flux density is directly proportional to magnetomotive force—and that, thus, μ is a constant. This is far from true, especially with the high-permeability materials that are used for shielding (Fig. 2). In addition to nonlinearity, magnetic materials saturate. At saturation the permeability is very low, and the material has little shielding ability (see table).

Experience indicates therefore that the thickness of shield material should be selected to keep the flux density in the material in the range of 2500 to 3500 gauss, because generally the permeability is maximum in this region of flux density.

When the flux densities become larger than can be handled by a single sheet of foil material, multiple layers can be used. Or heavier-gauge sheets, to about 0.05 in., can be bent, stamped or drawn into the desired shape with shop tools. However, unlike foil, heavier-gauge material re-



2. **Permeability—the slope of a BH curve (a)—is not constant,** contrary to the assumption in most mathematical analyses of magnetic systems. The BH curve of AD-MU-78, a high-permeability-alloy, is very steep, and it has an almost rectangular saturation point.

quires heat treatments after fabrication.

Obviously, it is desirable to use shield material with the highest possible μ. However, as the magnetic material table shows, high-permeability materials saturate at lower flux levels. Thus when multiple-layer shields are designed to provide high levels of attenuation, the outer layer—which is exposed to the highest intensity of flux density—should be selected from high-saturation-level, albeit lower-μ, material.

Shielding materials are classed as having low, medium or high permeability. Low-permeability materials, though, have high saturation levels—18,000 to 20,000 gauss. Medium-permeability materials saturate at somewhat lower levels—roughly 15,000 G. And the high-permeability materials saturate in the 7500-to-9000-G range.

Also, retentivity is related to permeability. Minimum retentivity may be an important requirement for assemblies that are sensitive to low dc magnetic fields. High-permeability materials have the lowest retentivities.

An example where theory can be misleading because of saturation occurs in the often-quoted criterion[2] for optimum shield thickness.

$$t = 3r_i/2\mu.$$

In this case it is better to use multilayered construction. In the previous example, with $r_i \simeq 1$ in. and $\mu = 10^5$, $t = 1.5 \times 10^{-5}$ in.

However, most magnetic materials, when this thin, quickly saturate in a field of any reasonable intensity. Moreover the material would be too fragile to fabricate.

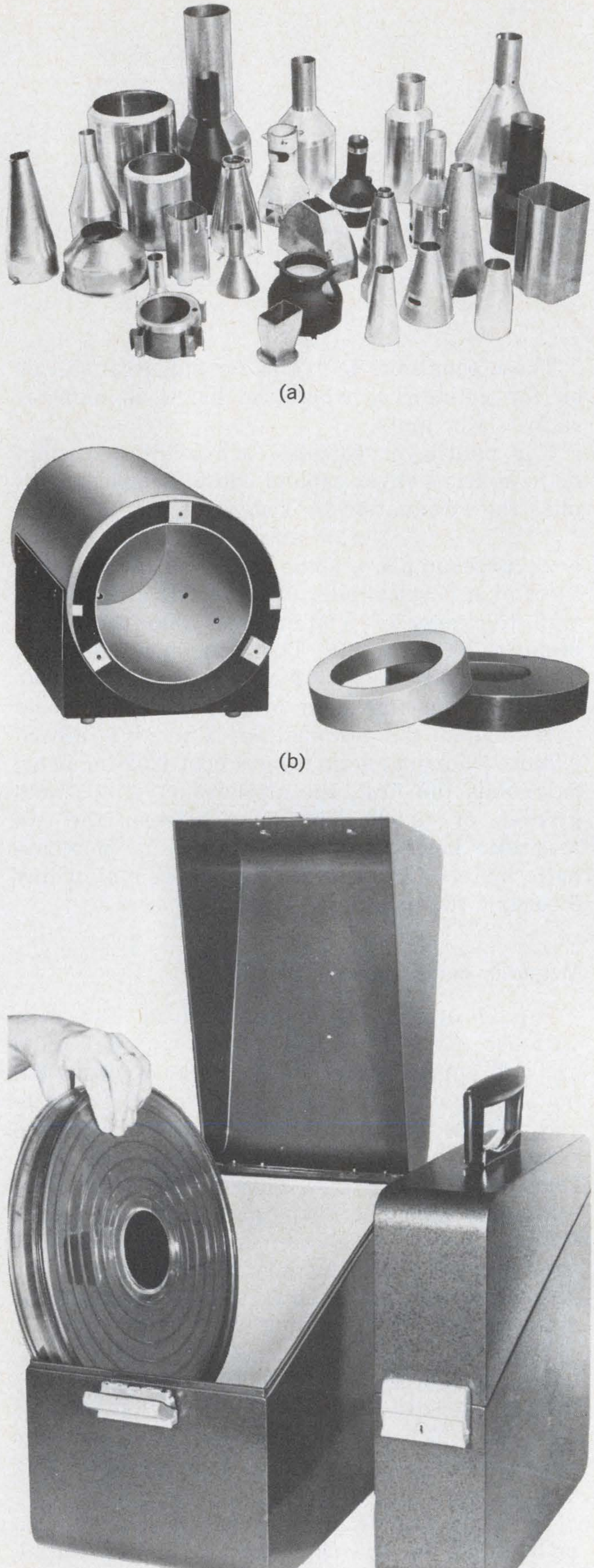
When do you need magnetic shielding?

Often it's hard to determine whether a problem is caused by magnetic fields. Many sources, including the earth, generate magnetic fields. Many other system components such as CRTs, photomultipliers, every coil and magnetic memories and tapes, can be affected by these fields. The effect can be a simple positioning error in a dc field. Or if the field is time-varying, it can cause hum or degradation of a CRT's resolution.

It used to be difficult to measure a magnetic field accurately. A small coil, excited with a distinctive ac signal, could serve as a source to determine if the circuit was susceptible to magnetic interference. Or the small coil could be used as a pickup probe to detect ac fields.

Though crude, these improvisations were often very effective, but they provided little in the way of accurate measurement of the field strengths that were present.

Today gaussmeters accurately cover the range from 0.02 to 50,000 G for frequencies from dc to 20 kHz and higher. They provide direct readings—as easily as a voltmeter does. The probes to detect the magnetic field are usually Hall-effect,



(a)

(b)

(c)

3. **One of the many available custom-fabricated shields (a),** or magnetic-isolation chambers (b), or perhaps a standard package such as a special protective case for magnetic tapes (c), might fill your need for shielding.

Typical dc magnetic properties for shielding alloys

	Material	Initial permeability at 40 gauss	Permeability at 100-200 gauss	Maximum permeability	Saturation induction gauss	Coercive force oersteds
High permeability	Carpenter HY-MU-80	50,000	60,000	350,000	7500	0.010
	Ad-Vance AD-MU-80	35,000	45,000	350,000	8200	0.015
	Ad-Vance AD-MU-78	20,000	30,000	300,000	7500	0.015
Med. permeability	Allegheny 4750	12,500	17,500	150,000	15,500	0.02
	Ad-Vance AD-MU-48	11,000	27,000	100,000	15,200	0.03
Low permeability	Millen Low Perm.	290	1000	9000	19,000	0.9
	Ad-Vance AD-MU-00	300	500	3000	22,000	1.0
	AISI M-36	280	600	5000	20,000	1.0

InAs elements. And for calibration of the meters, the National Bureau of Standards will certify the flux value of a simple permanent-magnet reference.

A well-stocked electronic laboratory should have a gaussmeter, and its probe can be used to hunt and measure interfering magnetic fields with ease.

After the offending field is detected and mapped, the accessibility and component layout in the region of the field will determine whether it is better to enclose the source or the pickup device, or perhaps both. A first-trial shield can be put together with the foil-and-scissors technique, and the results can be checked with a gaussmeter probe. Several adjacent foil layers can be applied to provide a simple, thick shield. Or a spirally wound foil, sandwiched with copper or aluminum foil, can produce a multilayer shield for greater shielding.

When the shape, thickness, number of layers and material types have been established by rough mathematics and measurements, more permanent designs can be undertaken, and companies that specialize in magnetic-shield fabrications can be called in. Now you can talk intelligently, with known facts and figures. Often a manufacturer may have a stock shield to suit your problem, or he may be able to modify one of his shields economically.

Note: The magnetic properties in the table are valid only if the material is properly annealed, especially after it has been stressed during fabrication of the shield. Even dropping or jarring the shield can, with some materials, substantially affect permeability. Thus it is wise to order by specifying permeability and saturation—the vendor's material number is not enough.

The annealing process generally is not simply a heating process with slow cooling. It must be done under the proper atmosphere—sometimes in a vacuum—and with careful control of cooling rate at predetermined temperature levels.

And, of course, the shield material may require protective finishes, such as cadmium plating or painting.

Shields can also handle electrostatics

Since ferromagnetic shielding alloys are reasonably conductive, proper grounding of an electromagnetic shield can usually provide an adequate electric-field shield at low frequencies. Grounding is not necessary to obtain magnetic shielding, but it's good practice.

At increased frequencies, skin effect becomes a dominant factor, and the conductivity of the shield material should be greater than that of permeable alloys. For good conductivity, materials like aluminum or copper are needed. One way of combining magnetic and electrostatic capabilities in a single-layer shield is to copper-plate the magnetic shield with sufficient copper to satisfy skin-effect requirements. ■■

References

1. Giovanni Battista della Porta, Magiae naturalis, sive de miraculis rerum naturalium . . . *Libri VIII* (1589).

2. Wadey, W. G., "Magnetic Shielding with Multiple Cylindrical Shells," *The Review of Scientific Instruments*, Nov., 1956, pp. 910-916.

3. Kraichman, M. B., "Handbook of Electromagnetic Propagation in Conducting Media," NAVMATP-2302, available from Supt. of Documents, Gov't Printing Office, Washington, D. C. 20402.

When you have no choice but changeover,
good planning, the right technical talent and cooperation between hardware and software people can ensure success.

The challenge is this: to change over from making one electronics product to making a different one—and to do it without losing a beat. What's it like to try? And what does it take to succeed?

Four years ago we decided to make the shift from hardware to systems. Our company had been selling the old product line of hard-wired digitizers and had discovered, with the aid of the 1969-70 recession, that the market wasn't big enough for us to be successful. We decided to enter the interactive graphics market for automated drafting.

Our elements of success may seem obvious, but you have to work at them. They were these:

- Good planning. We were able to define a superior product, and it has become an industry standard.
- The right technical talent. We had to attract it.
- An extremely cooperative attitude between the hardware and software people. We developed it.

Designing for the future

The biggest challenge was to develop an operating system that was versatile and fast, so we could add new applications to the software. Initially we chose to pick a hole in the interactive graphics market; it was integrated circuits. We knew that we could sell there, and we knew there was a need.

We had to design the basic operating system, and the hardware that would make it work smoothly, in such a way that it could later accommodate automated mechanical drafting, schematics and PC boards. The challenge we faced was how to design the proper software operating system and how to drive those peripherals in a way they hadn't been driven before.

To define the product, we didn't use outside consultants because little was known about the new market we were entering. But we did rely heavily on the opinions of our customers. In many cases these digitizer users were actually in applications that could be better served by an interactive system. We told them this was what we planned to do, and we asked them what they thought. Most thought we were right.

Our product line at the time of the changeover consisted of a series of hard-wired digitizers that were used to convert graphical information, such as maps, charts and other drawings, to computer-readable form. The result was then recorded on magnetic tape via an incremental recorder.

The company's new product line consists of a modularized series of interactive graphic systems that contain their own minicomputer, disc storage, magnetic-tape output, interactive digitizing and editing terminals, and on-line plotters operating in the background mode.

The new product line, the graphic data system, is used in the IC printed-circuit board, mechanical drafting and cartographing applications. It not only performs the graphical data-acquisition conversion and storage function, but sophisticated data-processing and art work generation functions as well. Only the data-acquisition and conversion functions were retained from our product line. The remainder were discarded in favor of more sophisticated technology.

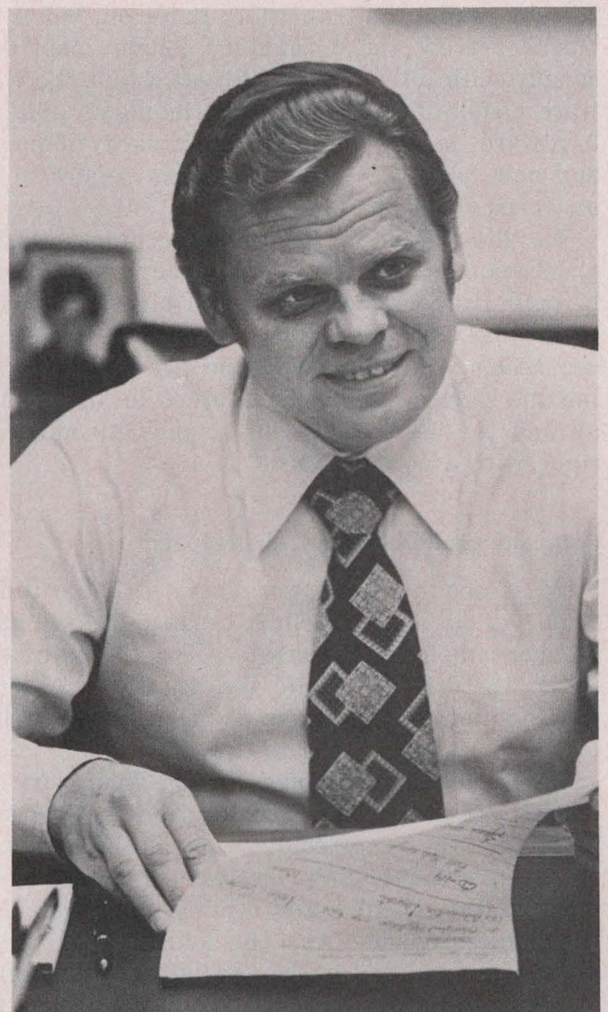
Pricing considerations led us to abandon certain designs that could have been carried over from our old line. We thought that a system this size should be priced at 100k, to be competitive with other systems emerging on the market and to appeal to a larger segment of potential purchasers.

Another consideration was the availability of financial resources. We knew what had to be done, but because of the financial picture in 1970, we had to compromise in the area of packaging and esthetic appeal. We decided that performance was much more important than appearance. We did not redesign or repackage the input terminal, for instance, knowing that the option for doing that would always be available.

The cash-flow consideration also led us to retain in our new logic designs the concept of

Bob Benders, President, CALMA Company, Sunnyvale, Calif. 94086.

Robert Benders and CALMA Company



Three and a half years ago Bob Benders had risen from a research assistant to a company president. He was just over 33 and he'd taken only 11 years to reach the top. Today, at 37, he presides over CALMA, a company that makes, markets and supports minicomputer-based interactive graphics systems. Incorporated in 1964, CALMA Company develops and markets a line of high-quality digitizing equipment.

From that job as research assistant in airborne infrared scanners and coherent optical data processing at the University of Michigan Institute of Science and Technology, Benders went on to work as a senior research engineer on digital systems development, at both Boeing and Lockheed. He had received his BSEE at the University of Michigan. He's married and has four children.

As president and former chief engineer of CALMA, Benders directed the company change from hardware manufacturer to systems supplier. Applications for CALMA systems began with electronic circuit artwork generation and have expanded to encompass general drafting and various types of mapping. Continuing research and development activities consume approximately 10% of company revenues—the majority devoted to new and improved programming. Current programming staff members number 22.

CALMA sales have grown from $1.5 million in Fiscal 1972 to $5.4 million in Fiscal 1974 and are projected to reach $20 million by 1977. A direct marketing force was established in 1974 with offices in eight U.S. cities and London.

packaging IC chips on large wire-wrapped boards. This resulted in lower over-all cost but more difficulty in maintenance, since repair was by the chip rather than by the board. We could do that kind of maintenance, however, because the company had a good maintenance group. But when the number of systems grew to over a hundred, we had to redesign and repackage the logic. We realized this at the beginning and built our plans around specific engineering talent.

Matching skills with needs

We couldn't keep every engineer when we switched over. We had to define carefully the design problem in terms of what could and could not be compromised. The most important principle was to produce the most powerful and cost-effective system in its price range. In this area, we made no compromises. We defined the system in general terms and arrived at a basic configuration. Next we examined the availability of key components, such as minicomputer, CRT displays, disc and tape storage units, plotters and others. From these data, we made "buy and build" decisions and examined available designs.

We kept those engineers who were essential to design the configuration, as defined—about 30% of the staff. This decision was partly dictated by the economic conditions in 1970; we didn't really have much choice.

The most important hardware job titles we had to fill were:

- Logic design. We needed this expertise to connect a minicomputer to various terminals, such as plotters, tape drives and inputs.

- Analog design. We were developing a CRT terminal base, and we were doing some work on the digitizing tables.
- Mechanical design. We had to improve the design of the digitizer. Formerly I had been chief engineer of the company and knew what our people could do. When it came time to match up people's skills with our needs, I had all the information I needed. We kept six engineers and used them throughout the changeover.

When I took over the company presidency, I also retained direct managerial responsibility for the engineering department and helped to preserve morale and to provide motivation. This direction gave the engineers a better feeling for what they were doing and quicker access to top management. Over-all, our engineers were dedicated professionals who wanted to see the company succeed.

We were never a large company, so little reorganization of personnel was needed. Senior engineers had to do additional tasks that formerly had been done by lower-level people; we also transferred some technicians to a manufacturing and field service unit.

Small talented groups are best

Later we needed software capabilities, which have to be continually enhanced to remain competitive. I don't want to minimize our hardware, which is in some ways superior to many competitive units on the market. But hardware, once developed, tends to remain stable for a time, whereas one can always think of new applications and programs to add to a software package.

I believe that most superior products are developed by small groups of extremely talented technical people, rather than large numbers of people. This is true for hardware and software. A company's return on investment is much greater from a small group of extremely capable people, although obviously they are more highly paid. This assumes, of course, that it's a job that lends itself to a small-group solution.

I also believe that, in programming, a person's basic ability is more important than specialized experience. When we were going into computer graphics, I felt that instead of getting computer programmers to build a system that was better, I needed instead the best possible engineering to build it. We found the proper people through the usual channels without having to make compromises.

We've been very liberal with stock options to engineers, which is meaningful because we're still a privately held operation. This company had always been managed by engineers, and we've always tried to maintain a good working environment.

When we made the change, we anticipated some problems integrating the hardware people with the software people. To minimize these, I had all employees report to me. This not only gave them access to top management; it also helped them to be aware of one another's problems, thereby easing the transition. Later on, when the business grew and I could no longer meet personally with all of the employees, I put the software people under a software manager and the hardware people under a hardware manager, and now have those two managers report to me on an equal basis.

We didn't run across any technical design problems, because we defined exactly what could be built from the beginning and hired the people to do that task. Retraining wasn't necessary in engineering; the hardware people had been doing the same tasks on a different product. They all had the necessary skills to pick up and continue with a new product.

Company profitable since changeover

What about tooling and facilities? We didn't require a lot of new tooling, because we buy most of the complex components—like the minicomputer, the disc drive and the tape drive. We do have tooling for digitizers, but we already had this.

We needed some changes in the laboratory facilities, but the prime consideration in 1970 was to balance the requirement against the available financial resources. We needed some lab equipment to test IC chips and other components. But the biggest change was the additional requirement of a facility for the testing and debugging of computer programming. We decided that the most cost-effective method of providing this was to use the same product we ship to customers as a programming tool, with some additions.

