July 3, 1972 $1.00 A McGraw-Hill Publication

Electronics

Plastic optics

Low-cost components for optoelectronic systems

IF YOU OWN A PDP-11...

Let Datacraft Add a Think Tank

Other companies make expansion memories...a think tank made Datacraft's DC-38-11. There's an idea behind it — build a memory you install and forget. *NO* using accepted procedures just because they've been around for awhile. *NO* let's do-it-this-way-because-everybody-else-does.

YES, an idea. The idea being that Datacraft's think tank thought reliability. *FACT:* In a traditional memory system certain design techniques actually fight reliability. *EASY WAY OUT:* design around the culprits. *THE THINK TANK WAY:* Banish the culprits so they can't come back to haunt you.

Datacraft purged such classic culprits as linear transformers and their related problems. *Out* went hard backpanel wiri and core stack risers. *Out* went all the gremlins.

In went advanced state-of-the-art components, and modul ity...everything compatible to grow your system as your nee change. *In* went PARITY GENERATE and FAILSOFT — exclusive combination you get only with Datacraft. T FAILSOFT feature automatically isolates the memory from t UNIBUS in case of a UNIBUS receiver circuit failure.

A think tank is for ideas. Our idea was to look at the ha before we made the glove. We did...we took a close lo at the PDP-11 and designed the DC-38-11 to fit. It fits.

Specifics on the DC-38-11

It's THIS	Its MAKEUP
• It's a 3-wire, 3D, random access, magnetic core memory • Compatible in every way with PDP-11 systems and UNIBUS ...connectors, digital stack cards • Its reason for being is the PDP-11 • Nothing fits the job better	• 4K---16K X 18 8K---32K X 18 • Basics---Two plug-in cards. the timing and control card plus a digital stack card. Any additional increments of 4K X 18 or 8K X 18 require just one more board. • It's not add-on electronics...it's a normal functioning peripheral device

For more information on the new Datacraft expansi memory for the PDP-11 write for:

The DC-38-11,
Datacraft Corporation,
P.O. Box 23550,
Fort Lauderdale, Fla. 33307

Datacraft

Circle 900 on reader service card

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LO21 8 CHANNEL MUX

$1.00 Per Channel Fully Decoded

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Electronics

The International Magazine of Electronics Technology

July 3, 1972

Volume 45, Number 14

Highlights

1,024-bit TTL RAMs challenge the customer, 65
For a market that's barely on the horizon, companies are already competing hard with large, new, bipolar random-access memories. Fairchild with its Isoplanar device, Raytheon with its V-ATE chip, and Signetics have the first available products.

Plastic lenses that outclass glass, 77
Injection molding can cut the cost of the lenses in an optoelectronic system by 50% to 90%. The process eliminates the need for polishing, which makes glass lenses so expensive, and maintains a consistently high level of quality in high-volume production.

Program talks the circuit designer's language, 81
Aedcap enables the engineer and computer to discuss a a circuit design in engineering terminology. The program can perform linear and nonlinear dc analysis, small signal ac analysis, and large-signal transient analysis for almost any size of circuit.

Collector diffusion isolation breeds bipolar LSI, 96
Recent work on the CDI process will pay off this year in a 1,024-bit memory on a chip, probably with a 80-ns access time. Breakdown voltages are 7.5 to 8 V, allowing the chip to be used in 5-V TTL systems. And digital and linear function can be processed onto the same device.

And in the next issue . . .
The V-ATE process: more about one of the new bipolar memories . . . what the EE needs to know about digital panel meters . . . high-speed digital logic for communications.

The cover
For many purposes, injection-molded plastic lenses are indistinguishable from glass—except that their price is lower.

Electronics

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Publisher's letter

We like to think that it takes aggressive editors, with finely-tuned intuitions and generous expense accounts, to dig up the kind of really great, exclusive articles and stories that attract and hold a prime audience. And that's usually the case. But there's occasional serendipity in this business too, in which one story leads to another. For example, take our cover story on plastic optical components by Roger L. Howe (p. 77). That found its way into *Electronics* because of a series on optoelectronics that we ran in late 1971 and early this year.

Not long after the first article in that series appeared, Howe, who is president of a firm called U.S. Precision Lens Inc., phoned our editor-in-chief Kemp Anderson to say some nice things about the series—and to pass on the intelligence that recently the vast majority of technical people calling on his company for help had electronic rather than optical backgrounds.

Intrigued by this, Anderson asked Howe for more details about his company's products, and soon after, a large box arrived containing dozens of plastic optical components, like those shown on the cover, in a variety and complexity that were staggering. Packaging and Production Editor Steve Scrupski immediately recognized he had the makings of a first-rate feature on these new cost-cutting componenets for optical systems, and the article was soon committed.

There's been a lot of talk about how much electronics can contribute to the easing of the many social problems facing us today. But actual applications are scattered and, what with funding problems and arguments over priorities, progress toward new applications is slow.

But when our Microwave and Communications Editor, Lyman Hardeman, polished off his research for the telemetry report that starts on page 90, he had found a notable exception. "The common denominator of most new telemetry applications is the solving of social problems—that is, if you define 'social' fairly broadly," says Lyman.

He points out that the business was traditionally dominated by the electric utilities, which had a pressing need to coordinate the workings of the many remote points that make up an electrical distribution network. But pollution control monitoring now accounts for an increasing share of the business. What's more, emerging applications are as diverse as snowload measuring, which can help predict and control flooding, and, in automobile safety tests, the monitoring of signals sent direct from cars spinning around test tracks. Then, there's the field of medical telemetry—especially the transmittal of signals from heart patients—that is beginning to fulfill some of its promise.

"And as more people become interested in what telemetry can offer," notes Lyman, "there's a trend developing toward the cooperative use of telemetry nets. Even the National Forest Service is a member of a remote data gathering setup in the Northwest."

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- Programming (remote control) and sensing functions are accessed through rear-mounted plug connectors. You don't fuss with wired lugs to get on line.
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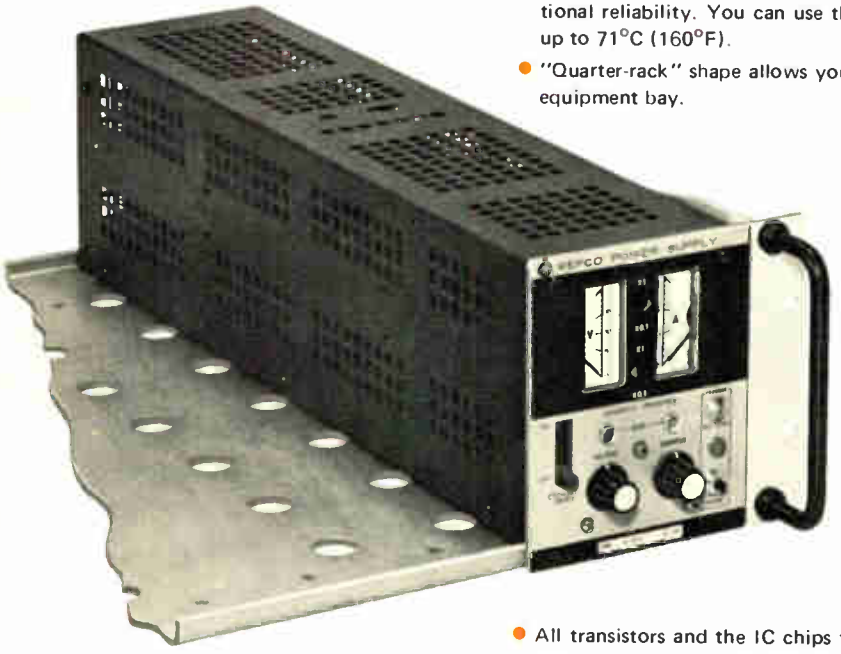

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Readers comment

What else is new?

To the Editor: In "Communications systems benefit from monolithic crystal filters," [*Electronics*, Jan. 31, p. 48], Robert C. Smythe insists, ". . . about 1965, Sykes and his coworkers at Bell Telephone Laboratories and Onoe and his colleagues in Japan independently recognized that the divided-electrode filter was basically two acoustically coupled resonators."

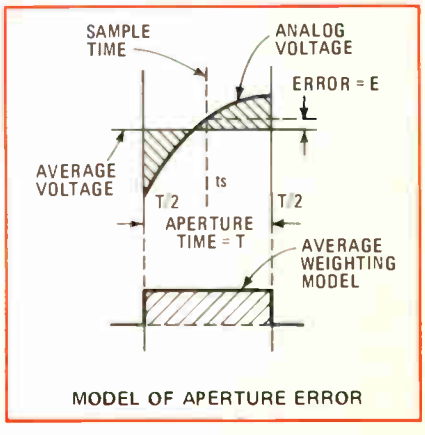
What took them so long to recognize that simple fact? Even as a student of electronics engineering in Vienna, I built such a filter in 1951. The principle of exciting a mechanical resonator by an electrical-to-mechanical transducer and using the frequency-selective function of the resonator to filter the signal and reconvert it by means of a mechanical-to-electrical transducer was already old hat.

I eliminated electrical coupling over the capacity between the electrode pairs by means of a balanced bridge, fed by a balanced transformer, so that only a pure mechanical, frequency-selective signal path remains.

Furthermore, why mechanical signal paths in monolithic crystal filters should be termed "acoustical" is beyond my comprehension, since they rarely have anything to do with "hearing." Walter K. Grossman
Jasper, Alta., Canada

Erratum

■ *We regret that the wrong illustration of Arthur G. Stephenson's model showing aperture error when sampling a sinusoidal rf carrier signal was printed in the June 19 issue. This is the correct illustration:*



MODEL OF APERTURE ERROR

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40 years ago

From the pages of Electronics, July 1932

Dozens of industries and hundreds of small factories and shops are today waiting to be made more efficient or more productive, by some application of electronic tubes, photocells, or other devices familiar to the reader of *Electronics*. The difficulty in getting such special applications installed has lain in the cost of the special engineering involved, which usually cannot be borne by the maker of the tube equipment alone.

But scattered all over the country today are the principles of these electronic devices. These engineers can find plenty of opportunity for their own ingenuity if they will drop into local shops and factories in their vicinity (particularly "hometown people" they know), and ask to be taken through the shop or plant to suggest opportunities for saving money. Practical uses will at once suggest themselves, and the engineer can arrange to install the electronic apparatus and get it working.

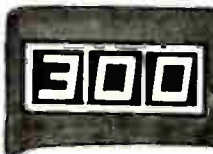
In this way the man out of a job will find agreeable occupation along his own lines doing creative work—he will be putting his leisure to use—he will be building economic independence for himself—and he will be speeding the inevitable day of electronic control in the shops and factories of his community.

Plans are now under way for the operation of high-speed trains at 200 miles per hour, on a roadway of special construction to be built between Camden and Atlantic City, N.J., and operated by the Aeroland Transportation System Inc. The traffic will be handled by single cars which run over the roadway on rubber-tired wheels. Since it will not be possible to use an ordinary track circuit, it is required to control the trains entirely by inductive means. This will be accomplished by placing a large coil of wire on the cars and a single loop of No. 0000 conductor on the roadway. These loops are arranged in sections one-half mile in length and the system will be operated with alternating current of 500 to 750 cycles per second.

I'm Dana's **New 3300 DMM** & Really Boss! I outclass competition going away with all the performance specks you need and all these zingy features to make your job easier & safer.

WOW! at only $350.00 I'm "pleased-as-punch" to be attached to the 3300 – It's really a complete DMM.

Ugh! I can't break the case - it's even weather & dust proof - reliable for the roughest field use - won't quit on-ya!



LED's my name - 3 digit readout's my game - with a 4th digit for 100% overrange. I'm cool & reliable. I even suppress my insignificant zeros. No wrong readings.

The 3300 tips me at only **7½ lbs.**, with battery pack - makes it easy to carry anywhere.

You can't **GOOF** here - exclusive cam switches prevent miss match of range & function

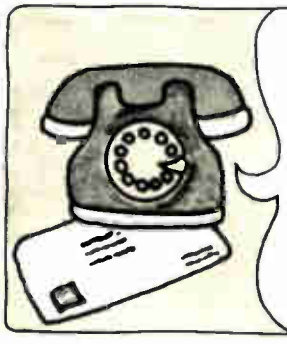
We're 2 screws! Loosen us to get at plug-in display, battery pack & components.

A bright idea - LED intensity automatically adjusts to ambient light conditions which we create.

I check battery life! You know how many operating hours remain. When battery's low, it shuts off. No damage, No wrong readings.

I'm a **spare** in the rear compartment, & always with the 3300. You're never left dead in the field.

I keep the 3300 in it's place - my **gripping** personality won't let this DMM slip & slide.



Great Stars - there's sure a lot packed into the 3300 that you can't find anywhere else - & at such a price. Use us to contact Dana for complete information.*

* If you need a unit now, a collect phone call to (714) 833-1234 will get you immediate action

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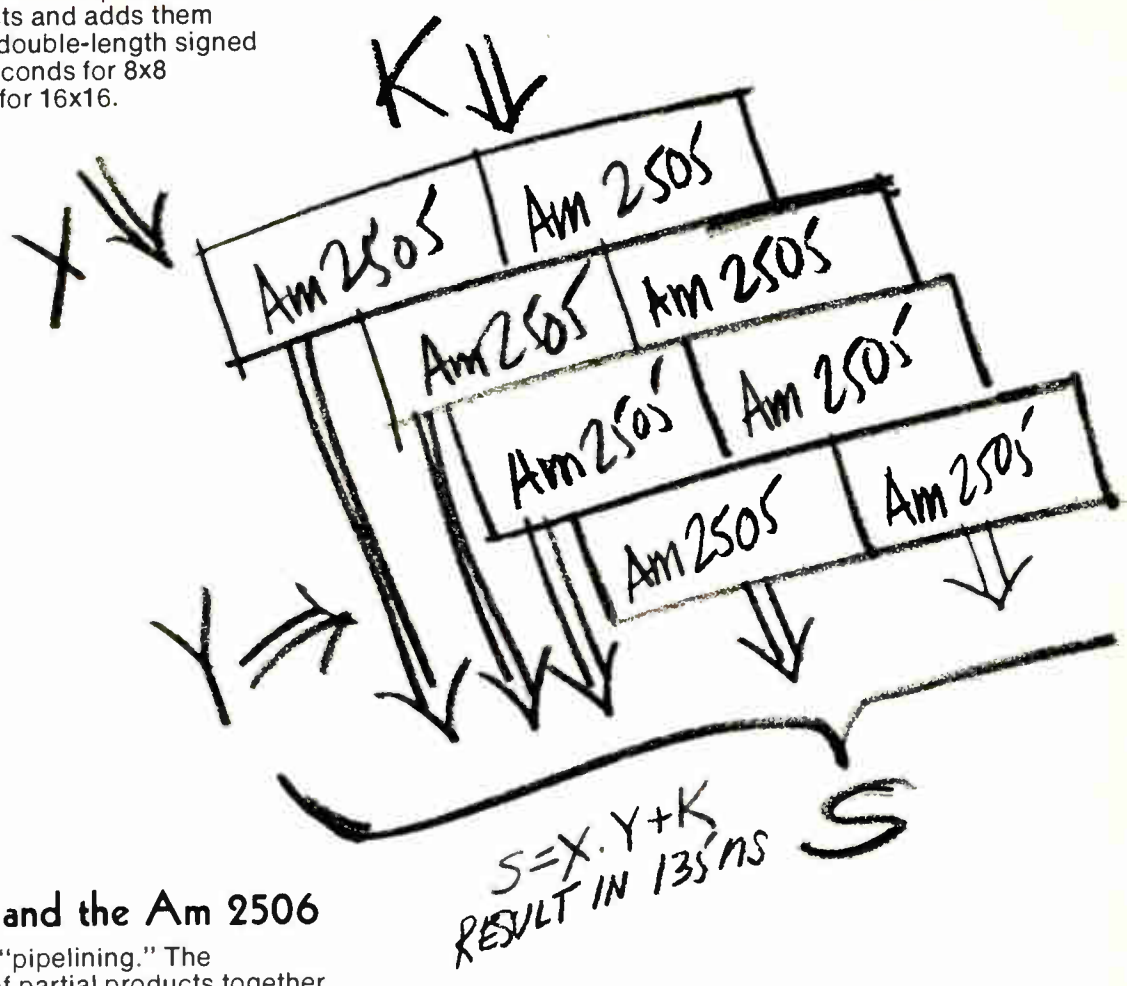
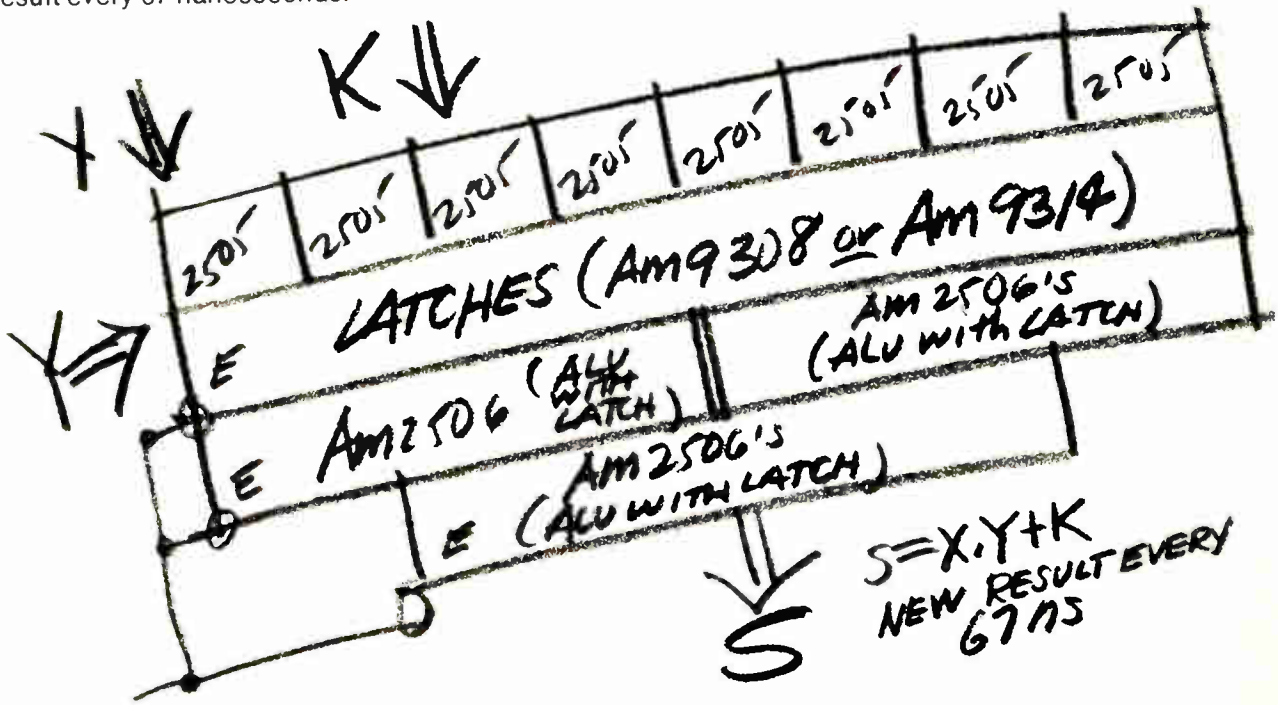
The Am 2505

A 2's complement digital multiplier. It forms partial products and adds them together giving you a double-length signed product in 135 nanoseconds for 8x8 multiplication. 265 ns for 16x16.



The Am 2505 and the Am 2506

Superfast, supersafe "pipelining." The Am2506's add pairs of partial products together. Latches serve to hold and synchronize the data at each level. In 8x8 multiplication you get your first answer in 210 nansoseconds and a new result every 67 nanoseconds.



The first digital multiplier and the first ALU with a built-in latch. Together. $S=X\cdot Y+K$.

We're first with both products. In fact, we're starting to collect a lot of firsts.

(We're first in ALU's, Low Power MSI and Flat Paks.)

It doesn't take too many #1's to get to #6. That's one of the reasons why we're going to be the sixth largest integrated circuits company in the country.

We mean it. We're going to be #6.

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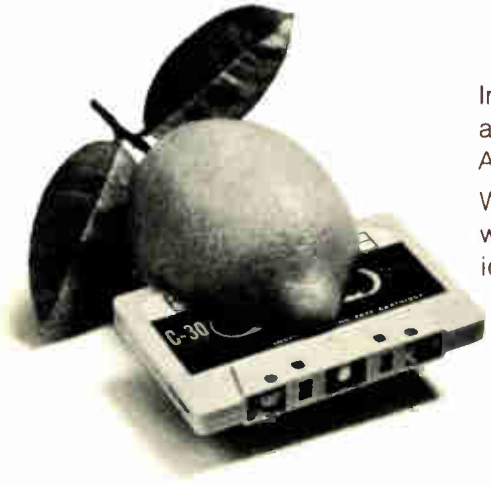
Circle 11 on reader service card

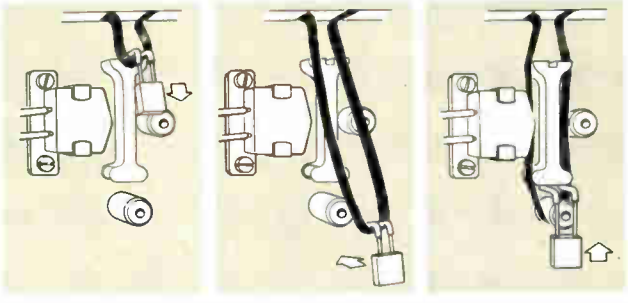
Two Years Ago, Almost



Including us. A digital cassette recorder. Seemed like a great idea at the time. But there was too much garbled info. And lousy reliability. A bumper crop of real lemons.

Well, we licked our wounds along with everyone else. But we also went back to the drawing board because we still thought the basic idea was sound. And we came up with a unit that really works.

A Whole New Concept

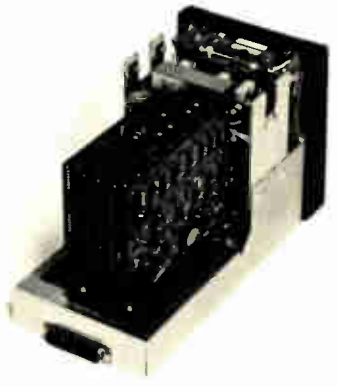


To get super reliability, we reasoned, you have to control that tape. So, we started from scratch. Got rid of the traditional pinch rollers, belts, solenoids, levers and mechanical linkages from the transport. Took out the head guide forks.

Eliminated the need for pressure pads. Those were the main cause of head and tape wear, oxide shed and dropout.

Then, instead of just pushing the head up to the tape as it rolls by, we decided to get the tape out of the cassette. (That way the cassette is just a tape holder.) So we designed two little fingers that pull the tape down past the head, over a precision guide and around a capstan. That maintains optimum head wrap angle—critical for read-after-write operation. And it's all done automatically as you load. (We've got a patent pending, in case you're interested.)

The Insides



Next, we put in three DC motors. One for the capstan and one for each reel. Servos positively control tape tension on both sides of the capstan. And tension sensors confirm proper loading to BOT—no writing on tape leader. There's no drag on the tape. Ever.

So now we have high bi-directional tape speed, fast start/stop times, precise start/stop distances.

Reel motor torque is automatically reduced when EOT or BOT is sensed to prevent pulling tape from cassette reel hubs or other possible tape damage.

All modular electronics. Plug in PC boards. Logic and interface that're TTL compatible.

Everybody Brought One Out

The Outsides

All these components are mounted in a cast aluminum frame. Very, very rugged. So it works for any number of EDP OEM applications. And we supply it for users in a handsome case with straightforward, push-button controls.

Real Reel to Reel Performance

Our basic Model 240 has 2 tracks, selectable data rates from 2 to 20 ips, with start/stop times of 15-30 msec. Same start/stop times for 50 ips search or fast forward/reverse. It operates in incremental and/or continuous modes, and in several combinations of recording codes/data channel selections. Test data indicates: calculated MTBF in excess of 2,000 hours. Thousands of passes without tape damage.

Options

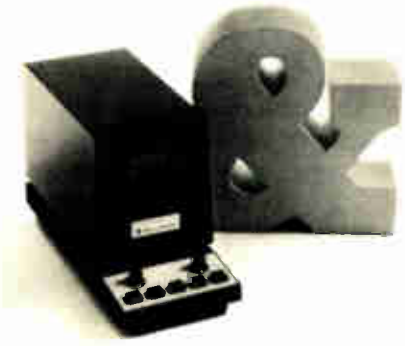
All sorts of options. Like two selectable read/write speeds. Dual gap read-after-write head. Separate read-after-write heads. Power supply. Rack mount kit. Automatic tape cleaner. Etcetera.

Don't Wait. Order Now

Now that we've really licked performance and reliability problems, we figure our recorder's a natural for business machine manufacturers, terminal makers, mini computer builders.

And users. A great replacement for punched paper tape. Even some reel to reel mag tape applications. Especially at the price. About $500 to $600 in bunches.

Bell & Howell & a Digital Cassette Recorder That Works



☐ Send me all the specs.
☐ Send a guy around for a demo.
☐ Here's my P.O. You fill in the blanks.

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BELL & HOWELL

People

Fradin seeking to bridge industry-student gap

Dave Fradin finds it more productive to sit down than sit in.

For this reason, the 20-year-old interdisciplinary-engineering student organized Fasst on the University of Michigan campus two years ago, with the aim of bringing students and industry together at the conference table. Fasst, for the Federation of Americans Supporting Science and Technology, is trying to get a dialogue going between industry and university communities, principally to develop student awareness of the importance of technology, but also to provide government and industry with student views on science and technology.

Image. "We've got to get over the idea that industry's the big, bad-blooded corporate technocrat, and industry's got to get over thinking that students are all long-haired kids high on dope all the time."

Fasst was originally formed to support the supersonic transport, "the whipping boy for those that wanted to strike out at technology," he says. "The SST was no longer just an airplane; it was an opportunity to punish technology for every dirty river, traffic jam, smoke plume, and oil slick." But the group, now trying to go national, is diversifying to address seven fields that could use technological shots in the arm: transportation, communications, detection of potential natural disasters, education, energy, health care, and environment.

"We're predominantly aerospace now, but the electronics industry has got a hell of a lot more potential than aerosopace for solving society's problems." Fradin says, and cites medical electronics, computers for accurately predicting weather conditions, and computer- and communication-aided instruction.

The latest firm to voice support of Fradin's Fasst is Texas Instruments, which faced demonstrators several weeks ago at its Austin, Texas, facility. They distributed leaflets aimed at TI's defense-related production. That incident, and others like it, made TI receptive to Fradin's advances, and company officials have agreed to support his efforts to establish a dialogue with the University of Texas, he says. TI joins an impressive roster of top-echelon officials in government and industry, including Bendix, LTV Aerospace, Martin-Marietta, Northrop, Boeing, and United Aircraft. "Most of these companies have had demonstrations outside their plants," Fradin adds, "and they find it very unproductive to communicate with young persons in this fashion."

"About half the antitechnology feeling in this country has been caused by the aerospace and electronics industries talking to themselves about it." Fradin contends they should listen a little. "Students have a lot to say to industry, and if given a chance, they say it well—they have good, important input. As it is now, we bypass the talking stage and go directly to the confrontation stage."

Hartman of CTS figures on lion's share or nothing

There's a new kid on the block, as far as competitors in the market for uhf varactor tuner components are concerned, and he's talking tough. The name: the CTS Corp. of Elkhart,

Outlook. Dave Fradin looks at world of semiconductors. TI's Linda Kinslow is guide.

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400 kHz to 500 MHz with 115-dB dynamic range and 0.005-dB resolution. Precise measurements of transmission and reflection properties — magnitude, phase, group delay, and S-parameters — all direct reading and neatly displayed on a built-in scope. Complete characterization of filters, amplifiers, cables, antennas, delay lines, transistors, or most anything else that comes to mind — all at the push of a button.

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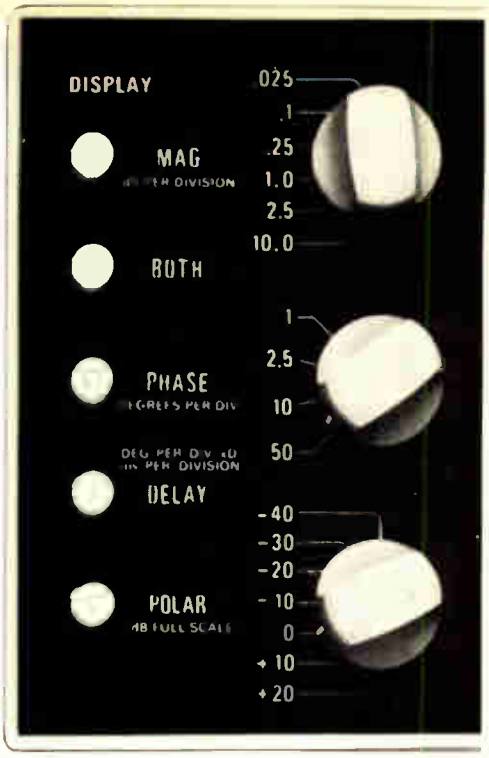
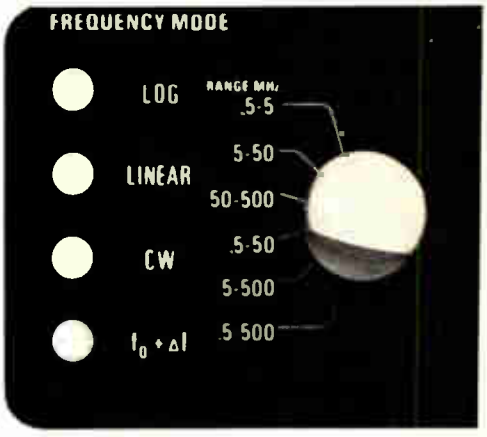
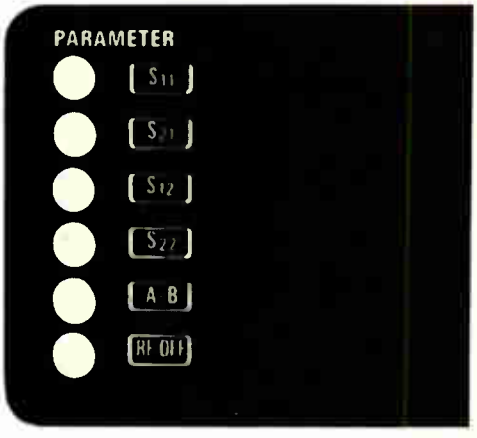
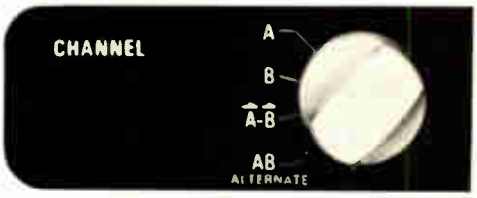
For a demonstration of this remarkable system, call your local GR center. The price for the basic 1710 RF Network Analyzer? Only $6850 (*truly* remarkable).









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Circle 15 on reader service card

People

Ind. The game: to capture 65% of the market.

That objective isn't so surprising to those who have worked with CTS president Clinton Hartman. His marketing philosophy is to take over a large share or stay out altogether. Not only that, but Hartman believes that his firm's components shouldn't just sit around on shelves. "We don't stock anything," he explains. "When an order comes in, it goes into production and is shipped immediately when the run is finished—all in about four or five weeks."

It works. It all seems to work for Hartman and CTS. In 1971, the company did $84.5 million in sales, compared to $73.8 million the previous year. Some 98% of its production is custom work, mostly for home-entertainment products. For example, CTS manufactured about 125 million variable resistors last year.

Hartman, who holds a degree in chemical engineering from Purdue and served as a lieutenant colonel in the Army, also feels that continuing expansion is another key to success. In the components business, he says, a "fantastic amount" of retooling is necessary. So CTS bought a tool and die works and an automated machinery plant. The company also has its own plastics facility, and claims to be one of the largest users of Bakelite in the U.S.

Togetherness. Another Hartman philosophy is to manufacture components as close to the user's plant as possible. The result is a CTS division on Taiwan making components to be assembled on the island and one in Mexico City that supplies the Mexican electronics industry.

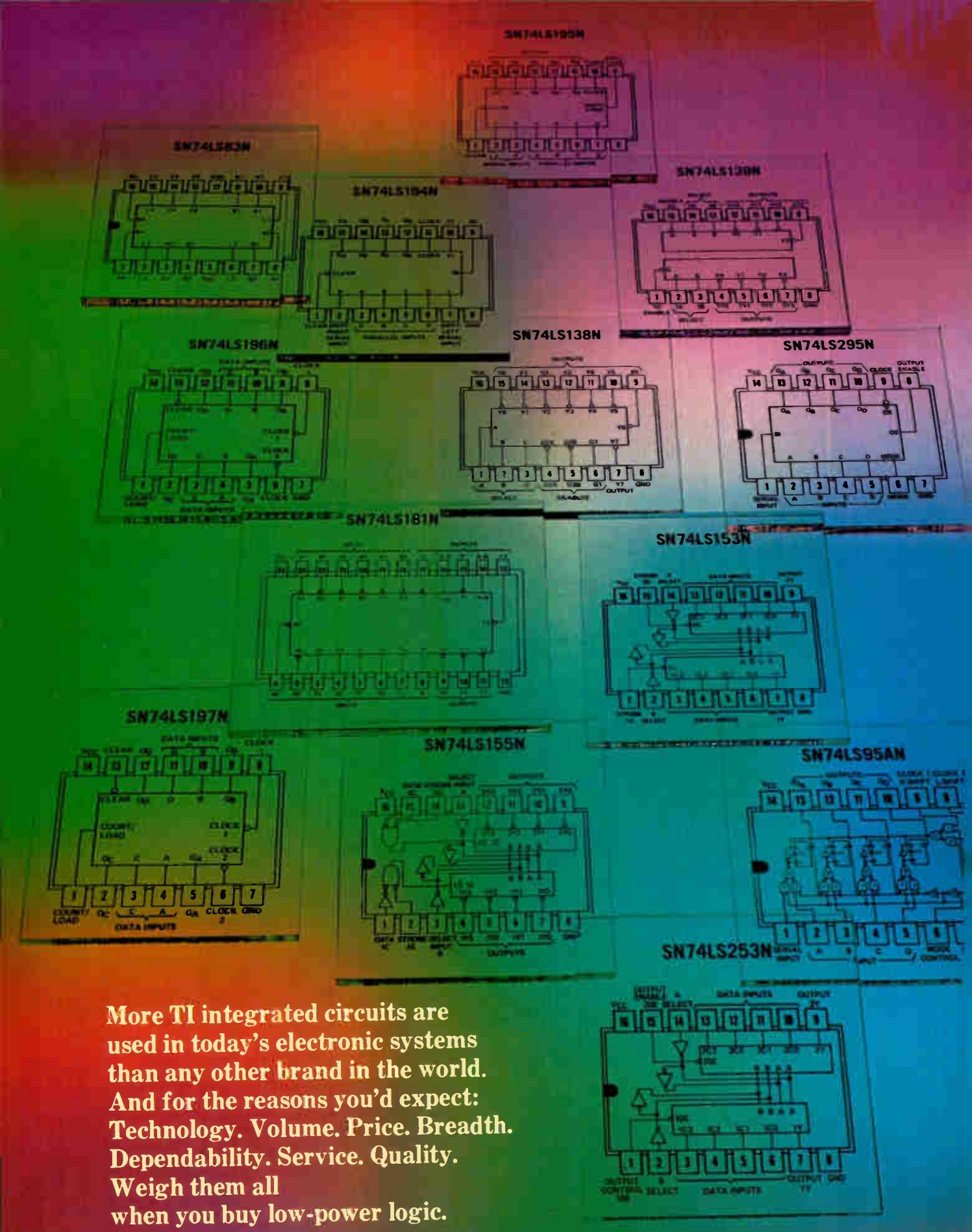
Hartman has been with CTS since 1946, when he joined the company as a quality-control engineer. He became president of the Microelectronics division in 1966, and was a prime mover in the company's push into thick-film technology. Then he served as director and vice president of the Berne, Ind., division as that facility became the company's most successful operation.

Says one fellow executive, "Clint has had just about every job in the plant, which accounts for his approach to marketing and sales."

More TI integrated circuits are
used in today's electronic systems
than any other brand in the world.
And for the reasons you'd expect:
Technology. Volume. Price. Breadth.
Dependability. Service. Quality.
Weigh them all
when you buy digital logic.

Someday all TTL circuits
will probably be Schottky-clamped.
High-speed. Low-power. Memories.
Since we produced the first one,
we've offered you
the best and biggest choice.

SCHOTTKY



More TI integrated circuits are used in today's electronic systems than any other brand in the world. And for the reasons you'd expect: Technology. Volume. Price. Breadth. Dependability. Service. Quality. Weigh them all when you buy low-power logic.

SCHOTTKY

TI announces low-power Schottky MSI: 10 ns at less than 2 mW.

TI's new low-power Schottky TTL line provides all the performance of low-power TTL (Series 54L/74L) with increased speed of 10-ns/gate and power dissipation of less than 2 mW.

Improved performance in power-critical applications

Low-power Schottky offers greatly improved speeds in portable or remote systems, or in any application where minimum power is a prime consideration. Compared to their low-power TTL counterparts, low-power Schottky circuits require less than 1 mW/gate more power—but offer a three-fold increase in gate speeds.

Typical Speed/Power Performance Comparison

Family	54H/74H	54/74	54S/74S	54L/74L	54LS/74LS
Average Propagation Delay (ns)	6	10	3	33	10
Average Power Dissipation (mW)	22	10	19	1	2
Speed/Power Product (pJ)	132	100	57	33	20

Full compatibility

TI's new low-power Schottky series is compatible with all TTL—standard, high-speed, low-power and Schottky. Together, these TI families offer more than 250 integrated circuit functions with compatible logic levels, voltage swings and noise margins. No interface circuits or level shifters are required.

Broad MSI line available now

TI's low-power Schottky TTL line now includes 13 high-complexity functions. These circuits offer you the full benefits of MSI design—fewer packages, smaller PC boards, fewer system interconnections—all contributing to lower component and system costs per gate, plus added reliability.

And within weeks, TI will introduce a full line of low-power Schottky SSI, including 13 gates and eight flip-flops.

Here are the MSI functions available now:

	DESCRIPTION	TYPICAL SPEED	TYPICAL POWER (mW)	100-PIECE PRICE
SN74LS83N	4-bit full adder	35 ns	80	$ 3.51
SN74LS95AN	4-bit left-right shift register	30 MHz	52	4.78
SN74LS138N	3 to 8 line decoder. 1 to 8 line demultiplexer	20 ns	30	4.78
SN74LS139N	Dual 2 to 4 line decoder. Dual 1 to 4 line demultiplexer	20 ns	35	4.78
SN74LS153N	Dual 4 to 1 data selector/multiplexer	15 ns	35	4.78
SN74LS155N	Dual 2 to 4 line decoder	20 ns	30	4.78
SN74LS181N	Arithmetic logic unit/ function generator	30 ns	105	25.85
SN74LS194N	4-bit bidirectional universal shift register	30 MHz	60	4.78
SN74LS195N	4-bit parallel-access shift register	30 MHz	52	4.78
SN74LS196N	Presettable decade counter	30 MHz	55	4.78
SN74LS197N	Presettable binary counter	30 MHz	55	4.78
SN74LS253N	3-state version of SN74LS153	20 ns	45	5.74
SN74LS295N	3-state version of SN74LS95A	30 MHz	60	5.74

Immediate availability

Low-power Schottky circuits are available in the plastic dual-in-line package. Evaluation quantities are available immediately from your authorized TI distributor or direct from factory inventories. Production quantities are available four weeks ARO.

Send for data sheets

For complete information on TI's new, low-power Schottky family, circle 210 on the Reader Service Card. Or write Texas Instruments Incorporated, P. O. Box 5012, M/S 308, Dallas, Texas 75222.

TEXAS INSTRUMENTS
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More TI integrated circuits are used in today's electronic systems than any other brand in the world. And for the reasons you'd expect: Technology. Volume. Price. Breadth. Dependability. Service. Quality. Weigh them all when you buy high-speed logic.

SCHOTTKY

TI announces more Schottky MSI:

decoders, D-registers, shift registers, multiplexers and arithmetic elements.

In any logic form, complexity is the key to low system cost, maximum performance and reliability.

You'll find your best choice of high-complexity, high-performance Schottky TTL circuits at TI—now and in the future.

We've just added more MSI circuits to the 3-ns 54S/74S line (nearly doubled it) and all are in volume production now.

Your best high-performance logic choice

TI's Schottky TTL reaches back through the evolution of transistor-transistor logic for reliability, design simplicity, volume availability, low cost and versatility—and combines these advantages with superior performance previously achieved only with unsaturated logics.

Here are the benefits of designing with TI Schottky MSI:

- Improved system speeds—internal-gate propagation delays as low as 1.5 ns, with an average of 2.4 ns.
- Reduced power dissipation—as low as 8 mW/gate, with an average of 13.7 mW.
- Total compatibility with all other 54/74 TTL families.
- Design rules similar to 54H/74H TTL.
- Guaranteed operation over full military (−55°C to 125°C) and industrial (0°C to 70°C) temperature ranges.
- Full package range—plastic and ceramic DIP and flat pack.
- Fewer system interconnections for increased reliability.
- Fewer packages, smaller PC boards.
- Lower component and system costs per gate.

For new systems—or easy upgrading of existing designs

Not only can new systems incorporate the performance advantages of Schottky MSI, but existing designs can in many cases be upgraded by replacing 54/74 MSI functions with a pin-compatible, functionally identical 54S/74S version.

TI's Series 54S/74S Schottky TTL is totally compatible with all TTL...standard, high-speed, low-power and low-power Schottky. Together, these TI families offer more than 250 integrated circuit functions with compatible logic levels, voltage swings and noise margins. No interface circuits or level shifters are required. In addition, Schottky TTL will interface directly with DTL and most low-threshold MOS.

Broad choice of functions

Series 54S/74S offers you 17 MSI functions, supported by an SSI line that includes 13 gates, a power buffer, a line driver, and 4 dual flip-flops. MSI circuits available now include:

100-MHz Shift Registers/Storage Registers

SN54S/74S174	Hex D-type storage register
SN54S/74S175	Quad D-type flip-flop, complementary outputs/clear
SN54S/74S194	4-bit bi-directional shift register
SN54S/74S195	4-bit parallel-access shift register

Arithmetic Elements

SN54S/74S86	Quadruple Exclusive-OR
SN54S/74S135	Quadruple Exclusive-OR/NOR
SN54S/74S181	4-bit arithmetic logic unit and function generator
SN54S/74S182	Carry look-ahead generator for SN54S/74S181

Data Selectors/Multiplexers

SN54S/74S151	8 to 1-line
SN54S/74S251	8 to 1-line with tri-state outputs
SN54S/74S157	Quad 2 to 1-line, true output
SN54S/74S257	Quad 2 to 1-line with tri-state true outputs
SN54S/74S158	Quad 2 to 1-line, inverting output
SN54S/74S258	Quad 2 to 1-line with tri-state inverting outputs
SN54S/74S153	Dual 4 to 1-line

Decoders/Demultiplexers

SN54S/74S138	8 to 3-line
SN54S/74S139	Dual independent 2 to 4-line

Send for brochure

For details on TI's TTL Schottky family, get a copy of Bulletin CB-147. Circle 211 on the Service Card or write Texas Instruments Incorporated, P. O. Box 5012, M/S 308, Dallas, Texas 75222.

TEXAS INSTRUMENTS
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Meetings

International Symposium on Electromagnetic Compatibility: IEEE, Arlington Park Towers, Chicago, July 18-20.

Joint Automatic Control Conf.: AIAA, IEEE, et al., Stanford University, Palo Alto, Calif., Aug. 16-18.

Western Electronic Show & Convention (Wescon): WEMA, Convention Center, Los Angeles, Sept. 19-22.

Engineering in Medicine and Biology: IEEE, Americana, Bal Harbour, Fla., Oct. 1-5.

International Symposium on Remote Sensing of Environment: U. of Michigan, Willow Run Labs, Ann Arbor, Oct. 2-6.

U.S.A. & Japan Computer Conf.: AFIPS, IPSJ, Tokyo, Oct. 3-5.

Ultrasonics Symposium: IEEE, Statler Hilton, Boston, Oct. 4-6.

National Electronics Conf.: NEC, Regency Hyatt O'Hare, Chicago, Oct. 9-11.

International Conference on Cybernetics and Society: IEEE, Sheraton, Washington, D.C. Oct. 9-12.

Conference on Display Devices: IEEE, United Engineering Center, New York, Oct. 11-12.

Eascon: IEEE, Marriott Twin Bridges, Washington, D.C., Oct. 16-18.

The Business Equipment Show: McCormick Place, Chicago, Oct. 16-20.

International Conference on Computer Communications: IEEE, ACM, Hilton, Washington, D.C., Oct. 24-26.

Nerem: IEEE, John B. Hynes Civic Auditorium, Boston, Nov. 1-3.

International Conference on Magnetism and Magnetic Materials: AIP, IEEE, et al., Hilton, Denver, Nov. 28-Dec. 1.

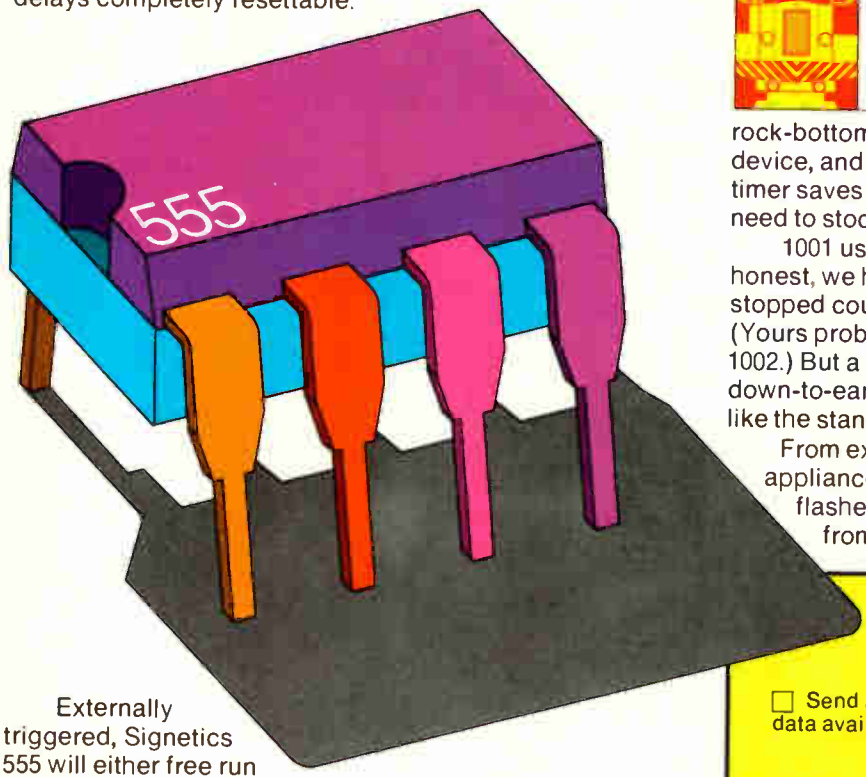
The timer of 1001 uses.

(Priced so low it's measured in cents.)

At last. A true standard IC timer with almost universal applications. The new low-cost 555. From Signetics-Linear, of course.

And the most extraordinary advantage of 555: it's so ordinary, and so simple to use. With designed-in flexibility that's never been matched, spec for spec.

555 functions interchangeably as a time delay, oscillator, pulse detector or power modulator. Timing from microseconds through one hour. With time delays completely resettable.

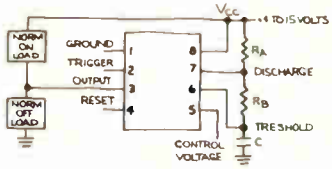


Externally triggered, Signetics 555 will either free run or latch, in adjustable duty cycles from 50% to 0.01%. Timing can be changed 10:1 with control. Operating from 5 to 15 volts with only a 1% change in timing. Output can source or sink 200mA. Temperature stability: 0.005% per °C.

And applying the adaptable 555 is practically child's play (if the kid knows basic math). Requires only a resistor and capacitor to do the job. With all kinds of options for starting the timing action. And you can operate 555 from just a single power supply.

All this, in one simple 8-pin dual in-line circuit. Available off-the-shelf now, from your distributor at rock-bottom cost. The 100-up price is only 75¢ per device, and the multi-function capability of our 555 timer saves you still more on the parts you no longer need to stock.

1001 uses? To be honest, we haven't stopped counting yet. (Yours probably makes 1002.) But a versatile down-to-earth IC timer like the standard 555 suggests applications unlimited.



From exotic technology to household appliances... from copying machines to barricade flashers... Start thinking. And you can take it from there.

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☐ Send all the literature, specs and applications data available for the great 555 breakthrough.

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What the industry taught us about price/performance.

Hottest core in the time trials.

Here she is, racing fans. The flash of the industry. Speed to burn. The first mini to break the billisecond barrier. Yessir, just listen to that baby purr.

Unfortunately, of course, speed doesn't mean much by itself. Details like I/O handling and realistic operating systems tend to spill a little oil on the track.

The old benchmark trick.

Simply design a "standard" benchmark that happens to rely heavily on the particular strengths of your computer. Never mind the actual application. Just look at those cycle times. Sure . . .

The Interdata New Series. What you see is what you get.

We play it a little differently at Interdata. If we're forced to use numbers, our Model 70* has an LSI bi-polar control store that gives you a 90-nanosecond access time.

But if you want a minicomputer to do a job for you, consider this: It has 113 instructions with direct addressing to 65,536 bytes. Built-in multiply/divide and 32-bit floating point hardware. 255 I/O interrupts with automatic vectoring to service routine. Four direct memory access ports and a double-buffered Teletype interface. And 16 general purpose registers.

And our Model 80 has everything the Model 70 has — plus its own set of fancy numbers for the die-hards: a 75-nanosecond control store access time and a 240-nanosecond semi-conductor main memory.

So now you can choose from a whole family of mini-computers with price/performance you just couldn't get until now.

Now it's part of the extras you get from Interdata. INTERDATA®

*Basic 8KB Model 70 — $6800. $4828 with OEM discount (quantity of 15).

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Circle 24 on reader service card

Electronics newsletter

New IBM models to have space for 2 million bytes

Look for IBM to take dead aim with its upcoming 370/157 and 370/167 computers at competition from add-on and enhancement memory manufacturers by providing the physical space for 2 million bytes. **Customers will get the same size box, no matter how little memory they buy, so later they'll be able to increase capacity simply by sliding in additional memory cards.**

And to confound the foe further, the new machines, geared to multiprocessing instead of the batch-processing modes of the 155 and 165, **will rely on n-channel MOS memory devices in packages of 4,096 bits.** Initially, IBM will house two 2,048-bit chips in a single package, then introduce 4,096-bit chips when they become available. Such multichipping was accomplished in IBM's first semiconductor-memory machine, the bipolar 370/145.

Ampex working on two-tune tape

The Ampex Corp., seeking to capture a piece of the record market, is developing a counterpart to the 45-rpm record—a two-tune tape. **However, the company says a major redesign is still needed to get the retail price down.** William Slover, Music division vice president, says, "The product shouldn't cost the user more than $1.25." The reason is that the 45-rpm "single," backbone of record sales, is priced at 70 to 90 cents. The two-tune tape will probably be in eight-track format since cartridges outsell cassettes.

TI readies more calculators

Texas Instruments isn't going to limit its attack on the consumer calculator marketplace to the rechargeable LD2500 Datamath, a hand-held, LED-display machine selling for $149.99 (see p. 44). **TI has printed promotional material for the LC2000, a liquid-crystal version that runs as long as 20 hours on size AA batteries, and for a desktop model** that retailers say probably will be introduced in August or September.

