APRIL 12, 1979

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A versatile design component: analog divider ICs/120

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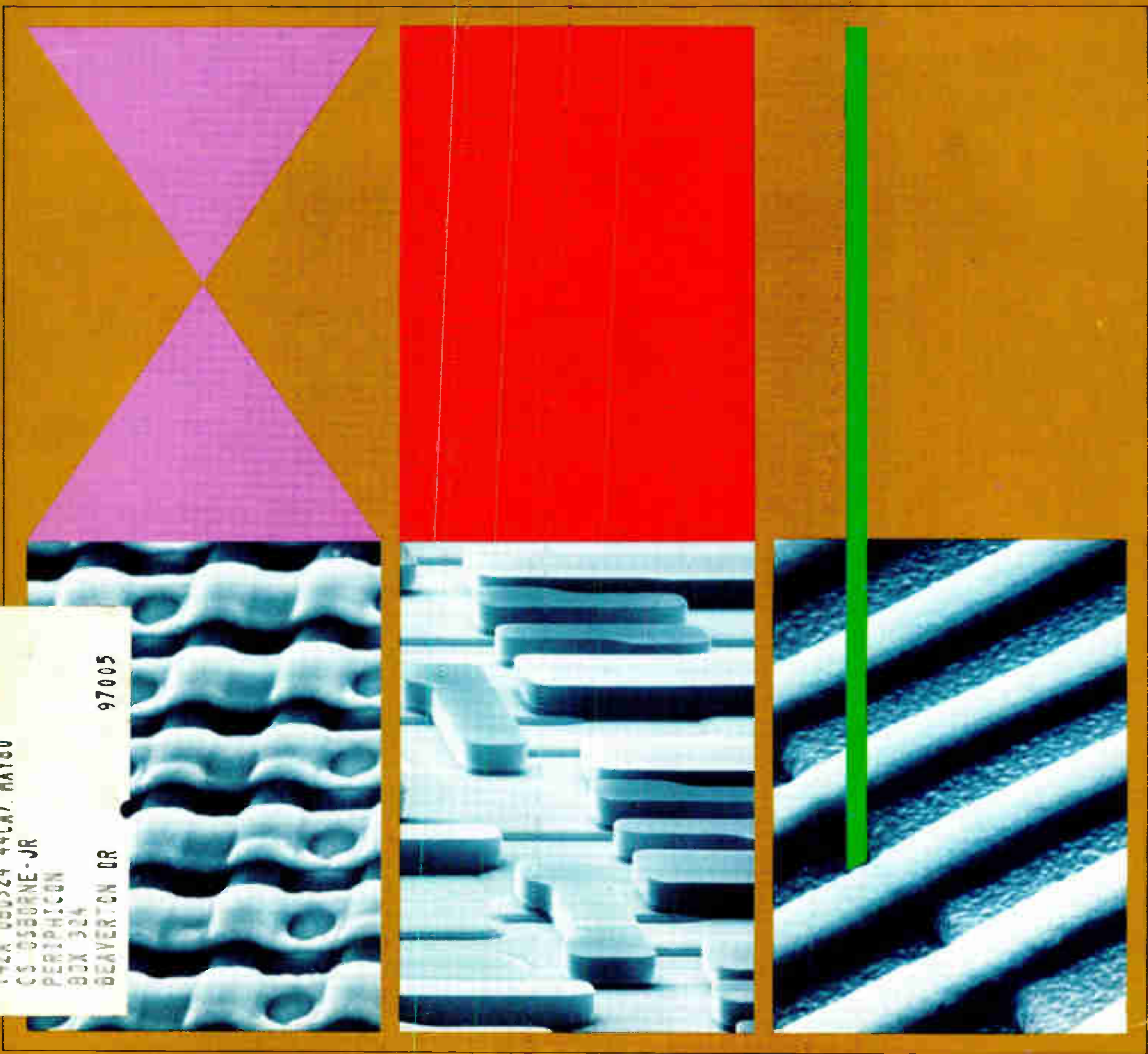

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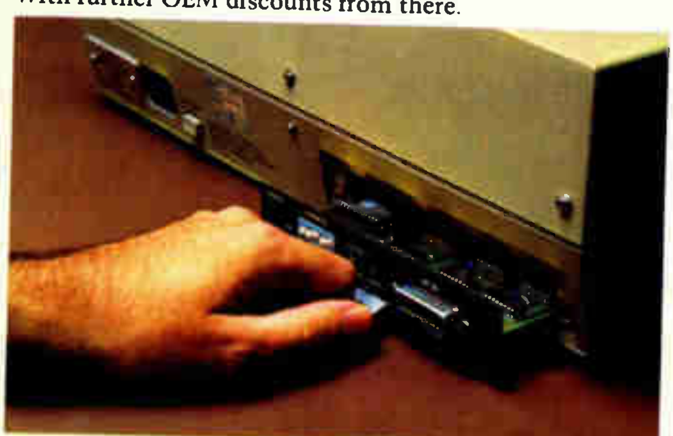

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Electronics

The International Magazine of Electronics Technology

Vol. 52, No. 8 • April 12, 1979

Highlights

Cover: In pursuit of the submicrometer line, 105
The chip density demanded by very large-scale integration is pushing the development of lithographic techniques. Mask making seems likely to remain the prerogative of electron-beam systems, but the X-ray approach is more promising for mass production, says this special report.

Cover is by Associate Art Director Charles Ciatto.

Can microprocessors stop midair collisions? 81
The Federal Aviation Administration is investigating new microprocessor-based airborne collision-avoidance systems that would be capable of cooperating with ground-based air traffic control.

Electro79 looks beyond the chip, 162
The technical sessions this year will focus on software manufacture, industrial control networks, personal computers—everywhere except on semiconductor technology, notes this special report.

Analog dividers attain hybrid status, 120
Profiting from the recent advances in integrated-circuit technology and design, analog dividers now come in dual in-line packages costing less than $20 each yet achieve great accuracy: error can be held to 0.1% over a 1,000/1 denominator voltage.

. . . and in the next issue
Two more special reports: the Electronic Components Conference previewed, and fast static random-access memories . . . an interface chip for the IEC bus.

Electronics

Publisher's letter

With this issue *Electronics* enters its 50th year of publication, marking a half century in which the industry has grown from essentially a radio and broadcast business into the most pervasive and influential technology in the world.

The design shown above and on the cover symbolizes our pride in having been a part of this history. It will appear on the magazine for the next 12 months, leading up to our commemoration next April of the 50th anniversary of *Electronics*.

Dan McMillan, for 10 years the publisher of *Electronics*, has become our corporate boss: he's been promoted to a group vice president of the McGraw-Hill Publications Co. During his time as publisher Dan earned an international reputation as an incisive industry observer and a superb manager.

It's customary in taking over a successful operation to say that it will be a tough act to follow—and it will indeed. However, Dan leaves behind him a topnotch team. Together, we intend to carry on the high standards he set as we move into the next 50 years.

Lithography is undoubtedly the foundation of the VLSI age, as the special report (p. 105) by packaging and production editor Jerry Lyman underscores. He has been following the development of fine-line lithography and reporting on it since VLSI was merely a gleam in device designers' eyes. In the course of preparing this article, Jerry donned more white gowns, hats, and shoes to enter the clean rooms than he had ever expected. Our bureau managers in Europe and Japan had similar white room experiences preparing their contributions to this report.

As he passed through those dust-defying rooms, Jerry was struck by the change in lithographic techniques in just two years. Step-and-repeat equipment, which was only being discussed a few years ago, is now firmly entrenched. He sees this type of equipment turning up everywhere.

"One point I heard over and over," Jerry reports. "The 1-micrometer production processing nut may take much longer to crack than the lithography nut. Except for chip processing going on at a couple of R&D labs, we are not quite there yet."

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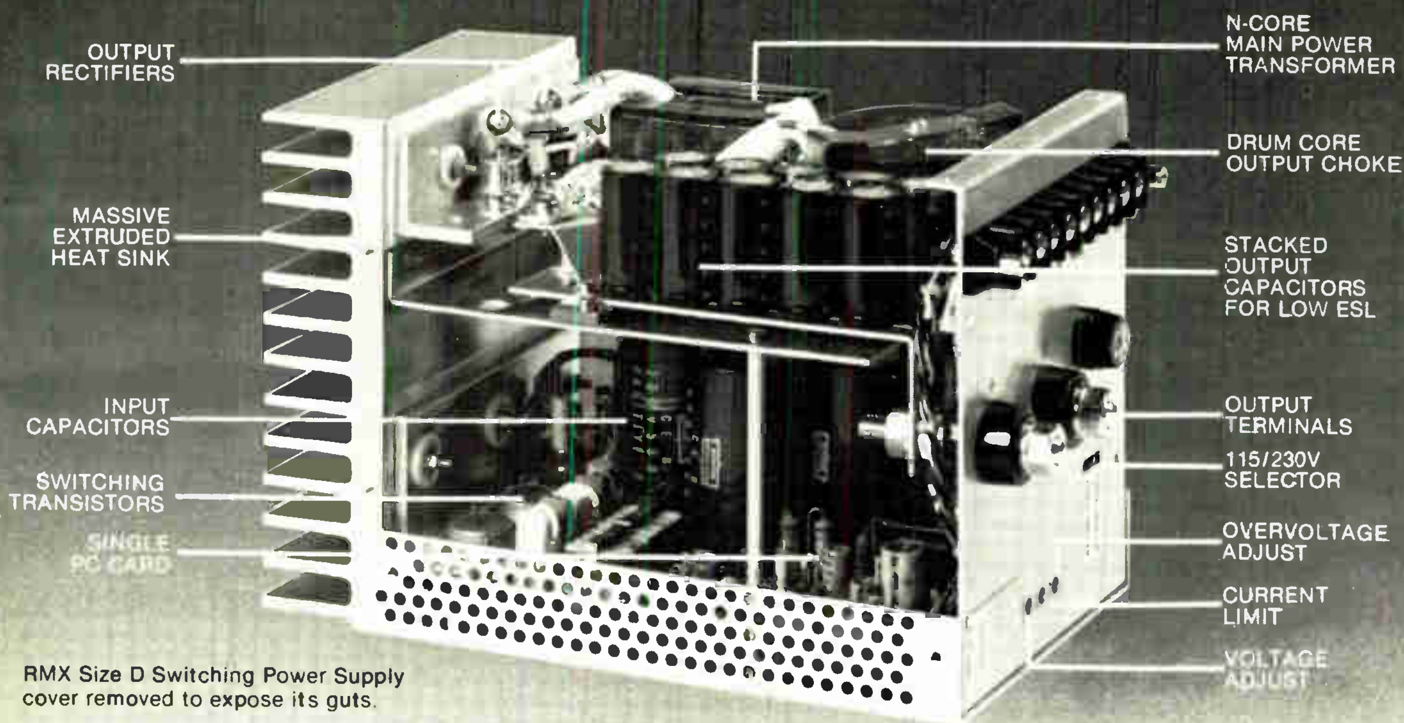

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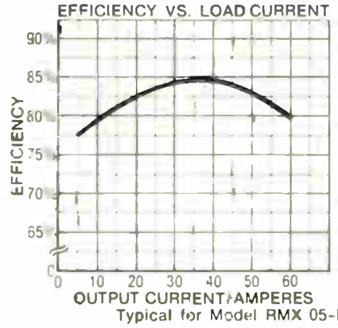
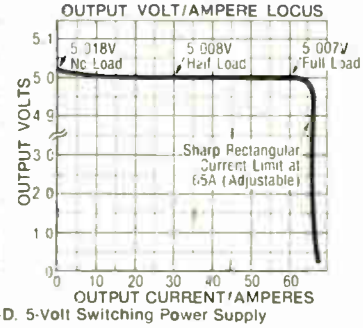
RMX 15–D	10.5–16.5	23A
RMX 24–D	16.8–26.4	16A
RMX 28–D	19.6–30.8	13.7A





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Readers' comments

Some friend?

To the Editor: Leo Young's defense of the Professional Activities Committee workshops run by the Institute of Electrical and Electronics Engineers' U.S. Activities Board [Readers' Comments, Feb. 1, p. 6] is not unexpected, given his long record as an apologist for the IEEE's establishment.

There is another action that reveals the bankruptcy of the U.S. Activities Board. This board, of which Dr. Young is so proud, has refused a request from 62 Sperry engineers, who were fired as a result of alleged age bias, that it file a "friend of the court" brief in their lawsuit.

We working American EEs deserve far better from our professional society.

Irwin Feerst
Committee of Concerned EEs
Massapequa Park, N.Y.

Not ready

To the Editor: Contrary to the impression conveyed by your story "Wiring system rivals multilayer, Multiwire" [Feb. 1, p. 74], representatives of Laboratoire d'Electronique et de Technologie de l'Informatique (LETI) have informed us that they have not yet reached a point where the K6 process is ready for commercial development.

Furthermore, a recent meeting with them confirmed our considered opinion that the K6 process and concept depend on the use of technology covered by certain claims in Kollmorgen's Multiwire patents. Accordingly, we are conducting discussions with LETI that we hope will lead to a satisfactory resolution of the proprietary issues.

William P. Sharpe
PCK Technology Division
Kollmorgen Corp.
Glen Cove, N.Y.

1978 Index ready

The index of articles published in Electronics *in 1978, which was previously announced in the March issues, is now available. For a free copy, please circle 340 on the reader service card.*

Last year, this $1000 device convinced over 300 companies they could cut the high cost of digital troubleshooting.

Company after company is becoming convinced that it can significantly reduce the huge costs involved in microprocessor troubleshooting by using HP's signature analysis technique. The savings on board inventories alone can run into hundreds of thousands of dollars. In brief, it is now possible for a modestly trained technician to accurately troubleshoot microprocessor boards right down to the component level in the field or on the production line.

A simple concept.
Subtle errors in the lengthy bit streams of microprocessor-based products are definitive clues to component failures which cause them. But lengthy bit streams are very tedious and costly to examine by traditional means.

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Just activate a digital exercise routine in the circuit under test and compare the bit stream signature at each data node with the known good signatures previously written into your service manual. Digital signal tracing now becomes as simple as analog tracing used to be. But more accurate. So accurate that it catches almost every possible fault, including many that can be detected in no other way. It once again becomes realistic to think of field or production troubleshooting to the component level by technicians.

Design it in or retrofit.
The savings in service costs and spare circuit board inventory are well worth the effort of designing with signature analysis in mind. It could possibly eliminate the need to partition your product for modular service. In some cases, it could even pay you to "retrofit" by developing exercise circuitry and a signature manual for your existing equipment. It's a fascinating—and very workable—concept. Amazingly the price of the HP 5004A Signature Analyzer that makes all this possible is a low $990.*

To help you make the most of this breakthrough we've prepared Application Note 222—"A Designer's Guide to Signature Analysis." Contact your nearest HP field sales office or write for your copy today. *price, domestic U.S.A. only

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News update

■ Downtown Boston has a fine, new retail store. Surburban Framingham, Mass., also has a new shopping place. But the merchandise in each of these stores is unusual for the average window-shopper. Digital Equipment Corp. of Maynard, Mass., is displaying small-business computer systems in the Boston store, whereas The Computer Store Inc. in Framingham has Apple computers for personal use and Data General microNovas for business applications. Although not the first attempts at computer retailing, these stores do mark a growing trend to take computers directly to the user [*Electronics*, March 31, 1977, p. 89].

DEC opened its first retail store in a mall in Manchester, N. H., last August, and business has been booming ever since, according to Jonah Kalb, merchandising manager for retail products. "We're essentially selling computer systems for small businesses and professional offices. Computer systems range from $11,400 to $13,000," he says. The second store, in Boston, opened in February, and "early results are encouraging."

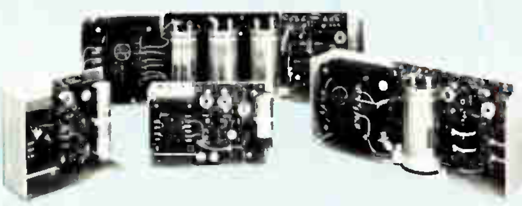
Richard Brown, president of The Computer Store Inc. in Burlington, Mass., notes that his store does very little hobbyist business, "although many of my customers are first-time users." The latest store opening, in Framingham in March, coincides with a growing trend to personal computer sales. Brown opened his first store in February 1976 and now has three stores and several franchise outlets operating.

Out West. Not all the action is on the East Coast, however. The first retail computer store to open is still doing a brisk business in Santa Monica, Calif.

Dick Heiser, president of the Computer Store—no relation to the eastern stores with the same name—has been in business since July 1975 and thinks he will be for quite a while. "The personal computer business is growing" fast, he notes.

"We'll keep adding new products as they become available," he says. The store now carries products from 50 companies. **-Pamela Hamilton**

"Talk about Open Frames"



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5	3.0 6.0 12.0 18.0	B5-3 C5-6 D5-12 E5-18	$24.95 44.95 74.95 104.95	12	1.7 3.4 6.8 10.2	B15-1.5 C15-3 D15-6 E15-9	$24.95 44.95 74.95 104.95	18	1.3 2.6 5.2 7.8	B24-1.2 C24-2.4 D24-4.8 E24-7.2	$24.95 44.95 74.95 104.95	24	1.2 2.4 4.8 7.2	B24-1.2 C24-2.4 D24-4.8 E24-7.2	$24.95 44.95 74.95 104.95
6	3.0 6.0 12.0 18.0	B5-3 C5-6 D5-12 E5-18	$24.95 44.95 74.95 104.95	15	1.5 3.0 6.0 9.0	B15-1.5 C15-3 D15-6 E15-9	$24.95 44.95 74.95 104.95	20	1.3 2.6 5.2 7.8	B24-1.2 C24-2.4 D24-4.8 E24-7.2	$24.95 44.95 74.95 104.95	—	—	—	—

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2	3.0 6.0 12.0 18.0	HB2-3 HC2-6 HD2-12 HE2-18	$29.95 49.95 79.95 109.95	12	0.5 1.7 3.4 5.1 6.8 10.2	HA15-0.5 HB12-1.7 HC12-3.4 HN12-5.1 HD12-6.8 HE12-10.2	$22.95 24.95 44.95 64.95 74.95 104.95	24	1.2 2.4 3.6 4.8 7.2	HB24-1.2 HC24-2.4 HN24-3.6 HD24-4.8 HE24-7.2	$24.95 44.95 64.95 74.95 104.95	48	0.5 1.0 3.0 4.0	HB48-0.5 HC48-1 HD48-3 HE48-4	$29.95 49.95 79.95 109.95
5	1.2 3.0 6.0 9.0 12.0 18.0	HA5-1.2/OVP• HB5-3/OVP• HC5-6/OVP• HN5-9/OVP• HD5-12/OVP• HE5-18/OVP•	$22.95 24.95 49.95 69.95 79.95 114.95	15	0.5 1.5 3.0 4.5 6.0 9.0	HA15-0.5 HB15-1.5 HC15-3 HN15-4.5 HD15-6 HE15-9	$22.95 24.95 44.95 64.95 74.95 104.95	28	1.0 2.0 3.0 4.0 6.0	HB24-1.2 HC28-2 HN28-3.0 HD28-4 HE28-6	$24.95 44.95 64.95 74.95 104.95	180, 200 250	0.12 0.1	HB200-0.12 HB250-0.1	$34.95 $34.95

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5	25.0 35.0	F5-25/OVP• G5-35/OVP•	$149.00 185.00
12	16.0	F15-15	$149.00
15	15.0	F15-15	$149.00
24	12.0	F24-12	$149.00
28	10.0	F24-12	$149.00

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5	14 18 23	63% 60% 57%	RE5-23/OVP•	$130.00
5	25 32 40	63% 60% 57%	RG5-40/OVP•	$220.00

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CC15-3.0	12V @ 3.4A or 15V @ 3.0A	−12V @ 3.4A or −15V @ 3.0A	$84.95

DUAL OUTPUT — HI-VOL

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MODEL	OUTPUT #1	OUTPUT #2	PRICE 1-9
±12 to 15V HAA15-0.8 HBB15-1.5 HCC15-3.0	 12V @ 1.0A or 15V @ 0.8A 12V @ 1.7A or 15V @ 1.5A 12V @ 3.4A or 15V @ 3.0A	 −12V @ 1.0A or −15V @ 0.8A or −5V @ 0.4A −12V @ 1.7A or −15V @ 1.5A or −5V @ 0.7A −12V @ 3.4A or −15V @ 3.0A	 $39.95 49.95 79.95
±18 to 24V HAA24-0.6	 18-20V @ 0.4A or 24V @ 0.6A	 (−)18-20V @ 0.4A or −24V @ 0.6A	 $39.95
±5V HBB5-3/OVP HCC5-6/OVP	 5V @ 3.0A• 5V @ 6.0A•	 −5V @ 3.0A• −5V @ 6.0A•	 $61.95 92.95
5V and 9-15V (Isolated Outputs) HAA512 HBB512 HCC512	 5V @ 2.0A• 5V @ 3.0A• 5V @ 6.0A•	 9-15V @ 0.5A 9-15V @ 1.25A 9-15V @ 2.5A	 $44.95 54.95 86.95

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MODEL	OUTPUT #1	OUTPUT #2	OUTPUT #3	PRICE 1-9
BAA-40W	5V @ 3.0A	12V @ 1.0A or 15V @ 0.8A	−12V @ 1.0A or −15V @ 0.8A	$ 69.95
CBB-75W	5V @ 6.0A	12V @ 1.7A or 15V @ 1.5A	−12V @ 1.7A or −15V @ 1.5A	$ 91.95
DBB-105W	5V @ 12.0A	12V @ 1.7A or 15V @ 1.5A	−12V @ 1.7A or −15V @ 1.5A	$126.95

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HTAA-16W	5V @ 2.0A•	9-15V @ 0.4A	(−)9-15V @ 0.4A or −5V @ 0.2A	$ 49.95
HBAA-40W	5V @ 3.0A•	12V @ 1.0A or 15V @ 0.8A	−12V @ 1.0A or −15V @ 0.8A or −5V @ 0.4A	$ 69.95
HCBB-75W	5V @ 6.0A•	12V @ 1.7A or 15V @ 1.5A	−12V @ 1.7A or −15V @ 1.5A or −5V @ 0.7A	$ 91.95
CP-131	5V @ 8.0A•	12V @ 1.7A or 15V @ 1.5A	−12V @ 1.7A or −15V @ 1.5A or −5V @ 0.7A	$110.00
HDBB-105W	5V @ 12A•	12V @ 1.7A or 15V @ 1.5A	−12V @ 1.7A or −15V @ 1.5A or −5V @ 0.7A	$126.95
HDCC-150W	5V @ 12A•	12V @ 3.4A or 15V @ 3.0A	−12V @ 3.4A or −15V @ 3.0A	$149.00

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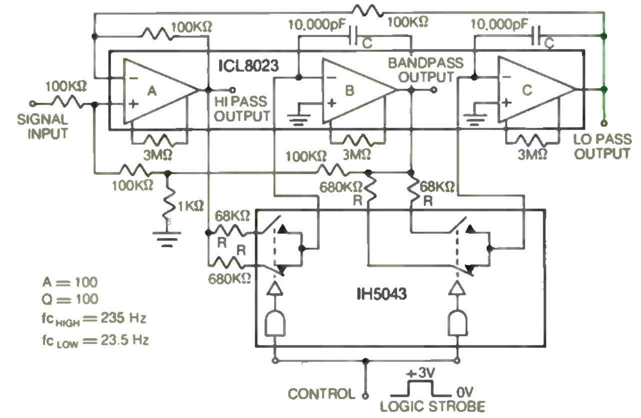

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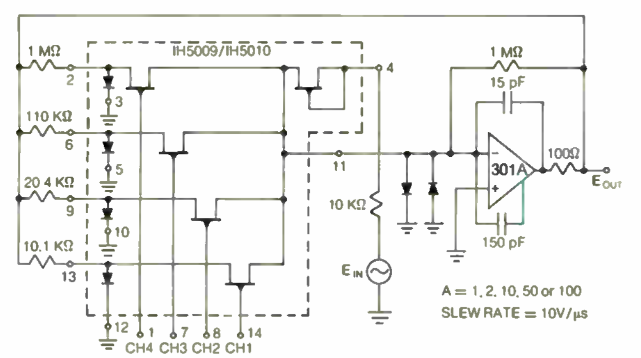

The IH5009 through IH5024 are a complete family of low cost 1, 2, 3 and 4-channel analog switches capable of interfacing with either 15V or TTL logic. No external power supplies are required.

PART #		100 PIECE PRICE
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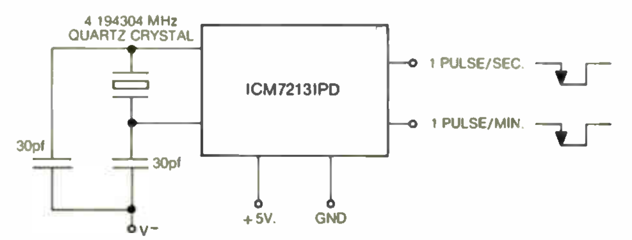

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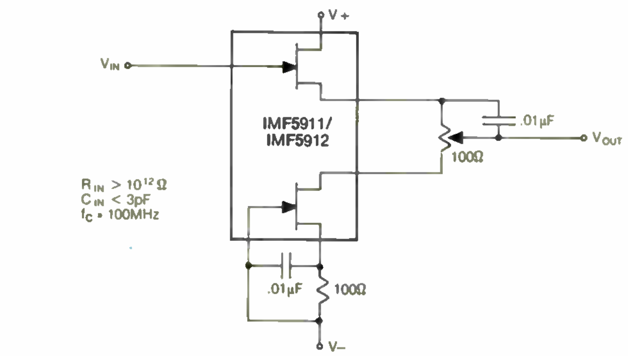

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"I wouldn't expect anything less than a long and distinguished history."

1955: Fluke introduces the world's first DC differential voltmeter.

Over 23 years ago, we began building differential voltmeters — in most instances setting new standards for the industry. Here are four.

The 893A is an AC/DC differential voltmeter routinely used as a secondary lab standard. DC accuracy is ±0.01% with infinite input impedance from 0 to ±1100 VDC. AC accuracy is ±0.05%.

The 887AB and 895A differential voltmeters both achieve a DC accuracy of 25 parts per million for 60 days, and both offer a resolution of 1µV. The 887AB also has outstanding AC specifications.

The 931B is a true RMS differential voltmeter designed for rapid measurements of AC waveforms to within ±0.05% regardless of their shape. Frequency response extends to 2MHz.

1957: Fluke introduces ultra-stable DC calibrator.

Two years after introducing differential voltmeters, we expanded our precision measurement line to include DC calibrators. Now Fluke provides a full range of instruments for all DC calibration needs. Here are three.

The 343A is a seven-dial, 20 ppm DC calibrator that provides parameters of stability, temperature range and response time required by a wide range of applications.

The 382A operates as a combination ±0.01% voltage calibrator and a ±0.02% current calibrator. It offers voltage outputs to 50V and current capabilities to 2A.

The 335D provides 10 ppm accuracy as both a DC voltage standard and a differential voltmeter.

1963: Fluke introduces standards.

We started it all in 1963; now the 540B stands by itself in the industry. It is a primary standard thermal transfer device for NBS traceable measurement and calibration of AC voltage and current. Measurement capability is 0.25V to 1000 Vrms over 14 ranges, with a frequency range from 5 Hz to 1 MHz.

The 510A is a precision fixed-frequency sinewave voltage source suited to calibration or test applications. Outputs are 10 Vrms at 10 mA with available frequencies from 50 Hz to 100 kHz.

The 731B DC transfer standard is an electronic standard cell designed to give metrology people a portable working DC standard. The 731B can be hand-carried anywhere and subjected to severe environmental conditions.

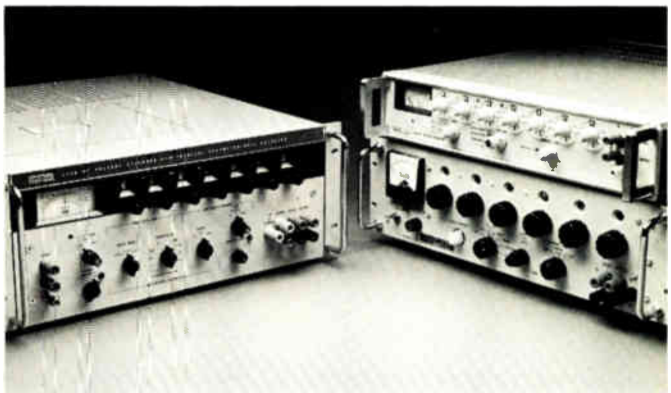
And look at the 515A portable calibrator. This lightweight precision calibration source is ideal for on-site calibration of measuring instruments. With four DC voltage ranges, three AC ranges, resistance capability from 10Ω to 10 MΩ and a rechargeable battery pack, you can perform eight hours of field calibration.

1966: Fluke introduces DC calibration systems.

Eleven years after we introduced our first precision measurement instrument, we offered the Fluke-designed 7105A system.

Accuracy to 5 ppm is standard in this DC voltage and ratio calibra-

893A, 931B, and 895A differential voltmeters.



335D, 343A, and 382A DC calibrators.

6101-8502

tion system, with resolution and ratio accuracy to 0.1 ppm.

In a functional self-contained enclosure, the 7105A offers voltmeter and power supply calibration capability, a differential voltmeter, ratio calibrator and a null detector.

The system is self-calibrating, and is supplied with certificates of traceability to the NBS.

1972: Fluke introduces AC calibration system.

We entered the market with a fully programmable AC calibration setup. Together, the 5200A precision ±0.02% AC calibrator and the 5205A precision power amplifier can calibrate AC devices up to 1200 Vrms. Frequency range is 10 Hz to 1.2 MHz.

The calibrators interface easily with almost any system. Field installable IEEE 488 and parallel isolated programming options are available.

1977: Fluke introduces the cal lab in a box.

In this year, we introduced the first "calibration laboratory in a box."

Our new 5100A/5101A calibrators can calibrate VTVMs, VOMs, 3½- and 4½-digit DMMs in a fraction of the time it takes you now, unless — of course — you're already using one!

The heart of these calibrators is a microprocessor, eliminating mechanical switch failure and providing large systems flexibility at a fraction of the previous cost.

Both calibrators supply AC and DC to 1100 volts, with a DC accuracy of 50 ppm and AC bandwidth of from 50 Hz to 50 kHz standard. AC/DC current to 1.99999 amps and decade resistance values from 1Ω to 10 MΩ at cardinal points.

Optional IEEE interface puts either calibrator in your total calibration systems. The 5101A's built-in cassette tape deck lets you store calibration and test programs and perform them error-free under microprocessor control.

The microprocessor also provides error computation in percent or dB, full scale or fraction of full scale.

1978: Fluke introduces the most advanced DMM.

Our 8502A microprocessor-based DMM, a total systems instrument, has uniquely enhanced bench capability as well.

The 8502A measures DC volts and amps, AC volts and amps (RMS or averaging), resistance (two or four terminal measurements) and performs AC or DC ratio. The 8502A has microprocessor control, computational capability, 6½-digit resolution, 6 ppm accuracy (DC volts), limits, peak reading, cal-memory, zero memory, digital filtering, diagnostic routines and IEEE 488, RS232C, and full parallel interfaces. The 8502A has them all; other DMMs only have some!

All functions are front panel controlled as well as remotely (systems) programmable.

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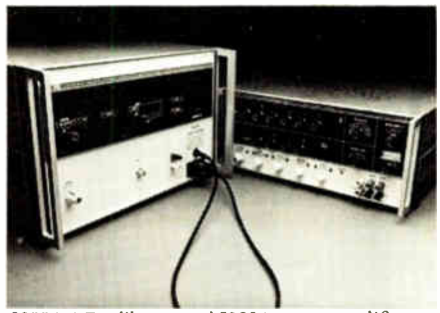
The 8502A μP-controlled DMM.

7105A DC calibration system.



5200A AC calibrator and 5205A power amplifier.

731B, 510A, 540B standards.

515A meter calibrator and the 5101A "cal lab in a box."

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People

Motorola's Jarrat to decide on fast Schottky logic

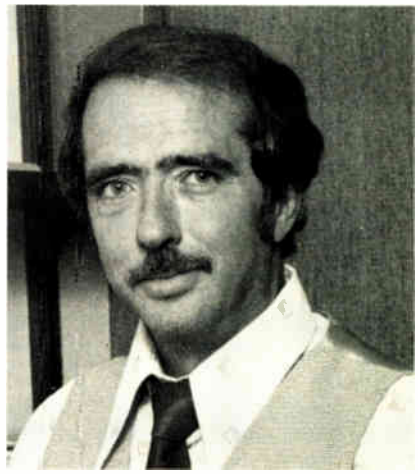
Henri Jarrat of Motorola Inc.'s Integrated Circuits division, Phoenix, admits to sitting in a pretty good spot for dealing his firm into what looks like a big-stakes semiconductor pot for the 1980s. The pot involves fast Schottky logic, and the situation is this: two firms, Texas Instruments and Fairchild Camera and Instrument, are taking the lead, each with a somewhat different type of fast Schottky logic for computers [*Electronics*, Feb. 1, p. 88].

"Both lines have merit," Jarrat says diplomatically, but neither can prevail yet, an opinion neutral observers also hold. What will tip the scale decisively is another major semi house—Motorola, for instance—backing one or the other by second sourcing. Until then, "it could be a mess, with the industry heading in different directions," comments the director of Motorola's bipolar operations.

As for his fast-Schottky trump card, he notes, "We have the technology base in our hands to do either one and crank out devices in a matter of weeks." So what is holding up the decision? "We are still talking to key fast-Schottky customers," answers the French-born Jarrat. "Then we will decide, for certain before the second half is over."

Analysis. If it's TI, the issue will be settled quickly, he predicts, but if the Fairchild parts win, then the Texas firm's vaunted staying power could make it a horse race for a while. Generally, evaluation shows TI with somewhat better performance specs, but Fairchild with a manufacturing edge in getting them into the field.

In TI's case, the youthful-looking, 40-year-old Jarrat surely knows whereof he speaks. He came from Texas Instruments in 1977 shortly after Alfred J. Stein also came from there to take over Motorola's integrated-circuit operations. A hard-driving executive out of Stein's mold, he has pushed his bipolar troops hard since being named to his job in early 1978. As he also holds three master's degrees (in electrical engineering, solid-state physics, and business), the result is a resurgence for Motorola. The company now has large-scale integrated logic and memory parts for all the major technologies, most notably the transistor-transistor-logic area in which it struck out in the past.



Choosey. Both lines have merit, says Henri Jarrat of TI's and Fairchild's fast Schottky.

Coming along soon are such unheard-of things for them as 8-K random-access memories and 16-K programmable read-only memories. At the same time, the linear business, featuring converters, is also on a steep upward curve, due to Jarrat's urging.

This reflects Stein's philosophy of making "Motorola a supplier with a full portfolio," as Jarrat puts it. Jarrat's success in broadening the product range has propelled him into the front rank at Motorola Semi. "He's the one who made all these [bipolar] things happen," complimented Stein recently to financial analysts visiting Phoenix.

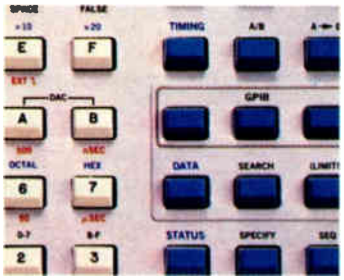
Dataproducts' Wieselman looks toward ink jets

Printers, like so much else in electronics, have felt the onslaught of large-scale integration. With LSI replacing functions previously performed with mechanical parts, the latest printers are smaller, many

Biomation's K100-D-- no other logic analyzer even comes close.

No wonder the K100-D is our fastest selling new logic analyzer ever. It gives you 16 channels, 1024 word memory, clock rates up to 100 MHz, signal timing resolution to 10ns-plus a built-in display and keyboard control.

Biomation's K100-D puts it all right at your fingertips — more performance and features than any logic analyzer ever.



It starts with the microprocessor-controlled keyboard and interactive video display. To give you fast, precise control, the display serves as a comprehensive control status menu, with all selectable parameters in reverse video. There's a single, labelled key for each function, corresponding directly to status display choices. So guesswork is eliminated.

For example, in the data domain, you can direct the display to read in hexadecimal, octal, binary or ASCII, or any combination, by selecting one of four control buttons. There's also a unique "sequence" key that enables you to rearrange the order in which channels are displayed, to aid in data decoding, to simplify side-by-side comparison of timing signals and to enable you to cancel any channels you're not interested in seeing. A separate key controls horizontal expansion.

That gives you an idea of the K100-D's display versatility. Here's a picture of its astounding capture capability.

By providing timing analysis of signals as fast as 100 MHz, you can capture logic signals with resolution to 10ns. And the 100 MHz clock rate protects against obsolescence as the speed of your systems gets faster and faster. The K100-D also has a latch mode that can capture glitches as narrow as 5ns.

With the 32-channel input adapter, the K100-D is ideal for exploring the new world of 16-bit microprocessors. To give you unprecedented analysis capability, there's a built-in Auto Stop capability you can use to detect, record and display any match (or mismatch) between incoming data and previously recorded data held in a reference memory. Or using Search Mode you can key in a specific word and the K100-D will find it in memory.

To get the full impact of the K100-D, you really do need to have it at your fingertips. That's why we would like to arrange a demonstration. Call us at (408) 988-6800. Or, for more information, write: Gould Inc., Biomation Division, 4600 Old Ironsides Drive, Santa Clara, CA 95050.

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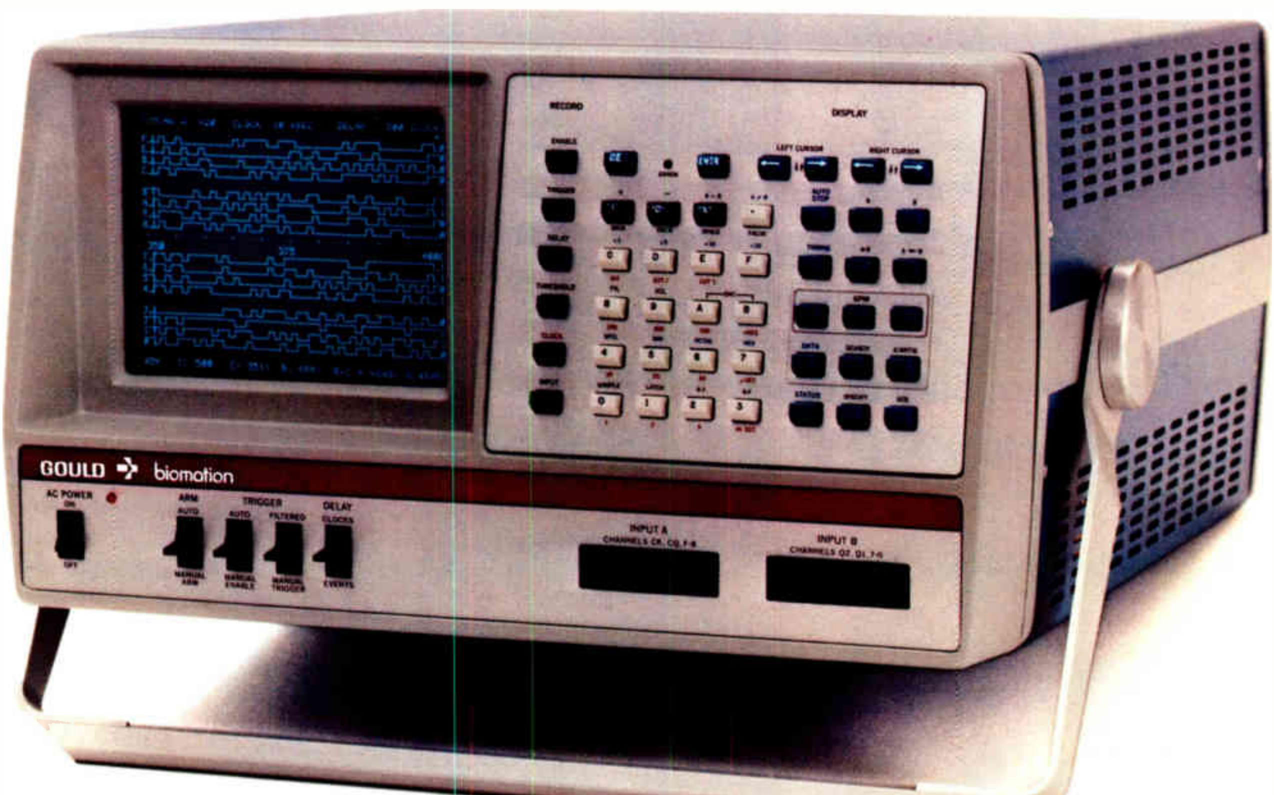

People

times more reliable, and programmed for much greater flexibility. Now the printing technology itself is beginning to receive close attention.

At Dataproducts Corp., Woodland Hills, Calif., the largest independent supplier of computer-driven printers, attention is on nonimpact, ink-jet printing. "Anyone who wants more than 3,000 lines per minute had better look at something other than impact printing," says industry veteran Irving L. Wieselman, vice president for technology assessment. At Wieselman's urging, Dataproducts recently entered into a joint research venture with a company that has mastered the ink-jet technology, A. B. Dick Co., Chicago, a maker of business equipment, including ink-jet printers.

With ink jets, already established in the marketplace by IBM Corp., "printed characters can be formed on any surface by projecting minute ink droplets through the air at very high speeds," Wieselman explains. Until recently, the cost of memory needed to obtain high enough resolution with dot-matrix techniques would have been prohibitive, he continues. But LSI can help lower costs and enhance the kind of control that is possible.

Low end. Dataproducts' agreement with A. B. Dick is intended initially to push the state of the art. But Wieselman indicates Dataproducts will consider applying the technique to the low end of the printing range. (IBM's 6440, for example, prints at a high-quality 54-line-per-minute rate and sells for $5,000; a very high-speed, low-resolution unit leases for $5,800 a month.)

Around Dataproducts' campus-like complex, Wieselman is called the "in-house guru" because of his scholarly bent and some 20 years in the business, 17 at the company. Outside, he is a well-known expert on computer printers, appearing on numerous panels and the author of many papers. Part of his responsibility is to help direct a $10 million research and development budget, considered high for a firm with $155 million in annual sales. □

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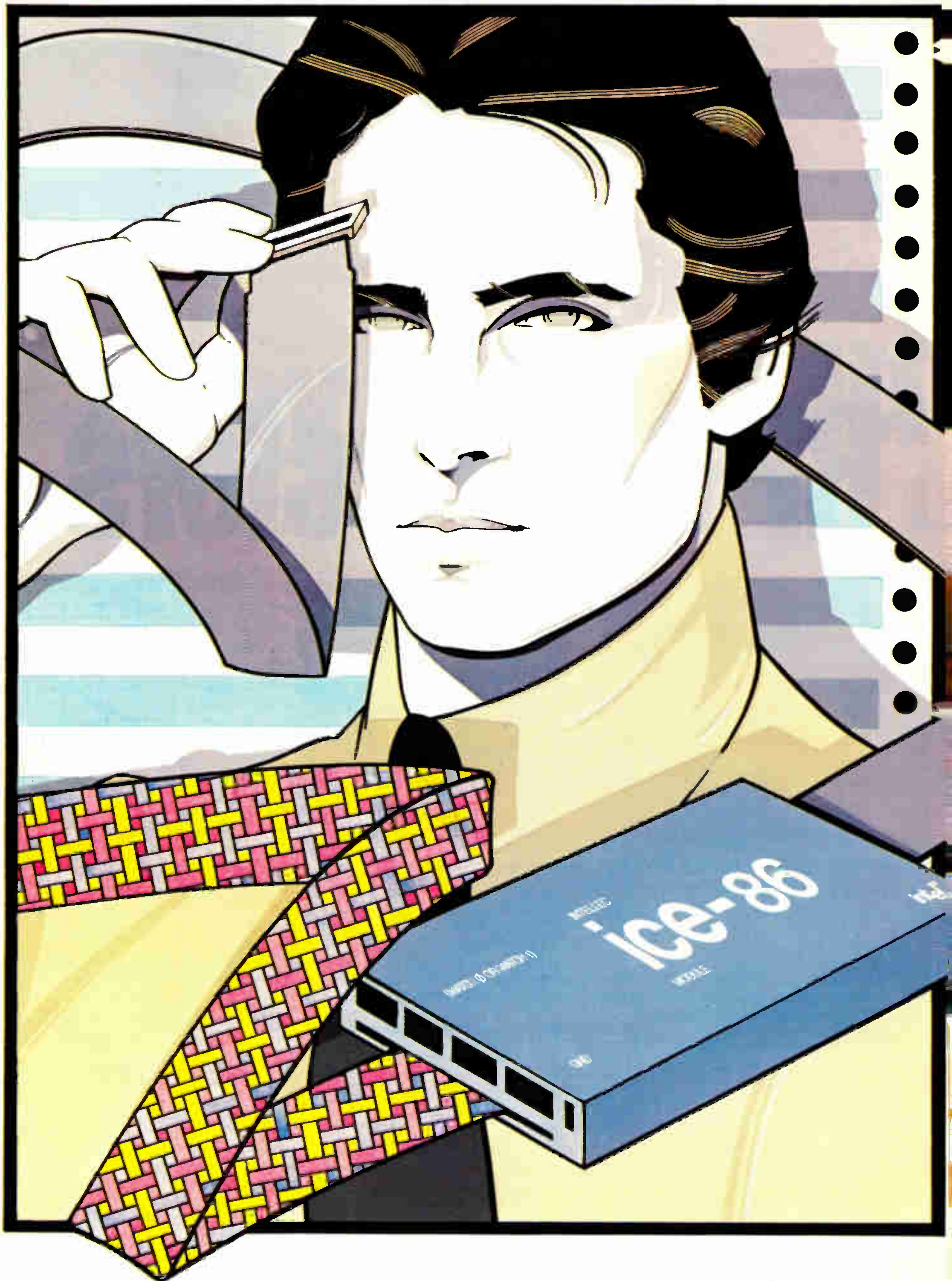
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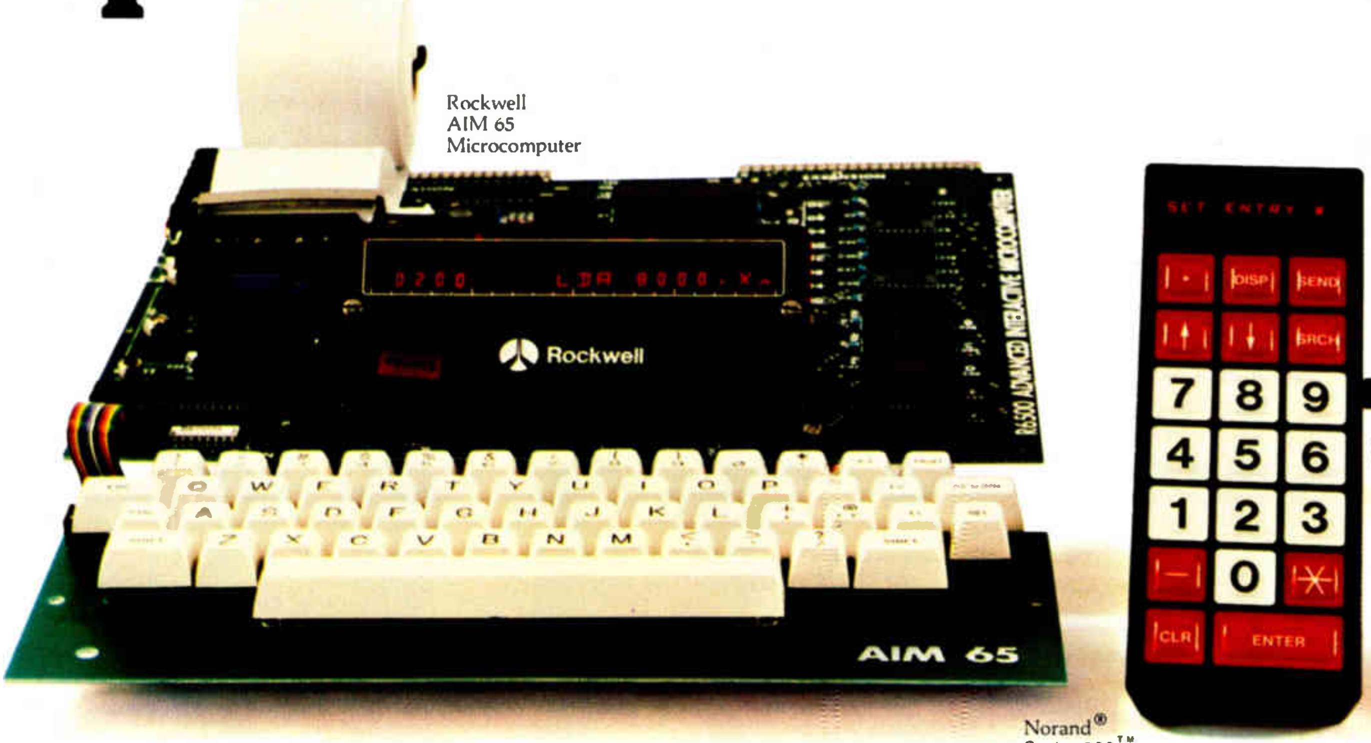
"See us at Computer Caravan, Houston, May 8-10"

How Litronix' opens a new world



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Now designers have a communications peripheral perfectly matched in size and cost to the world of microcomputers. Litronix invented the Intelligent Display* to give microcomputers a new way of "talking" to users in words, numbers or even sentences. And not surprisingly, these displays are already

Part Number	Features	Character Height	Horizontal Row Spacing	Vertical Row Spacing	Viewing Angle	Character Positions	Character Segments
DL-1416	Standard General Purpose Display	.160"	.250"	1.200"	±25°	4	16
DL-1414	Compact Display For Hand Held Equipment	.112"	.175"	.800"	±50°	4	16
DL-2416	Premium Display New Rugged Package	.160"	.250"	.800"	±50°	4	17

*Intelligent Display is a trademark of Litronix, Inc.

beginning to create a new class of microcomputer-based products.

The Intelligent Display is an alphanumeric LED readout that incorporates ASCII decoder, multiplexer, memory and LED driver in a built-in CMOS IC. It interfaces simply and directly to any microprocessor bus, much like a RAM. Power is from a single +5V supply, and operating current is low enough for any battery powered device.

Litronix puts intelligent communications in the palm of your hand or anywhere panel space is limited. Three versions of the Intelligent Display are already available to fit a wide variety of applications. The smallest lets you fit 20 characters side by side in a space of only 3.5 inches.

Litronix' Intelligent Displays are already being used in the portable terminal, the low cost microcomputer and electronic translator above. They're also ideally suited for applications like control panel readouts. Handheld computer

Intelligent Display™ of microcomputer applications.

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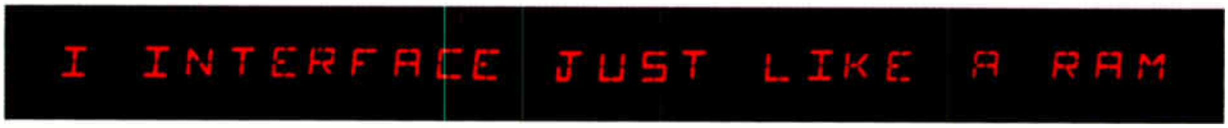
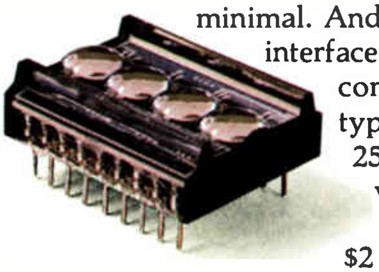
terminals. "Smart" games and appliances. Educational products, and more.

Use Intelligent Displays in any



product that calls for alphanumerics. They'll reduce component count and cut costs dramatically. Since everything is encapsulated in a single package, design and production costs are minimal. And because no display interface PC board is needed, component costs are typically reduced by 25%. Typical OEM volume pricing per digit will range from $2 to $5 per digit, depending on display type. For easy breadboarding with Intelligent Displays, ask about our inexpensive, prewired Evaluation Kit. To get data sheets and a copy of our applications note on Intelligent Displays, or for a demonstration, phone or write Litronix, Inc., 19000 Homestead Road, Cupertino, CA 95014. Telephone (408) 257-7910.



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Editorial

Electronics can help prevent more nuclear accidents

In the wake of the March 28 reactor accident at Middletown, Pa., it is necessary to note that the United States still faces a major commitment to nuclear power. Ever-increasing oil prices, stagnant Government energy policy, and a dearth of usable alternative energy sources will tend to force nuclear power upon us. The only things that might prevent this are an unlikely sudden shift to the use of coal or massive forced conservation, also unlikely with elections due in 1980.

Nuclear power is therefore almost certainly going to be with us, and we must try to minimize the risk, for in the words of the president of the utility that runs the ill-fated Pennsylvania power plant, "Anything that man makes will not operate perfectly." Nevertheless, what's needed for the immediate future is a reactor design that people can trust, and, while electronic technology cannot supply all the answers to such a design problem, it can certainly help. Electronics might even be able to help improve the safety potential of existing equipment.

Present nuclear plants are, at best, based on the technology of the late 1960s and early 1970s; early design freezes are a way of life in this industry, with its decade-long lead times. Thus, the plants coming on line today are technically dated in most cases. But use of modern electronic technology could make possible a new, safer generation of reactors.

Because of the massive improvement of the past few years in the price/performance ratio of small computers, it is feasible to consider seeding hundreds of micro- or minicomputers throughout nuclear power stations to monitor events; to predict temperature, pressure, and radiation trends; and to control critical systems. One solid reason for using small computers lavishly is their high reliability compared with analog or mechanical control systems. Any computer system maker with an eye for reliability will do a job with silicon rather than mechanical devices if possible. His payoff is in lower maintenance cost, but for nuclear power the payoff would be increased safety.

Although computer control is already used in modern nuclear plants, its technology is normally a generation or two behind current capability; further, it is usually centralized in one or two mainframe-type systems, making graceful degradation problematic. The problems of distributed data processing having already been solved for some commercial, military, and space applications, it seems appropriate to distribute information about a nuclear plant by microprocessor.

Because microprocessors are so inexpensive, it should be feasible to use them in voting blocks of three to five. Multiprocessor controllers could react almost immediately to potentially dangerous temperature, radiation, or pressure fluctuations, using majority voting to assure proper response. Such units could continually monitor all important parameters and project near-term trends, making it possible to actuate or deactivate critical systems before failures could occur. Of course, the know-how in radiation hardening acquired from years of fabricating devices for the military would have to be applied.

Electronics cannot solve all the problems associated with nuclear power, but it should certainly be able to enhance the safety of such systems by putting machine intelligence in charge of the most minor details. More cooling-system redundancy, tighter containment, and other engineering changes may be necessary before the public will accept the reactor as a neighbor. But putting in 1979's advanced computer-control capabilities is cost-effective now. Manufacturers who fail to take full advantage of this inexpensive aid to improved safety are rolling dice with their market, the nation's future energy supply, and perhaps with lives.

Ooops-free PROM programming with the CMOS buffered programmer.

Avoid lost or altered data, misprogrammed PROMs, ruined master PROMs with the M900B, the only programmer with built-in CMOS buffer.

Our new M900B has a buffer of 2048 8-bit words with capacity to 4096 words. It's CMOS with power-backup so you can shut off or lose AC power for up to 60 seconds and not lose data. That's plenty of time to replace one PROM personality module with another. Thus you can transfer data from one PROM type to an entirely different PROM type (UV eraseable to bipolar, for instance) or transfer from several small PROMs to a single large one. A Data-Shift feature lets you change data locations when transferring data between PROM and memory.

Helps prevent misprogramming.

The M900B lets you check, correct and verify your data in the buffer before you commit it to a PROM.

CMOS technology with power-backup guards against transients that can alter data stored in a cheaper but volatile bipolar RAM.

Use it with or without the buffer. Two-socket personality modules guard your master PROMs.

With the buffer switched out, the M900B gives you direct PROM to PROM copying. We use two sockets, one for the master PROM, one for the copy PROM. Operator error can't alter a PROM in our master socket because that socket contains no programming voltages.

The M900B, like all our control units and PROM personality modules, comes U.L. listed, designed and built to U.L. electrical safety standards.

The M900B with standard 2K buffer costs only $2,100. With full 4K buffer, it costs only $2,400.

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Meetings

1979 Photovoltaic Solar Energy Conference, IEEE and the Commission of the European Communities (Brussels), Kongresshalle, West Berlin, April 23–26.

Electro79 Show and Convention, IEEE, Coliseum and Americana Hotel, New York, April 24–26.

Reliability Physics Symposium, IEEE, Airport Hilton Hotel, San Francisco, April 24–26.

International Microwave Symposium and Workshops, IEEE, Sheraton Twin Towers, Orlando, Fla., April 30–May 4.

Newcom—The 1979 Electronic Distribution Show, Electronic Industry Show Corp. (Chicago), Las Vegas Convention Center and Hilton Hotel, Las Vegas, Nev., May 1–4.

25th International Instrumentation Symposium, Instrument Society of America, Sheraton Hotel, Anaheim, Calif., May 7–10.

ISS '79—International Switching Symposium, Colloque International de Commutation (Paris), PLM St. Jacques Hotel, Paris, May 7–11. For information in the U.S., contact A. E. Joel Jr., Bell Laboratories, Holmdel, N. J.

1979 SID International Symposium, Society for Information Display (Los Angeles), Chicago Marriott Hotel, Chicago, May 7–11.

29th Electronic Components Conference, EIA and IEEE, Hyatt House, Cherry Hill, N. J., May 14–16.

Electrical and Electronic Measurement and Test Instrument Conference, IEEE, Skyline Hotel, Ottawa, May 15–17.

Naecon—National Aerospace and Electronics Conference, IEEE and Naecon (Dayton, Ohio), Dayton Convention Center, Dayton, May 15–17.

Advances in Systems Technology: Trends and Applications, 1979, IEEE and NBS, National Bureau of Standards, Gaithersburg, Md., May 17.

Huntsville Electro-Optical Technical Symposium and Workshop, Society of Photo-Optical Instrumentation Engineers (Bellingham, Wash.), Huntsville Hilton and Von Braun Civic Center, Huntsville, Ala., May 22–25.

Failure Avoidance Seminar, Integrated Circuit Engineering Corp. (Scottsdale, Ariz.), Hilton Inn, Jamaica, N. Y., May 23–24.

1979 International Summer Consumer Electronics Show, EIA, McCormick Place, Chicago, June 3–6.

Conference on Laser Engineering and Applications, IEEE and Optical Society of America, Washington Hilton Hotel, Washington, D. C., May 30–June 1.

NCC '79—1979 National Computer Conference, IEEE, American Federation of Information Processing Societies, *et al.*, New York Hilton and Americana Hotels, New York, June 4–7.

Machine Vision, Automatic Assembly, and Productivity Technology, summer session, Massachusetts Institute of Technology, Department of Electrical Engineering and Computer Science, MIT, Cambridge, Mass., June 11–15.

Second Joint Intermag—Magnetism and Magnetic Materials Conference, IEEE and American Institute of Physics, Statler Hilton Hotel, New York, July 17–20.

Second International Fiber Optics and Communications Exposition, Information Gatekeepers Inc. (Brookline, Mass.), Hyatt Regency O'Hare Hotel, Chicago, Sept. 5–7.

Wescon/79 Show and Convention, IEEE and Electronic Conventions Inc. (El Segundo, Calif.), Brooks Hall and St. Francis Hotel, San Francisco, Sept. 18–20.