But, over-all, we had no major facility problems. We had just moved into a new building in 1968, and when we changed over, we needed less space. For a time we actually decided to rent part of the building to a new startup operation. About two years ago we obtained some additional space to accommodate our own manufacturing operation. In our initial stages we were mostly designing and developing.

We made the change all at once, although we did continue marketing the old systems and gave them some engineering support. There was a slight business slump when we first started, but I think it could be related to the over-all slump at that time. We didn't start shipping our new system until July of 1971. And we have been continually profitable since the new product line was introduced. ■■

These power semiconductor cooling ideas could get you out of a hot spot.

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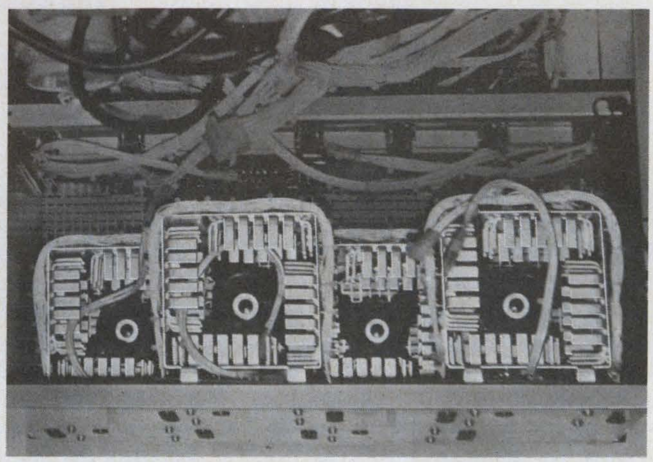
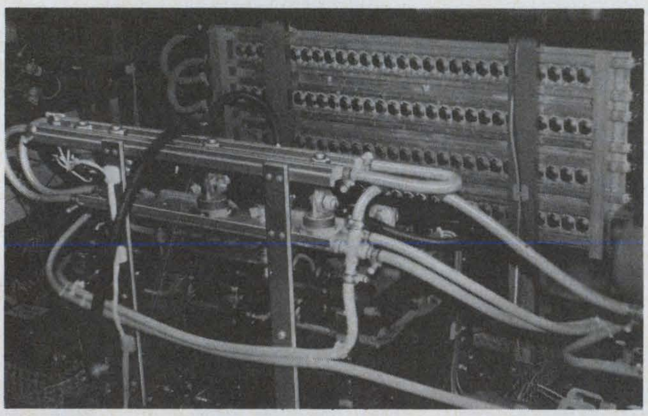
Semiconductor control of power means lots of heat generation in the semiconductor device. If the inherent power handling and switching capabilities of the device are to be taken advantage of, you've got to get rid of that heat. But in power applications, the capabilities of discrete dissipators relying on natural convection or unchanneled air movement are soon outstripped. Here are some innovative ways power circuit designers have used IERC liquid-cooled heat sinks, IERC heat dissipators in channeled air environments, and IERC heat dissipators in IERC forced air packages to get themselves out of big-power hot spots.

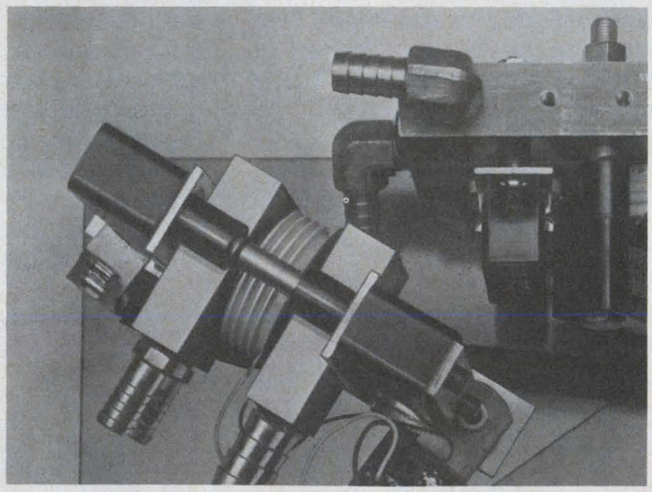
X-Y plotter designer put all his hot TO-3 power transistors in one basket to cope with heat problem. Utilizing existing chassis, he mounted devices in UP dissipators, wrapped a shroud around the assembly, and installed a blower. The UP's staggered fingers create turbulence in air stream for maximum efficiency of both the dissipator and air flow, and allowed the designer to meet his design goal of 80°C case rise maximum. He also had room within the shroud to cool his hot resistors.



Dissipate 1280 watts in 530 cubic inches was the word given to designer of this power supply so he turned to our FAHP4 forced air packages. It took 4 units to do the job at a cost of $26 ($6.50 each/1000 pc qty.) plus $40 for the fans. Average case rise of the 16 transistors was only 75°C.



6000 watts of heat produced by 125 TO-3 case transistors in an industrial welding machine power supply was raw-power problem solved by IERC E4 liquid cooled sinks. Designer brazed together four standard E4's cut to 36 inches in length and tier stacked two other E4's to cool high power SCR's. Total area of heat sinks used only a fraction of the space required for a blower-cooled system of similar capacity.



Fork-lift truck speed control used SCR's in hocky puck packages to handle thousands of watts in drive power. Big heat problem was solved with IERC liquid-cooled, double-side heat exchangers specially designed to let these big pressure-mount semiconductors dissipate on the order of 1000 watts each with just a 20°C case rise above ambient. Where did the designer get the coolant? He routed vehicle hydraulic fluid through the heat exchangers.

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INFORMATION RETRIEVAL NUMBER 37

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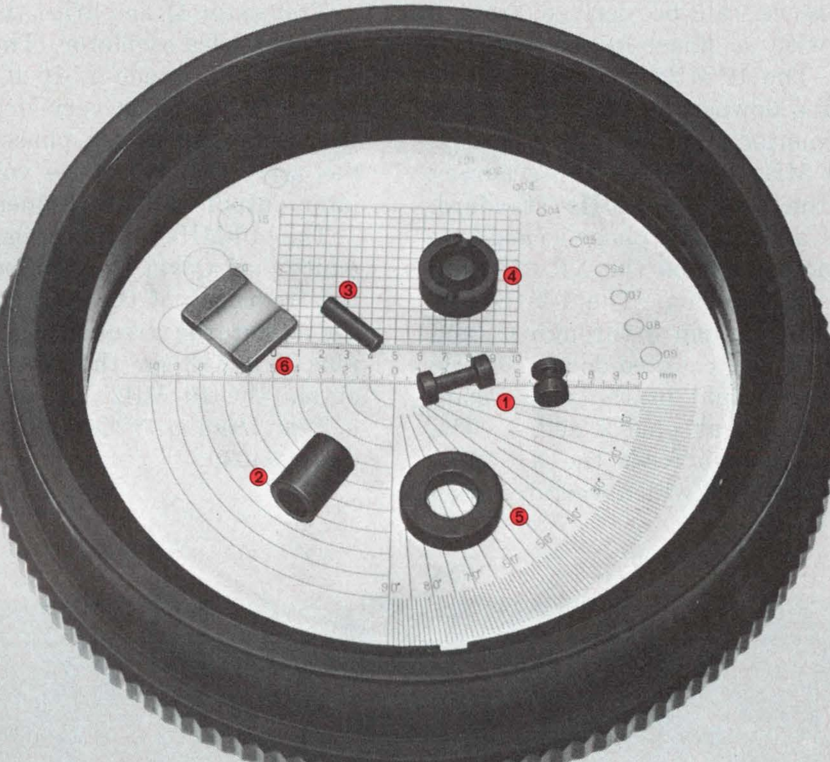

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2 Sleeves
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3 Rod cores
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4 Pot cores
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Accurate 10-MHz reference obtained from counter's 1-MHz internal standard

A 10-MHz reference can be derived from a 1-MHz standard with a phase-locked-loop frequency multiplier. The 10-MHz reference can be used in a microwave down converter, where the unit's frequency counter supplies only a 1-MHz standard. The 10 MHz will have the accuracy and stability of the original 1-MHz standard.

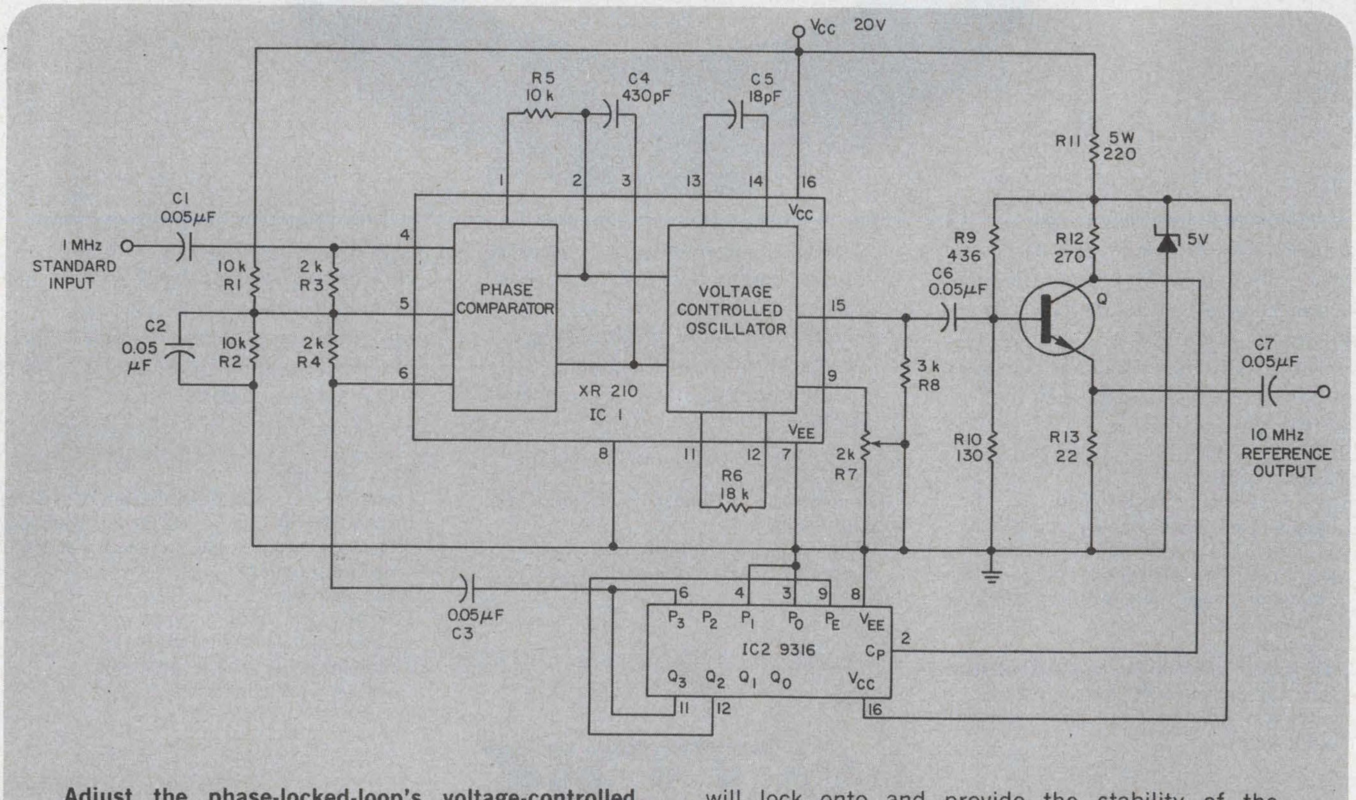
The circuit uses an XR 210 phase-locked-loop IC. The voltage comparator on the XR 210 chip is not used in this application. The 1-MHz reference signal couples into pin 4 through C_1 and compares phase with the counted-down 10-MHz signal at pin 6. The output of the phase comparator is filtered by C_4 at pins 2 and 3. The filtered control voltage then feeds the XR 210's voltage-controlled oscillator, which operates near 10 MHz.

Transistor Q amplifies the output of the voltage-controlled oscillator. The collector of Q drives a 9316, TTL divide-by-10 IC to produce a 1-MHz square wave. It is very important that the signals compared in the phase comparator be symmetrical. Otherwise the voltage-controlled oscillator output will be frequency-modulated.

The 10-MHz output signal comes from the emitter of Q via C_7. Components C_5 and R_7 set the frequency of the voltage-controlled oscillator. To adjust the frequencies, temporarily connect pins 2 and 3 on the XR 210 and vary R_7 to obtain the 10 MHz.

Tom Minnis, 77 Ortega Ave., Mountain View, Calif. 94040.

CIRCLE NO. 311



Adjust the phase-locked-loop's voltage-controlled oscillator near 10 MHz with R_7, and the circuit will lock onto and provide the stability of the input 1-MHz signal.

Programmable frequency multiplier uses octave scaler to simplify programming

An improved frequency multiplier, built around a programmable octave scaler, is simpler to program than conventional systems that use two dividers. In addition the multiplier has the following features:

- Fairly constant lockup and settling time.
- Square-wave output at any selected frequency.
- Maximum VCO (voltage-controlled oscillator) tuning range of one octave.

The standard multiplier requires selection of preset values M and N in the two dividers to output the desired frequency (Fig. 1a). The new circuit uses a single input and tunes the VCO to the highest octave of the desired frequencies. The remaining frequencies are obtained by octave division of the VCO frequency (Fig. 1b). A cascadable priority encoder, such as the 74278, and toggle-mode flip-flops make up the scaler (Fig. 2). The most significant bit of the encoder enables the highest frequency (lowest divisor) output from the scaler. The flip-flop counter has one less stage than the ÷N counter.

The VCO frequency ranges from $F_r \times (N_{MAX})/2$ to $F_r \times N_{MAX}$. As N changes so that the next highest-order bit is ONE, the scaler divides F_{VCO} by one less octave.

For example, choose a five-bit multiplier so $N_{MAX} = 31$. With $N = 7$, the 2^2 bit is ONE, and the scaler divides by $2^{5-2} = 2^3$, or 8. The total loop division is $N \times S = 56$. For $N = 8$, the scaler divides by 2^{5-3}, since the 2^3 bit is ONE and the loop division is (8×4) or 32. Finally, when $N = 15$, $S = 4$ (the 2^3 bit is still ONE), and the loop divisor equals 60.

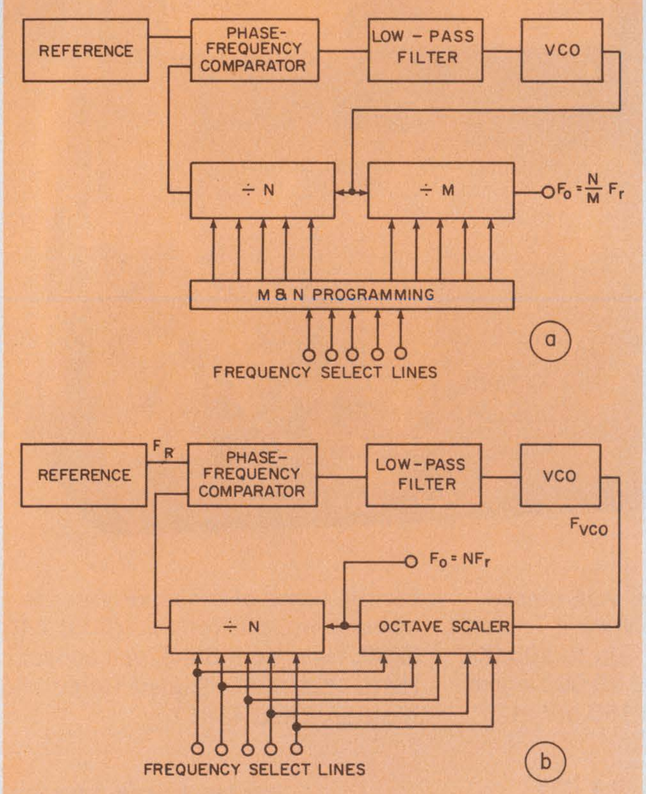
The output frequency is always NF_r, since

$$F_o = \frac{F_r \times (N \times S)}{S}.$$

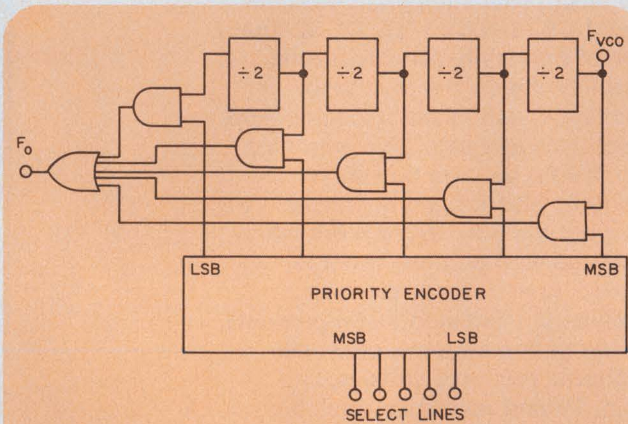
But the closed-loop gain, $N \times S$, varies by no more than a factor of two. This small variation in loop gain gives the system its fairly constant lockup and settling times.

Gary S. Vandeman, Associate Engineer, Burroughs Corp., 6300 Hollister Ave., Goleta, Calif. 93017.

CIRCLE NO. 312



1. **Conventional frequency multipliers** (a) require selection of M and N. An improved version (b) requires selection of only N, and it reduces the VCO tuning range.



INPUT SELECT	DIVIDER (N)	SCALER (S)	F_{VCO} (N x S)	F_o (N x F_r)
N=1	÷1	÷16	16 x F_r	1 x F_r
2	2	8	16	2
3	3	8	24	3
4	4	4	16	4
5	5	4	20	5
6	6	4	24	6
7	7	4	28	7
8	8	2	16	8
10	10	2	20	10
11	11	2	22	11
12	12	2	24	12
13	13	2	26	13
14	14	2	28	14
15	15	2	30	15
16	16	1	16	16
17	17	1	17	17
18	18	1	18	18
19	19	1	19	19
20	20	1	20	20
21	21	1	21	21

2. **The octave scaler uses** a priority encoder to determine the octave submultiple of the VCO frequency. The maximum variation of F_{VCO} is one octave for the entire tuning range.

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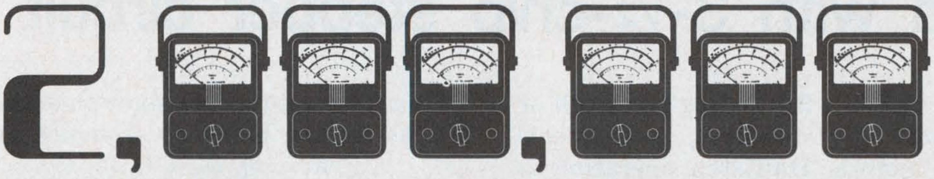

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INFORMATION RETRIEVAL NUMBER 40

Full and half-step motor operation obtained with 3-½-chip stepper circuit

A circuit built with 3-1/2 IC chips gives full or half-step operation of two-phase, permanent-magnet stepping motors. Half-step operation is often useful to provide additional resolution or to damp out rotor oscillations.

The stepping sequences generated cause incremental rotor advances of $\phi°$ or $\phi°/2$ (full or half step) for each clock sequence.