Over official TI protest that this is simply "the first part of a continuous program to test-market calculators through several channels of distribution," retailers report that they expect a full line of TI-made calculators in time for the pre-Christmas retailing push, **including a hand-held model with full printed readout, probably to sell for under $140.**

Victor to make hand models . . .

Victor Comptometer Corp., which advanced strongly into the electronic calculator market last year with 12 desktop models, is now aiming at the hand-held sector. The company is moving in with the MEC/1 and MEC/2, both reading out to 12 digits and using chips supplied by NRMEC [*Electronics*, Aug. 30, 1971, p.17]. **One problem: the $279 MEC/1 without memory, priced competitively with Japanese hand-helds, is still more expensive than other American units.** The MEC/2 with memory is $319. The next step will be the MEC/3, a programable hand-held machine for accounting and payrolling. Victor's re-emergence as an electronic calculator maker follows a period of caution after the company's abortive first attempt with electronics in 1966. [*Electronics*, June 24, 1968, p.25].

Electronics newsletter

. . . as Bowmar cracks the $100 barrier

Bowmar Instrument Corp. will crack the $100 price barrier with a hand-held calculator that is scheduled for introduction this fall. **The company will say only that expansion of production capabilities has made the low price possible.** Also slated for the fall is a line that includes hand-helds of varying prices and complexity, along with units of other sizes for a broader range of applications.

Tek keyboard boon to APL

Development of a new keyboard/CRT terminal at Tektronix may give the APL programing language the push it has needed. APL was developed as the answer to the scientist's prayer; **it's a convenient language for people who are not programers, but who have complex scientific problems to solve.** APL's power comes from an extensive character set—more extensive than teletypewriter-type terminals can handle—so that it requires special keyboards with upper and lower case.

The new Tektronix terminal, expected to be ready some time this fall, not only has the upper- and lower-case keyboard, **but also has the special character-generating hardware and CRT needed to make a completely APL-compatible graphics terminal.**

Data General lists Nova cassette

Data General Corp. is expected to announce a magnetic-tape cassette drive for its Nova minicomputer—the company's second in-house peripheral. The first was the Novadisk. **Emphasis in the design, probably using Philips cassettes, is on reliability first and cost second; but engineers are also taking certain liberties to keep cost down.** For example, they're not overly concerned about keeping the tape speed constant; they're using a coding scheme that works well at many speeds.

Here come slower CRTs and faster mechanical printers

While the CRT display terminal is being slowed down so that it can compete in price with standard mechanical teleprinters, those printers are being speeded up—to compete with CRT terminals.

ITT's Data Equipment and Systems division in East Rutherford, N.J., will have available in November its Asciscope CRT display. The display, which will lease for $65 a month and sell for $2,190, **will come complete with keyboard, 960-character buffered memory, and built-in modem to write at speeds to 30 characters a second.**

At the same time, General Electric is increasing the speed of its Terminet mechanical printer from 30 to 120 characters per second **to give a real-time data speed that makes efficient use of leased phone lines.** The printer, with a base price of $4,050 in the receiver-only configuration, also will be available in October with keyboard send-receive and automatic send-receive.

GE wins contract for Marines' radar

General Electric's Aircraft Equipment division in Syracuse, N.Y., has won out over Sperry Rand and RCA in the competition for the Marine Corps' TPS-59 phased-array air defense search radar. **The $6.9 million contract, which comes from the Naval Electronics Systems Command, calls for the fabrication of an engineering development model of the all-solid-state radar,** which will have an output power of 50 kilowatts.

With IFF (identification, friend or foe) capability, the L-band TPS-59 will be designed into both the Marine Tactical Data and the Marine Tactical Command and Control Systems.

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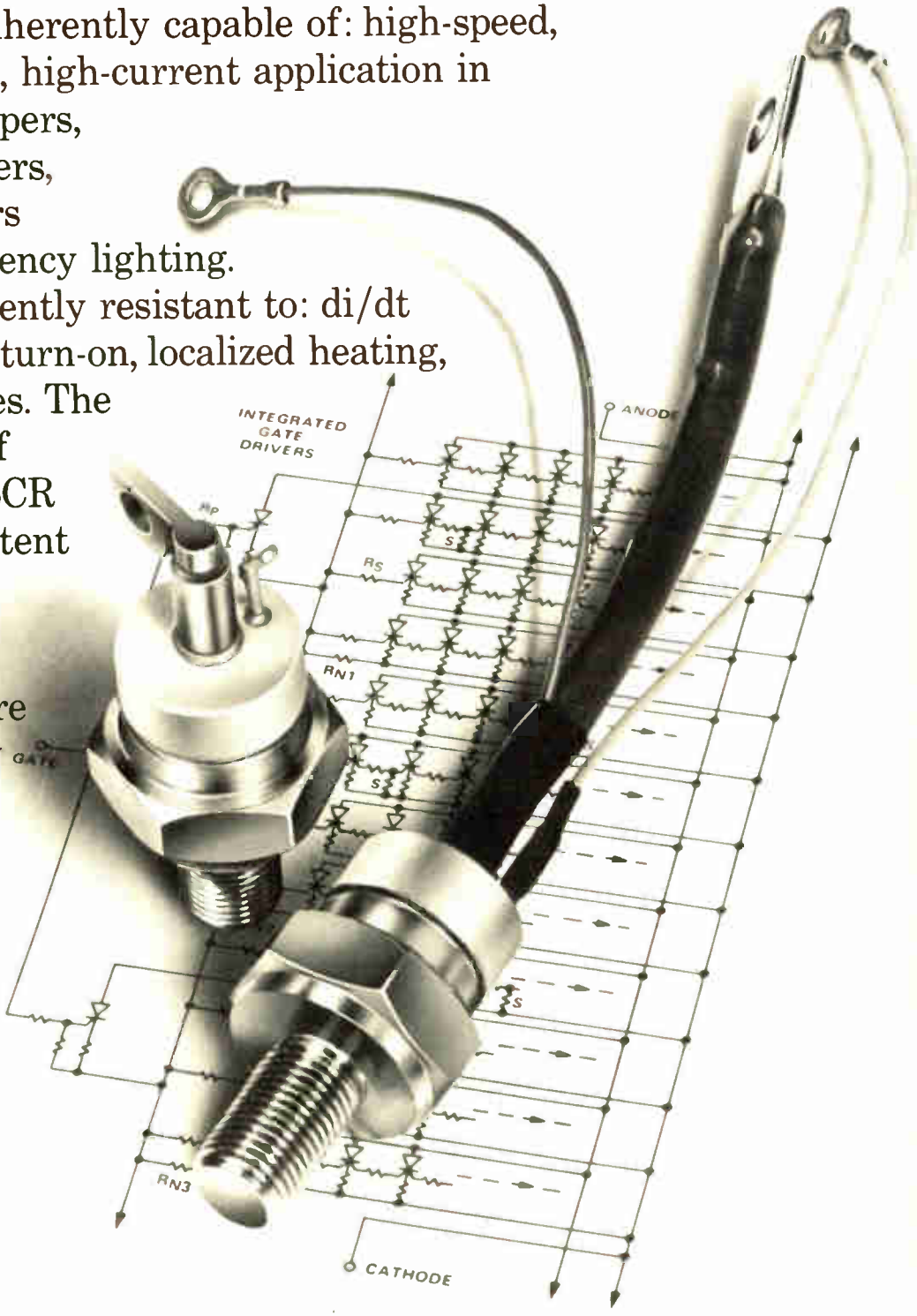

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U.S. TV makers cut convergence adjustments on tube

New RCA model needs no adjustments as Sylvania and GE reduce dynamic steps required to four

Of the television set improvements in the last few years, most have concerned the change to solid-state circuitry. Now the color picture tube is getting some of the play: RCA has made the first major change since Sony introduced its Trinitron in 1968, a change that carries it closer to the Trinitron concept.

Two other American companies along with RCA have brought out in-line, triple-beam gun structures with reduced dynamic convergence adjustments. To make the picture brighter, all use shadow masks with vertical slits instead of the tricolor-dot mask of the old delta system. And all showed 15-, 17-, and 19-inch tubes late last month during the IEEE Spring Conference on Broadcast and Television Receivers in Chicago.

Jump. But that's where the similarities end, for RCA has leapfrogged its competitors. While GE and Sylvania have reduced dynamic convergence adjustments to four from the 12 required with the delta system, and the Trinitron requires but two static and one dynamic adjustment, RCA has eliminated the need for dynamic convergence altogether. The trick is a permanently attached yoke-cemented to the CRT that eliminates all the adjustment circuitry. That, in turn, will simplify factory alignment, and do away with costly and time-consuming convergence realignment.

RCA's new tube is compatible with solid-state circuitry, so a custom-chassis design isn't needed. The gun is about half the size of current delta-gun arrays and fits into a 29-millimeter (rather than a 30-mm diameter) glass tube, shortening the present 90° color tube by 1.8 in.

Although all the improvements are significant, the biggest is the automatic convergence feature made possible by the lower-cost precision static toroidal deflection yoke. The yoke is simple to manufacture and can almost be checked out visually. Both vertical and horizontal deflection wires are precisely positioned in preset grooves—they're molded into plastic rings cemented to either end of the yoke's ferrite core. The yoke uses less than 80% of the copper wire required for the RCA engineers, yields are almost 100%—as against the 50% to 90% yields that are attainable with the saddle yoke type.

The Trinitron tube, on the other hand, uses a shadow mask with continuous vertical phosphor color stripes. This approach produces excellent brightness because there is less mask area to prevent the electron beam from striking the phosphor stripes. Moreover, vertical error in beam positioning doesn't cause a color difference. And the Sony tube uses only one gun and a common focus for all three beams in the tube. □

Pretty picture. RCA's tube, left, needs no dynamic convergence adjustments; old needs 12.

Hi-fi speakers monitor own sound

Audio buffs in this country will soon be hearing a hi-fi system developed in Belgium that features self-regulating speakers—they monitor the

mechanical positioning of the cones with respect to the audio signals driving them.

Suppression. The result, claims Servo-Sound America Inc., Ephrata, Pa., is a smaller speaker, which eliminates electronically the distortion that is usually controlled mechanically by cabinet size. Called Cybernetic Hi-Fi, the system has a circuit between the amplifier and the loudspeaker to sense the motion of the diaphragm, compare the result with the original signal, transform the difference into a correcting signal, and suppress any resonances created in the speaker enclosure.

The speaker-power amplifier cabinet measures 7.09 in. by 10.2 in. by 11.02 in., and the "cybernetic" circuit consists of seven transistors, seven diodes, and a thermistor. Price of the speakers is about $160 each.

The company, which has been marketing this line in Europe for about three years, also has a stereo crossing box that will match the speakers to conventional stereo amplifiers. The box fits any amplifier from 10 watts rms to 150 W rms. Because the speaker has its own amplifier, up to 70 individual units can be connected to the same preamplifier with 100 W rms total power, the company points out. Each speaker weighs 8 pounds. □

Do-it-yourself recording

Though a Federal law banning audio tape pirating has been in force since last February, duplication for private use was not affected. And now makers of tape-reproduction equipment have started to go after the private-use market with a point-of-purchase duplicator.

Make-a-Tape, Inc., Fraser, Mich., is building the CDS-81-A, a coin-operated, in-cartridge duplicator for eight-track tape. Selling for $2,495, it reproduces a cartridge in one 2-minute pass.

The idea is for the retailer to sell the customer the blank tape in a cartridge for about $3.50 and provide the copier at a charge of 50 cents per run. The CDS-81-A tape speed is 15 inches per second. The duplicator has four nonmovable fixed heads, each having four tracks, which makes possible the one-pass duplication. In addition, the unit has a direct-drive common capstan to control flutter and synchronization.

The company, which has been making professional stereo eight-track duplicators for five years, expects to sell the units to audio stores, department stores, gas stations, and shopping centers.

Meetings

Consumer show was ear-catching; winter session aims at 'furniture' men

With television manufacturers RCA, Zenith, Motorola, Magnavox, Philco-Ford, and Sylvania absent, this year's Consumer Electronics Show (CES) was again easily dominated by audio equipment. Nevertheless, the sixth annual display, sponsored by the Electronic Industries Association in Chicago last month, had more exhibitors than ever and record attendance.

Jack Wayman, vice president of the EIA Consumer Electronics Group, flushed by this success, took the opportunity to announce that the winter CES, scheduled also for Chicago, Jan. 12 to 16, will include exhibits by the major television manufacturers. The winter affair is designed to catch attendees at the Home Furnishings Market and the January Housewares Show, which take place just before and just after. But, because construction delays have forced CES to use the Conrad Hilton instead of the new McCormick Inn, the winter fixture will butt against the rival International Housewares Electronics Exhibit scheduled for the same hotel.

According to Wayman, the winter exhibit will be ideal for displaying the "furniture" end of television and stereo lines—the consoles and audio-video combinations. These units were invisible at the June exhibit amid the ear-wracking array of stereo and four-channel components.

Also, it's expected that a winter show will:

- Draw about 150 exhibitors (compared to 325 for the traditional June show).
- Cater to an expanding market for portable consumer electronic product lines that sell heavily in spring and summer.

Some 29,000 consumer electronics products from 325 manufacturers and importers covered the McCormick Place display areas last month. A total of 37,450 merchandisers registered to inspect the attractions that will reach the market this fall. While the show was an undoubted success, it was not without some problems.

The chief one was what to do about the Japanese exhibitors. Some U.S. companies have complained that the Japanese are dominating the show, despite not being members of EIA. On the other hand, should the Japanese be removed, their absence would cripple the show's income-producing ability, as well as cut attendance.

Another problem was the absence of television makers. As Jack Wayman admitted, "You had to look awfully hard to find a TV set." □

Microwave

MOS-type switch boon to radar

A microwave switch based on MOS techniques may greatly simplify drive circuitry for phased-array radar. Developed by Hughes Aircraft's Newport Beach, Calif., Re-

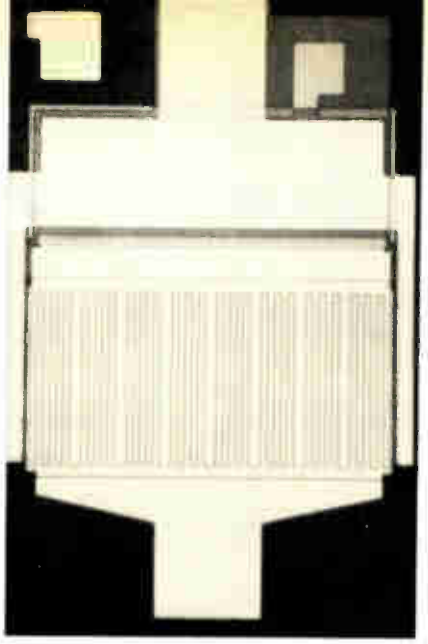
search Lab, the resistive-gate switch has much the same performance as the p-i-n diodes now used but, unlike them, requires no bias current. The 10,000 p-i-n diodes in a typical system may need up to 100 milliamperes each.

The new device is simple and inexpensive to manufacture, and high yields are expected. It promises high-power operation, and is resistant to radiation. In addition, it's a planar device, unlike the p-i-n diode, so is adaptable to integration with logic drive circuitry, and the switch is compatible with microstrip circuitry.

Though the part is still in development, Alex M. Leupp, section head, Electron Devices, says that considerable interest has been shown in it for systems. Early devices have about 1 ohm on-resistance and 1 kilohm off-resistance in the 2.0-to-2.7-gigahertz band.

Low is high. Up to now, MOS devices (with the exception of Signetics' double-diffused amplifiers) have not been usable above a few megahertz. A basic problem in conventional structures is the tradeoff between drain-source resistance and capacitances: for low-resistance devices, the capacitance has been too high for high-frequency uses.

The new switch consists basically of two aluminum electrodes (source and drain) and a very-high-resistivity polycrystalline film (gate), all deposited on an oxide layer over a high-resistivity substrate. To switch the device on, a bias is applied between the gate and substrate, creating a conducting channel in the substrate. In this mode, the microwave signal is conducted through the capacitances between the drain and channel, and between channel and source. In the off condition, the bias is removed, and the conducting channel disappears, so that the only signal conduction is through the high-resistance gate and the low capacitance between drain and source. For low on-resistance, an interdigitated structure and thin oxide layer are used. To provide enough carriers for fast switching, a doped layer is implanted around the active area.



Handy part. Microwave switch by Hughes is based on MOS, is simple to make.

This produces a three-terminal device. For many microwave applications, a two-terminal device is preferred, and this can be made if an MOS capacitor is formed in series with the source to isolate the source from the dc switching voltage.

The device can handle about 4 or 5 watts. Since it is planar, heat transfer is efficient. Switching time is in microseconds, and the part works only if the switching frequency is much less than the microwave frequency. Because of the capacitive coupling, the part is not useful at low frequencies. □

Satellites

New ERTS depends on old mail service

NASA and the Department of Interior hail the upcoming launch of the Earth Resources Technology Satellite (ERTS) as the start of a new era in resource surveillance for the 300 public and private customers here and abroad. But the success of the high-technology General Electric Co. satellite program could well hinge on the reliability of the old-fashioned U.S. mail.

Scheduled to be launched after July 21, ERTS will beam a flood of digital data to NASA receiving stations at Goldstone, Calif., Fairbanks, Alaska, and an automated image-processing center at Goddard Space Flight Center in suburban Washington, D.C. Goddard, after processing some pictures for NASA clients, will ship all the data to a new Earth Resources Observation Systems (EROS) center in Sioux Falls, S.D., which will sell or distribute the earth pictures upon request.

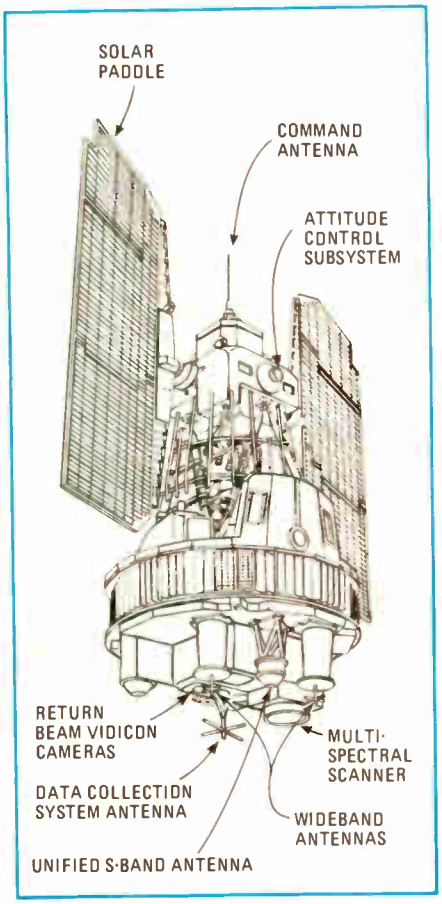
Thus far, managers plan to use the postal service to get the timely data from Alaska and California to Goddard and from there to Sioux Falls. "We might use air express at first, but we'll use the U.S. mail eventually," says William A. Radlinski, Interior's EROS program manager, who adds that the center expects to handle some 20 million pictures a year.

Since ERTS will fly over the same spot every 18 days, program managers admit that some users who are tracking vegetation changes, for example, may become impatient with the vagaries of mail service, but professional users will know how to use what they're getting.

Data flood. To handle the data, the EROS center will open in the spring of 1973, and Interior plans to add a $4.5 million data center to match Goddard's. Radlinski says, "We have to design the system so we don't get buried in data." As part of an effort to evaluate benefits of the year-long ERTS-A program, NASA is negotiating with Texas Instruments for a contract to determine the commercial utility of the spacecraft's infrared sensors for oil companies, and Interior plans to award $1 million for studies.

A follow-on ERTS-B is scheduled for launch next year as part of the $174 million NASA program. NASA is talking about a possible ERTS-C, and Interior hopes to "always have a satellite up there," Radlinski says.

While the on-ground data distribution may be old-fashioned, ERTS-A represents a new step in space image-gathering and data transmission. The most important achievement is "getting so much data down to earth with an rf link only," says Lewis T. Seaman, ERTS program manager for the GE Space division, Philadelphia. The 2,000-pound spacecraft will carry a return-beam vidicon camera subsystem



Ready. ERTS-A is awaiting launch. It will serve 300 users around the world.

built by RCA's Astro-electronics division, Princeton, N.J., and a multispectral scanner subsystem built by Hughes Aircraft Co., Culver City, Calif. The vidicon's rate of 3.2 megahertz, plus the 1.5-megabit scanners, "lets us transmit data with no degradation," Seaman says, "which hasn't been done before at that rate and precision." □

Software

Texas firm offers digital test programs

As designers cram more and more complex ICs onto their printed-circuit boards, the engineers who design tests find it ever more difficult to keep track of all the possible bad circuits. In fact, the cost of devising tests for digital assemblies is approaching the cost of designing the circuits themselves. The upshot is that generation of digital test programs has now become a brisk business.

Now, Telpar Inc., a Dallas firm that has been providing digital logic test design and documentation services since 1970, has begun offering its complete software package on a lease, lease-buy, or purchase basis—at what Telpar chairman Robert M. McClure calls "below in-house prices."

Smooth. The company, a Texas Instruments spin-off, calls its package Testaid—a streamlined set of programs designed to be cost-effective on computers as small as an IBM 360/30 with 65,536 bytes of storage. That, says McClure, is enough to generate tests of circuits with about 1,200 gates—or a typical printed-circuit board of 60 to 70 ICs. "At those numbers, bookkeeping literally collapses," he adds.

Minimum price for the complete package—which starts with package-level logic diagrams and turns out a standard tester tape—is pegged at a minimum cash figure of $32,000, or the firm will lease the software at $2,000 for installation, plus $4,000 per month. Computer run cost averages from $1 to $1.50 per IC, regardless of the machine the software is implemented on, says president Richard L. Petritz. "It's the first really commercial package made available for testers," he says. "Other systems either run on giant scientific computers or are bundled with hardware."

Ten to make ready. The Telpar software is built around 10 major subprograms and a device library that includes most of the TI 5400/7400 series and Fairchild's 9000 and 9300 lines. The package codes the logic, adds the device descriptions from the library, and produces a documentation set with a listing of all signals, packages, devices, and input/output assignments. The program then simulates all faulty circuits, automatically adds generated patterns, and yields test sequences and diagnostics that, in most cases, enable a technician to isolate the defect to a specific IC. The system also delivers a tester tape ready for loading on commercially available testers, or Telpar engineers will design a post-processor for creating tapes to fit in-house testers.

The company is also starting a two-day monthly seminar to instruct designers in testability, simulation, and fault simulation. □

Optoelectronics

Laser used to grade oil spills

The Coast Guard's duties include cleaning up oil spills in coastal waters. But it must identify what kind has been spilled, since different weights of oil require different cleanup methods. Generally, samples must be collected from a spill and sent to a laboratory for analysis, a time-consuming procedure. Now the U.S. Department of Transportation's Systems Center in Cambridge, Mass., is developing a system that uses the principle of fluorescence. In prototype tests, the system identified 28 different oils commonly shipped, and was able to determine thickness of a spill of lighter oils.

Flying low. The equipment will be mounted on a plane flying at 160 to 200 knots per hour at 1,000 feet.

Heart of the system is a pulsed nitrogen laser, supplied by Avco Everett Research Labs. It puts out 100 kilowatts at 3,371 angstroms with a pulse width of 10 nanoseconds and a repetition rate of 5 to 500 pulses per second.

A gated optical receiver, synchronized with the laser transmitter, picks up the fluorescence, which is then decomposed by a spectrometer with a spectral range of 3,500 to 7,500 angstroms. Both the optics and spectrometer have been contracted to Perkin-Elmer Corp., Norwalk, Conn.

When the light of the fluorescence spectrum leaves the spectrometer it impinges upon the target plate of an image dissector, releasing photo-electrons. These are fo-

7L12 Spectrum Analyzer Facts

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Specifications like this:

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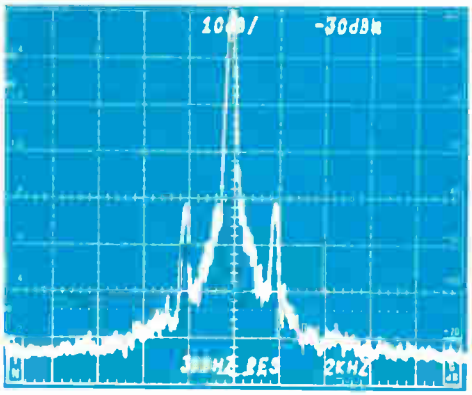
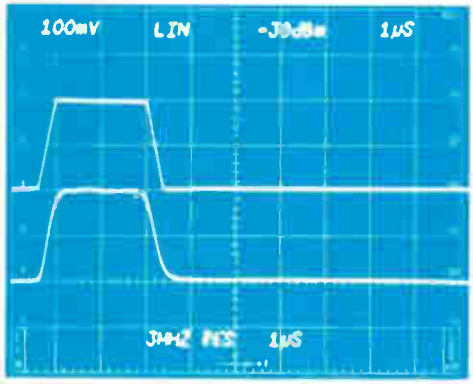
Mean that with the 7L12 low amplitude sidebands can be sharply resolved even when sideband frequency separation from the carrier is small. In the log, 10 dB/div display (at right) carrier is at —30 dBm, sidebands at —70 dBm, 2 kHz to each side. Note that the notches between sidebands and carrier are at —90 dBm.

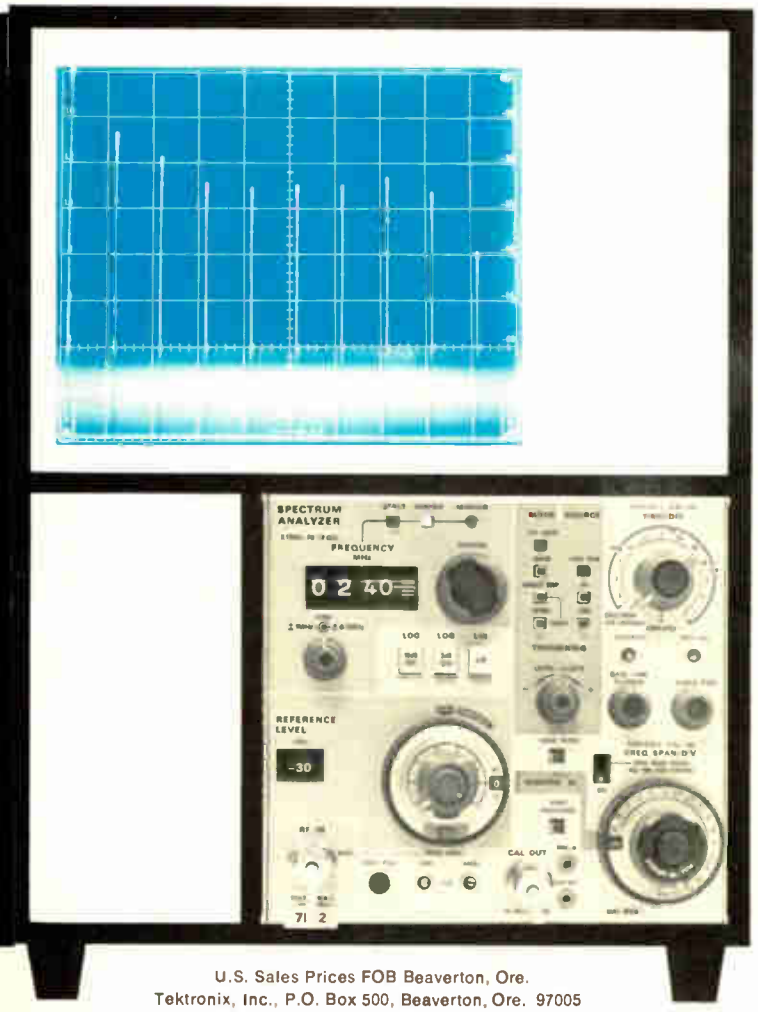


Specifications like this:

3 MHz resolution bandwidth

Mean a new dimension in time-base display of modulation waveforms. The lower trace (at right) is a modulation waveform as demodulated by the 7L12 and plotted by its calibrated time base. Add a plug-in amplifier to the other mainframe Y-axis compartment and a simultaneous display of the modulating signal can be plotted (upper trace).





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fact

Any 7000-Series Oscilloscope with a 7L12 Spectrum Analyzer Plug-in is an excellent 100 kHz to 1.8 GHz spectrum analyzer. Many mainframe choices are available.

fact

For $5806 the 100 kHz to 1.8 GHz spectrum analyzer at left is an excellent value. It consists of a 7L12 Spectrum Analyzer Plug-in ($4850) in a 7403N mainframe ($950) and a blank panel ($6) to cover the reserved-for-future-use compartment. Of course you can use the compartment now, if you choose, with one of many 7000-Series Plug-ins.

Note — The 7403N does not feature CRT readout.

*CRT readout is a feature of many 7000-Series mainframes.

For a demonstration circle 155 on reader service card

cused by means of electron optics to an image plane with a small aperture, which collects the electrons. Electrons emitted from different portions of the target plate correspond to different portions of the spectrum, and by moving the image plane, the area of the target plate from which electrons are collected can be selected. Behind the aperture is an electron multiplier, and the output is a spectral curve representing the number of electrons emitted.

Spectrum. The fluorescerce spectrum will be analyzed in intervals of 100 angstroms for a total of 40 channels, and by scanning all channels, the spectrum will be determined for the oil being surveyed. Hector C. Ingrao, chief, Optical Devices group, says the sweep rate of the channels will be adjustable, with a top speed of one pulse per channel. At 500 pulses per second, the interval between pulses is 20 milliseconds, giving a total sweep time of 80 ms. If more than one pulse per channel is received, sweep time will be longer.

The electronics subsystem is being developed by the Apollo group of MIT's Draper Lab, and Ingrao expects the first full-scale system to be ready in June for testing at Otis Air Force Base, Mass.

The system will operate in two modes. The detection mode will light an alarm when fluorescence goes above a threshold determined by natural fluorescence of the water. When the threshold has been passed, the classification mode will go into operation, jumping back and forth in the channels to find the shape and amplitude of the curve.

Eventually, Ingrao says, the center would like to use a signal processor that would store accumulated signals of many oils to compare them with incoming signals.

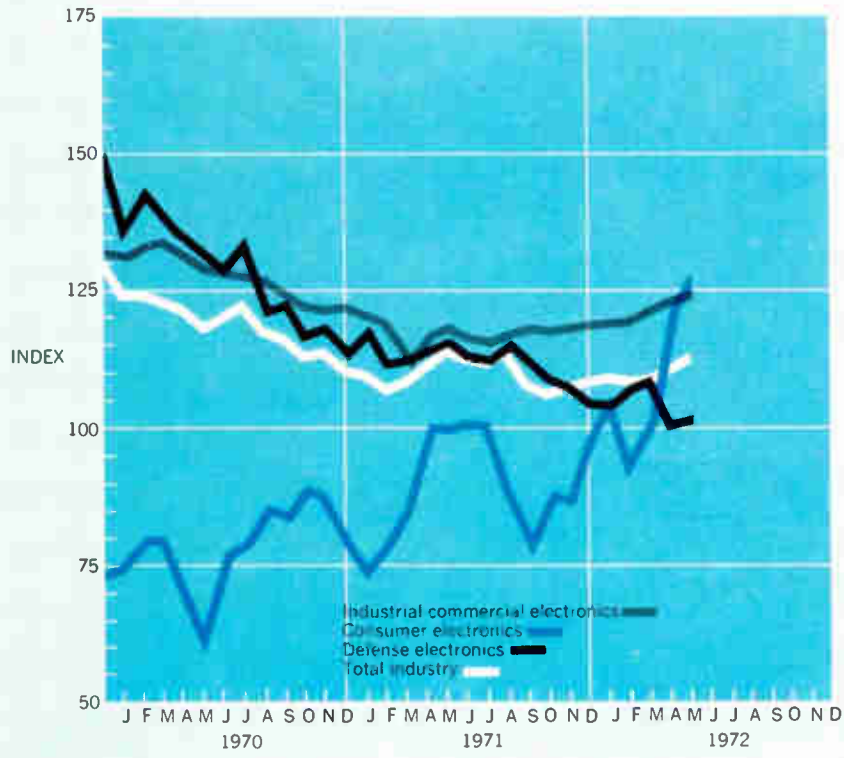
The Transportation Systems Center is also interested in finding out how spectra change when the oil has been on the ocean surface for a long time. □

Computers

CDC lab produces big, fast data file

Although large random-access data files with rapid data-transfer rates have been built, they are still neither big enough nor fast enough for some applications.

To alleviate that deficiency, an experimental project at Control Data Corp. of Minneapolis has brought forth a unit that promises a data-transfer rate of up to 80 million bits per second—compared, for example, with the 800,000 bits per second of the IBM 3330 disk file, or the 5.25 million of Precision Instru-



Electronics Index of Activity

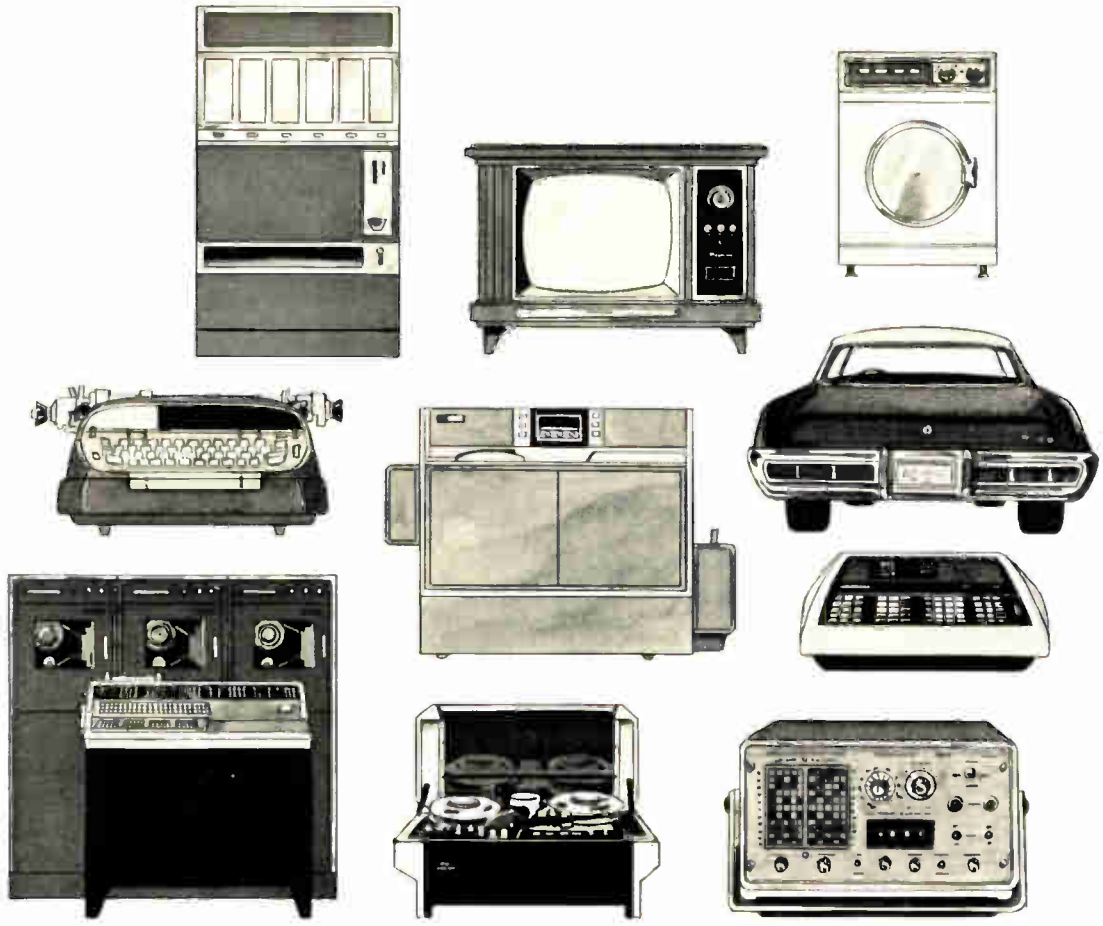
July 3, 1972

The index climbed 1.8% in May over April's revised 111.4. The increase over the May 1971 total was 4.8%.

All categories contributed to the rise, with consumer electronics showing the way with a 5.4% jump past April's highly revised 121.4. Defense was up 1.1% and industrial-commercial edged ahead 0.8%. Of all the categories, only defense was behind its year-ago level—off 2.7%.

Segment of Industry	May '72	April '72*	May '71
Consumer electronics	128.0	121.4	99.3
Defense electronics	102.2	101.1	105.0
Industrial-commercial electronics	124.9	123.9	118.8
Total industry	113.4	111.4	108.2

Indexes chart pace of production volume for total industry and each segment. The base period, equal to 100, is the average of 1965 monthly output for each of the three parts of the industry. Index numbers are expressed as a percentage of the base period. Data is seasonally adjusted.
* Revised.

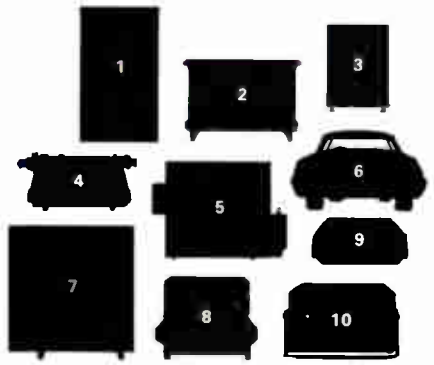


How many Cherry Switches can you find in these products?

HINT: Think big. Think of 97,650 switch configurations that let products like those above use mostly stock switches like those below. Think of Cherry's modern new facilities . . . with staffs of electrical, mechanical, tooling, industrial and manufacturing engineers guiding every phase of design and production. Think of 160 million switches produced during 19 solid growth years. And 104,000 more new switches passing through Quality Control every day, keeping our volume high . . . and our prices low.

How many Cherry switches can you put in your products? Find out: Check Cherry's latest big catalog. Send for your free copy today.

T20-01A Thumbwheel | 261-0100 Key Module | E69-20A Panel Mount | E62-00A Subminiature | S31-20P "Goldie"



1. Vending machine, up to 10 Cherry switches.
2. A TV tunes with 2 Cherry switches.
3. Washer-dryer combination, at least 3, up to 7.
4. Electric typewriter, 1 or 2 Cherry switches.
5. Photocopy machine, a surprising 55!
6. An auto, 1 to 6 Cherry switches.
7. A computer has 2 Cherry switches.
8. Electronic video recorder, 5 Cherry switches.
9. Electronic calculator—63 Cherry "Goldies."
10. Digital data generator, 4 Cherry thumbwheels.

IT ADDS UP TO AT LEAST 146 CHERRY SWITCHES!

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ment Co.'s trillion-bit Unicon mass memory.

The physical appearance of Scroll, as it's been named, is as unconventional as its speed. One version uses a strip of magnetic tape 10 inches wide and up to 5,000 feet long, as against the usual 0.5-inch-by-2,400-foot reel of tape. CDC claims that Scroll can handle tape of "virtually unlimited width." The wide tape unwinds from a spool, passes around a rotating drum, and winds up on another spool; the tape is separated from the drum by an air bearing.

Read/write heads are built into the drum's surface. If the tape spools remain stationary, the heads read the same section of tape repeatedly as the drum on Scroll continues to turn.

Data is recorded longitudinally on the tape at a density of about 4,000 bits per inch; one track down the full length of the tape, therefore, has a potential capacity of 240 mil-

Tape drive manufacturer makes a habit of beating IBM to the innovative punch

The computer industry is jammed with small companies. Some of them sprang up from scratch, and others have spun off from large established concerns.

But occasionally one of them gets into a position where it can make a much larger company follow its innovations—meanwhile making fistfuls of money. Take Storage Technology Corp., of Louisville, Colo., founded by a group of former IBM employees from the nearby plant at Boulder. STC, which makes magnetic tape drives and control units in direct competition with IBM, has beaten IBM to some marketing and technological changes.

Building. STC now owns its modern headquarters building next to the Denver-Boulder expressway, is building an adjacent structure into which it will expand by the end of the year, and leases two buildings in Broomfield, a few miles down the road toward Denver. One of the Broomfield buildings was formerly occupied by IBM while completing *its* new facility.

President Jesse I. Aweida founded STC in 1969, along with Tom Kavanagh, Juan Rodriguez, and Zoltan Herger; all four were IBMers from the Boulder plant, and, except for Kavanagh, had been at Poughkeepsie, N.Y., before the Boulder facility was built. Kavanagh was in field engineering before coming to Boulder. The company quickly picked up a number of other IBM people—some from Boulder and some from other locations around the U.S.—and swung into production of a series of tape drives compatible with IBM's 2420 drives.

Initially, these were sold to users to be plugged into an IBM control unit; but STC shortly added its own control unit to take maximum advantage of its drives' added capability—including the use of a more sophisticated error-detection and correction scheme than IBM used, a microprogramed control, and monolithic circuits (IBM at the time was using its hybrid solid-logic technology). The upshot was a control unit half the size of IBM's, but capable of running just as many tape drives—eight.

STC achieved a first in the industry with its microprogramed control, although IBM and many other companies have since adopted the technique or are seriously considering it for new equipment. The drive also had an automatic latch on its reel hubs, a faster rewind speed, a servo control utilizing velocity feedback to drive the tape reels—all of which have since appeared on later IBM equipment—and a dynamic amplitude control, which compensates for variations of up to 2 to 1 in the amplitude of the read signal when tape reels are moved from one drive to another. This control, incorporated in the design of the preamplifiers in the tape drive, resulted in a large decrease in the number of temporary and permanent errors.

IBM is a-d. IBM doesn't use dynamic amplitude control. Instead, it puts analog-to-digital conversion in the tape drive instead of in the control unit, claiming that this location makes the signal less susceptible to noise in the cable between the drive and the control. But most noise problems in magnetic tape are in the read-write head, not in the cable; and eight expensive a-d units are required for the eight drives instead of one in the control unit.

STC eliminated about 200 adjustments, upon which some of the specifications in IBM equipment depend; these are made by the field engineer at the time of installation or at other times if performance seems to indicate their need. These adjustments multiply rapidly—just one on each of nine tracks on eight drives accounts for 72.

STC's tape drives now compete directly with IBM's 3420s, even to the extent of having similar model numbers. IBM's machines are available with three different tape speeds—75, 125, and 200 inches per second, depending on the user's data-rate requirements; STC matched these, and also offers 100 and 250 in./s.

In the mode. In this new line, STC came one-up on IBM in the mode of tape switching. When IBM announced the 3420 in November 1970, it offered the capability of using up to 16 drives or two, three, or four controllers, so that a single collection of tape drives was operable from any of several computers.

About a month later, STC matched this capability, but also offered similar switching of up to eight drives. Thereupon IBM added this capability to its own tape systems. IBM, however, insists that the simpler eight-drive switch was available from the beginning, though it wasn't mentioned in brochures at first.

All of STC's models are available with either 800 bits per inch with NRZI encoding or 1,600 bits per inch with phase encoding—except for the 250-in./model, which has the 1,600 bit/in. density only. A 3,200-bit/in. version was also introduced in March. Any of STC's older 2400 series models can be changed to any density in the newer line at the customer's location; IBM can't make this change. □

The one in the middle is a Weston Series 660 VOM. And it's the only one of the three that's warranted to keep working even if it's accidentally dropped from a height of five feet. Weston is the only manufacturer who is making that statement.

A Weston Series 660 is also smaller and lighter in weight than competitive meters. It has an easier-to-read scale and range plate. And it costs no more than the meters that don't offer a drop-proofed warranty.

Like the others, it's available with a protective leather carrying case. But who needs one with a drop-proofed Weston VOM?

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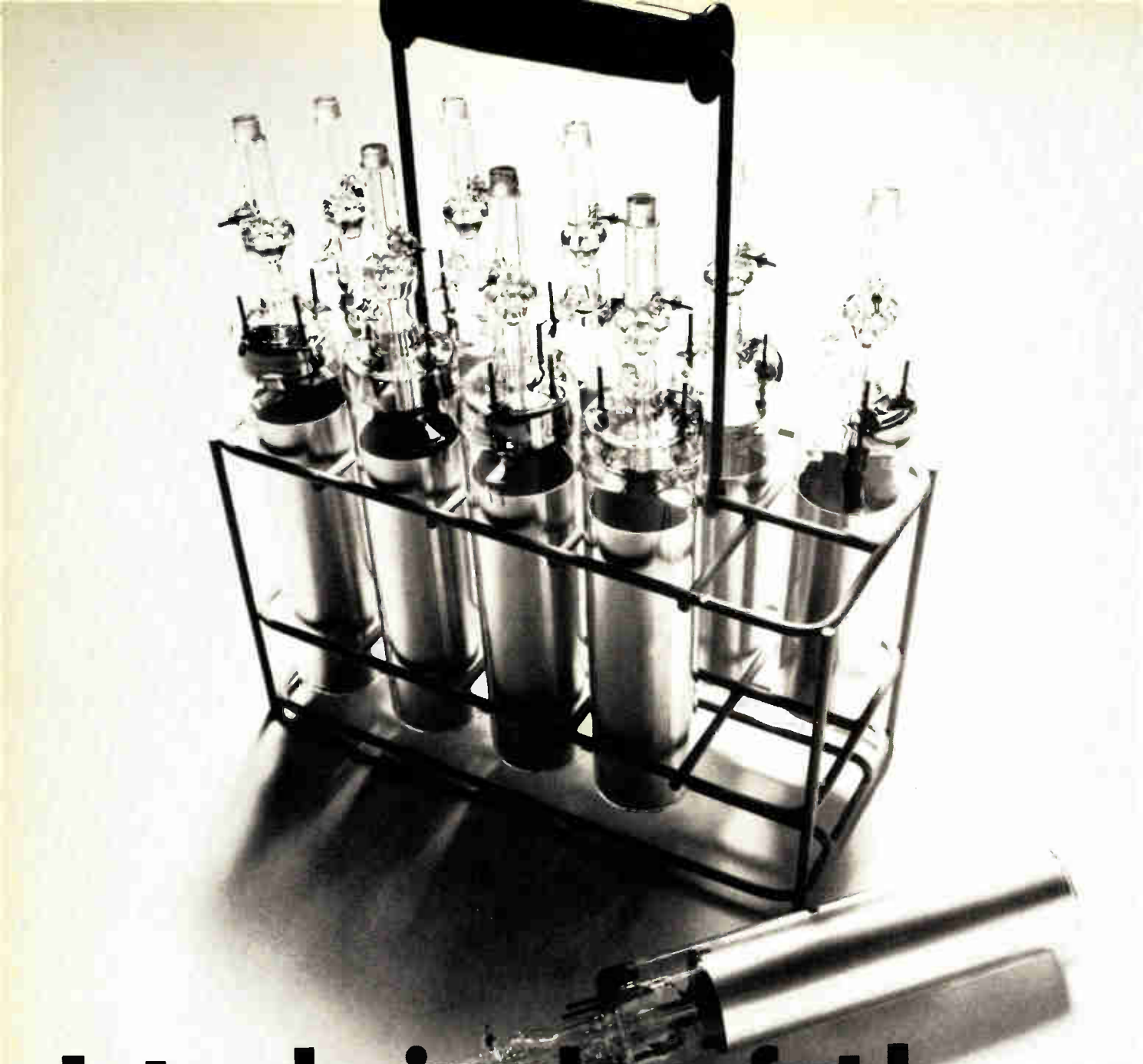

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Circle 38 on reader service card

lion bits. Tracks are spaced at roughly 100 per inch across the tape, making a total of about 1,000 tracks; one spool of 10-inch tape therefore can contain up to 240 billion bits—compared to the 3330's 100 million characters or 800 million bits per spindle (per disk pack). Wider tapes might hold as much as half a trillion bits per spool, or even more.

However, the drum doesn't carry 1,000 heads. That would make its cost prohibitive. Instead, it carries only a few heads, and the tape moves transversely parallel to the drum axis to permit the heads to read or write on any of the 1,000 tracks.

The file is not now in production at CDC, nor is it likely to be very soon. But it has been shown to several prospective customers with unusually large data-processing needs. CDC may make a limited number of the units for delivery to these agencies, beginning in a year or so, although it has made no commitments. □

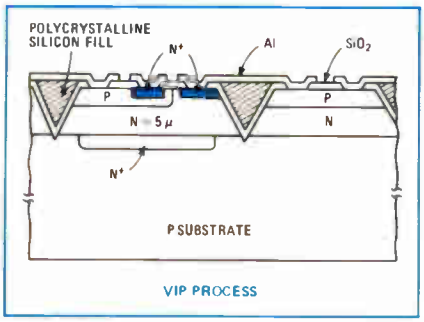
Memories

VIP for bipolars: dielectric isolation

As interest grows in the bipolar random-access-memory race, suppliers are rushing to get their entrants on the card, even though some aren't really in the running yet (see p. 65). One of the slower ones is Motorola Semiconductor, known for conservative starts in the past.

Motorola's hopes are on its high-density VIP process, named for vee-shaped isolation regions filled with polycrystalline silicon. VIP builds on a Motorola specialty, dielectric isolation, and combines it with conventional junction isolation for high-density chips.

Barry Werner, group marketing manager for bipolar memories and LSI in Mesa, Ariz., says, "The main advantage of the VIP process is that it permits us to make dice comparable to other bipolar parts but at lower cost due to improved yield and smaller die size. I think that the memory market will become very competitive, and the companies that will dominate it will be the ones with the lowest production costs. We think that they will include us."



V as in VIP. Motorola applies dielectric isolation knowhow to bipolar process.

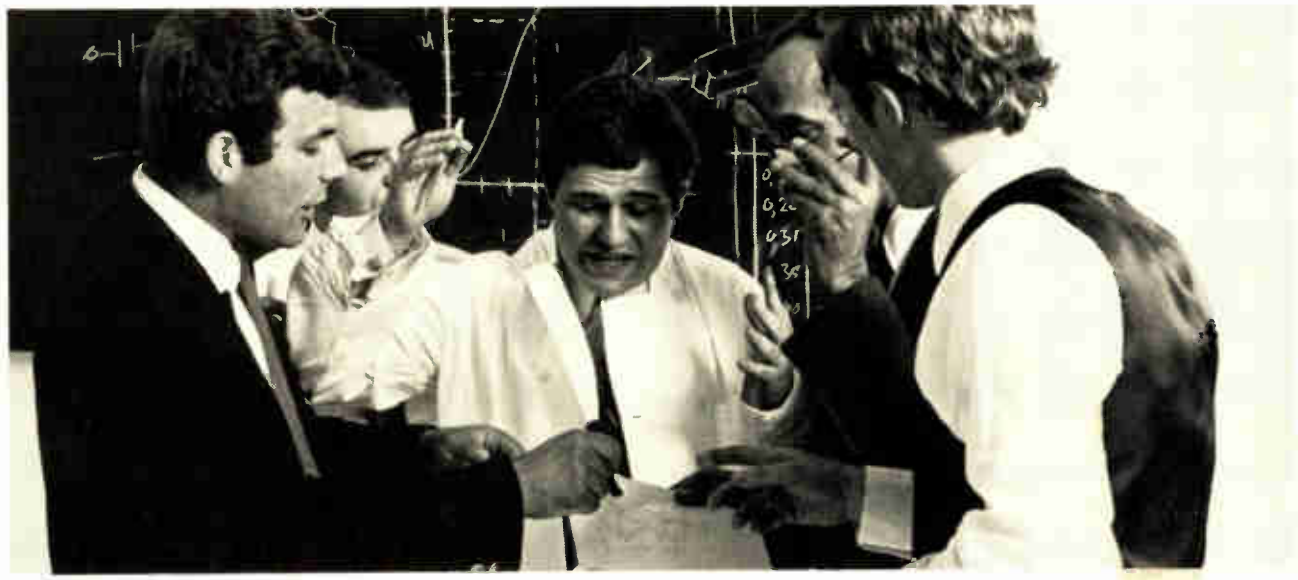
Motorola's first product, to be announced shortly, will be a 256-bit transistor-transistor-logic RAM. Larger, 1,024-bit TTL and emitter-coupled logic RAMs will follow early next year. The 256-bit RAM will use Schottky diodes for level shifting. The VIP process is usable with all conventional integrated circuit structures, says Motorola.

