April 18, 1974

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Electronics®

Maddox Speaks.

DAC's make the difference in displays.

Some really *clear, sharp* pictures are being generated for demanding computer CRT Display jobs like Air Traffic Control, Avionic Heads-Up, and others.

To get sharp, clean output on high speed X-Y deflection displays you have to start with good spot definition and intensity and then drive it with a clean deflection signal. And that's where high-speed display DAC's come in.

Here's how.

Display DAC's convert digital position commands to analog voltage levels which will position the spot on the CRT face. New commands are usually clocked in at a steady update rate. The spot is positioned to the start of a line or character and then moved by progressive commands to draw the line.

If the DAC's behave, all is well, but often lines wiggle, and show intensity variations.

Who's the culprit?

Glitch, (transient *spike* or bump in the DAC output) and *differential non-linearity*, (a wrong size step in a series of steps).

Display DAC's are "de-glitched" to achieve very low output glitch values, and are designed to have damn good differential linearity.

How to define spec limits?

First, determine maximum allowable glitch voltage as measured through a test filter which simulates your deflection circuit's passband. The test filter is the key. You can even lump together the effects of glitch and differential non-linearity. Then, ramping the DAC and comparing its band-limited output to an ideal ramp, you can check the errors. And after limits are set for intensity variation and wiggle, you can graphically arrive at ramp error limits for the DAC's.

Among other things.

You can also have an inherent lack of line fidelity due to the staircase-like DAC output. Smaller steps through greater DAC resolution will help. But beware, for the limits of maximum available update rate and minimum picture refresh rate set a resolution limit for line drawing. We can show you some filter techniques that can improve ramp fidelity by 10 to 1 or more, solving this staircase problem.

Settling is really important, too, and long settling tails must be absent so that line starting points will land where you planned.

Things like large-signal settling time, slew rate, zero offset, large scale linearity, and scale factor can normally be obtained much better than available deflection circuits, so use care; don't over-specify the DAC's. Save yourself some money.

Talk to the experts.

There are a lot more parameters to be considered in specifying high-speed display DAC's, so if you are into this, or going to be, probably the best approach is to consult us. After all, we have standard products such as our 12 or 13 bit DAC's (Models 4014 and 4017), and a lot of display knowledge and real experience. We've built and shipped more high-speed display DAC's than anybody else in the world.

Telephone, toll-free (800) 225-7883, in Mass. (617) 329-1600. Or write us, Dedham, Mass. 02026. In Europe, Tel. 73.99.88, Telex: 25881. Or write, 1170 Brussels, Belgium.

Ed Maddox, Sr. Engineer

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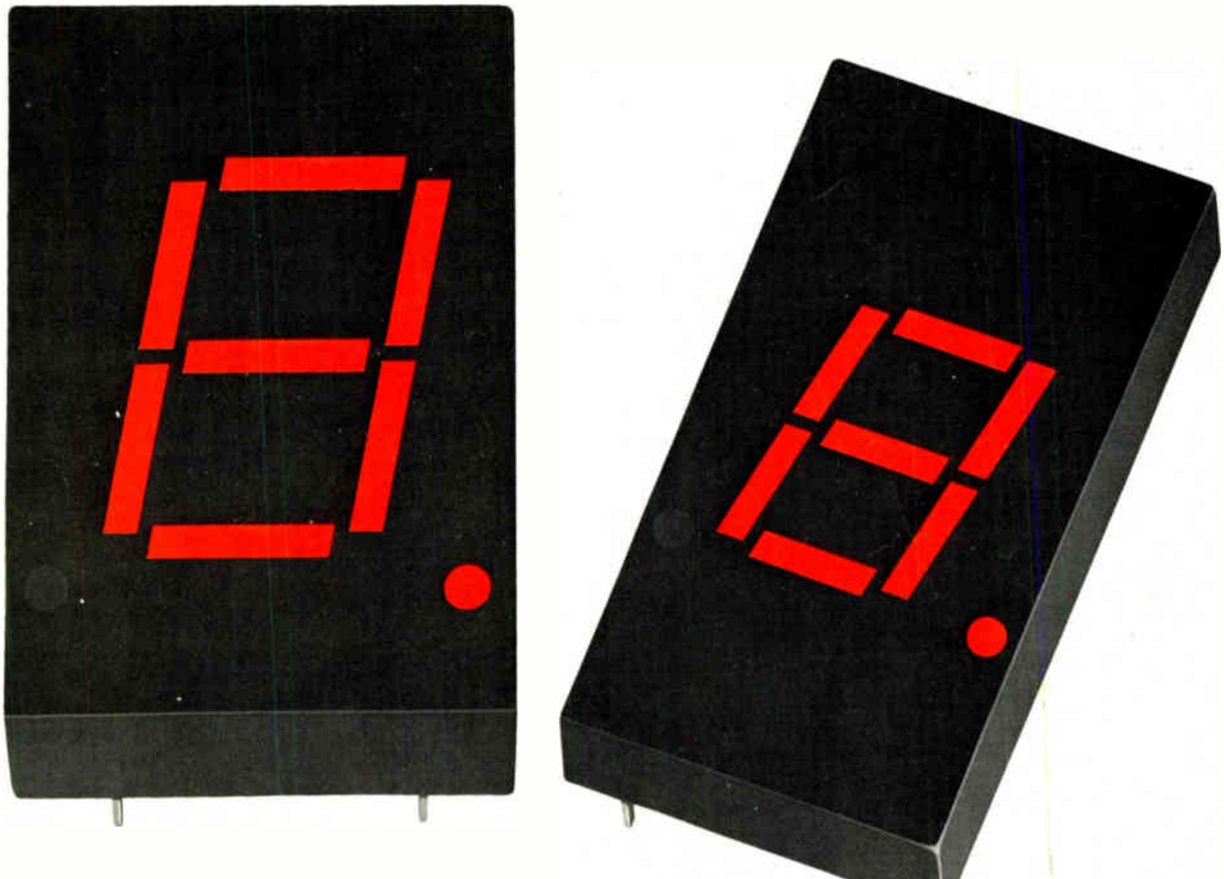

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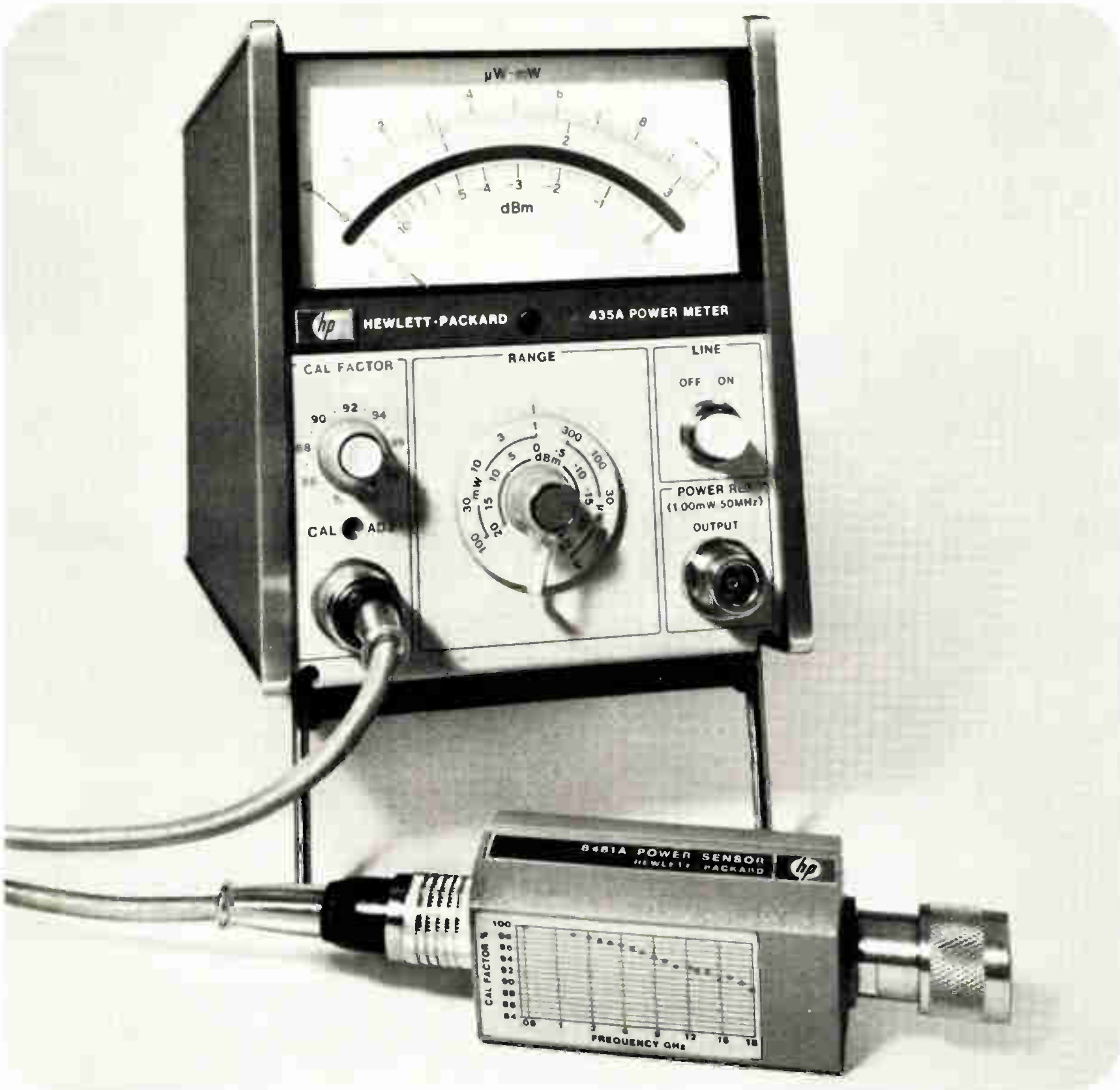

Measuring microwave power? Here's a big step forward.

With the new HP 435A Power Meter you get high accuracy plus convenience. A major error source, mismatch uncertainty, is virtually eliminated because the thermocouple Power Sensor (HP 8481A) has extremely low SWR (1.2 from 30 MHz to 12.4 GHz; 1.3 from 12.4 GHz to 18 GHz). This brings significant improvement in overall measurement accuracy.

This low SWR is achieved through the use of a unique silicon-integrated thermocouple element. The thermocouple is minute, yet dimensionally precise, resulting in good match over a wide frequency range (10 MHz to 18 GHz). And this same silicon technology produces a thermocouple that is sensitive, yet rugged. You can measure over a wide dynamic range (0.3 μW to 100 mW), with a substantial safety margin against burnout from inadvertent overload. Such broad frequency and power coverage in a single unit means real operating convenience.

To confirm that the sensor/meter calibration is accurate, a precision RF power reference is built into the 435A.

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Electronics
The International Magazine of Electronics Technology

Vol. 47, No. 8•April 18, 1974

Highlights

Cover: Versatility is microprocessor's bag, 81
Microprocessors clear the way to extremely low-cost computer-controlled systems. In the first of the set of three technical microprocessing articles in this issue, rules are given on where and when to use these as-yet unfamiliar devices and how to choose from the variety now available. Paper sculpture on the cover is by Leo Monahan of Group West, Los Angeles.

A microcomputer in many a 1980 car, 65
The news from Detroit is that microprocessors now being developed for automobile engine control could be in volume production by the early 1980s.

Microprocessors push on faster with n-MOS, 88
The new n-channel metal-oxide-semiconductor devices outdo the first generation of p-channel microprocessors in speed and instruction power. Needing fewer memory and peripheral support chips, they also economize on space and assembly costs, as Motorola's latest chip set proves.

Processor on a chip has 2-μs cycle time, 95
N-channel MOS technology is also crucial to Intel's latest 8-bit device. As a result, the microprocessor is 10 times faster than its p-channel predecessor and is easy to interface, since it fits in a standard 40-pin package.

And in the next issue. . .
A line of minicomputers bred from the new 4k semiconductor RAMs. . . a special report on computer networks. . . preview of the National Computer Conference.

Electronics

Publisher's letter

Microprocessors, the long-awaited computer on a chip, are beginning to roll off the assembly lines. The single-chip microprocessing units, or MPUs, "together with a handful of matched memory and logic circuits, provide equipment designers with the full power of computer hierarchy at unprecedentedly low cost." That's how Solid State Editor Larry Altman, in the report starting on page 81, describes the impact of these tiny devices that pack a lot of computing power.

Originally, we planned to run Altman's microprocessor round-up as the second part of his logic-design report [*Electronics*, Feb. 21, p. 81]. But with the MPU emerging at such a fast clip as a major product in its own right—fast becoming a rival technology to conventional logic—we decided that these up-and-coming devices merited the separate treatment given them in this issue.

And included in the microprocessor report are detailed articles on two of the second-generation MPUs. You'll find the story behind Motorola's M6800 family and Intel's 8-bit 8080 MPU on page 88 and page 95, respectively.

The design of microprocessors, fascinating as it is, is only part of the story. The other part is applications. On page 65, you'll find a Probing the News article on the move by automakers to equip cars with computer control—an evolutionary step that can be made only because of microprocessor-based cost breakthroughs.

Larry Armstrong, who heads our Midwest bureau, in interviewing user and producer alike, found that MPUs will be designed into Detroit's products by the time 1980 rolls around. Moreover, they will make possible a number of safety, economy, and convenience features that are just too expensive now.

Although the kind of mass market represented by Detroit is still a few years off, the microprocessor has been designed into a host of sophisticated products. So, we plan to start a new series called "Microprocessors in Action." An analog of our well-received "Minicomputers in Action," the series will bring you the case histories of a number of successful microprocessor applications. Watch for it in upcoming issues.

Manpower is one of the limits on how fast the electronics industries can grow. In the days when we were racing the Russians to the moon, engineering schools couldn't turn out EEs fast enough, even though the glamour of the space race drew a large number of students into engineering.

Under the depressing effects of the last few years—cutbacks in Government research and development, economic recession, widespread underemployment of engineers—EE enrollment fell off. Now, though, things are definitely looking up.

The immediate prospects are for another round of manpower shortage as EEs from the smaller, recession-hit classes enter the job market. On page 75, you'll find the heartening story about the engineering schools' efforts to recruit more students in the wake of a marked upward swing in job prospects.

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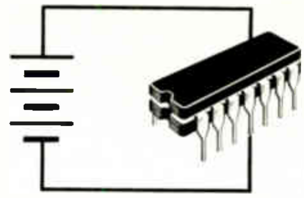
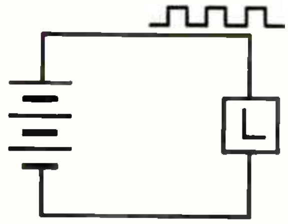
When you've got to power noise sensitive logic,

what do you want for the job?



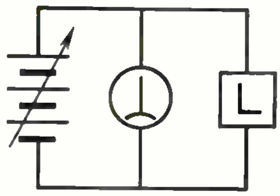
When your system draws a pulsating load current,

what do you want for the job?



When your specs call for adjustable voltage,

what do you want for the job?



When your programmed level must be accurately reproduced, when the current limit must be adjustable and square (not folded back), when you want a power supply that doesn't lose half its current rating at +71°C (or at −20°C). . . .

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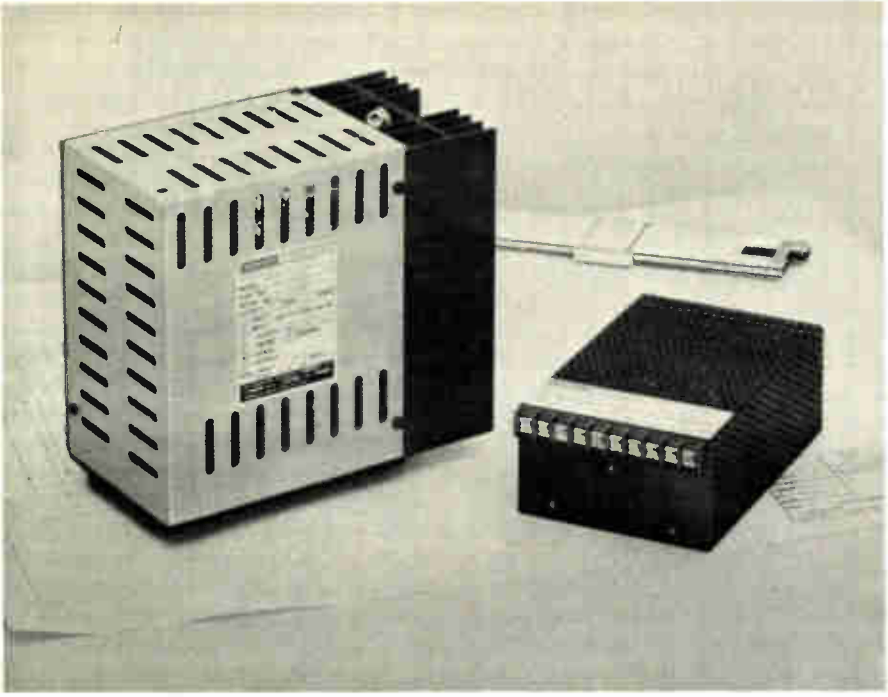


Readers comment

Making honest dice

To the Editor: The circuit described by Per J. Johnsen in Readers comment [*Electronics*, Dec. 6, 1973, p.6] on "Electronic dice ease tough decisions" [Aug. 16, 1973, p.118] will result in loaded dice.

The decoder input he gave was 2, 3, 6, 7, 10, 11. This depends upon a straight binary-count output from the B, C, D outputs of the 7492A. In fact, the outputs are not straight binary, and the decoder input code would be 2, 3, 6, 10, 13, 14. The dice would show a 6 twice per sequence and one undefined output.

R. M. Stitt
Burr-Brown Research Corp.
Tucson, Ariz.

■*Mr. Johnsen replies: I was surprised to see that there was an error in the circuit because when I built it originally, it worked nicely. The difference then, however, was that I had put the A section of the counter in front.*

When I recorded the circuit, I got the bright idea that the A section of SN7492 could be omitted, since the rest was an independent divide-by-6 counter. Unfortunately, I was unaware that this section did not count in a straight binary way. With the A section included, the table stated in my note is correct, since 0–5 is a straight binary sequence.

Correcting UGLI equation

To the Editor: I wish to point out an error in the equation of the figure for "UGLI may scare off large custom ICs" [*Electronics*, Feb. 7, p. 42]. It should read:

$$(A + jB)(C + jD) = (AC - BD) + j(BC + AD) = X + jY$$

G. Victor Wintriss, Comdr., USN
Fleet Combat Direction
Systems Support Activity
San Diego, Calif.

'Pong' belongs to Atari

To the Editor: Your article, "Anyone for tennis—via color TV" [*Electronics*, March 7, p.32] refers to another supplier's game as "Pong." The word "Pong" is a very valued trade mark of Atari Inc.

Tony Seidel
Atari Inc.
Los Gatos, Calif.

40 years ago

From the pages of Electronics, April, 1934

Technical employees organize

For several years past, while the unemployment problem has been at its worst, thoughtful observers of the conservative course of the "regular" engineering societies have felt that the social and economic situation of technical men would have to be given more attention and help, or else new organizations of engineering employees, built on wage issues alone, would arise to claim the interest and membership of employed engineers and younger men. Already such movements have come in several quarters. One trade union of "technicians" has obtained 2,000 members in New York, and has 3,000 more in Buffalo, Philadelphia, Pittsburgh, Baltimore, Chicago, and St. Louis. At first the membership of the new "Federation" was drawn chiefly from the unemployed, but later accessions have come 75 per cent from among men with jobs, who seek to better their conditions.

Mental courage

Mental courage may not receive any acclaim because most frequently it isn't even observed.

This mental courage demands, however, certain assistance.

In the first place, it demands DETERMINATION to face the situation at whatever cost.

Then it demands a STUDY of the situation, its conditions, its necessities, the means to meet it, the possible help to be obtained, the cooperation to be had, an analysis of what must be done, and planning along proper and essential lines.

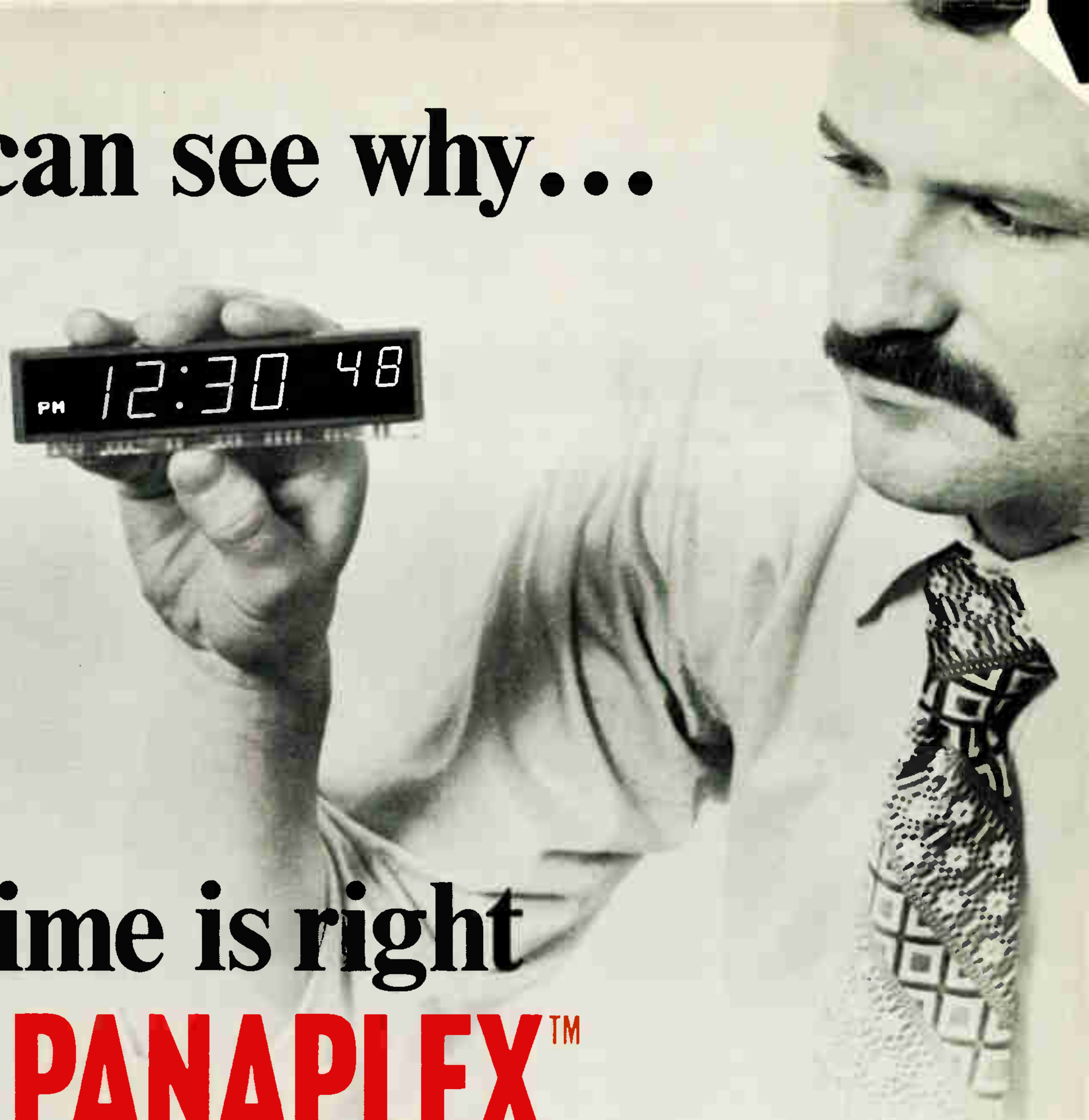
Usually it demands considerable SACRIFICES.

It demands a FIGHT to put the right methods across.

Finally it demands a FAITH and belief in plans and people.

But happily it MOST ALWAYS BRINGS SUCCESS where failure might have ensued.

There has not been for a long period such a time as now when such mental courage is needed, for the rich and the poor, the worker and the executive are in some distress.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People

Lyndes to tap market for paper-tape readers

In the past five years, Horace C. Lyndes has faced a recession and blindness, but had an idea he would not abandon. Now his own company, Teleterminal Corp., Burlington, Mass., is incorporated, and the first 50 units of his photoelectric paper-tape reader are nearing completion. Lyndes' product, the Fly Reader 45, has a maximum reading speed of 450 characters per second—higher than most on the market—and its price of $625 for 1 to 10 units places it in the lower-priced range.

Lyndes started out as a mechanical engineer with a degree from the University of New Hampshire, and became interested in paper-tape readers while with DI/AN Controls Co. and later with Adar Associates. He felt he could improve on the product and by the beginning of 1970 he had a working prototype. But due to the recession he wasn't able to find any venture capital, so he turned to consulting work to keep afloat. By 1971, he was back working on his device, redesigning and tooling it.

He completed development in 1972 and actually had some units in the field when he was forced once again to stop business, this time due to cataracts. He was blind for a year before an operation restored his sight.

Moving up. With his sight restored, he is now ready to enter the marketplace, this time financed privately. He tried his luck in the venture capital market, but with no success. "Venture capital people are looking for another Viatron or another IBM," he complains, "but I think they will find more Viatrons. They are looking for the big break, not for the guy in a cellar with a good product in a modest market." Lyndes is out of the cellar and into an office, but Teleterminal is still essentially a two-man operation.

He admits that paper-tape readers aren't exactly a glamorous product. "They're kind of a staple," he says. "But paper tape is still the cheapest way of keying in data, and as long as there are teletypewriter terminals around there is a need for readers. It is not a boom market, but it has consistently shown 10% to 15% growth." He estimates the total market is $40 million, with the Teletype Corp, Skokie, Ill. holding half of it. Mechanical readers hold half of the rest of the market, but Lyndes feels photoelectric readers will gradually take over that share.

Set to go. Horace C. Lyndes has his first 50 paper-tape readers in production.

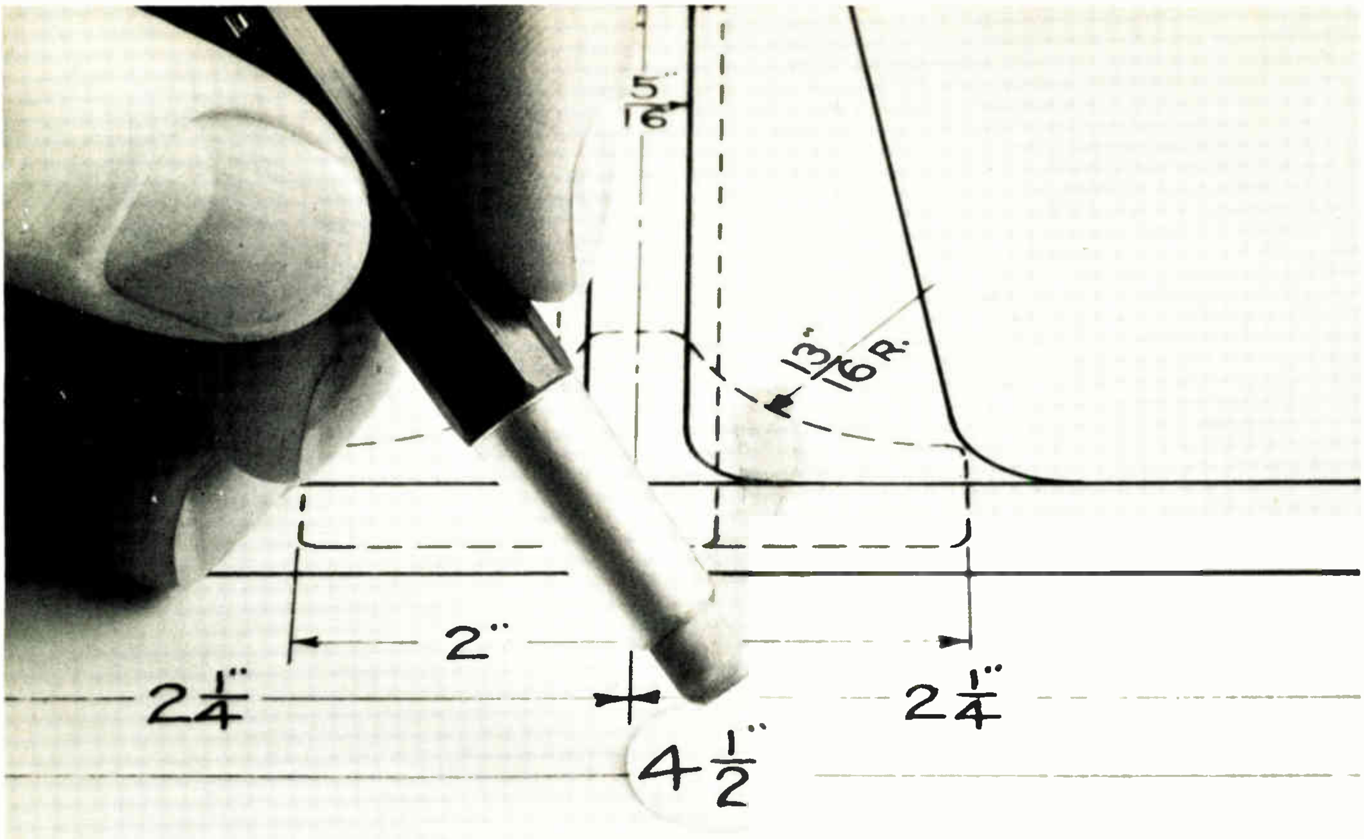
National's Landrum homes in on consumers

Novus Electronic Products "has only true consumer products in the offing," says Gene Landrum, recently named general manager of the division. Novus was formed just last October by National Semiconductor to penetrate the consumer products market through retail outlets such as drug, department, and hardware stores.

Landrum's working philosophy is that consumer products must be just that. "Many calculators are designed for engineers by engineers," he points out. "Those people know too much about calculators and aren't consumer-oriented."

The latest example of the Novus approach to consumer marketing is its planned deal with Scott Paper Co., Philadelphia, Pa., to sell calculators through coupons on Scott products.

Currently, the Novus division



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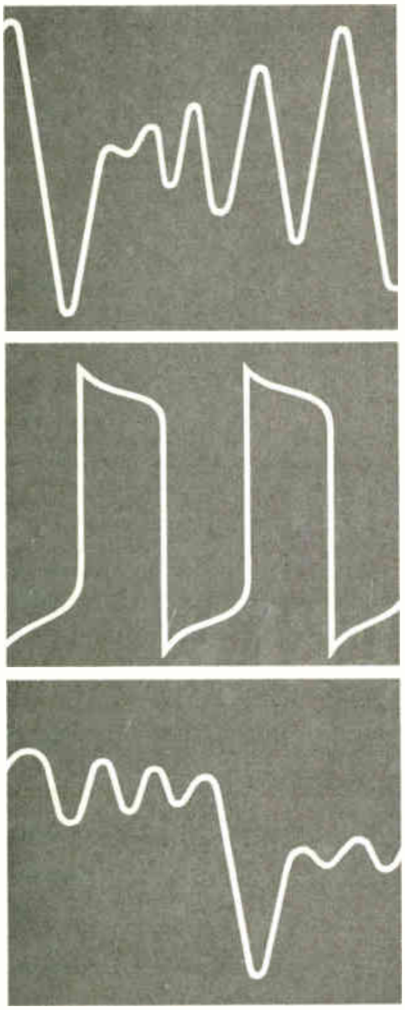

markets low-cost calculators aimed at housewives and students. Landrum wants to keep those customers while adding such products as clocks with LED displays, electronic slide rules along the lines of the HP-35, low-cost electronic printers, electronic scales for the home, and maybe an electronic chess game.

Looking at the market. "Anything that can sell" is a possible Novus item, says Landrum, with the qualification that "I believe in looking at the marketplace first. If the volume to be produced will allow us to do it at a profit, then we'll take steps to pursue" that product line.

Supermarket sales. National's Landrum manages new consumer products division.

This approach, says Landrum, will help put National in the number two slot of worldwide calculator manufacturers, and will also contribute to National's "dominant" position in the general electronics market. To succeed, Landrum depends on Novus' "very success-oriented" sales team and National's capacity to produce 70% of its own components.

A native of Florida, Landrum graduated from Tulane University with a B. A. in business administration and went to California to join the Singer Friden Co., where he became national sales manager.

He co-founded two companies—Unicom Systems Inc., Cupertino, Calif., and Eldorado Computer Co., Concord, Calif. before joining the Novus division of National Semiconductor.

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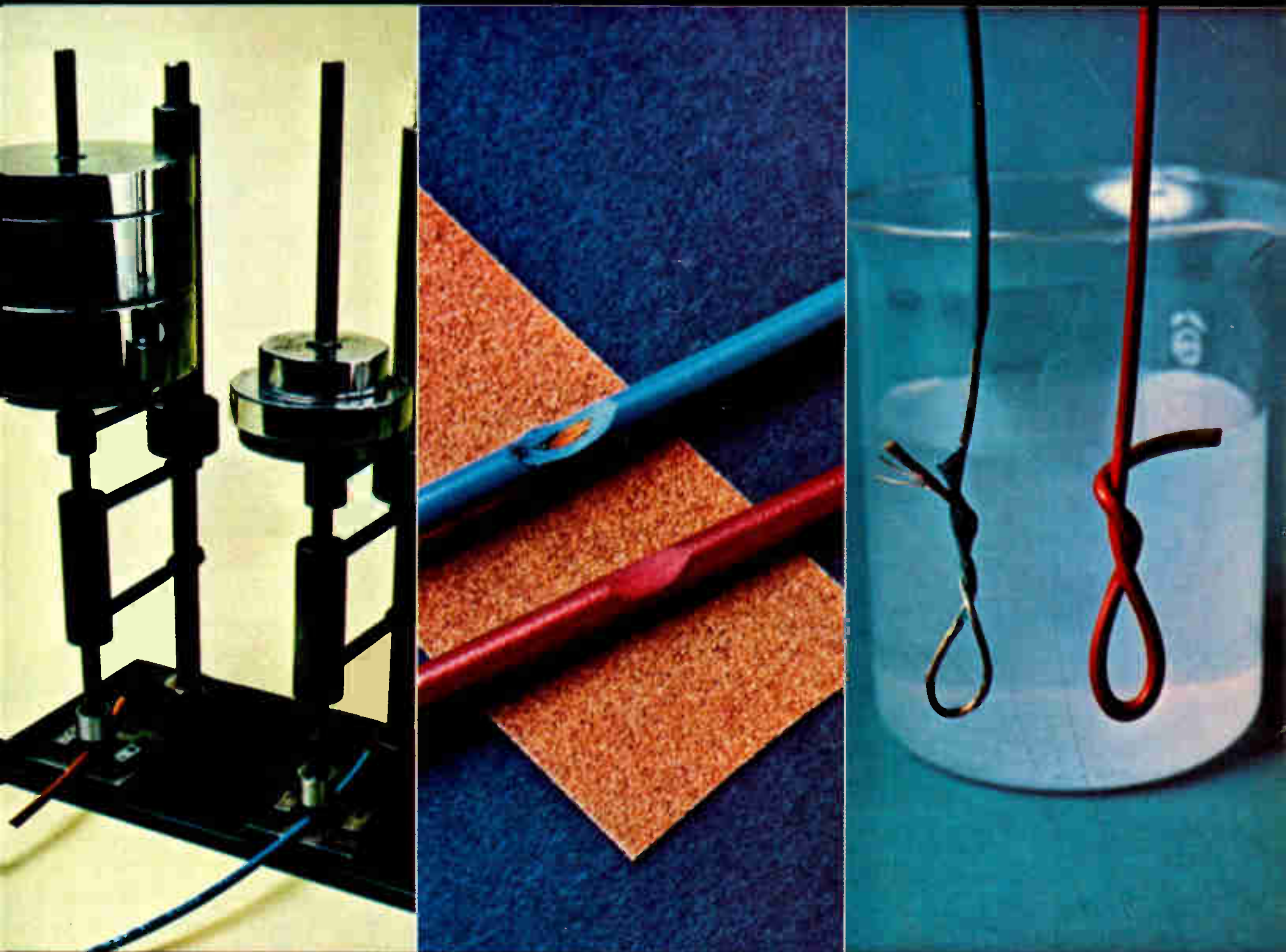
Vylink is the Brand-Rex trade name for its tough irradiated PVC insulated wire and cable. A thermosetting material, it has superior heat resistance, is unaffected when accidentally touched by a solder iron and has outstanding cut-through, abrasion and chemical resistance – all in addition to vinyl's inherent non-flammability (it meets UL's FR-1 requirements), high dielectric strength and insulation resistance.

Five important processing and operating characteristics of *Vylink* and conventional PVC insulated wires are compared in the following panels. Test procedures and *Vylink*'s properties are detailed in Brand-Rex specification BR-790. Write for your copy to Brand-Rex Company, Willimantic, Conn. 06226. Tel. (203) 423-7771.

Heat Resistance
After 96 hours at 350°F, *Vylink* is unaffected; conventional PVC flows. *Vylink* wire provides far greater protection against current overloads and high temperature environments. It is recommended for shrink-tubing and wave solder cable terminations where wires are exposed to heat guns or solder baths – an excellent low-cost substitute for the premium-priced "high temperature" wires usually used in this application.

Solder Resistance
When a weighted solder iron (1½ lbs. force) is applied to the wire surface, conventional PVC insulation melts almost instantly; *Vylink*, though it may exhibit slight surface discoloration, shows no substantial change – even after several minutes. Regardless of method – hand gun, solder dip, wave soldering – *Vylink* insulation will neither shrink back nor melt. Shorts due to soldering are avoided. Circuit integrity is assured.

and cables are tough, we prove it.



Cut-through Resistance
The relative resistance of *Vylink* and conventional PVC insulated wires to penetration may be demonstrated by applying a 90° V cutting edge attached to a weighted plunger perpendicularly to samples of each. To have the specimens cut through in the same length of time, *Vylink* wire must be subjected to at least 5 times the weight. This extra toughness makes thinner insulation walls possible without compromising physical properties. The result — lighter weight, smaller diameter, but equally reliable, cable.

Abrasion Resistance
In this test, a predetermined weight presses a conventional PVC wire sample against a moving 400 grit aluminum oxide abrasive tape until the insulation has been worn away and conductor exposed. By comparison, more than half the insulation remains when the same amount of tape abrades *Vylink* insulated wire under identical conditions. This toughness permits the use of thinner insulation which UL recognizes by rating 8½ mil wall *Vylink* wire at 125 volts (UL Style 1472).

Chemical Resistance
Electronic bombardment of the specially formulated *Vylink* compound causes a change in the molecular structure and transforms this PVC material from a thermoplastic to a thermosetting plastic. *Vylink*, like all thermosets is generally inert to chemicals and solvents. When *Vylink* and conventional PVC are boiled for two hours in MEK (methyl ethyl ketone), a good solvent for vinyls, *Vylink* is virtually unaffected; conventional PVC is completely dissolved.

Tests were conducted on 16 (26/30) AWG with 1/32" insulation.

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Meetings

Electronic Components Conference, IEEE, EIA, Statler Hilton Hotel, Washington, D.C., May 13–15.

Pittsburgh Conference on Modeling and Simulation: ISA, University of Pittsburgh, Pa., April 24–26.

National Computer Conference, AFIPS/IEEE Computer Society, McCormick Place, Chicago, Ill., May 6–10.

International Instruments, Electronics, and Automation Exhibition, Olympia, London, England, May 13–17.

International Magnetics Conference (Intermag) '74, IEEE, Four Seasons Sheraton Hotel, Toronto, Canada, May 14–17.

Society for Information Display International Symposium, Town and Country Hotel, San Diego, Calif., May 21–23.

International Instrumentation Symposium, Instrument Society of America, Hilton Inn, Albuquerque, N. M., May 21–23.

Semicon/West '74, SEMI, San Mateo Fairgrounds, San Mateo, Calif., May 21–23.

International Symposium and Technical Exhibition on Electromagnetic Compatibility, Swiss Federal Telecommunications Authority, Montreux, Switzerland, May 23–29.

Microwave Power Symposium, International Microwave Power Institute, Marquette University, Milwaukee, Wis., May 28–31.

Power Electronics Specialists Conference, IEEE, Bell Laboratories, Murray Hill, N. J., June 10-12

Quantum Electronics International Conference, IEEE, Hyatt Regency Hotel, San Francisco, Calif., June 10–13.

Utilities Telecommunications Council Annual Meeting, UTC, Chalfonte-Haddon Hall Hotel, Atlantic City, N. J., June 16–20.

 Circle 20 on reader service card

Circle 198 on reader service card

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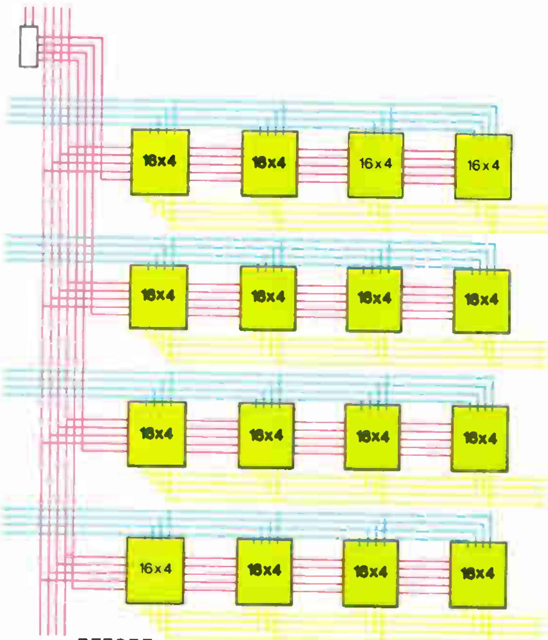

BEFORE

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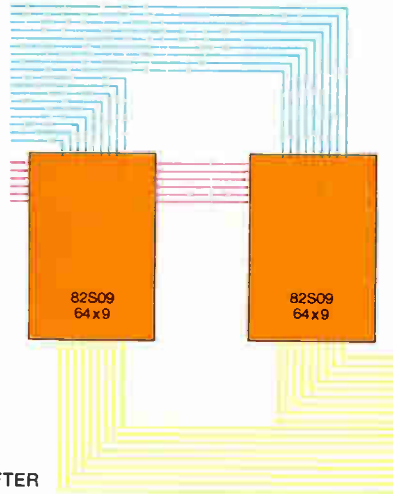

AFTER

		"Before"	"After"
Parts Cost*	Decoder 8225/7489	$ 2.80 96.00 $98.80	$ 0.00 85.20 $85.20
Board Space		1.5	1.0
Access Time (1)	Decoder 8225/7489	20ns 50ns 70ns	0 45ns 45ns
Power Dissipation	Decoder 8225/7489	0.1 Watt 6.4 Watts 6.5 Watts	0 1.7 Watts 1.7 Watts
Solder Connections	Decoder 8225/7489	16 256 272	0 56 56

(1) Even with 3101A (35ns), the total 64 x 16 array access time is 55ns.
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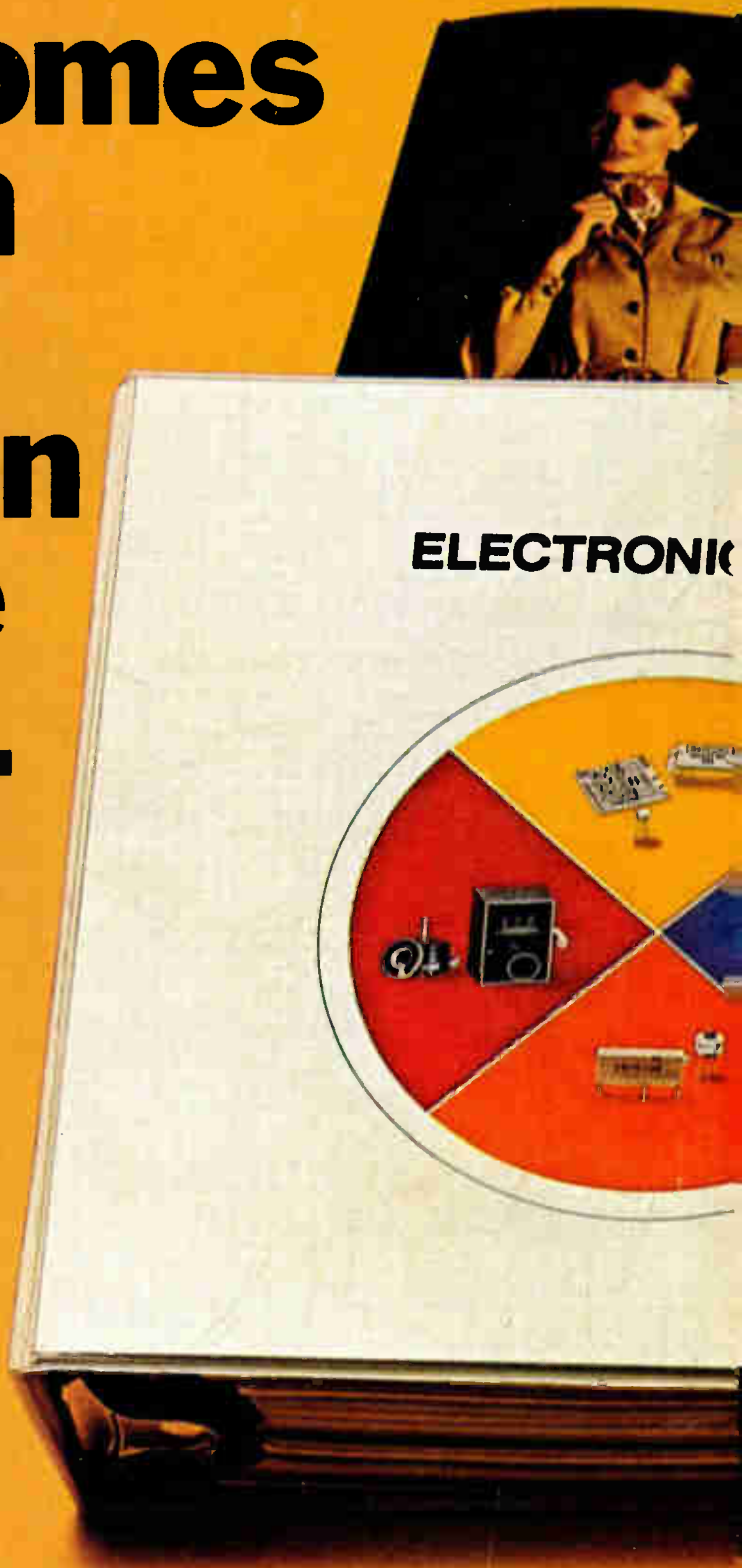
When it comes to breadth of product line, certain names are standouts.



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Circle 23 on reader service card

Electronics newsletter

Realm of 4k is divided into three parts . . .

A measure of stability is surfacing in the 4,096-bit random-access-memory business. Despite recent delays in Texas Instruments' production schedules [*Electronics*, March 7, p. 25], **RAM suppliers are increasingly committing to the TI pinout** for their product introductions over the next 12 months. Three camps have been formed on the pinout question—the 22-pin TI version, the different 22-pin Motorola/AMI version, and the 16-pin multiplex design from Mostek, which Fairchild also will supply.

But the number of suppliers designing their 4k RAMs with TI's pinout indicates that it could become the industry standard. Among them are Intel, National, Signetics, Intersil, Microsystems International Ltd., and Western Digital. Some are one-transistor designs, others use three-transistor cells. Intel, one of the earliest with a three-transistor, 22-pin design, **claims to be shipping already in small volumes its fast 300-nanosecond 2107A version.** And according to Mike Markkula, North American marketing manager, "We will be shipping tens of thousands of the 2107As by July."

. . . as AMS reports surging interest for p-channel

In a related 4k memory development, Advanced Memory Systems' 7004—the industry's only 4,096-bit p-channel RAM design—is drawing added interest because of start-up n-channel production problems. According to Herbert Woo, international marketing manager, "Designers are building memory boards using the 2k model 7002 memory, **but including an extra address line to accommodate future update to 4k."**

Woo says that, although the 7004 is slower than the n-channel products, "it uses an established p process that's highly reproducible in large quantities."

Dual isolator to feature gated outputs

To meet the growing demand for high-speed optical isolators, Hewlett-Packard will introduce next month **the industry's first dual optical isolator with gated outputs.** The device, which is TTL-compatible and operates from a 5-volt supply, offers high common-mode rejection (20 V at 1 megahertz) with typical delay times of 40 nanoseconds.

Rick Nis, marketing manager for optoelectronics, says that the new device's two channels will offer **the same high isolation and high speed—in the same size package**—as the popular single-channel device. The new isolator is attractive for high-speed digital applications such as line receivers, digital programing of floating power supplies, motors, and other machine-control systems.

National Semiconductor also is cranking up its optoelectronics capability with plans to introduce within a few months **its first optical isolator,** a six-lead transistor output device.

H-P is developing C-MOS on sapphire

An indication of how fast silicon-on-sapphire technology is moving into the real world of digital processing is Hewlett-Packard's decision to develop its own complementary-MOS-on-sapphire circuits for a new generation of minicomputers. **H-P is also in a major development program to identify the minicomputer design that best utilizes this technology.**

Electronics newsletter

Paul Ely, general manager of H-P's Data Systems division, Santa Clara, Calif., says in-house C-MOS-on-sapphire technology, which H-P hopes will provide input/output, processor, and memory, offers "the most attractive speed-power-cost trade-offs for minicomputer applications."

Another manufacturer, General Automation, has developed a minicomputer with custom C-MOS-on-sapphire CPU chips built by Rockwell International's Microelectronic Device division. [*Electronics,* Dec. 6, 1973, p. 39].

Macrodata delivers inexpensive testers for microprocessors

IC tester maker Macrodata, which has been expanding from memory testing to other IC test areas during the last year, **has delivered five low-cost systems for the fast-growing microprocessor market, and will shortly introduce a system to the market.** The under-$50,000 MD-1041, based on the MD-104 memory exerciser, will check the Intel 8008, 8080, and 4004 microprocessor CPUs, plus new designs coming from National, Motorola, and other firms. The system will check the processors from function rather than just logic, an important consideration since the powerful chips have shown sequence sensitivity. The system is oriented toward incoming inspection, R&D, and wafer-probe uses.

Fast MNOS memory coming from SEMI

Electronic Memories will introduce at the National Computer Conference, May 6 to 10, an MNOS memory system with a cycle time as fast as 80 nanoseconds. Access time is 150 ns. **This compares with a 650-ns cycle for core versions.** The system, to be made at the company's Phoenix SEMI semiconductor operation, is interchangeable physically and electrically with Electronic Memories' Micro-3000 core-memory systems. The price will be about 1 cent a bit in quantities of 100, slightly more than the core, and boards laid out 16,384 bits by 20 as well as 8,192 bits by 20 will be offered.

Electrolytic cell shows promise as display with memory

Researchers at Thomson-CSF's Corbeville, France, laboratories may put a new lease on life for a display device proposed and then discarded in the 1930s—the electrolytic cell. Thomson's experimental display, on the company's stand at the recent Paris Components Show, has seven segments—actually tin oxide electrodes deposited on a glass plate. A metal plate forms the other electrode for the cell and the space between the two is filled with an electrolyte. When 5 volts or so are applied across the electrodes, **cathode metal plates out onto the energized front electrodes in about 200 milliseconds and stays plated for about 15 days unless erased by a reverse potential.** The power requirement for the plating is 100 microwatts for each square centimeter of the display.

Thomson-CSF won't say what metal and what electrolyte it uses for these experimental cells, but the developers think the new devices could turn out to be cheaper to produce than liquid-crystal displays. Spacing between the cathode and anode is a relatively large 200 micrometers, compared to something like 10 micrometers for liquid crystal.

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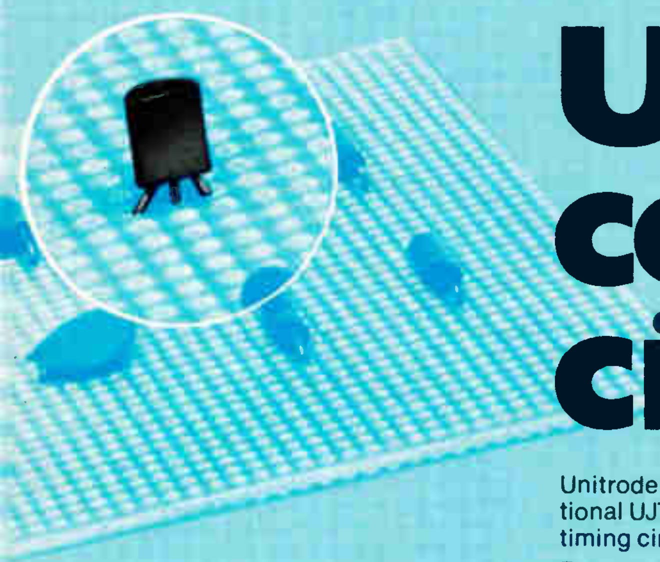

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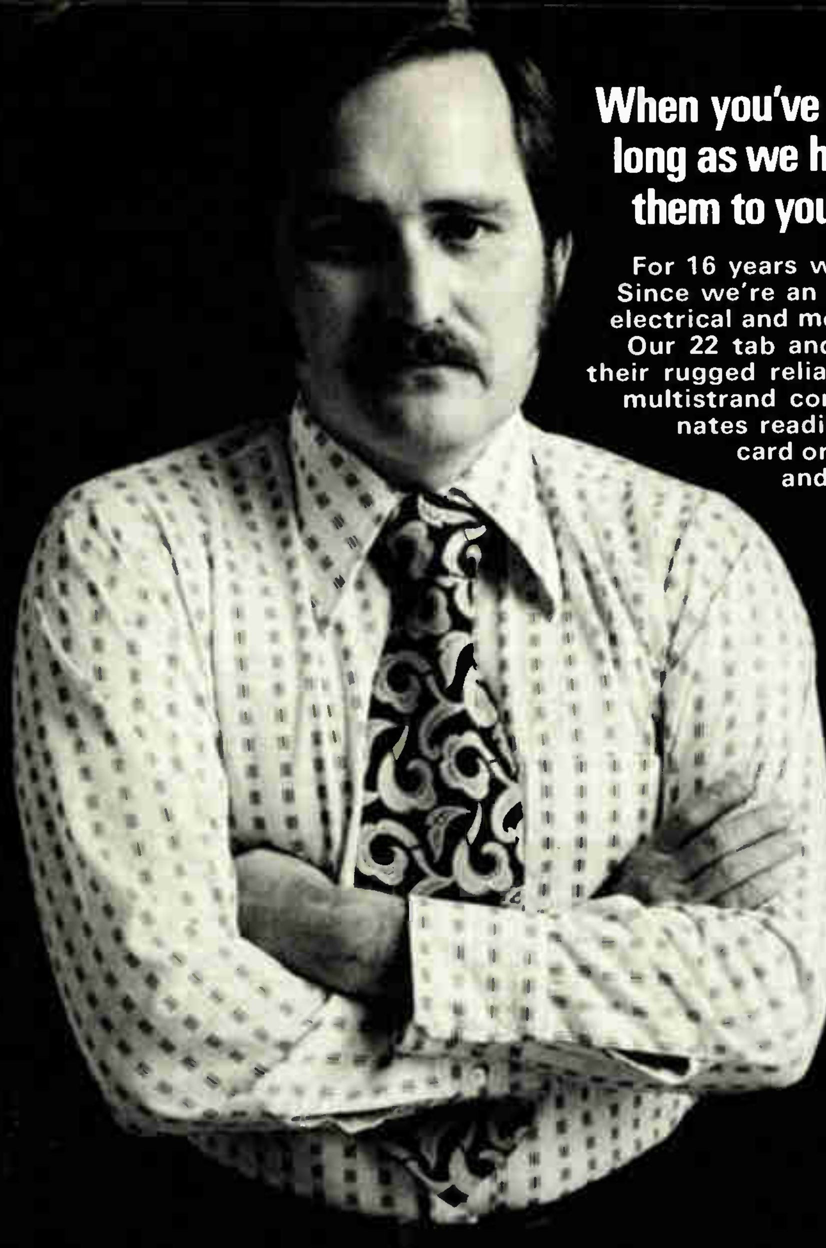

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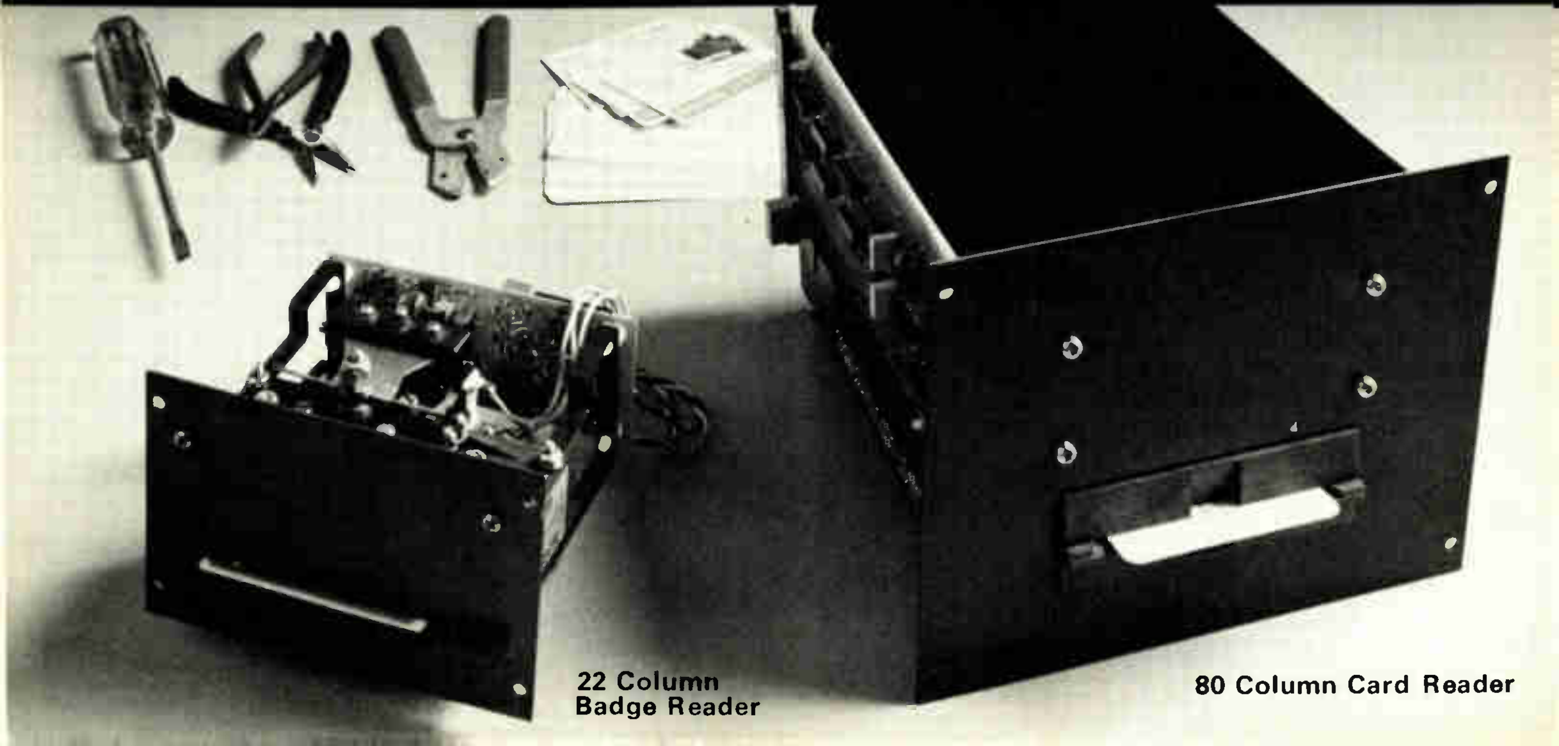


22 Column Badge Reader

80 Column Card Reader

Double-junction LED emits bright, clear colors over broad spectrum

Developed at Siemens, the double diode changes color by varying the drive at the two junctions

Researchers at Siemens AG have designed a new kind of variable-color light-emitting diode. The LED shines with a distinct red, green, or yellow, or any color in between, and has a wide spectral range. Siemens researchers have achieved these results by putting two differently doped gallium-phosphide layers with integrated pn junctions on the same crystal.

Up to now, most LEDs that produce three colors in a single device have used one pn junction, with the n and p layers doped to give green and red. Yellow is obtained by mixing these two colors. According to Siemens researchers, however, with single-junction LEDs, traces of red creep into the green and vice versa. What's more, the spectral range of single-junction LEDs is usually quite narrow.

Two is better. To solve these problems, Siemens turned to a double-junction LED—a double-diode structure on a single crystal—even though it is more complicated to produce. Either junction can be separately driven to give a clear red or a clear green. If both junctions are driven simultaneously, the light emitted is yellow. By using different drive currents at the two junctions, the color varies from greenish-yellow to reddish-yellow.

In the Siemens LED, the drive currents applied to the junctions are from 10 to 20 milliamperes at about 2 volts. The emission efficiency for the green is from 0.5% to 0.1% and for the red around 1%.

Not all parameters—for example, life expectancy and brightness—have been determined for the device. As for the brightness of the red, green and yellow colors, Manfred Plihal, a researcher involved in the development of the variable LED, expects it to be about the same as that of the single-color LEDs Siemens is offering.

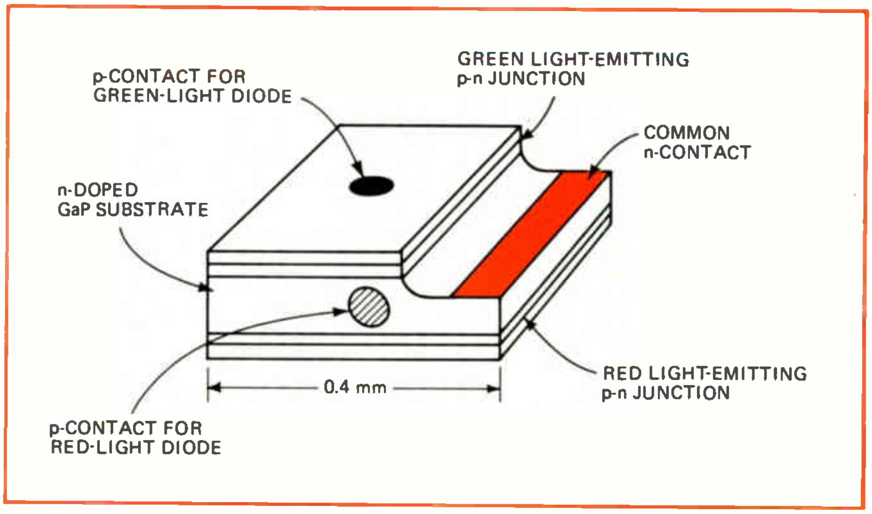
Applications. Siemens sees a wide range of possible applications for a variable-color LED. It could be used as an indicator lamp for showing four operating states of a system: red, green, yellow, and off (no light). Another potential application is as a warning light on a car dashboard, where the LED would go from green to red when a certain speed limit was exceeded. An experimental multicolor indicator with several dozen LEDs on tachometer and thermometer scales will be demonstrated next week on the Siemens stands at the Hanover Fair in West Germany.

The new LED consists of an n-doped gallium-phosphide substrate, with a gallium-phosphide layer grown by a Siemens-developed liquid-phase epitaxial process on both substrate surfaces.

The two layers— one nitrogen-doped for green and the other zinc-oxygen-doped for red— contain the respective light-emitting pn junctions. Then, p contacts are mounted on the upper and lower surfaces. The common n contact is made by etching away part of the substrate's upper p layer.

The variable LED measures about 0.4 millimeters on each side and 300 micrometers thick, with the substrate taking up about 160 μm and each of the two layers around 70 μm. The experimental three-lead device comes in a TO-18 header,

Glowing results. The Siemens color LED consists of two layers on an n-doped gallium-phosphide substrate: one is nitrogen-doped for green light, the other zinc-doped for red.



but a commercial one may come in a different package. Because of the low power dissipation—40 milliwatts maximum—there is no need for a heat sink. □

Communications

Millimeter waves to carry intracity data?

Even though the Federal Communications Commission has not formally opened up new millimeter-wave frequencies, the Norden division of United Aircraft Corp. is off and running with a low-cost transceiver intended to carry short-haul intracity voice and data messages in digital form.

Anticipating a large market among common carriers and private businesses with large data-transmission needs, the Hartford, Conn., company has developed a system that operates at 1.544 megabits per second and 6.312 Mb/s at carrier frequencies of 22 or 39 gigahertz. And it has already found at least one customer—Datran, a common carrier specializing in data transmission—that says it has already proposed using it for a customer in the Houston area.

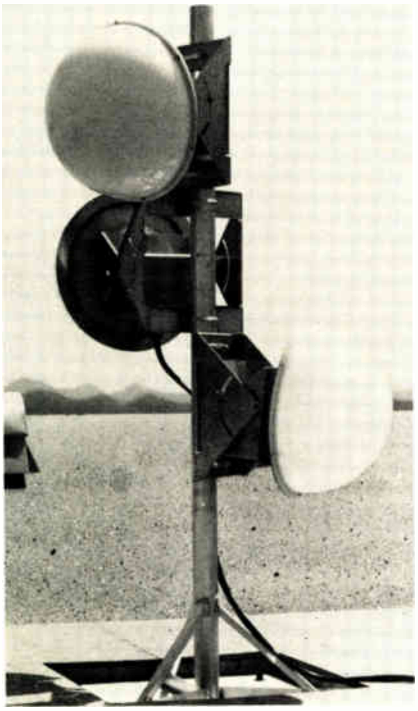
The Norden system consists of 30-pound roof-top installation comprising an antenna 21 inches in diameter and a transceiver mounted on a 3-inch-diameter antenna mast. A remote power supply is mounted inside the building. The system uses a Gunn diode as the millimeter-wave signal source (with 50 milliwatts output), and digital information is applied to the diode by frequency-shift keying, directly at the output frequency. A simple twisted pair carries power and digital signals from digital processing equipment, such as a multiplexer, inside the building. The system costs $8,250.

Norden uses a pulse-cancellation technique borrowed from radar technology to allow the system to both send and receive simultaneously in the same 50-megahertz channel. Although the receiver "sees" both the transmitted and received pulses, digital manipulations help it recognize the transmitted pulses and ignore them (the company says it has applied for a patent on the technique).

The range of the system (between line-of-sight installations), according to Norden's Lou Ebrel, design engineer in charge of applications, is about two and a half to five miles, depending on the intensity of rainfall in the path. (The system cuts off completely at about 2.3 inches of rain per hour over the entire path, but this is a relatively rare occurence, Ebrel says.)

Datran, Vienna, Va., says it would like to use the system later this year for the Houston customer, who will transmit data at 56 kilobits per second. The Norden system will carry the customer's data from his building to Datran's building, about three miles away, where it will be applied to Datran's microwave network.

Datran also points out that the system could prove valuable in industrial-park complexes, where individual millimeter-wave units could be scattered throughout the complex. Each unit could send signals to a central location where messages could be brought down to the normal 6-GHz band for transmission



For intracity calls. Norden's new transceivers are designed for rooftop mountings.

Datran files interstate tariffs

Following hard on the heels of AT&T's filings for interstate digital data-transmission tariffs [*Electronics*, April 4, p. 75], Datran, Vienna, Va.—the only common carrier specializing in digital data transmission—has filed its own interstate tariffs with the Federal Communications Commission. At the same time, the company asked the FCC to delay approval of AT&T's tariffs for at least four months, to prevent AT&T from preempting the market.