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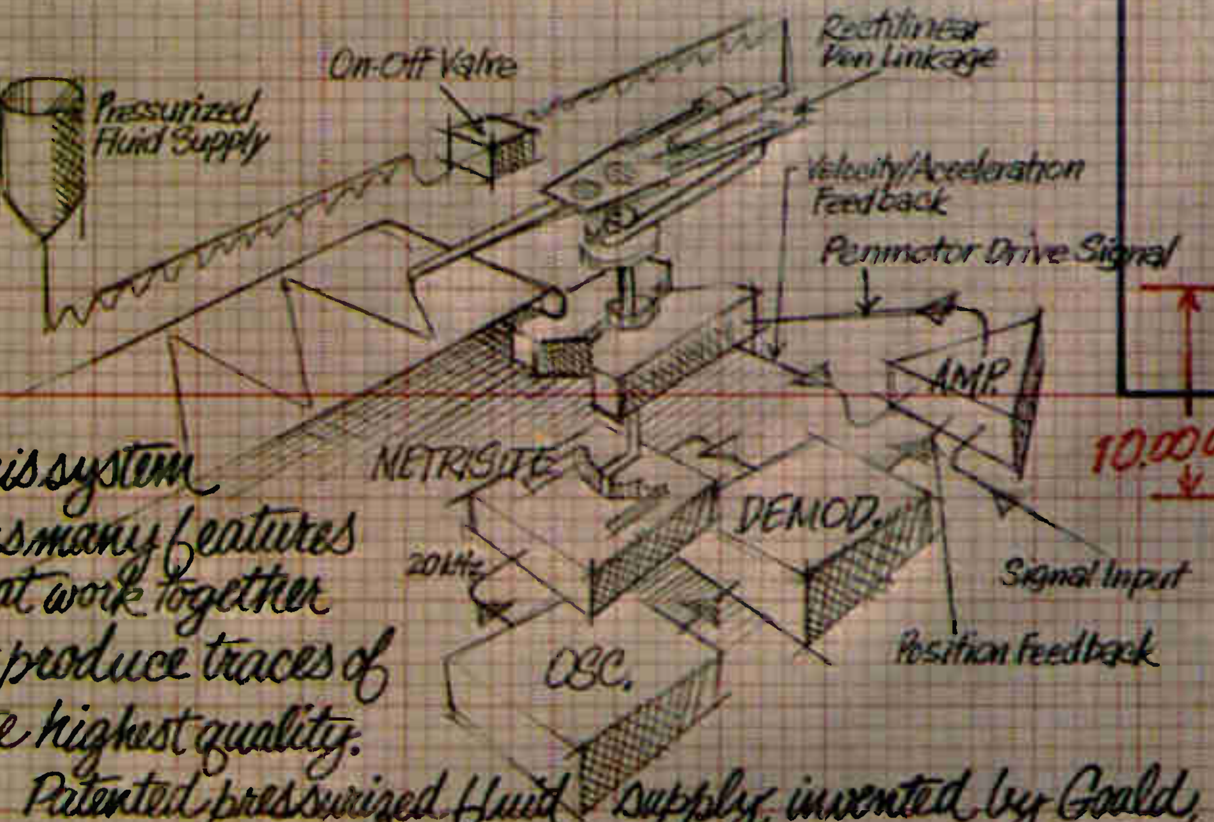

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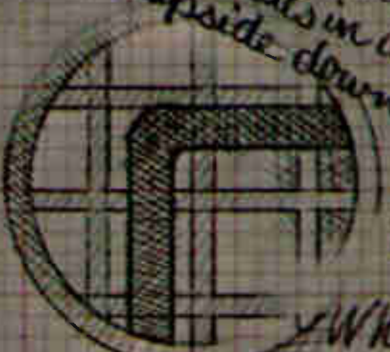

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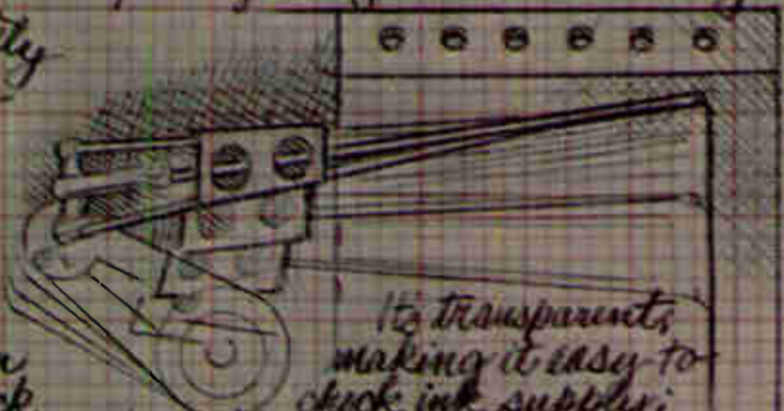

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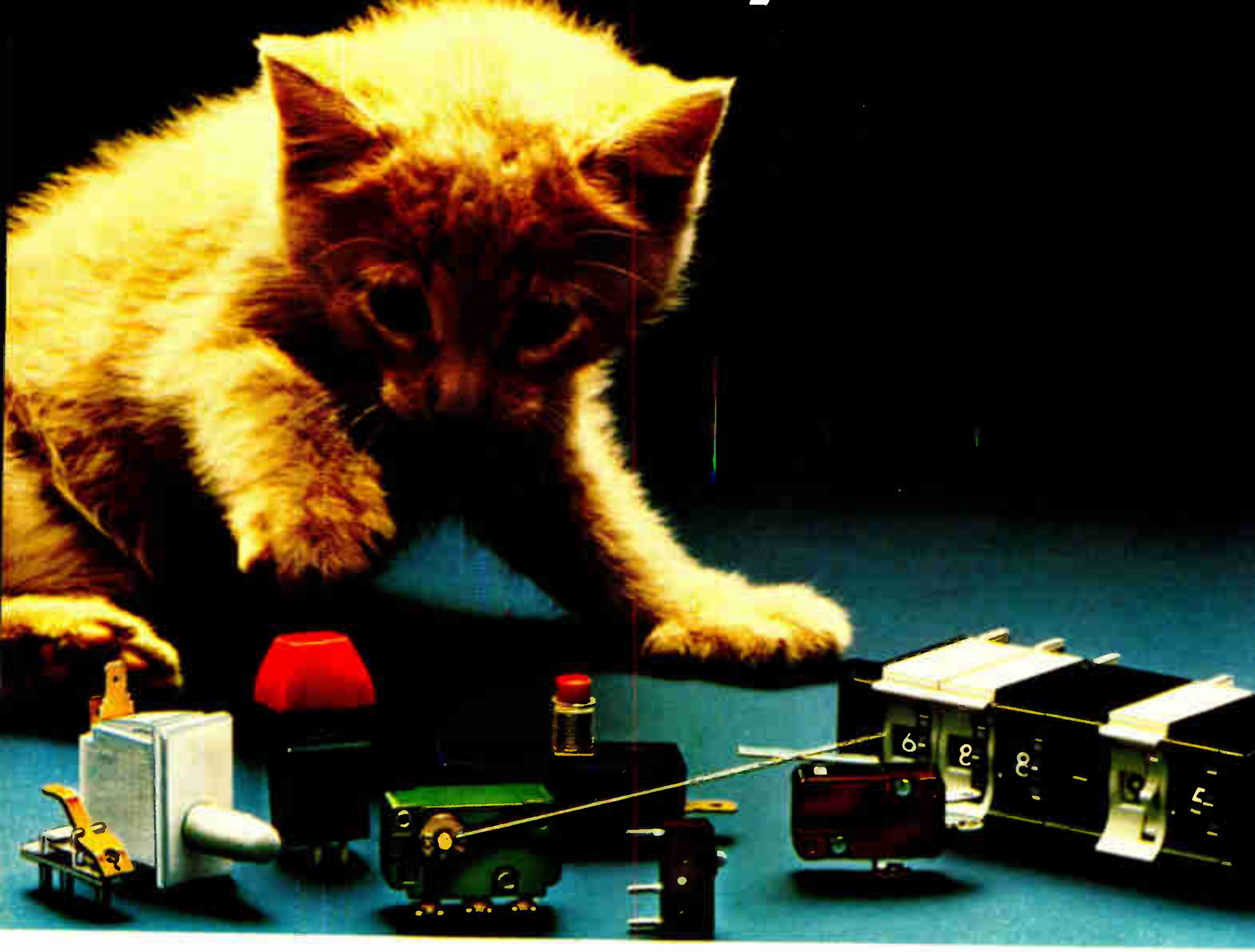

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Electronics newsletter

AMI bows with 16-K static RAM while Zilog changes mind . . .

Not content to let Texas Instruments Inc. hog microcomputer applications calling for a 2,048-by-8-bit static random-access memories, American Microsystems Inc. of Santa Clara, Calif., has samples available of a fully static device that is designed for both 8- and 16-bit systems. Made with AMI's V-groove MOS technology, **the S4028 features access times of 200 to 300 ns, requires only 370 mW for operation over the commercial temperature range,** has a die size less than 32,000 mil², and is pin-compatible with equivalent read-only memories and erasable programmable ROMs. Last year, TI described a similar n-MOS part [*Electronics*, July 20, 1978, p. 39], but production problems delayed its delivery. Now the company says it is building inventories for distributor introduction in late spring.

Zilog Corp., however, is concentrating its guns on the pseudostatic 4,096-by-8-bit RAM announced two months ago [*Electronics*, Feb. 15, p. 40]. Consequently, the Cupertino, Calif., company, which is dropping new clocked static RAMs, **has decided not to make the 6166 2-K-by-8-bit or any other 16-K static devices** [*Electronics*, Feb. 15, p. 33]. Also opting out of the 2-K-by-8-bit level of the static RAM market is National Semiconductor Corp., also of Santa Clara, which considers that part to be short-lived. It thinks a better building block will be an 8,192-by-8-bit fully static RAM with power down that it hopes to unveil in 1980.

. . . as Mostek prepares 16-K RAM with single supply

With a 2-K-by-8 single-supply part already under its belt, Mostek Corp. is making plans to go after the market for 16-K dynamic random-access memories using a 1-bit configuration and a single 5-V power supply. The MK4516, an improvement over conventional 16-K RAMs requiring three power supplies, is scheduled to be available in sample amounts in the fourth quarter. That's about the same time that the Carrollton, Texas, firm's 64-K RAM is expected. But the 4516 will get to production much faster than the 64-K, says Mostek marketing official Sam Young. **He declares that 5-V 16-K parts will be the industry's "next major project,"** before the emerging generation of 64-K RAMs become commodity devices. Other manufacturers with single-supply 16-K parts planned or announced include Intel and National Semiconductor.

Polyimide substrate breaks the ice

Normally, the coldest environment any circuit board will see is −55°C when operating or −65°C in storage. But in an unusual application, Pactel Corp. of Newbury Park, Calif., is supplying one of its aerospace customers with a five-layer, polyimide printed-circuit board [*Electronics*, July 22, 1976, p. 101] **that is slated to operate at absolute zero (−273°C).** Prototype boards have been cycled 10 times from ambient to liquid helium temperatures (−246°C) without opens or any other failure mode developing. This could be the first multilayer board to pass such a severe test.

More U. S. firms being sought by Thomson-CSF

Thomson-CSF, following its acquisition in early March of Solid State Scientific Inc. in suburban Philadelphia, is looking toward further U. S. expansion. Pierre Mestre, deputy director general of the Paris-based group and head of its components division, says **passive components are just one area where the company is shopping** for additional acquisitions. Meanwhile, it has reorganized its U. S. operations into the Thomson-CSF Components Corp., with SSS becoming SSM, the Solid-State RF and

Microwave division. Two divisions are in Clifton, N. J.: the Dumont division, responsible primarily for special cathode-ray tubes and photomultipliers, and the Electron Tubes division, producing standard professional tubes. The other divisions, both in Canoga Park, Calif., are NPC, which makes diodes, transistors, and power supplies, and Socapex, whose main business is connectors. Mestre says Thomson's U. S. subsidiaries last year sold $40 million worth of components.

Motorola ready to complete codec phone set

The last two LSI chips to complete Motorola Semiconductor Group's codec-based telephone subscriber channel unit should be ready by mid-year, predicts Neil Wellenstein, manager of communication systems engineering. Samples of the pulse-code-modulated (PCM) filter chip, manufactured in metal-gate C-MOS, are already being shipped and the subscriber loop interface circuit is being fabricated in sample quantities, he says. The PCM codec, on the market since early this year, and three discrete components **signal the Phoenix firm's entry into the rapidly heating-up codec business.** It is expected to sell for about $20 in quantity.

Two-chip set reduces noise for low-end audio

Eyeing a market in noise-reduction systems for low-end consumer audio products, National Semiconductor Corp., Santa Clara, Calif., is introducing a two-chip approach for applications where the industry-standard Dolby encoding technique might be too expensive. Called the NR-2 adaptive noise processor, **the chip set is aimed at products such as car stereos or entertainment centers drawing 20 W or less.** National employs a dynamic filtering approach where a high-pass filter controls two low-pass filters to reduce noise. This compares with the complementary or encoding-decoding technique popularized by Dolby.

Addenda

Rockwell International Corp.'s Microelectronic Devices operation has its version of the Pascal computer language off and running on its System 65 microprocessor development system. **Within a few months it will be ready for users of 6500 devices,** says Rockwell. . . . National Semiconductor Corp., running into problems with its patent suit against Digital Equipment Corp. over software protection of DEC's PDP-11-34 minicomputer [*Electronics*, Jan. 18, p. 88], has shelved plans for a competing System/200. **But National plans to go ahead with its plug-compatible System/400** to compete with IBM's System/370 and recently announced 4300 series even though first System/400 shipments are running three to six months late. . . . Masatoshi Shima, designer of the Z8000 16-bit microcomputer [*Electronics*, Dec. 21, 1978, p. 81], **is leaving Zilog to return to Intel Corp.** While at Intel from 1970 to 1975, Shima was instrumental in the design of the industry-standard 8080 8-bit microprocessor. . . . Memorex Corp. plans to use Fairchild charge-coupled-device memories in its new 3770 disk cache unit. But faced with uncertain supply, the Santa Clara, Calif., peripherals maker **has built a prototype using bipolar random-access memories.** . . . An optical-fiber transmission line is being installed by New York Telephone Co. **for network color TV broadcasts of the 1981 Winter Olympics in Lake Placid.** The 2½-mile line will link the Olympic broadcast center to the local phone switching office. At the same time, New York Tel is running a 30-mile link between White Plains and Manhattan for regular voice and data service.

Cut the cost of digital system checkout with Biomation's DTO-1.

There's a whole new approach to test, calibration and maintenance of digital systems. It's Biomation's DTO, the first Digital Testing Oscilloscope. Here's how it works. The DTO's front panel functions very much like a traditional oscilloscope but provides additional capabilities. It automates testing without having to worry about software implementation. Simply step through your test sequence once using the DTO to record the entire program on a tape cartridge. Then DTO plays it back to guide technicians, even setting up the instrument's front panel to match the reference program. All in all, DTO provides a faster, easier, far more accurate approach to the otherwise time-consuming, error-prone task of system checkout.

DTO-1: For production test.

Now there's a better way to move new products out of engineering and into production accompanied by a comprehensive production test program. Just use DTO to record the test sequence you want technicians to follow. Step by step, it enables them to compare the system under test with your "known good" system, automatically flagging any discrepancies. Compare DTO with the test equipment you're now using.

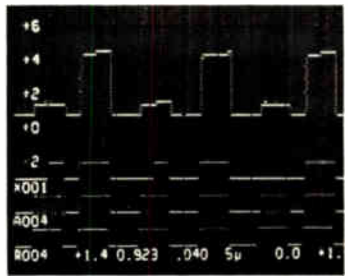
SYSTEM TEST CAPABILITY COMPARED

Testable system elements	Oscilloscope	Signature analyzer	In-circuit emulation with signature analysis	DTO-1
Power supplies	yes	no	no	yes
System clocks	yes	no	no	yes
Processor/control logic	no	no/yes	yes*	yes
Digital input/outputs	no	yes	yes*	yes
Analog I/O	yes	no	no	yes

*System must have a processor.

DTO-1: For calibration & repair.

The most sophisticated calibration and repair labs are using DTO to "document" digital systems they must service.



By developing a tape for each new piece of equipment and instrumentation, troubleshooting and recalibration is faster and more precise. The DTO's screen displays both reference traces and test traces simultaneously, highlighting any disagreement and enabling technicians to zero in on faults.

DTO-1: For facility maintenance.

When it may be weeks or months between repair and maintenance of complex digital systems, DTO brings technicans back up to speed in a hurry. DTO can be used to make a record of the system operation, so it remembers exactly how a perfectly functioning system operates. By following the test procedures and adjusting the system signals to match recorded logic traces, maintenance is virtually automated.

For details on how Biomation's DTO-1 can cut the cost of digital system checkout for you, write Gould Inc., Biomation Division, 4600 Old Ironsides Dr., Santa Clara, CA 95050.

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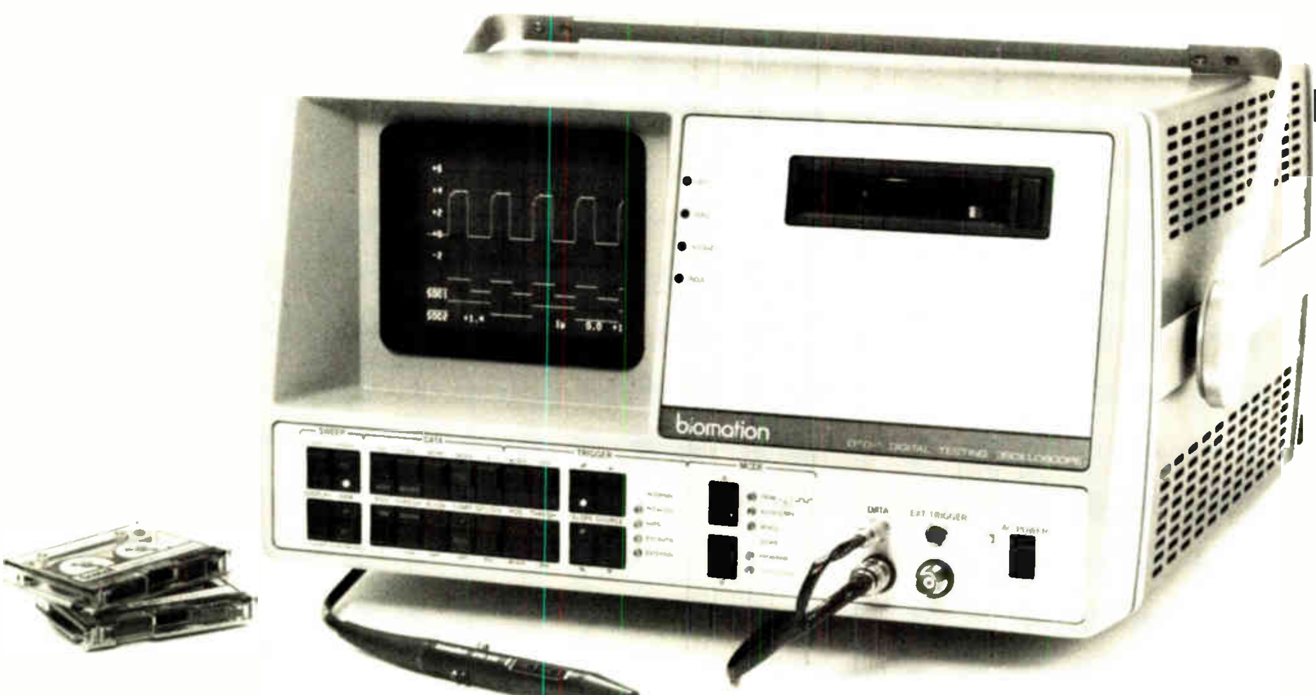

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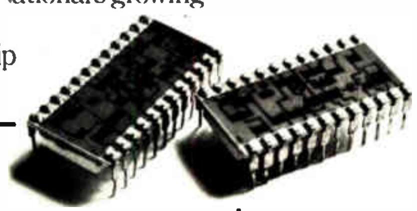

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National Semiconductor

New design doubles wiring density of Multiwire process

by Jerry Lyman, Packaging & Production Editor

Machines put down 80 wires per square inch of pc board and are available now; 110 wires/in.² are on the way

Multiwire, one of the more successful competitors of multilayer printed-circuit boards, is getting a new look. In response to the need for ever denser wiring as integrated circuits both shrink in size and sprout more leads, the PCK Technology division of Kollmorgen Corp. has developed what it calls High Conductivity Multiwire. The new machine it offers can "write" wire in a pattern based on a 25-mil-grid, instead of Multiwire's 50-mil grid, creating the equivalent of roughly four layers of multilayer board interconnection.

"We have been under constant pressure to raise our interconnection density," says Page Burr, president of PCK Technology, which is in Glen Cove, N.Y. "Our customers now want automatic wiring machines capable of packing more interconnections in fewer layers of wiring."

Packing wires on. With the emergence of chip carriers, for example, a square inch of circuit board may require as much as 200 inches of wiring, whether printed conductor or round wire. Just a few years ago, however, boards loaded with dual in-line packages needed only about 35 inches of wiring per square inch of surface.

High Conductivity Multiwire is built around a new machine for laying down an insulation-covered wire onto an adhesive-coated printed-circuit board. As with the older Multiwire, ultrasonic energy is then used to heat the wire as it is laid out and bond it to the board.

By "writing" 6.3-mil-diameter wires on the 25-mil grid, the machine produces an interconnection density of 80 in. of wire per square inch of wiring level—double that of Multiwire. And, as with the older Multiwire, terminations are formed by drilling through the wires and the board and plating the walls of the holes. A layer of adhesive can be placed over the wired surface and the process repeated to build up multiple levels of wiring on a single side of a board.

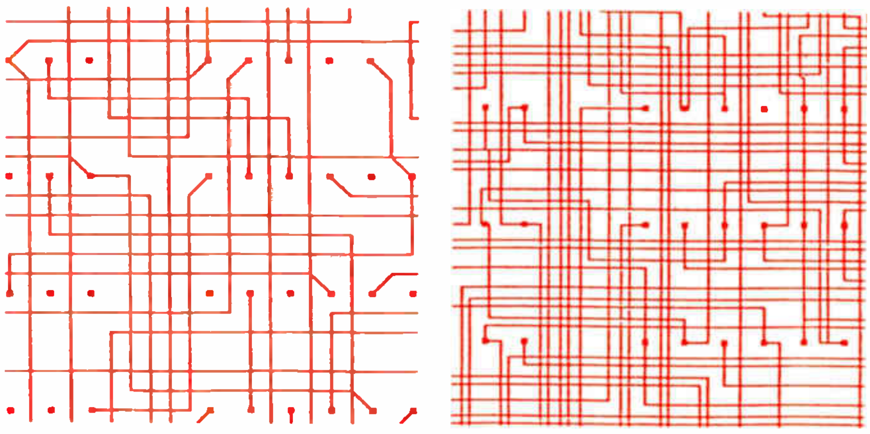
New styles. PCK Technology, which leases its Multiwire and HC Multiwire machines and also makes circuit boards to order, obtained the higher density by redesigning the machine's wiring stylus and wire-feeding mechanism. The results are tighter wire placement control and an ability to handle finer wires.

The company also made the energy from the ultrasonic bonding head proportional to the motion of the table on which the circuit pattern is laid out. This ensures uniform bonding energy regardless of the wiring complexity, resulting in a more reliable board, Burr says.

Even though HC Multiwire is new, PCK Technology has already modified it to build a prototype machine that can put down 4-mil wire on an 18-mil wiring grid. The prototype—slated, says Burr, for delivery to "a large data-processing firm"—has a connective capacity of 110 in. of wire per in.² of board.

The potential of HC Multiwire can best be illustrated by visualizing a pc board with a regularly spaced array of 24-pin chip carriers. A conventional pc board on a 50-mil grid would require 11 conductive layers to interconnect the carriers. The same packages could be interconnected on three levels of HC wiring using 6.3 mil wire on a 25-mil grid. With the even finer wire size and the smaller wiring grid of the prototype

New and old. High Conductivity Multiwire, right, packs more wires on a pc board by using a smaller grid than the original Multiwire, shown at the same scale to the left.



machine, chip carrier interconnection would only require two levels of HC Multiwire.

According to Burr, Multiwire is already competitive with all multilayer boards except at the highest production volumes. The new machines will lease at higher rates than the old, although he will not specify by how much. However, since the new machines will do more, users will save money, he says.

Medical

Artificial arm's processor recognizes different body signal waveforms

Building a control system around a microprocessor, researchers have developed an artificial arm that decodes the waveform of the slight electrical signals generated when a person tries to move a limb. The result is an arm more sensitive to control signals than any so far and more easily used by amputees with severely damaged nerve endings at the stubs of their limbs.

Developed at the Illinois Institute of Technology in Chicago, the new arm controls small electric motors that manipulate elbow, wrist, and hand joints. Because the system is so sensitive, it can be used with relatively little practice, unlike existing artificial arms, says Daniel Graupe, the 45-year-old project leader and a professor of electrical engineering at the institute.

The attempt to move a limb generates in the brain a faint electrical impulse of about 10 millivolts known as a myoelectric signal. Such signals, generated as well by those who have lost limbs, have been used for a number of years to control artificial devices. However, what Graupe's researchers have done is develop a processing system that looks for more than the presence of the signal. Rather, the system compares the myoelectric signal waveform with standard waveforms stored in memory, in this way determining exactly which joint movements are intended.

Detection. One electrode, or at most two, placed on the shoulder stump will detect the 10-mv myoelectric signals, according to Graupe. In more conventional arms, at least one electrode is needed for each joint. In some cases, depending on the extent of nerve damage, as many as 10 electrodes could be required, he points out. Not only can it be difficult to place so many electrodes on a stump but they are also hard to keep in place.

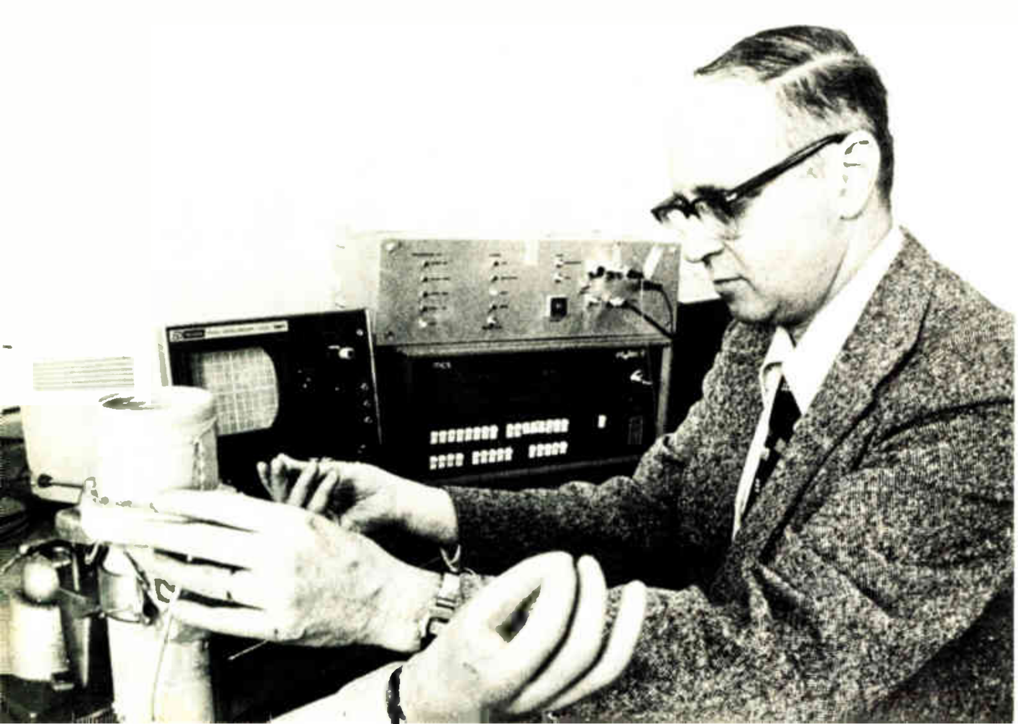
In the new arm, myoelectric signals sensed by the electrodes are amplified, converted by a 12-bit analog-to-digital converter, and compared by the microprocessor to the characteristics of the reference waveforms. Commands are transferred to transistor-transistor logic, which controls solid-state dc relays for the three joint motors powered by rechargeable nickel-cadmium batteries.

In the research model, Graupe uses an Intel 8080 microprocessor and 2 kilobytes of random-access memory. The system can recognize a command and activate the motors within 0.2 second. A simplified circuit design based on a 16-bit processor is under consideration.

The Israeli-born and educated Graupe says that the major challenge in the project was in developing the software to recognize and respond quickly to varying impulses. A series of algorithms for identifying different joint functions was prepared to change myoelectric signals into instructions.

A prototype model is undergoing tests on disabled veterans at a Veterans Administration hospital in Hines, Ill. The shakedown testing and further streamlining of the algorithms, funded by the National Science Foundation, are expected to lead to a device ready for the market within two years, says Donald Gustafson, vice president of Scientific Systems Inc., Cambridge, Mass., a software consulting firm hired to develop the programs. -**Larry Marion**

New arm. Artifical arm being developed by IIT's Daniel Graupe relies on internal microcomputer to control motors that operate joints in the elbow, wrist, and hand.



Careers

No razzle-dazzle, but lots of jobs

Boom times in the electronics business, a shortage of electronics engineers, and the start of the season for the major electronics shows: if that familiar combination seems to promise razzle-dazzle recruiting, think again. The Institute of Electrical and Electronics Engineers annual show, Electro79, may be just around the corner, but all involved swear they are going in without a single promotional stunt in mind.

Two recruiting firms planning major efforts in New York City environs say they plan nothing more than their typical career-days sessions. An admittedly selective poll of companies known to be beating the bushes for EEs discloses no plans other than the now-typical low-key hospitality suite—and frequently not even that.

Moreover, the show's management, aware that there will be plenty of recruiters around, is determined to do all possible to forestall any lurch towards the showmanship recruiting of the past.

Changes. Of course, plans can change between now and the April 24 opening of Electro. It doesn't take long to round up special buses ferrying showgoers from the Coliseum to their hotels (and to the hospitality suites) or to charter a skywriting plane. And, of course, other attractions are available on a pickup basis.

Still, it is no less a seller's market for job-hunting EEs than it was last year, and last year's shows were not marked by high-pressure recruiting, says Bob Akers, president of Akers & Associates. His Santa Ana, Calif., firm has sent out 5,000 fliers to EEs living in the New York metropolitan region seeking resumes and inviting recipients to stop by during the show for a talk.

Akers says there will be companies interviewing his prospects, as well as companies doing their own recruiting. But he expects no return to high pressure, partly because the show management is hostile to it and partly because the companies recruiting have decided they do not like its associations.

Also, the individual EE is more sophisticated these days, less likely to be attracted by a show-business approach, says A. C. Sugalski, president of Interstate Staffing Inc. His Narbeth, Pa., firm plans to start the applicants' interviews with specific companies after the show closes, besides opening its suite well after the show opens.

No one could approve more of these low-pressure tactics than William C. Weber of Electronic Conventions Inc., the show management organization. He speaks without fondness of the days when the show "became a headhunter's paradise," and says, "We do everything in our power to discourage recruiting"—including policing the Coliseum floor and tearing down recruiting signs.

Still, Weber reports that already the show newspaper put out by his staff has a rash of recruiting ads. Moreover, Akers and Sugalski report a wide range of companies looking for qualified applicants. They say this June's college graduates with such credentials as microprocessor experience can command at least $20,000, while EEs with perhaps five years experience might go $10,000 above that. **-Ben Mason**

Military

Navy tests Loral's radar warning unit

These days, tactical aircraft meet a growing tangle of hostile radar signals. Moreover, the increasingly varied frequencies of radar-guided weapons are overwhelming aircraft defense systems.

Fighting electronics with electronics, the U. S. Navy's Air Development Center, Warminster, Pa., and Loral Corp.'s Electronic Systems division, Yonkers, N. Y., have come up with the AN/APR-43, a microprocessor-controlled, dual-receiver radar-warning system. The Navy's Air Systems Command has begun flight tests of the system and has set an initial procurement for the current fiscal year.

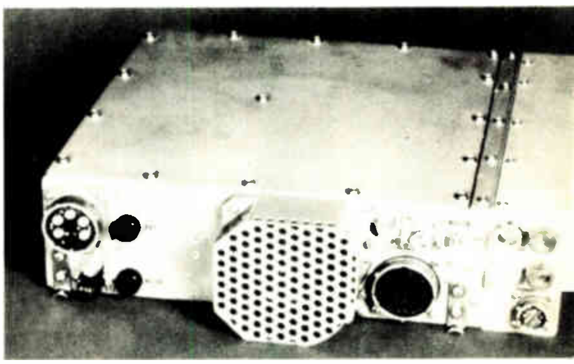
The APR-43 can detect a wide range of threatening signals in two different frequency bands and tell the pilot what direction they are coming from. Perhaps most important, however, is the fact that the system is reprogrammable. This means it may be altered in the field with relative ease to react to different frequencies and other threat parameters if new weapons suddenly appear—as when U. S. planes in Vietnam and Israeli planes in the Yom Kippur war faced radar-guided weapons that used new frequencies.

Smaller. The new system uses the militarized version of Texas Instruments' TMS 9900 16-bit microcomputer. The usual benefits of large-scale integration—such as smaller size, lighter weight, and lower power consumption—are crucial to the new system, for it is intended as an adjunct to the host plane's tactical warning radar, the AN/ALR-45. Also, the LSI solution fits the digital processor on one board instead of the three used in a hardwired setup, says Loral.

The hazards of the hardwired airborne defense system were particularly apparent to Israel, which lost many fighters to a Russian missile using a continuous-wave guidance signal. Other radar-guided weapons use pulsed frequencies in what is known as the guidance band.

The new Loral system packs in two receivers: a crystal video unit for the guidance-band signals and a tunable superheterodyne unit for the cw band. The digital processor, based on the integrated-injection-logic SBP 9900, operates the receivers on a time-shared basis, processes the incoming signals, and sends the results to the ALR-45's cockpit

Connections. Dual-receiver radar warning system has a back studded with connectors for incoming i-f and rf signals, outgoing control signals, and more.



display for the pilot.

However, the processor does not send all the processed signals to the display. Rather it winnows out threats to the aircraft from other signals, arranges them by priority, and sends strobe symbols to the display. It finds direction by calculating the amplitude ratios of the incoming signal.

Development. Loral says the 9900's instruction set is well suited to handle the data storage and manipulation input/output interfaces. A hardwired approach would have an unwieldy design and a complex solution.

Loral and the Navy have designed the APR-43 with an eye to the future. Its $5\frac{1}{2}$-inch-diameter antenna disk actually contains three antenna assemblies: one for the guidance band, one for cw signals, and one to work with the forthcoming AN/ALQ-162 jamming system, giving signals to confuse incoming projectiles detected by the APR-43. Also, the digital processor of the APR-43 could send data to the Harms airborne missile system, under development to knock out ground radars.

Loral Electronics Systems has big plans for its new digital processor. Already, the division is supplying one version for the forthcoming AN/APR-23 (V-2), a radar warning system the U. S. Army is testing for its helicopters. **-Ben Mason**

Peripherals

Displays head for under-$1,000 tag

Sparked by the availability of single-chip CRT controllers, the makers of cathode-ray-tube terminals are scrambling to dive below the magic $1,000 price barrier. Advanced Digital Data Systems Inc. of Hauppauge, N. Y., for one, is launching its Regent 20, with a price of $995 for one unit and considerably less for quantity orders. Moreover, Hazeltine Corp. of Greenlawn, N. Y., already established in the under-$1,000 terminal market, is bringing out the 1420, an upgrade of the existing two models.

The electronics in the low-end Regent 20 include an 8085A microprocessor, National Semiconductor's DP8350 CRT controller and INS8250 asynchronous communications element, and a 2,048-bit program in a read-only memory. Two more models also bowing at the Interface '79 show in Chicago this week, the Regent 40 and 60, use the 8085A and Intel's 8275 CRT controller, which gives greater display capability. The 40 has a 6,144-bit program, the 60 an 8,192-bit program; both the 40 and the 60 are asynchronous, as is the 20.

The asynchronous 1420 from Hazeltine follows in the footsteps of the 1400 and 1410. It uses the 8049 single-chip microprocessor, faster than and with twice the memory of the others' 8048. All three use National's 8350 and 8250.

The new controllers take advantage of their chip's capabilities to incorporate features found in higher-priced, earlier-generation terminals. The features differ from line to line and from model to model, as does pricing. Prices for the Regent 20 are $695 each for 100 or more; for simi-

Marching into distributed processing

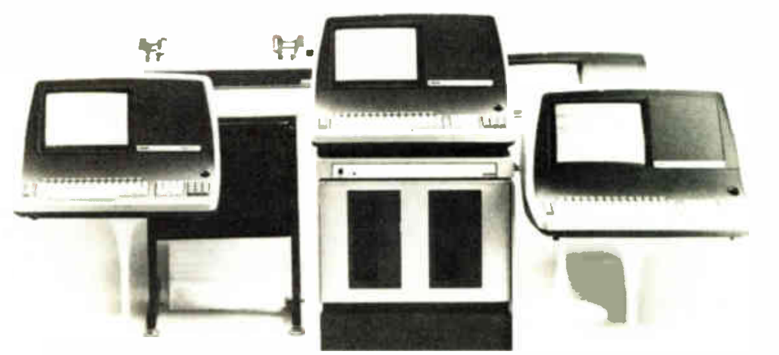
In the computer business, all roads are leading toward distributed processing, and Advanced Digital Data Systems Inc. is marching right toward that destination. Its new Regent 300 terminal-cluster system (below) essentially is an intelligent terminal for original-equipment manufacturers, and its new System 75 is aimed at the OEM who will be selling systems to users like small businesses. Both units offer asynchronous or synchronous binary communications hardware.

The heart of the Regent 300 is the terminal-cluster controller, which incorporates the 8080 and two diskettes giving $\frac{1}{2}$ megabyte of storage and 52 kilobytes of random-access memory. Its assembly language software includes the RDOS operating system (a CPM derivative), macro-assembler, editor, debugging package, and other utilities.

The controller can support up to four buffered editing terminals (the Regent 200) and has an interface for a serial printer. With the four terminals, it costs $8,080 per unit for 25 and up, a price that gives OEMs the controller and diskettes for little more than many firms charge for the smart terminals alone, maintains ADDS marketing vice president Alan M. Dziejma.

Aimed at OEMs who program small, stand-alone systems in Fortran or Basic, the System 75 has a controller similar to the 300's, but with 1.5 megabytes of storage on three double-sided floppies. It uses the ADOS II operating system and has a full complement of utilities with per-unit prices for 25 or more of $7,645 or $5,525 with two floppies.

The 75 will cost about 30% less than the ADDS System 70, yet it has three times as much program storage and more editing capabilities. The system shares many of its attributes with the Tandy 10, which Advanced Digital manufactures for Radio Shack.



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lar lots, the Hazeltine 1400 goes for $630, the 1410 for $660. For 51–99, the new 1420 costs $750, $10 less than the 1410 in similar quantities.

In comparison, the Bantam from Perkin-Elmer Corp.'s Terminals division costs $599 each for 100 or more. It uses a custom chip that combines the functions of a microprocessor and a CRT controller [*Electronics*, Oct. 26, 1978, p. 52].

One more. Still to be heard from is a fourth major terminal maker: Lear Siegler Inc.'s Data Products division. It is likely to introduce a new model with a CRT controller chip, although no date is set.

To some extent, these makers of low-cost CRT displays are playing a features game, each offering a mix of basic editing capabilities and other keyboard functions they hope will snare orders from original-equipment manufacturers.

For example, the new Hazeltine machine adds a program-function key mode to its numeric pad and incorporates a set of cursor control keys, some of which are on the 1400 and some on the 1410. It also has high- and zero-intensity and blinking display modes and has upper- and lower-case letters, whereas the other two have only capitals.

The Regent 20 also has upper and lower cases and adds to its RS-232-C/CCITT V.24 communications interface a switch-selectable 20-milliampere current loop. It can communicate with a serial printer through an auxiliary output without disturbing its own display.

Transformable. The 20 also has a mode that turns it into a line monitor displaying the data stream sent to the terminal. This mode will aid program debugging for OEMs and applications debugging after installation, says Frank Zelis, marketing manager for displays.

Nor is Advanced Digital neglecting customers who need more sophisticated CRT displays. With its more powerful chip set, the 40 offers more editing capabilities, and the 60 adds to that buffered transmission.

The three terminals do offer upward software compatibility, and their applications programs can also run on other ADDS terminals, such as the Regent 100 and 200, which continue in production. The 40 can be seen as an update of the 100, costing $950 apiece in hundreds, while the 60 is in effect an update of the 200, costing $1,240 in hundreds. These prices, slightly less than the earlier models, owe much to production economies ADDS achieves by new vertical integration of its manufacturing. -Ben Mason

Communications

E-Systems readies a voice coder

Though requiring lots of computational hardware, linear predictive coding (LPC) techniques have been recognized since the mid-1960s as a useful method for digitally analyzing speech and producing high voice quality at fairly low data rates—under 2,400 bits per second. But the compact number-crunching capabilities of high-speed microprocessors are bringing equipment costs and size down, and new machines designed for narrowband commercial applications are expected to emerge soon from various firms.

One such unit—the LPC-24 speech processor—was demonstrated by E-Systems Inc. of Dallas at the International Conference for Acoustics, Speech and Signal Processing held in Washington, D. C., April 2–4. The processor is designed to boost the efficiency of long-distance telecommunications networks.

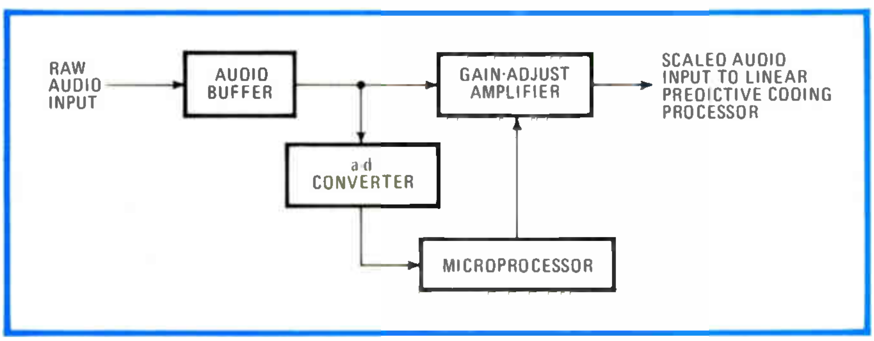
Using LPC techniques to sample and analyze audio input from conventional telephones, the unit produces a 2,400-b/s synchronous bit stream that can then be mutliplexed with up to 7,200 b/s of data over a common circuit. A second LPC-24 at the receiving end then reverses the process to convert the serial data back into an audio signal. Separate devices for encrypting and deciphering the digital stream may also be added at each end to make the line secure.

E-Systems engineers use Advanced Micro Devices Am2900-series bit-slice microprocessors to perform the high-speed computation of the complex LPC algorithms. Typical of the benefits to be expected from using the latest chip technologies, the new machine contains only five 6-by-12-inch circuit cards, compared with the 13 cards of previous-generation voice coders using a different method of analysis that E-Systems sells to the military.

Dollars. Available this fall, the LPC-24 will sell for some $2,000 to $3,000 less than the $14,000 machine sold to the military, says D. P. Fulghum, manager of speech processing at E-Systems' Garland division.

E-Systems has also carried the quest for improved voice quality and intelligibility one step further. A separate front-end processor suppresses background noise and automatically adjusts gain so as to present an optimized voice signal to the analog-to-digital converter in the unit's speech processor. Using an Intel 8085, the LPC-24's voice-oper-

Vogad. Voice-operated gain-adjusting circuit relies on 8085 microprocessor to suppress background noise and adjust gain to present optimized voice signal to LPC processor.



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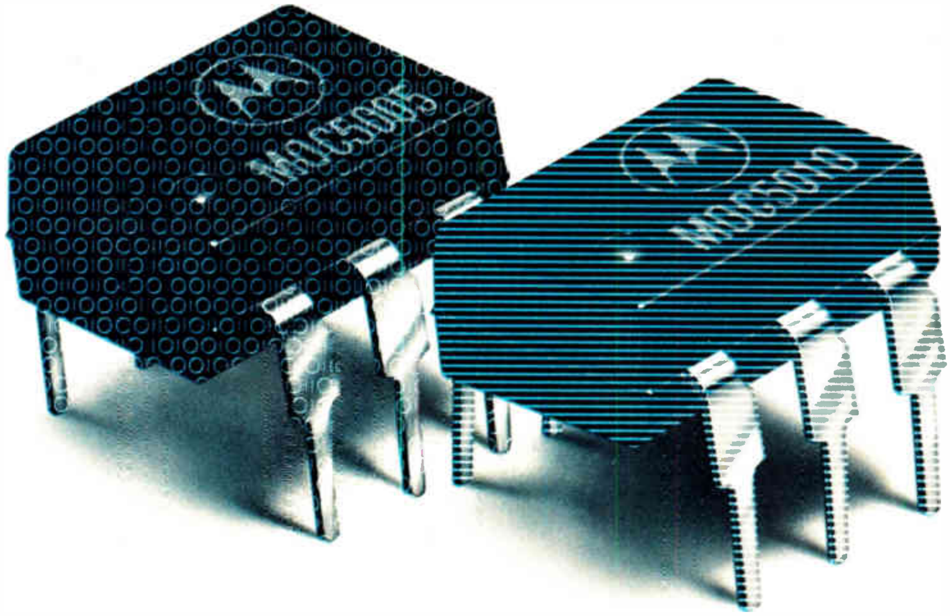

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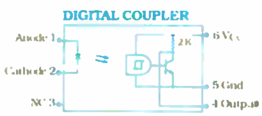

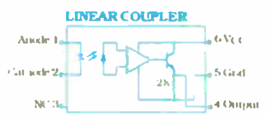

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Reduced. E-Systems' LPC-24 speech processor knocks about $2,000 to $3,000 off the price of older generation military units.

ated gain-adjusting circuit is believed by Fulghum to be the first to be microprocessor-controlled.

Different. Current LPC speech processors have not used front-end gain-adjusting devices. Instead, they depend on 12-bit accuracy in sampling the voice waveform to take care of the differences between users who speak more loudly or softly than the average. Noise-canceling microphones might be one way to attack the problem. But this approach breaks down when the mike is not held within ¼ to 1 inch of the speaker's lips, Fulghum says.

E-Systems front-end intelligent Vogad (for voice gain-adjusting device) is programmed to drive its own analog-to-digital converter to sample the audio input waveform at 8,000 hertz. The 8085 can then determine whether the input is noise, speech, or a combination of both. If the input is noise only, it is suppressed. For a combination of speech and noise, a gain factor is calculated to optimize the signal-to-noise ratio going to the LPC-24 and to avoid overdriving its a-d converter. **-Wesley R. Iversen**

Memories

Mostek 64-K pin 1 follows Motorola's

A showdown may be looming as Southwestern semiconductor makers stake their claims for pinouts on 64-K dynamic random-access memories. Flash point is the use of pin 1—Mostek Corp. is joining Motorola Inc. in using it for refresh, but Texas Instruments Inc. has a no-connect on pin 1 of its 65,536-bit RAM.

Mostek's MK4164 will incorporate a pin 1 refresh function that the company says is functionally compatible with one of two refresh modes provided on the Motorola 64-K RAM introduced early this year [*Electronics*, Feb. 15, p. 141]. With samples this fall, the Mostek part will fit into systems designed for the automatic refresh function on Motorola's MCM6664—so long as the activating pulse lasts the entire refresh cycle. A self-refresh function like Motorola's for power-down operation will not be provided.

The automatic refreshing capability on the 4164 is patterned after the Carrollton, Texas, firm's recently introduced MK4816, a 2-K-by-8-bit pseudostatic RAM designed for the microprocessor market. The 4816's self-refresh mode was eliminated because it would have increased die size and power dissipation. Such shortcomings do not matter in small-system microprocessor applications but would be a major drawback in large mainframe memory banks where the new 64-K-by-1-bit RAMs are expected to find major use, says marketing manager Sam Young.

Others. TI says the no-connect approach in its TMS4164 introduced last fall is geared to mainframe and minicomputer makers. Main-memory users cannot benefit by a pin 1 refresh function, the firm says, adding that the feature also restricts flexibility as well as contributing to a larger die size. Motorola, on the other hand, says it designed its refresh functions only after extensive talks with the same users.

Other firms planning similar 16-pin, 5-volt parts include Intel, National Semiconductor, Fujitsu, Nippon Electric Co., and Hitachi—all reportedly with no-connect pin 1. (Mostek officials say they are not ready to announce detailed pricing and availability).

With auto-refresh, the 4164 eliminates external row-address strobes and synchronization hardware by generating the addresses internally. It can substitute for the TMS 4164 and similar parts, though it would require external refresh circuitry.

Other features of the part include transparent refresh, allowing the output to remain valid during a refresh cycle and thus eliminating data output latches; a low 10-milliwatt typical standby power dissipation; and a 1980 access time under 100 nanoseconds.

Like Motorola's part, the 4164 has a 128-cycle, 2-millisecond refresh time, which requires 512 on-chip sense amplifiers. TI's part has a 256-cycle, 4-ms refresh, thus halving the sense amps and easing the way for 256-K RAMs, the firm claims. Young concedes the 512 sense amps will require a die of 37,000 to 38,000 square mils, compared to TI's 33,300 mil², but says they are necessary in order to produce a part that will provide good yields. **-W. R. I.**

Trade

Message to Japan: open up NTT market

The White House and U. S. trade officials are prepared to lay it on the line during the hastily arranged visit of Japanese foreign minister Sunao Sonoda scheduled for this week. Their object is to convince Japan that it must open its telecommunications market to competition from U. S. equipment makers.

Robert Strauss, U. S. special trade representative, broke off talks with Japan late last month, calling its offer to open $5 billion in government procurement to foreign competition "wholly inadequate." He singled out Japan's proposal for strictly limited procurement from U. S. bidders by the Nippon Telegraph and Telephone Public Corp.

The Japanese offer is less than half of the more than $10 billion worth of nonmilitary goods and services that the U. S. proposes opening to foreign bidders. Unless Japan improves its offer before June,

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when industrialized nations will hold a summit meeting in Tokyo to approve the treaty, the U. S. will sign with a reservation excluding the Japanese from any of the bilateral provisions.

The U. S. Government makes clear it is unhappy with more than the value of proposed Japanese buys. The rigid limitations in the proposed telecommunications procurements would restrict foreign suppliers to items like steel telephone poles and test equipment. "There should be no misunderstanding," says one U. S. official. "NTT will have to open a significant share of its transmission and terminal equipment markets," initially about 1% of its estimated $3.3 billion annual procurement budget.

The Government official says Strauss had little choice but to break off negotiations in view of rising congressional criticism of Japan's position on NTT equipment buys. He says Strauss suspects that, unless Japan relents on the NTT issue, the treaty might not pass Congress.

Limits. Angry U. S. telecommunications industry lobbyists are persuading Congress to limit Japanese imports into the growing and increasingly competitive domestic equipment market unless Japan complies. "The bedrock issue is that their market is closed and ours is open," says John Sodolski of the Electronic Industries Association, "and there are only two ways that problem can be resolved." This statement by the vice president of the EIA Telecommunications division reflects growing U. S. resentment of Japan's unbending trade stance.

Of NTT's reported concerns that foreign equipment might not meet Japanese standards and might thus damage the network, the Government official responds, "That sounds like an old AT&T argument a few years ago, one that they have long since dropped. There is a simple solution: NTT can draft its own equipment specifications in every category before it opens them to offshore competition, permitting only suppliers meeting them to participate." **-Ray Connolly**

Microwaves

Test ranges stir citizens' ire

Activist groups in Massachusetts have brought suit against two electronics firms to prevent them from installing microwave test ranges. The groups' concern is that the ranges—the kind used since the 1940s to map an antenna's beam pattern, a task done with 1 watt or so of power—will harm people's health by exposing them to microwaves.

"You can't fight emotion with logic," points out John M. Osepchuk, 59, a consulting scientist at Raytheon Co., Lexington, Mass., and an acknowledged expert on the biological effects of microwave energy. Raytheon, a $3-billion-a-year conglomerate, wants to install a range in nearby Wayland. The other company, Radant Systems Inc., a small consulting and antenna testing firm in Wayland, wants to build its range in Stow, also nearby.

It took months for Raytheon to get a permit from the town of Wayland to construct its range. Then, on March 9, both the town and Raytheon were slapped with a citizen's suit aimed at stalling or preventing construction of the range.

Unknown. It's what they don't know that bothers Wayland residents. George W. Faison, a 39-year-old English teacher, admits that he has little technical knowledge of the subject, but he backs the complaint against Raytheon. "Our major concern is that there are few standards for exposure, and those that exist differ and are arbitrary," he says.

Like many others, he worries about biological effects: "I am told that microwave exposure can increase the incidence of cancer, particularly of leukemia. But nobody can tell me what the certain effects of long-term, low-level irradiation are." If it is safe, "the burden of proof is on the industry, not on us," he concludes.

When Radant's plans for a range in Stow became known, handbills appeared saying: "Do you know: Microwaves are known to cause blindness and other harmful effects; radars are usually high power [sic] and dangerous at long range . . . such antennas have sidelobes in their radiation patterns [and] radiation will 'splash' in many directions." It also warns "Military contracts are anticipated. YOU will be subjected to microwave radiation!!!"

Figures. In response, Richard H. Park, president of Radant, did some math for Stow residents and showed that, 2,000 feet away on a road directly in front of the antenna, exposure would be about 0.1 microwatt per square centimeter, whereas exposure at a sidelobe would be only 0.003 microwatt.

In comparison, the Soviet Union's upper limit for exposure of civilians is 5 μW, though the exposure duration is not specified. The United States has no similar standard, but it is working on one; so far no nation has a standard for long-term low-level exposure.

The lack of standards, and Paul Brodeur's book, "The Zapping of America," which warns of an America awash in dangerous microwave radiation, have fueled the concern of many in the general public. (Scientifically educated reviewers have roundly criticized the Brodeur book for what they say are the questionable references on which it bases its hazard claims.)

The demonstration by Park did not assuage concern. "People are asking us questions that we engineers cannot answer—and shouldn't really," Park says. "The information they want has to come from the medical profession, and that's going to take upwards of 10 years."

Smaller. Radant has been hauled into court by two residents whose land abuts the company's and who are demanding a halt to the project. In response, Park insists that the power densities his firm will generate in Stow will be only one ninth those measured by the U. S. Environmental Protection Agency in the heart of Boston: "If Stow has a problem, which I doubt, then Boston has a bigger one." On the other hand,

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"We're being asked to prove a negative," Osepchuk says, "and it's almost impossible to prove that there will never be any long-term effect at all." -James E. Brinton

Companies

Intel sets up plants in Phoenix

The rush among Silicon Valley semiconductor firms to do their expanding outside of California picked up speed late last month when Intel Corp. officially announced its big move into the Phoenix area. The Santa Clara, Calif., firm says it is opening two new plants there.

A 150,000-square-foot facility in Deer Valley, northwest of Phoenix, will be operating as part of its Commercial Systems division by July, building memory boards for end users. The second is a single-chip microcomputer plant in Chandler, southeast of Phoenix, scheduled to start up in late summer.

Rumors circulating throughout the industry on the basis of Intel's first recruiting forays in Arizona hold that at peak employment possibly 5,000 personnel will be required across the board. Declining to comment more specifically, Intel's director of business development Jerry Diamond does make it clear that Intel's decision was influenced by the abundance of technical and assembly talent in Phoenix, compared with other areas.

"We're taking as few [with us] as possible," says Diamond of Intel's staffing plans. "By transplanting only a nucleus we can build around it from the Phoenix area and by recruiting from the entire U. S."

Intel's choice of Phoenix is an important sign for several reasons, in the opinion of a veteran industry consultant who counsels firms on moving (but not Intel). Recognition of the Arizona site's obvious advantages shows semiconductor firms are getting "smarter about such things," says Glen Madland, president of Integrated Circuit Engineering Corp., Scottsdale, Ariz. "Semiconductor firms have been very unsophisticated in terms of site selection." The result was that they often plunged into new geographical areas without fully weighing the pros and cons, he continues, and had to pay for the move in delays, personnel problems, and lost production.

An example is the way Motorola moved its microprocessor and memory operations to Austin, Texas, in 1975–77. "That was a mistake that other firms have learned by," Madland says. Motorola tried to transfer most of the people it needed, but turnover of more than 75% severely hampered getting the plant on stream. "They should have recruited them in Texas," says Madland, a lesson that Intel and others have learned well. Reportedly, Intel considered going not to Phoenix but to Colorado Springs, where Texas Instruments Inc. and Inmos Ltd. are opening plants. But Phoenix's obvious attraction tipped the scale. "Over the years Motorola has built a good labor pool of maybe 30,000 people," Madland says.

In addition to Intel and Motorola, other firms already in some form of the semiconductor business in the Phoenix area include: General Instrument, EMM Semi Inc., General Semiconductor, Northern Telecom, and Medtronics. There are also growing LSI commitments by California minimaker General Automation and the West German–based

News briefs

Dutch firm to test compatible 3-d TV system

With engineering help from American researchers, Digital Optical Technology Systems B. V. of Amsterdam has developed an optical/electronic system that allows TV broadcasters to beam three-dimensional pictures into the home. The system, to be installed next month at a TV station in Australia, is compatible with all existing broadcasting standards and TV sets, but the viewer must wear special glasses to see the 3-d effect.

Unlike existing 3-d systems, which create two images that simulate depth, the Dutch system uses lenses and color filters to color-code the extent a foreground or background object is out of focus relative to the camera's focal plane. A sophisticated digital electronic system then enhances the coloration, but restricts it to an amount unnoticeable without the special glasses, which contain two color filters to defocus color-coded objects to their original depth. Demonstration at U. S. TV stations is planned.

Hogan to retire from Fairchild

C. Lester Hogan, 59, whose career is practically synonymous with the rise of the semiconductor industry, is retiring as vice chairman of Fairchild Camera and Instrument Corp., Mountain View, Calif., effective with the company's May 4 annual meeting. He will continue as a member of the board and special consultant to president Wilfred Corrigan, whom he brought to Fairchild, and he will serve his second term as executive vice president of the Institute of Electrical and Electronics Engineers.

Sharp puts rolling displays into calculators

Filling the gap between hard-to-use programmable and expensive but limited-function scientific calculators, Sharp Electronics Corp. of Japan has introduced two new models with rolling alphanumeric displays. Each permits direct entry of algebraic and trigonometric equations that appear, as they are entered, on a liquid-crystal five-by-seven-dot matrix display of 24 or 16 characters. After the equations have been entered, the user switches to the compute mode and punches in constants and coefficients. The unit then solves for unknown variables or uses the equation as a subroutine in a larger expression of up to 80 steps. Both models use low-power complementary-metal-oxide-semiconductor circuits that allow the internal battery to store up to five expressions after the unit is turned off. When available in stores this August, the 24-character 5100 will retail for a price of $99; the 16-character 5101 will sell for $80.

Here are the choices

With several clients now involved in evaluating new plant locations, Integrated Circuit Engineering's Glen Madland is up to date on what they should be looking for. At the top, of course, is a good labor pool of not only engineers and scientists but assembly and support people as well. Schools at the university and vocational level are important, as are zoning, transportation, and local attitudes toward business. What should be obvious, but is often ignored at the expanding companies' peril, is a basic rule especially critical to semiconductor firms: "Never be the first into an area. In other words, don't be a pioneer."

All areas contemplated for expansion by semiconductor firms are in the Western United States. As summed up by Madland:

- Phoenix with all the ingredients in good supply "still has room left for semiconductors to grow in."
- Colorado Springs, Colo., with many new arrivals, and Albuquerque, N. M., just starting to take off, have many of the advantages of Phoenix and are right behind it.
- "San Diego is the last part of California with a chance and Texas is not all that bad." Also, Salt Lake City has some things to say for it, and several firms are going in.
- One previously well-thought-of place, Oregon, is dropping out as a site. "It's not as good as companies thought it would be," he remarks. Madland's information indicates that it is difficult to persuade people there to work overtime, especially on weekends, and also tougher to recruit working wives than elsewhere because they do not want to drive more than five miles.

giant Siemens. Other Silicon Valley firms with plans for operations elsewhere include Advanced Micro Devices in Austin, National Semiconductor in Salt Lake City, Signetics in Orem, Utah, and Zilog in Boise, Idaho. Intel already has operations in Aloha, Ore. **-Larry Waller**

Lasers

RCA boosts stability of planar diode

Stabilizing the power output of a laser diode is not easy, especially if the device is designed to have a planar construction. Yet planar is the preferred approach because it is the easiest to fabricate of all the semiconductor diode geometries. So recent research at RCA Laboratories in Princeton, N. J., to overcome the instability with a new planar geometry is particularly welcome.

The new diodes are stable even when their drive current increases much above the laser threshold operation level. This increase is necessary for signal modulation but has been difficult to achieve while maintaining stability. The lasers also combine "continous-wave operation in a single spatial and temporal mode," says Dan Botez, a member of the RCA technical staff. This combination enhances their stability even more.

Botez developed the diode, dubbed a "double-dovetail" constricted double-hetero laser, out of the same material—aluminum gallium arsenide—as other solid-state lasers. But before the needed epitaxial layers are deposited on the gallium-arsenide substrate, two adjacent dovetail-shaped channels are etched into its face. This geometry accurately locates and confines the generating spot of laser light to a space between the dovetails.

A superior device. The double-dovetail structure is easier to fabricate than other structures that lead to single-mode operation, Botez says. This is because the mesa and channel patterns are visible on the top surface of the device. Therefore, alignment of the laser contact stripe with the constricted active region is a simple task.

Optical power comes out of the diodes in the near-infrared region of

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820 to 860 micrometers. In addition, the optical beamwidth is typically less than 0.009 μm, and this highly monochromatic signal ensures that the fiber-optic carrier frequency for any communications application is extremely well defined.

Applications. Future high-speed fiber-optic communication systems will use single-mode operation with as small a diameter fiber as possible (typically 4 to 5 μm) to keep attenuation low. The new laser diode will be useful here since the laser-light-emitting region is constricted by the novel geometry to a physically narrow beam only 10° to 35° wide.

What is more, Botez notes, "the light spot is only about 2.5 μm in diameter. This means that up to 70% of the optical power that's emitted can be put into a single-mode fiber with a numerical aperture of 0.1—a typical case."

Earlier diodes had their emitting region much larger than the fiber-core diameter, wasting much power. This was recognized as a problem early on, and, as Botez observes, "RCA is not alone in developing monochromatic narrow-beam single-mode diodes. Much work is going on in Japan. Those diodes, however, are more complicated to fabricate."

Dynamic range. Samples of the double-dovetail laser have shown linear variations in power output as a function of current drive level up to powers of 25 milliwatts. In a typical communication system, this translates into modulation capabilities and a dynamic range that are not available with conventional laser devices. At the higher power levels, operation is multimode and suitable for currently available multimode optical fibers.