It provides dielectric isolation laterally between components on the surface of the chip, plus conventional junction isolation between the transistor collectors and the substrate. Reduction in size of the isolation regions is about 40%, and base-to-base spacing can be reduced from about 1.2 mils to 0.3 mil, since no area is required for tolerances; the bases can touch the isolation region.

The wafer processing begins in the usual manner, with buried layer and epitaxial growth. The only special demand is for 1-0-0 crystal orientation, which Motorola now uses for ECL and some other parts. This orientation, used with anisotropic etchants that etch 30 to 40 times faster in the 1-0-0 plane than in the 1-1-1 plane, permits the creation of vee-shaped grooves between transistors. Etching stops when the point of the vee is reached.

The wafer is then passivated with an oxide, then a silicon nitride layer, followed by a layer of polycrystalline silicon that more than fills the

What's all this noise about noise?



Philips' 30-series high noise-immunity logic modules solve noise problems instantly, right on the circuit design.

How to eliminate the effects of self-induced and externally generated a.c. and d.c. noise in logic circuits... there's a subject to keep earnest circuit designers debating into the night.
But it's time to call time, gentlemen. All this noise about noise is just valuable energy going to waste.
Philips' new 30-series high noise-immunity logic modules provide an **instant solution**, not only to problems caused by so-called d.c. noise, but to the more troublesome spurious a.c. pulses that can cause a logic system to go all illogical.
The trick is in matching up the relationship between noise-immunity and speed-of-system response. With a 30-series module you simply add, where necessary, a slow-down capacitor in the circuit... selected, of course, to fit the situation... and there's no more noise problem left to talk about!
Don't leave yet. The 30-series includes not only logic elements, but timers, power amplifiers, lamp/relay drivers, interface modules, p.c. boards, connectors, mounting racks... everything you need to build a complete system.
Modules come in 16 and 20 pin dual-in-line packages ready to insert. Philips provides full application support... we'll even design a prototype for you.
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isolation grooves. Then the surface of the wafer is polished.

Compared to Isoplanar, another major contender in the high-density race, the VIP process is not limited to thin epitaxial regions and shallow diffusions, and the long oxidation cycle is eliminated. Also, Schottky diodes cannot be made by the Isoplanar process.

Compared to V-ATE, the Motorola process offers two major advantages, in Motorola's opinion. One is that it has a planar surface rather than an uneven one. VIP also uses conventional metalization, including multilayer, rather than V-ATE's expensive platinum-titanium-gold. □

Communications

ECM devices fight the 'phone phreaks'

"Ripping off Ma Bell" is becoming popular among antiestablishmentarians. Every year, their illegal activities cost phone companies a good deal of cash and exasperation. But a bigger problem is a legion of self-styled "phone phreaks"—that's the way they spell it—who use electronic equipment, including even home-made minicomputers, to break into long-distance lines and make hours-long calls to each other. They also rearrange available circuits and otherwise play games with the complex international phone network. Some officials fear that the intruders could tap the heavily coded military phone networks.

Weapons. Now, however, Northeast Electronics Corp., Concord, N.H., has developed an arsenal of electronic-countermeasures equipment to help phone companies combat the phreaks. A solid-state system, costing about $5,300, would let a company detect and monitor illegal calls without actually listening to the conversations—an important consideration when a company takes a suspect to court. The company has already received orders from some phone companies, reports Charles V. Parker, vice president, and prototype units of the equipment are being tested by AT&T Systems and Bell Laboratories in Holmdel, N.J.

Well read. Phone phreaks use the same frequencies as the phone companies to activate circuits and route calls. Some years ago, AT&T decided to base its long-distance toll system on six basic frequencies. When paired, these would yield 10 numbers, plus sign-on and sign-off signals. These multifrequency (mf) tones were published in a technical journal several years ago, and they fell into the hands of people who were soon making their own "mf" or "blue boxes." Some even mass-produced them for bookmaking syndicates.

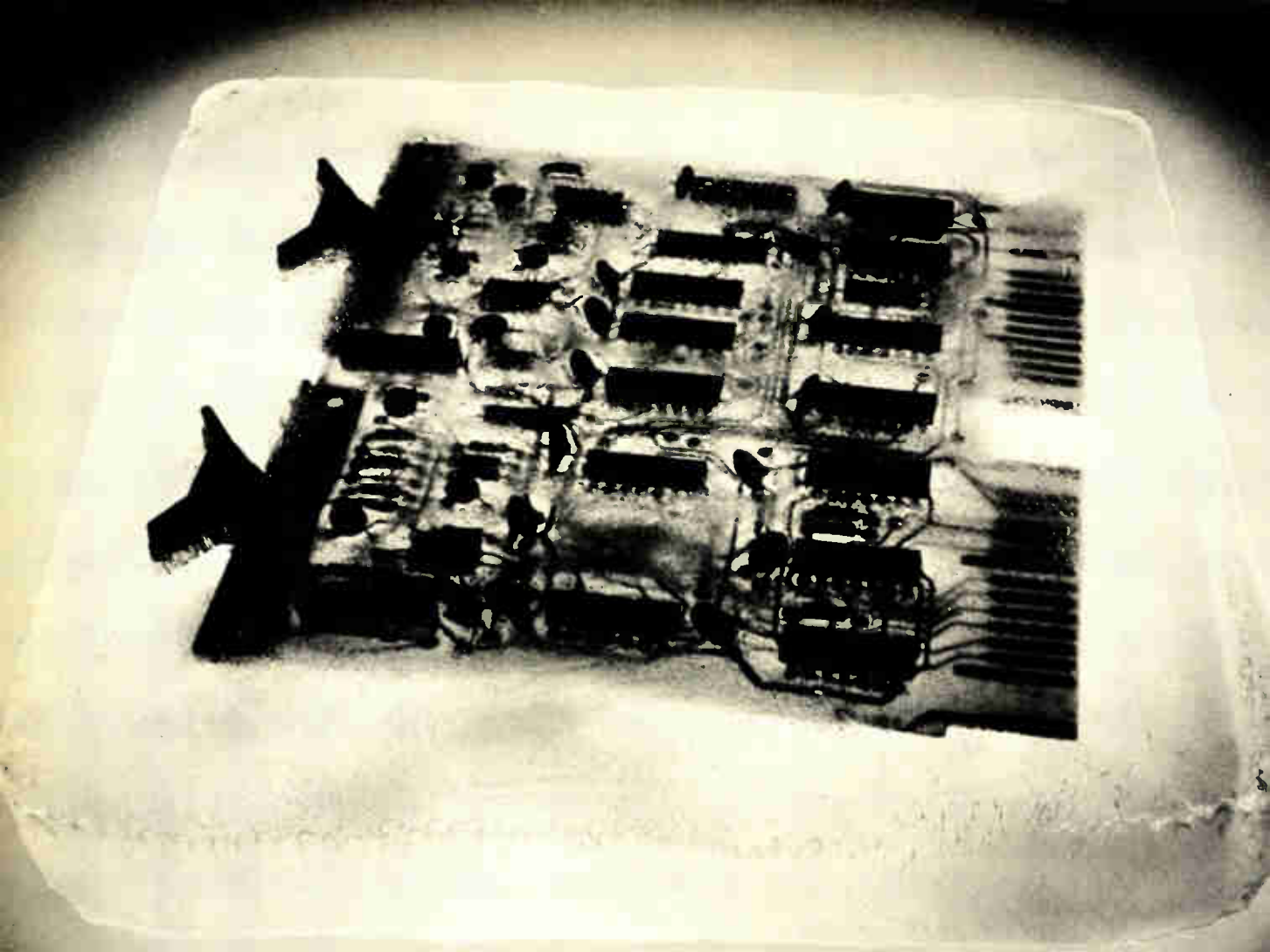
Though there seem to be several ways for a phreak to get into the phone system, the most popular is by using a toll-free 800 area code reservation number. With that circuit, he or she can use a "blue box" to generate other numbers and call up virtually anyone. Since the shadowy wizards can spend a lot of toll-free time exploring the system and exchanging information, they soon become very knowledgeable about which numbers to use to route calls.

Weak spots. Star of the firm's lineup is the new mf majority detector; it takes advantage of the usually poor quality of illegal equipment to spot illicit calls. The telephone system has tight specifications about the tone, amplitude, and timing of multifrequency signals. The detector compares tones through a network of dual clock generators, flip-flops, and active bandpass filters, and sorts out those that are phony. □

Components

FET microwave transistors gain

The mainstay of microwave transistors thus far has been the silicon npn bipolar device. "But we are now entering a new era where field-effect transistors may supersede bipolar transistors both as low-noise and as



Augat asks: are you freezing your circuits in a block of ice?

Consider the printed circuit board. Cheap. Reliable. Compact. So where's the fuss?

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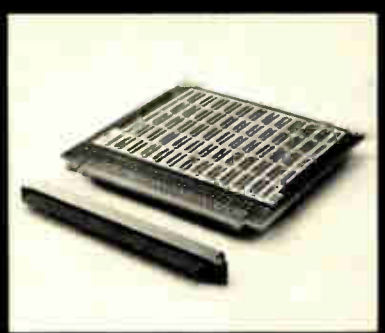

But flexibility isn't all you get. Our exclusive (tapered-entry) socket gives you integrity unsurpassed by any other interconnecting method, including solder. And our high density pattern arrangement gives you up to three times the density of planar P.C. boards.

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Circle 42 on reader service card

power devices," says Sanehiko Kakihana, who manages FET development efforts at Hewlett-Packard Inc., Palo Alto, Calif.

The first FET takeover is expected for low-noise applications at C-band and above. Today's bipolar transistor has a noise figure as low as 4.5 decibels at 4 gigahertz and can be used effectively in communications and radar systems in L, S, and low C band. "However," predicts Kakihana, "as a low-noise device at frequencies beyond 6 GHz, the bipolar microwave transistor will be fighting a losing battle against FETs." And with a planned production schedule of early 1973, the hungry microwave industry may not have long to wait.

Target performance for these new devices, according to H-P, will be a noise figure of 4 dB at 12 GHz. When optimized for low noise, the gain of this device is expected to reach 5 dB. When optimized for gain, a 7-dB gain should be achieved with noise figure degraded to about 8 dB.

Although H-P will not now project pricing, Kakihana notes "we are well known for our aggressive marketing in the bipolar transistor field. You can expect this same aggressiveness in our marketing of FET lines."

High-power FETs are also in the

For the record

Golden State heads off tax

California Governor Ronald Reagan has signed a measure that for two years will block any state tax on computer software. The State Board of Equalization had been considering a personal-property tax on the estimated $1.5 million worth of software in the state, but the legislature moved in before the deadlocked board could act.

TV makers win tuner waivers

The FCC has granted TV set makers more time to make 40% of their sets with detent tuning for both uhf and vhf. The move is due to the inability of tuner manufacturers to make enough 70-position detent uhf devices in time for the July 2 deadline.

RCA, Motorola, Zenith, Magnavox, GTE Sylvania, GE, Philco-Ford, Wells Gardner, and Teledyne Packard Bell now have extensions varying according to their needs—RCA, for example, has until Sept. 1.

Engineering unattractive

To no one's surprise, a report just issued by the Engineering Manpower Commission of the Engineers Joint Council states that there are very few women in engineering today. Only 17% of all women engineers are EEs, according to the report, compared to 23% among men.

On time with calculators

North American Rockwell Microelectronics Co. (NRMEC), Anaheim, Calif., has delivered the first 1,500 calculators under its commitment to Lloyd's of California [*Electronics*, March 27, p. 26]. A NRMEC spokesman says the machines were delivered on schedule at the end of June, and that production will grow to a peak of some 40,000 a month by August.

Ampex eyeing vtr

Ampex Corp. has installed its first high-speed broadcast videotape recording systems, ADR-150, which turn out one-hour color programs in six minutes. And a company official has hinted that this duplicator could be redesigned to handle half-inch and ¾-in. tape, thus raising the possibility that Ampex will get into supplying copiers for making home-vtr cartridges.

Electronics review

offing. By late next year, H-P hopes to introduce a 12 GHz device with one watt output. □

Commercial electronics

TI calculator draws raves from retailers

Texas Instruments has stuck a first cautious foot in the door of the consumer marketplace by introducing its hand-held calculator into home-based test markets.

But response from the retailers—Foley's of Houston and Sanger-Harris in Dallas—was little short of ecstatic. Says one: "They seem more organized than most outfits in the business. They presented us with very detailed spec sheets and a better-looking machine—it's more streamlined and more tasteful than the Canadian and Japanese-made jobbies we've been selling." Adds the other: "At that price—$149.99— it should sell up a really big storm."

The Datamath, as it's dubbed, is being sold under TI's trademark. The symbol is virtually unknown to consumers, and the retailers are taking pains to introduce it to the world.

"Texas Instruments, the people that make electronic calculators work, now make an electronic calculator" was the headline on Foley's ad, followed by a description of the firm's MOS LSI one-chip calculator work [*Electronics*, May 22, p. 34].

The 12-ounce, battery-operated device, guaranteed for one year, features an eight-digit light-emitting-diode readout that displays numerals, a negative sign, floating decimal, overflow indication, and low-battery warning. Except for the character in the first-digit position, the display turns off after about 15 seconds. It can be recalled via a dual-function button. □

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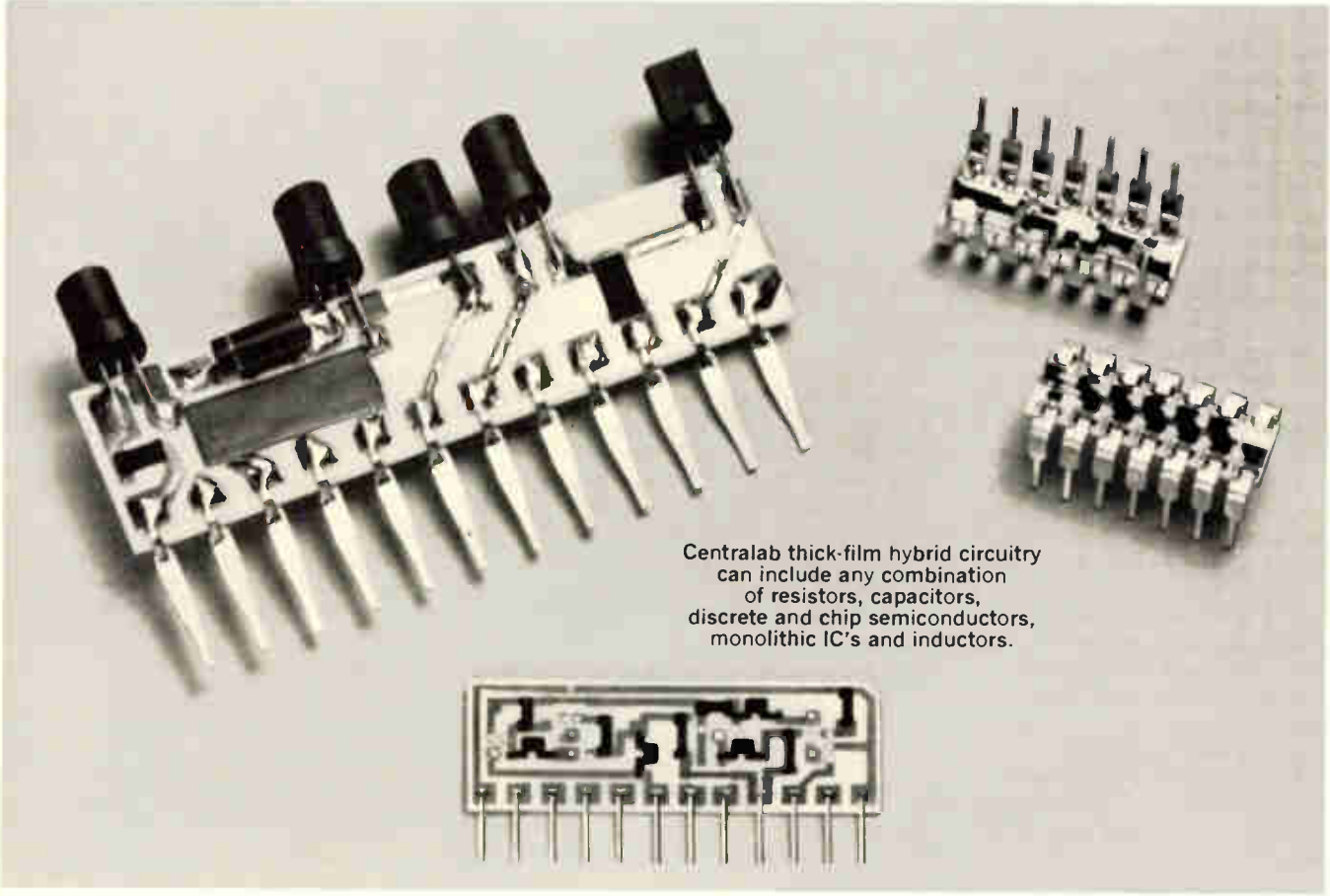

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Our specialized designs include resistor values to 1 gigohm, voltages to 50 kV and resistor value ranges from 10 ohms per square to 10 megohms per square.

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The $400-Billion

According to a recent survey by the Opinion Research Corporation of Princeton, New Jersey, most Americans think that business profits run about 28%. That is, that the average U.S. company or corporation nets 28¢ on the sales dollar.

Nothing could be further from the truth. The truth is that *U.S. business as a whole nets less than 3¢ on the sales dollar.*

In 1971, as reported by the Department of Commerce, total U.S. corporate profits after taxes amounted to $47.4-billion—or 2.9% of total sales of $1,650-billion.

Some companies, of course, do better than the average. But even the largest, most successful U.S. corporations do not begin to approach the mythical figure that the public has in mind. A Standard & Poor's analysis of the 1971 earnings of major corporations shows that these leaders averaged a 5.6% net on sales. Almost double the national average, but only one-fifth of the reputed average.

But it does not matter, except to the companies concerned, that business *makes* less, as a percent of sales, than most people think.

What matters, and matters greatly to all Americans, is that business *has* less than most people think. Less, far less, in total profits after taxes—which is to say in disposable income to use for its own needs and purposes, or to contribute to other needs and purposes.

If U.S. business had netted 28¢ on the sales dollar in 1971, total corporate profits would have amounted to $462-billion. This is a fabulous amount of money. In every sense of the word—imaginary and immense.

The difference between $462-billion and $47-billion is roughly $400-billion. And it is this difference—this $400-billion misunderstanding—that leads to a great deal of fruitless debate, dissension and division in American society today.

To the extent that the American people believe the myth about business profits—either the precise myth about $462-billion or the more general myth that business has a vast hoard of undistributed wealth—they are deluding themselves.

Or are being deluded. By the very few who think that profits are immoral, or by the very many who think that profits are a very good thing—that ought to be more widely shared. Because they believe that the sharing will solve most of the nation's public and private ills.

The demand for wider sharing presupposes that business profits are a public, as well as a private, asset—a national resource, money in the bank, to be drawn on in case of need.

Let us, for the sake of argument, accept this concept.

And let us also accept the validity and the urgency of the whole array of public and private needs that are usually cited.

The practical question remains—what then?

How much money is there in the bank? If we simply confiscate *all* corporate profits, exactly $47.4-billion.

How far will it go? That depends. Suppose, for example, that we divide it fifty-fifty—half for public needs, half for private. Half to add to the $37.2-billion that business *already* pays in taxes, and half to add to the $450-billion that business already pays in wages.

The $23.7-billion in additional taxes would increase total U.S. tax revenues by about 8%. For one year.

The $23.7-billion added to wages would increase the average American worker's pay check (before taxes) by about 5%. For one year.

Why only for one year? Because the final, practical question remains. What happens when the money is gone?

The confiscation of profits would leave business with nothing to reinvest in the business, and nothing to pay out in dividends to stockholders. Nothing, in short, to invest in the future. And without an investment in the future, there is

Misunderstanding

simply no way of reading the future.

In 1972, American business plans to reinvest some $30-billion in retained earnings (past profits) in the maintenance and expansion of physical facilities. Other billions will be invested by individuals and institutions as an advance on future earnings, in the expectation of profits, and dividends, to come.

Without these commitments, what can we expect from the U.S. economic system? What can we expect from aging, neglected and deteriorating facilities? From an economy without growth or the hope of growth? From, in sum, a free enterprise system no longer free and no longer enterprising?

No one, in all honesty, knows. We can speculate about confiscating $47-billion in profits today, but what would there be to confiscate and divide tomorrow? $40-billion? $20-billion? Nothing? One guess is as good as another—it is purely and simply a gamble.

And a wildly, almost insanely, reckless gamble. Profits are the lifeblood of business, as we know it or can realistically conceive it. To cut off or restrict the flow of profits, to further diminish that vital 3%, is to knowingly risk the health, the well-being and perhaps the very existence of American business.

Business is not sacred. It holds no special mandate, enjoys no special immunity. But neither does it live or die in a vacuum. It lives or dies as an integral part of an interdependent society. A society in which the health and well-being of each major group—business, professions, labor, government, the public—depends on the health and well-being of all. And in which whatever fatally weakens one, fatally threatens all.

It makes little sense to demand that business do what it cannot do. It makes even less sense to take great risks for small rewards. But then it has never made sense to kill the goose that lays the golden egg—and yet the urge endures.

Against this ancient, consuming urge, it may not help to point out to the impatient and avid that it is their own goose they would cook.

But it might help a little, if more people understood that the fabulous egg of business profits is neither so large nor so golden as rumor hath it. So that killing the goose may simply be not worth the trouble.

In the end, business profits can be regarded as a fee. A fee for financing, maintaining and managing the U.S. economy.

A 28%, $462-billion, fee may seem a bit much.

But a 3% fee for financing, maintaining and managing a trillion-dollar economy?

It seems more than reasonable.

The problem of business profits reemphasizes the interdependence of American society. And the misunderstanding about profits reemphasizes the need for a better recognition of the mutual dependence and respective contributions of the major groups in our society—business, labor, government and the general public.

We at McGraw-Hill believe that it is the responsibility of media to improve this recognition. This editorial message is one of a series that we hope will contribute to better understanding.

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John R Emery

John R. Emery, President
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330 W. 42nd St., New York 10036.

N-Channel Si Gate RAM Boosts Memory Speed, Reduces Power and Cost.

Electronic Arrays, Inc., is producing a 1024-bit n-channel silicon gate RAM that is four times as fast as typical p-channel MOS RAMs, just as fast as bipolar. Yet the random-access memory circuit dissipates much less power than conventional RAMs and is easier to control in memory systems.

Precharge and refresh addressing are eliminated by a new internal design. The EA1500 goes from standby to active operation without precharge. In addition, every cell in the memory is refreshed by a single pulse, permitting the EA1500 to operate in an automatic refresh mode that simulates the operation of core memory systems.

Bipolar logic interfaces and power supply design are also simplified by the EA1500. The n-channel silicon gate process provides positive-logic operation on standard ±15V supplies or ±12V supplies.

The storage configuration is the standard 1024 x 1 expandable organization. Pinouts are compatible with those of conventional p-channel RAMs.

High-Speed Operation. Maximum access time of the EA1500 is 85 nanoseconds on ±15V supplies, a speed previously achievable only with expensive bipolar RAMs. In contrast, access times of p-channel MOS RAMs range from about 180 to 500 nsec.

The EA1500 also has the fastest cycle times—150 nanoseconds for read, 270 nsec for write and only about 105 nsec for refresh. Ordinarily, it takes from 8 to nearly 30 microseconds to completely refresh a conventional MOS RAM because 32 pulses are required.

The n-channel process allowed Electronic Arrays to build buffering into all 1024 cells. Every pulse on the write line simultaneously refreshes all cells, although only an addressed cell can be written into.

Automatic Refresh. Since any write pulse refreshes the EA1500, the system designer can simply pulse the write bus every system cycle. During write cycles, the normal write pulse is bused to all packages. The memory segments not accessed by an address will only be refreshed.

During read cycles, a refresh pulse is used between accesses, after the chip-enable (CE) pulse.

Called automatic refresh, the read-refresh technique lets the EA1500 simulate a core memory because there are no "memory busy" interruptions of the regular memory cycle.

Low Power Dissipation. During active operation at ±15V, the EA1500 typically dissipates 160 mW—only 35% to 40% as much as typical p-channel RAMs. Operation at the optional ±12V differential cuts dissipation to less than 90 mW while adding only about 100 nsec to the average cycle time.

Dissipation drops to about 35 mW during standby, Logic "0" standby, as noted above, avoids the high power consumption generally associated with precharging.

Evaluation P.C. Card. EA has made a memory board available for the potential user to evaluate the EA1500. The P.C. board contains all the necessary interconnections for a 2K x 4 memory board including address and data buffers, output sense amplifiers and timing signal generator. The timing signal generator is capable of demonstrating both "automatic refresh" and asynchronous operating modes.

Washington newsletter

'Fair trade' unit pushed White House . . .

The Treasury Department's broad inquiry into alleged Japanese government support of consumer electronics exports to the U.S. [*Electronics* June 19, p. 30] **was undertaken after an informal request by the White House** following pressure by the Electronic Industry Committee for Fair International Trade, according to a reliable U.S. Government source. "It was their first score," the source said of the high-powered committee formed early this year by a group of electronics manufacturers and led by Washington superlawyers Robert D. Murphy and former Attorney General Herbert Brownell [*Electronics*, Feb. 14, p. 33].

. . . into prompt TV duty action

Through its Bureau of Customs the **Treasury Department responded quickly to a Magnavox Corp. complaint earlier this year,** when it began an investigation to see if imports from Japan could be subject to countervailing duties because of the Japanese government's subsidies to manufacturers making overseas shipments. In June, this investigation was expanded to include consumer product parts. The speed with which Treasury responded to the Magnavox complaint was regarded in the capital as surprising since **a similar Zenith Corp. protest had languished for two years** without a Federal response. Both Zenith and Magnavox are charter members of the new industry committee.

RCA, Honeywell gain from an FCC CAS decision

Competing airborne collision avoidance systems by RCA Corp. and Honeywell Inc. are seen as getting an advantage over McDonnell Douglas Corp.'s older system, now that **the Federal Communications Commission has slapped down an attempt by McDonnell Douglas to lock up the CAS frequency band for its time-frequency-based EROS units.** The company had petitioned the commission to move from developmental to regular licensing of the 1,592.5–1,622.5-megahertz CAS band, which would have had the effect of securing the band for McDonnell Douglas alone, says an FCC staff member. Citing the lack of a national CAS standard, **the FCC said it would be "premature" to decrease the number of frequencies available** because "it might inhibit the development of CAS systems."

Navy proceeds on Trident communications

The Naval Electronics Systems Command is proceeding with plans for advanced development design and prototype construction awards by the end of this year for **two competing integrated communications centers for the Trident submarine.** (Trident is proposed successor to the Polaris/Poseidon ICBM missile submarine initially known as ULMS for Underseas Long-range Missile System.) **Proposals are due by mid-September from three competing industry teams** now working under contracts of approximately $500,000 each. They include: ITT, Control Data, and Dunlop; GTE Sylvania Electric Products, TRW Systems, and Spears Associates; plus RCA, IBM, and Collins Radio.

Navy sources say they expect the effort to proceed even though long-term congressional support for Trident is in doubt. The reason: Trident R&D money is available and, **regardless of the project's fate, integrated interior communications hardware developed under the program is to be retrofitted to existing Polaris/Poseidon boats.**

Washington commentary

Engineers' pensions: a spur to activism

The subject for a special June meeting of Washington area members of the Institute of Electrical and Electronics Engineers was corporate pension plans for engineering professionals. "We're getting screwed," said one slightly gray and very angry member after the assembly of some 200 persons at NASA's Goddard Space Flight Center. "That's all I have to say. That says it all."

That doesn't say it all, of course. But it should say to many of the nation's manufacturers of electronics that it is time they took a fresh look at the pension plans they offer their engineers. That look should be taken in the hard light of both the increasing dissatisfaction among their professional staffs and the knowledge of a brand new amendment by Sen. Jacob Javitts (R., N.Y.), to a pending White House pension reform bill (S. 3598), which would make it a congressional policy that protection of pension rights for engineers and technicians be written into Federal contract procurement regulations. Since congressional policies, unlike specific directives, can be ignored by affected agencies for a time, it is likely that the Defense Department, the largest Federal customer, will do just that for as long as possible as it tries to reduce its contract costs, not increase them. Nevertheless the Javits amendment is one more pressure being brought to bear for improvement of private pension plans.

The issue of vesting

The problem with pensions is that their promise is illusory, according to an extensive study by the Senate labor subcommittee now considering S. 3598, the Retirement Income Security for Employees Act for 1972. In the past 20 years, as many as 95% of all persons who left jobs with pension plans never got any of the benefits. "And when it comes to engineers and scientists," sympathetically observed Sen. J. Glenn Beall Jr., (R., Md.) to the angry IEEE members at the Goddard meeting, "almost everybody loses."

"Vesting is really at the heart of the pension problem," explained attorney Paul Robbins as he testified later before the Senate subcommittee, representing the strong views of the National Society of Professional Engineers as well as the IEEE and two other professional societies—some 300,000 engineers in all. Only when an engineer has a vested interest in a pension, when he owns it, or at least part of it, does he have an irrevocable right to receive payment of benefit on retirement. But engineers and scientists are known to change jobs on the average every five years, so that IEEE sees only limited gains to be achieved in S. 3598, with its provision that all private plans will have 30% vesting after eight years, and 10% more per year thereafter until full vesting is achieved in 15 years. They strongly favor immediate vesting but, recognizing industry opposition to the increased costs and resultant lower benefits, are willing to compromise and agree to full vesting in five years at a rate of 20% per year.

The problem of job mobility

The American engineer's job mobility represents "a very specialized problem, and will probably require a very specialized solution," in Sen. Beall's view. His suggestion: "perhaps the professional societies which represent engineers and scientists can develop a multi-employer pension plan into which all engineering companies can contribute and in which all engineers can participate, and continue to participate without forfeiture, as they move from job to job." Thus does a conservative Republican bolster the concept of some engineering activists of an IEEE-operated pension, or, perhaps better, a multi-disciplinary plan for engineers that might be developed under an organization like the National Society of Professional Engineers or the Engineers Joint Council.

And what is the view of the nation's electronics manufacturers? The Electronic Industries Association, which represents most of them, says it "has not taken an independent position on the proposed legislation" in the Congress, "nor does it plan at this stage to do so." That statement was contained in a brief covering letter to members along with testimony of the U.S. Chamber of Commerce on pension reform legislation in the House. The position of the Chamber of Commerce, which EIA believes represents "a valuable addition" to its members' files, opposes mandatory minimum vesting requirements pending further study, and supports "maximum encouragement for continued growth and expansion of private pension plans" without "governmental restrictions." Maintenance of that status quo will be difficult in face of increasing opposition from the IEEE, other professional societies and technicians backed by their unions. **—Ray Connolly**

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International newsletter

Britain's civil air agency turns to IBM computer . . .

Britain's Civil Aviation Authority has abandoned its five-year attempt to develop its own computerized flight-plan processing system for air-traffic control over southern England, and will buy through the U.S. Federal Aviation Administration an IBM 9020D, complete with the software developed for the FAA. It's hoped this can be adapted to British conditions and put into operation by 1975, **probably five years sooner than if the system remained all-British.** The core of the present system, three Marconi Myriad computers, will be expanded and used for military flight-plan processing in middle airspace—8,000 to 20,000 feet. Marconi will also work on adapting the 9020D for British use.

. . . as Eurocontrol has to upgrade its planned capacity

The CAA is not alone in having to change its mind. Eurocontrol-responsible for the upper air space over Germany, Holland, Belgium, Luxembourg, France, Britain, and Ireland—has had to switch computers, too. It changed the computer base of the system being developed for its center at Maastricht in Holland from twin IBM 360/50s, each with 500,000 bytes of store, to twin 370/155s with 1 million byte stores for the same basic reasons that prompted the CAA switch. **The reasons: an underestimate of the computing capacity required to do individual jobs and a great expansion in the number of jobs—mainly due to the growth in charter air traffic.** Maastricht will now start commissioning about the end of this year and take one to two years to get fully operational. **The second center, planned for Karlsruhe in south Germany, profiting from the Maastricht experience, will use a similar computer complex.**

Connector for glass fibers has 0.4-dB loss

For optical communications systems using glass-fiber transmission media, engineers at West Germanys AEG-Telefunken have developed **a connector that provides attenuation losses of less than 0.4 decibels between the fiber ends coupled.** The new connector, functionally similar to a coaxial plug, can be hand-installed just like an ordinary male/female connector.

What has held back the design of a practicable, detachable glass-fiber connector till now, AEG-Telefunken researchers say, have been the difficulties encountered in aligning the fiber ends with the accuracy required. To achieve, a coupling efficiency of 90%, for example, the angle between the two fiber axes must be less than 2°. Also, the distance between the fiber end faces can not exceed 4 micrometers, and the maximum offset must be within fractions of a micrometer.

In the AEG-Telefunken connector, a coupling efficiency of better than 90% is obtained. This efficiency is achieved by an eccentric arrangement of the fibers in pins. Optimum coupling is achieved when these pins are turned relative to each other, an operation that can be carried out by hand, despite the high accuracy requirements.

Plessey acts to second-source National RAMs

Look for Britain's Plessey Co. to become an increasingly important factor in the memory business. Plessey's latest move in memories is the negotiation of a second-sourcing agreement with National Semiconductor Corp., Santa Clara, Calif. Plessey later this year will start second-sourc-

ing National's 1,024-bit random-access memories type-numbered 4260 and 5260. Plessey will carry out the entire manufacturing operation, not just part of it, but beyond this no one at Plessey will elaborate on the company's plans. However, it's obvious that a successful second-sourcing operation **could give a boost to the other ICs in Plessey's line, especially in the U.S., where the company is pushing to sell its wares.**

Thomson-CSF rift still not healed

Thomson-CSF, France's largest professional electronics company, has yet to patch up the rift that triggered the resignation of four key executives early this year. [*Electronics,* International newsletter, Jan. 27]. **Rather than naming a new president at the firm's late-June annual meeting as originally planned, the company's board of directors set up a "coordinating committee" to sort things out.**

Paul Richard, president of both Thomson-CSF and of its parent company Thomson-Brandt, heads the interim six-man directorate. It includes four other Thomson top brass and Michel Barré, president of Compagnie Internationale pour l'Informatique (CII), the "Plan-Calcul" computer company. Barré may well later be tapped for the top job at Thomson-CSF.

Originally, Thomson-CSF had picked Robert Gachet, currently president of a large French chemical company, for the job. Gachet accepted early this spring, but in mid-June he turned the job down ostensibly because he couldnt get the assurances that he wanted on defense orders and research contracts. **Actually, insiders say, Gachet may have turned out to be personna non grata with defense minister Michel Debré.**

Japan to ease computer hardware, software imports

Although the decision won't take full effect for two years, Japan's cabinet is expected to approve a complete liberalization of the regulations covering imports of computer hardware and software technology. **The first step would be a doubling of the threshold at which imports of computer hardware must gain government clearance.** Thus, computer hardware valued at up to $100,000 will be able to enter without prior approval. However, **the present $50,000 ceiling for computer software imports will remain in effect until all lids are lifted in 1974.**

Fiat aims anti-skid units at trucks, busses

Fiat, the big Italian automaker, will start offering on the European market this fall an electronic anti-skid system as optional equipment on trucks and busses. According to Fiat AG, the German subsidiary of the Turin-based firm, **the system will be the first in Europe to hit the commercial-vehicle market in production quantities.** It's also said to be simpler in construction and maintenance than anti-skid system now being developed or tested by other companies.

The initial cost of the Fiat system, an in-house development, will be between $250 and $300 per vehicle axle, or from $750 to $900 for a typical three-axle truck. **But with increasing production, Fiat says, the price could drop to as low as $185. per axle.** The Fiat anti-skid equipment is designed for normal compressed-air brake systems. Electronic sensors at each wheel feed turning-rate information to a computer, whose output controls valve settings for the air pressure cylinders.

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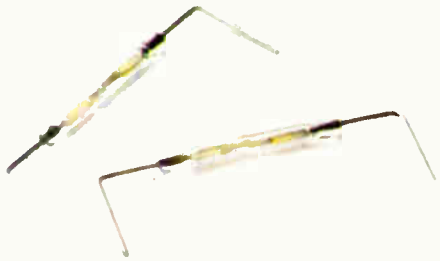

Switches under glass.

The heart of every AE correed is a reed switch consisting of two overlapping blades. For protection, we seal them inside a glass capsule. But only after we pull out all the dirty air and pump in a special, pure atmosphere. That way there's no chance of contact contamination or oxidation. Ever.

Notice our terminals are one piece. A special machine delicately forms them to precision tolerances. It's a lot of work, but one-piece terminals have distinct advantages over the two- and three-piece kind.

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And to help you remember which terminal is which, we mold the terminal numbers into the end of the bobbin. You can read them at a glance.

Little things mean a lot.

Reliability means that we pay attention to the little things. Like the tiny pressure rods we use in every miniature correed. They're placed at each end of the bobbin, across the one-piece terminals. What they do is prevent stresses from being transmitted from the terminals to the reed blades. This keeps the contact gap right on the button. All the time.

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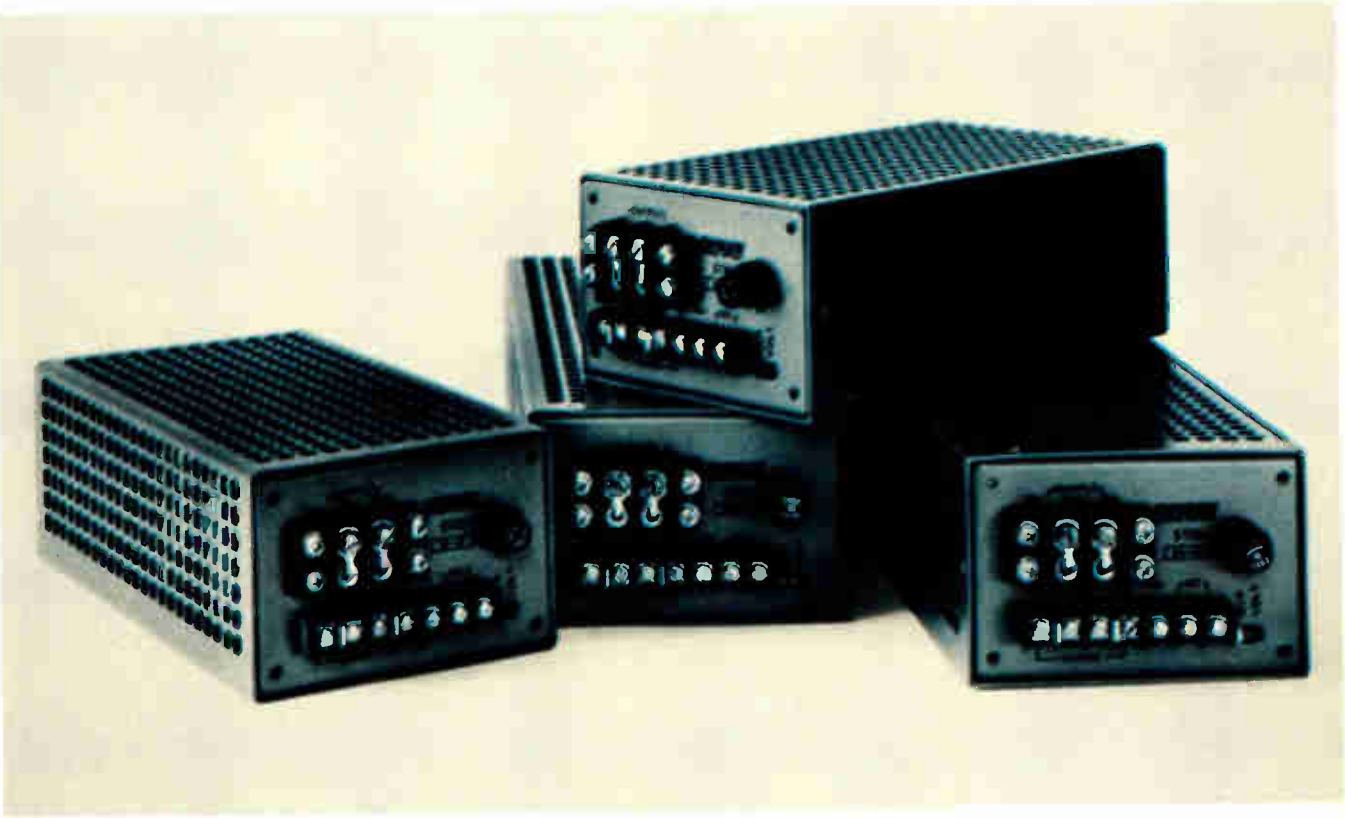

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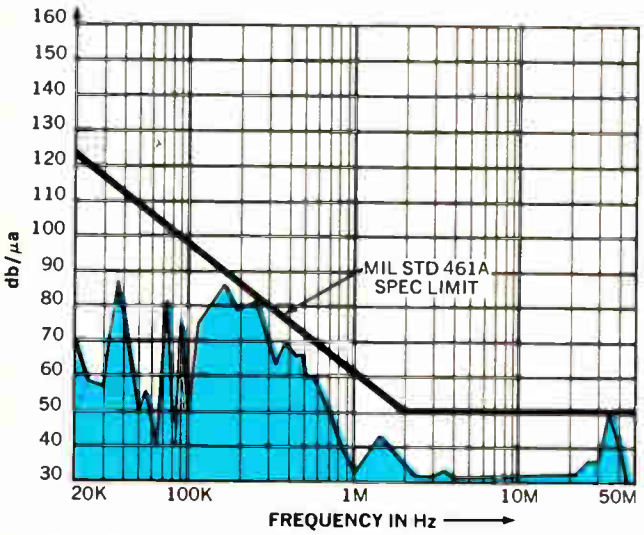
Package Size: Module III – 3-5/16" x 5-1/8" x 9-1/2" – Weight: 6.5 lbs.														
STM3.5-24	3.0	4.5	24	19.4	14.9	9.6	.05%	5 mv 50 mv	105-132	1.8	50-440	150±15%	1.5	$229
STM5-24	4.5	6.0	24	19.4	14.9	9.6	.05%	5 mv 50 mv	105-132	2.3	50-440	150±15%	1.5	229
STM9-12	6.0	10	12	9.7	7.5	4.8	.05%	3 mv 50 mv	105-132	2.1	50-440	150±15%	1.5	239
STM12-12	9.5	13.5	12	9.7	7.5	4.8	.05%	3 mv 50 mv	105-132	2.9	50-440	150±15%	1.5	249
STM15-10	13	17	10	8.1	6.2	4.0	.05%	3 mv 50 mv	105-132	2.7	50-440	150±15%	1.8	239
STM18-10	16	20	10	8.1	6.2	4.0	.05%	3 mv 50 mv	105-132	3.2	50-440	150±15%	1.8	249
STM24-8.5	19	25	8.5	6.8	5.3	3.4	.05%	3 mv 50 mv	105-132	3.3	50-440	150±15%	1.9	249
STM28-7	24	30	7.0	5.6	4.3	2.8	.05%	3 mv 50 mv	105-132	3.2	50-440	150±15%	1.9	249
STM36-4	29	43	4.0	3.2	2.5	1.6	.05%	3 mv 50 mv	105-132	4.0	50-440	150±15%	1.9	259
STM48-4	42	56	4.0	3.2	2.5	1.6	.05%	3 mv 50 mv	105-132	4.0	50-440	150±15%	1.9	269
Package Size: Module IV – 3-5/16" x 5-1/8" x 14" – Weight: 9.0 lbs.														
STM3.5-36	3.0	4.5	36	29.1	22.3	14.4	.05%	5 mv 50 mv	105-132	3.8	50-440	150±15%	2.2	319
STM5-36	4.5	6.0	36	29.1	22.3	14.4	.05%	5 mv 50 mv	105-132	4.2	50-440	150±15%	2.5	324
STM9-20	6.0	10	20	16.2	12.4	8.0	.05%	3 mv 50 mv	105-132	3.8	50-440	150±15%	2.2	299
STM12-20	9.5	13.5	20	16.2	12.4	8.0	.05%	3 mv 50 mv	105-132	4.8	50-440	150±15%	2.8	289
STM15-15	13	17	15	12.1	9.3	6.0	.05%	3 mv 50 mv	105-132	4.3	50-440	150±15%	2.6	289
STM18-15	16	20	15	12.1	9.3	6.0	.05%	3 mv 50 mv	105-132	5.0	50-440	150±15%	3.0	299
STM24-13	19	25	13	10.5	8.0	5.2	.05%	3 mv 50 mv	105-132	5.5	50-440	150±15%	3.2	309
STM28-11	24	30	11	8.9	6.8	4.4	.05%	3 mv 50 mv	105-132	5.5	50-440	150±15%	3.2	309
STM36-6	29	43	6.0	4.8	3.7	2.4	.05%	3 mv 50 mv	105-132	4.5	50-440	150±15%	2.6	329
STM48-6	42	56	6.0	4.8	3.7	2.4	.05%	3 mv 50 mv	105-132	5.5	50-440	150±15%	3.2	329

*Free – air rating – no external heatsink **Worst case. Typically less than 30 mv †U.S.A. list prices



DC Load Leads. Conducted Current Level in db above a Microamp/ MHz

Specification	Sorensen STM5-24	Brand "X"
Size	$3\frac{5}{16}$ x $5\frac{1}{8}$ x $9\frac{1}{2}$	$4\frac{15}{16}$ x $7\frac{1}{2}$ x $9\frac{3}{8}$
Volume	160 in^3	344 in^3
Price	$229	$235
Efficiency	58%	29%
Regulation (line & load combined)	0.05%	0.2%
Temperature Coefficient	0.01 %/°C	0.03%/°C
Overload Protection	Current limiting-adjustable electronic	
Overvoltage Protection	Built-in adjustable, all models	Optional @ $30 (except built-in, fixed, on 5-volt model only

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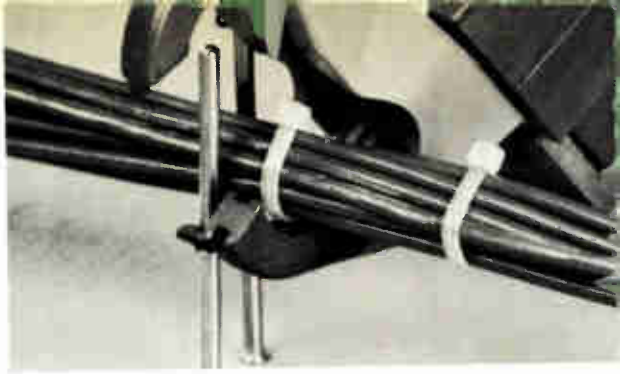
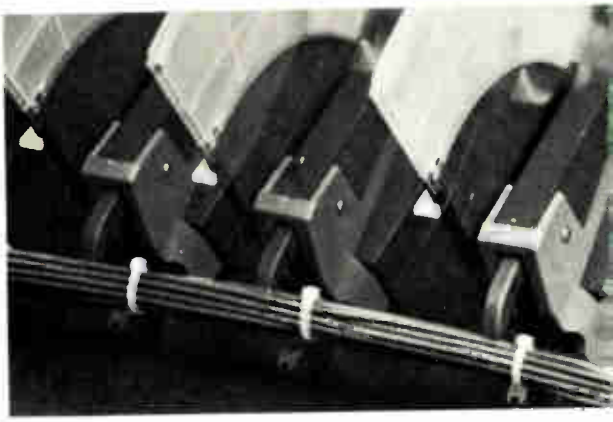
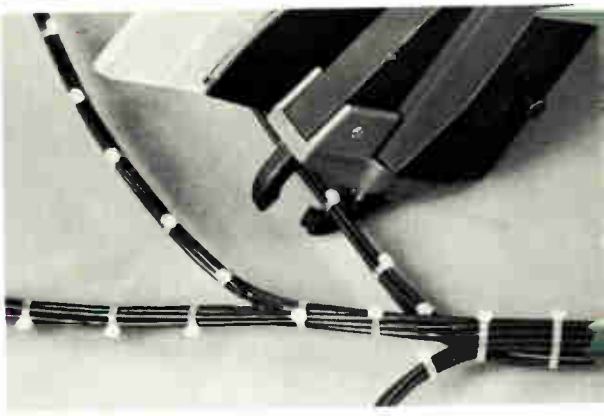


goes where hands can't



ties in less than a second



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Circle 64 on reader service card

The great bipolar RAM race

Entering the market, at reasonable prices, are several different solutions to the problem of how to pack many more bits onto a bipolar chip

by Stephen Wm. Fields, San Francisco bureau manager

The 1,024-bit bipolar RAM stakes have LSI makers jockeying for position in a race that's hard to handicap—there's such a diversity of processes backing the TTL devices. Fairchild Semiconductor, Mountain View, Calif., was first out of the gate with its announcement of a 1,024-bit bipolar random-access memory employing the company's Isoplanar process [*Electronics*, June 5, p. 41]. But hard on its heels are Raytheon, Signetics and Intersil, with Motorola and Texas Instruments slightly behind and Ferranti hanging in.

The 1,024-bit bipolar RAM will give the systems designer four times the storage capacity of 256-bit RAMs, with no increase in power requirements. Access times will be about the same as for the 256-bit RAMs—30 to 60 nanoseconds. And the cost per bit will be halved.

Most manufacturers believe that the 1,024-bit RAM will be an economical component for high-speed buffers and control stores. But at least one company, Telex Corp., Tulsa, Okla., will be designing them into an IBM add-on memory system.

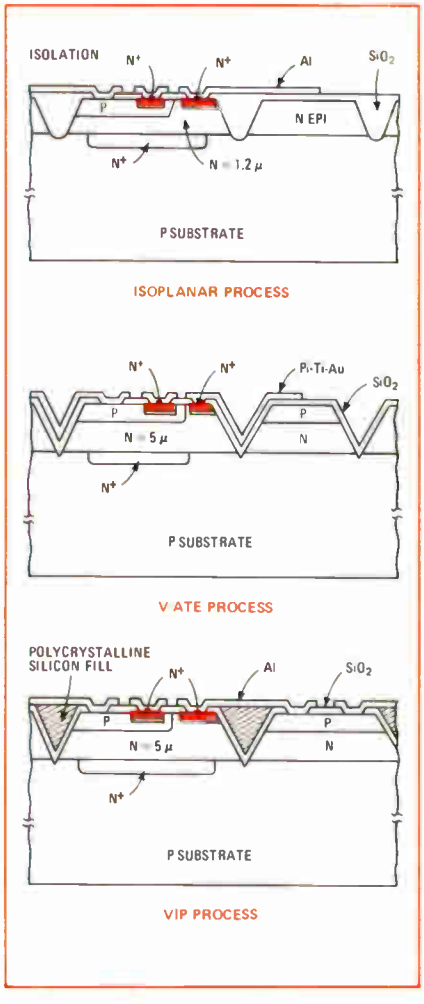
Fairchild won't quote volume prices publicly. But Raytheon's Gene Selven, director of marketing, says his company's 1,024-bit RAM will sell for $18 each this year and at about $11 (or 1 cent a bit) next year. At Signetics, director of marketing Jack Halter says his firm's 1,024-bit RAM, after selling for about 2 cents a bit in quantities of larger than 10,000 in 1973, will drop to 1 cent a bit in '74 or early '75.

There will be little difference in performance in the parts, except that one may be a few nanoseconds faster than another. In fact, the Raytheon and Intersil RAMs will be pin-for-pin compatible with the Fairchild part. If this pinout becomes standard, most likely Signetics and Motorola will have their own versions. The same will be true when the emitter-coupled-logic versions come out later this year.