Datran's tariffs cover the company's links between Houston and St. Louis., which include Oklahoma City, Tulsa, and Kansas City. Datran has filed for service speeds of 2,400, 4,800, and 9,600 bits per second. Its rates are based on airline distance and speed of transmission, and users will also pay a monthly charge for the local distribution channel, a one-time installation charge, and a monthly charge for use of Datran's customer interface unit.

Monthly rates for Datran's long-haul channels are 75 cents per mile for 2,400 b/s and 4,800 b/s and 90 cents per mile for 9,600 b/s. AT&T's filing with the FCC was: 40 cents per mile for 2,400 b/s, 60 cents for 4,800 b/s, 90 cents for 9,600 b/s, and $4.00 for 56 kilobits/s (and a monthly charge for local distribution channels, interface units and a one-time installation charge).

Datran, however, is hoping to one-up AT&T with a money-back performance guarantee—99.95% of all 1-second intervals will be free of error, the company says, or the subscriber's bill will be credited for the period of substandard performance. AT&T, in filing for its Dataphone Digital Service, said its objective was to provide at least 99.5% error-free seconds, but that better performance has been achieved in trials between New York and Boston.

via a microwave relay.

The FCC, however, has yet to approve the use of the frequencies. A Commission spokesman says that the docket (18920) which covers 18, 22, 25, 27, and 39 GHz, is not controversial, but it still may be a couple of months before there is any action. However, Norden says that the equipment can be operated now under a developmental license, pending the final ruling. □

Navigation

C-LAD steers ship via computer

After several years of development, the Coast Guard is ready to release to manufacturers the design of its Loran-Assist Device (C-LAD) [*Electronics,* Sept. 11, 1972, p. 32]. Developed by Johns Hopkins University Applied Physics Laboratory, C-LAD is a navigation and autopilot system used with a Loran-C receiver. Once in production, the Coast Guard estimates, the units can be sold for about $3,000 each.

C-LAD is connected to the outputs of the Loran-C receiver that provides a ship's latitude and longitude. The coordinates of the ship's destination are input to C-LAD by means of thumbwheel switches. Loran-C uses hyperbolic coordinates specified in microseconds and mathematically transformed into a grid on a chart specified in yards.

C-LAD provides a reading of the ship's course and its distance from its present position to its destination in thousands of yards. The same mathematical solution to the distance to be traveled also gives the bearing angle from the ship's position to its destination. C-LAD updates its course information every 8 seconds, and errors in the calculation converge to zero as the ship approaches its destination.

Autopilot. The ability to determine the present position-destination bearing also allows C-LAD to act as an autopilot. In that mode, a user dials in the bearing angle to the destination and C-LAD compares it with the bearing determined by the Loran-C coordinates. The user can also set up a maximum course deviation, or corridor width. When a ship leaves the corridor, a C-LAD relay is closed, turning on a light that indicates drift to left or right. This output can be used to drive simple servomechanisms on the rudder to keep the ship on course. When the ship returns to the corridor, rudder correction ceases.

At the heart of C-LAD is Intel's MCS-4 microprocessor chip, which contains an arithmetic unit, logic control address, and address to control subroutine handling. It is a 4-bit parallel microprocessor with 16 general-purpose and index registers and a cycle time of 10.8 microseconds [*Electronics,* April 24, 1972, p. 112]. The microprocessor supports two types of memory: six Intel 4002 read/write chips for a scratchpad that can store four 20-digit numbers each, and Intel's 1702 programable-read-only memory instruction memory—when in production, this would be replaced by a read-only memory. There are also chips to interface to the receiver and a clock to drive the logic.

Charles R. Edwards of Johns

Are the Russians really coming, Or: the missing metal-film resistors

Last month's IEEE Intercon 74 seemed like an auspicious kick-off for the first trade-show appearance in the U.S. of electronic-component marketers from the Soviet Union. That very week, in a quiet conversation at the Russian exhibit booth, J. Guchin, an Electronorgtechnica official, said that General Electric had just signed a million-dollar order with Electronorgtechnica, the USSR's trading organization that handles exports of metal-film resistors, vacuum tubes, and semiconductors.

What is smooth? By the Russians' indications, all was going smoothly and as planned. Not so, say sources within General Electric. And herein lies a tale of what it could be like to do business with the Soviet Union.

Destined for GE's television-receiver-assembly plant in Portsmouth, Va., the resistors would begin arriving late in 1974, according to Guchin, with most of the shipment to come next year. But the agreement, which was actually signed seven months ago, specified that delivery was to have started five months ago, says one GE man in a position to know.

So far, no production quantities have been received. Engineering samples were acceptable, he continues, but promised preproduction samples have never showed up. The next shipment commitment is due in another few months, he continues, but, "I'll believe it when I see it."

Dealing with the Russians. In placing its order with the Russians, General Electric, which maintains a sales office in Moscow, apparently wanted to open a two-way trading avenue.

Moreover, the price quoted for the resistors was a very good one, according to a GE source, even with the American tariff added on. But while promises apparently come quite cheaply, delivery and actual business dealings with the Russians are other matters.

It was extremely difficult to maintain working relationships with the Russians, says another GE man. Letters and telegrams went unanswered for months at a time. And in face-to-face talks, it seemed to be the practice never to meet the same men twice. "There was a brand new crew of faces every time," he continues. And this seemed to be by design, so that no rapport could be established between the negotiators.

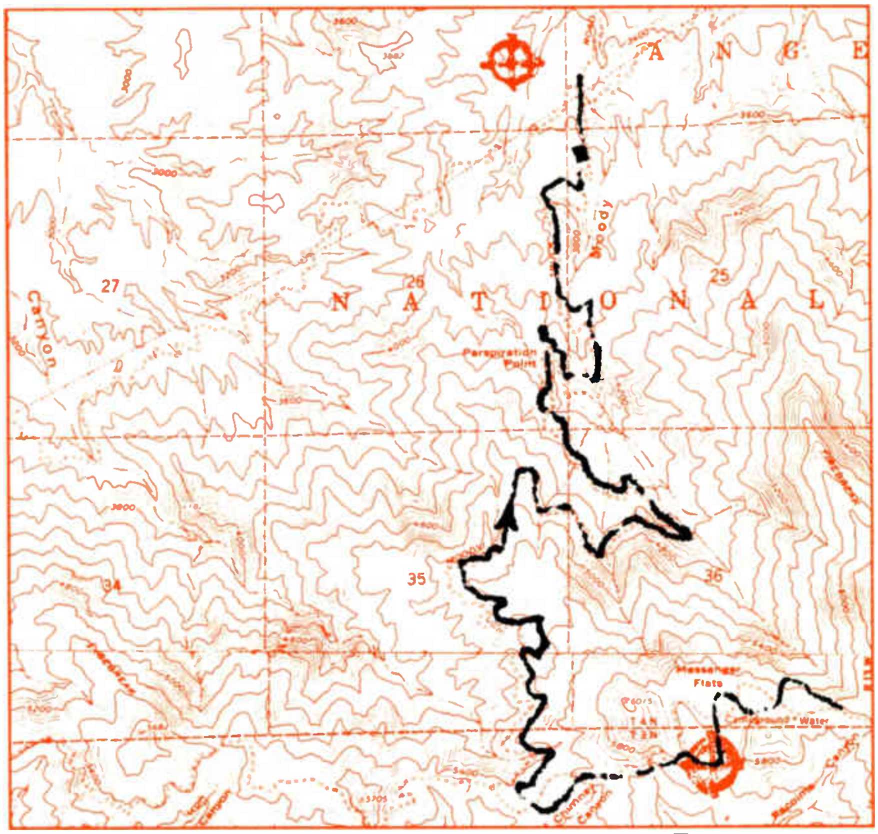
Is there any advice for others counting on Soviet suppliers? Yes, replies one GE man dryly, "Back up your program with regular sources."

Hopkins lab says: "We program C-LAD as though it is a mini, but it's really a microprocessor." Subroutines have been developed for the system; the labs have invented an intermediate language that minimizes the amount of data in store.

Prototypes of C-LAD have been in the field for about six months, and development plans for its manufacture are expected to be released next month. But companies are already beginning to express interest in the product. Navigation Systems Inc., Silver Spring, Md., a subsidiary of Decca Navigator Co. Ltd. of England, which makes Loran-C receivers, is "taking a look at the market [for C-LAD]" a spokesman says. "We want to see what it will do and at what price." But he feels it can offer the shortest route to a particular point, and that it offers potential to fishermen. □

Commercial electronics

Vehicle-tracking unit could cost only $500



On the trail. Tracings from Hileman's vehicle-tracking system superimposed on a map.

A simple vehicle-tracking system developed by an avocational rockhound and mapmaker for $5,000 appears to do much the same job as the $1.8 million position-and-azimuth-determining system (PADS) that Litton Industries designed for the U.S. Army [*Electronics*, July 31, 1972, p. 22].

But being somewhat less accurate and reliable, the unit—which its inventor says could be produced to sell for $500—is not suitable for military use. It does, however, permit dead reckoning to within 6%, or a few hundred feet for a trip of several miles.

As an on-board tracking system, it looks promising for locating police cars, fire engines, and taxicabs in a city. The system was conceived by Dale Hileman of Topanga, Calif., and developed into a working, all-digital model with help from Bob Phillips, president of the consulting firm, Fundamental Products, North Hollywood, Calif.

It derives distance information from a pulse pickup from the vehicle's odometer-speedometer. To determine heading, Hileman developed a magnetic compass using a constantly rotating pickup coil, and the sine-wave output generated by it is processed to give any of 32 position headings.

The data from the distance and heading sensors are combined in a small "computer," for display on a specially made digital X-Y plotter that uses pulse-operated motors. The computer, built mainly with discrete components, measures 12 by 6 by 6 inches. Hileman, though working on converting it to C-MOS and reducing its size, is mainly interested in selling the concept.

Magnetic effects. The system is independent of the car's motion and of any externals other than the earth's magnetic field. The compass sensor is mounted on a gimbal that allows front-back motion, and travel over hills produces relatively minor errors, about 1% for a very steep slope. The biggest error is caused by the large magnetic mass of the car.

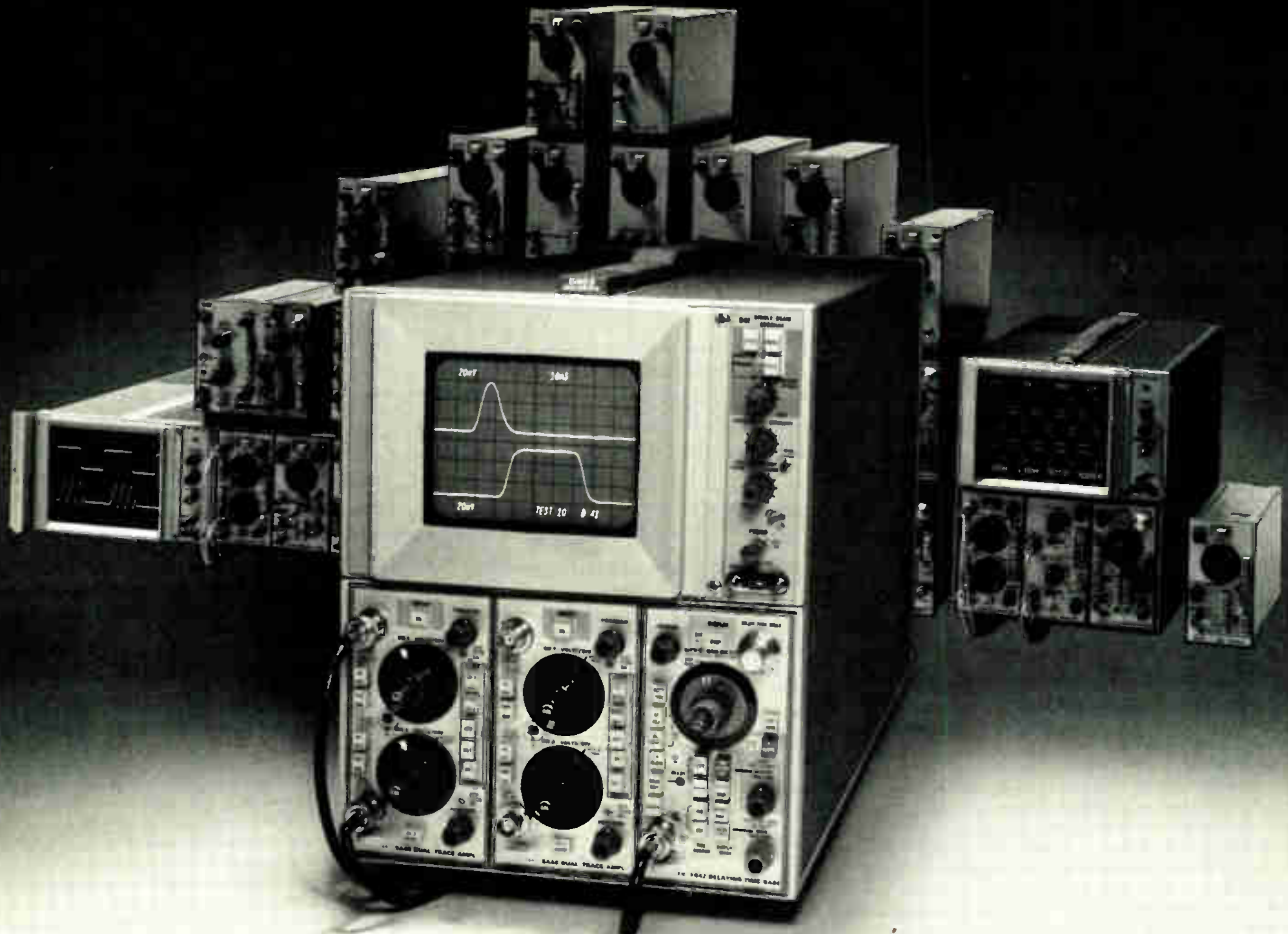
The big market, he feels, is in vehicle location. "Our system could store locations digitally, then transmit them over the existing radios in a vehicle. To correct for the cumulative error, it could be checked automatically and corrected by passing near a proximity detector—which could be passive lines in the street every few miles."

This combination of dead reckoning plus proximity could be built for less than $500 in quantity, he says. It would overcome the problems with proximity, dead-reckoning, and triangulation systems. □

Materials

Recycling of silicon found to be practical

Silicon-wafer reclamation, considered an "R&D wonder for seven years," according to the president of Silicon Valley's six-month-old Silicon Material Inc., is beginning to



Capture Those Hard to View Signals at Low Cost

Single shot events; high speed, low repetition rate signals; changes in successive sweeps, very slow signals; repetitive signals obscured by random noise—all of those hard to display waveforms are easy to view using the new 5403/D41 Variable Persistence Storage Oscilloscope from Tektronix.

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The flexible 5000 Series is designed to handle your present measurements and is expanding to meet your future needs.

To learn more about the new 5403/D41 Variable Persistence Storage Oscilloscope and how this low cost instrument can make difficult signals easy to measure, contact your local Tektronix Field Engineer or write Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005. In Europe write Tektronix, Ltd., P.O. Box 36, St. Peters Port, Guernsey, C.I., United Kingdom.

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pay off as a result of the silicon shortage.

SMI president John E. Lawrence, opened his Mountain View, Calif., shop after estimating that the weekly supply of "virgin" silicon is about 800,000 wafers but the demand is 1 million wafers. Lawrence is looking at that 20% gap, urging semiconductor firms to have their defective wafers reclaimed at SMI.

So far, SMI has rung up $70,000 in orders, and Lawrence expects that figure to jump to $1 million by the end of the year. The firm's present processing capacity is 30,000 wafers a week, and this will reach 50,000 a week in June, Lawrence says. A reclaimed silicon wafer costs 35% as much as a virgin wafer—$2.50 for a 3-inch wafer that originally cost $7.

Recycler. John Lawrence, president of SMI, developed means of recycling silicon.

In-house facilities. Even though he believes "there will be adequate supplies of silicon by the fourth quarter, SMI's "lower cost will always keep us in business." Lawrence does admit that "every semiconductor company with sales over $50 million a year will develop its own in-house" reclamation facility.

Such firms as Signetics, Tektronix, Fairchild, AMI, National, Intel, and Sprague, which have sent in experimental wafer batches, will use the firm for six months, says Lawrence, and then develop their own wafer-processing facilities.

But Lawrence, in fact, hopes to work with companies that wish to set up their own facilities. SMI would set up the facility and work with that firm's employees for two years, when the facility and all rights to the process would be sold.

The process. SMI uses a proprietary gettering process to neutralize contaminants electrically. Next, oxides, metals, nitrides, polysilicons, and other surface impurities are removed chemically. The diffused impurities are removed by diffusing phosphorus into the wafer to a depth of 1 micrometer. The phosphorus attracts the impurities, and the phosphorus layer is then removed chemically and mechanically. Moreover, as the phosphorus is diffused, the silicon substrate heats up, creating dislocations in the crystal lattice that absorb any remaining contaminants.

The process will not work with wafers with diffusions less than 0.7 μm deep, since these wafers have no space left to absorb impurities from below. Nor can gold-doped wafers undergo reclamation because gold precipitates into dislocations in the bulk silicon and affects device performance negatively.

While it is true that the few other contaminants—not absorbed by the phosphorus—are also drawn into dislocations in the bulk silicon, these do not affect the performance of a device, Lawrence says. This leaves the surface, where most semiconductor activity occurs, free of impurities. "We're taking advantage of bulk defects to absorb surface defects in the wafer," Lawrence says.

SMI is reclaiming wafers for 34 companies, mostly on an experimental basis. Stanley G. Billingsley, materials control manager at Hewlett-Packard Co.'s Santa Clara, Calif., integrated circuit department, says that the several hundred wafers SMI sent to H-P were "at least equivalent to virgin materials and worked as well with no more problems than with new material." H-P previously scrapped its defective wafers, says Billingsley, because "historically, there was nothing you could do with a bad IC." H-P now has an order for several hundred at SMI and awaits the test runs to determine whether or not the wafers can be used for new products, as well as test wafers.

Economics. Financial considerations seem to be the impetus for SMI's growing list of customers. "It's a very attractive process economically," says Electronic Arrays' director of processing techniques, Joseph J. Curry. The Mountain View, Calif., firm went to SMI, says Curry, "because manufacturers can't provide the volume [of wafers] we need. This process provides us with a good measure of protection against any further shortage." EA has already made products with the reclaimed wafers, finding them "no better or worse" than virgin wafers. □

Production

How phosphorus abets IC destruction

If the silicon dioxide used to passivate a plastic-encapsulated semiconductor device contains excessive amounts of phosphorus, this material, laid down to protect the chip, may actually hasten its destruction. This is the finding of Motorola researchers—senior engineers Wayne Paulson and Ralph W. Kirk, who was formerly of Motorola, but now with Hewlett-Packard. Their results were presented at an IEEE Reliability Physics Symposium early this month. Since silicon dioxide is a glass and extremely brittle, phosphorus is often added to the silicon dioxide to reduce the microscopic cracks that might otherwise form.

Paulson and Kirk point out, however, that there is an optimum percentage by weight that can be added—between 2% and 6%. They say that raising the phosphorus level

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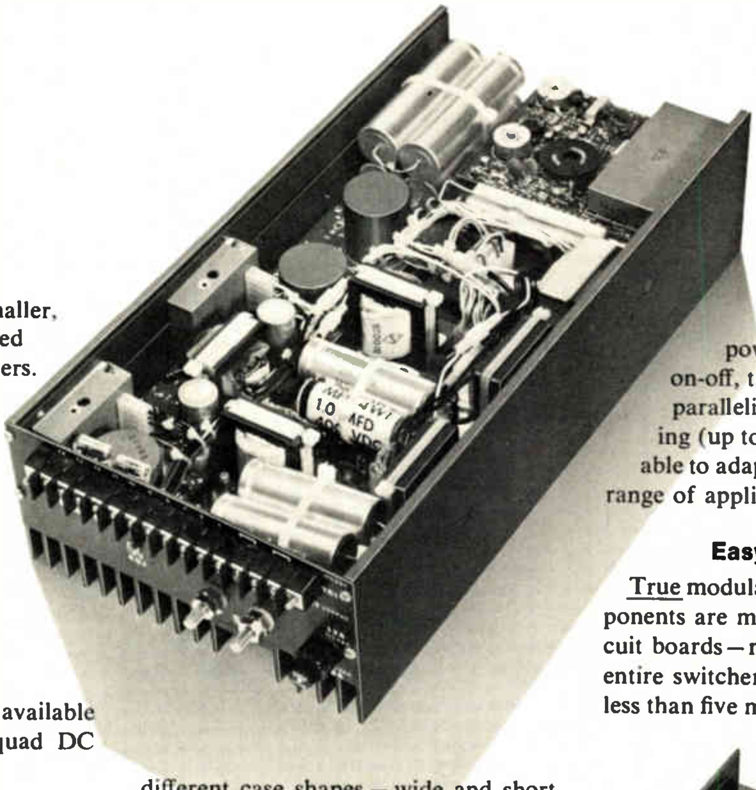


And LH has 84 other equally exciting models to choose from — all of them smaller, lighter, more efficient and priced lower than competitive switchers.

250 to 1500 watts

LH offers 7 standard wattage ratings — 250, 300, 500, 600, 1000, 1200 and 1500** watts. This is the most comprehensive line of high-efficiency switchers available anywhere.

4 outputs

Standard LH switchers are available with single, dual, triple or quad DC outputs.

Low DC voltage, high power outputs

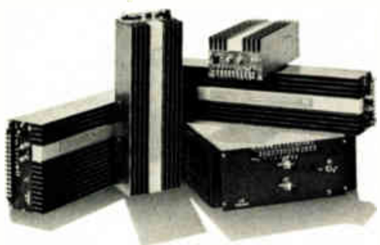
Primary voltages are at 5 VDC; 50, 100, 200 and 300 amps**. 2nd and 3rd voltages are standard ±12, ±15 and ±18V at 8 amps each; 4th voltage is 24V at 2 amps. Other voltages available.

Input voltages externally selectable

110/220 VAC, 47 to 440 Hz, can be selected by simply changing a jumper on the front terminal strip. DC input, 24 to 300 VDC, also available.

6 case configurations

All LH switchers use one basic *proven* design and package it in six different case shapes — wide and short or narrow and long — for customer convenience. With a nominal power density of 1.37 watt/cu. in., LH switchers pack more power into a smaller package than any other switchers you can buy.



80% efficient

On single output models, over 80% of the primary input power is delivered to the output terminal. On models with dual, triple and quad outputs, efficiency averages 75%.

Lighter weights

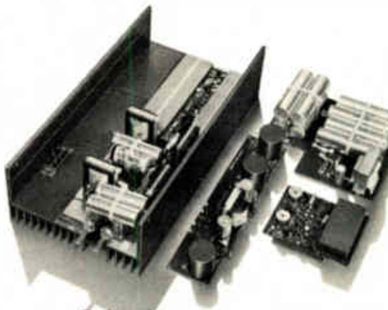
For example, LH's 250-watt single output model weighs only 7 lbs.; the 1200-watt, quad output unit, just 30 lbs.

A number of options

Over-voltage protection, power fail detection, remote on-off, thermal cutoff, DC input, paralleling, master-slave paralleling (up to 10 units) — all are available to adapt LH switchers to a wide range of applications.

Easy maintenance

True modular construction — all components are mounted on just three circuit boards — make servicing easy. The entire switcher can be disassembled in less than five minutes.



Priced as low as 63¢/watt

Watt-for-watt, LH units are the lowest priced switching regulated power supplies you can buy. In 1 to 24 quantity, a 250-watt single output model sells for $360; a 1200-watt quad goes for $1245.

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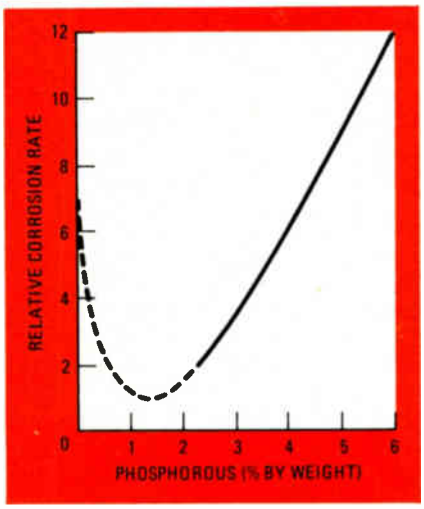

Just a pinch. The quantity of phosphorus added to passivation is critical.

above this range speeds corrosion of aluminum metalization.

The studies were performed on a silicon-dioxide glass 15,000 to 17,000 kiloangstroms thick, deposited on a 10,000-kiloangstrom-thick aluminum substrate. The corrosion product was aluminum hydroxide, which forms at a negative electrode in the presence of an applied electrical bias.

The aluminum hydroxide appeared first at the glass-aluminum interface, cracking the glass, and then spread out over the metalized pad area. Although the corrosion rate was difficult to determine, it was speeded by raising the temperature and the humidity.

The two researchers explain the failure mechanism this way: phosphorus from the glass reacts with water vapor to form acids. These acids provide hydrogen ions, which combine in a two-step chemical reaction to form the aluminum hydroxide. □

Trade

Multinational views dominate hearings

Organized labor appears to be fighting a losing battle against U.S. multinational electronics companies and aerospace exporters who are driving to expand the American share of the world's technology markets.

Recognizing the increasingly global nature of the electronics and aerospace businesses, members of the Senate Finance Committee showed far more interest in industry's support of the Trade Reform Act of 1973 than they did to the strong opposition of the AFL-CIO as the committee began April hearings. The Administration bill, H.R. 10710, already passed by the House, is now before the Senate.

Opposing views. Opposition by the AFL-CIO to the bill by George Collins, assistant to the president of the International Union of Electrical, Radio, and Machine Workers, was particularly strong against re-importation of electronics under tariff schedule categories 806.30 and 807, in which duties are charged only on value-added by off-shore assembly.

Views of manufacturers differed significantly on some specifics of the bill, however, and in at least one case, were opposed. For example, the Aerospace Industries Association of America, the Electronics Industries Association, and were solid in their support of provisions that permit importation of U.S. components exported for offshore assembly with duty only on the value added by labor. But they were divided on the issue of assessment of countervailing duties against foreign products dumped in the U.S. market at prices lower than those of their home market.

Option. Where the EIA opposes the bill's option that would permit the Secretary of the Treasury to waive countervailing duties for up to four years for trade negotiation purposes, both the AIAA and Wema support the provision. AIAA's president, Karl G. Harr Jr., offered unqualified support of the provision, while Wema urged deletion of the one-year limitation on a countervailing duty waiver on products produced "in foreign-government-owned or controlled facilities." That limit, according to William R. Hewlett, "may be much too short to permit negotiation of a satisfactory agreement on subsidies" by foreign governments to their exporters.

Hewlett, president and chief executive of Hewlett-Packard Co., testified on behalf of Wema with C. Lester Hogan, president and chief executive of Fairchild Camera & Instrument Corp. Hogan addressed himself to the value-added provisions and non-tariff trade barriers—such as the new European Rules of Origin for products sold in EEC.

Strong industry support for trade negotiations on an industry-by-industry basis was questioned by some senators, who asked how this could be accomplished with countries that buy such U.S. products as commercial aircraft or farm goods but have no comparable domestic industries available to to export.

An inhibitor. The White House Office of the Special Trade Representative believes mandatory sector bargaining would inhibit its flexibility. Similarly, the Special Trade Representative is uneasy with industry demands that the section of the bill calling for consultation with industry prior to trade negotiations be further strengthened.

EIA president V.J. Adduci urged expanding the role of the 26 industry advisory committees to give them responsibility for policy recommendations as well as for developing technical information to be used by U.S. negotiators.

All of the industry groups urged the elimination of the requirement that minutes of meetings of the advisory groups be made publicly available. "Without this change," EIA's Adduci noted, "any spokesman of any foreign country or industry will be made fully privy to the recommendations of these committees." □

Automotive

Indicator shows miles per gallon

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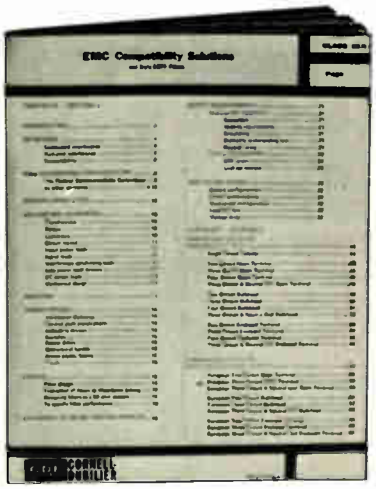

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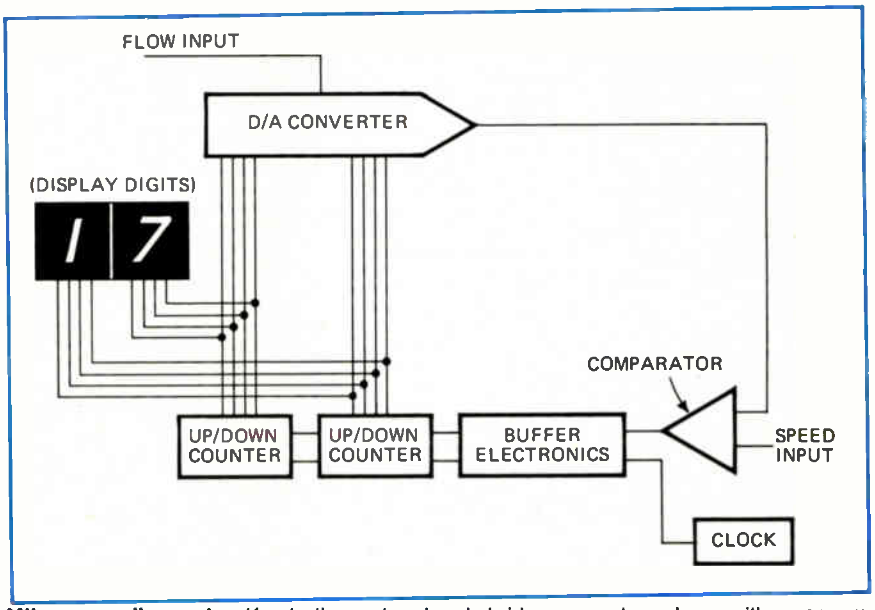


Miles-per-gallon meter. Key to the system is a hybrid pressure transducer with a vacuum reference etched on a silicon chip and a Wheatstone bridge composed of four resistors.

eration. Well, two National Semiconductor engineers, Duane Tandeske and Richard Billette, are showing auto makers and accessory makers a system that tells a driver how many miles per gallon he's getting. One version of the indicator may be installed on next year's cars.

Tandeske and Billette developed a breadboard system which has been inspected by two of the Big Three automakers.

Key to the system is a hybrid-IC pressure transducer, the National LX3700D, which has a vacuum reference etched out of a silicon chip, and a Wheatstone bridge arrangement of four piezoelectric resistors diffused into the same chip [*Electronics*, Dec. 4, 1972, p. 83]. Two National op amps serve as buffer amplifier and output amplifier.

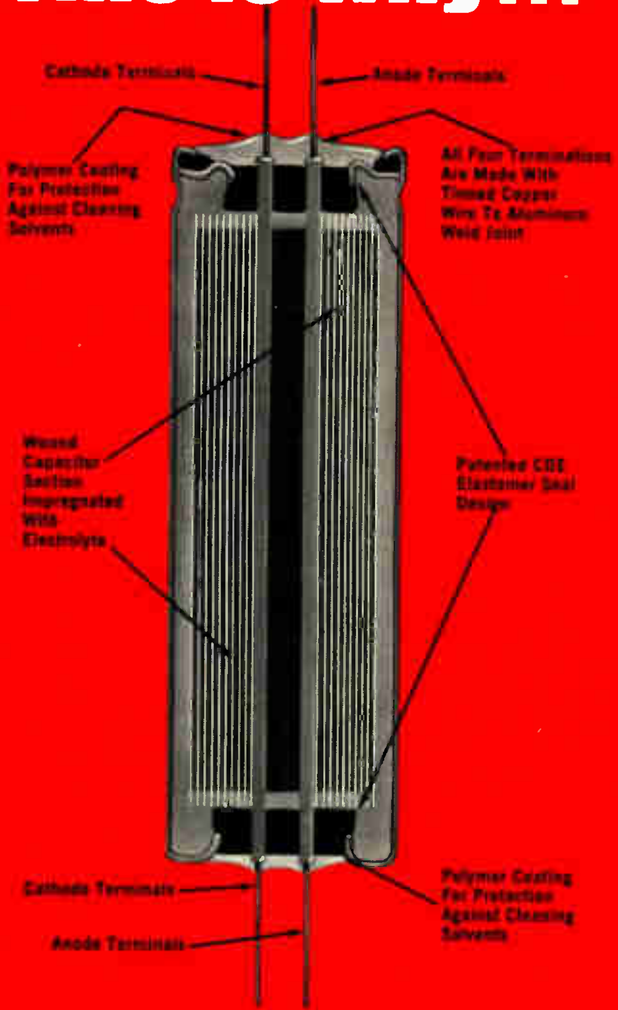
The system operates by sensing the instantaneous rate of fuel consumption and the instantaneous speed of the car and finding their ratio by feeding the sensed data into a tracking ratiomeric analog-to-digital converter. Fuel is sensed by using the LX3700D to measure a pressure drop across the wide and narrow parts of a venturi tube in the gas line between the fuel pump and the carburetor. The voltage increases as the gas flowing through the line increases. Speed is measured by sensing the voltage produced by a tiny generator at the end of the speedometer cable. The tracking ratiometric a-d converter is one that has its internal reference-voltage source replaced by one of these two inputs.

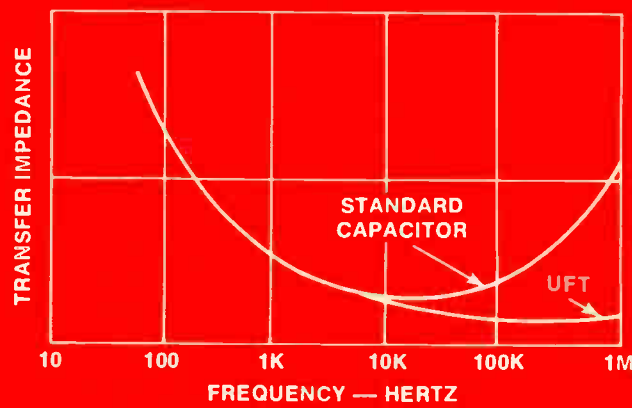
Essentially, the circuit tries to make the flow-rate input match the speed input. If the flow rate goes up while speed remains constant, the counters will count down until their input to the d-a converter equalizes the inputs to the comparator. If the speed goes up while the flow rate is constant, the counters count up.

In practice, both variables will move. The results displayed, according to Billette, are startling. Jamming the foot down on the accelerator causes the miles-per-gallon reading to drop by a factor of four or five—from 19 to four miles per gallon, for example—in seconds.

One representative of the "specialty" market (auto stores) estimates that the average driver will save $100 a year watching a miles-per-gallon indicator. But how much he will have to spend for such a device in the first place is problematical. As an accessory, the system will probably cost around $70. As a hybrid IC sold to the automakers to put in their own packages, with shared display (possibly a digital clock) and speed pickup, usage-rate indicator might add $10 to the cost

This is why... this is Best...





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of making a car. It's not clear how much that would add to the price.

There is nothing to stop anyone else from buying the same parts and packaging them for automakers. That's fine with National because the firm is the only manufacturer of the LX3700D, and without an IC

News briefs

Matsushita-Motorola deal challenged

The prospect of antitrust-law violation in Motorola's proposed sale of its home-TV-receiver business to Matsushita Electric Industrial Co. has been raised by Sen. Birch Bayh. The Indiana Democrat, voicing concern for the eventual loss of U.S. jobs, has asked Attorney General William Saxbe to determine if the acquisition by the world's largest maker of TV receivers [*Electronics*, March 21, p. 41] would violate Federal guidelines on horizontal mergers. Bayh also asked for a similar investigation by Sen. Philip Hart's subcommittee on antitrust and monopoly in the Senate Judiciary Committee.

Meanwhile Matsushita and Motorola have issued a joint statement that the proposed transaction is not anticompetitive, since the combined penetration of the U.S. color-TV market by the two firms totals less than 10%.

Collins' Wilson moves to aid Memorex

With a lure of a salary guarantee in addition to the usual stock options, the Bank Of America has induced Robert C. Wilson, savior of Collins Radio Co., to try some of his magic on the troubled Memorex Corp., which lost $119 million on sales of $177 million in 1973 and whose current president and founder, Laurence L. Spitters, has resigned, effective April 26.

The Bank Of America will accept Memorex preferred stock in place of $40 million of current Memorex debt, reduce the interest rate on the balance to 4% for a 3½-year period, and extend the company a $35 million line of credit—all contingent on Wilson's taking over. He's scheduled to arrive May 15, when Collins will move executive vice president Donald R. Beall to its presidency.

Decibels go digital in multimeter

United Systems Corp., Dayton, Ohio, has introduced what appears to be the first inexpensive general-purpose digital multimeter with a decibel scale. The DMM is for use in the installation and maintenance of data-communications equipment. Called the Digitec 2180, the 3½-digit instrument sells for $395, which is about half the price of comparable DMMs.

MCI charged with monopoly

Giant AT&T and two Illinois Bell companies filed a triple damage, antitrust countersuit against MCI Communications Corp. on April 1, charging the small specialized common carrier with attempting to monopolize the private-line market and the business of other specialized common carriers.

Cassette recorders may explode

Cassette tape recorders manufactured by Norelco, Voice of Music, Sharp, and Wollensak may explode, says Kenneth Komoski, director of the Educational Products Information Exchange Institute. Komoski says the use of long-life alkaline batteries when connected to ac power lines for built-in recharging can result in battery leakage or explosion. The Institute is filing a charge of hazardous practice against these manufactures to the Federal Trade Commission.

Western Electric cuts staff by 3,000

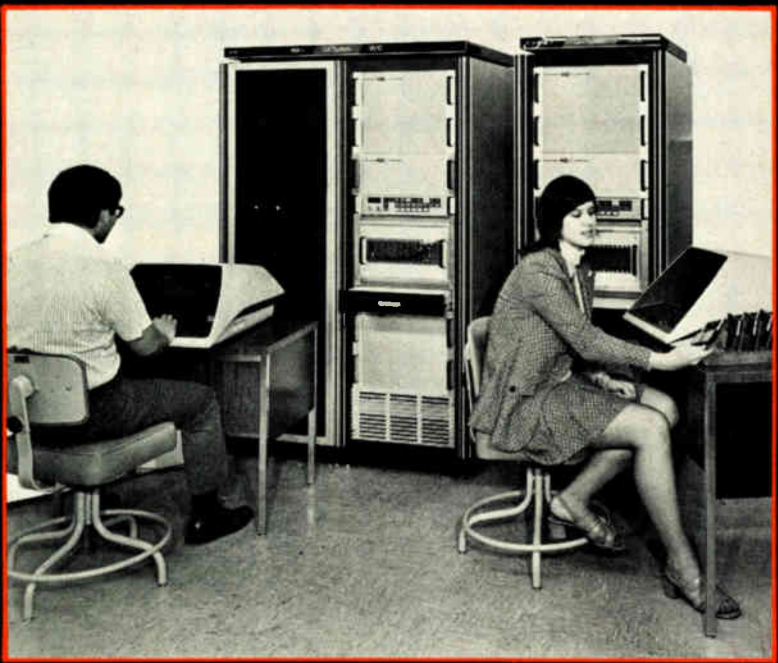
Because of a flattening of parent company AT&T's telephone sales, manufacturing division Western Electric has cut its staff by 3,000 people. The company attributes two thirds of the cut to attrition. Thirty engineers and about 1,000 production workers are involved. A spokesman says the cuts don't portend a drop in AT&T sales.

S-D's ATE system saves you $75,000/year*

But the best reason for buying it is MUSDBASIC.

What's MUSDBASIC? It's the **only** ATE software system in existence that allows you to write and de-bug programs while performing actual testing of PC boards and instruments. We call it Multi-User S-D BASIC. It's an English test language that took two years to perfect.

The beauty of all this is that only **one** 3600 series CATSystem is needed to write programs and test simultaneously. That's because S-D's multi-user BASIC provides two terminals for time-sharing the entire system, including the instruments. Also, up to 6 more terminals can be added with this time-sharing feature.



HE PROGRAMS WHILE SHE TESTS. ONLY WITH CATSystems.

It's no secret that many ATE systems take a year to put into operation because programs can't be written while testing goes on. Who wants to write programs at night or on week-ends?

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*Based on manual vs. CATS testing of 60,000 PC boards (200 types). Manual testing costs $99,800. CATS $25,000. Price of CATSystem used in this study (yours for the asking) $97,500.

SYSTRON DONNER

Circle 41 on reader service card

transducer that is insensitive to vibration and fail-safe, the system is not workable. □

Computers

CDC expands network capabilities

To capitalize on the increasing importance of computer networks as a means of boosting performance and reliability, Control Data Corp. has developed a family of four large-scale computer systems, called the Cyber 170, designed specifically for such applications. The family includes the models 172, 173, 174 and 175, all compatible with the company's older Cyber 70 and 6000 series systems.

Included with the family is a host communications processor, part of a network-communications system, including both hardware and software that provide an interface between communications channels and the associated computers and terminals. This processor performs packet switching and other functions similar to those of the interface message processors in the Department of Defense Advanced Research Projects Agency Network (Arpanet).

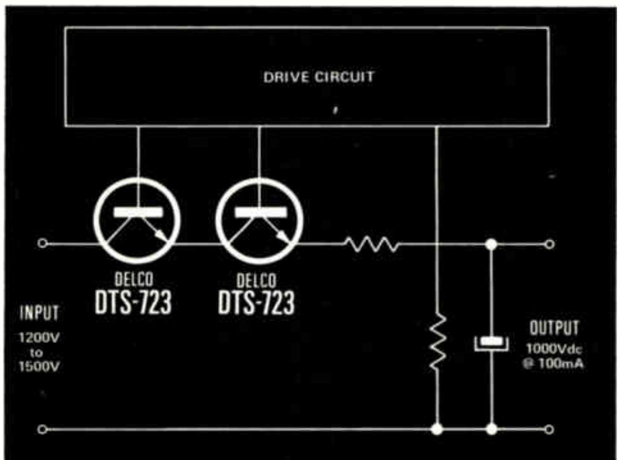
CDC will add this capability to its existing Cybernet computer network, and enable non-CDC computers to tie into the net.

Monolithic. Cyber 170 also displays a number of other characteristics, some of which are more significant as a first for CDC than they are for the industry. For example, the line is the company's first built wholly with off-the-shelf IC's.

All models of the Cyber 170 also have metal-oxide semiconductor memories, assembled from 1,024-bit chips. They have 400 nanoseconds access time and come in modules of 4,096 words, expandable to 262,144 words, each with 60 bits plus 8 redundant bits coded for single-error correction and double-error detection. The new machines will lease for $18,000 to $75,000 a month. □

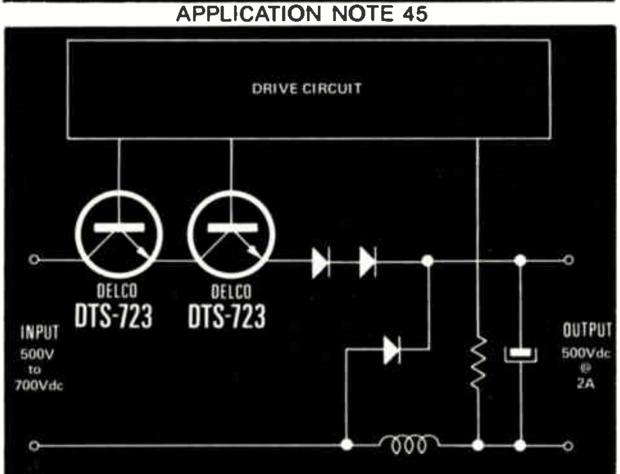
NEW VALUES HIGH ENERGY

TYPE	I_C(max.)	V_{CEO}	V_{CEV}	$V_{CEO\ (sus.)}$	$V_{CE\ (sat.)}$ @ I_C, I_B	Power Dissipation (max.)	h_{FE} min./max. @ I_C, V_{CE}
DTS-701	1.0 A	800V	—	600V	—	50W	20/— @ 150mA, 5V
DTS-708	3.0 A	900V	900V	600V	2.0V max. @ 1.0A, 250mA	50W	—
DTS-709	3.0 A	900V	900V	600V	1.0V max. @ 2.0A, 800mA	50W	—
DTS-710	3.0 A	900V	—	600V	—	50W	10/50 @ 150mA, 5V
DTS-712	3.0 A	900V	1200V	700V	—	50W	2.5/— @ 2.0A, 5V
DTS-714	3.0 A	900V	1400V	700V	—	50W	2.5/— @ 2.0A, 5V
DTS-723	3.0 A	1000V	1200V	750V	0.8V max. @ 1.0A, 250mA	50W	10/— @ 500mA, 5V
DTS-801	2.0 A	800V	—	700V	—	100W	20/— @ 200mA, 5V
DTS-812	5.0 A	900V	1200V	700V	—	100W	2.2/— @ 3.5A, 5V
DTS-814	5.0 A	900V	1400V	700V	—	100W	2.2/— @ 3.5A, 5V



1000 VOLT LINEAR DC REGULATOR

APPLICATION NOTE 45



ONE KILOWATT DC SWITCHING REGULATOR

APPLICATION NOTE 46

Delco Electronics has made it possible for your Delco distributor to offer you better values than ever on these ten silicon high-power transistors. What's more, he has them in stock now and there's a healthy factory inventory to back him up.

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Some are specifically designed for use in high voltage switching circuits where inductive loads or fault conditions pose problems. Some are ideal for linear regulators and power amplifiers.

In fact, all the devices share Delco's reputation for being ideal where circuit conditions and high energy requirements are a concern. And because they're 100 percent pulse energy tested, you know they're rugged.

The circuit diagrams in this ad will give you a quick reading of how these ten transistors can meet your needs.

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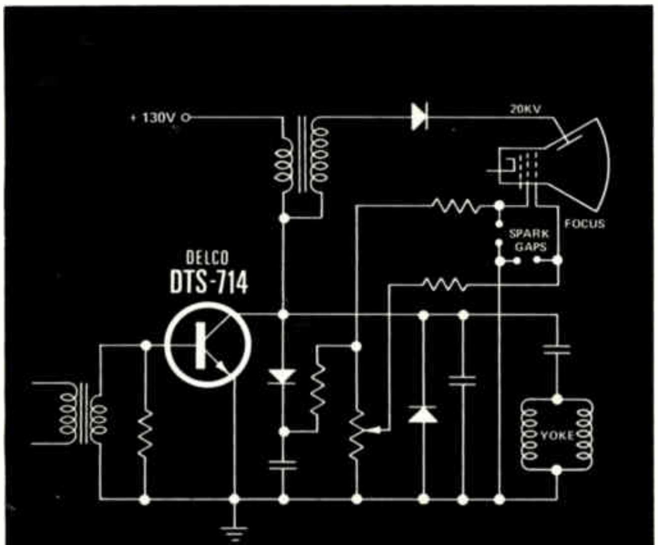
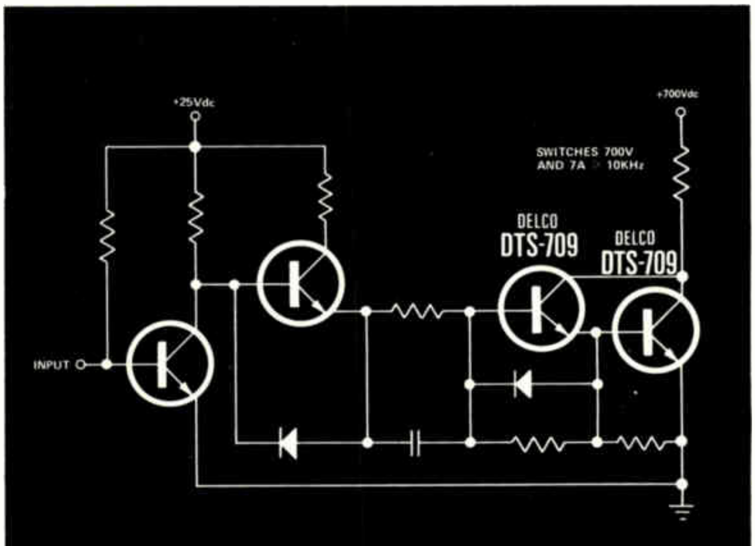


130V MONOCHROME HORIZONTAL CRT DEFLECTION



HIGH SPEED SWITCHING CIRCUIT

APPLICATION NOTE 54

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Trade groups resist threat to IR&D reimbursement

Government electronics and aerospace contractors are set to oppose **another congressional challenge to Federal reimbursement of companies' independent research and development costs** by releasing an in-depth study calling for a uniform Federal policy on IR&D as well as bid and proposal (B&P) costs. The comprehensive study, a joint effort of the Electronics Industries Association, the National Security Industrial Association, and the Aerospace Industries Association of America, is designed **to counter an investigation of IR&D now in progress at the General Accounting Office.**

The GAO study was initiated last year at the request of Sen. William Proxmire (D., Wis.) and Sen. Thomas McIntyre (D., N.H.), chairman of the research and development subcommittee of the Armed Services Committee. **While calling for a Government-wide policy for "reasonable" reimbursement of IR&D and B&P costs, the industry associations will resist establishment of a new agency to administer or oversee the policy** while urging that individual companies retain the right to set the amount and type of effort each undertakes in these two areas.

Army RFPs set for Shorads; $61 million available

Army requests for proposals are expected to be issued no later than early May for **the Short Range Air Defense System (Shorads) using one of three European missiles** licensed for U.S. production—the Crotale (France), the Rapier (U.K.), or the Roland (FRG-France). The fiscal 1975 defense budget calls for $61 million to develop Shorads, **with $35 million earmarked for five systems and 100 test missiles. The remaining $26 million calls for upgrading 1,500 Chaparral missiles.**

NASA struggles to save Earth Observatory program

Contractors selected to perform systems definition studies for **the $100 million Earth Observatory Satellite (EOS) program** have an added mission: helping the National Aeronautics and Space Administration **save the embattled program from budget cutting by the White House Office of Management and Budget.** NASA will use the studies by General Electric, Grumman, and TRW to justify the program as a fiscal 1976 new start. It might be tough, as OMB has already frozen some funds and delayed EOS more than a year.

The $600,000 six-month design studies are due in the fall, just in time for a confrontation with OMB. **But even if NASA wins, it won't be able to select a spacecraft contractor until April 1976.**

Mitre to install minicomputer instruction system

Minicomputers could boost computer-assisted instruction (CAI), according to **Mitre Corp., which is installing prototype systems late this spring in two community colleges,** Northern Virginia Community College in Alexandria and Phoenix College, Phoenix, Ariz. **Developed under a $5.5 million National Science Foundation project,** Mitre's system is called Ticcit, for time-shared, interactive, computer-controlled, information television. Ticcit's pair of Data General Nova 840 minicomputers, backed by disk drives, feed 128 keyboard terminals, equipped with Sony 12-inch Trinitron color TV sets. **Estimated production cost would be $500,000 to $1 million per system. The military might be one market,** since the Navy is acquiring one Ticcit system and could buy more, says a Mitre project officer.

Can Congress reform trade?

"It's a special interest bill," argues the AFL-CIO's George Collins of the Trade Reform Act of 1973. "It does nothing about industry's massive investment abroad, about tax loopholes on overseas profits, about the shifting production beyond our shores or the export of taxpayer-subsidized technology."

But the complaints of Collins, assistant to the president of the International Union of Electrical, Radio, and Machine Workers, on behalf of his own union, as well as two other AFL-CIO affiliates, produced little interest and less sympathy at the Senate Finance Committee's hearings on the trade bill. Already voted by the House, H.R. 10710 seems certain of passage in some form this session, barring an impeachment of the President that could bring Senate action to a halt in this election year.

Collins' testimony on behalf of "more than two million members who have been prime victims of the decline in this nation's international trade position and the lack of a comprehensive foreign trade policy" began with Arizona's conservative Republican Paul Fannin the only member present and concluded with Fannin gone and a committee staffer listening politely from the chairman's seat.

Industry's opposing view

Manufacturers of electronics and aerospace hardware got a lot more mileage out of their presentations, which contrasted sharply with those of labor (see p. 36). Beyond their agreement with labor that the U.S. has long lacked a national foreign trade policy, officials of the electronics and aerospace industries associations offered nothing that agreed with the AFL-CIO perspective.

The differences are of long standing, of course. Fundamentally, they turn on the issue of multinational corporate expansion. Labor is naturally interested in jobs being created and maintained within the U.S. Manufacturers are naturally interested in sales and the profits they create, contending that the markets for electronics must be viewed globally.

Specific issues that derive from this fundamental dispute are much more complex and have economic and legal ramifications of no appeal to the general public. One typical example involves Items 806.30/807 of the U.S. Tariff Schedule, under which products assembled from U.S. components in offshore plants may be re-imported with tariffs payable only on the value added by foreign labor and any non-U.S. components.

As expected, organized labor calls 806/807 "a loophole" that has become a $1 billion annual business for U.S. multinational electronics companies at the expense of American jobs. But manufacturers, to no one's surprise, argue that repeal or suspension of 806/807 would "cause a decline in U.S. production and U.S. employment" and "make worse the U.S. net trade balance and the balance-of-payments deficit," according to V. J. Adduci, president of the Electronic Industries Association.

Is anyone listening?

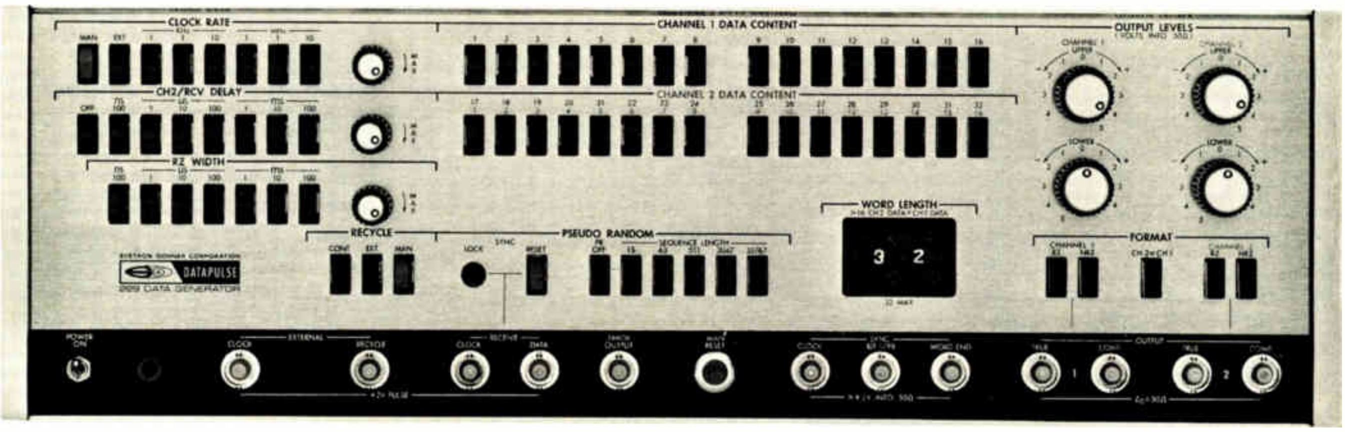
The problems for the Congress in resolving these and other conflicting positions in the current trade legislation in the country's favor seem to be that few—and sometimes none—of the members are listening during the public hearings process. And, as one Senate committee staffer conceded, few members "read the published testimony. Either they don't care, or they don't have the time."

Neither industry nor labor can do much about those senators and congressmen who don't care about legislation affecting their future success or failure. But for those legislators who don't have the time—and they are increasing in number as congressional staffs and budgets have failed to expand proportionately with the executive branch—there is an option available. Simply put, it would consist of making the public hearings process an adversary proceeding, pitting proponents of a given bill against their opposition during the questioning period subsequent to formal testimony.

Such an approach would have obliged EIA president Adduci to rebut the charge of the AFL-CIO's Collins that offshore operations are costing jobs in the American economy. And Collins, similarly, would have been required to respond to EIA's contention that Items 806/807 are "essential if U.S. manufacturers are to compete in U.S. electronics markets."

As the congressional hearings process now operates, members of the Senate and the Congress get more data and less useful information than they need to make an informed judgment. This could prove disastrous for the U.S. electronics industries and their workers as the Congress pushes to develop the nation's first comprehensive foreign trade policy. At a time when foreign managements and labor are working closely with their governments to compete in the world's marketplace, neither U.S. labor nor management is being well served by the present legislative system. **—Ray Connolly**

Some data generators can do only one thing.



But S-D's Model 229 offers all these capabilities:

1. Single/Dual Channels 32/16 bits with variable word length. Variable delay between channels. Data rate to 10 Mbps. Output formats: RZ (with variable width) and NRZ. Adjustable output levels.

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All of this capability comes standard on Systron-Donner's Model 229 for $2,025.00. Remote programming and error display are optional. Applications include testing of tape/disc memory systems and high speed digital communication systems. Get in touch with us and we'll tell you about others especially suited for the 229.

Contact your Scientific Devices office or Systron-Donner at 10 Systron Drive, Concord, CA 94518. For immediate details, call our Quick Reaction line (415) 682-6471 collect.

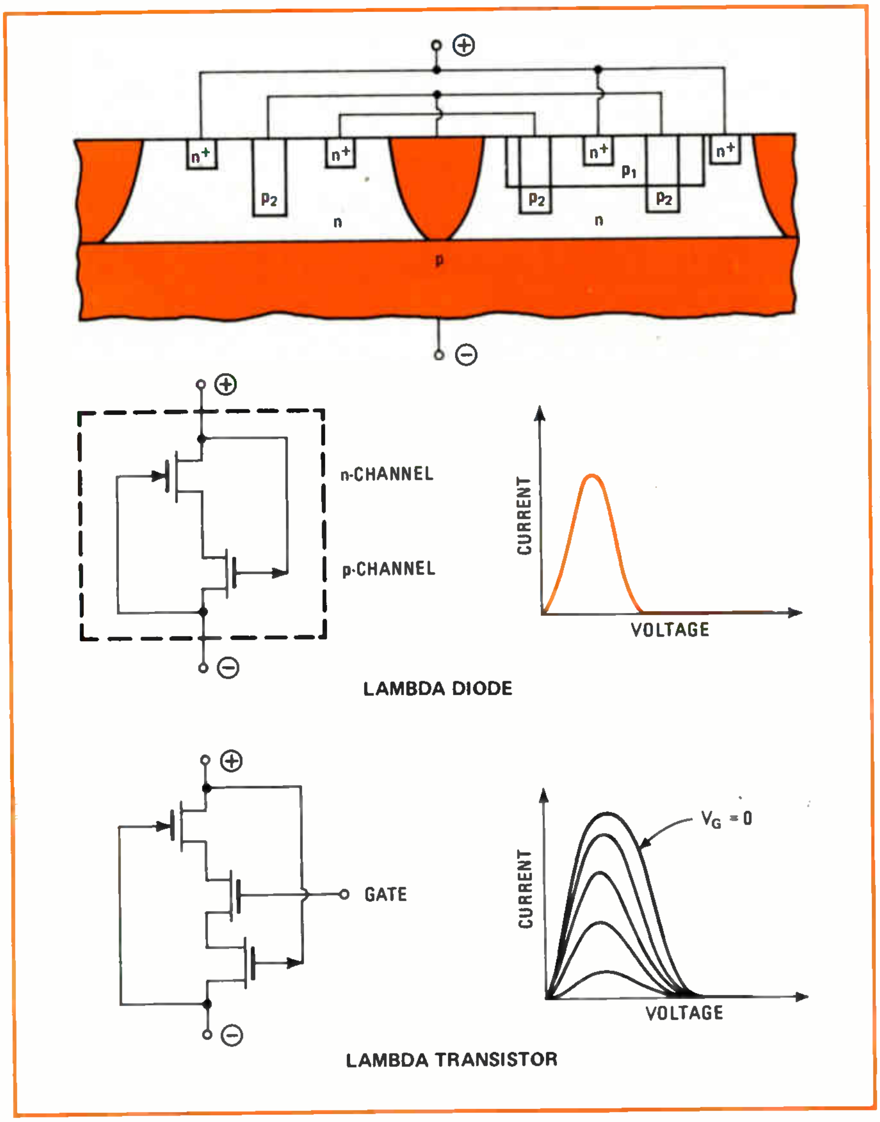
SYSTRON DONNER

Negative resistance shown in dual FET device

A new negative-resistance device, based on the functional integration of two complementary field-effect transistors, has been developed by researchers at Matsushita Electronics Corp.'s research laboratory.

The device, which has voltage-controlled negative resistance, differs from the tunnel diode and other such devices in having a valley current that is essentially zero—in the order of nanoamperes—over a wide range of voltages in excess of the valley threshold voltage. Matsushita thus chracterizes its devices as having lambda characteristics, in contrast to the N-shaped characteristics of the tunnel diode, and proposes to call the new device the lambda diode.

Curves. By integrating two field-effect transistors, workers at Matsushita Electronics have come up with negative-resistance device, which they call a lambda diode. A third FET gives a "lambda transistor" where current peak depends on gate voltage.



Peak-to-valley current ratios are in the order of 10^5 for practical devices, about 10^4 times greater than those for tunnel diodes. Peak voltages run in the range of 0.5 to 5 volts, and valley voltage thresholds in the range of 2.5 to 12 V, making for easy interface with other devices.

A number of the new devices can be integrated on a single chip, and they can also be integrated on the same chip with bipolar devices. What's more, they can be fabricated to have predetermined characteristics—unlike the tunnel diode, which often had to undergo successive etching and testing until the characteristics were trimmed to fit specifications. Fabrication is easier because operation depends on feedback in a circuit equivalent to two FETs and not on exotic physics.

The device is fabricated in two epitaxial n-type isolation regions in p-type material. The n-channel depletion-type J-FET is fabricated with two diffusions, the p_2 diffusion for the gate and the n^+ diffusion for the source and drain. The same p_2 diffusion forms the source and drain of the p-channel depletion type J-FET, while the n^+ diffusion forms the gate and also the "substrate" connection. In between these two diffusions there is a p_1 diffusion to form the p channel. With this structure, the source and drain extend completely through the p-well and into the p-type material, but this has negligible effect on the transistor characteristics.

The sources of the two transistors are connected together, and the gates of each are connected to the drain of the other transistor. Because channels of these depletion transistors are normally conducting, current increases as voltage across the composite device is increased from zero. But the voltage drop across the individual transistors biases the gate of the other transistor in a manner that tends to reduce the current flowing through the transistor.

Therefore, device current goes through a peak, typically a fraction of a milliampere to 1 milliampere. Current through the device then decreases until it reaches the valley-current threshold, where both transistors are pinched off, and leakage current through the device is in the nanoampere order. Terminal current remains at this low value for further increases in terminal voltage until zener breakdown occurs at one of the gates.

Applications for which the lambda diode can be used include discrete and integrated memories, switches, oscillators, and amplifiers. Initial applications will be for consumer products produced by Matsushita Electric Industrial Co. Matsushita Electronics, a joint venture of Matsushita Electric and Philips Gloeilampenfabrieken, is a subsidiary of Matsushita Electric. □

Around the world

BPO is still at work on analog systems

Eventually, all telephone traffic and a good portion of television video traffic is likely to travel in digital form, but that doesn't mean no new analog transmission systems will be developed and installed. For one thing, there always will be circumstances in which economics favor analog transmission— short, lightly used links, for instance. For another thing, digitization won't be widespread tomorrow, allowing ample time to get the investment back on new and improved analog systems. For both these reasons, the British Post Office is investing in new analog systems.

One development is for high-capacity telephone-trunk transmission using an 18-tube coaxial cable and frequency-division multiplexing in each tube over the 4–60-megahertz band. This gives a capacity of 10,800 telephone circuits per pair of tubes, or 86,400 circuits in the 16 tubes that will be in operation. The other pairs of tubes are for standby; they're switched into operation within milliseconds in the event of trouble. The first 100 miles of cable will be installed this year between Birmingham and Manchester.

The BPO is considering using the same types of coaxial pairs and line repeaters to carry television signals. In that case, four TV channels, each with a 5.5-MHz bandwidth will be double-sidebanded onto carriers at approximately 12.6, 26.2, 39.7, and 53.2 MHz. Long-distance TV transmission is already well taken care of by microwave links.

Great Britain

After quad sound, it's ambisonics

With quadraphonic sound still reverberating in the consumer marketplace along comes ambisonics. According to the British academics who have invented it, ambisonic sound is fundamentally different from quadraphonic.

Quadraphonic sound is essentially the pure sound of, say, an orchestra divided up into four portions according to rules, which may be pretty arbitrary, and pumped at the listener from the four corners of a room. Ambisonics, on the other hand, is the sound made by the orchestra as heard at one point in the concert hall, determined by where the microphone complex is placed, and including all the reverberations and other effects that are heard at that point.

Crosstalk. The ambisonic developers say that the defect of stereo and quadraphonic reproduction is that too often the listener is aware that the total sound is emanating from two or four discrete points in the room. They say that this drawback has been largely eliminated, in normal circumstances, by dividing up the total sound for transmission to four or more separate speakers rather differently than has so far been done in quadraphonics. How it's divided up the inventors won't say, except, that it has been done after a lot of study on how acoustics can be used to achieve different psychological effects. In other words, the crosstalk between the speakers creates the right illusion.

Point source. Peter Felgett, professor at Reading University, who worked out the encoding and decoding technique, says the ambisonic approach started in the 1930s with a British patent for using a directional microphone for stereo sound reproduction. The microphone complex that Felgett is using at present has four separate cardioid mikes. They are only fractions of an inch apart, with their faces aligned to form an upside-down equilateral tetrahedron— an inverted three-sided pyramid and its base.

Felgett says that microphone arrangement provides all necessary information to identify the direction of incoming sounds, including reverberations, and the height of the mike in relation to the sounds. For the normal speaker layout, where they are all on the floor, the height data is redundant, but it could be used in expensive layouts that have some speakers on the wall.

The psycho-acoustics work was done by Michael Gerzon, a mathematician at Oxford University. An important part of it is mapping the total ambient sound so that a listener sitting in the middle of the speaker complex hears everything coming from the right direction. Because there's a limit on the number of speakers that people will use, the map has to be modified, using the directional information to create an illusion of directionality for points between the speakers. Though the height data isn't used with four ground-level speakers, Felgett says that some illusion of height can be obtained.