The sequence for full-step motor drive (Fig. 1a) is a four-step cyclic rotation of A'_1, A'_2, A'_3 and A'_4. The sequence for the half-step motor drive (Fig. 1b) is an eight-step cyclic rotation of A_1, A_2, A_3 and A_4. The truth tables developed from these sequences show that the driving functions for the half-step sequence are:

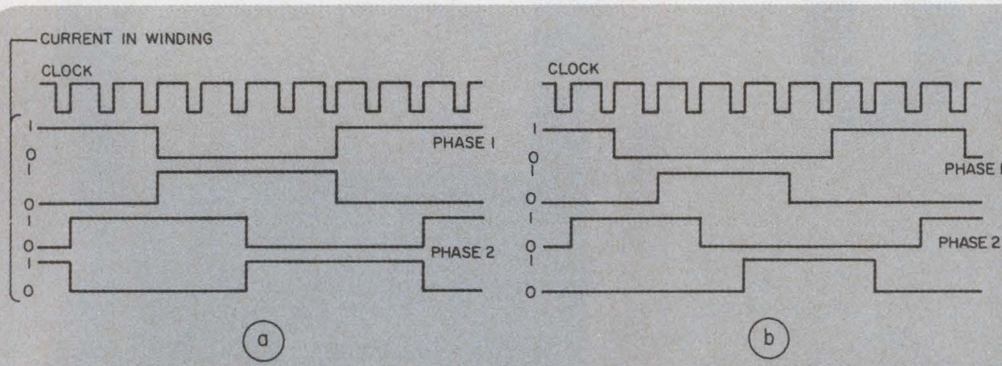
$$A_1 = Q_C\, Q_B + \overline{Q_C}\,\overline{Q_B}\,\overline{Q_A} \quad (1)$$

$$A_2 = \overline{Q_C}\, Q_B + Q_C\,\overline{Q_B}\,\overline{Q_A} \quad (2)$$

$$A_3 = \overline{Q_C}\,\overline{(Q_B\, Q_A)} \quad (3)$$

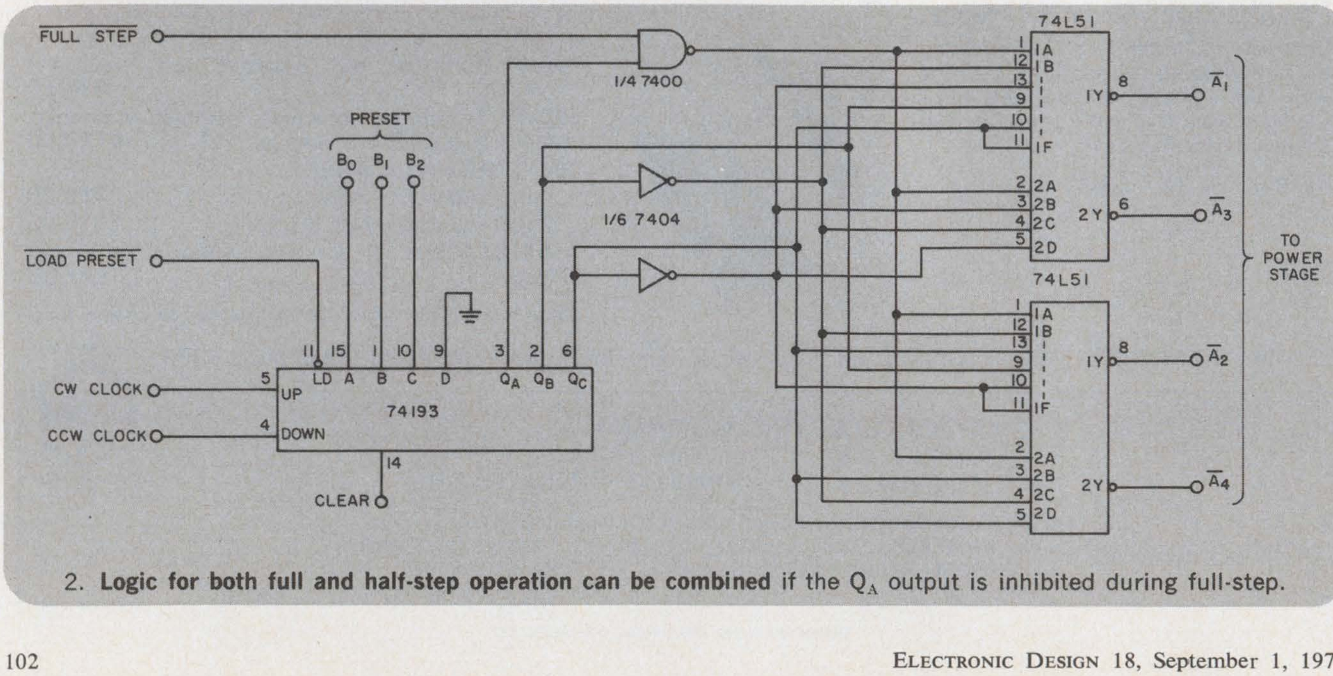
$$A_4 = Q_C\,\overline{(Q_B\, Q_A)} \quad (4)$$

As seen in Fig. 1, for every Q_A in the full-step sequence, there exists a $\overline{Q_A}$ in each driving function. Therefore driving functions A'_1, A'_2, A'_3 and A'_4 can be derived from Eqs. 1 through 4 when $\overline{Q_A}$ is forced to equal 1. Hence the logic for the full-step and half-step sequences



	COUNTER OUTPUT			FULL STEP SEQUENCE				HALF STEP SEQUENCE			
	Q_A	Q_B	Q_C	A'_1	A'_2	A'_3	A'_4	A_1	A_2	A_3	A_4
0	0	0	0	1	0	1	0	1	0	1	0
1	1	0	0	1	0	1	0	0	0	1	0
2	0	1	0	0	1	1	0	0	1	1	0
3	1	1	0	0	1	1	0	0	1	0	0
4	0	0	1	0	1	0	1	0	1	0	1
5	1	0	1	0	1	0	1	0	0	0	1
6	0	1	1	1	0	0	1	1	0	0	1
7	1	1	1	1	0	0	1	1	0	0	0

1. **The coil current sequence** for full-step motor operation has four cyclical permutations (a) and that for half-step operation has eight permutations (b). The table summarizes these relationships as a function of counter state, and is used to derive the output equations.



2. **Logic for both full and half-step operation can be combined** if the Q_A output is inhibited during full-step.

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OUTPUT VOLTAGE	OUTPUT CURRENT AMPS.	REGULATION LOAD ±%	REGULATION LINE ±%	RIPPLE MV RMS	PRICE	MODEL	SIZE INCHES
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5	.500	.1	.05	1	49.00	5E50A	3.5 x 2.5 x 1.00
5	1.0	.2	.05	1	69.00	5E100	3.5 x 2.5 x 1.25
5	1.5	.3	.1	1	98.00	5E150	3.5 x 2.5 x 1.25
5	2.0	.15	.05	1	110.00	5E200	3.5 x 2.5 x 2.00
5	2.5	.15	.05	1	125.00	5E250	3.5 x 2.5 x 2.00

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INFORMATION RETRIEVAL NUMBER 41

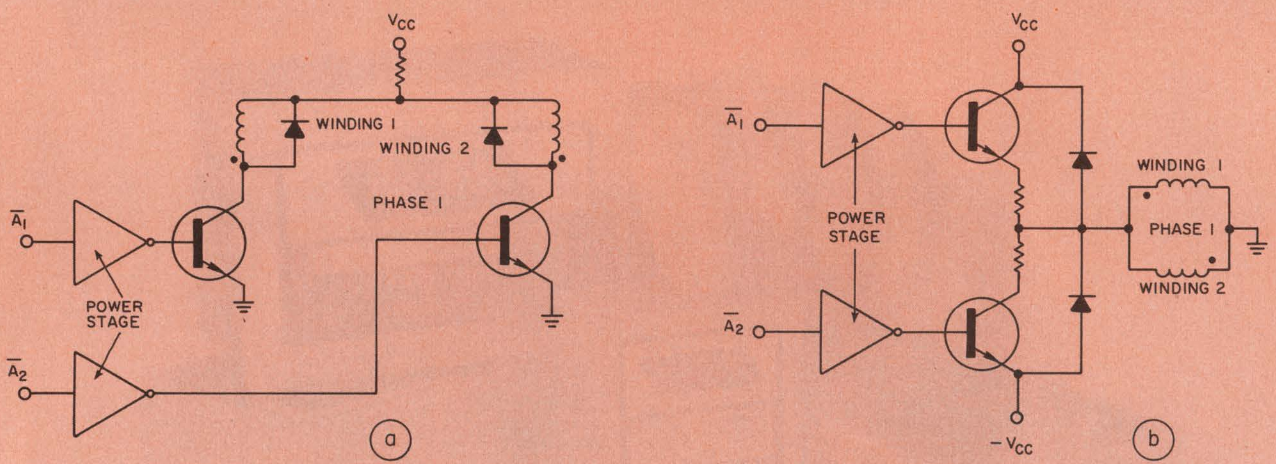
can be combined by simple inhibition of the Q_A output during the full-step sequence.

The half-step/full-step sequence driver can be implemented as shown in Fig. 2. The 74193 up/down counter provides for the clockwise and counter-clockwise rotation of the A_1, A_2, A_3 and A_4 driving functions, depending upon whether the up or down clock inputs are pulsed. The counter also provides a preset input, thus allowing the drive sequence to be preset to any of the eight counter states. A clear input is also provided. The 74L51 AND-OR-INVERT gates decode the counter outputs into the $\overline{A}_1$, $\overline{A}_2$, $\overline{A}_3$ and $\overline{A}_4$ driving functions.

Outputs $\overline{A}_1$, $\overline{A}_2$, $\overline{A}_3$ and $\overline{A}_4$ can be used with either unipolar or bipolar power stage drivers. For unipolar drive $\overline{A}_1$, $\overline{A}_2$, $\overline{A}_3$ and $\overline{A}_4$ each provide the drive to a single winding (Fig. 3a). For a bipolar drive, a positive voltage at $\overline{A}_1$ causes current to flow in the positive direction through the phase-1 winding pair, and a positive voltage at $\overline{A}_2$ causes current to flow in the negative direction through the pair. The same operation occurs with $\overline{A}_3$ and $\overline{A}_4$ with respect to the phase-2 winding pair (Fig. 3b).

Eugene Levine, Senior Engineer, Martin Marietta Aerospace, P.O. Box 5837, Orlando, Fla. 32805.

CIRCLE NO. 313



3. **Unipolar and bipolar power stages are handled** by the logic. Lines $\overline{A}_1$ and $\overline{A}_2$ provide drive to the phase-1 winding in the unipolar setup (a). With bipolar operation (b), a positive voltage at $\overline{A}_1$ causes positive currents in the pair of windings, and a positive voltage at $\overline{A}_2$ causes current flow in the opposite direction. Lines $\overline{A}_3$ and $\overline{A}_4$ operate the second phase through identical circuitry.

IFD Winner of April 26, 1974

Surjan Dogra, Gull Airborne Instruments Inc., 55 Engineers Rd., Smithtown, N.Y. 11787. His idea "A Few Parts Convert 741 Op Amps for High-Voltage-Swing Applications" has been voted the Most Valuable of Issue Award.

Vote for the Best Idea in this issue by circling the number for your selection on the Information Retrieval Card at the back of this issue.

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A CHECK

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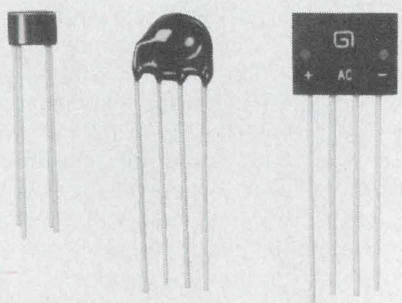
1—Who has a 4A rated bridge rectifier?	✓	✓	☐	☐	☐	☐
That does not require heatsinking?	✓	☐	☐	☐	☐	☐
At 85¢* each in 10K quantities?	✓	☐	☐	☐	☐	☐
2—Who has a ¾A rated bridge rectifier?	✓	☐	✓	☐	☐	☐
Available in three case styles?	✓	☐	☐	☐	☐	☐
All at 20¢* each in 10K quantities?	✓	☐	☐	☐	☐	☐
3—Who has a bridge rectifier that can replace 4 rectifiers at no additional cost?	✓	☐	✓	☐	☐	☐
4—Which is the first and only company using flame-retarding materials (classified 94V-0) in the construction of its rectifiers and bridge rectifiers?	✓	☐	☐	☐	☐	☐
5—Which company should be checked for the lowest priced bridges, anywhere?	✓	☐	☐	☐	☐	☐



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GENERAL INSTRUMENT CORPORATION
SEMICONDUCTOR COMPONENTS

INFORMATION RETRIEVAL NUMBER 42

international technology

Flat-panel color TV explored in Britain

Thin panels that have sheets of birefringent plastic (Cellophane) in liquid-crystal, electro-optical shutters show promise for a flat-panel color TV system. The color of the sheets, developed at the Royal Radar Establishment in Britain, may be varied by application of 10 V ac.

A problem with liquid-crystal displays—their relatively slow response time—has been overcome, the Radar Establishment reports. The liquid-crystal cells can be switched at greater than 25 Hz, with rise and fall times of a few milliseconds.

With use of the new technique in a color panel mounted in front of a monochromatic cathode-ray tube, a sequential display of 50 frames a second can be obtained. Synchronization of different frames of information on the CRT with the rapidly changing colors of the panel allows the eye to integrate the frames, giving two-color or multicolor displays.

Improvements in color purity are obtained by choice of CRT phosphors that give two or more emission lines. The panel switches between these peak phosphor wavelengths. The production of multicolor displays with these techniques is being investigated.

Simpler forms of the display may be produced without the fast switching technique. Two-color, four-digit numeric displays have been demonstrated, and multicolor-pattern displays have been produced that change their pattern and color continuously in response to an audio signal. These techniques will probably be applied in colorimetry and color printing.

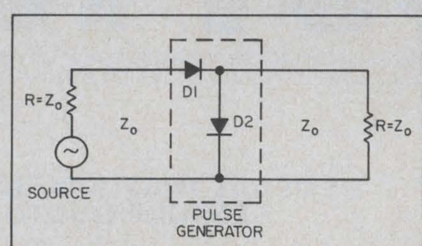
Pulse-generator design simplified in Turkey

A two-step, recovery-diode pulse-generator circuit developed in Turkey eliminates the additional elements usually required as inductors, capacitors and biasing and matching networks. The Turkish design conceived at the Middle East University in Ankara, Turkey, consists simply of two matched step-recovery diodes (see illustration).

The simple circuit can be built in coaxial form, and it may be sine-wave or square-wave driven. When the input signal is positive, both diodes are forward-biased, and they store a charge, D_1. This is slightly greater than charge D_2, since some of the input current flows through the load.

During forward bias, the turn-on voltage of D_2 (about 0.7 V) appears across the load. On reversal of the input polarity within less than the minority-carrier lifetime of the diodes, the currents through the diodes reverse. The output voltage then remains almost constant until the stored charge in one of the diodes is completely recovered.

The charge in D_2 is recovered first, since the equivalent resistance seen across the terminals of



D_2 is less than that of D_1. D_2 then ceases to conduct, and the output voltage rises towards the input-voltage level at a speed determined by the transition time of D_2. As soon as the D_2 transition is complete, D_1 recovers and stops conducting, so that the output voltage falls to zero.

Since no external components are required, both diodes can be integrated on a single chip to form a pulse generator.

TV-telephone network to be tested by Dutch

An experimental video-telephone system will be set up by the Netherlands PTT (post office) for joint use with Philips over two years.

Philips Research Laboratories has tested a local network since 1972 and plans technical and operational evaluation of the new network. Changes in subscriber communication patterns will be watched, as well as the extent to which picture telephony reduces the need for travel.

Discussions are leading toward the setting up of international standards for video telephone systems. The Netherlands delegation is in favor of compatibility with broadcast television, so existing TV equipment can be used.

The total of subscribers on the PTT/Philips experimental system will be 65. Existing transmission and switching equipment will be used wherever possible, but the whole system will be separate from the public telephone network. Three hundred repeaters will be employed, and two picture telephone conversations will be possible simultaneously on a radio-relay link by use of a special modulator-demodulator developed by the post office.

The pictures will have 325 lines, with a bandwidth of 1.3 MHz sufficient to convey a head-and-shoulders picture. This bandwidth is about a quarter that required by European TV pictures with 625 lines per frame. Because compatibility with 625-line TV is required, the picture telephone will be developed to use 313 lines—the closest possible approximation to half the 625 lines of standard TV.

IR's new glass passivated, high voltage Power Transistors and Darlingtons...

Better performance where it really counts.*

The three other largest selling high voltage power transistor lines of today offer you good characteristics. But while a specific device may excel in specs for one parameter, it may be marginal in other equally important characteristics. Not so with IR's new high voltage power transistors. They easily meet or exceed all established specifications. Now you can design a better, more efficient circuit without compromising.

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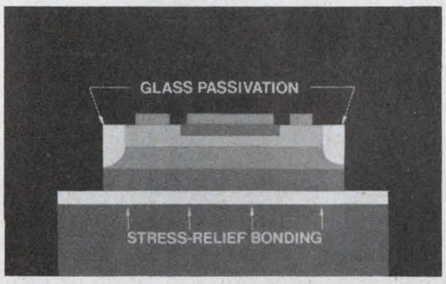

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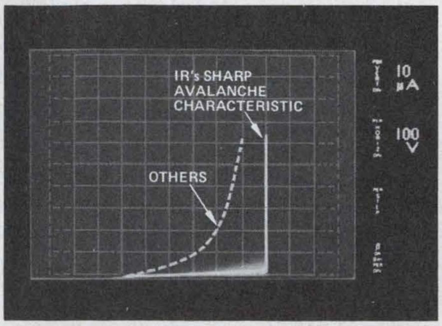

The avalanche curve pictured shows our "sharp" curve and the "soft" curve of the others. Convincing evidence of better junctions that you can operate at full rated specs without a worry.

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IR saturation voltage is lower than the others. Higher efficiency, less power loss, reduced power consumption and system operation at lower power levels are your new advantages. And you won't have to sacrifice switching speeds or voltage capability.

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IR's "Stress-Relief" bonding between the chip and mounting surface gives better protection from thermal cycling, gives you an extra margin of safety in thermal design considerations, with a broad safe-area that is more than adequate for any application.

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IR high voltage power transistors are available in 12 models rated from 300 to $700V_{CBO}$ with an I_C from 7 to 10 Amps (pulse). Monolithic Darlingtons in 15 models are rated to $600V_{CBO}$ with an I_C from 15 to 25 Amps (pulse). All are in the standard TO-3 package.

Find IR's equivalent to the devices you're now using, then ask your local IR salesman, Rep or Distributor for complete specs and a test evaluation sample. When you've put it to the test, we think you'll agree. It's better – everywhere that counts.