How to speed up. The RAM from Fairchild has a typical access time of 60 ns and dissipates 500 milliwatts. The Isoplanar process enables the transistors to be placed closer together because it substitutes a thermally grown oxide isolation for the much thicker p^+ isolation used in conventional bipolar integrated circuits. Consequently, as with other new passive-isolation schemes, the junction capacitance of the transistors is reduced, so that they operate at higher speeds. A second factor affecting the RAM's speed is the circuit design itself. The Isoplanar device has an ECL layout that reduces access time and is made TTL-compatible by a small buffer on the chip.

The next 1,024-bit RAM to be available will most likely come from Raytheon Semiconductor Corp., Fairchild's next-door neighbor in Mountain View [*Electronics*, June 19, p. 44]. By the end of this month, Raytheon will have samples of its V-ATE RAM in stock. This memory has an access time of 35 ns, and typically dissipates 400 milliwatts. The V-ATE (vertical anisotropic etch) process replaces the conventional p^+ isolation diffusion with a vee-shaped groove. To eliminate microcracking in the grooves, Raytheon uses a complex tri-metal system of platinum, titanium, and gold. The air in the groove isolates the adjacent transistors in a circuit, and circuit density and speed are again increased.

In Sunnyvale, Calif., Signetics Corp.'s 1,024-bit RAM was produced for the Telex IBM add-on memory. But the company is developing a commercial version, and it will be available later this year. The Telex part uses a more conventional thin



To make 1,024-bit bipolar RAMs. Fairchild uses its Isoplanar process, Raytheon its vertical anisotropic etch technique, and Motorola its vee-isolation with polysilicon backfill.

(3-micrometer) epitaxial process, which requires shallow diffusions and small geometries to get high density. Access time is 35 to 40 ns, and power dissipation is 500 mW.

While the 3-micrometer epi process is sufficient for a 1,024-bit RAM, it will not be thin enough for anything larger. Says Michael Shields, manager of bipolar processing at Signetics, "For anything past the 1,024-bit RAM, we'll need some passive-isolation technique like Isoplanar or VIP if we are to get the density needed to make a larger device practical. We chose a thin epi for the 1,024 because we wanted to get the part out as fast as possible."

On the way. In the works are 1,024-bit RAMs from Intersil, Ferranti Ltd., and Motorola. Like Signetics, Intersil, of Cupertino, Calif., is also looking at the new processes, but for a different reason. Joseph Rizzi, director of the firm's memory work, says Intersil went with "a standard, 1/10-mil, gold-doped bipolar process" because it wanted to get a product to market as fast as possible. The result "is not the fastest RAM," says Rizzi, "but it is very 'makable'." Samples will be available in August. The speed is 100 ns, and maximum power dissipation is 500 mW. In a stand-by mode, the chip draws only 100 mW—a power-down feature that will also be available from Fairchild.

But while Rizzi doesn't feel limited by density—he says he could build a 4,096-bit RAM with his process—ultimately, he says, "we'll have to go to some form of side-wall isolation scheme to get the junction capacitance down so we can make a TTL RAM with an honest 50-ns access time."

The Ferranti part will employ a version of the CDI process (collector diffusion isolation) invented at Bell Labs, Murray Hill, N.J. CDI is a form of diffusion isolation. It will have an access time of 80 ns and will be priced at $50 in quantities of 100 when it becomes available in December.

Motorola's RAM will employ what the company calls the VIP process (vee-isolation with polysilicon backfill). It has the same vee-shaped isolation regions as the Raytheon device, but they are filled with polycrystalline silicon to make a planar surface, thus eliminating microcracking that might be found in an aluminum system.

The density obtained with the process is the same as with the V-ATE process, but the poly backfill, plus an aluminum metal system, makes the processing conventional once the manufacturer gets past the isolation stage.

Another plus for VIP is that the isolation grid of polycrystalline silicon, because it is an insulator, can be employed for feedthroughs in a two-layer metal system. The significance of this is that even with high-density bipolar processing techniques the problem of becoming metal-limited on the surface is still present, and a two-layer metal system would alleviate it (see p. 39).

Evolution. At Texas Instruments, plans call for a more evolutionary approach to the 1,024-bit bipolar RAM. Instead of going full blast on oxide isolation products, as in Fairchild's Isoplanar devices, or on an etch fabrication scheme, as in Raytheon's V-ATE or Motorola's VIP backfill process, TI has chosen a more cautious adaptation of a standard MOS-masking technique.

Called compose masking, it utilizes multiple-mask images on a single nitride mask for all critical diffusions—such as collector, emitter, and isolation—instead of separate mask steps for each element. "This conjunction mask technique allows us to achieve the kind of high-precision registration that is required to build devices like the 1,024-bit memories," says H. Dean Toombs, engineering director for TI's Semiconductor group. The process can be applied to other silicon bipolar ICs without limitations and probably will be used for other products. TI's 1,024-bit bipolar RAM is scheduled for introduction before the end of the year, "and we intend to continue to broaden our line of memories," Toombs says.

Meanwhile, back at Fairchild, planners are already looking beyond the 1,024-bit TTL RAM. The next Isoplanar RAM will be a purely ECL version without the buffer that makes the present unit TTL-compatible. Some samples are already in customers' hands; the part will be available in quantity by the fourth quarter. Thus, the great bipolar RAM race might move on to the ECL track even before most of the contestants get to the starting line in TTL. And there's still n-channel MOS in the wings, with its promise of bipolar-like performance of 85-ns access time at a quarter the power of bipolar devices. □

Pick your process

Convinced that his firm will have to graduate from its thin-epitaxial process to one of the newer schemes to get bipolar memory devices with more than 1,024 bits, Signetics manager of bipolar processing, Michael Shields, has evaluated the other techniques. He feels Motorola's VIP "may be the way to go" because the process permits design freedom as well as use of two-layer metal.

Shields continues, "Isoplanar would limit us in the freedom we have in designing circuits because we can't get vertical or lateral pnp transistors, Schottky diodes or high-value resistors with it." He adds that Raytheon's V-ATE process allows more design freedom and high density, but terms its platinum-titanium-gold metal system "exotic" and says it presents "horrendous" production problems.

Arguing for V-ATE, not unnaturally, is Keith Taft, a Raytheon technical development section head. Although he admits the tri-metal system is more expensive to produce than Motorola's aluminum technique, he points out that Raytheon's process evolved from its beam-lead work, with which Raytheon has considerable experience. "We had it in our bag, and we don't backfill with poly (as Motorola does) because we don't have experience with poly and polishing surfaces. It's easier for us to run metal up and down the grooves than it is for us to fill them up."

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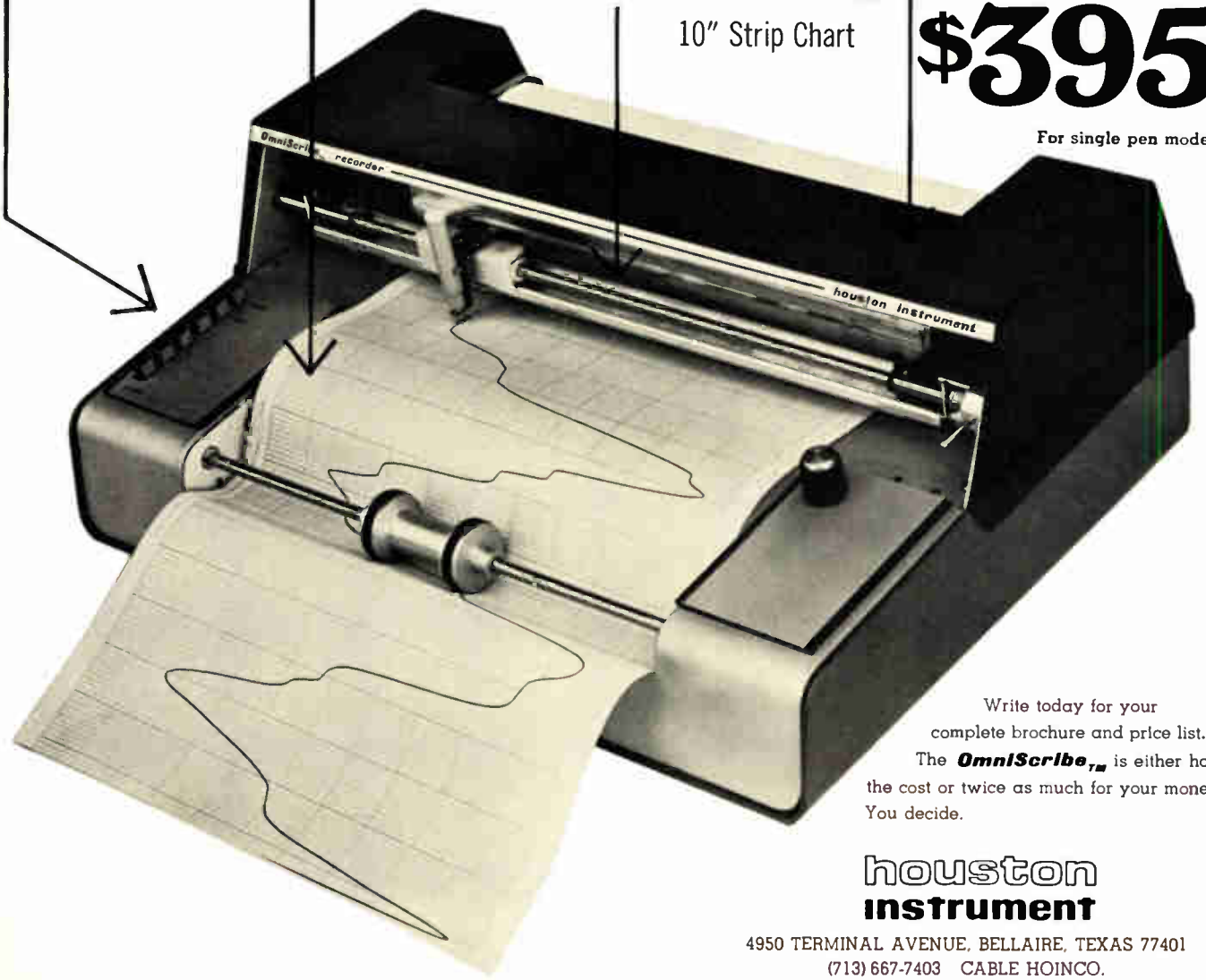

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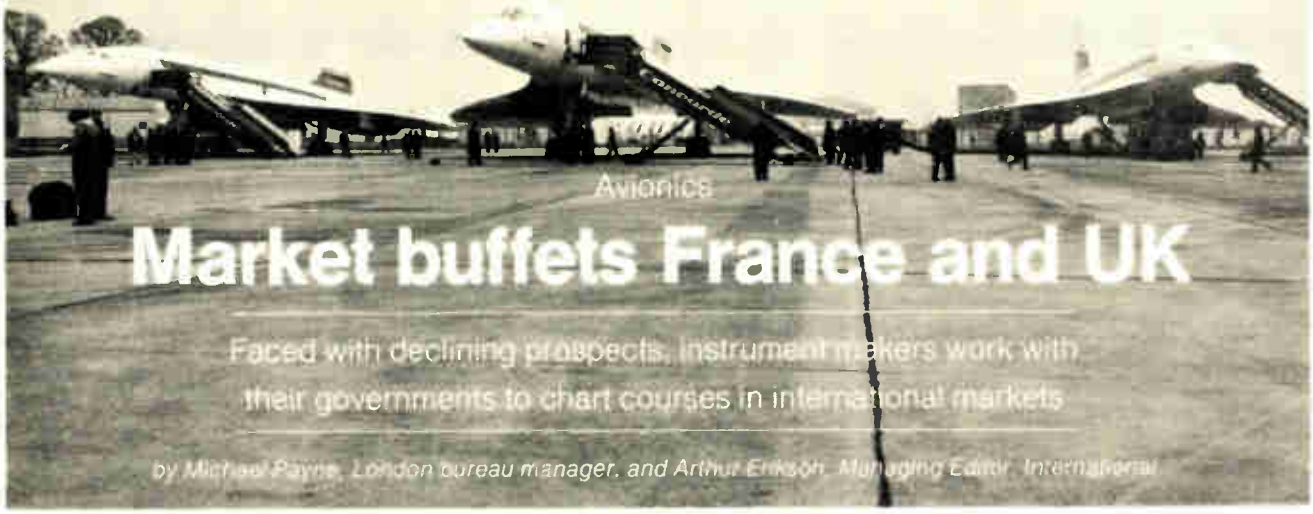

Avionics

Market buffets France and UK

Faced with declining prospects, instrument makers work with their governments to chart courses in international markets

by Michael Payne, London bureau manager, and Arthur Erikson, Managing Editor, International

Europe's airborne instrument makers participated in the developments that have forced the decline of the legendary "seat-of-the-pants" pilots. But British and French avionics makers today would trade a cockpitful of instruments for the instinct to indicate what direction to take in the volatile world market.

In fact, most British and French avionics companies are being forced to lower their market sights. The military business that kept their sales climbing and the research and development money coming in through the 1960s has leveled off. What's more, the big new aircraft projects nowadays are nearly always international affairs. And international cooperation being what it is, every country tries to get back at least as many pounds, francs, marks, or lira as it pays for development of a new plane.

As a result, the German and Italian avionics industries, throttled for a long time after World War II, figure to grow somewhat during the next decade as they cut down the lead of the British and French. These two countries have developed jointly the Concorde supersonic transport, and the project has engendered a new generation of nonmilitary avionics.

However, the development phase of Concorde has ended, and for future aircraft, the Germans and Italians will get a slice of the action. The two late starters will benefit from the share-out of avionics R&D money on such international projects as the British-German-Italian swing-wing Multirole Combat Aircraft (MRCA) and the French-German A300B Airbus.

Big market, but . . . To be sure, there's still a whopping worldwide market for airline jets and business planes. One French market study predicts that 4,500 new airliners and some 7,000 business jets will go into service during the next 10 years. But British and French avionics producers who head into these markets face competition from such entrenched American companies as Bendix Corp., Sperry-Rand Inc., and Collins Radio Co. Some British and French companies are trying to diversify out of avionics. And smaller outfits are looking for ways to team up without losing their identities.

Aware of the outlook for some time, Britain's avionics companies two years ago came up with a plan to bolster their technology. The plan was presented to the government, but the effect has been scant.

In France, it is the government that is pressuring the avionics producers to consolidate. But it will probably be years before neat groupings turn up in avionics.

Diversification. For one thing, staggering numbers of companies are involved. Total business in airborne equipment for French makers last year ran about $400 million, but it was split up among 120 producers. "Only six companies have a turnover of more than 100 million francs (about $20 million), but more than 60 have less than $5 million francs," points out Jacques Larpent, president of the Société de Fabrications d'Instruments de Mesure (SFIM) and vice president of the trade association Union Syndicale des Industries Aéronautiques et Spatiales (Usias).

A third major drawback slowing French restructuring, in Larpent's view, is the difference in the importance of airborne equipment to the companies in the field. For some, it's the bread-and-butter line. For others, airborne hardware accounts for as little as 20% of the company's business.

Despite the differences, there has been some regrouping. The top eight airborne-equipment makers account for some 70% of the business in France, and five of them this year consolidated their after-sales service organizations. Société Française d'Equipment pour la Navigation Aérienne (SFENA), whose majority stockholder is the government, is handling servicing worldwide for the others: Thomson-CSF, (SFIM), Crouzet, and Société d'Application Général d'Electricité et de Mécanique (Sagem).

Thomson-CSF and SFENA this spring agreed to work together on airborne electronics hardware for future generations of civil and military aircraft. Their pact covers R&D, production, and sales of autopilots. SFIM, says Larpent, is trying to work out a cooperative R&D effort with Crouzet. Electronique Marcel Dassault (EMD), another of the French heavyweights in avionics, has yet to join in this latest rash of restructuring. But the company's general

manager, Bertrand Daugny, points out that EMD has been paired up with other avionics companies for years with different sorts of agreements. EMD and Thomson-CSF, for example, work closely on doppler radars, and EMD splits both R&D and production of airborne digital computers with Sagem.

The short-term goal is to boost French avionics spending from $100 million annually to around $150 million by 1975. The long-range goal is to pin down a 6% share of the world market for civil avionics. As it stands now, the U.S. has 90% of the world market for civil aircraft.

What the French companies are trying to do is develop unique hardware that will sell worldwide. SFENA already has had significant success in the U.S. with an artificial horizon. "The agreement we've made on after-sales service should help us do better in world markets," says Robert Lavigne, SFENA's secretary general.

Thomson-CSF, the largest French avionics producer, has a strong position in airport instrument landing equipment and radars. The company expects to break into the civil aviation market for airborne hardware, too. "Right now our business is 99% military," says Alexandre Boudigues, head of Thomson-CSF's avionics division. "We hope to have a split of 80% military and 20% nonmilitary within three years."

Boudigues' division already has developed three product lines he feels sure can succeed. One is a combined weather and instrument-landing radar monitor, the second a head-down display, built around a color cathode-ray tube, and the third an area-navigation computer. Thomson-CSF has teamed up with Edo Commercial Corp, Melville, N.Y., for production of the computer.

Meanwhile. In contrast to what's happening in France, British avionics producers are the ones pressing their government for action. They claim that the avionics industry has come off third-best to the airframe and engine industries when it comes to splitting up the work on international projects. Among other things, U.K. avionics people are troubled by the way that U.S. companies have picked up business in the MRCA program as part of the German share.

Industry men believe their lobbying has had some effect. But there's a tight limit to what the government can do, and some slowdown seems inevitable for avionics. Turnover last year was between $250 million and $300 million. Some two-thirds of the business is done by only three companies—Ferranti Ltd., Marconi-Elliott Avionics Systems Ltd., and Smith's Industries Ltd.

When the MRCA avionics development money was divided up, all three British companies got short shrift. Marconi-Elliott will design the digital autopilot; therefore, the company should be able to compete for other autopilot contracts into the late 1970s. But this leaves Smith's Industries with no apparent outlet for its flight-control systems when present work for Trident, Fokker F.28 transports, and the Franco-German Airbus comes to an end.

Smith's contract for MRCA's head-up display won't hit Elliott so hard because Elliott has big export contracts for its own head-up display system that will help it to fund its future R&D. But Ferranti's MRCA inertial navigation system contract means that the know-how Elliott had acquired in developing the inertial navigator for the Anglo-French Jaguar light fighter will probably go to waste. And the decision to buy MRCA's nose radars from Texas Instruments means that British airborne radar makers, mainly Elliott and Ferranti, have no new business in view.

Smith's Industries' future flight-control activity seems particularly vulnerable, although it accounts for only 30% of Smith's aviation activity. John Rivaz, planning director of the company's Aviation division, says that for next-generation flight-control systems he is counting on a civil-transport project, probably a short-take-off-and-landing aircraft. But any project big enough to generate worthwhile R&D is almost bound to entail international collaboration.

Apart from his interests, Rivaz is worried that if a British company is not involved in a major transport project soon, the lead in advanced civil flight-control systems in Europe could pass to France.

Because they have more MRCA contracts involving their major skills, Ferranti and Elliott are less immediately vulnerable. But Donald McCallum, director and general manager of Ferranti's avionics activity, acknowledges that eventually Ferranti may pull out of some fields; airborne radar is an obvious candidate. McCallum also feels that time may show there are too many companies in Europe building airborne computers. Jack Pateman, managing director of Marconi-Elliott, is counting on the company's size to maintain a broad range of activity. □

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Communications

FCC lays ground rules for domsat

Industry reaction to the FCC's decision on domsat applications could postpone the start of the operation by another two years

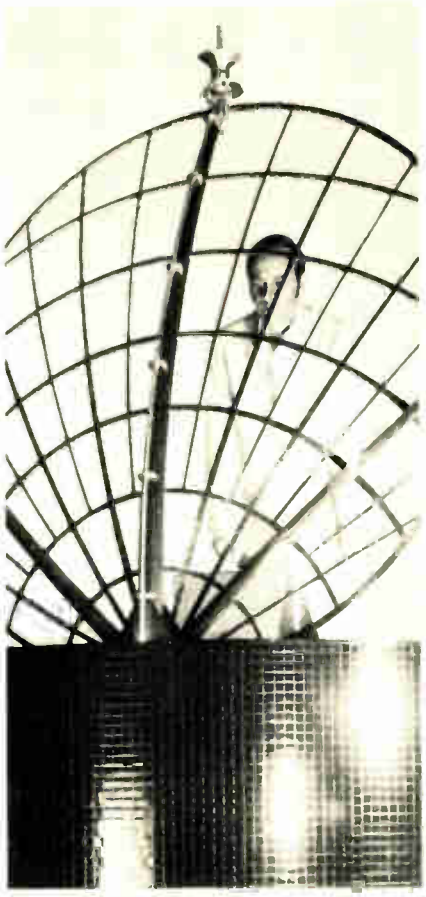
by William F. Arnold, Aerospace Editor

The go-ahead on a domestic satellite system given by the Federal Communications Commission last month lifts the lid of the expected treasure chest of electronics equipment for ground terminals. But equipment suppliers can only look—not touch—for at least a year, probably two.

The reason: the Communications Satellite Corp., one of the eight contenders for running a satellite system, indicates it will ask the FCC for reconsideration in the hope that the commissioners will reshape their decision along lines more favorable to Comsat. And it is likely that American Telephone & Telegraph, another powerful contender, will do the same on its own behalf.

This process certainly will delay final system approvals long enough to slow expansion of the multimillion dollar ground-station market from the few large two-way terminals used today by Comsat for overseas communications to the many smaller, receive-only stations that will flourish when one-way communications, like broadcast, cable television and data, are transmitted over a domestic satellite. The Electronic Industries Association's satellite subdivision has forecast a $100 million ground-station market through 1977 [*Electronics*, April 12, 1971, p. 113].

The Commission has stated that its "broad policy objective is to aim toward a flexible ground environment which would permit a variety of earth station ownership patterns." FCC officials think there could eventually be a maximum of four domestic satellite system operators providing different kinds of services. Industry sources believe one such system would offer wholesale service and two would offer retail service.



Domestic stock. Canada's communications satellite, designed by Hughes, may be the prototype for a continental U. S. system.

Five applicants—AT&T, Comsat, Hughes-GTE, Western Union Telegraph Co., and RCA Global Communications—came out of the decision with varying degrees of well-being, though some will have to carefully consider their next moves. All have until July 25 to tell the FCC if they will reframe their proposals or request extensions of 30 days or more for extensive modifications.

The other three applicants—Fairchild Industries, MCI-Lockheed Satellite Corp., and Western Tele-Communications—were not referenced by the FCC. According to government sources, they did not meet the commission's requirement that applicants be qualified technologically and economically. Although the Fairchild and MCI-Lockheed systems are larger than any others, they do not represent the tried-and-true technology required for profitability in commercial communications. Western Tele-Communications' bid was not seriously regarded because of its limited economic resources.

As it stands now, the FCC policy:

- Requires that a domestic satellite operator must offer services either to the common communications carrier (such as AT&T) or to non-common carriers such as broadcasters and cable television operators, but not both.
- Rejects the AT&T-Comsat system which specifies Bell System ground stations and Comsat-leased satellites. (But the Commission said Comsat could become a carrier's carrier for AT&T and others if it does not opt to lease satellites to non-common carriers.)
- Offers AT&T the option of either itself operating a satellite restricted to message telephone service or buying from a wholesaler of such services.
- Suggests GTE and Hughes Aircraft Co. may want to compete with AT&T for satellite message service since this could "tend to lessen AT&T's dominance and economic influence." But GTE would initially be limited to telephone service.

"No one was completely happy because everyone got somewhat hurt," explains one Comsat source, who indicates his company plans to ask the FCC to reconsider Comsat's application.

Sore toes. The Commission stepped on three big toes in announcing its "multiple entry" policy: AT&T, the White House Office of Telecommunications Policy (OTP), and Comsat. AT&T, in calling the FCC restrictions "competitively and economically unsound," states that message toll service "was our objective when the Bell System pioneered in satellite research with the Telstar experiment ten years ago next month." And the company adds, "we believe strongly that artificial restrictions on our use of satellites for private line services are not in the public interest." The OTP has repeatedly asked for unrestricted competition.

Will the decision stand? FCC Chairman Dean Burch led the opposition in the four-to-three decision. He strongly opposes the restrictions placed on AT&T and Comsat, and can be expected to blast the decision when he issues his dissent. Industry sources believe the chairman, along with the OTP, probably will try and change the Commission's mind when questions for reconsideration come up.

The unknown quantity in any FCC reconsideration of its domestic satellite policy is Commissioner Benjamin L. Hooks, the Tennessee judge and preacher who took his seat on the Commission on July 1. As yet known only as the FCC's first black commissioner, Hooks could become better known as the man who overturned the four-to-three FCC policy on domestic satellites, if he joins the three dissenters to reverse the majority and opt for unrestricted competition.

However, speculation in industry is that Hooks is unlikely to rock the boat. First, he would find it almost impossible to brief himself on all that has gone on before the case, and second, a Hook's vote to alter the ruling could lead to a protracted appeal in the Federal courts by any dissatisfied party. "This is unlikely," opines one industry insider, "because this is a Presidential election year, and I am sure Nixon wants to get some of this satellite business out into industry quickly."

Comsat appears to be in a difficult position, say observers close to the scene. Although FCC struck down a Comsat system serving only AT&T, the Commission's order allows Comsat mostly to serve AT&T making it highly dependent on AT&T's income. AT&T could conceiveably pull out later on to build its own system, leaving Comsat without a major customer.

Significantly, the Commission restricted AT&T to long-distance toll traffic, wide-area telephone service, and Autovon service for at least three years. After that, the FCC says "It will entertain a petition by AT&T for authority to provide additional services within the continental U.S." That is construed to mean such services as TV, message, data and others which would give Ma Bell powerful incentive to broaden its domsat market share.

Who gets what. Hughes Aircraft Co. appears to be in a strong position because its Intelsat-type satellites have been proposed for several systems. MCI-Lockheed, however, believes that their three-axis stabilized larger birds provide better system growth possibilities. Fairchild, which has been having funding problems with its applied technology satellite program [*Electronics*, Feb. 14, p. 49], isn't expected to fare well with its two proposals that are aimed at AT&T and the networks.

Already there are rumblings within electronics industry that U.S. suppliers should get a definite preference in supplying new American markets like domestic satellites created by Government fiat.

"It is the same 'infant industries' kind of thing for which our tariffs were set up in the first place," observed one industry source, noting also that Japan is now the world's leading supplier of commercial satellite earth stations. "If, for example, an initial market develops for 40 receive-only ground stations for cable television $1,000,000 apiece, shouldn't U.S. companies get first crack at it?" argues another manufacturer's man in Washington. "We created the market in this country and we should have the first opportunity to develop it." □

Distributors

Middlemen expand sales, services

The recent slump boosted the popularity of distributors—and their suppliers and customers alike seem happy for the trend to continue

by Alfred Rosenblatt, New York bureau manager

It took a recession to prove it, but manufacturers of a broad range of electronic parts—from ICs to relays—have found that distributors can save them money and often reach more customers than the manufacturers' own sales force. Distributors are also broadening the types of services they provide, increasing their attractiveness to parts makers and handling a fast-increasing share of sales to OEMs.

During the recession, component manufacturers went through "a traumatic experience," says Seymour Schweber, president of Schweber Electronics Corp., the Westbury, N.Y., distributor. "OEMs were paying 8% on money frozen in inventory," Schweber says, and they found it healthier to cut their inventories and rely on the stocks and fast delivery distributors provide.

The trend is evident in the Electronic Industries Association's projection for this year's semiconductor business: 1972 discrete and integrated-circuit sales through distributor's channels, as opposed to supplier sales to OEMs, are expected to total $222 million, or 18.3% of the total market. This is up from 1971's $176 million, or 16.5%, and almost double the estimated 10% figure of ten years ago. And by 1975, O.F. Henning, manager of distributor marketing at Texas Instruments, predicts it will reach as high as 30% of the industry's business.

This figure may already be reached by manufacturers of discrete components, estimates Stuart Beyerl, distributor sales manager at Allen-Bradley Co., Milwaukee. Manufacturers at last month's annual meeting of the EIA's Distributor Products division feel sales through distributors will top 40% "in the near future," reports Ira Gates, vice president, sales, Dale Electronics Inc., Columbus, Neb.

But this year already looks good. Bernard J. Shine, marketing manager of Sprague Electric's distributor-supply subsidiary, says a 25% increase in sales forecast for 1972 will be a company record. This growth pertains across the board, covering capacitors and resistors, as well as semiconductor products. A similar sales growth is seen by Dale's Gates for its trimmer pots and wirewound and film resistors. And for items like relays, the picture is comparable. As much as 25% may already be handled by distributors, says Robert Axthelm, manager of distributor sales for Chicago-based C.P. Clare & Co., a manufacturer of signal relays. This could grow by 10% to 15% in three to five years, he says.

The buyer's end. Distributors offer several advantages for managers of OEMs, as well as for the design engineer. "Number one—we are a bank," says Joel Girsky, secretary-treasurer of Jaco Electronics Inc., a distributor in Hauppauge, N.Y. "And number two—inventory is maintained by us instead of the user."

Perhaps equally important, distributors can sometimes offer lower prices than suppliers themselves. Buying in large quantities, as they do, affords them a discount which they may choose to pass on. They might shave the price, whereas a manufacturer generally won't, says one purchasing agent. In addition, when OEMs place "blanket" orders to purchase a given dollar value of components in the course of a year, a large-quantity discount applies even though orders are placed for a few pieces at a time.

Another plus is fast delivery. Three-day, two-day or even twenty-four-hour delivery is commonplace. Many distributors also have "will-call" departments, where engineers can pick up what they need almost immediately. Manufacturers, geared as they are to production runs, often take weeks.

"I can't think of a distributor who can't respond faster than a manufacturer, no matter how efficient he is," emphasizes Walter Senges, distributor marketing manger at RCA's Solid State division, Somerville, N.J. "The distributor is just much more geared up for that kind of service." Also expediting matters is the fact that distributors will accept telephoned orders, simplifying paperwork.

"They have even taken over parts of the customer's material control functions," adds a spokesman at

Electronics expert. Seymour Schweber sees 50,000 potential customers for electronics distributors by 1980.

TRW Electronic Components divisions in Los Angeles. Hal Mumma, vice president, distributor sales at Motorola Semiconductor Products, Inc., observes that distributors are "coding parts, striping wires, conducting special tests and performing burn-in." Other services include programing read-only memories, matching resistors, checking capacitor tolerances, and assembling connectors.

Happy suppliers. The distributor's value to the manufacturer has also increased. He carries inventory for the manufacturer, and he—not the manufacturer—worries about tracking down receivables. And he sells in areas which the latter just could not reach. "There's no way we could cover OEM and maintenance, repair and operational users without the distributors' sales force," says C.P. Clare's Axthelm.

"Multiplying the number of sales calls we can make" is also cited by Hewlett-Packard Associates, Palo Alto, Calif., as the reason it is considering distributors for marketing its optoelectronic semiconductor products, which include light-emitting-diode lamps and arrays, and optical isolators.

Suppliers also are becoming more efficient at meshing distributor and direct OEM sales forces. "An amazing number of manufacturers didn't know the function of distributors," says James S. Silverman, president of the 500-member, Chicago-based National Electronics Distributors Association (NEDA) and of his own firm, Electronic Expeditors Inc., Milwaukee. "Often, OEM sales people were competing against their own distributors."

One of the clearest views of the relationship between OEM and distributor sales staffs is expressed by RCA's Senges. "They're complementary, not competitive. We work closely together and even make joint calls. However, our people will concentrate on sales requiring engineering backup while the distributors deal more with purchasing-level sales. But at the small firms, the distributor may do it all."

As a result of this changing balance of power, more people with engineering backgrounds are being hired by distributors. Los Angeles distributor Wesco Electronics, for example, has a roving liaison man who used to be an applications engineer at Motorola.

But perhaps in the long run their large sales base will be the distributors' greatest asset. Of the $25 billion electronics industry, half is in what Schweber calls the "non-electronic market."

By 1975, some 35,000 companies will use electronics products—up from 20,000 in 1970, and only 6,000 in 1960. By 1980, the number will hit 50,000.

"Marketing in this unkown, non-electronic market will be like invading a vast no-man's land, the greatest challenge of the '70s," Schweber concludes. □

Department store or specialist?

Opinion varies as to which type of distributor—the one with a broad line, or the one who specializes in a particular product such as capacitors—will prove more successful as the market expands.

Herbert J. Kaufman, president of Compar New England, Newton, Mass., and Hamden, Conn., part of a nationally franchised chain, says his company falls somewhere between a distributor and a manufacturer's rep. He contends that the broad-line distributors tend to become "jack of all trades and masters of none, whereas specialists tend to have a better idea of inventory control and technical capabilities."

But Timothy X. Cronin, of Cramer Electronics in Boston, points out that the department store distributor will do well because "a person can come to us for everything and get it in one call instead of many." And while specialty houses can afford to have greater expertise in their product area, the broad-line houses try to overcome this by stressing major as opposed to secondary lines, and by hiring knowledgeable product specialists.

In the main, the feeling is there is room for both types of operations. RCA Solid State's distribution manager Senges remarks he has no favorites: "I'll work with whichever type of distributor gives the best service to my customer in a particular area."

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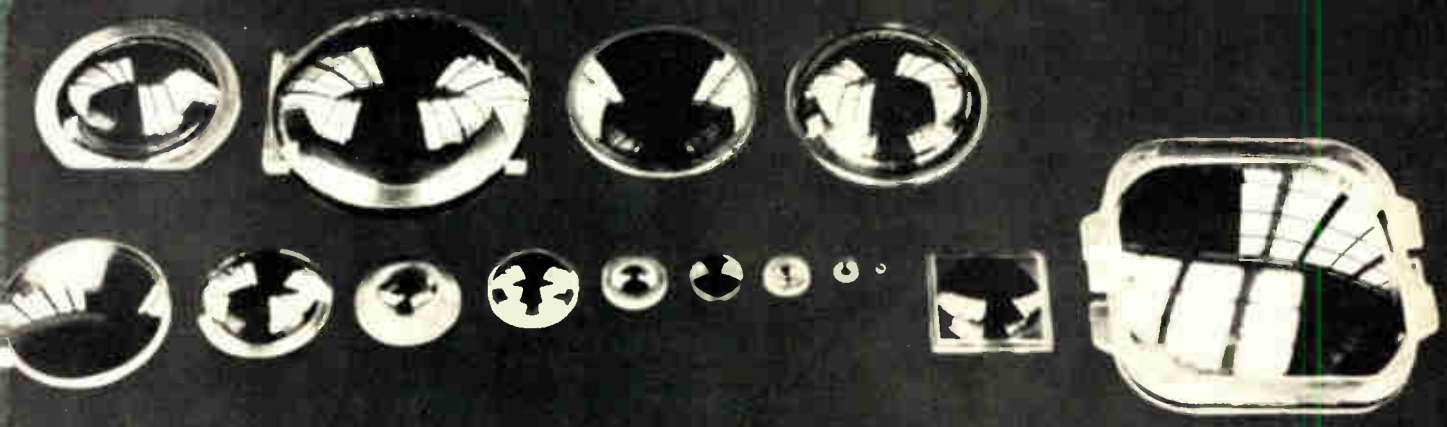
Plastic reduces costs of optoelectronic systems



Injection molding provides consistent quality in volume production; expenses are reduced further by molding the mounting hardware as integral parts of the optics, thus reducing labor and inventory

By Roger L. Howe and Philip H. Almand, *U.S. Precision Lens Inc., Cincinnati, Ohio*

☐ The design of optoelectronic systems for large-quantity production requires low-cost approaches—for the optics, as well as for the electronics. Until recently, glass had been the dominant optical raw material, but high-quality glass lenses are expensive. Now, except for the highest-precision optics, plastic can provide quality equivalent—and often superior—to glass. Most important, plastic maintains consistently high quality in high-volume production.

Molding plastic optics, which eliminates the need for polishing, offers substantial cost-savings—as high as 50% to 90%. Other benefits include light weight, break resistance, and configuration flexibility. Many discrete parts can be eliminated because mountings and spacers can be molded as integral parts of plastic optics, thus reducing inventory requirements, as well as assembly labor, which can cost more than the optics.

The plastics most widely used are acrylic, polystyrene, and polycarbonate. Coatings can provide qualities of reflection or anti-reflection and anti-abrasion, but such treatment can sometimes cost more than the plastic.

Low resistance to heat is the main drawback to plastic, but this shortcoming can usually be overcome by design or choice of material. Although intricate designs can be molded in small optical configurations that would be impractical with glass, the diameter is limited to about 4 inches.

Plastic optics, of course, have been around for a long time, serving such low-quality functions as toy lenses, pushbuttons, and dial covers. Only in recent years has plastic been developed for critical optical uses.

Injection molding combines consistent quality and design flexibility with large-volume, low-cost production techniques. The molding machine injects molten plastic under high pressure into a steel mold with optically finished surfaces. The mold may have multiple optical cavities, which will reduce the part price. Plastic provides better quality uniformity from lens to lens because of the repeatability achieved by molding.

Temperature is threat

Plastic, however, does have a few limitations which make it unusable in certain optical applications. It is more sensitive to temperature and abrasion than glass. Thus, because of its higher coefficient of thermal expansion, it is unlikely that plastic will replace ultra-precision glass optics. But, except for such demanding applications, plastic lenses being made now are better than many glass counterparts, at a fraction of the cost.

For example, the scratch-dig test is an important measure of minute surface disturbances which cause unwanted light refractions. It is specified by two numbers, the first representing the average width of scratches in micrometers and the second representing

the diameter of imperfections, such as pits or bubbles, in hundredths of a millimeter. It thus is a measure of the quality of the polishing given to glass lenses.

Although plastic lenses are not polished—their optical-quality surfaces come directly from the mold—the scratch-dig test can still be used to compare surface quality. A finished glass lens having a 40-30 scratch-dig specification requires extra care in manufacturing and consequently sells for a premium. It is routine to achieve this specification in plastic at no extra cost.

Molding is accurate

Because of the repeatability of the molding process, focal length variation is greatly minimized in plastic: interferometer measurements have shown variations in optics from one cavity can be held to less than a wavelength. Tight mechanical tolerances are also easier to achieve in plastic because of the molding repeatability. Plastic lenses, particularly in the smaller sizes that are harder to produce in glass, are usually held to diameter and thickness production tolerances of 0.001 inch or less. This is helpful, as it reduces the need for error allowances in spacing and mounting.

For certain types of optics, plastic is the only answer. The single-unit lens array shown in Fig. 1, developed for a punched-card reader, is an example of a part that could not be ground and polished practically in glass because of the many, closely spaced surfaces. Although glass can also be molded to a finished product, its viscous nature severely limits quality. Plastic, because of its relatively low viscosity during processing, will conform to the fine geometry and surface of the mold.

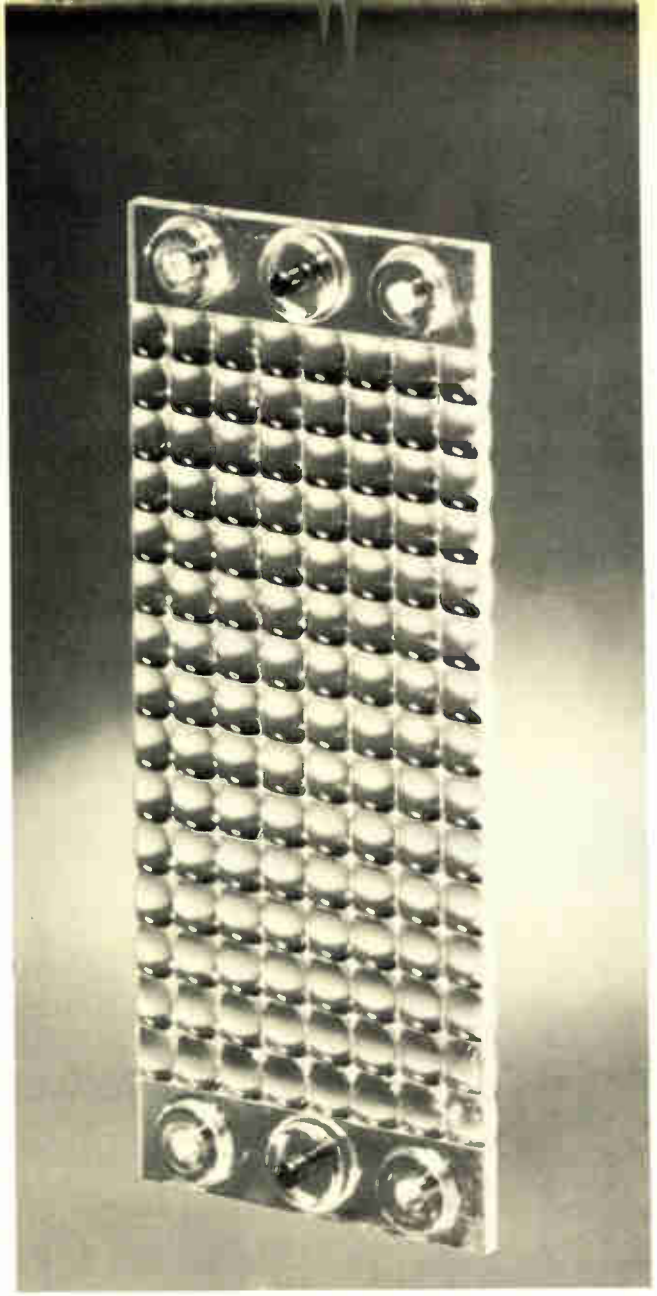
The major drawback of plastic optics is heat resistance. Careful design and proper choice of material can often eliminate the problem, but in some cases the differences are too extreme, and glass is the only alternative. Depending on the raw material, plastic will deform at continuous operating temperatures between 170°F and 250°F.

Ambient temperatures seldom reach the danger level, but the absorption of infrared energy by the lens itself could be a problem. However, such absorption can easily be checked in the actual application. The plastic materials in use have about 90% transmittance in the visible part of the spectrum, but they do have almost complete absorption at wavelengths greater than about 2 micrometers. However, one way to protect the plastic is to use a planar sheet of heat-absorbing glass between the plastic and the light source, thus removing the infrared energy before it gets to the optics.

Plastic lenses that resolve up to 300 line pairs per millimeter have been built. However, for sophisticated imaging systems, where incident light may be limited, plastics may not be the best choice, since the coatings needed to reduce reflections would probably cost much more than the lenses themselves. Thus, the user would probably use glass, since such anti-reflective coatings adhere more tightly to glass than to plastic.

Size is limited

There are also size limitations on plastic optics—generally, 4-inch diameters appear to be the upper limit. The major problem is that, as lens size gets large, the material's shrinkage in the mold becomes more difficult to control. Thickness, as well as diameter, is related to shrinkage, and thus for high-quality objective lenses, it's best to keep focal length/diameter ratio at f/2.8 or above. Plastic lenses, however, have been made at an f/1 ratio for condensing and non-imaging systems.

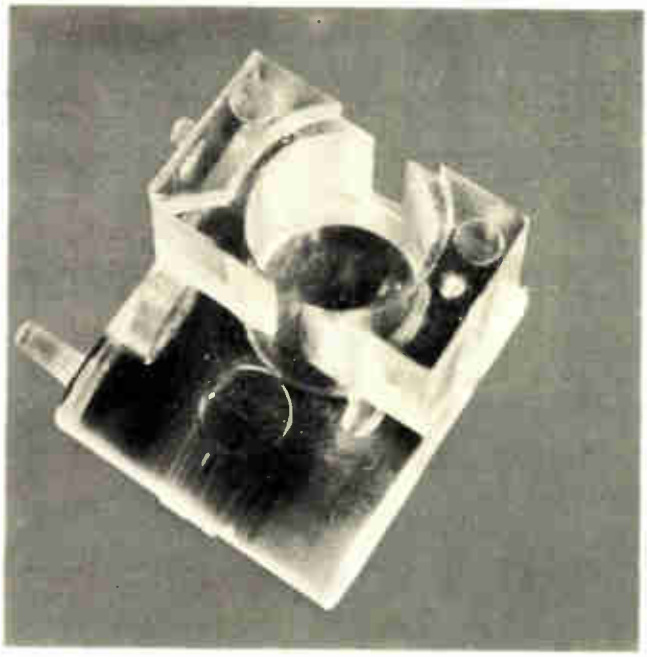


1. Multi-faceted. In plastic, a multi-lens array is not much more difficult to produce than to mold a single lens.

Plastic's cost advantages are somewhat offset by initial tooling costs, but if quantities reach the 1,000-piece level, tooling costs usually can be amortized economically. And, unlike glass grinding and polishing, which require continual replacement of tools, the injection molding equipment needs to be made only once.

Often the user has a choice between complete and partial tooling. Complete tooling is paid for and owned by the customer. Partial tooling is an engineering charge for custom components that are used with supplier-owned molds.

If the mass and curvature configurations are not radically different, it is possible to mold several different optics in a "family mold"—a single, multi-cavity mold. This approach allows a variety of lenses to be made in



2. All in one. The capability to mold mounting fixtures as an integral part of the lens structure is one of the major advantages of plastics.

only a fraction of a minute longer than would be required to produce the same number of identical elements.

For example, if an engineer planned to use the same quantity of two different lenses of a similar size, he could have a four-cavity mold made with two cavities for each optic. In contrast to the cost of two four-cavity molds, the savings in tooling costs would be substantial, even though there would be little difference in optical piece price. When ultimate volume is uncertain, molds can be made in a given number of cavities with the provision for adding more later.

For spherical optics without special configurations, complete two-cavity tooling costs between $1,800 and $2,200. Four-cavity tooling ranges from $2,400 to $3,000, and eight-cavity is between $3,300 and $4,500. Partial tooling, however, commonly costs only one-third to two-thirds as much as complete tooling. Depending on the part and the number of cavities, mold life ranges from a few hundred thousand to a few million units.

Furthermore, mold cavities can be added at proportionally lower expense as quantity goes up, causing unit price to drop further. Inasmuch as the mold is optically polished, there are no costly secondary operations. The finished plastic lens, before mounting, frequently costs from 50% to 90% less than glass.

The second cost reduction is in assembly. Because tight mechanical tolerances increase glass cost, the glass user often finds it advantageous to use less expensive optics and spend more in related adjustment and mounting apparatus. However, plastic does not present this problem because of the repeatability achieved in injection molding.

Shapes can be molded

Configuration flexibility, which allows the inclusion of mounting brackets, spacers, and other related parts to be molded with optics, is the third big opportunity for cost reduction. Figure 2 shows a lens part combination that provides optical, as well as positioning, features. Because of its small size, this part would have been costly to mount accurately in a special bracket. Complex mechanical shapes do increase tooling expense, but the effect on part cost is only minor.

Small diameters and short focal lengths are difficult to control in glass, and extra care costs extra money. This is not true with molded plastic optics. In fact, small plastic optics are generally even less expensive because they can be produced more quickly.

As an example of plastic savings in small lenses, one electronics company had been buying a 0.25-inch diameter double convex glass lens of 0.30-inch focal length for use with a gallium-arsenide light source. The

TABLE 1: OPTICAL PLASTICS CHARACTERISTICS

PROPERTY	ACRYLIC	POLYSTYRENE	POLYCARBONATE
Refractive Index (n_D)	1.491	1.590	1.586
Abbe Value (v)	57.2	30.9	34.7
Dn/DT x 10^{-5} / C	8.5	12.0	14.3
Haze (%)	< 2	3	< 3
Luminous Transmittance (%)	92	89	88
Critical Angle (i_C)	42.2	39.0	39.1
Deflection Temperature ($^{\circ}$F) 3.6°F/min 264 psi 3.6°F/min 66 psi	 198 214	 180 230	 280 270
Coefficient of Linear Thermal Expansion (in./in./$^{\circ}$F x 10^{-5})	3.6	3.5	3.8
Recommended Maximum Continuous Service Temperature ($^{\circ}$F)	198	180	250
Water Absorption, Immersed 24 hours at 73°F (%)	0.3	0.2	0.15
Specific Gravity (Density)	1.19	1.06	1.20
Hardness (0.25 -in. sample)	M 97	M 90	M 70
Impact Strength (Izod Notch)	0.3 - 0.5	0.35	12 - 17

price was $1.29 each in quantities of 2,500. An acrylic plastic lens was designed for the required focal length with a ±0.005-inch focal tolerance and a ±0.002-inch diameter tolerance. A thickness tolerance of ±0.0015 inch was assigned. In addition, a small protective rim was added to the exposed surface of the lens, and a sleeve was put on the back side to pre-position the lens over a detector. To convert to plastic, the manufacturer had to pay a one-time tooling charge of $1,420. In quantities of 2,500 the unit price was 12.5 cents. This provided an initial saving of $1,492.50—more than 50%—on the first buy. Subsequent production orders hit 90% savings, plus eliminating two pieces of mounting hardware and a tedious assembly operation.

Although many plastics function optically, only three are widely used; in order of popularity, they are acrylic, polystyrene, and polycarbonate. The significant optical and physical values of these and a few others are listed in Table 1; transmission characteristics are shown in Fig. 3. Special formulas, of course, can increase or reduce transmission at any wavelength, making the lenses function as filters.

Properties of materials

Acrylic combines exceptional clarity, good impact and scratch resistance, excellent mold-ability, and moderate cost. It is the leader in optical plastics, and by and large, the best plastic optics are made from it. Acrylic holds up without perceptible aging for years in outdoor environments. It has an excellent "memory" which causes it to return to its normal shape after thermal shock.

Polystyrene is the least expensive optical plastic and has the highest refractive index. It molds easily and, therefore, is popular for mass consumer use. Its disadvantages are poor scratch resistance and ultraviolet degradation over long periods of exposure to sunlight.

TABLE 2: PLASTICS vs GLASS

QUANTITY	DIAMETER (inches)	PLASTIC	GLASS
1,000	1.6 to 2.0	$0.33 to $0.99	$2.25 to $4.50
5,000	0.6 to 1.0	0.14 to 0.23	1.20 to 1.90
10,000	1.0 to 1.6	0.11 to 0.18	1.20 to 1.50
50,000	0.2 to 0.6	0.05 to 0.11	0.38 to 0.67

(Round optics – all surfaces spherical or plano-spherical)

Polycarbonate is a high-impact, heat-resistant material with a refractive index nearly that of polystyrene. Like polystyrene, it scratches easily. It costs about twice as much as acrylic and is comparatively difficult to mold. Polycarbonate is popular in systems where heat can be a problem.

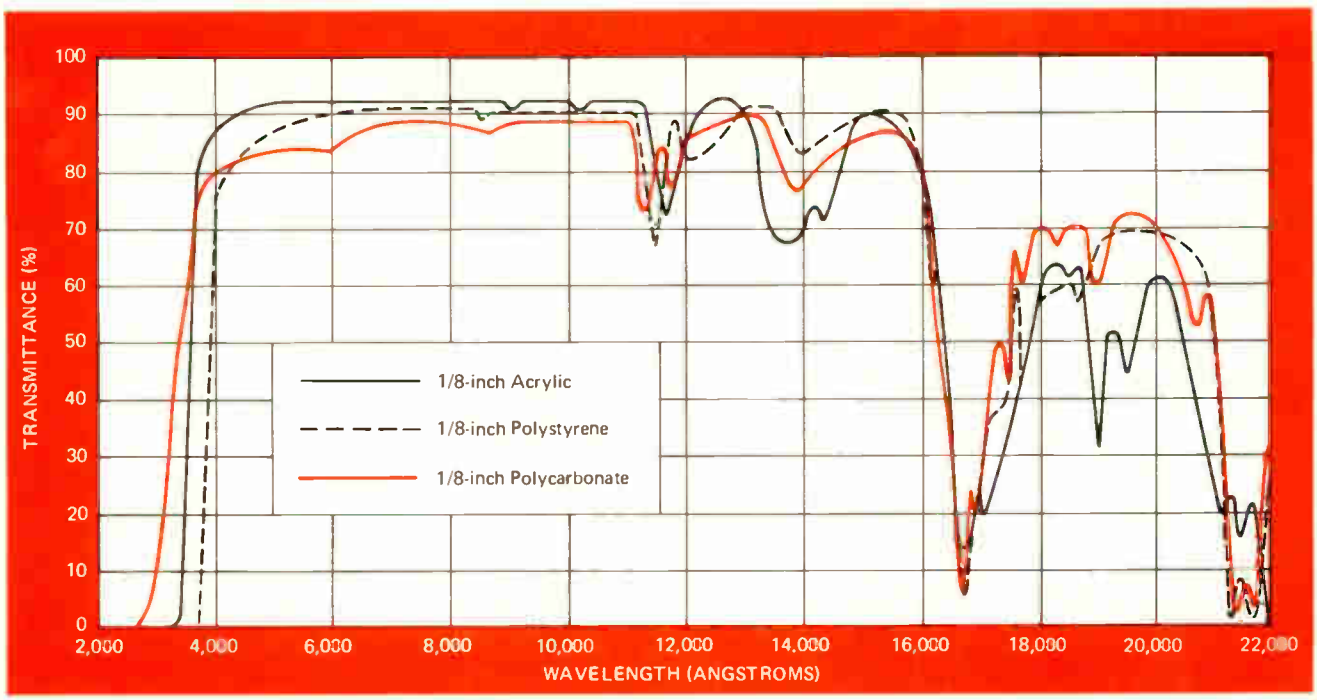
Three types of coatings are now in use—anti-reflective, reflective and anti-abrasive. The first two are applied by conventional vacuum-coating techniques and the third by a variety of methods. Unfortunately, any of the coating methods can cost more than the plastic lenses to which the coating is applied.