Felgett and the company he's working with, IMF Ltd. of High Wycombe, have built their experimental systems for two information channels and four speakers because that's the established configuration and will interest most people. However, three channels and four speakers will enhance psycho-acoustic accuracy higher up the frequency range. If four channels are available six speakers can be used, three high and three low, and the recorded height information can be used. □

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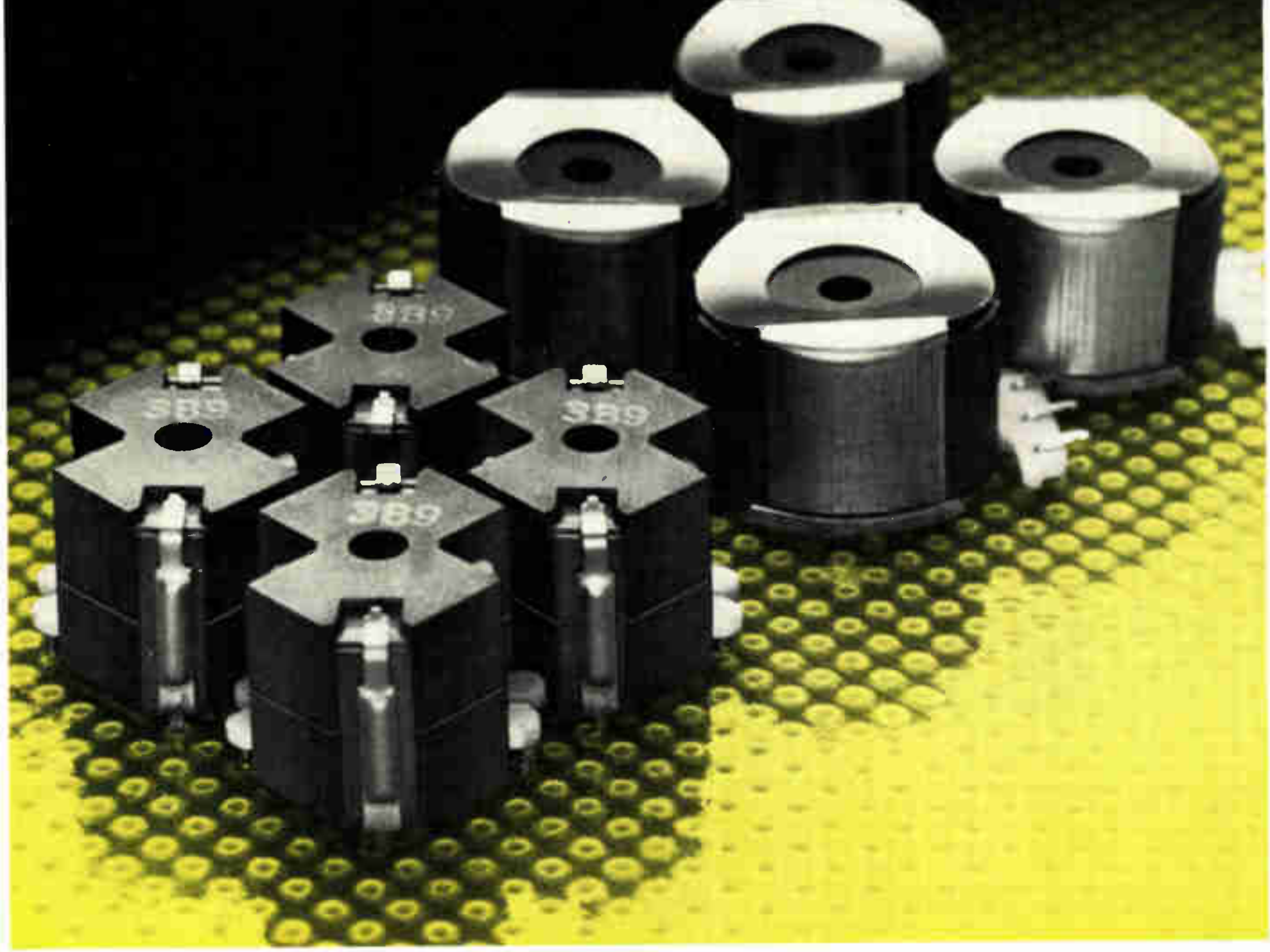
save up to 30% in inventory



Ferroxcube's new RM Series square cores save up to 40% in pc board space over round pot cores. Furthermore, RM Series saves up to 40% in assembly and mounting time. Two simple, gold-plated clips hold them together and readily snap them into place on the pc board.

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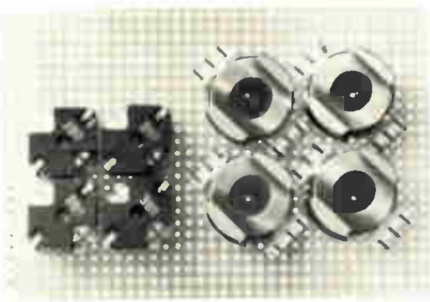

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Siemens, Philips plan cooperation in IC development

Philips Gloeilampenfabrieken of the Netherlands and West Germany's Siemens AG have agreed to expand their cooperation in semiconductors. The two firms had worked together in developing discrete semiconductor devices under an agreement existing since 1959. **Now the deal has been extended to cover integrated circuits as well.** Both firms will exchange IC licenses and patents and will make available their knowhow in IC development and fabrication. However, establishment of joint IC production and sales facilities have not been negotiated.

The deal puts together two firms with considerable expertise in their respective IC specialties. While Eindhoven-based Philips is unquestionably Europe's leader in integrated circuits for consumer applications, Siemens, of Munich, has a strong hand in ICs for industrial uses because of its involvement in professional electronics and computers.

With new color tube, GTE-Sylvania aims to increase market share

GTE-Sylvania figures it will wind up with a respectable market share among independent setmakers when its "new generation" color-TV receivers start reaching the market starting in late summer next year. The company figures it can win customers because **its new in-line color tube can be fitted to current chassis designs with practically no changes in circuitry.**

Sylvania unveiled the tube for Europeans at the Paris Components Show earlier this month and **expects to get it into pilot production at its Belgian plant by early next year.** Like Philips Gloeilampenfabrieken, Sylvania has opted for a 110° design with a large neck, in-line gun, large striped screen, and slotted shadow mask. Philips bills its tube as self-converging: the saddle-yoke deflection system takes care of convergence except for some small dispersions corrected dynamically. Sylvania uses a low-gradient magnetic deflection yoke—either saddle or toroidal—and pairs it with a quadripole winding to handle dynamic convergence. Combined with the in-line gun arrangement, Sylvania claims, the design simplifies convergence setups so that a maximum of six to eight adjustments will do. **There are also savings in copper for neck hardware and no power penalty in the deflection circuits.**

Mullard material may cut surface-wave acoustic filter costs

Mullard Ltd. hopes to get the price of acoustic surface-wave intermediate-frequency filters for TV sets down by making the substrate out of bismuth silicon oxide instead of lithium niobate, which is the usual ASW substrate material. The complicated specification of TV i-f filters makes them a natural for surface waves because it means a bulky electronic module can be replaced by a single, simple, plug-in microdevice. But so far, no component maker has got the ASW filter price down to the $2 or so that the electronic filter costs.

The wave-propagation velocity on bismuth silicon oxide is half that on lithium niobate, and the slower speed means substrate area can be halved. Mullard engineers think that area saving should be sufficient to bring down the cost to electronic filter levels, even though the bismuth silicon oxide crystals have to be grown specially because there's no other market. The company plans to make a large evaluation batch at its Southampton plant to check out the economics, but there'll be no decision for a year to two.

Japan's electronics production should climb 11.6% this year

Japan's electronics output will grow 11.6% in 1974, according to a forecast by the Electronic Industries Association of Japan. Production value during the year is estimated at $15.7 billion. Consumer electronics production is expected to rise 6.2%, totaling $6.5 billion, while industrial electronics equipment output is figured to rise 19.8%, hitting $4 billion. **Electron tubes, semiconductors, and integrated circuits should gain 11.7% over 1973, with value estimated at $2.3 billion.**

TV-set output is expected to decline 11.5% although only dropping 1.7% in value during 1974, with production hitting 12,760,000 sets. Computer output, on the other hand, is expected to gain 24.9% in 1974, with 590,000 units to be produced. Electronic measuring equipment will be up an estimated 22.4%, with 194,800 units to be manufactured.

Asian imports are increasing headache to France

The French government is finding it hard to stem the flow of consumer electronics into France from Southeast Asia in general and from Japan in particular. Franco-Japanese trade in products like radios, television sets, and tape recorders is **producing a deficit twice as large as that predicted by government planners four years ago.** In addition, European economic community rules prohibit new protectionist measures.

From now on, that deficit is likely to grow larger. An agreement covering the most sensitive products ran out at the end of March and even though import quotas will stay for radio and TV sets, the French will have to depend on Japanese goodwill for other products. If pocket calculators are any measure of that goodwill, the French can not hope for much. Imports of those products jumped 50% last year to reach $26 million—about the same as last year's imports of all Japanese radios, TV sets, and tape recorders put together.

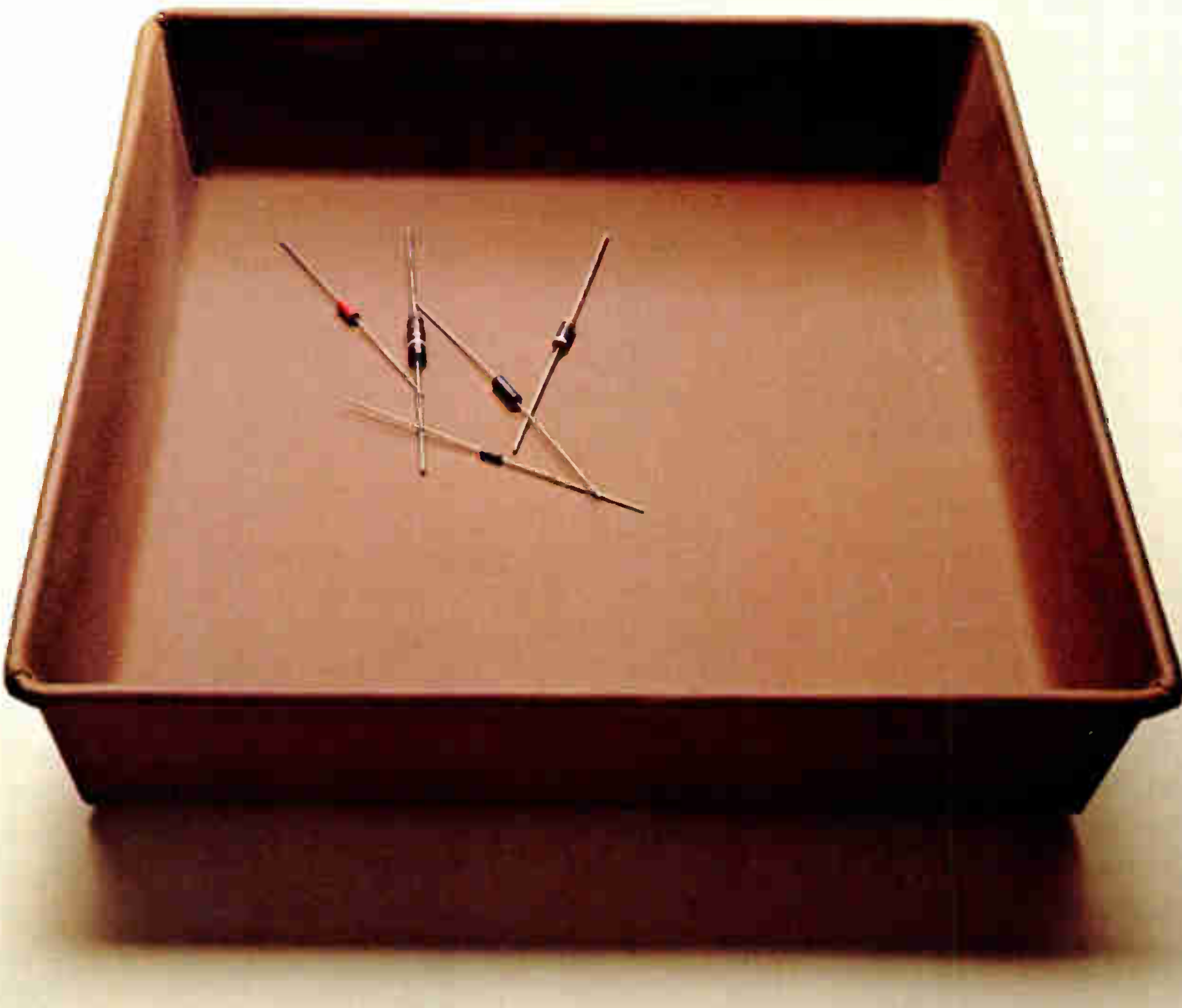
Demand in West Germany for components shows no let-up

Market researchers at Valvo GmbH, a Philips subsidiary and West Germany's largest electronic components supplier, see the country's components demand continuing strong for the rest of this decade. Gert Lorenz, a managing director at Valvo, expects **demand to rise from last year's $1.5 billion level to more than $2.6 billion in 1980.** Scoring the biggest gains, Lorenz says, will be semi-conductors, with a share of the total components volume growing from 26% now to 34% within the next six years. The Valvo director puts the one for Western European components market at $4.3 billion. That, he says, compares with $5.4 billion for the U.S. Of note is the different structure of the American and West European markets, Lorenz points out. While the volume for tubes, including picture tubes, is roughly the same on both continents—$1.2 billion—semiconductors account for twice as much volume in the U.S. as in Western Europe—$2 billion versus $1 billion.

Matsushita is Japan's top money maker

Matsushita Electric Industrial Co. leads the list of top corporate income earners in Japan for 1973, according to government tax authorities, with approximately $394 million on sales of about $4.15 billion. **Matsushita edged out Toyota Motor Co. to regain the top spot after four years.** Consolidated sales by Matsushita in 1973 were up 20% with gains of 38% in home appliances, sales, and 37% each in industrial equipment and in lighting equipment, tubes, and semiconductors.

Why is Corning running an 8-page ad on its components, now, during the worst component shortage since 1942?



Here's why:

To our customers — We know your production and design plans depend on a clear and accurate picture of component availability. And since Corning's components represent such a large percentage of total supply, we'd like to show you where we stand today… and tell you what you can expect from us in the future.

To our prospects — We believe we're the first component supplier to emerge from a backlog situation. We'd like to update you on our new capacity, expanded lines, and developments.

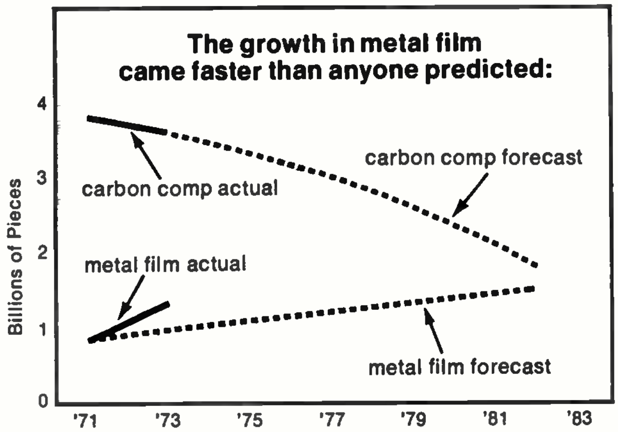
That's why we're running this 8-page report.

The metal film resistor shortage and what we're doing to end it-

Demand for our metal film resistors soared during the past 18 months. There were two reasons…

First, designers continued their move away from carbon comps and wirewounds to metal films as they recognized the superior price/performance value that metal film resistors offer. The effect of lower metal film prices combined with the tighter tolerance needs of upgraded circuits suddenly created demands far beyond the industry's most optimistic forecasts.

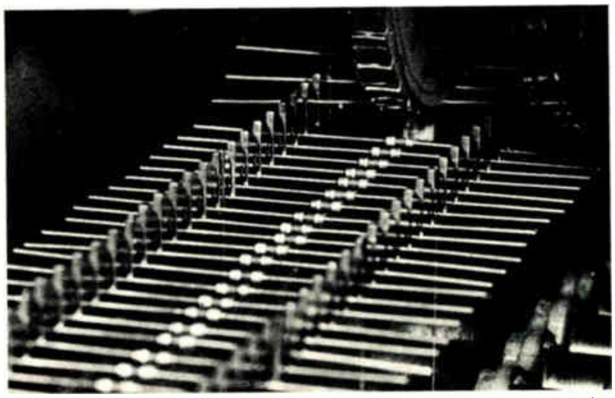
And second, we were deluged with larger metal film resistor orders because other suppliers couldn't deliver as fast as we could. Demand was heaviest for the ¼ and ½-watt styles.



Industry demand vs. Corning production.

At its worst, order lead times ranged from 24 to 60 weeks and longer — compared to 6-week deliveries that were normal for us the year before.

But fortunately we had already begun a major metal film resistor expansion program. As such, we were able to meet an exceptionally high percentage of all promised shipments, and then gradually reduce lead times to a current



Our engineering staff developed many new techniques in all phases of resistor production.

average of 12 weeks — with 6-week delivery on several styles.

Our expansion program came in three phases, which let us move faster than the "brick and mortar" route to expansion.

Immediately, we moved to a full 3-shift-per-day 7-day-per-week production schedule. Our production and quality control staff was expanded quickly by transferring many experienced people back to our plants. And many more were hired and trained.

Secondly, we designed, tested and installed new high speed automated equipment and improved techniques in practically every stage of manufacturing. More than 18 state-of-the-art devices were developed by our engineering staff in this program.

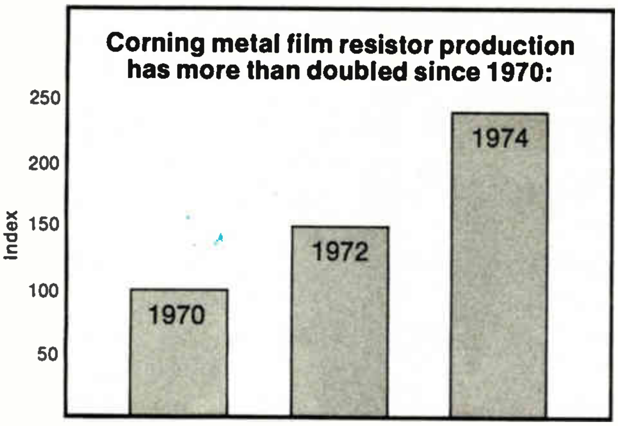
Thirdly, we significantly expanded our basic resistor manufacturing operations at both Wilmington, N.C. and Bradford, Pa. This included a doubling of our resistor substrate capacity to keep us free from shortages in basic raw materials.

Just these last two stages required a multi-million dollar investment in capital equipment and facilities—all geared to increase output.

Throughout, our chief concern was keeping absolute control on product quality. More resistors — but bad resistors — is no progress at all! So we moved quickly — but at a pace and on a plan that would not risk quality problems that could cancel out production gains.

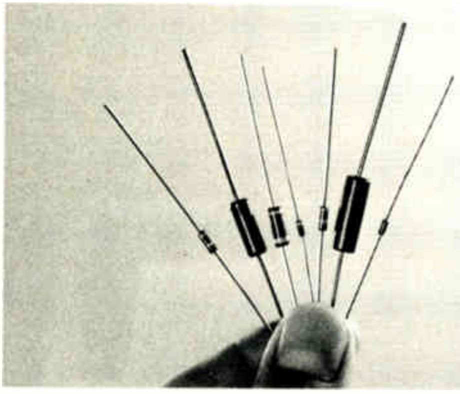
Corning is a major supplier of metal film resistors.

As a result of this expansion, we're now shipping more than twice as many metal film resistors as we did in 1970. We supply more metal film resistors than anyone else in the U.S. today.



New additions you can expect to see this year.

Our current resistor line includes precision, semi-precision and general purpose parts—in a wide range of sizes and styles including ER and our flame-proof resistor line.



We are adding substantially increased capacity for precision parts with temperature coefficients of 50ppm/°C. And 25ppm/°C. parts are in the final stages of development. This will extend the range of our metal film performance capabilities significantly. As soon as samples of our 25 ppm resistors are available for evaluation, we'll let you know.

What to expect in the next 3 to 5 years.

We believe the metal film resistor supply situation will greatly improve in the second half of this year. But we also expect metal films to continue to be the fastest growing segment of the discrete resistor market.

As the lower power requirements of new designs make wirewounds less popular, and the needs for greater precision (particularly in automotive and instrumentation applications) make carbon comps less suitable—we expect to see an annual demand growth of at least 10 to 12 percent. And we've geared our production to meet this demand.

Keeping tabs on our progress.

Throughout the shortage, we've regularly surveyed our customers to measure how we're doing versus other suppliers.

The result of the latest reading is shown below...

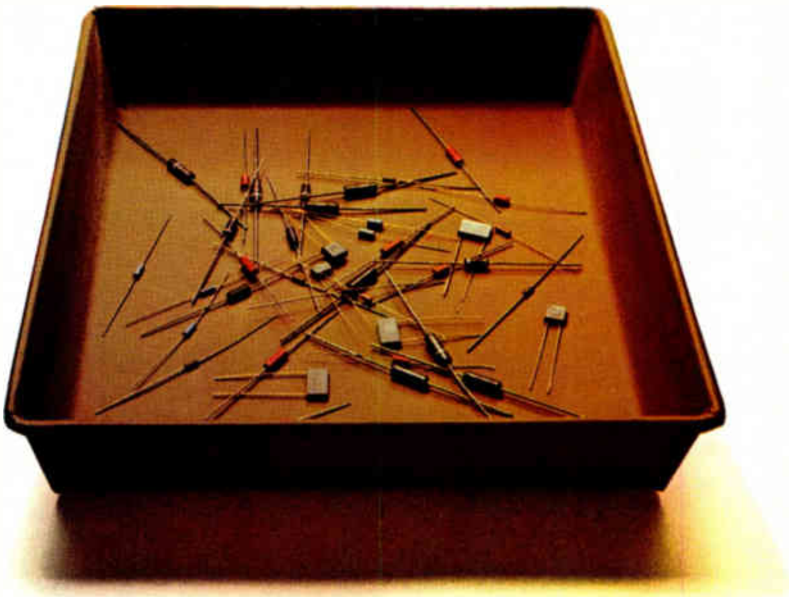
How users rate Corning's metal film resistors

	Corning	Firm A	Firm B	Firm C
Buyers' ranking of				
—best quality	#1	#3*	#3*	#2
—best value for cost	#1	#4	#3	#2
—best distributor availability	#1	#4	#3	#2
Engineers' ranking of				
—best quality	#1	#4	#2	#3
—best value for cost	#1	#4	#2	#3

*tie

We're pleased—but not totally.
Obviously, we're still having to say "no" too often to new orders from new customers.

We hope we can change that soon. We're working at it. And we'll keep you posted as our metal film resistor supply backlogs further ease.



The Capacitor Shortage:

And what we're doing to end that too-

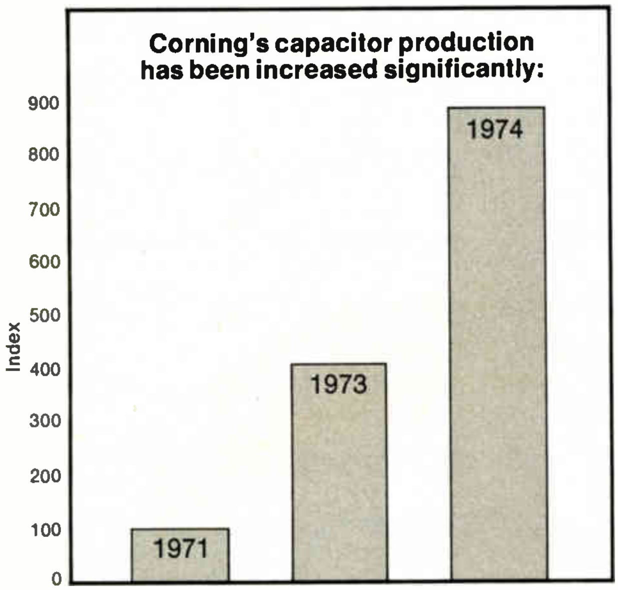
Corning has begun a major expansion into the ceramic capacitor market. And we're gearing our initial operations to very large volume production of a relatively tight line of low cost parts.

For the past three years we've been supplying a major portion of the computer industry's axial monolithic ceramic capacitor needs. And have initially concentrated on miniature size, epoxy-cased ceramic capacitors for automatic insertion applications.

Now, with a number of new product developments nearing completion, we are planning the introduction of a high volume low cost commercial axial ceramic line and an expansion into commercial radials in a major way.

Corning's expansion into ceramic capacitors.

During the past year, we've more than doubled our capacitor production. And because capacitor production is far more labor-intensive than resistor production, this has required a significantly enlarged technical and manufacturing staff, plus facilities expansion at our Raleigh, N.C. plant.

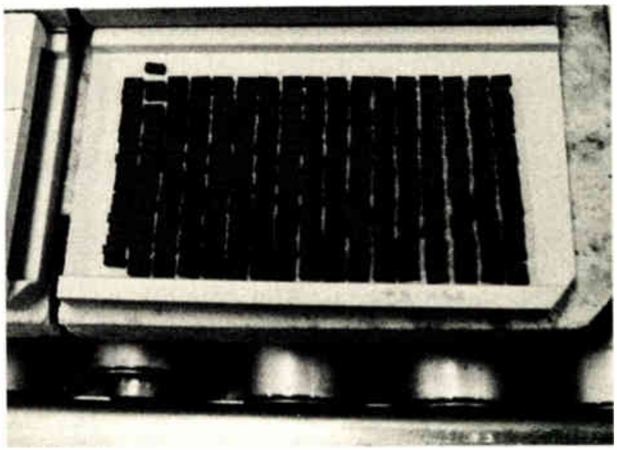


But 1973 increases will be eclipsed by the size of our expansion schedule this year and beyond.

1975 production will triple 1973 levels. 1978 production will have tripled again. And 1980 production will be 70 percent over 1978 levels.

But our expansion program is just beginning.

And the impact on longer term ceramic capacitor supply will go far in precluding another ceramic capacitor shortage.



Ceramic chip inventories are being built at this very minute.

Glass and Glass-K™ Capacitors.

Our glass-dielectric capacitors have been in strong demand for applications where high stability over a wide temperature range is required. In the fall of '73, delivery lead times rose to 30 weeks, but 8- to 10-week schedules are now more typical and distributor stocks are being rapidly replenished. Soon availability will be back to normal.

The same holds true for our Glass-K glass-ceramic capacitors—which combine the volumetric efficiency of a monolithic ceramic with the stability of a glass-dielectric.

New developments nearing completion.

Our new "spin-seal" conformal-coated axial could be the industry's long-term answer to a truly low cost automatically insertable ceramic capacitor.

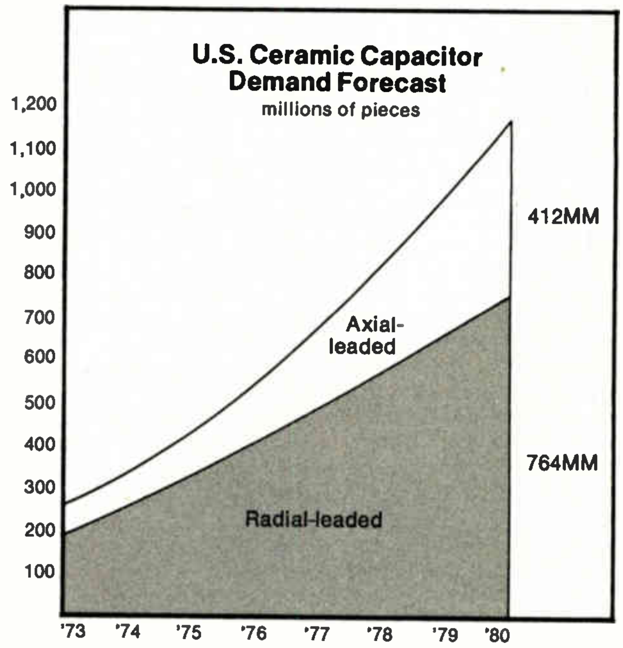
Using techniques we originally developed for—and currently use in producing—our resistor line, this epoxy-jacketed series has the uniformity and handling characteristics necessary for automatic insertion. But at lower cost in larger volume production. The "spin-seal" technology permits us to manufacture axials at much higher speeds than are possible with molded case styles. Throughout, coating thickness is automatically gauged and controlled to keep uniformity and performance exact.

As soon as evaluation samples are available in quantity, we'll announce their availability.

Industry demand forecasts:

Currently, molded axials represent 25 percent of the leaded ceramic capacitor market. Through 1980 they'll continue to move in on radials based on current trends to automatic insertion. As such, axials will remain a prime area of concentration for us.

When our "spin-seal" axials are ready, we expect to be able to supply axials at prices that



encourage a switch away from radials. This should push axial growth even faster.

But we'll also be ready with our radial line, to provide whichever types of ceramic capacitors your production requires.

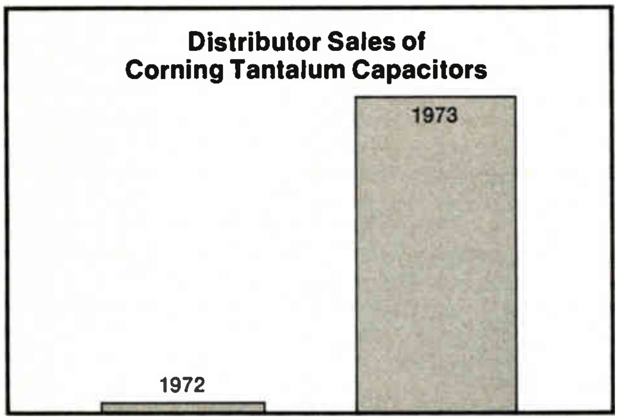
In short, Corning plans to become a major factor in all types of ceramic capacitors in the years ahead.

The Tantalum Capacitor Shortage:

And what's available now-

During 1973, we concentrated on keeping our distributors supplied as fully as possible with tantalum capacitors from our Components Incorporated subsidiary.

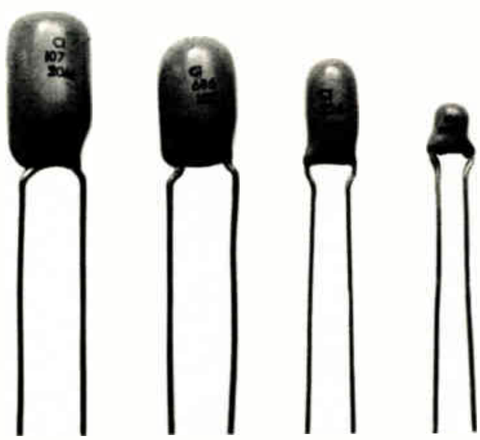
By year end, this meant that a major percentage of the tantalum capacitors being sold through distribution were ours.



Recently, we introduced two more tantalum lines into distribution and availability on both should be excellent soon in most areas of the country.

1. Our TK line:

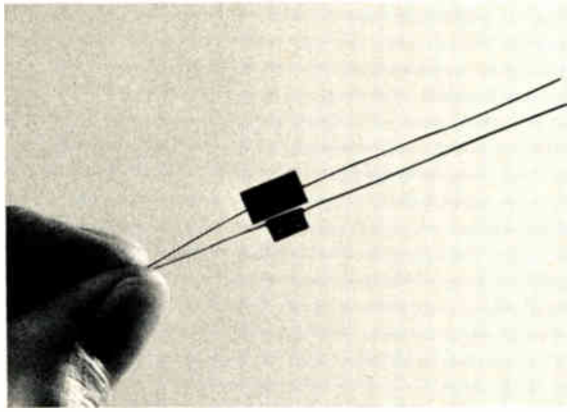
These low cost, radial leaded, epoxy dipped solid tantalum capacitors have capacitance values in the 0.1 to 330MFD range—with working voltages of 6 to 50VDC and tolerances of ±10% and ±20%. Their low-profile configurations



and availability with a choice of lead bends make them well suited for convenient insertion and assembly.

Incidentally, our companion line of DIPATAN® TD series epoxy-coated radials are now in fairly good availability in most areas, too.

2. Our MINITAN™ line:



These microminiature solid tantalum capacitors are epoxy-sealed in a polyester sleeve. They're available in both cylindrical cordwood and rectangular modular form, with a choice of axial or radial leads. Capacitance values are 0.001 to 220MFD, working voltages are 2 to 50VDC, and tolerances are ±10% and ±20%. They're in excellent supply. We can meet your needs now.

Supply problems exist elsewhere.

Industry wide, supply problems are still enormous for axial-leaded, metal-can-enclosed solid tantalum capacitors. These parts have soared in demand because of their wide use in high volume machine-insertion applications.

Corning, like other suppliers, has been unable to gear up quickly to new demand levels for these metal-cased parts, because their fabrication is labor intensive and the very skilled workmanship required cannot be expanded rapidly without risk of quality.

We are in the process of training additional personnel and have supplemented existing facilities, but frankly it will take months to catch up with current demand levels for both our MILITAN® hermetically sealed ER line and our ECONOTAN® epoxy-sealed consumer and industrial line.

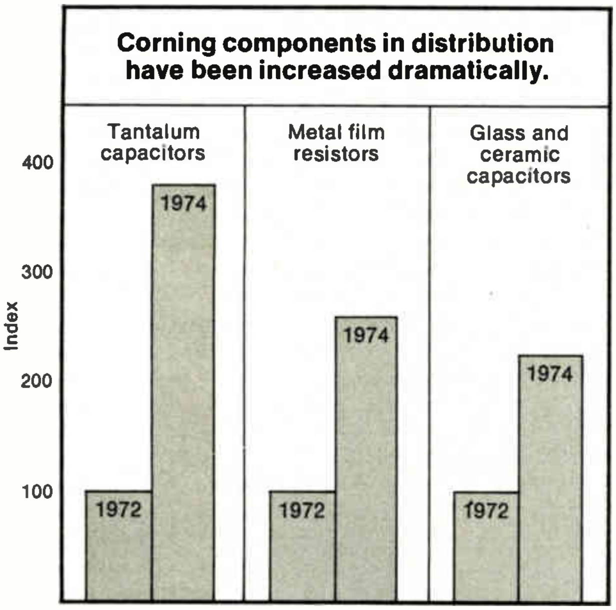
In the meantime...

In the meantime, we suggest you take a closer look at our MINITAN and TK series as good alternatives to your immediate needs.

Our distributors have assumed a pivotal role:

Corning component availability -

In spite of shortages, we've made significant gains in distributor availability across all three Corning component lines. Progress here can be seen in the chart below.



We believe that a strong, well supplied authorized distributor network is the only way a component supplier can responsively meet the large and growing needs of the thousands of firms across the electronics marketplace.

That's why our distributors are now our largest "customer," and why they'll be assuming an even more pivotal role in Corning's future marketing and supply plans.

An expanded distributor supply center.

To make this work, we've added a major new distributor supply center at a location separate from our plants. This supply center literally buys Corning components from all locations in anticipation of future distributor needs. In the fullest sense, it's become a "Distributor's distributor." And it operates under a strict policy that prevents our OEM sales group from tapping into distribution supplies.

Frankly, it will take a few months before our new distributor supply center builds inventory to levels where we can once again meet our goals of shipping distributor orders directly from off-the-shelf stocks.

But each week we're making progress. For example, our lead time on RN55D metal film resistors has dropped from 22 to 11 weeks. CK12, 13, 14 BX ceramic capacitors are now available for off-the-shelf delivery from your local distributor.

Strong emphasis on distribution means more firms will be introduced to Corning components than ever before. Engineers and buyers who've never used our resistors and capacitors will be buying them in future months.

We'll keep you posted.

By being first to ease component supply, Corning hopes to make new friends and win new long-term users. This in turn will let us keep expanding in increments large enough to achieve low cost pricing for our parts.

We'll keep you posted.

What Corning makes:

Metal film resistors—precision, semi-precision and general purpose—including ER and flame-proof types. Precision resistors with TC's down to 50ppm/°C.—with 25ppm/°C. parts coming on later in the year.
Ceramic capacitors—miniature, precision multi-layer axials with molded epoxy cases have been our main area of emphasis. Lower cost commercial axials and commercial radials will be our major area of expansion in future months.
Solid tantalum capacitors—axials in metal cans (in both hermetically sealed and epoxy-sealed types). Low cost, low profile epoxy-dipped radials in a range of types and sizes. Microminiature axials and radials—epoxy-sealed in both cylindrical and rectangular cases.
Glass capacitors—a complete line of precision, fused monolithic glass-dielectric capacitors. Introduced 30 years ago and still the ultimate in stability.
Glass-K™ capacitors—miniature, multilayer, molded-case axials that combine the volumetric efficiency of ceramics with the stability that only a glass dielectric can provide.

Our Distributor Network:

ALABAMA: Huntsville; Cramer/EW (205)539-5722. **ARIZONA: Phoenix;** Liberty Electronics (602)257-1272. **CALIFORNIA: Culver City;** Avnet* (714)522-8220/(213)836-7200. **Gardena;** Bell Industries Electronics Corp. (213)321-5802. **Los Angeles;** Liberty Electronics (213)322-8100. **Mountainview;** Elmar Electronics (415)961-3611. **San Diego;** Liberty Electronics (714)565-9171. **Sunnyvale;** Acacia Sales* (408)735-0100. **COLORADO: Commerce City;** Elmar Electronics (303)287-9611. **Denver;** Cramer Electronics (303)758-2100. **CONNECTICUT: North Haven;** Cramer Electronics (203)239-5641. **FLORIDA: Hollywood;** Cramer/EW (305)923-8181. Hamilton/Avnet Electronics (305)925-5401. **Orlando;** Cramer/EW (305)894-1511. **ILLINOIS: Chicago;** Bell Industries (312)282-5400. Schweber Electronics (312)593-2740. **INDIANA: Indianapolis;** Graham Electronics Supply (317)634-8202. **MARYLAND: Baltimore;** Radio Electronics Service Company (301)823-0070. **MASSACHUSETTS: Watertown;** Sterling Electronics (617)926-9720. **Newton Centre;** Cramer Electronics (617)969-7700. **MINNESOTA: St. Paul;** Ragon Electronics (612)488-0201. **NEW JERSEY: Cherry Hill;** Cramer Electronics (609)424-5993. **NEW MEXICO: Albuquerque;** Cramer Electronics (505)265-5767. **NEW YORK: Freeport;** Milgray Electronics (516)546-6000. **Hauppauge;** Cramer/Long Island (516)231-5600. **Rochester;** Cramer/Rochester (716)275-0300. **Syracuse;** Cramer/Eastern (315)437-6671. **Westbury;** Schweber Electronics (516)334-7474. **Woodbury;** Harvey Electronics (516)921-8700. **NORTH CAROLINA: Winston-Salem;** Cramer/EW (919)725-8711. **OHIO: Cincinnati;** Sheridan Associates (513)761-5432. **Cleveland;** Schweber Electronics (216)464-2970. **Columbus;** Hughes-Peters (614)294-5351. **PENNSYLVANIA: Philadelphia;** Almo Electronics (215)676-6000. **TEXAS: Dallas;** Solid State Electronics (214)352-2601. **Houston;** Hamilton/Avnet Electronics (713)526-4661. **UTAH: Salt Lake City;** Cramer Electronics (801)487-4131. **WASHINGTON, D.C.:** Cramer/EW (301)948-0110. Milgray/Washington (301)864-1111. **WASHINGTON: Seattle;** Liberty Electronics/NW (206)763-8200. Almac/Stroum* (206)763-2300. **CANADA: Montreal;** Cesco Electronics, Ltd. (514)735-5511. **Toronto;** Cesco Electronics, Ltd. (416)661-0220.

*Tantalum Capacitors only.

CORNING
ELECTRONICS

Microprocessors steer to Detroit

Car makers testing devices for sensing and control applications, but obstacles are unreliability, input/output interfaces

by Larry Armstrong, Midwest bureau manager

The concept of computers to control functions in automobiles has been bandied about Detroit for at least five years without becoming a reality. But with increasing volumes and varieties of microprocessors becoming available, the Big Three auto makers are now finding ways to cost-effectively implement the sophisticated and glamorous concept that they now regard as inevitable as death, taxes—and, of course, increasing Government pollution and safety legislation.

To date, all on-board microprocessor work has been limited to each company's advanced-development projects, which is to say that production volumes are still a way down the road. With traditional caution, the auto makers peg volume introductions to the early-1980 time frame; more enthusiastic semiconductor vendors tend to place it in the 1978 or 1979 model years. The major obstacles now are device unreliability and the need for input/output devices and interfaces.

"Knowing the lead time to develop an automotive product, I can say with quite a bit of confidence that there will not be any significant usage in the 1970s," says John L. Webster, manager of electronic-product development at Chrysler Corp.'s Huntsville (Ala.) division, which has an impressive track record for automotive electronic firsts. "But I think we'll have a few hundred thousand of them in cars in the early '80s."

Auto makers say they are now learning to program and use microprocessors, as well as trying to determine optimum system configurations. Potential applications for engine management include spark timing, combustion control, emission control, automatic-transmission control, and cruise control—all of which manufacturers say could be controlled by a single microprocessor.

Detroit watchers, on the other hand, are betting that the Big Three will take the more traditional approach: individual functions based on dedicated custom MOS LSI, each justified in terms of cost, consumer value, and reliability, and introduced one by one. A second-generation system would combine the separate engine-control functions into a subsystem under the control of a single microprocessor, perhaps tied to a central processor that coordinates other satellite microprocessors for safety functions (including antiskid braking), driver-assistance features (such as diagnostic and fuel economy readouts), and interior-temperature control.

"Whether it should be done in one microprocessor or many is still an open issue," says Shaun S. Devlin of Ford's Vehicle Control department in Dearborn, Mich. And, mirroring his counterparts at GM and Chrysler, he adds, "It really comes down in the final analysis to economics."

Ideally, the manufacturers would like to see a single box that could be applied, regardless of the options a customer chooses. Variability could be built into the software and isolated to a section of a read-only memory that would be plugged into a standard CPU.

Solutions. Detroit agrees that microprocessors, along with custom LSI and probably programable logic arrays, are an inevitable solution to future electronic-applications problems. And while certain specifications—noise immunity, wide-temperature operation, and the ability to tolerate some aberrations in power supply—will have to be standard on microprocessors shipped to Detroit, the auto makers haven't decided on, and currently don't agree on, other parameters of the device

Actuators have them worried

Talk to automobile manufacturers about the use of microprocessors, and they'll agree on two things: the device will inevitably appear under the hoods of their products, and some of the biggest problems they have to solve concern the input/output electronics associated with microprocessors.

Perhaps the greatest interface problem is the one presented by the actuators. The starter solenoid, for example, produces transients on the order of 70 volts, and window-lift motors, windshield-wiper motors, and fuel-injection solenoids all require sizable starting-current surges.

"All these things were made to operate with pieces of metal that come together, and now we've got to find better ways to do the work—ways that are compatible with semiconductor driving," says John T. Auman, a General Motors executive engineer. "If you look at that very critically, you realize that it's the tail tending to wag the dog."

that would provide the best performance. Vendors report that the auto people have adaptions of every available product on the road.

General Motors pioneered computers in cars with minicomputers in the trunks of its highly publicized Alpha series auto of the future. The microprocessor, an early 4-bit building block from Intel Corp., made its debut in the Alpha IV. While GM officials aren't saying what the devices are being used for, they're pretty well satisfied with what's commercially available. "We know exactly what we want in a microprocessor, and we think that microprocessors, for the most part, to take care of our requirements are available," notes John T. Auman, an executive engineer on GM's advance-product-engineering staff.

No injection. In a less splashy program, Ford used a Digital Equipment Corp. PDP-11 to control spark timing, exhaust-gas recirculation, and fuel injection. Ford has since evolved that program into a microprocessor and custom-LSI system for timing spark ignition and positioning the exhaust-gas-recirculation valve. The fuel-injection portion of the earlier attempt has been abandoned as too complex to justify its benefits.

"It's a very classic control problem," reports Devlin, "but it's higher-speed than most, in a terrible environment, and we don't know enough about the car to cast anything in the concrete of a hard-wired system."

Ford, unlike GM, opted for the custom route with a 12-bit microprocessor, because the auto maker didn't see anything on the market that could do the job. "There's no such thing as a general-purpose, industrial-control microprocessor," says Ron H. Temple, Devlin's co-researcher at Ford. "Standard microprocessors are not fast enough, nor are they accurate enough at the speed we need to carry our numerical calculations," Devlin adds.

Wants 12 bits. "We need interrupts—we've got to relate to asynchronous things happening in the engine, and we can't afford the memory consumption to do status-checking," Temple explains. "And we need 12 bits, at least; otherwise, we end up doing double precision all the time to get the accuracy we need. We need signed multiply and divide: we're using formulas involving square roots, for example, to compensate for things in the engine that we correct for temperature and flows."

Settles for 8. Chrysler, on the other hand, disagrees with the need for a 12-bit machine. "Admittedly, there are a few instances that require this precision, but not enough to need a 12-bit format in a microprocessor," Webster comments. "An 8-bit device may miss on a few of the informations you're processing but all you do is stick in another word and you've got it. A processor of higher order would be wasteful," he says.

Chrysler is developing microprocessors in three applications—entertainment, engine electrical, and body electrical, or instrument panel. Its first work was with the MCS-4 chip set from Intel, and it's now studying larger processors, including General Automation's LSI 12/16 silicon-on-sapphire chip (see p. 72). "We're looking to SOS for speed, primarily," Webster says.

Engine functions, especially those that maximize fuel economy at minimum emissions, are getting the bulk of the auto makers' attention. "Because of the increasing amount of legislation on emissions and fuel economy, we'll be forced into more and more precise and more sophisticated control of the engine," says Ford's Temple.

Economy. And even putting aside the potential threat of legislated engine control, Detroit will probably find consumers willing to pay for a fuel-economy option as they see fuel costs pushing toward a dollar a gallon. Using 1973 Environmental Protection Agency figures on gasoline consumption, Robert B. Hood, manager of Fairchild's Advanced Automotive Products department, estimates that using microprocessors for engine control could yield a factor of 1.8 to 2.0 improvement in economy.

Barring the way to speedier implementation of microprocessor-based systems in autos are Detroit's doubts about reliability, and a lack of input and output interfaces.

"The electronics industry has a long ways to go to supply something as complicated as a microprocessor chip," comments one automobile official. "It's still learning how to sell us a simple transistor that meets our reliability needs. Microprocessors have a heck of a lot more wire bonds, and I hope they beat the wire bonds by the time we get around to using them. Today's devices just aren't going to make it through the thermal cycles we have to live through.

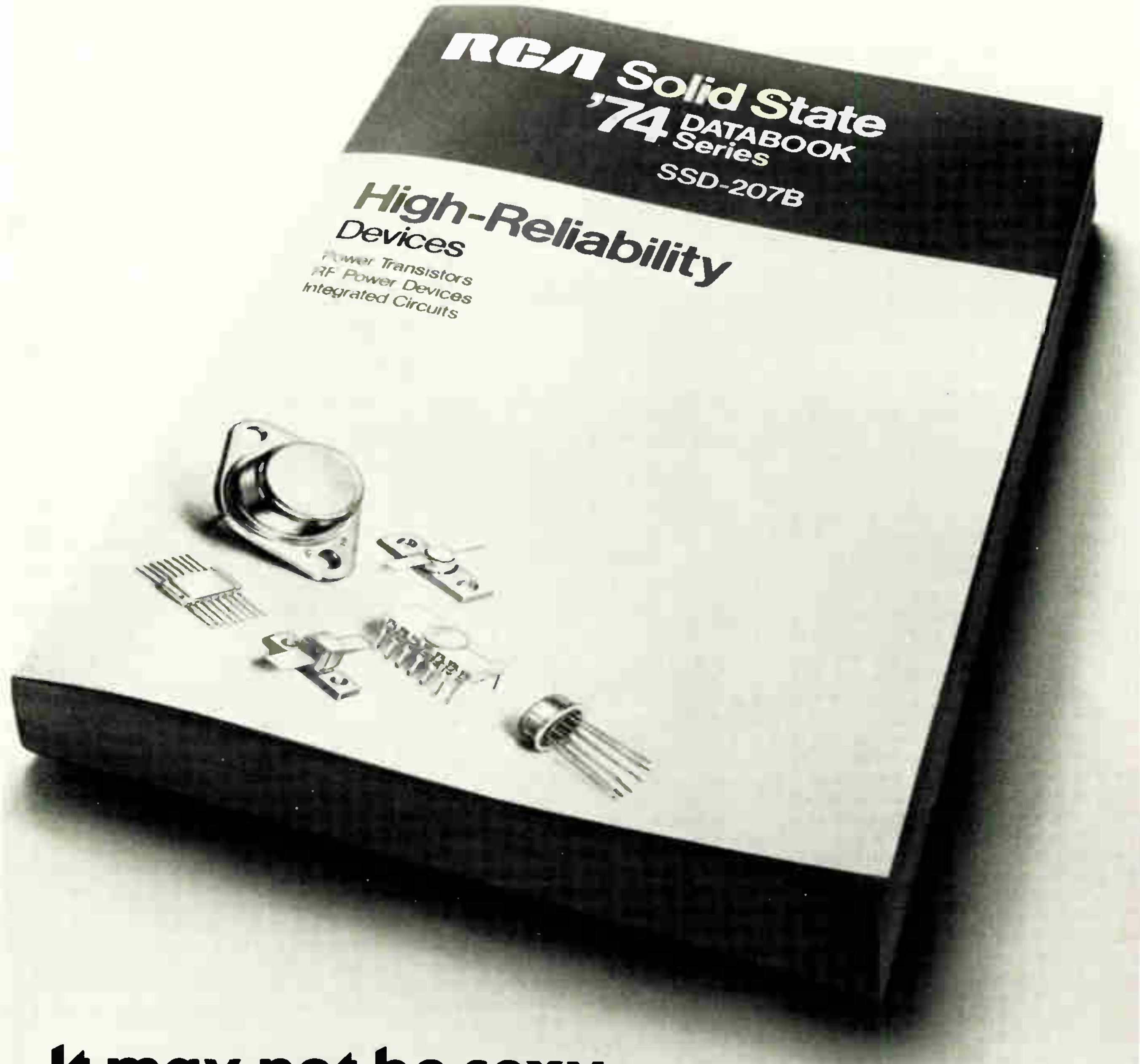
When it comes to obstacles, at least one, system reliability, will have to be worked out between Detroit and its vendors. "They want to understand all a microprocessor's failure modes," says Floyd Kvamme, vice president and director of marketing for National Semiconductor. "Most things they've used to date have degraded gracefully. With most of the things electronics companies have proposed, when the system blows, the car stops running."

Interconnects. Auto manufacturers emphasize, and some semiconductor manufacturers recognize, that only a small percentage of the cost and problems of eventual on-board microprocessor systems are in the microprocessors themselves. "Microprocessors are here; what we're waiting for are the input and output devices," Webster says, "and frequently the people in the electronics side of the house ignore that problem."

Adds GM's Auman: "The problems of reliability and cost as they associate themselves with the interconnect, with the sensors, and with the actuators are really the first-order problems that have to be solved."

"The bulk of the problem really lies in the interfacing elements—both the input and the output," echoes Fairchild's Hood. "For instance, using an inductive pickup for wheel positioning or crankshaft positioning requires fairly good signal processing to get a digital signal that can be fed to a microprocessor," he explains.

"We're trying to come up with good digital sensors that that don't need a lot of analog-to-digital converters for," Auman says. □



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Communications

Police are buying digital systems

Cleveland is about to announce winner of $600,000 contract, Los Angeles plans to equip 200 cars, and many other departments get in line

by William A. Arnold, Aerospace Editor

Police cars are starting to respond to a different kind of call: digital communications. Although far from being universal, digital electronics is being bought or considered for scores of law-enforcement units because digital technology speeds response time, makes better use of available frequencies, and otherwise improves communications between cars and with headquarters.

Cleveland is expected soon to announce a contract to equip 125 cars with mobile digital-communications terminals. The $600,000 award for an initial system will go either to the tiny Kustom Electronics Inc. Data Communications division in Chanute, Kan., or IBM's Data Processing division, White Plains, N.Y. Other police departments talking or buying digital communications include Las Vegas; Seattle; San Francisco; Minneapolis; Boston; Rochester, N.Y.; New York City; Chicago; Palm Beach, Fla.; and the states of Massachusetts and North Carolina.

A potentially big purchase will be made by the Los Angeles police department, which plans to outfit 200 cars within the next year. William A. Shand, marketing manager for Atlantic Research Corp., Alexandria, Va., predicts that the specialized Los Angeles system will be expanded eventually to include approximately 1,000 cars.

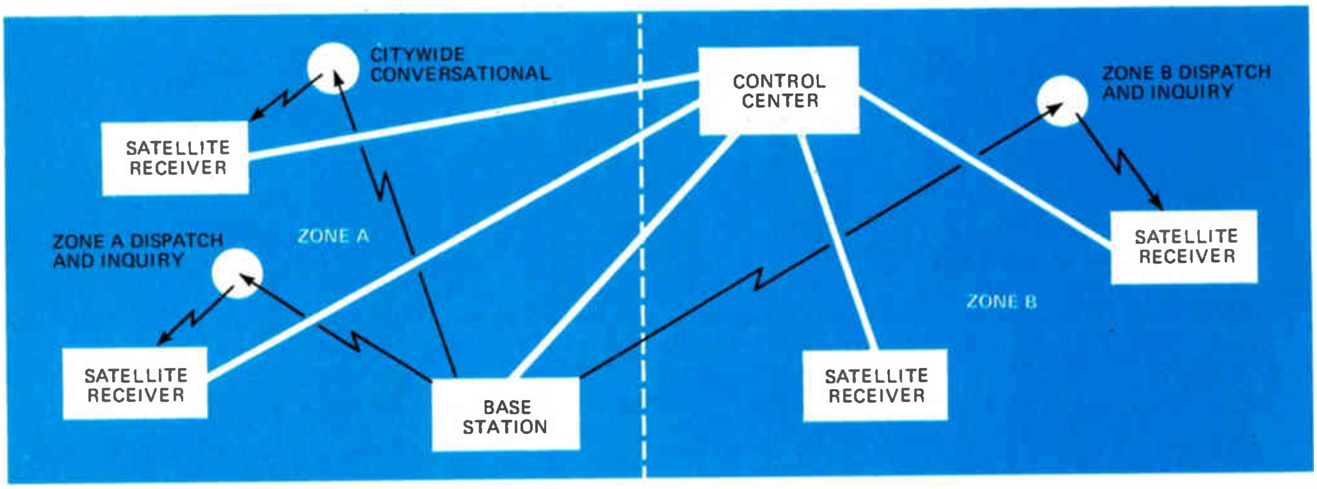
Shand adds that he's sold 15 units to Dearborn Heights, Mich., and is awaiting an order for another 15 from Hampton, Va. Other manufacturers include the big and the small in mobile communications: Coded Communications Corp., E-Systems Inc. (which bought GTE Sylvania's system), Motorola Inc., RCA Corp., Sunrise Electro-Service Corp., Teletype Corp., and Xerox Corp.

Giving impetus to digital gear is the Justice Department's Law Enforcement Assistance Administration. LEAA provides funds for demonstration systems, such as those in Kansas City and Cleveland, where departments can test and get used to the idea. The well-heeled agency also can pump a great deal of money into new police equipment, often with the police departments paying only 10% of the cost of the gear.

Furthermore, LEAA has practically endorsed digital electronics in the report of a survey of departments using digital gear. The study was performed by Urban Sciences Inc. of Wellesley, Mass., a subsidiary of Sentor Security group of New York City. It was done for the Law Enforcement Standards Laboratory of the Commerce Department's National Bureau of Standards, which performs services for LEAA's research arm, the National Institute of Law Enforcement and Criminal Justice.

But the market isn't just lying there, ripe for the picking. IBM spokesmen concede that the giant computer corporation hasn't sold any equipment and has no potential business at the moment. Atlantic Research's Shand says, "Everything is LEAA money." Companies "won't

Keeping in touch. This sample digital police communication system uses phone lines (in white below) and rf links (zigzag lines).



sell if cities have to buy units themselves." The real problem, he avers, "is that the equipment isn't as cheap as the real market wants."

Even a 20-unit system costs $120,000, "a big chunk for a city to bite off," Shand says. And, if a company has to produce 15 at a time, there's no way to get the price down. He advocates changing the designs to reduce the price, largely by integrating circuits on chips. But, the "chip manufacturers aren't interested unless you can order 5,000 chips," Shand concludes.

Developing standards. The Government's next step is to contract with Urban Sciences to develop minimum performance requirements for units, says Marshall J. Treado, program manager for communications systems at the NBS standards laboratory. While he emphasizes that the Government will do no compliance testing and that the standards will be voluntary, it is obvious that a set of standards will make it easier for departments to buy equipment with Government help.

The Urban Sciences study [*Electronics*, Feb. 7, p. 59] cites the advantages of increased speed, ability to handle a greater volume of communications, and inherent security of digital signaling.

The report concludes that "digital communications represents one of the most useful means that technology can offer for improving communications operations for law enforcement."

The study surveyed 16 law-enforcement agencies using digital communications ranging from status-only to fuller, more computerized, communications, and it evaluated 15 car terminals from 10 manufacturers.

The available equipment from manufacturers will meet user needs and provide a "flexible choice of system configurations," the report states, but "operating experience with these equipments is limited, so no quantitative conclusions can be made with regard to maintenance and service performance."

Marketing managers will be glad to learn that two-way digital communications is a definite requirement, according to the law-enforcement agencies surveyed, as is a system that provides "full-text" and "status" capability. Half of the departments indicated that they plan to equip all of their vehicles with digital gear, while the other half would equip according to varying work loads. For the base station, about half want both visual and hard-copy terminals, while the rest specify visual information displays only.

For the vehicles, about 40% require CRT-type displays with printers added in selected cars, about 35% want both for all cars, approximately 20% had no definite opinion, and only 5% wanted only a two-way printer. More than half of the departments said they wanted automatic polling of mobile units for status updating.

For the future, companies should reduce the size of their car terminals. All police agencies surveyed "voiced considerable concern over the bulk" of many of the digital terminals available, the study says. Front-seat space is limited, and most police departments would like as much of the digital gear as possible to fit in the trunk of their cruisers.

The agencies also think that systems should be compatible with automatic vehicle-monitoring networks and with computer-aided dispatch systems. Also, among other objectives, displays should be readable in direct sunlight, messages should not be displayed while no officer is in the vehicle, multiple-channel systems should have channel-switching controls, and these systems should provide digital identification of which radio channels are in use.

Overall, departments like using digital communications. About 80% mention security and improved response time, while 55% like the reduction in channel utilization, confirms Treado. Using a digital system, one police department reports a 140-fold increase in patrol queries and a 15-second response time from the patrol car to the FBI's National Computer Information Center and other computerized data banks.

During slow nights, some patrolmen swing around motels and check license plates, which has brought about an astonishing increase in the number of hits, or identifications of cars sought as stolen or in connection with crimes. "The hits per time on the air go up drastically," says Treado. "If you can check 100 times more license plates, you'll probably get 100 times more hits."

How big is the market? "I think there's a very large potential market," says John L. Aker, Kustom's data-communications manager. He lists Motorola and IBM as formidable competitors, even though Kustom beat out IBM in Kansas City [*Electronics*, Dec. 6, 1971, p. 39]. Sunrise, which has sold a digital system for a New York City taxi fleet [*Electronics*, Feb. 7, p. 39] and offers the highest transmission rate of any system, also is interested in the police market, says William Smith, president. □

Cutting congestion, but not traffic

Police-communications systems are using the proven advantages of digital technology to update law-enforcement electronics. Instead of slow voice transmission with its inherent delays, garbles, and relays, digital gear will let a patrolman in a squad car quickly query a base station or a central data bank for the desired response. One great advantage of digital communications is that it dramatically lessens frequency congestion while allowing for an increase in traffic volume.

A typical terminal in a squad car can weigh up to 45 pounds, use CRT, light-emitting diode, plasma, or hard-copy display for the digital information, and have a keyboard with numerical keys for codes and other keys for special functions. One bugaboo has been the allegation that digital systems are less secure than voice, even though they need no voice-scrambling apparatus. However, if one is stolen, that unit can be left out of the network because, since the unit is selectively addressed, it can also be selectively "deaddressed."

Companies

GA moves to meet new competition

Maker of minicomputers and automated systems, which grossed $30 million in 1973, faces squeeze from mini, semiconductor firms

by Paul Franson, Los Angeles bureau manager

At its inception in 1967, General Automation Inc., the Anaheim, Calif., maker of minicomputers and computer-based automation systems, placed itself in a growth arena—the industrial-automation business. The company's 1973 sales of $30 million are largely derived from that business, which was chosen because one of GA management's basic tenets was to go after industries that were ready to turn to computer-based automation.

But the still-young company faces some of its most serious challenges as it sets its sights on sales of $200 million by 1978. It is offering more visible competition to such larger minicomputer manufacturers as Digital Equipment Corp. and Data General Corp., and it has to contend with possible inroads into its business from semiconductor microprocessor manufacturers.

Competitor. GA's SOS processor chip, the 12/16, is designed to battle semiconductor companies in the market.

GA has made some moves to counter the technology thrust of the semiconductor community. It has developed its own silicon-on-sapphire microprocessor CPU for use in its minicomputers, and it has invested in an MOS supplier in Mountain View, Calif.

On the business-strategy side, GA is even more aggressively exploiting the automotive industry's readiness to automate, as well making acquisitions that have positioned it in other growth markets.

Founder and chairman Lawrence A. Goshorn was the main architect of the firm's strategy in choosing its markets, but he admits to at least one miscalculation. Fortunately, that market remains promising. His criteria were four: Go after fields in which the leaders "had a minimum amount of energy; when the timing was right to position GA as the leader; where the industry was ready to turn to computer-based automation; and where the market size was right—"large enough, but not too large."

'Mistake' in timing. The "mistake" he admits was to underestimate the automotive market. "Through 1985, $10 billion will be spent on automation." Yet GA has done well, both because it was well positioned, and because it concentrated on some 200 submarkets—for example, carburetor manufacturing and testing, and transmissions, tires, and diagnostic centers.

General Automation has concentrated right from the start on three major markets for both OEMs and end users: industrial automation, communications, and scientific systems. The industrial segment includes the lucrative automotive market, which accounts for about 11% of its business, with many test, alignment, and assembly systems used worldwide on automobile production lines.

The industrial-automation business accounts for about 13% of sales, and special systems are used in electrical and electronic production for coil winders, parts inserters, printed-circuit-board drilling machines, and wire wrapping.

Data communications, a major growth market, accounts for about 16% of business, with about a quarter of GA's sales in the business and scientific arena. Here GA 18/30 systems compete with IBM 1130s in disk monitoring systems, and with IBM 1800s in supervisory control.

In all these markets, GA is up against stiff competition from the biggest and the most successful firms in the electronics industries—though, perhaps fortunately, none is a competitor across the board.

Chip makers threaten. But for the future—a future that may already be here—president Raymond J. Noorda says the semiconductor companies are the most serious threats to minicomputer makers. However, Goshorn says, "I do believe that we're going to see more companies integrating semiconductor capacity into their companies, particularly as we see the rampant semiconductor companies try to become everything to everyone."

GA's response has been two-fold. First, there is the silicon-on-sapphire microcomputer; second, GA is investing in a semi-captive MOS house, Synertek of Mountain View, Calif. Noorda feels that GA is in better shape than rivals whose microprocessors, say, have been developed by semiconductor houses. "We feel that we have something proprietary to offer our customers." He adds, "the OEM customer wants to put you out of his business and do as much as possible himself. If he can make the fundamental product himself more cheaply by buying a few chips, he will. If you expect him to keep you, he has to know you will continue to have something to offer. We will have very low-cost, high-performance 'iron' product for the OEMs."

GA has delivered sample SOS microcomputers to a number of customers, including RCA Corp., but doesn't expect product flow to start until late summer, says marketing vice president Michael Ford. "It takes three to nine months for customers to need the flow. We have 40 customers that could turn into big buyers, with a dozen already committed." He estimates that requirements could be 15,000 to 17,000 or 30,000, depending on acceptance of the customers' products.

SOS deal. In view of GA's sour attitude toward the semiconductors suppliers that are now competitors, the firm's relationship with SOS supplier Rockwell Microelectronics is interesting. Noorda points out that both companies have contributed a lot to the development of the 12/16. GA has exclusive use of its parts, of course, but "we're anxious for Rockwell to develop the SOS technology and sell it to others. We don't want to have the only SOS products; it's a very lonely position."

General Automation also has made a number of significant moves toward vertical integration through acquisitions and investments in suppliers, customer-marketing arms, and a new venture in Japan. Last year, the firm acquired Dynamil Inc., a manufacturer of multilayer circuit boards.

A significant GA investment is in Silicon Valley. There, Synertek expects to start supplying GA with 1103 and 2102 MOS random-access memories later this year and eventually to supply a major part of its memory needs. Other Synertek investors are Victor Comptometer and American Telecommunications. At present, GA buys these MOS products from other MOS suppliers. Goshorn points out that semiconductor memory will account for 70% to 80% of the microcomputer business. Meanwhile, the company and its investors are involved in a lawsuit with major MOS maker American Microsystems Inc., which claims that Synertek management has misappropriated AMI trade secrets and recruited its employees.

In forward integration, GA announced in February that it is acquiring Tal-Star Computer Systems Inc., Princeton, N. J., GA's major printing-industry computer customer for four years. Its systems are used to automate production, typesetting, printing, and distribution of many major U. S. newspapers. Goshorn expects expansion downward to smaller systems. And last year GA acquired Data Systems Engineering Inc., in Anaheim, a system development and product development company.

GA's foreign business already accounts for significant 27% its sales. And in December, the company received approval for a 50-50 joint venture with Koyo Electronics Industries Co. in Tokyo. □

Hands on the tiller

Although Lawrence A. Goshorn has relinquished the presidency and day-to-day management of General Automation Inc. to Raymond J. Noorda, no one should conclude that Goshorn is moving out of the picture in the company he founded and shaped. He remains chairman of the board and chief operating officer, and he intends to concentrate on product planning, financing, acquisitions, and executive hiring, plus technology, an area of great interest. The 38-year old Goshorn, who contends that he can serve better outside of the hectic daily routine, states, "Ray is a much better administrator than I am."

Goshorn is a soft-spoken but emphatic Kentuckian (he moved to Arizona when he was 11), with a BS in computer engineering and MS in control engineering from Arizona State University. He served five years in the Navy and has been director of engineering at Decision Control (now Varian Data Machines), manager of technical marketing at Computer Control Co. (now part of Honeywell Information Systems), and he started out at General Electric Co.'s process-control computer department, where he helped design and develop some of the industry's earliest computers. Goshorn sees his strength in technical concepts, but his marketing insight has obviously helped General Automation.

One of Goshorn's favorite topics is that semiconductor companies are aggressively going after the markets that his and other minicomputer makers have opened. "Up to now, component companies have been going after loose-toothed tigers that roll over and die—old industries like electromechanical calculators, meters, relays, and watches. They won't find such an easy fight when they try to take over the computer business. The computer companies themselves are young, aggressive, and already electronics-based. They won't fall down and let the components companies have the business."

Goshorn isn't interested in helping the suppliers who are now becoming his competitors, hence his internal SOS-design group, and investment in MOS maker Synertek. He's also stated in the past that Texas Instruments, which is pursuing the minicomputer and automation markets, as well as making ICs, isn't a GA supplier for precisely that reason.

President Noorda has had a strong background in process and automation control at General Electric—in fact, he was responsible for hiring Goshorn at GE. After 21 years, Noorda decided that a lot of things he wanted to do technically couldn't be done at the giant company, and he joined his old friend's firm.