The lasers operate both in the continuous-wave and pulsed modes, and at temperatures of up to 70°C to boot, without the usually expected kinks in the power-current curve. These distortions can cause system nonlinearities. Lifetime—that bugaboo of the fiber-optics industry—is not yet established by statistically significant data, but Botez says that "samples have been tested up to 3,000 hours." **-Harvey J. Hindin.**

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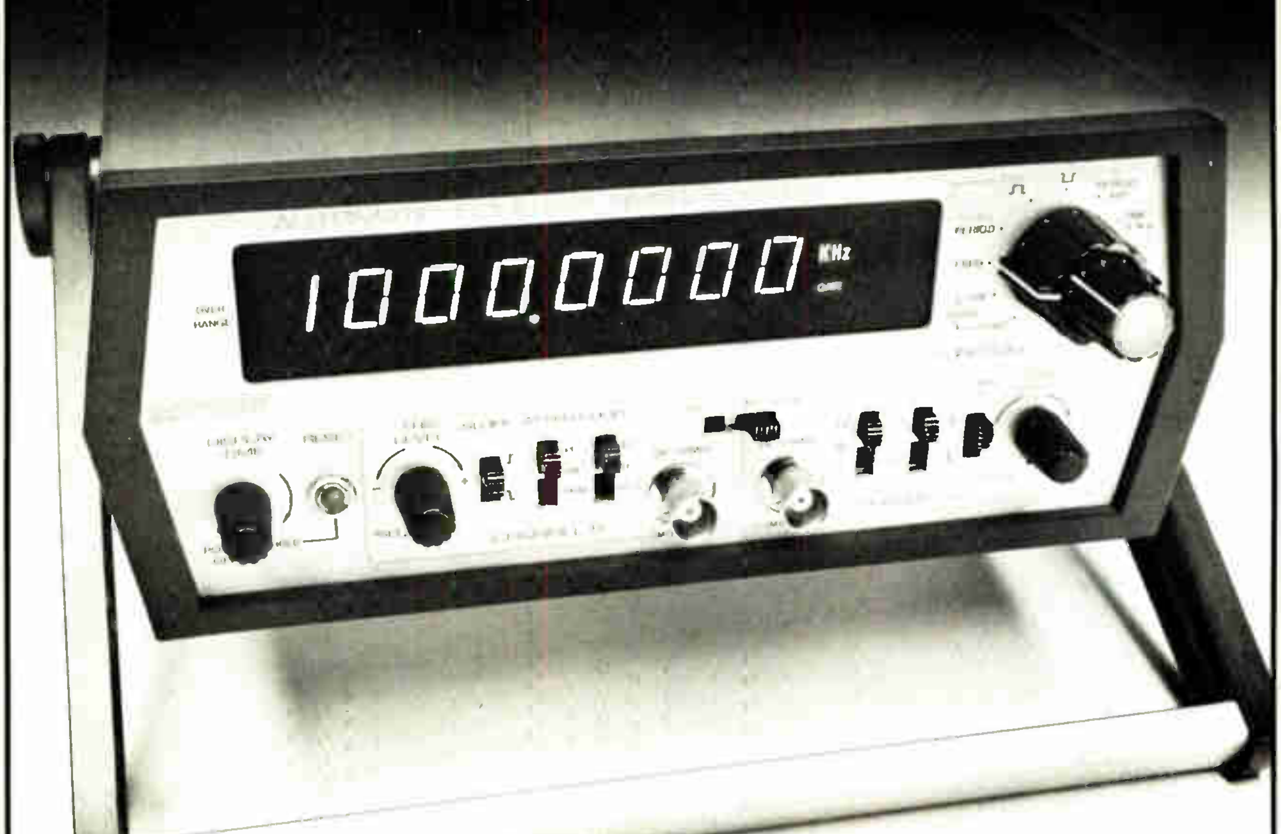

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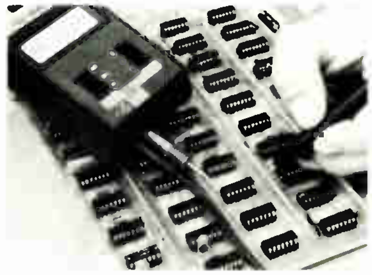

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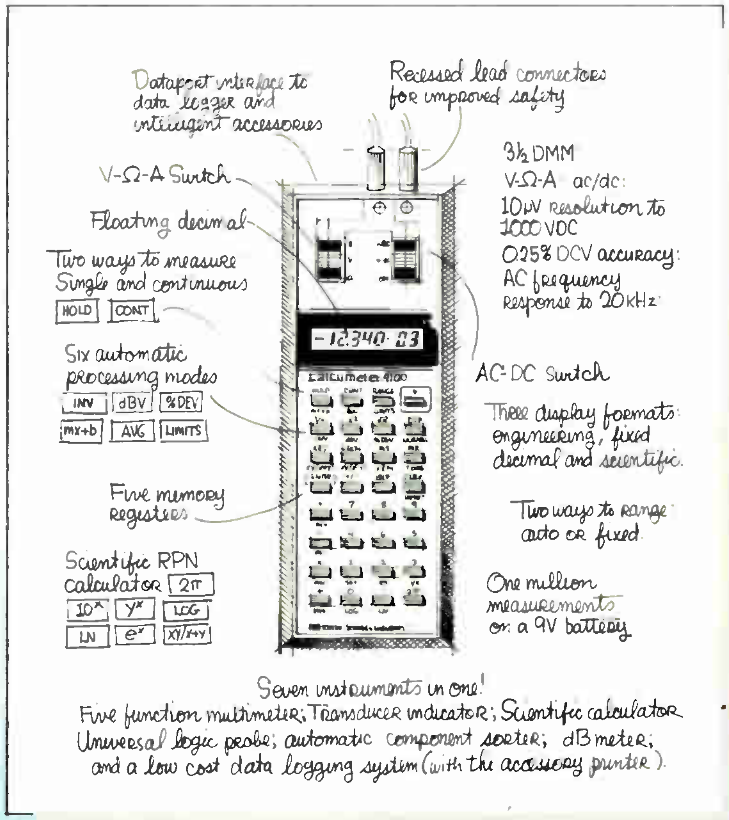

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Washington newsletter

Consumer imports rise 18% in 1978 to $4.6 billion . . .

American imports of home entertainment electronics jumped sharply once more in 1978 to nearly $4.6 billion, 18% more than 1977's total $3.9 billion, with Japan accounting for almost 56% of the total with more than $2.5 billion. New Commerce Department figures show that, although imports of color television receivers from Japan dropped 29% to 1.4 million units as a result of Orderly Marketing Agreement controls, Japan earned $105 million more last year—a 4.3% gain from 1977. **The reason: sharp increases in unit shipments of color video cassette recorders and higher prices for a smaller number of audio tape recorder-players,** reflecting a continuing shift to top-of-the-line exports to the U. S. plus appreciation of the yen. Even though VCR imports rose 129% to 480,000 sets last year, there still are no domestic manufacturers. Audio tape equipment imports dropped nearly 30% to just under 20 million units, yet the dollar value rose 34% to $1.5 billion.

. . . Korean color TV shipments up 350%; Taiwan gains 94%

Taiwan and South Korea ranked second and third with growing import market shares of $733 million (16%) and $355 million (7.8%), respectively. Both registered major gains in color TV shipments. Orderly Marketing Agreements with those countries on color TVs just went into effect Feb. 1 after 1978 shipments from South Korea soared 350% to 430,000 sets, **largely from Japanese affiliates,** while Taiwan scored a 94% increase to 624,000 units.

U. S. is lazy in export competition, Strauss complains

U. S. industries are making "real bum" efforts compared with Japan and West Germany to expand export markets, says Robert Strauss, special trade representative for President Carter. He told a Senate subcommittee early this month that part of the reason this country's comparative lack of competitiveness in world trade is that **"we've gotten lazy because we've got a real fat, easy market right here."**

Responding to questions by the Senate select subcommittee on Government procurement, Strauss explained, "Today there are probably 12,000 to 15,000 very competent Japanese individuals in New York selling Japanese products against American products. They speak good English. In Japan, there are maybe 75 Americans, and maybe two speak Japanese." Given those circumstances, Strauss says, "you know how we'll come out."

Jamming of JTIDS seen possible threat to air traffic control

The possibility exists that intentional jamming of the triservice Joint Tactical Information Distribution System (JTIDS) now in development might interfere with international air traffic control functions sharing the same 960-to-1,215-MHz band. This prospect is causing concern among some member nations of the International Civil Aviation Organization (ICAO). But the Pentagon says that the **JTIDS spread-spectrum approach will use its antijam frequency-hopping techniques across only 190 MHz of the 255 MHz in the band and avoid civil aviation frequencies.** JTIDS is a multibillion-dollar integrated system that will provide navigation, communication, and identification functions for military aircraft, ships, land vehicles, and installations. In addition to military assignments in the 960-to-1,215-MHz band, the Federal Communications Commission says the band is used by distance-measuring equipment, which tells an aircraft the distance from radio beacons, and by the air traffic control radar-beacon system, which provides aircraft identification and altitude.

Washington commentary

Kicking a lazy Government

A number of U. S. electronics executives are, to say the least, unhappy with special trade representative Robert Strauss's generalization about U. S. industries. He said they are both lazy and incompetent when it comes to competing with Japan and West Germany in the world's export markets. A relative newcomer to the world of international trade negotiations, Strauss might have expressed himself more diplomatically in his Senate testimony (see p. 57). Yet his political instincts probably told him that any softer phrasing would have gone unnoticed outside the hearing room.

While Strauss is certainly correct in his observation that there are many more Japanese businessmen who speak English than there are Americans who speak Japanese, he overlooks the fact that Japanese public schools require a minimum of six years of English language training. There is no comparable program in U. S. schools because America was not subject to occupation by Japanese armed forces at the end of World War II.

Moreover, economic history shows that the United States has never ranked among the great trading nations because, as Strauss puts it, "We've got a real fat, easy market right here." Thus America, unlike Japan, has never cultivated a sense of urgency about trade.

It is not that many managers in U. S. industries have become lazy—rather, they have never recognized the need to trade in a global marketplace as other nations recovered from the wartime disaster of World War II and began challenging U. S. economic superiority. That may make those managers open to charges of shortsightedness and overconfidence, but no more so than the governments that have been elected to lead them.

The quick fixes

While Robert Strauss is negotiating hard to get Japan to open Nippon Telegraph and Telephone Public Corp.'s $3 billion annual market to U. S. bidders, as well as eliminate other inequities in the trade relationships between the two countries, his superiors in the White House need to do a great deal more at home to encourage domestic manufacturers to export more.

For the short term, the White House should immediately push for a realistic upgrading and simplification of computer export controls. As these are now, they tend to discourage direct U. S. exports while encouraging American computer makers to set up plants overseas. Though disagreeing on particular points, the manufacturers all agree that Government export procedures are both antiquated and overly long.

Similar problems exist when it comes to domestic enforcement of U. S. antidumping laws, as manufacturers of home entertainment electronic products have long insisted. "The long periods of time required to conduct investigations, and delays averaging 3 to 3½ years in assessing duties after findings of dumping, make it highly improbable that U. S. industry is being adequately protected" by its own Government, reports the General Accounting Office. What is left of the domestic television receiver industry learned that long ago, of course. Its complaints of Japanese dumping of color TV sets are still unresolved after 11 years.

As the investigative arm of Congress, the GAO also reported to legislators that even though the International Trade Commission and the Departments of the Treasury and Commerce all have roles in enforcement of antidumping laws, there is still no reliable data on the extent of dumping and its impact on national production and jobs. Worse yet, there is no Government program to assess the damage, much less take action to correct it.

Making a policy

What these criticisms say in sum is that the United States, the world's largest and richest marketplace, has no comprehensive trade policy. If the White House won't move to change that, then Congress should.

Perhaps the best recommendation thus far has emerged after a year of study from the Senate Banking subcommittee on international finance. It calls for the establishment of a new Department of Trade that would consolidate trade responsibilities now divided among the Departments of Agriculture, Commerce, State, and Treasury, as well as Strauss's office, the ITC and the Export-Import Bank. Citing the proposal's similarity to Japan's Ministry of International Trade and Industry, one electronics manufacturer smilingly concedes that "no one can say we are unable to learn from the Japanese."

-Ray Connolly

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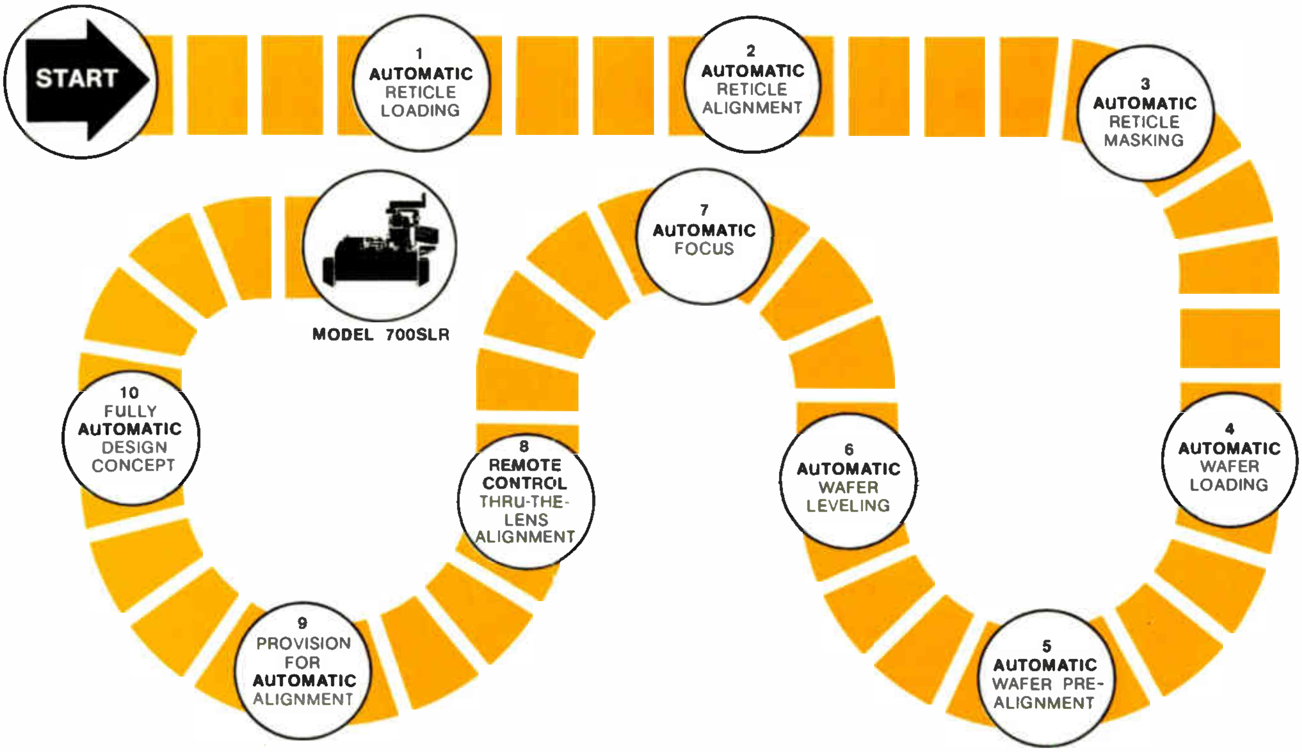

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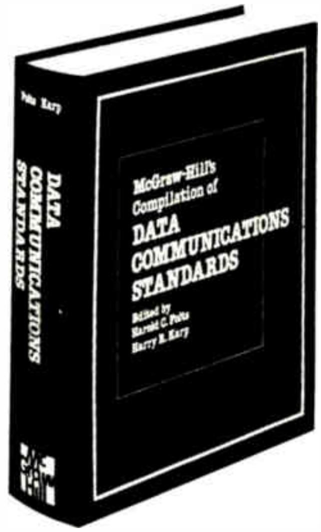

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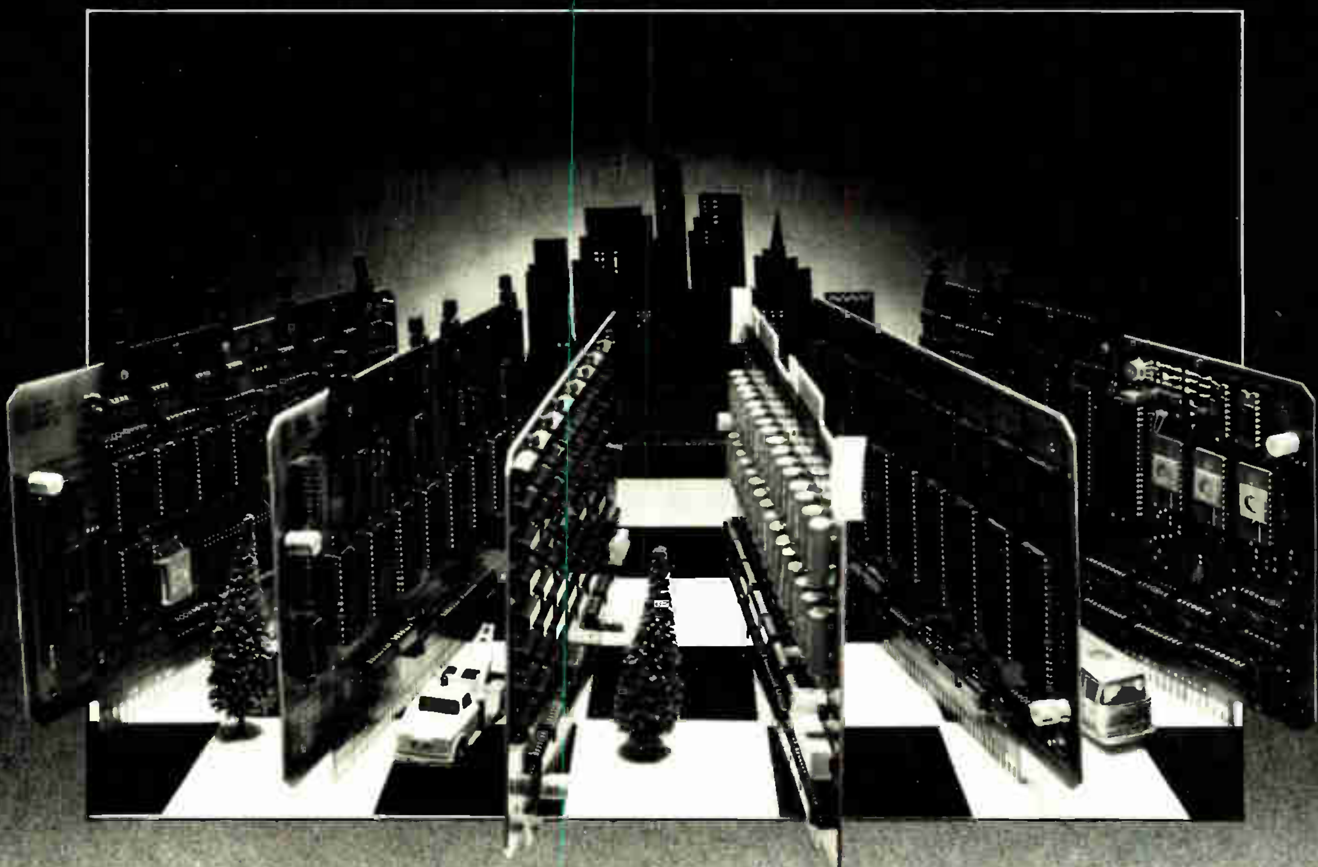

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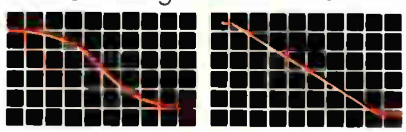

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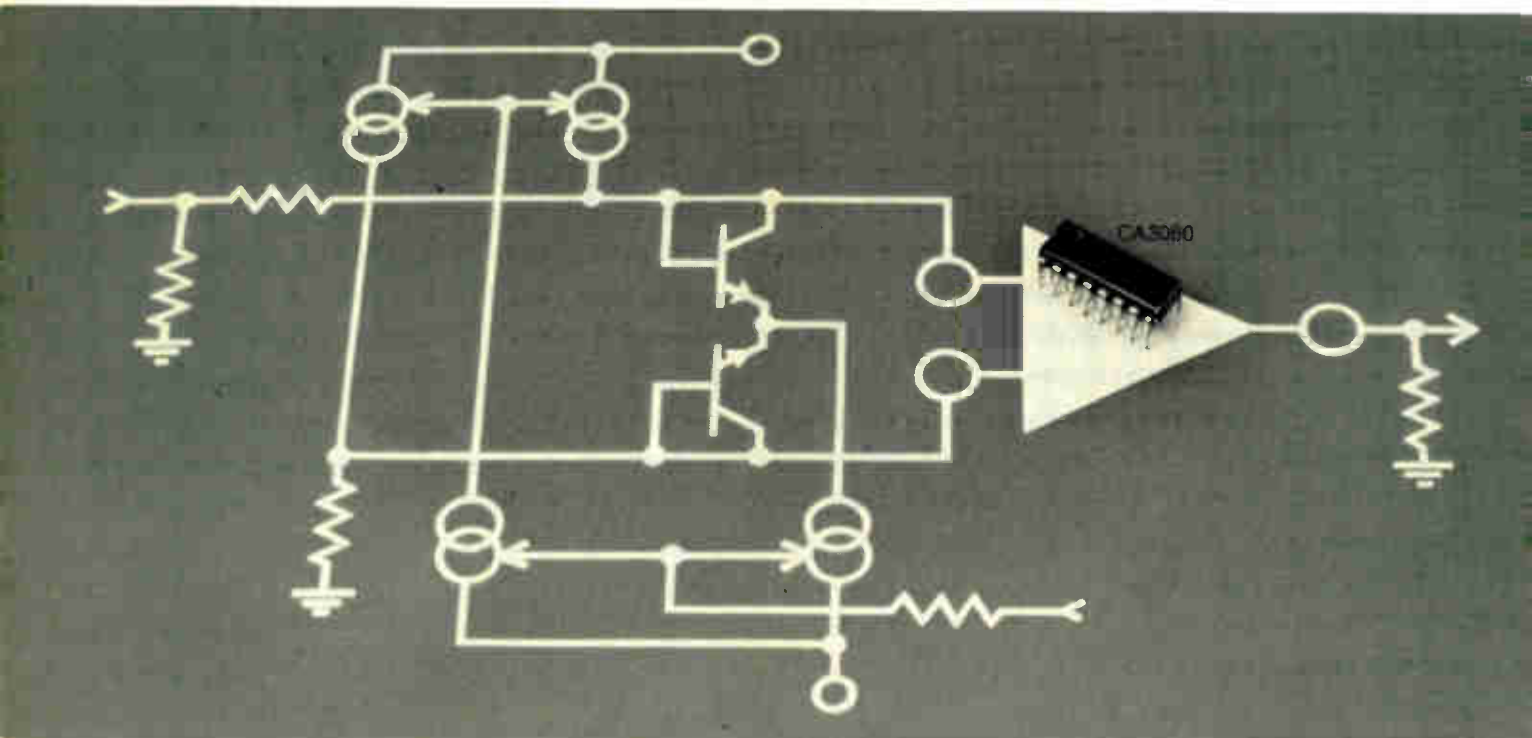

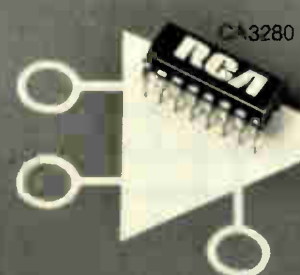

RCA

International newsletter

Data ring that transmits 1 Mb/s to go commercial

A packet-organized data ring and its associated operating system developed at Cambridge University's computer science department to link in-house mainframe and minicomputer resources is to be exploited commercially by the British software systems company Logica Ltd. **The closed loop operates at up to 1 Mb/s** over a simple twisted-pair cable and is currently accessed via a transistor-transistor-logic card. As part of a government-financed advanced computer techniques project, a two-chip version is to be developed over the next 12 months by Ferranti Semiconductors Ltd. using its uncommitted-logic-array technology. London-based Logica is a key member of the Nexos word-processing consortium of companies recently launched by the National Enterprise Board with $80 million funding, so the "portable" software could play a vital role in linking Logica's word processor to coming electronic office systems.

Siemens to introduce space-switched PBXs at Hanover fair

Microprocessor control, modular construction, and low power consumption are the prime features of a new family of space-switched private-branch-exchange (PBX) systems that Siemens AG will show for the first time at West Germany's Hanover Fair, April 18–26. The EMS (for electronic, microprocessor, and stored-program-controlled) family consists of five systems, the smallest for 10 subscribers and the largest expandable to handle an unlimited number. A 30-subscriber system is so compact it easily fits under a desk. Power consumption for a configuration handling 600 subscribers is only 1.5 kW.

Universal logic gate promises denser custom chips

Now being evaluated by one semiconductor company for use in custom microcircuits is a bipolar universal logic gate that can be **programmed to yield any three-input combinatorial function or a bistable device** by a choice of input/output connections. According to its developer, S. L. Hurst of the department of electrical engineering at Bath University in England, a chip array of such gates could be interconnected with a single masked metalization, thus achieving greater circuit densities and lower design costs than are possible with rival uncommitted logic arrays. That's because the metalization layers interconnect only gates and not the components within individual cells as in a ULA. The technique, says its developer, could perhaps also be applied to custom complementary-MOS circuits.

Antiskid control goes into high gear in West Germany

Robert Bosch GmbH, Stuttgart, is producing 1,000 antiskid control systems per month for Mercedes Benz and Bayrische Motoren Werke (BMW) automobiles in West Germany. The system uses six custom chips—two large-scale integrated p-MOS and four bipolar circuits—for separately monitoring the braking action of the rear wheels and each of the two front wheels [*Electronics*, July 20, 1978, p. 64]. Previous systems were shunned by consumers because of high cost and frequent breakdowns, but **the new unit has a fail-safe system, developers claim, to prevent accidental wheel locking** caused by electronic malfunctions. The logic chips are linked in a phase-locked loop for processing sensor signals, company officials explained at the Vehicular Technology Conference in Arlington Heights, Ill., at the end of March. Field tests indicate a failure rate of less than 0.5% per year while reducing braking distance on wet roads by 40%. A low-cost version is on the drawing boards for export that will use an off-the-shelf microprocessor rather than custom chips to keep the retail price at less than $500; introduction is scheduled for 1983–84.

IEC proposes standards for medical equipment

The International Electrotechnical Commission, continuing its push for acceptance of medical equipment standards, has drawn up a series of norms for diagnostic X-ray equipment and electron accelerators used for radiation treatment of cancer patients. Adopted at a 10-day technical conference in Paris in late March, **the standards now go to the national committees in each of the 42 IEC member countries,** which include the U. S., the USSR, and virtually all other developed countries. In the past, only a handful of members have accepted IEC medical equipment norms. Still, the commission believes eventual acceptance is inevitable because it is expensive for each country to develop its own norms and international norms should facilitate international sales for manufacturers.

ITT Components will be first non-Sony firm to make Trinitron tubes

Watch for the ITT Components Group Europe to start producing Sony Corp.'s Trinitron color TV tubes for the Japanese company's TV plant in England. Sony and ITT have reached **an agreement that provides for the production initially of 60,000 22-inch tubes,** to be made at the group's tube-manufacturing facility in Esslingen, West Germany. This, an ITT representative says, would be the first time that Sony is having its Trinitron tubes produced in a plant other than its own. For the Japanese firm, the agreement spells a big savings in tube transportation costs; for the ITT group it means much-needed business for its Esslingen facility, which already makes TV tubes for other companies but has been operating significantly below capacity because of the decline in TV sales in Europe.

Grundig to make VCRs programmable for two TV shows

Seeking to enhance the versatility of its 4-hour video cassette recorder, the SVR4004, West Germany's Grundig AG is coming out with a modified version that can be preprogrammed to come on automatically at two different times, thus allowing the recording of two different TV shows, which may be on different channels. **The first European company to offer such "double-programmable" systems,** Grundig says this feature will also be available on its Secam VCRs intended for the French market. Like the standard SVR4004 [*Electronics*, June 8, 1978, p. 70], the new version, called the SVR4004EL, permits programming of turn-on and turn-off times as much as 10 days in advance of the show or shows to be recorded.

Addenda

Mostek Corp. has selected Blanchardstown, Ireland, near Dublin, for a wholly owned $80 million production facility that it says will employ 1,100 when fully operational after 1982. The two 100,000-square-foot buildings are planned for a 50-acre site, where the Carrollton, Texas, firm **will fabricate wafers and make microprocessor and memory products** for sale primarily to the European market. . . . Datasaab AB, the year-old Swedish computer firm, lost about $26 million last year, $9 million more than had been estimated when it was formed by the state and Saab-Scania AB. The owners are now kicking in $13 million each to cover the loss. Minister of Industry Erik Huss says the owners don't expect the company to be in the black for another three years, but he stresses that **the state is determined to support Datasaab in order to maintain domestic computer competence.**

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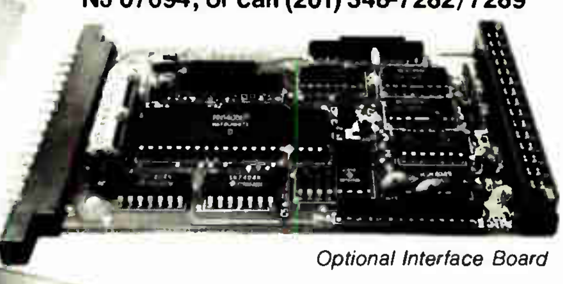

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Circle 701 on Reader Service Card

Trip computer gets more functions and greater intelligence

by John Gosch, Frankfurt bureau manager

Interactive system from BMW, Siemens uses variable weighting to estimate time of arrival and range

Building computers that supply information on fuel economy, distance to a destination, estimated time of arrival, and other vehicle- and trip-related data into cars is a growing trend in the U.S., and European auto makers have begun to follow suit. Joining the lineup is West Germany's Bayrische Motoren Werke AG (BMW), a Munich-based company known as a builder of high-performance cars.

It is gearing up to fit its top-of-the-line models with an interactive microcomputer system that it claims has a level of intelligence unmatched by any system built thus far. Developed at Siemens AG in cooperation with BMW, the system is now in the prototype stage and will probably be installed in quantity next year. Its price, not yet determined, will be about that of a high-quality a-m/fm car radio.

Information plus. As Rüdiger Müller, head of the automotive electronic systems group in the Siemens Components division, explains it, the computer performs some 15 functions. These consist of purely informative indications like average speed, estimated time of arrival, and average and instantaneous gas consumption (either in miles per gallon or liters per 100 kilometers), as well as warnings on various travel- and car-related conditions.

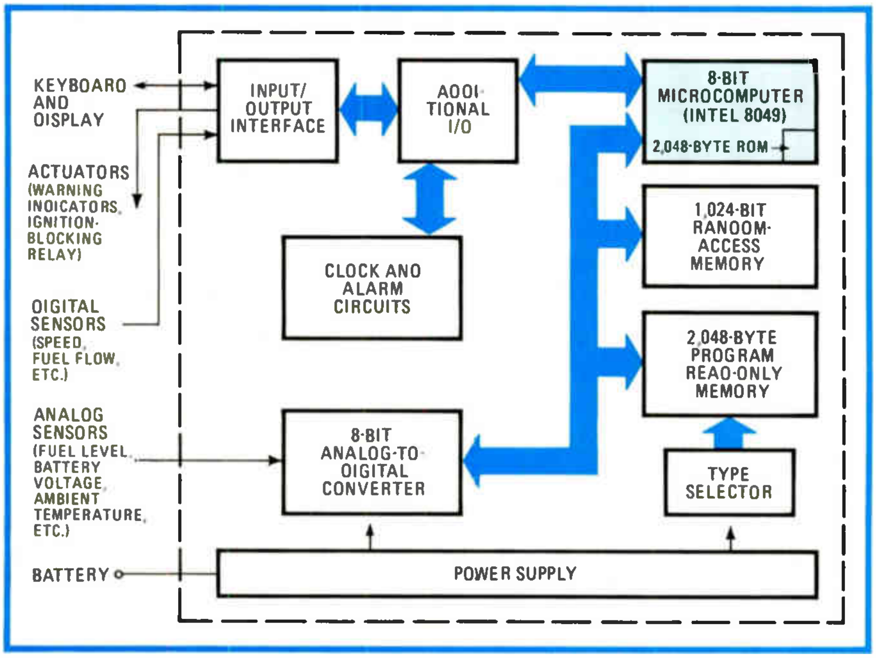
In support of the claim of unmatched intelligence, Müller explains how the computer estimates, for example, the time of arrival and the miles to empty fuel tank, or range. For both, the indications of course depend on the figures used.

Undesirable. If the calculations are based on, say, instantaneous driving behavior, the results would be subject to considerable variations and would therefore be useless. If, on the other hand, they are based on the average driving behavior so far, the indications would be quasi-static and most likely highly inaccurate, because an overall average is not nearly so good a predictor of the future as is an average taken only over the recent past.

The Siemens-BMW solution is a compromise. The computer calculates the ETA using the car's average speed over the past 1 to 4 kilometers, depending on how fast the car is going—the slower the speed, the less distance it is averaged over. Similarly, the indicated range is based on an overall average value of fuel consumption weighted against the fuel consumed over the latest distance covered.

Of note, too, are the computer's warning features, items that, according to Müller, most other systems do not have. For example, if the outside temperature falls below 3°C, a light-emitting diode flashes and an alarm is sounded, warning the driver of the chance of icy roads. In the same way, the driver is warned when the car exceeds the keyed-in speed limit.

What's more, the driver can key in



Information, please. The central electronic unit of the BMW-Siemens interactive trip computer accepts analog and digital data to perform 15 functions that inform or alert the driver.

On the alert. Keyboard and display unit contains eight LEDs, to supply warnings (red), as well as information (green).

the distance to a desired highway exit and the system will alert the driver both optically and acoustically when he is approaching the exit. It also figures out the approximate exit-arrival time.

Locked. Then, too, there is a scheme that helps prevent theft or unauthorized use of the car. To start up, the driver unblocks the ignition system by keying into the computer an identification number of up to four digits. If a wrong number is keyed in three times in a row, the computer keeps the ignition blocked and triggers the horn.

Basically, the system consists of the dashboard-mounted keyboard and display (see photo) and the central electronic unit, which is 18.5 by 12 by 3.5 centimeters and installed in the passenger compartment. The keyboard contains a four-digit light-emitting-diode display and 12 double-function keys, as well as eight informative (green) and warning (red) LEDs.

Electronics. The central electronic unit is built around Intel's single-chip 8-bit 8049 microcomputer. Peripheral to it are an 8-bit analog-to-digital converter, complementary-metal-oxide-semiconductor clock and alarm circuits, a 256-by-4-bit random-access memory for all car-derived and keyed-in data, and a 2,048-by-8-bit read-only memory for program storage (see diagram) that supplements the 2-kilobyte ROM on the microcomputer chip.

Other peripheral components are input/output devices that interface with the keyboard display, the clock and alarm circuits, and the microcomputer. Finally, there is a type-selector switch that adapts the electronic unit to the various BMW models such that it takes into account the different speed sensors, wheel diameters, fuel tank geometries, and other parameters of the different models. The peripheral devices come from Siemens and other suppliers.

Inputs are such analog information as fuel level, battery voltage, and outside temperature, and digital data like the speedometer-derived speed pulses and the fuel-injection pulses. The latter come from the electronic injectors found on top-of-the-line BMW models. The battery voltage input is used to compensate for variations in voltage to the fuel injection system and the fuel sensor.

The only extra sensor required is for the outside temperature. For this purpose Siemens has developed a special high-accuracy negative-temperature-coefficient thermistor that responds to temperature variations within seconds.

Great Britain

Coding scheme sends data by tone signals

There's a new, highly reliable way of transmitting data over radio and telephone links, achieved by expanding the number of frequencies used and replacing the tunable filter generally employed in the decoder.

The coding technique is called HSC, for hexadecimal sequential code. It comes from Consumer Microcircuits Ltd., a small British company that has also designed complementary-metal-oxide-semiconductor circuits to perform the coding and decoding. The Witham, Essex–based firm specializes in the design and assembly of tone-signaling microcircuits for the mobile-telephone and radio-paging industry and exports over 80% of its production.

Its latest products build on the 5-tone (out of 12) sequential calling system that is already employed by the mobile-telephone industry to page a single receiver. The set, the company says, "would be ideal for a data link between microprocessor-based systems."

Integrity. Says Brian Hardy, Consumer Microcircuits' marketing director, "Tone signaling works well because of the integrating effect of detecting a tone over a long interval." In contrast, other popular data-communication transmission techniques like frequency shift keying have a far higher data rate (some 10 times as fast) but show poor integrity under heavy noise conditions. "It's the high-integrity market that we are after," Hardy says.

To transmit quadridecimal or hexadecimal data—say, a police car's status—Consumer Microcircuits has added 5 frequencies to the 12-frequency tone code. More importantly, it has redesigned the decoder to enable it to receive data.

Tuning in. In the existing set, a sequence of five tones, each typically 33 milliseconds long, is transmitted to address a particular mobile unit. Transmitting data is a problem, though. That is, says Hardy, "conventional decoders can decode their address and nothing else."

In operation, a tunable filter in the decoder is set to the tone representing the first digit of its address and will not shift till it hears that tone. Then it tunes to the second digit, and so on, till all five digits have been decoded.

To receive data, the decoder must respond to all possible tones, so Consumer Microcircuits has thrown out the tunable filter and chosen a digital autocorrelation technique to discriminate between tones.

The input signal is first digitized. Then it is passed to a tapped shift register and compared with a version of itself that has been delayed by passing through a second shift register. Periodic signals are reinforced, while nonperiodic random noise signals are "washed out." As a result, Hardy says, "a signal which is 6 decibels down in the presence of

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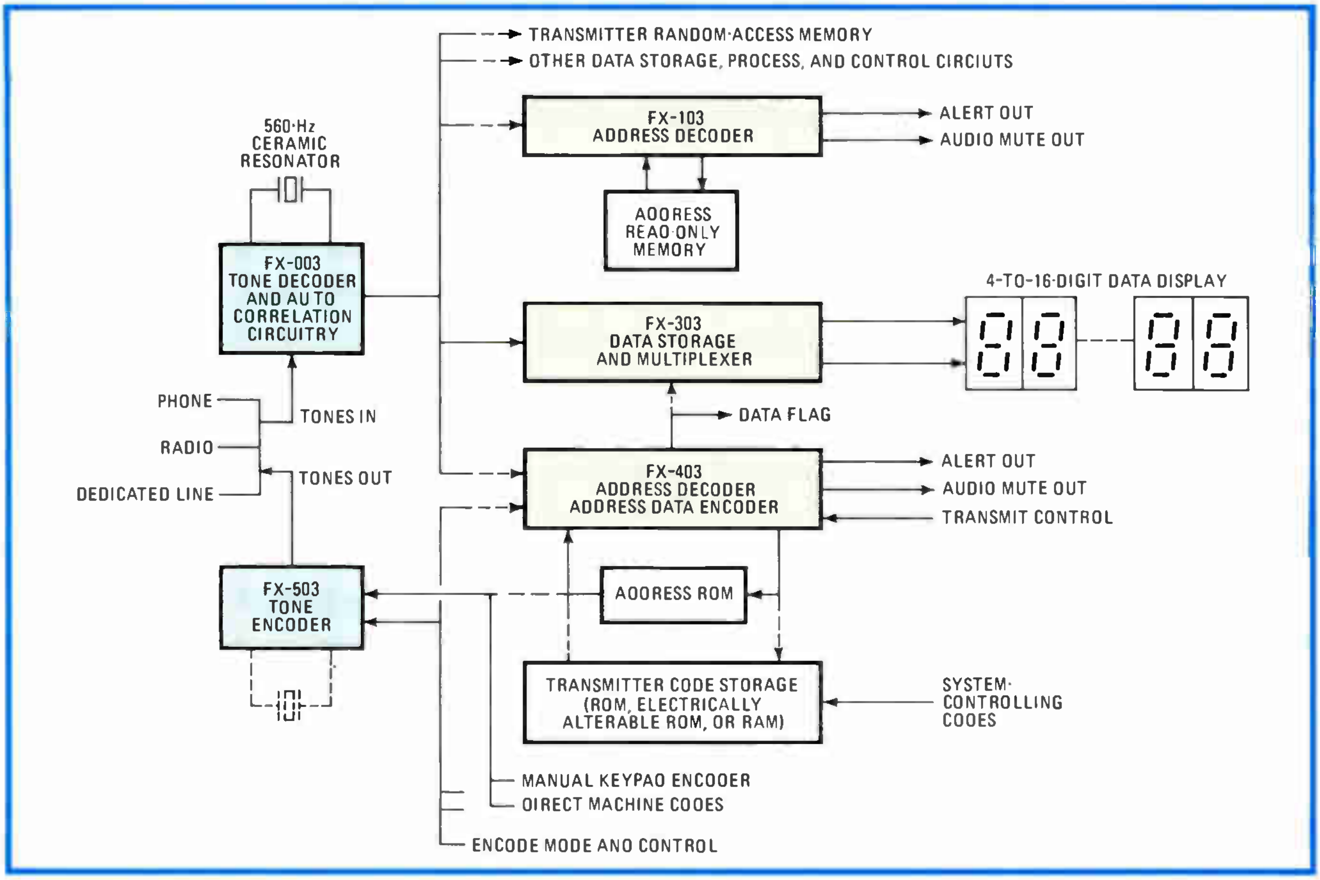

By the tones. Principal members of Consumer Microcircuits' 003 tone-signaling set are the FX-003 tone decoder and the FX-503 tone encoder. They can interface directly with a microprocessor using 4-bit parallel hexadecimal data words.

wideband noise is lifted to + 18 decibels above the background noise by the correlator."

Key device. The autocorrelation is performed by one chip, the FX-003, which puts out a 4-bit hex code. Several versions of this chip will be available for the various major national and international standards. Quadridecimal code set versions, too, will be made.

The FX-003 is the key circuit in the system and was "technically the most difficult," Hardy says. It will be available in the second half of the year. The other circuits making up the system, although simpler, all should be available by year-end.

The FX-103 performs the selective address function and compares the incoming 4-bit word with the address, stored in read-only memory, and beeps when the correct code sequence has been received. The FX-303 is a data store and display multiplexer, and the FX-503 a tone encoder that includes a frequency synthesizer capable of generating both the hexadecimal and quadridecimal tone sets.

The company is using Hughes Microelectronics Ltd. and General Instruments Microelectronics Ltd. to produce the circuits. **-Kevin Smith**

France

Transpac starts up, wants small users, too

People who want to converse by telephone in France often grumble about the quality of phone service, but those who want to converse by bits have nothing to complain about. With the inauguration late last month of Transpac, the French public packet-switching data-communications network, France now boasts Europe's most advanced digital telecommunications system.

The French postal and telecommunications administration, usually called the PTT, stresses that Transpac, a grid covering the entire country, is available to customers of any size, and at low cost.

The cost is based primarily on the volume of data transported, regardless of the distance between sending and receiving points, and speed ranges from 50 to 48,000 bits per second. Access to the system is based on the X.25 international data-communications protocol, the 128-byte packet and interfacing standard developed by the International Consultative Committee on Telephony and Telegraphy (CCITT).

The network consists of a series of switching nodes connected by a grid of high-speed links that handle up to 72,000 b/s. A national control system in Rennes monitors overall operations and changes routing if any link gives out. A customer plugs

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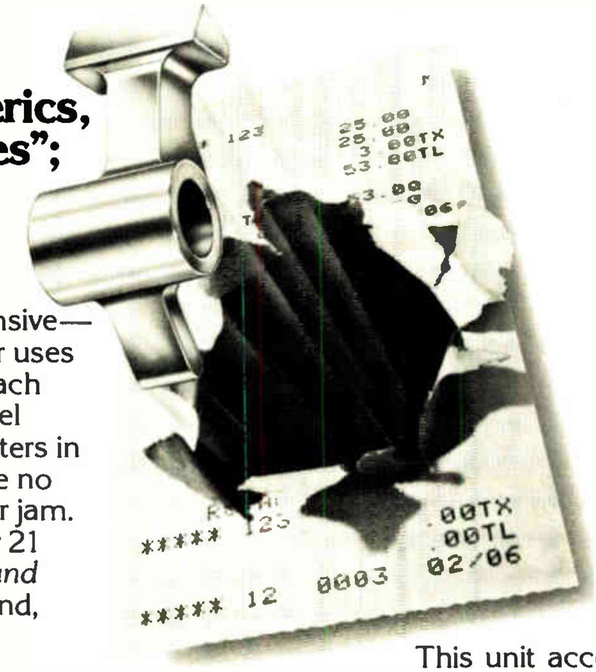

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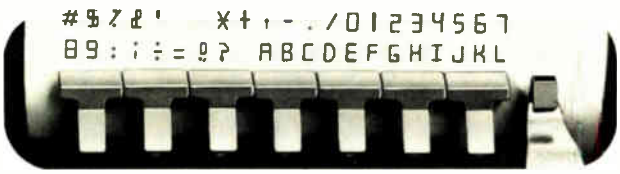

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Expanding. Experimental use of Transpac began in December [*Electronics*, Dec. 7, p. 107], and switches are now operating in 10 cities, with two more due to come on line shortly and plans for a total of 25 by the end of the year. The PTT believes the system will catch on quickly and foresees between 40 and 100 switching nodes by 1985. Eventually, no user will be more than 100 kilometers from a switching exchange.

When the network was inaugurated, 70 customers were linked directly to Transpac, and 60 others tied in through telex or telephone lines. The system is now capable of handling 1,500 customers, with the capacity projected at 4,500 next year and 25,000 by 1985.

The PTT believes much of the appeal of Transpac lies in the cost, and cites examples of savings ranging from 14% to 80%. The fact that customers pay basically only for what they send is aimed at attracting subscribers who might otherwise be unable to afford such an elaborate data-transport system.

Ad hoc. Transpac links depend on the use of virtual circuits, which permit simultaneous bidirectional exchanges of strings of packets regardless of the length of the messages transmitted. These virtual circuits may be either switched—links are activated on a correspondent's initiative—or permanent, at the customer's choice. They are employed in order to eliminate idle time, a key factor for a public telecommunications system. Transpac also offers multichannel access.

At the heart of the network are the switching nodes, each of which consists of a control unit and a switching module. The former is a general-purpose Mitra 125 minicomputer manufactured by the Thomas-CSF subsidiary, Société Européenne de Mini-informatique et de Systèmes (SEMS). It establishes and terminates calls, monitors operations, and recovers and retransmits any faulty messages. Two control units are located at each switching point, with the second serving as a stand-by. The error rate is put at less than 1 in 10^{10}.

Switches. The switching module handles line control and actual switching. Manufactured by Télécommunications Radioélectriques et Téléphoniques (TRT), a Philips subsidiary, each CP50 switching module can handle 256 X.25 ports. Asynchronous multiplexers provide 250 additional line interfaces. With two such modules at each switching point, the switching node has a maximum capacity of 16,000 lines.

The transit time of a packet, from input switch to output switch, depends on the routing; the PTT claims it is less than 200 microseconds at peak-usage hours 90% of the time. For switched access circuits, the connection time likewise depends on routing but is said to be less than 1.5 seconds in 90% of the cases.

Design and installation of the Transpac network was handled by the Société d'Etudes des Systèmes d'Automation (SESA) over a three-year period. Jacques Stern, president and director general of SESA, believes that with Transpac in operation his company is in a good position to compete for contracts for public data-communication systems elsewhere. He has his eye on markets in the U. S. and Latin America, as well as in Europe. **-Henry Dreyfack**

Sub hunter goes digital

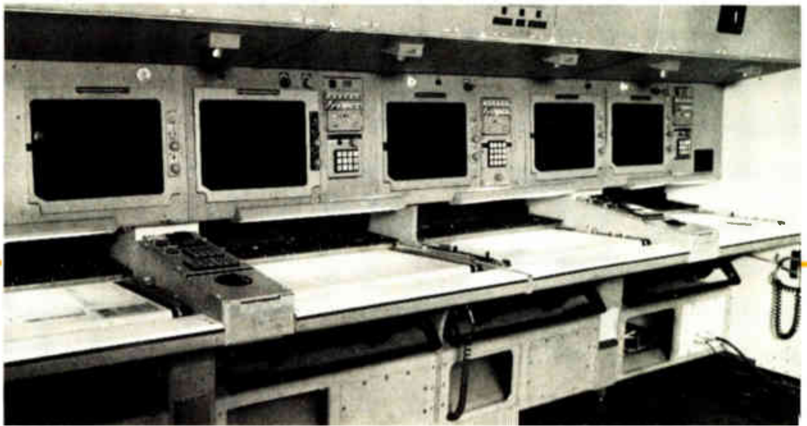
In the cat-and-mouse defense game of measure and countermeasure, an Anglo-Australian venture headed by Marconi Avionics Ltd., Rochester, Kent, has come up with an all-digital airborne antisubmarine system to locate and identify nuclear submarines. The new system, designated the AQS901, counters the subs' quietness, deep-diving capability, and high speed with improved speed, sensitivity, and flexibility stemming from the use of microprocessors for signal processing.

The system teams the new Australian Barra, a passive directional sonobuoy, with the AQS901 listening equipment carried by Royal Australian Air Force P3-C Orion or British Royal Air Force Nimrod maritime patrol craft. Barra provides accurate target positioning by direct bearing, hyperbolic fix processing, or doppler fix processing.

Its acoustic signals, telemetered aloft, are processed extensively before being fed to the visual display and the chart recorder. From the display and the chart, the operator can, with training, identify the characteristic noise signatures of both surface and submarine vessels.

The signal-processing tasks are split among 30 Advanced Micro Devices Am2901 bit-slice microprocessors, each performing a specific function for speed and flexibility, says Paul Rayner, manager of Marconi's Maritime Aircraft Systems division. One processor, for example, is a fast Fourier analyzer used to plot the energy in different frequency bands, thus providing the noise signatures. It is capable of performing 2,048 complex transforms in 1.25 milliseconds. The hardware was developed by Marconi, and Computing Devices of Canada Ltd. provided the sonar signal-processing subsystems.

The whole system is controlled by Marconi's well-proven 920 ATC digital computer, which, by allowing the operator to call up a variety of analyzer techniques to pinpoint a submarine's location, makes it highly flexible. Thus the AQS901 can work with every other type of sonobuoy in the North Atlantic Treaty Organization inventory. **-K. Smith**



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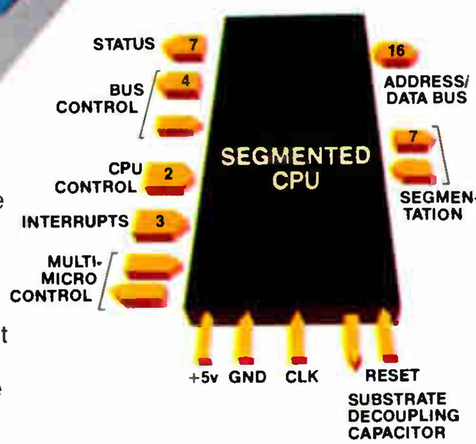

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favoring a mix of airborne and ground CAS for all types of air space—controlled and uncontrolled, high density and low density. Now, however, it is also requiring that the system mix be compatible. But the agency has yet to convince the general aviation community that once new ground equipment for Atars-DABS (discrete address beacon system) is in place a small plane will be able to spend what the FAA calls "a modest cost increment" to replace its present air-traffic-control beacon transponder with a new DABS transponder and still use the existing altitude-encoding system.

On the other hand, airline operators are more favorably inclined toward the FAA's approach that—unlike the case with early systems—"will ensure that the first aircraft that equips will receive substantial protection immediately," since existing altitude-encoding beacon transponders are already widely used and required by law in some terminal areas for operation above 12,500 feet.

Control fight. Problems of air traffic control policy may be even more difficult for the FAA to resolve than those of technology. The reason: the mix of ground and air CAS would also involve putting air space now open to visual and instrument flight rules under what the FAA calls "positive control."

Citing new statistics on near midair collisions, especially in terminal control areas, from the National Aeronautics and Space Administration, the General Aviation Manufacturers Association (GAMA) is asking Congress, "Why is it thought that more controllers—with more potential for human error—can correct or improve conditions that cause near misses" that are in fact a function of human actions? (See "The numbers game.")

"We are genuinely convinced," argues GAMA vice chairman J. Lynn Helms, "that the FAA does not have the capability to provide the additional air-traffic-control services that would be required in a more restricted system without severely limiting access to that system. □

The numbers game

Statistics are flying in the dispute between the Federal Aviation Administration and its opponents in the general aviation community over how many near midair collisions occur in U. S. air space. At issue is whether the FAA's dramatically lower figures are valid compared with the sharply higher figures reported by the aviation safety reporting system set up in 1975 by the National Aeronautics and Space Administration to provide independent statistics. The issue is becoming increasingly important with the advent of the Civil Aeronautics Board's deregulation policy that has caused significant increases in competitive air traffic.

Whereas the FAA reports "approximately two per million operations in terminal control areas" for 1978 and part of 1977, new NASA data for the same period shows 24.3 near misses, or 12 times as many. FAA Administrator Langhorne Bond hints that the discrepancies may be attributable to the fact that NASA's system offers immunity from prosecution and anonymity to reporting pilots, whereas the FAA has authority to prosecute violators of flight rules that cause a near collision.

Though Bond says he favors maintenance of NASA's amnesty provision for pilots, he is distressed that it prevents prosecution of pilots "even if the violation was witnessed and subsequently reported by others." He cites the example of a Spokane, Wash., incident where "a DC-9 on a missed approach almost hit a DC-10 taking off on the same runway at the same time. Both the DC-9 pilot and a controller were in serious error—and we all knew about the near-miss as soon as it occurred. But the pilot filed a report with NASA, and the FAA was blocked from taking any action against either man."

CAS: past and present

U. S. efforts to develop an independent airborne collision-avoidance system (CAS) began in the early 1960s when McDonnell Douglas Corp., working primarily with the nation's airlines, came up with its EROS system based on the use of expensive and delicate atomic clocks in each aircraft. Later, RCA Corp. and Honeywell Inc. entered the market with potentially cheaper systems called Secant and Avoids, respectively.

Though the technology of the newer entrants differed from that of EROS, the concepts of the three were similar. None provided horizontal directional data for aircraft entering the so-called electronic shield surrounding the user, and all were limited to vertical escape maneuvers. The Federal Aviation Administration entered the act in 1971, awarding contracts to all three developers to come up with operating systems for flight testing. In its evaluation of the systems, the FAA found fundamental deficiencies.

Reacting to congressional pressure resulting from last year's midair collision over San Diego of a light plane and a commercial airliner that took some 150 lives, FAA Administrator Langhorne Bond presented Congress with an air traffic control plan for the future that is already generating controversy. His proposal to bring more aircraft operating by visual flight rules under "positive air traffic control" is being strongly opposed by the nation's 10 leading aviation organizations.

On the technology side, the FAA is being criticized for not moving faster with development and system procurement. Its principal ground-based system in high-density regions, now called Atars—for automatic traffic advisory and resolution service—and supported by the discrete address beacon system (DABS), is not expected to be widely operational for another decade. The FAA is just beginning tests this year on the three Atars systems.

Developmemt of active and passive beacon-based airborne collision-avoidance systems are regarded as interim steps to bridge this gap, although the BCAS hardware will be capable of working with DABS and Atars. The Atars package uses ground computers independent of normal air traffic control computers. The Atars computers work with the upgraded DABS radar transponder and provide an automatic data link in all weather conditions between aircraft transponder and the ground computers.

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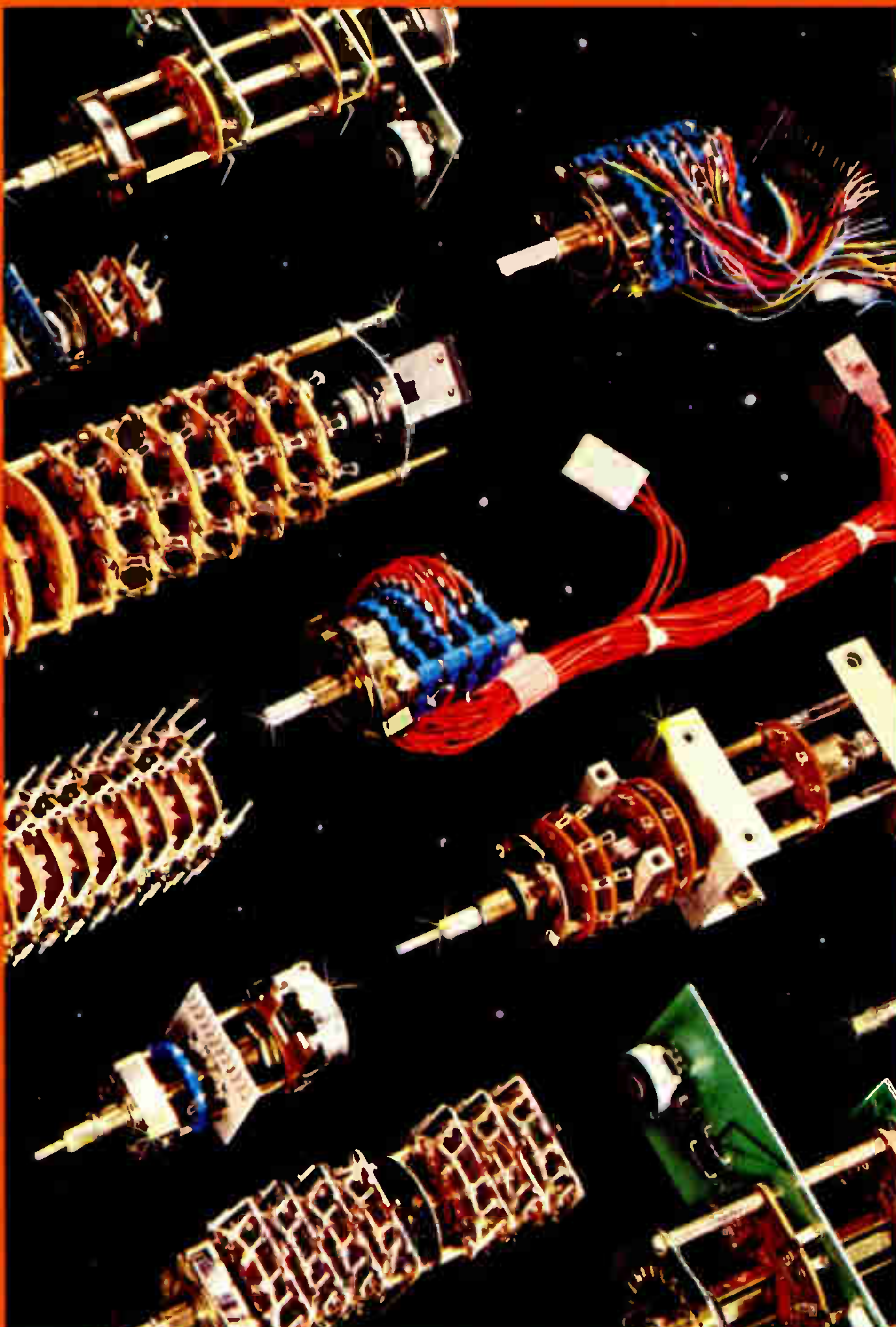

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Medical electronics

Microwaves help detect tumors

Researchers find that mass screening in 1.3-to-3.3-GHz range may be viable alternative to potentially hazardous X-ray exams

by Harvey J. Hindin, Communications & Microwave Editor

The very thought of breast cancer is terrifying because of its potential for physical and psychological mutilation. Mass screening to detect it in its early, most curable stages is a most welcome public health measure, and mammograms—breast X rays—were thought for 20 years to be the best way to go about it.

But this may not be so. Many questions have been raised by the National Institutes of Health, and separately by the NIH's National Cancer Institute, and by the Congressional Office of Technology Assessment, among others, as to the efficacy and safety of routine mammograms. The likelihood that breast X rays will cause cancer is small but real. Worse yet, the data that indicates that the procedure catches tumors early and saves lives is not very solid. And the cost is relatively high. However, there appears to be a solid alternative technique: detection of the breast's natural microwave radiation.

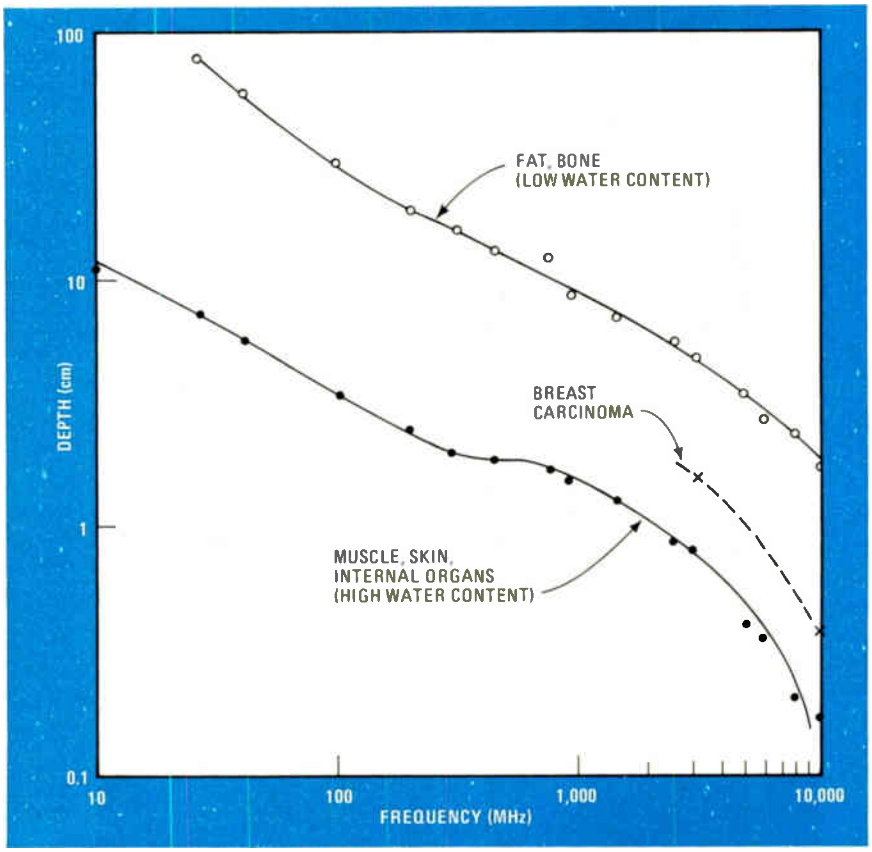
This is usually combined with thermography—passive infrared scanning of the breast (see "Detecting human radiation"). Infrared scanning is harmless since it also relies on the breast's natural radiation for its information. It is based on the fact that tumors are warmer than the surrounding tissue and thus generate more infrared radiation; however, the temperature difference is only about a degree or two. Point-to-point variation in breast temperature may exceed this figure, so even with the best available detection equipment it is very difficult for the medical specialist to be sure he has not missed any small tumors.