Magnesium fluoride, the best known anti-reflective coating used on glass, can be applied to plastic but its adhesion is inferior because high temperatures cannot be used in the process. Since plastic has to be handled more carefully anyway, adhesion is not normally a problem. Reflective coatings work well on plastic.

Anti-abrasive coatings are becoming more available all the time, particularly for polycarbonate. However, as a practical matter, customers who run tests frequently conclude the benefits do not warrant the extra cost.

Thus, despite a few drawbacks, plastic has become a dominant factor in bringing down costs of optoelectronic systems; Table 2 shows a few comparisons with glass optics. □

3. Transmission characteristics. Three principal types of plastic used for optics produce about 90% transmission in visible range.



Aedcap: the circuit designer's computer-assisted slide rule

This powerful conversational software system solves circuit problems easily; designs can be analyzed quickly for dc, ac, and transient analysis, and their sensitivity to component tolerances can also be determined

by Ronald A. Rohrer and Jorge E. Rodriguez, *SofTech Inc., Waltham, Mass.*

☐ Although the virtues of computer-aided circuit design are well known by now, most engineers still avoid using the computer because they don't know how to interface with the machine. A year-old fully conversational computer program called Aedcap, however, allows the designer to communicate with the computer in an instruction-reply format that is written in engineering terms.

Available on a time-shared basis, Aedcap (Automated Engineering Design Circuit Analysis Program) provides as much analytical power as batch-processed software packages while making efficient use of computer time to hold down design costs. Circuits can be treated as prototypes being probed with an instrument.

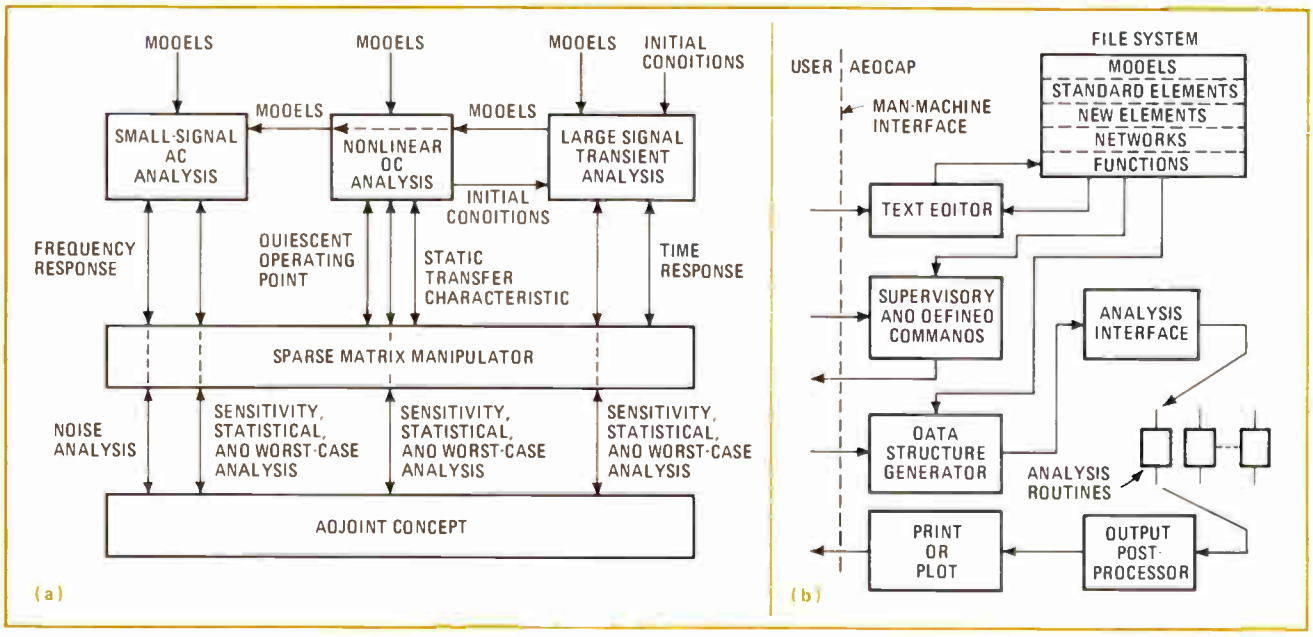
Aedcap can perform linear and nonlinear dc analysis, small-signal ac analysis, and large-signal transient analysis. All three analysis modes can be easily intercoupled. Moreover, the roles of signals and parameters can be interchanged so that a single computation can assess accurately the effects of every circuit parameter perturbation on a selected signal.

The program can simulate circuits composed of linear resistors, capacitors, and inductors; independent voltage and current sources; voltage-controlled current sources; junction diodes; bipolar junction transistors; and MOS and junction field-effect transistors. Theoretically, there is no limit to the size of the circuit Aedcap can accommodate, but, from a practical point of view, circuit size is restricted by the amount of computer memory available. Presently, hundreds of circuit nodes can be analyzed in a single computer run.

Models are built-in

Diode and transistor models are predefined; the user merely specifies the electrical parameters that characterize the active device. If the user chooses to leave a parameter value unspecified, the program inserts a default value, which usually simplifies the model.

Once characterized, a model can be stored so that it can be called out by name when needed to describe a circuit. Models for physical devices are used to reduce the circuit being described to N nodes (not including



1. Framework. Flowcharts map Aedcap's analysis (a) and control (b) structures. The program can perform dc, ac, or transient analysis, as well as sensitivity, statistical, or worst-case analysis. Sparse matrix (one having many zero-valued entries) conserves computer time; adjoint network technique permits reversing roles of signals and parameters. Aedcap's interactive framework eases interface between user and computer. Conversational language and built-in active device models keep program instructions simple.

the datum or ground node) and B branches. Each branch is defined by a relationship between the branch current and the branch voltage. The unknown circuit variables are the N node voltages.

Aedcap employs nodal analysis to solve circuit problems. The program applies Kirchoff's current law at each node to produce a set of N independent equations in matrix form. A large circuit often has a nodal admittance matrix that is typically 75% to 95% sparse. (Sparsity denotes the percentage of zero-value entries in the matrix). The sparse matrix approach saves computer time. Flow charts for Aedcap's analysis and control structures are presented in Fig. 1.

To perform dc analysis, Aedcap replaces capacitors and inductors by open and short circuits, respectively, and then solves the circuit for fixed source values. A set of static transfer characteristics can be obtained by solving for sequential values of a given source.

Of course, dc analysis is used to determine a circuit's quiescent operating point so that linearized model parameters can be computed for small-signal ac analysis. Nonlinear elements are then replaced by linearized equivalents, and the resulting linear circuit is solved at sequential frequency points.

Large-signal transient analysis is used to determine the time-domain response of a circuit to various input waveforms, starting with the initial conditions found with a dc analysis.

Full sensitivity analysis capability

Aedcap allows the user to perform dc or ac sensitivity analysis, finding the change in a circuit output parameter caused by variations in one or more circuit elements. Since dc or ac sensitivity analysis is an inherent part of any dc or ac solution, its presentation does not require a new solution of the circuit. Worst-case analysis and statistical analysis are also available as part of a dc or ac solution.

Worst-case analysis computes the output degradation that will occur if all the element parameter tolerances vary collectively in the most pessimistic possible manner. A design that passes this test may be used with the utmost assurance that it will function properly.

Statistical analysis with Aedcap predicts the percen-

Bipolar transistor model

Aedcap offers a built-in bipolar junction transistor model that is an extension of the Ebers-Moll charge-control model used by most programs. The model includes an emission coefficient in each exponential term that characterizes a junction. Additionally, three series parasitic resistances and an output resistance augment the dc transistor characterization, while nonlinear capacitors model the base and depletion layer charge storage. A linear collector-substrate capacitance is also added to complete the modeling of transistor charge-storage effects.

The circuit shown is an npn transistor model. It is characterized by six equations—two defining junction currents I_{BE} and I_{BC}, and the other four defining capacitances Q_{BE1}, Q_{BE2}, Q_{BC1}, and Q_{BC2}:

$$I_{BE} = I_{ES}[\exp(qV_{BE}/n_{BE}kT) - 1]$$

$$I_{BC} = I_{CS}[\exp(qV_{BC}/n_{BC}kT) - 1]$$

$$Q_{BE1} = C_{jE0}\int_0^{V_{BE}} dV/(1 - V/\phi_{BE})^{1/2}$$

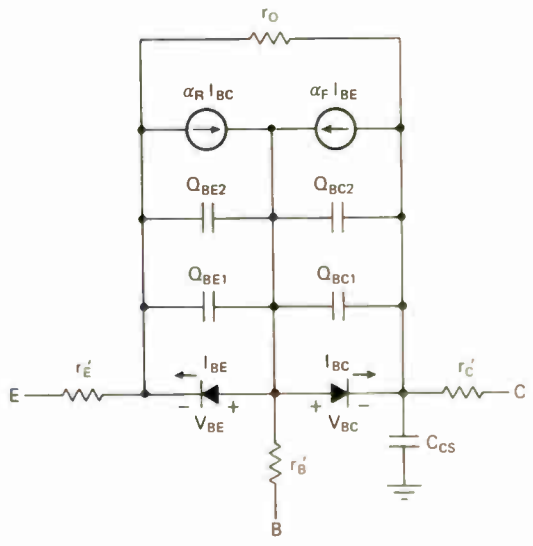
$$Q_{BE2} = \alpha_F \tau_F I_{BE}$$

$$Q_{BC1} = C_{jC0}\int_0^{V_{BC}} dV/(1 - V/\phi_{BC})^{1/2}$$

$$Q_{BC2} = \alpha_R \tau_R I_{BC}$$

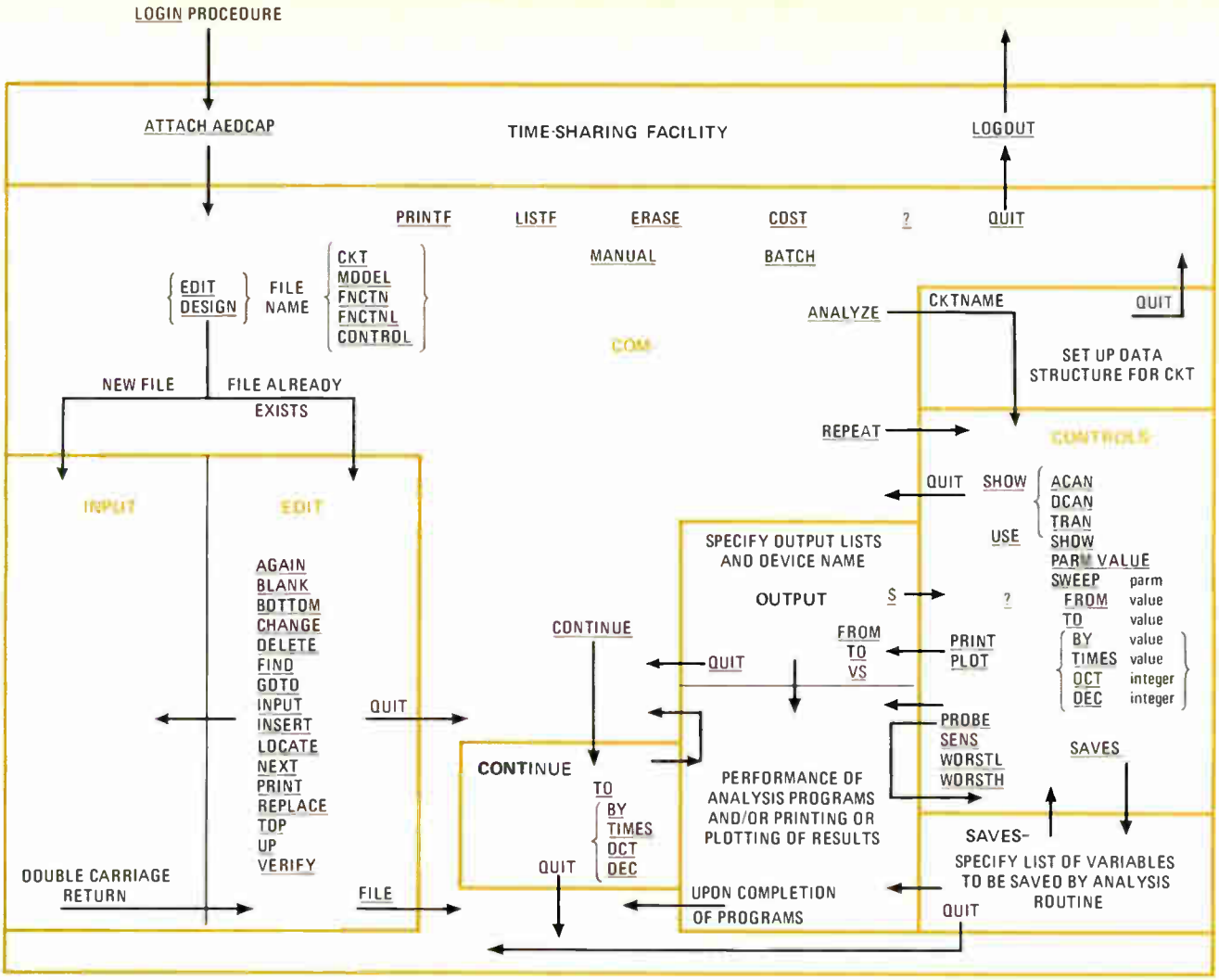
In all, 18 parameter values are needed. Default values are put in by Aedcap when parameters are not specified.

For a pnp transistor, polarity is reversed for voltages V_{BE} and V_{BC}, currents I_{BE} and I_{BC}, and dependent generators $\alpha_R I_{BC}$ and $\alpha_F I_{BE}$. Voltages V_{BE} and V_{BC} coincide with terminal potential differences only when the voltages across resistors r_B', r_C', and r_E' are negligible.



TRANSISTOR PARAMETERS

Parameter Symbol	Aedcap Name	Parameter Name	Default Value
Type		Transistor type, npn or pnp	
β_F	BF	Forward common-emitter current gain	100
β_R	BR	Reverse common-emitter current gain	1
r_B'	RB	Base ohmic resistance	0
r_C'	RC	Collector ohmic resistance	0
r_E'	RE	Emitter ohmic resistance	0
C_{CS}	CCS	Collector-substrate capacitance	0
τ_F	TF	Forward transit time	0
τ_R	TR	Reverse transit time	0
C_{jE0}	CJE0	Zero-bias base-emitter capacitance	0
C_{jC0}	CJC0	Zero-bias base collector capacitance	0
I_{ES}	IES	Base-emitter saturation current	1×10^{-14}
I_{CS}	ICS	Base collector saturation current	2×10^{-14}
n_{BE}	NBE	Base emitter emission coefficient	1
n_{BC}	NBC	Base collector emission coefficient	1
ϕ_{BE}	PHIBE	Base-emitter junction potential	1
ϕ_{BC}	PHIBC	Base-collector junction potential	1
r_O	RO	Output resistance	∞



2. Road map. Using Aedcap does not require special skills. Road map charts basic chain of command and shows how they are related to each other. The three primary command areas are COM-, controls, and input/edit. Instructions typed on terminal by user are underlined.

tage of circuits that will be out of tolerance in a production run. This analysis is a variation of sensitivity analysis that yields a simulated standard deviation of the desired circuit output parameter. The standard deviation figure gives a tolerance or voltage deviation within which roughly two-thirds of the circuits in a production run will fall. Before his design is firm and the production line set up, the designer can learn what his yield is likely to be.

In practice, Aedcap's statistical analysis has only limited accuracy. But, taken in conjunction with other design uncertainties, the predictions Aedcap makes can be useful to engineers engaging in statistical design.

Instructions are conversational

Three types of commands are available to the Aedcap user. The road map of Fig. 2 outlines the instructions included in each major command area. Control commands, for instance, are the various analyses that may be performed, while input/edit commands are the instructions needed to describe or modify circuits. The central command area, designated as COM-, provides access to the controls and input/edit sections, and also contains several auxiliary commands.

Sitting at his computer terminal, the user logs into the time-sharing network and then gains access to Aedcap by typing ATTACH AEDCAP. The system responds with the word COM-, signifying that it is ready to accept any command listed in the COM- area on the road map. (User-supplied commands are underlined).

The designer then calls for a circuit already filed in the system, or he describes a new circuit. He may do this by typing DESIGN AMPLIFIER CKT, if "amplifier" is the formal name by which he wishes to file his circuit. The system then searches for any circuit with this name. If it does not find one, the system notifies the user, who may then proceed to describe his circuit.

After executing any edit commands given by the user, the system returns to the COM- area, from which the user can exit with the command ANALYZE. ANALYZE precedes requests for the various analysis routines listed under controls. When the analysis is complete, the system returns to COM-. If he wishes, the user may now terminate the session and log out to study his results. The circuit he has just analyzed may be filed in the Aedcap system for future reference or for subsequent additional analysis.

Pointing out some limitations

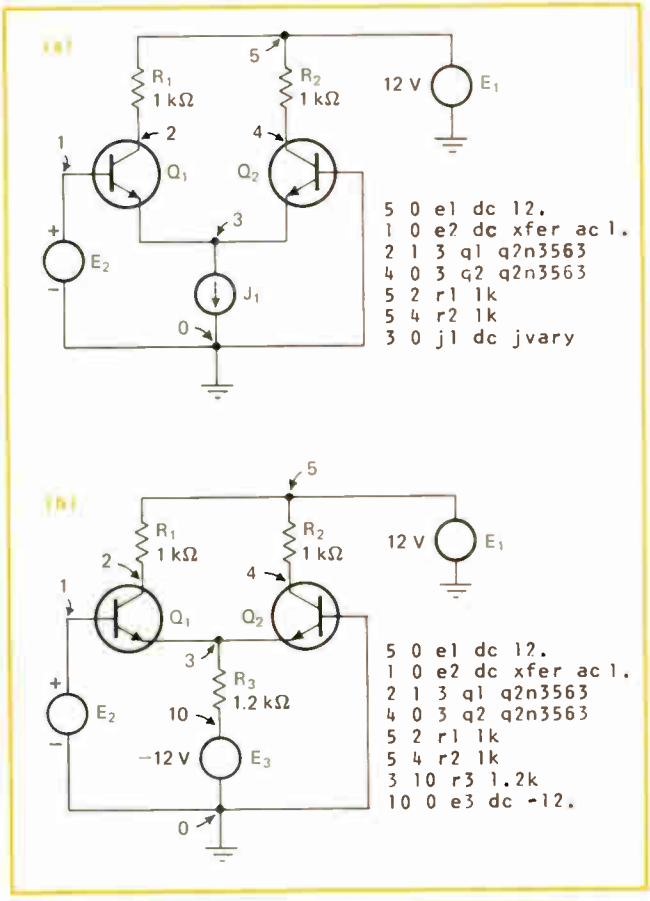
Parameter determination and modeling are still two of the most significant limitations to the effective application of circuit-simulation systems. Aedcap attempts to

minimize these problems with a large model library. Device models can be stored permanently and made available for future designs and other engineering users.

Although Aedcap's built-in bipolar junction transistor model (see panel) is adequate for most circuit applications, it does neglect a number of higher-order effects that may occasionally be important. For example, the common-emitter forward current gain, is not a constant, as assumed in the Ebers-Moll and Aedcap models. However, a reasonable representation of the beta variation can be obtained by augmenting Aedcap's built-in model with other standard elements.

Other shortcomings of the modeling equations can often be handled in a similar manner. Aedcap's modeling equations do not currently extend to microwave frequencies, but microwave devices can be simulated through suitable manipulations.

Another common problem is getting the series expansions for the solutions to converge. Aedcap minimizes this problem, with the help of the designer. For example, a bistable circuit can be particularly troublesome, since the computer does not know which of the two stable modes represents the desired solution. The designer's knowledge of the circuit he is analyzing should suggest to him that this may occur. He can avoid the problem by biasing the simulated circuit so as to eliminate the superfluous solution.



3. Designing with Aedcap. Differential transistor pair (a) must supply voltage gain of 50 ±10%. After approximating value of ideal current source that provides desired gain, real supply (E_3) and series resistors (R_3) can be substituted, as in (b). Tables are Aedcap circuit descriptions. Once all circuit nodes are numbered, elements are described on a line by listing the higher-potential node first. Transistor terminal nodes must be ordered—collector, base, then emitter. Also, a transistor must be identified as one of Aedcap's built-in models.

The bistable example illustrates a general property of simulation circuits. Practical circuits will always present more possibilities than could be envisioned by any set of program equations. The designer, therefore, must have some idea of what he wants his circuit to do, and how it is likely to perform before he can make intelligent use of a simulation system. He cannot expect the computer to describe all the possibilities inherent in a particular design.

Using Aedcap is easy

A typical design session will illustrate how to work with Aedcap. Figure 3a shows an every-day circuit—a differential transistor pair containing transistors Q_1 and Q_2, resistors R_1 and R_2, voltage sources E_1 and E_2, and ideal current source J_1. The circuit has five nodes, which are numbered. (The ground node is always made 0 by Aedcap convention; otherwise, any node numbering scheme will do.)

The Aedcap description for the differential pair also appears in Fig. 3a. It is a listing, by node connection, of the circuit elements. Only a few simple rules must be followed to describe a circuit. Each line in the table describes an element; the node that lies at the higher potential is listed first. Therefore, supply E_1 has its node connections written as 5 and then 0, since node 5 is at 12 volts and node 0 is ground.

For transistors, the collector node is listed first, followed by the base and emitter nodes, respectively. Transistors, it should be noted, must be separately described as models so that the computer can refer to them when they are used in a circuit. Failure to specify all 18 parameter values of Aedcap's built-in transistor model will cause default values to be used.

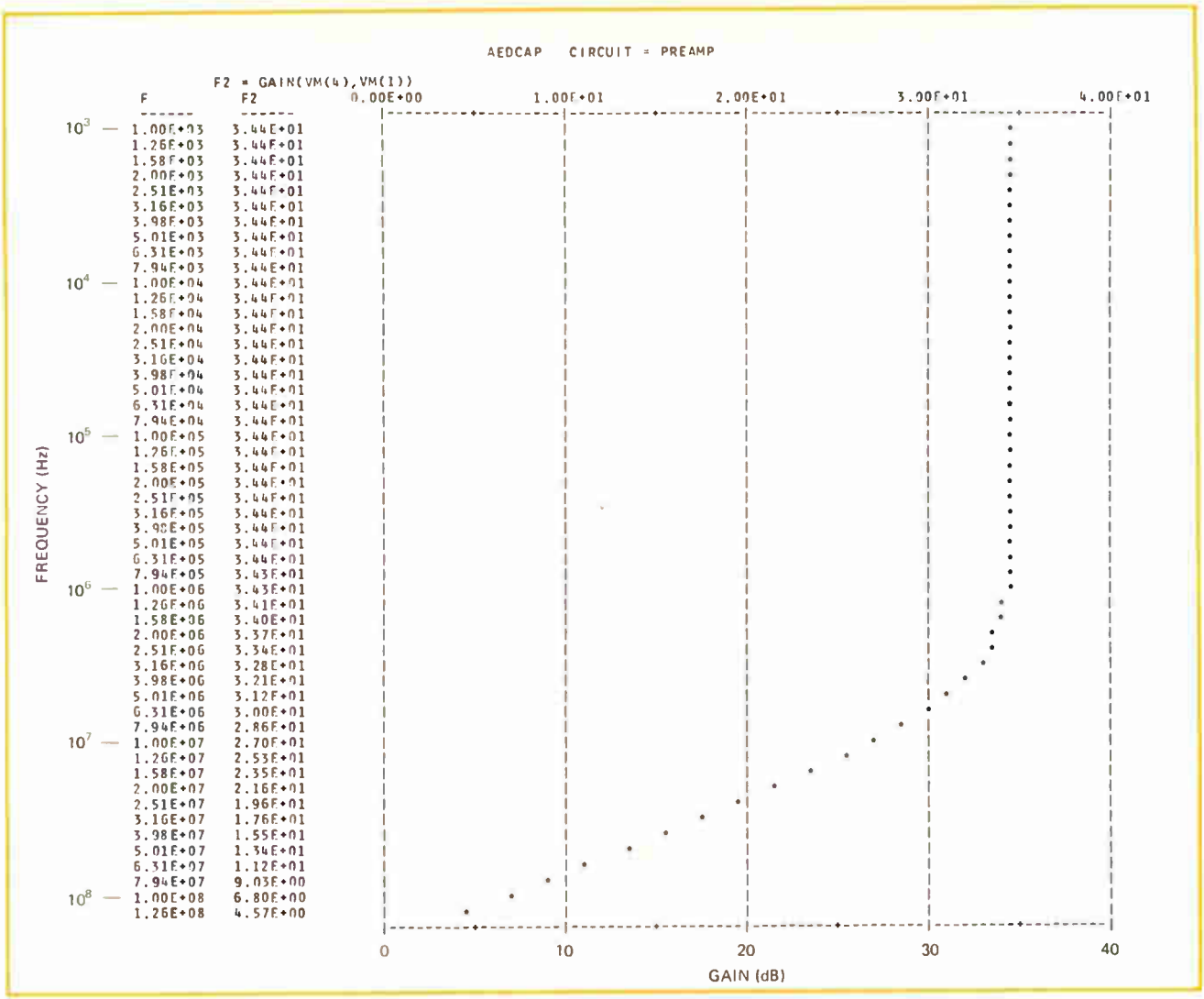
The differential pair of Fig. 3a is to be a preamplifer in a larger circuit configuration. Its load resistance will be 1 kilohm, and a single-ended voltage gain of 50 ±10% is desired. The power supplies are +12 v and −12 v. (The negative supply is to be added later in place of the ideal current source.) Transistor model parameters are known and stored in the Aedcap file.

From circuit design experience, it is known that the gain of this circuit depends on the value of transistor emitter current, I_E. The design procedure, then, consists of establishing an ideal current source (J_1) to determine the correct value of I_E. After this value is found, the ideal current source can be replaced by an emitter resistance and a negative supply.

A computer run

Once the circuit is described, the current for J_1 can be estimated and tested. Since the frequency response of this preamp should be essentially flat, ac voltage gain can be quickly checked by computing the voltages at nodes 2 and 4 for a signal frequency of 1 hertz (for simpler calculations). Knowing the voltage at either node 2 or node 4 would be sufficient, but finding the potential at both nodes will help confirm expected performance.

To test a 2-milliampere value of J_1, the user simply types a request for an ac analysis, specifying the 2-mA



4. Performance check. Computer plot of frequency response for differential pair in Fig. 3b shows that gain is about 35 dB out to 1 MHz.

estimate in place of JVARY in the table of Fig. 3a. At the same time, he requests a printout of the voltages at nodes 2 and 4. The computer will find that both voltages are approximately 7.3 V.

Since the estimate of 2 mA yields a voltage gain of only 7.3, the analysis is repeated for a current source of 10 mA. This gives a satisfactory gain of about 55.3.

Ideal current source J_1 can now be replaced by a real resistor and a real supply. By calling in the Aedcap editor, source J_1 can be removed, and a 1.2-kilohm resistor (R_3) and a −12-V supply (E_3) can be inserted. The practical differential pair is illustrated in Fig. 3b, along with its Aedcap description.

Again, circuit gain is checked by computing the voltages at nodes 2 and 4 for a 1-Hz input. If the gain is not within the desired specification of 50 ±10%, the value of resistor R_3 must be changed. A computer run shows that the gain is within tolerance, indicating that the circuit is essentially designed.

At this point, there are a number of possible analyses that can be performed. For example, the circuit's dc transfer characteristics can be determined by plotting the output voltages at nodes 2 and 4 as functions of dc input E_2. Or the common-mode gain can be computed by first calling in the Aedcap editor to connect Q_1's base to Q_2's base and then looking at the output voltage transfer curve at node 4.

The circuit's pulse transient response can also be checked out by using standard Aedcap pulse functions or any user-desired pulse function. And the sensitivity of the circuit can be tested to see how well the design is likely to fare under production conditions.

Since the circuit's frequency response was initially assumed to be flat, a sensible computation is checking the gain of the differential pair over a broad range of frequencies, taking advantage of Aedcap's ability to do full frequency sweeps. The computer printout of Fig. 4 shows the results of sweeping the circuit from 1 kilohertz to 100 megahertz and obtaining a plot of gain (in decibels) versus frequency. The graph verifies that the frequency response will be essentially flat to 1 MHz.

Program availability

Aedcap requires a large in-house computer, or it can be used interactively through the time-sharing facility of National CSS in Stamford, Conn. The computer terminals that the program can now accommodate include the IBM model 2741, Teletype models 33 and 35, and the Tektronix types T4002, T4002A, and T4010 graphic computer terminals. □

Schmitt trigger prevents clock train overlap

by R.R. Osborn
Roberts Enterprises, Flagstaff, Ariz.

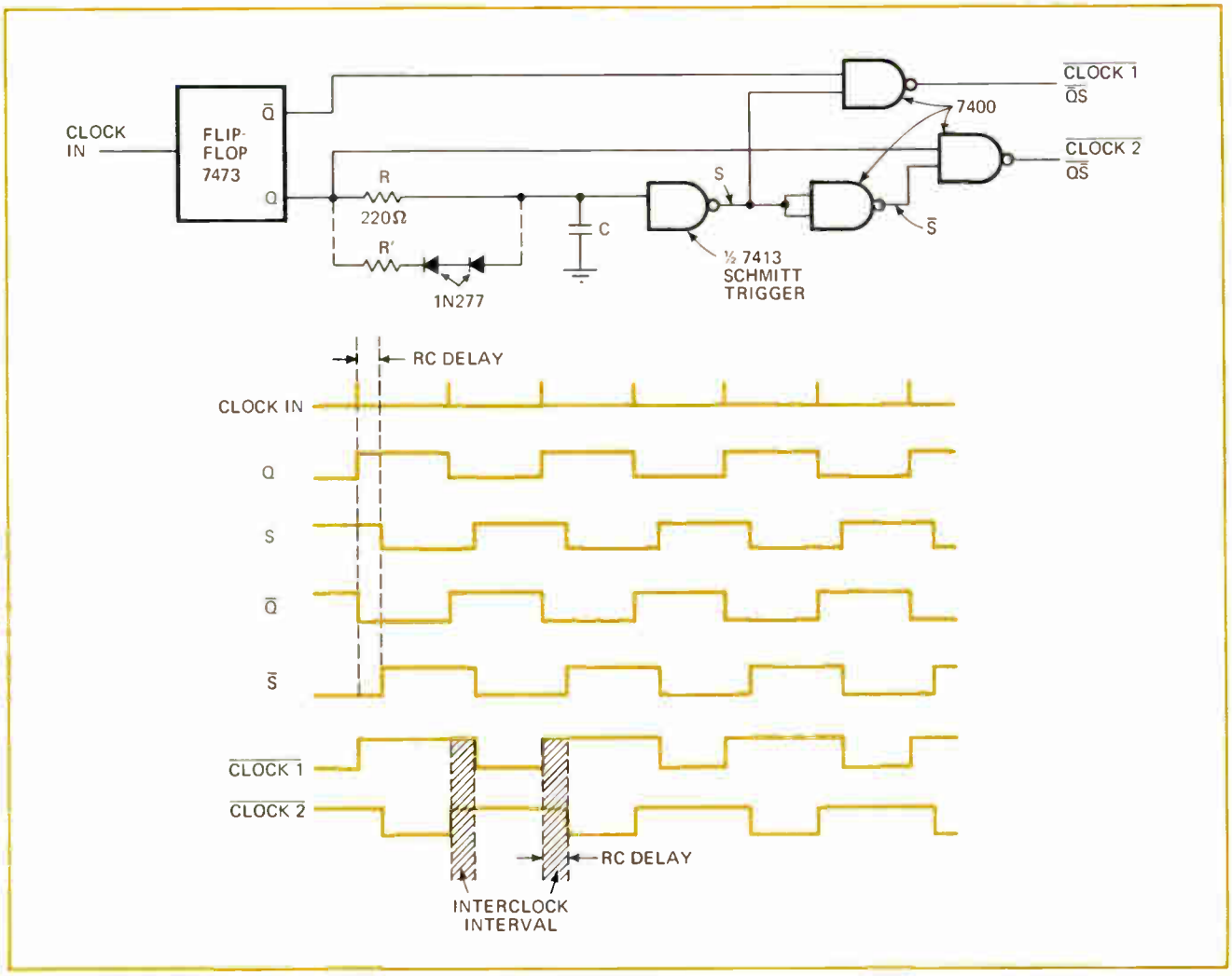
Non-overlapping clock trains are often required in digital systems, especially when transistor-transistor-logic circuits must be interfaced with metal-oxide-semiconductor logic circuits. A single integrated Schmitt trigger, using only one RC time constant, can provide the appropriate delay between clock trains. Moreover, the temperature stability of the IC Schmitt trigger assures that the separation between output clocks remains constant, despite changing temperature.

The Schmitt trigger delays the Q output of the flip-flop for the time fixed by resistor R and capacitor C; it does not delay the flip-flop's $\bar{Q}$ output. The delayed and undelayed pulse trains then pass through a combination of NAND gates, producing the two desired non-overlapping output clocks.

Interclock intervals, which occur when both clock outputs are high, are unequal if resistor R alone sets the delay, because of the flip-flop's output levels and the Schmitt trigger's input current. Adding resistor R′ and two diodes, as shown by the dashed lines, allows the interclock intervals to be made equal to each other. The value of R′ can range from 0 to 5 kilohms.

Capacitor C can vary from 0 to 1,000 microfarads, producing interclock intervals of 30 nanoseconds to 1 second. The time between input clock pulses must always be greater than the output clock interval; input clock frequency can be as high as 10 megahertz. □

Staggering clock phase. Circuit produces two non-overlapping output clock trains from single input clock to flip-flop. Q output of flip-flop is delayed by Schmitt trigger for one RC time constant. Delayed clock from Q and undelayed clock from $\bar{Q}$ are combined by NAND gates to yield separate output clock trains. Adding dashed components yields equal interclock intervals. Clock speed can be as fast as 10 MHz.



Broadband cutoff limiter is phase-transparent

by Roland J. Turner
RCA Missile & Surface Radar Division, Moorestown, N.J.

When information is transmitted in the phase domain, the video or intermediate-frequency processor in a radar or communications system frequently requires a limiter circuit that does not alter the zero crossings of the input signal.

By using current cutoff limiting, a broadband phase-transparent (zero phase-shift) limiter can be built that maintains input zero crossings within 14 picoseconds, while providing a gain of 20 decibels over its linear range. This limiter, which operates from dc to 30 megahertz, can improve receiver sensitivity, allowing smaller targets to be resolved in a radar system or, in a communications system, reducing level- and frequency-dependent phase noise so that phase-detection thresholds can be lowered.

The limiter circuit uses microwave transistors that have a unity-gain crossover frequency (f_T) of greater than 1 gigahertz. The bandwidths of the transistor stages making up the limiter can then exceed 500 MHz to yield the limiter's over-all wideband performance by using conventional microstrip techniques.

Exceptional signal control is realized by driving the transistors into their cutoff regions to achieve limiting action. Transistor cutoff parameters are more controllable and more clearly defined than transistor saturation parameters. And with cutoff signal limiting, the transistors look like high impedances to low load impedances, thereby achieving fast limiting action with controlled passive elements.

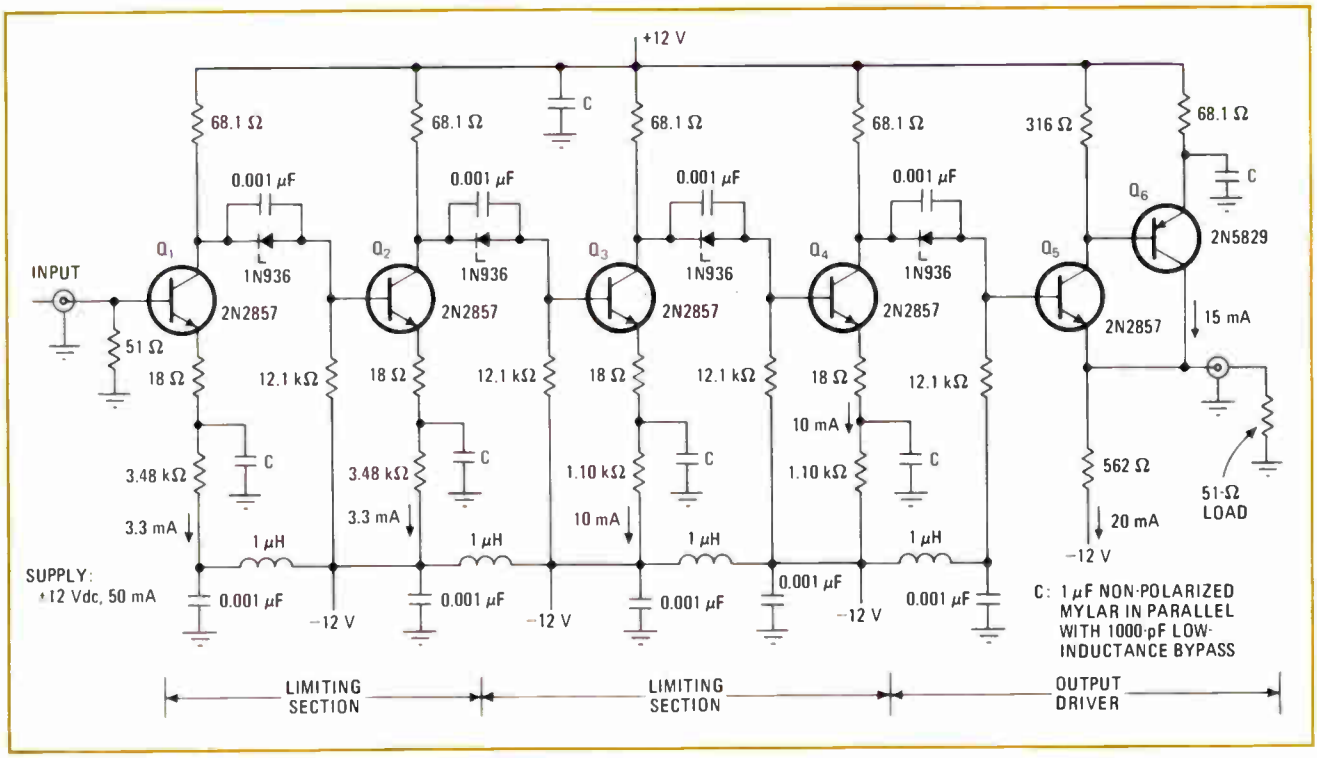
Transistors Q_1 through Q_4 perform the limiting function, while transistors Q_5 and Q_6 operate as a unity-gain output driver. There are two limiting sections, one consisting of Q_1 and Q_2, and the other of Q_3 and Q_4. Two transistor stages, then, form each limiting section.

For one polarity of the input signal, one transistor stage operates as a low-gain broadband amplifier, while the other limits the section's output by performing as a cutoff isolation amplifier. During the opposite polarity of the input signal, the transistor stages reverse roles. Each limiting section supplies a gain of 3.3. The output level of each section is determined by its quiescent operating point.

This limiting scheme provides extremely low carrier output phase shift for the full dynamic range of the input signal. Over a 40-dB input range, from 100 millivolts peak-to-peak to 10 volts pk-pk, the limiter circuit is phase-transparent within 0.25°. For example, the output is 1.2 V pk-pk for a 120-mV input. For frequencies up to 20 MHz, the output impedance of the driver section is less than 5 ohms.

From dc to 20 MHz, the time displacement of adjacent zero crossings of the output waveform are within 14 picoseconds of the period established by the input zero crossings. In the phase domain, this means that the phase of a 20-MHz input will be shifted less than 0.1° at the output, making the limiter phase-transparent for all practical purposes. □

Linear-phase signal limiting. Operating from dc to 30 megahertz, limiter circuit remains phase-transparent within 0.25° over 40-decibel input dynamic range. Each limiting section contains two transistor stages. Depending on input signal polarity, one stage is low-gain broadband amplifier, while the other acts as cutoff isolation amplifier. Optimum usage of transistor cutoff parameters achieves desired limiting action.



Preset generator produces desired number of pulses

by Glen Coers
Texas Instruments, Components Group, Dallas, Texas

Computer systems and medical instruments are likely applications for a digital pulse generator that will deliver, on command, any desired number of full-width pulses from 1 to 999. Three 10-position switches set the number wanted.

Rotary switches S_1, S_2, and S_3 fix the number of output pulses. S_1 controls the most significant digit, while S_3 controls the least significant digit. For example, if S_1 is set to 3, S_2 to 6, and S_3 to 8, the number of output pulses will be 368.

Gates G_1 through G_4 eliminate any count error caused by contact bounce from toggle switch S_4. When S_4 is placed in its count position, flip-flop FF_1 inhibits gate G_4 until the trailing edge of S_4's count pulse occurs, so that even the first output pulse is full width.

Placing S_4 in its count position results in a high at both inputs to G_2, enabling this gate (its output goes low) and resetting the decade counters to zero. The count command also causes one input of G_1 to go low, making its output high. This clears flip-flop FF_1 and keeps its Q output low. The high from G_1 also drives FF_1's preset function high, as well as one of the inputs to G_4. The output from G_5 is now low.

The first negative edge of a clock pulse triggers the flip-flop and makes Q go high. The output of G_3 then goes low, presetting the flip-flop to maintain Q in the high condition. When G_3's output goes low, one input to G_1 also goes low, enabling this gate so that clock pulses are passed to its output.

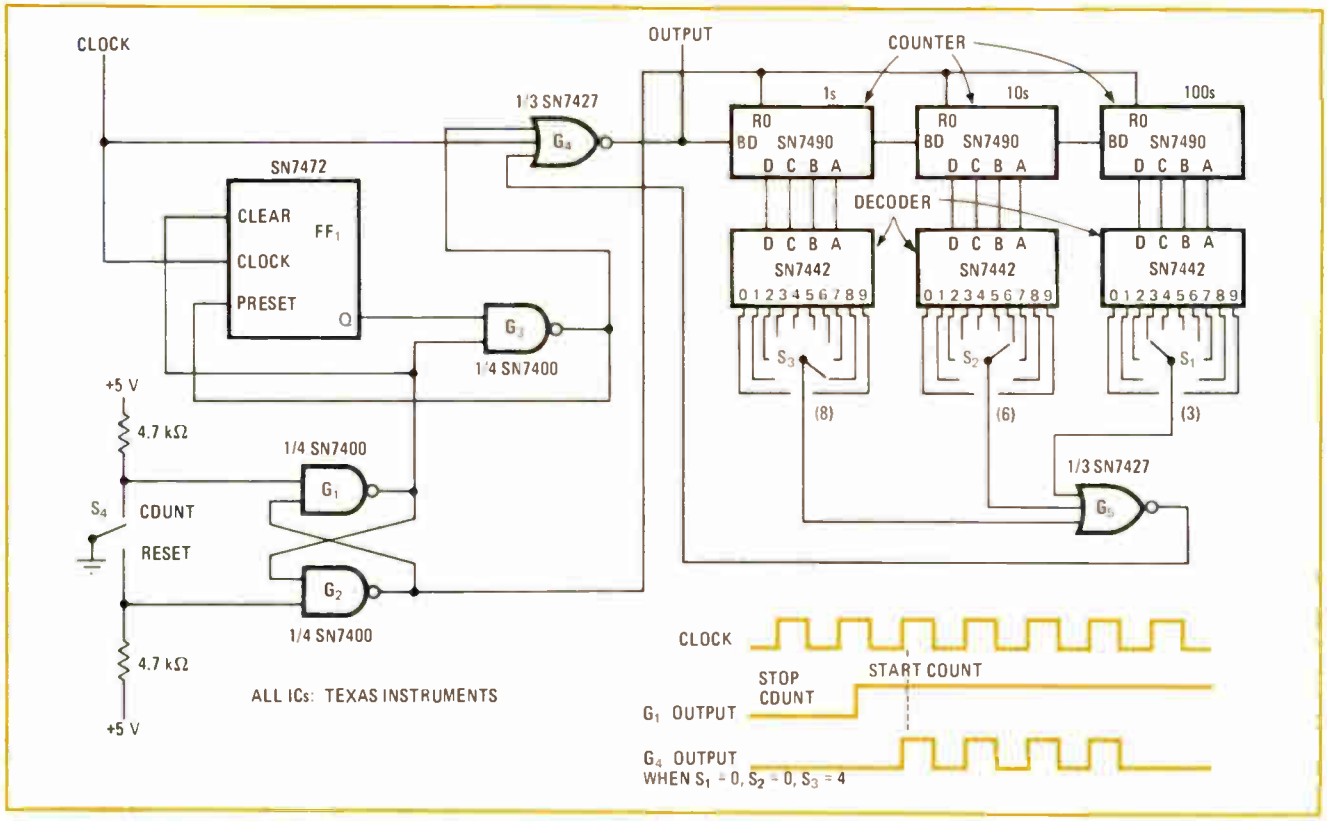
The binary-coded-decimal count that is accumulated in the divide-by-10 arrangement of decade counters is transferred to the BCD-to-decimal decoders. A decoder output goes low when that decoder reaches the setting of its associated rotary switch. When all three decoder outputs are low, gate G_5 is inhibited (its output goes high). This causes one input to G_4 to go high, stopping the transfer of pulses.

Placing switch S_4 in its reset position drives one input to gate G_2 low, making its output go high and operating the reset function of the decade counters. Both inputs of G_1 are now high, while its output, the clear function of the flip-flop and one input to G_3 are low. This clears Q to a low condition, causing G_1's output, FF_1's preset function, and one input to G_4 to go high. The circuit is now ready to start a new count.

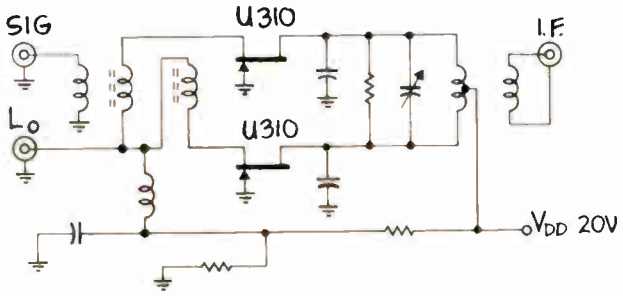
Adding more counters, decoders, and switches will, of course, increase the number of pulses that can be counted. □

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.

Pulse counter. Three rotary switches control number of output pulses that can be generated; settings may range from 1 to 999. Flip-flop and gates G_1 through G_4 assure that all output pulses are full width. Toggling switch S_4 to its count position allows gate G_4 to transfer clock pulses to divide-by-10 arrangement of decade counters. Each BCD-to-decimal decoder counts to setting of its rotary switch.



to build a better VHF/UHF FET mixer:



Try our U310 junction FET in this balanced mixer and make your own performance comparison. Our results are below. The inherent square-law transfer characteristic of the FET ensures high intermodulation intercept and signal desensitization. The grounded-gate connection is most stable, while source injection of both the signal and local oscillator make easy impedance matching into the FETs. Also, the balanced configuration reduces l.o. radiation from the signal port and suppresses the generation of even harmonics (which helps reduce intermodulation).

How do you select an optimum JFET for a mixer? Low gate capacitance is needed for wide bandwidth – the Siliconix U310 typically has C_{gs} = 4.5 pF and C_{gd} = 1.9 pF. Useful conversion gain comes from high transconductance. Our U310 has typical g_{fs} = 14,000 μmhos. Dynamic range is bracketed by the lowest drain current for an acceptable noise figure and the maximum drain current – typically I_{DSS} = 40 mA for the U310. For an optimum balance, matched pairs are available.

50-250 MHz Mixer Performance Comparison

Characteristic	JFET	Schottky	Bipolar
Intermodulation Intercept Point	+32 dBm	+28 dBm	+12 dBm†
Dynamic Range	100 dB	100 dB	80 dB†
Desensitization Level (the level for an unwanted signal when the desired signal first experiences compression)	+8.5 dBm	+3 dBm	+1 dBm†
Conversion Gain	+3 dB*	−6 dB	+18 dB
Single-sideband Noise Figure	6.5 dB	6.5 dB	6.0 dB

† Estimated * Conservative minimum

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Telemetry broadens its scope, monitors weather, pollution, EKGs

Though the requirements for telemetry systems vary from industry to industry, some common guidelines to cost/performance tradeoffs can be deduced; recent trend is the move to all-digital systems for finer control

by Lyman J. Hardeman, *Communications & Microwave Editor*

☐ With a boost from the technology developed by the aerospace industry, telemetry and control systems have penetrated new markets such as pollution control, weather monitoring, and vehicular testing. This advance, combined with a steady expansion in the requirements of the pipeline and electric utilities, promises the industrial telemetry industry a healthy future.

By definition, telemetry is measurement at a distance. It is part of the much larger industry of data communications, which covers the transfer of any information between any two points. For present purposes, telemetry excludes industrial process control, which does not involve the long-distance transmission of data, but does include the expanding field of supervisory control, which involves both remote measurement and remote control.

General requirements for telemetered signals

Because telemetry systems serve such a variety of industries, the signals they have to relay also vary a good deal—primarily in frequency (or sampling rate) and their required accuracy (see Table 1). In fact, the performance required of a system is primarily determined by these signal characteristics, which are interrelated.

The discrete sampling of analog data can lead to a form of distortion known as aliasing error. The lower the sampling rate in relation to the rate of change of the process being measured, the higher the error. On the other hand, as sampling rate is increased to prevent possible aliasing error, the load on the communications line is increased, to say nothing of the data storage and data reduction requirements at the master station.

As a result, each telemetry system must be tailored to the rate of change of the quantities it measures. For example, the parameters sampled by a weather monitoring system vary slowly, and require from a few minutes to several hours between samples. At the other extreme, vibration and noise associated with vehicular testing systems require sampling rates of 80,000 samples per second and higher to reproduce the measured waveforms with accuracy.

Elements of a telemetering system

Almost every telemetering system includes: a sensing transducer at the remote site; signal conditioners; remote signaling equipment (multiplexers and modulators); a communications link; master station signaling equipment (demultiplexers and demodulators); and displays or data collecting and recording equipment (Fig. 1). Though the telemetry manufacturer's main concern is with the signaling equipment on either end of the transmit-receive link, he often builds or is responsible for other functions in the total system.

The character of the transducer output is as varied as the different quantities to be measured, but is usually conditioned to a standard 0–10-milliampere range or a 0–5-volt range acceptable for further processing. At first, telemetry systems simply hardwired these baseband signals in a dc link between the remote and master stations. These wire-pair links are still used occasionally for short hops when only one or two quantities are to be telemetered. But it soon became obvious that, for greater efficiency and to allow the use of rf links over longer distances, multiplexing and modulating schemes could be useful.