Noorda feels his main contribution at GA has been to make it work on a business-like basis. "Before, they were going after too many markets in a somewhat haphazard way, and if there's one thing I learned in the 10 years I spent in marketing, it's that you've got to concentrate on a few markets to do well in any of them." Now, Noorda spends more and more time with legal and financial people and requirements—areas that Goshorn appears to have left without many tears. "He keeps telling me about all the opportunities I've gained," says Noorda, smiling.

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Education

EE enrollment recovers from slump

But the short-term outlook is for a shortage, now that engineers from recession-hit classes are beginning to enter the job market

by Mary Chalupsky, staff writer

EE enrollments are making a comeback from the recession-fed decline of the early 1970s as college administrators push to make curriculums more flexible, broader-based, and more appealing.

Still, some administrators say the short-term prospect is for a shortage of graduate EEs. Their forecast is based on smaller 1974 graduating classes that reflect the diminished interest in electrical engineering on the part of 1970's freshmen. Manpower cutbacks, particularly in the aerospace industry, frightened potential students, and schools are still struggling to attract people.

Another recession now, says John Alden, director of the Engineers Joint Council, could really hurt those efforts. And looking still further ahead, Alden points out that a decline in the U.S. birth rate is beginning to slow elementary-school enrollment. This could mean another reduction in college enrollment and, ultimately, yet another problem for industry.

One approach being taken by engineering school administrators is to widen their curriculums in subjects like sociology, business, economics, and humanities. Thus, the traditional approach to engineering education, with concentration on math and the sciences, is evolving into more flexible programs based upon the demands of a new breed of engineer.

"The guy with the slide rule, flat top, and white socks isn't the engineer of today," says one educator. "In fact, a pocket calculator is replacing the symbolic slide rule."

At the same time, more students are transferring to engineering programs from liberal arts curriculums as well as from junior and community colleges. That shift stems from a growing scarcity of jobs for graduates in the humanities.

David Boylan, dean of the college of engineering at Iowa State University, Ames, Iowa, terms the new emphasis on engineering education a "multi-disciplinary outlook." However, he points out, "although companies would like a broader-educated individual, they are still looking for the specialized engineer."

But most administrators agree on their major predicament—that for the short term there's more demand for engineers than there are graduates entering the profession. One school reports that requests from industry recruiters are so plentiful that the recruiters are referred to other institutions. Some schools simply turn them away.

Spending. Another tack being taken by colleges is to increase recruiting budgets—double, in some instances—with college representatives promoting their programs via TV, stepping up direct mail, and increasing contact with high school counselors and science instructors. At Georgia Institute of Technology, an institution that draws easily from the southeastern part of the U.S., administrators are starting students early. They are skipping recruitment at the high school level and going straight to elementary and junior high students, with favorable re-

EE ENROLLMENT 1970 – 73

	1970		1971		1972		1973	
	1st year	total	1st year	total	1st year	total	1st year	total
AEROSPACE	3,213	12,836	1,407	6,819	1,028	4,656	966	3,923
BIOMEDICAL	43	212	88	363	182	590	156	862
ELECTRICAL	11,911	54,183	9,958	50,103	8,255	45,061	9,141	43,447
TOTAL	15,167	67,231	11,453	60,285	9,465	50,307	10,263	48,232

Source: Engineering Manpower Commission of Engineers Joint Council

Numbers picture. While over-all totals have been dropping for aerospace and electrical engineering, the amount of the slide has decreased significantly for the latter discipline. At the same time, the total of first-year students increased in 1973 for the first time in three years.

sults. And the University of Michigan has gone on the road with a mobile unit that travels to shopping centers, schools, and fairs to demonstrate basic experiments in an effort to attract more students into engineering.

So while technical schools try to train more new engineers, industry has to wait for the lag to work itself out. According to a forecast by one New York consultant, a 50% increase in demand for technical manpower during 1973 is being carried over into 1974. Behind the surge in demand are the energy crisis and accompanying environmental problems, increased research and expenditures, and continuing technical breakthroughs.

In fact, the energy crisis has brought a renewal of interest among students. But many administrators are apprehensive about the long-lasting effect of the energy shortage on engineering education. While some see it as a top drawing card, others assert that energy reverberations could have an adverse effect by causing a complete reversal in the economy.

Administrators also point to relatively untapped sources of students: minority groups and women. Opinion here is mixed, for while the Massachusetts Institute of Technology notes that 20% of 1974's freshmen will be women and Columbia University reports that the enrollment of women has doubled, other schools say minority groups aren't responding to enrollment drives as expected.

Eyes on goals. Another change noted by administrators of engineering schools in general, and EE programs in particular, is in the students themselves. They agree that undergraduates today are more serious and goal-oriented than they were five years ago. For one thing, there is less anti-technology feeling now, what with concern about energy and environmental problems. MIT's James Bruce, associate dean of engineering, says the about-face is logical because the problems of the world today are of a technical nature, and they can be solved only by technical people. Moreover, he notes, engineering has evolved from device-oriented to a people-oriented discipline, with emphasis placed on social and urban concerns.

At the California Istitute of Technology, Charles Wilts, EE department head, says that he feels EEs have remained at the forefront of the engineering spectrum. "The future of electronics is very, very bright and is limited only by the ingenuity of man," he says. "Everyone recognizes it as a relevant and useful field with a major part in the solutions of today's energy-related problems."

And Demetrius Paris, director of the EE department at Georgia Tech, offers this summation: "The future looks good, and enrollments can only go up. Since determining decisions are made in the market, then that's where industry's needs will be met." □

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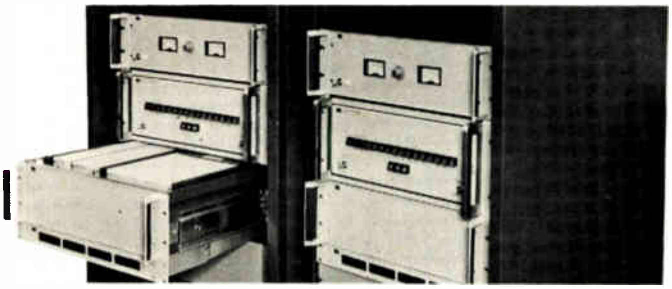

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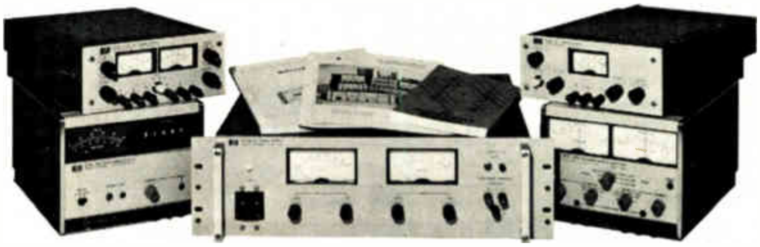

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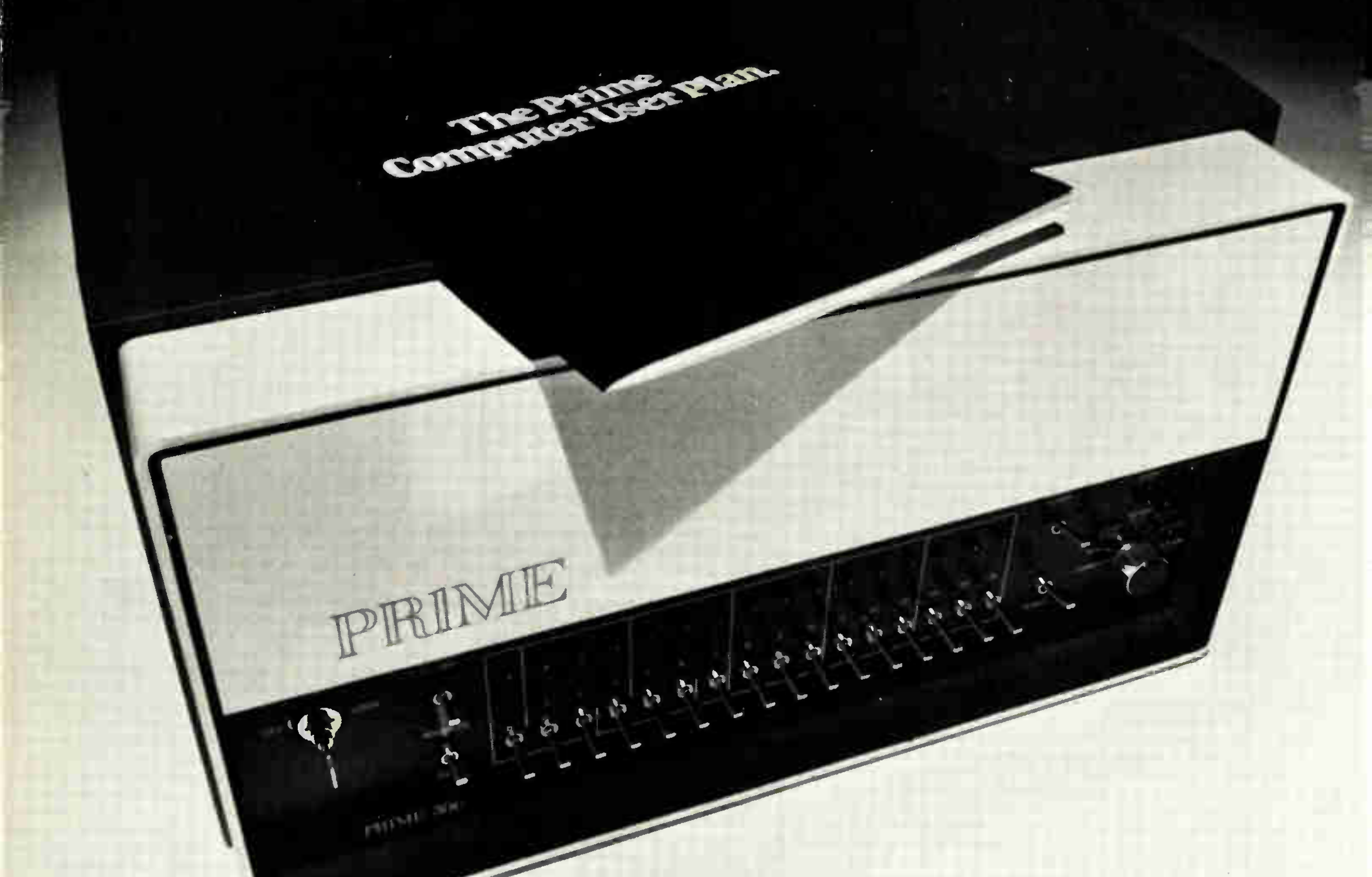

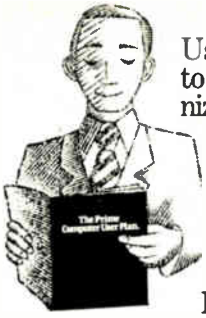

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	• Stack Procedure Instructions • Micro Verification Routines** • Hardware Multiply/Divide and Double Precision Arith.* • DMC/DMT Capability* • Automatic Program Load From Input Devices (PTR, TTY, CR, MT, Disk)*
Prime 200 Central Processor (1 board)	• Memory Byte Parity • Processor Byte Parity • Full Addressing Modes – direct, indirect, and indexed in both sectored and relative modes • Virtual Instruction Package (VIP) – automatic trapping of unimplemented instructions and substitution of functionally equivalent software subroutines.
Prime 100 Central Processor (1 board)	• 8-Channel Programmable DMA • 4 Channel Full Duplex Asynchronous Serial Interface • Multi-level Vectored Priority Interrupt System

* Optionally available on Prime 100 and 200
**Optionally available on Prime 200

The chart suggests there's a little 300 in every Prime computer. Naturally, we planned it that way. Our 300 is just the reverse of the big box with a little computer inside.

Other 300 features will tell you just how big it is. For instance, there's high-speed MOS memory with 32K words per board. Up to 256K words per system. There's floating point arithmetic and writable control store, too. In short, there's everything you'll need in the computer you can plan with. Work out a multi-function system or plan a multi-user arrangement. The diagram that follows is just one way to go.

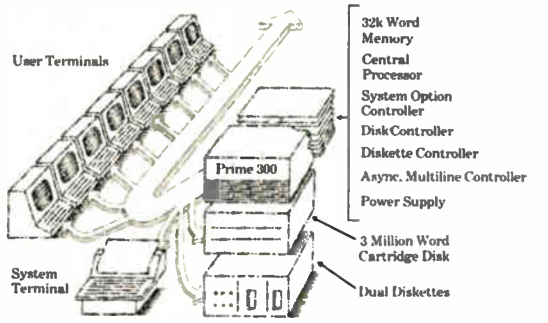
The Prime 300 supports a multi-user, virtual memory Disk Operating System (DOS VM) and a foreground/background Real Time Operating System (RTOS VM).

A Prime 300 with virtual memory easily accommodates over a dozen users. What's more, each is guaranteed 64K words of virtual memory available to program in FORTRAN, BASIC, Macro Assembler and Micro Assembler.

The system files and paging space are all provided by cartridge disk. Our new diskettes offer low cost storage for personal user files.

A Prime 300 is good. How good can best be seen in The Plan. It shows how to upgrade from the 100 right on to the 300. In the process, you don't change software. The time and expense of reprogramming are gone. You can also use the 300 as a software development system. The software will run on 100's or 200's without modification. The Plan guarantees this kind of system compatibility.

The Plan also goes into system integrity features. Memory Byte Parity and Processor Byte Parity are standard in the Prime 300. Micro-verification routines (also standard) and controller loop-back allow you to isolate faults to a single board.



Prime 300 Multi-User Disk Operating System

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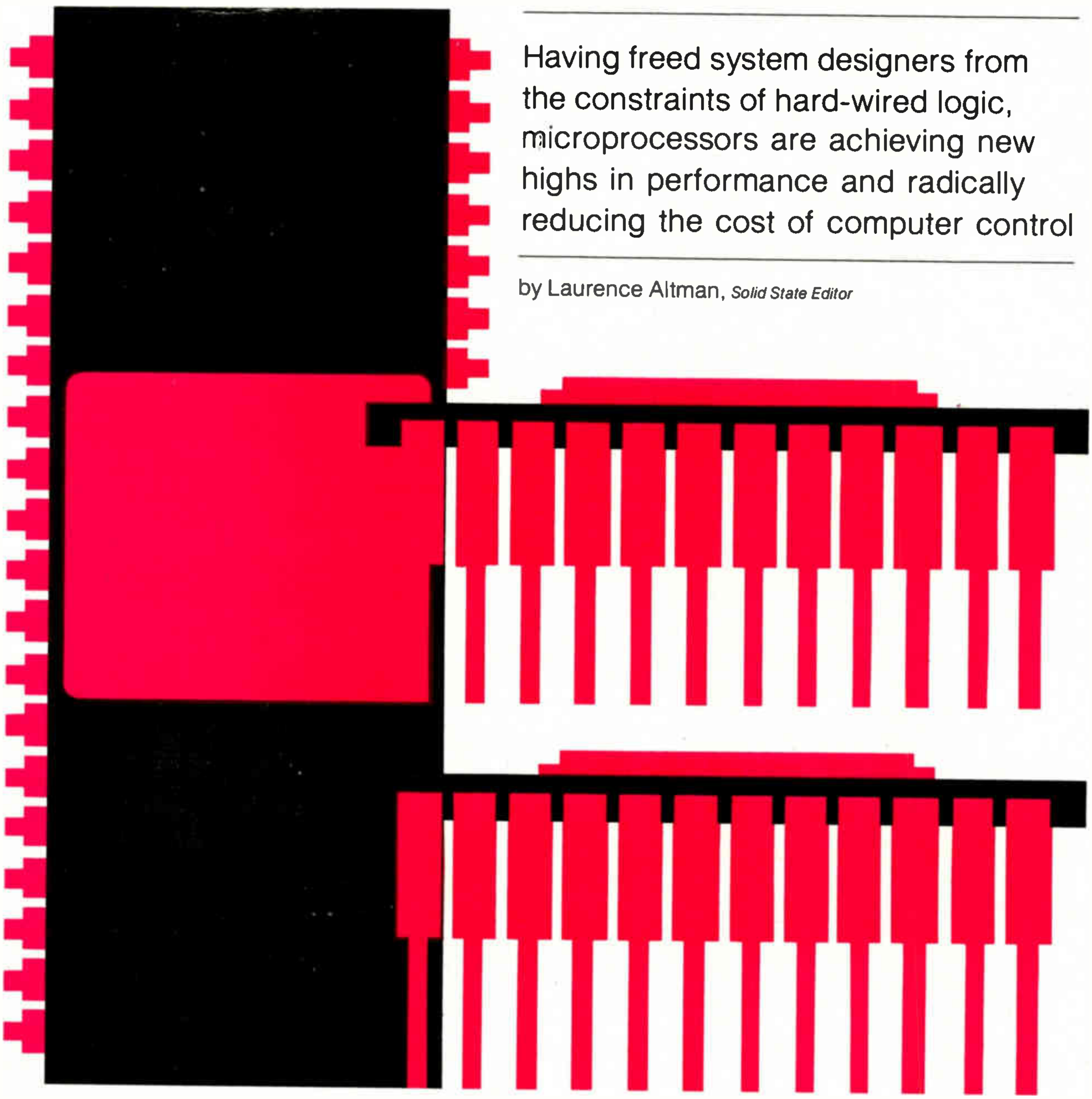
ANALOG DEVICES

Then it was special. Now its a standard.

Single-chip microprocessors open up a new world of applications



Having freed system designers from the constraints of hard-wired logic, microprocessors are achieving new highs in performance and radically reducing the cost of computer control

by Laurence Altman, *Solid State Editor*

□ The first single-chip high-performance microprocessors are rolling off the production lines, splendid confirmation of the power of large-scale integration. These second-generation microprocessors, together with a handful of matched memory and logic circuits, provide equipment designers with the full power of computer hierarchy at unprecedentedly low cost—about the price of a dozen medium-scale TTL integrated circuits.

Inexpensive computer control—that is the miracle of the new microprocessor. All the other advantages inherent in its innovative organization are secondary, even the versatility that results from the ability to simulate logic with software and to reprogram corrections and system changes quickly with no changes in hardware.

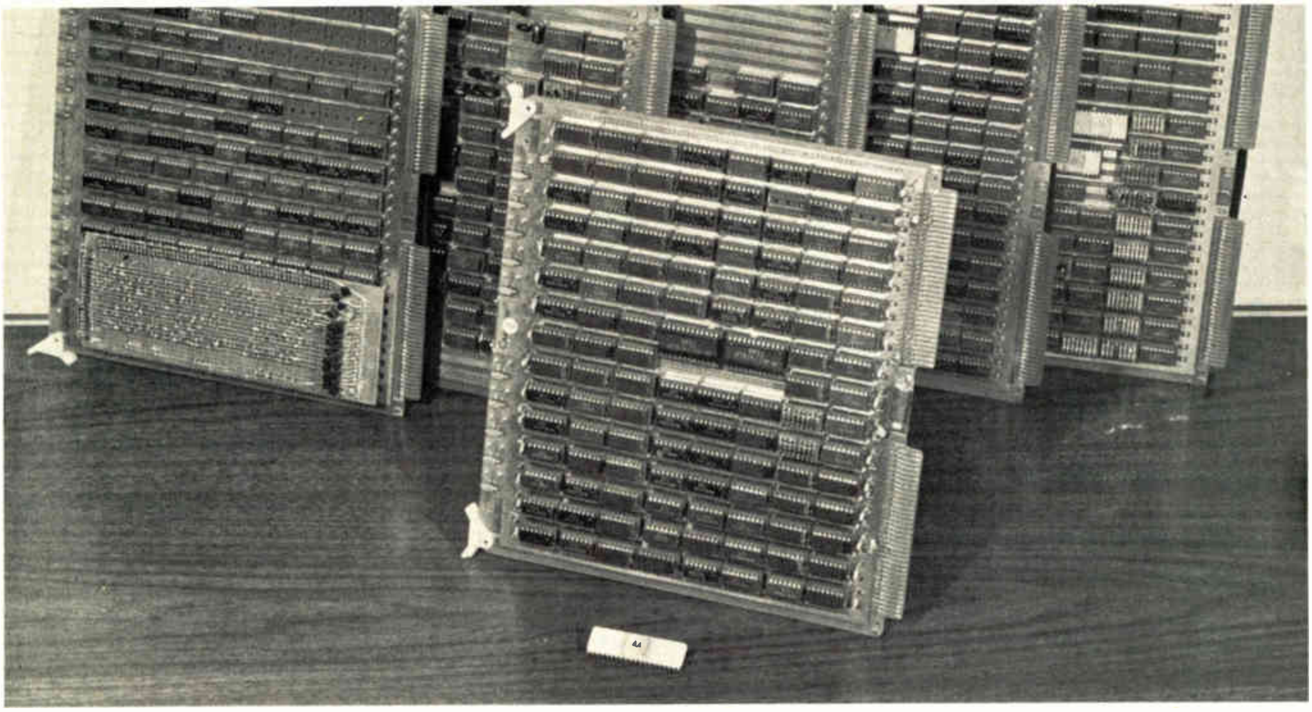
The implications of such cheap, distributed one-quarter-horse computer power are only beginning to be understood. A Teletype computer terminal capable of transmitting 300 bits of data per second can now be implemented with 12 LSI packages costing less than $300. Traffic-light controllers can be built with 12 microprocessor family packages, where an equivalent TTL design requires 200. A simple gas-pump meter needs one microprocessor and only nine other packages, an electronic scale needs eight chips. A digital instrument panel displaying five functions can be built from a five-chip microprocessor family, plus display circuits. A microprocessor control system already is operating in experimental automobiles, monitoring dozens of operational parameters at a potential component cost of less than $200. No other electronic method could perform these functions at a practical cost.

Indeed, the microprocessor is really the first truly general-purpose LSI logic device—calculator chips are decidedly special-purpose. That's because the microprocessor, replacing hard-wired logic, offers the twin advantages of LSI circuitry and programability.

Software-implemented logic, few packages, low power-supply and cooling requirements, and few pc cards and connectors simplify system re-evaluation, redesign, and testing. They also reduce assembly costs and inventory requirements.

Using software programs to affect the behavior of the processor instead of hardware interconnections may be an unfamiliar technique to many circuit designers, but pays off by boosting system performance. A typical software program consists of a series of orders or commands to the processor stored in a companion read-only memory. Since ROMs are easy to program—and programable ROMs easy to reprogram—the microprocessor's behavior can be much more conveniently adapted to a changed application than if extensive, time-consuming changes in hardware were necessary. New designs, too, can be turned around faster because a standard microprocessor architecture can be used along with a different ROM program for each new application.

Designing systems with microprocessors is still largely



1. The big attraction. Built using standard TTL hardware, this microprogramable processor circuit requires 451 packages on five circuit boards. Using advanced MSI logic and read-only-memory programing, it requires 114 packages on one board. Yet the same circuit, when built with today's n-channel LSI techniques, can be packed into one 40-pin microprocessor package—Motorola's new M6800 system.

uncharted, but some rules of thumb are beginning to emerge. Since a complete microprocessor system requires from five to 50 ICs—including clocks, control logic and memory, and peripheral buffering—microprocessors should only be considered for a sequential digital design requiring more than 50 hard-wired logic ICs. Such a design will have more than a trivial number of steps to its logic flowchart and will also have some logic or arithmetic data-processing requirements. At the same time, the speed cannot be too fast, say, not more than 5 to 10 microseconds per instruction.

These system requirements, clearly less stringent than those handled by today's minicomputers, would cost $2,000 to $20,000 to build with hard-wired logic. But with microprocessors costing a 10th of that, their range is almost inexhaustible: point-of-sale terminals, electronic cash registers, inventory-control systems, credit-card verification systems, process, numeric, and machine control, automatic test systems, digital instruments, traffic controllers, communications systems, peripheral controllers, navigational systems, game machines. This is the domain of the microprocessor.

How to choose a microprocessor

Selecting a central processing unit (CPU), the major component in a microcomputer design, is a matter of deciding the best way to process the data. For example, data word length may be fixed by the processor design or it may be variable if the design allows multiple processor chips in parallel. A variable data word length is to be preferred when the needs of a variety of applications must be satisfied. For instance, a 16-bit CPU chip could be programed into 4-bit words for BCD display control, calculators, or cash registers, 8-bit words for CRT terminals or data concentrators, 12-bit words for handling the output of a-d converters, 16-bit words for general-purpose processing, or even 24- to 32-bit words for high-accuracy or high-throughput applications.

Instruction power is the next feature to watch out for in a CPU chip. Because the power of individual instructions and methods of counting may vary widely, the number of instructions in the set executed by a microprocessor is a poor index of its usefulness. The only realistic method of comparing instruction sets is to experiment with programs typically required for the intended applications and to compare the execution times and number of bits of storage they use.

Often overlooked in choosing a microprocessor is its interface structure—that part of the CPU which connects the arithmetic and logic unit and the control memory with the input/output peripheral circuitry. Clearly, this structure should adapt easily to a variety of system parameters without imposing a high overhead in hardware or software. The application may demand anything from a simple low-cost bus (either parallel or serial) having separate input, output, and address lines and heavily dependent for its control on the processor, to a sophisticated, high-speed, bidirectional bus with addresses and data multiplexed over the same lines. For maximum flexibility, look for provisions for input/output control, which allow convenient interfacing with peripheral components of varying response time. On the other hand, fixed I/O timing may provide higher I/O speed. In any case, the microprocessor I/O circuitry should directly interface with the 5-volt bipolar logic required to drive I/O lines; if not, buffers will be necessary, adding expense and needing more in the way of power requirements and board space.

Since the memory is often a major portion of the system cost, its selection is nearly as crucial as the CPU's. Read/write memories (random-access memories or RAMs) are best used for variable data storage and for program storage during program development. Programs for prototype or preproduction systems are often stored in a programable ROM, while a ROM is used during high-volume production.

What's available

The rush with which microprocessor devices are appearing—and will continue to appear throughout the year, according to semiconductor manufacturers—is a tribute to the intensity of the demand for them. They fall into three classes.

The pioneering 4-bit microprocessor systems were

What a microprocessor is . . .

. . . but first, what it isn't. A microprocessor is not a computer but only part of one. To make a computer out of a microprocessor requires the addition of memory for its control program, plus input and output circuits to operate peripheral equipment. Also, the word is not short for microprogramable central processing unit. For, though some microprocessors are controlled by a microprogram, most are not.

What a microprocessor is, then, is the control and processing portion of a small computer or microcomputer. Moreover, it has come to mean the kind of processor that can be built with LSI MOS circuitry, usually on one chip. Like all computer processors, microprocessors can handle both arithmetic and logic data in a bit-parallel fashion under control of a program. But they are distinguished both from a minicomputer processor by their use of LSI with its lower power and costs, and from other LSI devices (except calculator chips) by their programable behavior.

In short, if a minicomputer is a 1-horsepower unit, the microprocessor plus supporting circuitry is a ¼-hp unit. But as LSI technology improves, it will become more powerful. Already single-chip bipolar and C-MOS-on-sapphire processors are being developed that have almost the capability of the minicomputer.

built largely with p-channel MOS calculator technology, examples being Intel Corp.'s MCS-4, Rockwell International Corp.'s PPS-4 system, and Microsystem International Ltd.'s MC-1. Next came the 8- and 16-bit p-channel processor sets that are extensions of the early 4-bit units. These devices, while intended for applications up to the minicomputer level, generally require either multichip CPUs or considerable peripheral circuitry. Intel's MCS-8 and National Semiconductor Corp.'s IMP-16 are the most popular examples of each kind. Into the third and newest class, considered by many to be the second generation of microprocessors, fall the new n-channel 8-bit systems like Motorola's MC6800 and Intel's 8080 chips, which, together with matched memory and input/output circuit interfaces, form a completely self-contained large-capacity microcomputer family of chips (see pp. 88–100).

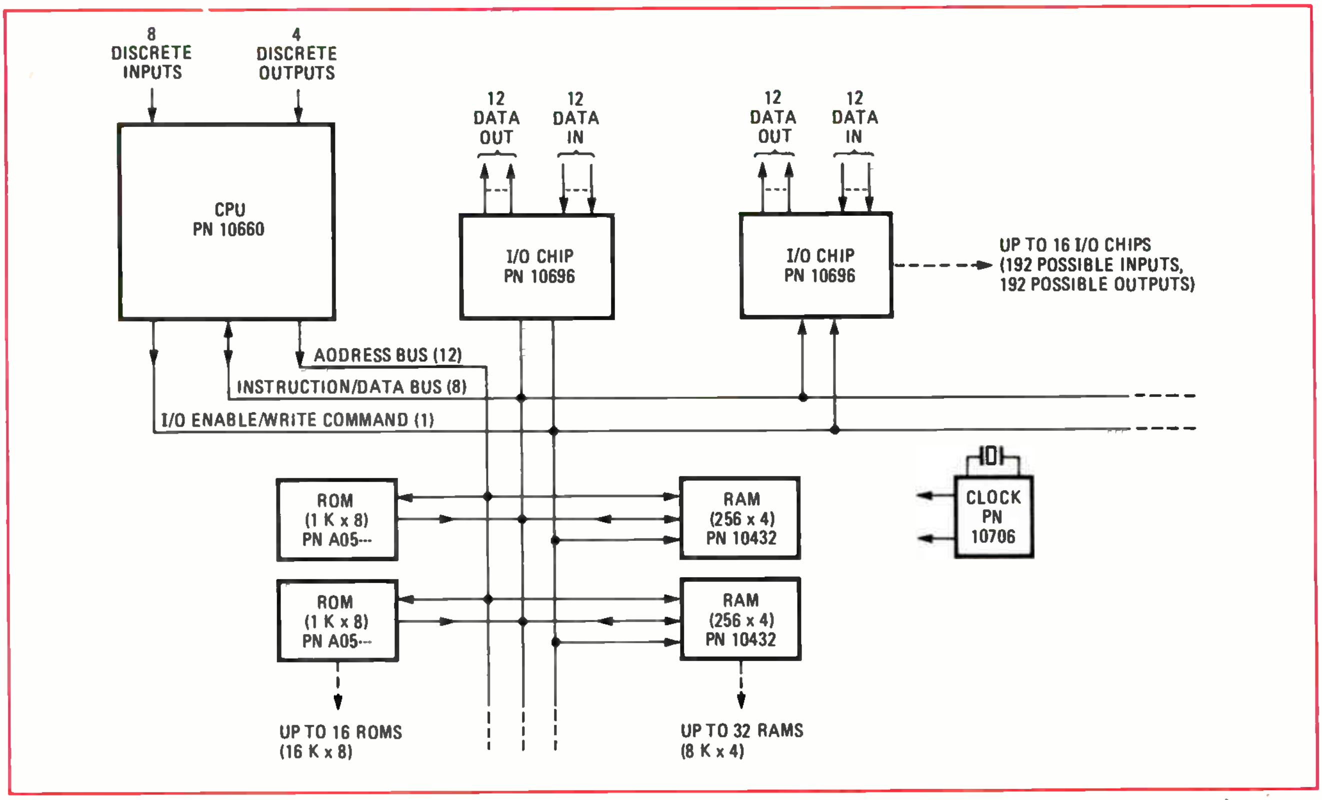
Introduced late in 1972, the 4-bit microprocessor units were the first to provide the microprogramable parallel processing required in many keyboard and slow-throughput terminal and process-control applications. Indeed, using as few as two devices, like Intel's 4004 CPU chip plus a 1,024-bit ROM, a 4-bit microprogramed dedicated computer could cost less than $50.

Intel's basic MCS-4 system, however, was designed for general applications. Its single-chip CPU performs all control and processing functions and interfaces directly with ROMs, which store microprograms and data tables, and RAMs, which store data and pseudo-instructions. This system communicates with input/output devices, found here on each ROM and RAM chip. In addition, a 10-bit parallel shift register is provided to expand the system's I/O capability. Thus just four chips are needed for complete microcomputer capability.

Even this relatively simple 18-pin 4-bit package provides up to 45 instructions, cycling in 10.8 microseconds with standard two-phase clock operation. The system can drive up to 4,096 8-bit ROM words (16 chips), 1,280 4-bit RAM characters (16 chips), 128 I/O lines (without a shift register), and unlimited I/O capability with shift registers. And, adding even more to the MCS-4's flexibility and further accelerating the design cycle, the CPU and RAMs may be interfaced with conventional electrically programable and erasable ROMs, allowing fast program development and quick prototype realization.

Equally versatile is Rockwell's 4-bit PPS system, which comes complete with five compatible support circuits: a 256-by-4-bit RAM, a 1,024-by-8-bit ROM, a RAM-ROM combination chip containing a 704-by-8-bit ROM and 76-by-4-bit RAM, an I/O buffer, and a multiphase clock generator (Fig. 2).

The CPU in this system can directly address up to



2. Four bits' worth. In Rockwell's self-contained 4-bit PPS system, versatility is a major design asset. Five compatible elements—CPU, RAM, ROM, a RAM-ROM combination chip, and an input/output buffer—provide up to 4,096 8-bit ROM words and 4,096 4-bit RAM words.

4,096 8-bit ROM words and as many 4-bit RAM data words over its 12-bit parallel address bus. This large number of data words gives this family the capability of a 4-bit minicomputer. The basic instruction set contains 50 instructions, and instruction fetch and execution time is a speedy 5 microseconds.

Apart from power and clock-signal requirements, 21 multiplexed lines interconnect the CPU with ROM, RAM, and I/O circuits. These lines, as shown in Fig. 2, are functionally grouped into 12 parallel address lines, eight parallel data lines, and one write command and I/O enable line. The address lines originate at the CPU and are time-multiplexed within it to provide direct addressing capability for up to 4,096 locations on both ROM and RAM. In addition, the ROM has two chip-select inputs and the RAM has one chip-select input, which may be directly controlled by discrete outputs from the CPU or I/O circuits to expand on memory without the need for auxiliary circuitry.

The move to eight bits

For greater capacity, both Intel and Rockwell are extending their 4-bit p-channel systems to 8-bit capability. The Intel MCS-8 is an 8-bit fixed instruction set and consists of a single MOS chip in an 18-pin DIP. Also on the chip is an 8-bit data/address I/O bus that interfaces the processor with external memories. It contains a total of 14 instructions, which can control a lot of memory and I/O circuitry. It does, however, require substantial TTL circuitry to implement most 8-bit systems, a condition corrected by Intel's newer, very flexible 8080 chip.

Rockwell's soon-to-be-announced 8-bit system is a completely self-contained system. Prototypes will be operational in July, with deliveries to begin late in 1974. The PPS system consists of a CPU, RAMs, ROMs, clock generator, a direct-memory-access controller, and an assortment of general-purpose I/O devices, all of them accessible on the same bidirectional data/instruction bus (Fig. 3). This bus provides 8-bit parallel communication within the computer at a rate of 500 kilohertz—a most important factor for systems savings.

With this setup, more than 90 instructions can be executed in 4 microseconds each, which covers a ROM access for instruction fetch and a RAM access for data fetch, as well as the processing of the data. In addition, the system can be supplemented with special-purpose and custom I/O devices for specific applications. Examples are a 1,200-baud modem device and a keyboard/display controller with independent input and output buffers.

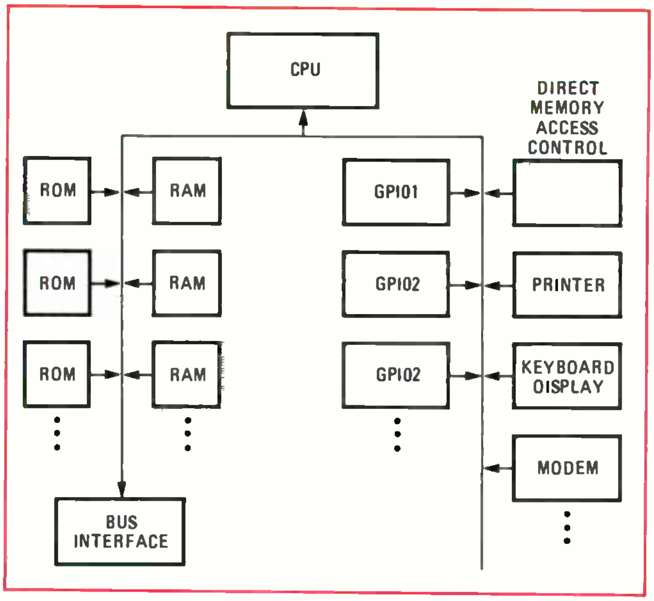
In Microsystem International's 4-bit system, the CPU contains two memory pointers—the usual program counter and a data pointer—which allow logical as well as physical separation of program and data. Both pointers are 12 bits long and can directly address 4,096 memory locations. Each memory location contains 4 bits of data. Up to 34 kilobytes may be addressed over field switching in the typical MC-1 microcomputer.

Even more powerful is National Semiconductor's multi-chip CPCP CPU, shown in Fig. 4, from which National's IMP-16 systems can be built. It can provide computing power that ranges from simple 4-bit keyboard address capability right up through full 16-bit minicomputer capability. In IMP-16 systems, processing is done by four 4-bit arithmetic logic units controlled by microprogramable ROMs. With this arrangement, data exchange happens over a 16-bit-wide data bus, while I/O and control operations take place over a set of 16 general-purpose addressable registers (called FLAGs).

Consisting of a five chips, this CPU is contained on a board along with 256 words of random-access and 512 words of read-only on-card memory. Also available on the card are external interface circuits such as an address bus, data input and output buses, additional control FLAGs, system timing lines, and an interrupt input.

In essence, the IMP-16, which is expandable to 32 bits, is composed of four 4-bit ALU slices, each with control registers, ALU logic, and I/O data lines. The control ROM contains all control logic and microinstruction storage necessary to control the ALU chips. A total of 43 instructions is available though, if one considers the multiplicity of branch conditions, I/O FLAGs, and general-purpose accumulators in the system, the effective instruction count comes to well over 150. (For smaller systems, National now also provides 4-bit and 8-bit versions of the IMP-16.)

The microprocessors now appearing from a good



3. Twice four is eight. This 8-bit microprocessor chip set, which also is fabricated by Rockwell, contains more than 90 instructions with 4-microsecond execution times. All of the components shown work directly off the CPU.

many semiconductor manufacturers take full advantage of the knowledge gained in the past two years and incorporate those features that have proven most effective for the greatest variety of applications. What is obviously wanted is a single-chip 8-bit CPU device, offering 70 instructions or more, at speeds above 1 megahertz, with an extremely flexible input and output structure, and requiring only a few support memory and logic circuits to do most 8-bit jobs. Above all, these support circuits must be easy to use—that is, work directly with the CPU without requiring additional buffers and power supplies. Moreover, the CPU must be able to work directly with standard memory products. This adds up to a need for a self-contained 8-bit microcomputer set of chips—one CPU, and maybe five or six matched memory and logic hang-on packages.

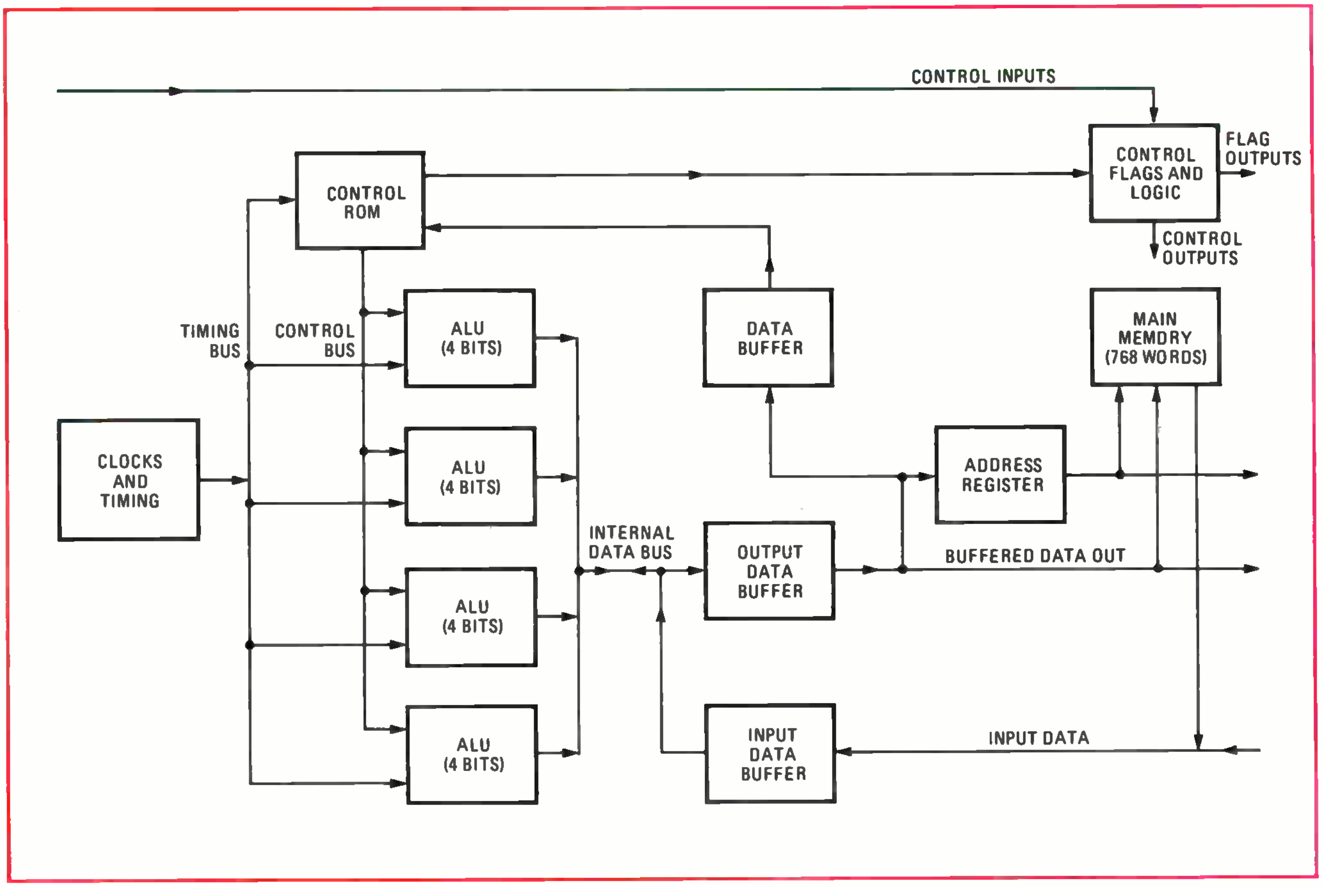
The new generation

To build them, most manufacturers have settled on n-channel technology because it can pack many memory and logic structures onto one CPU chip, provides high capacity, and operates at high speed from 5-V (TTL) power supplies. Since the new n-channel memories would be directly compatible with such CPU chip, ease of use falls out automatically.

Besides the 8-bit n-channel microprocessors that have already arrived from Intel and Motorola, standard n-MOS products are being planned by Texas Instruments, American Microsystems, Signetics, National, Fairchild, General Instruments, and Western Digital. Rockwell and MOS Technology Inc. are staying with p-channel, and RCA has already announced a C-MOS microprocessor prototype.

The Signetics device, called PIP for programable integrated processor, is a single-chip 8-bit unit in a 40-pin DIP. The customary address logic, control memory and ALU are organized around a bidirectional 8-bit data bus, and there are also 15 address lines for handling external memory and I/O circuitry. In the PIP device, the address logic handles all instructions. It also includes a return address stack that lets eight subroutine levels be stacked.

As for RCA's C-MOS microprocessor, the two-chip 8-bit design has all the advantages that C-MOS circuits offer. (A single-chip version is under way.) It can operate off power supplies providing anywhere from 5 to 15 V, it



4. Sixteen-bit systems. The block diagram of National Semiconductor's IMP-16 microprocessor system shows that the system is made up of four 4-bit ALU slices with control registers, ALU logic, and I/O data lines. Altogether 43 instructions are available.

has high noise immunity, and it dissipates power at the microwatt level. Needing so little power and being easy to use, the chip set will be particularly useful for low-cost high-volume applications, and the C-MOS process could make it especially attractive for use in cars.

The microprocessor will come in a 40-pin package and can be used with any mixture of RAM, ROM, and peripheral I/O circuits. It is capable of addressing up to 65,536 8-bit bytes, so that quite large and flexible processing systems could be implemented, even though it has only 25 instructions. What's more, when operating from a typical supply of 10-12 V, the machine cycle time is a respectable 3 microseconds. And using a standard 1-microsecond RAM, the chip set has a maximum 6-μs fetch-execute time for any instruction.

Another manufacturer favoring C-MOS for microprocessors is Intersil, which is developing a 12-bit single-chip CPU to work with its C-MOS and n-channel memories. Intersil chose a 12-bit structure so that designers could use software programs that already exist for PDP-8A systems—and in fact, when combined with appropriate memory and I/O hang-ons, the 12-bit unit can perform all the MSI functions of the PDP-8A minicomputer but needs only a fraction of the packages.

The implications of all this activity are tremendous. Indeed, many observers feel that the MOS microprocessor families now just emerging will have a bigger impact on the electronics industries than any other semiconductor device has had so far. Quite soon, too, improved LSI structures should result in single-chip microcomputers combining the CPU, I/O, and memory in one LSI device. Moreover, the same sort of excitement is being generated around the bipolar LSI processor work that's now a priority in many semiconductor laboratories; for that technology, too, points to full-instruction minicomputer capability on a few LSI chips, but at even faster speed.

The next two articles take a look at the first two n-channel microprocessors—Motorola's M6800 chip set and Intel's 8080 chip. Both are second-generation devices, offering high speed, ease of use, and flexible control capability for many new applications. □

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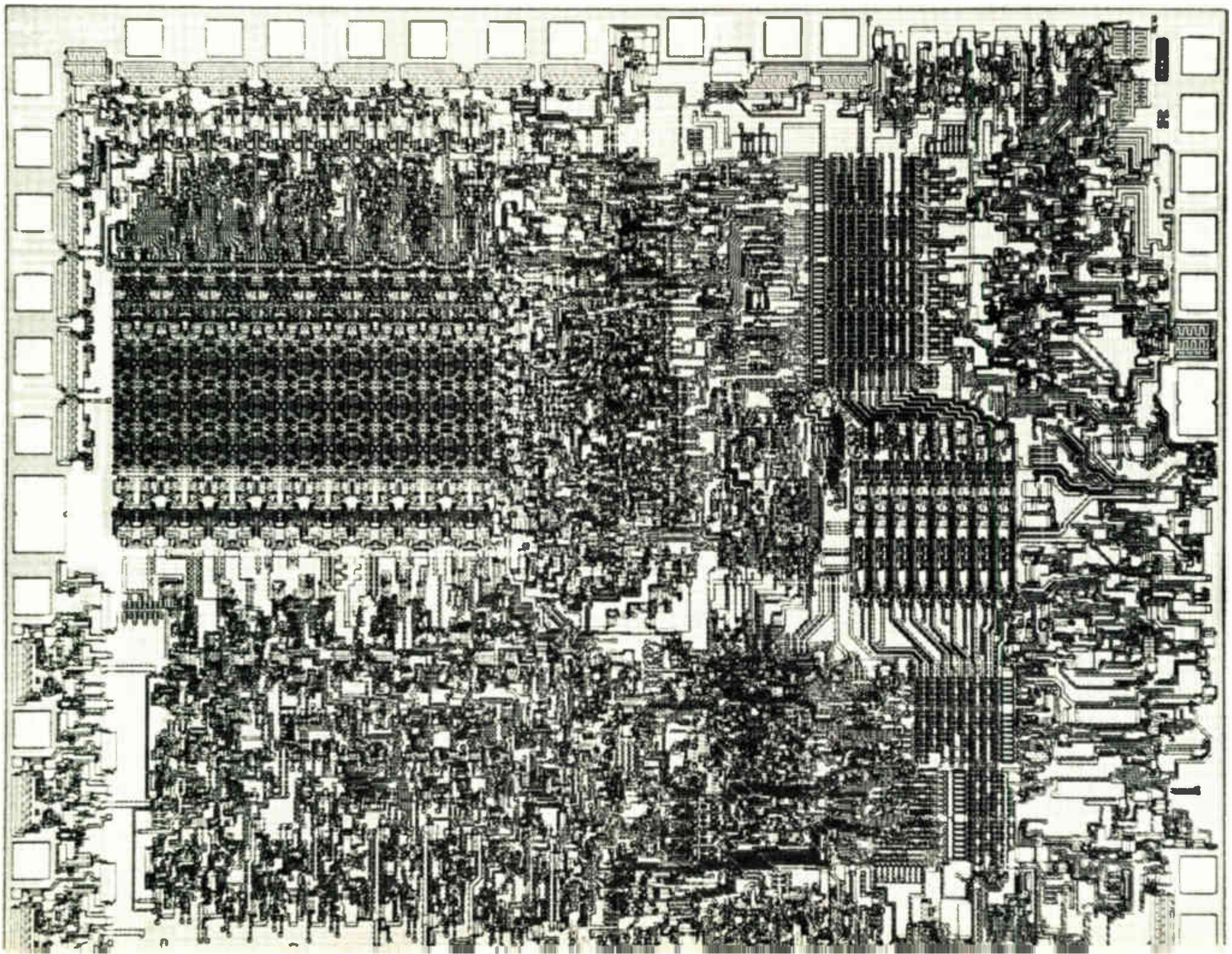
5. The rising generation. N-channel silicon-gate technology is bringing enlarged capacity, great versatility, and high speed to today's new microprocessor chips. This Intel 8080 CPU offers altogether 78 instructions in an 8-bit system.



N-channel MOS technology yields new generation of microprocessors

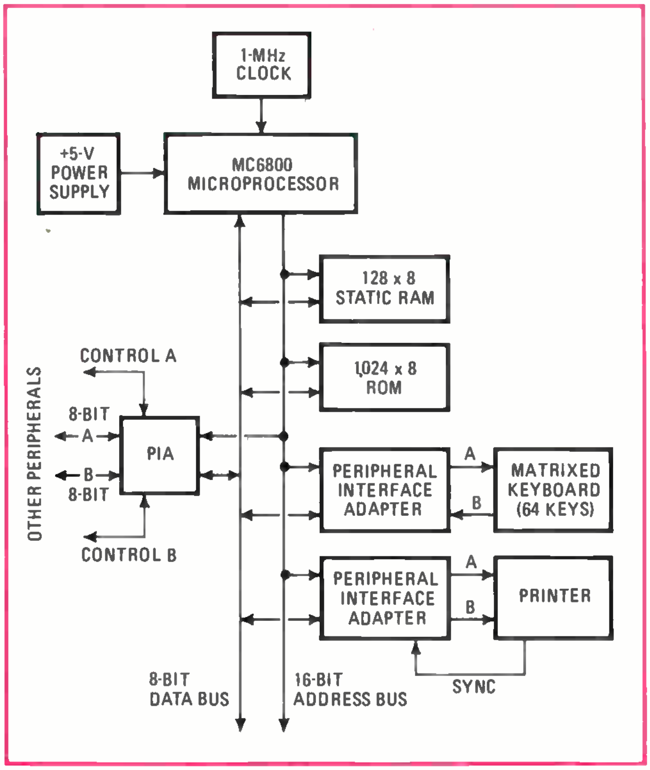
The latest microprocessor chips are faster than p-MOS devices and handle many more peripherals; often, too, as in Motorola's M6800 family, a CPU chip will come in a matched set of memory and input and output chips, simplifying system production

by Link Young, Tom Bennett, and Jeff Lavell,
Motorola Semiconductor Products Inc., Phoenix, Ariz.

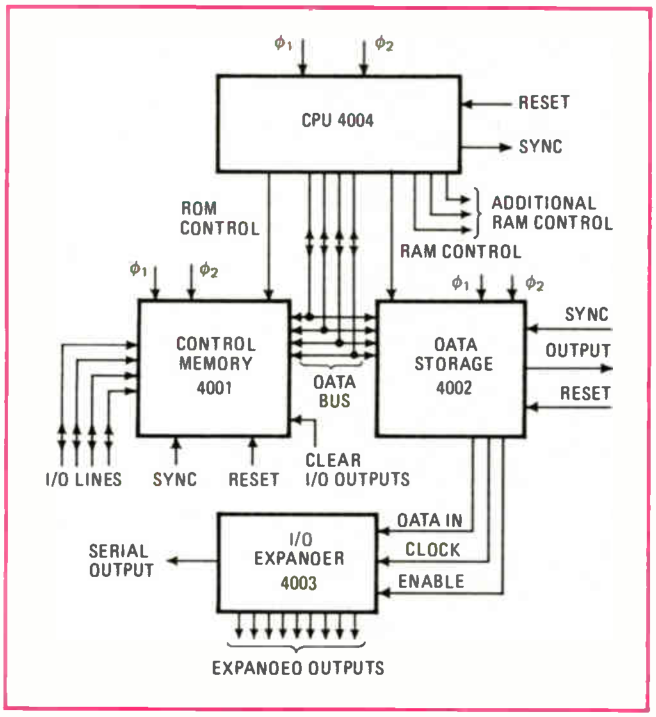
☐ The great promise that programable LSI circuits have for all kinds of control applications is fulfilled in the second generation of microprocessors, such as Motorola's and Intel's 8-bit devices. These new n-channel MOS chips have many more instructions and need much less in the way of costly systems circuit support than did the first wave of 4- and 8-bit p-channel systems. Their level of computing power is also high, and they are versatile and easy to use.

The n-channel metal-oxide-semiconductor microprocessors are completely self-contained. They are designed to work directly with a minimum number of memory and peripheral support chips, all of which are supplied in coordinated families to allow them to operate off the same voltage and power-supply conditions as the central processor chip.

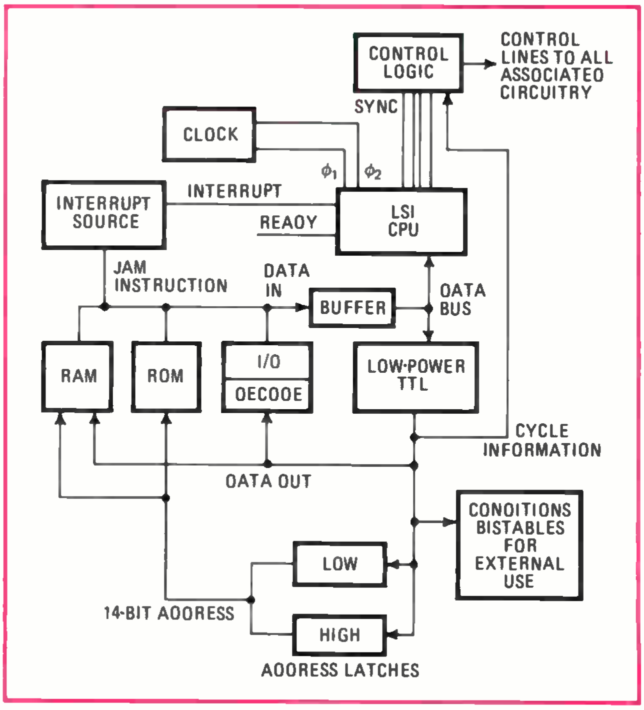
A typical set contains the CPU chip, a random-access memory for fast scratch-pad logic control, a read-only memory for storing the system's program parameters, and a set of input and output chips. These input/output chips enable the CPU to control a large variety of industrial and communications equipment: process and manufacturing control systems, peripheral and terminal hardware, parameter-control systems of all types—from microcomputers in the automobile to control systems



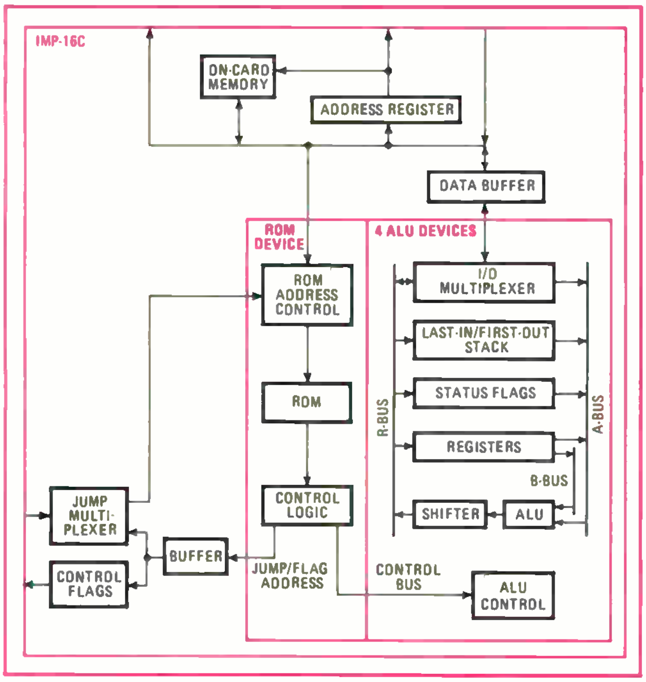
1. Eight-bit family. Motorola's M6800 family of components is organized around the concept of the parallel data bus. Consequently, all memory and peripheral interface adapter (PIA) chips are simply designed to hang on its CPU's eight bidirectional data lines.



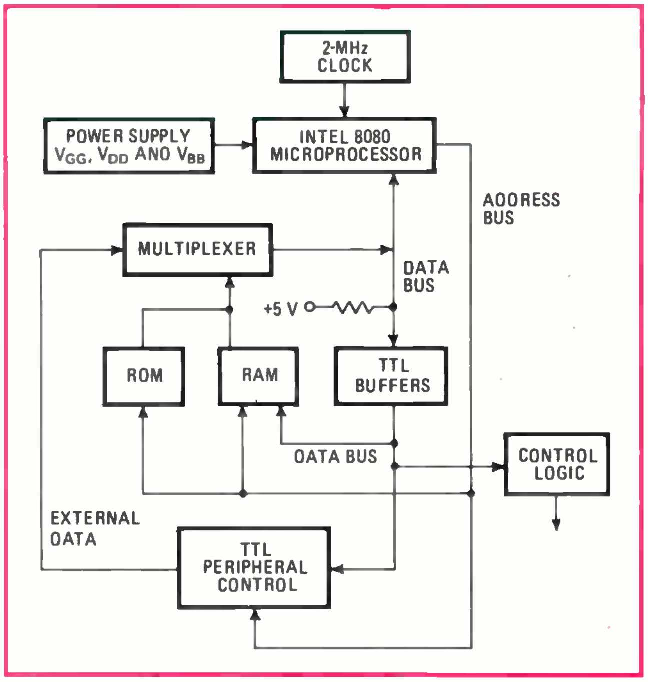
2. Basic computer. One of the first microcomputer chip sets to have been fabricated comes from Intel. Called the MSC-4, it consists of four simple LSI blocks and provides 45 instructions with an instruction cycle time of 10.8 microseconds.



3. Heavy duty. The first 8-bit microcomputer system, Intel's MSC-8, can interface with over 16,000 8-bit words of read-only, random-access, or shift-register memory. Its drawback: substantial external circuitry is needed for most applications.



4. Sixteen bits on a board. National's IMP-16 architecture supplies a full 16-bit minicomputer capability on a single pc board. Microprogramable ROMs control the four 4-bit arithmetic logic units that do the processing. Four- and 8-bit versions are also available.



5. Straightforward. The new n-channel microprocessor chips make designing microcomputers simply a matter of choosing a family of matched components. This Intel 8080 system, for example, requires only a half a dozen standard products.

for traffic lights—and anywhere else that random-logic computer control needs optimizing.

These second-generation n-channel units expand considerably on the system benefits offered by the first microprocessors. Over 70 instructions may be available, as against about 40 for the largest p-channel unit. As few as four packages are required to build a complete 8-bit microcomputer. Moreover, in the Motorola family, the M6800, TTL compatibility is achieved with only a single +5-volt power supply, instead of the usual three supplies. Therefore, board space, package count, and component costs are reduced, even while system capacity is increased.

Other benefits to the system

Consequently, as with all microprocessor system designs, board layouts are simplified. The complex interconnections required for large numbers of conventional ICs are replaced by ROMs. The only interconnect wiring on printed-circuit cards runs between the various address and data buses and input/output devices.

The cost savings are not limited to direct circuit component costs but they extend to other, related, system hardware costs. Connectors can be decreased in number, cabling can be simplified, the card cage can be reduced in size, and so on. Associated indirect costs also fall, of course, since assembly takes less time, documentation is simpler, and maintenance is easier.

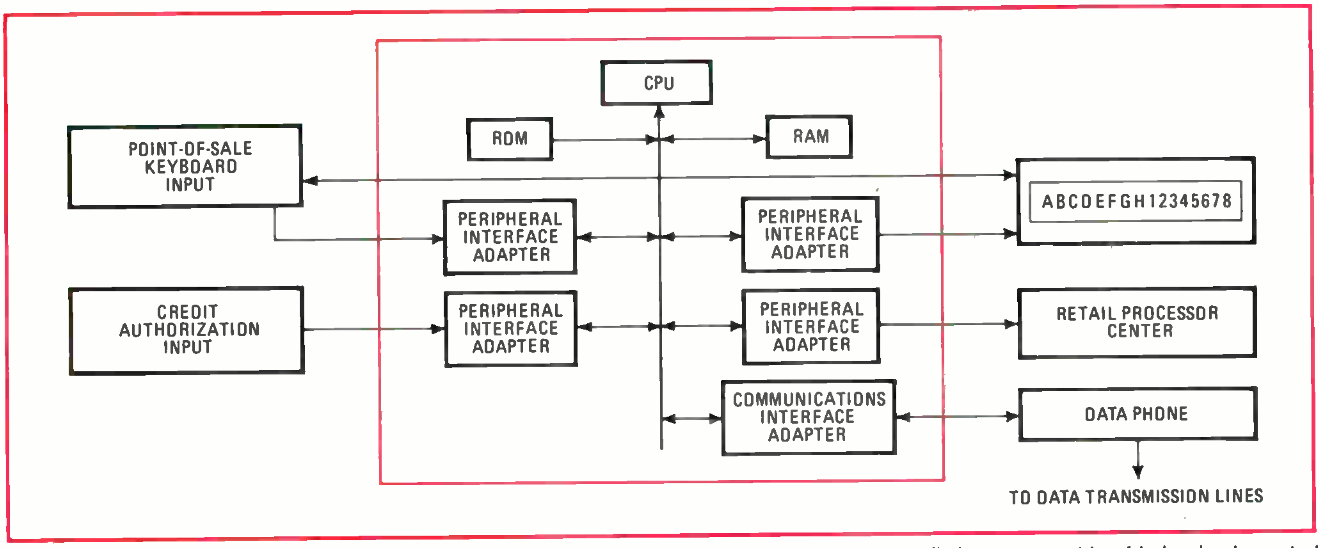
Equally important to cost savings in hardware systems is the ability of system engineers to build a proposed design quickly. No hardwire logic need be simulated, optimized, or breadboarded. The logic design portion of the cycle now becomes the manipulation of functional building blocks, where the control sequence takes the form of writing a software program into an external ROM. Breadboarding consists of interconnecting a few LSI packages.

Design changes, too, are simply a case of modifying the control program, in contrast to designing and laying out the logic afresh. The various microprocessor manufacturers offer the use of simulators, so that most of the design can be verified even before it is committed to hardware. This all cuts at least 90% from the design time.

The numerous instructions and system versatility despite the very few packages stems directly from the organization of the new CPU chips. For example, the MC6800 chip is organized around the popular parallel data bus concept (Fig. 1), so that all the memory and peripheral interface chips simply hang on the MC6800's eight bidirectional data lines (16 address lines are provided). Up to 10 LSI chips can be directly attached to the bus for operation up to 1 megahertz. To drive still more peripherals, a bipolar extender can be added.

This direct access to a variety of interface and peripheral equipment, obtained with a minimum of packages (see "The M6800 microprocessing family," p. 92) is a tremendous advance on many of the early microprocessor chip families—even though the first single-chip microprocessor was introduced just two years ago.

Intel's MCS-4 and MCS-8 and Rockwell's PPS-4, which all used p-MOS silicon-gate technology, were excellent starting points, in that they were self-contained sets of circuits requiring no external logic. In the 4-bit MCS-4, for example, the CPU, random-access memory, and read-only memory interfaced optimally as a set (Fig. 2). However, these first microprocessors had major limitations. Selecting correct memory locations required complex address logic: 12-bit addresses needing three 4-bit words had to be multiplexed onto the CPU's input



6. Selling well. With microprocessor design techniques, systems such as this point-of-sale installation are capable of being implemented with only five or six circuit blocks, which are designed to work directly with the basic CPU family.

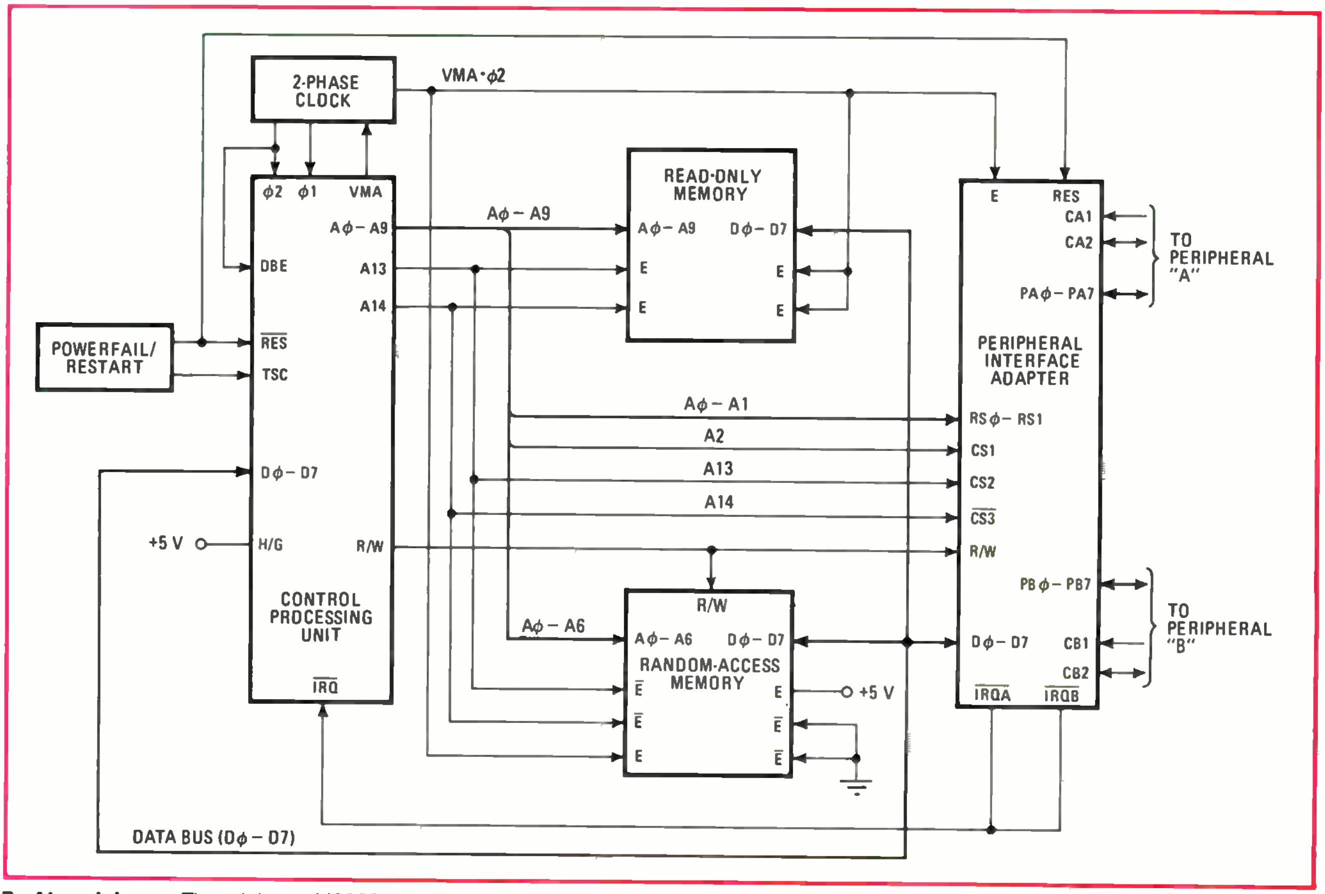
matrix. All instructions operated on complex 4-bit data signals, as did even simple word fetches for each instruction. Still more restrictive was the fact that input and output access was serial, not parallel, limiting the number of peripherals that could work with the CPU. Instruction speeds were also slow—it could take 80 microseconds to execute one—and power-supply requirements were complex and costly.