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IR403	DTS 403		
IR409	DTS 409		
IR410	DTS 410	RCA410	MJ410
IR411	DTS 411	RCA411 2N5838 2N5839	MJ411 MJ1800 MJ3029 MJ3430
IR413	DTS 413	RCA413 2N5840	MJ413
IR423	DTS 423	RCA423	MJ423
IR424	DTS 424		MJ424
IR425	DTS 425		MJ425
IR430	DTS 430	2N5239 2N5240	MJ430
IR431	DTS 431	RCA431 2N5240	MJ431 2N5241
Monolithic Power Darlingtons			
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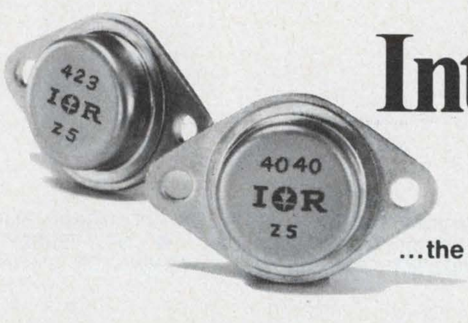

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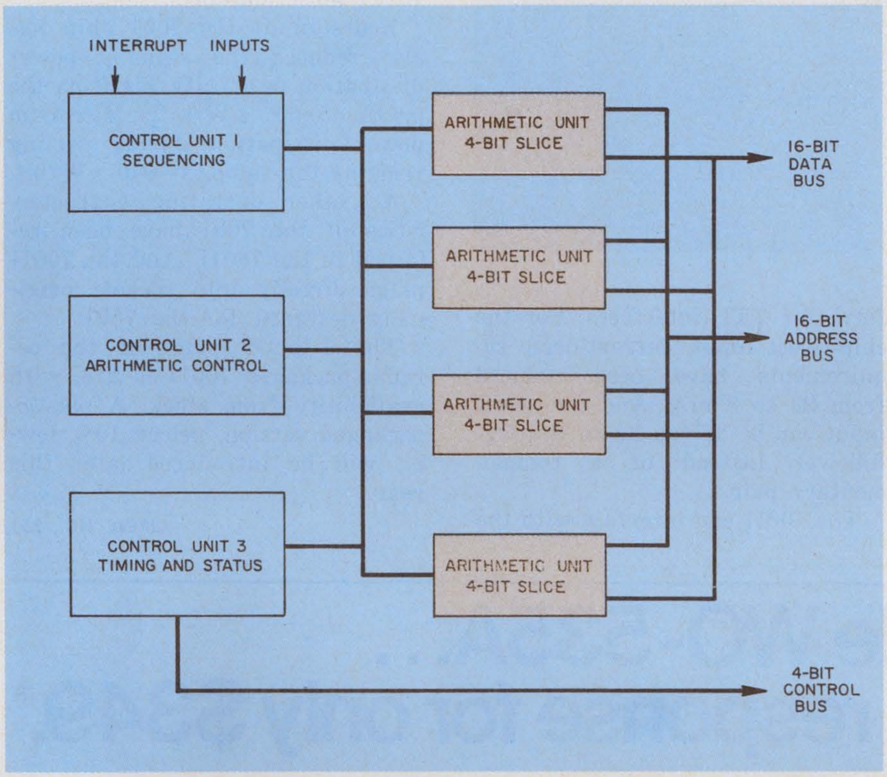
INFORMATION RETRIEVAL NUMBER 43

Bipolar/LSI processor races to the forefront



Raytheon Semiconductor, 350 Ellis St., Mountain View, Calif. 94042. (415) 968-9211. P&A: See below.

The first bipolar/LSI microprocessor, a 16-bit multichip parallel processor (Model RP16) announced by Raytheon Semiconductor, offers a 200-ns cycle and 1-μs instruction time. These are the highest speeds available from general-purpose "computers on a chip" (see "Focus on Microprocessors," this issue, p. 52).

The only other LSI processor to use bipolar technology is a special-purpose, 16-bit unit from Monolithic Memories, Inc., 1165 E. Arques Ave., Sunnyvale, Calif. 94086. Called the Model 6701 microcontroller, this circuit is intended more for the computer architect rather than the random-logic designer. It requires microprogramming techniques and aims for applications such as the emulation of conventional computers.

Other microprocessors employ MOS technology. One example is the IMP-16 (also a 16-bit unit) from National Semiconductor, 2900 Semiconductor Dr., Santa Clara, Calif. 95051. Architecturally the National and Raytheon units resemble each other. Both are multichip models built around two building-block chips—a 4-bit register and arithmetic logic unit (RALU) and a control read-only memory (CROM).

However, use of standard PMOS technology for the National IMP chips results in somewhat slower data processing, compared with Raytheon's RP16, which is manufactured using the company's high-density V-ATE process. For example, a basic register add time (per data word) for the IMP-16 is 1.4 μs vs 1 μs for the RP16.

Seven chips make up a complete Raytheon microprocessor (see diagram). Four RALUs—each containing eight registers, for 32 bits of storage—constitute the arithmetic section. And three CROMs provide storage for the fixed instruction set and the control logic for the RALUs. For a complete processing unit, a delay line is also needed to obtain the required clocking. The RP16 can interface with low-power Schottky-TTL circuits (standard 54/74LS circuits).

The new bipolar microprocessor responds to 32 16-bit instructions. Although the number of instructions isn't as large as that for, say, 8-bit processors, the RP16 repertoire provides instructions that require routines in 8-bit units. For example, the RP16's 32 instructions include multiply and divide, add and subtract in single and double precision, and logic Inclusive and Exclusive-OR. Also in the set are seven conditional and unconditional jump commands, as well as five skip instructions that perform increment, decrement, compare or mask operations.

Data words can be 8 and 16-bits in length for fixed-point arithmetic, 16 bits for logic operation and 32 bits for double-precision arithmetic. In addition the RP16 has 11 address modes—seven basic and four extended—for increased flexibility and efficiency in programming.

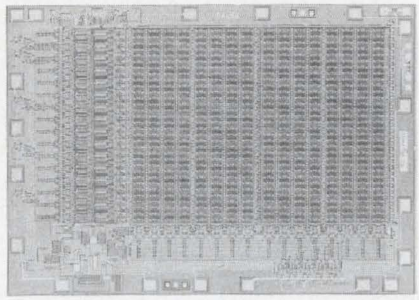
The RP16 can address directly 64-k words of memory. An asynchronous timing scheme allows the use of virtually any speed or type of memory. However, Raytheon plans to offer a semiconductor memory card for the RP16.

Other features include a two-level interrupt scheme—direct or program controlled—that can be expanded to provide a multilevel priority network. Moreover the bipolar microprocessor requires only a single 5-V supply. And the processor operates over the MIL temperature range.

Two versions of the RP16 are planned. Model A emphasizes arithmetic capabilities, while Model B stresses byte handling. Both models are expected to be available early next year at an introductory price of well under $300.

CIRCLE NO. 252

Redesigned 1-k NMOS RAM eliminates drive circuits



Advanced Memory Systems, 1276 Hammerwood Ave., Sunnyvale, Calif. 94086. (408) 734-4330. P&A: See text.

The unusual input level and drive requirements of the 1024-bit 7001 NMOS static RAM can be eliminated without loss of the circuit's high speed (60-ns access time and 180-ns cycle time). An improved version—the 7001I from Advanced Memory Systems—is much easier to use, and also adds some of the needed interface circuitry.

The new version uses standard TTL, 2.4 and 0.8-V, input levels. The old AMS memory required pullup resistors to change the 4 and 0.8-V input levels to a usable form for TTL interfaces. For the chip-select input, current-drive requirements have been reduced from 20 to 8 mA. And the select input can be driven by an emitter-follower instead of a complementary pair.

The 7001I can interface with the Texas Instruments' or equivalent 75261 sense amplifier.

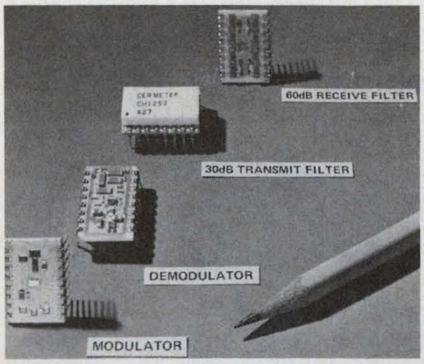
Redesign of the 7001 chip has also reduced the standby power dissipation to 0.5 μW/bit from the previous 60 μW/bit. Maximum power dissipation during cycling remains the same, at 640 μW/bit.

All other operating characteristics of the 7001 have been retained in the 7001I. And the 7001I plugs directly into sockets originally designed for the 7001.

The 1-to-999 price of the ceramic-packaged 7001I is $18, with availability from stock. A plastic-packaged version, priced 10% lower, will be introduced later this year.

CIRCLE NO. 251

4-package modem costs less than $62



Cermetek, Inc., 660 National Ave., Mountain View, Calif. 94043. (415) 969-9433. P&A: See Below.

Four thick-film hybrid circuits can handle the great bulk of functions for a modem in 300-baud FSK applications. Called the mini-Modem, the quartet of hybrid circuits needs few additional components to create a Type 103/113 compatible modem—at a total parts cost of less than $62, in 100-unit quantities. The circuits and their unit prices (100 up) are as follows: the CH1213 demodulator ($19.50); the CH1214 modulator ($10.65); the CH1252 dual frequency 30-dB transmit bandpass filter ($12.70) and the CH1257 dual frequency 60-dB receive bandpass filter ($16.45). All circuits are available from stock.

CIRCLE NO. 253

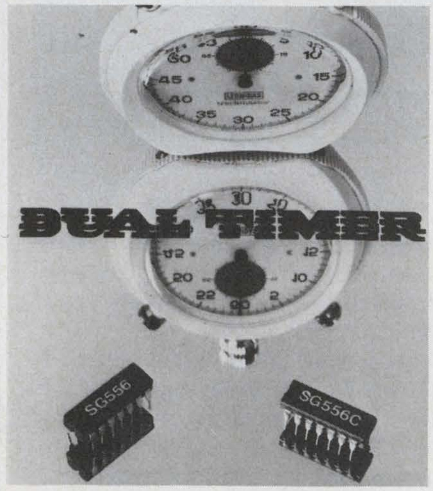
'Stik' family aims for calculator use

Western Digital Corp., 19242 Red Hill Ave., Box 2180, Newport Beach, Calif. 92663. (714) 557-3550.

Using MOS/LSI silicon-gate technology, the manufacturer offers an expanding line of single-chip calculator circuits, dubbed the Stik family. The units incorporate the following features: full floating-point entry and results, algebraic entry, automatic constant, chain calculations and reduced power consumption. One IC, the MC1532B, has a selectable 10 or 12-digit display for positive or negative numbers, permits user selection of arithmetic or algebraic entry and provides various fixed-point rounding options, such as roundup, rounddown and roundoff.

CIRCLE NO. 254

Two 555-type timers come on single IC



Silicon General Inc., 2712 McGaw Ave., Irvine, Calif. 92705. (714) 556-1600.

Two standard 555-type timers are available in one 14-pin DIP. Each section of the new dual timer (SG 556) can be used to produce accurate time delays ranging from microseconds to hours. Also, each timer has independent output and control terminals, and each can source or sink 200 mA and drive TTL. Timing accuracy (military grade) is typically 0.5%.

CIRCLE NO. 255

Interface ICs aid bussed-data designs

Signetics, 811 E. Arques Ave., Sunnyvale, Calif. 94086. (408) 739-7700.

A series of interface circuits, including transceivers, is available for bus-organized data systems. The two bus transceivers in the offering are the 8T34, which has three-state outputs, and the 8T38 with open-collector outputs. Each IC package contains four sets of drivers and receivers and they have a common two-input disable control for the drivers. Outputs can drive 100-Ω terminated busses. The drivers of the 8T38 can each sink 50 mA at 0.7 V, and those of the 8T34 sink the same amount of current at 2.4 V. In addition, each of the 8T34 drivers can serve as a source of 10.4 mA at 2.4 V.

INQUIRE DIRECT

FIFO measures 40-words × 9-bits

Fairchild Semiconductor, 464 Ellis St., Mountain View, Calif. 94042. (415) 962-3816. $15.60 (100).

Problems associated with the interfacing of digital systems with different data rates can be solved through the use of a 40-word by 9-bit first-in, first-out (FIFO) memory called the 3351. The Isoplanar memory operates at data rates from dc up to 1.5 MHz, has independent asynchronous inputs and outputs and is compatible with TTL circuitry. It comes in a 28-pin DIP.

CIRCLE NO. 256

ECL 10,000 circuits include 200-MHz gate

Motorola Semiconductor Products, Inc., P.O. Box 20924, Phoenix, Ariz. 85036. (602) 244-3466. $2.26 to $5.10 (100-999).

Three new circuits in the MECL 10,000 series are offered in ceramic 16-lead packages for the −30 to +85 C temperature range. The circuits consist of a binary counter (the MC10178L), a negative-clock quad latch (the MC10153L) and a high-speed dual 2-NOR/1-OR gate (the MC10212L). The gate has minimum toggle frequencies of 200 MHz.

CIRCLE NO. 257

Analog switch has 3 SPDT circuits

Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, Calif. 95054. (408) 246-8000. $6.50 to $26.25 (100); stock.

A triple SPDT analog MOS switch, the DG170, incorporates bipolar transistors, Schottky diodes and p-channel MOSFETs on a common substrate. The circuit is directly compatible with TTL, CMOS and DTL logic, and requires no external interface components. Features of the DG170 include 300-to-400-ns switching speeds and break-before-make switching action. ON resistance (DS) is 800 Ω, and analog signal range is −10 to +10 V. A level-shifting push-pull driver function enables low-level logic to control the ON/OFF state of the switch.

CIRCLE NO. 258

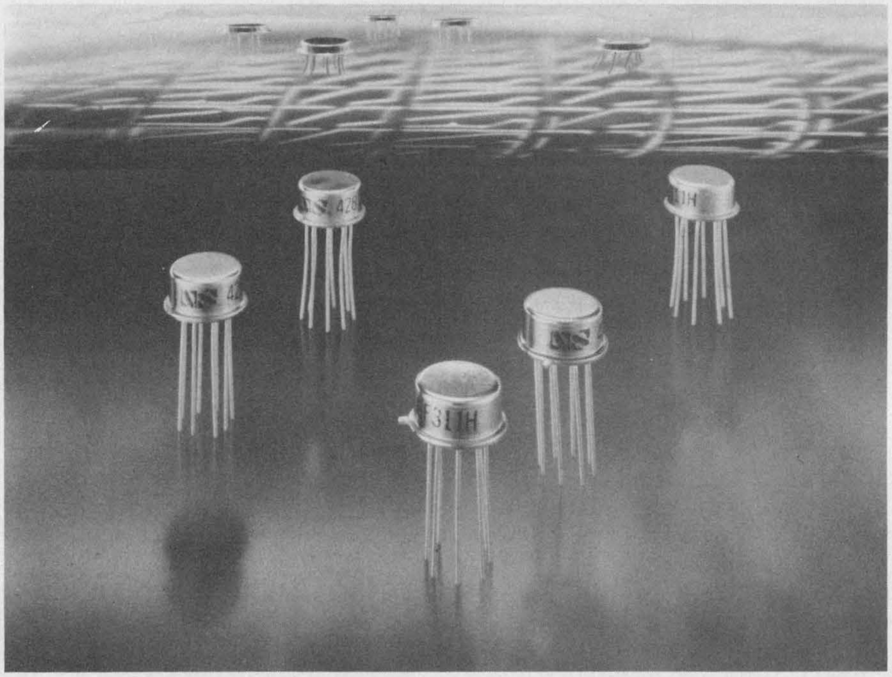
Audio amp works off 4-to-12-V supply

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. (408) 732-5000.

The LM386 audio amp, designed for use in battery-powered equipment, operates from 4-to-12-V supplies. It features a low quiescent current drain of 3 mA, and requires few external components. A complete audio amplifier capable of delivering 500 mW into a 16-Ω load when operated from a 9-V supply consists of the LM386, an output coupling capacitor and a volume potentiometer. Gain is internally set at 20, but with the addition of an external RC, it can be set anywhere from 20 to 200. Another feature of the circuit, which comes in an 8-pin DIP, is a low total harmonic distortion of typically 0.2%.

INQUIRE DIRECT

FET voltage comparators shrink input currents to pA



National Semiconductor, 2900 Semiconductor Dr., Santa Clara, Calif. 95051. (408) 732-5000. P&A: See text.

FET-input voltage comparators can eliminate source loading, and thus serious inaccuracies. The National Semiconductor LF series have input currents down in the picoamp region, to eliminate most input current-loading errors.

The LF111, LF211 and LF311 FET comparators can replace directly the older LM111, 211 and 311 bipolar-input models. Most of the basic comparator specifications have been maintained. The major change is an input offset current of 25 pA, max, and 5 pA, typical. The comparators' input bias current is 50 pA, max, and 20 pA, typical. By comparison, the older LM units have offset and bias currents of 10 and 100 nA, respectively.

Positive input voltages to the new series can be up to 30 V above the negative supply level. Negative input voltages can be equal to the negative supply or 30 V below the positive supply, whichever is less. For ±15 V supplies, this permits an input signal of ±15 V. The relatively high input voltages are made possible without internal bootstrapping circuitry, because the input FET is a high-voltage (50-V), p-channel ion-implant device. National says it is the first use of such a transistor in a monolithic IC.

Some of the other comparator specifications include: maximum power dissipation of 500 mW; max differential voltage input of ±30 V; typical voltage gain of 200 V/mV; output leakage current of 0.5 μA, max; and a typical strobe ON current of 3 mA.

The LF series is available in metal TO-99 cans, flat packs, DIPs and miniDIPs, with both commercial and military temperature ratings.

The price of the least-expensive version, LF311H, with 0-to-70-C rating in a metal can is $4.25 in 100 quantities, while the most expensive, LF111F, with −55-to-125-C rating in a flat pack is $25 for 100 lots. Units are available from stock.

INQUIRE DIRECT

Our 4203 four-quadrant monolithic IC Analog Multiplier is not only tiny and priced to sell, but it is completely self-contained. It needs no external components to deliver a guaranteed untrimmed accuracy of up to 1%. And, if you need even less total error, it can be trimmed to just 0.6%.

What does it mean to you that it is self-contained? Less design time, and a lower installed cost, that's what. Also, because it doesn't need trimpots to adjust offset voltage and gain errors or external amplifiers, there are less circuit components to drift with time and temperature, and less space needed. This hermetically sealed TO-100 unit is versatile, too. Its internal op amp allows you to use it as a highly accurate two-quadrant divider. Add a simple diode, and you have a neat little square rooter. You get high reliability, fully monolithic construction, versatility, and performance that equals some of the high cost modular units. You get a 25V/μsec slew rate, a 1 MHz bandwidth, and a settling time to 2% of final value of just 1 μsec. And, you get a unit that is ideal for hundreds of medical, industrial, and commercial applications. **The best part is that prices start at only $17.00 in 100's. Write or call us for complete details.**

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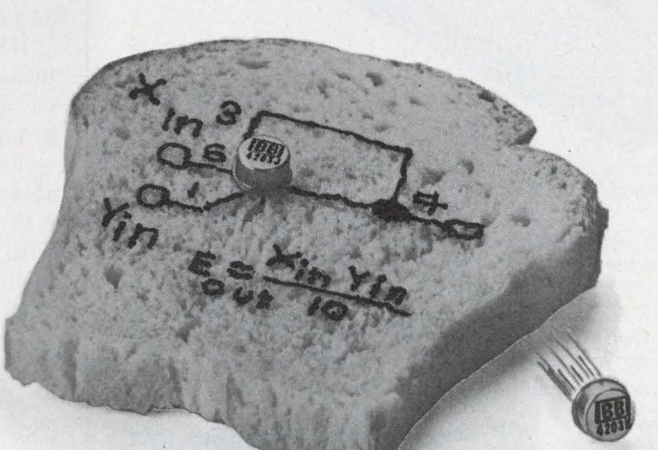
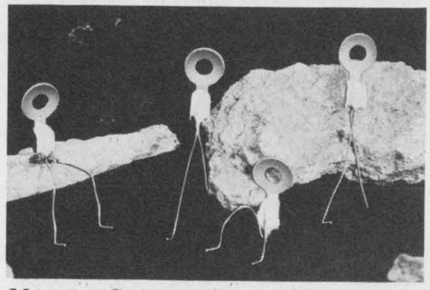


Another Analog IC from Burr-Brown

INFORMATION RETRIEVAL NUMBER 51

Posistor protects semicons from overload



Murata Corporation of America, 2 Westchester Plaza, Elmsford, N.Y. 10523. (914) 592-9180.