On the other hand, microwave radiation—much maligned in recent years, and accused of causing everything from headaches to cancer—is being used in many research laboratories to detect tumors. In spite of all the talk about low-level microwave radiation's potential for bad effects, there is no question that microwaves can detect breast tumors. There is a chance microwaves can even help cure the malignancies.

Microwave detection at 1.3 and 3.3 gigahertz has been used in clinical tests by Philips C. Myers and Alan H. Barrett of the department of physics of the Massachusetts Institute of Technology in Cambridge, Mass., since 1974. Tests have been done at Faulkner Hospital in Boston, where radiologist Norman L. Sadowsky cooperates in interpreting the infrared and X-ray analyses that are taken for data correlation for all three methods.

While the cancer detection rate depends on microwave frequency,

Penetration. Depth of penetration, hence depth from which microwaves escape, depends on wavelength and tissue's dielectric properties. Tissue water content is large variable.



tumor depth, and tumor size, among other variables, some conclusions have already been drawn. Most importantly, the dual approach—microwaves and infrared—can detect as many cancers as can X rays alone and has the same true negative rate. (The true negative rate or specificity of a test is the fraction of normal cases that the criterion identifies correctly.) Detection can be accomplished with a significant reduction in the number of women exposed to X rays if X rays are used only when the combined techniques (infrared and microwave) indicate a cancer presence.

Similar. Both the 1.3-GHz and 3.3-GHz radiometers are similar in construction. They are comparison-type superheterodyne receivers with a 100-megahertz intermediate frequency bandwidth centered at 60 MHz. The input to the first-stage tunnel-diode amplifier is switched at an 8-hertz rate between the antenna that picks up the human body radiations and a matched load whose temperature is controlled by a thermoelectric refrigerator.

The radiometer compares the emissions from the human source with the thermal emission from the temperature standard. Its output signal is fed both to a strip chart recorder and a light-emitting-diode display that indicates the temperature numerically. When properly tuned up and calibrated, a root-mean-square temperature sensitivity of 0.1° is readily achieved.

The antenna itself is a piece of rectangular waveguide placed flush against the skin when data is taken. Its impedance is adjusted so that there are minimal reflections of energy at the skin-waveguide-air interface.

The MIT-Faulkner team still has a lot to do. Work is continuing at the breast cancer detection clinic so quantitative tests can be applied to the measured temperatures in order to produce still higher true positive and true negative detection rates. And, to explore the effect of changing operating frequency, they have started work with a microprocessor-controlled 6-GHz radiometer.

Medical studies of this type tend to be long-range projects and conservative approaches are taken whenever human health is at stake. For example, James E. Thompson of the electrical and computer engineering department of the University of South Carolina in Columbia "does not plan to use human subjects in the near future" in his work. But he does have hopes that his technique will ultimately facilitate thermographic mass screening for tumors, because he has found that the inherent low sensitivity of thermography can be improved with the use of active low-level microwave radiation. Simply put, Thompson and his associates, Ted L. Simpson and Michael N. Huhn of the college of engineering and James B. Caulfield of the school of medicine at South Carolina, find that some tumorous tissue exposed to low-level microwaves heats up more intensely than the surrounding tissue. They then show up better on an infrared scanner.

NIH-sponsored research has started to answer some of the questions that naturally arise. Do all types of tumors react the same way? What if they are below the skin? Are the microwaves dangerous? Since ultrasonic energy also increases tumor temperature, that kind of radiation also will be examined. Because of the way research must be conducted, it will be a long time before these questions and others are answered, and years before the tests can be used on humans.

Yet Caulfield, for one, finds the prospect of improving the potential for spotting breast cancers and reducing the need for mammography an exciting project. While none of the researchers sees his work as the ultimate detection scheme, each would be a useful adjunct to the diagnostician's art if shown to be statistically significant.

Tryout. NIH-funded tests of the properties of millimeter microwave thermography (11 and 30 GHz) are being carried out by Jochen Edrich of the Denver Research Institute's Electronics division. He uses a noncontacting antenna to pick up the emitted energy and his system produces a gray-scale image similar to infrared thermography but different from the more discrete data obtained by Myers. Edrich's group is doing clinical trials of his millimeter systems combined with conventional infrared and mammograms at Denver's Swedish Hospital.

Still other work is in progress in Europe, where a group from Phillips GmbH in Hamburg, West Germany, is doing 2-GHz examinations at a breast cancer detection clinic in Strassburg, France. Their system features real-time compensation for variable antenna-skin interface energy reflections. □

Detecting human radiation

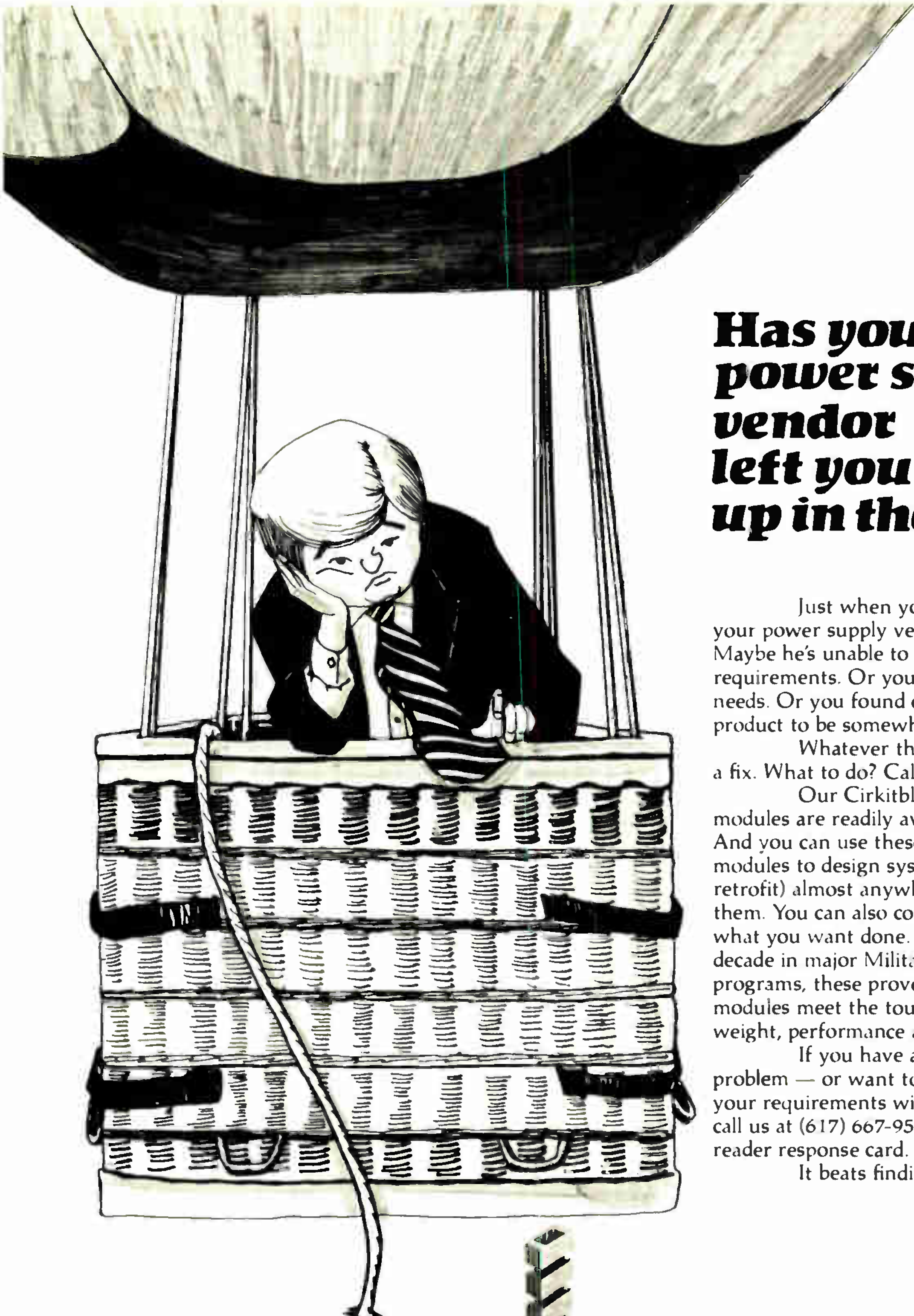
All human tissue—normal or otherwise—emits thermal radiation that ranges in wavelength over a wide span of the electromagnetic spectrum. At microwave frequencies, the radiation intensity is proportional to the temperature of the tissue.

By itself this is of little interest in medicine. But a cancerous mass is usually accompanied by an increase in local temperature of a few degrees. This radiation can travel through human tissue for distances up to several centimeters. It can also escape from the body if its source is close enough to the surface.

Once out, the radiation is readily detected by present-day microwave radiometric receivers. So, scanning of a patient's natural microwave emissions can be used to locate possible cancerous hot spots.

At normal body temperatures the maximum intensity of the naturally emitted thermal radiation occurs at a wavelength of about a 10 micrometers—the infrared range. This has led to the use of infrared receiving equipment for scanning. At a wavelength of 10 centimeters (typical microwave frequency), the radiated intensity is reduced by a factor of 10^8. But microwave radiometers—originally developed for radio astronomy—are more than sensitive enough anyway.

Both the microwave and infrared procedures are passive. No radiation is sent into the body and the patient is completely safe.



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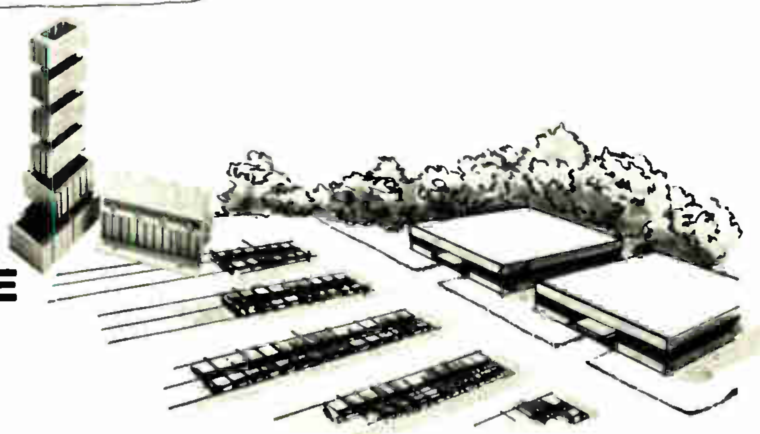

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Consumer electronics

Auto stereo is a hot market

New emphasis on high-end sets approaching home-equipment quality has doubled expenditures in last three years

by Robert Brownstein, San Francisco regional bureau

In less than five years, automobile stereo systems have turned into big-ticket items. They are moving from the tacky cardboard displays in discount auto parts and department stores and are now shown in elaborate listening rooms like those used in quality home stereo retail stores. To be sure, these new environments are not designed to display those old "$59 specials" but instead sport systems that sell in many cases for $300 to $400. This high end is where most of the recent activity is taking place, helping to double the auto stereo market in the last three years to $1.3 billion.

This is only part of the story. "Of the 115 million passenger cars on America's roads, 29.9 million or 26% are equipped with stereo systems," says John J. Houlahan, president of the market analysis company J. J. Houlahan Co., Los Angeles. His outlook for the next two years is bullish; he sees a doubling in market size by an influx of 29 million more purchases.

The new high-end receiver-cassette tape combinations abound with features like those of quality living room stereos. Because they must build them small to fit within the auto dashboard, auto stereo manufacturers need integrated circuits more than makers of the bigger household systems. In addition to a-m/fm intermediate-frequency and multiplex decoder chips, auto stereo makers use ICs for phase-locked-loop varactor tuning, digital display drivers, voltage regulation, and a growing list of other functions. Most of the systems are imported from Japan and use mostly Japanese ICs. But RCA Corp.'s Solid State division and Motorola Inc.'s Semiconductor Group, in addition to supplying domestic auto radio manufacturers with chips, are turning out their own lines of high-end auto stereos.

Top-of-the-line systems often have tape-bias equalization switching and Dolby noise-reduction circuitry. However, unlike the home stereo situation where consumers are lukewarm to convenience features but demand performance touches, auto stereo buyers like such things as automatic tuners, which at the touch of a button scan the band in search of the next signal. Another product that is unique to the auto stereo market is the booster amplifier, a device with both low-impedance input and low-impedance output that boosts the typical system's 8-ohm output of 5 watts or less to 15 to 60 W. Most automobile speaker systems are unable to handle that much power, so speaker manufacturers like Jensen Sound Laboratories, Schiller Park, Ill., are now offering speakers that can.

One executive, however, feels that too much emphasis is being placed on the high end. Martin Roth, president of Comm Industries, Boston, says there's still a lot of growth potential in the mid-range auto stereo market. "Aside from L. A., Chicago, New York, and other high-end areas, the country is made up of mid-range buyers," he says. Roth believes most of them would balk at high-end prices.

Others, though, seem to agree with the president of Pioneer Electronics of America, Jack Doyle, who declares, "The mandate is clear;

Higher power, performance, prices

A sampling of Pioneer of America's 19 new products tells a typical car stereo story. Consumers will have more choice in performance and convenience features with this year's crop of new systems, but will pay more to get them. Here are some new models:

The KE-5000 is a top-of-the-line a-m/fm stereo with cassette player. It sells for $399.95 and has Dolby noise reduction, selectable tape-bias equalization, scan-and-seek station-finding, and front-to-back fader controls. In addition, the system features a varactor-tuned oscillator that is controlled by a phase-locked loop for electronic tuning and digital display of frequency. It also has a built-in clock.

The CD-7 graphic equalizer offers users the ability to tailor their music with adjustable active-filter circuitry covering the audio spectrum in seven segments. Selling for $179.95, the CD-7 also has an IC delay line to emulate concert hall acoustics.

The GM-120 power amplifier will produce 30 watts per channel at 0.8% total harmonic distortion into a 4-ohm load. It can put out up to 60 w per channel, but with higher distortion. Its price is also $179.95.

The TS-696 high-power-rated speakers were designed because an amplifier like the GM-120 would destroy the voice coils in conventional auto speakers. Pioneer offers this pair of 6-by-9-inch oval speakers rated to handle 40 W each at $119.95 per set.

Not a movie prop. This is the auto stereo dealer's answer to the sound rooms found in stores selling quality home stereo sets. The marketing methods of the two are growing similar.

consumers want better sound quality in their cars and are willing to pay for it." Pioneer is casting its line for a larger share of the $1.5 billion Doyle predicts for sales in 1980. To do so, it plans 19 new products almost exclusively geared to high-end setups.

Scruples. A problem that used to plague scrupulous home stereo manufacturers—specifications—is a current problem for auto stereo manufacturers. Whereas all quality home stereo products are power-rated with a root-mean-square value at a given distortion level and frequency (typically 1,000 hertz) into an 8- or 4-ohm load, power specifications for auto stereos are seldom so qualified. Then, too, there is the problem that the systems offered by auto makers are usually not rated at all, except to describe function and the number of speakers. Don Coleman, vice president of marketing for Clarion Corp. of America, Lawndale, Calif., says Clarion and several others have informally agreed to a standard for advertising specs.

Presently, analyst Houlahan says, 11% of auto stereo systems are installed by auto makers and the remainder by aftermarket companies. More than half of the aftermarket pie is gobbled up by manufacturers and retailers who sell to consumers who want to replace original-equipment radios with stereo units. Pioneer, Sanyo Electric of Japan, and Clarion belong to this group. Another group, with members like Altus Corp. of Melrose, Mass., and Audiovox Corp. of Hauppauge, N.Y., have made $500 million a year selling their wares to new car dealers as an alternative to the equipment installed by the automobile manufacturer.

This second group is fearful of a Detroit strategy that would make more new car models have radios as standard equipment. The Custom Automobile Sound Association has been formed to combat what it sees as an auto maker squeeze play.

The effect of the dollar's downslide with respect to the yen is causing some prices to rise to avoid whittling away profit margins on these largely imported products. However, some retailers indicate that the Japanese manufacturers have been good at throwing in some extra features along with the price increase, thus defusing consumer resistance. Some analysts believe that if the trend in price increases continues unabated it may provide an opening for domestic makers RCA and Motorola to develop a larger market share. And there is talk of Japanese manufacturers moving more production offshore. □

Solid state

Semiconductor makers at crossroads

Hogan says they must become systems houses to survive, whereas Petritz foresees growing market for chips

by Arthur Erikson, Managing Editor, International

No one yet has come up with an equation for predicting the pervasiveness of the electronic technologies. And perhaps one really is not needed. For despite this shortcoming, forecasters almost to a man say that the electronics industries seem set for another decade of fast-paced growth as their traditional markets, like mainframe computers and telecommunications gear, continue to expand and completely new markets sprout as did calculators and microcomputers during the 1970s.

Confident. Richard Petritz, who heads Inmos, the new semiconductor firm, sees chip makers secure as markets expand.

But the bullish forecast for electronics business during the 1980s does not necessarily portend easy days for semiconductor suppliers, whose chips make all these marvelous possibilities possible. For semiconductor technology, with the advent of very large-scale integration (VLSI), has reached a watershed—a perilous one for the people who run semiconductor houses. Those who cannot divine the right stream to follow simply risk seeing their business dry up.

Two opinions. The trouble is, no one knows for sure where the mainstream will flow, and so there is considerable argument over the best way to find it. For C. Lester Hogan, who has just announced his retirement as vice chairman of Fairchild Camera and Instrument Corp., the only way for a large semiconductor company to cross the divide successfully is to integrate vertically and become a systems house as well. Richard Petritz, not surprisingly, holds a different view. As managing director of Inmos Ltd., the new semiconductor firm backed by $100 million from the British government, he is convinced that the big market expansion in sight will leave plenty of room for merchant semiconductor houses.

Both Hogan and Petritz spelled out their reasoning in London last month at the "Tomorrow in World Electronics" conference held by Britain's daily business newspaper, the Financial Times. Both agreed that a new era is at hand as VLSI brings the promise—or the threat—of chips bearing a million components. But Hogan asks, "How many customers are there in the world who will buy thousands upon thousands of such large and complex pieces of electronic equipment?"

Not many, Hogan believes. And Gordon Moore, chairman of Intel Corp., agrees. He told the International Solid State Circuits Conference at Philadelphia in mid-February that if million-transistor technology were available today, he really wouldn't know what to do with it.

For Hogan, this means the end of

Changes. C. Lester Hogan, about to retire as vice chairman of Fairchild, says large semiconductor makers must turn to systems.

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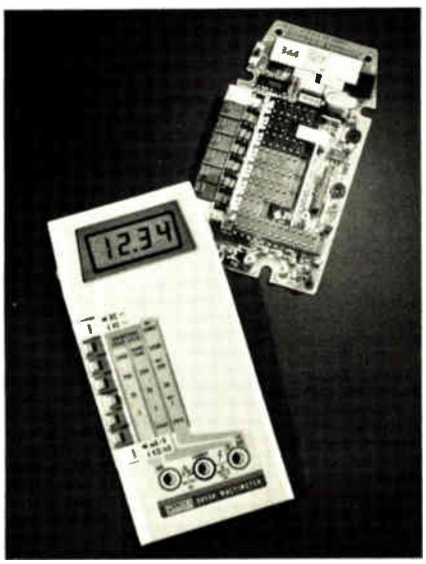

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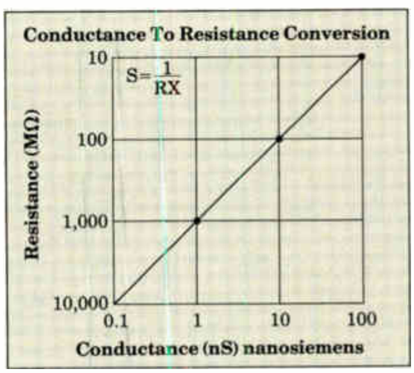

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the time when electronics markets were driven mainly by advances in technology. In the integrated-circuit era, chip densities doubled every year, going from about 30 components on a chip in 1965 to approximately 30,000 in 1975. All along, semiconductor suppliers turned out what was technically feasible and found thousands of equipment makers who wanted to buy it.

But this state of affairs, which semiconductor houses found fairly comfortable, cannot continue. With the 64-K random-access memory, the count has reached about 135,000. Although the curve shows signs of flattening—to a doubling every two years—Hogan maintains that within five years the largest possible chips will be overkill for any reasonable system requirement.

"We can then no longer just build the most complex chip we can dream up," he says. "Precious few customers will find such a chip economical to use."

The changed market, Hogan insists, will go to the companies that take a complete systems approach. In a few rare cases the total system cost might be best with million-transistor chips, but most often the cost-effective volume-selling chips will have much lower component counts—100,000 or even 10,000.

The trend has already started. For example, Hogan puts the world market for 4-bit microprocessors this year at $15 million and projects a spurt to $207 million by 1982. "The 4-bit microprocessor has far outsold its much ballyhooed big brothers, and if we look to 1982, we expect the gap to get larger, not smaller," he comments.

The exception. The one main segment Hogan expects will carry on as before, with bigger and bigger chips driving system costs down and thus winning thousands of customers, is memories. And this exception, for Inmos's Petritz, proves a different rule. He maintains the chip of the future will be a big one, with "lots of memory controlled by on-chip logic." The new families of standard circuits that semiconductor houses will market, he agrees, will be sold by system costs rather than by sheer technology.

Hogan concluded his talk at the Financial Times's conference like this: "Personally, I believe that 10 years from today there will be no large pure semiconductor companies surviving. The same is true for large systems and equipment companies. Since the advent of the integrated circuit, systems companies have resented the loss of design flexibility, which they have surrendered to the semiconductor industry in the name of economy. Now, also in the name of economy, the two functions must again merge."

For the moment, Petritz has no mergers in mind. Except that it takes a lot more money now, he thinks the conditions for entrepreneurs in the semiconductor business are as good now as they were in the days when companies like Intel Corp. and Mostek Corp. started up (Petritz, remember, was one of the founders of Mostek). With the $100 million Inmos has from the UK government, Petritz has the wherewithal for a strong start. And Inmos will be getting into the business, he points out, when VLSI is forcing a shift to 2-micrometer technology. So newcomer Inmos will be working down the same learning curve as the established producers, which today mostly have 3- to 5-μm technology.

What is more, Petritz sees a big chance for innovation in the more powerful VLSI microprocessors and memories that are in the offing. And he is sure that fully integrated systems houses will not be the only ones able to tap the strong growth ahead for electronics markets new and old. IBM, the stellar integrated heavyweight in the computer business, he notes, recently placed whopping orders with Intel for memories and with Texas Instruments Inc. for logic circuits.

Above all, Petritz insists that success in the semiconductor business has always been highly dependent upon a few skilled circuit designers and process people. In the new semiconductor game that will be played over the next decade, a lot of players inevitably will wind up on the sidelines; but Petritz thinks that at Inmos he has put together a winning team.. □

Electronics abroad

East, West meet at German TV maker

A year after Yugoslav company's takeover of financially troubled West German manufacturer, recovery plan is working

by John Gosch, Frankfurt bureau manager

Some people still can't get over it: a company in Socialist Yugoslavia coming to the rescue of a financially troubled electronics firm in capitalist West Germany. It all happened last summer when, for about $12.5 million, Yugoslavia's Gorenje concern bought control of a family-owned German television and hi-fi equipment firm, Körting Radio Werke GmbH, in Grassau, Bavaria, and set up Gorenje Körting Electronic GmbH & Co.

As expected, there were skeptics predicting that Gorenje would not get Körting back on its feet. But now that early results are in, the doubters have quieted down. "Not only have we reached our initial goals, we have passed them," says Yugoslavia-born Oskar Pistor, Körting's president since last Sept. 1, when the Gorenje/Körting deal took effect.

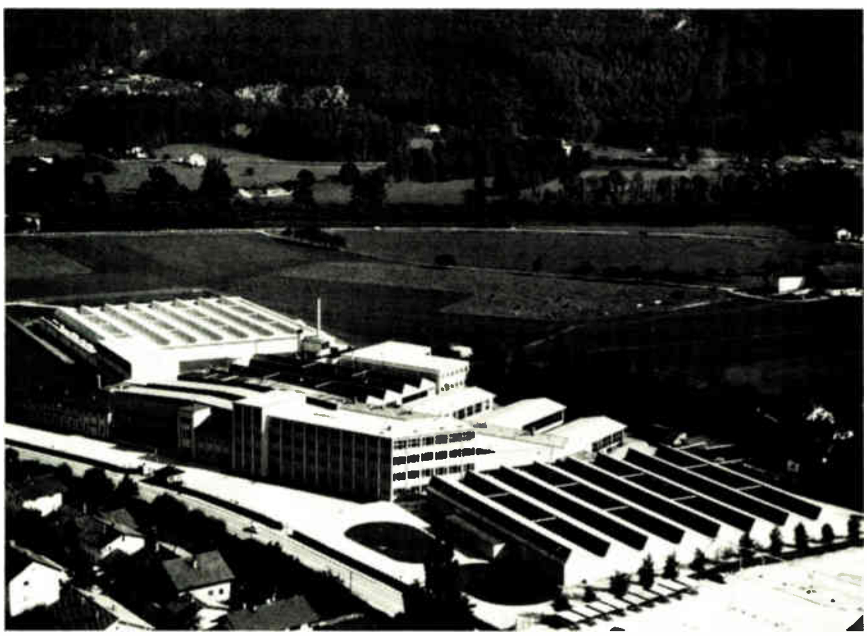
Pistor points to several accomplishments. His plans, he says, called for raising the number of employees by mid-1979 back to 1,200, the number Körting had before the change in ownership. But several months before the target date, the company already had a work force of 1,300. As for sales, "the $120 million level we have envisioned for this year will be reached," Pistor asserts. For 1980, he predicts, sales will increase to about $135 million, a jump of better than 12%. Such confidence is particularly remarkable as West Germany's entertainment electronics industry is now in the doldrums, with most companies expecting only minimal gains.

Körting's 1979 sales target translates into 170,000 color TV receivers and 35,000 high-fidelity systems plus some equipment for speech and language laboratories in schools. Since last September the company has invested about $2.2 million in research and development, and test and production facilities. More money will be earmarked for those purposes for 1980, Pistor declares.

A difference. To reach its sales targets, Körting has adopted a marketing strategy quite different from its former concept. Instead of selling its wares almost exclusively to a mail-order house, the company is now pushing sales to radio and TV dealers, says Bernd Zumkeller, general manager responsible for marketing. At the same time, the firm is emphasizing exports. What's more, "we are finding new market niches and filling them with products representing the latest in TV and hi-fi design," Zumkeller notes.

It was that mail-order business that was mainly responsible for the firm's financial troubles. When the mail-order firm was bought by one of Germany's biggest department store chains—one that had its own entertainment electronics suppliers—Körting found itself without its prime outlet. The firm also was unable to adapt to the changing monetary conditions triggered, for example, by devalued currencies in some foreign markets.

What is the company behind Körting's revival and what are its motives in gaining control of the German firm? The Gorenje concern, with annual sales exceeding $800 million, rates among Yugoslavia's top 20 industrial organizations. Known as a maker of household



Meeting place. Located at the foot of the Bavarian Alps, Gorenje Körting Electronic GmbH expects to make 170,000 color TV sets and 35,000 hi-fis this year.

Chief. President of the Yugoslav-German firm is Oskar Pistor, a native of Yugoslavia. He is optimistic about the future.

appliances, electric machinery, and semifinished goods, Gorenje exports a hefty 30% of its output. The company's most lucrative foreign markets are in Western Europe.

Like virtually all Yugoslav firms, Gorenje is run by a workers' council that makes all decisions pertaining to investments, profit sharing, exports, vacations, and other social and business aspects. In this regard, Yugoslav firms are different from those in other Socialist countries where industrial enterprises are state-run.

Headquartered in the Slovenian town of Velenje, in northwest Yugoslavia, Gorenje developed from a small metal shop in 1953 into an industrial combine now employing some 20,000 people in 13 plants. Pistor, a 21-year Gorenje veteran, is one of the company founders. Before becoming president of Körting, he headed his firm's Munich-based sales operations in West Germany.

If appliances are Gorenje's forte, the company is no weakling in electronics equipment. Its product lineup encompasses color and black-and-white TV receivers, antennas, and various types of components and accessories. Electronic and electrical goods account for about 30% of Gorenje's total sales. Production of color and black-and-white sets last year came to about 100,000 and 70,000 units, respectively. The TV receiver output is mainly for Yugoslavia's own consumption.

Why the buy? There are several reasons for Gorenje buying into Körting, Pistor explains. One is to get around the high import duties imposed both by Yugoslavia and the Common Market. On TV display tubes and other electronic parts that Yugoslav firms buy in the West, the Belgrade government puts a duty of up to 35% of the product's value.

The Common Market, on the other hand, imposes a duty of 15% on TV sets that Yugoslavia exports to member countries. Faced with such high import and export tariffs, a Yugoslav company obviously has a hard time competing with Common Market–based firms. And with the Belgrade government unwilling to subsidize exports, Gorenje's financial involvement in Körting enables it to buy components and sell finished products under the same conditions that apply to other Common Market firms.

Another reason is to have a manufacturing base in West Germany from which to export entertainment electronics gear to other countries in the West. At present, exports account for a spectacular 58% of Körting's color-TV production, general manager Zumkeller points out.

Better access. Still another reason is to have access to Western TV designs and production know-how. To be sure, the two firms have had know-how exchange and parts-supply agreements since the early 1970s. But now, with the German firm under its control, Gorenje can draw directly on the expertise Körting has acquired since it was established more than half a century ago.

Although part of the Gorenje concern, Körting is autonomous in making decisions and setting its sales policies, Pistor points out. The Yugoslavs define the overall goals, however, and expect Körting to be profitable. A self-sufficient company within the Gorenje group, Körting has its own by-laws conforming to the standards of West German business and social legislation. And the Bavarian state government has pledged $2.7 million to help the company—and job rolls—grow. □

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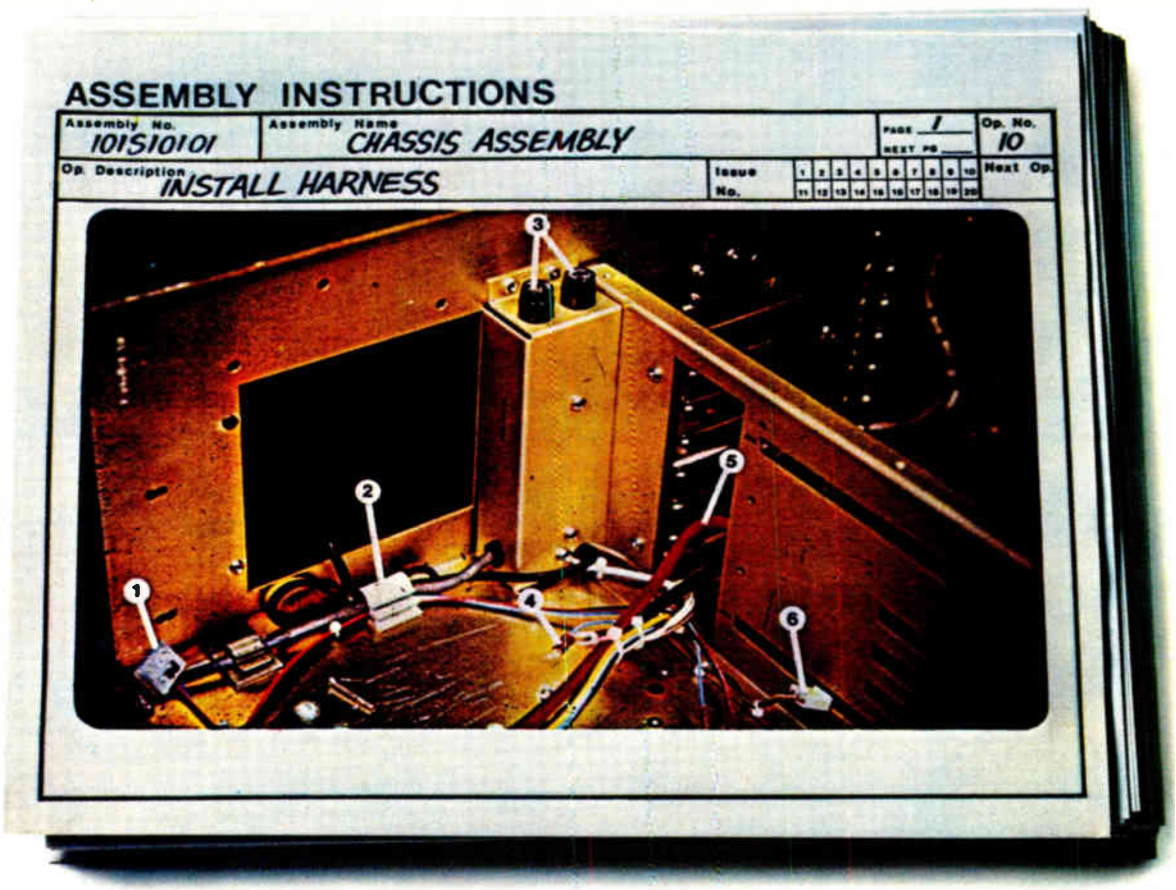

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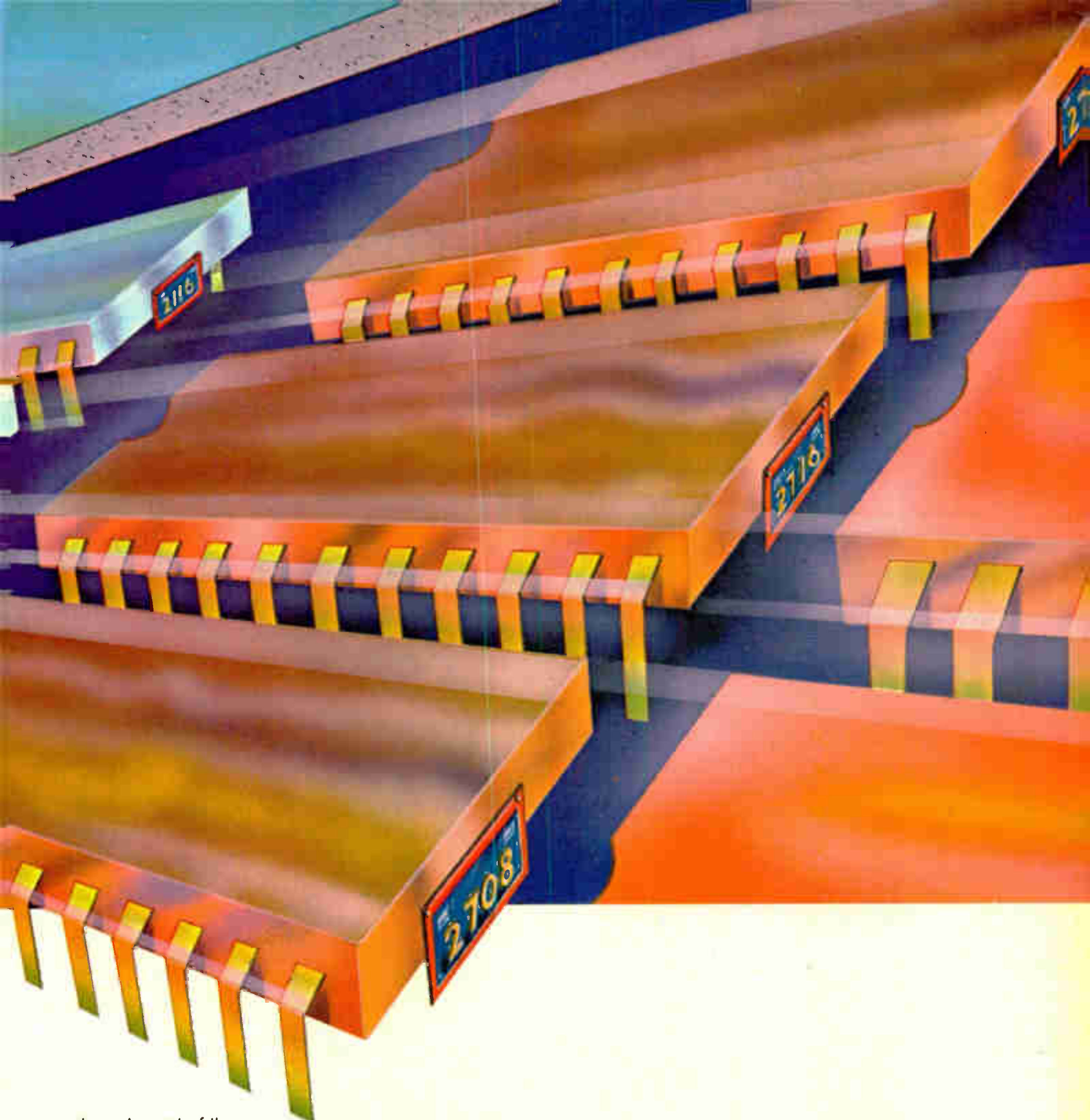
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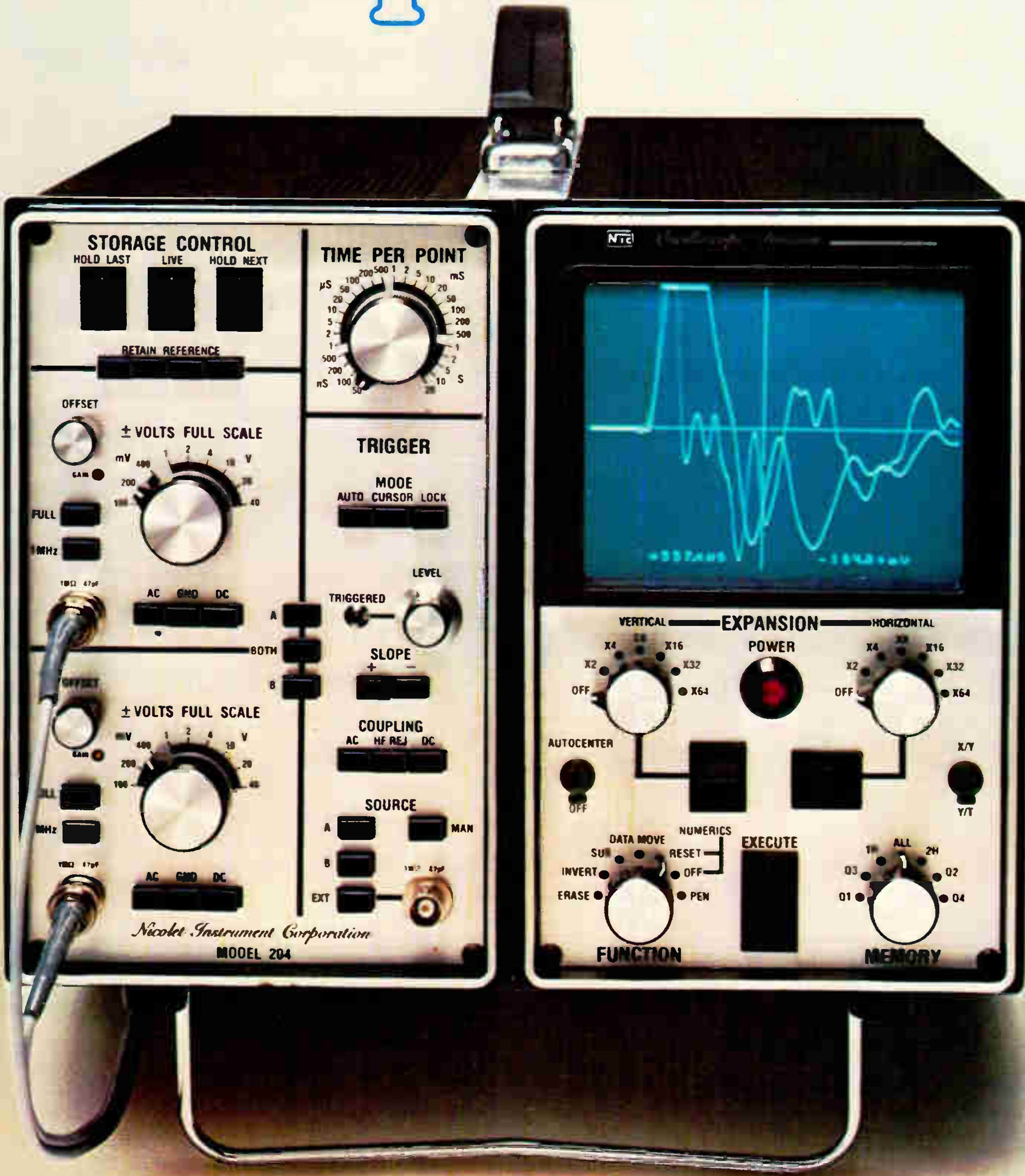

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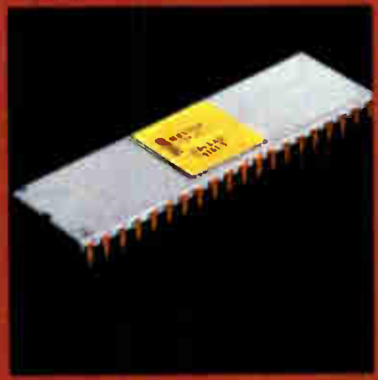

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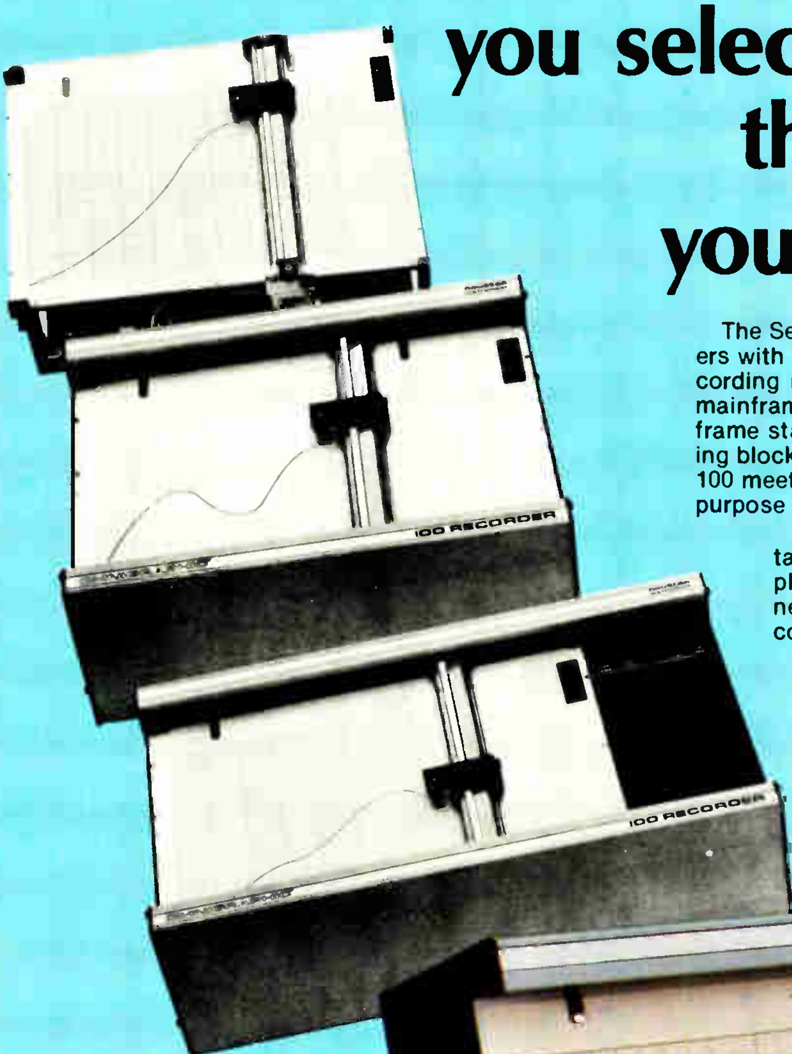

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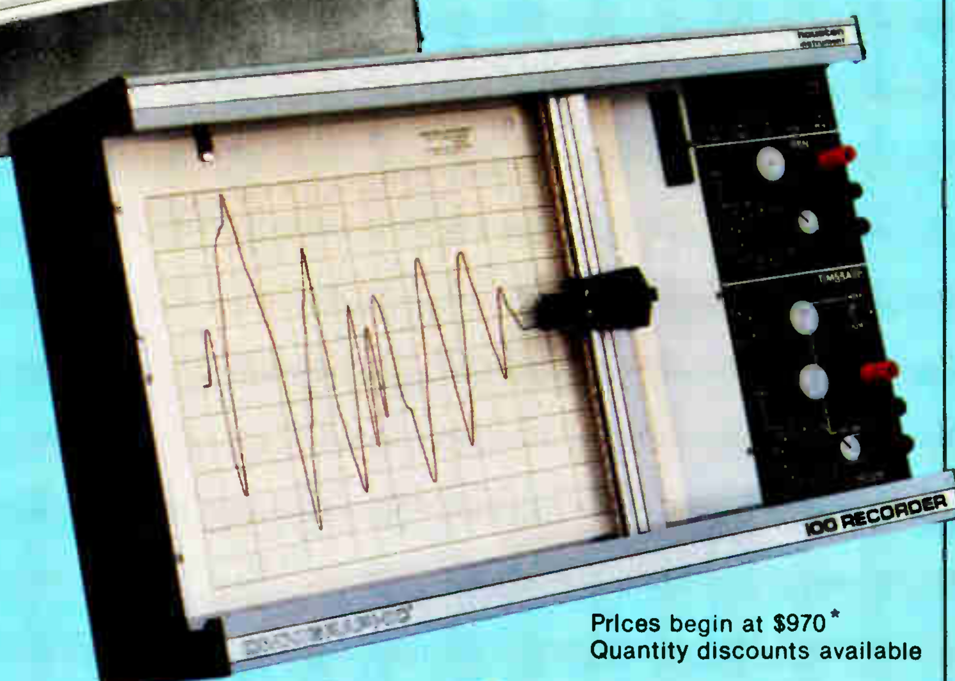

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Lithography chases the incredible shrinking line

With better optical, electron-beam, and X-ray systems on the way, mass production of chips with submicrometer line widths will soon be here

by Jerry Lyman, *Packaging & Production Editor*

□ In laboratories and design centers in Silicon Valley, Japan Inc., and Europe, integrated-circuit designers are busy shrinking line widths and lengths on current LSI designs while creating incredibly finely detailed, dense semiconductor structures for the coming generation of very large-scale integrated circuits. The aim is to produce chips containing over 100,000 gates each—a shrinking of IC patterns that is already bringing increasing switching speeds and reducing chip power consumption. Already a few ICs that need the VLSI definition have appeared—mainly 64-K random-access memories made with metal-oxide-semiconductor technology—and more are in the development stage.

But if VLSI is ever to go into full-scale production, a whole group of major breakthroughs in materials, lithography, processing, and circuit design and testing must occur. This report will concentrate on the lithography aspect of VLSI manufacturing, since VLSI is not possible without the ability to make clean and accurate exposures on resist-covered silicon wafers of circuit patterns with minimum line widths of 2 micrometers or less.

A wide choice

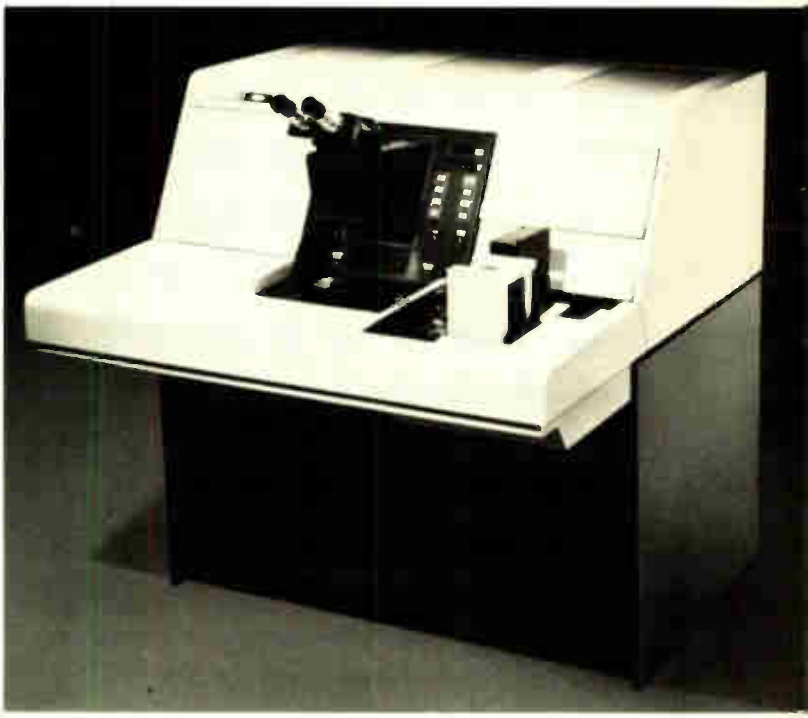
Today the IC processing engineer has a wide range of lithographic methods to choose from. They include contact, proximity, 1:1 projection, step-and-repeat reduction projection, X-ray, and electron-beam systems. Table 1, which purposely omits proximity lithography, summarizes each technique's parameters.

At the present time, contact and proximity printing are still in heavy use, but they will undoubtedly be gradually phased out because of their poor yield. Projection printing, mainly 1:1, is currently the most popular. Scanning electron-beam lithography is at present used mainly to make wafer masks and reticles—in effect, chip masks—for projection printers; in the future it will be used for writing circuit patterns directly onto resist-covered wafers. X-ray lithography has potential as a high-resolution, high-throughput process but still has a number of many practical problems to be ironed out.

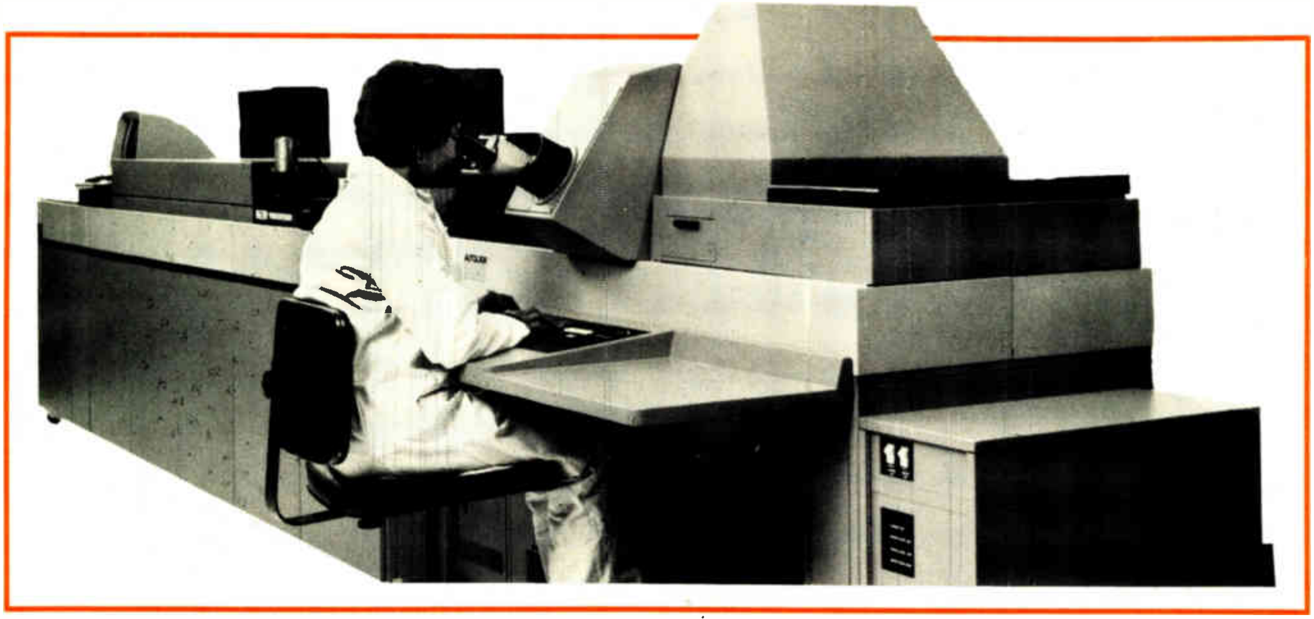
Contact and proximity printing are the oldest types of lithographic systems available. In contact printing, a glass mask bearing an emulsion or chromium-film pattern is first aligned with reference points on a resist-coated wafer, then pressed directly onto the wafer and exposed to ultraviolet light with a wavelength of 3,600 to 4,600 angstroms. In proximity, or soft contact, printing, a gap of several micrometers divides mask from wafer.

The resolution of contact printing is limited only by the wavelength of the light used, so that 1-μm-wide lines can easily be printed with this technique, making it suitable for LSI and VLSI chips. Proximity printing has a slightly poorer resolution that varies with the gap size. However, the defect density of chips made with both these techniques is extremely high due to the mask damage and wafer contamination caused by contact between wafer and mask.

In spite of these deficiencies, contact aligners are still



1. One-on-one. Most production projection lithography is done on Perkin-Elmer Micralign machines capable of resolving 3-μm-wide lines. With a deep-UV source, it is theoretically possible to achieve 1.5-μm resolution with this type of machine.



2. In line. A strong competitor to the Micralign is Cobilt's CA 3000, shown interfaced with an automatic in-line wafer-processing system. The CA 3000 features automatic mask-to-wafer alignment and can accommodate up to 92% of a 5-inch wafer.

in heavy demand, for their good resolution and low price ($50,000 to $100,000) make them suitable for custom LSI or research and development applications. For instance, Computervision Corp.'s Cobilt division in Santa Clara, Calif., has supplied many of its $42,000 CA 2020 contact aligners to companies engaged in magnetic-bubble work. Only one mask is normally required for this type of device, and its 1-μm details are exposed by the CA 2020 with an alignment accuracy of ±0.125 μm. The only other way of achieving this degree of accuracy would be by writing the bubble pattern directly on the chip with a scanning electron-beam machine or direct-step-on wafer projection system.

Canon Inc. in Japan has extended contact printing into the submicrometer range with a new deep-ultraviolet aligner, the PLA 520A. A combined contact and proximity aligner, it uses light in the 2,000-to-2,600-Å range, which has far less of a problem with diffraction effects than longer UV wavelengths. The PLA 520A can expose lines 0.5 μm wide in the contact mode or 2 μm wide in the proximity mode, with a gap of 20 μm between mask and wafer. This year's entire production of the $160,000 machine is already sold out.

So far as LSI and VLSI are concerned, however, contact/proximity lithography can never be a viable production method because of its high defect density—a problem neatly circumvented by projection systems.

Projecting an image

A sharp dividing line runs through the world of optical projection lithography. On one side of it are the well-established 1:1 reflective optical systems having resolutions in the 2- to 3-μm range, alignment accuracies of 0.5 to 1 μm, and throughputs of about 60 wafers per hour. On the other side are the reduction projection systems, or wafer steppers, with 1×, 5×, and 10× lenses. These machines have a better basic resolution (about 1.5 μm) and tighter alignment but lower throughput.

Perkin-Elmer Corp., Norwalk, Conn., delivered its first 1:1 optical projection printer, the Micralign, in 1973. Hundreds of these systems are now in use at almost every major IC manufacturer because they have much higher yields than contact aligners.

The Micralign has a complex reflective lens system that uses a mask to project an image the same size as the mask onto a wafer. Because it does not touch the wafer and therefore cannot damage it, the mask can be made of a hard material like chrome and thus achieve an extremely low defect density, thereby eliminating the chief drawback of the contact aligners. As for other specifications, the Perkin-Elmer machine exposes lines and spaces 2 μm wide with an alignment error of no more than ±1 μm—more than adequate for the 2- to 6-μm features of today's LSI.

A new 1:1 projector

The latest Perkin-Elmer aligner, the model 140 (Fig. 1), can expose 90% of the area of a wafer 100 millimeters, or 4 inches, in diameter. With an automatic wafer feeder, it can process about 60 wafers an hour—about half the throughput of a contact aligner.

Perkin-Elmer's main competition in this field is Cobilt's CA 3000 (Fig. 2), which first appeared in 1978. This system has a 3-μm average resolution and a ±0.5-μm alignment error, and it can expose 100% of a 4-inch wafer and 92% of a 5-inch wafer. Alignment of wafer with mask may be manual or automatic, and if automatic, will allow a throughput of up to 100 wafers per hour, says Ed Segal, Cobilt's marketing vice president.

Both the CA 3000 and the model 140 have a resolution of basically 3 μm. Perkin-Elmer's next goal is 2-μm resolution with an alignment error of ±0.25-μm, and a machine with these specifications will probably appear before the end of this year.

A deep-UV option—say a 2,400- to 3,000-Å source—could reduce the average resolution of this machine to 1.33 μm. However, before this UV dream machine is constructed, some major problems remain to be solved.

TABLE 1: SCANNING THE LITHOGRAPHY FIELD

Method	Resolution (μm)	Alignment (μm)	Typical throughput (wafers/hr)	Approximate price
Scanning, 1:1 optical projection	2 (low volume) 2.5–3 (production)	± 1	60	$150,000–200,000
Scanning, 1:1 optical projection, deep ultraviolet	1–1.5 (not commercially available)	± 0.25	60	"about" $300,000
Direct-step-on-wafer, optical	1–2	± 0.25–0.5	10–60	$450,000–500,000
X-ray, contact/proximity	0.5–2	± 0.1–0.25	10–60	$150,000–200,000
Scanning electron beam, direct-write-on-wafer	0.2–1	± 0.05–0.1	1–2* (commercial machines) up to 22–30* (in-house types)	$1,000,000–2,000,000

*A function of resist, line width, wafer size, machine, etc.

Source: General Instrument Corp.

The lenses for deep UV will need new coatings and better optical tolerances. Available photoresists are not sensitive enough at these short wavelengths and require excessive exposure times. A light source has yet to be optimized for producing light at 2,400 Å. Finally, deep UV requires masks made not of glass but of fused silica, which is both fragile and expensive. These problems have deterred Cobilt from working on a deep-UV option for its projection aligner, though the company is developing a contact aligner with a deep-UV source.

The DSW alternative

For all their popularity, the 1:1 projection machines do have a serious limitation: if a wafer is distorted in processing, it will throw layer-to-layer registration of successive masks on the wafer out of specification, reducing the IC yield. In an effort to reduce this danger, a whole new class of projection aligners has sprung up in the world-wide centers of IC activity. They deal in smaller areas, aligning chip with mask, and aim at better than 3-μm resolution. Variously called reduction projection or direct-step-on-wafer (DSW) machines or wafer steppers, they all operate on the principle shown in Fig. 3—reduction of the size of the mask patterns.

A UV source is shone through the blown-up portion of an IC wafer pattern, commonly known as a reticle. The reticle's pattern is projected down through a reduction lens onto the surface of a resist-covered wafer. (The resist is a standard positive or negative UV type.) After exposure, the table is mechanically stepped to a new site for another exposure. This procedure is repeated until the reticle image is projected across the entire wafer surface. A high-resolution example of what is being done with a wafer stepper is shown in Fig. 4. This, of course, is the same step-and-repeat method that has been used in optical mask making for years.

The wafer stepper's main competition is the 1:1 projection machine, so a comparison of the two types is in order. The stepper boasts better resolution (1.5 μm versus 3 μm) and greater registration accuracy (it makes many alignment checks per wafer, not just one). It can handle much larger wafers, and reticles are much simpler to make than a 1:1 mask. The straight projection aligner, on the other hand, costs much less ($150,000 versus $500,000), has an inherently higher throughput (it makes one exposure instead of many), and is smaller.

Proponents of wafer stepping dispute the merits of high throughput. To quote Bill Tobey, marketing director of GCA/Burlington, Mass., division of GCA Corp.: "What is important is not wafer throughput per hour but good dice per month." Unfortunately, it is too soon to compare the two rivals on this score, although wafer stepper people expect a higher yield due to their system's potentially better layer-to-layer registration.

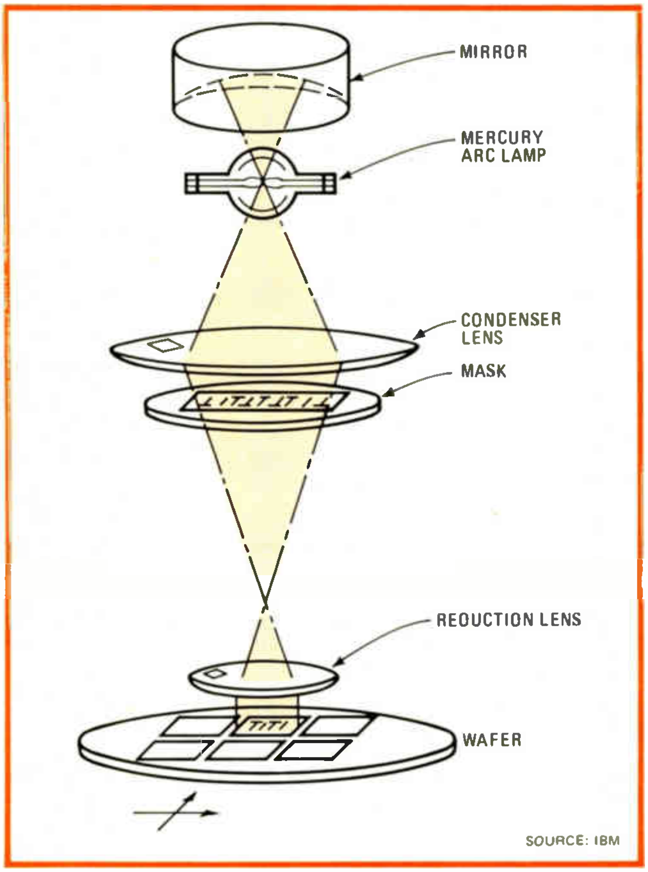
But no one disputes that the 1:1 systems are smaller. Most of the new reduction projection machines are quite large and a few approach an electron-beam lithography system in size and complexity. In any case, the potential advantages and sizable market for wafer steppers has brought forth many entries into this field.