For larger systems, the 8-bit MSC-8 microprocessor chip set (Fig. 3) could be used, but it was not a self-contained system, requiring external TTL for any application. It was, however, quite powerful: the 8008 CPU of that system can interface with 16,384 8-bit words of read-only, random-access, or shift-register memory. It was also quite economical to build: all communication between functional units and the CPU is carried out over the single 8-bit data bus, a sync line, a ready line, an interrupt line, and just three status lines. Its low cost, together with its respectably fast instruction execution time of 12.5 microseconds, makes the 8008 microprocessor still very useful for moderate-performance systems in point-of-sale terminals, credit-card verifiers, calculators, and other keyboard-addressed applications.

It does, however, fall short of being a useful general-purpose microprocessor chip set, primarily because, unlike its 4-bit predecessor, the MCS-4, it is not a system of compatible parts. Indeed, it requires many small-scale packages to build even a moderately powerful system—a simple modem hook-up would need about 50 TTL packages, increasing circuit board area and systems costs.

Another problem is addressing it. True, its 18-pin package saves board space, but it must be multiplexed both for address and data on common input/output pins, which in the end lengthens excessively the time it takes to execute an instruction. Not only that, the need for seven control registers on the CPU chip makes it difficult to manage the logic cycles, limiting subroutines and creating problems in programing and interrupt handling. Finally, its outputs are compatible, not with standard TTL, but with rarely used low-power TTL, so that circuits are needed to boost voltage level in most applications.

Most of these problems were overcome with National Semiconductor's IMP-16 (Fig. 4), a 16-bit microprocessor set that for the first time provided full mini-



7. At a minimum. The minimum M6800 system configuration contains four functional blocks but can be expanded to 10 modules of memories, I/O adapters, and even additional CPUs on the same data bus with no external interface packages.

computer CPU capability on a single board. Designed to operate on both ends of the MCS-8 performance curve, this p-channel microprocessor unit is central to a family of systems with typical execution times of 4.5 to 10 μs for a system and 9 to 18 μs for a 8-bit system. Although it gained wide strong acceptance for many 16-bit mini-computer applications, it has been less used for 8-bit systems because the designer is forced to use micro-programing—a far more complicated task than the programing techniques required for any of today's 8-bit microprocessors. (Because of this, National has now designed 4-bit and 8-bit versions of the basic IMP system.)

The problem then from a design point of view is how to incorporate the maximum system flexibility into an 8-bit unit, make it self-contained, have it offer a large variety of instructions, but nevertheless require the fewest possible external parts. Motorola's newly announced MC6800 microprocessor set and Intel's 8080 are examples of just such a system (Fig. 5). Using implanted n-MOS silicon-gate technology instead of slower p-MOS and operating from a single clock, each is based on a single 40-pin package containing a CPU chip that's far more versatile than previous microprocessor products. (For details of the 8080, see pp. 95–100.)

The M6800 family

The M6800 microprocessor set incorporates many of the qualities of the 8080, but exhibits additional flexibility because it requires fewer external circuits to implement most control and communication systems. The fact that the family can operate from a single +5-V power supply immediately reduces system cost by about $20 over a typical 8080 system, which needs three power supplies. What is more, the peripheral memory and input/output logic adapters, instead of needing external logic packages, have been designed so that they

The M6800 microprocessing family

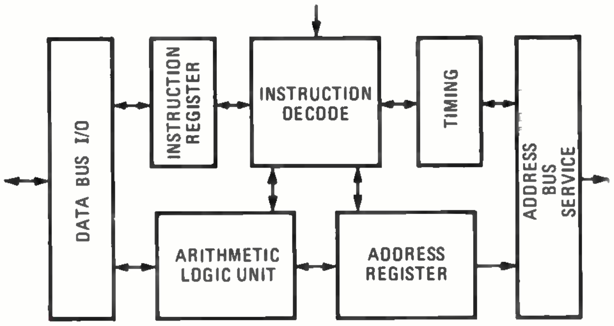
The family comprises five chips: a single-chip central processor unit, a 128-by-8-bit static random-access memory, a 1,024-by-8-bit read-only memory, and one from each of two groups of input/output interface circuits—a peripheral interface chip designed to provide a buffer to terminal and peripheral systems, and a communications interface adapter circuit for interfacing communications hardware. They all operate from one 5-V power supply, and for many applications require far fewer interface packages than other microprocessor sets.

Basis of the M6800 family is the CPU chip (MC6800) packaged in a 40-pin DIP (see figure). Built with ion-implanted, n-channel silicon-gate technology, this chip contains all the functions required for multi-instruction processing: an arithmetic and logic unit, instruction decode and address registers, an instruction register, all of the clock and logic circuits required for timing, and a full complement of data-bus input and output matrices and address bus drivers.

The equivalent of about 120 MSI TTL packages, the chip provides 72 self-contained basic instructions that have decimal and binary arithmetic capability. The variable-length instructions include double-byte operations (such as increment or decrement, load, store and/or compare) and have tri-state outputs, two-accumulator capacity, and enough registers to provide seven addressing modes. A typical instruction time is under 5 microseconds, and there is direct memory access on the chip. Up to 64 bytes of memory can be addressed in any combination of RAM, ROM, or peripheral registers.

All other members of the set (see table) have been designed specifically to work directly with the CPU chip from the same 5-V power supply. The peripheral adapter (MC6820) is a bidirectional unit with two parallel 8-bit outputs that can either drive two peripherals or, if tied together, provide a higher throughput. The adapter can interface with Teletype and display terminals, with cassettes and test equipment, with keyboards and control panels, and even with large computers for time-shared expansion of computer capability.

The communications interface adapter (MC6850), on the other hand, couples the processor to most standard modems for communications with other computer systems via telephone lines. For still more system flexibility, it's possible to use without adapters not only the static RAM and ROM in the table but other memories, too.



MICROPROCESSOR

MICROCOMPUTER FAMILY OF CIRCUITS
8-bit microprocessing unit
128-by-8 static random-access memory
1,024-by-8 read-only memory
Peripheral interface adapter
Asynchronous communications interface adapter
0–600-b/s low-speed modem (compatible with Bell 100 series)
Quad, bidirectional data/address bus extender

can work directly with the chip containing the CPU.

The smallness of the package count is dramatically illustrated by the comparison of the breadboard, engineering model, and final chip design of an MC6800-type CPU (see photograph on p. 82). The breadboard, a gate-to-gate implementation of the CPU employing basic gates and flip-flops, needs five 10-by-10-inch boards containing 451 packages. The engineering model is a functional implementation of the design and made extensive use of MSI logic packages and programable ROMs to reduce package count to a mere 114, packed into a single 10-by-10-in. board by means of today's most effective hardwire logic techniques. Yet all this is replaced by the single 40-pin package containing the CPU chip. The example epitomizes the impact LSI chip design is having on the implementation of complex computer functions.

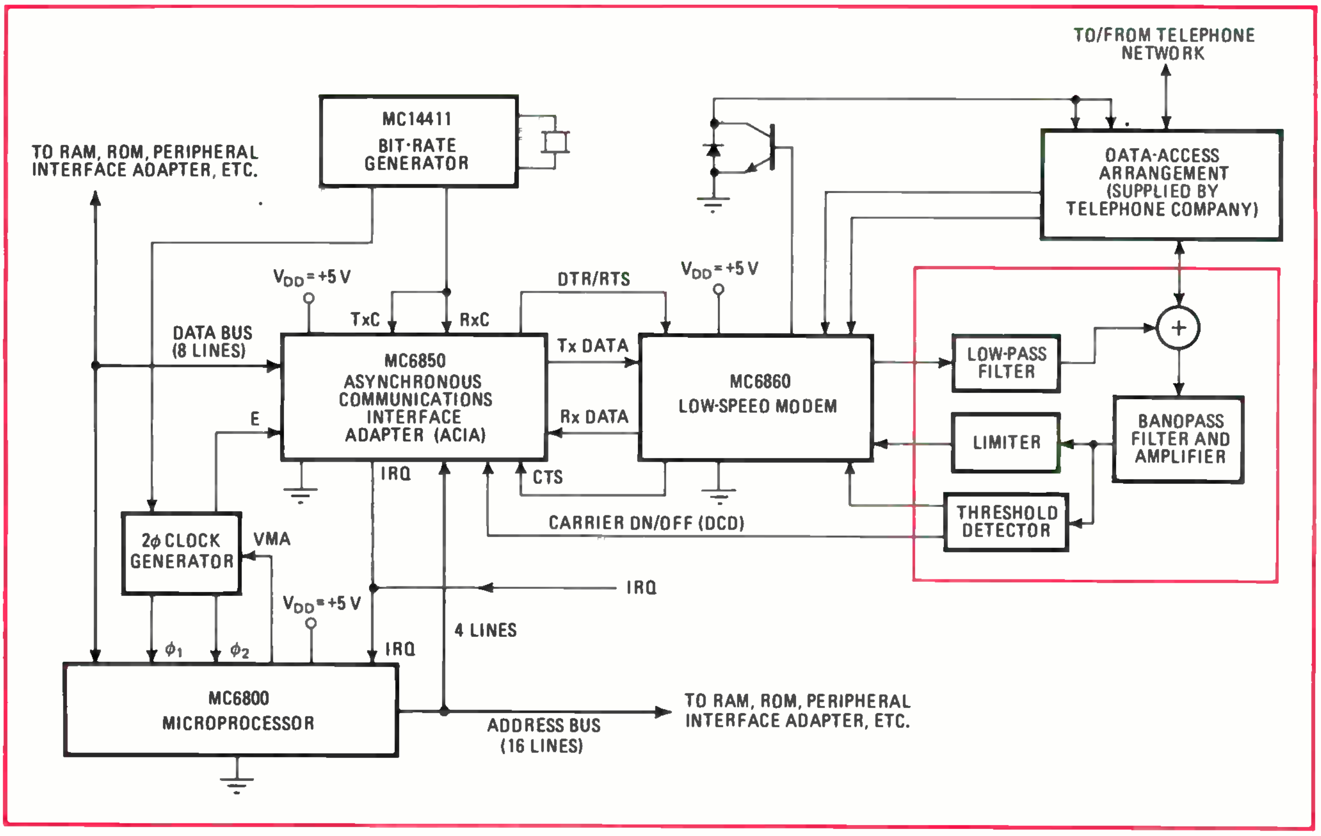
The new n-channel microprocessors go still further, by addressing themselves to other parts of the system as well. For the families of circuits are designed to minimize assembly costs by reducing the number of ancillary parts necessary to realize a design.

Consider the block diagram of a typical small terminal, a generalized point-of-sale terminal (Fig. 6). Since every CPU needs several peripheral interfaces, one key to cost-effective designs with a microcomputer lies in the input/output interface.

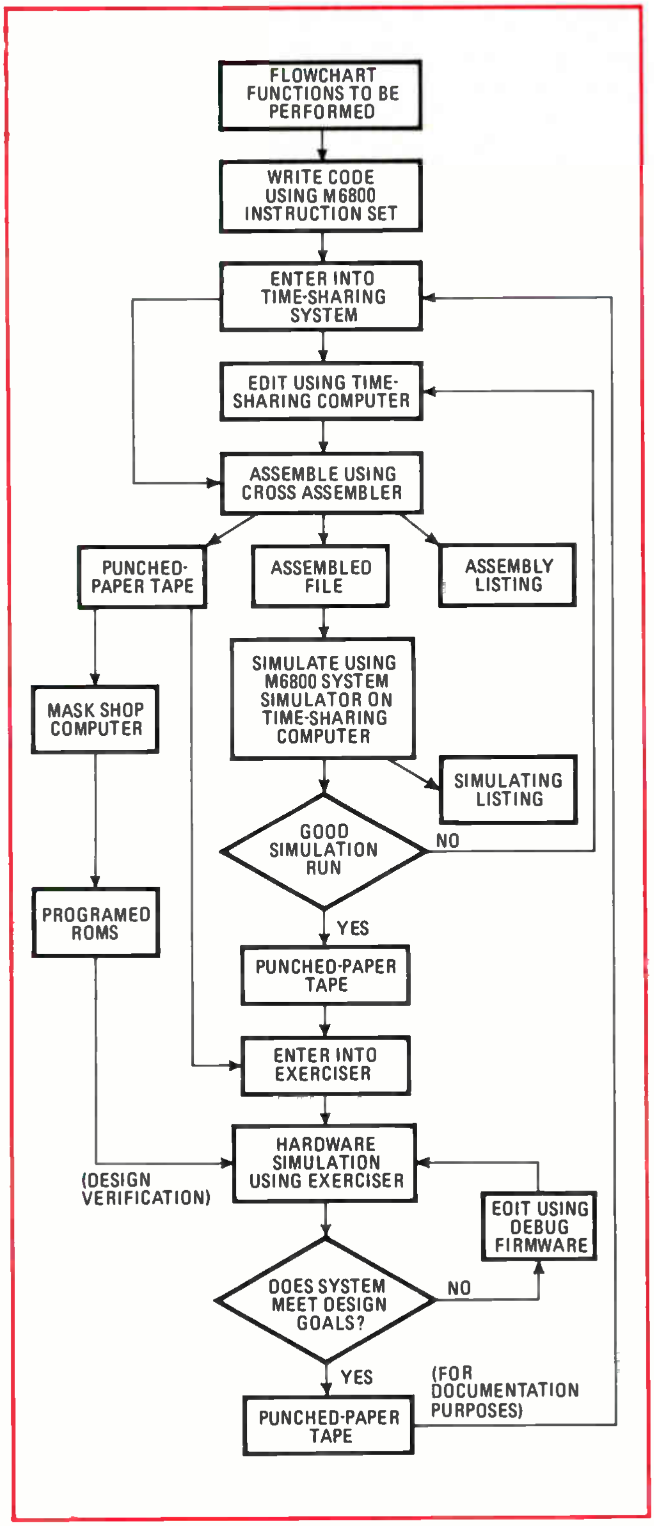
Indeed, anything that has to interface with a microcomputer ought to be compatible with the data-bus arrangement and with the particular addressing scheme. Moreover, this bus-compatibility requirement holds good for not only in the input/output area but in the memory area as well. Consequently, since a microprocessor is a word-oriented system, more and more word-oriented memories are beginning to appear.

The M6800 family is directed at just these system needs. It includes flexible input/output adapters and word-oriented memories, in addition to the basic microprocessing unit, as indicated in the minimum system configuration of Fig. 7. This system can maintain its 1-MHz level of operation even when expanded to 10 modules (memories, input/output adapters and additional CPUs) on the principal data bus, with no external interface package.

In order to handle applications that require 1-MHz operation with more than 10 modules on the data bus, bus extenders are provided. For systems that do not require 1-MHz operation, up to 30 modules can be added to the data bus without requiring bus extenders—for example, more than 20 modules can be added to the data



8. Communicating. A boon for communications systems, this microprocessor setup can be implemented using standard communication interface adapters (CIAs). These adapters' function is to give the CPU system access to any standard modem.



9. Working up the software. This design sequence, which is organized for ease of use with the GE time-sharing network, allows the designer to enter his specific program, which is then simulated on a cross assembler resident in the GE computer.

bus in a design for a typical 500-KHz control system.

Another example of how few packages are necessary with microprocessors is given by a typical modem communications system (Fig. 8). Here the asynchronous communication interface adapter performs the basic serializing/deserializing function required to interface the modems with the CPU. It also provides such additional logic capability as start, stop, and parity compensation. It can be used with a line driver/receiver for high-speed data transmission up to 5,000 bits per second, or with standard modems like the single-chip Bell 100 Series low-speed modem. Significantly, the 116 TTL and modem packages formerly required by this system are here replaced by only seven packages. The assembly costs alone are reduced by as much as two thirds.

Using the microprocessor

Most microprocessor manufacturers supply the software required to program their devices in a form usable with readily available computer systems. The software programs for the MC6800, for instance, are currently available on the ubiquitous GE time-sharing network. A designer might use them in the sequence shown in Fig. 9. Working with the GE edit program, the designer enters his specific applications program, which is simulated on a cross assembler resident in the same host computer. The cross assembler checks for obvious errors and violations and indicates them to the designer.

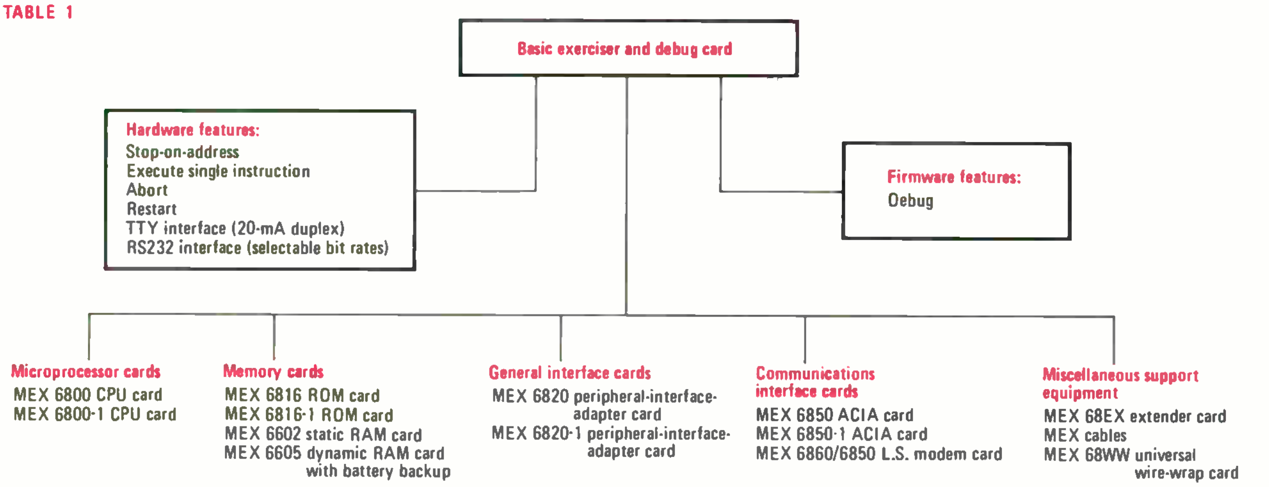
After the program has been assembled, the designer has two choices—to go to hardware directly, or to simulate his system by making use of the large GE host computer containing all the parameters of the particular system. If he chooses to simulate and his program works, he can then go to the hardware stage. If his program does not run, the simulator will pinpoint his problem areas, and he can modify his program and go through the loop again. This process can be continued until the designer is completely satisfied with his program.

In addition, exercisers, hardware, and programs are provided by many manufacturers to verify breadboard operation. In the system that is described in Table 1, the designer chooses the cards required to breadboard his system, plugs them into the machine, cables the input/output cards to his various peripherals, reads his program in through the TTY, or equivalent, network that interfaces to the debugging card. His program is contained in the read/write memory until it is debugged.

Then, in the debugging stage, a panel switch enables the flexible RAM to look like the appropriate ROM. If his program does not run, the exerciser will help him find out why and enable him to modify the program.

It's estimated that exercising aids like the off-the-shelf software and the Motorola Exerciser can save the designer from six to 12 man-months by providing him

TABLE 1



with a convenient method of communicating with the microcomputer.

Systems that are based on microprocessors are cheaper to manufacture, require shorter design cycles—and are also easier to modify or upgrade. The personality or function of the system, being determined by a master control program stored in a memory, is changed simply by modifying that program.

In the case of market testing, systems can be adapted in the customer's own environment to meet his needs better. For the first time a manufacturer has the capacity to make his product smarter and add features at any instant simply by expanding his master control program. A whole range of products becomes potentially available by simply adding LSI modules with their associated features.

System flexibility mostly depends on the new type of memory used, and here the choice is rich. For example, an inexpensive, volatile read/write buffer memory could be used in conjunction with a cassette or a floppy disk for very low-cost systems requiring moderate speed. For faster systems, such as modem interfaces, ROMs, programable ROMs, or even dynamic RAMs with battery backup could be used. In this area, the emerging 4,096-bit RAMs appear to offer the best speed/cost tradeoff. □

In switch to n-MOS microprocessor gets a 2-μs cycle time

Intel's 8-bit successor to its 4-bit p-MOS CPU chip has 30 extra instructions, is 10 times faster

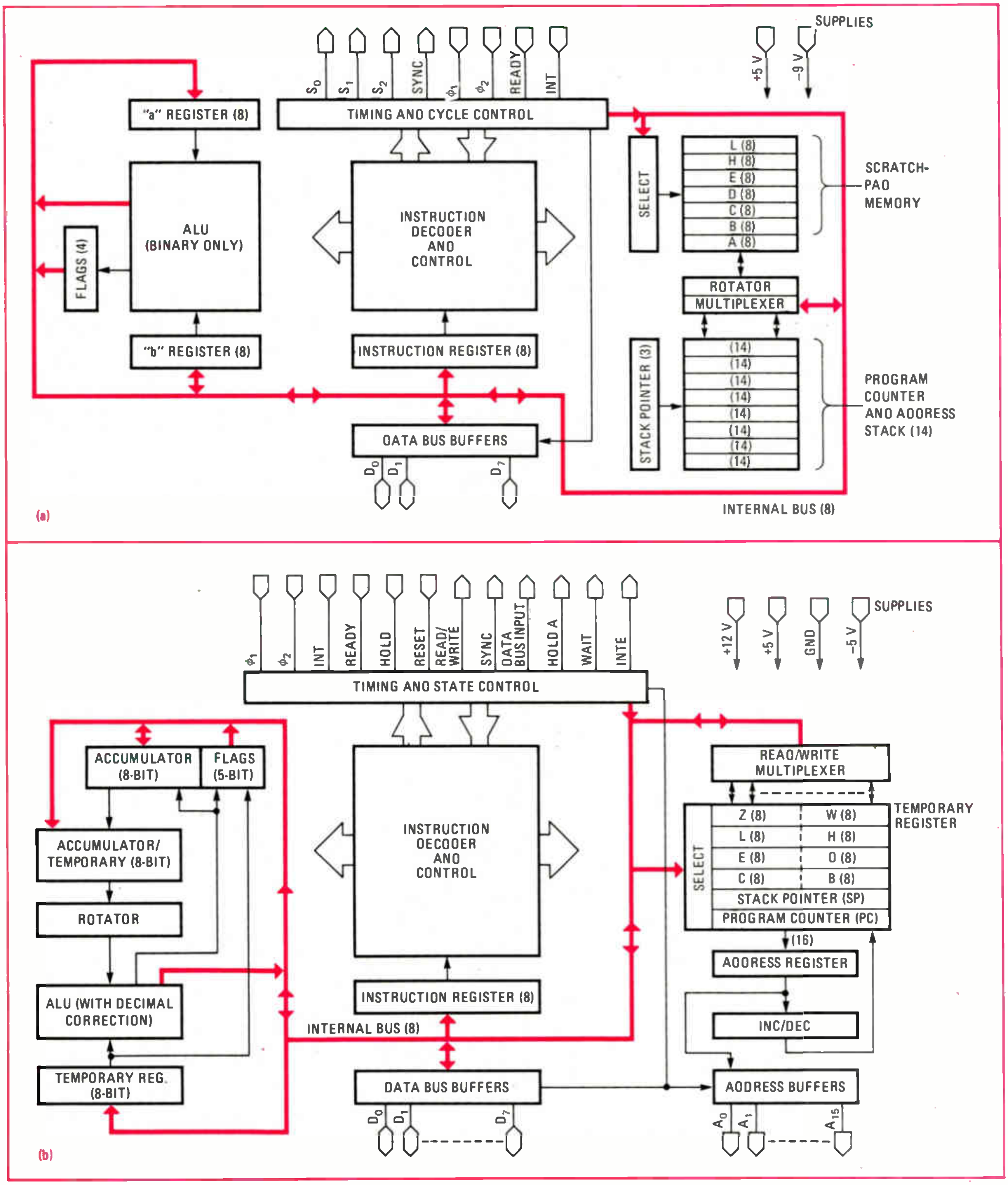
by Masatoshi Shima and Federico Faggin, *Intel Corp., Santa Clara, Calif.*

□ The first microprocessors borrowed many desirable architectural features from minicomputers—but not their speed. The 8-bit Intel 8080, however, achieves typical execution times of 2 microseconds, which are comparable to those of many of today's minis.

In so doing, it improves on the speed of its predecessor, the Intel 8008, by an order of magnitude or more, and, since it also adds 30 new instructions to the 48 shared with the 8008, it can be considered the start of a second, more powerful generation.

The key to both improvements is the shift from the 8008's p-channel MOS technology to n-channel MOS. Indeed, the decision to develop the 8080 was taken about 18 months ago, as soon as high-volume production of silicon-gate n-channel devices was feasible. The goal was a single-chip central processing unit (CPU) compatible with but markedly superior to the earlier 8008. The 8080's characteristics were to include:

- A 10:1 speed improvement over the 8008.
- None of the known limitations of the 8008 (such as interfacing problems and lack of multiple interrupts).
- Improved functional capability plus retention of all



1. Comparison. Intel's earlier single-chip microprocessor, the 8008, has a separate scratch-pad memory and address stack (a). In the 8080, these have been combined into the six 16-bit registers (b). The accumulator has been moved into the arithmetic and logic unit, avoiding the use of the internal bus for data transfers between the scratch pad and the ALU during arithmetic and logic operations.

of the various features and instructions of the 8008.

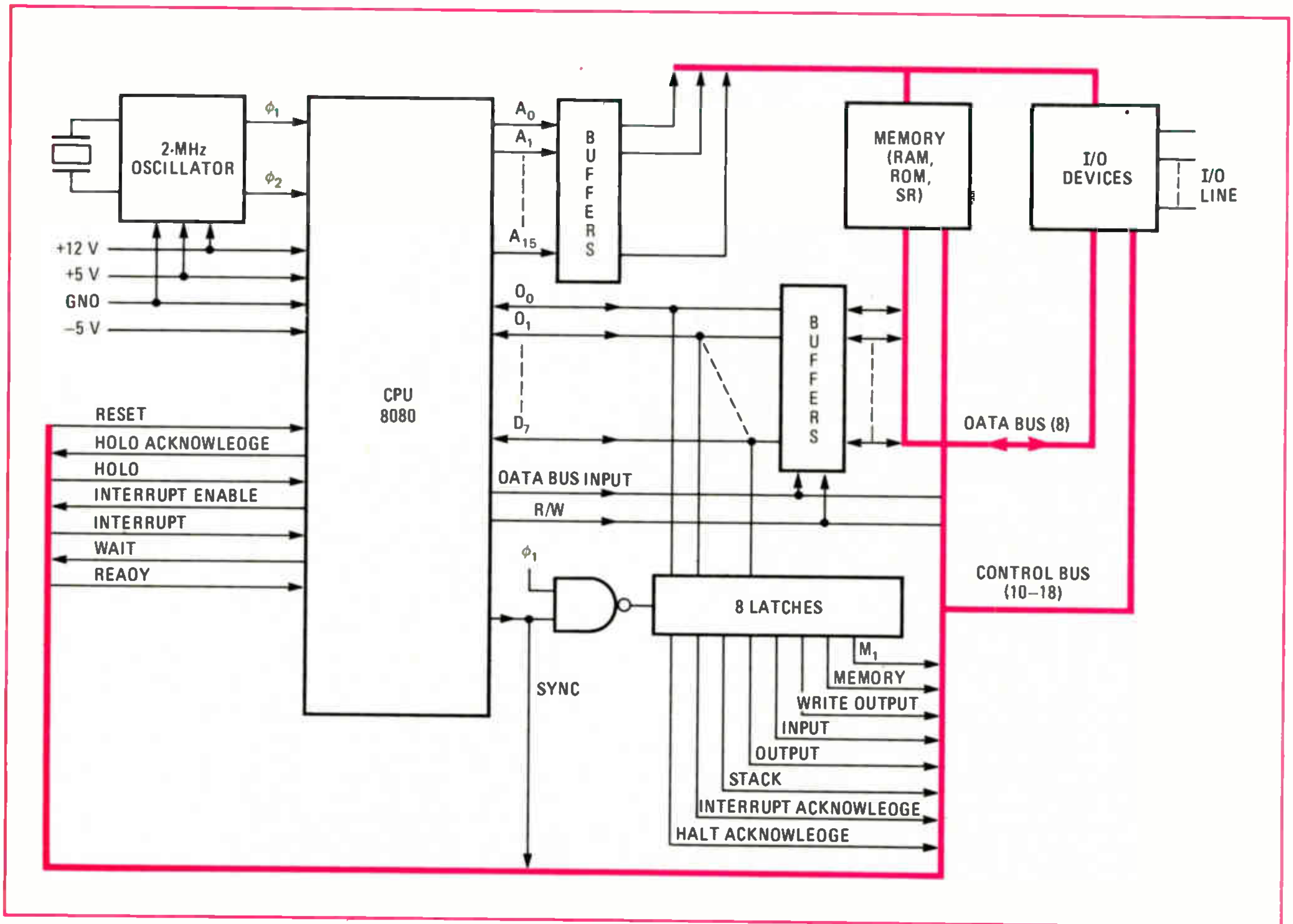
- Economic feasibility—a small chip and conventional packaging.

If the higher mobility of electrons versus holes were the only difference between the n-channel and p-channel technologies, only a 2.4:1 improvement in speed could have been expected. But n-channel's lower threshold allows use of a 5-volt supply for internal logic, with a 4:1 improvement in speed-power product.

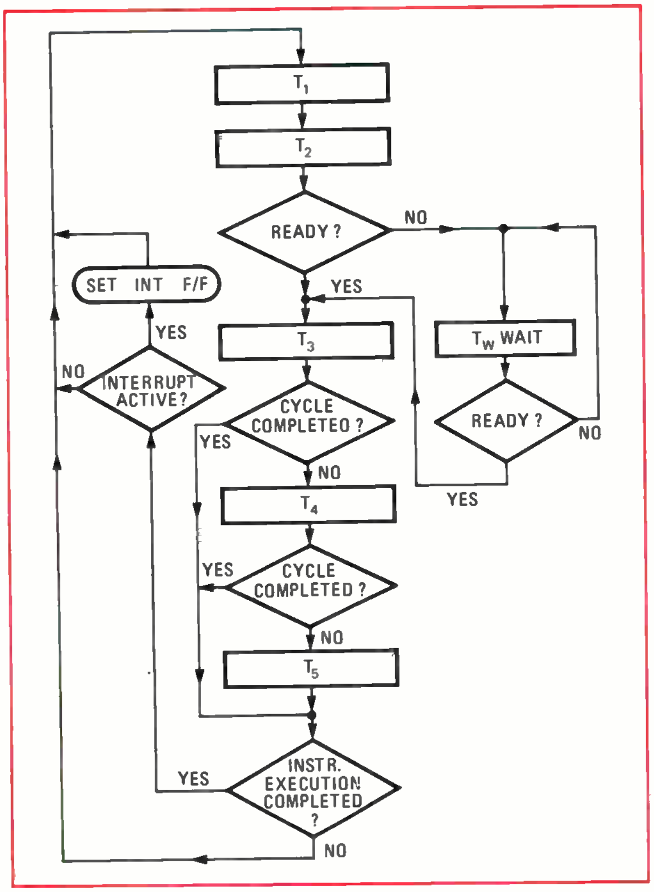
There are other contributions to higher speed. The higher substrate concentration of the n-channel starting material, combined with the lower supply voltage, allows channels to be shorter than with p-channel technology, so that input capacitance is lower and size smaller. Finally, lower junction capacitances and lower resistivities of diffusion and polysilicon areas, which result from the n-channel process and the use of substrate bias, reduce the interconnection time constants by a factor of four—and, in logic circuits of this type, one of the limiting speed constraint lies in the electrical properties of the interconnections.

The interfacing requirements were simplified because n-channel technology allows a big reduction of the power dissipation of individual output buffer circuits, so that the 8080 could be packaged in a 40-pin package to include 30 buffers as against the 12 of the 8008. In the 8008, each output buffer sinks two low-power TTL loads (440 microamperes) for a total dissipation of 250 milliwatts. Eight of the 8008 buffers are shared (time-multiplexed) for addresses and data outputs, reducing the number of package pins but increasing the complexity of the interface. The 8080's 30 output buffers, on the other hand, are six times faster, sink 1.9 milliamperes each, and dissipate a total of 150 mW. The 100 mW saved was used to improve the speed of the internal circuits (a 40-pin ceramic package allows a maximum dissipation of about 750 mW, so the power budget was limited).

The layout effort took 18 man-months because it required great care to minimize parasitics and to optimize signal flow for increased speed and smaller size. The result was a 165-by-191-mil chip that is smaller than



2. 8080 at work. When connected in a microprocessor system, the 8080 requires only six external TTL packages, as against the 20 needed by the 8008. The address bus can access up to 64 kilobytes of memory and up to 256 input and 256 output ports.



3. State diagram. A typical machine cycle requires three to five states. The operation is basically as follows: during T_1, the content of the internal address register is sent to the address bus; during T_2, READY is tested; during T_3, data is transferred between the CPU and memory or I/O devices; T_4 and T_5 are used when necessary to complete the instruction execution; and finally, the circuit goes back to T_1 for the next machine cycle. Only after the last state of the last machine cycle is the interrupt request line tested.

many of today's single-chip calculators. Great effort went into both logic and circuit design minimization, as a result of which the complex functions of the 8080 were implemented in only about 5,000 transistors.

The effectiveness of a CPU can be measured by its execution speed and memory storage requirements for a representative class of practical benchmark programs. The real improvement in performance is highly dependent on specific applications. If the 8080 had only the same 48 instructions as the 8008, it would handle the same problems about eight times faster (and five times faster than the 8008-1, a high-speed version of the 8008). However, with the 30 new instructions, the 8080 offers speed improvements on the order of 10:1 to 20:1 with smaller storage requirements—from 95% to 70% for an equivalent program written for the 8080.

The internal organization of the 8080 is shown in Fig. 1b, while Fig. 1a shows the same detail for the 8080.

The most important change concerns the internal memory organization. The 8008 has separate memories: an address stack—eight 14-bit registers which comprise one program counter storing the current effective address and seven others that store the addresses of nested subroutines—and a scratch pad, which contains the 8-bit accumulator and six additional 8-bit registers used for memory addressing and temporary storage of operands. In the 8080, these memories have been combined into a single internal 16-bit-wide memory with paired 8-bit register organization. The 8080's program counter and stack pointer, also each 16 bits wide, replace the 8008's internal address stack.

The 8008 has an internal 3-bit stack pointer, which gives the user up to seven levels of nesting of subroutines. The 8080's 16-bit stack pointer can address up to 64 kilobytes of external stack memory, providing essentially as many nesting levels as needed.

The 8080's accumulator and its associated circuitry have been moved into the arithmetic logic unit (ALU) section, to speed up the operation of the processor (data transfers between memory and ALU on the internal data bus are therefore not required for arithmetic and logic operations). Notice that the 8080 memory is double-ended—information can be transferred from the internal bus 8 bits at a time, while 16-bit transfers can take place from the address register.

Extra benefits

This organization yields a number of other new features for the 8080. The most important are:

- New instructions allow the contents of any register pair (B-C, D-E, H-L, or ACCUMULATOR-FLAGS) to be quickly stored and retrieved by being "pushed into" or "popped from" the top of the external memory stack. This is a fast way to save the machine status (the contents of the registers) when an interrupt occurs and then restore the status after the interrupt has been serviced. The stack can also be used as an extension of the internal registers.
- Other new instructions allow easy manipulation of addresses and the memory stack, since the registers B-C, D-E and H-L, and STACK POINTER can be incremented and decremented with 16 bits in parallel.
- The temporary register pair W-Z can be used as a program counter to hold a direct address to quickly load or store H-L or ACCUMULATOR. Also possible are double precision additions between any register pair and H-L.
- Fast, parallel transfers of H-L to PROGRAM COUNTER or STACK POINTER are now possible with a minimum amount of internal control logic.
- The addition of decimal correction to the ALU section enables binary and BCD arithmetic to be performed at about equal speeds.
- The addition of many new, easy-to-use control and

The 8080's inputs and outputs

The Intel 8080 takes four control inputs and generates six control outputs:

SYNC—output; a synchronizing signal that indicates the beginning of each memory cycle.

DATA BUS INPUT—output; a signal that indicates when the data bus is in the receiving mode, i.e. when data is expected by the CPU.

READY—input; a signal to the CPU that valid data is available. If not activated, the CPU enters a WAIT state.

WAIT—output; a signal that acknowledges that the CPU is in the WAIT state.

WRITE—output; a signal that tells the memory and output devices that valid data from the CPU is available on the data bus.

HOLD—input; a signal used by an external device to request access to the CPU address and data bus. Request is granted upon completion of memory access and it is acknowledged on the HOLD ACKNOWLEDGE output pin. The CPU address and data buses become floating (in a high-impedance state), but internally, the CPU completes the execution of the current memory cycle. After that, the CPU idles for as long as HOLD is active. HOLD and HOLD ACKNOWLEDGE can be used for DMA (direct memory access) control and in multiprocessor applications.

HOLD ACKNOWLEDGE—output; signals acknowledgment of the HOLD state.

INTERRUPT REQUEST—input; the interrupt input is sampled at the end of the current instruction cycle and if the internal software control interrupt enable flip-flop is set, it initiates the interrupt servicing sequence.

RESET—input; a signal that clears the content of the program counter so that program execution will start from location zero in memory.

INTERRUPT ENABLE—output; a signal that displays the status of the interrupt enable flip-flop.

The CPU also provides eight status bits on the data bus at SYNC time:

HALT ACKNOWLEDGE—a response to the HALT instruction.

INTERRUPT ACKNOWLEDGE—follows the acceptance by the CPU of an interrupt request.

INPUT CYCLE—indicates that the address bus holds the address of an input device.

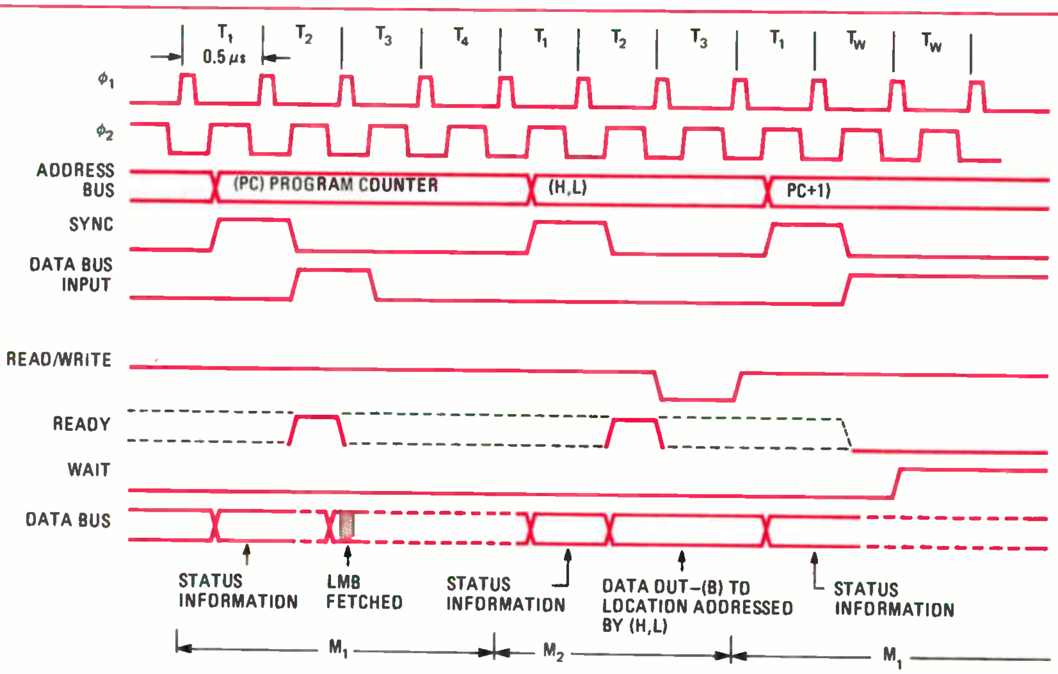
OUTPUT CYCLE—indicates that the address bus holds the address of an output device.

MEMORY READ—indicates that the data bus will have data coming from memory.

M_1—indicates that the current cycle is for fetching the first byte of an instruction.

STACK—indicates that the address bus holds the push-down stack address.

WRITE OUTPUT—indicates that the data bus will have data for memory write or for an output operation.



4. Timing. The instruction LMB (load the content of register B into the location addressed by the contents of registers H and L) requires two machine cycles (M_1 and M_2). During M_1, the address bus holds the program counter contents, and during M_2 it holds the contents of the H-L register pair. DATA BUS INPUT shows when the CPU expects data from the data bus. WRITE shows when data from the CPU is available on the data bus. READY shows that valid data is available to the CPU. The bottom waveform shows the corresponding data-bus actions.

status signals simplifies interfacing, allows direct memory access, and helps in program debugging.

Figure 2 shows how the 8080 interfaces with outside chips to make a microprocessor system. An external crystal-controlled oscillator supplies two non-overlapping clocks, ϕ_1, and ϕ_2. Buffers interface to external address and data buses, and a gate and eight latches set up status bits during sync time. All inputs and outputs are TTL-compatible, with the exception of the two clocks, which require +12 V. A memory and the input-output devices complete the system.

The amount of external interface logic necessary to implement any system depends on that system's complexity. The minimum requirement is six packages of conventional TTL (the 8008 needs at least 20).

External signals are organized on three buses. An address bus with 16 lines addresses up to 65 kilobytes of memory and up to 256 input and 256 output ports. A bidirectional eight-line data bus carries data to and from memory and I/O ports. A control bus synchronizes

COMPARING THE GENERATIONS

	INTEL 8008	INTEL 8080
Technology/threshold voltage	p/1.5–2.5 V	n/0.8–1.4 V
Supply voltage	+5, –9 V	+12, +5, 0, –5 V
Number of pins on package	18	40
Number of interface chips	20	6
Number of instructions	48	78 (48 + 30)
Instruction execution speed	12–22 μs	2–9μs
Internal memory type/number of bits	dynamic/168 bits	static/104 bits
Chip size (mils)	124 x 173	164 x 191
RAM size/speed (typical systems)	256/1 μs	1,024/500 ns
ROM size/speed (typical systems)	2,048/1 μs	4,096/600 ns

the CPU, external memory, and I/O devices, and also has the job of handling interrupts, direct-memory-access (DMA) controls, and CPU status information.

Instructions in the 8080, as in the 8008, use one, two, or three bytes of storage. Each instruction requires from one to five machine (or memory) cycles for fetching and execution. Machine cycles are called M_1, M_2, . . ., M_5. Each machine cycle requires from three to five states—T_1, T_2, . . ., T_5—for its completion. Each state has the duration of one clock period (0.5 microsecond). There are three other states (WAIT, HOLD, and HALT) which last one to an indefinite number of clock periods, as controlled by external signals. Machine cycle M_1 is always the operation-code fetch cycle and lasts four or five clock periods. Machine cycles M_2, M_3, M_4, and M_5 normally last three clock periods each.

To understand the basic operation of the 8080, let's refer to the simplified state diagram shown in Fig. 3, starting at cycle M_1 and state T_1.

During T_1 the content of the program counter is sent to the address bus, SYNC is true, and the data bus has status information pertaining to the cycle that is currently being initiated. T_1 is always followed by another state, T_2, during which the condition of the READY input is tested. If READY is true, T_3 is entered; otherwise, the CPU will go into the wait state (T_w) and stay there for as long as READY is false. READY thus allows the CPU be synchronized to a memory with any access time and to any I/O device. Also, by controlling the READY line, the user can single-step through his program.

During T_3, the data coming from memory is available on the data bus and is transferred into the instruction register (during M_1 only). The instruction decoder and control sections then generate the basic signals to control the internal data transfers, the timing, and the machine-cycle requirements of the new instructions.

At the end of T_4, if the cycle is complete, or else at the end of T_5, the 8080 goes back to T_1 and enters machine cycle M_2, unless the instruction required only one machine cycle for its execution. In such cases, a new M_1 cycle is entered. The loop is repeated for as many cycles and states as required by the instruction.

It is only during the last state of the last machine cycle that the interrupt request line is tested and a special M_1 cycle is entered, during which no program-counter incrementing takes place and INTERRUPT ACKNOWLEDGE status is sent out. During this cycle, one of eight possible single-byte calls will be sent to the CPU by the interrupting device.

Execution times

Instruction state requirements range from a minimum of four states for non-memory referencing instructions, like register and accumulator arithmetic instructions, up to a maximum of 18 states for the most complex instructions—such as XTHL (exchange the contents of registers H and L with the content of the top two locations of the stack). At the maximum clock frequency of 2 megahertz, this means that assembly-language instructions can be executed in 2 to 9 μs.

As an example of 8080 timing, Fig. 4 shows the timing diagram for the one-byte, two-cycle instruction LMB (load the content of register B into the memory location addressed by the contents of registers H and L). This example also illustrates the timing when a WAIT state is entered after the execution of LMB. Notice that seven states (a total of 3.5 μs) are required to fetch and execute the LMB instruction. The same instruction would require 28 μs by the 8008, 17.5 μs by the faster 8008-1.

Though this example demonstrates an 8:1 improvement in speed over the 8008, the real impact of the new 8080 will not be as a replacement for the 8008. The 8008 has, after all, adequate speed for a large number of applications. The 8080 will be used in new systems that were not feasible before because the first-generation microcomputers were not powerful enough. □

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Designer's casebook

IC logic units simplify binary number conversion

by Harvey F. Hoffman
Norden Division, United Aircraft Corp., Norwalk, Conn.

A variety of digital arithmetic processing applications require one arithmetic notation to be converted to another. Six of the most widely used conversions can be accomplished easily with a pair of medium-scale integrated circuits called arithmetic logic units. The table lists these six conversions and their associated rules.

The function chart for an arithmetic logic unit is given in Fig. 1. As an example of how to wire the ICs, consider circuit (a) in Fig. 2 for converting an 8-bit number in two's-complement notation to a number in signed-binary notation. The number to be converted is N, and the converted number is P. The eighth bit (N_7, P_7) is the sign bit, and the least significant bit is the first number bit (N_0, P_0).

The function-select inputs are $S_0 = 0$, $S_1 = S_2 = S_3 = 1$, and the mode (M) input controls the sign bit. The arithmetic function (when $M = 0$) that may be performed is A plus (A OR $\bar{B}$) with no carry (C_n) input to the first unit. (A and B are the input numbers.) The logic operation (when $M = 1$) for these same function-select inputs is A OR B, no matter the state of the first unit's carry input.

If number A is set to zero and the carry-in term is set to one, then to arithmetic operation ($M = 0$) is $\bar{B}$ plus 1, which is the binary representation of a negative number in two's-complement notation. With number A again set to zero, the logic operation ($M = 1$) gives an output of B.

Therefore, if the inverse of the sign bit is applied to the mode (M) input, the A inputs are held at zero and the number in two's-complement form is applied to the B inputs. The resulting output is then in signed binary notation. If only the magnitude of the number is required, the sign bit, P_7, should not be used.

This notation conversion is completely reversible. That is, the identical circuit may be used to convert

ARITHMETIC-NOTATION CONVERSION RULES

From signed binary to two's complement:
- If sign bit is negative, complement each number bit and add 1 to result.
- If sign bit is positive, output number equals input number.

From two's complement to signed binary:
- If sign bit is negative, complement each number bit and add 1 to result.
- If sign bit is positive, output number equals input number.

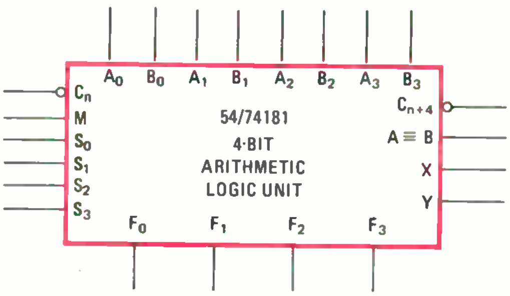
From signed binary to one's complement:
- If sign bit is negative, complement each number bit.
- If sign bit is positive, output number equals input number.

From one's complement to signed binary:
- If sign bit is negative, complement each number bit.
- If sign bit is positive, output number equals input number.

From two's complement to one's complement:
- If sign bit is negative, subtract 1 from number.
- If sign bit is positive, output number equals input number.

From one's complement to two's complement:
- If sign bit is negative, add 1 to number.
- If sign bit is positive, output number equals input number.

Notes:
- The sign bit is the most significant bit.
- A logic 1 in the sign bit location represents a negative number.
- A logic 0 in the sign bit location represents a positive number.

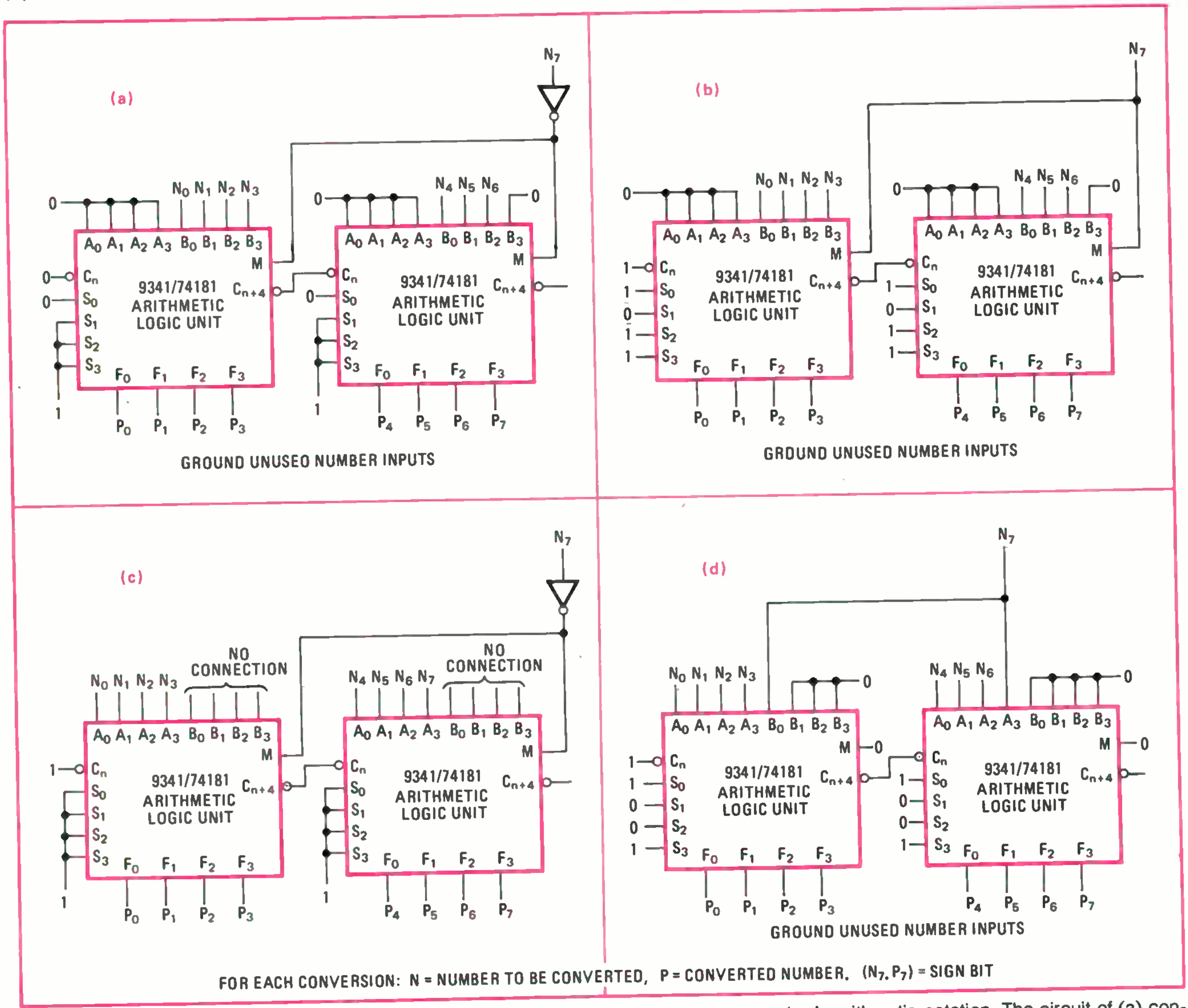


S_0 S_1 S_2 S_3	Arithmetic ($M = 0$, $\bar{C}_n = 1$)	Logic ($M = 1$)
0 0 0 0	$F = A$	$F = \bar{A}$
1 0 0 0	$F = A + B$	$F = \overline{A + B}$
0 1 0 0	$F = A + \bar{B}$	$F = \bar{A}B$
1 1 0 0	F = minus 1 (2's comp.)	F = Logic 0
0 0 1 0	$F = A$ plus $A\bar{B}$	$F = \overline{AB}$
1 0 1 0	$F = A\bar{B}$ plus $(A + \bar{B})$	$F = \bar{B}$
0 1 1 0	F = A minus B minus 1	$F = A \oplus B$
1 1 1 0	$F = A\bar{B}$ minus 1	$F = A\bar{B}$
0 0 0 1	$F = A$ plus $A\bar{B}$	$F = \bar{A} + B$
1 0 0 1	F = A plus B	$F = \overline{A \oplus B}$
0 1 0 1	$F = AB$ plus $(A + \bar{B})$	$F = B$
1 1 0 1	F = AB minus 1	$F = AB$
0 0 1 1	F = A plus A (2 X A)	F = Logic 1
1 0 1 1	F = A plus (A + B)	$F = A + \bar{B}$
0 1 1 1	$F = A$ plus $(A + \bar{B})$	$F = A + B$
1 1 1 1	F = A minus 1	$F = A$

1. Functional capability. The operation of an arithmetic logic unit is outlined in the table for all possible selection (S_0, S_1, S_2, and S_3) inputs. The input numbers are A and B, and the output number is F. When the unit's mode (M) input is low, it produces the arithmetic function given in the middle column. When the mode input is high, a logic operation takes place, as indicated in the right-hand column.

from signed-binary notation to two's-complement notation.

The wiring connections for the four other conversions listed in the table are also shown in the figure. Circuit (b) is for converting from one's-complement notation to signed-binary notation, or vice versa. Circuit (c) is for converting from two's-complement notation to one's-complement notation. And circuit (d) is for converting from one's-complement notation to two's-complement notation. □



2. Number conversion. Two arithmetic logic units can be interconnected to change a number's arithmetic notation. The circuit of (a) converts two's-complement notation to signed-binary notation, or vice versa; circuit (b) converts one's complement to signed binary, or vice versa; circuit (c) converts two's complement to one's complement; and circuit (d) converts one's complement to two's complement.

Storing computer data with a cassette recorder

by Richard Eckhardt
Massachusetts Institute of Technology, Cambridge, Mass.

Two simple interface circuits permit data from a teletypewriter to be recorded and played back on a portable cassette tape recorder. This means that a conventional tape recorder can be employed as a compact reusable storage device for minicomputers, with a teletypewriter operating as the only input/output equipment. And remember that a single 120-minute cassette will hold as much information as 600 feet of paper tape.

Teletypewriter data is transmitted at the rate of 10 characters per second (110 bits per second), a frequency that is far too low for most audio recorders. Therefore, the data is converted to tone bursts at a frequency the recorder can use. On playback, the tone bursts are detected, and the original data format is reconstructed.

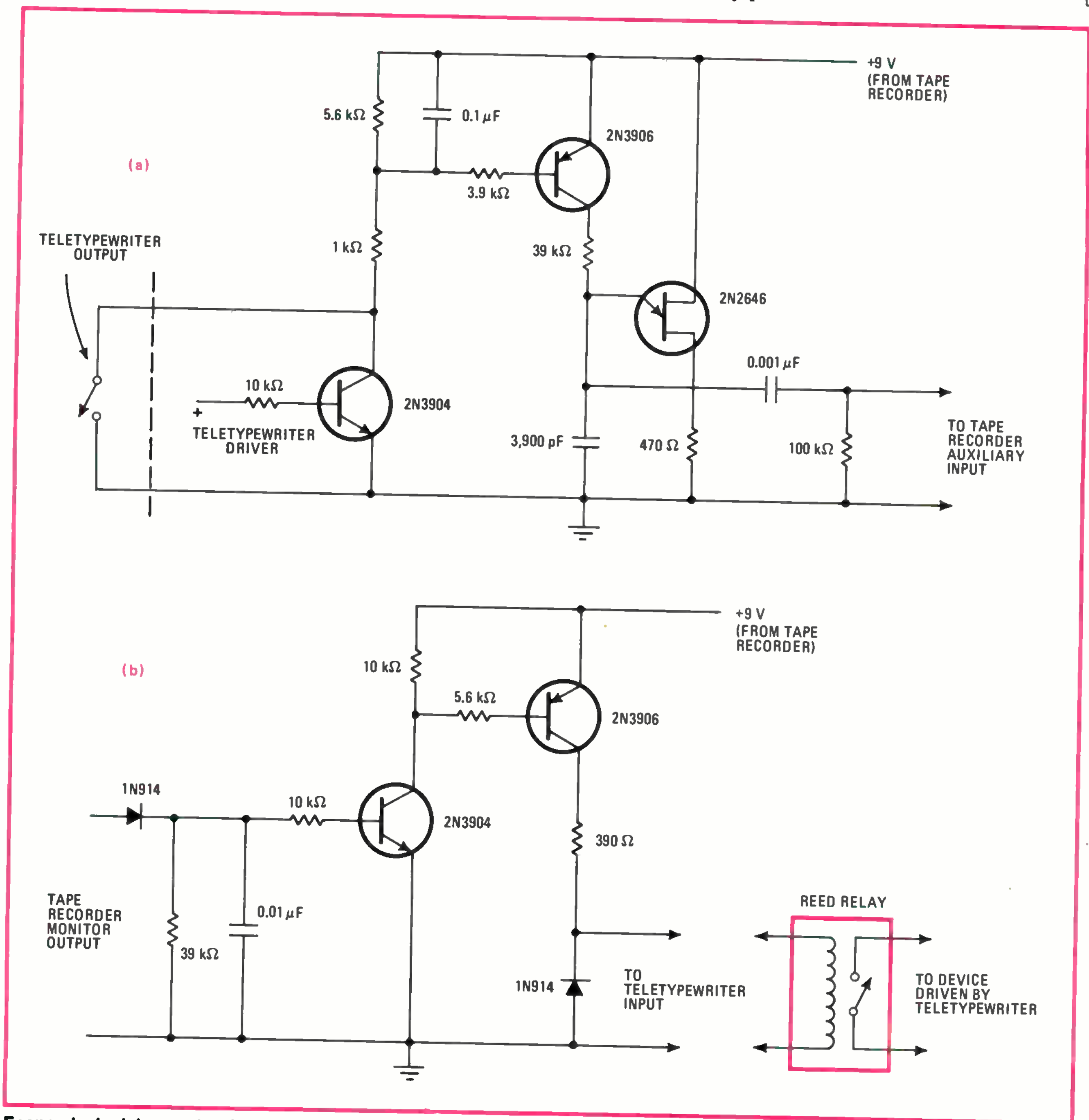
The teletypewriter-to-recorder interface circuit (a) can be driven either directly by the teletypewriter output or by the circuitry that drives the teletypewriter.

The output of a teletypewriter resembles the opening and closing of a switch. In the interface circuit, this switching waveform is first filtered slightly to remove bounce, and then it is used to gate a unijunction oscillator. If a teletypewriter driver is used instead as the input device, its drive current is fed to the base of a transistor that simulates the teletypewriter's switching action.

The circuit's output is a sawtooth waveform having a frequency of 6 kilohertz. It is applied to the recorder's auxiliary input (high-impedance low-sensitivity input). If the recorder does not have this input, it can be simulated by placing a 470-kilohm resistor in series with the microphone input.

The recorder-to-teletypewriter interface circuit (b) detects the recorder's output, and then rectifies and filters it so that a positive voltage is developed whenever a tone is present. A bleeder resistor is placed across the recorder output lines to produce the proper decay when the tone is removed. This decay voltage is then used to turn on a two-transistor driver that operates the teletypewriter. The output of this detector circuit can also be used to drive a reed relay to produce switch closures like those of a standard teletypewriter output.

It should also be noted that both interface circuits run off of a 9-volt supply, which can often be taken from the recorder's battery pack. □



Economical minicomputer data storage. Interface circuits for an everyday cassette tape recorder enable the unit to record and playback teletypewriter information. The recording circuit (a) can be driven by either the teletypewriter itself or by a teletypewriter driver. The playback circuit (b) can drive the teletypewriter directly or interface with a relay driver. The recorder's battery can run both circuits.

Making music with IC timers

by Kenneth R. Dugan
General Telephone and Electronics, Clearwater, Fla.

The versatile 555-type IC timer has yet another application—as a poor-man's music synthesizer for playing the musical signature of simple songs. Two timers are needed: one generates the rhythm, while the other produces the tones.

The circuit shown is intended for use as an audible alarm for a telephone exchange; it plays the first 10 notes of "A Pretty Girl Is Like a Melody." With the CONTROL INPUT lead of Timer$_1$ returned to the V_{CC} supply line, the tune will recycle continuously. But if a relay or flip-flop is connected to this lead, the number of times that the tune recycles can be controlled.

Since the output for Timer$_2$ is a pulse train having a duty cycle between 40% and 60%, a low-pass filter is used to soften the somewhat harsh audio quality of this waveshape. The setting of the STYLE switch causes the notes to either step or glide through the tune.

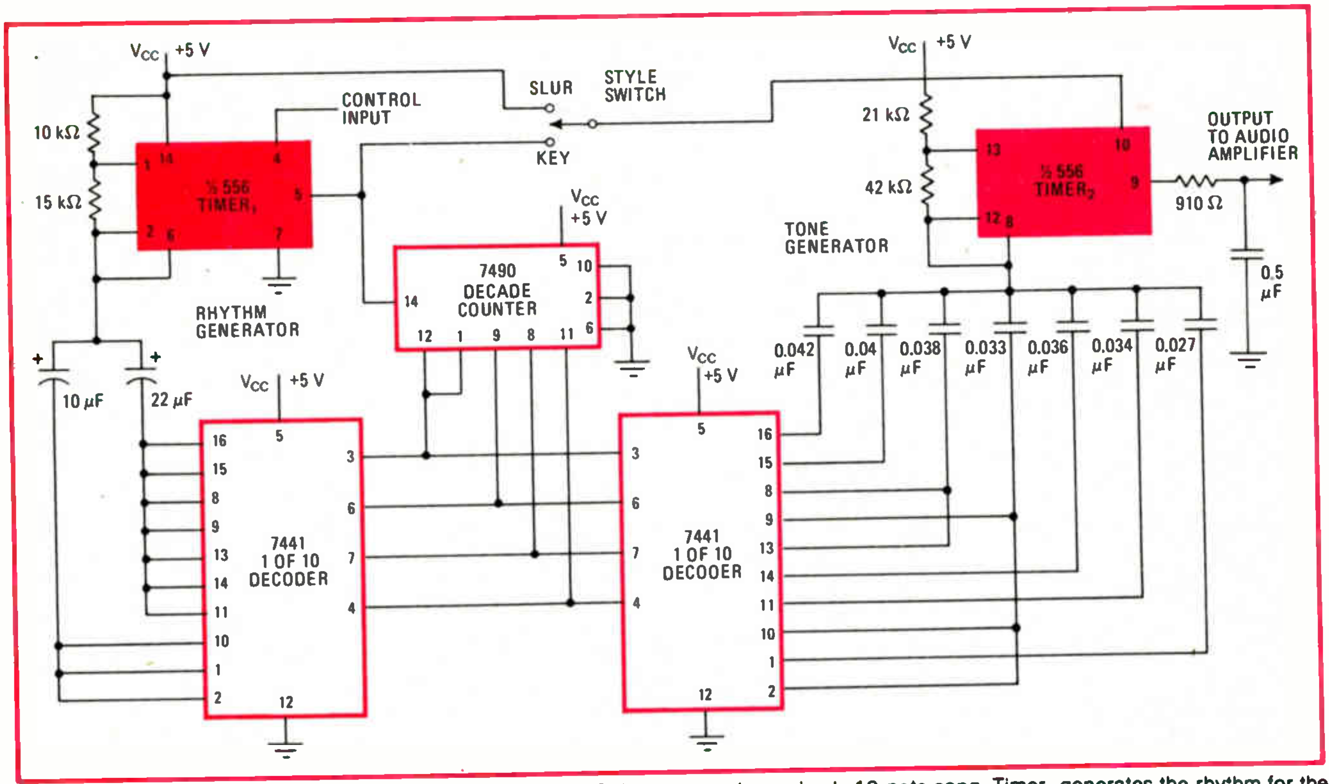
When used in conjunction with a diode bridge that detects the presence or absence of a ringing generator on the telephone line, the circuit can be programed to play a distinctive musical signature as a personalized telephone bell signal. Of course, many different combinations of resistors and capacitors can be used to obtain the desired music frequencies.

TONE-GENERATOR FREQUENCIES FOR "A PRETTY GIRL IS LIKE A MELODY"

COUNT	TONE CAPACITOR (μF)	FREQUENCY (Hz)
0	0.042	329
1	0.040	349
2	0.038	370
3	0.033	440
4	0.038	370
5	0.036	392
6	0.034	415
7	0.033	440
8	0.027	523
9	0.033	440

One less IC package is needed if a dual 556-type timer is employed, as done here, instead of two individual 555-type timers. □

Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.



Tuneful timers. This music synthesizer, which relies on two IC timers, can play a simple 10-note song. Timer$_1$ generates the rhythm for the tune, while Timer$_2$ generates the tones. If the CONTROL INPUT is tied to the supply line, the tune recycles continuously. The position of the STYLE switch determines whether the tones are played individually or blended. This circuit plays "A Pretty Girl Is Like a Melody."