A positive temperature-coefficient resistor can sense the case temperature of a high-power semiconductor and reduce its power dissipation when power limits are approached. This new Posistor, the PTH 487A, is mechanically affixed to the semiconductor device's case and electrically connected in series with its base-biasing circuit, in typical applications. The resistance of the unit, nominally 500 Ω at normal operating temperatures, increases rapidly once the protective temperature threshold is reached—2000 Ω at 176 F and 3000 Ω at 194 F. Maximum voltage and current ratings are 12.5 V dc and 0.1 A. Maximum external withstanding voltage is 15 V dc.

CIRCLE NO. 259

Ceramic chip capacitors take up to 4000 WV dc

Johanson/Monolithic Dielectrics Div., Box 6456, Burbank, Calif. 91505. (213) 848-4465. $0.40 to $4.11 (1000 up); stock to 8 wks.

HV series ceramic chip capacitors for operation up to 4000 WV dc are now available in a new group of monolithic ceramic construction. The capacitors are available in five standard sizes from 0.15 × 0.15 to 0.54 × 0.40 in. with a 0.12-in height. Each size includes units for 1000, 2000, 3000 and 4000 WV dc operation with standard RETMA capacitance values from 330 pF to 0.082 μF. Their small size and high voltage characteristics make them ideal for applications in high voltage power supplies and meter multiplier circuits.

CIRCLE NO. 260

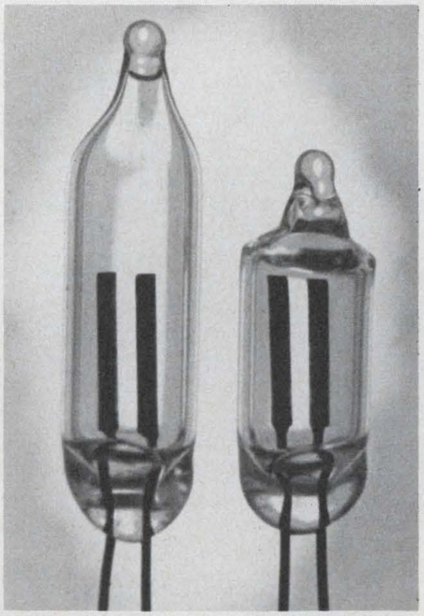
Capacitors can store to 5000 joules at 20,000 V

Capacitor Specialists Inc., P.O. Box 2052, Escondido, Calif. 92025. (714) 747-4000.

Large energy-storage capacitors, designated Series ES, range from 1125 to 5000 joules at voltage ratings from 3000 to 20,000 V dc. They are all housed in cases with standard 7-1/4 × 14-in.-base sizes made of heavy-gauge heliarc-welded steel and have the latest paper/polyester-film dielectric construction. Of particular interest is the availability of two bushing styles in each rating: a standard low-profile bushing, where applications require under 40 nH inductance, high reversal and high peak currents; and a lower-cost, convoluted, pillar-type bushing for flashlamp service.

CIRCLE NO. 261

Neon glow-lamp life increased with long bulb



ELT Inc., Pauls Valley, Okla. 73075. (405) 238-5541.

Glow-Lite increases the photometric longevity of neon lamps by using longer glass envelopes than usual. In this way, disposition of sputtered material is confined to the lower two-thirds of the lamp, which leaves the tip clear. This is particularly important in photocell applications. However, the process can be adapted to suit any neon lamp, where end-on light output is critical.

CIRCLE NO. 262

Incandescent indicator guaranteed for 5 years

Data Display Products, 5428 W. 104th, Los Angeles, Calif. 90045. (213) 641-1232. $2.32: lights; $0.39; sockets (1000 up); stock to 4 wks.

Two types of long-life indicators are guaranteed for a period of five years when failure occurs during normal operation within specifications. Replacement will be made automatically, free of charge, upon receipt of failed lights. Type A07 or D07 at 5 V, 30 mA is for low-current applications and type A1 or D1 at 5 V, 60 mA is for standard applications. And both have a built-in lamp driver with keep-alive lamp bias. Both types are in a miniature 1/4-in. dia. housing for use with inexpensive panel-mounting sockets. The socket mounts in a 5/16-in. dia. panel hole, and it may be mounted on 1/2-in. centers.

CIRCLE NO. 263

LOOKING FOR ICs AND SEMICONDUCTORS?

TRW SEMICONDUCTORS

intel

MOTOROLA

RAYTHEON

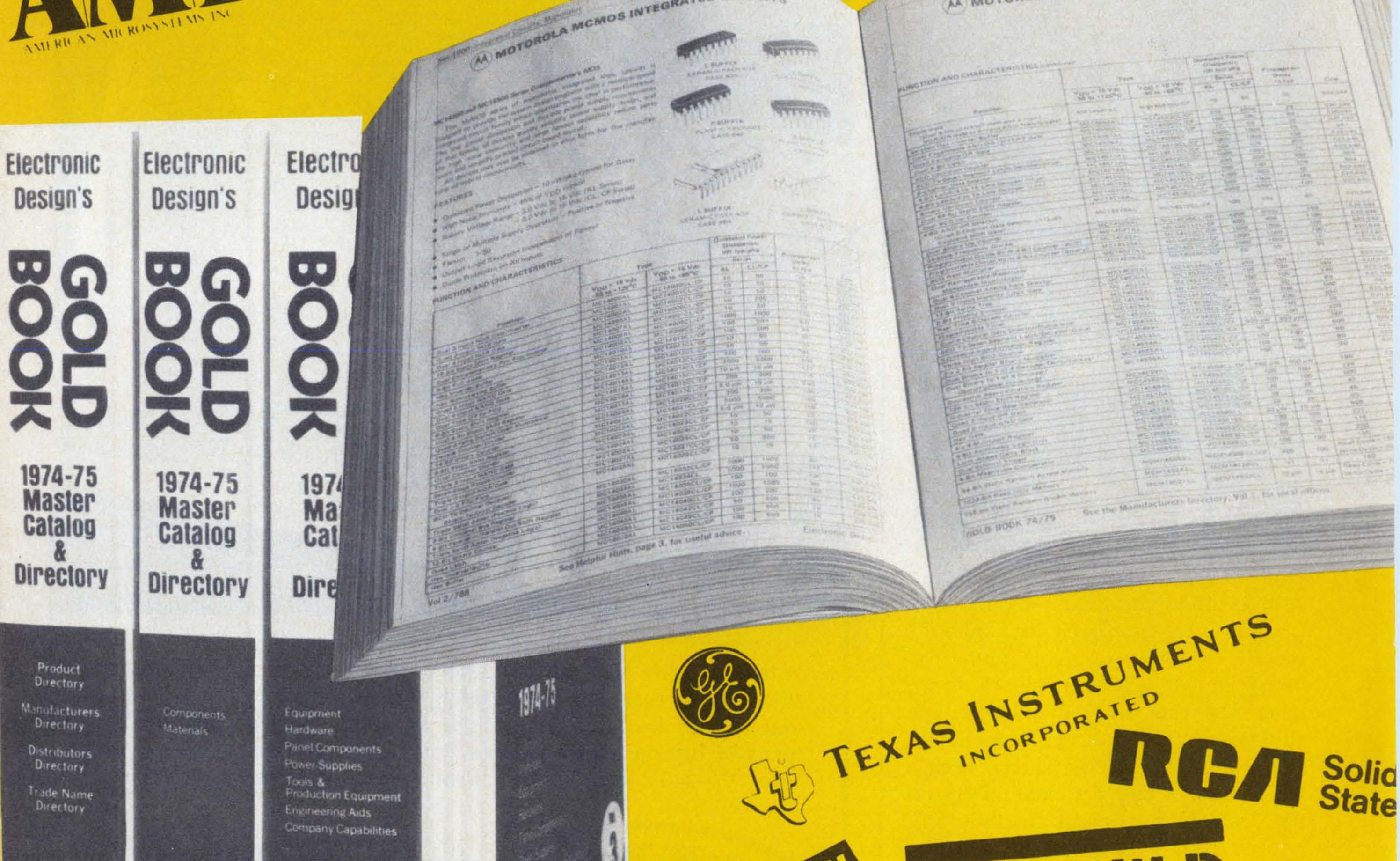
Siliconix incorporated

GENERAL INSTRUMENT CORPORATION SEMICONDUCTOR COMPONENTS

ANALOG DEVICES

Beckman

AMI AMERICAN MICROSYSTEMS INC



TEXAS INSTRUMENTS INCORPORATED

RCA Solid State

MOSTEK

FAIRCHILD

Intersil

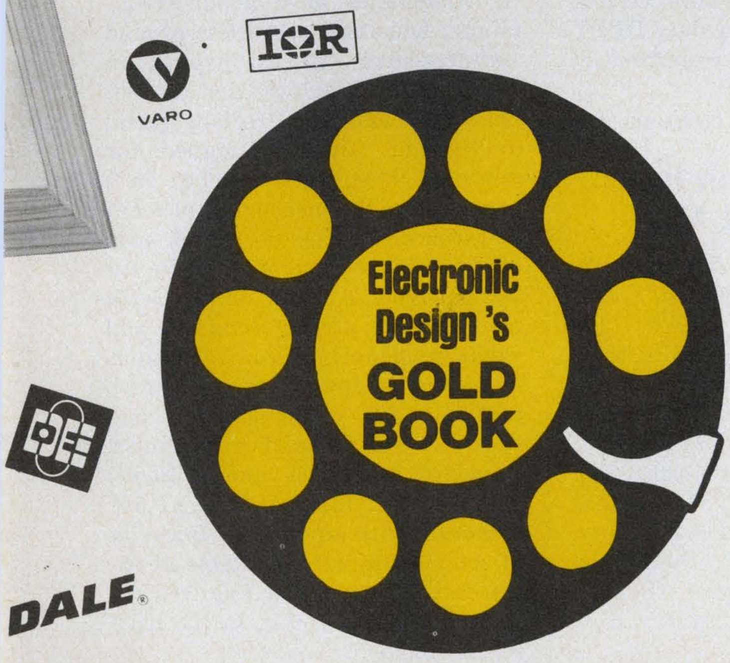
National Semiconductor Corporation

LOOK FIRST IN Electronic Design's GOLD BOOK

MORE THAN 500 CATALOG PAGES DETAIL ICs AND SEMICONDUCTOR PRODUCTS

More than one-third of Vol. 2 of *Electronic Design's* GOLD BOOK is devoted to manufacturers' catalog pages on ICs and semiconductor products. There are separate sections on *Hybrid ICs, Monolithic ICs* and *Discrete Semiconductors.* LEDs are found in Vol. 3 as are products related to semiconductor use (such as IC sockets and other hardware). The catalog pages are filled with technical data you need to select and specify the right IC or semiconductor to suit your needs.

If you are interested in a particular manufacturer, move directly to the INDEX OF CATALOG PAGES to see what he has to offer. If you want to find new sources go to the PRODUCT DIRECTORY (Vol. 1) and check the roster. Boldface listings at the beginning of each product classification signal those companies who have placed catalog pages in *Electronic Design's* GOLD BOOK for your convenience.



LOOKING FOR A DISTRIBUTOR?

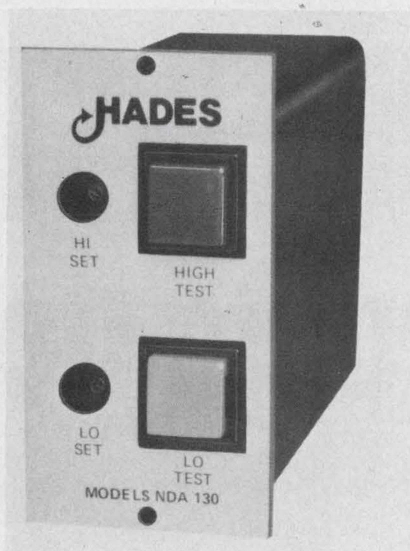
Distributors are listed 3 ways in *Electronic Design's* GOLD BOOK.

1. **BY THE MANUFACTURERS THEY REPRESENT** U.S. distributors follow each manufacturer's listing in the MANUFACTURERS DIRECTORY (Vol. 1).
2. **ALPHABETICALLY BY NAME** 5,700 distributors are listed with complete addresses and phone numbers. When provided, you'll also find sales volume or net worth, year established and names of key officials.
3. **GEOGRAPHICALLY BY STATE** You can find a distributor near your town—or one nearby. Check the alphabetic section to learn more about them.

IT'S ALL THERE . . . IN ELECTRONIC DESIGN'S GOLD BOOK

COMPONENTS

Current/voltage alarm repeats trip point 0.1%



Hades Manufacturing Corp., 151A Verdi St., Farmingdale, N.Y. 11735. (516) 249-4244. $89 (unit qty); 4 wks.

Model NDA130 current/voltage alarm has a trip-point repeatability of 0.1%, is surge protected and has complete isolation between input, output and power. Multiple input ranges are available to accept a wide range of transducer voltage and current levels. Response time is 15 ms. Trip-level adjustments are made with a 20-turn potentiometer. Line voltage effect on trip point is 0.2% for line voltage changes of ±10%. A built-in noise-rejector circuit reduces the effect of noise on the input lines. Output of the alarm is a heavy-duty DPDT relay with a 10-A resistive-load contact rating.

CIRCLE NO. 264

Resistor test unit has 1-Ω steps to 11 MΩ

Phipps & Bird, Inc., P.O. Box 2V, Richmond, Va. 23205. (804) 644-5401. $48 (unit qty); stock.

Small enough to be easily hand held, a new aluminum-housed resistance-substitution unit provides a range from 1 to 11,111,110 Ω in 1-Ω steps with slide switches. The Model 236-A uses 1/2-W resistors with 1% accuracy and it has three binding posts—one to ground the case. Its aluminum case, finished in wrinkle blue, measures 4 × 6 × 1-3/16 in.

CIRCLE NO. 265

Thin-film resistor net uses nichrome elements

Analog Devices, Inc., P.O. Box 280, Norwood, Mass. 02062. (617) 329-4700. See text.

A family of seven discrete thin-film resistors in a single ceramic 14-pin DIP or Flatpak, the AD1830 series, can have resistances from 50 Ω to 500 kΩ. Ratio accuracies are to ±0.01%; ratio TCR tracking is to ±1 ppm/°C max, noise to −50 dB; response time under 10 ns max; and long term ratio stability is ±0.01% per year at 25 C. Prices for a ±0.1%-ratio accuracy family with a 0-to-70-C temperature range, the AD1830J, are $8 in small quantities, $4.50 in hundreds. A ±1% version, the AD-1830H, is priced at $3 in hundreds. Nichrome thin-film resistive elements are used. The resistor series is also available in a chip version with optional certification to MIL-STD-883 and a −55 to 125 C temperature range.

CIRCLE NO. 266

Linear-motion pot measures displacement

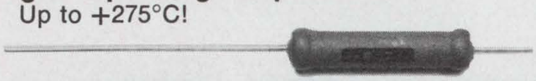
Waters Manufacturing, Inc., Wayland, Mass. 01778. (617) 358-2777. $100 to $300; 8 wks.

Linear-motion potentiometers with plastic elements can measure mechanical displacement with an incremental sensitivity of 0.00005 in. Assemblies have anodized-aluminum housings, centerless-ground stainless-steel shafts, precision needle-roller bearings and a Delrin wiper carrier. Precious metal multifinger wipers, designed for minimum hysteresis (≦0.001 in.), are used on the measuring element and collector. The series of pots offers standard lengths in 6-in. intervals from 0.5 to 3.0 ft. with nonstandard stroke lengths and various mounting configurations available as special options. Also available are dual elements and through-shaft configurations. Standard resistance value is 10,000 ±10% Ω/ft. Linearity is ±0.5% standard, with an optional linearity of ±0.1% absolute available at extra cost. The nominal required operating force is 100 g, in the horizontal plane.

CIRCLE NO. 267

Add it all up...

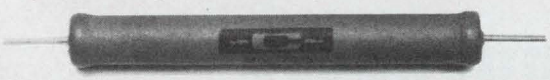
+ Higher Operating Temperatures —
Up to +275°C!



+ Higher Stability —
Full power stability is typically better than 0.1% in 2000 hours!

+ Extra-Close Temperature Tracking —
Matched resistor sets provide TC tracking as close as 2 ppm/°C!

+ Higher Voltage and Power Ratings In Smaller Sizes —
Micronox power films handle more power over a wider resistance range with proven long-term stability!



+ Exclusive Non-Inductive Design —
Serpentine film pattern produces axial-lead resistors with full voltage and power ratings!

= Higher Performance in All of Your Circuits!

Caddock Power Film Resistors will help you up-grade your equipment...now!

Caddock has over 700 models of 12 standard resistor types to choose from, and our program of continuous testing proves the superior performance and stability that we claim!

Look into EEM for technical data, and write or call to Caddock Electronics, Inc., 3127 Chicago Ave., Riverside, Calif. 92507, Tel: (714) 683-5361 — TWX: 910-332-6108. We'll send you our 12 page catalog and the results of the full power stability tests that have been running continuously for over 5 years! Then you'll have positive proof of the performance you can expect from —

CADDOCK

INFORMATION RETRIEVAL NUMBER 57

Solder Clads
for Electronics

TMI produces solder clads by pressure-bonding (cladding), re-flowing, and other proprietory methods. This enables us to offer a complete range of solder thicknesses and physical properties.

Advantages:

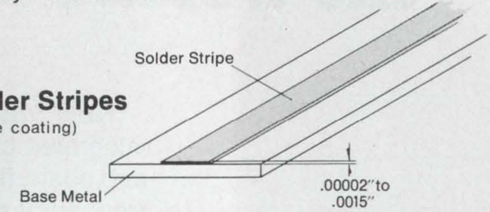
1. Reduced labor cost.
2. Increased flexibility in design.
3. Elimination of multiple handling and inspection of stamped parts.
4. Improved and consistent quality of the end-product.
5. Permanent solderability, providing increased shelf life.

Applications:

Among the major users of solder clads are the semiconductor and electronic industries. More recently, manufacturers of communication equipment, connectors for data processing equipment, jewelry, automotive, and computer parts have recognized the advantages offered by solder clads.

Availability:

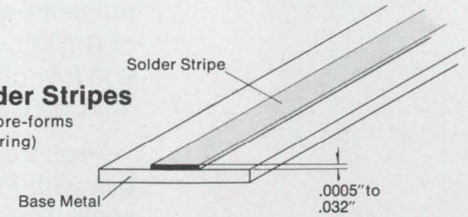
Thin Solder Stripes
(for protective coating)



- To insure a solderable surface when subsequently soldering or brazing.
- To replace gold as a contact material.

Stripes can be on one or both sides. Complete overlay on one or both sides. All types of solder alloys.

Thick Solder Stripes
(for replacing pre-forms or hand soldering)



- Eliminates costly preform placement, applicable even to stainless and aluminum.

One or more stripes on one side only; however, complete overlays on one or both sides. All types of solder alloys. Base metals of any temper.

Write for our new "Design Aid for Solder Clads", showing all mill limits and tolerances, and a solder-alloy guide. Free on request.