The signaling equipment developed for this purpose has evolved primarily around the standard 3-kilohertz voice-grade telephone channel. If a radio communications link is desired, this 3-kHz subcarrier can then be made to modulate an rf carrier.

Baseband modulation of the 3-kHz channel is accomplished by both analog and digital techniques. Both are widely used in existing telemetry systems.

Analog telemetry, as now defined, refers to a system in which the telemetered data is continuously variable over the measuring range and is not quantized into a discrete binary code. However, to avoid modulation inaccuracies due to phase jitter in the communications link, a direct-phase or frequency-modulation of the communications channel is not often used. Instead, the analog signal modulates a train of pulses, and the envelope characteristics of the pulses carry the desired analog data.

Three basic analog-type modulation systems have evolved (Fig 2). They are: pulse-amplitude modulation (PAM), where the amplitude of a train of pulses varies with the analog input; pulse-duration modulation (PDM), where the time that a given pulse remains in an "on" state varies with the modulating signal; and pulse-rate or variable-frequency modulation (VFM), where the pulse frequency varies with the input, typically between 5 and 30 pulses per second.

Pulse-amplitude-modulation systems are seldom met with in practice. The reason is that they suffer from

TABLE 1: TYPICAL SIGNAL CHARACTERISTICS

Application/Parameter	Typical Sampling Rate	Typical Error Allowed (% of full scale)
Environmental control		
Dissolved oxygen	1 spm*	±1%
Temp (air and water)	<1 spm	±1.5%
Sulphur dioxide	<1 spm	±2 %
pH	<1 spm	±0.1 pH unit
Solar radiation	<1 spm	
Power utility		
Volts, amps, vars and watts	1 sps**	±0.5 – 1%
Medical monitors		
EKG (diagnosis)	400 sps	2%
EKG (monitoring)	100 sps	10%
Blood pressure	1 sps	2%
Vehicle testing		
Fluid pressure	20 sps	5%
Vibration	50 k sps	2%
Temperature	1 sps	1%
Velocity	10 sps	1%
Noise	200 ksps	NA

* spm = samples per minute
** sps = samples per second

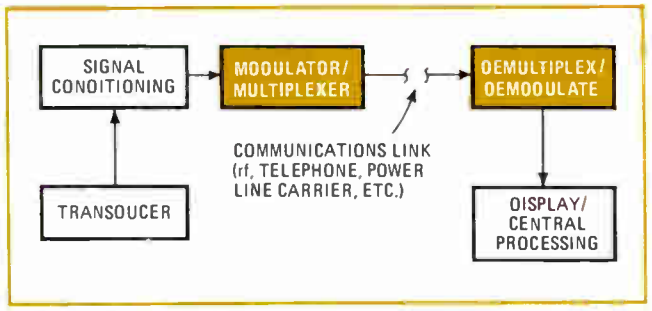
variations in attenuation of the transmission medium.

A PDM pulse typically lasts 5 or 10 seconds, so this technique is generally used only for slowly varying data requirements. Measurement error is about ±1% or more. However, the method is easy and inexpensive to implement, requiring little more than a bistable multivibrator to achieve the pulse envelope. The technique is often used for simple remote-control functions, like the control of model airplanes and boats.

Variable-frequency telemetry is widely used in the pipeline and electric utility industries, where fairly low error (less than 1%) and quicker response times (more than one sample per second) are required.

Pulse-duration modulation and variable-frequency modulation are similar, except that PDM employs a fixed cycle or frame rate and has a varying duty cycle, while VFM has a fixed duty cycle (usually 60%) and a varying frame rate.

As in the rest of the communications business, the general trend in telemetry today is away from analog and toward the more expensive, all-digital systems. Here, analog data is coded into a binary form before being processed at the remote terminal.



1. Telemetry components. Six components are basic to a telemetry system. Although often a total systems contractor, the telemetry equipment manufacturer is primarily concerned with the signaling equipment on each end of the communications link.

This shift has occurred in response to system requirements for greater size, speed and accuracy, and to the fact that an increasing number of systems use the computer for digital processing at the master station. And telemetry engineers are finding that, at the higher end of the performance spectrum, the over-all economy of the all-digital systems more than offsets the increased cost of digital signaling equipment.

The all-digital signal is much less susceptible to noise and distortion in the communications link than its analog counterpart. The only error introduced in digital systems is an occasional bit loss, and sophisticated error-detecting and-correcting techniques decrease the probability of this type of error to almost zero.

The communications link

The choice of a transmission link between a remote and a master station is generally independent of the type of signaling equipment and methods used—and heavily dependent on cost and availability. The transmission link may be, more or less in order of popularity, a leased telephone voice-grade channel, vhf or uhf radio, microwave radio, power-line carrier communications channels, the ubiquitous dial-up phone network, or a wire-pair.

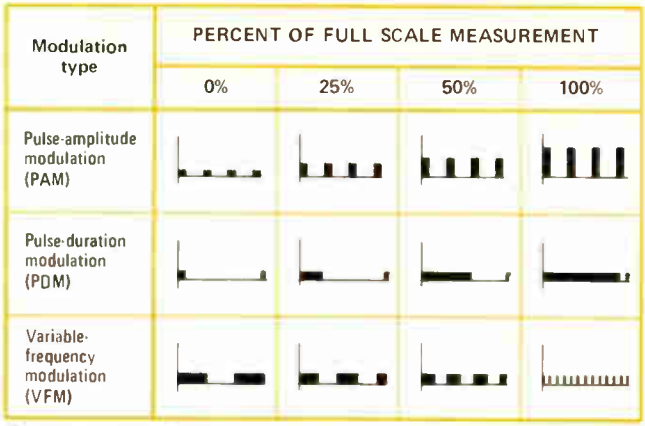
A rough comparison of voice-grade channel costs is found in Fig. 3. As shown, the leased telephone channel turns out to be best in most situations.

Radio channels are often used in remote areas where alternative transmission means are not available, in vehicular testing, in medical systems requiring a mobile remote station, and for remote measurement and control in hazardous areas such as atomic-energy facilities and high-voltage transmission-line environments.

In general, non-Government telemetry channels are allowed in the already overworked mobile radio bands at 150 and 450 megahertz on a shared basis, and in the 216–220-MHz Government telemetry bands, also on a shared basis. In addition, some narrow guardbands between mobile radio channels (called splinter frequencies) are being used. And when it is a case of very low powers in an indoor environment, the 88–108-MHz broadcast band has been employed. As can be seen, telemetry radio users have had a scramble to find spectrum space.

Effective May 9, 1972, however, seven new frequency pairs are now available exclusively for biomedical telemetry. Master stations, whether fixed or mobile, have been allocated seven frequencies in the 460–463-MHz range, while mobile-only stations are allocated corresponding frequencies in the 465–468-MHz range. According to this recent Federal Communication Commission's rule, "the new frequencies are primarily for telemetry transmission and secondarily for radiotelephony associated with the telemetry operations."

The dial-up phone network is beginning to find its way into telemetry systems, especially for environmental measurements or low-priority electric utility substations, where the remote station requires probing only once every several hours or longer and dedicated tele-



2. Analog telemetry. Although they are characterized by pulses, these modulation schemes provide information which is continuously variable, or analog, over the measuring range. The data is not quantized into discrete codes.

phone lines cannot be justified on economic grounds. To supply this need, a few companies are now marketing products that automatically dial distant stations.

One of these telemetry dialers was recently introduced by Quindar Electronics, Springfield, N.J. With the Quindar unit, a call can be originated by either a master or a remote station by means of standard touch-tone coding. The master has the capability of calling 99 10-digit numbers. The remote can call only the master. The time it takes to establish a connection is about 32 seconds. If the channel is not established within a predetermined time, the automatic dialer will "hang up," wait a programed time, and try again. After the message exchange is completed, both ends automatically terminate the connection.

Multiplexing for communications efficiency

The method adopted for multiplexing, or combining low-speed data channels into a single communications link, is determined mainly by the resulting cost per channel (see Fig. 4).

Frequency-division multiplexing tends to have a cost per channel essentially independent of the number of channels, but is cost-competitive for systems with about 10 channels or fewer. A time-division multiplexed system suffers from a cost disadvantage for systems with fewer than about 10 channels, but solidly outperforms competing techniques as the communications link becomes loaded with more than 10 data channels.

For short-haul monitoring systems, where hardware communications can be installed, multiple data signals are occasionally transmitted on separate wire-pairs. This technique can be considered as a form of space-division multiplexing, where each signal takes a different physical route.

Getting the right message through

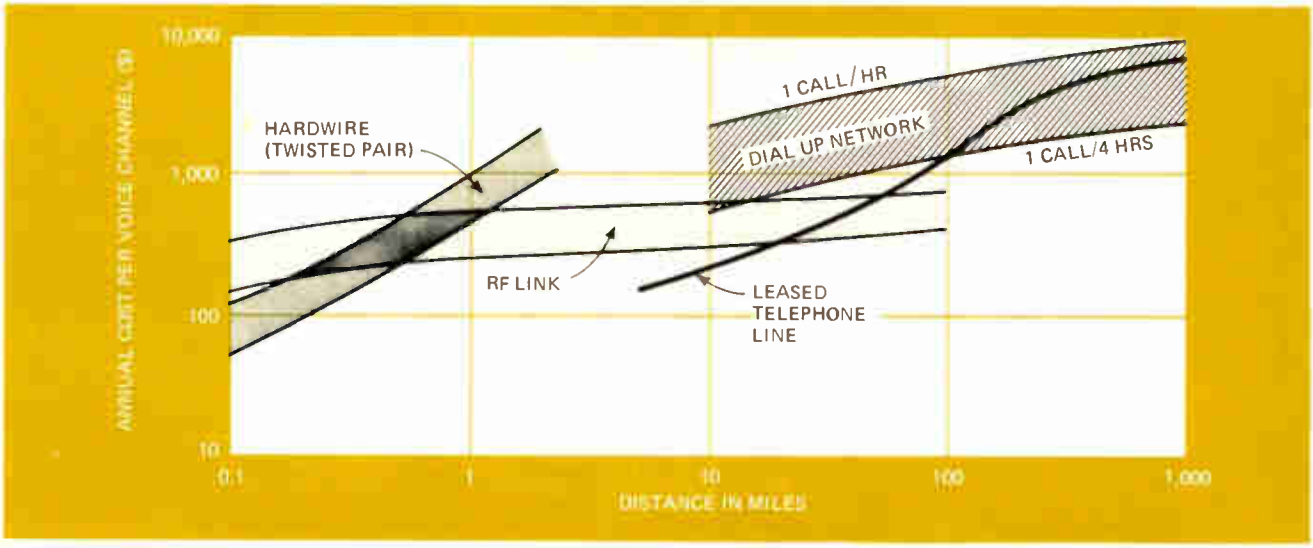
Many situations in industrial telemetry require a very high degree of certainty that there be no errors in the information transmitted. In electric power distribution systems, for example, errors in commands to control switches could prove disastrous if they were not detected and corrected.

Several coding techniques have therefore been developed to aid in detecting false data and safeguarding the communications link. In general, the circuitry required to implement this coding is simple, compared to the signaling and transmitter circuits. Although some of the sophisticated codes can be used to correct any errors they detect, virtually all systems used in industrial telemetry simply retransmit the signal.

The more common detection methods employed in telemetry systems include two-out-of-five coding, dual transmission redundancy, select-before-operate with check-back, and the Bose-Chandhuri (BCH) code. For any specific system, various combinations of these techniques may be used. The choice of method is determined mainly by a tradeoff between the effectiveness of the security obtained and the efficiency of the technique in terms of its added requirements of the communications link.

Dual transmission of a message is a very straightforward way of improving security and is inherently

3. Transmission tradeoffs. The leased private phone line is least costly in most telemetry applications. For data update requirements of less than one sample in four hours, the ubiquitous dial-up phone is sometimes useful and profitable.



50% efficient. However, it often doesn't provide the level of assurance necessary.

A more efficient scheme is the two-out-of-five parity code. Here, for every word of five bits, two of the bits are always transmitted high and three bits low. The five-bit word contains from four information bits and a parity check bit in a 7-4-2-1-check code. For example, the digit "5" would be transmitted in the binary form 01010. Notice that the final check bit is controlled to ensure that exactly two bits in the code are high (binary 1). If the receiver detects something other than two high bits, retransmission is requested.

The BCH code treats a message, usually 24 or 32 bits in length, as a polynomial, with the binary digits as the coefficients of the polynomial. For example, a four-bit message may be 1010, or in polynomial form, $1x^3 + 0x^2 + 1x^1 + 0x^0$. This message polynomial is then divided by a predetermined "primitive" polynomial, and the remainder, in binary form, is added to the message transmitted. The primitive polynomial is chosen for each message length to provide the maximum level of security. For any given system, the primitive polynomial is fixed. The receiver equipment performs the same division of the message and checks its remainder with that transmitted. In practical systems, retransmission is requested if errors are detected.

In addition to error-detection coding, a "select-before-operate" technique is often incorporated into systems requiring high-level security. Since communications efficiency is sacrificed with this method, it is generally limited to control applications where very little information actually need be transferred.

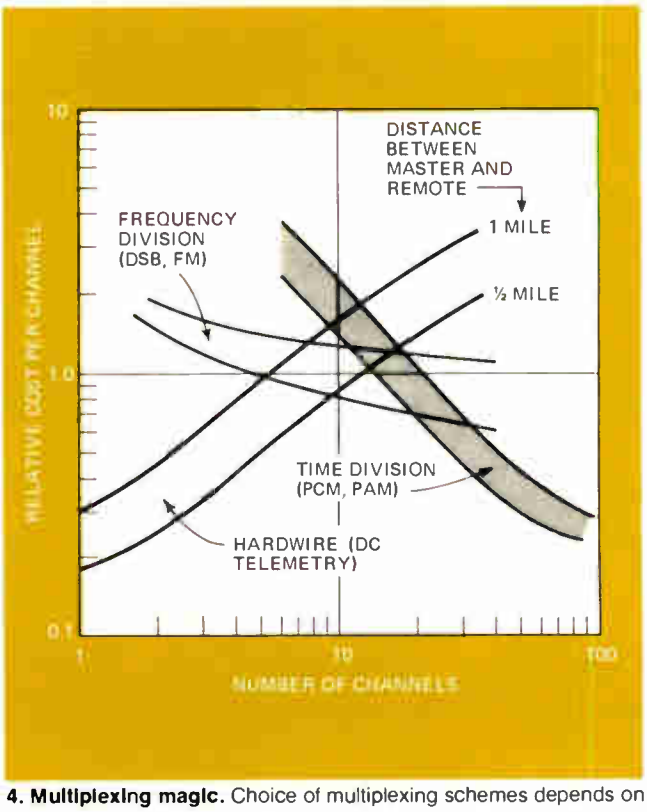
With the select-before-operate scheme, the remote station is sent an enabling address-with-command that allows the remote to operate with a second command. A checkback signal then informs the master station that a valid command has been received and that the remote is ready for a final command. This command is obeyed, and subsequently the new status is telemetered back to the master. Select-before-operate security can be put into effect fairly easily with either solid-state logic circuitry or electro-mechanical relays.

Nature of the business

Unlike many other electronics endeavours, the industrial telemetry market is highly segmented. While one company may choose to supply the power utility and pipeline fields only, another company may use essentially the same technology to supply water pollution controllers.

"The design and configuration of our equipment to meet system requirements is relatively simple and secondary. The real job is to learn in great detail the nature of the industries we supply," explains Earl Channel, manager of EMR Telemetry's instrumentation department in Sarasota, Florida, whose company zeros in on pollution control and vehicular testing systems. His comments are echoed and rigidly followed by almost every other marketing and product line manager in the business.

So if the present and future potential for telemetry and control equipment is to be understood properly, it is helpful to take a look at representative requirements



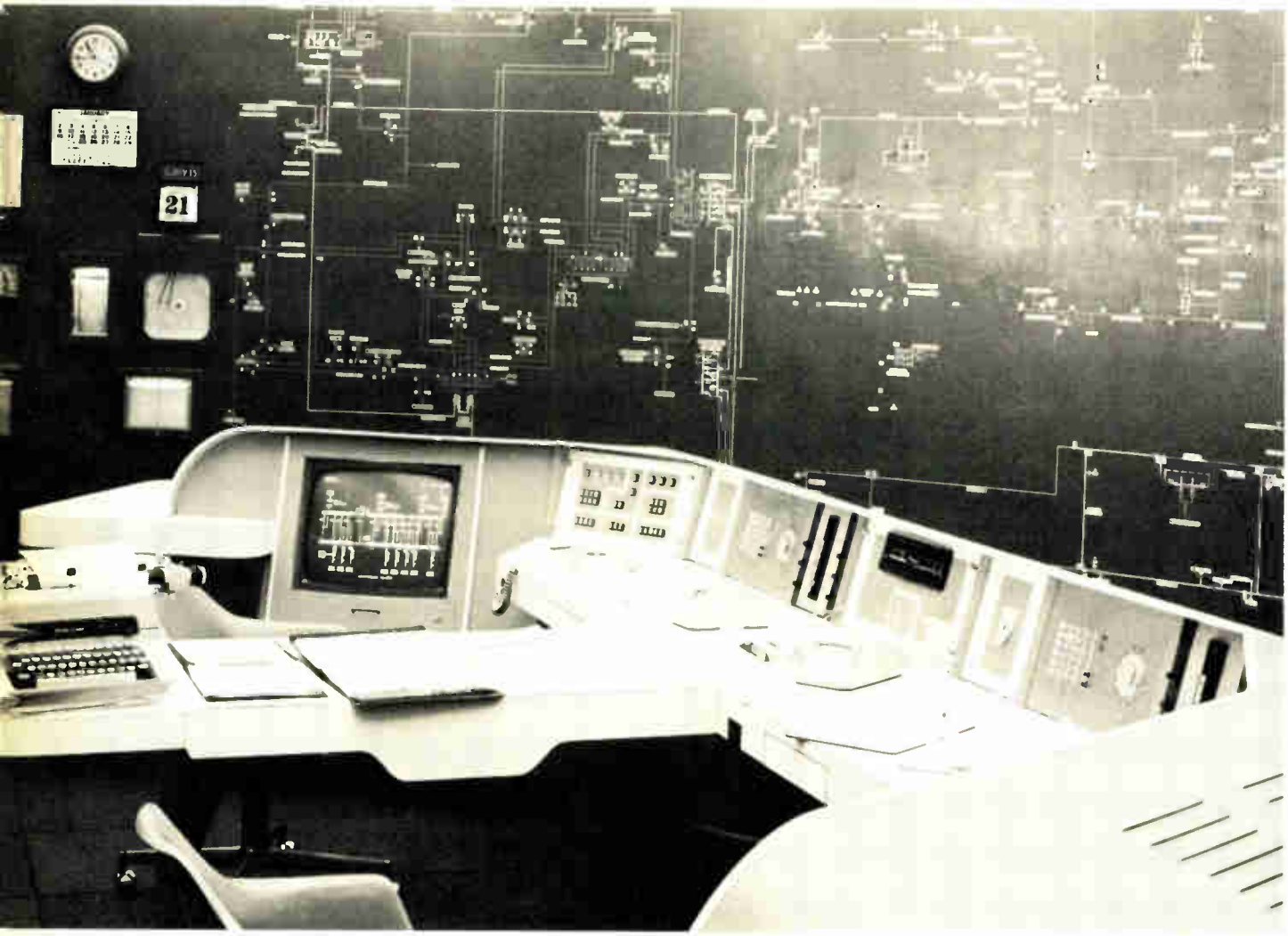
4. Multiplexing magic. Choice of multiplexing schemes depends on the number of channels required. For systems with 10 channels or over, time-division multiplexing is hard to beat.

and typical installations in each of the major market segments. Major industrial users are: electric utilities; pipeline utilities (both liquid and gas); hospitals; traffic controllers; environmental controllers; vehicle testers; and the railroads. The sizes of these market segments are given in Table 2.

Electric utilities are the largest and probably the most sophisticated users of telemetry equipment. Telemetered information required at the master station includes the status of distribution switches, transformer tap positions, and the volts, amps, vars and watts readings at critical points in the remote substations. The more recent electric utility systems are computer-controlled, and telemetered data is presented on a color cathode-ray-tube display instead of the analog panel meter and wall incandescent light displays showing power routing.

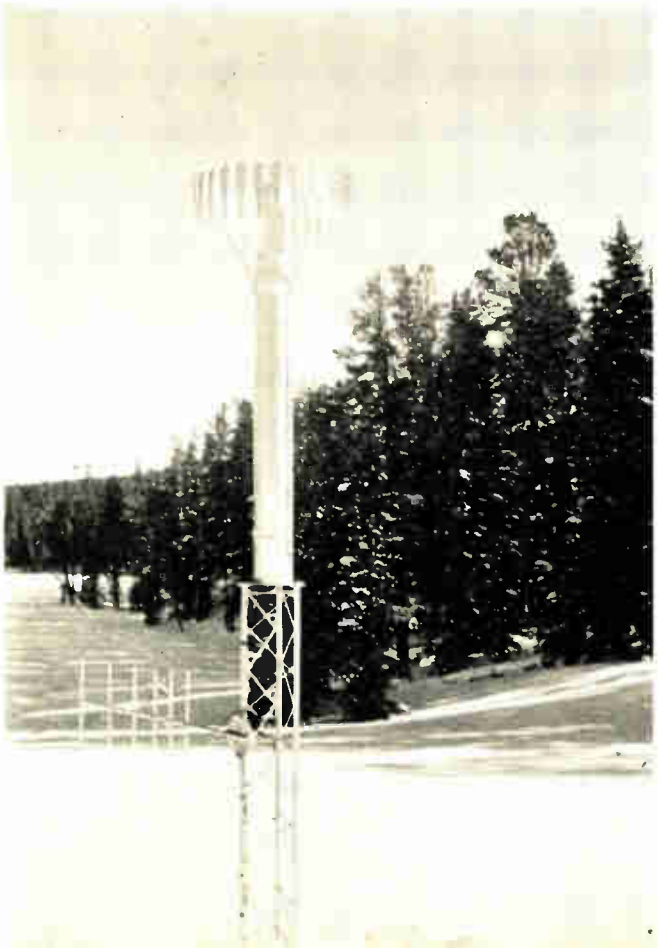
One such system is now being tested at Consolidated Edison Co. in New York City. Installed by Quindar Electronics, Inc., Springfield, N.J., it is a departure from the power company's traditional one-master/one-remote philosophy. Where inputs from multiple remote stations have in the past been received by separate master consoles, this entire system is now integrated with central control.

Control of remote station function is still performed manually by the operator at the master station. Taking the human being out of this control loop is a large step for the conservative power industry, which generally feels that the trained operator is in a better position to make the control decision than the programed computer. Jim Stites, marketing manager for the Westinghouse Relay and Instrument Div., Newark, N.J., is



5. Compact console. A modern console with color CRT displays can replace a wall covered by telemetered data (background) that show electric utility's substation status. Getting away from a one-master/one-remote philosophy, the new master station now processes data from 20 or more remote stations. This console was built for Pennsylvania Power & Light by Radiation's Control division.

6. Environmental relay. Battery-powered remote stations relay hydrological data over radio to a central base. On top of the mast is a shielded precipitation gauge. Yagi antenna feeds the uhf transceiver which is buried in snow. This station in Utah was installed by Thiokol Chemical's Wasatch division for the U.S. Forest Service.



confident that the totally computer-controlled systems can meet the reliability requirements of the industry, but feels that "automatically closing the loop is still several years away."

Oldtimers supplying telemetry gear to the electric utilities are Westinghouse, General Electric, Leeds & Northrup (previously Automatic Electric), and Radiation Inc.'s Controls Division (previously North Electric). Other active suppliers include Control Data Corp., Quindar Inc., RFL Industries, and TRW.

Environmental control

The greatest growth area in industrial telemetry is almost certain to be in environmental control systems. These systems vary widely in purpose, and range from the short-distance single-channel telemetering of a processing plant's wastes to nationwide networks such as the one presently being installed in the Netherlands [*Electronics*, June 5, p. 75].

Numerous air-pollution reporting systems are already being used in such U.S. cities as Los Angeles, New York, Denver, Philadelphia, and Chicago. The real advantage of systems such as these is that telemetered data is available at one control point—in real time. "This for the first time enables city officials to forecast a temperature inversion and to alert major air polluters to cut back in time to soften its effect," says Hank Brown, director of marketing for Motorola's Applied Systems Unit in Washington, D.C.

On a much broader scale, hydrological data acquisition systems have been installed over vast territories such as the Pacific Northwest. A typical system is one developed for the U.S. Geological Survey by Thiokol Chemical's Wasatch division in Ogden, Utah. The system, currently using about 20 remote stations, provides the Government agency's Tacoma, Washington district headquarters with such data as water and snow conditions, temperature, wind speed and direction, humidity, and stream levels.

The measurement of remote hydrological conditions does not solve environmental problems of itself. This information is used when processed to determine optimum conditions for controlling hydroelectric and flood reservoir levels, to project river flow rates, and to provide a base for studying long-term environmental trends. It is anticipated that telemetry systems such as the one described above will expand and be integrated with other systems to provide even greater data bases in the future.

In the medical world, telemetry's main use is for remote recording of electro-cardiograms. This is necessary either in emergencies, when ambulances are carrying patients to hospitals, or in more routine circumstances, to monitor coronary cases during their recovery in the hospital.

Heart of problem

To allow for detailed analysis in the emergency case, a bandwidth from 0.05 to 100 hertz is required to accurately reproduce an EKG at a central point. The waveform obtained allows a licensed physician to diagnose the EKG waveform and prescribe treatment to be administered by paramedical personnel in the ambulance.

TABLE II: TELEMETRY MARKET BREAKDOWN (1972 ESTIMATES IN $ MILLIONS)

Electric utility	24.0
Pollution control	5.3
Weather monitoring	5.0
Pipeline (liquid and gas)	9.0
Traffic control	5.0
Medical	6.5
Railroads	0.7
Vehicular testing	1.5
Total	57.0

Statistics show that the use of these systems significantly increase a coronary patient's chances of getting to the hospital alive.

During recovery in the hospital, the patient's EKG must be continuously monitored. The use of dc wirepairs makes this easy to do for the bedridden patient. But for several days before a patient's release, he has to exercise and move about. This means weaning him away from wired devices.

To answer this need, a number of companies have designed fm radios to telemeter EKGs to a central point in the hospital. The frequencies used are often in the commercial broadcast band, but power levels are below the Federal Communications Commission's interference standards. Since the resulting EKG is not being critically diagnosed, less bandwidth is required of the transmission system. Typical monitoring bandwidth is 0.5 to 50 Hz.

Trend to larger systems

Following the general information explosion in data communications, there is a definite trend toward integrating the systems considered here into even larger systems with central control. In electric utilities, this means an emphasis on applying telemetry to high-voltage distribution networks, in addition to the substation monitoring and control which predominates today. For environmental telemetry the larger systems will require greater coordination between interested users—various Government agencies, hydro-electric utilities, and potential industry polluters.

All-digital telemetry, with time-division multiplexing of data channels, is very cost-competitive in these expanded systems. As a result, these systems will undoubtedly make their way into an even greater number of future applications. □

Collector diffusion isolation packs many functions on a chip

Now that it has been refined, the CDI process can be used to build LSI arrays that combine the simplicity and function density of MOS with the performance of bipolars

by D.L. Grundy, J. Bruchez and B. Down, *Ferranti Ltd., Oldham, England*

☐ Collector diffusion isolation (CDI) was despaired of too soon. Usable breakdown voltages and straightforward transistor fabrication proved possible, after all, and the future now is bright: CDI can achieve 1,000 gates on a chip with a 5-nanosecond delay, provided power dissipation from such a complex package is not a problem. (Delays of 1 ns are achievable, for that matter, but dissipation would prevent the use of such a circuit.) In addition, the process, a practical approach to large-scale integration, works for both linear and digital functions, enabling the designer to put both on a single chip and to do away with many interface problems.

To date, all circuit functions for a large memory have been checked out on a test chip at Ferranti Ltd., and designers expect to have a 1,024-bit memory chip by the end of 1972. They hope to achieve an 80-ns access time for the chip.

Two advances have been responsible for this progress. When the isolation technique was originally suggested at Bell Laboratories,[1] circuits made with it had a breakdown voltage of only 3 volts, and fabricating a bipolar pnp transistor proved very difficult. Investigators at Ferranti, however, succeeded in pushing the breakdown voltage up to 7.5–8.5v, so that the circuits can be used in the same system with 5-volt transistor-transistor logic, and also make it easy to build p-channel junction-field-effect transistors.

How it's better

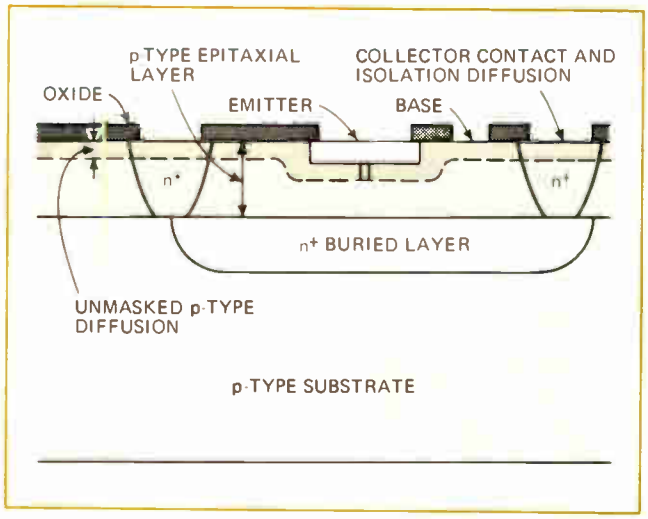
In conventional bipolar integrated circuits, much of the silicon chip area is occupied by the isolation diffusion, which separates transistors from one another and reduces the difficulties presented by the parasitic transistors that would otherwise be present. The area of isolation is further increased by the tolerances that must be allowed for the various diffusion steps because of registration problems with the masks and because added materials tend to diffuse in all directions under the mask edges and not just straight down. These tolerances are even wider because the several epitaxial layers used in conventional processing are relatively thick—6 to 16 micrometers—and therefore aggravate the problems of sideways diffusion.

Collector diffusion isolation not only eliminates the separate isolation barrier that conventional processing requires, but uses epitaxial layers no more than 2 μm thick. Furthermore, only five masking steps are necessary, compared with up to nine in conventional bipolar ICs and four in metal-oxide semiconductors.

The CDI construction begins with a layer of n^+ material diffused into a p-type substrate (Fig 1). This is the buried layer, placed under every transistor, diode, and resistor in the completed array. Over this is grown a 1.5-micrometer p-type epitaxial layer. This layer's high resistivity, its thickness, and the concentration and depth of the p^+ material combine in a complex way to produce CDI's resistance to voltage breakdown. Thirdly, a masked n^+ diffusion is made through the p-type layer, contacting the first (now buried) n^+ layer, providing isolation and defining the base and resistor areas. The n^+ diffusion completely surrounds each island of the buried layer. The fourth diffusion, made without a mask, forms a shallow p-type layer over the whole slice; its sheet resistivity, with the shapes previously defined by the n^+ diffusion, gives resistors in the completed IC their desired values.

Fifthly and finally, a small shallow diffusion of n-type material is placed in the p-type epitaxial layer to form the emitter of the transistor. It pushes the p-type skin diffusion down into the p-type epitaxial layer, improving transistor f_t and thus giving faster switching in digital circuits and higher frequency in linear operation.

In total, CDI uses eight fewer processing stages than



1. CDI structure. Only five processing stages are required to build an integrated circuit with collector-diffusion isolation—eight fewer than conventional processing requires, so that yields are better.

conventional processing, thereby improving yields. The eight omitted steps are gold diffusion, a separate deep collector contact photoresist deposition, base photoresist deposition, contact photoresist depositions in excess of one, a separate p^+ glassing stage, a separate p^+ drive-in stage, oxide deposition after the emitter diffusion, and densification. An even larger number of steps can be omitted in linear processes, depending on the particular process used.

During the fabrication of a CDI wafer, as in conventional processing, the oxide characteristically grows thicker over n^+ areas than over p areas. Furthermore, since the areas of previously diffused n^+ material have moved sideways under the mask, with a gradual decrease in concentration around their edges, the oxide comes to mirror this effect and creates a smooth and nearly flat transition between the two oxide thicknesses, as shown in Fig. 2. It is compared with the conventional thick-oxide process in Fig. 3.

This has two advantages: first, one of the masking steps is eliminated because a single mask gives the proper thickness everywhere. Two contact masks are needed conventionally to provide the necessary thickness variations. Second, in the finished wafer, the metal layer is less likely to crack when it passes over the smooth transition than if it were to pass over a sharp edge in the oxide. This cracking of metal at an edge or step of oxide has been one of the main causes of failure in ICs. And in fact, accelerated life tests have confirmed the high reliability that the smooth transitions inherent in the CDI surface indicate.

In other respects, CDI processing is no more difficult than that of MOS. But it uses only thermal oxides (which means that the critical final passivation is easier to control and is almost completely free of pinholes) and thinner oxide layers (the shallow diffusions require oxide thicknesses of only about 1,500 angstroms, compared to 10,000 angstroms for MOS). Since yield is limited as much or more by pinholes than by any other defect, these advantages promise to keep the manufacturing cost of CDI competitive with, or lower than, that of MOS.

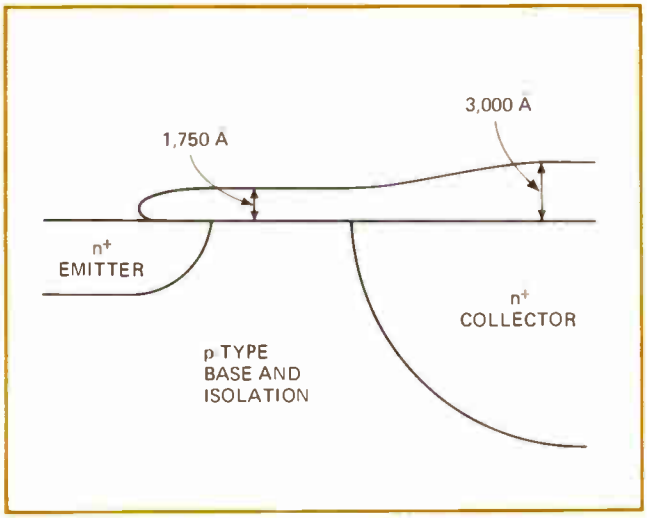
The significant savings in chip area made possible by CDI are shown in Fig. 4. The upper transistor, made with conventional bipolar processing, requires a large area for isolation and collector contact, whereas the lower transistor, made with the same tolerances and emitter areas, occupies less than one third the area.

Another major problem in large-scale integration is how to cross one conductor over another as they pass between devices on a chip. Two solutions have been tried: one uses multiple layers of metalization, and the other uses a diffused "crossunder" of heavily doped material. The former requires the more critical processing steps, while conventional crossunders must be isolated just like transistors and other devices, being, in fact, merely low-value resistors. But crossunders made with the CDI process need only a strip of the isolating n^+ material, without any additional isolation, and are only a quarter the size of conventional crossunders, as shown in Fig. 5.

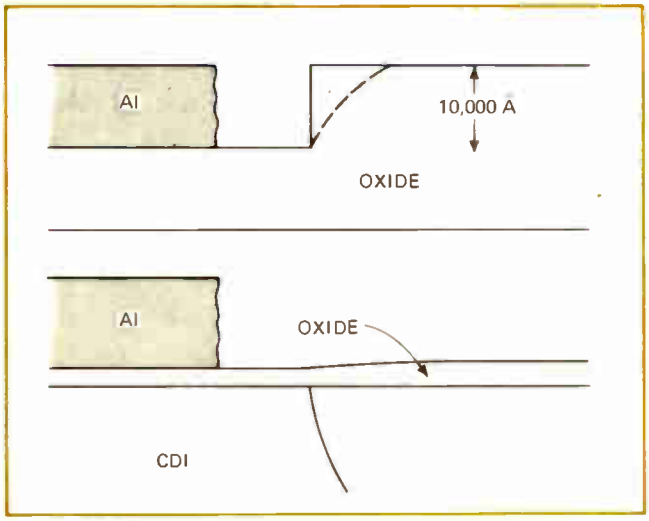
Offset voltage and saturation resistance of CDI transistors, important parameters in switching, are significantly lower than those of conventional transistors, as shown in Table 1. As a result, the saturation voltage at 100 milliamperes is about half that of conventional circuits, and approaches a 1:10 ratio for small currents of 1 mA. This makes the logic level of a binary closer to actual ground, where it is usually assumed to be anyhow. Low offset is a direct result of the transistor's high inverse gain, and the saturation resistance is low because the combined isolation wall and collector contact completely surrounds the transistor.

No gold

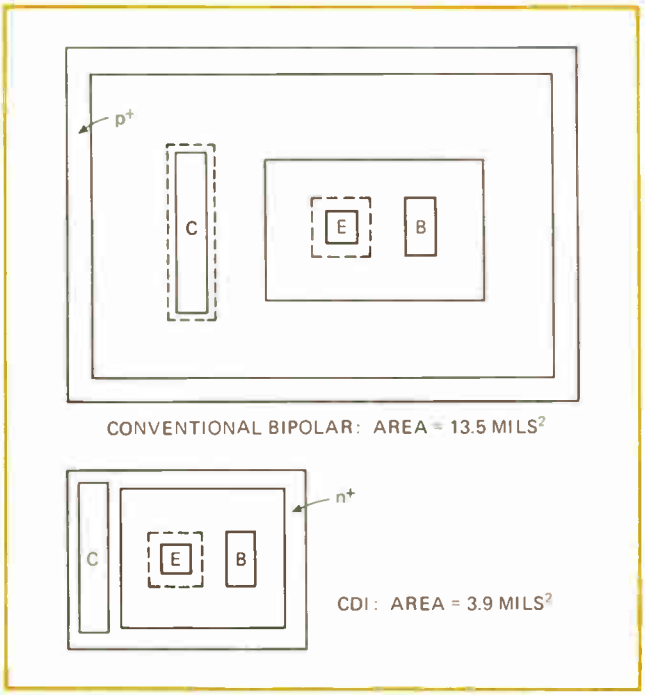
Furthermore, gold doping in the collector is not required in CDI. In bipolar processing, it is needed to speed the turn-off of the saturated transistor. When saturation occurs, both emitter-base and collector-base junctions become forward-biased, and minority carriers are stored in the base and the collector. These stored carriers have to be swept out when the transistor is switched off, causing a delay, and gold doping helps clear them out. But in a CDI transistor, very few carriers are stored by the highly doped collector, while those in



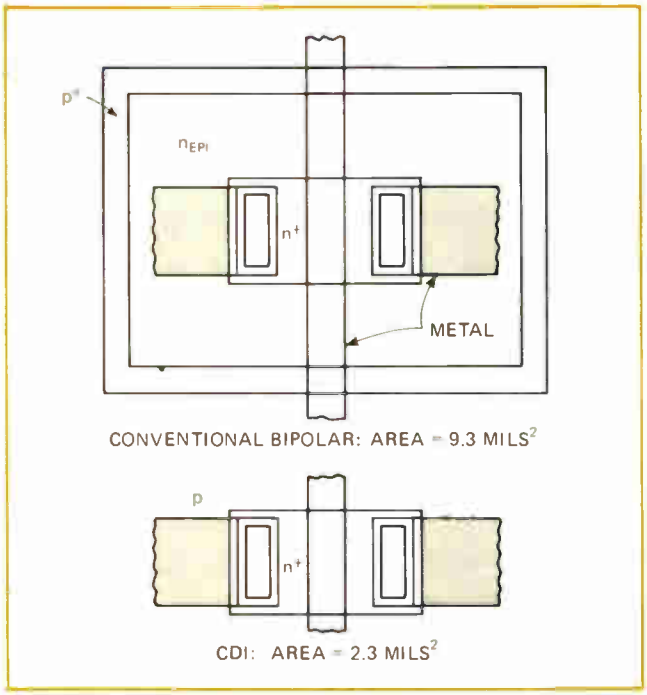
2. Smooth. The nearly flat transition between two oxide thicknesses over n^+ and p areas is characteristic of the CDI process. It eliminates one masking step and improves reliability



3. Contrast. Conventional thick-oxide process leaves a step in the oxide that may be three to five times as high as the oxide thickness in CDI. Metal laid over this step may crack, causing IC failure



4. One-third the area. Small isolation and collector contact areas of CDI reduce chip size substantially. CDI transistor (bottom) is only 3.9 mils², compared to conventional device's 13.5 mils².



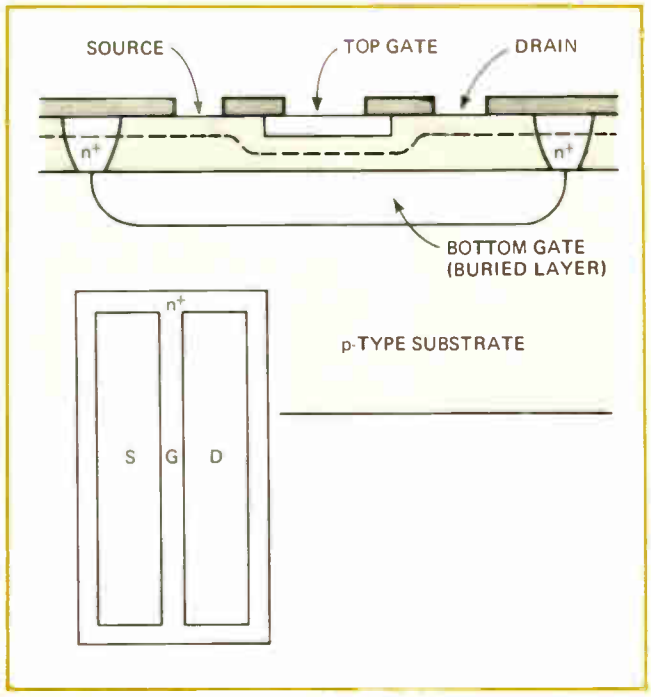
5. Small crossing. Where conductors must cross on a CDI chip, only a strip of n+ material is needed, compared to wide isolation areas or complex multiple metalization in conventional processes.

TABLE 1: SWITCHING PARAMETERS

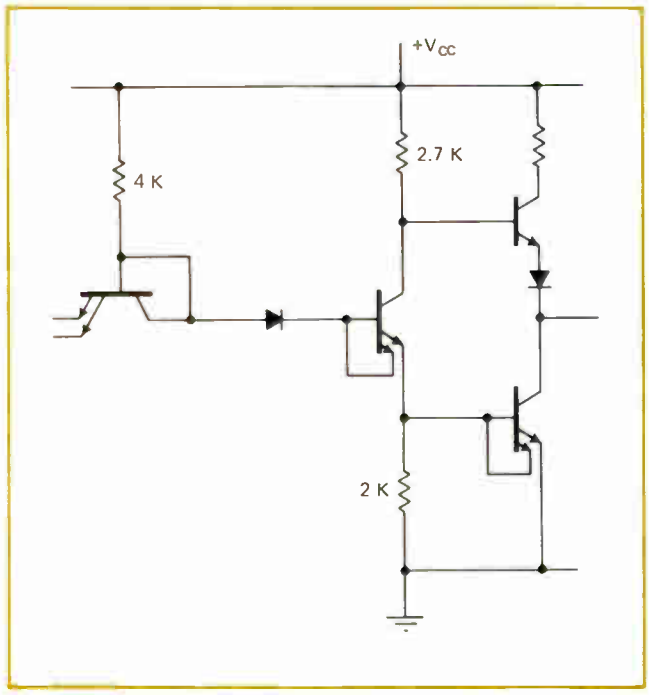
	Offset voltage	Saturated resistance
CDI	3.0 V	8.7 Ω
Conventional gold-doped	80.0 V	15.0 Ω

TABLE 2: COMPARISON OF TYPICAL BIPOLAR, MOS AND CDI CHARACTERISTICS

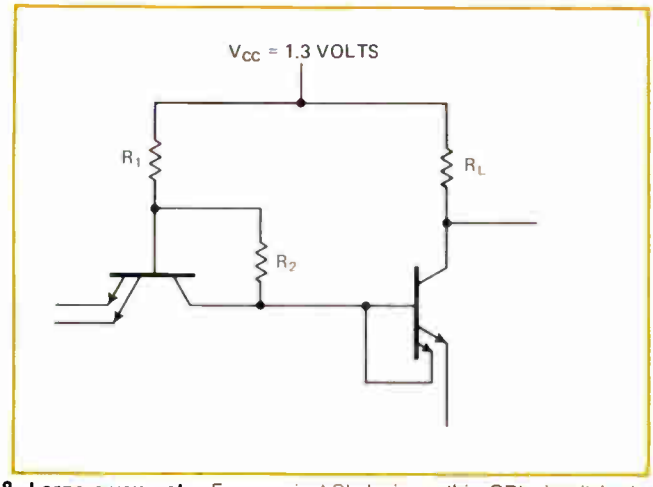
	Conventional bipolar	MOS	CDI
Propagation delay	10 ns	100 ns	5 ns
Dissipation	10 mW	1 mW	2 mW
Speed power product	100 pJ	100 pJ	10 pJ



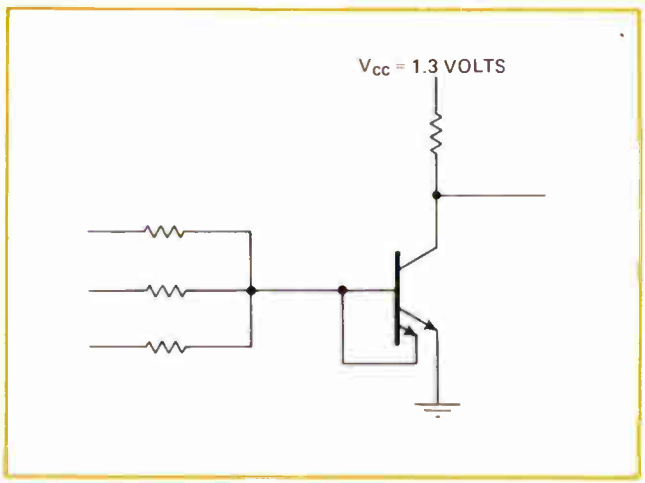
6. Simple J-FET. The buried layer in CDI makes one of the two gates in a p-channel J-FET, which can be used as a current source in much the same way as a conventional pnp bipolar transistor.



7. Single TTL gate. For small-scale ICs driving off-chip circuits, this CDI circuit is equivalent to TTL, although physically it resembles DTL. Diode beyond input switches the transistor quickly.



8. Large-array gate. For use in LSI designs, this CDI circuit both looks and acts like TTL. Feedback emitter in this and other schematics sweeps stored carriers out of base, turning off transistor quickly.



9. Free crossunders. Resistive inputs to this RTL gate occupy space through which crossunders can also be made with negligible additional chip area. Thus circuit is useful in complex arrays.

the base can be cleared out through a second emitter connected through an overlying metal connection back to the transistor's base. When the transistor saturates, the extra emitter acts as a collector and removes many of the extra carriers. Because the connection is optional, it allows slow and fast transistors to be made in the same chip.

This absence of the gold doping is characteristic of linear processing. Consequently, both digital and linear circuits can be made on one chip, a combination that Ferranti calls Digilin.

In Table 2, CDI is shown to have better performance than conventional bipolar circuits. These advantages stem directly from CDI's high cutoff frequency, short storage time, and low saturated resistance.

CDI junction-FETs

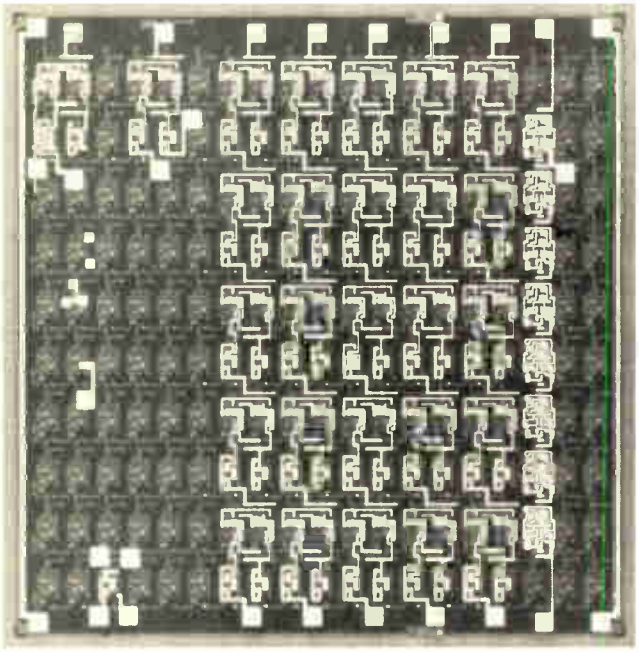
Whereas CDI as first described did not include a means of producing a pnp transistor with the CDI process, a p-channel junction-field-effect transistor can be made quite easily. This transistor can be used as a current source in a similar way to the pnp bipolar type.

The J-FET is made in much the same way as the npn transistor. As its cross-section and plan view in Fig. 6 show, it has two gates, with the conduction channel sandwiched between them. In CDI the buried layer serves as one of the gates. As the voltage on the top gate is increased relative to that of the drain, the two depletion layers from the two gates spread toward one another and eventually pinch off the channel, as in a conventional J-FET.

Digital circuits

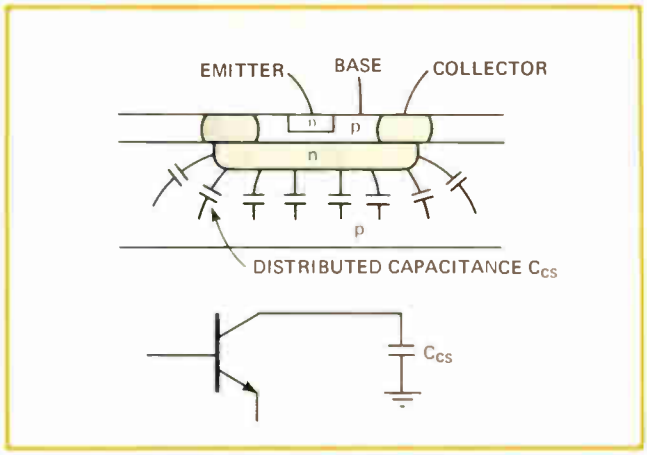
With CDI technology, both static and dynamic logic configurations are practical, just they are with conventional bipolar and MOS technologies.

CDI circuits require only one supply voltage, and can be designed so that this voltage is anywhere between 1 and 5 volts. This supply makes CDI directly compatible with DTL and TTL circuits. Although MOS can also be directly compatible with these circuits and can use a single supply voltage, it is not capable of doing both at once; and its supply may be as high as 30 volts.

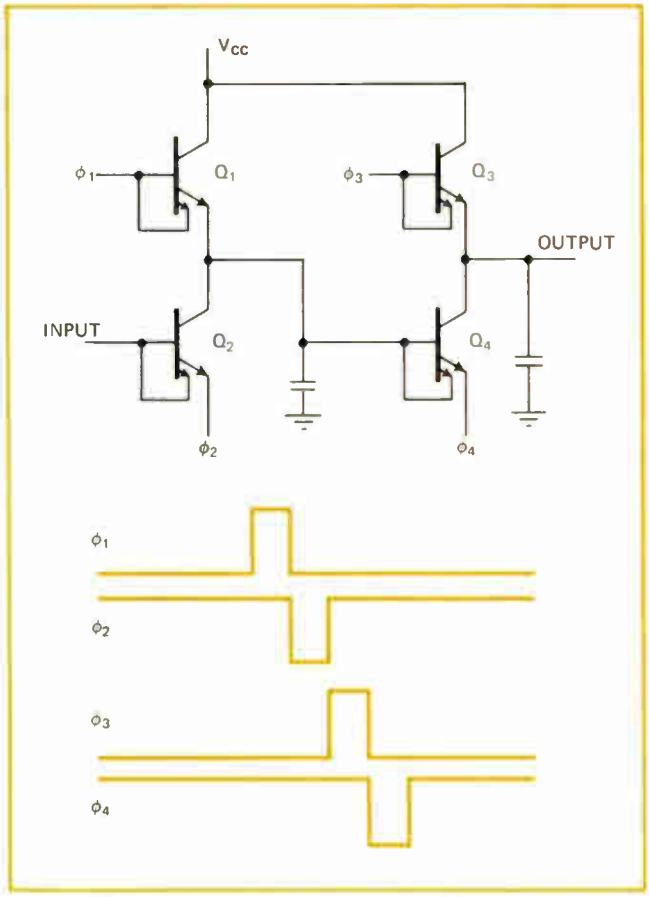


10. Uncommitted. Like some delegates before a political convention, this array of 200 RTL gates is uncommitted to any particular application. One metal layer customizes it to any requirement.