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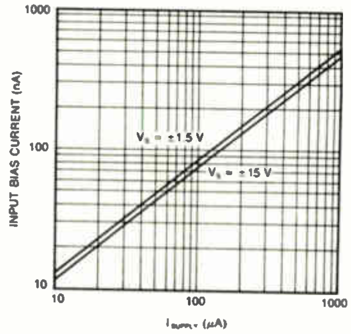
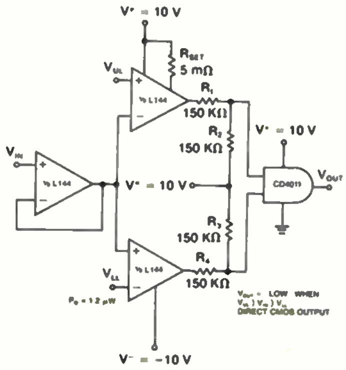


Applications examples:



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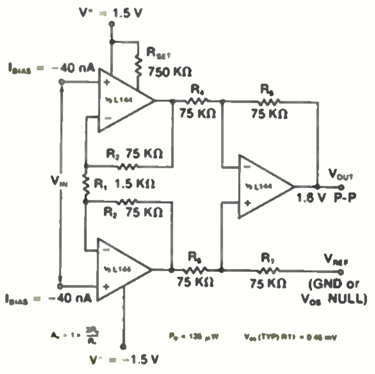

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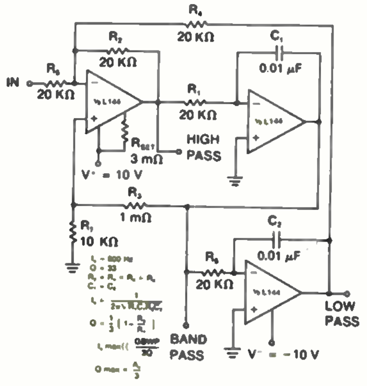

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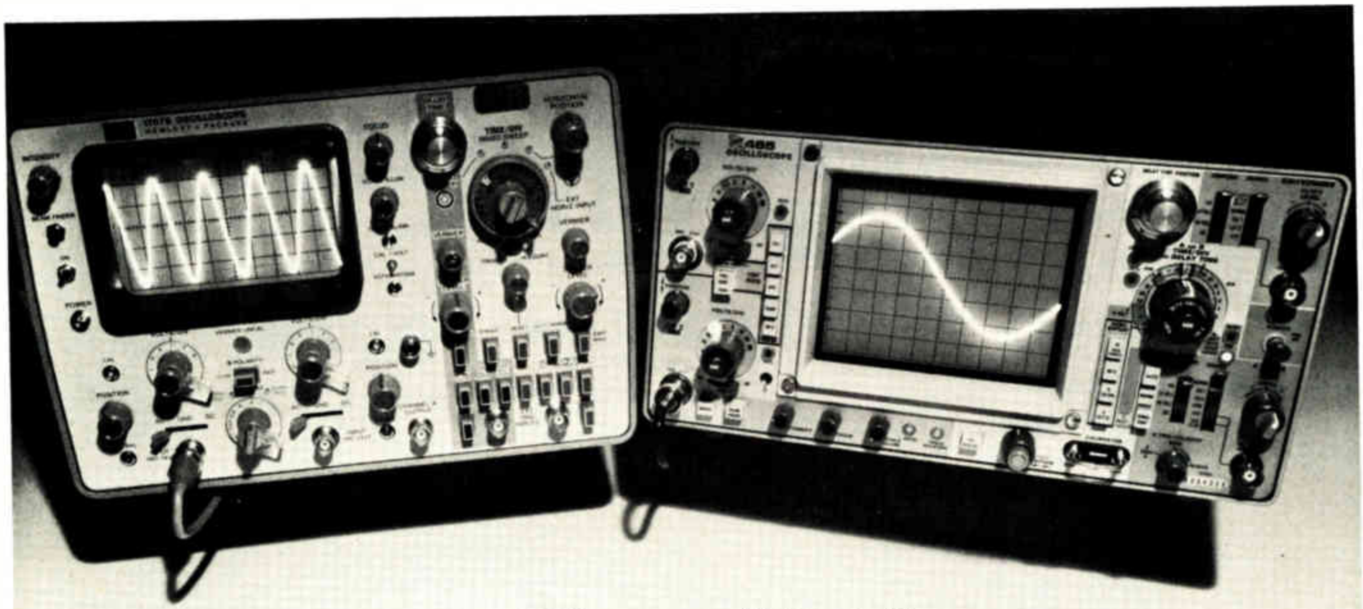

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Program called ASTAP makes fast work of analyzing large-scale circuits

No programing experience is needed to use this new software program, though it can handle networks containing thousands of elements and can perform dc, ac, and transient analysis as well as statistical simulation

By G. W. Mahoney, D. A. Mehta, H. Qassemzadeh, T. R. Scott, and W. T. Weeks, *IBM Corp., System Products Division, Hopewell Junction, N.Y.* and A. J. Jimenez, *IBM Corp., General Systems Division, Boca Raton, Fla.*

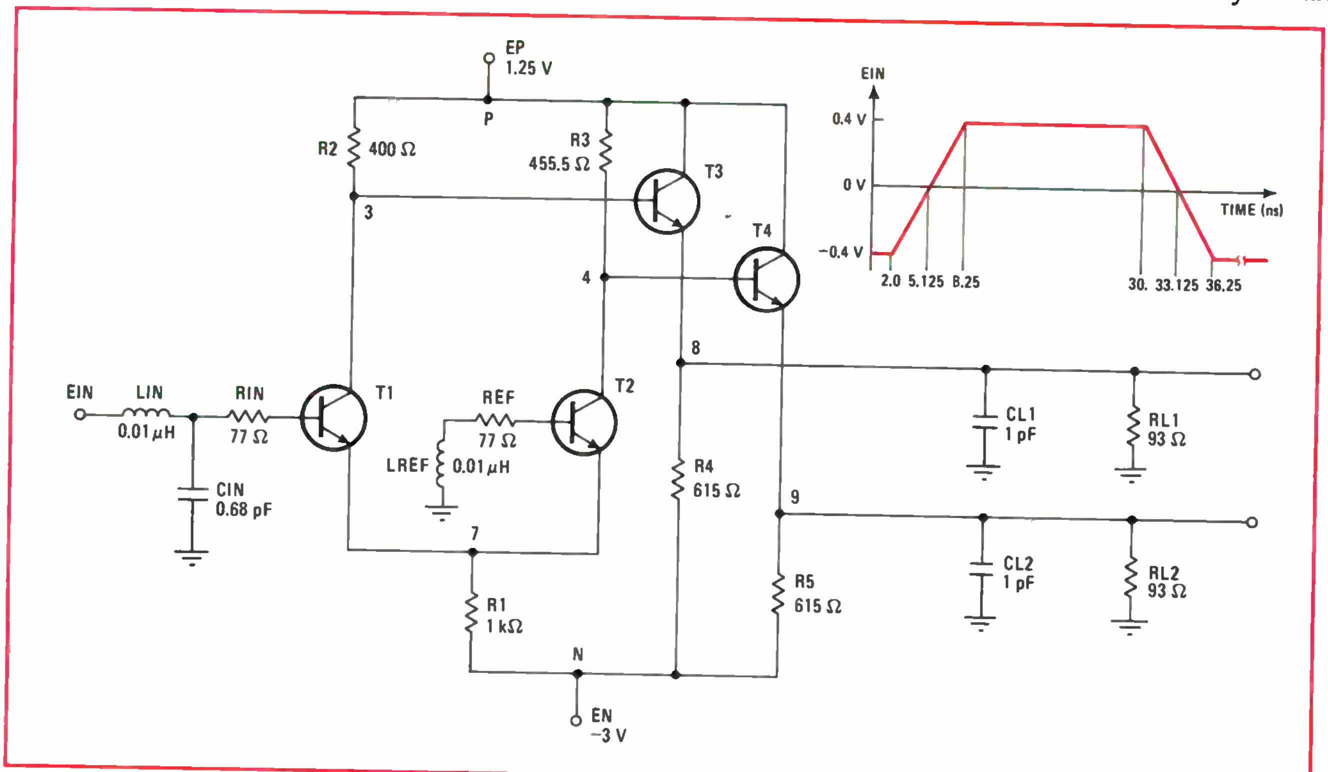
☐ Paralleling the development of more complex circuits, particularly large-scale ICs, circuit-analysis programs are becoming more and more indispensable as design tools. They are helping to speed up design cycles, reduce redesign, and enhance reliability prediction. Yet the demands being made of these programs continue to grow. Their capacity must be expanded to handle today's larger and denser circuits. What's more, they must operate ever faster to keep computational costs low and to improve computer turnaround time.

Advanced Statistical Analysis Program (ASTAP), a newly introduced software system, features those two essential characteristics: extensive capacity and high speed. ASTAP is basically a batch program that requires an IBM S/360 or S/370 computer, as well as suitable peripherals and memory storage. It was released just last year [*Electronics*, April 26, 1973, p. 40] and is available as one of IBM's Installed-User programs.

Unlike earlier programs, which are limited to one or two analysis modes, ASTAP can perform dc, ac, and transient analyses. This means that the same language can be used for all three analysis modes, and data can be transfered easily from one mode to another. Furthermore, since ASTAP employs a user-oriented language, the engineer need not have previous programing experience. ASTAP can analyze networks containing thousands of elements, and it can accept new device models without reprograming.

Analysis capabilities

With this new software package, the designer can predict how circuit performance will be affected by component tolerances, component aging, or ambient temperature. He can also simulate his circuit statistically so that



1. Determining propagation delay. A computer transient analysis can be used to find the turn-on and turn-off delays of this current-switch logic circuit. With ASTAP, the analysis can be done with either nominal element values or statistically distributed element values.

ASTAP versus Sceptre

ASTAP (Advanced Statistical Analysis Program) is one of the newer high-power general-purpose circuit-analysis computer programs. It can handle exceptionally large circuits very quickly, and it can perform a dc, ac, or transient analysis for a linear or nonlinear network. The program can also provide a Monte-Carlo statistical simulation for all three analysis modes, and it permits unlimited model nesting.

One of ASTAP's chief competitors is Sceptre (System for Circuit Evaluation and Prediction of Transient Radiation Effects), a tried-and-true nonlinear computer program that is used principally for transient analysis. While Sceptre is currently limited to a capacity of around 300 elements, ASTAP can accommodate up to approximately 3,000 elements.

Like Sceptre, ASTAP employs a model library, rather than taking the built-in-model approach. The languages used by both of these programs permit arbitrary device models to be described easily and then stored in the programs' model libraries. This means that a user can choose the model that suits his design best from the model library. He is not restricted to a single model that is built into the program, nor does he need a programmer's assistance if he wishes to change models.

Additionally, ASTAP employs an implicit-integration technique to solve transient responses. This eliminates the time-constant pattern that plagued the explicit integrators used in programs like Sceptre. It should be noted, however, that a recently released version of Sceptre does provide an implicit-integration approach.

he can estimate the output variations due to these effects. Even quality-assurance determinations, like yields and defect levels, can be predicted with ASTAP.

The program can compute the transient response of both linear and general nonlinear networks. The output for this analysis mode is in two formats: a tabulated one and an automatically scaled printer plot. Variable-order formulas[1] are used for the implicit numerical integration of the differential equations used in the solution. The time step-size during integration is controlled automatically, and even initial conditions can be determined automatically prior to a transient analysis.

Dc analysis can also be performed for linear and general nonlinear networks, and dc problems are solved automatically by adding pseudo-reactive elements to the network, converting the elements to a transient form. The resulting network is then integrated until dc levels are reached. Approximate dc solutions may be entered by supplying a set of initial conditions from which the correct dc levels are found. In this way, the network may be put in the region of the desired state of a multi-state network.

For a steady-state small-signal ac analysis, ASTAP can accept a linear or nonlinear network for which an operating point is specified. The network is automatically linearized at the operating point, and the resulting network is analyzed in the frequency domain. General frequency dependencies can be expressed for all types of elements. The real and imaginary components, as well as the magnitude and phase components, of complex-value response variables may be tabulated and plotted against frequency. In addition, transfer functions represented by seven different types of matrix parameters (i.e., Z, Y, S, etc.) may be requested as outputs. Bode and Nyquist plots are also available.

The operating point for a nonlinear network can be supplied by the user, or it can be obtained automatically from a dc or transient analysis. In determining this point automatically, the user can supply one network description for both modes of analysis; this requires a common topology. Or he can supply a separate network description for each mode, permitting elements to be added or deleted at will during the ac analysis.

Furthermore, a network can be simulated statistically for either ac, dc, or transient analysis. A Monte-Carlo technique is used to compute the probability distribution of a system's output parameters from known distributions of its inputs. Element values are specified in terms of a tolerance and a statistical distribution. Nonlinearities are entered as statistical tables that give a tolerance and distribution to the nonlinear curve. Parameters may also be statistical variables and may be used to define other element and parameter values, as can general statistically dependent or tracking relationships.

The basic output of a statistical simulation consists of histograms of specified output parameters. For a transient or ac analysis, outputs such as delay or transition times and bandwidths may be defined as output parameters. Moreover, for these two analysis modes, envelope plots can be obtained that display the envelope of the responses as functions of time or frequency. A scatter diagram indicating the correlation of one output to another can also be requested.

Data is entered into ASTAP for all three modes of analysis with a common input language. This free-form language is easy to use and almost entirely unrestrictive. For example, there are no limits on the length of names, the number of points in a table, and the number of continuation cards.

Device descriptions

For large-signal analysis, semiconductor devices require equivalent circuits that contain nonlinear elements. With ASTAP, any element voltage or current can be used to describe a nonlinear dependence that defines any element value in the network description. Fortran-like expressions and tables of points can be employed for defining element values, and Fortran function-type subroutine references, which may be Fortran-supplied, system-supplied, or user-supplied, can be included in these expressions. (Two examples of system-supplied subroutines are a diode equation and a field-effect-transistor characteristic.) Parameters may be defined along with the elements, enabling them to be used as auxiliary quantities in element-value expressions or for establishing special outputs.

ASTAP's modeling facilities considerably simplify the process of describing networks that are formed by repetitive subnetworks—for example, an equivalent circuit representing a transistor. In ASTAP, the subnetwork can be defined in terms of basic elements as a model itself, and this model can be used repeatedly to build a more complicated network. Each time the model is called for, individual element values within the model may be changed. A model can also be referenced to another lower-level model. This model nesting can be carried to any level.

Another advantage of ASTAP's language is that it allows arbitrary device models to be described easily. The designer can express characteristic device equations that constitute mathematical device models in terms of mathematical expressions or tables defining linear or nonlinear dependent elements. Therefore, the designer is given a good deal of freedom in defining element values in device models, but he must exercise care in constructing his definitions so that the model is physically realizable.

Also, the designer must be certain that element values are mathematically valid under all circumstances. For example, values of R, C, or L elements must never be identically zero, and expressions or tables defining these elements must be greater than zero for all values of the independent variable. The user must avoid situations where element values become unrealistically large or small, leading to possible overflow or underflow conditions. Most problems of this sort can be avoided as long as the user is careful to define dependent elements over all possible values of the independent variables.

The program's model library provides additional flexibility. Any model can be stored in one of two libraries—the user-model library or the program-model library. Once stored, models in either library can be referenced by any user. The program-model library is intended for standard general-usage models at a given installation. Models may be stored or deleted from this library only through the use of a special key. Any user may store his model in the user library.

No internal size limits

Because ASTAP employs dynamic storage allocation to manage program data, there are no internal restrictions on the various dimensions—such as the number of elements or the number of nodes—of a problem. The size of the network that can be analyzed by ASTAP is limited only by the amount of main storage available. Under virtual storage on an IBM 370 machine, even this restriction is removed. Furthermore, the program is automatically extendable to the amount of storage specified for each job. On an IBM 360 computer, networks of up to about 200 elements can be analyzed using 220 kilobytes of storage, and networks of up to 3,000 elements require less than 1.5 megabytes of storage.

In the solution of a network, a tableau formulation[2] of the network equations is used for all three analysis modes. This approach combines traditional topological concepts with a modification of an earlier tableau formulation[3]. Only the voltages across and currents through the network elements are employed in the modified tableau.

Sparse-matrix techniques are used to solve the linearized equations that occur in the solution of the general network equations. When the linear equations are being solved, the growth of fill-in elements is controlled by the joint action of a weighted-tree selection scheme and an optimal ordering strategy. The user can select any one of three techniques to solve the linear equations. The three methods provide a tradeoff between the amount of storage needed and computation speed, allowing the user to optimize ASTAP for his installation. The first method is the slowest but uses the least storage, the second is faster but uses more storage, and the third is the fastest but requires the most storage.

Default values are built into ASTAP for all the run controls. For most standard analyses, these controls need not be set, and they can be overridden if necessary. The program also has a rerun facility that permits a network to be modified and then re-analyzed. In this

```
MODEL DESCRIPTION
MODEL CURRENT SWITCH ()
ELEMENTS
      RIN, 1-2 = .077
      REF, 5-6 = .077
      R1, 7-N = 1.0
      R2, P-3 = .4
      R3, P-4 = .4555
      R4, 8-N = .615
      R5, 9-N = .615
      RL1, 8-GND = .093
      RL2, 9-GND = .093

      LIN, EIN-1 = .01
      LREF, 5-GND = .01

      CIN, 1-GND = .68
      CL1, 8-GND = 1
      CL2, 9-GND = 1

      T1 = MODEL JCNTRAN (2-3-7)
      T2 = MODEL JCNTRAN (6-4-7)
      T3 = MODEL JCNTRAN (3-P-8)
      T4 = MODEL JCNTRAN (4-P-9)

      EP, P-GND = -1.25
      EN, N-GND = 3
      EIN, GND-EIN = TABLE EIN(TIME)

      PTONDIN =   (TRISE(VRL2,0) - 5.125)
      PTONDOUT =  (TFALL(VRL1,0) - 5.125)
      PTOFFDIN =  (TFALL(VRL2,0) - 33.125)
      PTOFFDOUT = (TRISE(VRL1,0) - 33.125)

FUNCTIONS
      TABLE EIN,  0,-.4, 2,-.4, 8.25,.4, 30,.4,
                  36.25,-.4, 50,-.4

FEATURES
      GROUND = (GND)

MODEL JCNTRAN (B-C-E)
ELEMENTS
      RE, 6-E = .0005
      RC, C-5 = .008
      RB, B-4 = (.182 + DLOG(3/(JE+.1))/20)
      CRB, B-4 = 2.5
      CC1,B-5=(.6264/(.8-DMIN1(0,VCC1))**.333)
      CC2,4-5=(0.108/(.8-DMIN1(0,VCC1))**.333)
      CE,4-6=(0.4+10.4*JE+DMAX1(.01,JE/5)**4.4)
      JE, 4-6 = (DIODEQ(2.5E-13,38.1,VJE))
      JC, 5-4 = (.983*JE)

EXECUTION CONTROLS
ANALYZE CURRENT SWITCH (TRANSIENT)
      CURRENT SWITCH EMITTER FOLLOWER USING
      BIPOLAR JUNCTION TRANSISTORS.
RUN CONTROLS
      STOP TIME = 50
      MAXIMUM STEP SIZE = .5
      TOPOLOGY
OUTPUTS
      PRINT PTONDIN,PTONDOUT,PTOFFDIN,PTOFFDOUT
      PRINT  IRE.T1,IRE.T2,IRE.T3,IRE.T4
      PLOT  N1,N2,N3,N4
      PRINT,PLOT (LABEL=(PROPAGATION DELAY),
           COMMON SCALES) VRL2(VRL2-IN-PHASE),
           VRL1(VRL1-OUTOF-PHASE),EIN
```

2. Nominal transient analysis. Nominal element values are used here as the input data to ASTAP. The program will tabulate the input-to-output propagation delays of the circuit drawn in Fig. 1, as well as plot the voltage (with respect to ground) at nodes 1, 2, 3, and 4.

```
MODEL DESCRIPTION
MODEL CURRENT SWITCH ()

     CURRENT SWITCH EMITTER FOLLOWER CIRCUIT.
     STATISTICAL DESCRIPTION.

ELEMENTS
     PTRACK = DISTRIBUTION NORMAL (.077, 15%)
     RIN, 1-2 = D NORMAL (PTRACK, 5%)
     REF, 5-6 = D NORMAL (PTRACK, 5%)

     PS = D NORMAL (.15, 8%)
     R1, 7-N = D NORMAL (6.67*PS, 3.6%)
     R2, P-3 = D NORMAL (2.66*PS, 3.6%)
     R3, P-4 = D NORMAL (2.97*PS, 3.6%)
     R4, 8-N = D NORMAL (4.1*PS, 3.6%)
     R5, 9-N = D NORMAL (4.1*PS, 3.6%)
     RL1, 8-GND = .093
     RL2, 9-GND = .093

     LIN, EIN-1 = .01
     LREF, 5-GND = .01

     CIN, 1-GND = .68
     CL1, 8-GND = 1
     CL2, 9-GND = 1

     T1 = MODEL JCNTRAN (2-3-7)
     T2 = MODEL JCNTRAN (6-4-7)
     T3 = MODEL JCNTRAN (3-P-8)
     T4 = MODEL JCNTRAN (4-P-9)

     EP, GND-P = 1.25
     EN, GND-N = -3
     EIN, GND-EIN = TABLE EIN(TIME)

     PTONDIN =    (TRISE(VRL2,0) - 5.125)
     PTONDOUT =   (TFALL(VRL1,0) - 5.125)
     PTOFFDIN =   (TFALL(VRL2,0) - 33.125)
     PTOFFDOUT =  (TRISE(VRL1,0) - 33.125)

     PIDBG = DISTRIBUTION 3 (4, 20, 47.3)

FUNCTIONS
     TABLE EIN,  0,-.4, 2,-.4, 8.25,.4,
                 30,.4, 36.25,-.4, 50,-.4
     DISTRIBUTION 3 (NORMAL) MIN=4, MEAN=20,
                             MAX=47.3, SIGMA=9.1

FEATURES
     GROUND = (GND)

MODEL JCNTRAN (B-C-E)

     DIFFUSED NPN JUNCTION TRANSISTOR MODEL.
     STATISTICAL DESCRIPTION. -

ELEMENTS
     RE, 6-E = .0005
     RC, C-5 = .008
     PIDB = D NORMAL (PIDBG, 20%)
     RB,B-4=(2/PIDB**.8+DLOG(3/(JE+.1))/PIDB)
     CRB, B-4 = TABLE 1 (PIDB)
     PY = D NORMAL (0.27, 20%)
     CC1,B-5=(2.32*PY/(.8-DMIN1(0,VCC1))**.33333)
     CC2,4-5=(0.4*PY/(.8-DMIN1(0,VCC1))**.33333)
     CE, 4-6 = (0.4 + (2.6*PIDB**0.464*JE)
                + DMAX1(0.01, JE/5)**4.4)
     PISAT = (2.5E-13*(20/PIDB)**.84)
     JE, 4-6 = (DIODEQ(PISAT, 38.1, VJE))
     PBETA = (1200*(1 - 1/PIDB)/PIDB)
     PALPHA = (PBETA/(1 + PBETA))
     JC, 5-4 = (PALPHA*JE)

FUNCTIONS
     TABLE 1, 5,3.5,10,3.5,20,2.5,40,.1,50,.1
FEATURES
     GLOBAL = (PIDBG)
EXECUTION CONTROLS
ANALYZE CURRENT SWITCH (TRANSIENT)
     CURRENT SWITCH EMITTER FOLLOWER
     USING BIPOLAR JUNCTION TRANSISTORS.
RUN CONTROLS
     STOP TIME = 50
     MAXIMUM STEP SIZE = .1
     CASES = 100
OUTPUTS
     PRINT  EIN,VRL1,VRL2
     PRINT  IRE.T1,IRE.T2,IRE.T3,IRE.T4
     PLOT   N1,N2,N3,N4
     HISTOGRAM  PTONDIN,PTONDOUT,PTOFFDIN,PTOFFDOUT
     HIST (SAMPLE=(0,30,50))   VRL2
     PLOT(ENVELOPE,COMMON SCALES,
         LABEL=(IN PHASE DELAY))  EIN,VRL2
     PLOT(ENVELOPE,COMMON SCALES,
         LABEL=(OUT OF PHASE DELAY)) EIN,VRL1
     SCATTERGRAM  PTONDIN, VS PIDBG
     SCATTERGRAM  PTOFFDIN, VS PIDBG
END
```

3. Statistical transient analysis. In this ASTAP input data listing, element values for the current-switch circuit are represented as statistical distributions, rather than nominal numerical constants. Even the circuit's four transistors are modeled statistically. This type of simulation allows actual manufacturing variations to be taken into consideration.

way, parameter studies can be carried out under any of the analysis modes. During the re-analysis, only the analysis phase of the program is repeated; the set-up phase is executed only once.

Error checking is performed throughout a program run. Either warnings or error messages may be issued; an error message will terminate the job. There are over 300 diagnostic messages designed to assist the user find the problem so that he can continue his job run.

A sample problem

As an illustration of how ASTAP works, the propagation delay of a current-switch emitter-follower logic circuit will be investigated through both a nominal transient analysis and a statistical transient analysis. Figure 1 shows the circuit. The propagation delays between its input and output are defined as the time differences between zero-crossings of the input signal and the corresponding zero-crossing of the output signals.

When many of these circuits are tied together to form various logic functions, it is necessary to know the delay through the logic chain and the statistical distribution of this chain delay. The sample-problem circuit is first analyzed by using nominal values for the circuit parameters, and then statistical distributions are assigned to the parameters so that a statistical simulation can be performed. In actual practice, a nominal transient analysis need not be performed first, since the nominal results are part of the statistical analysis output.

The equivalent circuit in Fig. 1 includes parasitic elements, like lead inductance and stray capacitance—in this case, LIN, CIN, LREF, CL1, and CL2. All the circuit elements and nodes are named, and model reference names are given to the transistors—T1, T2, T3, and T4. Element values may be expressed in any consistent set of units. Here, the units are volts, milliamperes, kilohms, picofarads, microhenries, and nanoseconds.

Figure 2 shows what the input data to ASTAP looks like for this circuit. Individual elements are assigned nominal values, which are all numeric constants except for the independent voltage source, EIN. The value of this independent input signal is given by a table of points (under the FUNCTIONS heading) that describes the time-dependent input pulse shown in Fig. 1.

The use of parameters for defining special output quantities is shown under the ELEMENTS group. Parameters PTONDIN and PTONDOUT define the turn-on in-phase and out-of-phase delays, respectively. Parameters PTOFFDIN and PTOFFDOUT define the turn-off in-phase and out-of-phase delays, respectively. The values of these parameters are established by the system-supplied mathematical functions of TRISE and TFALL.

The basic variables computed during an analysis consist of all the element voltages and currents. These variables can be used for output quantities or in general mathematical expressions for defining element values.

Node voltages can also be requested as output data, as long as a ground node is defined explicitly. (This is done here under the FEATURES heading.) A node name that is prefaced by the letter N refers to a node voltage that is referenced to ground. One of the PLOT statements requests node voltages N1, N2, N3, and N4.

Under the ELEMENTS group, the transistor model references—T1, T2, T3, and T4—refer to transistor model JCNTRAN, which is a modified Ebers-Moll model that is not driven into saturation. Whenever the transistor model reference name is listed, the elements that make up this model are inserted automatically into the overall circuit.

As mentioned previously, the equations defining the nominal element values for the transistor model can be translated directly into Fortran-like expressions, which can be general provided that they represent physically meaningful relationships. Additionally, standard Fortran library functions or functions supplied by the system or user may be used in these expressions.

For example, the current source JE, which models the base-emitter junction characteristic, references the system-supplied function, DIODEQ. This sort of generality of element definition permits models to be developed easily for a variety of devices. And the model data can be described in either tabular or equation form.

The EXECUTION CONTROLS heading contains the major program instructions. It is here that ASTAP is told to do a transient analysis of the current-switch circuit: ANALYZE CURRENT SWITCH (TRANSIENT). A stop time of 50 ns is set under the RUN CONTROLS listing. This is the only transient run control that must be set, since all the other program controls have assigned default values. The maximum step size can be specified, as done here, to assure that the program properly describes the pulse rise times needed for this problem.

In addition to the circuit's four propagation delays, the OUTPUTS listing requests a printout of the emitter current in each of the transistors and a plot of four node voltages. The quantities requested here for tabular printout are grouped in one block at each time point, and each PLOT statement produces a separate plot.

For the Monte-Carlo statistical transient analysis of the current-switch circuit, the constant values used for the elements in the previous nominal transient analysis are described as statistical distributions instead. In general, the Monte-Carlo technique assumes the variables to be statistically independent. However, elements are sometimes dependent on a common factor; such element and parameter dependence is called tracking.

Figure 3 shows the input data for the statistical description of the current-switch circuit. Resistors R1 through R5 depend on the sheet resistivity of the material used to fabricate them. Additional variations within their dimensional tolerances produce yet another statistical spread about their nominal resistance values.

In the program listing, parameter PS represents the sheet resistivity. It is normally distributed about a nominal value of 0.15 and varies ±8% from this nominal at ±3-sigma points of the distribution. The nominal values of resistors R1 through R5 are each defined as some factor of parameter PS in order to model the tracking between these elements as a function of sheet resistivity. In addition, each resistor has an independent normal distribution of ±3.6% about its nominal value. The lead resistors, RIN and REF, form a separate independent tracking group with respect to parameter PTRACK.

An appropriate statistical description of the transistor model is called for under the MODEL JCNTRAN heading. Such a description can include nonlinear elements, as well as correlate the relationships between dependent and independent parameters. The model elements can be described in either equation or table format.

Many of the elements of the transistor model are nonlinear. Also, they are correlated with each other. To describe this correlation to the program, independent parameters are found on which the parameters of interest depend. For instance, several transistor parameters depend on total base doping; and an intrinsic current, IDB, which is proportional to the sheet conductivity, is an independent parameter that is correlated with the total base doping.

To request ASTAP to run a statistical simulation for any of the modes of analysis, the CASES run control is set equal to the number of individual statistical analysis runs needed for the simulation. For each individual analysis run, values for the statistical elements and parameters are randomly selected from their associated distributions.

The outputs produced for the first three OUTPUT statements are similar to those obtained for the nominal transient analysis. However, special outputs are available for showing statistical responses.

The HISTOGRAM statement generally requests the program to plot histograms of the single-valued variables listed in the statement. Here, the first HISTOGRAM listing asks for histograms of the four delay parameters. For variables that are functions of time, the SAMPLE option can be requested to sample a certain variable at specified times. In the example, variable VRL2 is sampled at 0, 30, and 50 ns.

Another available statistical output for variables that are functions of time (or frequency) can be requested by the ENVELOPE option in a standard PLOT statement. This instruction produces an envelope of all the responses of each variable over all the cases in the statistical simulation. The mean value at each time point is also plotted with the upper and lower envelope values. The example shows how to request envelope plots for the in-phase and out-of-phase outputs.

The SCATTERGRAM statement requests another form of statistical output—a scatter diagram of one or more variables plotted against another variable over all the statistical cases. This sort of diagram can be used to determine visually the correlation between variables. In the example, the turn-on and turn-off in-phase delays are plotted against a transistor parameter (PIDBG) to evaluate the correlation of the circuit's delay with this parameter. □

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Converting tables to equations cuts program length for calculator use

Eight basic equations can describe most tables of physical variables, and all the other factors can be handled by power-series expansions; lengths of the programs can often be reduced by more than half

by Roger Story, *Hewlett-Packard Co., Loveland, Colo.*

☐ Modern programable calculators are unquestionably the answer for those individuals and organizations whose needs do not justify the expense of even a minicomputer and its peripherals. Of course, when compared to computers, calculators have certain shortcomings, particularly in their storage capacity. Users of calculators are finding that many programs, often written with computer execution in mind, cannot be run with the 4,000 words of memory to which a programable calculator is typically limited.

Store equations, not tables

The solution to this problem, in many cases, is to use curve-fitting techniques to convert tabular or graphic data into equation form. In many scientific programs, it turns out, much of the program's length is taken up by tables of data. For these programs, dramatic reductions in length can be obtained if the data is calculated as it is needed, instead of simply being pulled out of a look-up table. In addition to reducing memory requirements, replacing tables with equations may allow increased accuracy through interpolation between data points.

Obviously, not all data is amenable to this treatment. Tables with only a small number of entries, for example, probably require less space than would the equations needed to reproduce them. More often than not, however, considerable space can be saved by using equations. By way of illustration, our department recently developed a program for the design of power transformers. The program, written in Basic, was run on a time-shared computer terminal. By rewriting the program to use equations rather than data tables, we were able to reduce its memory requirement from 7,000 words to 4,000 and thus were able to run it on an HP-9830 calculator.

Although reducing the memory requirements was the motivation behind the rewriting of the program, the use of equations turned out to have another important advantage: the information in the program is more easily updated because an equation is much easier to change than a data file. Although for purely mathematical data this may not be much of an advantage, much industrial data is constantly in need of revision—either to eliminate small errors that have been discovered through ex-

MODEL 1. $y = a + bx$	MODEL 5. $y = a\exp(bx)$
MODEL 2. $y = a + b/x$	MODEL 6. $y = ax^b$
MODEL 3. $1/y = a + bx$	MODEL 7. $y = a + b\ln(x)$
MODEL 4. $1/y = a + b/x$	MODEL 8. $y = a + bx + cx^2$

1. Equations. Most tables or curves of physical variables can be represented by one of these eight equations. Canned programs for fitting data to equations and for estimating quality of the fit are available from calculator and computer manufacturers, as well as from operators of computer-time-sharing services.

WIRE GAUGE	TURNS/IN.
10	8
15	15
20	26
25	37
30	65
35	114
40	224
44	340

$y = ae^{bx}$

$a = 2.83$

$b = .109$

x = Wire gauge

y = Turns/in.

2. Exponential. Turns-per-inch data in table is represented by exponential equation with constants as shown. The data shown here applies to double-film coated wire.

perience in the use of the data or because of changes in some process on which the data is based. For these situations, equations can be of significant value, even when memory space is not severely limited.

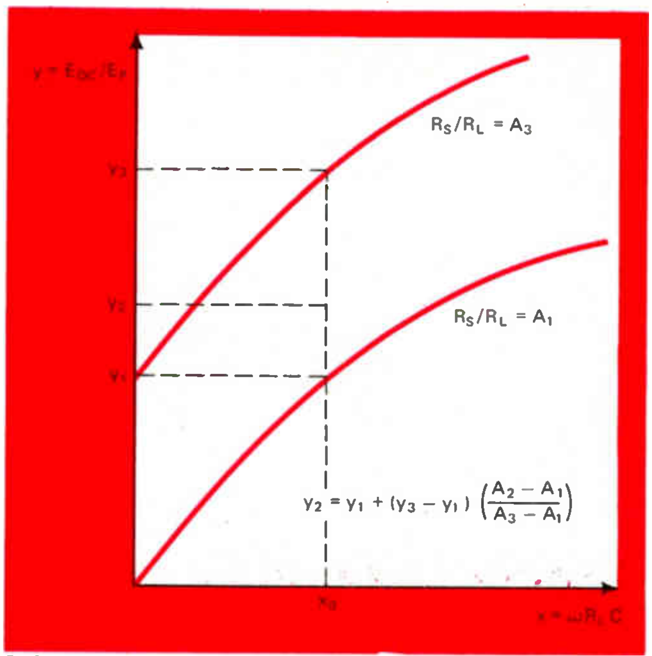
Writing the equations

Nearly any data table can be converted into an equation by developing a power-series expansion for it. The only proviso is that the data be sufficiently well ordered for the series to converge. It turns out, however, that many tables involving physical variables can be represented by an exponential function or by one of the handful of other functions listed in Fig. 1. When this can be done, program length can be reduced even more than with a straightforward power-series approach.

To get a feel for the kinds of savings equations can provide, consider the reduction of wire tables to equation form. In the design of most magnetic components, one refers to a table of wire sizes to determine such parameters as turns per inch, ohms per foot, cross-sectional area, and turns per square inch. Two listings of turns per square inch are needed—one for layer-wound coils, and one for random-wound coils. Thus, for the 37 wire gauges spanning #8 through #45, 185 data entries, or about 740 16-bit words, must be stored.

All of this data happens to be of the form $y = a\exp(bx)$. The wire-table excerpt of Fig. 2, for example, shows the values of a and b needed to write the equation for turns per inch of double-film coated wire. By taking advantage of the exponential nature of the wire-table data, the 185 data entries can be reduced to five equations, or 50 words. The saving in this case is 73%.

What's more, equations are particularly useful when the original data is in the form of a family of curves. When designing the filter for a power supply, for example, certain parameters describing the diodes, the transformer, and the various filter components are re-



3. Interpolation. Family of Schade voltage curves shows how ratio of dc voltage to peak voltage (y-axis) varies with changes in the product of frequency, load resistance, and filter capacitance (x-axis) for different values of the ratio of source resistance to load resistance. For such values of R_S/R_L as A_2, for which no curve is plotted, the formula provides a linear interpolation that can greatly increase the accuracy of the calculated results.

lated by a family of curves known as Schade curves. For a capacitor-input filter following a full-wave rectifier bridge, the Schade curves, which relate power-supply ripple to power-supply loading, are plotted for values of the ratio of source resistance to load resistance.

Plotting curves

A total of 23 curves—14 for voltage and nine for current—is needed for a typical application. To represent each curve with sufficient precision for most design work requires at least 20 data points per curve. The storage needed for this example is thus 460 data entries, or 1,840 words.

The Schade voltage curves are found to be of the form $y = a + b/x$ (Fig. 3) while the current curves satisfy the relationship $1/y = a + b/x$. The coefficients of these equations are data entries, each pair defining a curve. The memory capacity required to store 23 curves in equation form is 46 entries (184 words) for the coefficients and 129 words for the two equations. The total of 313 words represents a saving of 83%. If the coefficients of the equations can themselves be fitted to an equation, still greater simplification will result.

However, one problem with families of curves is that data points frequently fall between the curves. When high accuracy is not required, it is probably sufficient to use the curve that comes closest to the one that is needed. For higher precision, a linear interpolation can yield greatly increased accuracy, as illustrated by the Schade-curve example of Fig. 3. The formula shown in Fig. 3 is, of course, universal; once the values of y_3 and y_1 are taken from the curves, it simply interpolates between them. □

Production logic tester checks a variety of ICs

by T.K. Tawfiq
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A complete stand-alone IC logic tester, which is ideal for small production lines, can be built at low cost by making use of Hewlett-Packard's model 10529A logic comparator. This production IC tester performs full functional testing of a logic circuit, yet is compact enough to fit on a small metal plate.

The performances of two identical circuits—that of the device being tested, and that of a reference device—are compared. All possible binary combinations are applied to the inputs of both devices, and the states of their outputs compared. A defective IC will light the display on the logic comparator.

The figure shows the schematic for the tester, and the photograph depicts an assembled tester (excluding the main body of the logic comparator). Three decade counters are connected in series; their outputs, which are designated A through M, are brought out to a row of jacks. The clock signal is applied to a BNC-type connector before it is gated to the counter chain.

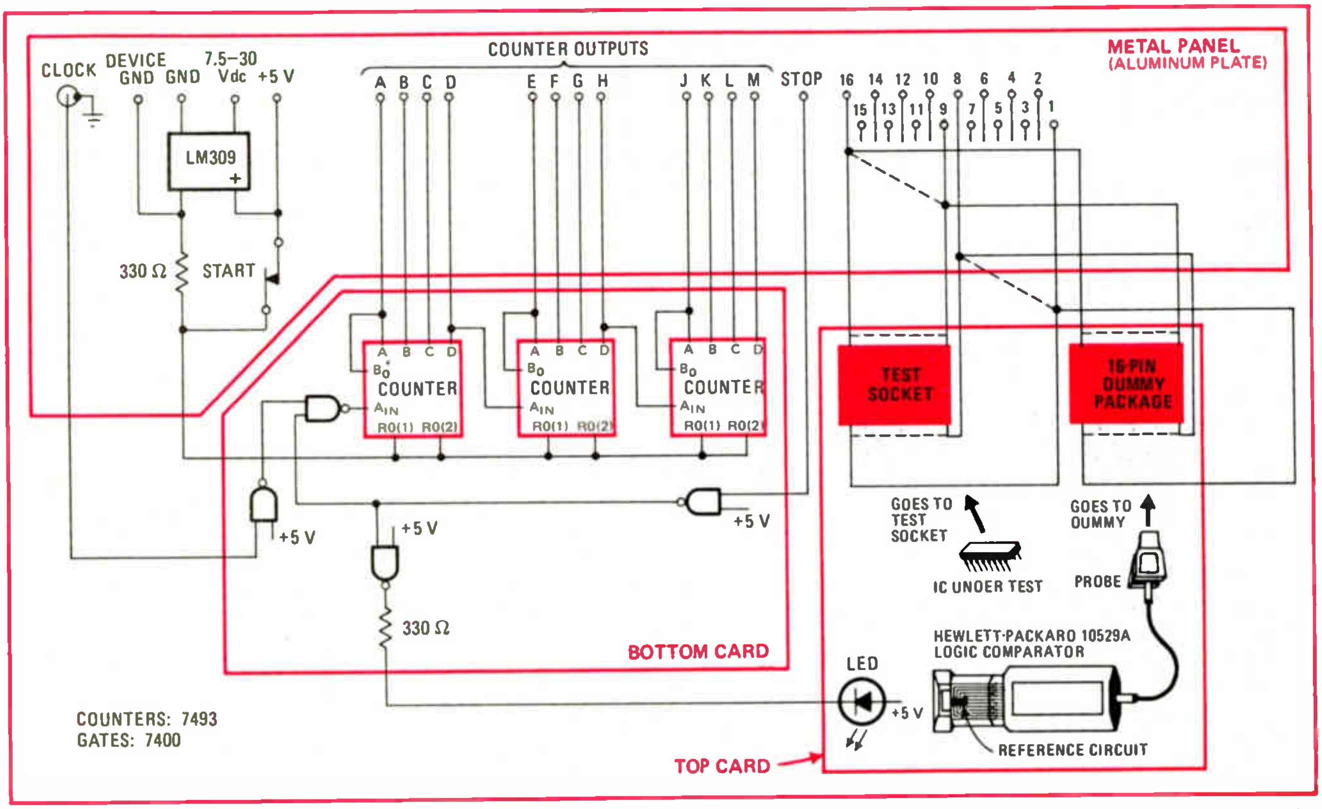
To fix the duration of a test, a patch cord is run from the STOP jack to the counter output jack following the last-used counter output. This output goes high at the end of the test cycle, preventing the clock from reaching the counter input. When the test ends, the light-emitting diode on the top card turns on. The START push button manually clears the counters for a new test cycle.

The power-supply terminals labeled 7.5–30 volts dc and GND are for the counters, while the ones labeled 5 V and DEVICE GND are for the package being tested. Here, a 22-pin socket serves as the socket for the device to be checked, and a 16-pin dummy package receives the probe of the logic comparator.

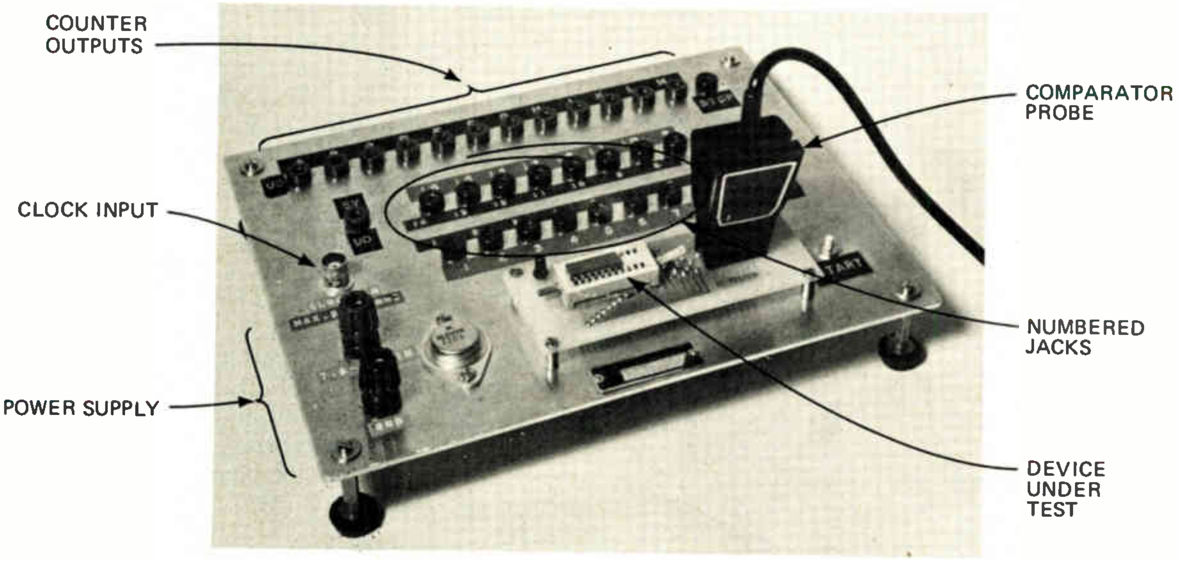
The pins of the dummy package are connected in parallel to the pins of the IC test socket. These same pin connections are also brought out to two rows of jacks and numbered to correspond with the two sets of socket pins. Patch cords can be used to connect the pin jacks to the appropriate supply terminals and counter outputs.

To test a device, begin by inserting a reference circuit into the logic comparator and plugging the comparator's probe into the dummy package. Next connect the dc power supply to the tester's supply terminals, and then run patch cords from the 5-V and DEVICE GND jacks to the appropriate numbered jacks of the IC to be tested. The on-indicating LED in the logic-comparator's display will now light.

Using a data sheet as a guide, connect patch cords be-



Functional checkout. Compact IC tester makes a complete functional check of many different logic circuits. The performance of the device under test is compared with that of a reference circuit. Series-connected decade counters provide the necessary binary inputs for the test device. A defective unit will light the display on the logic comparator. The assembled tester occupies a small metal panel (see photo).



tween the counter output jacks and the numbered jacks to the inputs of the IC to be tested. Run another lead from the STOP jack to the jack following the last-used counter output. The clock signal generator can now be hooked up to the CLOCK jack. (The maximum clock amplitude should not exceed 5 V, nor the maximum clock frequency 10 megahertz.)

After inserting the test device, depress the START button and observe the LED display on the logic comparator. If any LED position in this display lights, the test device is defective. At the end of the test cycle, the LED on the top card lights.

To speed up the testing process, patch-cord connection charts can be prepared for various logic ICs. □

Oscilloscope probes can do many jobs

by Arthur D. Delagrange
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If you walk into a design prototyping area and see oscilloscope probes sprouting not only from scopes but from oscillators, counters, meters, filters, and even power supplies, don't jump to the conclusion that either you or the engineer who works there is a bit daffy. On the contrary, when you are working with breadboarded circuits, especially the sloppy variety, scope probes are useful for getting signals both in and out of a circuit.

Scope probes are handy, shielded, insulated lines that have a built-in ground connection. They attach readily to component leads on one end and are equipped with BNC-type connectors on the other, as is most test equipment. An ordinary probe from one maker will work fine on equipment from another manufacturer.

For example, a Tektronix P6011 1× probe has a series resistance of about 300 ohms. This is insignificant when the probe is used with a measuring instrument providing an input resistance of 1 megohm, which is generally the case. A 1× probe is also usually acceptable for inserting signals into circuits that have an input impedance of 1 kilohm to 1 megohm. However, if the exact input signal amplitude or phase must be known, it may be necessary to measure the signal at the circuit, instead of at the driving source.

A Tektronix P6012 10× probe has a series resistance of 9 megohms; it operates into an input resistance of 1 megohm shunted by a capacitance of 15 to 47 picofarads. Many measuring instruments other than oscilloscopes have a similar input impedance, and the probe works equally well with them. At low frequencies (roughly those below 1 kilohertz), it is not even necessary to adjust the capacitance.

Sometimes when you're inserting a signal, you must either greatly attenuate the voltage (as for a preamplifier) or insert a current rather than a voltage (as for the virtual ground of an op-amp circuit). For these sorts of jobs, a series resistance is necessary, and the 10× probe with its 9-megohm resistance is handy.

If it is properly matched to the input impedance of a measuring instrument, a probe is accurate from dc to well up in the megahertz region. In fact, a probe can often improve the accuracy of your measurements, suffering from neither the noise picked up by unshielded test leads nor the loading caused by high-capacitance shielded cables.

When you insert a sine wave with a scope probe, there is no loss in accuracy provided that the signal's amplitude and phase are measured at the circuit. And if you are applying complex waveforms to your circuit, you must also check to see that distortion has not occurred because of attenuation and phase shift. □

Continuous monitor for seven-segment displays

by Kenneth J. Wellington
Syracuse University, Syracuse, N.Y.

One of the major drawbacks of seven-segment displays is the ever-present possibility that one of the segments may fail and go undetected for some time. All the readings taken in the interim would, of course, be erroneous.

Here's a circuit that solves this problem by testing every segment automatically once every second. It is a full-time monitor that can be used with either incandescent or light-emitting-diode displays operating from a segment supply voltage of between 5 and 15 volts.

Unlike other failsafe circuits, this one does not require a separate differential amplifier for each segment being monitored. Instead, the circuit uses a resistor at each segment and a single multiple-input NAND gate to which the segment resistors are connected.

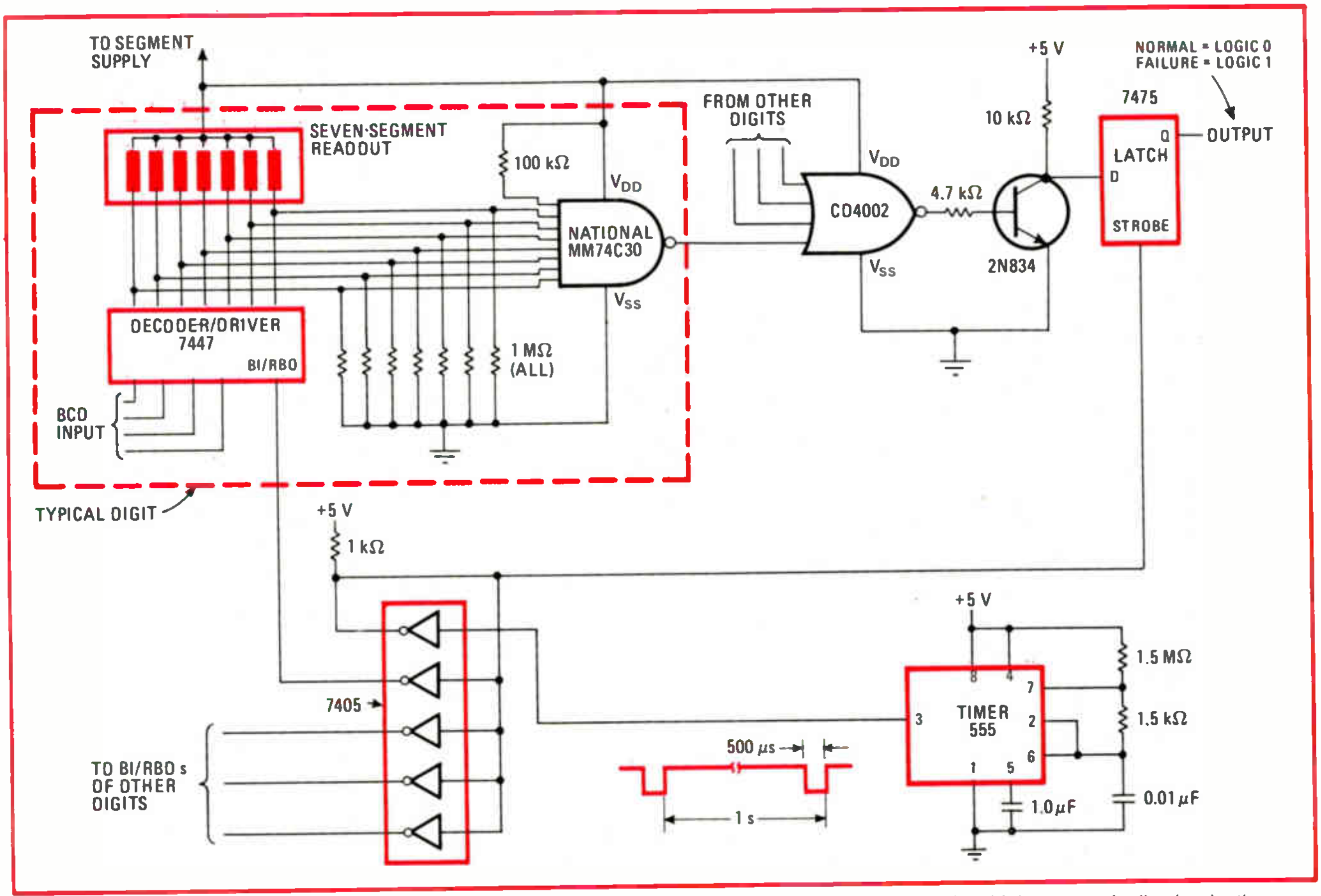
The gate is a complementary-MOS device that has its high-impedance inputs tied to the open-collector outputs of a decoder/driver. The segment resistors perform as the pull-down resistors for the multiple-input C-MOS NAND gate.

When the blanking-input/ripple-blanking-output (BI/RBO) line of the decoder/driver is activated, all seven of this device's outputs become open circuits, and the NAND gate checks the continuity between each segment and the segment supply voltage. An open filament or LED will result in a logic 1 at the gate's output.

The monitoring circuitry for each digit of the over-all display is identical to that drawn within the dashed color rule in the diagram. The outputs from all the digits drive the C-MOS NOR gate, whose output is inverted and shifted to TTL levels by the transistor. The translated gate output is then stored by the data latch.

A 555-type timer, operated in its astable mode, generates the waveform for controlling the BI/RBO line of each decoder/driver in the overall display. The inverters activate the BI/RBO output of each decoder/driver for 500 microseconds once every second. Since these inverters have open-collector outputs, the normal operation of an individual display's ripple-blanking is not affected.

The data latch is strobed at the end of the 500-μs pulse. Its Q output will normally be a logic 0, but will go to logic 1 if a segment failure is detected. This output can be used to turn off the display, turn on a warning light, or indicate in some other way when a segment has failed. □



Watching for failures. Open segments in a seven-segment readout are detected by this failsafe circuit, which automatically checks the continuity of each segment once a second. As long as the segments are operating normally, the output of the latch remains at logic 0. If a segment fails, this output goes to logic 1. Either incandescent or solid-state readouts can be monitored by the circuit.

Chances are you own a continuously tunable electronic filter. So by now you probably realize that continuously tunable filters are low performance instruments with, at best, 5% accuracy. And with poor reproducibility of settings, poor frequency accuracy and poor phase drift characteristics. And although continuously tunable filters provide infinite resolution, most users find infinite resolution neither important nor desirable unless there's corresponding accuracy.

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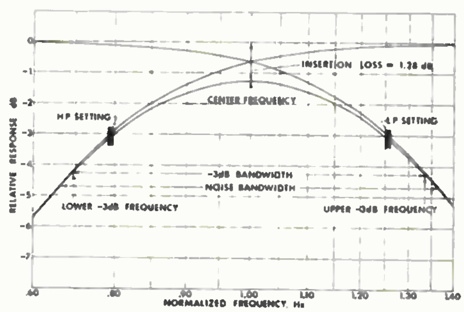

Normalized gain, attenuation, phase, and pulse response curves are printed on top of the filter. The other type uses the internationally accepted 1/10 decade [1/3 octave] frequency step — so you can operate with octave, decade and other convenient band pass settings, and still have sufficient frequency resolution for general lab and data acquisition applications. These filters have all the information shown on the graph printed on top — for all filter settings. And that's why we say "take your laboratory filter and junk it."

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ITHACO

Circle 119 on reader service card

Engineer's newsletter

To control load conditions, use IC voltage regulators

Here's a novel idea for those versatile three-terminal IC voltage regulators—use them to control load conditions instead of supply conditions, suggests John van den Heuvel, Singer Business Machines, San Leandro, Calif. **Adding a single resistor between the regulator's output and ground terminals will produce a very effective constant-current load** between the regulator's input and ground terminals.

This load characteristic can be obtained even at relatively low current levels because these regulators have excellent temperature and voltage stability. Also, the device's internal current limiting and thermal shutdown, which make it virtually indestructible, **protect the power transistor at the output of a circuit from gross overvoltages.**

To determine the resistor value needed, just divide the regulator's output voltage by the difference between the constant current desired and the regulator's output quiescent current. **For larger constant-current levels, a power transistor can be included at the regulator's output.** (Its base is connected to the IC's output pin, its collector to the IC's input pin, and its emitter to the load resistor, which is then returned to the IC's ground pin.)

DTL is on the way out . . .

If you're designing any equipment around diode-transistor logic, better get back to the drawing board. That's the advice of Charles Clough, marketing vice president for Texas Instruments, who says **DTL is fading fast as a market, and as a result it's hard to get and prices are rising rapidly.** In this semiconductor "crunch," Clough says you can do much better with the newer logic families.

. . . and 8k RAMs will never arrive

And if you're waiting for an 8,192-bit RAM, forget it. According to the "Gordon Moore Rule of Four" (Moore is vice president of engineering at Intel Corp.), **it's not worth merely doubling the capacity of a semiconductor memory.** Previously RAMs have increased by factors of four—from 256 to 1,024 to 4,096 bits. So **the next level of integration in a RAM should be 16 kilobits,** but that probably won't happen for two or three years yet.

Lighten the load of cable tying

Have your shop manager check out Panduit Corp.'s new tool for tying cable. It's fully automatic, hand-held, and less than 2 pounds in weight (a fraction of the weight of other tiers) and ties cable bundles 1/16 in. to ¾ in. in diameter. Operating from air pressure, the tool holds 100 cable ties that meet Mil Spec standards. Write Panduit Corp., 17301 Ridgeland Ave., Tinley Park, Ill. 60477

Service helps user cope with parts shortages

Information Handling Services of Englewood, Colo.—the people who run the VSMF (Visual Search Micro Film) service—have announced the addition of a new **Integrated Circuit Parameter Retrieval system** to their Design Engineer's package. **The service will list approximately 16,000 of the ICs most commonly used** and, by grouping similar devices side by side, provide the user with **large numbers of alternate sources.** The service begins in June.

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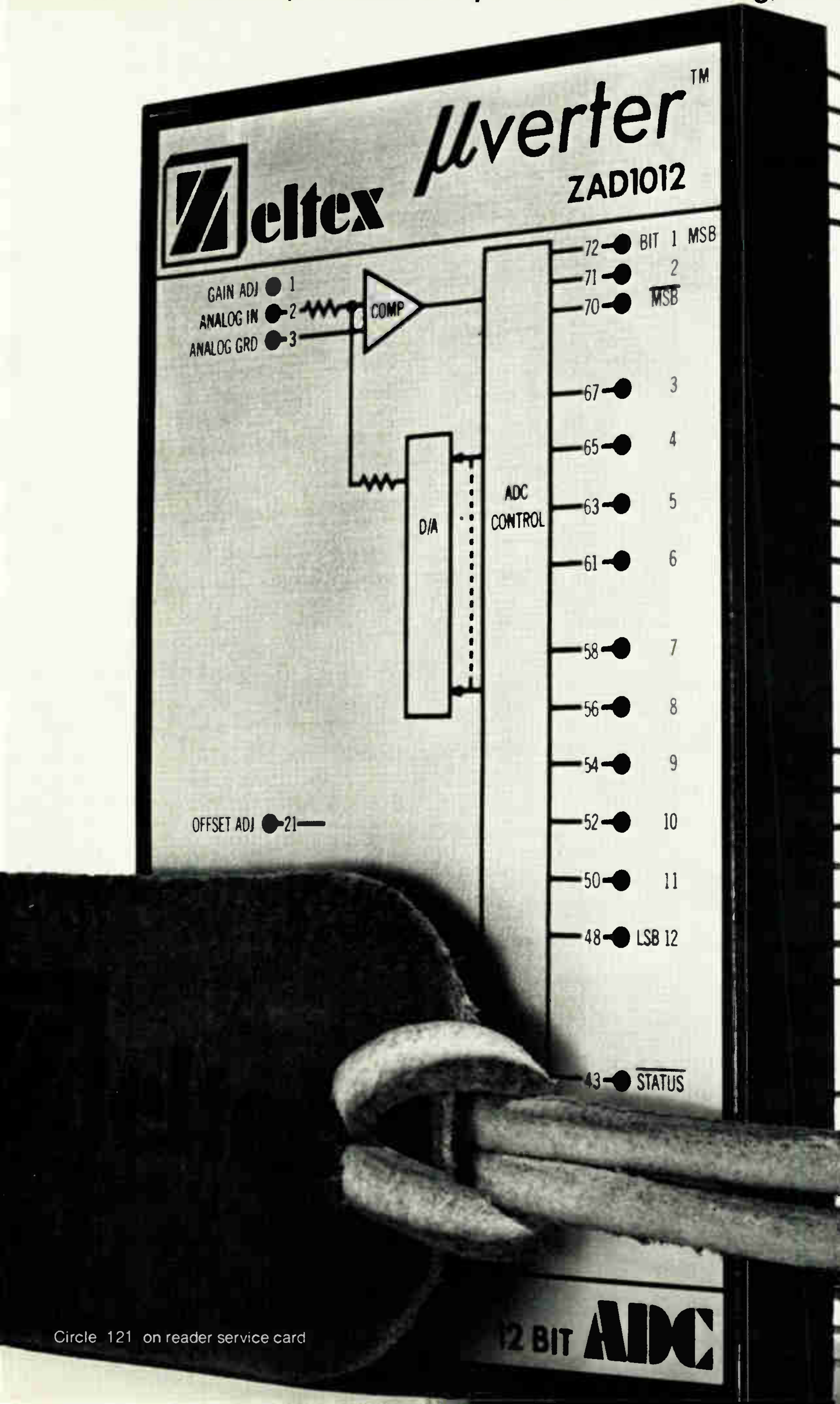

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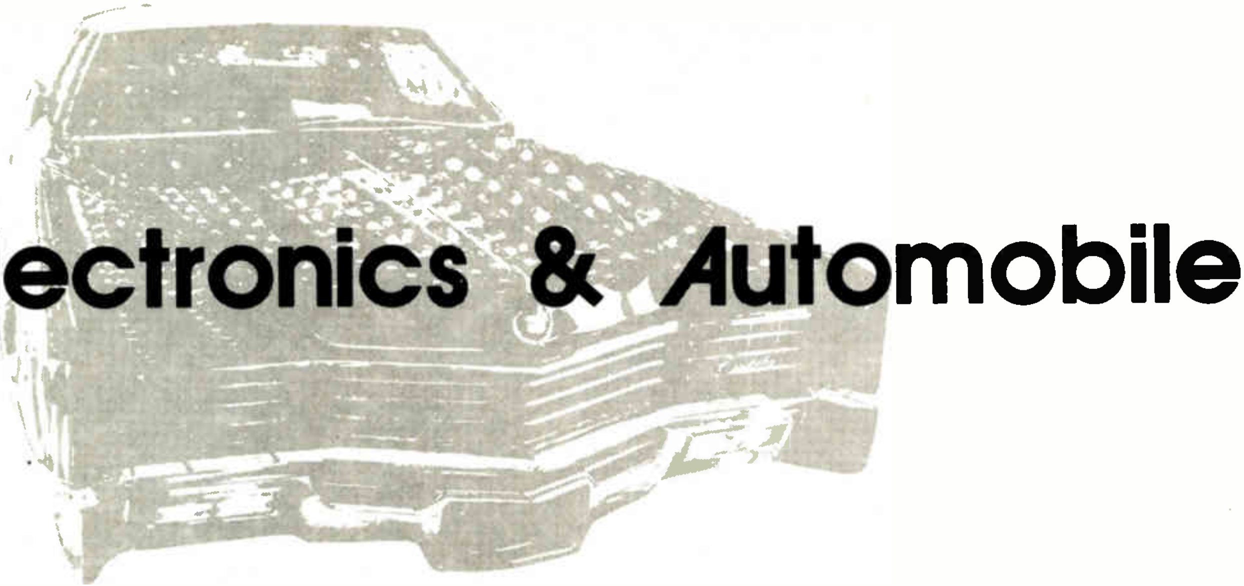

Electronics & Automobiles

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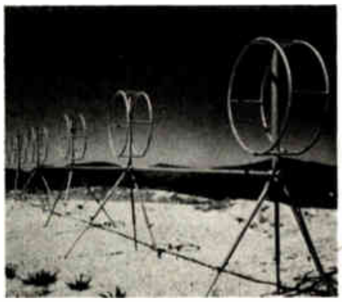

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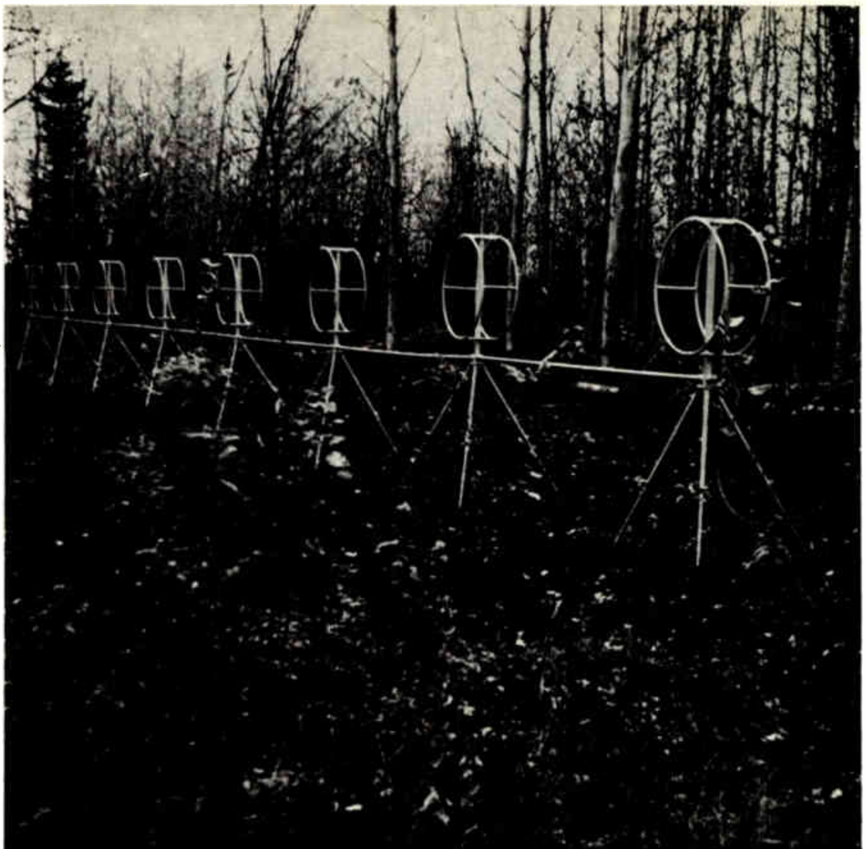

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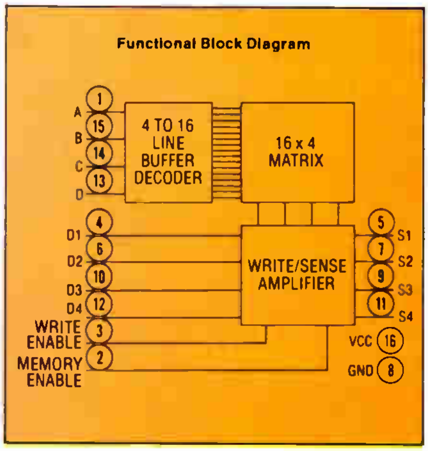
The SN54S/74S289 (3101A equivalent) has an open-collector output to use whenever data-bus line impedances are defined by other sources. Both have PNP inputs biased for standard 54S/74S threshold levels.



But the best is price. Both the SN74S189N and SN74S289N are only $4.24 in the 100-piece quantity. At under 7¢/bit, that's less than other 64-bit Schottky RAMs now on the market.