TECHNICAL MATERIALS, INC.
25 Holden Street
Providence, Rhode Island 02908
Tel: (401) 272-4343

INFORMATION RETRIEVAL NUMBER 58

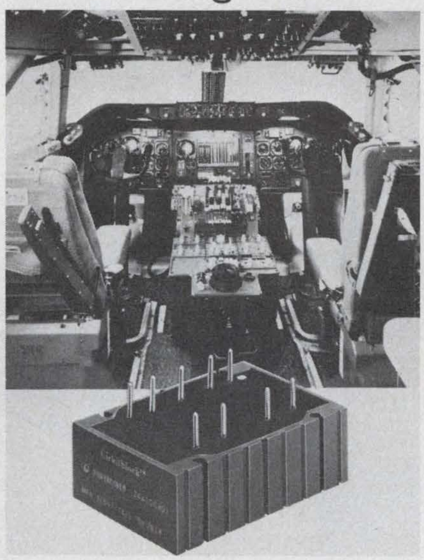
Industrial power module cuts price by 20%

Abbott Transistor Labs, 5200 W. Jefferson Blvd., Los Angeles, Calif. 90016. (213) 936-8185. $121 to $139; stock.

The RN5 family of industrial power modules provides 5.0 A at various voltages between 4.5 and 37 V dc. Line and load regulation are 0.1% and ripple is less than 0.02%. Standard features include short-circuit protection, input-transient protection and remote error sensing. Predicted MTBF is more than 75,000 h. Anodized aluminum-case permits sustained full-load operation at an ambient temperature of 71 C without heat sinks or forced air cooling. Tempco is 0.03%/°C.

CIRCLE NO. 268

Compact ac-to-dc unit delivers a big 100 W

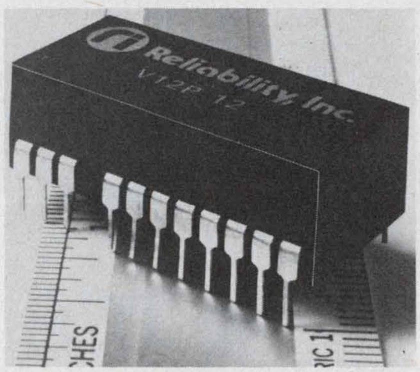


Powercube Corp., 214 Calvary St., Waltham, Mass. 02154. (617) 891-1830. $65 (100 up); 3-4 wks.

Series 300 Cirkitblock module is said to be the smallest known 100-W ac-to-dc isolated converter. The modules measures 2 × 3 × 1 in., weighs 13-1/2 oz., and operates over the full "Mil" temperature range. The unit accepts a three-phase, 400-Hz input (120/208, MIL-STD-704A) and develops single or dual unregulated dc outputs. Typical ranges include 20 V at 5 A, 40 V at 2.5 A, or dual 20 V at 2.5 A each.

CIRCLE NO. 269

Dc/dc converter needs less than 1/3 cubic in.



Reliability, Inc., P.O. Box 35733, Houston, Tex. 77035. (713) 729-4444. See text.

Small both in size and price, the V12 Series unregulated dc/dc converter, from Reliability, Inc., accepts a 12-V-dc input and delivers 1-W at a variety of isolated positive and negative dc voltages, from 5 to 15 V.

Forming part of the company's V-PAC Series, the V12's volume is less than 1/3 of a cubic inch—claimed by Reliability to be the smallest of competing converters. And its DIP-like package means you can mount the unit on the PC board along with the ICs to be powered. Mounting is on 0.6-in. centers and can be in standard sockets or flow soldered.

Seven different sources now comprise the V12 Series. Included are single-output units (5, 12 or 15 V), and dual-outputs—+12/−6, ±12 or ±15 V. Typical prices are $17.60 each for the dual 12 or dual 15 units, in quantities of 100 to 199.

All of the Reliability, Inc., sources are hermetically sealed components and are short-circuit proof with automatic reset. And all are burned in and checked before shipment.

The V12 Series is rated to operate at temperatures between 0 and 70 C in free air. Minimum isolation from the driving source is 10 MΩ (at 50 V) and maximum input current at any load is 200 mA. All units exhibit an efficiency of 50% at full load. Noise of the series is a maximum of 50 mV rms but this figure can be reduced with an external capacitor.

Evaluation units are available from stock; production quantities take 30 days for delivery.

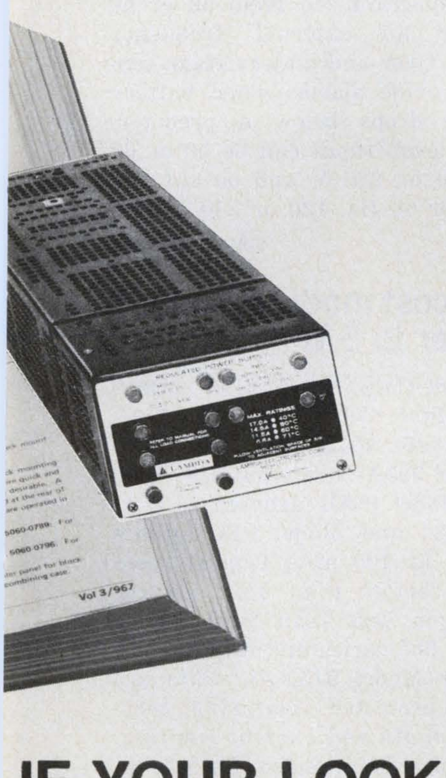
CIRCLE NO. 250

SUPPLIES

Electronic Design's

GOLD BOOK

IS THE PLACE TO LOOK



296 CATALOG PAGES DETAIL POWER SUPPLIES FROM 55 SUPPLIERS

Almost 300 catalog pages containing technical information, key parameters and specs on *power supplies* can be found beginning on page 852 of *Electronic Design's* GOLD BOOK (Volume 3). Fifty-five suppliers are represented. Hewlett-Packard alone gives you 68 pages of data including general information, features, descriptions, ratings, performance, price and ordering information. Lambda has 59 pages, Acopian has 26. AMP Incorporated offers a library of over 1,000 designs or will build to suit your needs. Amphenol stresses their "minis", Power/Mate Corp emphasizes same day shipment, Powercube Corporation talks about their modules . . . and so on.

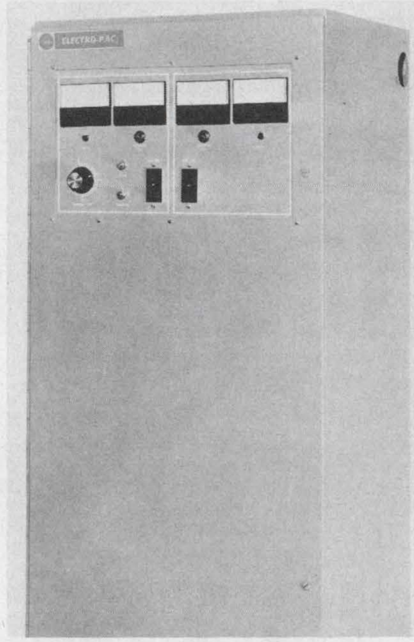
Look over this section carefully, you may well find help in solving a design problem or even the exact product you're looking for. You can call the supplier with much of the details already covered, save time, or in some cases move directly from catalog page to purchase.

Get to know *Electronic Design's* GOLD BOOK and keep it handy. It will save you hours and hours of valuable time in the months ahead.

IF YOUR LOOKING FOR PRODUCT INFORMATION . . .
LOOK FIRST IN ELECTRONIC DESIGN'S GOLD BOOK

POWER SOURCES

Standby power system delivers 2 kVA



Electro Pac Div., Instrumentation & Control Systems, Inc., 129 Laura Dr., Addison, Ill. 60101. (312) 543-6200. $4000; 2-4 wks.

Model UP20E 120-8-3A universal standby power system provides 2 kVA of power. Special line synchronization permits the inverter to be synchronized from 50 or 60 Hz or an external frequency source. Over and undervoltage sensors provide alarms when battery voltage drops below a predetermined level. Input can be 50 or 60 Hz, 120 or 240 V and output can be 50 or 60 Hz, 120 or 240 V.

CIRCLE NO. 270

Low-cost modular units deliver to 5 W

Dynasyn Corp., 77 Elm St., Anesbury, Mass. 01913. (617) 388-5187. 905A: $28; 905B: $24; 915: $34.

Model 905A is rated at 5 V, 1000 mA; Model 905B delivers 5 V at 500 mA; and Model 915 outputs ±15 V at 100 mA. Typical specs include better than 1% load-line regulation, less than 5-mV ripple for the 905 series and less than 10 mV for Model 915. All units are doubly protected, featuring thermal turn-off and current limiting. 900 series is intended for use in DPMs, MODEMs, test equipment, card-mounts, replacements and prototypes.

CIRCLE NO. 271

FOR PEOPLE WHO WANT TO READ ALL ABOUT IT!

We have nothing less than a fully illustrated, systematic, easy-to-use survey of the entire field of data management as it exists today. It covers it all, from A to Z, so it's for everybody. The programmer tightening up his files. The analyst working out a workable timesharing program. Top management needing industry-wide perspective on competitive system designs.

It's a rare publication that takes a unique "blueprint approach" to current know-how. Beginning with the single data item as the first building block in total system design. And progressing through specific techniques for data structures, streams, files . . . total hardware and operating system control . . . the latest advances in timesharing and multiprogramming . . . system modeling and simulation . . . complete designs for various types of commercial accounting and document-oriented storage and retrieval systems. It all adds up to a vast and impressive "top to bottom" view.

And it does it all in fresh, jargon-free language, with scores of illustrations and diagrams for a rapid, visual grasp.

Whether you use it as an on-the-job manual, as a desk-top reference, or as a conference room companion with all the answers, it's an indispensable tool guaranteed to broaden your perspective and practical skill in a field that knows no limits to growth and progress. And generally give you the professional confidence that comes from knowing just about everything that's going on.

#5100-X, 6 x 9, 300 pages, cloth $14.95

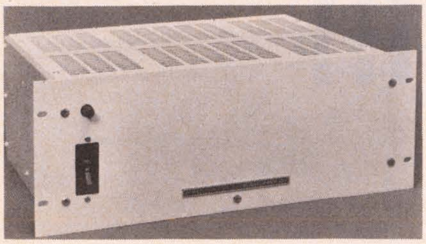
To Order:

Circle the **Information Retrieval Number** to order your 15-day free examination copy of **Data Management for On-Line Systems by David Lefkovitz.** At the end of that time please remit payment or return the book with no further obligation.

Hayden Book Company, Inc., 50 Essex Street, Rochelle Park, N. J. 07662

INFORMATION RETRIEVAL NUMBER 62

Inverters work under rugged conditions

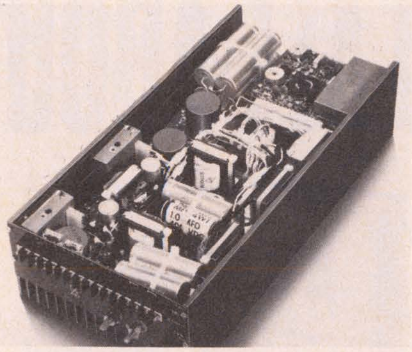


Topaz Electronics, 3855 Ruffin Rd., San Diego, Calif. 92123. (714) 279-0831. Start at $675.

GP series inverters are designed for natural convection cooling under rugged environmental conditions. Protective circuitry prevents damage from reversed input polarity, low or high input voltage, overload, and short-circuits. Voltage regulation is less than ±5% for both line and load. Total harmonic distortion is less than 10% at full load and nominal line. Standard frequency stability is 1%. Ratings are 200, 250 and 500 VA, with outputs of 115 or 230 V ac, 50 or 60 Hz.

CIRCLE NO. 272

Compact switchers offer up to quad outputs

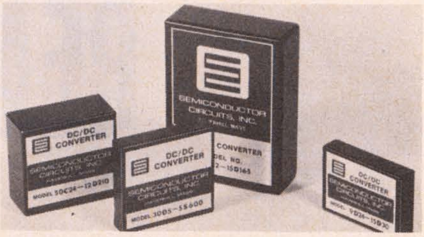


LH Research Inc., 2052 S. Grand Ave., Santa Ana, Calif. 92705. (714) 546-5279. $493 (1000).

The 600 Series is a line of 600-W switching-regulated power supplies available in single, dual, triple, and quad-output models. Size is 3.9 × 7.5 × 16.12 in. and weight is 13 to 14 lbs. The complete line includes 85 standard models in six wattage ratings—250, 300, 500, 600 and 1000 W. A 1500-W series will be available in Sept., 1974. Efficiency of all single-output models is over 80%; multiple-output models average 75%.

CIRCLE NO. 273

Dc/dc converters deliver to 10 W



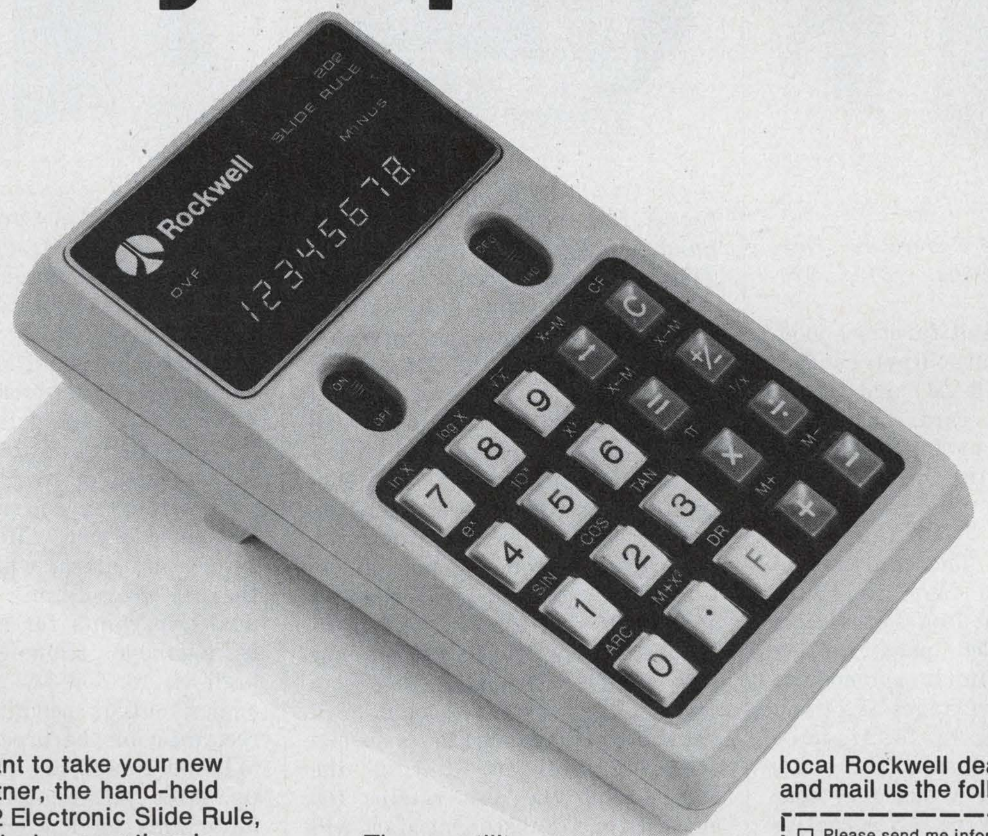
Semiconductor Circuits, Inc., 306 River St., Haverhill, Mass. 01830. (617) 373-9104. From $45.95; stock to 10 wks.

This new series of regulated dc/dc converters consists of encapsulated modules that deliver from 0.9 to 10 W. Sizes range from 1.5 × 2 × 0.4-in. to 2.5 × 3.5 × 0.875 in. Standard output voltages are 5, ±12, ±15 and ±18 V, with standard input ranges of 5, 12, 24 or 28 V. Featured are regulation of 0.02% line and load, a Pi filter to minimize input reflected noise and no derating thru 71 C. All outputs are short-circuit protected and electrostatically shielded on five sides. The units come without input-polarity protection.

CIRCLE NO. 274

Logs, roots and trig are your business.

Meet your partner.



You'll want to take your new business partner, the hand-held Rockwell 202 Electronic Slide Rule, wherever and whenever there's work to be done. It's as portable as your old slide rule, but the similarity really ends there. For the 202 can perform a spectrum of scientific calculations with computer-like speed and accuracy—

ARITHMETIC FUNCTIONS
+ − × ÷

LOGARITHMIC FUNCTIONS
ln X   log X e^x 10^x

TRIGONOMETRIC FUNCTIONS
sin X   arc sin X   degrees
cos X   arc cos X   radians
tan X   arc tan X

OTHER FUNCTIONS
X^Y $\sqrt{X}$ 1/X   +/−   ⟷

MEMORY FUNCTIONS
M+   M−   X←M   X→M
X⟷M   M+X²

The versatility of the 202 is enhanced by a fully-addressable memory. And a degree/radian selector. Underflow. A full-floating decimal system and automatic constants.

You'll agree, the 202's big, easy-to-read 8-column digitron display is a big improvement over your standard slide rule. And when you compare it with most other hand-held calculators, even more costly ones, you'll see just how much easier the 202 is to read.

Now that's the right kind of business partner.

For more information on the 202 Electronic Slide Rule or the entire family of Rockwell hand-held professional calculators, call your local Rockwell dealer, or complete and mail us the following coupon.

☐ Please send me information on the Rockwell 202. 8
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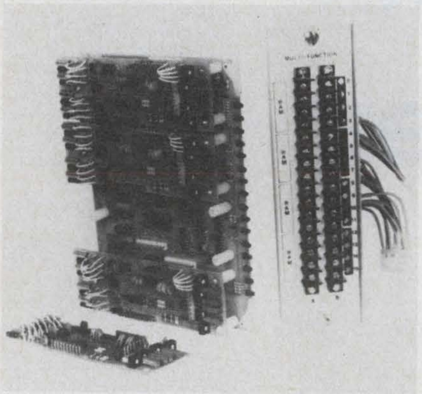
Our family has a mind for business.

Unicom Systems
Rockwell International
...where science gets down to business

INFORMATION RETRIEVAL NUMBER 64

Four-function controller is programmable



Eagle Signal, 736 Federal St., Davenport, Iowa 52803. (319) 326-8111.

The CP640 multifunction module combines input, output, random access memory (RAM) and timing functions on one card. The device includes these four functions on a card occupying the space of only one input/output (I/O) module in the company's CP600 programmable controller. The card is submodularized into four groups of four circuits (or functions) each. These submodules plug into a mother board. Input submodules are available for voltages of 24 and 120 V ac or 5, 10, 12, 15, 24, 48 or 120 V dc. Output submodules are available for 120 V ac, 1 A continuous, 5 to 48 V dc, 0.5 A continuous, or 120 V dc, 0.5 A continuous. Output submodules with a 10 VA reed relay output and special input and output voltages are also available. LEDs are used to indicate the logic status of each input/output circuit.

CIRCLE NO. 275

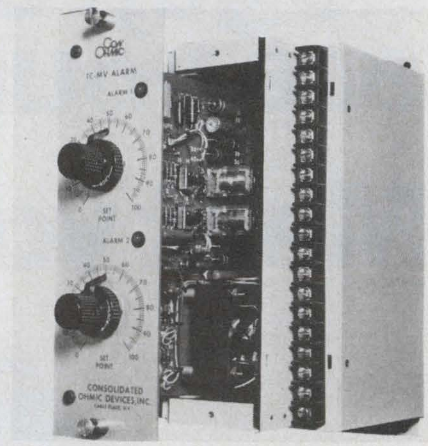
Digital control timer settable to 0.1 min

Alpha Components Corp., 115 Eucalyptus Dr., P.O. Box 947, El Segundo, Calif. 90245. (213) 322-7780. $275 (unit qty).