A CDI equivalent of an individual TTL gate, shown in Fig. 7, is significantly different from conventional TTL in several ways. First of all, although the input transistor has the usual multiple emitter, its collector and base are short-circuited, so that the configuration is actually DTL. This connection is necessary to compensate for CDI's high inverse gain. Beyond the input transistor is a diode formed from the collector-base junction of another CDI transistor. In the absence of gold doping in the collector, this diode stores a large quantity of charge, which helps switch the following transistor quickly. (In conventional gold-doped DTL, a small capacitor shunting the diode is necessary to achieve the fast switching.) The output circuit is similar to conventional TTL; the phase-splitting transistor and the pull-down transistor use the feedback emitters, as described previously. No feedback emitter is necessary in the pull-up transistor, because it is an



11. Collector-substrate capacitance. This capacitance is the basis of dynamic logic in CDI, as gate capacitance is the basis in MOS. Transistor operates in inverse mode, for low leakage.



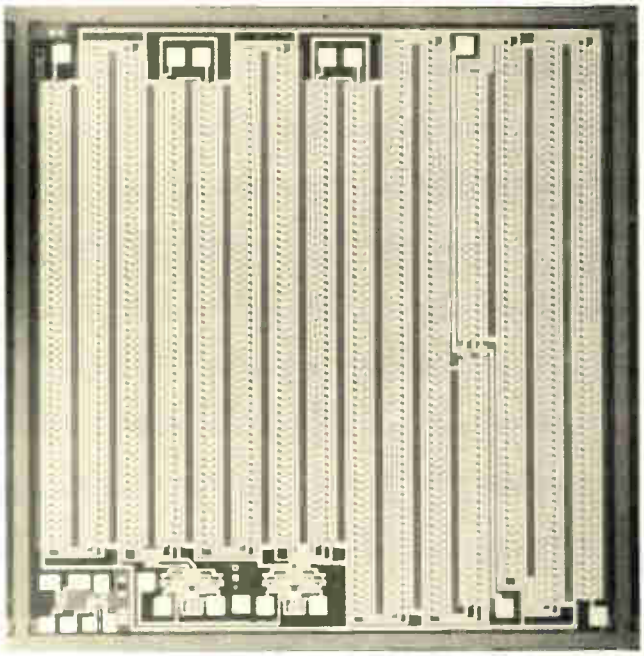
12. One-bit dynamic storage. Operating like its MOS counterpart, this circuit stores data on its output capacitance, inverting and then reinverting it with each cycle of four clock pulses.

emitter follower, and therefore cannot saturate.

The CDI equivalent of conventional TTL, shown in Fig. 8, is preferred for large arrays operating at medium speed.[2] Its speed-power product is about 10 picojoules; the resistors in the input transistor circuit have a ratio chosen to prevent saturation and problems with inverse gain. The output transistor has a feedback emitter.

A simple resistor-transistor logic (RTL) gate, shown in Fig. 9, has a particular advantage in CDI that it doesn't have in other technologies. Because it uses input resistors, which on an LSI chip are elongated rectangular areas of doped semiconductor material, crossunders for an average of six metal conductors can be made at each resistor with negligible chip areas relative to the area of the resistor. This crossunder is "free." The RTL circuit is therefore useful in complex arrays.

A modified RTL gate uses a separate transistor on each logic input, in contrast to the more common connection of the input resistors of Fig. 9. Since these transistors draw smaller base currents than the simple resistor network, they present less of a load to the preceding circuit, so that the fanout for this logic gate is greater than for the simpler gate with the pure resistive input.



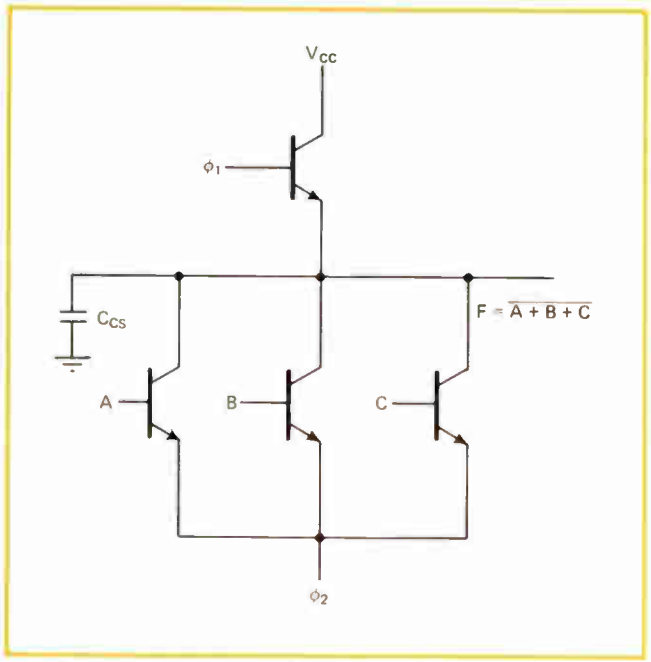
13. 1,024-bit shift register. This CDI chip contains four shift registers of 256 bits each, placed end to end. The schematic of a single cell on this chip is in Fig. 12.

TABLE 3: DYNAMIC PARAMETERS

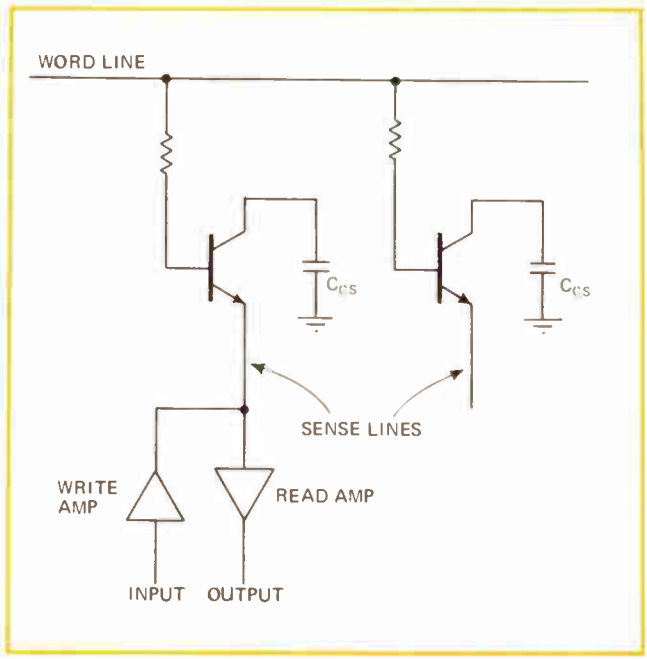
Parameter	Typical value
Upper cutoff frequency f_T	1 GHz
Saturation resistance	10 Ω
Leakage	10 pA
Normal current gain β_N	60
Inverse current gain β_I	20
Offset voltage	5 mV

Customized logic

Another RTL modification is the basis of a large uncommitted logic array being developed at Ferranti. The array contains 200 gates and can be customized to fit any application with a single metalization layer added to the basic standard unmetalized chip (Fig. 10). Power and ground connections in the circuit are fabricated from semiconductor material, so that no conflict can arise between these connections and whatever the customer's requirements may be in the metal layer.



14. Dynamic logic. This three-input NOR gate can be inserted in place of transistor Q_2 in the dynamic cell of Fig. 12. Thus the basic cell can be used for logic as well as for storage.



15. Random-access cells. Ferranti is developing a 1,024-bit random-access memory based on dynamic storage cells like these two. Target access time will be about 80 nanoseconds.

TABLE 4: FUNCTION DENSITY

Function	Chip area in square mils		
	Conventional bipolar	MOS	CDI
Flip-flop	250	60	35
Four-phase shift register position	NP	17	17
Static gate	100	30	20

NP = Not Practical

Dynamic logic in CDI is based on the capacitance between the collector and the substrate (Fig. 11), just as in MOS it is based on gate capacitance. This capacitance depends on the low leakage of a CDI transistor operating in its inverted mode—that is, with the roles of collector and emitter interchanged. If both the normal emitter and the base are taken to a positive potential of, say, 5 volts, then the collector-to-substrate capacitance charges to this level, minus the voltage drop across the collector-base junction. Then if the base is returned to ground potential, the capacitance discharges at a slow rate determined by the transistor's leakage current.

The switching speed of a CDI transistor is not limited by the series resistance—which is very low, typically about 10 ohms—but is set by the cutoff frequency, which is about a gigahertz. If the load capacitance is 3 picofarads, the charging time constant is about 30 picoseconds. The corresponding cutoff frequency is therefore quite respectably high, and gives a complete charge and discharge cycle of the load capacitance in less than 10 nanoseconds.

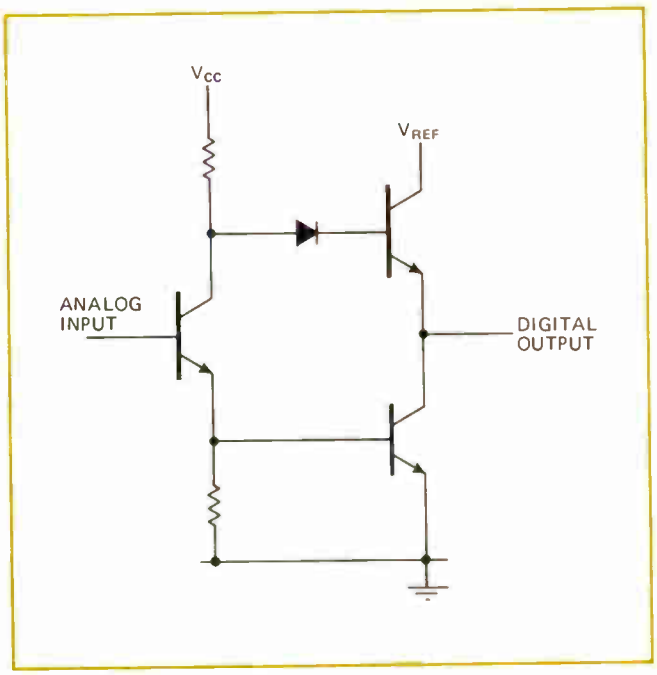
The power dissipation in any dynamic circuit is the product of the switching frequency, the load capacitance, and the square of the capacitance voltage. For the CDI, these circuit values are typically 20 megahertz, 3 pF, and 1 volt, respectively, giving a power dissipation of 60 microwatts. The corresponding speed-power product is 0.6 picojoule—a considerable improvement over the product for static circuits and an order of magnitude better than the product for MOS technology.

The low-frequency cutoff is determined by leakage currents, as well as temperature. For reliable operation at 70° the cutoff frequency is about 1 kilohertz. Dynamic logic circuits built on the basis of the characteristics discussed above include a four-phase shift register and a dynamic random-access memory.

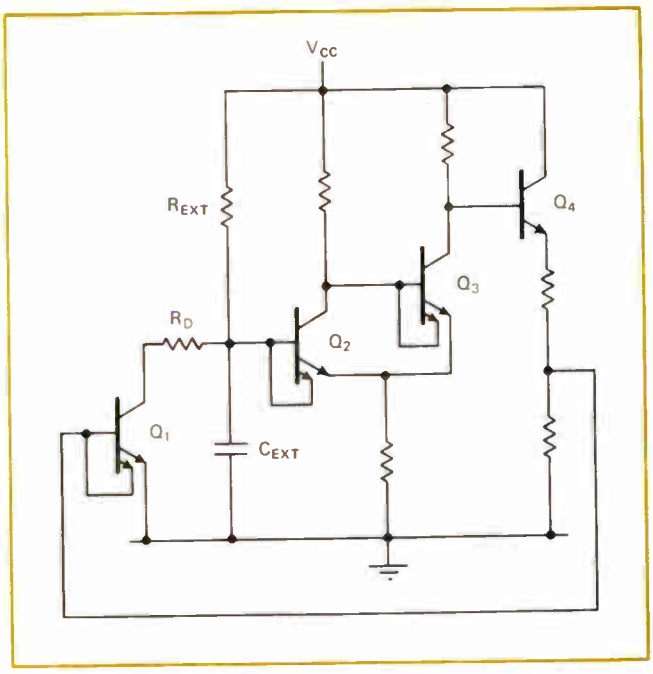
The shift register (Fig. 12) closely resembles its counterpart in MOS, in that each stage of the register contains four transistors. When a stage is momentarily at rest, phases ϕ_1 and ϕ_3 are down, and phases ϕ_2 and ϕ_4 are up. During a shift, ϕ_1 goes up, turning on Q_1 and charging the collector-substrate capacitance of Q_2 to the level of ϕ_1, minus the base-to-emitter drop of Q_1. Then both ϕ_1 and ϕ_2 go down. If the output capacitance of the preceding stage is charged, Q_2 is turned on, and its capacitance discharges through it; otherwise, the capacitance retains its charge. The same sequence is then applied to Q_3 and Q_1 with the other two phases. The result is that the state of the output capacitance on the preceding stage (set of four transistors) has been transferred to the output capacitance of Q_4.

A typical CDI chip might contain more than 1,000 shift-register stages like those that are shown in the diagram. The photo (Fig. 13) contains 1,024 shift-register stages in the form of four 256-bit registers placed end to end. Likewise, a logic configuration such as the three-input NOR gate of Fig. 14 can be inserted in the circuit in place of transistor Q_2.

Shift registers, of course, are serial-access, and system designers often require random-access memories. Such a memory can be made from dynamic CDI circuits[3], and two of its cells are shown in Fig. 15. In operation, the



16. Precision switch. This circuit depends on the low collector offset and low saturation resistance of CDI transistors. Voltage error is less than 5 mV and "on" resistance under 10Ω.



17. Oscillator. External RC network determines the frequency of this Schmitt-trigger circuit. Both external components connect to the same pin, R to the power bus and C to ground.

word line is raised to a high voltage and a binary 1 inserted through the write amplifier and stored on the capacitance in the form of a voltage equal to that on the word line, minus the collector-base drop. With the word line at its low level the voltage is retained on the capacitance, storing the bit. For a binary 0, the amplifier is kept off and no charge is stored. To read the stored bit, the word line is again raised and the potential on the emitter sensed through the read amplifier. The transistor operates in inverted mode when writing, and in normal mode when reading.

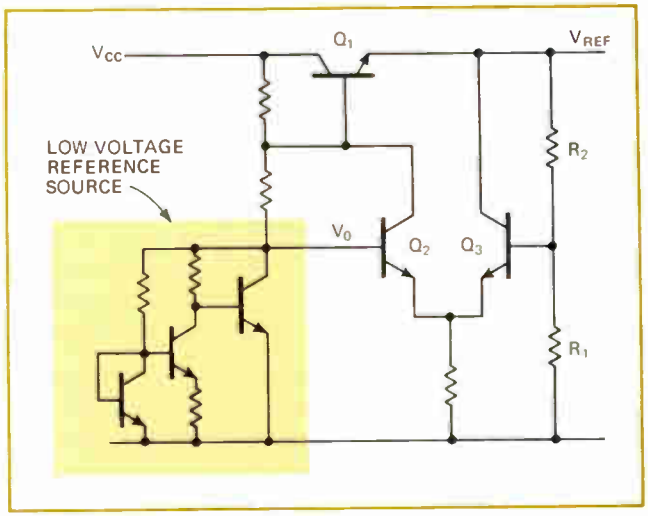
This cell is the basis of a large random-access memory being developed at Ferranti. It will have a capacity of 1,024 bits, plus all decoding and sense and write amplifiers, and will be compatible with DTL and TTL. It has a target access time of 80 ns, and requires refreshing about once every millisecond at 70°C. It will be packaged in a 16-pin dual in-line package and dissipate 25 milliwatts in standby and 300 mW when being accessed.

Linear CDI circuits

Such characteristics of CDI devices as low leakage, low collector offset, high cutoff frequency and high gain, are ideal for such linear circuits as precision analog switches, oscillators, voltage references, and operational amplifiers.

The precision switch, for example, makes use of the CDI process' low collector offset and low saturation resistance. Shown in Fig. 16, this switch comprises a phase splitter and two CDI transistor switches, which are a pull-up and pull-down for the output. The voltage error is less than 5 millivolts and the "on" resistance is less than 10 ohms, which makes very rapid switching possible.

The oscillator (Fig. 17) uses a simple Schmitt-trigger circuit. Its frequency is determined by an external resistor and capacitor. These—the only external components required—are both connected to the same pin on the oscillator package. Initially Q_1 and Q_2 are off, while Q_3 and Q_4 are on. The current through the external resistor charges the capacitor until the Schmitt threshold level is reached. When this happens, Q_2 turns on, and Q_3 turns off; this turns on the emitter follower Q_4, which in turn activates Q_1. Now the external capacitor discharges through Q_1 until the lower Schmitt threshold is reached. Thereafter, the cycle repeats itself.



18. Reference circuit. This series regulator depends on a low-voltage reference source, shown in the tint block. Differential pair compares this reference with supply through divider R_1-R_2.

In conventional bipolar technology, voltage reference circuits usually provide well over 5 volts—too high for use with CDI. But CDI circuits can use a conventional series regulator circuit that has a low-voltage reference source.[4] This circuit (Fig. 18) uses a differential pair Q_2-Q_3 to regulate the supply voltage coming through the

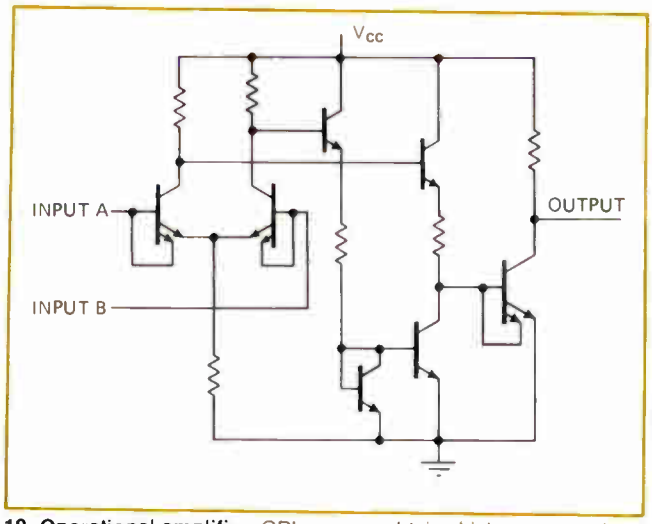
controlled transistor Q_1. The circuit as shown is a simplified version of one that would be used in practice, but illustrates the principle of operation.

The high current gain that the CDI process obtains at very low current levels is a particular advantage in an operational amplifier. The circuit of Fig. 19 has low drift and a minimum voltage gain of 20,000, and it recovers quickly from saturation caused by overdriving because its transistors have the feedback emitter. Although this circuit would have only limited application as an IC in its own right, it is valuable as an LSI building block.

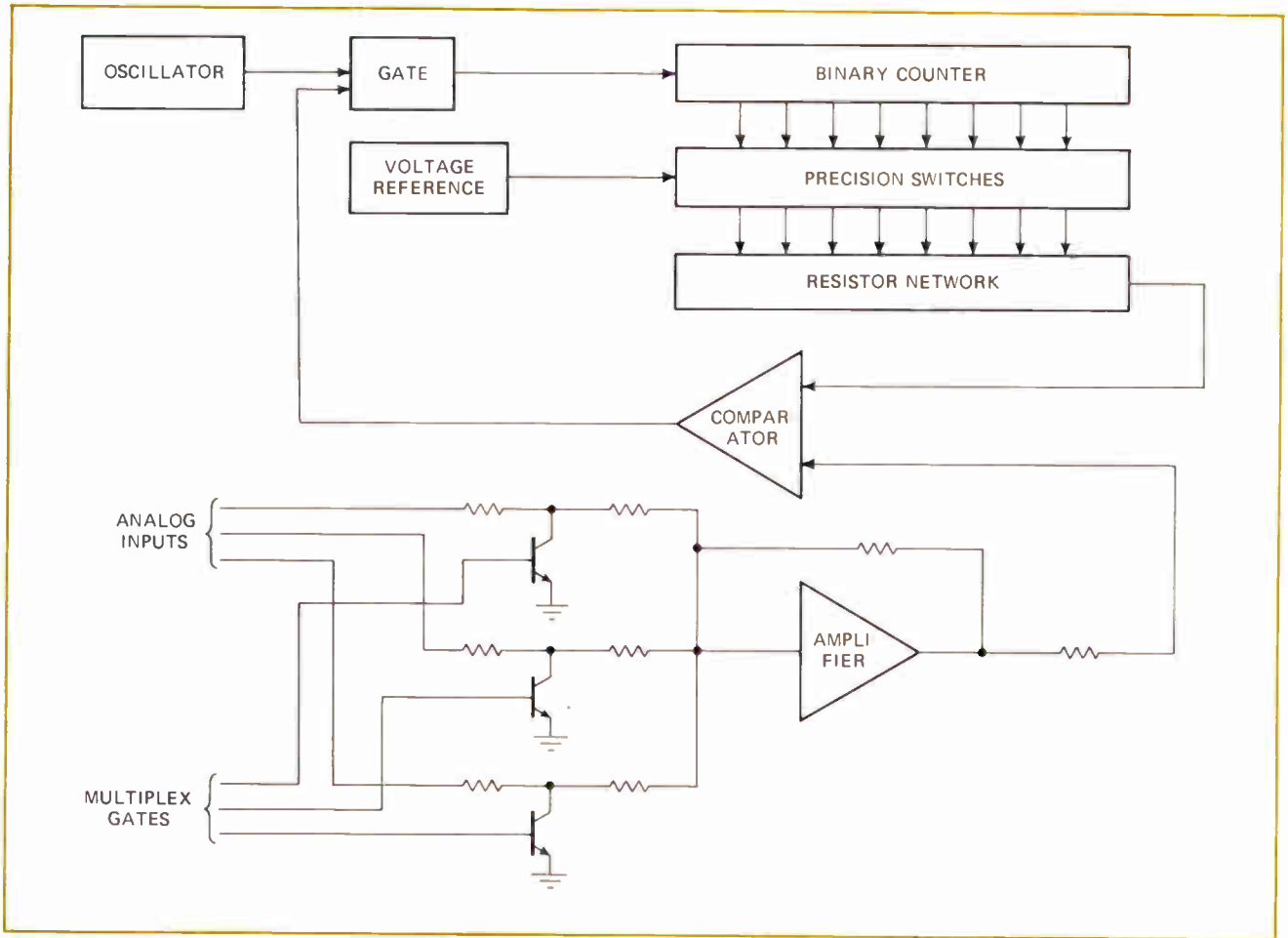
CDI's Digilin capability, which combines digital and linear functions on a single chip, is useful in many circuit functions that combine the elementary circuits described previously. Examples of these are an analog-to-digital converter, a fuel-injection system, and a photoswitch circuit.

In the analog-to-digital converter (Fig. 20), which operates on the same principle with CDI as with conventional circuits, the analog input—one of several multiplexed inputs—drives an operational amplifer and, in turn, one input of a comparator. A clock drives a binary counter, and the counter's outputs control a set of precision switches that connects either ground or a voltage reference to a binary resistor network. As the counter contents increase, the resistor network produces a linear ramp voltage that drives the other input of the comparator. When the ramp voltage equals the output of the operational amplifier, the comparator inhibits the further operation of the binary counter, the contents of which at that moment are a digital representation of the analog input.

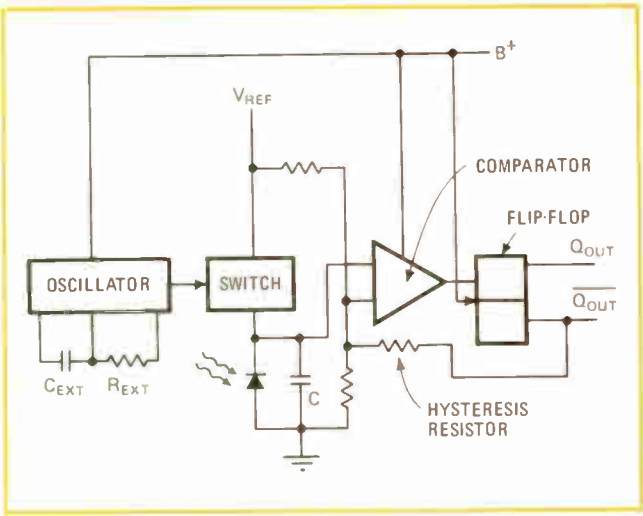
The accuracy of the resistor network and the precision switches determines the accuracy of conversion. If



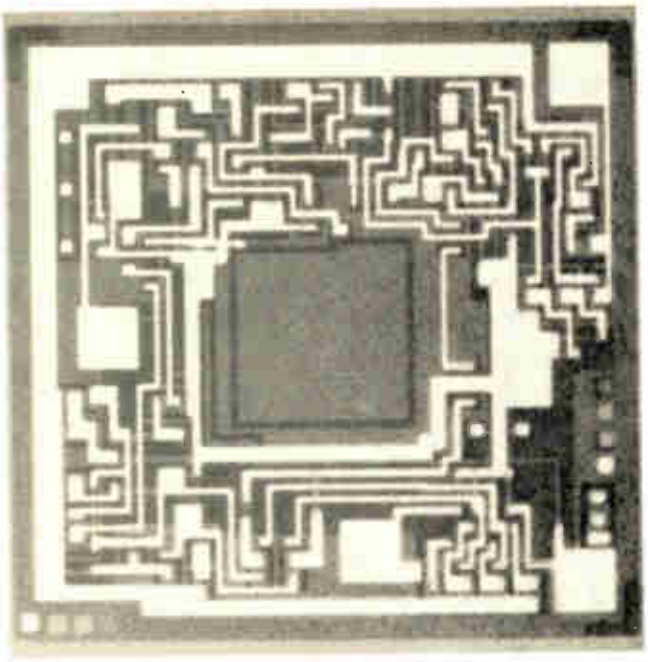
19. Operational amplifier. CDI process obtains high current gain at low current levels, an advantage in this op amp, which has a voltage gain of 20,000, low drift, and fast recovery from overdriving.



20. A-d converter. This subsystem combines many of the circuits plus both digital and linear circuits, all on a single chip. It can itself be part of a much more complex one-chip system, such as a fuel injection system



21. Photo-switch circuit. Showing how optoelectronics benefits from CDI's combined digital and linear capability, this switch measures light intensity by photodiode capacitance discharge rate



22. Photo-switch. This unit is available in either four-lead or six-lead packages; hysteresis is controlled internally in the smaller version. External RC network controls sensitivity of either device

the resistors are made by CDI, their accuracy can be better than 2%. For a better value, the two or three most significant digits can be trimmed by external resistors. The switches are good for about 0.1%.

This analog-to-digital converter can serve as one component of a fuel injection system. This system computes the amount of fuel required by an engine, based on measurements of certain engine parameters and environmental conditions, such as manifold pressure, engine speed, water temperature, air temperature, and throttle setting. Digital processing is mandatory, since environmental conditions are likely to vary enough for the accuracy of analog processors to be seriously affected. Nevertheless, economics dictate analog transducers for most of the inputs. Since both digital and linear functions are involved, the system can be built on a single chip from CDI's Digilin capability.

The system adds an increment store and an arithmetic unit to the analog-to-digital converter just described. The increment store is a fixed memory that relates each engine's unique characteristics to the monitored variables, and deposits the result of each analog input, as it is sensed and converted, in the arithmetic unit. The latter processes all the accumulated data and generates an output pulse of a computed duration that is applied to the valves in a fuel injection unit. The whole system is contained on a single silicon chip—proof of the power of CDI in Digilin applications.

Versatile

The photo-switch circuit (Fig. 21) is a good example of how Digilin techniques can be applied to optoelectronics. The switch uses CDI photodiodes, which have very low leakage currents when not illuminated, and takes advantage of the high packing density possible with CDI. A photo of the switch is in Fig. 22.

A light-operated switch's most important performance parameters are sensitivity and switching speed. To satisfy both of these requirements and maintain a consistent sensitivity, the refill diode technique is most appropriate. With this technique, an oscillator's output initially charges the capacitance of a photodiode up to a well-defined potential. This charge decays at a rate depending on the amount of incident light when the diode is illuminated. After a fixed time interval, the amount of charge remaining on the diode is a measure of the illumination level.

Applications like these demonstrate the versatility and flexibility of CDI, which are possible because the technology has the process simplicity and function density of MOS, plus the speed and flexibility of bipolar technology.

Table 4 is another way of saying the same thing. It compares the active area required by the three processes to build three functions often used in large-scale integration. On this basis, CDI shows increased function density in two of the three examples and equals MOS in the third.

Function density is not to be confused with component density. After all, the customer is buying functions—he doesn't care how many or how few components are required to produce the function he wants. Because many kinds of components are available with CDI, because the CDI transistor provides good drive capability without wasting chip area and because the crossunder structure is simple, the process gives substantial area savings. Therefore a figure for component density, though perhaps meaningful for MOS, is not relevant to CDI, which has a function density considerably higher than that of MOS. □

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3. J.A. Bruchez and S. Colaco, "Application of Collector Diffusion Isolation Techniques to Memory Circuits," Man-made Memories Conference, 1971, London.
4. Robert K. Widlar, "New Developments in IC Voltage Regulators," IEEE J. Solid State Circuits, February 1971, p. 2.

Etching your own pc boards quickly and accurately

by Herman Levin and G. Thomas Oppenheimer
Colorado State University, Fort Collins, Colo.

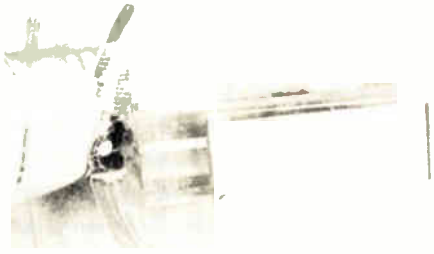
Putting together an efficient etching tank for laboratory or prototype production of printed circuits is relatively simple. There's no need to buy a commercial kit for a tank that will require constant stirring and either takes at least half an hour to etch one board or, if large enough to work faster and ensure no undercutting, becomes very costly.

This froth etcher is designed for fast turnaround of both single- and double-sided boards on which fine resolution is also important. It produces uniformly etched pc boards in about four minutes with very little undercutting. As a bonus, the process automatically aerates the etchant, greatly extending its life.

Constructing the etcher is quite simple. All that you need is a heat-resistant glass dish with cover, a tungsten-carbide hacksaw blade for notching the dish cover, some two-part epoxy adhesive, a holder for the boards being processed, three ceramic aquarium aerators, some rubber air tubes for holders, and a thermometer. You cement the aerators to the bottom of the glass dish, and a quick-change pc-board holder to the cover. Then you cement the thermometer and tube holders to the side of the dish and notch the cover to provide egress for them. Mix up a batch of ferric chloride in a concentration of 1¼ pounds of FeCl to every quart of water at a temperature between 100°F and 110°F, and you're ready to start etching.

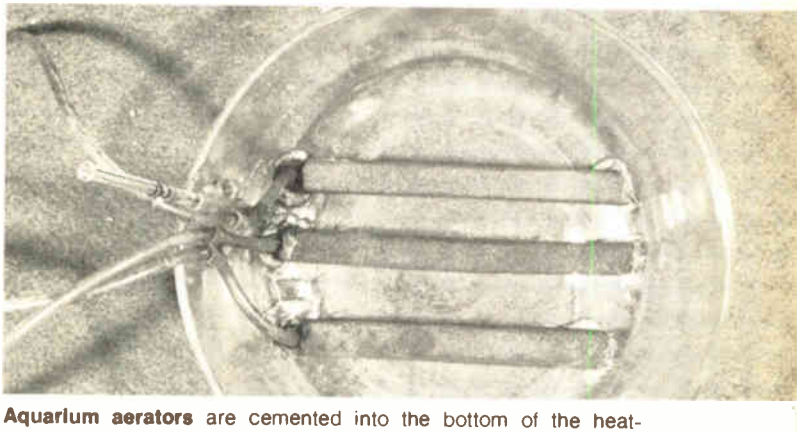
To etch, you simply:

- Place the etcher on a hot plate and fill it with etchant to a level that just reaches the bottom of the copper-clad pc board.
- Heat the etchant to its lower operating temperature

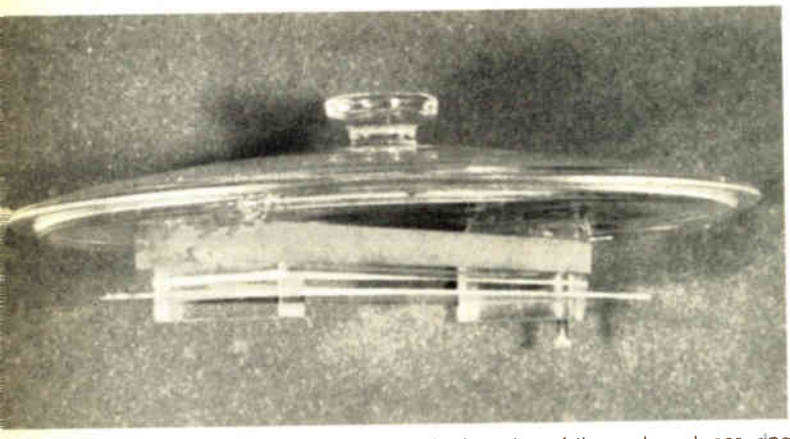


Observing the etching process is easily done by lifting the heat-resistant glass etcher cover to which the printed-circuit board is attached. Before the cover is removed, the air supply must be turned off to prevent any spattering of the etchant.

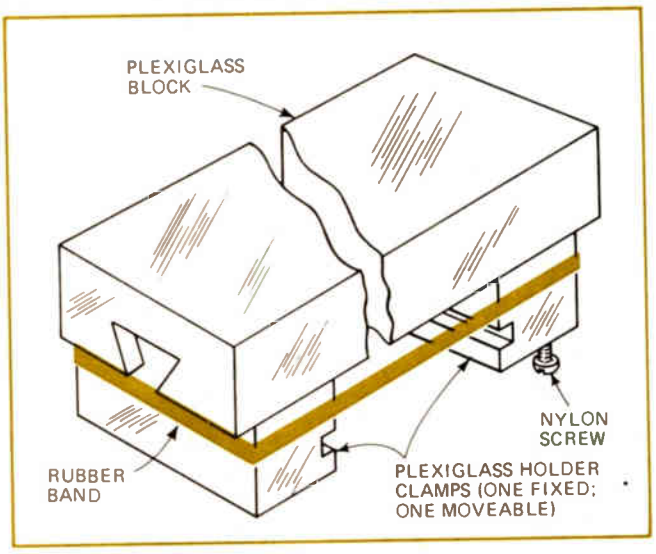
The continuous air flow through the aerators creates a surface froth that scrubs the board with constantly agitated etchant. The sliding clamp holder which is attached to the cover dish permits rapid insertion or reversal of the printed-circuit board.



Aquarium aerators are cemented into the bottom of the heat-resistant dish, along with sections of plastic tubing to support the rubber tubing and thermometer. The tubes are connected by T-fittings to a single tube connected to the main air supply.



Plexiglass holder clamps grip the edge of the pc board, assuring uniform etch of the entire surface. One clamp is threaded and fitted with a nylon screw to accommodate boards of various sizes. A rubber band around the clamps provides tension.



(100°F) and turn the hot plate off.

- Place the board to be etched in the holder, cover the dish, and turn the air supply on, adjusting it to create a continuing vigorous froth over the total surface of the etchant.
- After a few minutes—anything from three and a half to eight minutes, depending on the freshness of solution—inspect the board, if you want to, by raising the cover (the air supply must be turned off first to prevent splattering of the etchant).

This system is also easily adapted to etching outsized boards that don't fit the glass dish. For these, you replace the glass dish with a covered polystryene box, of a type sold for household storage. You then place the etchant container in very hot water, so as to heat the etchant before pouring it into the etcher. The etchant, of course, could be used at room temperature at some sacrifice in speed. □

Compensating couplers improve measurement accuracy

by John Zorzy
General Radio Co., Concord, Mass.

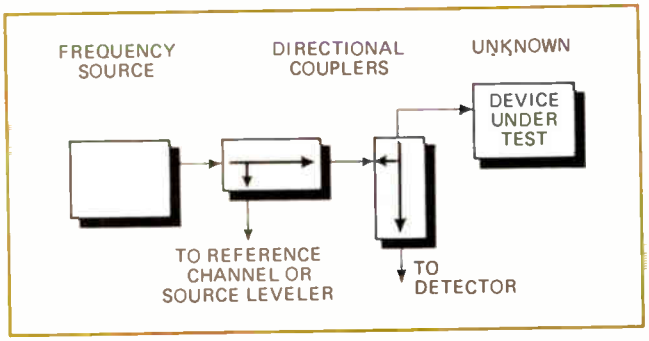
Broadband swept-frequency measurements in the microwave region are not renowned for extreme accuracy. One of the main reasons is that broadband directional couplers with good directivity tend not to have very flat coupling characteristics.

To overcome this problem, it is helpful to observe that, though it's difficult to get a single coupler with an extremely flat coupling response over a wide frequency range, it is much easier to get two couplers with coupling characteristics that track each other very closely. For example, the return-loss test setup shown uses one coupler to make a measurement and a second one to compensate for the lack of flatness in the first. The second coupler can be used to drive the reference channel of a network analyzer, or possibly to level the output of the microwave source.

The illustrated reflectometry configuration, which uses two couplers, improves measurement accuracy in two more ways: it reduces source pulling, and upgrades the equivalent source match. *Source pulling* is the change in output amplitude and/or frequency that occurs when the immittance at the coupler test port is changed. (This can happen when the level is set with a standard mismatch or short circuit.) *Equivalent source match* is the return loss or SWR, looking back into the coupler test port. A poor match causes reflections that produce ripple in the coupler output as the frequency is swept. A source-match return loss of 20 decibels, for example, will cause a 10% error in the measurement of a 0.1 reflection coefficient.

With the setup illustrated, the test port is isolated from the source by an amount equal to the coupler's coefficient of coupling. This is typically 15 to 20 dB. (Extra attenuation can be added at the output of the source if needed.) Furthermore, since most detectors provide a better match than do most sources, the equivalent source match is also improved. □

Engineer's Notebook is a regular feature in Electronics. We invite readers to submit original design applications and measurement ideas. We'll pay $50 for each item published.



Auxiliary coupler flattens over-all measurement system response when used either to level the frequency source output or to drive the reference channel of a network analyzer. By isolating source from device under test, setup reduces source pulling.

DATA GENERAL ENTERS THE MINIPERIPHERAL WAR.

A NEW DISC WITH GUTS.

Data General, the world's number 2 minicomputer company, has just introduced a new line of compact, fixed-head discs – the Novadiscs.

They're the ruggedest, most reliable mini discs on the market.

When we designed the Novadiscs, we recognized that a critical consideration was reliability: most minicomputer discs simply can't stand up to the kind of hard use that minicomputer mainframes take.

So we made sure the Novadiscs have the guts to go anywhere our computers go – including the tough on-line industrial applications in which modern minicomputers work.

Instead of trying to fly the read-write heads on a fragile 30- or 40-gram air bearing, we designed an air bearing that can stand up to 4 pounds of force. So the heads aren't disturbed by the bumps and jolts that make other discs crash.

When they're not flying, the heads are secured, outside the disc pack cylinder. So you don't risk a crash every time you move the unit across the room – or across the country.

The Novadisc recording medium is an industry-standard, 10-surface disc pack. The motor, drive spindle, drive belts, and air filters are the same ones used on big, mass-produced disc drives. Some of those parts are over-engineered for our requirements. They're also a lot less expensive and more reliable than anything else on the market.

The Novadiscs have all the other right specs, too.

Price. A Novadisc with storage capacity of 128K 16-bit words costs $5,200, 256K is $6,750, 512K is $9,250, and the 768K Novadisc costs $12,560. Quantity discounts are available.

Size. Including power supply, the Novadiscs are only 12¼ inches high.

Speed. Average latency time is 8.4 milliseconds, and data transfer rate is 2 million bits per second.

Software. Novadiscs are compatible with our device-independent Disc Operating System, which handles user I/O and provides interrupt-driven buffered service for peripherals.

DOS supports a relocatable assembler, editor, linking loader, Extended ALGOL, Extended FORTRAN, and Extended Timesharing BASIC.

Peripherals. You can add mag tape, other DOS-compatible discs, A/D and D/A, communications equipment, CRT's, plotters, printers, card readers, paper tape equipment.

In the past few years, over 2,500 Nova-line minicomputers and systems have been delivered.

We've made a reputation for making some pretty pushy claims – and for living up to them.

Now we're in the peripheral business. And just as pushy as ever.

DATA GENERAL

Southboro, Massachusetts 01772, Tel. (617) 485-9100

Engineer's newsletter

Bipolar RAMs moving to 4k

Although semiconductor manufacturers are talking only 1,024-bit bipolar random-access memories right now, **don't be fooled into thinking that the technology will stay at that level for long.** From the power-delay products that some of these makers are now getting in the 1k parts (2-nanosecond propagation delay at 1 milliampere), it's clear that **the manufacturers will soon be producing 4k memories.** Memories of this size are the most efficient parts for large memory applications. So it's a good bet that the bipolar 4k memory units will be on the market at this time next year.

Smaller loss: gain for microwave ICs

Microwave integrated circuit designers take note: new transmission-line **structures now under development may circumvent the problem of high radiation losses in microstrip transmission lines** at frequencies in Ku and Ka bands and the millimeter region. The Air Force has given $50,000 contracts to groups at General Electric, Utica, N.Y., and at Raytheon, Bedford, Mass., to **continue their development work on structures that are closer to waveguide than microstrip.** If the efforts meet the cost objectives, you'll be able to achieve the same degree of integration with lower losses than you're accustomed to in microstrip lines used in present microwave ICs.

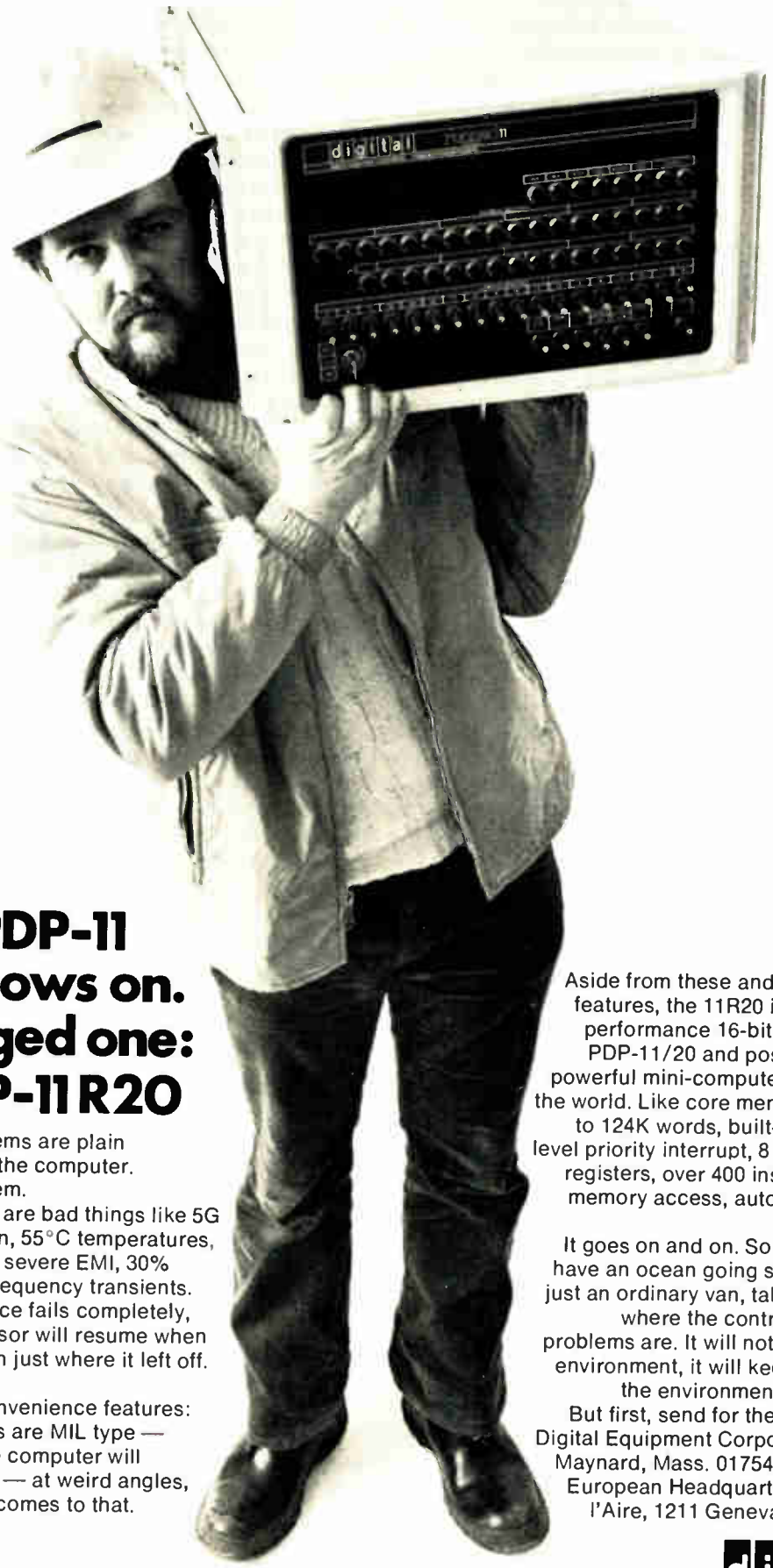
Give an IC facility to the college of your choice

When updating your monolithic or hybrid circuit fabrication facility with newer units, you might consider donating the old equipment to a nearby university. A survey taken by Jay W. Lathrop, now of Clemson University, Clemson, S.C., for the Parts, Hybrids and Packaging group of IEEE shows that 42% of college EE departments who responded now have some type of facility, but that **altogether, 66% of U.S. and Canadian universities plan to have such facilities in the future.** Lathrop points out that those universities that developed their facilities early did so with the help of Government grants, but now Government assistance is disappearing, and the institutions coming on line in this second wave are less affluent.

Handbook and hint on calibration

If you were setting up a service organization, would the first thing you did be to publish a handbook that told people how to do for themselves what you're offering to do for them? Odd though it seems, that's what a nine-month-old instrument calibration and service company, Incal Service Corp., 73 Southfield Ave., Stamford, Conn. 06902, has done. A letter to that company will get you a copy of the book, **a collection of calibration procedures, checklists, and conversion charts.**

We don't know if this tip is in the Incal handbook, but if you're calibrating or even just using an inexpensive oscilloscope, you should know that **the sweep speed, and thus horizontal calibration, may vary with the sweep repetition rate** (how often you trigger it). Reasons are that if power supplies are poorly regulated, more frequent triggering lowers average power supply voltage, and if transistors are poorly heat-sinked, more frequent triggering causes heating and subsequent change in characteristics. Thus, you should calibrate the scope at the trigger rate at which you're going to use it.



The PDP-11 family grows on. The rugged one: PDP-11R20

Some computer problems are plain impossible to bring to the computer. PDP-11R20 goes to them.

Goes where there are bad things like 5G shocks, 500Hz vibration, 55°C temperatures, 95% relative humidity, severe EMI, 30% voltage swings, 10% frequency transients. Even if the power source fails completely, the PDP-11R20 processor will resume when the power does — from just where it left off. You won't lose data.

Then there are convenience features: Peripheral connections are MIL type — quick and reliable. The computer will operate in any attitude — at weird angles, even upside down if it comes to that.

Aside from these and other protective features, the 11R20 is the same high-performance 16-bit computer as the PDP-11/20 and possesses the most powerful mini-computer architecture in the world. Like core memory expandable to 124K words, built-in multi line and level priority interrupt, 8 general purpose registers, over 400 instructions, direct memory access, automatic power fail and restart.

It goes on and on. So if you happen to have an ocean going ship, or a tank, or just an ordinary van, take PDP-11R20 to where the control or processing problems are. It will not only survive the environment, it will keep processing in the environment for a long time.

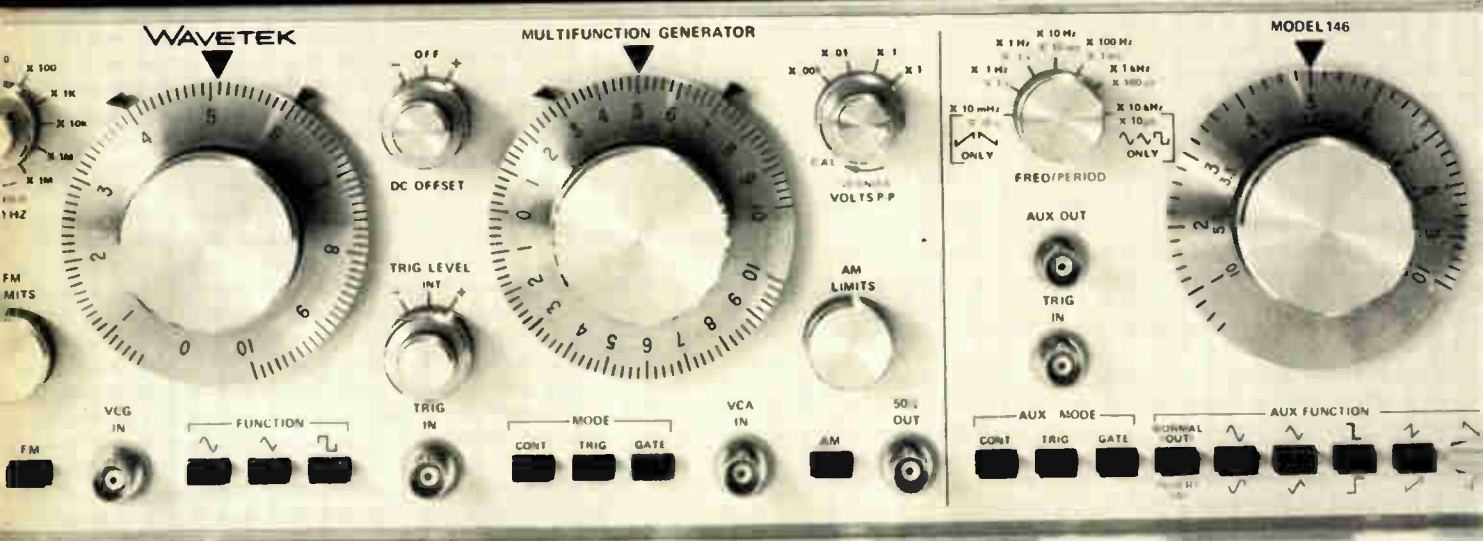
But first, send for the complete story. Digital Equipment Corporation, Main St., Maynard, Mass. 01754. (617) 897-5111. European Headquarters: 81, route de l'Aire, 1211 Geneva 26 Tel.: 427950

digital

Circle 109 on reader service card

Dial direct and save.