For data sheets, indicate by type number and write: Texas Instruments Incorporated, P. O. Box 5012, M/S 308, Dallas, Texas 75222.

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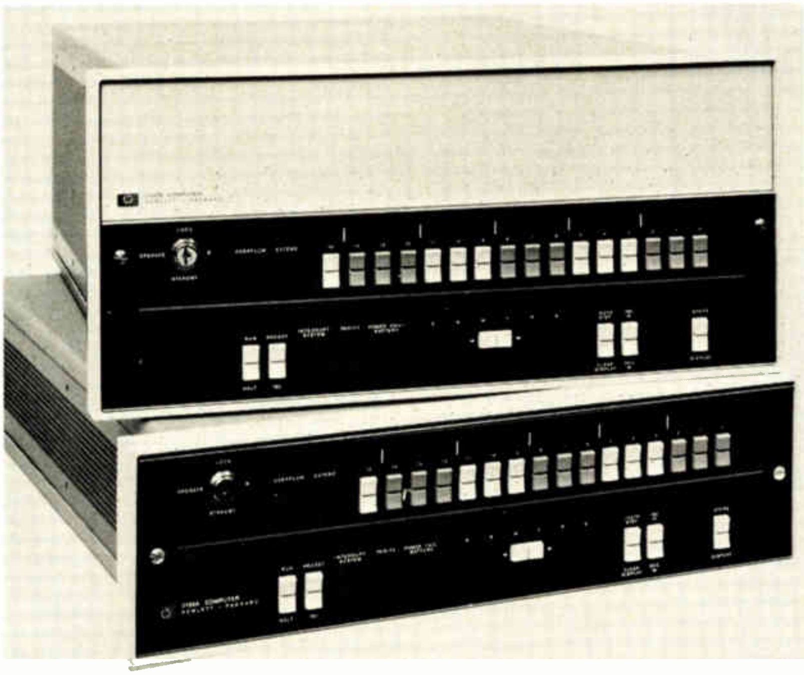
Minicomputer family adopts 4k RAM

Semiconductor device is main memory in new H-P line to bow at NCC; extensive microprograming capability for user is designed into machines

Predictions that 4,096-bit semiconductor memories would break into the mainframes of computers this year have been fulfilled with the introduction by Hewlett-Packard of a new family of minicomputers using 4,096-bit random-access memories as the main memory. The first two models of the new family of 16-bit minicomputers will be demonstrated at the National Computer Conference and Exposition, running May 6-10 in Chicago.

In addition to employing semiconductor main memory, the machines can be microprogramed by the user to an unprecedented extent, enabling him to tailor a minicomputer more precisely to his specific application.

Use of the new memory system, H-P points out, makes it possible to achieve reductions in size, weight, power consumption, and cost, as well as improvements in memory speed and reliability. The 4k MOS RAMs are being supplied to H-P by Texas Instruments, Motorola, and Mostek. What's more, H-P says, devices of other vendors are under test. H-P expects that mean time between failures of the new minicomputers will be from two to 15 times better than core-based machines, and extensive tests are underway to confirm that expectation. In addition to the memory, the processor, power system, and mainframe packaging of the machines are all new.



Beginnings of family. The model 2108A, at top, and the 2105A are the first in a line of minicomputers from Hewlett-Packard that uses 4,096-bit semiconductor memories for main storage. The machines are fully microprogramed with a 24-bit processor.

The first two models to be introduced are fully microprogramed. Memory parity, power-fail provisions, and extended arithmetic units are standard on both. The smaller unit, designated the model 2105A, is only 5¼ inches high and can contain within its mainframe 32,768 16-bit words of memory. It has four powered input/output channels. The model 2108A, which is 8¾ in. high, has nine powered I/O channels and a 32k memory, expandable later this year to twice as many words, all within the mainframe.

There are 42 new instructions, including 28 index register instructions, bit and byte manipulation instructions, move and compare firmware, and floating-point hardware (optional on the 2105A and standard on the 2108A). Another option is fast Fortran processor firmware which, by speeding a number of popular Fortran routines, causes some programs to run as much as 28 times faster than before, the company says.

The program and I/O compatibility are maintained throughout the new family. Compatibility is also maintained with earlier (HP 2100) minicomputers. Emulating earlier processors, the new series delivers comparable performance when running earlier programs. The entire instruction set of the earlier models is microprogramed within the new mini's processor-control address space. Emulation of earlier processors occupies less than an eighth of the new units' much enlarged processor-control address space. There is no loss in speed from the emulation procedure.

H-P user-accessible processors treat language instructions as directives to processor programs, which actually execute the instructions much more rapidly than they can assembly-language instructions. The new processor, common to both models, now has control address space for 4,096 24-bit words, up from the 1,024 words of earlier units, and 14 16-bit hardware scratch-pad registers. These are useful in storing temporary values locally during computing operations, adding speed by avoiding main-memory references.

For specific needs. Processor-control store and scratch-pad registers are easily accessible by the user. He can tailor microroutines precisely to his own needs, using writeable control store or programable-ROM writer options. Firmware microcode instructions can be plugged into the processor.

From the front panel, as many as four ROM-stored programs can be loaded by the user. A LOAD button and a new bootstrap loader automatically set the program counter to the starting address of the bootstrap program.

Beyond the usual direct memory access, a two-channel selector is available that connects any two peripherals, under program control, directly to the memory system. The two-channel selector contains control logic, memory address, and word-count registers not contained in the direct-memory-access facilities commonly found in minicomputers.

All H-P device interfaces include the ability to use the selector at no extra charge. This controller is dynamically assignable under program control to any two device channels simultaneously.

Memory-protect is obtainable on either new model, to protect the integrity of operating systems against accidental modifications. Memory-protect sets up a fence that divides memory space into areas, separating the operating system from user programs. If any part of a user program seeks to modify system space, the system will interrupt and take control.

Any of the more than 70 peripherals attachable to earlier H-P processors can be plugged into the new computers through powered I/O channels. As many as 34 more I/O channels can be added to either mainframe with an external extender.

An efficient power module copes with a wide range of power fluctuations and brownouts. If the power line should fail for as long as 10 cycles, the new minicomputers will operate normally, instead of going into a power-fail routine with loss of a single power cycle. Specified performance is maintained even if line voltage drops to 88 volts or as low as 176 V in a 220-V connection. Line frequency may vary from 47 to 66 hertz. Power supply efficiency is above 70%. The model 2105A consumes less than 300 watts; typical power consumption for the model 2108A is 400 W.

Power can be removed from everything but the semiconductor memory with a front-panel STANDBY switch. An optional power standby system—battery and charging and automatic-switching circuitry—preserves memory content for at least two hours if a total line failure is experienced. Power failure detection and automatic restart is available.

Self-protection. Unusual environmental immunity has been designed into the new minicomputers. Not only do they operate normally with varying line frequencies or low line voltages, but they protect themselves automatically against high-voltage conditions, and function to specification at temperatures from 0° to 55°C. Also, they are tested to withstand the same shock and vibration conditions as are H-P instruments.

Availability of both models is restricted to purchasers of five or more. The price to OEMs for model 2105A is $7,400 each with 16k memory; $11,000 with 32k memory. The price of model 2108A, with the same memory but with more I/O channels and with floating point as standard, is $1,000 higher. First deliveries are expected in June.

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

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Counter/timers cover 80 MHz to 1 GHz

Line of portable instruments to be introduced at Hannover Fair features factory-modular design, with extensive use of common subassemblies

by Arthur Erikson, Managing Editor, International

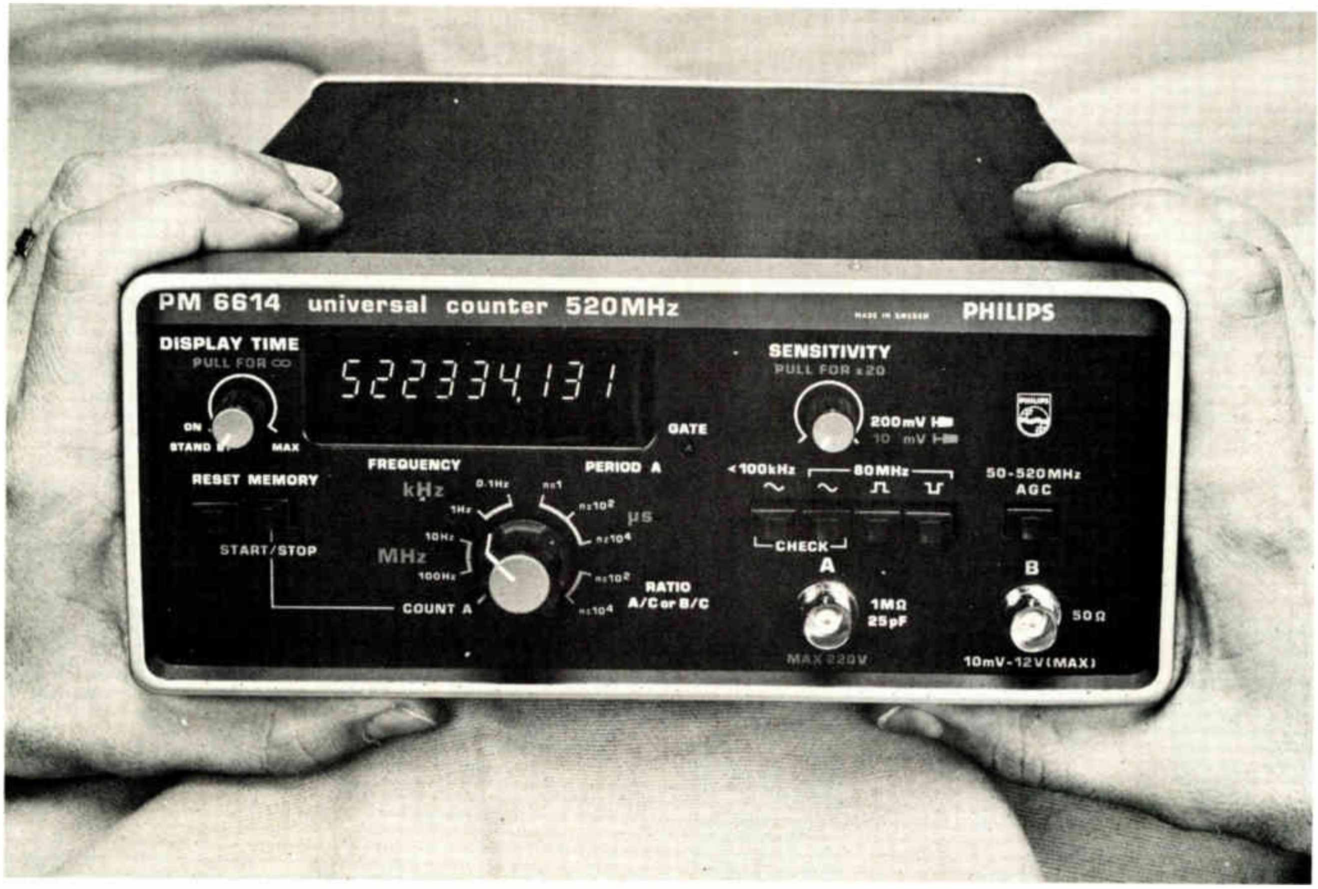
In recent years, fast-paced technology changes and heavy competition have sent prices of digital counter/timers tumbling by as much as 50%. And though prices have at the moment firmed up somewhat, instrument makers have to give customers a lot more for their money to hold their market shares.

Philips Industries so far has stuck to the upper and lower brackets of the counter/timer market, but now the company has readied an assault on the mid-range, which last year accounted for about $16 million of the $30-million counter/timer market in Western Europe. After a sneak preview early this month at the Paris Components Show, a new family of Philips counter/timers will have its big premiere at the Hannover Fair in late April.

Designated the PM6610 series, the family has five basic models—all portables—that span a frequency range from 80 megahertz to 1 gigahertz. The price tag for the bottom-of-the-line PM6611 runs roughly $800. For the most sophisticated version, the top-of-the-line PM6615, the basic price will be around $1,950. Sensitivity for the whole family is 10 millivolts, and time resolution for all models is 100 nanoseconds.

Jan C. van der Windt, product line manager for Philips counter-timers, calls the new family of instruments "factory-modular." All five basic models and the many different options possible were designed at the same time at the Philips group counter/timer supply center in Stockholm, using as many common parts and subassemblies as possible.

With that strategy, a large multi-



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Low package count. In PM6610-series counters from Philips, four custom C-MOS circuits handle the functions that would otherwise require about 50 TTL packages.

purpose C-MOS circuit could be incorporated to cut costs and boost performance—and in fact each of the new models contains four identical ceramic C-MOS packages. Other major common subassemblies include a thin-film hybrid front-end circuit, a special transistor-heated crystal oven for the time base, and a nine-digit "mini planar Pandicon" gas-discharge display. "By designing everything at once," maintains van der Windt, "we cut design costs by half."

The C-MOS circuit serves in both the instrument's time base and decade counters, a pair for each purpose. The chip itself measures 9 square millimeters (3.77 by 2.42 mm) and has the equivalent of 450 gates on it. The functions available are four decade counters plus latches, a multiplexer, and a three-stage output for cascading decades. About 90% of the functions available are used by the decade counters and rather less than 50% in the time base. The clock rate at 10 volts is guaranteed as 10 MHz. "Actually," says van der Windt, "it usually measures out between 15 and 17 MHz.

Van der Windt's list of advantages that can be traced back to the LSI/C-MOS packages is a long one. Among other things, the instrument has a high 100-nanosecond time resolution, very low power consumption for the digital circuitry, small size, and high reliability. However, the benefits of the front-end circuitry are equally remarkable, he points out.

In the rf channel, there's a multistage p-i-n diode circuit that attenuates the input signal to a level just slightly above 5 to 6 millivolts, the value of the trigger window. For the user, this means no worries about the level of the input signal, as long as its amplitude lies between 10 mV

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"Scotchflex" Flat Cable and Connectors can offer you trouble-free packaging for your next generation equipment.

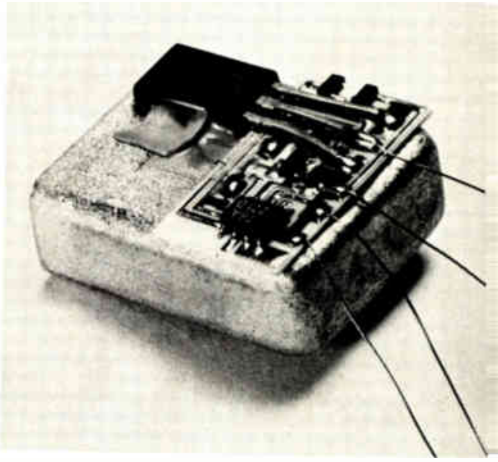
There's built-in reliability for your circuit inter-connects. Our flat, flexible PVC Cable has up to 50 precisely spaced conductors. The gold plated U-contacts are set into a plastic body to provide positive alignment. They strip through the insulation, capture the conductor, and provide a gas-tight pressure connection.

Assembly cost reductions are built-in, too. "Scotchflex" Connectors make up to 50 simultaneous connections without stripping or soldering. No special training or costly assembly equipment is needed.

Off-the-shelf stock offers you flat cable in a choice of lengths and number of conductors from 14 to 50. Connector models interface with standard DIP sockets, wrap posts on .100 x .100 in. grid, or printed circuit boards. Headers are available to provide a de-pluggable inter-connection between cable jumpers and printed circuit boards (as shown). Custom assemblies are also available on request.

For full information on the "Scotchflex" systems approach to circuitry, write to Dept. EAH-1, 3M Center, St. Paul, Minn. 55101.

3M COMPANY



Ovenized. A transistor heats the crystal oven that is incorporated into high-stability versions of the PM6610 series.

and 12 V. (In other words, the dynamic range is 62 dB.) Better still, the p-i-n diode attenuator eliminates false counts from noise on the measured signal. The noise is suppressed so much that it cannot span the trigger window. Actually, most models in the line offer two input channels, one for signals up to 80 MHz and one for signals higher than that. For noise-free low-frequency measurements, there's a low-pass filter that wipes out signal components that are higher than 100 kilohertz.

Van der Windt sees telecommunications servicing as a major market for medium-range counters, and for that reason the first model of the family to be marketed by Philips will be the PM6614. It spans the frequency range from 10 Hz to 520 MHz, has two input channels and the choice of four time bases (as do all models in the line). Other options include a battery pack for portable operation, binary-coded-decimal output to drive a printer, and a digital-to-analog converter that converts any three consecutive digits or the two least significant digits of the nine-digit readout. Room for the batteries and the BCD, a-d or printed-circuit cards is designed into the basic instrument.

Philips Industries, P.O. Box 42099, S-126.12, Stockholm, Sweden [339]

Philips Test and Measuring Instruments Inc., 400 Crossways Park Dr., Woodbury, N.Y. 11797 [364]

At last.

A FULL RANGE, 5-FUNCTION 3½ DIGIT MULTIMETER

$189.00

Data Precision's new Model 134 is the least expensive full function digital multimeter you can buy.

A real workhorse.

Designed as the first real alternative to analog meters, the Model 134 delivers digital precision at analog prices.

Measurements appear on a bright, 7-segment planar gaseous display, a full half inch tall and 3½ digits wide.

And they're precise measurements. Approximately 5 to 10 times more accurate than what you'll get from an analog meter. And a great deal easier to read.

Model 134 measures DC and AC volts, DC and AC current and resistance through a total of 22 range scales. No interpolations are necessary.

And the specs speak for themselves: basic accuracy of ±0.2% reading ±0.2% f.s. with autopolarity, auto-decimal positioning and 100% overrange. Optional Isolation and High Voltage Probes available.

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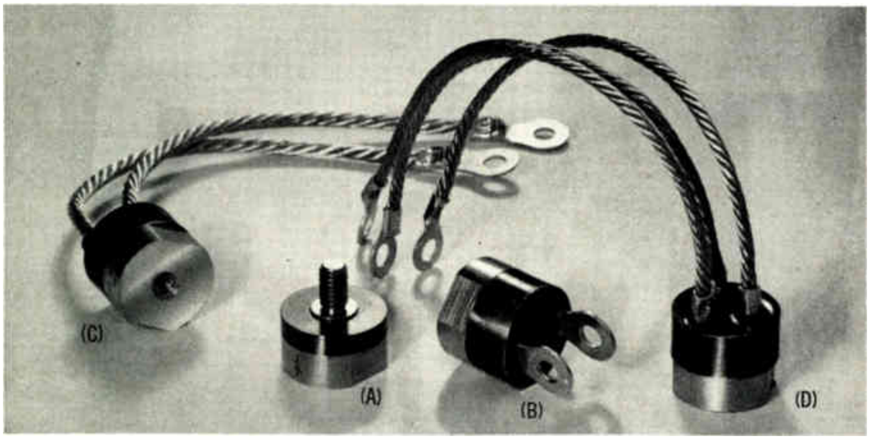
FAST RECOVERY POWER RECTIFIERS

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
PIV: 100, 200, 300 & 400 V.
I_R (@ 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.
I_R (@ 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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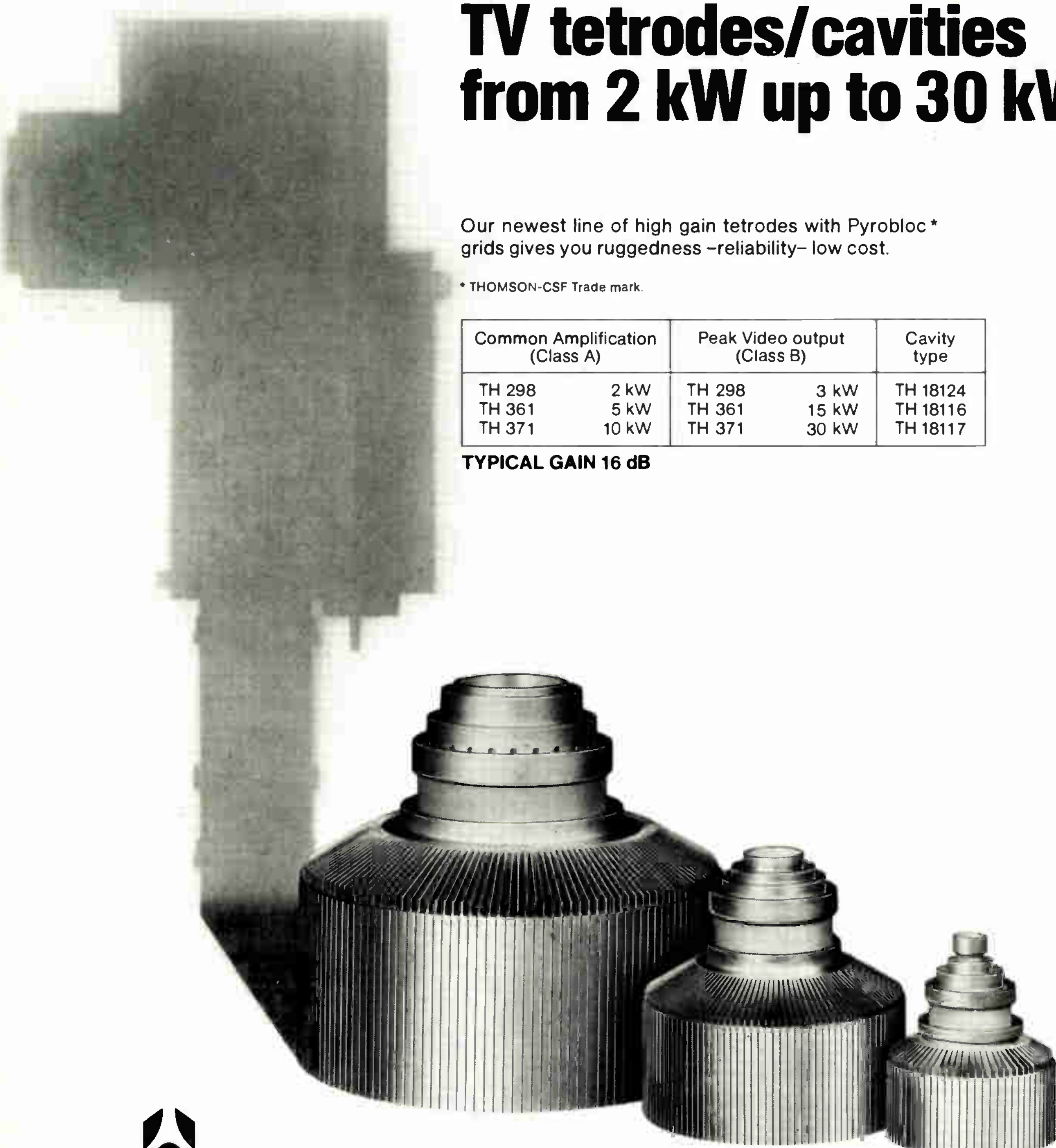
TH 361	5 kW	TH 361	15 kW	TH 18116
TH 371	10 kW	TH 371	30 kW	TH 18117

TYPICAL GAIN 16 dB



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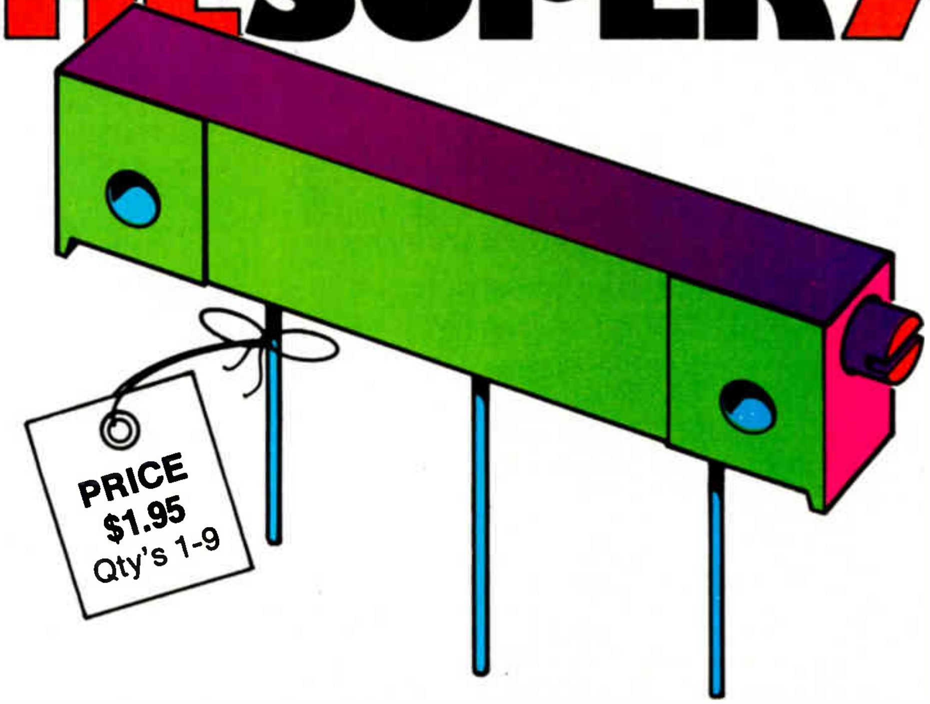
2004

THE SUPER 70



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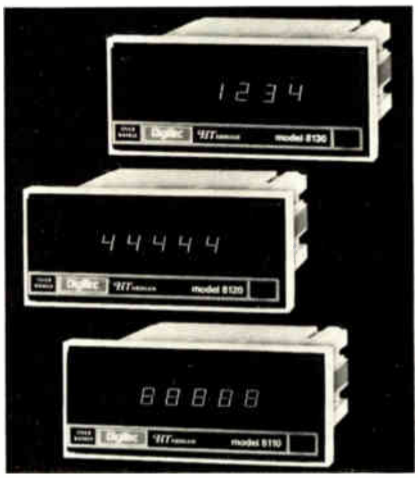
Instruments

Counter/timers are programable

Factoring types permit transducer readouts in any desired unit

Electronic instrumentation does not always interface easily with industrial transducers—but United Systems' 8100 series of programable factoring counter/timers should make the job easier. Each instrument in the panel-mountable series contains a crystal-controlled clock and a programable divide-by-N chip which combine to yield a time base that can be varied from 0.05 millisecond to 13 seconds in steps of 0.05 ms. This enables standard transducers to produce readouts in any desired units—English today and, if necessary, metric tomorrow—when some pin-to-pin wiring is changed.



The three instruments in the 8100 series feature full five-digit Monsanto LED displays. The model 8110 is a frequency counter that will transform the output of any frequency-producing transducer into any desired units. The model 8120, a totalizer, accumulates the output of any pulse-producing transducer and then factors it to read in such units as dozens, gross, cases, etc. The 8130 is a timer that is designed to measure time intervals and produce a direct reading in any desired units proportional to the time interval.

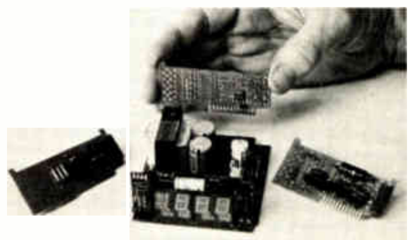
The trio also belongs to United Systems' new HT series [*Electronics*, March 7, p. 25] and have the same distinctive case design. Operating power is either 115 or 230 volts ac, at any frequency from 50 to 400 hertz. The meters mount in a standard panel cutout measuring 3.75 inch wide by 1.72 in. high.

The instruments, which are being sold under the Digitec tradename, cost $275 apiece and are obtainable from stock. Substantial quantity discounts are available.

United Systems Corp., 918 Woodley Road, Dayton, Ohio 45403 [361]

Digital panel instrument is all things to all users

The biggest problem confronting the user of digital panel meters is how to interface them into his systems. To help him, Analogic Corp., Wakefield, Mass., has developed a 3½-digit (2,000-count) panel meter with a built-in edge connector into which a customized signal-conditioning network (see photo) can be plugged. Thus, for just a few dollars' worth of parts—typically $1 to $3—a user can convert the instrument into a pH meter, a linearized cold-junction-compensated thermocouple meter, a microwave power meter, a position of force indicator, or any of



hundreds of other measuring instruments.

According to Bernard M. Gordon, President of Analogic, more than 200 instruments have already been designed and are described in a handbook which will be available later this month. The instrument, it

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should be noted, provides regulated voltages of ±12 volts dc and +5 v dc to the plug-in board so that active as well as passive components can be used in the signal-conditioning circuitry.

Even if its novel pluggable-transform feature is ignored, the new meter is impressive. It has a symmetrical, balanced, bipolar, true-differential front end, a power transformer that lets it run off any ac line voltage, a choice of LED or Beckman gas-discharge display, and a single-unit price of $119, which drops to $97 for quantities of 100 and up. A straight panel meter version, without the pluggable-transform capability, costs $109 in singles, and $87 in hundreds. Delivery of the meter is from stock.

Analogic Corp., Audubon Road, Wakefield, Mass. 01880 [363]

Low-cost generator operates up to 1 MHz

When is a frequency synthesizer not a frequency synthesizer? When it does not use the phase-lock technique, says Schneider Electronics Inc. The company prefers to call its model GF102 a frequency-synthesized generator, because the device reconstructs the sine wave by successive steps—a technique that keeps costs low.

Price of the GF102 is in fact $495. It generates both sine and square waves in the range from 0.01 hertz to 100 kilohertz. The GF102A, priced at $595, operates at up to 1 megahertz.

The sine-wave reconstruction works like this: the output from an 18-megahertz crystal-controlled oscillator is divided into segments, the length of which depends on the setting of thumbwheel switches. These segments are fed into a complex TTL system, which generates a code that goes to a digital-to-analog converter and an output amplifier. Each code constitutes an address which the converter sees as another step in building the sine wave. The duration of each step depends on the code that is going through the

thumbwheel switches. Between frequencies of 0 to 10 kHz there are 400 steps per sine wave, and up to 100 kHz there are 40 steps per sine wave.

Sine wave output has harmonic rejection of better than 50 decibels up to 10 kHz, 45 dB up to 100 kHz, and better than 40 dB for the model 102A. The nonharmonic rejection is respectively 50, 40, and 60 dB at 1 kHz from the carrier. Distortion is lower than 0.5% on the 102, and lower than 1% on the 102A.

As for the relative noise level, at 10 kHz it is 100 dB, and at 10–100 kHz, it is 90 dB. Relative noise level is also 90 dB in the 102A. Output voltage is 10 watts peak to peak. Attenuation is 50 dB with an accuracy within 0.1 dB.

The square-wave output has a rise and fall time of less than 50 nanoseconds. The duty cycle, which is fixed at 50%, has an accuracy within better than 0.5% for frequencies above 10 kHz, while below 10 kHz displacement is less than 100 microseconds. Output voltage is 5 volts on 50 ohms, and impedance is 50 ohms ±5%.

For both sine and square waves, output is floating, and frequency is accurate to within 0.005%. Internal impedance of both the 102 and 102A is 50 ohms ±5%, while inductance in the 102A is 15 microhenrys ±20%. Both units have a maximum output power of 0.2 watt and can operate in a temperature range of 0-50°C, with a temperature coefficient of 0.001%/°C. Since the units are digital, there is no drift over time.

Although the reconstructed-sine-wave technique limits the units to frequencies of not more than 1 MHz and introduces some phase jitter, Schneider believes the 102 and 102A can be used in most applications except control of transmitters. And on the plus side, Schneider claims there is no limit on low frequency: the sine wave always starts at zero.

Both instruments are one-half 19-inch-rack size. Delivery time is 8 days.

Schneider Electronics Inc., 3 Hazel St., Peabody, Mass [352]

Error rate tester has automatic synchronization

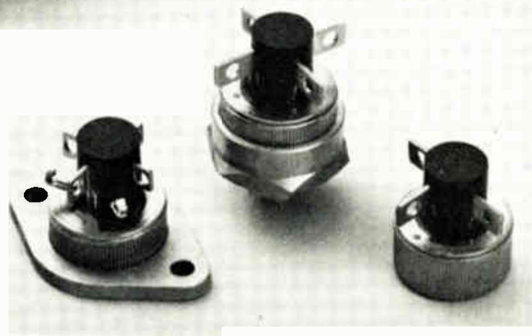
The use of emitter-coupled logic throughout a new bit error rate tester from Tau-tron Inc. yields a good increase in speed for only a small increase in cost over conventional testers, according to Tau-tron vice president John Connolly. The tester has a frequency range of 1 hertz to 75 megahertz, a minimum width of 5 nanoseconds, and a price of $1,800.

Designated the MB-1, the unit is the latest addition to a line of plug-in, modular instruments that provide various electrical stimulus and measuring functions. Intended for use in production, they are a departure for a company known principally for its expensive, laboratory-type test equipment and instruments.

The new tester provides automatic synchronization, with two error thresholds of 20 errors in 100 bits, and 2×10^4 errors in 10^5 bits. A burst-error-rate indicator lights whenever the auto sync error threshold is exceeded. The unit can also be synchronized manually from the front panel or by an external-standard level.

The unit operates at six different sequence lengths. A six-position code switch selects the number of bits per frame, expressed as 2^{n-1} where n equals 6, 9, 11, 15, 17, or 20. Frame sync is derived from a 20-bit digital comparator. After link-up, error rates are displayed on a four-digit LED display with overflow and gate time indicators.

Also measured by the MB-1 is block error, something Connolly says few units above a few megahertz do. A four-position switch se-



NEW

SCR CONTROLLED BRIDGE RECTIFIERS AND POWER SWITCHES

The VCB series of 25A and 50A controlled bridges and power switches are available in a ¾" press-fit package, with three mounting options and in epoxy packages. All units are hermetically sealed.

The epoxy packages are explosion proof and electrically isolated with double isolation available. SCR's are glass passivated. All chips are soldered to an integral copper mounting pad for improved thermal characteristics, typically $<1°C/W(R_{\theta jc})$. Epoxy barriers have been placed between standard .250" Faston and/or #10-32 terminals. Spacing exceeds NEMA standards.

Typical applications include DC motor speed controls, temperature controllers, battery chargers, inverters, frequency changers, D.C. power supplies, and servo systems.

All units are available in 60V, 115V or 230V, (V_{RMS}).

Typical economical pricing: VCB252-7 (200V, 25A) **$9.00 ea.**, 100 qnty.

PRESS-FIT

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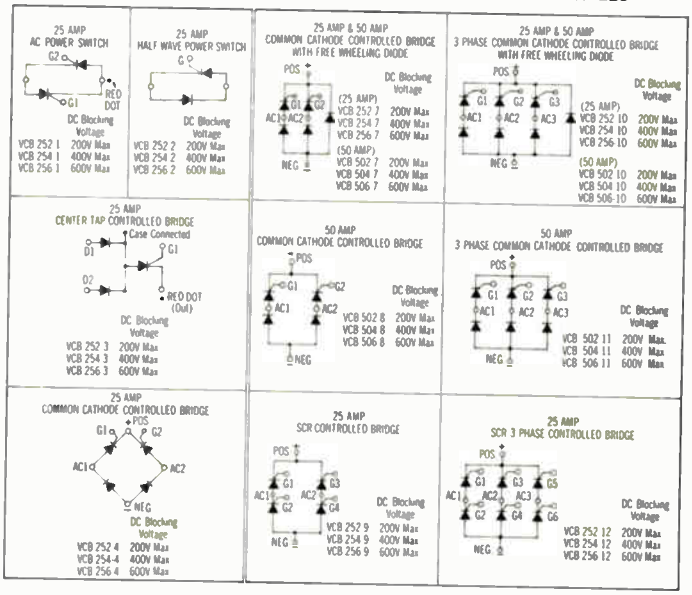

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VARO SEMICONDUCTOR, INC.

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lects bit rate or block lengths of 10,000 or 1,000 bits per frame. Block error is also displayed on the LED panel.

A three-position switch selects the counter mode; "time rate" selects bit or block error mode, "frame" displays errors per pseudo-random bits sequence, and "totalize" accumulates error pulses on an internal time base or a time defined by the external counter gate.

The unit is intended for standard communications markets such as microwave radio, as well as offbeat applications like magnetic recording. The 7-by-8-by-19 inch unit is priced at $1,800, or $3,500 when Tau-tron's MN-1 random-sequence generator, frame, and power supply are included.

Tau-tron Inc., 11 Esquire Rd., No. Billerica, Mass. 01862 [362]

Noise-power ratio is displayed digitally

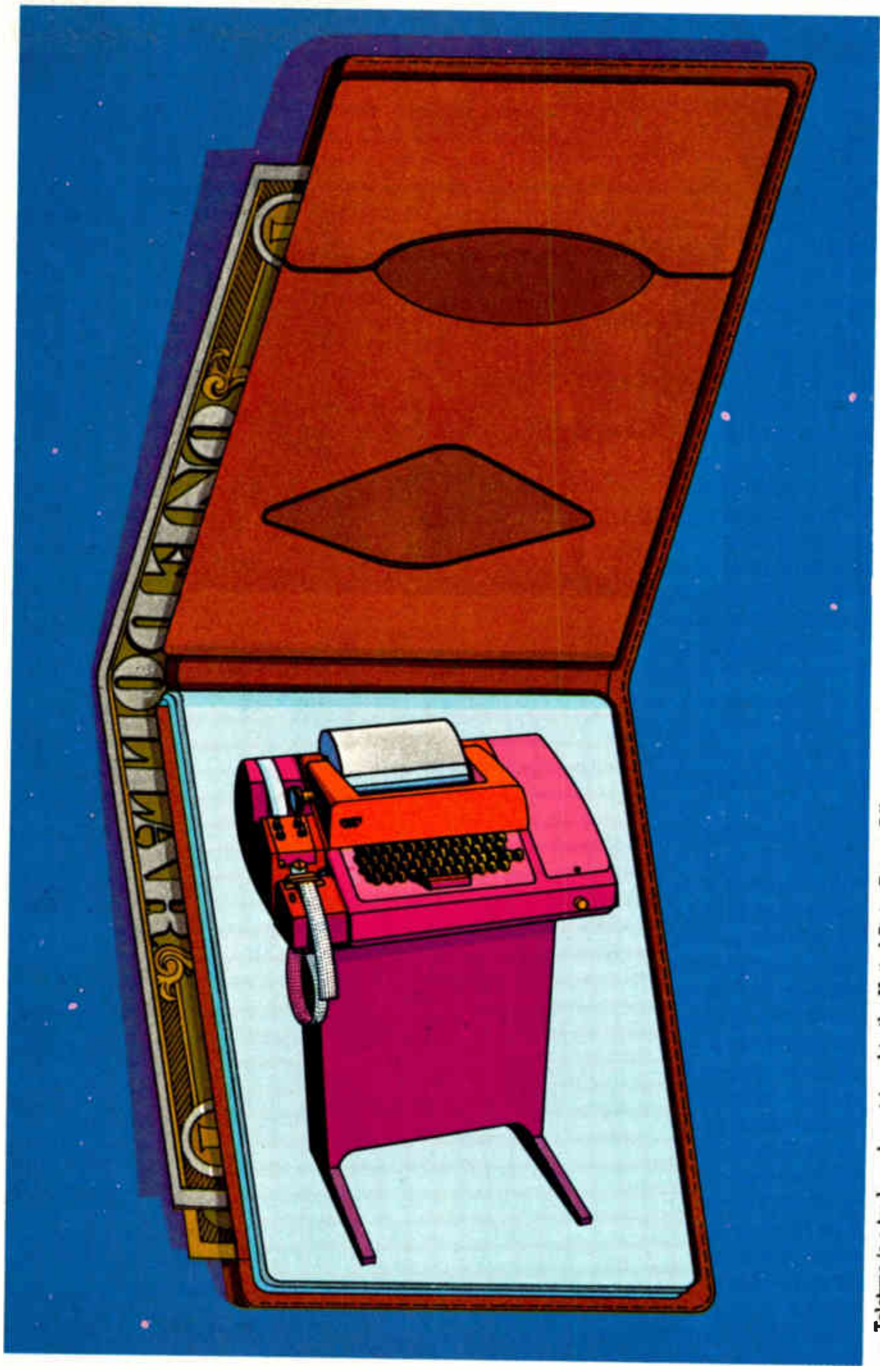
One of the most useful techniques for testing broadband communications channels is measurement of the noise-power ratio. An automatic white-noise loading receiver, designated the model 2092C, was designed for this type of test and can be used in conjunction with existing generators in the semiautomatic mode. The receiver automatically adjusts its sensitivity to the incoming noise level, intermodulation noise level, or residual noise level. The noise-power ratio is automatically determined and the result presented in a three-digit display. Programable control and digital output permit use of the unit in automatic test systems at central radio sites and satellite ground stations. Price is $3,500.

Marconi Instruments, 111 Cedar Lane, Englewood, N.J. 07631 [353]

Frequency synthesizer covers to 20 MHz

Designed to allow users of test oscillators to economically step up to frequency synthesis, the model 801

This member of our family is still the thriftiest ASR terminal around.



Teletype is a trademark registered in the United States Patent Office.

Dollar for dollar, the Teletype® model 33 is the least expensive, most reliable data terminal in its class. Because once you see how well it performs, you won't believe its price.

That's one reason why the model 33 is the most popular terminal in the industry. But it's hardly the only reason.

The model 33 is designed and built for extremely reliable operation at 100 wpm. And since it operates on the eight-level ASCII code, it speaks the language most computers understand. Both mini-computers and maxi-computers. Which makes compatibility another reason behind its popularity.

Then there are some reasons you can't see. But they're there just the same. Like complete technical sales and service back-up to help you with installation and maintenance.

Available in three basic configurations, the model 33 is a lot of machine. At a very small price.

It takes more than manufacturing facilities to build the machines Teletype Corporation offers. It also takes commitment. From people who think service is as important as sales. In terminals for message communications and computers.

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For more information about any Teletype product, write or call: TERMINAL CENTRAL, Teletype Corporation, Dept. 53P, 5555 Touhy Avenue, Skokie, Illinois 60076: Phone 312/982-2500.

frequency synthesizer offers a signal source with crystal-controlled stability, high frequency accuracy and resolution, and remote-control programing. The unit offers coverage to 20 megahertz in four synthesized digits, plus two additional vernier digits. Using the first four digits, frequency error is ±0.001% and, by using the instrument's phase-lock input, the unit can be slaved to an external frequency standard for higher accuracy. Price is $1,995.

Exact Electronics Inc., Box 160, Hillsboro, Ore. 97123 [357]

Sound-level meter includes miniature microphone

The model db-202 sound-level meter provides a remote miniature microphone, which is placed next to the user's ear to determine sound-level measurements. In this way, sounds are measured in real time. Pendant-type and boom microphones are also offered. The small pendant microphone is attached to a subminiature 5-foot shielded cable, while the boom microphone, which is smaller than a pencil, is attached directly to the sound meter.

Metrosonics Inc., Box 18090, Rochester, N.Y. 14618 [358]

Portable oscilloscope has 120-MHz bandwidth

Providing a remote dc switching function for optimum control-panel layout, the model PM3260 portable oscilloscope operates over a line variation of 90 to 250 volts and 46 to 440 hertz. Its basic specifications include a 5-millivolt-per-division sensitivity, as well as a 5-nanosecond-per-division maximum sweep rate. Bandwidth is 120 megahertz. In addition, the 3-nanosecond rise time can be displayed in separate, alternate, chopped, or X-Y mode, and a 1-MHz chopping rate helps to eliminate interference in the displayed signals. Price is $1,850.

Test and Measuring Instruments Inc., 224 Duffy Ave., Hicksville, N.Y. 11802 [359]

A flexcircuit for low-light home movies.

We did it for Kodak.

In turning the idea of low-light home movie making into the reality of the KODAK XL-55 Movie Camera, Kodak engineers solved tough design problems at every step. Among these problems, the design of a circuitry system of minimal bulk and maximum reliability.

They accomplished this with a Schjeldahl flexcircuit.

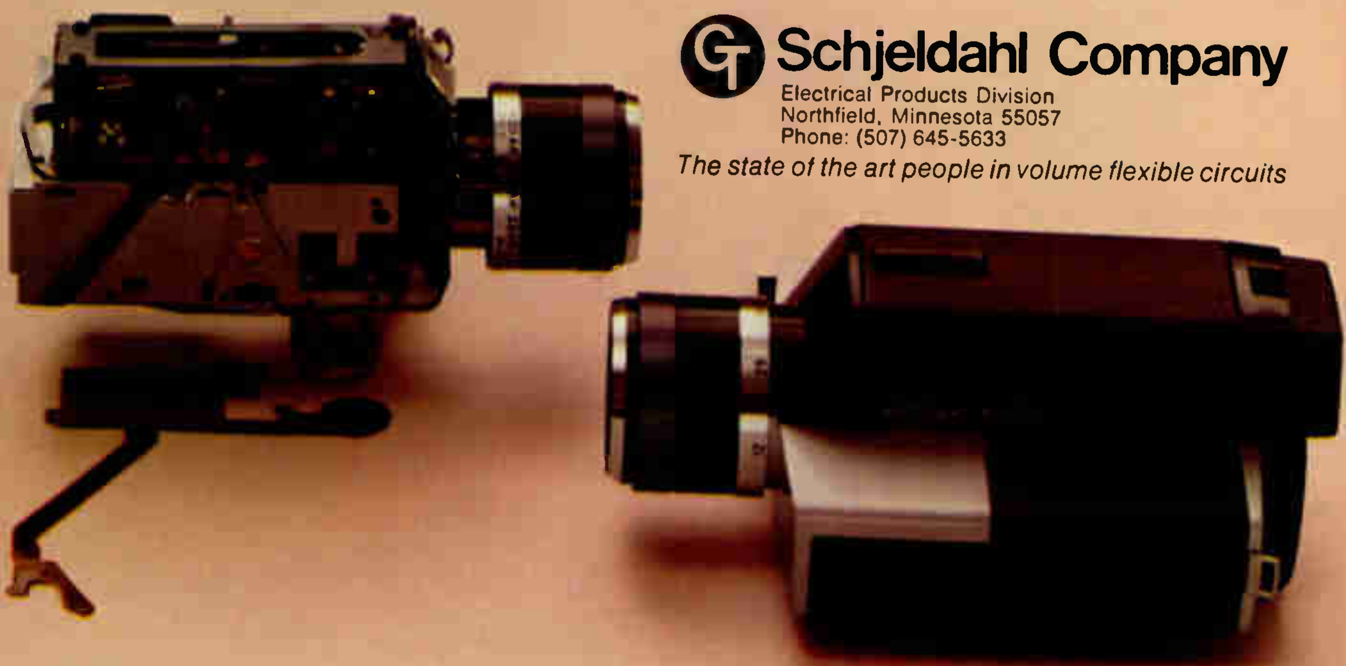
Flexing in four planes, this Schjeldahl flexcircuit has two 180 degree fold-over sections. This provides circuit reversal, transfers conductors to opposite sides of the circuit without the expense of plated-through holes and permits placement of seven conductors in a five conductor space — all without two-sided circuitry.

This Schjeldahl flexcircuit makes all electrical connections in the camera and carries all electronic components. For manufacturing efficiency, a hardboard back-up section permits auto insertion of components and continuous process wave soldering.

The flexcircuit fits available space and is designed for volume production. It does for Kodak what flexcircuitry does best.

Perhaps Schjeldahl flexcircuitry advantages can help in your design problems. It only takes a call to Schjeldahl to find out.

Schjeldahl did it for Kodak.



Schjeldahl Company
Electrical Products Division
Northfield, Minnesota 55057
Phone: (507) 645-5633

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In less than 2 years, our amplifier-per-channel System 620 has become industry's most popular high speed data acquisition system. Today, thousands of channels are performing reliably in the field. In scores of applications from Turbine Engine Test to Earthquake Engineering. Now System 620 is even more flexible than before. With 3 input amplifier options, four analog-to-digital converters and several computer interfaces to choose from. So here's the latest chapter on System 620, the new approach in data acquisition.

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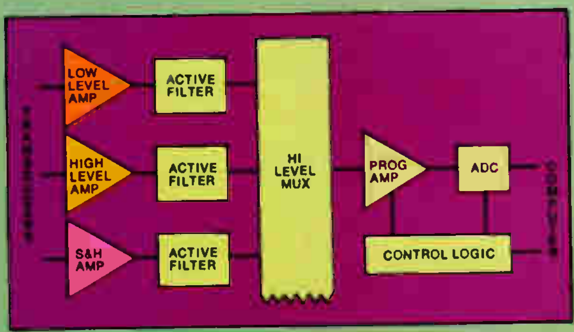
Our field proven low-level differential amplifiers are perfect for strain gages & thermocouples since transducer signals are isolated right at the source. Our specs are impressive, too. With gain accuracy of 0.01%, 2 microvolt stability and 120 dB common mode rejection. More protection, too. If one channel gets wiped out by an overload, the rest don't feel a thing.



NEW HIGH LEVEL AMPLIFIERS

Since high gain isn't always required, we've added an amplifier option which, for just $80 a channel, provides system gain of 1 to 400. That's more than adequate for many applications. Yet, retains all the features of our low-level amplifiers.

NEW SIMULTANEOUS SAMPLE & HOLD AMPLIFIERS

Low level sample & hold amplifiers are absolutely necessary in applications such as transient and vibration analysis, where data must be grabbed in a few nanoseconds or time correlation of data is important.

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System 620 now has four analog-to-digital converters to choose from. If you need high accuracy, we can give you 14 bits at 20kHz. In most systems our economical 12 bit, 10 kHz analog-to-digital converter will suffice. Or if higher speed is your need, specify 12 or 15 bits at 50 kHz.

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System 620 has been interfaced with a number of computers, both large & small. Interface hardware and software is available for most popular computers.

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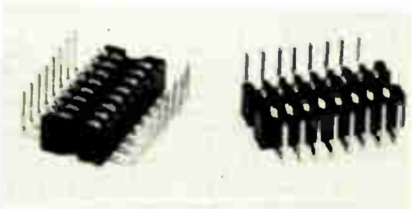
Circle 150 on reader service card

Packaging & production

IC socket keeps board profile low

Terminals are on same side as sockets, giving over-all height of 0.355 inch

Each printed-circuit board in a densely packaged electronic system should have a low over-all profile. But that goal can be difficult to achieve if the designer uses wire-wrapped tails, because they jut out



from the side of the board opposite the component side.

This problem is eliminated by an integrated-circuit socket developed by Robinson-Nugent Inc. Socket and terminals are mounted on the same side of the board, and the result is an over-all board height of 0.355 inch. The close proximity of socket contacts and wiring terminals also makes it easy to identify pins and component leads, thus eliminating a major cause of wiring errors.

"The pressure for a low profile is growing," says Marc Amster, Robinson-Nugent's national sales manager, "because designers are eager to mount many IC functions in equipment such as point-of-sale terminals, reservations systems, and credit-card validators—and still end up with a compact package."

The contact/terminal system developed by the Indiana company is also said to provide a good electromechanical mating of socket contact and IC lead. Since the contact bears on the flat side rather than on the edge, contact surface area is about 60% greater, lowering contact resistance and increasing the reliability of the contact interface.

Made from a spring-tempered beryllium copper, the contact provides a good mating with IC leads ranging in thickness from 8 to 18 mils. The socket is available with either gold- or tin-plated contacts. Socket bodies are molded of glass-filled nylon and are end-notched to facilitate mounting either singly or in series with #2 fillister-head, self-tapping screws.

Robinson-Nugent Inc., 802 E. Eighth St., New Albany, Ind. 47150 [391]

Panel mount accepts any dual in-line LED

A universal panel mount accepts any dual in-line LED display packaged with a 0.3-inch row spacing. The unit consists of a one-piece nylon bezel, a circular polarizing window, and a one-piece socket assembly that is located behind the panel, thus eliminating the need for individual DIP sockets. Dual in-line displays with 14 or 16 pins can be accommodated in presentations from two to eight units. The socket as-

sembly has wire-wrapping terminations and a 20-pin capacity. Further, no mounting holes are needed other than a single panel cutout, and after installation of the bezel, the display package aligns itself.

Industrial Electronic Engineers Inc., 7720-40 Lemona Ave., Van Nuys, Calif. 91405 [393]

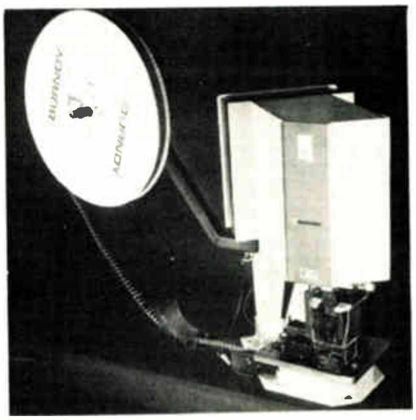
Pc connector eliminates need for interfaces

A printed-circuit connector, which eliminates the need for a hybrid interface between electrical and electronic circuitry, substitutes for as many as four conventional interconnect techniques. It does away with many connections among logic boards, flexible cable, barrier blocks and terminal blocks. Designated the PCB Block, the connector permits direct plug-in of 0.200-inch-contact-spaced pc boards on which components or flat flexible cable can be mounted. The block also provides 300-volt insulation between circuits, and each circuit can carry up to 5 amperes. Blocks can accommodate six, 12, 18, 24, 30 and 36 circuits.

Amerace Corp., Control Products division, 2330 Vauxhall Rd., Union, N.J. 07089 [394]

Terminating machine offers low deflection

The UTM-2 universal terminating machine provides high-volume installation of open-barrel strip terminals and contacts, with end- and side-feed capability. Low deflection is achieved by using a 5-ton steel press and a roller clutch, which insure crimps of consistent quality and long tool life. A dial permits fast selection of crimp and insulation height for a wide range of AWG sizes without changing the crimp tooling.



Burndy Corp., Norwalk, Conn. 06852 [396]

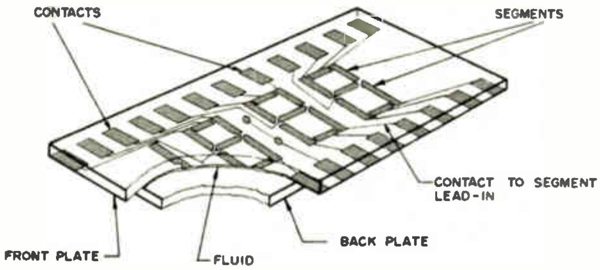
IC socket board replaces solder joints

An integrated-circuit socket board with 108 patterns is a wire-wrapping system; it contains a two-piece wire-wrapping-to-wire-wrapping connec-

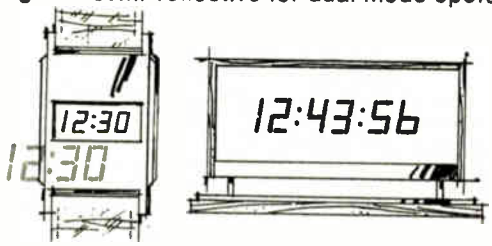
The case for Liquid Crystal Displays

Liquid crystal displays; light emitting diodes; incandescent and flourescent displays and "Nixie" tubes are popping up frequently in circuit designs as the trend to digital readout continues. Each has a purpose and the design engineer should become familiar with all types. We make liquid crystal displays.

The display of the future?
Our display is a sandwich of two plates, joined and hermetically sealed at the perimeters. A space of about .005" separates the plates, and this is filled with a nematic liquid crystal solution.



When the liquid is not electrically excited, its long, cigar-shaped molecules are parallel to one another in a position perpendicular to the plates. Thus, the liquid appears transparent. Applying an electric current creates ion activity which leads to turbulence and causes the liquid to scatter incident light. The visual effect is that of a frosted glass. LCD's can be made completely transmissive for back-lighting, reflective for ambient light or semi-reflective for dual mode operation.



Producing an image — digital or other — simply requires a conductive surface the shape of the desired image on the glass plate toward the viewer. Current flowing from the conductive image on the front plate through the crystal liquid to the common-ground back plate causes the liquid to change from clear to a frosted appearance in the current-carrying area.

These images are almost always in the form of seven segments that make up the numerals 1 through 0. Energizing the proper segments produces the desired numerals. Lead-ins connect the segments to external contacts on the sandwich (display).

Consider the advantages.
Liquid crystal displays have a number of distinct advantages. Simplicity is the reason for several of these. The elements are few and passive — very little can go wrong with an LCD and this means reliability and long life.

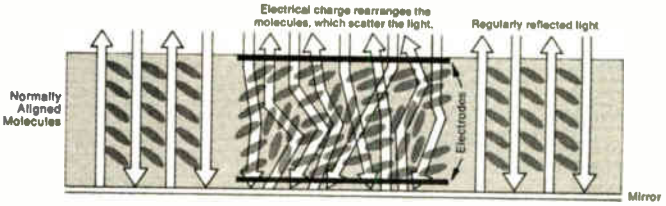
Simplicity means low cost, too — lower than that of most comparable displays. Packaging costs are low because LCD's can be driven directly by MOS and C/MOS circuits. In our dynamic scattering displays very narrow character widths are possible and still provide a good viewing angle — 60 degrees in many cases.

Low power consumption makes the LCD a logical choice where power limitations rule out other display types. Watch type LCD's use only 30 μW, for example, with all segments energized at 15 volts.

LCD's offer the greatest flexibility of any display type. Several standard displays are immediately available from Hamlin's stock. Special displays with virtually any type of image can be produced with surprisingly low preparation or "tooling" cost. Because of the LCD's simplicity, lead time on specials is only a matter of weeks.

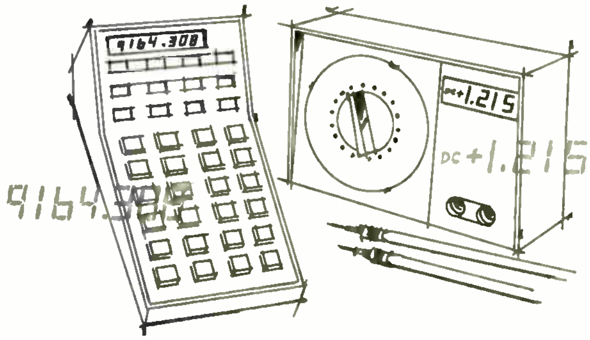
A few limitations.
LCD's have limitations, too. Operating temperature range is one. Liquid crystals slow down and may even cease to function at temperatures below 0°C. Above 50-60°C, crystals go into solution and will not function normally.

DYNAMIC SCATTERING



Extremes do not damage LCD's. Once the temperature returns to normal, operation is automatically resumed.

LCD's do not generate light, and they are somewhat difficult to read under low ambient light conditions. (Side or back lighting can remedy this.) Visibility under medium to high ambient light conditions is excellent.

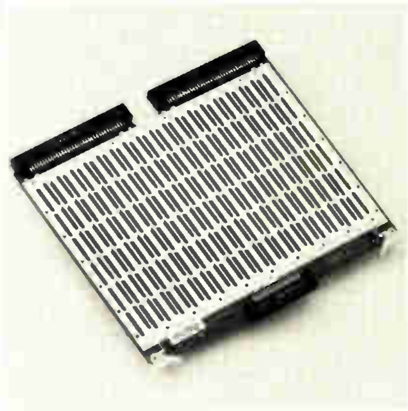


In the majority of display applications, MOS and C/MOS compatibility, reliability, flexibility and low power requirement are important considerations. No other display type can match the liquid crystal display on these jobs. They could become the display of the future. And that's the case for the LCD. For specification and application data, write Hamlin, Inc., Lake Mills, Wisconsin 53551. Or call, 414/648-2361. (Evaluation samples are available at moderate cost.)

HAMLIN
INCORPORATED

9791

tor, which eliminates the need for solder joints on the feed-through pins. With the system, there is no need for bridged pins, copper pads, or gold-plated copper fingers on the input and output of the panel, so that tolerances on the routing of the panels need not be exact. This re-



duces the chances of misalignment of edge fingers to the connector contacts. Price is less than $170 for 10 pieces.

Mupac Corp., 646 Sunner St., Brockton, Mass. 02402 [395]

DIP sockets contain built-in heat sinks

A series of dual in-line sockets, called the PD1000 series, has built-in heat sinks for 14-, 16-, and 18-pin integrated circuits. The heat sink is located under the IC, where most heat occurs and packaging density is not affected. The socket insulator features a closed-entry front end that is probe-proof and is designed to accommodate a finned extrusion for heat dissipation. The resultant increase in thermal conductivity improves the reliability of high-wattage ICs. Also offered are a tuning-

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fork contact design and various plating options to meet environmental requirements.
Teradyne Inc., 183 Essex St., Boston, Mass. 02111 [397]

Universal panel disconnect suits modular systems

A universal panel disconnect, called the model PD-20 and designed for modular component systems, uses the Elcon helix connector, which provides many points of contact with the male pin. This feature provides low contact resistance and low

temperature rise in high-current applications—a 2,000-ampere load applied for one minute results in a 75-millivolt drop through the helix connector. Insertion and retraction forces of 5 pounds nominal permit easy removal and insertion of the modular panels.
Elcon Division, Icore International Inc., 180 N. Wolfe Rd., Sunnyvale, Calif. 94086 [398]

Chip-removal machine uses shaving action

A chip-removal machine has a four-directional pendulum arm and a positive-rake angle scraper, the depth of which is adjusted so that the machine does not injure conductor paths, land areas or substrates. Using a shaving rather than a cutting action, the tungsten carbide scraper slices smoothly without creepage or roughness. The arm can

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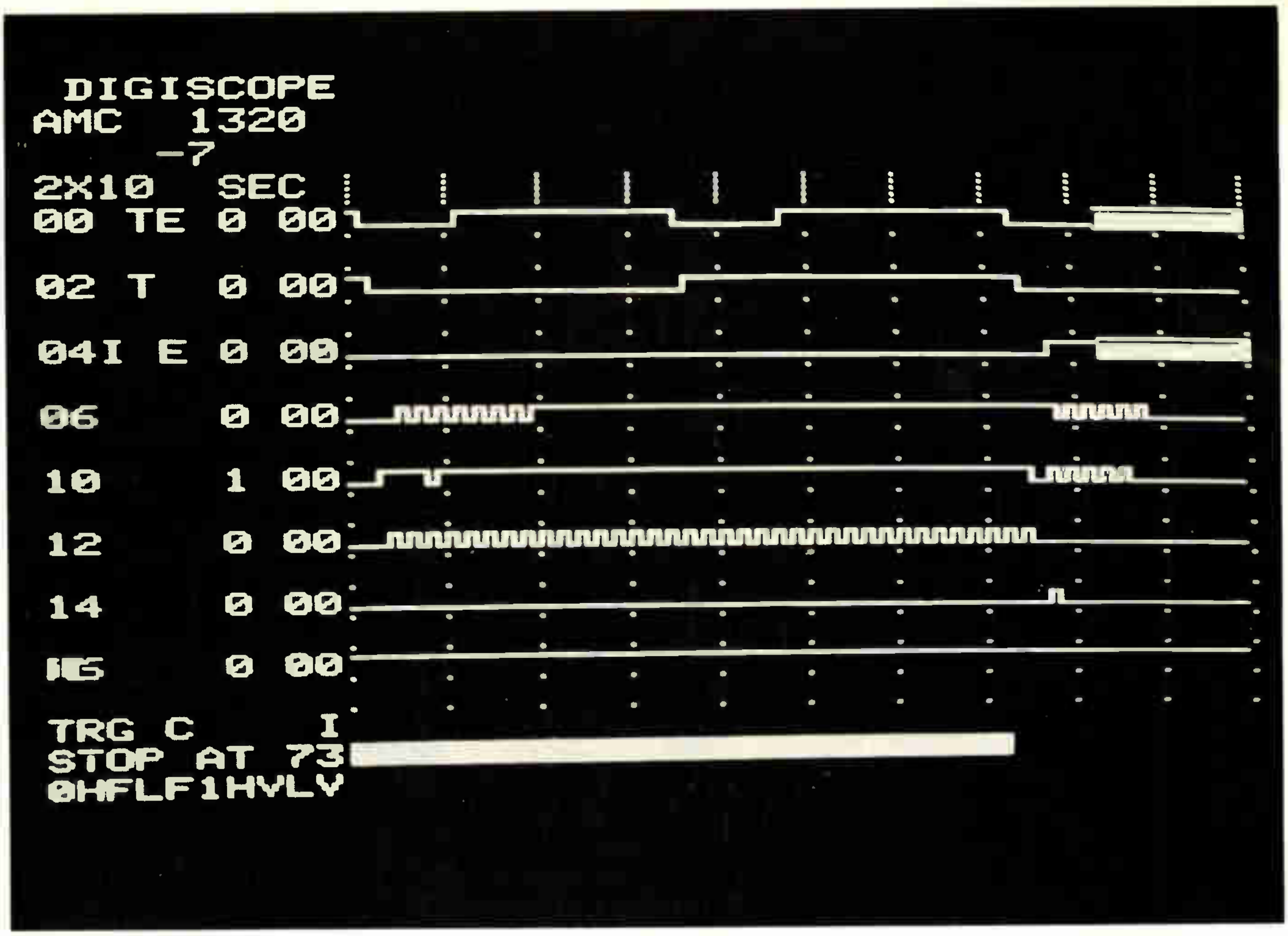
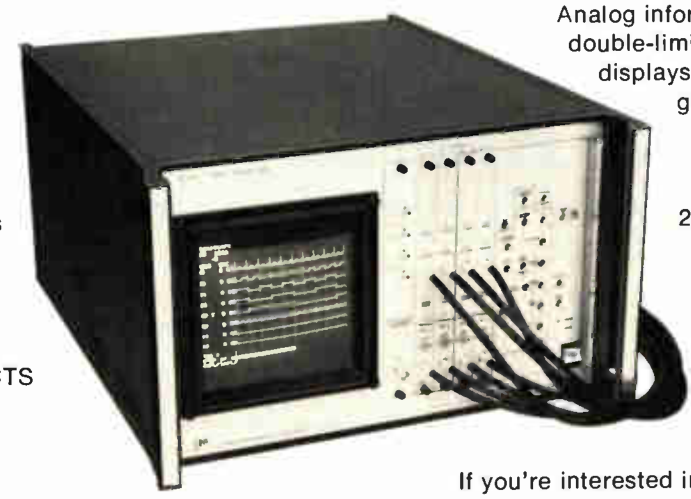


Digital timing, analog problems–only the Digiscope shows you both

"A radically new logic state analyzer from E-H Research gives you the equivalent of an 8 or 16 gun, 50 MHz, real time scope display of logic timing. It lets you see such analog parameters as glitches, ringing, rise and fall times, and voltage levels."
— Jerome Lyman, ELECTRONIC PRODUCTS Magazine, 1/19/74



The Digiscope gives you eight channels of digital data simultaneously acquired at 50 MHz, up to 100 bits of pre-trigger lookback, and single shot measurements without sacrificing critical analog information in the signals.

Now Digiscope lets you see such anomalies as glitches (Channel 14), slow rise times (Channel 6), low "one" levels (Channel 12), high "zero" levels and ringing (Channel 10) that are often the cause of mysterious system failures.

Analog information is preserved with unique, double-limit threshold comparators. Screen displays all instrument settings for photographic recording.

You can trigger on any logical combination of the eight inputs. Probe impedance is greater than 20 megohms, shunted by less than 8pF, so you don't have to worry about a probe loading the circuit.

We think when you see it, you'll agree: Digiscope is the most efficient, error-free test instrument ever made for designing, debugging, and maintaining digital electronic equipment.

If you're interested in the whole story about this radically new logic state analyzer, let us know. We'll send you the AMC 1320 Digiscope brochure immediately.