The high steppers

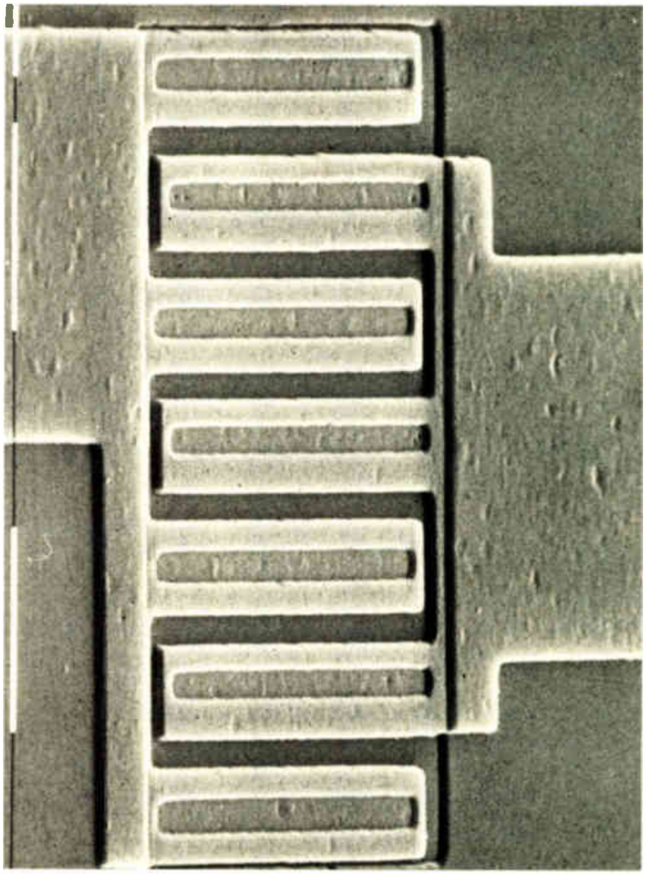
A great many firms are convinced that the wafer stepper is the way to go for low micrometer resolution. In the U. S., GCA Corp. dominates with its 10× stepper, and Electromask and Optimetrix have entered similar $500,000 machines. All three offer minimum line widths of 1.5 μm and alignment accuracies of ±0.25 μm. Optimetrix and Ultratech also have 1× steppers with slightly higher resolution but lower prices. GCA Corp.'s Burlington, Mass., division already has orders for at least 50 of its $454,000 Mann 4800 DSW machines. At least 13 have been delivered. Prototype devices such as a bubble-memory with 1-μm details have already been exposed on a GCA stepper.

GCA's stepper has a 10× reduction lens (an optional 5× lens is also available) that can resolve usable line widths to 1.25 μm. Throughputs of 30 to 60 wafers per hour are possible with the 10× lens, and wafer sizes up to 5 inches in diameter can be accommodated.

The present system provides for one-time alignment of a wafer on the stage referenced to the system's optical axes. Mask-to-wafer alignment is through a television monitor with a push-button and joystick control. X-Y motion of the state is governed by a laser interferometer that controls the drive servos, the arrangement used in



3. Stepdown. The step-and-repeat reduction projection system, shown in a simplified form, can expose 1-μm geometries. A reduced image of a 10×-2× mask is stepped across a resist-covered wafer. With this method it is possible to align at each exposure.



4. Chip shrink. This four-layer bipolar high-frequency transistor with 1-μm details is an example of the lithography possible with a direct-step-on-the-wafer projection. The transistor's wafer was exposed on a Philips Silicon Repeater SIRE-3, a system with 5× optics.

most scanning electron-beam lithography units. Alignment is accurate to within ±0.25 μm for 2 sigma values.

This off-axis alignment, shown in Fig. 5, contrasts with the through-the-lens alignment of other wafer steppers. In the future, GCA will have an automatic aligner option based on its off-the-axis technique. However, it is also evaluating the through-the-lens alignment method.

In the U. S., GCA's main competitors are three California companies—Electromask Inc. of Woodland Hills, Optimetrix Corp. of Mountain View, and Ultratech Corp. of Santa Clara. Electromask is the strongest, having already received orders for several of its $450,000 systems. It expects to ship its first 700 SLR system this month. The Electromask wafer stepper has a 10× lens system and a wafer stage controlled by a laser interferometer. Resolution is 1 to 1.25 μm depending on field size. Throughput is 20 to 45 3-inch wafers per hour, and 4- and 5-inch wafers can be handled.

The 700 SLR achieves alignment accuracy to ±0.25 μm with a through-the-lens manual alignment method, which aligns the reticle directly with the wafer. In contrast the off-axis method aligns the reticle with fixed targets in the top block of a closed-circuit TV camera, and the wafer with a separate set of targets and optics at the lower end of the camera (Fig. 5).

Frank Chase, Electromask's vice president of marketing, points out that by aligning through the lens there is only one uncontrollable variable—the lens distortion—whereas in the off-axis system there are many variables, such as the lens orthogonality and lens reduction ratio. This is why Electromask can claim a machine-to-machine compatibility of 1 μm. In addition, through-the-lens alignment permits every chip to be aligned if necessary to compensate for wafer distortion.

In the future, according to Chase, Electromask will add an automatic alignment capability to its stepper. Another possibility is a redesign of the lens and source to be suitable for a 3,650-Å UV line. This could push the 700 SLR to 0.5-μm resolution.

A 10× model

Optimetrix, which is a Cutler-Hammer affiliate, also has a 10× stepper capable of 1-μm resolution with an automatically aligned through-the-lens system. Alignment and layer-to-layer overlap are specified at less than ±0.2 μm. Throughput is 30 to 60 4-inch wafers per hour and a laser interferometer controls an air-bearing wafer stage. The first of the $400,000 to $500,000 machines will be delivered in the spring. Aside from excellent optical specifications, the new machine measures only 46 by 38 by 70 inches, which is much smaller than either the GCA or Electromask machines. Also, it supposedly can work out on the production floor and not just in a temperature-controlled environment.

A second machine in development at this firm is a 1:1 stepper having a resolution of 1.5 μm on a 38-millimeter-square field. Alignment accuracy is to ±1.5 μm and throughput is 60 to 100 wafers per hour. Delivery on this $300,000 to $400,000 unit is in the summer. A 7× system with a larger field but the same accuracy as the 10× system is slated for the end of the year.

Last of GCA's U. S. competitors is Ultratech's model 900 projection stepper. It is a relatively low-cost ($185,000), automatically aligned 1:1 stepper.

Martin Lee, vice president of Ultratech, says: "We started out to make a 10:1 stepper but found we needed too much hardware and space to create this type of system with the performance we wanted. Instead we went to a system with simpler optics and less temperature control. A smaller overall unit resulted."

This stepper uses a 3-inch-square 1× mask with four 10-by-10-mm images on it. This allows a user either to choose an image with minimum defect density out of four identical images or conceivably to print four different ICs from four different images. Resolution of the system is 2.5 μm and alignment accuracy is to within 0.25 μm. The automatic alignment system aligns every chip to the reticle. Throughput is about 40 4-inch wafers per hour. Resolution could be extended further, down to 1.5 μm, with a lens design.

The system is controlled by a HP 9825 calculator rather than the minicomputer found in the other U. S. steppers. Size of the aligner is 36 in. deep by 46 in. wide by 60 in. high. Ultratech at present has a feasibility model running and expects to accept orders in mid-1979.

Japanese and European manufacturers are not sitting idly by but have developed optical steppers to compete with their American counterparts. In Japan, Canon has two high-throughput 1:1 steppers, while Nikon has a 10:1 model that competes directly with GCA's 4810 DSW. In the Netherlands, Philips has an improved model of its 5:1 stepper, while Liechtenstein's Censor Inc. is developing a 10:1 stepper due out in 1980. All of these machines resolve features in the 1-to-2-μm range.

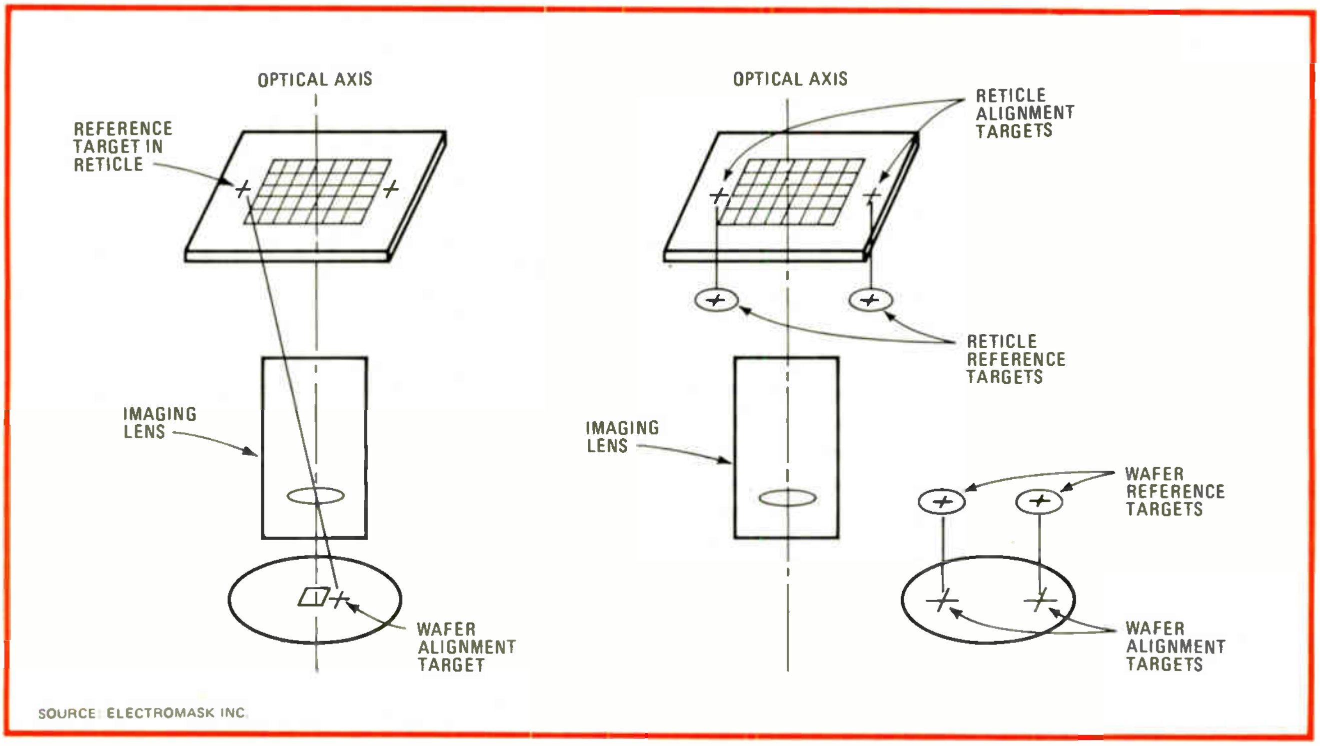
Overseas steppers

The two Japanese companies that have developed optical steppers did so in cooperation with the VLSI Cooperative Laboratory [*Electronics*, June 9, 1977, p. 104]. Both machines can operate in the ultraviolet only at 4,360 and 4,050 Å because their makers believe that it is not feasible to design well-corrected lenses for operation at deeper UV wavelengths. Canon Inc. has started to sell its unit, the EP211A, but Nippon Kogaku Ltd. (Nikon) is not in production yet.

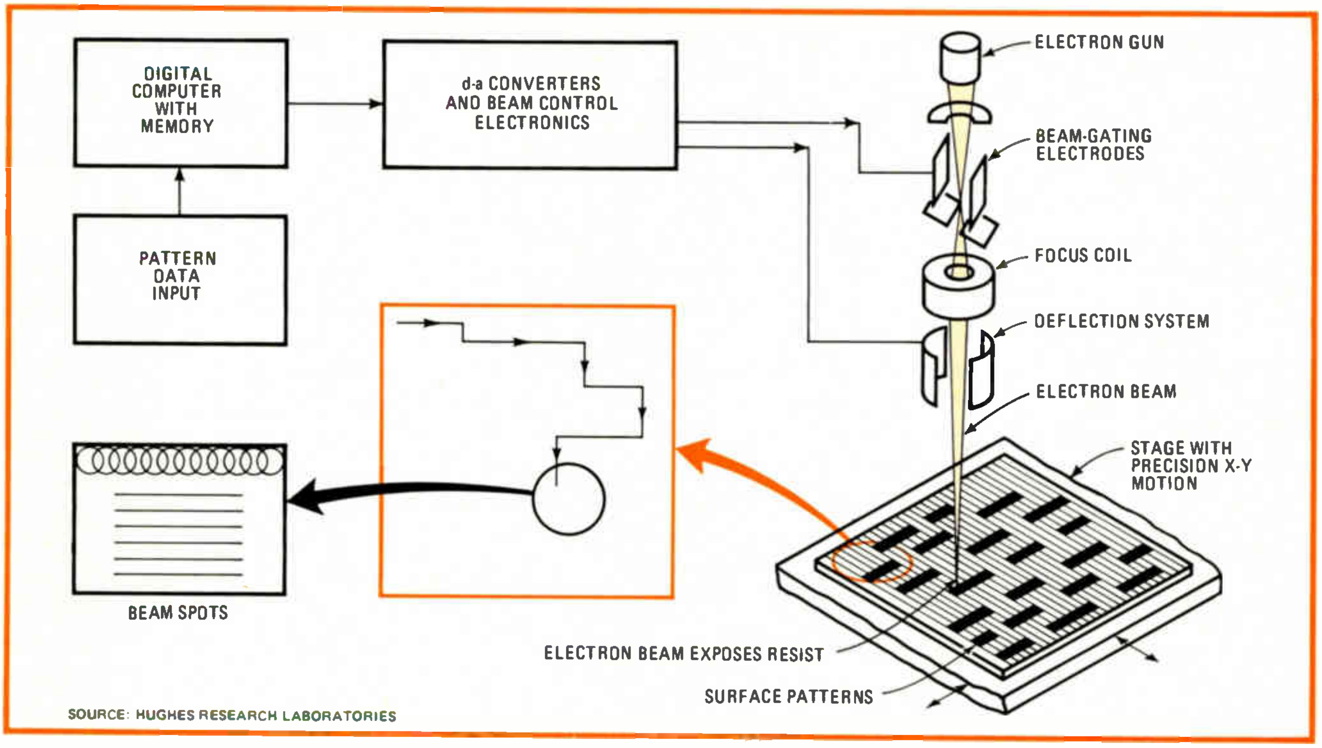
The Canon aligner has unity ratio optics and projects a 30-mm-square image. It can expose a 4-inch wafer in seven shots. Minimum line width is 2 μm, alignment error is ±0.3 μm. Alignment is done on each step, exposure control is automatic, and a throughput of 46 4-inch wafers per hour is claimed.

Canon has also announced the FPA 112A. This model exposes a 22-mm-square image on each shot. Resolution of the narrow field lens is higher, permitting exposure of 1.5-μm lines. Other stepper characteristics are the same. Either unit costs 50 million yen, or about $250,000.

The Nikon aligner features 10:1 reduction optics for a resolution of 1 μm. It also can handle 4-in. wafers. Automatic focusing at each step maintains resolution despite wafer distortion. Image size is 10 mm square. The system is designed for either automatic alignment at the initial position or automatic alignment at each step;



5. Alignment alternatives. Wafer steppers align wafer and reticle in one of two ways. Either the reticle is aligned with the wafer by eye directly through the lens (left) or alignment is referenced to off-axis targets. Most new steppers favor the first, easy-to-automate method.



6. Scanning by electron beam. In the scanning electron-beam system, a high-resolution pattern is written directly onto the surface of a resist-covered wafer by a computer-controlled electron beam. This technique eliminates the delay and defects of optical masks.

either way, the time per step is less than 10 seconds.

Philips' unit is called SIRE 3—short for third-generation Silicon Repeater. It projects a 5:1 reduced image of a pattern directly onto a wafer, stepping the wafer after each exposure. The machine's automatic wafer-reticle alignment system ensures an overlap precision of ±0.25 μm. Minimum resolution attainable is 1.5 μm. Throughput is at least 50 4-inch-diameter wafers per hour. An unusual feature is the use of a helium-neon laser for the automatic alignment system; another is used for interferometric position sensing of the X and Y slider. Few steppers have a laser for autoalignment.

Delivery of the SIRE 3 is expected by the end of 1980. Estimated price is $500,000 to $600,000.

Censor's SRA-100 is a 10:1 reduction stepper featuring a resolution of 1 μm, autofocus, and autoalignment. Through-the-lens alignment at each step gives a registration accuracy of ±0.2 μm at 2-sigma probability. Throughput is 60 4-inch wafers per hour and unit cost is $450,000. The first SRA-100 will be assembled at Censor's Reno, Nev., facility in time to be demonstrated at Semicon West in 1980.

Going public?

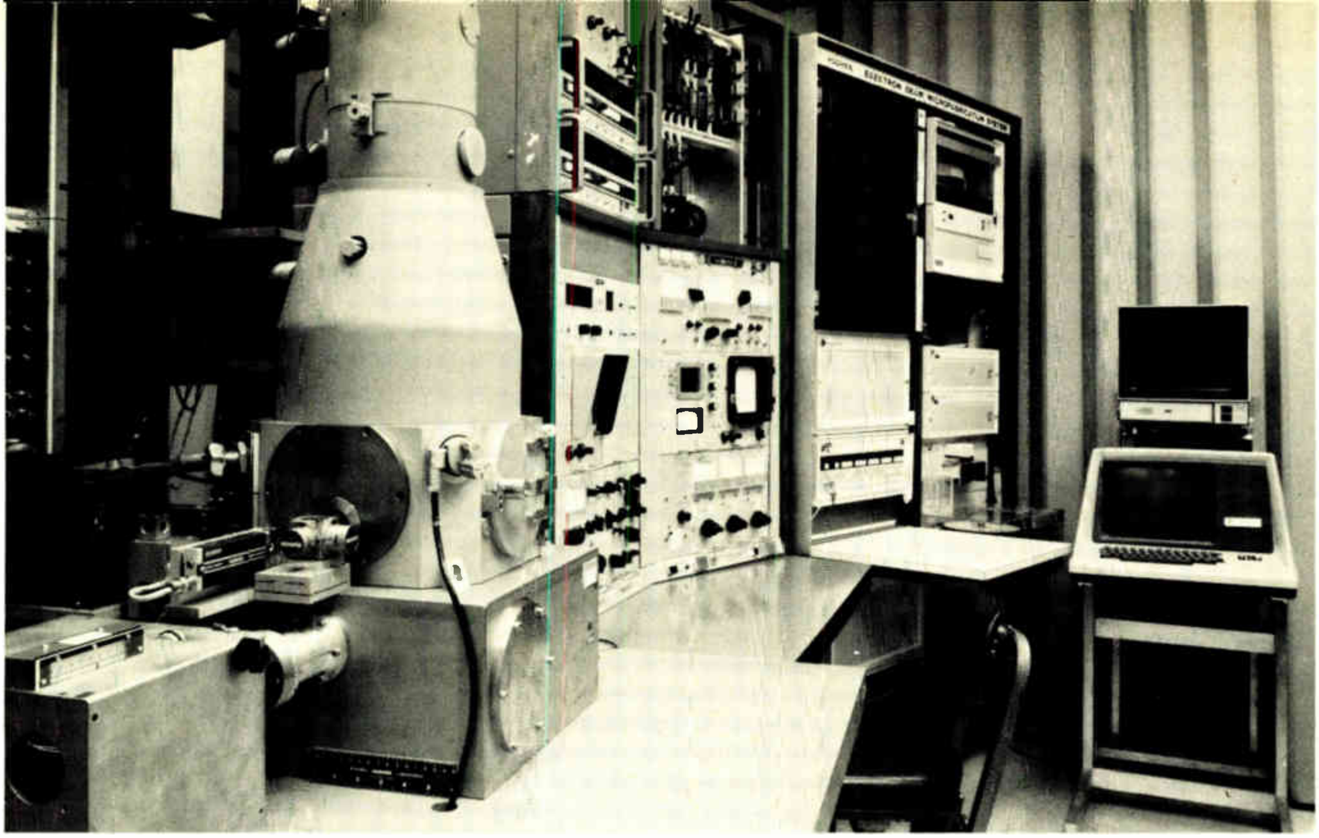
Despite the large array of machines here and abroad, step-and-repeat imaging directly on the wafer is still mostly in the research and development phase at IC fabrication facilities. Often purchase of these systems is veiled in secrecy to mask out company plans.

In the U.S., however, the Motorola Semiconductor Group in Phoenix, Ariz., admits to purchasing a GCA direct-step system. Bill Howard, director of strategic planning for Motorola Semiconductor's IC division, says, "We consider step-and-repeat a strong contender for the mainstay of the early 1980s." But he emphasizes that the promise of direct-step equipment "precludes nothing else" and Motorola has an open mind. Direct-step registration down to 0.25 μm is possible, he says, but he expects other types of equipment to come along to go with direct steppers that will be more economical.

National Semiconductor Corp., Santa Clara, Calif., has been heavily into conventional projection printing with Perkin-Elmer Micralign systems. Now, however, this IC giant is evaluating two GCA steppers. It is also fairly certain that Fairchild Semiconductor, Mountain View, Calif., is evaluating direct stepping. Finally, at IBM Corp.'s Thomas J. Watson Research Center, Yorktown Heights, N.Y., scientists have built an experimental 5:1 direct stepper that has exposed 0.8-to-1.0-μm images on resist-covered wafers.

In Holland, Philips has built five versions of its SIRE 2 for in-house use. In France, the EFCIS (Société pour l'Etude et la Fabrication de Circuits Intégrés Spéciaux) program shared jointly by Thomson-CSF and the Commissariat à l'Energie Atomique (CEA) is banking on direct stepping for ICs with 2-to-3-μm design rules. CEA's research facility in Grenoble is centered around a GCA DSW 4800 machine with a 10× reduction. Next year, the machine will be modified to accept a French-designed 5× lens that should permit 1-μm resolution.

No matter which kind of projection system—1:1 or stepper—comes out on top, all masks and reticles must be made by electron beam. And the same holds for any other high-resolution system that requires a mask. Only when IC design rules move to 1 μm and below is the era of direct writing on the wafer with an electron beam likely to begin. In any case, scanning electron-beam lithography is vital to VLSI.



7. Home-brewed. Hughes Research Laboratories has built five of these vector-scanning electron-beam lithography machines. They are mainly used for writing circuit patterns in the submicrometer range directly on the wafer, for either discrete microwave devices or ICs.

Scanning electron-beam lithography is now a fact of life in major IC facilities worldwide. In this approach a computer-controlled electron beam scans an IC pattern with extremely high resolution and accuracy across a resist-covered silicon wafer or a resist-covered mask substrate (Fig. 6).

Electrons to the fore

Today, a wide range of commercial electron-beam machines exist, all in the $1 million to $2 million range, and more are in the works. Most machines sold are committed to making masks—sometimes around the clock—for use in projection and X-ray lithography, and already several IC firms in the U. S. are ordering their second unit for this purpose. The direct scanning of patterns on wafers, on the other hand, has been mainly confined, at least in the U. S., to firms that have developed their own electron-beam systems. Some of the leaders in this field include IBM, Texas Instruments, Bell Labs, and Hughes Research Labs, Malibu, Calif.

Finally, a different type of electron-beam lithography, one with both great potential and great technical problems, has surfaced at Philips' Redhill facility in England and Electron Beam Microfabrication Corp., San Diego, Calif. (see "The electron-beam projector," p. 112).

The three greatest advantages of the scanning electron-beam system, in ascending order of importance, are its 0.2-to-1-μm resolution, its ability to align a pattern to within 0.05 μm, and its ability to correct for wafer distortion. Its greatest drawback is its throughput, which is invariably low. A complex function of the beam's characteristics, wafer and chip size, feature resolution, and resist, it ranges from 1 to 2 wafers per hour in commercial machines up to as high as 22 in IBM's EL-1 used in a production mode. Vector scanning, in which the beam scans selected areas of the chip, has a higher throughput than raster scanning, in which the beam moves across the entire surface, being switched on and off as the chip pattern requires.

Resolution is another problem. In electron-beam–fabricated structures, it is limited not by the electron optics, but by electron scattering in the resist. This is what sets the bottom limit of resolution to about 0.15 μm.

Finally, the initial cost of a scanning electron-beam machine is extremely high and there is a standing argument in the industry as to whether it can be cut. Undoubtedly, the improved scanners of the future will cost more than today's slower units.

Units for sale

Despite these disadvantages, electron-beam machines are selling at a rapid rate. Most sales in the U. S. have been made by three firms: ETEC Corp., Hayward, Calif., the Extrion division of Varian, Gloucester, Mass., and Cambridge Scientific Instruments Ltd., Melbourn, England, although GCA/Burlington and California's Electron Beam Microfabrication Corp. are developing high-throughput systems of the vector-scanning type to be available early 1980. The two commercial American machines are being used almost exclusively as mask makers. The British unit is a development tool capable of extremely fine submicrometer resolution when writing directly on the wafer, but the company has also sold electron-beam columns and scanning electron microscopes that have ended up or been converted into in-house electron-beam lithography systems.

The ETEC and Extrion machines are uprated licensed versions of Bell Laboratories' EBES [*Electronics*, May 12,

The electron-beam projector

One of the major obstacles preventing the scanning electron-beam-lithography direct-writing system from taking its place on IC fabrication lines is low throughput. A high-throughput alternative is the electron-beam projection system [*Electronics*, Nov. 23, 1978, p. 73], which two companies are in the process of developing. They are the Solid State Electronics division of Philips' Research Laboratories in Redhill, England, and Electron Beam Microfabrication Corp., San Diego, Calif.

This system is analogous to a 1:1 projection system, except that an electron-beam flood lamp replaces the ultraviolet-light source. To use it, a chrome-on-quartz mask is coated with photo-emissive caesium iodide and loaded into a vacuum chamber. Illumination from an intense ultraviolet lamp causes the unmetalized mask areas to emit electrons. These electrons are accelerated onto the wafer by an electric field of high intensity and focused there by a uniform magnetic field with unity magnification.

The method was first proposed by researchers at Westinghouse in the late 1960s. But it was put aside in favor of the scanning system because of problems with the mask and mask-to-wafer alignment and layer-to-layer registration. Now Philips has solved these problems and has a prototype electron image projection in operation at Redhill. Other systems are being constructed. Philips aims to have some pilot products made with its image projectors available within three years.

The wafers processed by the Philips system have special metallic guides on them that emit X rays. These are used by an automatic aligner to align mask to wafer and layer to layer to an accuracy of ±0.1 micrometer. Devices that actually have been fabricated in this way include logic circuits with 2-μm details and bubble memories with 0.6-μm geometries. Minimum resolution of the Philips' electron-beam projector is 0.3 μm. Complete exposure of a wafer take as little as 30 seconds (120 wafers/hr).

Electron Beam Microfabrication is working on a system for the Naval Ocean Systems Center. Its objectives for its system are a throughput of 60 4-in. wafers per hour with 0.5-μm resolution and ±0.2-μm alignment accuracy. Delivery is slated for 1980.

P. J. Daniel of Philips' Research Laboratories is bullish on the chances of the image projector against direct electron-beam writing systems. These, he claims, will retain a specialized niche in the low-volume custom VLSI market, but the larger markets will be served by either X-ray lithography or electron-beam imaging systems, since high-volume production will justify the cost of the specialized masks either technique needs.

1977, p. 95]. This is a raster-scanning unit with a continuously moving table, full wafer alignment, and a laser interferometer to feed the table position back to the electron beam's computer.

ETEC's MEBES is the electron-beam system most heavily sold in the U. S. Twenty-four of the systems have been ordered, about 12 of which have already been shipped to firms like Fairchild, Motorola, National Semiconductor, General Instrument, and RCA.

ETEC's system, aimed specifically at mask making, has a 1-μm resolution and an overlay accuracy with ±0.25 μm. Exposure time for a 4-inch mask is 40 minutes. The present unit can take up to nine 5-inch wafers and developmental work is in progress for even larger wafer sizes. A 10-cassette airlock substrate feeder is now available. System price is $1.6 million.

Wafer confrontation

ETEC also has a program for an advanced system that could write directly on the wafer. Objectives of the program are a throughput of 10 to 20 3- or 4-inch wafers per hour with improvements in line resolution and alignment. The new unit will be built around vector rather than raster scanning [*Electronics*, May 12, 1977, p. 94].

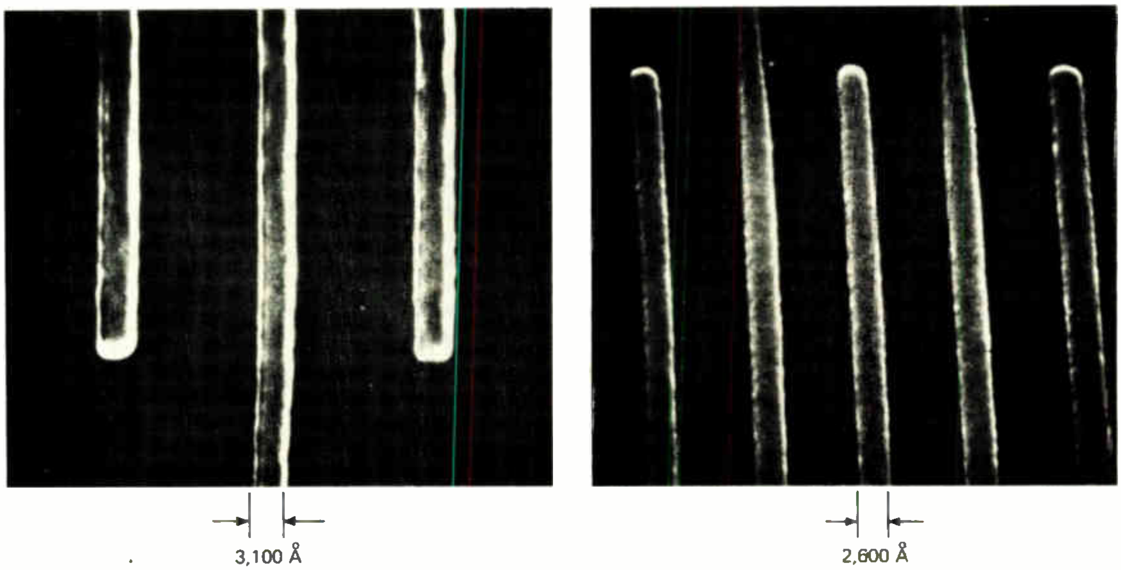
Extrion has recently improved the data rate and software of its version of the Bell EBES. The 20-megahertz data rate of its older EBMG-20 has been uprated to 40 MHz in the newer EeBES-40, enabling it to process a 3-inch wafer in 20 minutes. Otherwise, the two machines are identical. The EeBES-40 still has 1-μm resolution and ±0.125-μm alignment error, and it can accommodate up to a 6-inch wafer. A vacuum loading system for 10 cassettes is standard.

Varian has delivered one of these $1.5 million machines to Ultratech Corp., a maker of masks rather than chips, and recently sold another to Fairchild.

John Dougherty, Extrion's manager of electron-beam lithography, says that making reticles for direct-step-on-wafer machines is becoming just as important as 1:1 mask fabrication. Because of this Extrion has developed special software to go from the optical pattern-generator format to one acceptable to the EeBES-40. For extremely large, dense reticles, the electron beam is faster than optical pattern generation. For instance, a reticle for a large LSI chip that took 1 million flashes to expose at 25,000 flashes per hour would require about 40 hours to produce with an optical pattern generator. The same reticle could be turned out in less than an hour on the new Extrion system. Dougherty also points out that the uprated machine turns out reticles four to five times faster than its earlier version.

Cambridge Scientific Instruments is producing two vector-scanning electron-beam systems, EBMF-1 and -2. The EBMF-1 is a low-cost system having a 75-mm stage and with full computer control and full precision pattern writing. The EBMF-2 is Cambridge's main system with a laser-controlled 105-mm stage and temperature-controlled chamber and airlock; a fully operational system costs about $700,000.

As mentioned before, the EBMF system is a laboratory tool for directly writing high-resolution features onto resist-covered silicon (although it certainly can also be used to make a mask). Minimum line width is about 0.25 μm and alignment accuracy is specified at ±0.15 μm (2-sigma value). The EBMF-2 can handle 4-inch wafers or 5-inch mask plates. Since it is intended for use in research and development, throughput is less important than resolution and layer-to-layer registration.



8. Fine lines. These are samples of submicrometer geometries exposed on a Hughes electron-beam system. The two views show the interdigitated fingers of the pattern of surface acoustic-wave delay lines. Even finer lines have been successfully exposed.

Cambridge Scientific Instruments has been delivering electron-beam systems and components for more than a decade. Its U. S. customers include Xerox, Rockwell International, Hughes Research, Motorola, Cornell University, and General Motors. A European competitor is Philips Gloeilampenfabrieken in the Netherlands, which makes the electron-beam pattern generator EBPG-3 [*Electronics*, Nov. 9, 1978, p. 68].

Versatile

The EBPG-3 is a vector-scanning machine for either making masks or generating patterns directly on the wafer. The typical minimum line width it produces is 0.4 μm. It takes 20 minutes to cover a 3-inch wafer with a pattern using lines less than 2 μm wide and exposing 30% of the chip area to the beam; for a line width of 0.8 μm it takes 65 minutes.

Philips has orders for six machines both from outside customers and from in-house users that make components, such as its Dutch Elcoma division and affiliates outside of Holland like Signetics in California. The $2 million price of the EBPG-3 includes installation, training of personnel, and operational support.

In Japan under the guidance of the VLSI Cooperative Laboratory [*Electronics*, June 9, 1977, p. 104], two commercial electron-beam systems have been developed. One is a raster-scanning system developed at the research and development center of Toshiba Corp. but now being manufactured by an affiliate, Toshiba Machine Co. The Toshiba system was followed by one developed by Jeol Ltd., which vector-scans rectangular areas of variable size.

A prototype of the Toshiba system and the first commercial unit are both in operation at Toshiba. The system is designed for beam diameters of 0.25, 0.5, and 1 μm, with minimum line widths of four times these values to prevent rounding of the corners. The two finer resolutions are designed for direct exposure of masks; the coarsest resolution is designed for making 10× reticles for direct stepping on the wafer. A lanthanum-boride emitter provides density almost an order of magnitude higher than tungsten emitters of other systems.

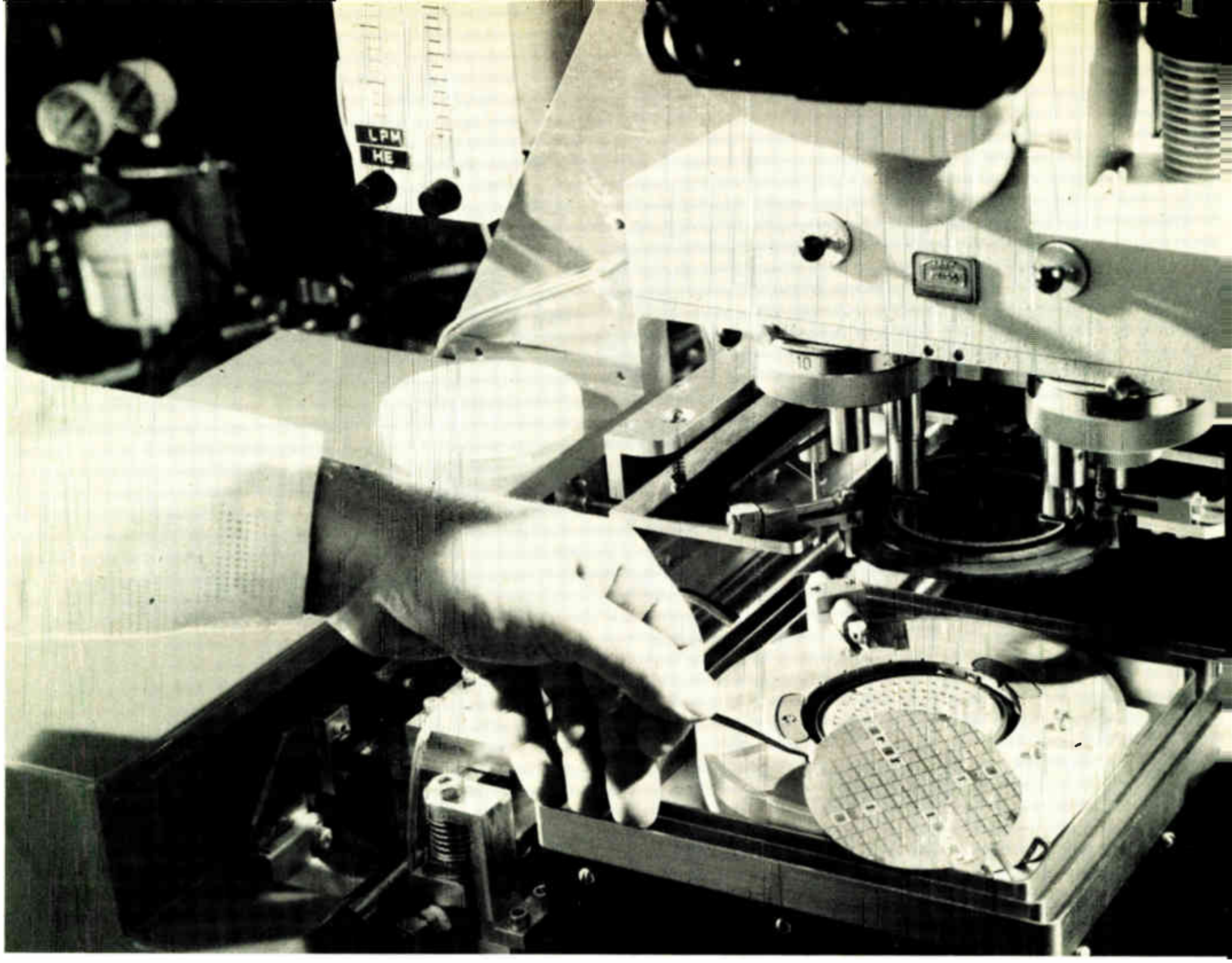
Toshiba engineers claim their system can write patterns easily for several different devices on a mask without loss of time—an especially helpful feature during development. Typical exposure times for a 100-mm-square mask are 208 minutes for a minimum line width of 1 μm, 58 minutes for 2 μm, and for a 100-mm-square reticle, 34 minutes for a 4-μm minimum line width. Price of this system is 400,000 yen.

The Jeol Ltd. variable-rectangle vector-scanning system differs from the Toshiba unit in that the exposure time is proportional to the complexity of the pattern. The sides of the rectangles can vary between 2 and 12.5 μm in increments of 0.1 μm, with a maximum area per shot of 100 μm^2. The normal exposure rate inside the 2-mm-square area within which the beam can be deflected is 50,000 shots per second.

Movement of the stage makes it possible to expose masks up to 5 inches square. Benchmark performance for a 4-inch hard chrome mask with a resist sensitivity of 10^{-6} coulomb per square centimeter and a pattern with about 200,000 rectangles/cm^2 is about 25 minutes.

The system can also be operated to generate lines as fine as 1 μm wide. Three of these units have already been delivered to Japanese customers for a price of 420 million yen each.

The company introduced its earlier vector-scanning



unit, JBX-5A, in 1975 and has sold more than 20 copies of it. The maximum wafer diameter the JBX-5A can handle is 3 inches, and the exposure time for sensitive resist is about 20 hours. The system is capable of submicrometer patterns. Some customers have used the system for direct wafer exposure, in particular for microwave transistors, which are small and expensive.

In-house electron-beam units

Some of the most sophisticated and highest-resolution chips are being exposed on sophisticated machines designed in house at firms like Hughes. IBM, TI, and Bell Labs. In fact, IBM is one of the few companies in the world to write directly on production wafers.

Hughes Aircraft Co.'s Research Laboratories has been writing circuit patterns directly on wafers for about 12 years. It specializes in building high-performance submicrometer devices like gallium-arsenide field-effect transistors and charge-coupled devices. GaAsFETs with 0.5-μm details have been routinely produced, samples of the same circuits with 0.3-μm details have been made, and a program for 0.25-μm devices is under way.

At its Malibu facility Hughes has built five vector-scanning electron-beam systems based on its modification of scanning electron microscopes from Cambridge Scientific Instruments (Fig. 7). These systems can resolve 0.1-μm details, as shown in the views in Fig. 8, and have an alignment accuracy of $\pm$0.01 μm. Exposure time for a 4-inch wafer is about 57 minutes.

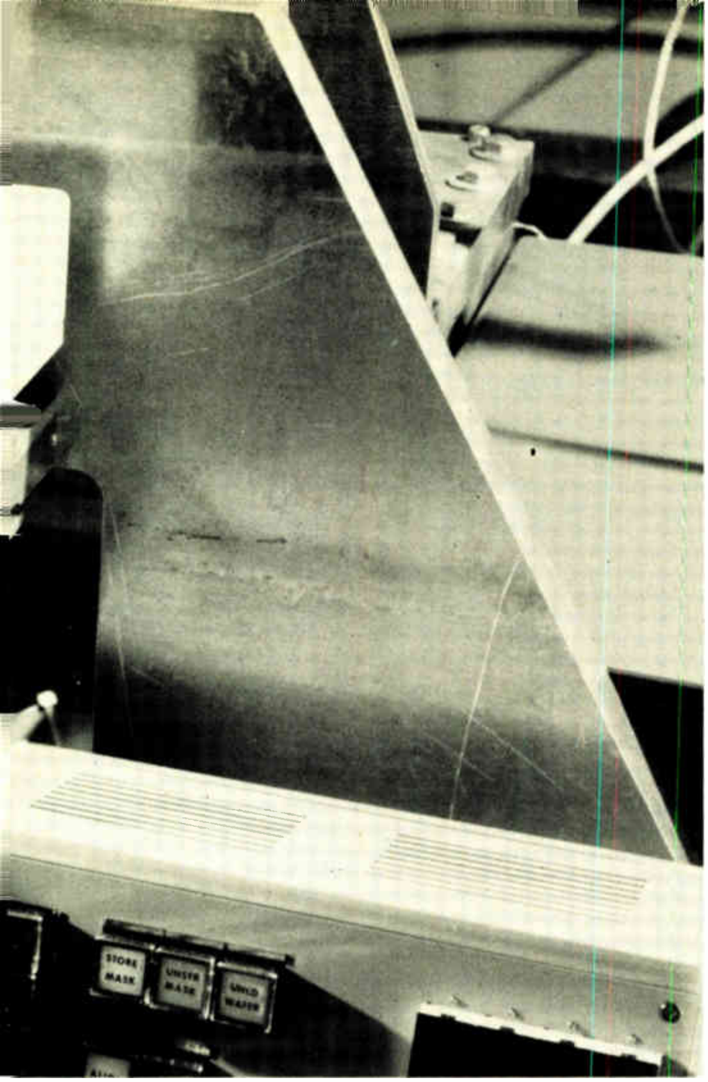
Being an R&D facility, Hughes has been less concerned with throughput than submicrometer ability. But now, with more demands from other Hughes facilities, it is becoming more production-oriented and is considering building or buying a system that could scan four wafers per hour at submicrometer levels.

IBM is one of the pioneers in electron-beam research, and its twofold effort backs both vector and raster scanning. Its Thomas J. Watson Research Center has developed the VSI system, a laser-interferometer–controlled machine that takes about 5 minutes to vector-scan a 3-inch wafer with 2½-μm details. For lines 1 μm wide, overlay accuracy is $\pm$0.1 μm. The system is exclusively an R&D tool and has exposed 0.5-to-0.6-μm line widths routinely, 0.016-μm and 0.025-μm details with the aid of a special technique.

IBM's other track

At IBM's facility in East Fishkill, N.Y., the EL-1 raster-scanning system is producing 22 2¼-inch wafers per hour in a direct writing mode. Minimum line width is 2½ μm. The system is at present being used to expose patterns for customized IC layers on logic chips for IBM's System/38 [*Electronics*, March 15, 1979, p. 108].

Texas Instruments has developed its own series of vector-scanning, laser-interferometer–controlled machines, mainly for production photomask making but



9. X-ray lithography. Bell Laboratories uses this experimental X-ray tool for exposures of 1-μm features on experimental integrated circuits. A palladium target provides 4.3-Å radiation for exposure of an organic, X-ray–sensitive resist through a gold-patterned mask.

also for writing directly on the wafer for evaluation purposes. TI's goal is a machine that can scan 10 4-inch wafers with 2-μm details per hour.

William Holton, manager of research development and engineering for TI's Semiconductor Group in Dallas, predicts that by next year electron-beam systems will be making masks for 1:1 projection systems and reticles for wafer steppers as well as writing on chip directly in a few areas. By 1985 he sees them becoming TI's primary tool, with X-ray lithography a "maybe."

Bell Laboratories in Holmdel, N. J., is the originator of the EBES raster-scanning electron-beam lithography system on which both the ETEC and Extrion commercial systems are based. Bell uses the EBES mainly for mask making, but has set one machine aside to see if its parameters can be extended. At the present time this machine has been converted to vector scanning, and extensive software redesign is also in progress.

X marks the spot

Bell Labs and the other firms that use electron-beam systems all recognize that they are too expensive and too slow. This is why there is renewed interest in X-ray lithography. Such systems promise to combine electron-beam resolution with higher throughput for the price of a projection aligner. As Jerry Molitor, manager of the physical electronics laboratory at Hughes Research Laboratories, says, "Eventually we are going to need a batch replicator like X-ray lithography or possibly electron-beam projection to get the throughputs needed."

The first commercial X-ray lithography machine has been produced in Japan, and a U. S. commercial machine is in the works. Meanwhile home-built machines at Bell, Hughes Research, General Instrument, and elsewhere are successfully turning out 1-μm, multimask ICs with good yield and reliability.

X-ray lithography [*Electronics*, Nov. 9, 1979, p. 99] is simply a form of contact printing in which an X-ray source replaces the UV source. It appears suitable for lines 0.5 to 2 μm wide and, with appropriate power sources, resists, and masks, should be capable of throughputs of 10 to 60 wafers per hour.

Resists designed specifically for X-ray exposure are now becoming available. But the masks, which must be opaque to X rays, have been a special problem; made of gold deposited on a layer of silicon, Mylar, or polyimide only 2 to 10 μm thick, they are very fragile. Fortunately, despite their fragility, they can be aligned easily with wafers by modified commercial optical contact aligners. Other problems with X rays are distortion caused by ripple in a processed wafer and a lack of standardization of mask designs.

Bell's X-ray approach

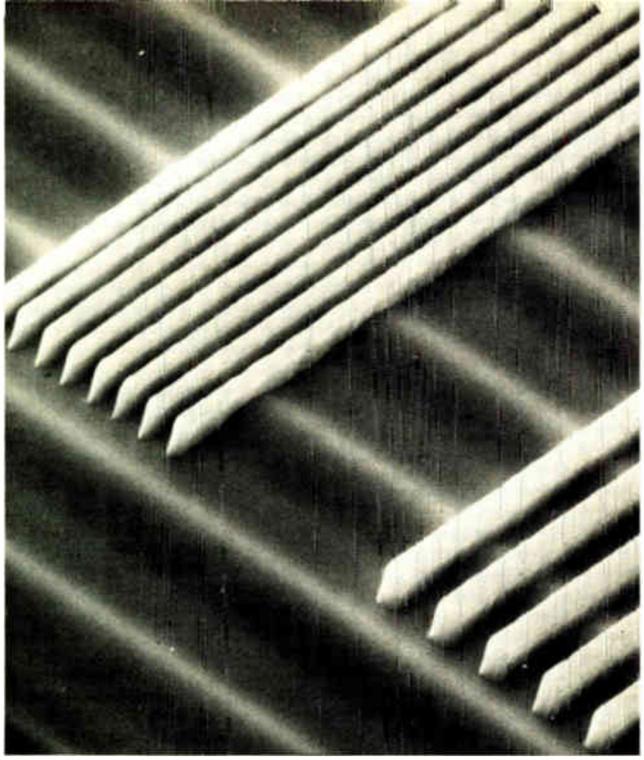
Bell Labs, one of the leaders in X-ray lithography, is now using a second-generation machine (Fig. 9) that has a stationary 4-kilowatt palladium source and uses a gold-plated Kapton mask on a Pyrex support. It can expose a 3-inch wafer in 4 minutes and has achieved registration accuracies of less than 0.5 μm on fast metal-oxide-semiconductor devices with 1-μm details.

Bell opted for a stationary power source to avoid vibration that could blur details in the exposed wafer. Don Herriot, head of lithography systems development in advanced LSI at Bell Labs in Holmdel, N. J., says that line widths so far are limited by the resist, the optical aligner, and the electron-beam–fabricated mask. However, he feels 1-μm devices are possible. Figure 10 shows some samples of present Bell devices.

In an effort to evaluate the reliability of devices exposed to X-ray beams, Bell took similar optically exposed devices and irradiated them with X-ray doses equivalent to those experienced during X-ray lithography. Their performance was not degraded.

Hughes Research has already made 1-μm devices in a similar program in X-ray lithography. The Hughes system employs a rotating 10-kW aluminum source, a Kapton mask, and a Cobilt contact aligner. Hughes can expose a 2-inch wafer coated with copolymer resist in 8 minutes. Tests comparing X-ray and optical lithography complementary-MOS-on-sapphire shift registers produced similar results to those of Bell Labs.

Synchrotron radiation has often been discussed as a source of high-power radiation for X-ray lithography. In France, a half dozen firms are testing this concept on



10. X-ray exposure. Shown above is a resist pattern of 1-μm-wide lines and spaces created by exposing a 2 6-μm-thick resist to X rays on a Bell Laboratories X-ray system. The steps shown are 1 μm high. Note the perpendicularity of the stepped features.

an electron storage ring at the Laboratoire d'Utilization du Rayonnement Electromagnétique at the University of Paris [*Electronics*, March 29, 1979, p. 74].

The firms share 18 hours a week on one of the six light lines out of the storage ring. Experiments being run include the effects of X-ray radiation on mask materials and silicon wafers. So far the damage to these materials is less than was expected.

Commercial rays

The single commercial X-ray aligner available to date was developed jointly by the Electrical Communication Laboratory of the Nippon Telephone and Telegraph Public Corp. and Nippon Kogaku (Nikon). Nikon has a prototype scheduled for completion in April and then will seek orders for delivery for 10 months or so later.

The system uses a rotating water-cooled silicon target with power inputs of 20 kW at voltages of 20 to 25 kilovolts. The system is relatively compact with a distance of only 350 mm between X-ray source and wafer. Mask-to-wafer spacing is 5 to 10 μm ± 1 μm.

The minimum incremental step of the work stage is 20 μm with a resolution of better than 0.1 μm. Pattern position detection is also better than 0.1 μm. Alignment accuracy is within 0.2 μm—more than sufficient for Nikon's stated goal of 1-μm-wide lines.

Several types of masks have been used with this machine. The most promising is a sandwich of silicon dioxide between two layers of silicon nitride on a silicon wafer, because its optical transparency of 80% facilitates optical alignment and the three layers minimize stress that could otherwise warp the thin substrate. Silicon is etched away only in the region corresponding to the actual active chip areas, being left untouched elsewhere for added strength. Thus the mask resembles a multipane window, having a gold pattern formed by electron beam lithography on its planar lower surface.

In-house X-ray systems at General Instrument, Hughes Research, and Bell Labs all use Cobilt contact aligners to align delicate X-ray masks to wafers. In view of this, it is no surprise that Cobilt is developing its own X-ray lithography system complete with source and aligner and due out in about two years.

What users can expect

Most of this report has been about the makers of lithography equipment makers and the electronic giants who generate and use their own in-house lithographic equipment. But the IC industry, especially in the U. S., is composed mostly of firms that go outside for their equipment. In general, at independents like Motorola, RCA, Fairchild, National Semiconductor, and General Instrument, most small- and medium-scale ICs are still being made with contact aligners. Large- and very large-scale ICs (down to 2-μm geometries) are produced on Perkin-Elmer's 1:1 projection systems with masks made on electron-beam machines. Step-and-repeat projection systems at these firms are still being evaluated.

Each of these firms has a scanning electron-beam system committed to full-time mask making, and a few have already ordered a second such unit.

Only General Instrument is actively pursuing an X-ray program. This firm has constructed its own machine [*Electronics*, Nov. 9, 1979, p. 106], as well as masks and aligner, and arrived at a satisfactory resist. It has successfully fabricated MOS LSI chips with 1- to 2-μm line widths.

Most other independents are either not considering X-ray lithography or are wary of it. For instance, Jim Dey, manager of the Image Technology Center of National Semiconductor Corp., Santa Clara. Calif., says: "X-ray potentially is the highest-resolution lithographic process currently under development. But there are many problems to be solved before it can become a production technique. It will probably come into prominence at about the 1-μm level. But it could be as long as 8 to 10 years before it becomes economical to use in high volume." Dey thinks that the gap between 1 μm and 2.5 μm will be filled by wafer-stepping techniques and the use of electron-beam wafer writing to design products and write on selected layers in volume production.

For the 1980s, Bill Howard of Motorola can see getting down to 1-μm size with a million components per die by incremental improvements of present technology. "For now, it's electron-beam below 1 μm," says Howard. "But after 1982–3, all bets are off."

Bob Fink, director of industrial engineering of General Instrument Corp. in Hicksville, N. Y., has an entirely different projection of the future from the last two IC people. By 1980 he sees 1:1 projection lithography sharing VLSI with the wafer stepper. And he sees X-ray lithography taking hold as a production tool in 1982.

That is the foreseeable future, for, of course, everyone could be wrong. There is always the chance that some completely new form of IC lithography—perhaps based on ion beams, step-and-repeat X-ray, or laser scanning—could appear and upset all predictions. □

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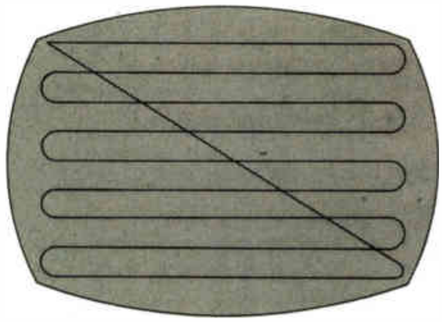

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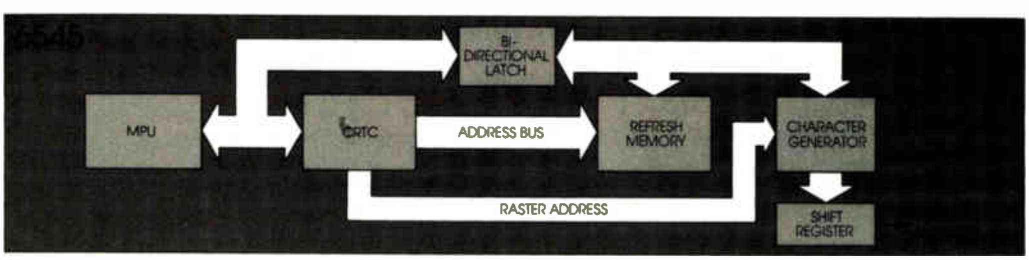

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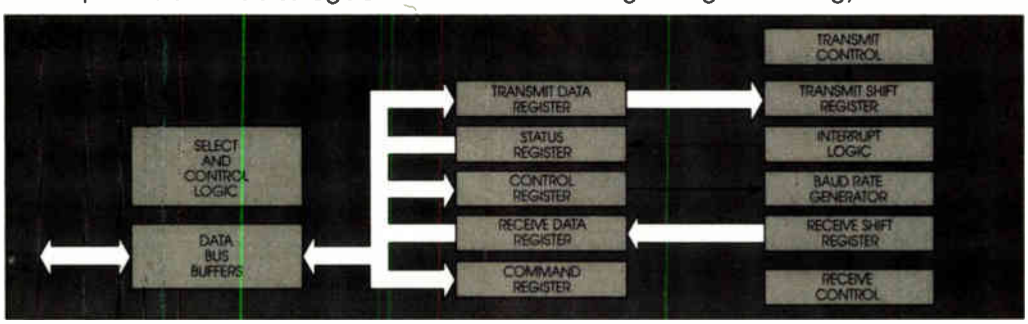

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Analog ICs divide accurately to conquer computation problems

Housed in dual in-line packages, the hybrids can multiply, divide, or take the square root

by Yu Jen Wong, *Burr-Brown Research Corp., Tucson, Ariz.*

☐ Although analog dividers are basic building blocks in a wide variety of applications, until recently they remained bulky, very limited in operating range, and prohibitively expensive. Within the past two years, though, they have profited from the kinds of technological and design advances that have characterized the progress of integrated circuits in other areas.

Now, dedicated analog dividers are available in dual in-line packages, and their low price—typically less than $20—has gone hand in hand with performance that has improved by orders of magnitude. Burr-Brown Research Corp., for instance, makes a hybrid precision divider, the 4291, with a guaranteed maximum error of less than 0.25% over a 100/1 denominator voltage. With optional external trims, the error may be held to 0.10% over a 1,000/1 range.

What is an analog divider?

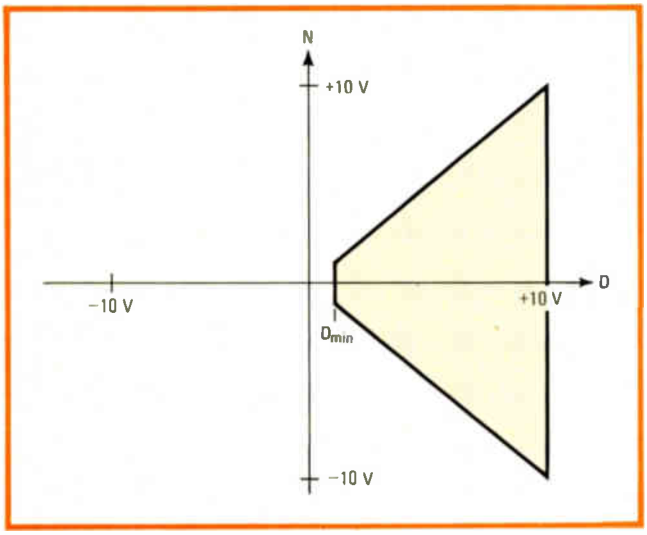
Analog dividers are widely used in such applications as ratiometric measurements, percentage computations, transducer and bridge linearization, automatic level- and gain-control systems, voltage-controlled amplifiers, and analog simulations. They may be thought of as black boxes having two inputs and one output and the transfer function given by the equation:

$$E_o = K(N/D)$$

where:
E_o = output voltage
K = a constant
N = numerator input
D = denominator input

For most commercial packaged dividers, K is internally set at 10. Since the divisor can never pass through zero, D is always unipolar. Because N can be bipolar, the divider will operate in two of the four quadrants, as shown in Fig. 1; it is therefore called a two-quadrant divider. Dividers that are designed for operation with N of one polarity are called one-quadrant dividers. At this point, no commercial four-quadrant divider exists, because it is impractical, though not impossible, to design one that would accept bipolar denominator voltages with a dead zone around zero.

There are two limiting conditions for every divider. First, the absolute value of N must be smaller than that of D to prevent the output from saturating beyond 10 volts. Second, a lower limit, D_{min}, is always specified for the denominator below which the divider will exhibit unacceptably large errors. These two conditions define the operating region of a divider (the shaded area in Fig. 1). For one-quadrant dividers, the operating region is either the top or the bottom half of the operating region of a two-quadrant divider.



1. Operating region. The shaded area represents the operating region of a two-quadrant divider. A one-quadrant divider will perform in either the top or bottom half of the shaded area. Below D_{min}, the denominator exhibits unacceptably large errors.

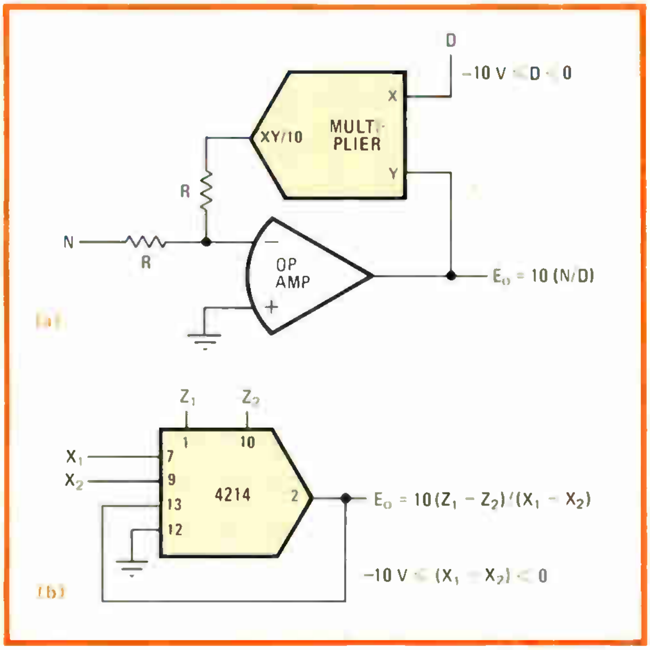
Performing division with multipliers

The oldest and perhaps still the most common method of performing analog division is to connect a multiplier in a feedback loop of an operational amplifier (Fig. 2a). An extra op amp is not needed with commercial packaged multipliers, since their output op amps can be employed through external pin connections.