Remember the old swee
function generators? If you wante
frequency modulation, amplitud
modulation, frequency shift keyin
or any other exotic waveform, yo
needed two generators, right? And a
oscilloscope. Plus you had to mak
lots of complex control adjustment
Well, that was before we i
troduced the Model 146 Multi-fun
tion Generator. The 146 gives you a
of those features because it's real
two complete generators in one bo
You can use each one independentl
or you can use one to control th
frequency and amplitude of the othe
Note that the 146 has calipe
type dials. This unique calibrate
system allows center frequenc
sweep width, amplitude and fr
quency modulation limits to be s
and read without an oscilloscop
The Model 146 has a fr
quency range of 0.001 Hz to
MHz and sells for $1495. That's
bargain price, considering the tim
and oscilloscopes you'll sav



WAVETE
P.O. BOX 651, SAN DIEGO, CALIFORNI
TELEPHONE (714) 279-2200, TWX 910-3

Circle 110 on reader service card

Peripherals flood erodes mini prices

PDP-8/E system cost is nearly halved through introduction of memories, displays, disk drive system, modem control unit, and software packages

by James Brinton, Boston bureau manager

Minicomputer system prices are determined less by the mainframe than by the costs of peripheral equipment, and this is where Digital Equipment Corp. has decided to push down the pricing structure of its PDP-8/E.

DEC has developed the biggest flock of new peripherals in the history of the PDP-8 series—ranging from an inexpensive core memory to a $250 modem-control unit. New Basic and Fortran IV software increase capabilities. And one program sells for as low as $15. Taken together with price cuts in mainframe modules, these innovations have enabled the system price to be cut by $16,085 to $19,900—nearly half—for equivalent computing power.

A typical configuration—a PDP-8/E that includes 8 kilowords of core, a high-speed paper-tape reader/punch, a DECwriter, and 1.6 million words of disk memory—has been reduced 45%, and still is subject to discount for quantity buys. With a new in-house-produced 8,096-word core memory, the PDP-8/E itself drops from $7,740 to $5,650; a package price on the DECwriter and paper-tape gear lower their combined price from nearly $6,700 to $5,700. DEC's former disk store cost $20,400; the equivalent new unit is priced at $7,900.

And DEC is broadening its peripheral base with introductions like the VT8-E, a $1,900 alphanumeric display.

The new video terminal also has a limited point-plotting capability, and it uses the PDP-8 memory for refreshment. Though the peripheral is inexpensive, it offers selective blink down to the character level, as well as selective brightness, and it can underscore its entire field of 22 lines of 64 characters each.

Also new is the RK8-E moving-head disk drive. At $7,900, including built-in controller, it replaces a system that required twice its bulk to provide the same 1.6-million-word storage capability at a price of $20,400. Savings resulted from doubling storage density of the former 1,100 bits per inch and from moving production in-house. The built-in controller can control three additional drives, priced at $5,100 each. The new disk systems are discountable.

Also discountable is the VR20 two-color CRT display, which provides red and green graphics and is listed at $5,100. This kind of product formerly was available only with minicomputers having greater capabilities than the PDP-8. Alphanumerics can be supplied under software control.

DEC has made two changes in its DECwriter. One adds an industry-compatible serial interface that allows the unit to be used as a remote terminal. Its former parallel interface limited the distance that wires could be run from the mainframe. The new $3,195 unit, which can work with all common modem formats, is expected to broaden penetration into such applications as hospital information centers.

A read-only DECwriter—without keyboard—at $2,850, is expected to stand in for line printers in light-duty applications. It also is offered with the new serial interfacing, and both new DECwriters are discountable.

For continual-duty line-printer applications, DEC is offering the LS8-E at $5,000. It operates at 165 characters per second across 132 columns and uses a 64-character ASCII font. Somewhat like the DECwriter, it uses a dot-matrix hammer technique to print text.

DEC has simply improved some products, at no increase in price, and has added others to fill out equipment lines.

Among the improved products is

Additions to the family. New peripherals for the PDP-8 line of minicomputers include, left to right, a read-only DECwriter, disk storage unit, line printer, and graphics display.

the VT05-B, a $2,795 alphanumeric display terminal with eight times its former speed. The first model operated at 300 baud, but now the VT05-B, with added buffering and a faster clock, has made possible switch-selectable speeds to 2,400 baud at no increase in price. Likewise, the CR8-F card reader now has a throughput of 300 cards per minute, a 50% speed increase, at the same $4,500 price.

Plasma. Still another terminal, the RT02, formerly offered with other DEC computers, has been adapted to the PDP-8 line and is priced at $1,300. It also is industry-compatible, but instead of the usual CRT above the keyboard, it uses a Burroughs self-scan plasma matrix.

To enhance the communications capabilities of the PDP-8/E, DEC has developed the KL8-M modem-control unit. The $250 module, having full interface with data sets, services modem-control leads and allows ring- and carrier-detection. This, in turn, allows an automatic answering capability on data lines, and the control makes possible unattended data transfer.

The KL8-E and KL8-F, like the KL8-M, are individual Omnibus modules. The E module is a $350 single-buffered asynchronous data interface. It handles eight-bit words and transmits at 2,400 baud, but, because it is single-buffered, it can receive only at 600 baud. But the F module improves on this by handling five-, six-, seven-, and eight-bit words, and double buffering enables it to receive and transmit at 2,400 baud— as well as at an odd 137.5-baud rate that permits the module to operate with IBM-compatible terminals.

"With all these communications building blocks, we can communicate with anything," says DEC's vice president for small computers, Andrew Knowles.

Power. Adding the FPP-12 floating-point processor, which has a discountable price that DEC is cutting from $9,900 to $6,600, and a newly developed Fortran IV software package, PDP-8/E computing power has been increased significantly. Although some of this increased capability comes from the dual-processor configuration that results when the FPP-12 performs double-precision and/or floating-point calculations, much of the speed increase has been brought about by the new Fortran package.

"With a PDP-8/E and 16,000 words of core, we now can do programs that required 128,000 words and a 7090- or 360-class computer," says Knowles. The Fortran allows full overlap, is tree-structured, runs under the PDP-8 operating system, and allows such real-time operations as oscilloscope display or direct access to the outputs of analog-to-digital converters. The new software increases fourfold the speed of the original FPP-12.

Capping the software array is a new form of Basic, the ninth version offered for PDP-8 machines. This broadens Basic's market by replacing much of the mathematical symbology by a textual format.

Data-file and data-string capabilities add to this power. The data-file capability enables users to generate data bases that can be read back by any PDP-8 operating program. Data stringing makes possible use of alphanumerics as inputs and outputs—formerly, it was difficult to manipulate text with Basic because mathematical protocols continually got in the way.

Also coming to the software catalog are four aids to the PDP-8 operating system—TECO, Source-Compare, Bitmap, and EPIC.

TECO, priced at $55, is a text-edit and correction program. Source-Compare, priced at $30, could mate with TECO in that it allows only text changes to be displayed—an aid in computer typesetting applications. Bitmap, at $30, yields absolute maps of binary files, and finds openings—addresses that can be used instead of wasted, thus making for more efficient use of memory—and it works on tape, core, or disk. EPIC at $150, gives users an easy way to adapt PDP-8s to new operating system developments—by generating program patches that allow new material to be merged.

The Digital Equipment Corp., 146 Main St Maynard, Mass. 01754 [338]

Components

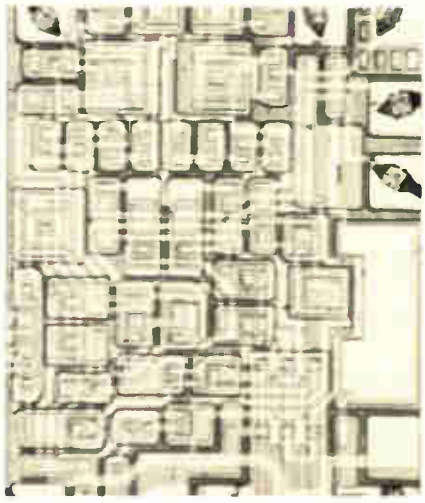
Preamp offers low input

Unity-gain FET device built to buffer sample-and-hold and other linear circuits

The push for specialized operational-amplifier designs and away from the "universal" device has received additional momentum from development of a unity-gain field-effect transistor preamplifier by Harris Semiconductor. With very low input characteristics, the preamp can be used as a buffer-input device in linear systems, such as sample-and-hold and comparator designs, where very careful measurements are required.

The preamp, designated the HA-2000, has an input bias current of 1 picoampere, an input resistance of 10^{12} ohms, and a slew rate of 120 volts per microsecond. It is, therefore, custom-tailored as an input device to a system that needs the low input characteristics of typical FET op amps but cannot tolerate the sacrifice of speed that their use would entail. A system designer can couple the HA-2000 with any of the many high-gain op amps on the market to get maximum performance, Harris points out.

Significantly, the 2000, which has a junction-FET input and a bipolar



output, has a much wider common-mode range than do simple FET pairs; therefore, op amps can be connected as voltage followers to get full output swing. An important use of the HA-2000 will be as a high-impedance unity-gain buffer for differential or two single-ended signals from dc to rf. Response of the preamp is flat to 10 megahertz and is down 10 decibels at 100 MHz.

Housed in a TO-99 package, the HA-2000 is priced at $6.50 each for 100 or more. Delivery is from stock.

Harris Semiconductor, P.O. Box 883, Melbourne, Fla. 32901 [341]

Capacitors measure 200 mils square by 45 mils thick

The 9410 series trimming capacitors have a body size of 200 mils square and are 45 mils thick. Their size allows them to be used in critical microcircuit applications where high-

capacitance trimming is required. Applications include electronic watches, crystal oscillators, and uhf microwave systems. Two mounting styles are available, for printed-circuit or stripline mounting. The series includes five models with capacitance ranges up to 40 picofarads, Q greater than 3,000, and working voltages of 250 V dc. Price is 95 cents each in volume.

Johanson Manufacturing Corp., 400 Rockaway Valley Rd., Boonton, N.J. 07005 [343]

Subminiature lamps have short-proof flying leads

Miniature and subminiature lamps are available with insulated flying wire leads. The leads are assembled to the lamps with a technique that leaves the insulation in a state of compression against the glass surface of the lamp. This eliminates the possibility of lead-shorting caused by insulation slippage. The leads can be supplied in any length of any standard AWG gage wire, solid or stranded. Price is as low as 25 cents, depending on type, lead length, and the quantity.

Industrial Electronic Engineers Inc., 7720-40 Lemona Ave., Van Nuys, Calif. [342]

Miniature ceramic capacitors are epoxy-coated

A line of miniature epoxy-coated ceramic capacitors is available in voltages of 50, 100, and 200 volts dc. There are four dielectrics offered, and construction is completely monolithic. Capacitance values are from 4.7 picofarads to 10 microfarads. The capacitors are designed with radial leads, and sizes are: 100 by 100 mils, 150 by 150 mils, 200 by 200 mils, 300 by 300 mils, 400 by 400 mils, and 500 by 500 mils. Prices start at 9 cents in quantity.

USCC/Centralab, 2151 North Lincoln St., Burbank, Calif. 91504 [344]

Photoelectric control offers six modes of time delay

A photoelectric control offers six modes of time delay. The unit is housed in an 11-pin plug module and supplies a lamp power of 5 volts dc. The R336/T336 series units contain an isolated regulated power supply, electronic amplifier, Schmitt trigger-level detector, and timer. Time-delay modes consist of delay on either light-energize or dark-energize when the lamp is on or off, adjustable-pulse-width dark-ener-

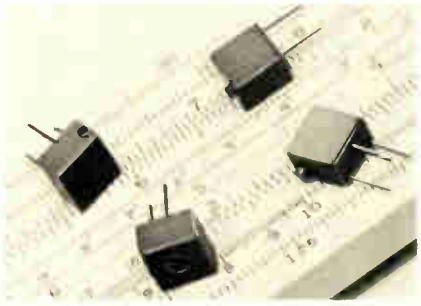
New products

gize, and adjustable-pulse-width light-energize.

Skan-a-matic, P.O. Box S, Eldridge, N.Y. 13060 [345]

Pot's resistance element is bulk metal film on ceramic

The model 1240 trimming potentiometer, which is a ¼-inch square, features a resistance element made of bulk metal film set on ceramic. Specifications include a temperature coefficient of 10 ppm/°C maximum through the wiper and element, a resistance range from 2 ohms to 5



kilohms, nonmeasurable inductance, no dc offset, and no thermal noise. In addition, the unit offers 20-turn adjustment. Price is $5 each in 100-lots.

Vishay Resistor Products Division, Vishay Intertechnology Inc., 63 Lincoln Highway, Malvern, Pa. 19355 [346]

Miniature resistors cover 44 standard values

Miniature precision wirewound resistors are available in 44 standard values from 10 ohms to 300 kilohms, have a diameter of 5/32 inch, and are 5/16 inch long. Tolerances offered are ±0.01%, 0.025%, and 0.1%. Called the MiniOhms, the units are axial-encapsulated for applications where accuracy, stability, and reliability are required and component density is high. Power ratings are 0.25 w at 85°C and 0.2 w at 125°C. Temperature coefficient is ±5 parts per million/°C over a range of −55 to +125°C.

General Resistance Inc., 500 Nuber Ave., Mt. Vernon, N.Y. 10550 [347]

Instruments

Vhf generator has low drift

512-MHz unit goes as low as 61 kHz with extender; offers modulation versatility

Until recently, if an engineer required a very stable vhf signal source with modulation capability, he had to spend $9,000–$12,000 for a frequency synthesizer. Or he could phase-lock a signal generator by adding an external phase-lock box, which in turn usually required an external counter to set the frequency. Even then, short-term stabilities were seldom better than 20 parts per million. Residual fm, incidental fm in the presence of amplitude modulation, and low output amplitude have also been problems with signal generators.

Singer Instrumentation, Palo Alto, Calif., has now introduced the model 6201/6202 signal generator, which promises to remedy many of the difficulties. The 6201, which covers the basic range of 7.75 megahertz to 512 MHz, is priced at $4,250. The 6202, a plug-in which extends the range downward to 61 kilohertz, is priced at $850.

A digital automatic frequency-locking circuit allows the user to lock the frequency to whatever is displayed on the internal six-digit counter. After a one-hour warmup, frequency drift is less than 1 ppm per hour and less than 0.5 ppm/°C. The six-digit display uses light-emitting diodes.

Resettability is provided to a resolution of 1 hertz from 61 kHz to 1 MHz; 10 Hz from 1 MHz to 8 MHz; 100 Hz from 8 MHz to 125 MHz, and 1 kHz from 125 to 512 MHz. The internal counter may also be used to measure the frequency of external signals from 100 Hz to 10 MHz with 1-Hz resolution. Residual fm is less than 0.25 ppm, peak.

The high output level of +20 dBm is leveled to within +0.25 decibel up to 125 MHz and then to within ±0.5 dB, eliminating the need for level adjustment when frequency changes occur. Output ranges down to −146 dBm.

The 6201's modulation capabilities include a-m/fm, or pulse and simultaneous modulation of a-m/fm and pulse. Even in the phase-locked mode, a-m, fm, and pulse-modulation are possible.

Another feature of the unit is its low broadband noise, which is better than 130 dB below the carrier in a 1-Hz bandwidth. Harmonic output is at least 30 dB below the carrier.

The 6201 can be used for receiver alignment in uhf and vhf communications, as well as in mobile communications and single-sideband receiver alignment and calibration. It is capable of high-level testing of amplifiers, mixers, and multipliers, and gives accurate, stable measurements of attenuators. It measures dynamic a-m rejection and a-m/fm systems, and analyzes narrow-band components. Because of its extensive amplitude range, the 6201 can do adjacent-channel sensitivity measurements, and it handles multiple-filter response characteristics.

The Singer Co., Instrumentation Division, Palo Alto Operation, 3176 Porter Dr., Palo Alto, Calif. 94304 [351]

Low-priced phase meter provides 'medium' bandwidth

There's more to a phase-angle voltmeter than meets the eye. This versatile instrument not only measures the phase angle between two signals, it also determines the in-phase and quadrature components of a complex signal, indicates harmonic content, and serves as a phase-sensitive null detector. Unfortunately, most phase-angle voltmeters operate at only a single customer-selected spot frequency, any deviation from which renders their readings inaccurate. Broadband units are available, but they cost upwards of $2,000.

North Atlantic Industries' latest phase-angle voltmeter is a compromise. It gives the user a ±5% bandwidth about a selected spot frequency, and it costs only $870 in single units. The instrument covers 300 microvolts to 300 V full scale in 13 ranges. It acts as a broadband voltmeter over the range from 10 Hz to 100 kHz, and as a phase-angle voltmeter over any specified ±5% bandwidth in the range from 30 Hz to 10 kHz. Maximum voltage error is 2% of full scale; maximum phase angle error, 1°.

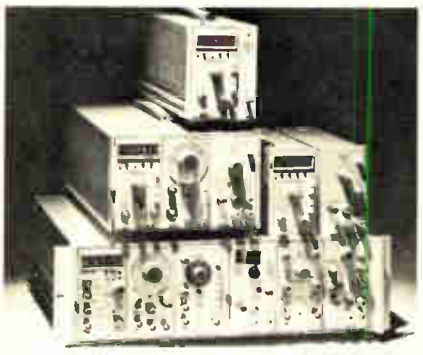
The voltmeter comes in two versions. The 213B, at $870, provides transformer isolation for the signal channel, but not the reference. The 213C, at $950, has transformers on both input channels.

Delivery is from stock on single orders or three weeks for production quantities.

North Atlantic Industries Inc., 200 Terminal Dr., Plainview, N. Y. 11803 [352]

Measurement system is made of plug-in modules

A compatible series of digital counters, digital multimeters, ramp, signal, pulse and function generators, and low-voltage power supplies makes up a modular measurement system. The compact units require about the same amount of space as a small oscilloscope plug-in. Each



plug-in module is designed for stand-alone capability in its power unit/cabinet, and the TM 500 series is designed so that connections between modules and/or external equipment can be made via the mainframe rear interface board and optional rear-panel connectors. Price per module ranges from $95 to $895.

Tektronix Inc., P.O. Box 500 Beaverton, Ore. 97005 [354]

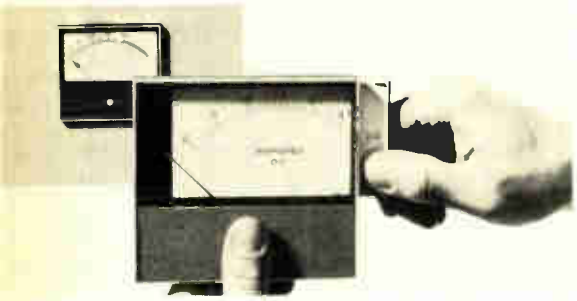
5½-digit multimeter offers 1 μV ac/dc resolution

The model 2540/A1 multimeter provides a measuring capability with ac/dc voltage resolution of 1 microvolt. The 18-range four-parameter unit reads out in 5½ digits. Capabilities are ac and dc volts from 100 mV full scale to 1,000 V full scale (+20% over-range), ohms from 100 ohms full scale to 10 megohms full scale, and dc ratio from ±1.00000:1 to ±100.000:1. Price is from $1,095 to $1,295, depending on the number of parameters.

Data Precision Co., Audubon Rd., Wakefield, Mass. 01880 [355]

Panel meter offers slide-in scales

The model 7025 panel meter is aimed at applications in power supplies and portable instruments. A feature of the unit is slide-in scales.

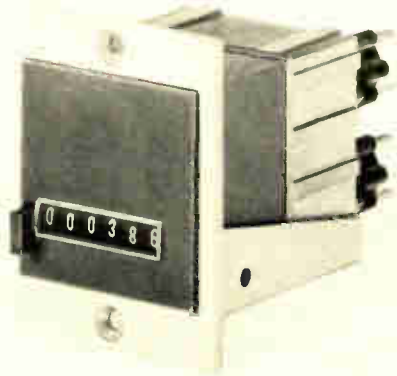


With this design, a small stock of meters can be modified with a larger number of slide-in scales to satisfy a variety of requirements. Tracking to within 1% is standard, and tracking to within ½% is available on request. In addition, several mounting styles are available.

LFE Corp., Process Controll Division, 1601 Trapelo Rd., Waltham, Mass. 02154 [356]

Counter does not jam on simultaneous inputs

A bidirectional counter, called the model GO431, is designed to accept positive and negative pulses, even simultaneously, without jamming or missing a pulse count. The unit uses two solenoids with a differential



mechanism to prevent miscounting. Offered are a 6-digit display and operation on 6 to 220 V ac or dc. Power consumption is 3.7 watts. Counter speeds are available from 10 to 25 counts per second, and construction is modular. Price is under $40, and delivery is from stock.

Hecon Corp., 31 Park Rd., New Shrewsbury, N.J. 07724 [358]

Function generator delivers ramp and periodic outputs

A function generator, designated the model 410.32, provides 10-volt full-scale single-amplitude sine, haversine, square, triangular, trapezoidal, and ramp-signal outputs. Both positive- and negative-going versions of all outputs are available. Output frequency of periodic functions is from 0.0001 to 990 hertz, and full-scale ramp rates are adjustable from 1 millisecond to 99,000 seconds.

MTS Systems Corp., Box 24012, Minneapolis, Minn. 55424 [357]

TWT amplifier covers 2-12.4 GHz, puts out 1.5 W

A traveling-wave-tube amplifier covers the S, C, and X bands in one package. The model 1704 has a range of from 2 to 12.4 GHz, and output is 1.5 watts with a gain of 25 decibels. The unit has the capability to be serrodyne-modulated over the full frequency range. In the continuous-wave mode, the unit is used as a broadband amplifier for component and systems testing. When used with serrodyne modulation, the amplifier becomes a test system for simulating moving targets in radar and for single-sideband transmission of data. Price is under $10,000.

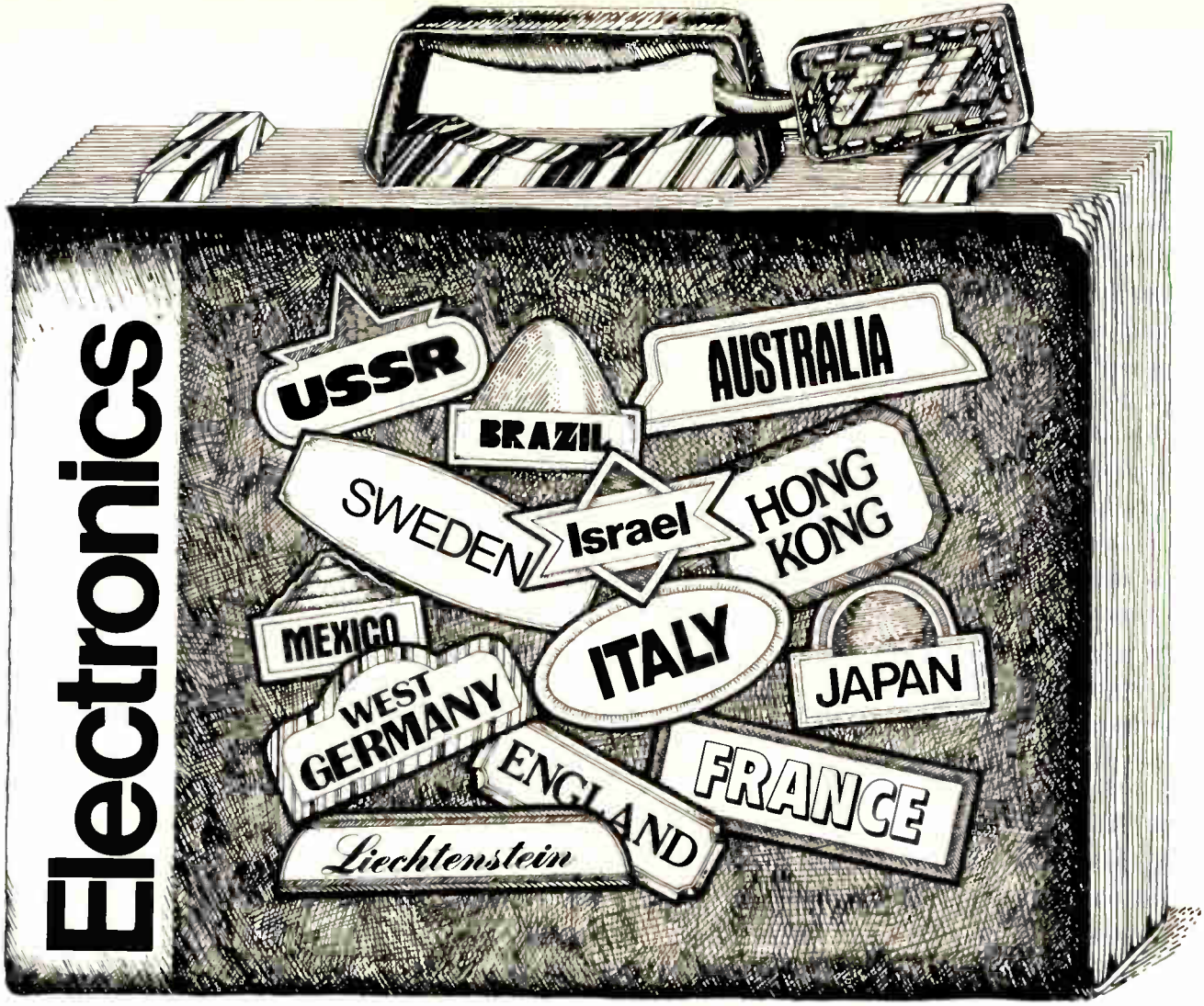
Cober Electronics Inc., 7 Gleason Ave., Stamford, Conn. 06902 [359]

Low-priced panel meter reads out 2¾ digits

A digital panel meter with a 2¾-digit display is aimed at users who don't require the standard 3½-digit readout. The series 2700 meters are dimensionally interchangeable with many other DPMs, and all models in

this series display a full-scale readout of 399. Ranges are available from 39.9 millivolts dc to 399 volts dc and from 39.9 microamperes ac to 399 milliamperes ac. Price is $68.

Faratron Corp., 280 Green St., Hackensack, N.J. 07606 [360]



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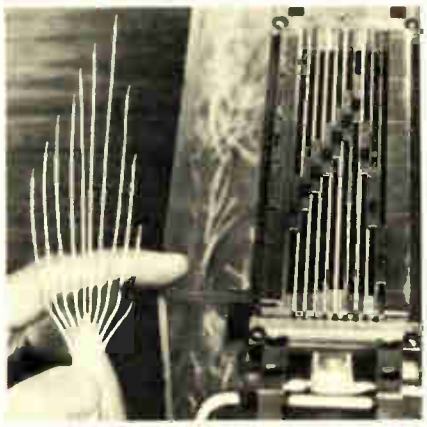
Packaging and production

Machines cut, strip cable

Programable, preset models for ribbon conductors trim harness, termination costs

One of the most tedious and costly labor factors in using ribbon cable is the preparation of the cable—spreading the wires to the proper spacing, cutting the individual conductors to the proper length, and then stripping each wire. Now, one of the major suppliers of such cable, Spectra-Strip Corp. of Garden Grove, Calif., is doing something about automating the process.

Two machines are being offered. Series 100 is fully programable for spacing and length of individual conductors, and sells for $4,000.



Series 200 is preset at the factory for one spacing and length, and sells for $2,000. The machines were originally developed for a major manufacturer of oscilloscopes who had held exclusive rights to the machines, but whose rights have now run out. The customer has said the machines reduce costs on harnesses and terminations by 65% compared with manual methods, reports Spectra-Strip.

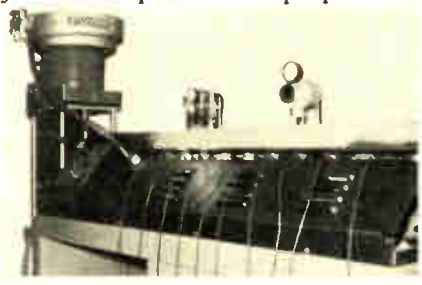
The operator simply inserts the cable and closes the locking lever. The machine draws the cable into the stripping and cutting heads, spreading individual conductors, each into its own channel. The programable unit can be adjusted for length of conductor, with mechanical stops locked in place by Allen-head bolts. (Different lengths of conductor may be needed to mate with, say, tube sockets, or with various points on the printed-circuit board.) The programing fixture can be easily withdrawn and replaced with another unit at the end of the production run. Or, if the same fixture is to be used, a simple jig, comprising 10 rods of varying length projecting from a base plate, can be used to quickly set the positions of the stops. Wire of 28, 26, 24, and 22 gage can be handled.

Spectra-Strip Corp., P.O. Box 415, Garden Grove, Calif. 92642 [391]

Machine attaches terminals to heat-shrinkable tubing

The application of heat-shrinkable tubing to terminals on the end of a wire can be a frustrating task. When the elements are joined by hand, the heat must be evenly applied from a heat gun while the tubing is held in place so that it meets inspection criteria—neither exposing too much of the terminal nor extending too far over the edge of the terminal. A machine from Varied Industrial Products, Paterson, N.J., makes the junction automatically, handling 1,200 to 1,500 assemblies an hour. The manual rate is 300 to 400 an hour, says VIP president Ed Nemeth.

The $4,200 machine uses a vibratory feed for the pieces of heat-shrinkable tubing, delivering the pieces to a position at the beginning of a belt that moves them through several stages of heating. The operator inserts each terminal into the tubing, bottoming it against an adjustable stop to assure proper coverage of the terminal. A foot-switch then moves the junction to the beginning of the heating cycle. Held between two belts, the terminal is first given a brief exposure to high-temperature air to perform most of the shrinking, and then subsequent stages deliver cooler air.

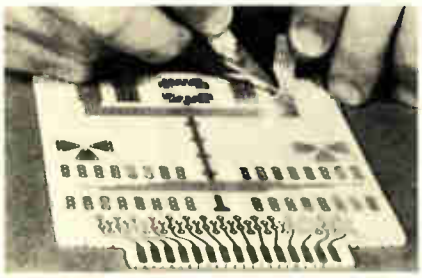


The machine, which handles a wide variety of solderless terminals and wires in sizes from 22 gage to 8 gage, requires 115 volts ac and 80 pounds per square inch of air.

Varied Industrial Products, 445 Fifth Ave., Paterson, N.J. 07514 [392]

Stripline subelements built for prototyping

Self-adhesive stripline parallel subelements that have epoxy glass substrates are designed for high-



density prototype applications. The units are available in many conductor line-widths from 0.01 inch to 0.25 inch. When used with other component subelements, the stripline is suitable for high-frequency breadboarding, for making card extenders, and for repair of production circuit boards.

Circuit Stik, 24015 Garnier St., P.O. Box 3396, Torrance, Calif. 90510 [397]

IC handler can sort 7,000 DIPs an hour

An integrated-circuit handler, the model IC-7000, can handle and sort up to 7,000 dual in-line packages per hour. The unit is aimed at production testing, incoming inspection, or sampling. The handler accepts 14- and 16-pin packages directly from shipping magazines and sorts them in three categories:

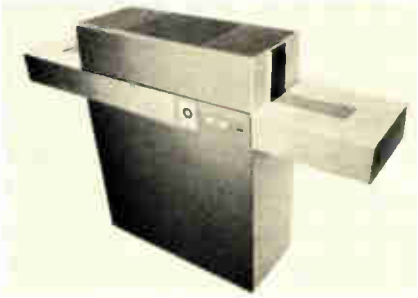
two grades of accept and one grade of reject. The unit operates under the control of an associated testing system. Price is less than $5,000.
Ramsey Engineering Co., Electro Mechanical Products Division, 1853 W. County Rd. C, St. Paul, Minn. [398]

2-level frame assemblies hold DIP socket boards

The H-2250 frame assemblies hold dual in-line socket boards with a capacity of 1,152 integrated circuits. The units open and swing out so that the component sides and wire-wrap sides of both levels are accessible. Four sizes are available, each with or without front panels: the assemblies can hold 288, 516, 864 or 1,152 circuits. The two levels can be machine-wired separately or as a single plane.
Electronic Engineering Co. of California, Electronic Products Division, 1441 E. Chestnut Ave., Santa Ana, Calif. 92701 [399]

Reflow soldering furnace is infrared-heated

An infrared-heated, conveyorized solder reflow furnace is designated the Heatpeak. Capable of chip attachment and package lidding, it features an adjustable quartz infrared heating element that can be positioned at an angle to the conveyor belt. The angular disposition of the heat source determines the



degree of profile peaking. The Heatpeak has a 4-inch-wide conveyor and solid-state temperature and belt-speed control.
Machine Technology Inc., 5 Great Meadow Lane, E. Hanover, N.J. 07936 [400]

Semiconductors

Pnp-npn input does job of FET

Complementary pair plus super-beta technique used in low-priced IC op amp

Engineers at the Semiconductor division of Sprague Electric Co. have combined super-beta techniques with an input-bias-current cancellation approach to get bipolar IC operational amplifiers that approach the performance of field-effect-transistor input devices with minimum sacrifice of input current and slew rate. The price is below the going rate for FET op amps.

Designed mainly for signal processing applications—such as long-term integrators, differentiators, sample-and-hold circuits, summing or logarithmic amps—the circuits have both high input impedance (up to 500 megohms) and relatively low input bias and offset currents.

Designated the ULN/S-2175 and ULN/S-2177, the circuits use a feedback loop around a pnp-npn complementary input stage that bucks current from the pnp transistor to the npn, thus lowering input bias. The loop compensates for variations in temperature, supply voltage, and beta. It is said to reduce bias current 10-fold below that of otherwise similar ICs.

The part of the IC that handles current compensation, input amplification and biasing for the input amp uses 36 active devices—most of them in the current compensation network. By contrast, the buffer and amp stages that form the latter part of the op amp use only 12 active devices.

Such design tricks as using feedback loops and super-beta techniques that Sprague employed exact their own tradeoffs, however. The low-bias (0.3 nA) ULS-2177 slews at 0.3 volt per microsecond, and the faster slewing ULS-2175 (1.5 V/μs) has 1.3 nA typical input bias.

But Sprague engineers say that the product of slew rate and bias may be the best combination now available to users shopping in lower price ranges. And if a given application requires either lower bias or faster slew, the user can pick the IC that satisfies the requirement.

Spokesmen also note that it is possible to establish a super-beta capability only after establishing firm process control. But having established such control, there are other payoffs. An important one is a much expanded operating temperature range for commercial circuits—in this case, the ULN versions. Compared with the usual commercial temperature range of 0 to 70°C, the ULN series performs within specifications over −55°C to +100°C. The ULS series carries this performance on to +125°C.

Prices of the 2175 and 2177 are equal, with ULS versions $12.77 each in lots of 1 to 24, and ULNs, $5.11. OEM lots (2,500 to 4,999) of ULS versions sell for $8.30, and of ULNs for $3.32.

Sprague Electric Co. Semiconductor Division, 115 Northeast Cutoff, Worcester, Mass. 01606 [411]

Power transistors built for TV deflection circuits

Five years ago, Texas Instruments, Bedford, England, and the British Radio Corp. built a fully transistorized television set. It was a little more expensive than the tube variety and didn't really catch on, says

Jeff Hendy of TI's Semiconductor marketing staff in Dallas. But it gave TI a jump on what eventually will be a sizable market, as TV manufacturers demand solid-state reliability.

At the Consumer Electronics Show in Chicago last month, TI introduced to the U.S. four high-voltage power transistors, designed and manufactured in England to replace horizontal-deflection vacuum tubes. "The problem was to come up with a high-enough-voltage transistor to deflect an electron beam," Hendy explains. "It must withstand voltage spikes of 1,200 to 1,400 V, and must turn off 3 amperes within half a microsecond." The TI series incorporates modifications of the original experimental work.

Similar devices are available: Delco has designed one for the horizontal-deflection function, and both Toshiba and Amperex import some power transistors from Japan and The Netherlands. RCA accomplishes the same function with SCRs, "and RCA is about sole source over here for SCRs that do this particular job," Hendy says.

The TIP 550 and 551, designed for monochromatic TV deflection circuits and high-voltage inverters, are priced at $2.10 and $2.50 each in 100-quantities. The TIP 552 and 553, intended for high-voltage inductive switching and high-voltage CRT deflection for color receivers, sell for $4.05 and $4.55 each. In larger quantities, the circuits vary in price from $1.25 to $2.25 each.

Switching speeds for the power transistors are 0.6 microsecond at 2 A for the 550 and 551, and 0.7 μs at 4.5 A for the 552 and 553. Continuous collector current and collector-emitter voltage are 3 A and 1,200 V for the 550, 3 A and 1,400 V for the 551, 5 A and 1,200 V for the 552, and 5 A and 1,400 V for the 553. The circuits are available in TO-3 cans, and delivery time is three weeks.

Texas Instruments Incorporated, Semiconductor Group, P.O. Box 5012, Dallas, Texas 75222 [412]

Germanium power transistors handle 25 amperes, 80 volts

Designed primarily for switching applications, a series of 25-ampere, 80-volt germanium power transistors offers improved leakage, low

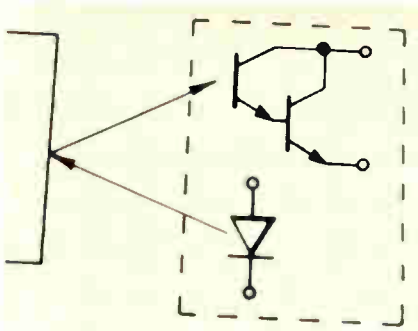
saturation voltages, and high-current efficiency. The devices are packaged in a TO-3 case that has special 60-mil emitter leads, resulting in a saturation voltage that is less than 0.5 V at 25 A. The units, designated the SDG-600 series, are priced at $1.05 each in quantity.
Solitron Devices Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404 [418]

LED package allows 180-degree viewing

A red-diffusive molded package for light-emitting diodes provides a full-flood viewing light instead of a small red spot. The package, called the RL-21, contains a gallium-arsenide-phosphide diode and provides a viewing area that extends 0.140 inch beyond the face of the mounting clip, thus allowing a full 180° viewing. The radiating area is 0.2 in. in diameter and presents a visual display that is suited for indicating functions on instruments and control panels. Leads are 0.025 in. square for wire-wrapping, soldering, or pc board mounting. The RL-21, which operates on 1.7 volts at 20 milliamperes, sells at 65 cents each in quantities of 1,000.
Litronix Inc., 19000 Homestead Rd., Cupertino, Calif. 95014 [413]

Reflective object sensor uses LED, photo-Darlington

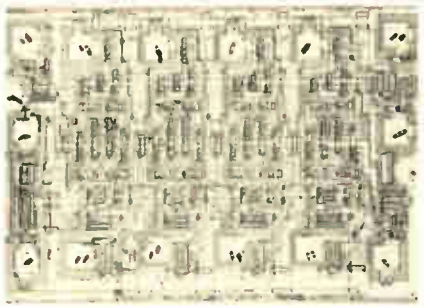
A solid-state optoisolator senses objects by using the reflected light from a light-emitting diode. The unit, called the MCA7 reflective object sensor, incorporates an LED infrared emitter and a photo-Darlington detector in one package. They are mounted in the same plane, so the light is reflected off any nearby opaque object and onto the detector, which remains in the off state in the absence of an object. Principal applications are object-sensing and limit-switch operations in tape recorders, paper-handling, machine tools, and automobiles. Prices range from $2.95 each for 1,000 units to



$4.80 each for quantities of 1 to 9.
Monsanto Commercial Products Co., 10131 Bubb Rd., Cupertino, Calif. 95014 [414]

TTL storage register has three output states

An MSI storage register added to the Texas Instruments 54/74 TTL family will accept typical input clock rates of 35 megahertz, and incorporates a three-state output configuration. The unit, which is designated the SN54/74173, consists of four D-type flip-flops and is a plug-in replacement for the DM8551/7551. Designed specifically for bus-oriented



systems, the three-state ouput permits the 173 to be connected directly and to drive the system bus. The TTL MSI register is offered in five versions, with prices ranging from $3.22 to $14.50 each.
Texas Instruments Incorporated, Inquiry Answering Service, P.O. Box 5012, M/S 308, Dallas, Texas 75222 [415]

Plastic TO-66 Triac offers blocking voltage up to 800 V

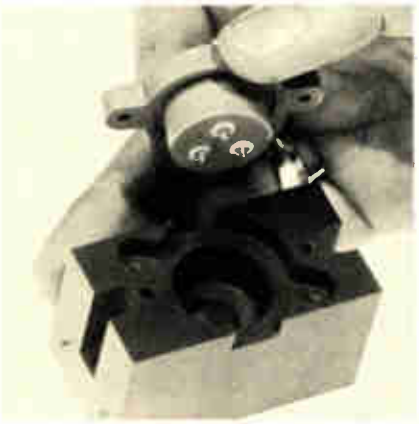
A family of Triacs in the new Thermowatt package provides full-wave ac control with rms currents of up to 12 amperes in the plastic TO-66 package. Blocking voltages of 200 volts up to 800 V are available in these devices, designated the 2N6342 through 2N6349. Gate triggering can be specified for two-mode or four-mode firing for all voltage and current ranges. Surge currents of 100 A are available for standard devices and 120 A for spe-

cial units. All are glass-passivated for added junction reliability. Applications include light-dimming and motor and heat control. Prices range from 95 cents each to $3.60 for quantities of 100.
Technical Information Center, Motorola Inc., Semiconductor Products Div., P.O. Box 20924, Phoenix, Ariz. 85036 [416]

One resistor programs micropower op amp

An operational amplifier called the LM4250 is designed for low-power, low-noise, low-input-current applications. A single resistor varies its input characteristics, noise performance, and standby-power consumption over a ±1-volt to ±18-V supply range. At a nominal value of the programing resistor, maximum input bias current is 7.5 nanoamperes, input offset current 3 nA, input offset voltage 3 millivolts, noise current 0.1 picoampere per square-root hertz, and standby power dissipation 255 microwatts. Packaged in an 8-pin TO-5, the LM4250 is specified for −55°C to +125°C operation and is priced at $8.75 for quantities of 100. The LM4250C, specified for 0°C to 70°C, sells for $3.25.
National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051 [417]

New products/materials



A two-part epoxy resin can be cast to within ±0.001 inch of its final dimension. The 409 material offers good machinability and has a predictable shrinkage rate of 0.002 inch per inch. This, combined with high impact strength, makes it useful for potting circuitry, connectors, coils, transformers, and mounting stands. Price is about $16.20 a gallon.
Castall Inc., Weymouth Industrial Park, E. Weymouth, Mass. 02189 [476]

Silicon materials for the semiconductor industry include subdiffused, deep-diffused, and epitaxial wafers. The products are made from dislocation-free substrates that have damage-free, clean surfaces. The oxide layer, diffused junctions, and epitaxial films are prepared to each customer's requirements.
Monsanto Commercial Products Co., 800 N. Lindbergh Blvd., St. Louis, Mo. 63166 [477]

A temperature-independent ferrite material for computer core memories permits an operating range of −25 to +100°C without temperature compensation. The material eliminates the need for thermal sensing devices, heat sinks, and blowers, as well as excessive testing and rework caused by failures in extreme temperatures.
Ampex, Computer Products Div., 13031 West Jefferson Blvd., Marina del Rey, Calif. 90291 [478]

Silicon carbide half-round boats for coin stacking and slice boats are both made of KT material. Applications are in heat diffusion or support tubing in the semiconductor industry. The high-density, virtually

New products / materials

laminate-free material can be substituted for quartz-slotted carriers in extreme-temperature applications.
Electrical Products Branch, Refractories and Electronics Div., The Carborundum Co., Box 339, Niagara Falls, N.Y. [479]

Two chemicals for cleaning of solder-plated circuits after etching to improve solderability of tin-lead surfaces are called the Lonco Alloy Surfact-TL-1 for automatic in-line equipment and tank dipping, and Lonco PPC #5 liquid cleaner for dip-tank operations. Both cleaners are available in 1-, 5-, 15-, and 53-gallon sizes.
London Chemical Co. Inc., 240 Foster Ave., Bensenville, Ill. 60106 [480]

A rigid, punchable epoxy glass flame-retardant laminate called PEG-FR is an epoxy matrix reinforced with glass fibers. The core is composed of a paper form of 100% glass fibers, and the surfaces are woven glass; the whole is saturated with epoxy resin and laminated together into flat sheets. Typical uses are in terminal boards requiring high strength and electrical properties, and in breadboards.
Spaulding Fibre Co. Inc., Tonawanda, N.Y. 14150 [481]

An aluminum-and-glass material called Quartzram is aimed at packaging of MOS, bipolar, and hybrid integrated circuits to provide increased mechanical or thermal capability. Special applications include desktop calculators and computer systems. The material is available in a granulated mixture in ready-to-press form, or in pressed and sintered preforms.
Mansol Ceramics Co., 142 Little St., Belleville, N.J. 07109 [482]

A tarnish and rust remover for varied electronic applications contains none of the acids associated with jelly-type removers. The nonflammable SC-400 is suitable for ferrous and nonferrous metals, and it is not necessary to time the period of immersion. Price is $15 for concentrate making 2½ gallons.
Starnetics Co., P.O. Box 9308, North Hollywood, Calif. 91609 [483]

New literature

Gunn oscillators. Micromega Div., Bunker Ramo Corp., 12575 Beatrice Ave., Los Angeles, Calif. 90066, has available a product bulletin providing technical data on phase-locked Gunn oscillators. Rf and mechanical data are also included. Circle 421 on reader service card.

Communications controllers. A four-page bulletin describes the models 2612 and 2612-1 asynchronous communications controllers. The brochure gives operating instructions, general information, features, and specifications. It is available from Microdata Corp., 644 East Young St., Santa Ana, Calif. 92705. [422]

Storage/retrieval system. Varian Adco, 470 San Antonio Rd., Palo Alto, Calif. 94306. An eight-page brochure describing the model 926 large-scale information storage and retrieval system provides data on the unit's encoder, mounter, remote viewer, rapid remote access, and options. [423]

Control devices. G-V Controls division, Sola Basic Industries, 101 Okner Parkway, Livingston, N.J. 07039, has published a catalog on devices for timing of temperature, voltage, and flasher applications. Included are distributor listings and product descriptions. [424]

Power-line filters. A six-page catalog that describes power-line filters is available from Corcom Inc., 2857 North Halsted St., Chicago, Ill. Five series are discussed, along with electrical and mechanical specifications. [425]

Slide switches. A product bulletin on printed-circuit-board slide switches is available from Siemens Corp., 186 Wood Ave. South, Iselin, N.J. 08830. The bulletin describes top-handle, side-handle, and momentary-pushbutton models of the nonshorting, break-before-make, double-pole double-throw type units. [431]

Stampings. The Stanley Works, New Britain, Conn. 06050. Min-

New literature

iature stampings for electronic strapping machines, small springs for computers, and coils of strip steel are the subjects of a brochure detailing product applications and data. [432]

Pin-diode switch. Bulletin M870/M871 provides data on a line of pin-diode control devices, the model M870 SP2T and model M871 SP4T switches, available from General Microwave Corp., 155 Marine St., Farmingdale, N.Y. 11735 [435]

Relays. A 32-page catalog from Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif., describes a line of relays, including time-delay, chopper, reed, latching, frequency-sensitive, binary, and microreed relays. [426]

Printer circuit. A printer interface circuit, manufactured by Mini-Systems Inc., 4935 Boone Ave. North, Minneapolis, Minn. 55428, is detailed in a brochure providing data on the peripheral controller unit. [427]

Modem. A six-page brochure from Intertel Inc., 6 Vine Brook Park, Burlington, Mass., describes the model 2012 synchronous modem, capable of automatic answer operation at 2,400 bits per second over dial-up telephone lines. The brochure gives theory of operation, descriptions of features, and technical specifications. [428]

Data set. The applications and benefits of Intertran 910 series, a modular data set for four-wire twisted-pair data communications facilities, are detailed in a brochure from Computer Transmission Corp., 1508 Cotner Ave., Los Angeles, Calif. 90025. [429]

Power supplies. Powertec Inc., an Airtronics subsidiary, 9168 De Soto Ave., Chatsworth, Calif. 91311. A catalog presents a line of standard OEM dc power supplies with specification, prices, and delivery schedules. More than 150 models are discussed, and application data and specifications are cited. [430]

Electronics Advertisers

July 3 1972

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* Advertisers in Electronics International
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The Time Machine...

New Heath/Schlumberger Programmable Timer... $395*

Precise, low cost time measurements. The new SM-102A is a compact, lightweight time-measuring instrument capable of 100 nanosecond resolution (direct count). Both Start and Stop inputs are internally switch-selected to allow for a zero-crossing or TTL-level signal. Although time-interval measurement is its primary function, the SM-102A will also measure period, period average, events, scaled events and frequency ratio.

Excellent sensitivity. The SM-102A will trigger with as little as 100 mV rms input. And the input is protected to ±50 V at DC and 25 V rms at 20 MHz.

Differential input. The true differential input of the SM-102A allows measurement of time interval between signals that do not have a common ground, as well as signals referenced to ground. Front panel binding posts and binding post-to-BNC adapters provide connection flexibility.

Programmable. Standard BCD output and programmability make automatic measurements easy. External control of range and reset is provided, as well as 5 digits of BCD output, over-range flag, and completion flag . . . a computer can easily program and control the SM-102A. Connect a TTL-compatible digital printer to the back of the SM-102A and recording is automatic.

If you have measurement problems in the anywhen, we have an accurate, low cost solution: the SM-102A . . . the Time Machine.

Assembled SM-102A, 8 lbs. $395.00*

SM-102A SPECIFICATIONS — START/STOP INPUT — Input Impedance: 1 megohm shunted by less than 50 pF. **Maximum Input Voltage:** ±50 V DC referenced to ground for either, or both sides of Input. **Sensitivity:** Zero crossing mode: 100 mV RMS. TTL/relay mode: TTL compatible. **Minimum Pulse Width:** Zero crossing mode: 100 ns at 300 mV pk-pk. TTL/relay mode: 50 ns at TTL levels. **GENERAL — Range:** Time A-B: 0.1 μs to 10^4 sec. Period Average: 5 x 10^{-8} sec to 9999.9 sec. Events: 1 to 99999. **Resolution:** Time A-B: 100 ms to 100 ns. Period Average: 100 ns/number of periods averaged. **Accuracy:** ±1 count, ± time base accuracy, ±trigger error (start/stop). **External Oscillator Input Range:** DC to 12.5 MHz. **Time Base:** Frequency: 10 MHz. Aging Rate: less than 5 ppm/year. Line Voltage Stability: less than ±1 part in 10^7 for 10% line variation. Temperature Stability: ±5 ppm 10°C to 40°C ambient. Referenced at 25°C. **Readout:** Five 7-segment LED's plus 3 incandescent lamps and 2 decimal points for range indication and overrange. **BCD Output:** Rear panel connector for 5 digits of BCD, Overrange flag, Completion flag, 5-volt reference (1 KΩ impedance), Ground, and Range programming inputs (binary). Maximum cable length, 18". **Power Requirements:** 105-125 volts, 50/60 Hz, 23 watts. (210-250 volts by changing internal switch and fuse). Fuse: 125 volt operation: ¼ ampere, 125 volt slow blow. 250 volt operation: ⅛ ampere, 250 volt slow blow. **Dimensions:** 9¼" deep, 6¾" wide, 2¼" high. **Net Weight:** 4½ lbs.

The Heath/Schlumberger frequency machines

If frequency measurement is your problem, we have a solution to that as well. Our SM-105A provides 10 Hz to over 80 MHz range, 5-digit LED readout, 100 mV rms input sensitivity and time base stability of ±10 ppm . . . for only $350*. Our SM-104A frequency counter provides the same range as the SM-105A, but has a research-grade TCXO time base guaranteed stable to 1 part in 10^8 per year and 5-digits of TTL-compatible BCD output . . . for just $500*.

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- ☐ Please send additional information on the SM-102A Timer.
- ☐ Please send additional information on the SM-105A, SM-104A and SM-114A.
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the 304 detects most types of smoke, giving added fire protection to secure areas

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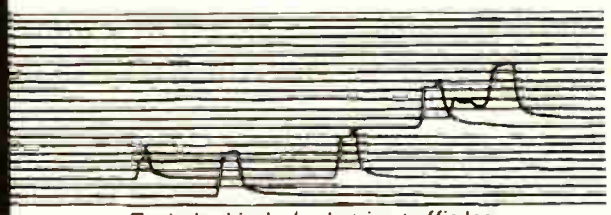

Typical vehicular/pedestrian traffic log

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