Model 901 solid state digital timer can be front-panel programmed to a maximum of 99.9 min. in 0.1 min. increments. The start of the countdown timing cycle initiates a contact closure. A three-digit LED display continuously subtracts from the present time to zero while the decimal point pulsates every second. Upon completion of a cycle, an audible alarm is sounded and the control contact opened. The unit has an emergency stop switch that opens the relay contacts and stops the count until the switch is returned to its normal operating position. During the stop period, the unit retains the elapsed time. Subsequent start will continue the original programmed time. The timer operates on 117 V ac, 60 Hz and has its own internal regulated power supply. The stainless steel panel is standard DIN, 100 × 100 mm (4 × 4 in.) and has a depth of 4.75 in.

CIRCLE NO. 276

Amplifier-annunciator uses tri-mode LED



Consolidated Ohmic Devices, 115 Old Country Rd., Carle Place, N.Y. 11514. (516) 741-1500.

Model SCA 1460 dual point millivolt alarm incorporates an annunciator display which visually and continuously monitors operating condition. A tri-mode LED provides a visual off/normal/alarm indication for each trip point. The unit accepts millivolt or T/C signals without a separate amplifier. The input signal will automatically actuate an alarm when it exceeds the set safety limit. A choice of dual trip points for a single input is available allowing high-high, high-low, or low-low alarming. An analog output permits continuous recording of the process. T/C and millivolt inputs are field selectable in three different ranges with minimums as low as 6 mV and maximums up to 160 mV. Internal T/C ambient compensation is adjustable from 0 to 10% of input span. Alarm repeatability is less than 0.05% of input span at 75 F. Ambient operating temperature range is 15 to 140 F.

CIRCLE NO. 277

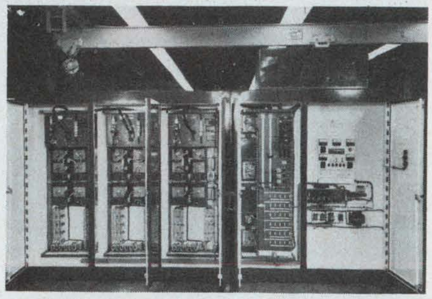
Digital delay module spans 10 to 1000 ns

Technitrol, 1952 E. Allegheny Ave., Philadelphia, Pa. 19134. (215) 426-9105.

A programmable dual delay module provides output pulses within 1 ns of digitally selected nominal times in a range of 10 to 1000 ns after trigger. It is ECL/TTL compatible and PC-board mounted. The unit is designed to trigger on ECL/TTL positive or negative edges. Programming is accomplished by three decades of remotely generated BCD inputs for the control of each of two independently timed ECL/TTL outputs. The module occupies a 5 × 10 in. PC board, and is accessed through edge and high frequency connectors. Supply voltages required are ±5 V dc.

CIRCLE NO. 278

Motor speed controllers handle up to 250 hp



Ramsey Controls, 341 Rt. 17, Mahwah, N.J. 07430. (201) 529-4400. From $30,000; 26 to 30 wk.

A 250 hp, ac motor speed control system offers an output frequency adjustment from 6 to 120 Hz with output voltages up to 440 V. This provides a motor speed range of 20:1. The system is enclosed in NEMA 12 TENV (totally enclosed nonventilated) housing, designed for installation in hostile environments. This system is cooled via natural convection—there are no fans, filters or pumps. All active system modules are mounted on aluminum heat sinks which protrude through the back of the system as cooling fins. Other systems include 1, 3, 5, 10, 15, 25, 50, 60, 75, 100 and 150 hp units. Most systems are available in NEMA 1 enclosures for normal factory conditions or the TENV NEMA 12 enclosure for wet, dusty and otherwise hostile environments.

CIRCLE NO. 279

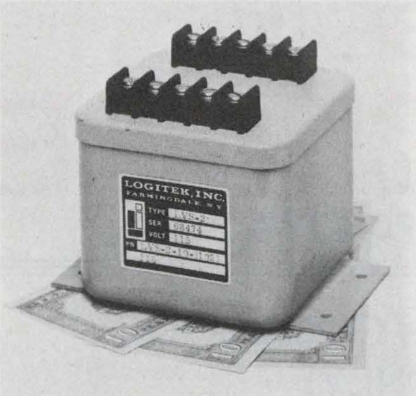
Hybrid s/d converter accurate to ±3.9 min.

ILC Data Device Corp., 105 Wilbur Pl., Bohemia, N.Y. 11716. (516) 567-5600.

Thick-film hybrid versions of the company's MSDC series of multiplexed synchro converters are known as the HMSDC series. Accuracy is ±3.9 min. ±1 LSB, and resolution is 1.3 min. The HMSDC series uses successive approximation techniques and has simultaneous sampling to eliminate data skew, give fast (150 μs) conversion time and random access capability. The HMSDC units are available in SHP NAFI format, to fit on standard 1A cards. Processing to MIL-STD-883 level C is standard procedure, with processing to level B available

CIRCLE NO. 280

Voltage sensors come in 3 or 10 A models



Logitek, 42 Central Ave., Farmingdale, N.Y. 11735. (516) 694-3080. $30.

The type LVS low voltage monitor is available in adjustable or nonadjustable 3 and 10 A options. The Model LVS-2, single-phase unit for 115-V operation, contains a relay that deenergizes and automatically shuts down equipment when voltage drops to danger level. After voltage returns to normal, power is automatically reconnected. A built-in 5-s time delay prevents turn-off due to momentary voltage surges. The units are suitable for stand-alone mounting or installation in a standard NEMA enclosure.

CIRCLE NO. 281

Transient suppressor absorbs 120 j pulses

MCG Electronics, 279 Skidmore Rd., Deer Park, N.Y. 11729. (516) 586-5125. $780; 4 to 6 wk.

The PTSA ac power transient suppressors can absorb high-energy transients of up to 120 joules. Damage from transients is prevented by the rapid switching of the PTSA unit from an open circuit to a clamping state, whenever the transient voltage exceeds the clamping threshold. Clamping occurs on overvoltages of either polarity and recovery is automatic when the transient passes. Some PTSA specs include: ac line voltage, 130 V ac rms (max); line frequency, 50/60 or 400 Hz; clamping voltage, 200 V peak ±5% (both polarities); clamping factor, 1.4 at 1 ms CF; response time, under 1 μs (clamping), under 2 μs (overload); and operating temperature range −40 to +175 C.

CIRCLE NO. 282

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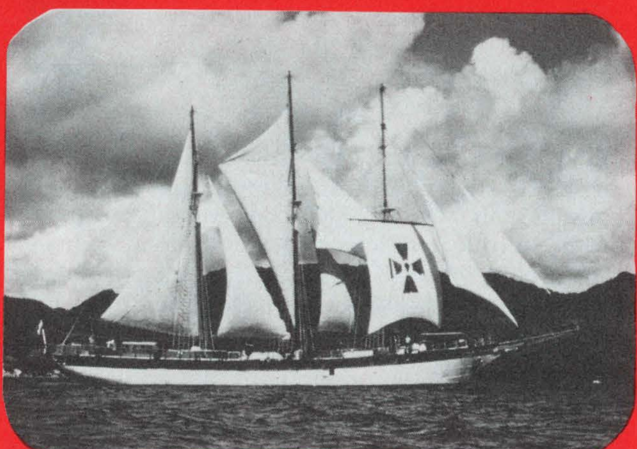

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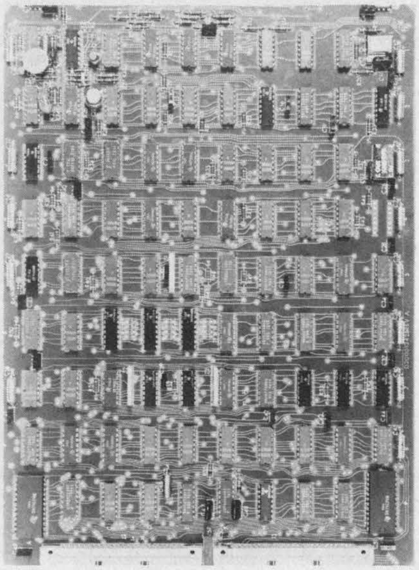
Microprocessor replaces 8-bit mini at low price



Microdata Corp., 17481 Red Hill Ave., Irvine, Calif. 92705. (714) 540-6730. Under $1000.

A board-mounted, 8-bit microprocessor unit, the Micro-One, sells for less than $1000 and replaces the manufacturer's 800/1600 Series mini. A unit with 1024 words of ROM and 1024 bytes of MOS memory occupies one 8.5-by-11 in. board. Operating characteristics include: bipolar CPU and circuitry, 1.2 μs memory cycle and 8-bit arithmetic unit. The ROM provides the control logic for the CPU and microcommands are executed at a 200 ns rate. Additional features include 15 general-purpose registers and a real-time clock.

CIRCLE NO. 283

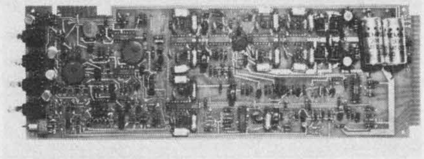
Budget calculator weighs 7.4 oz

Canon U.S.A., 10 Nevada Dr., Lake Success, N.Y. 11040. (516) 488-6701. $44.95.

The Model LE-83 calculator weighs only 7.4 oz and has an eight-digit capacity. Features include a constant switch, floating decimal point, system, zero suppression, underflow and minus indication. The LE-83 adds, subtracts, multiplies, divides, performs mixed calculations, calculations with a constant and n-th power calculations.

CIRCLE NO. 284

Auto-answer modems on card are 103-compatible

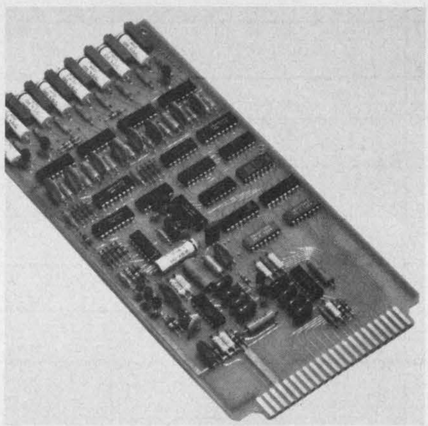


Tele-dynamics, 525 Virginia Dr., Fort Washington, Pa. 19034. (215) 643-3900. $200.

Full duplex communications at 300 bit/s are available with type 7113B-LC-4 modem card. And you also get automatic answer-only operation. These units are intended for users with many lines such as time-sharing houses. Up to 16 modems can be housed in one 22 × 22 × 7-in enclosure. Test facilities include individual or group loop-back and a busy control that can be set by a switch or on command from a processor. The modems are end-to-end compatible with Bell 103A2, 103E, 103G and 103F Data Sets.

CIRCLE NO. 285

Low-speed PC modem is a second-source



Advanced Terminal Systems, P.O. Box 90121, Los Angeles, Calif. 90009. (213) 644-5321. $95 to $105 (quan.).

Model M-2103F is a modem that gives full-duplex communications over two-wire voice grade lines. The unit is interchangeable with the Bell System 103F unit—also a 300-baud modem. In addition the unit is compatible with Intertel type 1038-9 modems. A TTY current loop interface is provided for receive and transmit lines. Design features include active filters, FET band-switching and crystal-controlled frequencies.

CIRCLE NO. 286

Pocket-sized calculator has dual role

Litton Monroe, 550 Central Ave., Orange, N.J. 07051. (201) 673-6600. $139.95.

The Model 40 calculator has a 20-digit capacity and provides calculator as well as adding machine functions in a single unit. These functions operate independently, but alternately share the same 10-digit display. For example, a person can add a portion of a column of figures, perform separate calculations, then continue with the addition. Other features include positive and negative accumulation of results, constant multiplicand and divisor, and repeat addition and subtraction. The calculator also has a percentage key with add-on and discount capability. The unit is supplied with four disposable batteries and a converter/charger for ac operation. Rechargeable nickel-cadmium batteries are optional.

CIRCLE NO. 287

Calculator family aims at broad user base

Corvus, 13030 Branch View La., Dallas, Tex. 75234. (214) 620-2454. See text.

A family of three calculators provides something for consumer, engineer or businessman. Model 400 at $39.95 provides eight-digits with floating point and features a percentage key and counts the number of entries. These are shown when the (N) key is depressed. The slide-rule calculator Model 411 uses scientific notation, does square root, reciprocals and memory-display exchanges. A 10-digit LED display shows a six-digit mantissa and two-digit exponent. The cost is $89.95. The business calculator Model 415 ($79.95) allows simultaneous operation on two calculation sequences via memory. An exchange key automatically reverses the role of multiplier and multiplicand or dividend and divisor.

CIRCLE NO. 288

Flexible-disc system includes controller

Tri-Data, 800 Maude Ave., Mountain View, Calif. 94040. (415) 969-3700. $5200.

Called FlexiFile 52, this on-line memory includes two disc drives, a built-in controller with formatting electronics and a power supply. Storage capacity is 524-k bytes in a 16-sector, 64-track format with a data transfer rate of 31 kbytes/s. The unit accommodates an additional two-disc slave system which increases the total capacity to 1 Mbyte. Access time is 10 ms track-to-track. All assemblies and electronics, including the disc drives, operate in an extended position to simplify maintenance. Tri-Data plans to offer interfaces and cabling for most popular minicomputers. Immediately available is an interface for DEC PDP-11 minicomputers.

CIRCLE NO. 289

Printing calculator does cross-foot totals

Toshiba America, 280 Park Ave., New York, N.Y. 10017. (212) 682-8416.

An adding machine with multiplication and division, 10-column unit, Model BC-1003P, is designed for general figure work. Model BC-1003P has a basic adding machine keyboard and offers the added capability of "cross-footing," by means of total and grand-total keys. Individual totals can be produced for each of a number of columns. These totals are automatically transferred to the grand-total register, and the grand total is printed out by depressing the key. And you get the printed tape as with any office machine.

CIRCLE NO. 290

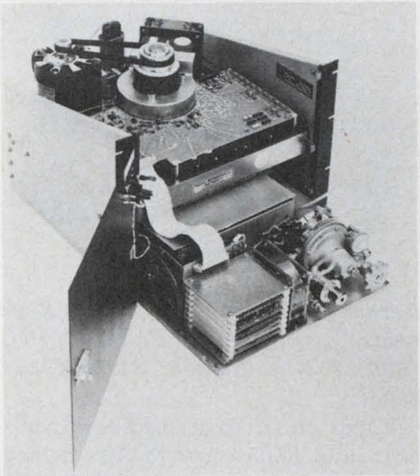
Peripheral accelerates mini's calculations

CSP Inc., 209 Middlesex Turnpike, Burlington, Mass. 01803. (617) 272-6020. From $5000.

The use of array processors to boost a minicomputer's computation rate is advanced to a fine art by the MAP peripheral. This programmable Macro Arithmetic Processor has up to four fast arithmetic units, uses 32-bit floating point arithmetic and can, if so programmed, do a 1024-point FFT in 3.5 ms. The MAP can operate its own I/O devices through use of semi-independent processors called Scrolls. In such cases the MAP need only give one command to the Scroll and continue its computational tasks while output occurs concurrently. Data transfer rates to 32 Mbyte/s can be handled.

CIRCLE NO. 291

Fixed-head disc unit stores 19.2 M bits



Pacific Micronetics, 5037 Ruffner St., San Diego, Calif. 92111. (714) 279-7500. Under $10,000.

A 19.2 Mbit fixed head disc system offers an average access time of 8.3 ms with a data transfer rate of 9 MHz. The unit can be field-expanded in 16-track increments to a maximum of 128 tracks. System upgrade can therefore be provided with minimum impact on system design. The nonrecoverable error rate is said to be no more than one error in 10^{12} bits transferred. Available options include write lock-out, dc voltage margin sensing, a burst rate buffer and NRZ data format. The system mounts in a 14.75 × 17 × 19-in. rack space and is available for either 50 or 60 Hz operation at 120 V.

CIRCLE NO. 292

Machine controller uses programs, not relays

Barber Colman Co., 1300 Rock St., Rockford, Ill. 61101. (815) 877-0241.

A solid state machine controller, called the Machine Commander, duplicates relay logic functions under program control. The input section senses limit switch condition, the logic section evaluates the pattern and the output section energizes or de-energizes the appropriate machine functions. The programmer section can store up to 2048 program words in increments of 256. Execution times range from 7 to 20 ms. The overall equipment is designed to replace relay logic in injection molding machines for plastics.

CIRCLE NO. 293

Portable keypunch goes to data source

Varifab, 1700 E. Putnam Ave., Old Greenwich, Conn. 06870. (203) 637-1434. $1525.

Punchcards needn't wait for the keypunch room. Model 411, a portable electric punch, will let you do them at your desk. The unit provides a complete alphanumeric keyboard plus keys to space, backspace and manipulate the card. Fourteen special keys are available to program various formats. If desired, Model 412 ($1645) will print numeric information as the cards are punched.

CIRCLE NO. 294

INSTRUMENTATION

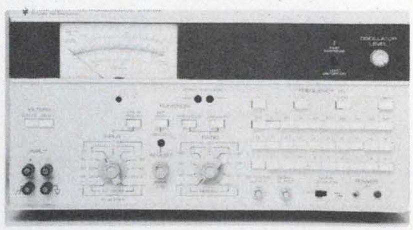
Two automatic DMMs added to line

John Fluke Mfg. Co., P.O. Box 7428, Seattle, Wash. 98133. (206) 774-2211. 8600A, $599; 8800A, $1099; stock.

Models 8600A and 8800A are two new automatic DMMs. The 8600A offers 4-1/2 digits (20,000 counts), 26 ranges of dc V, ac V, ohms and dc/dc current, and a basic dc accuracy of 0.02%. Autozero and auto-range are standard. The 8800A is a 200,000-count (5-1/2 digits) unit, with 0.005% accuracy and 15 ranges of dc V, ac V and ohms. Auto-polarity and auto-range are also standard.

CIRCLE NO. 295

Unit measures distortion down to 0.001%



Sound Technology, 1601 S. Saratoga-Sunnyvale Rd., Cupertino, Calif. 95014. (408) 257-9171. $1485; 90 days.

Model 1700A distortion analyzer measures distortions down to 0.001% with automatic nulling—no balancing controls are needed. The 0.001% figure is said to be about 25 dB better than existing equipment. The system includes the test oscillator which has an ultra-low distortion of only 0.001% and is tuned simultaneously with the analyzer. The unit operates from 10 Hz to 110 kHz.

CIRCLE NO. 296

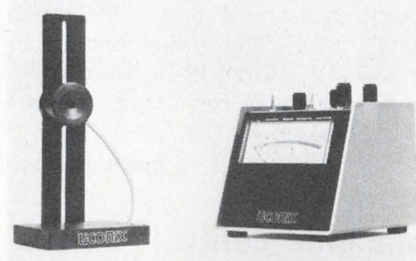
Two counter-timers offer variable trigger

Berkeley Instruments, 1701 Reynolds, Santa Ana, Calif. 92705. (800) 854-3253. 6305: $495; 6315: $695.

Two counter-timers—Models 6315 and 6305—provide frequency measurements up to 150 MHz (50 MHz with Model 6305). Adjustable trigger level and trigger lamps allow convenient operation. Time measurements with up to 100-ns resolution are standard. With the Model 6315, resolution can be optionally increased to 10 ns. A TXCO provides accuracy and stability. Both models use the Beckman (formerly Sperry) display.

CIRCLE NO. 297

Meter measures laser output power to 30 mW

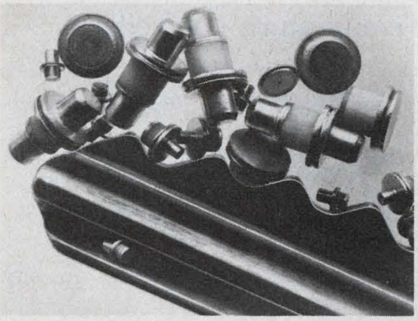


Liconix, 1400 Stierlin Rd., Mountain View, Calif. 94043. (415) 964-3062. $595.