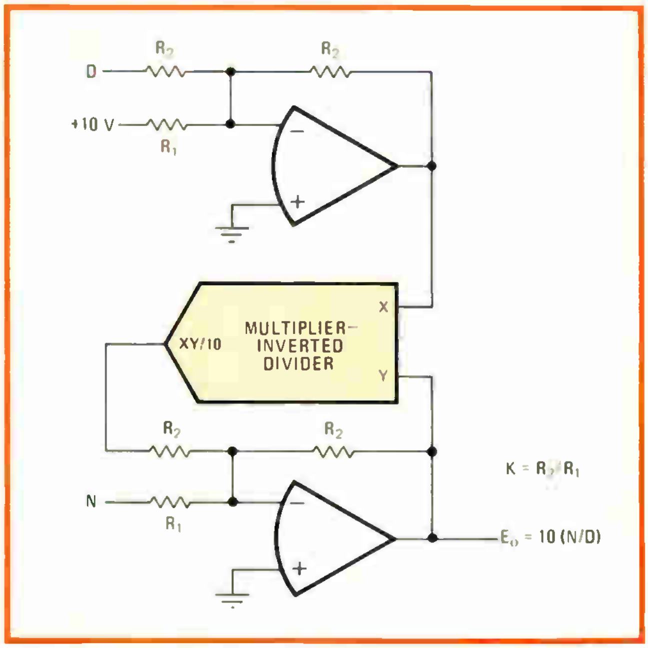
Figure 2b shows a 4214 transconductance multiplier connected as a differential divider. One limitation of the multiplier–inverted divider (MID) is its limited divisor range. The divider error that limits the ranges can be estimated by:

$$\epsilon_d \doteq 10(\epsilon_m/D)$$

where ϵ_m is the multiplier error specified by the manufac-



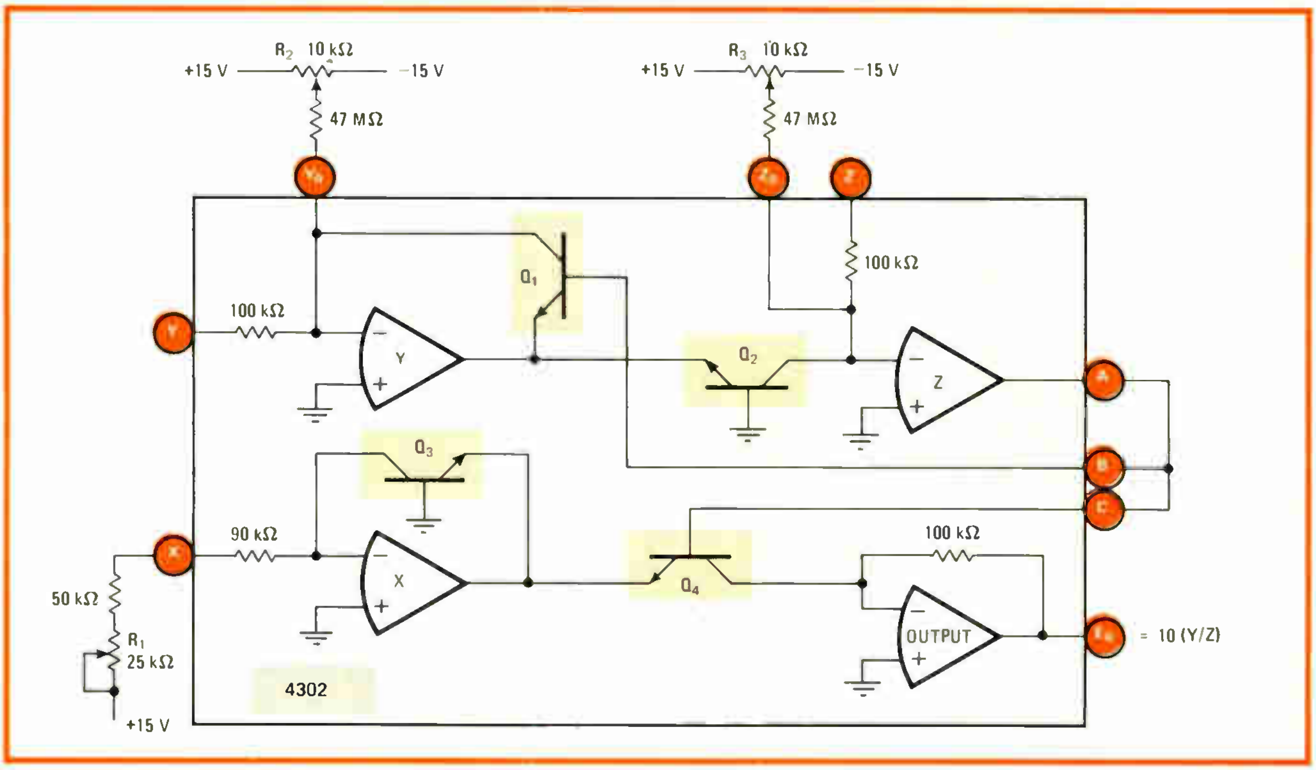
2. Economizing space. An analog divider can be constructed by connecting an analog multiplier in the feedback loop of an op amp (a). Packaged multipliers (b) do not require that extra op amp to be pin-programmed for performing division.



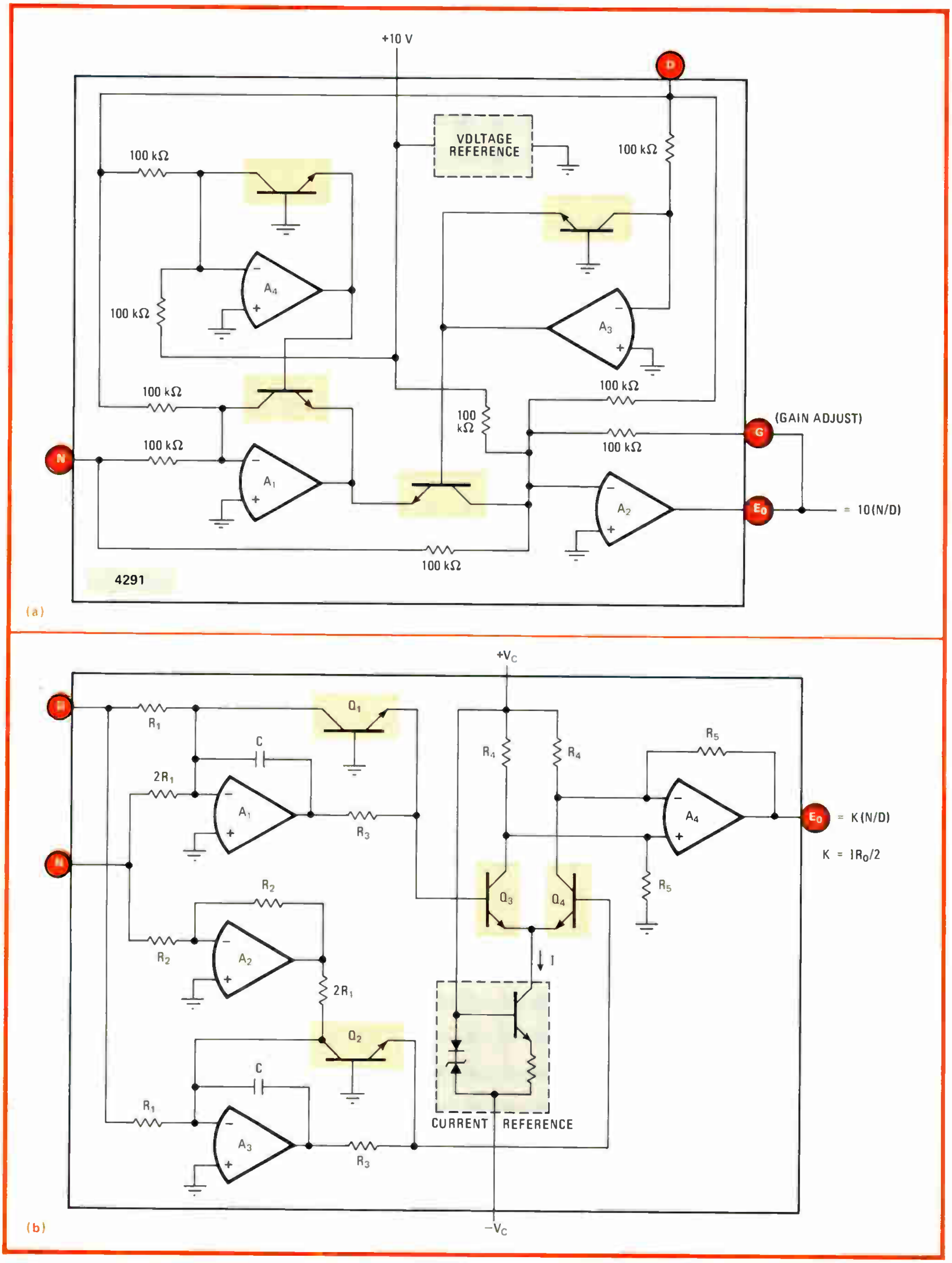
3. More accurate. The multiplier–inverted divider exhibits improved accuracy when connected in the manner shown. The error equation is given approximately by $\epsilon_d = 10\epsilon_m/(KD)$, where K is the ratio of R_2 to R_1 and can be used to optimize the divisor's range.

turer and D is the denominator voltage. With a 0.5% transconductance multiplier, the divider error will go as high as 5% when D goes down from 10 to 1 v. Hence, for practical purposes, these dividers are accurate only over a 10/1 denominator range.

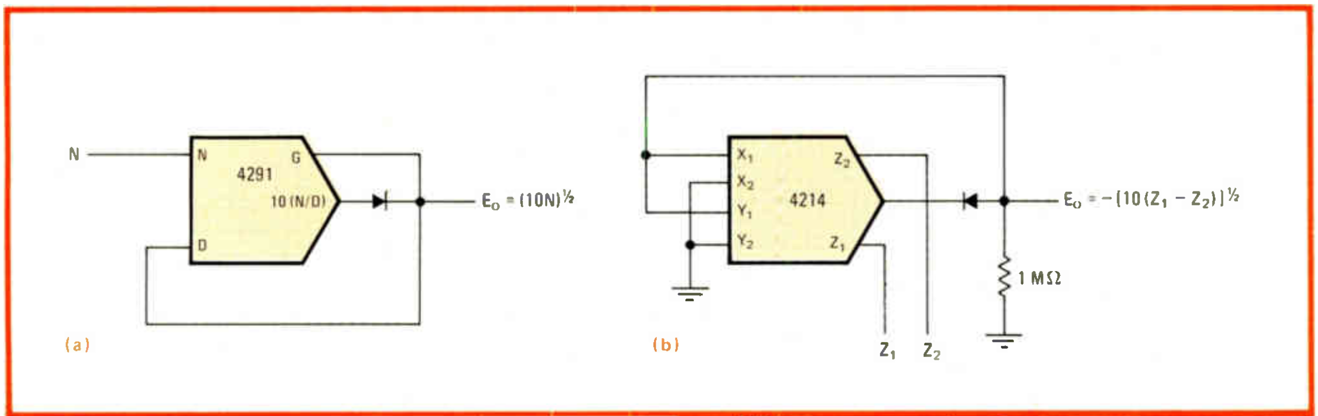
The divider error can be reduced by shifting the level of and preamplifying the divisor input and then shifting back at the output stage. In Fig. 3, with K defined by the ratio R_2/R_1, the divider error given by $\epsilon_d \doteq 10\epsilon_m/D$ will be reduced by a factor of K. However, the divisor input is thus limited to $-20/K$ volts. When K = 2, the divisor will swing within the same range of 0 to -10 v. In other

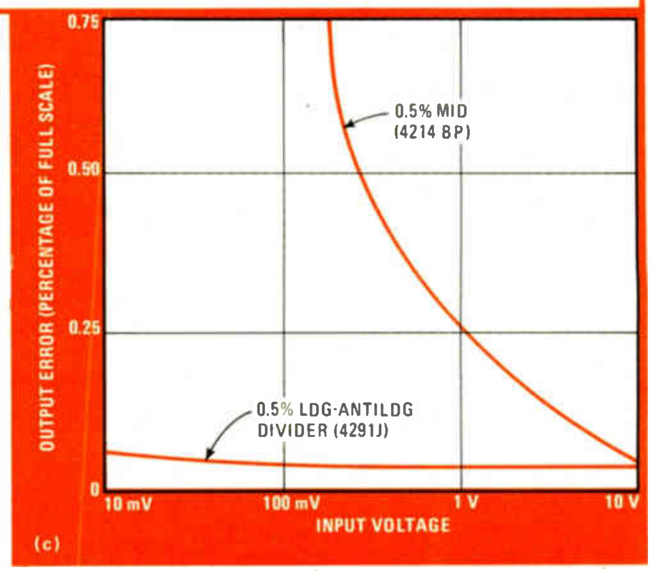


4. Converted converter. The multifunction converter may be used as a precision one-quadrant divider with a maximum error of 0.25% over a 100/1 denominator range. The maximum error can be reduced to 0.1% over a 1,000/1 range by using potentiometers R_2 and R_3.



5. Divider IC. The four op amps and the four logging transistors shown in the functional diagram (a) are rearranged and the voltage reference is replaced by a current reference to form a log-antilog divider that maintains a constant-level bandwidth with decreasing divisor voltages (b).





6. Taking the square root. Implementing either the multiplier–inverted divider (a) or the log-antilog divider (b) for finding the square root is a matter of the degree of accuracy wanted. Typical error curves for the two types are shown in the graph (c).

words, the divider error can be cut in half without sacrificing the divisor's dynamic range. With K greater than 2, say, K = 10, the divisor is limited to the range of 0 to −2 V.

One-quadrant divider

The well-known multifunction converter (MFC), through different external connections, can be used as a precision divider whose accuracy and dynamic range greatly exceed that of a multiplier–inverted divider. It is, however, good for one-quadrant operation only, whereas the MID is a two-quadrant divider.

The functional diagram of this converter is shown in Fig. 4. Its transfer function is given by:

$$E_o = X(Y/Z)^m$$

where m is determined by two external resistors and can range from 0.2 to 5. The circuit can be analyzed by applying to each of the four transistors used to achieve the logarithmic relationship, Q_1–Q_4, the Ebers-Moll equation:

$$V_{be} = (KT/q)\ln(I_c/I_s)$$

where:

V_{be} = base-to-emitter voltage
K = Boltzmann's constant (8.62×10^{-5} electron-volt/K)
T = absolute temperature
q = charge of an electron (1 eV)
I_c = collector current
I_s = emitter saturation current

Solving the equation for each of the four transistors simultaneously yields the converter's simple transfer function. This procedure assumes that the four transistors are matched, so that I_s and T are the same for all four equations.

The multifunction converter is capable of operating over a 100/1 denominator range with an error of less than 0.25%. At low input-signal levels, the offset voltages and bias currents of the Y and Z op amps contribute most of the errors. By trimming them out with potentiometers R_2 and R_3, the maximum error can be reduced to 0.1% over a 1,000/1 dynamic range. R_1 is used to trim out gain errors.

The 4291 analog divider has been optimized as a log-antilog divider. It is specified to be the most accurate two-quadrant, self-contained divider available in IC form. It operates in principle very similarly to a multifunction converter, but has several additional features. For one, it contains an internal level-shifting circuit for two-quadrant operation. For another, it is laser-trimmed to hold total error to less than 0.25% over a 100/1 dynamic range. In addition, both linearity compensation and an on-board temperature-compensated reference are provided.

Precise for two quadrants

The divider's functional circuit diagram is given in Fig. 5a. Q_1–Q_4 are the four logging transistors, which are always laid out on a monolithic chip along a thermal equilibrium line. Their geometries are specially designed for maximum conformity to a logarithmic output. In fact, log-conformity error is less than 0.05% over four decades of collector current from 100 microamperes to 10 nanoamperes. Thus, the divider can maintain its accuracy over many decades of denominator voltages.

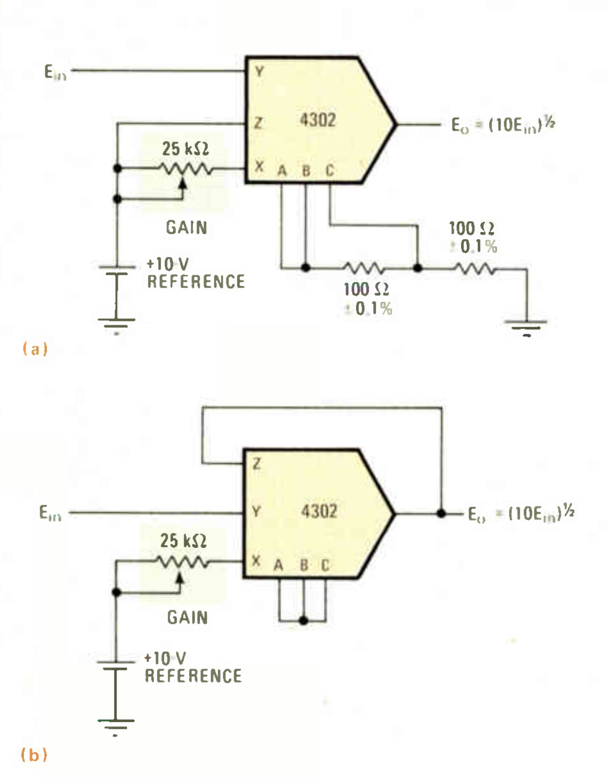
The error sources at low input levels are mainly due to the offset voltages and bias currents of the numerator and denominator input op amps, and not to the logging transistors. Optional trims are usually provided by manufacturers in order to eliminate the offsets and bias currents that are inherent in all op amps.

As with the multifunction converter and the multiplier–inverted divider, the bandwidth of the log-antilog divider decreases almost linearly with divisor voltage level; for example, a 400-kilohertz divider at a 10-V divisor voltage will become a 4-kHz divider at a 100-microvolt divisor voltage. By rearranging the four logging transistors and the four op amps and replacing the voltage reference by a current reference, a log-antilog divider whose bandwidth remains constant at high level even with decreasing divisor voltages can be realized (Fig. 5b).

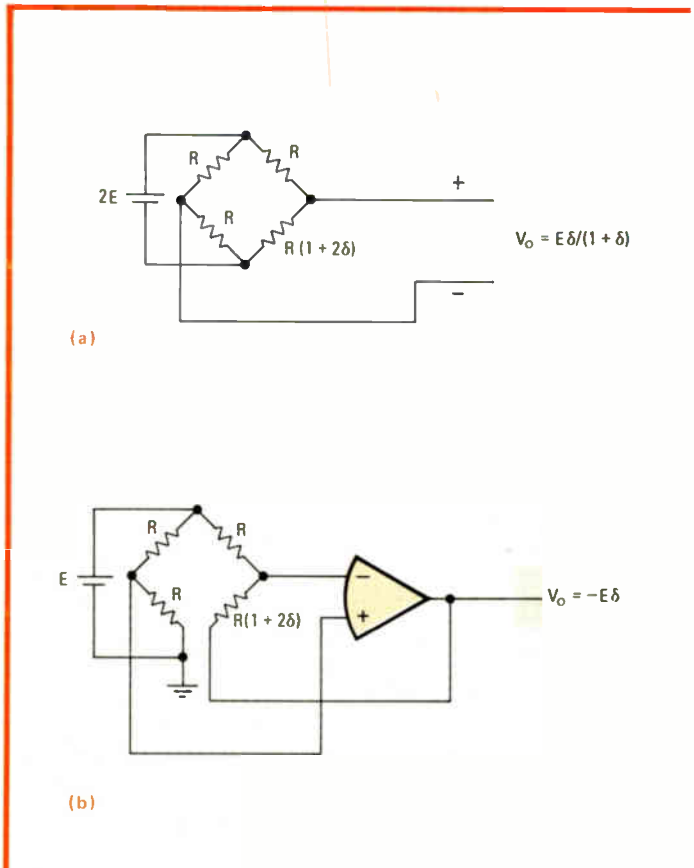
Notice that the current through the output stage (Q_3, Q_4, and A_4) is determined by the reference current, I, and remains constant. If I is set high, the divider's bandwidth will stay fairly flat from a 10-V divisor voltage down to 100 mV and then start to drop gradually, at a much slower rate than the circuit in Fig. 5a. Using 741-type op amps and setting I equal to 200 μA, typical component values are:

R_1 = 50 kilohms	R_4 = 10 kΩ
R_2 = 10 kΩ	R_5 = 100 kΩ
R_3 = 33 kΩ	C = 33 picofarads

As mentioned before, the offset voltages and bias currents of the op amps should be nulled out for low-signal operations. Unfortunately, with a reference current in place of a reference voltage, this divider circuit cannot be readily used as a three-input multiplier-divider to perform $E_o = XY/Z$.



7. Another approach. The multifunction converter (here, the 4302) may also be used as a square-rooter. To implement the transfer function, $E_o = X(YZ)^m$, m can be set equal to ½ (a) or to 1 (b), with the other connections appropriately made.



8. Linearizing bridges. The Wheatstone bridge has a nonlinear output dependent on the input variable (a). It may be linearized by using an op amp in a feedback loop (b), a multiplier–inverted divider (c), or an MID with an instrumentation amplifier (d).

One application of a precision divider is computing the square root of an input signal, often required in process-control systems. If the divisor's input is connected to its output terminal, the divider's transfer function, that is, $E_o = 10N/D$, becomes:

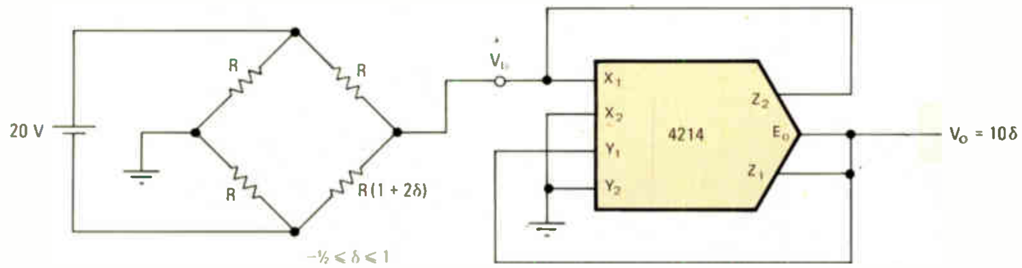
$$E_o = 10(N/E_o) = (10N)^{1/2}$$

The output is now proportional to the square root of the input, N.

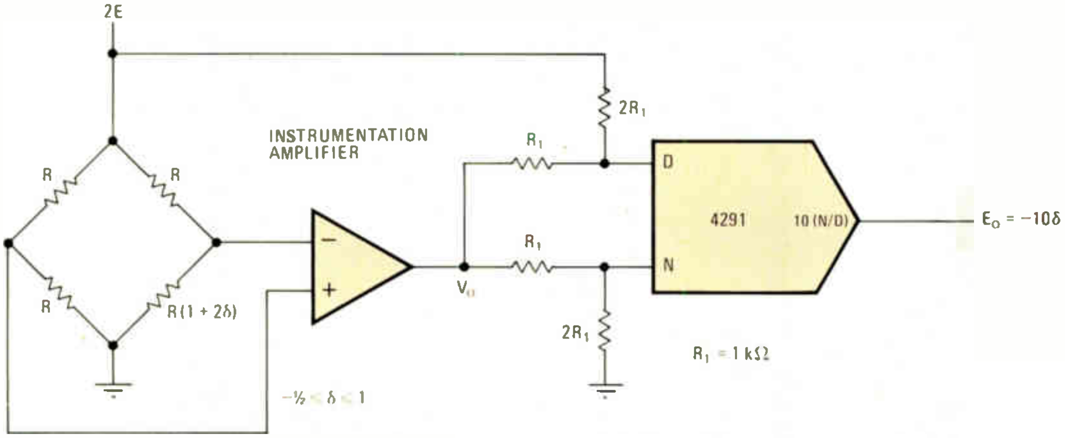
Square-rooters

Square-rooters employing a multiplier–inverted divider and a log-antilog divider are shown in Fig. 6a and 6b, respectively. Since E_o is always unipolar, adding a diode at the output of the divider will help prevent the square-rooter from saturating to the opposite supply voltage, which is occasionally caused by power-supply transients. In Fig. 6b, a 1-megohm output load may be necessary to turn on the diode, because the input impedances of the divider are so high (about 10 MΩ) that, without the load, practically no current will flow through the diode.

The square-rooter's accuracy is strictly dependent upon the accuracy of the divider employed. With a multiplier–inverted divider, the accuracy is poor at low input voltages. The error-versus-signal voltage can be estimated from:



(c)



(d)

$$E_o = (10E_{in} + 10\epsilon_m)^{1/2}$$

where E_o and E_{in} are the square-rooter's output and input voltages, respectively, and ϵ_m is the multiplier error specified by the manufacturer. For example, for a 0.5% multiplier, $\epsilon_m = 50$ mV maximum, and therefore the square-rooter's error would be 25 mV maximum at $E_{in} = 10$ V, but would be 109 mV maximum at $E_{in} = 500$ mV.

Figure 6c compares the typical error curves of square-rooters built with a multiplier–inverted divider and those made with a log-antilog divider. Typical errors would normally be much lower than in the graph. As can be seen, if small-signal accuracy is critical, a precision divider like the log-antilog type should be used.

With an external voltage reference, a multifunction converter may also be used to build a square-rooter. There are two ways to implement this function. The straightforward method is to set m = ½ with two matched resistors and connect X and Z to a 10-V reference (Fig. 7a). Then the output voltage becomes:

$$E_o = 10(Y/10)^{1/2} = (10Y)^{1/2}$$

Alternatively, m can be set to 1 as in Fig. 7b and the X input connected to a +10-V reference. By shorting Z to the output, E_o, the transfer function becomes:

$$E_o = 10(Y/E_o) = (10Y)^{1/2}$$

The accuracy of this square-rooter is about equal to that of a log-antilog divider.

The familiar Wheatstone bridge is widely used in measuring the resistance of sensors like strain gauges, pressure transducers, thermistors, and servo motors. Unfortunately, the output of the bridge is a nonlinear function of the input variable, the change in the resistance being measured. As illustrated in Fig. 8a, the output voltage, V_o, is related to the input variable, δ, by:

$$V_o = E\delta/(1 \pm \delta)$$

where 2E is the bridge supply voltage.

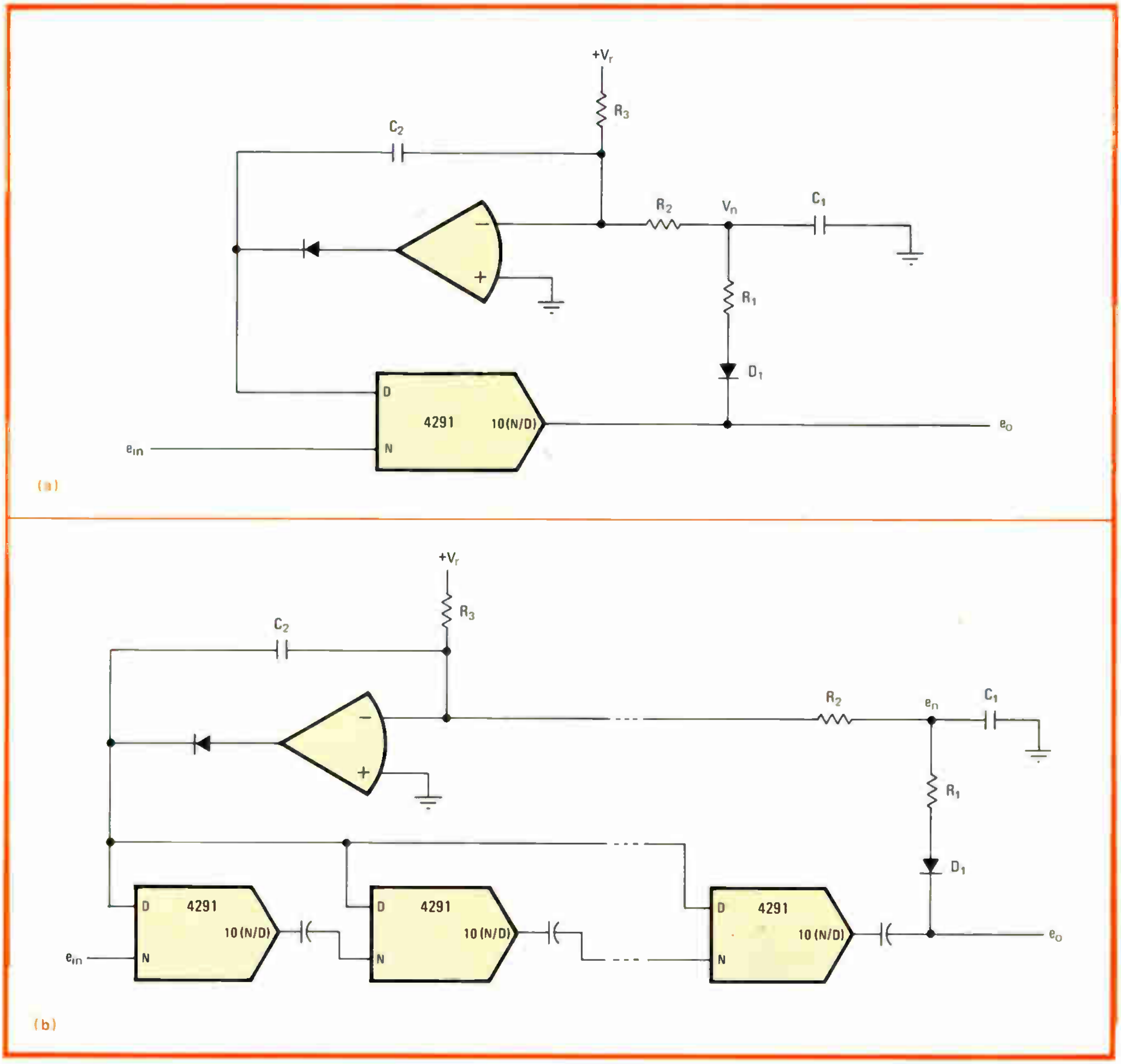
Linearizing the bridge

Because direct measurement and manipulation of nonlinear data is often undesirable, a circuit is needed to first linearize the bridge function. The simplest method of linearization uses an op amp. Connecting the variable-resistance arm in the feedback loop (Fig. 8b) causes the output of the op amp, V_o, to vary linearly with the variable, δ. Thus, $V_o = -E\delta$. However, some inexpensive bridges are packaged in four-terminal boxes and therefore will not work with this method, which requires five terminals.

A low-cost multiplier–inverted divider with differential Z inputs can, however, implement the inverse of the bridge function and linearize it. In Fig. 8c, the output voltage of the bridge, V_b, is given by:

$$V_b = 10\delta/(1 + \delta)$$

and the multiplier–inverted divider provides the transfer function, $V_o = 10V_b/(10 - V_b)$. The series connection of these two nonlinear circuits results in a linear function,



9. Controlling gain. The bandwidth of a 40-dB automatic-gain-control circuit using the 4291 (a), will be increased by n times, or its tracking range by n times, by cascading n dividers in the feedback loop shown in (b). The 400-kHz bandwidth, however, cannot be exceeded.

that is, $V_o = 10\delta$.

If the bridge supply voltage is single-ended, rather than floating as in Fig. 8c, an instrumentation amplifier is needed to convert the two output terminals of the bridge to a single output. The amplifier can be used effectively to compensate for bridge voltage variations. By inverting the signal such that $V_o = -E\,\delta/(1+\delta)$ and using four resistors to sum the bridge voltage with, and divide it by, V_o (Fig. 8d), the divider's denominator and numerator voltage become:

$$D = \frac{2R_{iD}}{3R_{iD}+2R_1}(E+V_o)$$

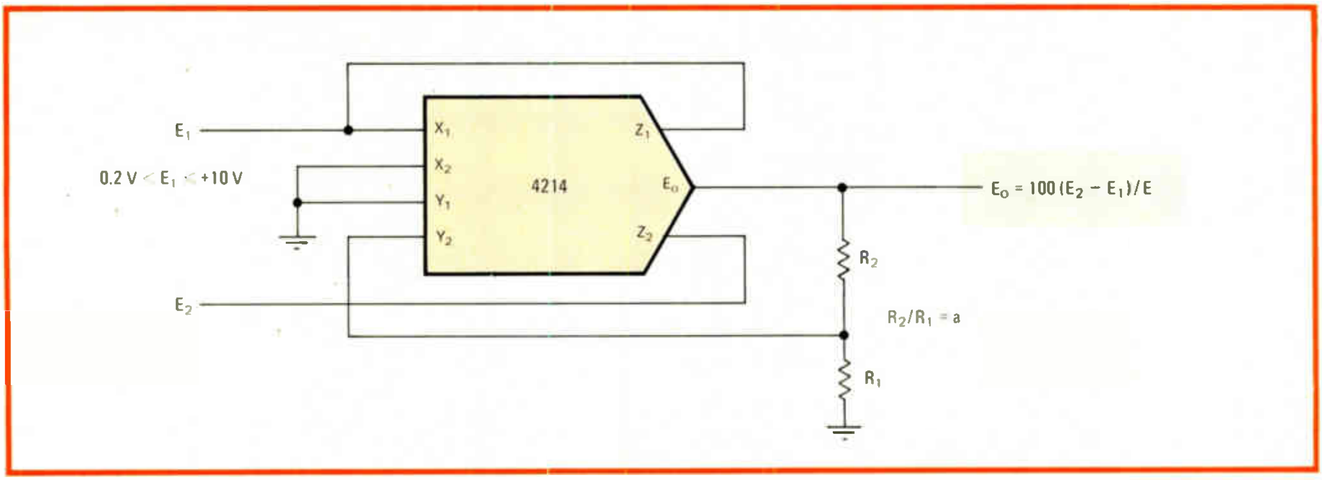
$$N = \frac{2R_{iN}}{3R_{iN}+2R_1}V_o$$

respectively, where R_{iD} is the input impedance of the divider's denominator input and R_{iN} is that of the numerator input.

The cleverness of this circuit becomes clear when D and N are substituted into the divider's simple transfer function, $E_o = 10N/D$. The bridge voltage, 2E, and the input impedance, R_i ($= R_{iN} = R_{iD}$), cancel out, resulting in $E_o = -10\delta$. Therefore, the output is independent of the bridge supply voltage. When R_1 is much smaller than R_i, the circuit is insensitive to the value of R_i.

Controlling the gain automatically

To compensate for amplitude fluctuations of any given signal, nothing less than a well-designed automatic-gain-control circuit will do. A good AGC circuit is one that can keep the output constant over a wide dynamic range of



10. A natural application. Direct readouts in percentage of such parameters as efficiency, distortion, gain/loss, and error are easily obtained by connecting a 4214 in a configuration that provides an output of 1 V = 1% with deviations measured up to ±10%.

input signal levels (tracking range). Analog dividers are excellent candidates for such appplications.

The tracking range of an AGC is directly related to the denominator's operating range of the divider employed. For example, if a divider has a divisor operating range from 10 V down to 100 mV, the AGC circuit associated with it will track ac signals over a 40-decibel range.

Figure 9a shows an AGC circuit using a two-quadrant log-antilog divider. The divider serves as a voltage-controlled amplifier whose output increases with a decrease in divisor voltage. Diode D_1 rectifies the output voltage, e_o. Low-pass filter R_1–C_1 produces a negative voltage, V_n, proportional to the negative peak of e_o. The integrator, comparing V_n with a positive reference voltage, V_r, determines the divisor voltage of the divider.

Automatic gain control is achieved thus: as the input signal, e_{in}, increases, e_o tends to increase, pushing V_n further negative. This increases the integrator's output voltage, which is connected to supply the divisor's input. As the divisor voltage goes up, it will pull e_o back down until it reaches an equilibrium.

Typical values for audio applications are:

$R_1 = R_2/10 = R_3/10 = 1\ k\Omega$

$C_1 = 10C_2 = 10\ \mu F$

$V_r = 0.3$ V

These values will provide a 2-V peak-to-peak output amplitude, which can be reset by adjusting either R_3 or V_r. For subaudio frequencies, an increase in the values of both C_1 and C_2 is necessary.

The upper frequency limit is determined by the bandwidth of the divider, and the bandwidth of most dividers decreases with decreases in divisor voltage. This means that the bandwidth of the AGC will decrease with input signal voltages.

As an example, with a divider's 3-dB bandwidth specified for 400 kHz at a 10-V divisor voltage, the bandwidth will be, as a rule of thumb, 40 kHz at a 1-V divisor voltage and 4 kHz at a 100-mV divisor voltage. With these specifications, a 40-dB AGC circuit will operate over a 40-dB signal range only up to 4 kHz and over a 20-dB range up to 40 kHz. Although it can function up to 400 kHz, the circuit will have no practical tracking range at those frequencies.

The bandwidth of the AGC circuit can be expanded by cascading two or more dividers in the feedback loop (Fig. 9b). For the 40-dB example, each of the dividers operates actually over 40/n dB, where n is the number of dividers cascaded. The bandwidth of the AGC circuit will thus be increased by n times, but will, of course, never exceed the divider's maximum bandwidth of 40 kHz. The cascading technique will also increase the tracking range of the AGC circuit by n times; that is, two 40-dB dividers will yield an 80-dB AGC circuit. Ac coupling at the output of each divider is recommended to eliminate unwanted divider offset voltages.

Taking ratios

For ratiometric applications, a divider naturally comes to mind. Percentage measurement:

$$E_o = 100(E_2 - E_1)/E_1$$

is just another version of ratiometric measurement, but it requires a divider with differential numerator inputs and adjustable gain (from the nominal 10 to 100). With low-cost IC dividers, it is practical to provide direct readout in percentages of such parameters as efficiency, distortion, gain/loss, error, and so on.

Figure 10 shows a percentage measurement circuit employing a differential multiplier–inverted divider. The circuit, which provides 1 V = 1%, is capable of measuring ±10% deviations. Wider deviations can be measured by decreasing the ratio of R_2/R_1, and narrower variations by increasing the ratio. If the dynamic range of E_1 is too wide for a multiplier–inverted divider to handle, a log-antilog divider may be employed, but an extra operational amplifier will be needed to take the difference $E_2 - E_1$.

The percentage circuit can also be used to sort components by first converting the component's parameter into a voltage and comparing it with a reference. A comparator at the output of the percentage circuit may then be set to separate units beyond a specified limit. □

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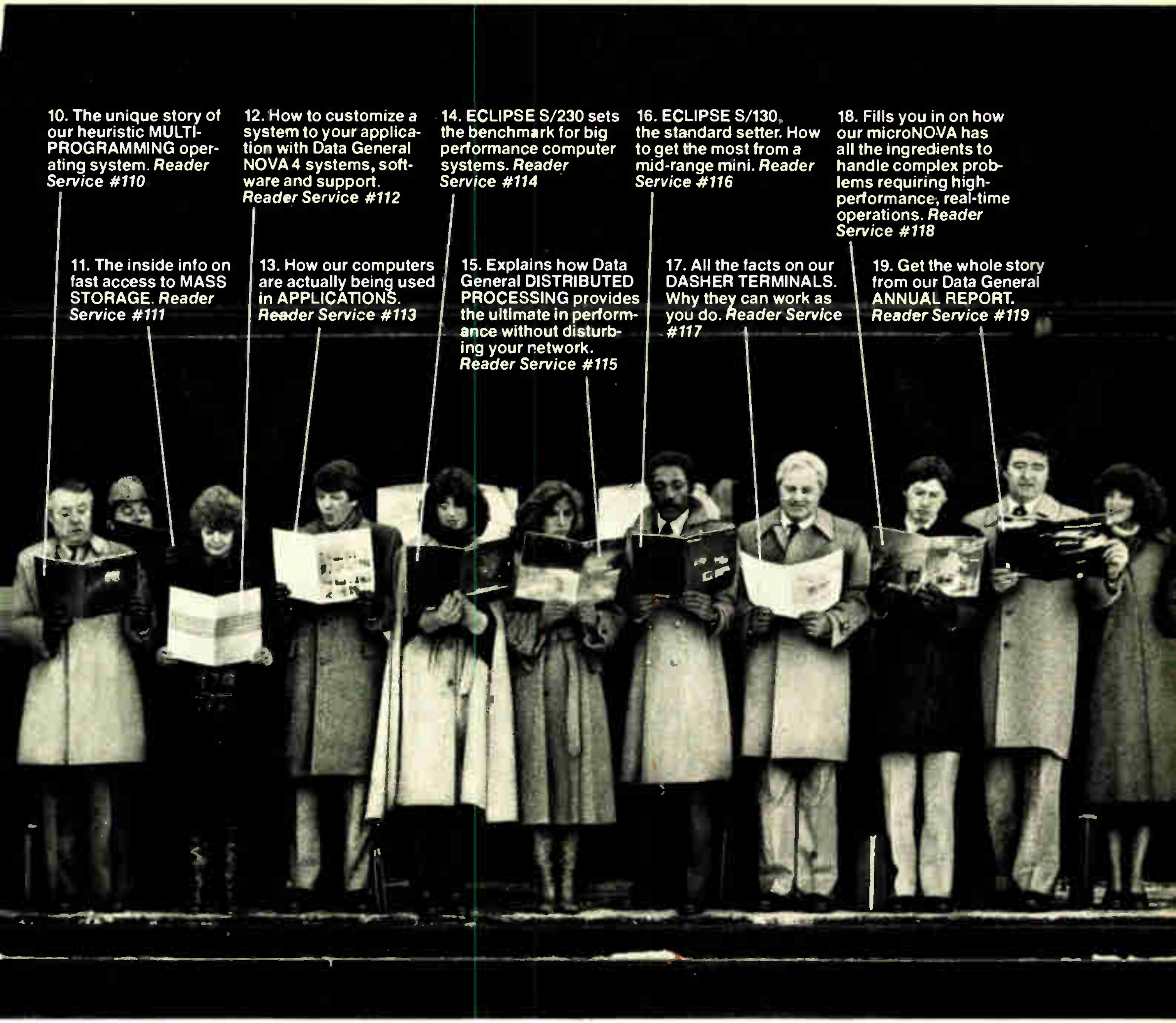

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Micropower regulator has low dropout voltage

by Kelvin Shih
General Motors Proving Ground, Milford, Mich.

Designed specifically to regulate the output of lithium batteries, which have a low terminal voltage at low temperatures, this circuit provides a stable 5.0 volts at 10 milliamperes for an input voltage as low as 5.2 V.

The low dropout voltage of the regulator (5.2 – 5.0 = 0.2 V) is attained in part by operating the circuit's output transistor in the common-emitter mode. As a result, its collector-to-emitter voltage drop is much lower than the base-to-emitter drop of transistors operated as emitter followers in standard regulators. And, because it uses a low-power operational amplifier operating from a single supply, and a low-current, low-voltage zener diode for the voltage reference, the regulator's idle current is only 250 microamperes.

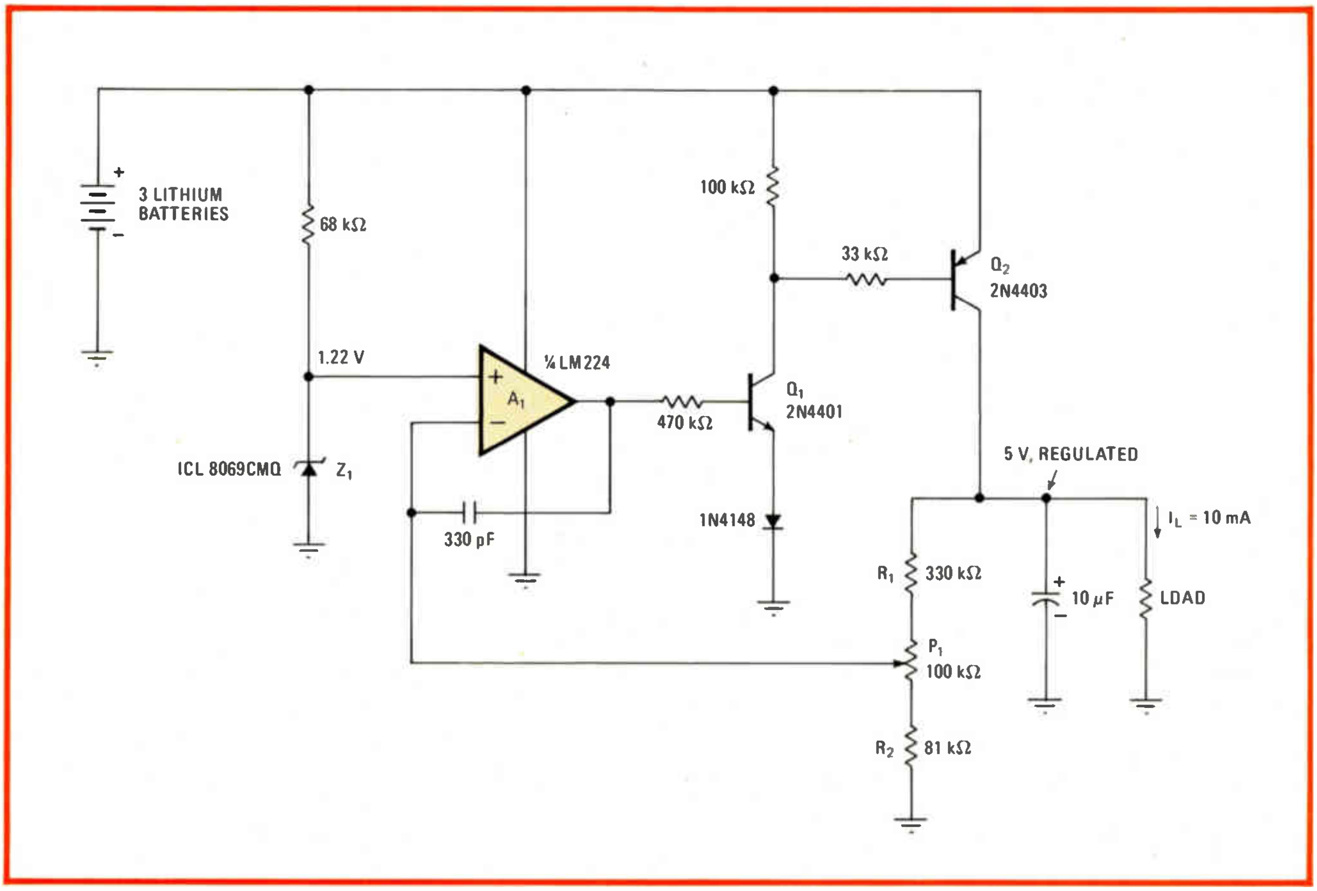
Three lithium batteries drive the regulator shown in the figure. Their terminal voltage is usually 3 V per cell at room temperature, but it will drop to 2 V at –40°C.

Z_1 provides a low-voltage reference (1.22 V) to the noninverting input of the LM224 op amp, A_1. The Intersil ICL 8069CMQ zener has been selected because it requires only 50 μA of bias current and has a temperature coefficient of better than 50 parts per million/°C.

The 1.22-V reference is compared to the output voltage from a divider network (R_1,R_2, P_1), which is used to trim the output voltage to the desired value. Any voltage difference appearing at the output of A_1 drives transistor Q_1, and thus determines the drive current to Q_2. As a result, Q_2 conducts more heavily if the output voltage is low, or limits the application of battery voltage to the load if the output voltage is high.

There will be no observable change of output voltage for an input voltage variation between 5.2 and 10 V, over the temperature range of –40°C to +70°C. □

Dropout minimum. Voltage regulator for lithium batteries maintains 5-volt output for a minimum input voltage of 5.2 V. Output voltage is constant over the temperature range –40°C to +70°C. Using a low-power op amp operating from a single-ended supply, and a low-current zener, the circuit holds the idle current to 250 μA, well below the 2 to 10 mA required by standard regulators.



Missing-pulse detector handles variable frequencies

by Joe Lyle and Jerry Titsworth
Bendix Corp., Aircraft Brake and Strut Division, South Bend, Ind.

Virtually all missing-pulse detectors require an input signal of fixed frequency in order to operate satisfactorily. They malfunction when the input frequency varies because their circuits employ detection networks that have a fixed time constant. Through the implementation of inexpensive voltage-to-frequency and frequency-to-voltage converters to derive an average, or reference, frequency that tracks the input signal, this circuit can pinpoint missing pulses without being affected by input frequency variations.

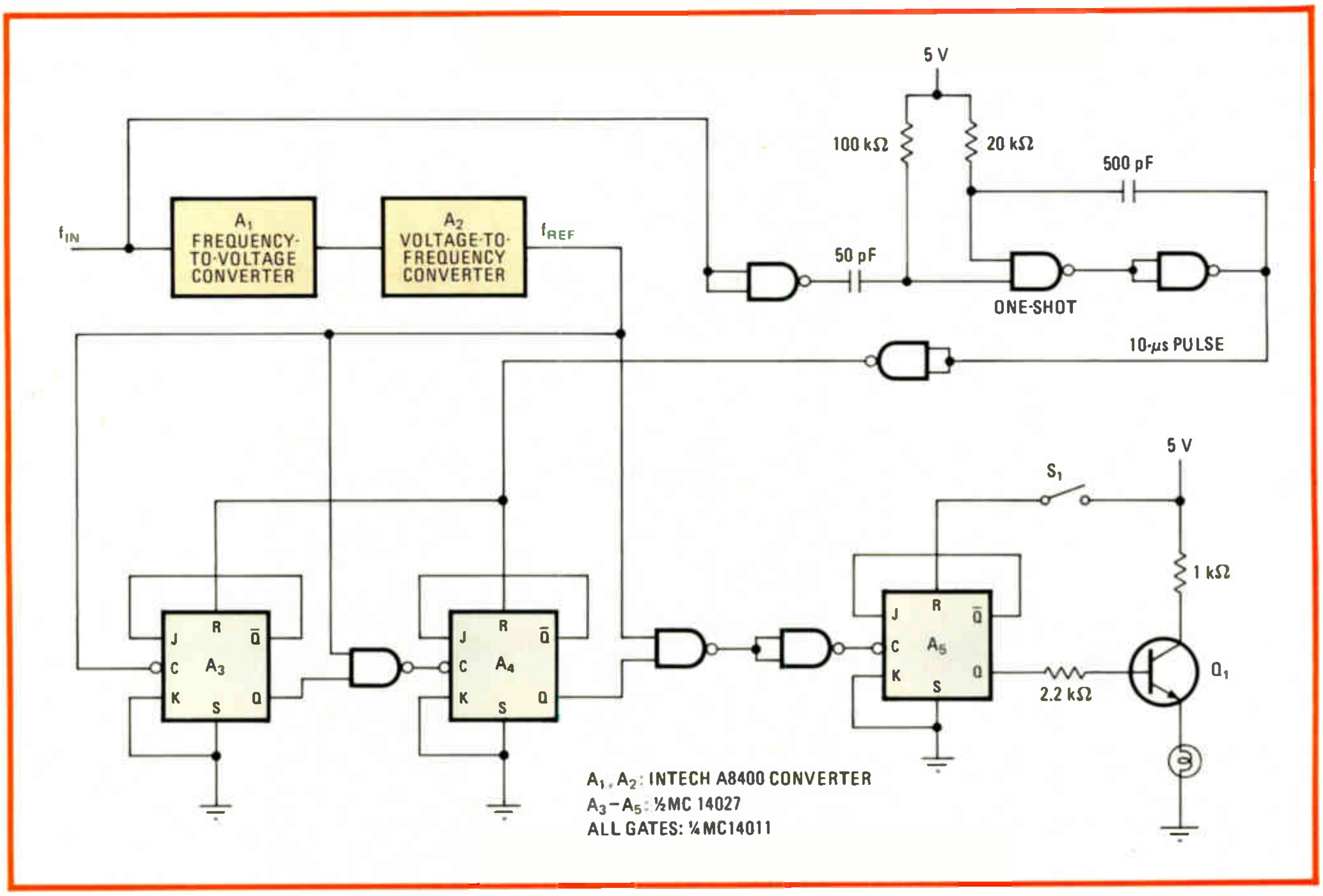
As shown in the figure, A_1 and A_2 establish the reference frequency, f_{ref}, using input frequency f_{in}. Missing pulses do not change the reference because of the integrating capacitors within the converters. Meanwhile, the three NAND gates comprising the one-shot produce pulses of 10 microseconds in duration, with a frequency determined by the input signal.

The chip labeled A_4 is clocked by f_{ref} and A_3 through a NAND gate. As long as the input train is continuous, the Q output of A_4 is low. If a missing pulse is detected, however, the one-shot will not generate a pulse to the reset pin of A_3, and the Q output of A_3 (which is also clocked by f_{ref}) will go high to clock A_4. A_4 and f_{ref} will then switch A_5's Q output to high.

This turns on transistor Q_1 and the pilot lamp glows. Switch S_1 is used to reset the circuit after a missing pulse has been detected. Note that circuit operation remains independent of the input frequency, since the arrival of f_{ref} and the 10-μs pulse at A_3 is synchronized to f_{in}.

The circuit should be calibrated by setting A_1 for an output voltage of 10 when a 10-kilohertz input signal is applied. Similarly, A_2 should be set to generate a 10-kHz signal for a 10-V input. □

Synchronous. The circuit detects the missing pulse independently of the pulse train frequency. Voltage-to-frequency and frequency-to-voltage converters derive a reference frequency whose average remains the same for small anomalies occurring in the pulse train: converters' integrating capacitors hold f_{ref} steady despite missing pulses. The reference in this way serves as a synchronous clock.



Charge pump cuts compandor's attack time

by Devlin M. Gualtieri
Allied Chemical Corp., Morristown, N. J.

Integrated-circuit compandors such as the Signetics NE570 could be more effective in high-fidelity noise-reduction schemes if it were not for one built-in shortcoming: their slow attack time permits large input signals to overdrive the device's compressor and thereby create distortion. But by adding a quad operational amplifier, a diode, and a few resistors, the compandor's attack-to-decay ratio (which is internally set at 1:5) can be dynamically controlled. Specifically, the attack time can be decreased for a given decay period. This concept can be extended to any charge-storage circuit, such as a sample-and-hold module, to speed voltage-level acquisition for a given set of circuit parameters.

The NE570 contains a full-wave rectifier, a variable-gain stage, and other peripheral circuits. The rectifier converts an audio-input signal into a pulsating direct current, which is averaged by an external filter capacitor, C, connected to the compandor's C_{RECT} terminal. The average value of the signal determines the gain of the variable-gain stage.

The compandor's attack and decay times are inversely proportional to the value of the filter capacitor. Thus attack time could be reduced simply by substituting a smaller capacitor for C. But the circuit's purpose is to reduce attack time without using a smaller C, because the third-order harmonic distortion generated when the compandor processes low- and medium-amplitude signals increases as the value of C decreases. The effective capacitance of C during charging is reduced by using this circuit as a pump to charge C more quickly for large input signals, thereby shortening attack time without appreciably reducing the average capacitance of C.

The averaging capacitor is connected to the compandor's rectifier through a 150-ohm resistor, R. At low signal levels, the LM324 quad op amp is not active, so that R contributes only 0.2% additional distortion to what would normally be expected with C alone.

When the rectifier processes a large signal, the relatively large voltage drop across R activates the circuit. Differential amplifier A_1–A_3 generates a large voltage at the input to A_4. This causes A_4 to charge C through D_1 at its short-circuit value of 40 milliamperes. C is effectively charged at 40 volts per millisecond, which corresponds to an attack time of less than 0.1 ms.

The threshold of the enhanced attack rate, which is set by the quiescent 1.3-V drop across C and the 0.7-V drop across D_1, is approximately 0.1 V root mean square (−20 dBm) with respect to the rectifier input. □

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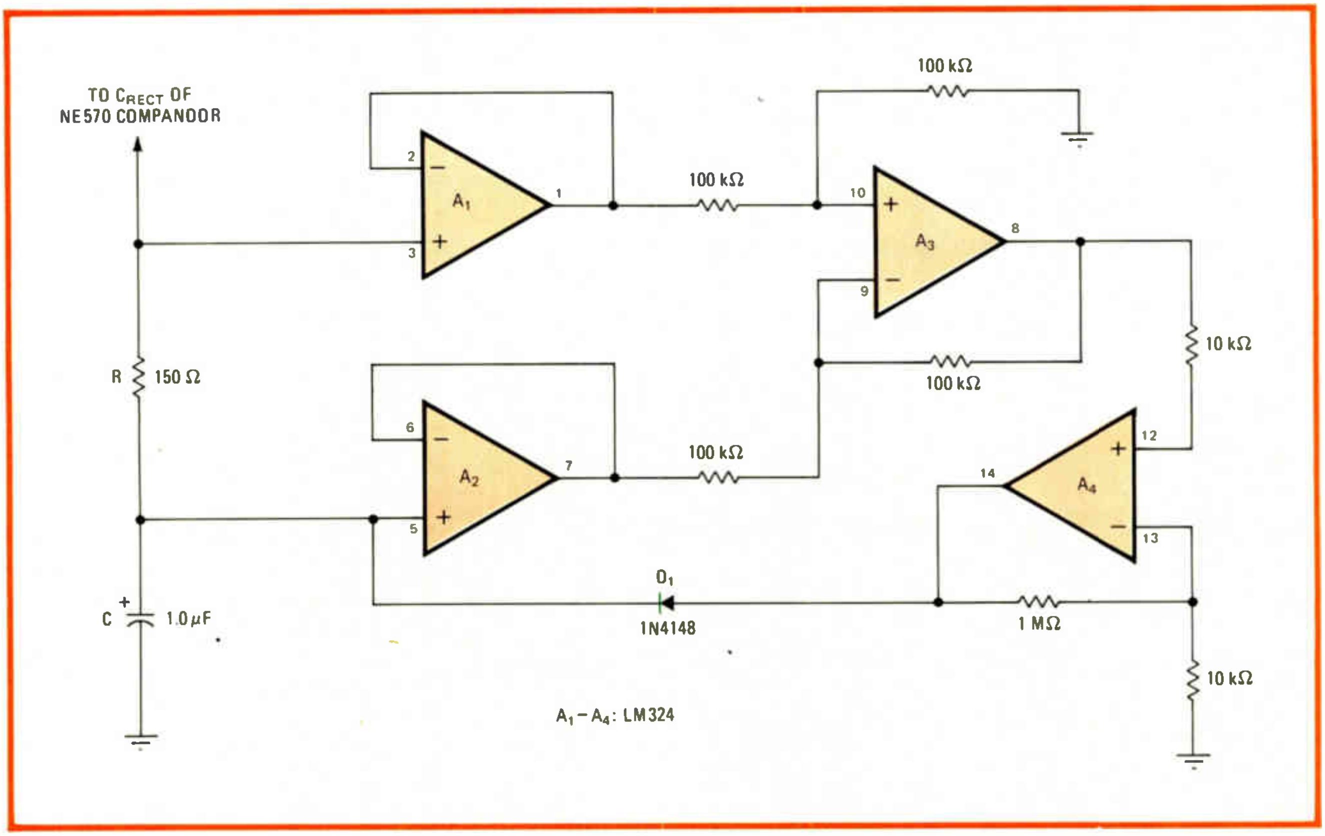

Dynamic. Circuit for decreasing NE570's attack time for large signals uses a quad operational amplifier for quick charging of compandor's averaging capacitor, C, in this way reducing its effective value. The fundamental waveform distortion from the compandor output is substantially reduced as a result, but third-harmonic distortion for low- and medium-amplitude signals is not substantially increased.

PROM controller makes fast work of serial jobs

Programmable memory outdoes microprocessor as replacement for flip-flops or logic array in sequential digital controllers

by John J. Petrale
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□ Certain types of digital controllers can be far more effectively upgraded with programmable read-only memories than with microprocessors. Sequential controllers, which jump from one state to another, are a good example. Used for process control and various other serially organized tasks, they often cannot afford the time required by a microprocessor to fetch instructions and store them. PROM microcontrollers, on the other hand, make short work of cycling through a number of states one at a time.

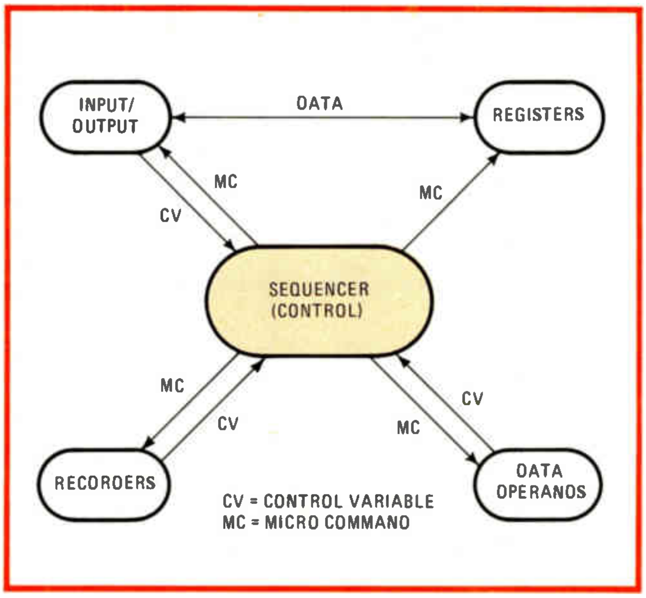
However complex this serial algorithm, only three integrated circuits are needed to perform it—two PROMs and a storage register. This set of chips costs less than a microprocessor, yet can also be programmed for a variety of different applications, simplifying production.

No competition

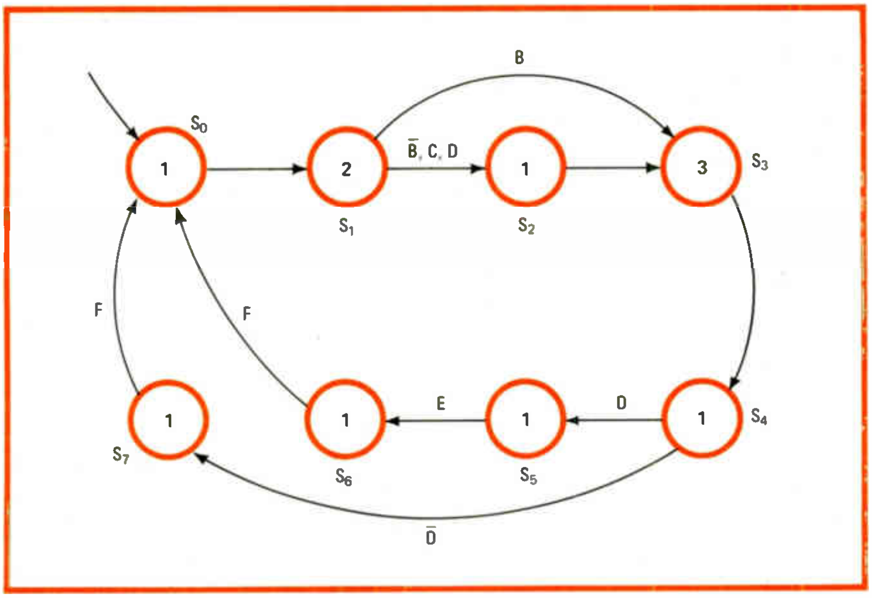
The dedicated hardware traditionally used to build sequential controllers can seldom compete with this combination of simplicity and versatility. The flip-flop controller has to add more and more flip-flops and logic gates, the more complex the algorithm, and the result is often an entanglement of wires. The programmable logic array has the opposite defect: it often has too few elements (like AND and OR gates) for the number of logical operations involved.