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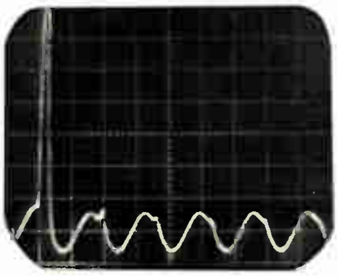

Airpax Type UPG/APG circuit protectors assure positive protection without nuisance tripping. This is accomplished by an exclusive Airpax inertial delay that provides tolerance of short duration inrush currents without decreasing steady state protection.

The UPG/APG line of low cost, compact circuit protectors offers series, shunt, and relay configurations with a choice of delays and ratings. Ratings are from 20 milliamperes to 30 amperes, 250 volts maximum at 60Hz, 250 volts at 400Hz, and 65 volts dc maximum. A SPDT auxiliary switch, for remote signalling or alarm, rated at 5 amperes, can be supplied with series trip types.

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To get the full story on Airpax Type UPG/APG electromagnetic circuit protectors, write for Bulletin 2003.

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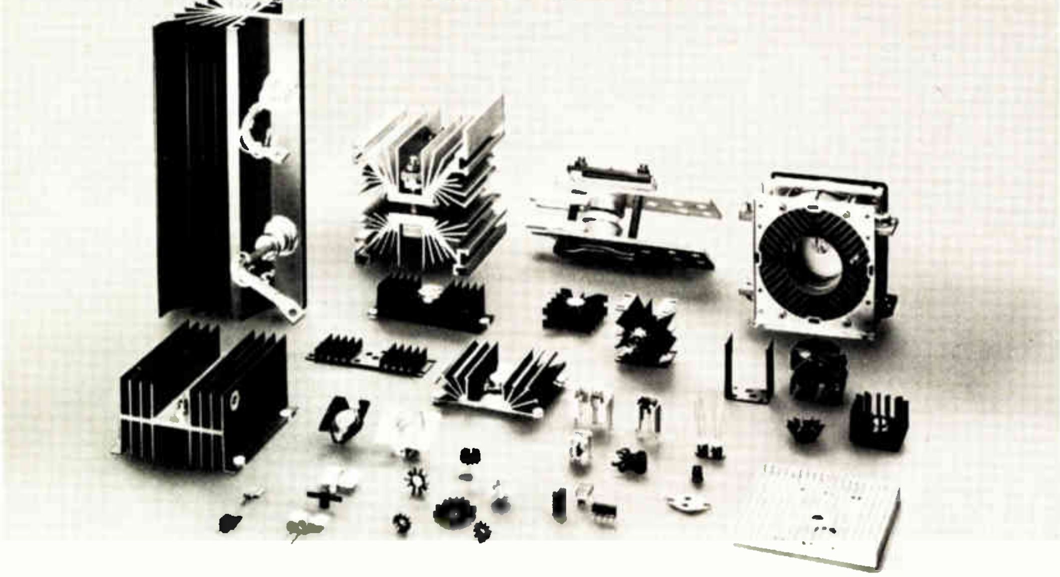

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●CAR-LAC ELECT/Bohemia	(516) 567-4200
CRAMER/East Syracuse	(315) 437-6671
CRAMER/Endwell	(607) 754-6661
CRAMER/Hauppauge	(516) 231-5600
CRAMER/Rochester	(716) 275-0300
●GENESEE RADIO/Buffalo	(716) 873-9661
MILGRAY/Freeport	(516) 546-6000
●NEWARK ELECT/Plainview	(516) 822-5000
NEWARK ELECT/Rochester	(716) 473-6600
NORTH CAROLINA	
CRAMER/EW/Winston-Salem	(919) 725-8711
HALL-MARK/Raleigh	(919) 832-4465
●KIRKMAN ELECT/Winston-Salem	(919) 724-0541
PYTTRONIC/Raleigh	(919) 782-6370
OHIO	
JOHN BECKER ELECT/Dayton	(513) 226-1341
CRAMER/Cincinnati	(513) 771-6441
CRAMER/Cleveland	(216) 248-8400
●HUGHES-PETERS/Cincinnati	(513) 351-2000
●HUGHES-PETERS/Columbus	(614) 294-5351
NEWARK ELECT/Cincinnati	(513) 874-5115
NEWARK ELECT/Cleveland	(216) 361-4700
●PIONEER/Cleveland	(216) 587-3600
●PIONEER/Dayton	(513) 236-9900
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HALL-MARK/Tulsa	(918) 835-8458
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ALTAIR/Houston	(713) 462-3029
● ALTAIR/Richardson	(214) 231-5166
CRAMER/Dallas	(214) 350-1355
●HALL-MARK/Dallas	(214) 231-5101
●HALL-MARK/Houston	(713) 781-6100
NEWARK ELECT/Dallas	(214) 271-2511
NEWARK ELECT/Houston	(713) 782-4800
UTAH	
CRAMER/Salt Lake City	(801) 487-3681
●NEWARK ELECT/Salt Lake City	(801) 486-1048
WASHINGTON	
CRAMER/Seattle	(206) 762-5755
●STERLING ELECT/Seattle	(206) 762-9100
WEST VIRGINIA	
RPC ELECTRONICS/Wheeling	(304) 232-7630
WISCONSIN	
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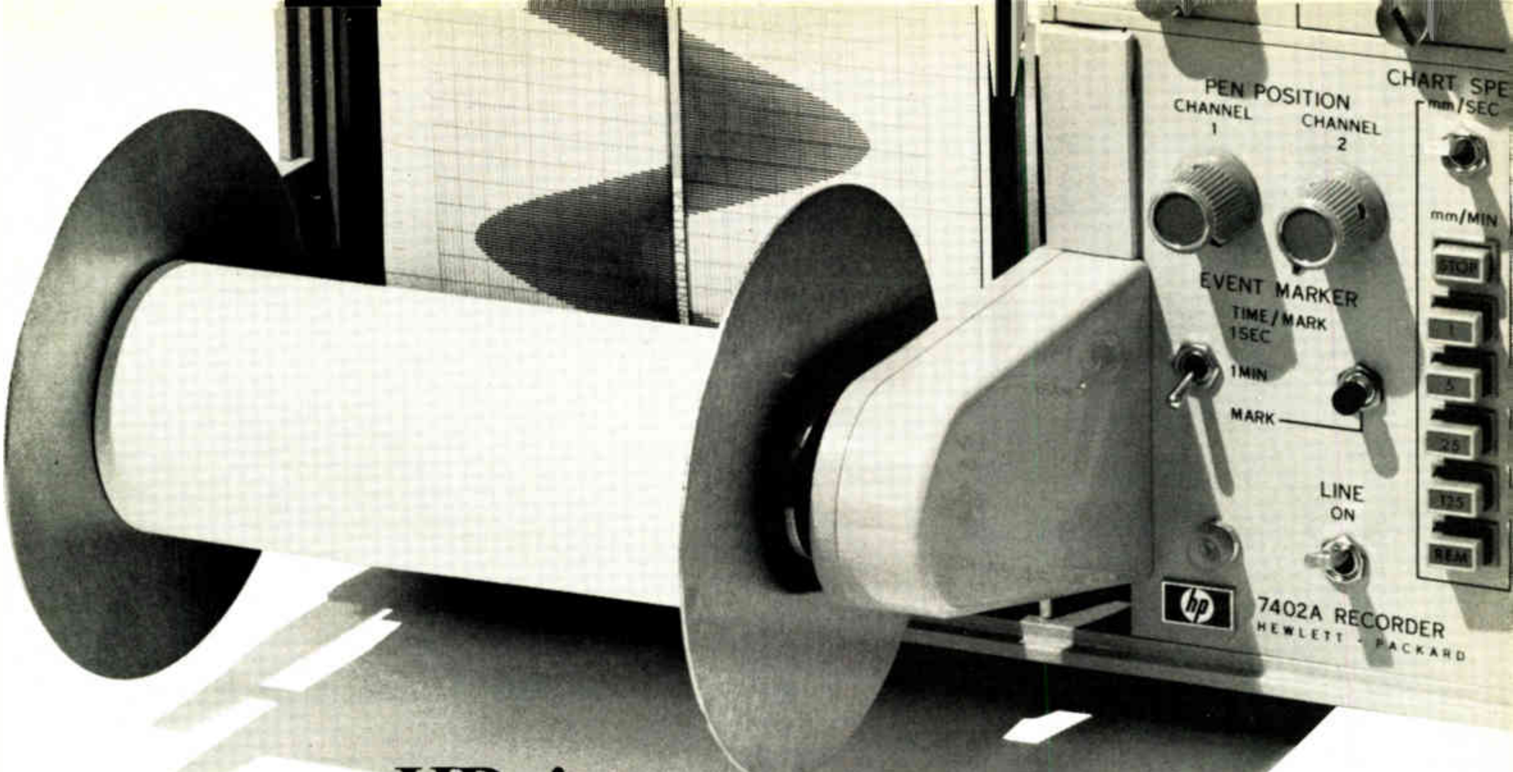
NEWARK ELECT/Brookfield	(414) 781-2450

●**Principal stocking points**



HP gives you weeks of continuous data, marking by the minute or second, a 50 or 100 mm picture and full remote control...

all rolled up into one low cost, plug-in oscillographic recorder.

Now there's a way to get precisely the recorder you want, without paying for more recorder than you need. Start with Hewlett-Packard's two-channel 7402A Oscillographic Recorder. For just $2,000* you can have two versatile 1mV/div DC plug-ins.

Then build from there.

For long-term measurements, add our seconds-to-minutes (60:1) chart speed reducer at $150. You can choose from eight speeds, 1mm/min to 125mm/sec. And there's an optional take-up available that neatly rolls up enough paper for up to 58 days of continuous operation. It's $110.

You can have a combination event marker and minutes-or-seconds timer with both TTL and contact closure remote control. It only adds $125.

High or low gain plug-in modules, priced from $145, provide increased capability when you need it.

But no matter how you customize your 7402A, HP gives you standard features you'll want to have in almost any situation. To study a single channel in minute detail, you can double picture size from 50 to 100mm. The performance-proven writing system puts down a crisp, bone-dry trace with non-fatiguing stainless steel pens. And since full remote control capability can be built in, you can easily use a 7402A recorder as part of a computerized data system.

There's more. Just compare the 7402A with recorders costing even twice as much. It gives you features, options and HP reliability. All rolled up into one. For details, write Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304. 11406

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Subassemblies

Unit changes V to Hz, Hz to V

Closed-loop design permits converter to operate in either direction

A designer at Datel Systems Inc. set out to build a voltage-to-frequency converter, but discovered that his closed-loop design could also do frequency-to-voltage conversions. This was the inadvertent birth of a series of "universal" converters: the VFV-10K, covering frequencies from 0 to 10 kilohertz, and the VFV-100K, covering 10 to 100 kHz. The respective unit prices of $59 and $79 are comparable to those of modules that can convert in one direction only, Datel says.

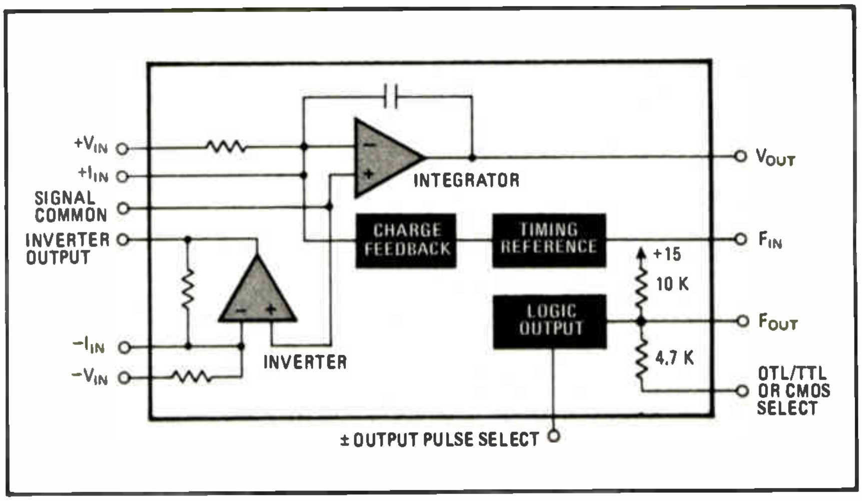
The converters use a charge-balancing feedback method to generate an extremely linear and temperature-stable output pulse frequency. Since this is a closed-loop feedback system, it can be used as a v-to-f or f-to-v converter depending on where the feedback loop is broken. In v-to-f applications, the integrator puts out a voltage to control timing of the pulses, and the pulses feed back as a charge to the summing point of the integrator.

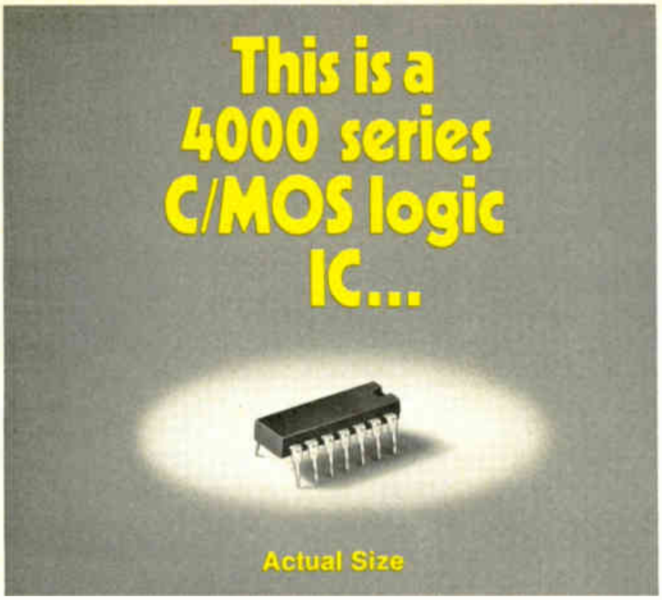
If the loop is broken, the user can inject his own pulses and use the integrator output as the voltage output of an f-to-v converter. The integrator compares the input voltage with output frequency and integrates the error, giving linearity within ±0.005% maximum in the 10K, and ±0.05% maximum in the 100K. Linearity holds all the way from full scale to zero.

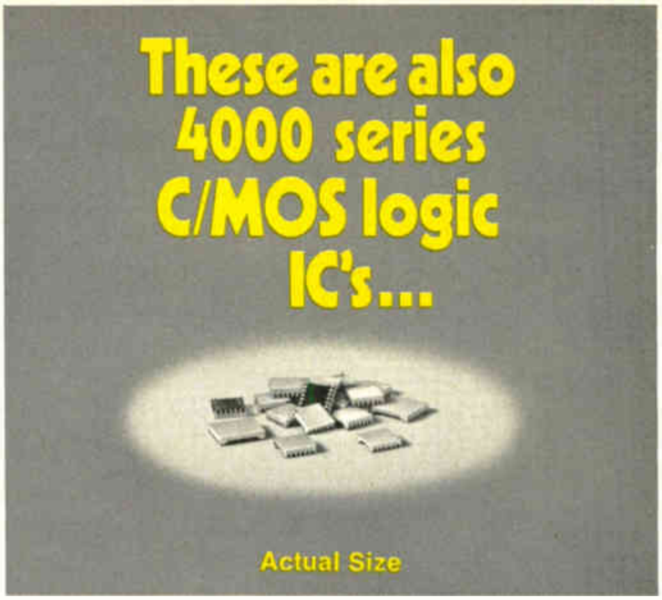
Different operating characteristics can be determined by external pin connection, including v-to-f or f-to-v conversion, v-to-f with voltage inputs of either 0 to +10 volts or 0 to −10 V, v-to-f with current inputs of either 0 to +1 milliampere or 0 to −1 mA, f-to-v with output of either 0 to +10 or 0 to −10 V, v-to-f with either positive or negative output pulses, and v-to-f with output logic levels either DTL/TTL-compatible or C-MOS-compatible.

Both units have full-scale and zero-offset adjustments, and inputs and output have a 10% overrange. Widths of the output pulses are constant, 75 milliseconds for the 10K and 7.5 microseconds for the 100K, with a repetition rate proportional to input voltage or current. If a step in voltage or current is applied to the input, the output pulse frequency settles to 0.01% of its new value after one pulse. In the f-to-v mode, the 10K accepts input pulse widths of 10-60 μs; and the 100K, widths of 1-6 μs.

The VFV series can replace an analog-to-digital converter in many applications; it can measure the difference between two frequencies as an analog value and, subtracting the







Now – for hybrid circuits... Amperex introduces microminiature LID versions of 14 of the most popular C/MOS logic IC's of the 4000 series.

Until now, hybrid circuit manufacturers have had only two ways to use C/MOS logic: the conventional packages that traded away space for C/MOS performance... or individual C/MOS chips trading away production-economy and yield to get C/MOS performance.

Now there's a third choice—C/MOS IC's in microminiature LID packages—and now you have C/MOS performance in small space *with* production-economy *and* high circuit yields.

With Amperex LID C/MOS IC's, you get a 20 times reduction in volume that allows you to take full advantage of the inherent high-density possibilities of C/MOS circuitry... and you get fully pre-tested packaged devices that mount directly, economically and reliably onto the substrate by ordinary reflow solder techniques. Your costly semiconductor-bonding operations are eliminated along with the need for expensive equipment and the skilled labor to handle it.

We can deliver LID versions of 14 of the most popular of the 4000 series C/MOS IC's off-the-shelf, in production quantities. They are available, with either 14 or 16 terminals, as indicated at right. Delivery schedules on others of the 4000 series can be obtained via telephone.

For technical data and details of how you can design C/MOS circuitry into your hybrid IC's with LID densities and LID economy... or for information on the full line of Amperex LIDS for hybrids... write: Amperex Electronic Corporation, Solid State and Active Devices Division, Slatersville, Rhode Island 02876. Tel: 401-762-9000.

TYPE	FUNCTION	TERMINALS
LFG4000	Dual 3-Input NOR Gate Plus Inverter	MA-14
LFG4001	Quad 2-Input NOR Gate	MA-14
LFB4009	Hex Buffer/Converter (Inverting)	MA-16
LFB4010	Hex Buffer/Converter (Non-Inverting)	MA-16
LFG4011	Quad 2-Input NAND Gate	MA-14
LFF4013	Dual "D" Type Flip-Flop	MA-14
LFR4015	Dual 4-Stage Static Shift Register	MA-16X
LFS4016	Quad Bilateral Switch	MA-14
LFC4017	Decade Counter/Divider	MA-16X
LFC4020	14-Stage Ripple-Carry Binary Counter	MA-16X
LFR4021	8-Stage Static Shift Register	MA-16X
LFG4023	Triple 3-Input NAND Gate	MA-14
LFF4027	Dual J-K Master-Slave Flip-Flop	MA-16
LFG4030	Quad Exclusive-OR Gate	MA-14

Actual Size

Amperex®

TOMORROW'S THINKING IN TODAY'S PRODUCTS

Sold through North American Philips Electronic Component Corporation

Circle 165 on reader service card

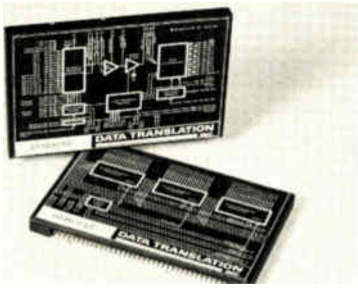
values of the voltages, can be used for high-voltage isolation of a signal. In digital data transmission, it can convert pulses driven over a line back to the original signal.

Both units measure 2 by 2 by 0.375 inches. Delivery time is 4 weeks, starting in June.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021 [381]

Data-acquisition modules run off minicomputer supply

Data-acquisition modules—small integrated subsystems that sit in a minicomputer on the same printed-circuit boards as the digital logic circuits—are a new kind of animal. But Data Translation Inc. is betting that their appeal is growing. As its first product, the Framingham, Mass. company has introduced the Datax series of modules, one 16-channel



and the other 64-channel, which run off the minicomputer's 5-volt power supply through a dc-dc converter.

The company believes its larger system is the first module to offer 64-channel data-acquisition capability. Until now, it says, users either had to build their own systems or buy one in a rack-mountable chassis. The larger system includes a 16-channel DT1620 data-acquisition module and a 48-channel DT48EX expander module, each in a plug-in package measuring 3 by 4.6 by 0.375 inches. (The DT1620 is also available separately). Cycle time is 20 microseconds, and throughput rate is 50,000 12-bit words per second with accuracy to within ±0.03%. The unit can be short-cycled by pin-strapping to 10 bits, giving a 40% increase in throughput.

The DT1640 is a 16-channel module of the same small size. But its cycle time is slower—40 microseconds—and throughput is 25 kilohertz for each 12-bit word. Both single-ended and differential inputs are available, with system accuracy within ±0.03% worst case.

Both units provide multi-channel multiplexing, sample-and-hold, 12-bit analog-to-digital conversion, and all programing and control logic in a plug-in module small enough to fit the 0.5-inch spacing that is common to minicomputers. Temperature coefficient is ±30 parts per million per degree centrigrade, and full-scale voltage inputs of ±5 volts, ±10 V, and 0 to +10 V are pin-selectable.

To prevent digital logic noise from getting into analog circuits, both systems have maximum separation between analog and digital circuits within the module, as well as a maximum of ground-plane shielding for the analog circuitry. Ground loops are further prevented by bringing all analog and digital grounds together at one point. A metal housing protects the modules from electromagnetic and electrostatic noise in the computer.

Sales will be to OEM houses—units have already been designed for Digital Equipment Corp.'s PDP-11 and Data General's Nova line—and probably to systems companies as well. Interface of the Datax series to terminals is left to the OEM.

Price of the DT1640 is $495, or $395 in quantities of 100. Price of the two-module 64-channel system is $1,195 for a single unit; the DT1620 is priced at $595 as a separate unit.

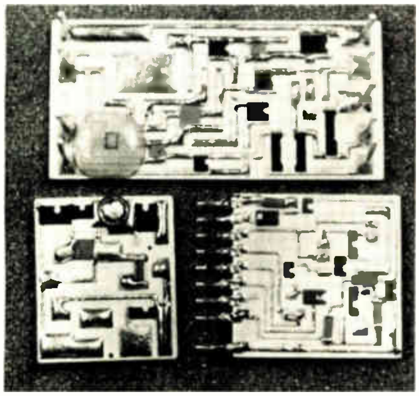
Delivery time is 4 weeks.

Data Translation Inc., 109 Concord St., Framingham, Mass. 01701 [382]

Compact thick-film networks provide variety of circuits

Standard and custom micronetworks for end-users consist of various conductors and mounting pads laid out on a ceramic substrate.

Trimmed thick-film resistors and chip capacitors and inductors are added. Input and output terminals are connected to the specified re-



quirements of the circuit, and the user then bonds the semiconductors on the mounting pads provided. A wide variety of circuits can be developed this way, and in ordering, the customer need only furnish the circuit schematic with passive components identified, the quantity required, size limitations, maximum electrical and environmental stresses to be encountered, active devices to be bonded or not, and bonding technique preferred.

Solitron Devices Inc., 256 Oak Tree Rd., Tappan, N.Y. 10983 [384]

Telephone tone filters operate to 1,633 hertz

The series 882 telephone tone filters are pretuned band-pass active devices. Center frequency is set ±0.5% to a standard tone frequency of 697, 770, 852, 941, 1,209, 1,336, 1,477, or 1,633 hertz, and Q is set to 18 ±10%. Gain is set at unity at the bandpass center frequency and, in addition,

each unit has an input impedance of 30 kilohms and can supply ±2 milliamperes output current with less than 1-ohm output impedance. Center frequency temperature coefficient is less than ±100 ppm/°C over 0° to 70°C.

Helipot Division, Beckman Instruments Inc., D962, Fullerton, Calif. 92634 [385]

Miniature amplifier covers 5 to 400 MHz

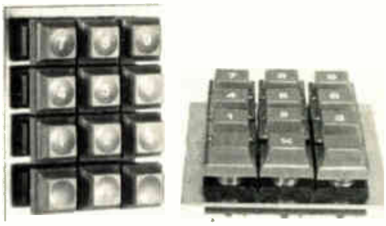
A miniature amplifier, designated the A-M series, is flat (+ 1.0 decibel) over the range from 5.0 megahertz

to 400 MHz with a nominal gain of 12 dB. Other specifications include a noise figure of 5 dB maximum, with the input-output impedance available in either 50 or 75 ohms. Constructed with solder pin connections, the enclosure is 1 by ¾ inch. Price is $27 in quantities up to 100. Delivery is from stock.

Spectrum Microwave Corp., 328 Maple Ave., Horasham, Pa. 19044 [387]

Mounted keyswitches are aligned in a metal plate

Arrays of the Lo-Pro keyswitches are provided premounted and aligned in a metal plate, ready for insertion into a pc board. The company claims that savings in assembly cost are achieved through th elimination of handling individual switches and the elimination of an extra pc board, cables and connectors. The arrays are available in 1 by



4, 2 by 4, 3 by 4, and 4 by 4 keys. The mounting plates are also available in special shapes to receive other components such as LEDs.

Stackpole Components Co., Box 14466, Raleigh, N.C. 27610 [388]

Solid-state timer is convertible

The model 1013U ac solid-state convertible timer offers on-delay or off-delay, normally open or normally closed static output by means of one

positive detent selector switch. Static output is rated for more than 100 million operations. The convertible unit also has an optically isolated ac control circuit with transient protection to 1,500 volts. Time ranges are from 0.02 to 2.6 seconds to 0.5 to 250 seconds.

Industrial Solid State Controls Inc., 435 W. Philadelphia St., York, Pa. 17405 [389]

Op amp is aimed at medium-power audio uses

Designed for medium-power audio applications, a low-noise operational amplifier, called the model

We take your reputation seriously.

That's why we build and test our Standard Power Modules so carefully.

A basic component like the power supply can put an expensive machine out of business. And, while the shutdown may be temporary—the loss of reputation and customer confidence may be permanent.

This is why many O.E.M.'s are taking another look at their power supply "economies." When they do, North Electric looks better and better.

This is because our line of Standard Power Modules offers the highest levels of engineering and quality control in the industry—the same standards that have made North the leading custom power source for more than 40 years.

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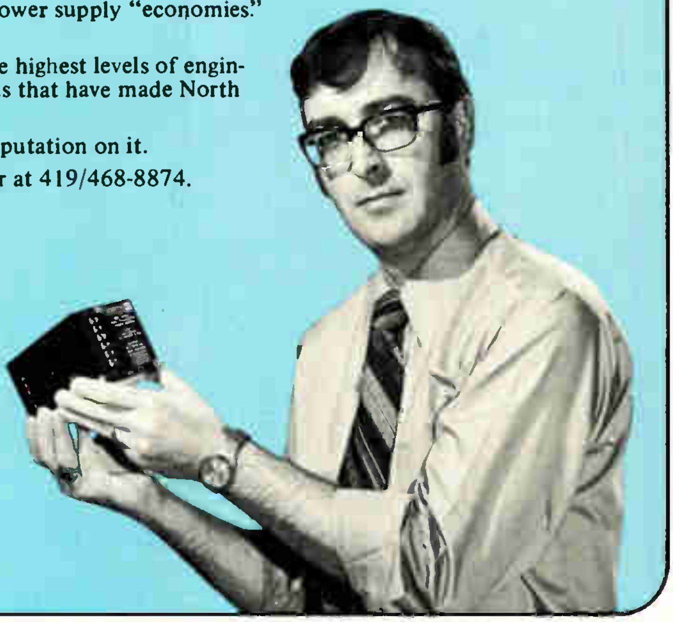


MODEL	11000	12000	13000	14000	15000	16000	17000	18000
VDC	AMPERES							
5.0	3.9	5.3	11.3	13.0	20.0	32.5	49.0	82.0
12.0	2.8	4.2	8.0	10.5	15.0	23.0	36.0	58.0
15.0	2.4	3.7	7.5	9.5	14.0	20.5	27.0	47.0
18.0	2.1	3.3	6.0	8.0	13.0	18.0	26.0	40.0
24.0	1.5	2.8	4.2	7.0	11.0	15.0	21.0	33.0
28.0	1.4	2.4	4.0	6.3	9.0	14.0	20.0	29.0
36.0	1.2	2.2	3.1	5.6	8.0	11.0	14.0	23.0
48.0	.95	1.8	2.6	4.2	6.0	8.0	10.0	18.0

DUAL OUTPUT SUPPLIES	
MODEL	N03052
VDC	AMPS
±15-12	400MA
MODEL	N60052
VDC	AMPS
±15-12	1.0A

MODEL	10000
VDC	AMPS
0-7.5	2.10
0-16	1.25
0-25	0.85
0-33	0.68

Listed here are the more popular models-many other voltages are available.

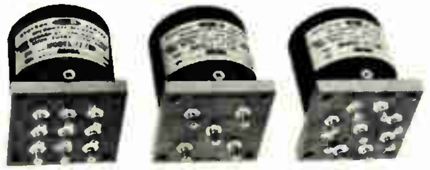
NORTH ELECTRIC COMPANY

North Electric Company / Galion, Ohio 44833 / A United Telecom Co.

SP-18

Circle 169 on reader service card

New Coaxial Switches For ATE



Systron-Donner's remotely programmable coaxial switches handle high-speed signal switching and multiplexing in 50 and 75 ohm systems. Choose from these 3 models:

Model Number	7714	7718	7732
Pole arrangement	1X4 (1P4T)	1X8 (1P8T)	3X2 (3P2T)
Rise time	<500ps	<1ns	<350ps
Transient aberrations (Pk - Pk, 1 ns step)	2%	2%	1%
Price	$130	$185	$165

For full details, call your Scientific Devices office or contact S-D at 10 Systron Drive, Concord, CA 94518. For immediate details, call our Quick Reaction line (415) 682-6471 collect.

SYSTRON DONNER

Circle 264 on reader service card

The Brush recorder module. It gives your system the competitive edge.

OEM recorder modules give you design flexibility along with all the Brush exclusives.

Choose single or dual channel, low profile or vertical models. There's a wide range of chart speed options.

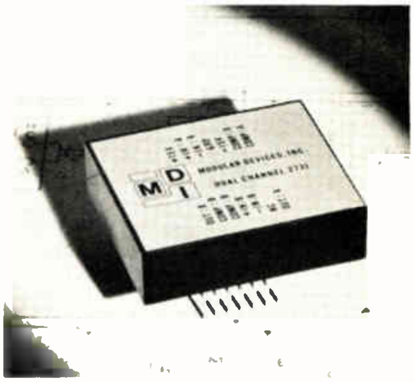
Plus Brush exclusives like pressurized ink writing and Metrisite® servo loop feedback system that assures 99.5% linearity.

Write Gould Inc., Instrument Systems Division, 3631 Perkins Avenue, Cleveland, Ohio 44114. Or Kouterveldstraat Z/N, B 1920 Diegem, Belgium.

GOULD

Circle 265 on reader service card

2731, is a dual device with two amplifiers in one package. This enables the user to design two combinational circuits with a minimum of extra components. With the addition of an output transformer, the module can drive a speaker to 4 watts continuous peak power. Output power is 2 W per channel. The unit comes in a 14-pin dual in-line configuration for pc-board mounting. Price is $39 in small quantity.



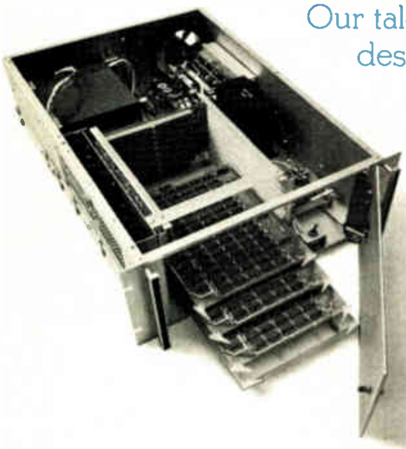
Modular Devices Inc., 1385 Lakeland Ave., Airport International Plaza, Bohemia, N.Y. 11716 [386]

Sample-and-hold module offers fast acquisition

The model 5025 sample-and-hold module provides an acquisition time of 30 nanoseconds for a 20-volt signal-level change and also offers a signal bandwidth of typically 50 megahertz. Slewing rate is greater than 600 volts per microsecond. Other specifications include a 50-ns maximum settling time and a 100-picosecond maximum aperture uncertainty. Price ranges from $160 to $130, depending on quantity.

Optical Electronics Inc., Box 11140, Tucson, Ariz. 85706 [390]

Memory Options Unlimited



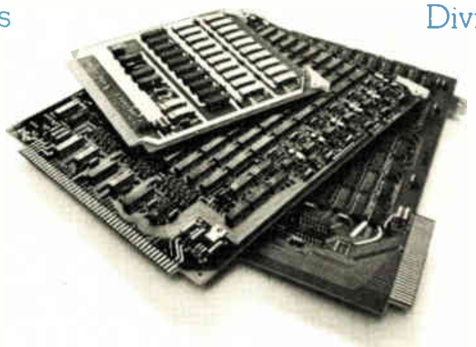
Our talent for combining design and manufacturing skills is only one reason large and small OEMs choose us to produce their memory systems. The other is the range of options we offer.

For some OEMs, we create systems with our standard card sets. For others, we design special cards. And we produce everything from cards to systems with power supplies, cooling fans, cables, even self testers. Some examples follow.

We designed a 48 megabit solid-state system with our IN-60 20K x 10 serial memory card to replace a rotating drum memory with a .1 MHz data rate.

The IN-62 88 kilobit serial card was designed into a 500 kilobit, 10 MHz memory to replace a small fixed head disc. The system can be expanded to several million bits, operates on batteries should power fail and has its own internal cooling.

And the IN-50, our 100 nanosecond random access card, is the basis for what we believe to be the world's fastest large buffer memory. Used with an analog to digital converter, the memory offers a data rate of 80 MHz—1.3 gigabits a second.



As for custom cards, how about an 8K x 18, 650 nanosecond RAM designed to fit a special card rack? Or an 8K x 12, 450 ns design for a point of sale computer, or 1K x 20 for an intelligent CRT terminal?

The list is almost endless. Intel Memory Systems boards have cycle times ranging from 100 nanoseconds to 1 microsecond and go into anything from telephone network monitors to ground support equipment.

And our customers will tell you that service is grade A+ on both short and long production runs. We have a long list of customers. The list, a catalog with details on standard and custom memory system products along with the name of our nearest representatives are yours for the asking.

If you call Intel at (408) 246-7501, demand to be connected to the Memory Systems Division. Intel only makes the chips—*we* make the systems. We have our own billion-bit production plant at 345 Middlefield Road, Mountain View, California 94042.

Memory Options Unlimited

intel memory systems

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When you need custom-developed integrated circuits for automotive applications, why go with a company that hasn't won its spurs? Pick ITT instead. We've already developed circuits for speedometers, tachometers, digital clocks and flashers; they're being installed daily by the automotive industry. And we have more developments on the way. When you need custom circuits for electronic ignition, instrument voltage regulators, fuel injection, automatic dimmers or any of the other automotive applications, look up the company that has the track record. Write today for details of our custom circuit capability.

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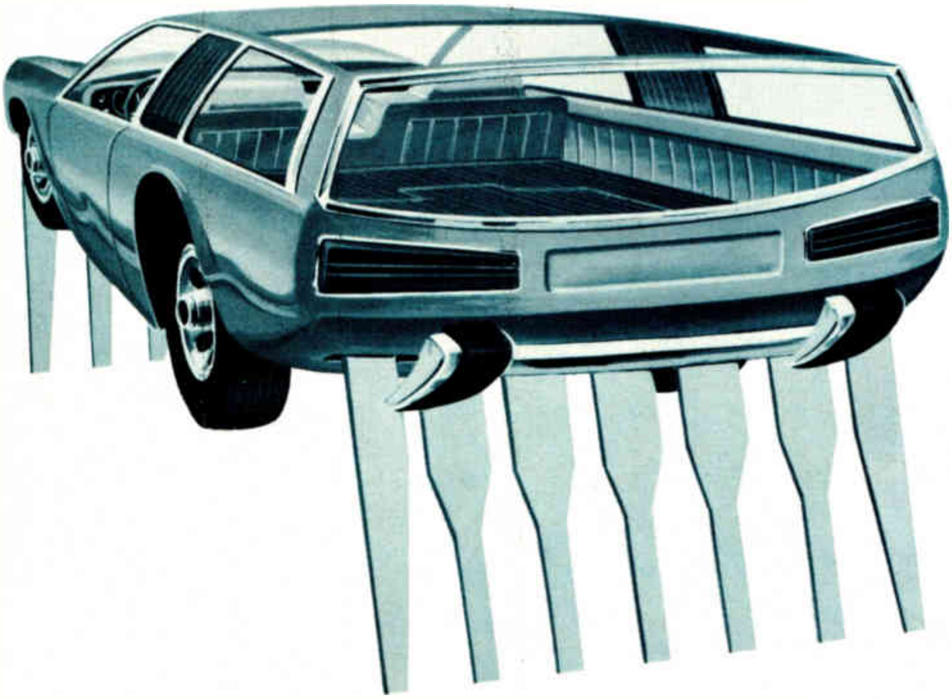

semiconductors

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ITT

Materials

Jacketing for cables is tough

High tear-resistance of thermoplastic urethane permits reduced thickness

As a jacketing material for flexible cable, polychloroprene—better known as neoprene—has been widely used for generations to shield the wires from weather and abrasion. But now a new thermoplastic urethane material made by the Uniroyal Chemical Co. is challenging neoprene. A key factor is the tear strength of urethane—250 to 400 pounds per lineal inch, which is 10 times higher than that of neoprene.

Admittedly, at $1.20 to $1.75 per pound it is more costly than neoprene, which sells for 55 cents a pound. However, the extraordinarily high resistance to tearing means that the wall thickness can be reduced and still provide the same protection to the enclosed wires. What's more, since urethane is a plastic, rather than a rubber, no vulcanizing step is required. Doing away with this step, which requires curing with heat and pressure, lowers cable-fabrication cost, putting urethane in a cost-competitive position.

As one example of the desirability of the new material, Mohawk Wire and Cable Corp., Leominster, Mass., switched from neoprene to thermoplastic urethane for television-camera cables, reducing the jacket from a 0.10-inch to a 0.055-in. wall thickness and still providing equivalent protection.

Another advantage of the urethane, which Uniroyal calls Roylar, is its tensile strength, 6,000 psi compared to 1,500 to 1,800 psi for neoprene. This property enables the jacket to play a second role by acting as a support cable. In one application, a urethane-sheathed cable supports a sonar detector lowered from a helicopter. The cable successfully survives pulls of 50 to 100 pounds as the aircraft flies about searching for submarines.

Times Wire and Cable Co., Wallingford, Conn., a manufacturer with a reputation for innovation, is replacing polyvinyl chloride (PVC) jacketing on many multiconductor and coaxial cables with the urethane. PVC has been in very short supply recently. David Peterson, marketing manager for OEM-engineered products at Times, says that a urethane-jacketed cable has delivered high performance in the subzero temperatures in Canada's Hudson Bay. Says Peterson: "PVC won't crack at low temperatures, but it does stiffen. However, the urethane not only resists cracking but stays flexible at temperatures all the way down to -80°F."

As for supply, neoprene has become hard to obtain due to shortages of chlorine, which is an important ingredient in its manufacture. The basic material for thermoplastic urethane is corncobs.

Uniroyal Chemical Co., Division of Uniroyal, Inc., Spencer St., Naugatuck, Conn. [476]

Clear taping film aids printed-circuit artwork

A clear, antistatic, stable-based polyester film is specifically designed for use in the preparation of printed-circuit artwork. Called Accufilm CTF, the film is dust- and lint-free and it will not stick to the cylinders of reproducing equipment, such as white print or diazo machines. The taping film is also resistant to humidity and temperature changes and is available in sheets and rolls, with a thickness of either 0.005 or 0.007 inch.

Bishop Graphics Inc., 7300 Radford, Ave., North Hollywood, Calif. 91605 [478]

Graphite adhesive bonds glass-to-metal fixtures

Graphi-Bond 551-R is a graphite-base adhesive for the repair and restoration of glass-to-metal seal fixtures. Suitable for use at temperatures to 5,400°F, the material will not deteriorate rapidly in the sealing atmosphere, as some glass-to-metal seals do, when exposed to temperatures of around 1,900°F, and will in

many instances outlast the base material. The new adhesive, which allows users to repair and retain fixtures that may otherwise have been discarded, is available in 1-pint and 1-quart containers priced at $25 and $40, respectively. Delivery time is two weeks.

Aremco Products Inc., Box 429, Ossining, N.Y. 10562 [479]

Conductive epoxy designed for microcircuit chip-bonding

Developed for microelectronic chip-bonding applications requiring rapid curing at relatively low temperatures, an electrically conductive silver epoxy called Epo-Tek H20E can be cured in 45 seconds at 175° C, 5 minutes at 150° C and 90 minutes at 80° C. The two-part system, because of its fast-curing properties, is suitable for use with the latest generation of high-speed automated epoxy-bonding equipment. Pure silver powder is dispersed in both the epoxy and the hardening agent. Pot life is four days at room temperature, and shelf life is two years at room temperature. Refrigeration is not recommended in shipping or storage. A 1-ounce trial kit is priced at $22.

Epoxy Technology Inc., 65 Grove St., Watertown, Mass. 02172 [480]

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New literature

Microwave components. RLC Electronics Inc., 83 Radio Circle, Mt. Kisco, N.Y. 10549, has released a new catalog on the company's line of precision microwave components. The 80 pages list more than 200 standard, passive, and coaxial components, such as filters, switches, attenuators, terminations, and detectors. Circle 421 on reader service card.

D-a converters. From Datel Systems Inc., 120 Turnpike St., Canton, Mass. 02021, comes a new brochure describing the DAC-HR series of digital-to-analog converter modules and giving applications information, specifications, and mechanical dimensions. [422]

Magnetic foil. The use of magnetic foil for determining the amount of shielding required in electronic circuits is discussed in a data sheet available from James Millen Manufacturing Co., 150 Exchange St., Malden, Mass. 02148 [423]

Semiconductor materials. A catalog of bonding agents, etchants, and other materials for semiconductor applications is available from the Transene Co. Inc., Rte. 1, Rowley, Mass. 01969 [424]

Powder cores. A technical bulletin describing the performance characteristics of moly-permalloy powder cores, which can operate at up to six times the flux density of other cores, can be obtained from Magnetic Core Corp., Box 368, Newburgh, N.Y. 12550 [425]

Dc op amps. A 20-page catalog giving details of the company's line of dc operational amplifiers is available from Modular Devices Inc., 1385 Lakeland Ave., Airport International Plaza, Bohemia, N.Y. 11716. Block diagrams, specifications, and applications and price data are provided. [426]

Test equipment. Baynton Electronics Corp., 2709 N. Broad St., Philadelphia, Pa. 19132, has issued a 64-page catalog with information on electronic test equipment. Included

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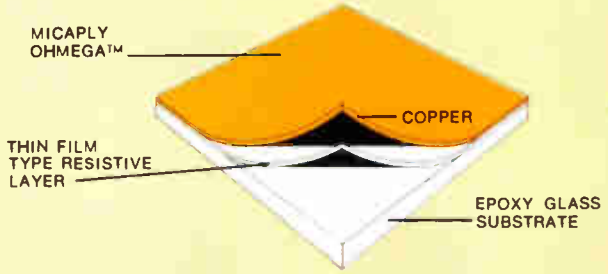

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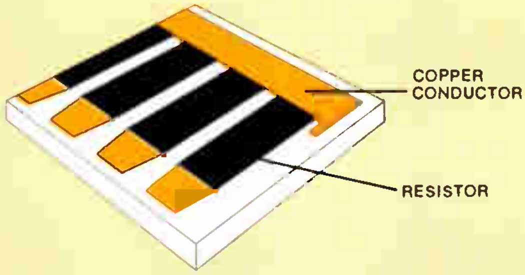

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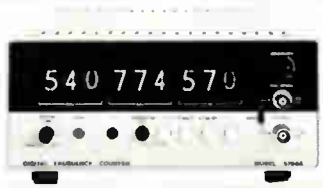

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are specifications and prices for signal generators, frequency converters, power supplies, counters, timers, microwave components, production tools, and other parts. [427]

Spectrum analyzer. An applications note from Sivers Lab, Box 420 18, S-126 12 Stockholm 42, Sweden, gives ideal measurements for the YIG-tuned, wide-dispersion spectrum analyzer designated model PM 7800. [428]

Microwave laminates. Keene Corp., Chase-Foster Laminates division, 199 Amaral St., Box 4305, E. Providence, R.I., has published a four-page bulletin on Di-Clad microwave stripline laminates. Di-Clad is a lamination of polytetrafluoroethylene-coated glass fabric with copper cladding on one or both surfaces. [429]

Wideband couplers. A seven-page catalog from Werlatone Inc., Rte. 22, Brewster, N.Y., contains specifications and outline drawings of the company's line of wideband directional couplers, which are available in both printed-circuit and connector versions. [430]

Optical components. A 62-page catalog of optical components and coatings from Spectrum Systems, Barnes Engineering Co., 44 Commerce Rd., Stamford, Conn. 06904, covers interferometer flats and windows, laser reflectors, quartz lenses, and Littrow prisms. [431]

Wall chart. A wall chart, including design tips, applications notes, process technology, and a selector guide to Darlington power transistors is available from Motorola Semiconductor Products Division, Box 20924, Phoenix, Ariz. 85036 [432]

Temperature controls. Love Controls Corp., 1714 S. Wolfe Rd., Wheeling, Ill. 60090. A line of single and dual digital setpoint temperature controls is described in bulletin 9460. [433]

Op amps. Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, Calif.

New literature

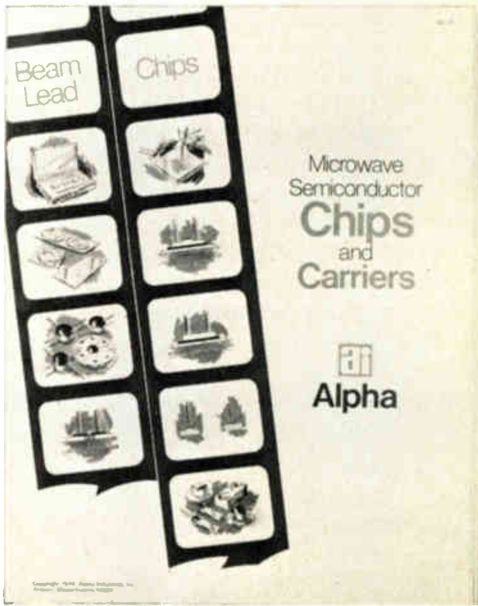
95054, has published an applications note that provides information on multiple micropower operational-amplifier integrated circuits for use where low current drain and low voltage are important. The bulletin outlines the functions of the devices, elements of programing, and the effects of slew-rate limiting. [434]

Power supplies. Deltron Inc., Wissahickon Ave., N. Wales, Pa. 19454. Bulletin 118A gives details of a new series of laboratory power supplies and also advises on the use of integrated circuits that give line and load regulation of 0.01% and ripple of 250 microvolts. [435]

Ac motor control. Ramsey Controls Inc., 333 Rte. 17, Mahwah, N.J. 07430., presents a discussion of adjustable-frequency ac motor speed control in a booklet that also gives information on applications.

Components. A catalog of more than 3,500 rf coils, rf chokes, and other electronic components has been released by J.W. Miller division, Bell Industries, 19070 Reyers Ave., Box 5825, Compton, Calif. 90224. A selection guide is included along with specifications, prices, and schematics. [437]

Microwave diodes. A 16-page catalog of microwave semiconductors, available in chip and beam-lead form for microstrip and stripline applications, is obtainable from Alpha Industries Inc., 20 Sylvan Rd., Woburn, Mass. 01801 [436]



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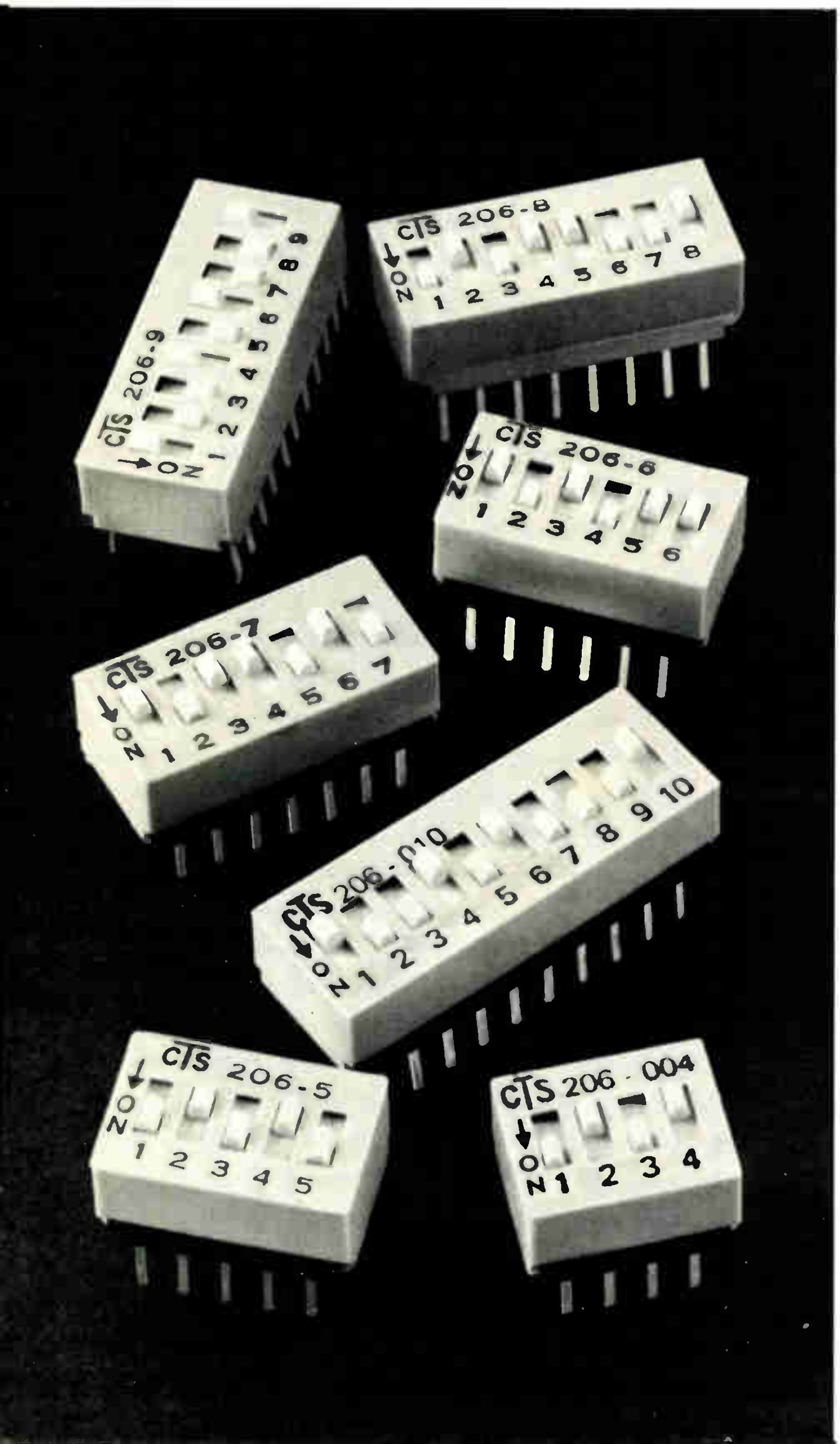

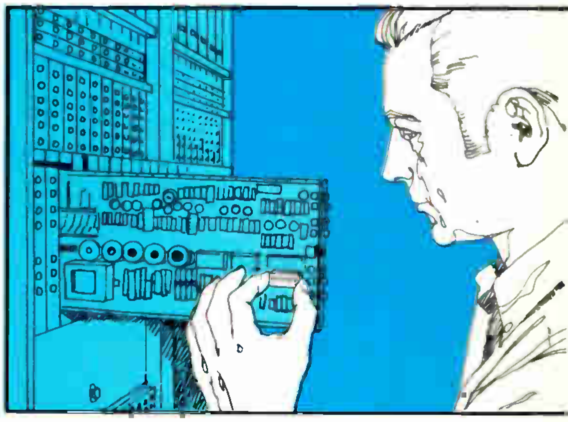

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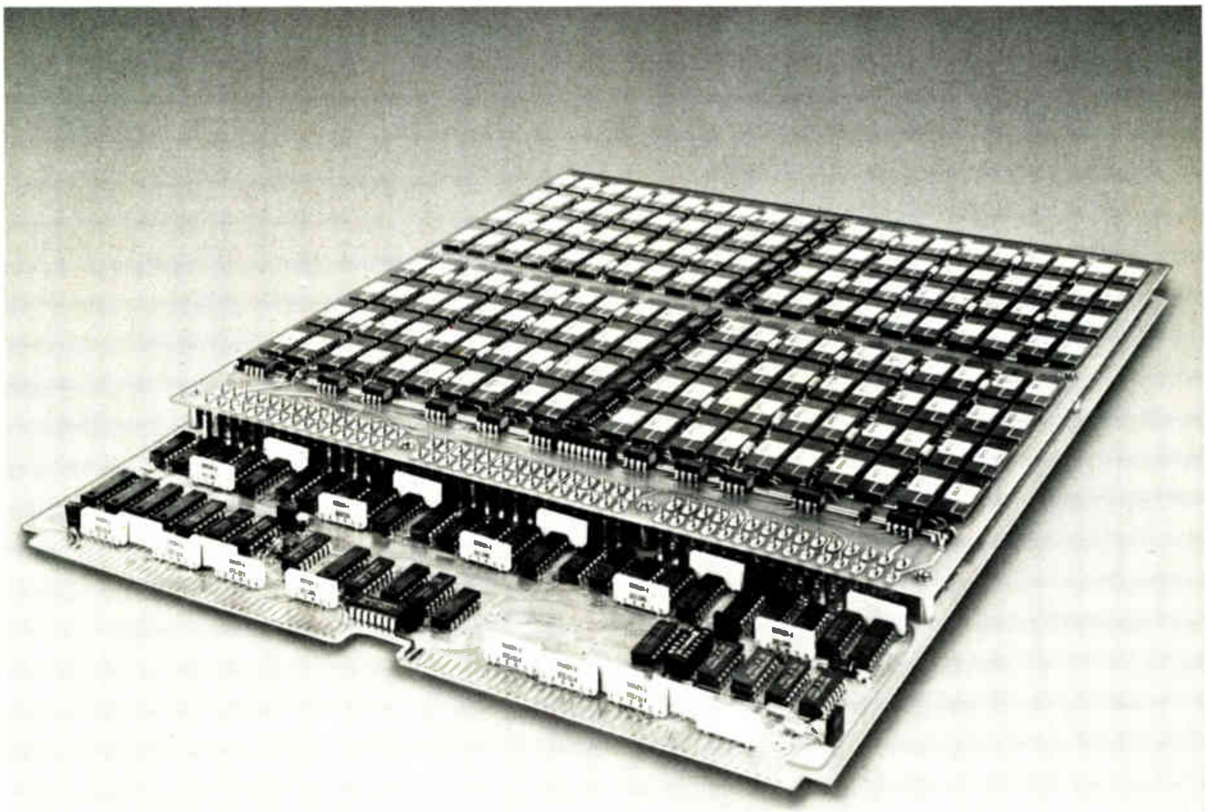

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COMPANY ______ DIV or DEPT ______

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All others pay higher than basic price of $25.00 per year.

Signature ______

2. ☐ 1 PLANT ☐ 2 DEPARTMENT

Indicate the primary product manufactured or service performed at your plant (Box 1) and in your department (Box 2). Be sure to indicate applicable letter in each of the two boxes even if they are the same letter.

A. Large computers
B. Mini-computers
C. Computer peripheral equipment
D. Data Processing Systems (systems integration)
E. Office and business machines
F. Test and measuring equipment
G. Communications systems and equipment
H. Navigation and guidance or control systems
I. Consumer entertainment electronic equipment
J. Other consumer electronic equip. (appliances, autos, hand tools)
K. Industrial controls, systems and equipment
L. Sub-assemblies
M. Passive electronic components
N. Active electronic components
O. Materials and Hardware
P. Aircraft, Missiles, space and ground support equipment
Q. Oceanography and support equipment
R. Medical electronics
S. Industrial equipment containing electronic components or products
T. Independent R&D laboratory and consultant
U. Research and development organizations which are a part of an educational institution
V. Government Agency and military
W. Industrial companies using and/or incorporating electronic products in their mfg., research or development activities
X. Utilities
Y. Broadcasting, sound and motion pictures and recording studios
Z. Commercial users of electronic equipment (railroads, pipelines, police, airlines)
9. College, University

3. ☐ Indicate your principal job function (place applicable number in box. If numbers 9, 10, or 11 are used, fill in name of college or university)

1. General and corporate management
2. Design and development engineering
3. Engineering services (evaluation, quality control, reliability, standards, test)
4. Basic research
5. Manufacturing and production
6. Engineering support (lab assistant, technician)
7. Purchasing and procurement
8. Marketing and sales
9. Professor at ______
10. Senior student at ______
11. Graduate student at ______

Senior and graduate students are eligible for professional rate for one year subscription only.

4. ☐ Indicate your principal job responsibility (place applicable number in box)

1. Management 2. Engineering

5. Are you engaged in or do you supervise the design or redesign of electronic components or equipment? (check one)

☐ YES ☐ NO

6. Estimated number of employees at this location. (check one)

☐ 1 to 49 ☐ 50 to 249 ☐ 250 to 999 ☐ over 1,000

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Complete entire card. Please print or type.

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NAME ______________________ TITLE ______________

COMPANY ______________________________________

STREET ____

CITY ____________________ STATE ____________ ZIP ________

Industry Classification (check one)

- **a** ☐ Computer & Related Equip.
- **b** ☐ Communications Equip. & Systems
- **c** ☐ Navigation, Guidance or Control Systems
- **d** ☐ Aerospace, Underseas Ground Support
- **e** ☐ Test & Measuring Equip.
- **f** ☐ Consumer Products
- **g** ☐ Industrial Controls & Equip.
- **h** ☐ Components & Subassemblies
- **j** ☐ Independent R&D Organizations
- **k** ☐ Government

1	21	41	61	81	101	121	141	161	181	201	221	241	261	343	363	383	403	423	443	463	483	503	713
2	22	42	62	82	102	122	142	162	182	202	222	242	262	344	364	384	404	424	444	464	484	504	714
3	23	43	63	83	103	123	143	163	183	203	223	243	263	345	365	385	405	425	445	465	485	505	715
4	24	44	64	84	104	124	144	164	184	204	224	244	264	346	366	386	406	426	446	466	486	506	716
5	25	45	65	85	105	125	145	165	185	205	225	245	265	347	367	387	407	427	447	467	487	507	717
6	26	46	66	86	106	126	146	166	186	206	226	246	266	348	368	388	408	428	448	468	488	508	718
7	27	47	67	87	107	127	147	167	187	207	227	247	267	349	369	389	409	429	449	469	489	509	719
8	28	48	68	88	108	128	148	168	188	208	228	248	268	350	370	390	410	430	450	470	490	510	720
9	29	49	69	89	109	129	149	169	189	209	229	249	269	351	371	391	411	431	451	471	491	701	900
10	30	50	70	90	110	130	150	170	190	210	230	250	270	352	372	392	412	432	452	472	492	702	901
11	31	51	71	91	111	131	151	171	191	211	231	251	271	353	373	393	413	433	453	473	493	703	902
12	32	52	72	92	112	132	152	172	192	212	232	252	272	354	374	394	414	434	454	474	494	704	951
13	33	53	73	93	113	133	153	173	193	213	233	253	273	355	375	395	415	435	455	475	495	705	952
14	34	54	74	94	114	134	154	174	194	214	234	254	274	356	376	396	416	436	456	476	496	706	953
15	35	55	75	95	115	135	155	175	195	215	235	255	275	357	377	397	417	437	457	477	497	707	954
16	36	56	76	96	116	136	156	176	196	216	236	256	338	358	378	398	418	438	458	478	498	708	956
17	37	57	77	97	117	137	157	177	197	217	237	257	339	359	379	399	419	439	459	479	499	709	957
18	38	58	78	98	118	138	158	178	198	218	238	258	340	360	380	400	420	440	460	480	500	710	958
19	39	59	79	99	119	139	159	179	199	219	239	259	341	361	381	401	421	441	461	481	501	711	959
20	40	60	80	100	120	140	160	180	200	220	240	260	342	362	382	402	422	442	462	482	502	712	960

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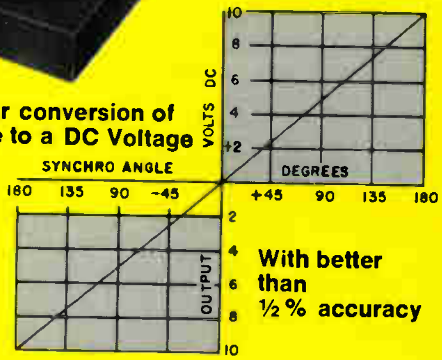
3 WIRE SYNCHRO TO LINEAR D.C. CONVERTER

ACCURACY ½%

#MAC 1422-1

Provides a linear conversion of a synchro angle to a DC Voltage



With better than ½% accuracy

Specifications

Accuracy: ±1% over temperature range
Input: 11.8V, 400 HZ line to line 3 wire synchro voltage
Output Impedance: less than 10 Ohms
Input Impedance: 10K minimum line to line
Reference: 26V ±10% 400HZ (Unit can be altered to accommodate 115V if available at no extra cost)
Operating temp. range: —25°C to +85°C
Storage temp. range: —55°C to +100°C
DC power: ±15V ±1% @ 75ma (approx.)
Case material: High permeabillty Nickel Alloy
Weight: 6 Ozs. Size: 3.6" x 2.5" x 0.6"

A.C. LINE REGULATION

A new method has been developed which allows us to provide a low distortion highly regulated AC waveform without using tuned circuits or solid state active filters of any kind.

The result is a frequency independent AC output regulated to 0.1% for line and load with greater than 20% line variations over a wide temperature range.

Features:

- *0.1% total line and load regulation*
- *Independent of ±20% frequency fluctuation.*
- *1 watt output*
- *Extremely small size*
- *Isolation between input and output*

Specifications: Model MLR 1476-1
AC Line Voltage: 26V ±20% @ 400Hz ±20%
Output: 26V ±1% for set point
Load: 0 to 40ma
Total Regulation: +0.1%
Distortion: 0.5% maximum rms
Temperature Range: —55°C to +125°C
Size: 2.0" x 1.8" x 0.5"

Other units are available at different power and voltage levels as well as wider temperature ranges. Information will be furnished upon request.

SOLID STATE SINE-COSINE SYNCHRO CONVERTER - NON VARIANT

This new encapsulated circuit converts a 3 wire synchro input to a pair of dc outputs proportional to the sine and cosine of the synchro angle independent of a-c line fluctuations.

- Complete solid state construction.
- Operates over a wide temperature range.
- Independent of reference line fluctuations.
- Conversion accuracy — 6 minutes.
- Reference and synchro inputs isolated from ground.

Specifications Model DMD 1508-2

Accuracy: Overall conversion accuracy 6 minutes. Absolute value of sine and cosine outputs accurate to ±30MV
Temperature Range:
Operating —40°C to +85°C
Storage —55°C to +125°C
Synchro Input: 90V RMS ±5%LL 400Hz ±5%
DC Power: ±15V DC ±10% @ 50MA
Reference: 115VRMS ±5% 400Hz ±5%
Output: 10V DC full scale output on either channel @ 5ma load
Temperature coefficient of accuracy:
±15 seconds/°C avg. on conversion accuracy
±1 MV/ °C on absolute output voltages
Size: 2.0" x 1.5" x 2.5"

Units are available with wider temperature ranges and 11.8V LL, 26V reference synchro inputs. Information will be supplied upon request.

4 QUADRANT MAGNETIC ANALOG MULTIPLIER

DC x DC = DC OUTPUT

#MCM 1478-1

Product Accuracy is ±½% of all theoretical product output readings over Full Temperature Range of −55°C to +125°C.

Maximum Output Error for Either
X = 0, Y = 10V
Y = 0, X = 10V
X = 0, Y = 0
would be ±2 MV over Entire Temperature Range.

Specifications Include:

Transfer Equation: E = XY/10
X & Y Input Signal Ranges: 0 to ±10V peak
Maximum Static and Dynamic Product Error: ½% of point or 2MV, whichever is greater, over entire temperature range
Input Impedance: X = 10K, Y = 10K
Full Scale Output: ±10V peak
Minimum Load for Full Scale Output: 2000 ohms
Output Impedance: Less than 10 ohms
Bandwidth: 1000Hz
DC Power: ±15V, unless otherwise required, at 20ma
Size: 1.3" x 1.8" x 0.5"
Output is short circuit protected

There is No Substitute for Reliability

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135 Bloomfield Ave., Bloomfield, New Jersey 07003 - Tel. (201) 743-2700

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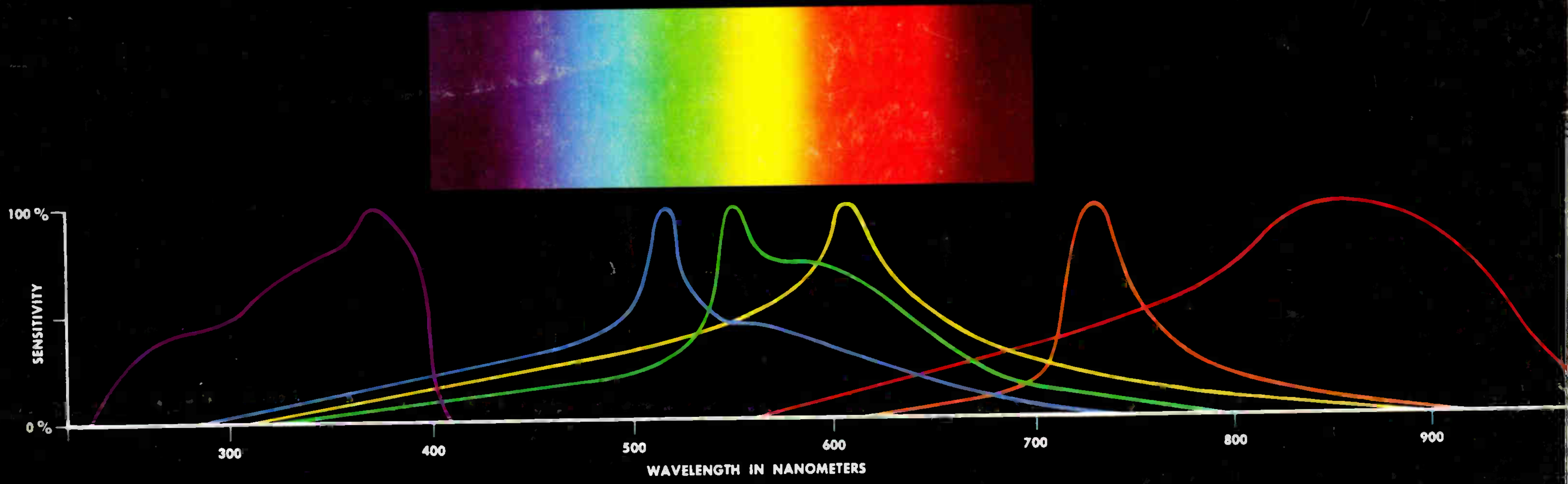

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