Model 35PM optical power meter measures laser power output from UV to near infrared. Each instrument is adjusted to provide direct readings at 325.0, 441.6, 530.5 and 632.8 nm. With an accuracy of 5%, the battery-operated Model 35PM can be used at other wavelengths with the supplied correction graph. Measurement range is from 10 μW to 30 mW full scale. Zero suppression control on all ranges facilitates the measurement of small variations in the presence of high signal laser output. An output jack for remote indication or strip-chart recording is provided.

CIRCLE NO. 298

Varactor tuning diodes have Qs up to 2600



Varian, Beverly Div., Salem Rd., Beverly, Mass. 01915. (617) 922-6000. $27 (100-up); 30 day.

The VAT series of tuning diodes is designed to minimize long term tuning drift in voltage controlled oscillators. The processing of the VAT-1000 series minimizes capacitance shifts and the PLESA passivation technique allows planar processing to be applied to surfaces containing silicon mesas. The VAT-1001 devices have a total capacitance of 2 to 3 pF, a minimum Q of 2600, a tuning ratio of 3.5:1 and a leakage current of 5 nA at 25 C. Similarly the VAT-1002, 1003 and 1004 have capacitances of 5 to 8, 2 to 3 and 5 to 8 pF, Qs of 2000, 2000 and 1500, tuning ratios of 4.75, 4 or 5.5:1 and leakage currents of 5, 3 and 5 nA, respectively.

CIRCLE NO. 299

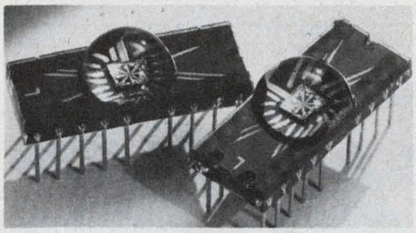
Power transistors are glass passivated

International Rectifier, 233 Kansas St., El Segundo, Calif. 90245. (213) 678-6281. From $2.83 to $9.50 (1000-up); 8 to 10 wk.

The glass passivated transistor line includes devices rated from 400 to 700 V at collector currents up to 7.5 A. The IR401 transistor, for example, is rated for 400 V and a minimum gain of 20 at 0.5 A. The IR402 is rated for 700 V, also with a minimum gain of 20 at 0.5 A. The Darlington transistor line has devices rated up to 600 V and 20 A. The IR5000 Darlington, for example, is rated for 400 V with a gain of 140 at 5 A. The IR4060 is rated for 600 V with a gain of 250 at 3 A.

CIRCLE NO. 300

Alphanumeric display uses 16-segments

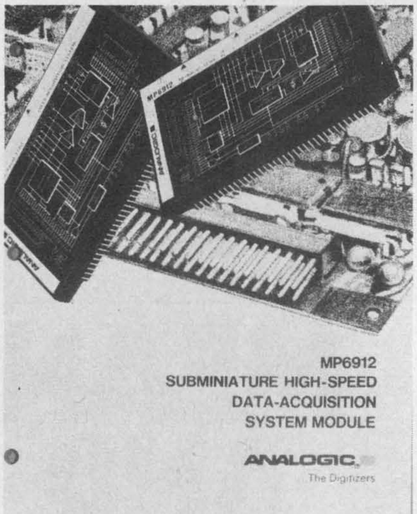


Litronix, 19000 Homestead Rd., Cupertino, Calif. 95014. (408) 257-7910. $5.65 (1000-up); stock.

The Data-Lit 16 is a 16-segment display packaged in a 20-pin DIP. It creates 0.15 in. high numbers, letters and many special symbols in response to a standard ASCII code. The display draws only 1.5 mA per segment and has a total power dissipation of 510 mW. Luminance per segment at 10 mA is typically 0.82 mcd and guaranteed to be at least 0.44 mcd. Forward voltage per segment at 10 mA is typically 1.58 V and 2 V maximum.

CIRCLE NO. 301

new literature



Data-acquisition module

A subminiature, high-accuracy high-speed data-acquisition system is described in a 16-page brochure. The brochure covers the theory of operation and provides application information for minicomputer, telemetry, spectrum analysis, communication systems and other uses. Data on design features, specifications, timing diagrams and setup and calibration procedures are included. Analogic, Wakefield, Mass.

CIRCLE NO. 302

ECG semi supplement

A supplement to the company's ECG semiconductor replacement guide adds 11,000 type numbers to the total number of units replaced by the ECG line. Transistors, ICs, diodes and rectifiers, special-purpose devices and transistor and IC accessories are included. GTE Sylvania, Stamford, Conn.

CIRCLE NO. 303

Circuit breakers

Electrical parameters, mechanical characteristics and performance curves of 190 thermal and magnetic-hydraulic circuit breakers are contained in a 36-page catalog. A discussion on "How to Specify Circuit Breakers Properly" offers practical information on breaker selections. Potter & Brumfield, Princeton, Ind.

CIRCLE NO. 304

Temperature controllers

A two-page catalog features solid-state output relays to switch 2, 10, 25 and 40 A at 240 V ac with their Half-Size 100 and 100 series temperature controllers. Thermo Electric, Saddle Brook, N.J.

CIRCLE NO. 305

SCR power controllers

A two-color eight-page condensed bulletin covers SCR power controllers. General design features, connection diagrams and output waveforms are also included. Vectrol, Rockville, Md.

CIRCLE NO. 306

Opto-isolators

Axial opto-isolators are presented in a six-page brochure. Included are dimensional drawings and 41 graphs covering all parameters of the 36 single-element and 20 dual-element units. Vactec, Maryland Heights, Mo.

CIRCLE NO. 307

Photosensitive devices

Specifications on hundreds of photomultipliers, phototubes, photoconductive cells, light sources, memory tubes and video equipment are contained in a catalog. Hamamatsu, Middlesex, N.J.

CIRCLE NO. 308

Silicon-nitrided devices

Beam-leaded silicon-nitrided devices and improved solid-state diffusion beam-lead bonding machinery are described in a 12-page booklet. Radio Materials, Microcircuits Div., Indianapolis, Ind.

CIRCLE NO. 309

Thyristors/rectifiers

Over 500 thyristors and rectifiers are described in a 36-page catalog. Data are given for JEDEC (1N and 2N) types, commercial types and developmental types. Photographs and dimensional outlines are shown. RCA Solid State Div., Somerville, N.J.

CIRCLE NO. 310

SEMICONDUCTOR AND DIGITAL TECHNOLOGY

SENIOR CORPORATE STAFF

Our rapid growth as a major force in digital LSI technology and application has generated a need for a senior staff engineer who can assume the broad responsibility of providing direction and guidance to our advanced development planning. You will work with various NCR Product Divisions concerned with microprocessor and MOS/LSI development to insure the maintenance of the leadership role we have gained.

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INFORMATION RETRIEVAL NUMBER 78

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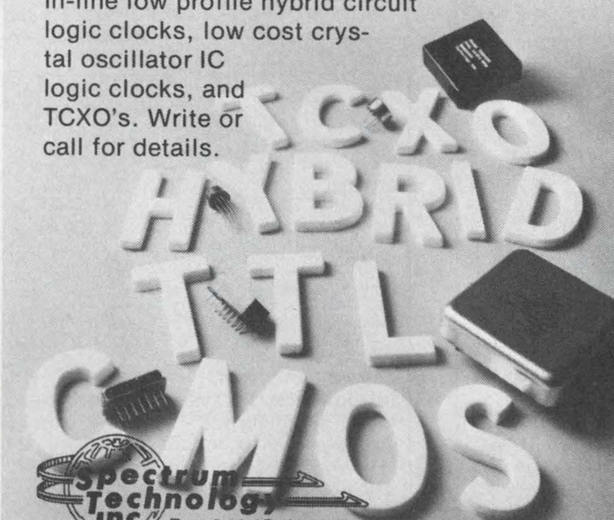

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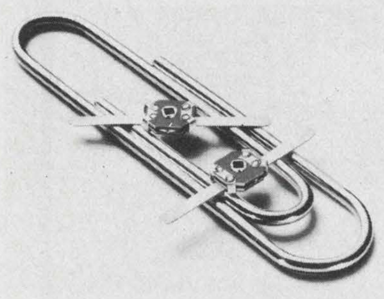

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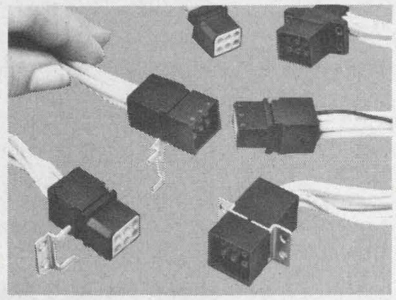

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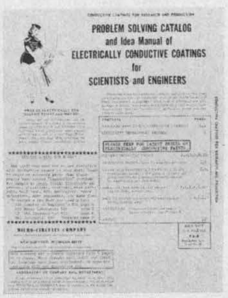

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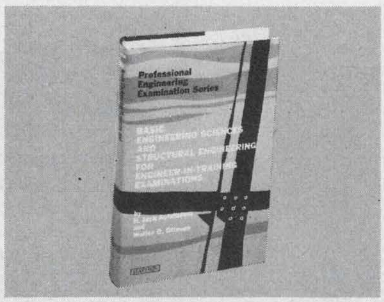

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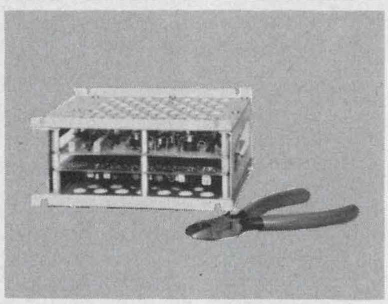

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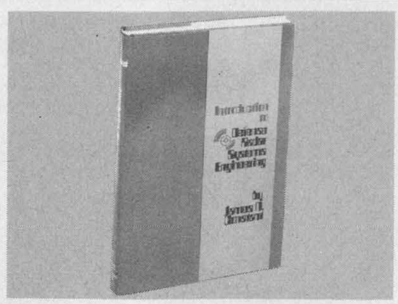

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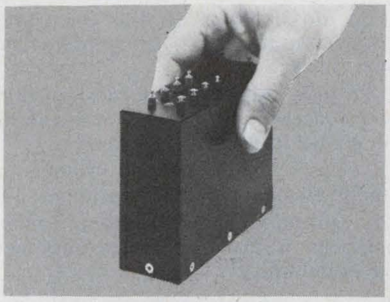

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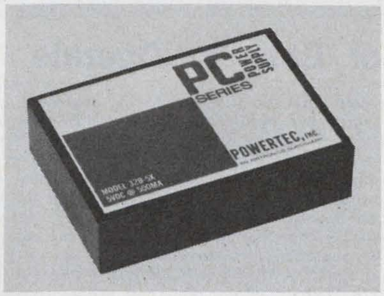

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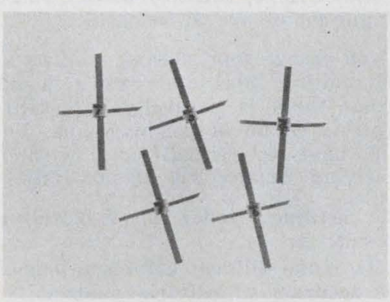

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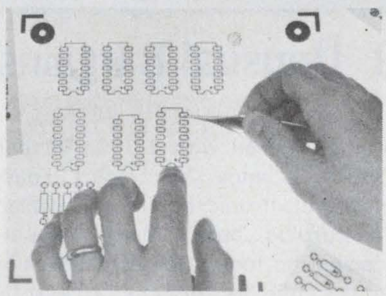

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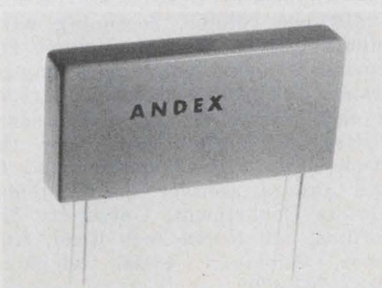

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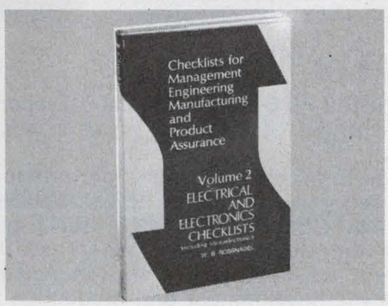

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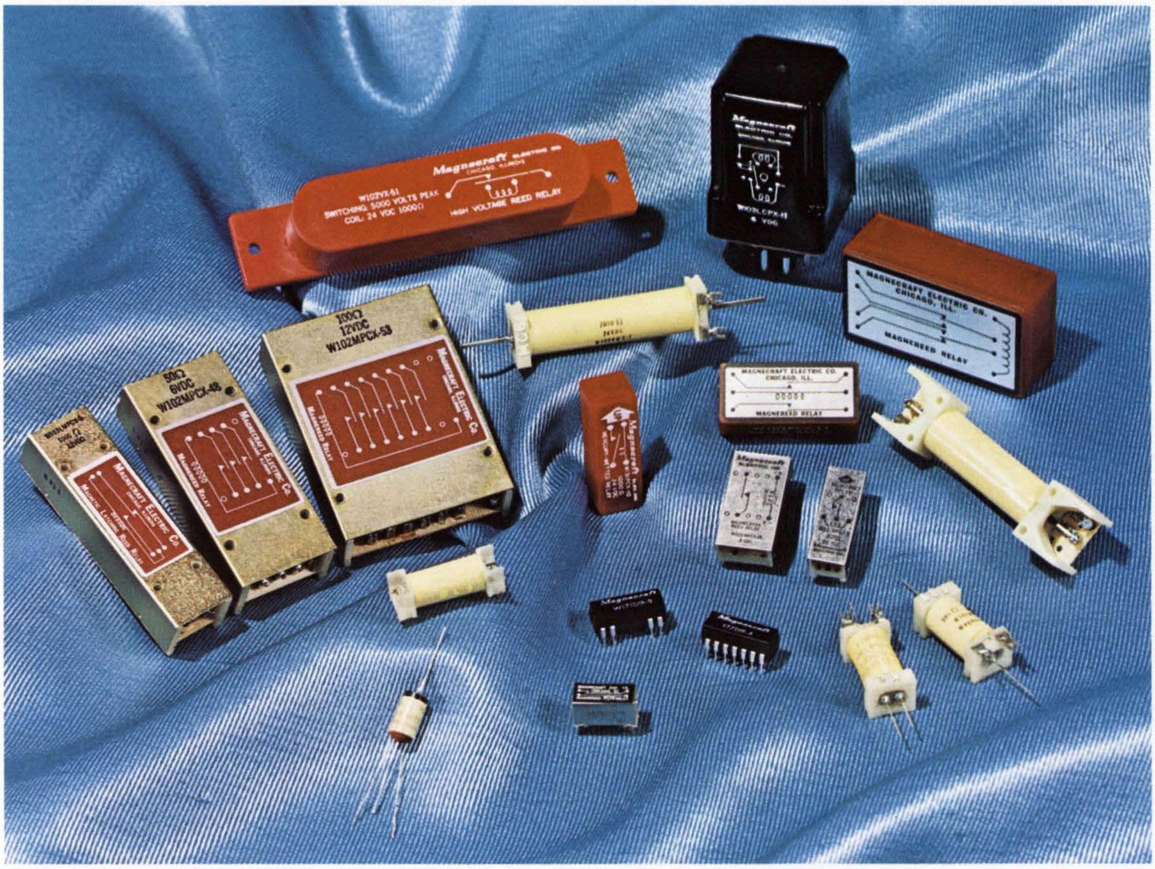

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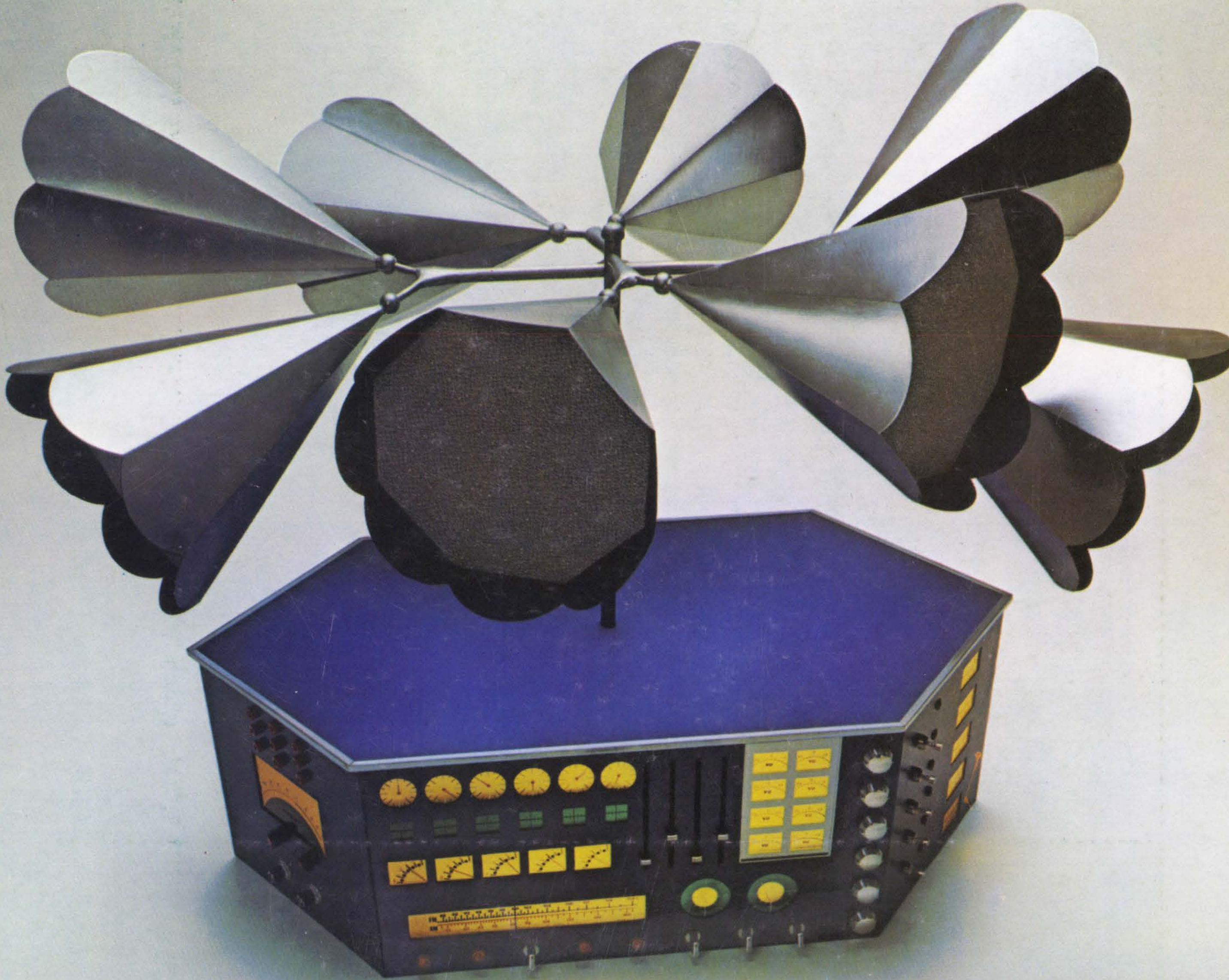

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