Structurally, the PROM microcontroller is a typical digital sequence controller. Figure 1 shows its block diagram. The controller section is the brain of the system; its logic elements execute commands in accordance with the algorithm designed to process the data. The input/output blocks format the data going into and out of the system, and the registers store the data as it is being processed. The data operands modify or change the data, and the recorders indicate the number of events or loops that occur for a given operation.

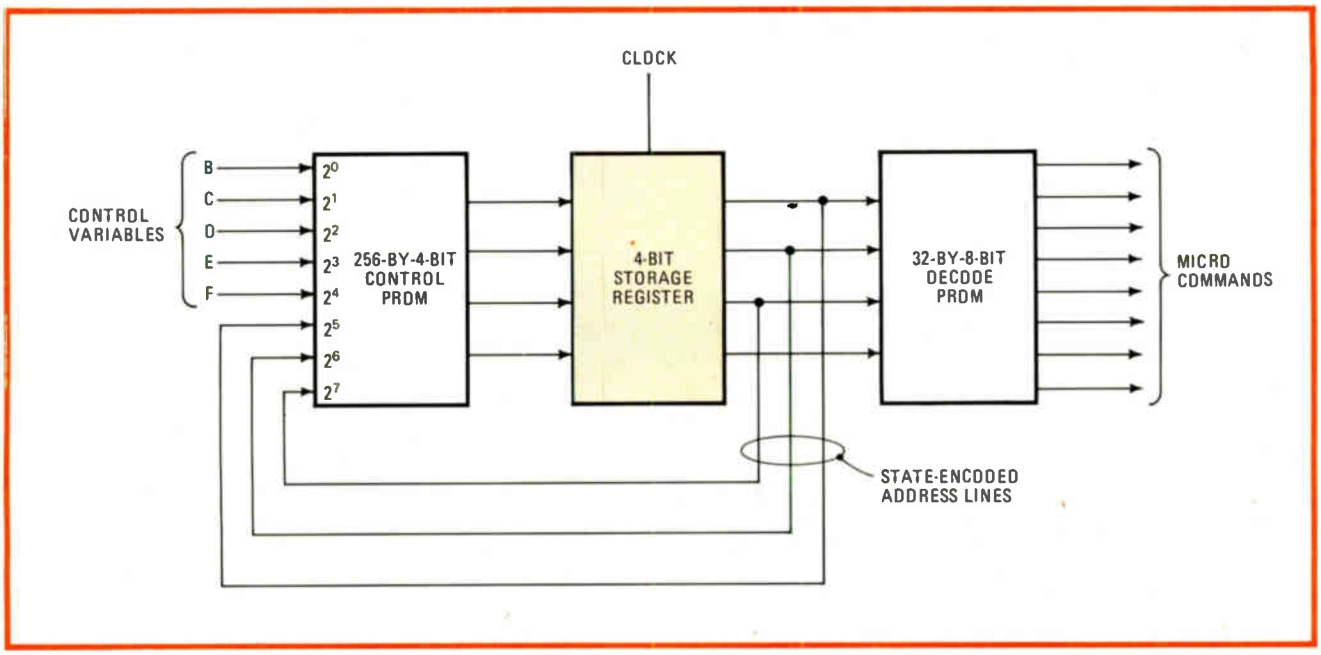
The system idles, waiting for input. When received,



1. Sequencer. The control block, the heart of any digital sequence controller, responds to control variables from the system's other functional elements by generating micro commands to carry out the algorithm. A PROM version is both capable and easy to use.



2. States. This state diagram illustrates an algorithm that sequences through eight states. The five control variables (B, C, D, E, and F) instruct the controller where and when to branch. The numbers in the circles indicate the number of micro commands generated in each state.



3. PMC. With a PROM microcontroller, any complex algorithm can be realized with two programmable read-only memories and a storage register. The register in the PMC is built from D-type flip-flops. The flip-flop controller uses the J-K variety, which is more subject to noise.

the data is formatted for processing by the I/O block, which then sends a control variable (CV) to the controller. The controller then sequences to its next state, issuing a micro command (MC) to carry out the operation dictated by the last state plus the control variable.

In control

The micro commands control all system functions. The actual processing of the data is done by the data operands; operations here include shifting, adding, and transferring data. Control variables from the recorders, operands, and I/O flag the controller to indicate the end of a specific operation, at which time the data is transferred to the system's output.

A state diagram is used to define the operation of the system. The one shown in Fig. 2 diagrams an algorithm involving eight states. The control variables B, C, D, E, and F tell the sequence controller when and where to branch. In any given state, one, two or three micro commands are generated to perform such tasks as: add one to a counter, or transmit a register's contents to an I/O port.

In a flip-flop controller the logic elements used for the control algorithm are logic gates and J-K–type flip-flops. The flip-flops form storage registers that keep the system in the same state long enough to perform any operation. The output logic gates decode the flip-flops, generating micro commands, and also feed back the state to the input logic gates, for AND-ing with the control variable to elicit the next state.

A complex system can contain hundreds of J-K flip-flops and gates connected in a highly organized way. In

TABLE 1: WORD ALLOCATION FOR CONTROL PROM

States	PROM addresses
S_0	0 to 31
S_1	32 to 63
S_2	64 to 95
S_3	96 to 127
S_4	128 to 159
S_5	160 to 191
S_6	192 to 223
S_7	224 to 255

translating its state diagram, the engineer must connect a myriad of wires between all these logic elements, knowing that he does so with a high probability of error.

The PROM microcontroller (PMC) reduces design time and hardware cost. Figure 3 shows a typical PMC. The input and output logic gates have been replaced by PROMs and the storage elements are the newer, faster, and less noisy D-type flip-flops. To synchronize all the logic functions, a clock is connected to all the registers, counters, and other such system elements. Otherwise, short high-frequency pulses may occur when the decode PROM switches from one location to another. (The situation is similar to what happens with a two-input logic gate when one input is falling while the other is rising—the overlap of the two signals causes a spike of noise.)

The control PROM at the input contains the truth table for the algorithm—the combinations of control variables and state-address lines that point to specific addresses in that PROM indicating the system's next state. At each clock pulse, the PROM outputs are transferred to the storage register, which in turn drives the decode PROM. For example, when the system is in state 1 (Fig. 2), the input address bits to the decode PROM will be 001, pointing to location 1. Location 1 will have 2 of its 8 bits programmed, so that either of two micro commands may be generated.

The size of the algorithm that the PMC can handle is a function of the number of control PROM outputs. For example, if a PROM has four outputs, it can handle 16 states. Control PROMs can, however, be connected in parallel to accommodate larger algorithms.

The control PROM

The 256-by-4-bit control PROM in Fig. 3 was selected to match the number of control variables and states. The algorithm in Fig. 2 has eight states, so that at least three output lines are required. The number of words, 256 or 2^8, corresponds to the five control variables and the three address lines encoding the states. For each additional control variable, the PROM doubles in size. If there were six control variables and three state lines, it would need to be a 512-word PROM.

Each of the 256 locations must contain a binary value corresponding to one of the eight states in the algorithm. Since the three address lines representing the machine's state are fed back to the high-order address lines of the PROM (Fig. 3), each state uses 32 PROM locations—more than enough for a system in which at most three CVs are required to occur concurrently. And in a given state, it is possible that the PROM will be switched through all 32 locations. The memory map in Table 1 shows the way the words are allocated.

The algorithm dictates how the locations in the control PROM will have to be programmed. For example, when the system is in state 5 (S_5), it will have to sequence to S_6

TABLE 2: PARTIAL PROM MAP FOR STATE 1

State	Input function: Control variables F	E	D	C	B	PROM address	PROM contents				Notes
S_1	X	X	0	0	0	32	0	0	0	1	Stays in S_1
S_1	X	X	0	0	1	33	0	0	1	1	$S_1 \rightarrow S_3$, B=1
S_1	X	X	0	1	0	34	0	0	0	1	Stays in S_1
S_1	X	X	0	1	1	35	0	0	1	1	$S_1 \rightarrow S_3$, B=1
S_1	X	X	1	0	0	36	0	0	0	1	Stays in S_1
S_1	X	X	1	0	1	37	0	0	1	1	$S_1 \rightarrow S_3$, B=1
S_1	X	X	1	1	0	38	0	0	1	0	$S_1 \rightarrow S_2$, B=0, C=1, D=1
S_1	X	X	1	1	1	39	0	0	1	1	$S_1 \rightarrow S_3$, B=1
S_1	X	1	0	0	0	40	0	0	0	1	Stays in S_1
S_1	X	1	0	0	1	41	0	0	1	1	$S_1 \rightarrow S_3$, B=1
S_1	X	1	0	1	0	42	0	0	0	1	Stays in S_1
S_1	X	1	0	1	1	43	0	0	1	1	$S_1 \rightarrow S_3$, B=1
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
S_1	1	1	1	1	1	63	0	0	1	1	$S_1 \rightarrow S_3$, B=1

X = "Don't care"

when the control variable E becomes 1 (Fig. 2).

Referring to the table, S_5 encompasses PROM locations 160 to 191. Each one of these 32 locations must therefore have a binary 5 or 6 programmed in to it. In those locations where E is a 1, 110 (S_6) must be programmed for a state change; where E is a 0, 101 (S_5) is burned in to keep the system in S_5. The status of all the other control variables is inconsequential.

Table 2 is a more comprehensive map for PROM locations 32 to 63 only. This area is reserved for state S_1, so that state-address lines from the storage register to the control PROM's high-order address lines are all 001.

PROM addresses 32 and 40 in the table indicate that when B, C, and D are all zero, the system stays in S_1. Therefore, both those locations must contain a binary value of 1. Two conditions must be met to sequence from S_1. When the control variable B is a 1, the system sequences to S_3. All the odd (not even) locations in Table 2—33, 35, 37, and so on—therefore contain 011 (S_3). Also, when B, C, and D are 0, 1, and 1 respectively, the PROM will point to locations 38, 46, 54, and 62 (S_2).

The decode PROM

A 32-by-8-bit PROM is used to convert the states into micro commands (Fig. 3). The number of outputs is determined by the number of micro commands in the algorithm, which in turn is determined by the number of logic functions under the control of the sequencer. For the problem being presented, there are seven micro commands which drive the various registers, operands, and counters in the system. As there are only eight states, an 8-word-by-7-bit decode PROM is sufficient. Since this size of PROM is not commercially available, a 32-by-8-bit PROM is used instead.

Truth tables are helpful in programming the control and decode PROMs. Table 3 shows a form the designer can use to map the control PROM. The present-state column defines the states in which the machine resides. This is followed by two columns for address locations. The grouping of the control variables and the present-state address lines represents the range of addresses in the PROM. Each location in that range must be programmed with the binary value of the next state.

The column for present-state address lines defines the bit configuration for the present state, while the control variable column defines all the control variables for the algorithm in Fig. 2. The X denotes the "don't care" conditions of the control variables for the state.

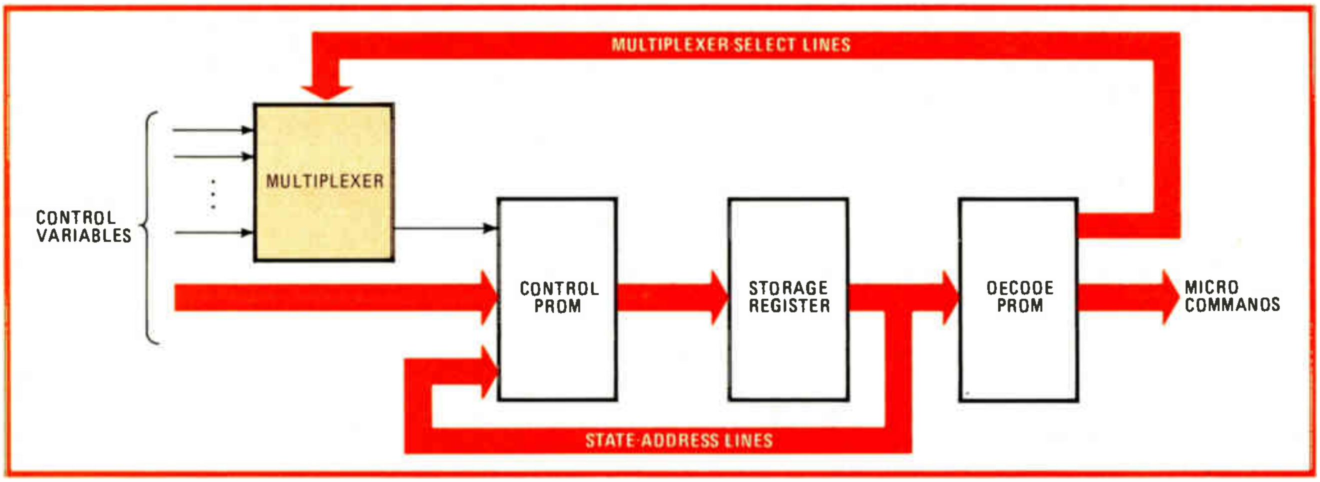
The next-state column gives the next state of the system when the appropriate CVs are activated. For example, if the machine is in S_5 and the control variable E is a 1, the PROM will point to a new location containing the binary value 110. All other locations within the range of addresses of S_5 will contain the binary value 101 (decimal value 5—the same state). Finally, the function

TABLE 4: DECODE PROM MAP

Input				Output of decode PROM micro commands (states)						
2^2	2^1	2^0	State	7	6	5	4	3	2	1
0	0	0	S_0	0	0	0	0	0	1	0
0	0	1	S_1	0	0	0	1	1	0	0
0	1	0	S_2	0	0	1	0	0	0	0
0	1	1	S_3	0	1	0	0	0	1	1
1	0	0	S_4	0	0	0	0	1	0	0
1	0	1	S_5	0	0	0	1	0	0	0
1	1	0	S_6	1	0	0	0	0	0	0
1	1	1	S_7	0	1	0	0	0	0	0
Addresses 8 to 31 are unused										

TABLE 3: SUMMARY SHEET FOR MAPPING CONTROL PROM

Present state	Address locations in PROM								Contents of PROM			Function
	Present state-address lines			Control variables					Next state			
				F	E	D	C	B				
S_0	0	0	0	X	X	X	X	X	0	0	1	$S_0 \rightarrow S_1$
S_1	0	0	1	X	X	1	1	0	0	1	0	$S_1 \rightarrow S_2$
S_1	0	0	1	X	X	X	X	1	0	1	1	$S_1 \rightarrow S_3$
S_2	0	1	0	X	X	X	X	X	0	1	1	$S_2 \rightarrow S_3$
S_3	0	1	1	X	X	X	X	X	1	0	0	$S_3 \rightarrow S_4$
S_4	1	0	0	X	X	1	X	X	1	0	1	$S_4 \rightarrow S_5$
S_4	1	0	0	X	X	0	X	X	1	1	1	$S_4 \rightarrow S_7$
S_5	1	0	1	X	1	X	X	X	1	1	0	$S_5 \rightarrow S_6$
S_6	1	1	0	1	X	X	X	X	0	0	0	$S_6 \rightarrow S_0$
S_7	1	1	1	1	X	X	X	X	0	0	0	$S_7 \rightarrow S_0$
Binary value	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	X = "Don't care"			



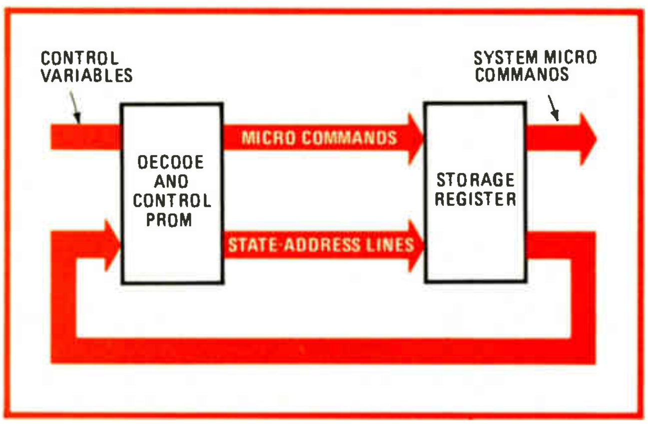
4. Multiplexed PMC. A multiplexer can be tacked onto the basic PROM microcontroller to accommodate more control variables than the control PROM could otherwise handle. This technique allows very complex algorithms to be implemented without large memories.

column summarizes what the controller will do when the appropriate CVs are activated for a specific state—for example, that it will sequence from S_5 to S_6 when E becomes a 1.

After the summary sheet is filled out, it is expanded to include all PROM locations. The map in Table 3 has "don't care" conditions for all the CVs when the system is in S_0. Therefore, every location from 0 to 31 must have a binary value of 001. Similarly, S_1, whose addresses span 32 to 63, must have the value 001 (S_1) assigned to 28 PROM locations. The remaining four (38, 46, 54 and 62) will have the value 010 (S_2). One of the four locations is activated when B, C, and D are in the combination 0, 1, and 1, regardless of the E and F values.

The control PROM just discussed is used to sequence the system through the algorithm. The decode PROM contains the sum of the product terms for each micro command; that is, the OR-ing of the various states that require the activation of the micro commands to drive the external logic circuits. The inputs to the decode PROM are the present state of the machine, as Fig. 3 should make clear.

Table 4 is a map of the decode PROM. Only those locations required for activation need to be programmed.



5. High speed. In applications where a very complex algorithm must be sequenced in very short time, pipelining can be used to eliminate the delay before the generation of the micro commands. However, the decode PROM must now be as large as the control PROM.

Each location represents a state, and since only eight states are used in this particular example, only eight locations are required. Each output of the PROM represents one micro command.

A multiplexed PMC

PROM microcontrollers can be built to accommodate input variables greater in number than the control PROM inputs. This allows very complex algorithms to be implemented with reasonably sized PROMs. Figure 4 shows how a multiplexer may be added to process the extra control variables. These variables are selected one at a time in accordance with the system's state; they therefore cannot include any that must occur simultaneously.

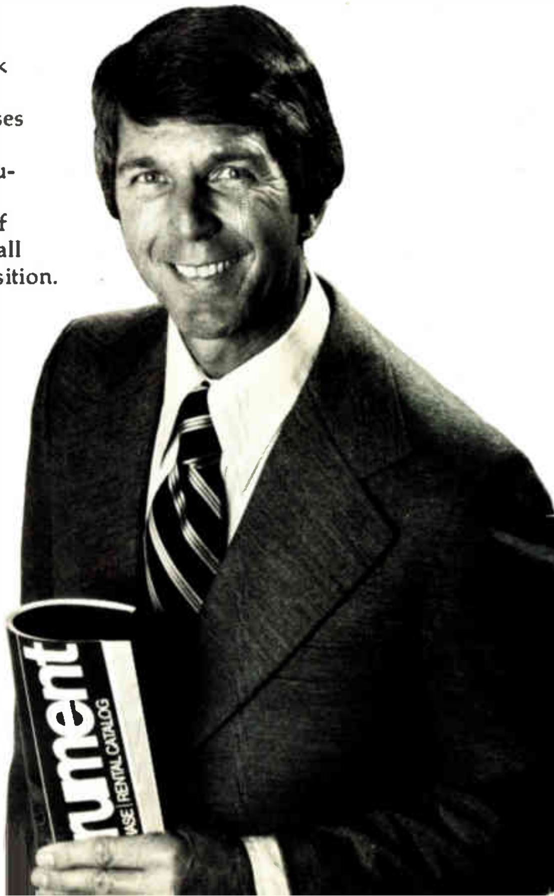
The control PROM's address is now composed of the S_0–S_7 address lines, the multiplexer, and the other CVs. Once again, the data at this location represents a state. The multiplexer-select bits, preprogrammed into the decode PROM, are used as for address of the multiplexer. These steer the selected CVs (B, C, D, E, or F) into the control PROM.

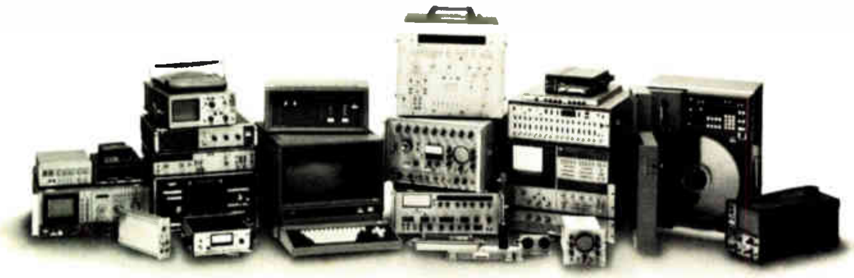
A high-speed version

In many applications a system must operate at very high speeds or a complex algorithm must be sequenced in a very short period of time. A technique called pipelining helps to satisfy this requirement by removing one level of delay between the state and the generation of the micro commands. It does so by moving the decode PROM to the control PROM position, as Fig. 5 illustrates.

Such a system no longer needs to wait until after the control PROM has entered the next state to decode the micro commands. They are now decoded in the previous state and are enabled at the same time the system goes into the next state. The only penalty is in the size of the decode PROM, which must now have as many locations as the control PROM.

The PROM micro controller is already an attractive alternative to a microprocessor, a programmable logic array, or J-K flip-flop controller. It will soon become still more attractive, with the availability of large-scale integrated circuits containing multiplexer, PROMs, and storage register on a single chip. □





Fast electrical test monitors chip-package bond quality

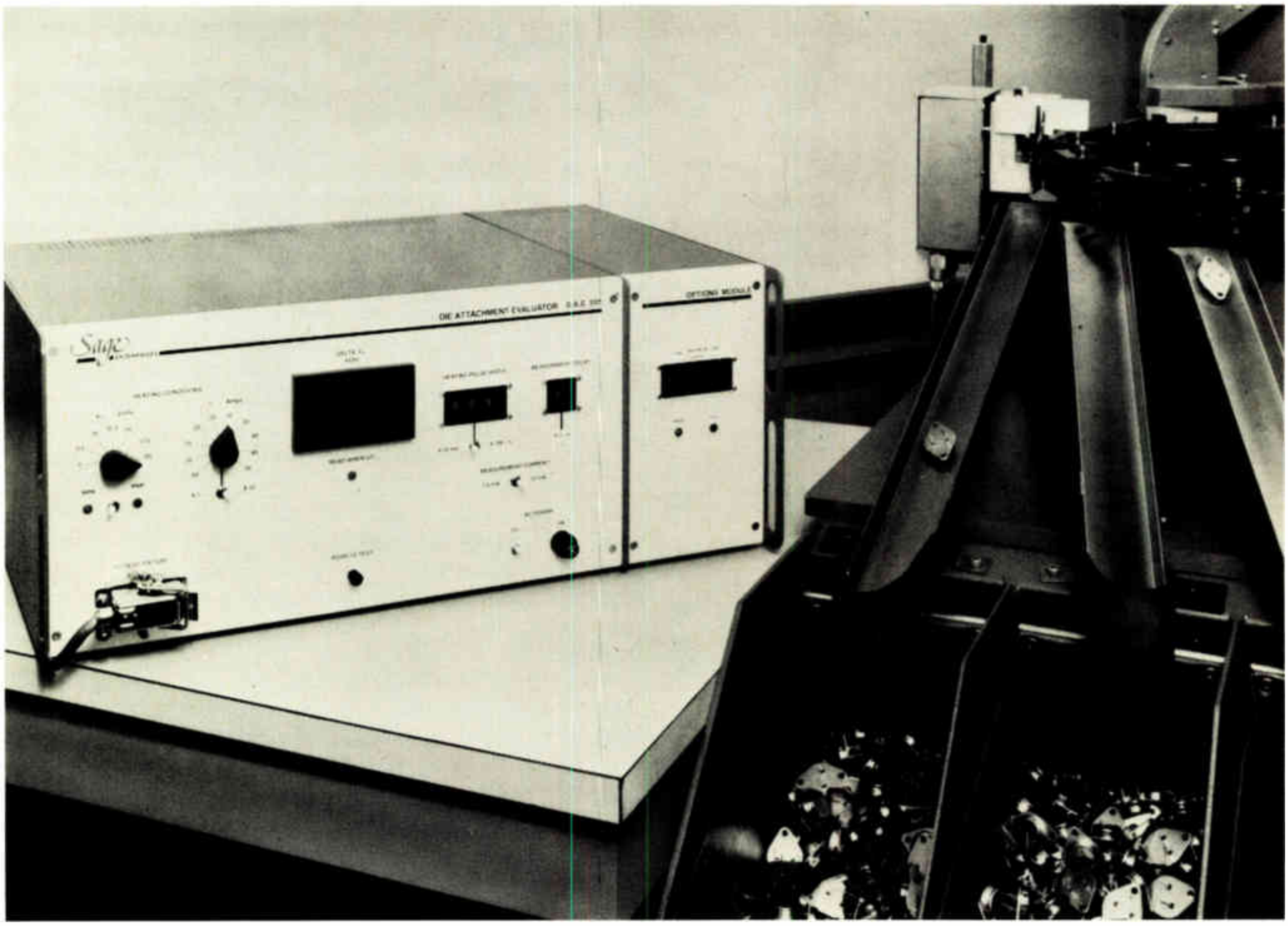
Quantitative technique checks heat flow from chip to mounting surface—a crucial performance and reliability factor

by Bernard S. Siegel, *Sage Enterprises Inc., Mountain View, Calif.*

□ The most critical heat-conductive link between a semiconductor chip and the outside world is the die attachment—the physical bond between the silicon and the package or header it is mounted on. Any gaps or voids between the chip and its mounting surface raise the junction temperatures in its active area and therefore degrade its parametric and functional performance. A mere 10°C rise in operating temperature can double a transistor's bias-current requirements and halve the life expectancy of a sensitive operational amplifier.

Clearly, any production quality control effort should include an accurate check of die attachment quality. A quantitative bond-quality specification would be very useful to potential users of a device in determining if it will meet performance and reliability requirements and in comparing different vendors' parts.

A number of bond quality evaluation techniques have been used in the past ("The hard way to judge bond quality," p. 142). But none of these has all the properties desirable for such a procedure: simplicity, speed, nonde-



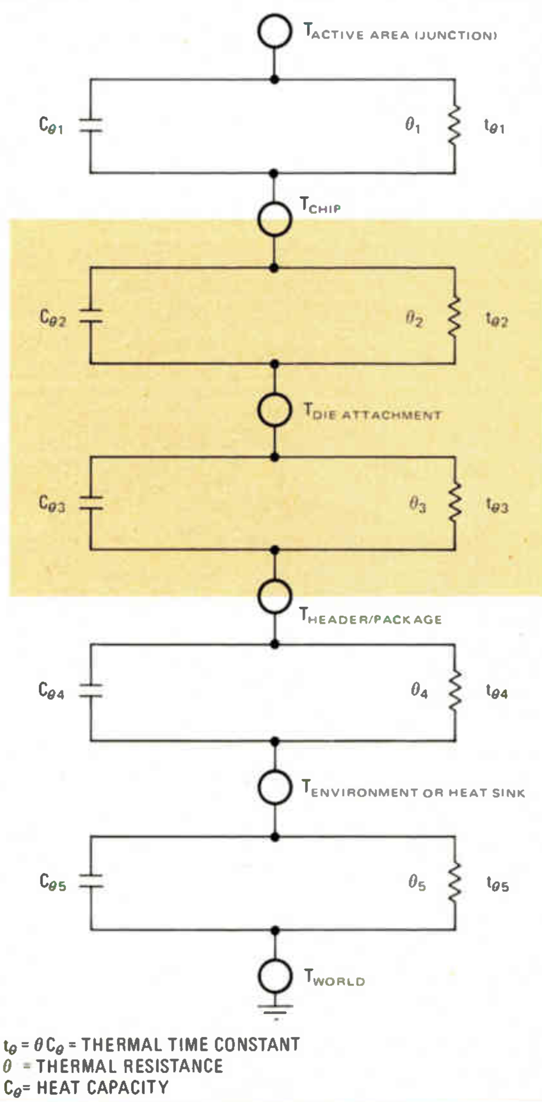
1. Chip checker. With the help of an automatic device handler, a die-attachment evaluator can test and sort up to 12,000 devices like these TO-3 power transistors in one hour. Photo is courtesy of Fairchild Camera and Instrument Corp.

The hard way to judge bond quality

The oldest method of evaluating the quality of a bond between a chip and its package is simple but destructive: the chip is physically sheared from its header or package. Examination of the mounting surface reveals how well the chip was attached. This method has three strikes against it: it's destructive, time-consuming, and non-quantitative.

Two newer, nondestructive techniques are X-ray examination and thermal resistance testing. In the former, the cross-sectional area where the chip meets its mounting surface is X-rayed. A trained operator examines the picture for shaded areas representing voids between chip and mounting surface. The approximate percentage of total mounting area that appears shaded becomes the assembled device's effective void area number. That number and the void locations are considered in the judgment of bond integrity. Although this method is nondestructive, it is expensive, time-consuming, and qualitative; it is also unsuitable for certain types of metallic chip-package combinations.

Thermal resistance testing [*Electronics*, July 6, 1978, p. 121] is nondestructive and quantitative, but very time-consuming and relatively insensitive. The technique measures the total thermal resistance between the chip's active area and the environment under steady-state thermal conditions—which may take 10 minutes to establish under ambient-air conditions. Thermal resistance testing is a good indicator of heat-transfer efficiency between a packaged chip and, say, a heat sink, but it is too slow and insensitive to track the rapid flow of heat from an operating chip to its package. Moreover, it yields absolute values of bond quality, which may be useful to designers but are of little value during testing of hundreds of devices.



2. Thermal-equivalent circuit. The simplified electronic analog of the flow of heat from a semiconductor device to the outside world is a series of resistors and capacitors in parallel. For transient conditions, both are important.

structiveness, and the ability to yield a pass/fail judgment of bond integrity.

A new technique called electrically induced thermal transient testing finally brings all these properties to the job. The method is embodied in a stand-alone instrument, dubbed the die-attachment evaluator (Fig. 1), that can examine the bond between a semiconductor and its package in milliseconds. A proportional numeric display indicates bond quality.

Heat versus time

The principle of electrically induced thermal transient testing relies on the following two properties of packaged semiconductors:

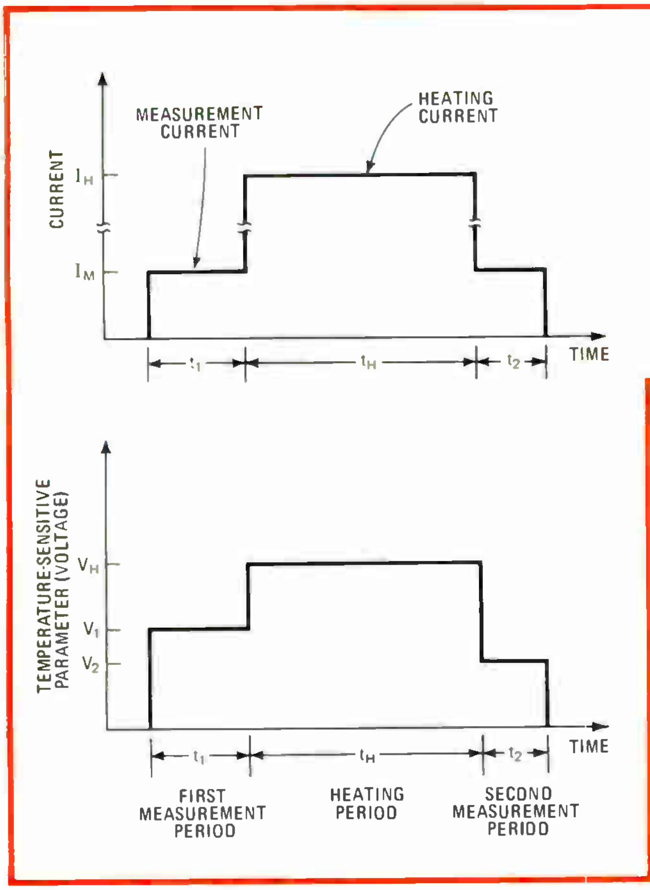
- Every semiconductor device has at least one electrical parameter that varies linearly with junction temperature. If this temperature-sensitive parameter (TSP) is measured before and after the device is heated, its change in value indicates how well the chip dissipates heat from its active area through the package to the environment. The smaller the change in the TSP, the better the bond.
- The thermal time constants of the various components that comprise an assembled semiconductor device—chip, substrate, and package—typically differ from one another by at least an order of magnitude. Figure 2 is an electronic analog of the path of heat flow from a chip's active area to the outside world. Each section has a thermal time constant t_θ equal to the product of its thermal resistance θ and heat capacity C_θ, which respond to heat just as electrical resistors and capacitors respond to electrons.

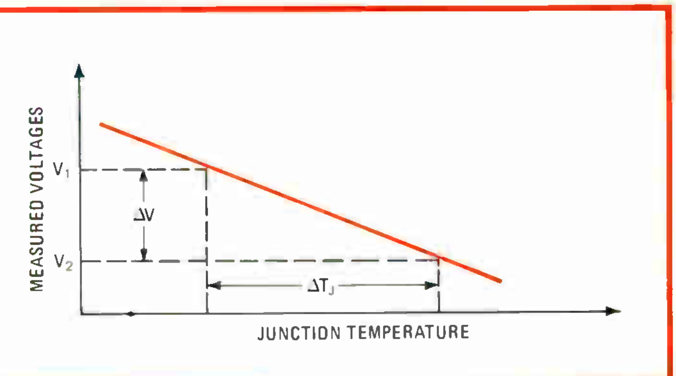
In thermal resistance testing, the active area is heated electrically for a relatively long time—longer than the sum of $t_{\theta 1}$, $t_{\theta 2}$, $t_{\theta 3}$, and $t_{\theta 4}$—to establish thermal equilibrium. When thermal equilibrium is reached, the heat capacities no longer affect the flow of heat; the thermal resistance value obtained is the sum of the θs and indicates the integrity of the entire series of bonds between active area and environment.

The large differences in time constants between sections allow individual sections to be heated selectively by applying heat for controlled durations. Thermal tran-

TEMPERATURE-SENSITIVE PARAMETERS AND TYPICAL TEST CONDITIONS		
Device type	Parameter voltage	Typical test condidtions
Bipolar transistors	base-emitter	$V_H = V_{CE}$
		$I_M = I_E$ = 1 mA for $I_H \leqslant$ 250 mA
		= 10 mA for 250 mA $\leqslant I_H \leqslant$ 5A
Gunn diodes	low-field	I_M = 30–50 mA for $I_H \leqslant$ 0.8A
		= 100 mA for $I_H \geqslant$ 0.8A
Impatt diodes	reverse	I_M = 1 mA
Schottky, pn, varactor and p-i-n diodes	forward	I_M = 1–10 mA for $I_H \leqslant$ 5A
		= 100 mA for $I_H \geqslant$ 5A
Integrated circuits	forward	I_M = 1 mA, on substrate-isolation diode
JFETs	gate-source (forward-biased)	I_M = 0.1–1 mA; V_{DS} = 0
MOSFETs	drain-body	I_M = 1–10 mA; V_{GS} = 0 or depletion voltage

I_H = heating current
I_M = measurement current
V_H = heating voltage
V_{GS} = gate-source voltage
V_{CE} = collector-emitter voltage





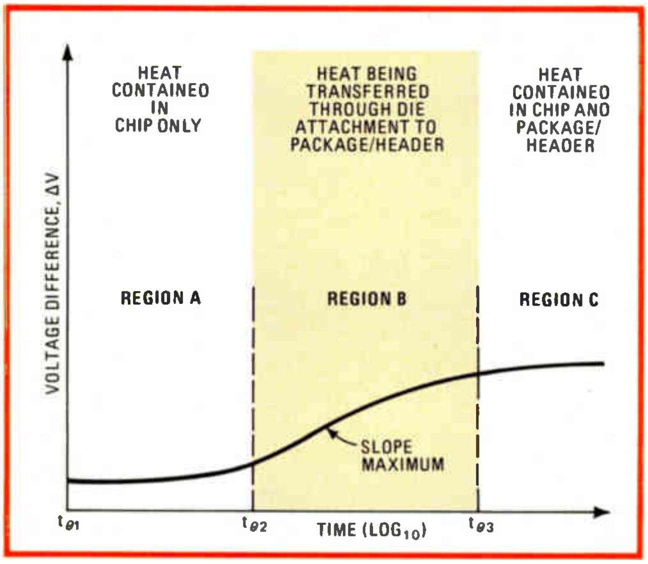
3. Temperature-sensitive. Powering a pn junction diode at I_M, then I_H, and then back to I_M changes the value of V_F from V_1 to V_2. The difference, ΔV, is proportional to the rise in junction temperature ΔT_J. This proportionality remains fairly constant for one device type.

sient testing, therefore, uses a chip's transient thermal behavior to measure the quality of individual bonds between sections. The behavior of the die attachment is of particular interest. If heat is applied just long enough for it to reach the die attachment—longer than $t_{\theta 1} + t_{\theta 2}$, but shorter than $t_{\theta 1} + t_{\theta 2} + t_{\theta 3}$—the measured change in the value of the TSP indicates how well the chip dissipates heat to that point.

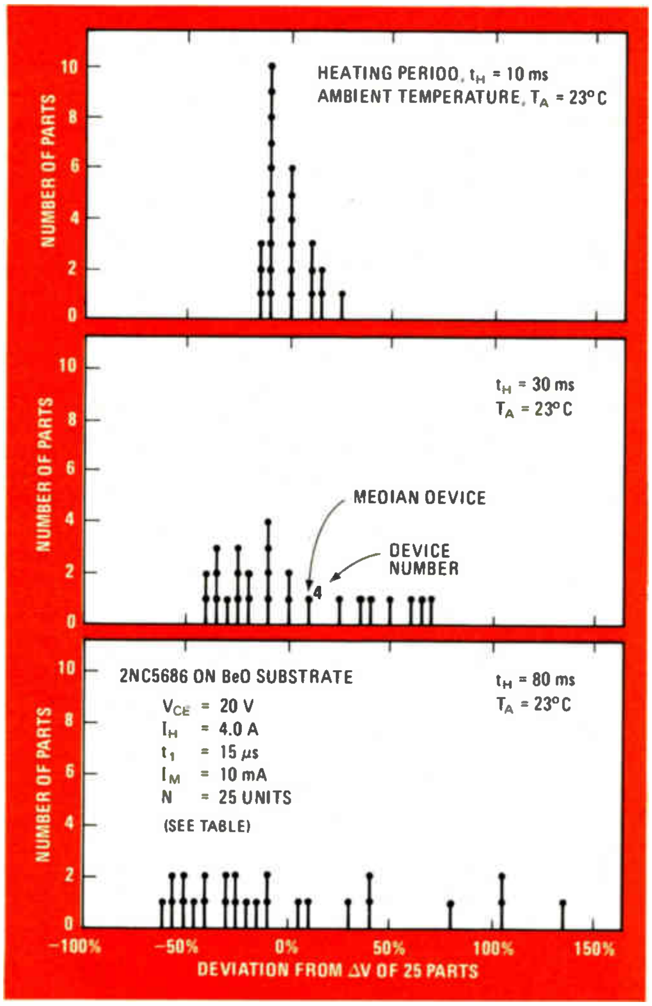
Implementing the concept

A thermal transient test of a chip-to-package bond is a three-step procedure: initial measurement of the TSP voltage, application of heat of specific amplitude and duration, and a second measurement of the TSP. The difference between the TSP values, ΔV, is proportional to the change in junction temperature, ΔT_J, resulting from the applied heat. ΔV is therefore a measure of die attachment integrity. Table 1 lists TSPs for various semiconductor devices.

The table also lists typical measurement conditions for



4. Heating up. Semilog plot of ΔV against time from 1 millisecond to 1 second shows that the rate of heat flow between sections of a packaged semiconductor is not uniform. The optimum heating time should correspond to a slope maximum of the curve in region B.



5. The median is the message. These plots show the range of deviations in ΔV_{BE} from the average ΔV of 25 chips. The median device is chip 4. In the lower plot, data skews to the right since the ΔVs of well-bonded chips approach 0 (−60% deviation).

the parts. Most important is I_M, the measurement current. As shown in Fig. 3, I_M is applied for time t_1—just long enough to measure the TSP. The tabulated amplitudes of I_M reflect the rule of thumb that I_M should be roughly one fiftieth the heating current I_H to avoid heating the part during the first test step.

Figure 3 shows typical test waveforms for a pn junction diode, obtained as follows: first, I_M is applied for t_1. The TSP, in this case the diode's forward voltage drop V_F, is measured and called V_1. Then the current is raised to the heating value I_H for heating time t_H. During t_H the diode receives and dissipates heat, and the value of the TSP changes. At the end of the heating period, the TSP is measured again during t_2 and called V_2. V_1 minus V_2 equals ΔV, which is used to judge the integrity of die attachment.

The heating time t_H must be chosen carefully to maximize the test's sensitivity to voids in the die attachment. The simplest way to optimize t_H is to choose a typical part in the lot and test it at several different heating times, plotting the results against t_H, as in Fig. 4. Heat transfer between sections of the packaged device occurs at slope maxima of the curve, since the thermal capacities appear as short circuits when heat first reaches each section. For maximum sensitivity to voids between the chip and the substrate, the optimum value of t_H is at the slope maximum of the curve, which is usually midway through region B.

To demonstrate the effectiveness of the test, the mounting surfaces of 25 bipolar power transistor chips were selectively etched to produce voids ranging from 0% to 50% of the total mounting area. The die attachment evaluator, a D.A.E. 205 (built by Sage Enterprises Inc., Mountain View, Calif.), was connected to each device through a special Kelvin contact fixture.

Fixure 5 shows the results of testing the chips at three values of t_H. The plots are frequency distributions versus ΔV: the number of parts that yielded various values of ΔV at the three heating times. Each plot's horizontal axis represents deviations in ΔV from the average value for the 25 parts. From the middle plot, device number 4 was chosen as the median part and then tested over a range of t_H values to obtain a curve similar to Fig. 4. For this part, the optimum value of t_H is in the 30- to 80-millisecond range.

Once t_H is chosen, an entire lot can be compared to the median part. Those parts with ΔV values greater than that of the median part by more than the statistical standard deviation of a multi-part sample can be rejected. The ΔV deviation limit can be correlated to other test methods for greater accuracy.

This procedure would be relatively useless if the ΔV measurement for the median device could not be compared to those of other devices as a measure of the rise in junction temperature upon heating. Although the absolute values of V_1 and V_2 at given values of T_J vary for large numbers of devices of the same type, fortunately the relationship between ΔV and ΔT_J seldom does. Thus, devices from several production runs can be compared to a typical device using the same value of t_H. Should a change occur in the relationship between ΔV and ΔT_J, the ΔV limit may be scaled up or down. □

Circle 144 for Literature

Circle 145 for Demonstration

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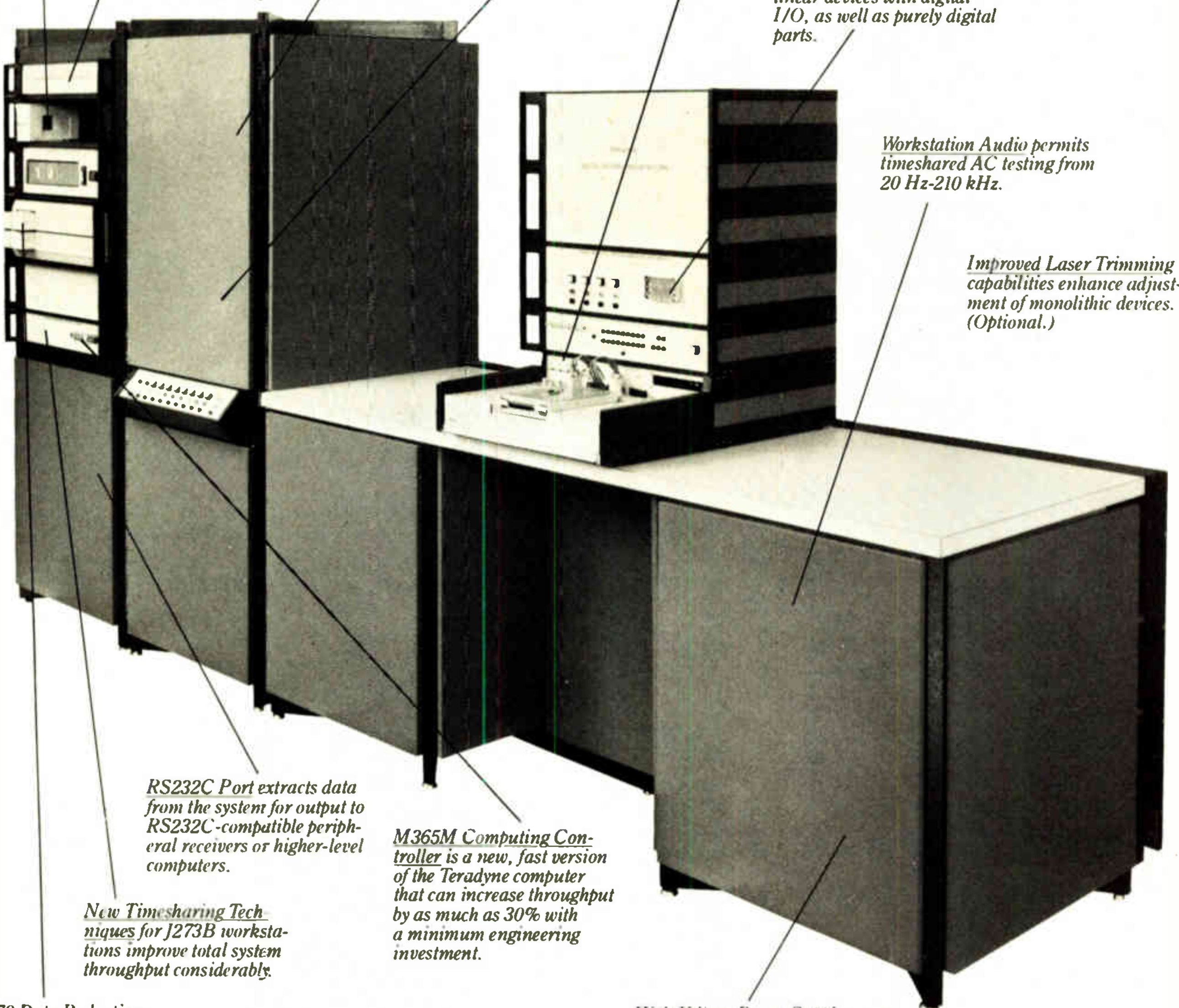

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Circle 147 on reader service card

Discriminator computes frequency differential

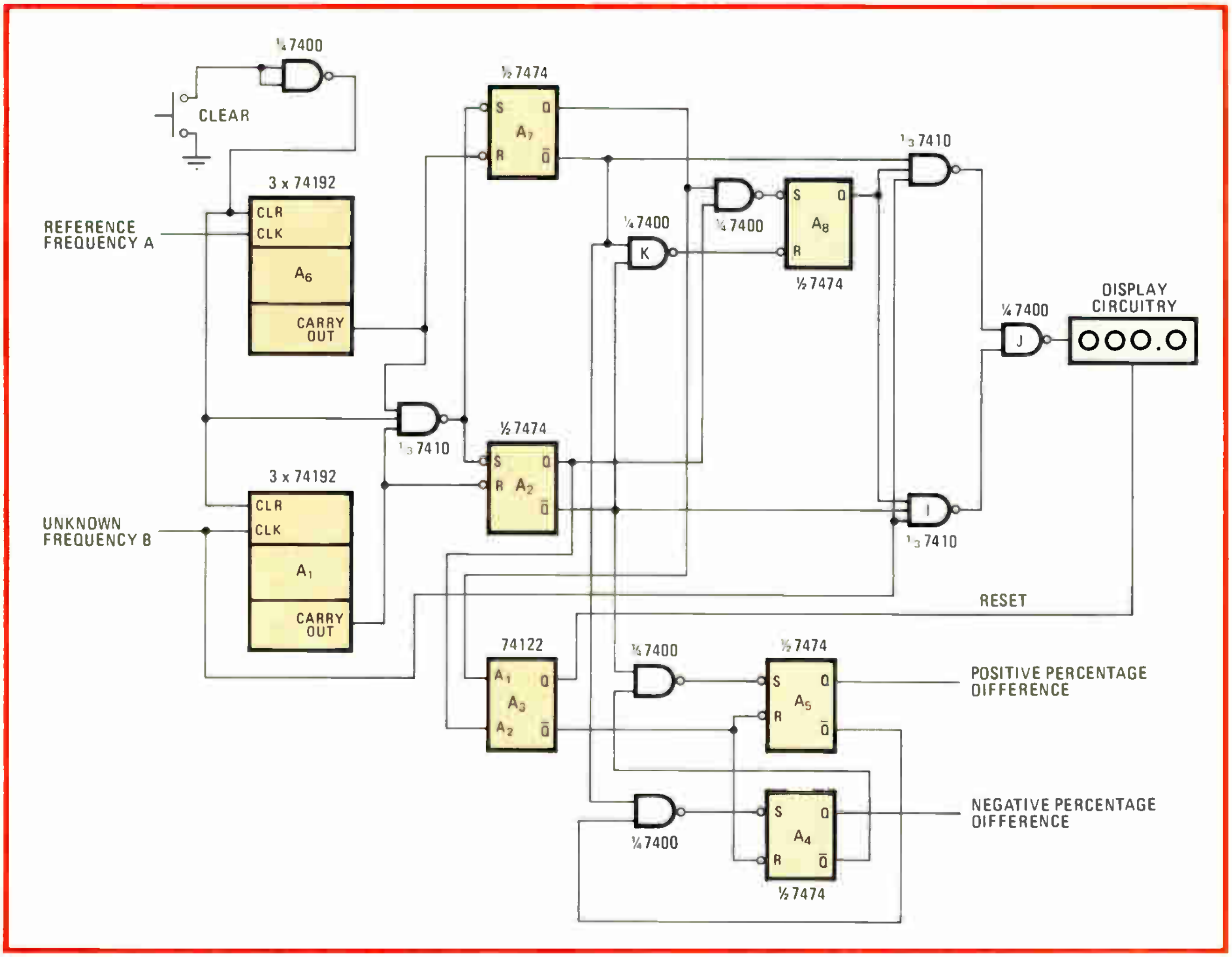
by T. J. John
Meerut, Uttar Pradesh, India

This circuit computes the percent difference of two frequencies to 0.1% without needing an accurate, crystal-controlled timebase. It is useful in industrial applications that convert a process variable into a train of pulses in order to monitor that unknown quantity.

The circuit finds $\pm d = 100(p_x - p_r)/p_r$, where d is the percent difference, and p_x and p_r are the number of pulses counted from an unknown and a reference source, respectively, in a given time. By making p_r equal to a decade multiplier of 10^n for any general n, the first equation becomes $\pm d = (p_x - 10^n)(10^{2-n})$, where $p_x - 10^n$ is the difference between the number of pulses generated by the unknown source and the 10^n pulses generated by the reference, and 10^{2-n} indicates the position of the decimal point. Thus the equation is reduced to a form where it can be solved in hardware with off-the-shelf logic elements.

Note that for an accuracy of 0.1%, the value of n must be 3. Therefore, three cascaded decade counters must be used at each input for counting up to 10^3 = 1,000, as shown in the figure.

A system clear initializes the counters to 0 and presets several circuit flip-flops. The carry output of the last 74192 in each chain then generates a negative-going pulse each time it counts to 1,000. Assuming a positive difference between unknown frequency B and reference frequency A, A_1 reaches 1,000 first and resets flip-flop A_2. A_2's $\overline{Q}$ output then fires one-shot A_3, whose on-time must be small compared to the period of the unknown



Comparison. The circuit for finding ± (A − B)/A, in percent, needs no frequency standard and it can be built with standard logic elements. Results are directly displayed. Accuracy of measurement is 0.1%, obtained by using three cascaded decade counters at each input.

frequency measured. Flip-flops A_4 and A_5, the polarity-difference indicators, are then reset.

The preceding actions permit the 1,001st pulse counted by A_1 to be passed directly from the input to the display-counting circuit through enabled gates I and J. For each pulse appearing at the output of J, the counter is advanced by 1, starting from the least significant bit displayed. When the reference-frequency counter, A_6, reaches 1,000, A_7 is reset. A_8 in turn is reset through gate K and gate I is disabled. At that time, the display will directly indicate the magnitude of the difference between frequencies A and B, in percent. Because A_1 reaches 1,000 before A_2, A_5 is set and will indicate there exists a positive frequency difference between B and A.

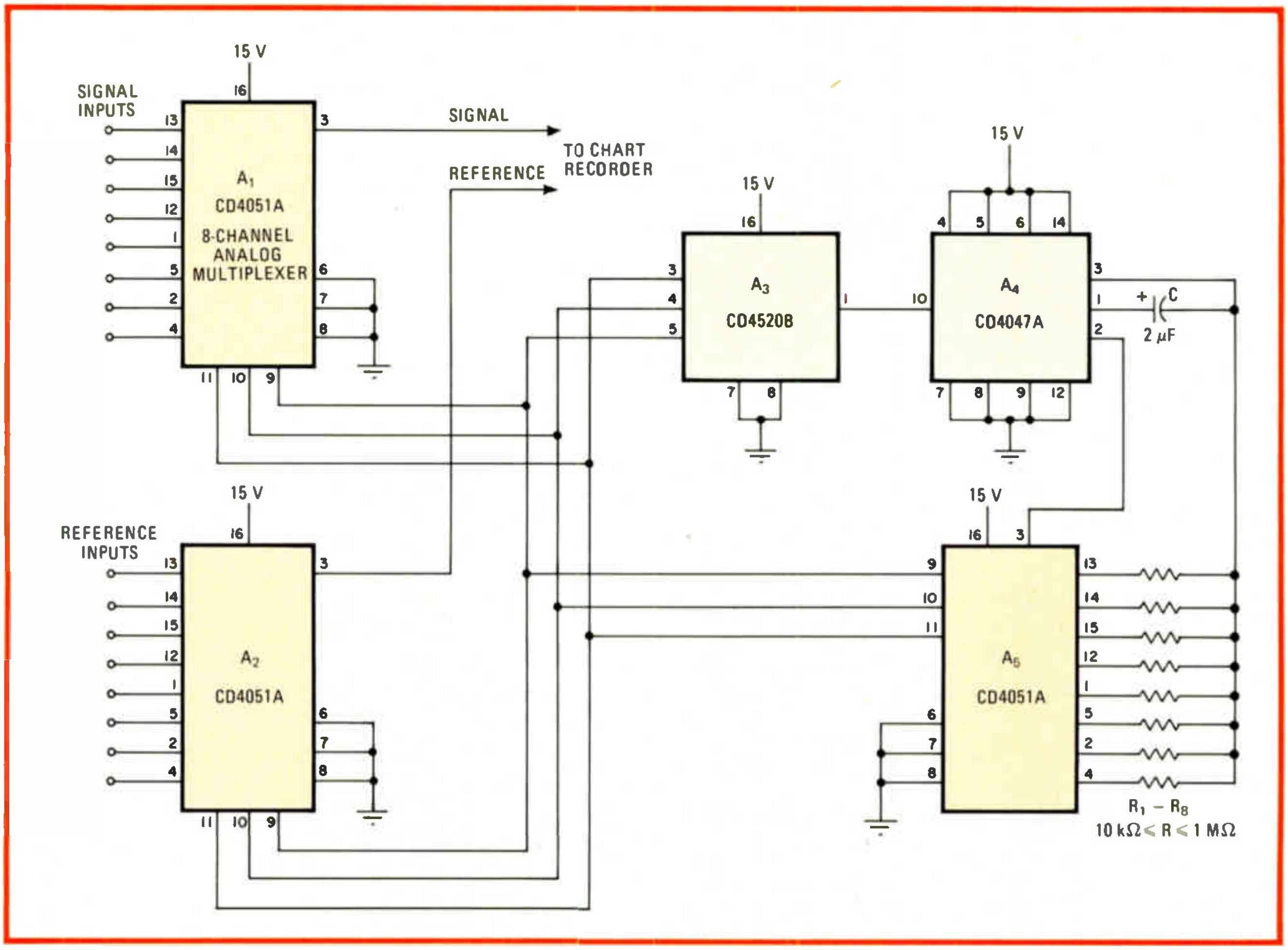
In the event a negative percentage difference is measured, A_2 reaches 1,000 first. A sequence of events similar to those discussed previously then occurs, but with the upper portion of the circuit becoming active first, and with the end result that the negative-difference indicator, A_4, is set. □

8-channel scanner multiplexes data for strip-chart recorder

by James M. Palmer,
Optical Sciences Center, University of Arizona, Tucson

Using low-power analog multiplexers, this circuit converts a single-channel strip chart recorder into one that can handle up to eight lines of data. The dwell time between channels is selectable. Excluding the cost of the power supply, the circuit can be put together for an outlay of less than $25.

A_1 and A_2 are configured as an eight-channel differential multiplexer stepped by a dual binary counter, A_3,



Scanning. Circuit multiplexes eight data channels applied to A_1 onto single-channel strip chart recorder. Reference-voltage inputs at A_2 position trace at different levels on chart. A_3, A_4, and A_5 sample channels in sequence. R_1 to R_8 set dwell time between channels.

and an astable multivibrator, A_4. Each signal to be multiplexed by A_1 is positioned appropriately on the strip chart by the corresponding reference voltage applied to A_2. The circuit's supply voltage is 15 V, so input voltages to A_1 and A_2 may range from 0 to 12; if bipolar signals in the range of −5 to +5 V are to be multiplexed, the circuit will require supply voltages of ±7.5 V.

Multiplexer A_5, which is also stepped, places resistors R_1 through R_8 in sequence in the timing network of A_4. As A_3 counts, A_1, A_2, and A_5 are advanced. Thus, the feedback loop formed by A_3, A_4, and A_5 automatically sets the monitoring time for each input channel, which is equal to $4.4R_iC$. Unwanted channels can be virtually skipped by using the minimum value required for R_i (10 kilohms), in which case the record time for that particular channel will be less than 0.1 second.

Several modifications can be implemented for increased circuit versatility. The circuit can be expanded to scan 16 channels by adding three additional multiplexers (two for channel selection, one for timing). If the multiplexing rate is slow, output voltages can also be measured with a digital voltmeter. Here, the output of A_4 is used to fire a second one-shot, thereby producing a trigger pulse for the voltmeter.

Finally, with the addition of a few resistors and switches, any channel can be randomly selected by jamming A_3's outputs. □

Reducing a PLL's even-order harmonics

by R. P. Leck
Bell Laboratories, Crawford Hill, Holmdel, N. J.

In contrast to the clean output they produce when operated in their fundamental mode, phase-locked loops generate even-order harmonics of the input frequency and excessive sideband noise when used in frequency-divider or frequency-multiplier circuits. The spurious responses may be reduced, however, by adding an extra break or corner frequency to the PLL's low-pass filter response, in order to reduce the modulation index at the input to the loop's voltage-controlled oscillator.

A block diagram of a typical PLL frequency multiplier is shown in (a). Detector A_1 compares the phase of the input signal, f_1, with the phase of the divided-down VCO signal. Thus A_1 generates a voltage proportional to the phase difference between its inputs. After passing through low-pass filter A_2, the signal is applied to the VCO, A_3, so altering its output frequency f_2 that the phase difference between f_2 and f_1 is minimized. The loop is in the so-called locked state when f_1 equals f_2 in frequency and phase.

As a result of placing divider N in the loop to make the PLL operate as a frequency multiplier, the output of the phase detector and thus the loop, which is picked off at A_3, also contains unwanted harmonics of f_1. The amount of sideband noise on each carrier signal, which is an indication of the modulation index (a relation too cumbersome to derive for most waveforms), is given by:

$$\theta_0(s) = NK_0F(s)V_d/s$$

where F(s) is the transfer function of the loop's low-pass filter, V_d is A_1's output voltage, and K_0 is the voltage-to-frequency control constant of A_3. So, by reducing the numerical value of F(s), $\theta(s)$ and the modulation index fall and harmonics are also reduced.

The transfer function of the active loop filter typically used in PLL circuits (b) is $F_2(s) = (s\tau_2+1)/s\tau_1$, where $\tau_1 = R_1C$ and $\tau_2 = R_2C$. By adding capacitor C′ across R_2 as shown in (c), the second-order filter previously shown is made a third-order network, whose transfer function is given by $F_3(s) = (s\tau + s\tau_3 + 1)/(s^2\tau_1\tau_3 + s\tau_1)$, where $\tau_3 = R_2C'$.

Note the corresponding curves of the filter's open-loop response. If the unwanted harmonics in question are all above the added pole frequency, $1/2\pi\tau_3$, they will be attenuated because the magnitude of $F_3(s)$ will be less than that of $F_2(s)$. At ω_{2f} in (b), there is no additional suppression beyond that which exists as a result of the integrating effects of the VCO and its low-pass filter. The attenuation is increased with the addition of C′ as shown in (c).

Adding C′ creates a network that, under some conditions, can be unstable. However, as long as the open-loop gain of the originally stable second-order loop is unchanged after C′ is added, and the slope at which the loop's log-magnitude plot crosses the unity-gain axis does not exceed −40 decibels per decade, there will be no problem. Both of these conditions are normally found in practice.

Adding the additional break point affects the network's damping factor, δ, and the system bandwidth, B, two of the most important parameters of interest in designing a loop filter. The effects of damping start to become noticeable when τ_3 starts to move down from infinity to $\tau_2/30$. It should be understood that with a reduction in harmonic output also comes a decrease in the range over which the PLL will operate.

As an example of how to design a filter network, consider the case where a PLL multiplier is to be scaled to generate a frequency f_{out} equal to $(108/109)f_{in}$, having a damping factor of 1.2 and a bandwidth of 100 hertz. Thus the VCO is made to multiply f_{in} by 108, and a divider is used to provide N = 109. Along with the initial considerations, an additional requirement is to suppress the sidebands at the divider output by 50 dB. This corresponds to a phase jitter of 0.4°.

A standard second-order filter design can meet the damping and bandwidth criteria, but a third-order filter is required to meet the sideband suppression and phase jitter requirements.

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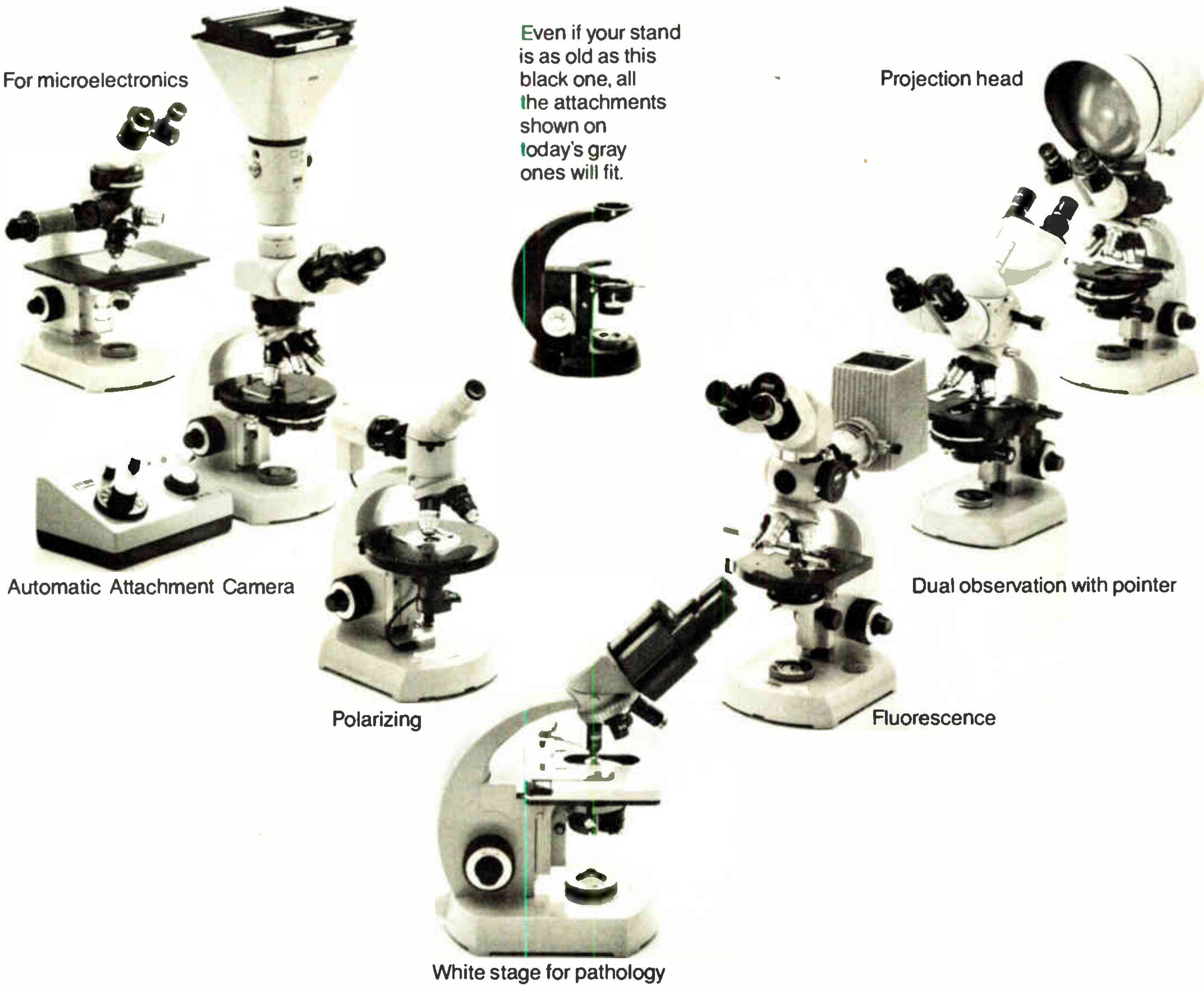
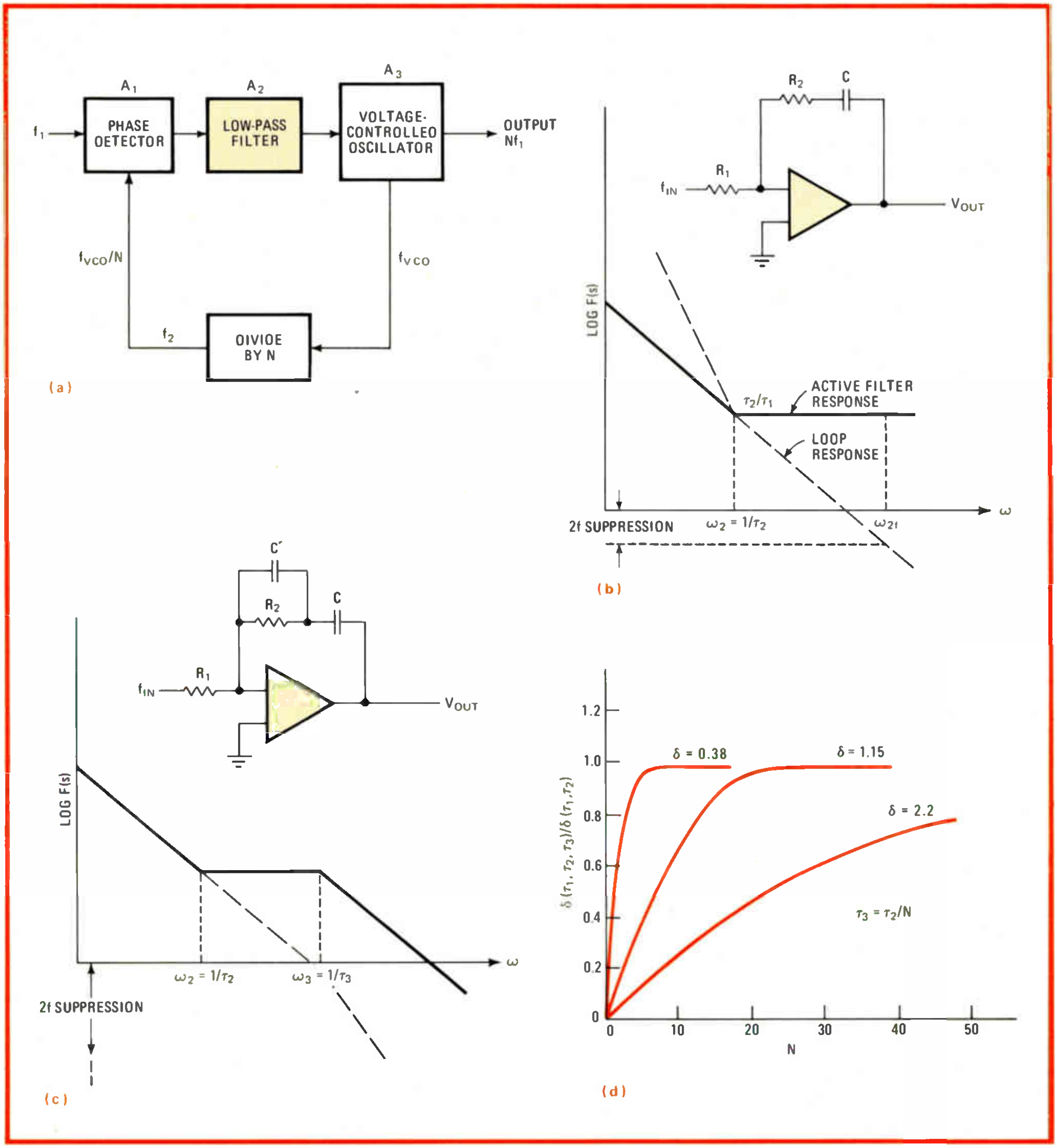


first-order sidebands at least 10 dB, if the sidebands at the output of the divide-by-109 unit are to be at least 50 dB below the peak output voltage. By using the well-known two-pole RC filter equations (this discussion assumes familiarity with the design procedures of basic PLL filters), and setting δ to 2.2 and B to 100 Hz to get V_0 = 10 dB below V_d, it is found that $\tau_1 = 6.7(10^{-2})$ and $\tau_2 = 5.09(10^{-2})$. R_1, R_2, and C can then be appropriately selected.

From (d), an experimental curve generated for use in designing the three-pole filter, it is found that an *equivalent* second-order damping factor of 1.1 is obtained for such a loop when N = 21.2 and $\tau_3 = \tau_2/N = 2.5(10^{-3})$. Thus $C' = \tau_3/R_2 = 0.5$ microfarad if R_2 = 50 kilohms, a typical value of resistance. □

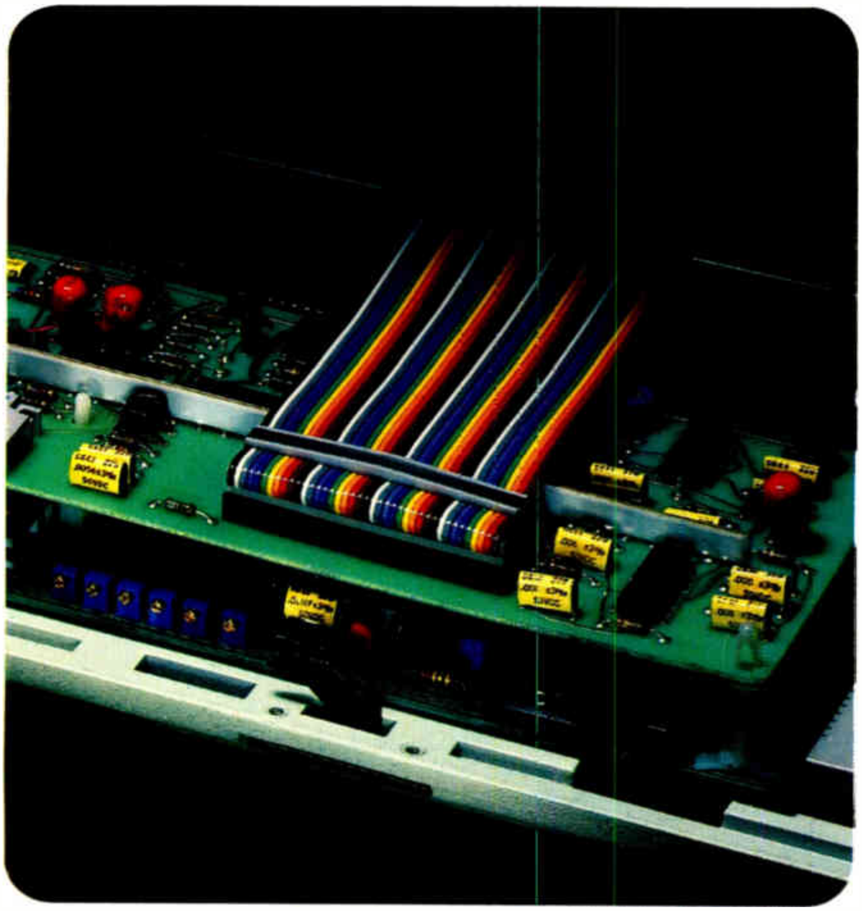
Engineer's notebook is a regular feature in *Electronics*. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.

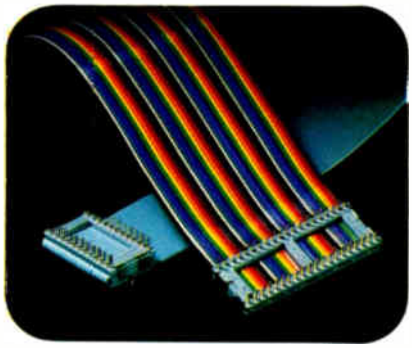


Break point. Phase-locked loop (a) generates spurious energy when used in frequency-multiplying circuits. Low-pass filter (b) cannot provide sufficient input frequency harmonic suppression. Capacitor C′ (c) adds break or corner frequency to filter response, enables increased rejection of even-order harmonics. Effects of τ_3 on equivalent second-order damping are plotted (d) to aid in design example discussed in text.

Need 24 or 40-pin DIP's off the shelf?

We're your source.





Want the speed, savings and reliability of mass termination with larger size D.I.P. connectors? Come to 3M. Our Scotchflex brand D.I.P. connectors in 24 and 40-contact sizes let you design quick, easy interboard jumpering with readily available parts. Their space-saving low-profile design makes them ideal for microprocessor applications. They also speed and simplify test jumpering or checkout of I.C. sockets.

Both connectors have .100″ x .600″ grid spacing and are available with either rectangular legs for use with standard I.C. sockets or round legs for use with high density packaging panels. They may be used with Scotchflex shielded, non-shielded or color-coded flat cable or with twisted pair or parallel lay woven cable.

Where frequent plugging and unplugging is necessary, strain relief bars and pull tabs are available for all Scotchflex D.I.P. connectors including 14 and 16-pin sizes.

Need some more ways to simplify wiring and increase circuit density? 3M's Scotchflex line offers you the widest choice of mass terminating cable, connectors and system components to accommodate your design packages. Plus proven reliability. Off-the-shelf availability. And the unmatched experience of the people who pioneered the concept of electronic mass termination.

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Engineer's newsletter

Timer halves keys needed for repeat commands

When used as an oscillator, the 555 timer has an annoying characteristic—the first pulse generated after the reset (inhibit) port has been disabled has double the length of those that follow. Robert Dougherty of Dunedin, Fla., turns this drawback into an advantage in a one-chip circuit for the repeat key function on computer keyboards.

Generally, a keyboard's repeat key must be depressed at the same time as the key whose data is to be retransmitted at some specified rate. **Dougherty's circuit makes every key its own repeat key.** Simply wire the timer as an astable multivibrator, connect its output to the appropriate transmit line, and tie its reset terminal to the normally low keyboard bus (key valid line).

The timer's abnormally long first pulse gives the user enough time to react and terminate a call when he doesn't want the repeat function. When he does want it, he must make a very conscious effort to hold a key down long enough for the second pulse to occur. Even with a transmission rate of 8 hertz, there are 250 milliseconds in which to strike and release a key before multiple repeats are generated.

Phaseless measurements don't faze reflectometers

When it comes to performing complete parameter checks on elements operated in the microwave region, the new six-port reflectometers don't come close to network analyzers in capability. Still, it is possible for an interconnected pair of these recently developed instruments to gauge the element's scattering coefficients by using only the magnitudes of the input and output signals—**measuring phase is not required, provided the reflectometers are properly calibrated.** The National Bureau of Standards recommends a good procedure in "Calibrating Two Six-Port Reflectometers with Only One Impedance Standard," which is to connect the two reflectometers together and then to a calibration circuit consisting of a known and unknown impedance and a leveling loop. Find out more by requesting SD-003-003-01956-9 from the U. S. Printing Office, Superintendent of Documents, Washington, D. C. 20402. The price is $1.60 plus 25% for mailing abroad.

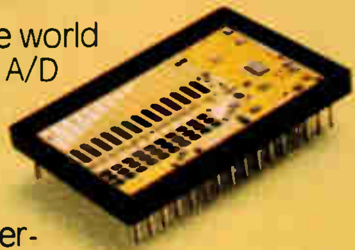
ICS expands its computer training programs

Integrated Computer Systems Inc. of Santa Monica, Calif., has come a long way since 1974, when it introduced a microcomputer home-training program geared to engineers. It will now offer at least ten workshop-type courses nationwide starting in April and running into early August. Most subjects, such as the fundamental-level course 160, "Microprocessor Hands-On Workshop," to course 444, "Spread-Spectrum Communications Systems," are discussed in intensive four-day sessions. Also offered are **courses in small computing systems, troubleshooting microprocessor systems, structured programming, data-base management, distributed processing and computer networks, and computer graphics,** as well as a one-day course in military and aerospace systems and a five-day course in digital signal processing. Each four-day session costs $695, the military and aerospace course is $195, and digital signal processing is $795. For complete schedules and other information, write or call ICS at 3304 Pico Blvd., P. O. Box 5339, Santa Monica 90405, (213) 450-2060, or 300 N. Washington St., Suite 103, Alexandria, Va. 22314, (703) 548-1333.

Vincent Biancomano

COMPUTER LABS TEAMS UP

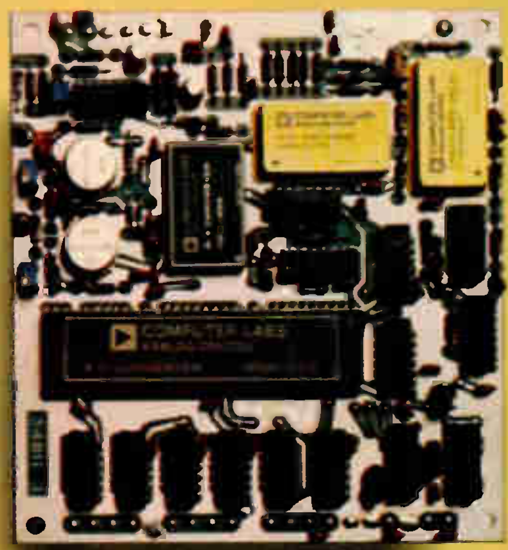
AN ADDED DIMENSION IN MULTI-MHZ A/D AND D/A CONVERTERS.



Computer Labs is the world leader in high speed A/D and D/A data converters. So it makes a lot of sense for Computer Labs to team up with the overall data converter leader, Analog Devices. And this means that all your data converter needs can now be served from a single source—everything from dc to multi-MHz in instruments, modules, hybrids, and monolithics.

Computer Labs puts Analog Devices on a fast track with its design and manufacturing expertise in high speed radar and video data converters and very fast hybrids, 150 products in all. Analog Devices brings its technological and customer support to Computer Labs in terms of sales and service, technical literature and documentation and application engineering. Which adds a new dimension to Computer Labs' wide range of high speed A/D and D/A converters, track and holds, deglitchers, and operational amplifiers in applications like computer interfacing, radar digitizing, digital communications, sonar systems and graphic display.

PRODUCTS LIKE THESE.



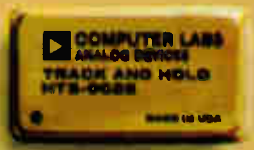
MOD-1005 HIGH SPEED VIDEO A/D CONVERTER

■ 10 bits @ 5-MHz word rate ■ Single PCB construction, only 27 sq. in. ■ Built-in track-and-hold with 25 psec. aperture ■ 20-MHz analog input bandwidth ■ Only 10-Watt power dissipation ■ Signal-to-noise ratio greater than 58 dB ■ Noise power ratio greater than 49 dB ■ Complete and self-contained with integral track-and-hold, encoder, timing circuitry, and output latches ■ Needs only power and encode command ■ 12-bit version available soon.

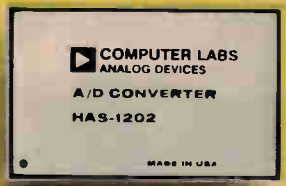
MATV-SERIES VIDEO A/D CONVERTERS

■ 8 bit accuracy, guaranteed monotonic ■ Ultra-high speed, dc to 20 MHz word rate ■ A family of the most economical video A/D's available featuring 11, 16 and 20 MHz word rates ■ All in 5.5" by 4.38" by 0.85" modules ■ Self-contained modules include input buffer, encoder, internal reference, timing circuits and buffered parallel output ■ Needs only power and encode command ■ Ideally suited for digitizing color television at three to four times NTSC or PAL subscriber frequencies as well as video time base corrector and frame synchronizer applications.

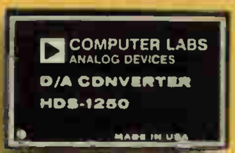
WITH ANALOG DEVICES.



HTS-0025 ULTRA-HIGH SPEED TRACK AND HOLD
■ Ultra-fast aperture of 20 psec. ■ Exceptional 20 nsec. acquisition time ■ Excellent 0.01% linearity ■ Highly reliable hybrid construction ■ Active laser trimming to null dc offset, hold pedestal, and switching transients ■ Hi-Z FET input of 10^{10} ohms ■ High output current can drive 50-ohm load.



HAS-1202 FAST HYBRID A/D CONVERTER
■ 12-bit resolution ■ Exceptional accuracy of 0.012% of F.S. ■ Low power, 1.8 Watts ■ 2.2 μsec. typical conversion time ■ Available in a glass or metal 32-pin DIP ■ Complete and self-contained for adjustment-free operation, no external pots required.



HDS-1250 HIGH SPEED CURRENT OUTPUT D/A CONVERTER
■ Fast 12-bit hybrid microcircuit ■ Ultra-fast settling time, 50 nsec. to 0.025% of F.S. ■ Guaranteed monotonic ■ 0.85 Watt power dissipation ■ Adjustment-free operation, no external pots required ■ Full 10mA output current.

YOU'RE THE WINNER.

With this combined strength, Analog Devices and Computer Labs will continue to lead the industry in data conversion products through the use of innovative circuit designs and advanced processing technologies. Which will lead to industry breakthroughs like monolithic high-speed video A/D converters and a lot more.

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For complete information on the products described here, call Ed Graves at (919) 292-6427. Or write Analog Devices, P.O. Box 280, Norwood, MA 02062.

ANALOG DEVICES

WAY OUT IN FRONT.

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Circle 157 on reader service card

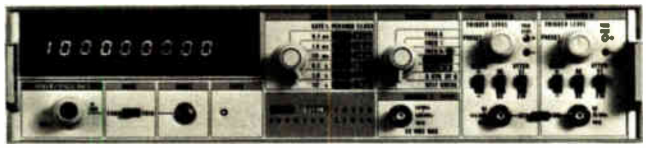
A glance at our counter guide shows how broad a selection you have when you choose the Fluke name.

Pick resolution from six to nine digits, and top-end frequencies from 80-1250 MHz. Notice that all Fluke counters are multi-function, from the frequency/period/totalize capability of the 1900A to the six-function 1953A Universal Counter-Timer. All models have input signal conditioning for reliable readings in the presence of noise, distortion, and ringing, and most have attenuators for increased dynamic range. So for R&D, GENERAL BENCH or PRODUCTION LINE applications, buy exactly what you need over an affordable, performance-effective price range.

For FIELD MAINTENANCE AND SERVICE, most of the line is available with an optional rechargeable battery pack installed inside the compact, portable case. Let autoranging keep the display full at all times for "hands-off" convenience, and rely upon autoreset to eliminate erroneous partial-readings. In the Fluke tradition, they'll take a real field beating, too.

COMMUNICATIONS people find the 1911A through 1925A attractive for VHF/UHF measurements. They're so sensitive that a simple optional whip on the 50-Ohm fuse-protected input makes transmitter checks quick and easy. With automatic clean dropout, you'll always be right because the reading goes to zero with a fading signal. They're RFI-shielded, and TCXO timebases are available for the kind of high accuracy you might need over environmental extremes. And if you choose the 1920A, you can get a resolution multiplier for high-resolution audio measurements.

If you have an ADVANCED BENCH or SYSTEMS application, the 1953A was designed for you. With fully programmable ranges and functions (including trigger level), the 1953A is available with



Fluke 1953A: a name and number to remember for perfection in programmable counter-timers.

IEEE-488 or BCD parallel options, at a price more than $1,000 *less* than the competition's similarly-equipped models.

CALL (800) 426-0361*, TOLL FREE and let us show you how the Fluke name is as meaningful in counters as it has been for other fine test and measurement instrumentation for the last 30 years. It's your assurance you've bought the best, backed by more than 32 service centers in 18 countries, worldwide.

John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, WA 98043. In Europe, contact Fluke (Nederland) B.V., P.O. Box 5053, Tilburg, The Netherlands. Tel. (013) 673973. Telex: 52237.

*Alaska, Hawaii, Washington residents please call (206) 774-2481.

Counter Selection Guide	1900A	1910A	1911A	1912A	1920A	1925A	1952B	1953A
Number of Digits	6	7	7	7	9	9	7/8	9
Frequency (MHz) *Basic Unit*	80	125	250	520	520	125	80	125
Options					1250	520		1250
Period	•	•	•	•		•	•	•
Totalize	•	•	•	•		•	•	•
Time Interval							•	•
Ratio		•*	•*	•*	•*	•*	•	•
A gtd by B							•	•
Sensitivity (mV)	25	15	15	15	15	15	50	30
Trigger Level Control		•	•	•		•	•	•
External Timebase Input		•	•	•	•	•	•	•
Battery Option	•	•	•	•	•			
TCXO Option		•	•	•	•	•	•	•
Ovenized Timebase Option						•		•
DOU Option	•	•	•	•	•	Std		•
Autoreset	•	•	•	•	•	•		
Autorange	•	•	•	•		•		
U.S. Price Basic Model (No Options)	$345	$395	$495	$620	$1095	$750	$995	$1195

*Using external timebase input

Command Performance: Demand Fluke Counters.

FLUKE®

7503-1900S

Circle #158 for literature

Circle #159 for demonstration

MODEL 610D SWEEP GENERATOR
WILTRON COMPANY
MODEL 6247D
SWEEP MODE
SWEEP TIME (SEC)
FREQ SELECTOR
VAR FREQ MARKER
HARMONIC MARKERS
AMPLITUDE
VARIABLE FREQ MARKERS
POWER
The complete sweeper.
It's a Wiltron.

You don't build a complete sweeper after the fact. You build it from the ground up. You build it for automatic measurement. You build it with solid state plug-ins to cover the entire 100 KHz to 40 GHz range. You build it with the options to meet the needs of all users.

You build the Wiltron 610D!

Simply, the best sweeper for automatic testing.

Cover the 10 MHz to 18.5 GHz range in one continuous sweep. No need to stop and change plug-ins or external components. One test set-up using Wiltron's new 10 MHz to 18 GHz SWR Autotester is all you need.

It's clearly the superb system for broadband and high directivity (40 dB) SWR measurements.

Plug-ins for cost effectiveness.

There are 26 RF solid state plug-ins covering single, dual and multiple bands—the only complete line of sequentially swept units. Pick the exact unit you need. All units feature outstanding spectral purity, flatness, and the latest YIG tuned oscillators. The 6247D plug-in sweeps from 10 MHz to 18.5 GHz in one continuous sweep. Others go up to 40 GHz.

Advanced features all the way.

Field proven reliability is so good Wiltron gives you a two-year warranty on the oscillator. The 610D features a selectable Intensity, Video or RF marker. Phase lock to an external standard for crystal controlled accuracy. All plug-ins feature slope control to compensate for cables and connectors. Main frame weighs 18 lbs., plug-ins, 10 lbs. And it's compatible with our new 560 Scalar Network Analyzer as well as the other fellow's. Options include crystal controlled frequency markers, preset frequencies, additional markers and GPIB (IEEE 488-1975).

Excellent service, free field seminars.

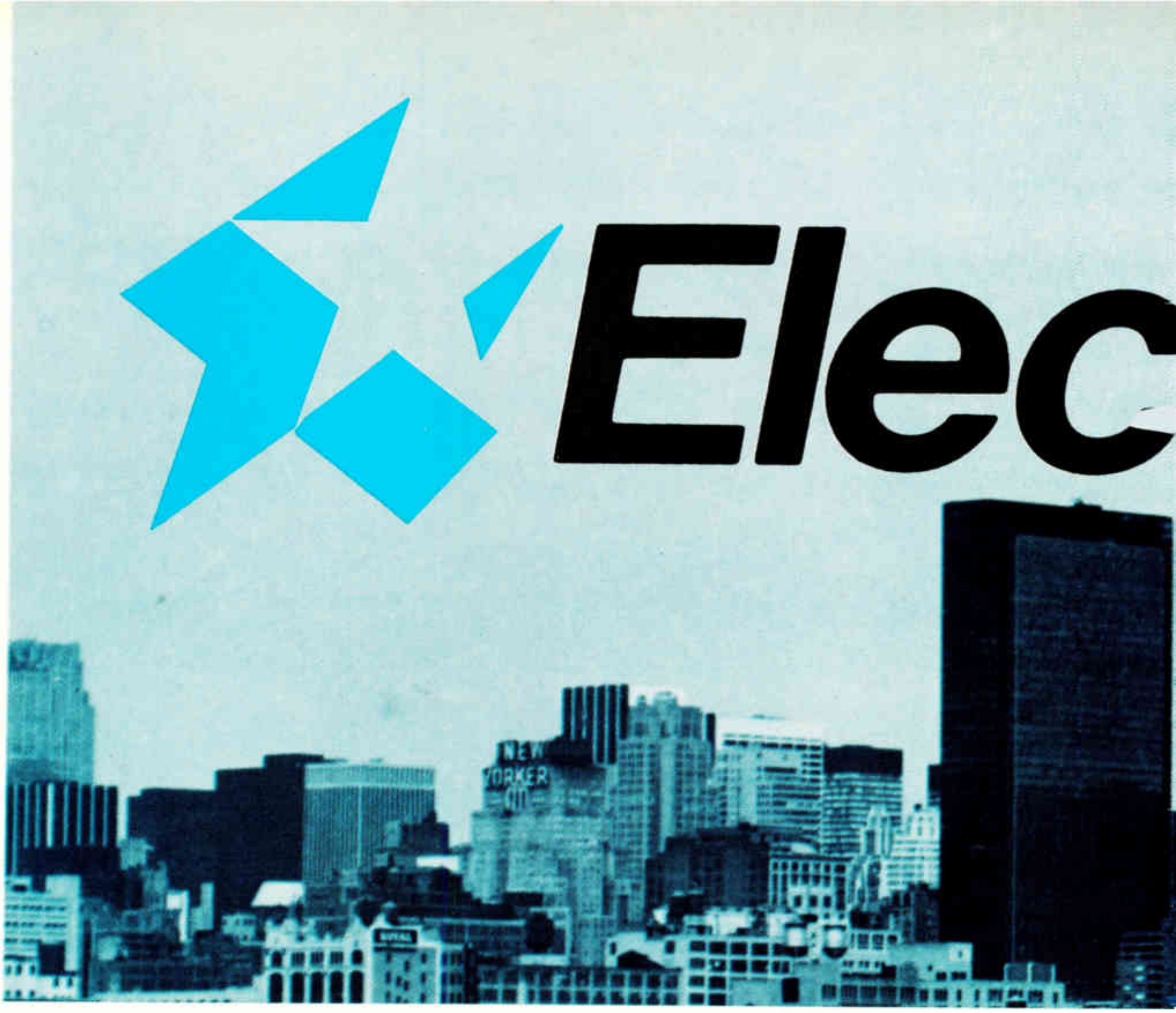
No one provides faster service than Wiltron. If you're in a spot, we'll help you with a loaner. So you can get the most from your Wiltron 610D, we offer user seminars and technical notes.

Isn't it time for the complete sweeper?

For an early demo or literature, call us today. Phone Walt Baxter at (415) 969-6500, or write Wiltron, 825 East Middlefield Road, Mountain View, CA 94043.

WILTRON

Circle 161 on reader service card



America's sociologists and other behavior-watchers have been telling us that the cities of the Northeastern Snow Belt are making a comeback, so what better place than New York to look ahead and examine the direction of electronics in the next decade? That theme—electronics in the opening years of the 1980s and its expected impact on industry and individuals—will be the focus of Electro79 at the New York Coliseum and the Sheraton Centre (formerly Americana) Hotel from April 24 through 26.

Whatever the seers decide about the years to come, it is obvious that the last two or three have been good to the electronics industries. In fact, judging by the growth of Electro since 1976 when it began convening alternately in Boston and New York, the period has been exceedingly good. At the 1976 Boston show, some 265 exhibitors occupied 509 booths; in New York the following year about 300 exhibitors were housed in 511 booths. In 1978 the show's sponsor, the Institute of Electrical and Electronics Engineers, reported 350 exhibitors in 655 booths. Now, 1979 will see 400 groups and companies facing an expected attendance of 30,000 design engineers, managers, and technical executives from over 700 booths. Times have been good indeed; though a slowdown in various forms from dip to depression is forecast for this or next year, spirits in New York this month should nevertheless be high.

A clue to what could be the increasingly prevalent theme of the '80s may come on the first day and turn out to be one of Electro's highlights: a 1 p.m. special session devoted to an international electronics executives' forum that will tackle technical management.

Program: agenda for the 1980s. The most conspicuous feature of Electro seems to be what does not appear on its program of technical sessions. There is no single session devoted to semiconductors as such, perhaps an eyebrow-raising indication of what the show's organizers know about the coming years and the direction of electronics technology.

Most attention is being paid to computers in all sizes, functions, and ramifications. There are

scheduled discussions of microcomputer data-base systems, software manufacturing, nonvolatile storage, industrial control networks, and personal computers. In allied sectors, there is scheduled coverage of testing bubble memories, packaging, and signal processing, and a scattering of sessions on professional matters ranging from minorities in engineering to the engineer and public policy. Finally, one session will commemorate the centennial of Thomas A. Edison's invention of an electrical lighting system.

Software for microcomputers. S. B. Yao is excited about session 10, which he will chair. Yao, an associate professor visiting New York University from Purdue University in West Lafayette, Ind., calls his session "Data-Base Management Systems on Microcomputers"; his excitement stems from the fact that this is a new use for microprocessors. And as microcomputers and data-base management intertwine, mutual interaction of the system can be seen.

"Data-base systems will have a definite impact on microcomputer software," says Yao. "They will make programs easier to develop and they will actually be more independent of the type of data they can handle. But microcomputers will also affect traditional data-base systems, and specialized data-base microcomputer systems will be developed."

Of the three main types of data-base systems, Yao has invited speakers on two. The first, called the network model, will be covered by Rob Gerritsen and Richard Hackathorn of the University of Pennsylvania, who will discuss their commercially available system, Micro-SEED. A second scheme, the relational model, will be covered by Peter Ting and David Chai from Bell Laboratories, Holmdel, N. J., who will speak on a distributed system of LSI-11 microcomputers. The third, or hierarchical, variety of data base is not represented in the session.

"Reducing Risks in Microcomputer Development," session 16, is headed by Carol Anne Ogdin, a consulting editor for EDN magazine based in Alexandria, Va. "The risk I will address concerns the project-management issue," says

For designers of software, there will be a discussion of how microcomputers and data-base management intertwine to make programs easier to develop in a break with tradition

Ogdin about the paper she will present. "I will discuss how to sequence things to avoid problems like committing yourself to a hardware design you can't write software for."

Another speaker, Harlan Mills of IBM Corp. in Bethesda, Md., will tell how to write software correctly the first time. "Harlan is well known in the software engineering field for his ability to show people how to write error-free software," says Ogdin, "The major risk here is the reliability of software. He [Mills] takes a pragmatic approach to see why it works, and what you can do to make sure it will the next time."

The last of Ogdin's speakers, William Broderick from Tektronix Inc., Beaverton, Ore., has perhaps the most interesting topic. He will focus on how to avoid problems involving contemporary large-scale integrated input/output circuits and central processing unit parts. "The 6802 has a major bug in its data sheet, for example," maintains Ogdin. "The sheet says it's static, but the part is dynamic and that makes a big difference when you go to design with it. Also, the 8251 programmable communication interface chip has difficulty handling its control signals. There are lots of problems like this."

Session 26, organized by Emerson Pugh, manager of exploratory magnetics at IBM's Thomas B. Watson Research Laboratories in Yorktown Heights, N. Y., concerns nonvolatile storage for very small processors. "The thrust of the session," says Pugh, "is what you do if you need nonvolatile storage and the total system cost must be kept to a minimum." Four speakers will give the pros and cons of the various solutions.

Donald Craycraft from NCR Corp. in Miamisburg, Ohio, will discuss semiconductor storage devices such as electrically erasable programmable read-only memories and electrically programmable ROMs, as well as chips that exploit metal-nitride-oxide-semiconductor technology. J. Egil Juliussen from Texas Instruments in Dallas will be concerned with bubble devices vs semiconductors (like complementary MOS random-access memories) with battery backup. Floppy-disk storage will be covered by George Sollman of Shugart Associates, Sunnyvale, Calif., and digital cassettes by Bruce Minildi, Verbatim Corp., also in Sunnyvale.

Pugh calls each approach reasonable for a particular range of applications, but beyond that range the method becomes impractical. For example, for larger small systems, rotating magnetic storage appears most viable because it offers the lowest cost per bit. "But mechanical storage isn't always the lowest cost per box," says Pugh, meaning that when the system is small enough, bubbles and semiconductor storage become attractive. He finds bubbles more advantageous than silicon parts, though, possibly from vested interest. "MNOS, for example, has reliability problems and a long write time, and needs unusual voltages," he says adding that bubbles have some definite advantages. "Rockwell has already demonstrated a 1-megabit bubble memory using standard permalloy techniques."

Industry takes heed. Prices of microcomputer-based equipment continue to fall, so it is not surprising that industry is assembling more and more intelligent hardware into distributed data-acquisition and control networks. Session 27, "Microcomputer Industrial Control Networks," alerts management personnel and system designers to the communication problems posed by future, more complex architectures and deals with ways of solving them.

Robert Grant of Pro-Log Corp. in Monterey, Calif., will describe the key role played by modular hardware in the design of a multiprocessor control system on an STD bus. He will discuss the benefits of modularity—lower costs, greater flexibility, and simpler maintenance—and offer some caveats on second-sourcing, sizing, and selecting a microprocessor.

Waiting for a standard for industrial distributed-control networks? Daniel T. W. Sze of IBM in Boca Raton, Fla., will bring his audience up to date on the work being done by the IPW TC-5/ISA-72 committee. That group is outlining a standard for a process-control system's functional properties, communications capabilities, and architecture.

Communication within distributed-data-acquisition and control systems is the subject of a paper by Cleveland State University's James D. Schoeffler. He will quantify the delays in various network architectures, and explain how intrasystem messages must become longer to guarantee reliable communication.

Solutions to some of the above problems will

'Engineers are the ones coming up with the most creative applications for personal computers,' so there will be a session on how to sell such computers, as well as one on how to use them

be found in two applications papers. "Master-Master Party-Line Bus in a Microprocessor Network," by A. DiMond, W. Levy, R. Roth, A. Simon, M. Stickel, and W. Wong of RCA's David Sarnoff Research Center in Princeton, N. J., describes a passive party-line bus that can extend over 1,000 feet and handle more than 100 processors. A key to the system is the communications protocol, which houses six control lines to route calls and data between processors.

Applications of MC6801 and MC68588 microprocessors in distributed processing will be described by Donald Tietjen and Robert Thompson of Motorola's Integrated Circuits division in Austin, Texas. They will show how those two processors have been used to form a data-acquisition and control device compatible with the IEEE-488-1975 bus, and discuss hardware and software considerations.

Getting personal Significantly, this year there are separate Electro sessions on marketing and using personal computers. Frank Burge of Regis McKenna Inc., Palo Alto, Calif., organized both sessions and expects a heavy turnout because "engineers are the ones coming up with the most creative applications for personal computers, both in the office and at home." Burge adds that marketing techniques should interest engineers, too, since greater consumer acceptance of the product will help lower prices and motivate manufacturers to build more versatile machines.

Session 3, "Marketing Personal Computers," will focus on the most difficult aspect of personal computers—selling them. Ben Rosen, an analyst at the New York investment firm of Morgan Stanley Inc., will lead off with some optimistic projections for sales—from just 200,000 units sold last year to sales of $1.25 billion in 1980 and $5 billion by 1985. Rosen's crystal ball will also reveal that small businesses and educational institutions will form the nucleus of this expanding market.

Next, representatives of two manufacturers will relate company experiences in the marketplace. Lewis Kornfeld of Radio Shack Inc., Fort Worth, Texas, which has sold its TRS-80 for the past 20 months, links the success of personal computers to maintenance, often a low-priority item for conventional consumer products. Gene Carter of Apple Computer Inc., Cupertino, Calif., will then demonstrate how personal computers are logical evolutions from the Eniac in the 1940s, through the time-shared systems in the '50s and '60s, to today's personal models that give complete access upon demand.

Finally, Elliott Greene, owner of the Computerland store in Carle Place, N. Y., will present the retailer's point of view. Greene will explain how to cope with a weak link in the sales chain—contact with the consumer. What is needed beyond a quality product, he says, are competent salesmen who can attract potential buyers without mystifying them with esoteric computer jargon.

Session 9, "The Personal Computer: Hobby-Horse or Work-Horse?," will be a panel discussion of applications. Phil Roybal of Apple Computer will kick off the session with an overview of personal computers presently at work in industry, schools, and homes. One of his examples will be an Apple unit that for one year has been controlling, without failure, an oil-drilling rig in the Gulf of Mexico.

Among the other panelists who will describe uses for personal computers is Tom Carpenter, an engineer at Bell Laboratories in Allentown, Pa. He has gotten his entire family involved with the computer by putting it in the family room, right next to the television set. Food recipes can be filed and reviewed by category and scaled to the number of dinner guests. His 11-year-old daughter is the typist—she now recognizes syntax errors in Basic—and his 7-year-old son plays video games. Carpenter uses a Process Technologies VDM unit with a memory-mapped video monitor because its S-100 bus is compatible with his earlier programs.

Next will be Bob Berkovitz, director of research at Teledyne Acoustic Research in Norwood, Mass. Berkovitz has programmed an Apple computer in machine code to check the frequency response of his company's AT line of speakers on the production line—a task previously done by an expensive PDP-11/40 minicomputer. The company's present 8-bit unit does 256-point fast Fourier transforms in 3 seconds with 16-bit precision, and has been taken into the field to give color-graphics presentations helpful in teaching salesmen the audio basics.

Another panelist is Max Ule, a discount stockbroker at Rosenkrantz, Ehrenkrantz, Lyon, and

With robots leaving the drawing boards and making their way into assembly plants, there will be an examination of sensors, programs, and part-mating science as they pertain to the machines

Ross in New York. Ule will explain how he is presently using two TRS-80 personal computers to follow the stock ticker, figure commissions instantly, and send mailings to his clients. He started with one TRS-80 and subsequently added memory and peripherals such as printers, electric pencils, and lower-case conversions.

Finally, Peter Jennings of Personal Software Inc., in Boston, will tell how he developed a chess-playing program to run on several personal computers. One of his firm's most popular programs, Jennings expects it to appear soon in Europe in a dedicated board game.

Let the robot do it. Automation, a word first heard in the 1950s, is center-stage in session 33. Today, robots are off the drawing board, doing such jobs as attaching light bulbs to car dashboards, and more sophisticated machines are on the way. Co-organizer K. S. Fu of Purdue says that the session should be of interest both to those in automation research and development and to industrial firms wishing to automate assembly lines in their plants.

A robot is only as powerful as its eyes, and sensors are the topic of two papers. Antal K. Bejczy of the Jet Propulsion Laboratory in Pasadena, Calif., will discuss the design and controlling aspects of smart sensors—computer-based transducers of proximity, force-torque, and touch, for example. "Programming and Data Structures for Sensor-Controlled Robots," by Purdue's Richard Paul, demonstrates how to code a sensor's output in software.

G. C. S. Lee and session co-organizer G. N. Saridis of Purdue will also discuss matching programming language to a robot's task. Their paper will describe the development of a high-level, English-like language that serves as the robot's operating system and frees the user from programming each movement of its manipulator. The language is developed in two parts. The higher level interacts with the user via monitor and interprets and decodes input statements, translating them into basic control motions; the lower level controls the manipulator in real time and coordinates feedback signals. A preliminary version of the programming language has been implemented on a PDP-11/45 minicomputer that is attached to an electric arm, from the Massachusetts Institute of Technology, Cambridge.

J. L. Nevins and D. E. Whitney of the Charles Stark Draper Laboratory Inc. in Cambridge, Mass., will discuss the application of part-mating science—the interaction of parts during assembly—to automated assembly systems. They attribute growing interest in programmable systems to those machines' good repeatability and adaptability to different parts and to different market conditions.

Although their research has led to development of a machine that inserts rigid parts precisely using only springs, they will emphasize the need for continued research into the economics, software, engineering specifications, and scheduling of programmable robots.

Electronics and the environment. Everyone has a stake in a clean environment. But session 24, "Environmental Monitoring and Assessment," should be of particular interest to electronics engineers who use instrumentation to measure environmental quality. Session organizer and chairman Harlan J. Perlis of the New Jersey Institute of Technology in Newark, N. J., has limited its scope to airborne pollutants, which include noise, low-level radiation, particulate matter, and oxides of nitrogen and sulfur.

John Wesler of the Federal Aviation Agency in Washington, D. C., will begin with a paper entitled "The Monitoring and Analysis of Airport Noise." He will detail the year-old sound-measurement system at the capital's Dulles and National Airports. Microphones in 24 locations at both airports feed noise-level measurements over commercial-grade telephone lines to a PDP-11 minicomputer at Dulles. By mixing those measurements with air-traffic control data, the computer can identify the worst offenders.

Harold L. Beck of the Department of Energy's Environmental Measurement Laboratories in New York City will tell the audience what today's sensitive radiation monitors can do, and how to interpret their readings. His paper also describes DOE's past and present use of sensing equipment like ionization chambers, scintillation detectors, and germanium diodes.

Air-quality measurement is the subject of two papers. Richard Paur of the U. S. Environmental

Communications system designers can learn how to improve the signal-to-noise ratio of data links in overcrowded regions of the rf spectrum in a discussion of adaptive antennas

Protection Agency in Research Triangle Park, N. C., will describe a mobile laboratory that measures gaseous and aerosol concentrations in the field and tags them with precise geographic coordinates in a Hewlett-Packard System 45 computer. "Indoor-Outdoor Relationships of SO_2, NO_2, Fine Particulates and Sulfates," by John D. Spengler of the Environmental Health Department at the Harvard University School of Public Health in Cambridge, Mass., will report on techniques for measuring indoor pollution levels. The study aims, for example, to determine the effects of cooking and cigarette smoke on respiratory disease.

Logic analysis in larger systems. Since the early 1970s commercially available logic analyzer techniques and equipment have aided the digital designer greatly in the design, initial turn-on, analysis, and debugging of logic systems as well as in field repair and maintenance of those systems. Most of the users of this equipment, however, were designers working with microprocessor-based systems.

Session 14, "The Use of Logic Analyzers in the Development of Processor Systems," concentrates on applying logic-analyzer techniques to larger systems. Chairman Sam Lee of Hewlett-Packard Co.'s Colorado Springs (Colo.) division, observes that designers of larger systems, and minicomputer and mainframe computers, have been slower to make use of these new techniques for at least two reasons. Commercially available equipment is tedious to operate first because of difficulty in hook-up and interpretation of the data and second because of lack of measurement and indexing power. The larger systems often had reasonable debugging software available with their operating systems, and system designers wrote more. Consequently, logic analyzer techniques were slow to be put to use.

But the increasing complexity of bus architecture and the continuing difficulty in locating glitches due to coupling or race conditions have pushed designers to realize the value of logic analysis techniques. The session will describe some specific situations in which the speakers have used these techniques to solve specific design situations for their products and to meet customer requirements.

Julie Cates from HP Data Systems, Cupertino, Calif., will discuss her use of logic-timing analysis during development of the floating-point processor hardware for HP's 21MX minicomputer series. A discussion of equipment built by Digital Equipment Corp. for sorting real-time bus problems on the unibus will be presented by Erik Anderson of DEC's Maynard, Mass., facility.

Steve Sensabugh of Tesdata Systems Corp., McLean, Va., will provide some insights into how logic analyzer techniques in computer performance-evaluation equipment can provide real-time transparent measurements. These measurements allow designers and users to make intelligent decisions about operating-system design and parameters for greatly increased performance.

Spreading the work. Organizer Carmen J. Luvera believes that session 11, "Adaptive Antennas," will be interesting to communications engineers who must deal with improving the signal-to-noise ratio of data links in some overcrowded regions of the radio-frequency spectrum. Discussion will center around current methods of deriving control signals (special processing) from samples of the radiation field received by the antenna itself. When applied to appropriate software-based feedback systems, the signals electrically adjust the antenna pattern for nulls in a desired direction or form a main lobe (beam) in the direction of a desired signal. State-of-the-art system designs using analog, digital, and hybrid feedback system systems will also be presented, with some recent developments sharing the spotlight.

Opening the session will be Bernard Widrow and H. Mesiwala of Stanford University in Palo Alto, Calif., who will discuss "Compression of Eigenvalue Range by Using a Surplus of Adaptive Antenna Elements." Widrow and Mesiwala show how placing more elements than the minimum required in a system reduces the range of eigenvalues that may be assumed in its defining correlation matrix, which in turn speeds the response time of the system. Not content with that, they claim that a by-product of their method also yields better antenna directivity than would normally be attained.

W. K. Masenten of Hughes Aircraft Co. in Fullerton, Calif., will then present "Trends in Adaptive Antenna Circuit Design." He will discuss

One of the latest wrinkles in LSI is the circuit that combines analog and digital functions on a single substrate, and the three technologies used to make the chips will be discribed by their backers

some problems inherent in the design of adaptive-array subcircuits in systems incorporating "frequency hopping" to obtain a spread-spectrum waveform over a wide band. He then covers the implementation of analog and hybrid versions that accommodate a frequency-hopped spectrum. For either version, the implementation of the pattern-forming network and what is called the cross-covariance measuring functions are the critical design objectives, and Masenten discusses these subjects in detail.

Vidas Mikenas of the Harris Corp. in Melbourne, Fla., then shares his findings in comparing analog and digital control techniques for adaptive array systems. He defines the precise tradeoffs between the faster and more stable analog system to the flexible digital system, which Mikenas notes has been made more attractive in recent years by LSI technology. Peter Sielman, from Cutler Hammer Inc.'s AIL division, then takes over, discussing the degree to which a digital system can help enhance the depth of convergence rate and dynamic range and the precision of an adaptive array.

Finally, Larry Horowitz of MIT's Lincoln Laboratory discusses the first lab model implementation of the well-known sample-matrix-inversion algorithm for controlling the receiving pattern of an airborne adaptive array. Horowitz produces performance data for a lab-nulling system implementing the algorithm, whose main advantage is that it minimizes the rate of observations and computations required in the airborne environment. The results of the tests at Lincoln are compared with performance predictions based on measured component variations of the laboratory system.

Analog + digital + LSI = hot subject. One of the liveliest products coming out of wafer ovens is the integrated circuit combining analog and digital functions on one silicon substrate. But where n-channel MOS rules the roost in microprocessors, single-chip analog-with-digital ICs are emerging in a variety of technologies: n-MOS, complementary MOS, and even integrated injection logic. Session 2 will provide an overview of these product types under the title "Analog-to-Digital LSI."

Says session chairman Rob Walker of Intel Corp., Santa Clara, Calif., "Unlike watches and calculators, where the whole system is already integrated onto one chip and further advances don't really buy you anything, these new ICs allow system designers to pull more circuitry—like a-d converters, keyboard interface, and output drivers—onto the same chip." But since there is no general agreement on the best technology to use, Walker will have experts on the three major approaches speaking together.

Discussing C-MOS as seen in his company's model 7106/7107 3½-digit a-d converter will be William D. O'Neil of Intersil Inc., Cupertino, Calif. He will stress the low-power advantage of the approach and may talk about the still-to-be-announced 12-bit converter presently on Intersil's drawing boards.

Speed-power is the theme of Phil Marcoux's talk about Signetics Corp.'s use of I^2L for a-d chip design. He will use the Sunnyvale, Calif., company's codec as an example of what he calls "a true LSI circuit." Marcoux believes I^2L runs a close second to n-MOS in circuit density but has an advantage in accuracy because high-value resistors can be integrated with it. And though conceding that n-MOS runs away with the speed title, Marcoux believes that second-generation I^2L, with its Schottky technology, will change that. Also, Marcoux says, C-MOS is in the running only in its low-power applications.

Not so, says Edmund K. Cheng, who designed Intel's 8022 a-d microprocessor. "The a-d portion of the 8022 takes up only one sixth of the chip and it's not a big chip," Cheng says. Compared to be I^2L a-d chip area, he says, n-MOS "beats them by a mile." He does concede, though, that n-MOS isn't the greatest technology for these types of circuits. Instead, he will attempt to show why its strength in other areas, such as cost and ease of interface to other relatively complex functions, are important tradeoffs that should be considered.

Doing it itself. The growing complexity of instrument designs, especially those based on microprocessors, continues to create testing and servicing challenges. Session 22, "Self-testing, Checking, and Calibration in Instrumentation," addresses the need for instruments with on-board diagnostics that can lower

Engineers working on large computers or telecommunications will have a session covering the problem of electromagnetic interference and how plastic packaging might solve it

servicing costs and earn more confidence from users, states session chairman Gordon Partridge of GenRad Inc., Concord, Mass. Although instruments with self-analyzing and calibrating features are more expensive, servicing and calibration costs, in addition to instrument downtime, are greatly reduced.

Partridge has lined up four speakers. Craig Johnston of Fluke Manufacturing Co., Mountlake Terrace, Wash., will stress the economy, and each of the remaining speakers will provide examples of instruments incorporating built-in diagnostic and calibration features. Michael Anthony of Keithley Instruments Inc., Cleveland, Ohio, deals with a parametric test system; the GenRad microprocessor-controlled impedance meter is Robert Sullivan's example. And James Griffin of Tektronix Inc., Beaverton, Ore., will demonstrate how self-testing added to a portable service instrument increases operator confidence in measurements at field locations.

Plastic packages as shields. More and larger systems are being packaged in plastic, particularly in the computer and peripherals fields. But along with the cost and shock-resistance advantages of plastic comes the problem of electromagnetic interference (emi). Session 6, "Plastic Packaging for Emi Shielding," is therefore of vital interest to engineers who are designers in large computer and telecommunications firms that are starting to package equipment in this type of material.

John J. Reilly of Electro-Kinetic Systems Inc. of Aston, Pa., points out that going to a plastic case or cabinet means losing all the shielding a comparable metal case would give, and John Jackman of NCR Corp., Wichita, Kan., discusses the use of economical metal-film coatings, flame-sprayed coatings, metal foil-tapes, and conductive molding compounds to protect data-processing systems packaged in plastic from electromagnetic or radio-frequency interference.

A paper by Dave Stutz of Battelle Memorial Institute in Columbus, Ohio, concludes that conductive plastic composites appear to be one of the better cost-effective ways to provide shielding. And Rick Stadterman of General Electric Co. in Pittsfield, Mass., discusses the cooperation necessary among the original-equipment manufacturers, packaging and component engineers, material suppliers, and shielding system vendors to identify and evaluate shielding systems early in the product-design phase of the operation.

Software in mass production. Computer manufacturers are spending an increasing proportion of their development budgets on software. It will therefore have to be manufactured in a standard manner, much like hardware, says Jacob Sternberg, chairman of session 4, "Software Manufacturing in the Distributed Environment—Theory and Practice."

Sternberg, who is with Conversational Systems Corp., a New York City–based systems house, notes that software "has traditionally been a customized, crafted product. The demand today is for a noncrafted, engineered product." Instead, he proposes, "software should be provided to users the way cars are. An automobile is assembled from basic subassemblies using standard tools. And after the car is sold, standard parts are available."

The question then is, who will create the software interfaces and modules? "Standards are coming up," Sternberg says. "Some will be dictated by industry giants like IBM and others by public utilities such as AT&T." The software modules themselves, he says, will be manufactured by a "new breed of company." To use the car analogy again, Sternberg makes the point that, "General Motors doesn't produce every part that goes into a car, and there will be no monopoly on software, either. Small software companies will supply small modules."

Among the various semiconductor technologies that have had an impact on computer design, the advent of dense random-access memories ranks as one of the most significant. And Sam Young, chairman of session 20, says the latest generation of 64-K RAMs will have an even greater impact.

"As memory has become denser and less expensive, computer designers use more memory. This has changed the thought patterns of software people," notes Young, of Mostek Corp., Carrollton, Texas. "Memories used to be precious, and the efficiency and compactness of a program was important. Now the philosophy

Caught between the FCC and Underwriters Labs, makers of switching power supplies will have a session that examines the question of emi limitations and their effect on the industry's future

has changed and less time is spent on software optimization." In addition, equipment such as microcomputers could not exist without the availability of low-cost RAMs, Young notes. This will be discussed by Wendel Sanders of Apple Computer, Cupertino, Calif.

Another area in which RAMs have made a significant impact is in minicomputer technology. "As the cost, power requirements, and size of RAMs have decreased, their performance and reliability have increased," says Michael Gutman of Digital Equipment Corp., Maynard, Mass., who will examine their effect on minicomputers. At the other extreme, Paul Higatshi, of NCR Corp.'s large systems facility in San Diego, Calif., will discuss the impact of the large dynamic RAMs on main frame computer design.

The road ahead for switchers. Session 34 on "The Future of Switching Power Supplies" should be provocative, for it explores the fate of the growing solid-state power supply industry. Chaired by Walter J. Hirschberg of ACDC Electronics, Oceanside, Calif., it will focus on a crucial aspect of power supply design—electromagnetic interference (emi). The industry currently is being confronted by both ends of the regulatory spectrum. On one hand, the Federal Communications Commission is considering sharply limiting emi radiation in the environment. On the other, Underwriters Laboratories is prescribing the amount of leakage current that can be reflected back into electric utility sockets.

Faced with these constraints, future switchers will have to be designed with tighter specifications on both subsystem assembly and component levels. To that end, three papers discuss novel circuit-design techniques and incorporation of basic supply circuits in integrated form to fine-tune the balance between high efficiency and compactness in switching power supplies.

Ken Check of Intel Corp.'s OEM Microcomputer Systems division in Hillsboro, Ore., will present a novel approach to silicon controlled rectifier-switched resonant inverters, where the regulating mode varies the frequency within an 18- to 36-kilohertz range. He will discuss a 400-watt switcher under design at Intel slated for the company's new line of supplies for computers and instruments in early 1980.

Barry Harvey of Siliconix Inc., also in Santa Clara, will deliver a get-acquainted paper on the power field-effect transistor, one of the most controversial parts to come out of the semiconductor industry for use in switching power supplies. The power FET is generally regarded as a mixed blessing by supply manufacturers, so Harvey will try to still the mistrust of potential users. Although much faster than bipolar transistors, FETs need a substantial amount of support circuitry to come close to the overall attributes of the bipolar devices. Interfacing either bipolar devices or FETs to the rest of supply circuitry is the subject of Stan Dendinger of Silicon General Inc. of Garden Grove, Calif.

Two papers concentrate exclusively on major hurdles—reliability problems and emi. Phil Koetsch of ACDC will look at reliability, specifically addressing the validity of the MIL-217B military standard in evaluating failure rates, since commercial switching supplies on the market now far exceed the rates stipulated by the standard.

The emi dilemma will be addressed by Joseph Banasiak of R&B Enterprises, Plymouth Meeting, Pa., who will investigate the impact of Government regulations concerning emission controls. With the proposed docket 20178 in front of the FCC, switcher manufacturers are faced with, among other requirements, a minimum noise suppression figure that will be difficult to meet.

Space spies. Organized and headed by chief scientist John Burgess of Rome Air Development Center, Rome, N. Y., session 5 provides an overview of RADC-sponsored work in satellite surveillance. Five contractors will discuss their work on space antennas, how to build them, and how to keep them powered.

"The programs to be described are all long-range," says Burgess, "with practical applications many years in the future." Typically theoretical are "The Space-Fed Lens—an Antenna for Space" by Jack Schultz of the Grumman Aerospace Corp. in Bethpage, N. Y., and "Space Antenna Far-Field Patterns" by Robert Hancock of Simulation Technology Inc. in Antioch, Tenn.

Schultz will describe his idea for an electronically steered, dual-frequency, dual-polarization antenna for a three-axis stabilized satellite. □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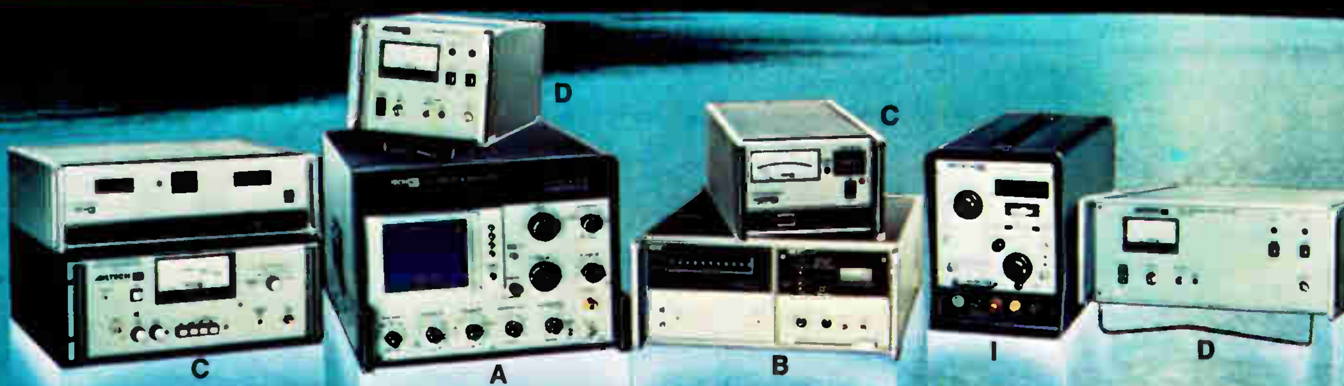

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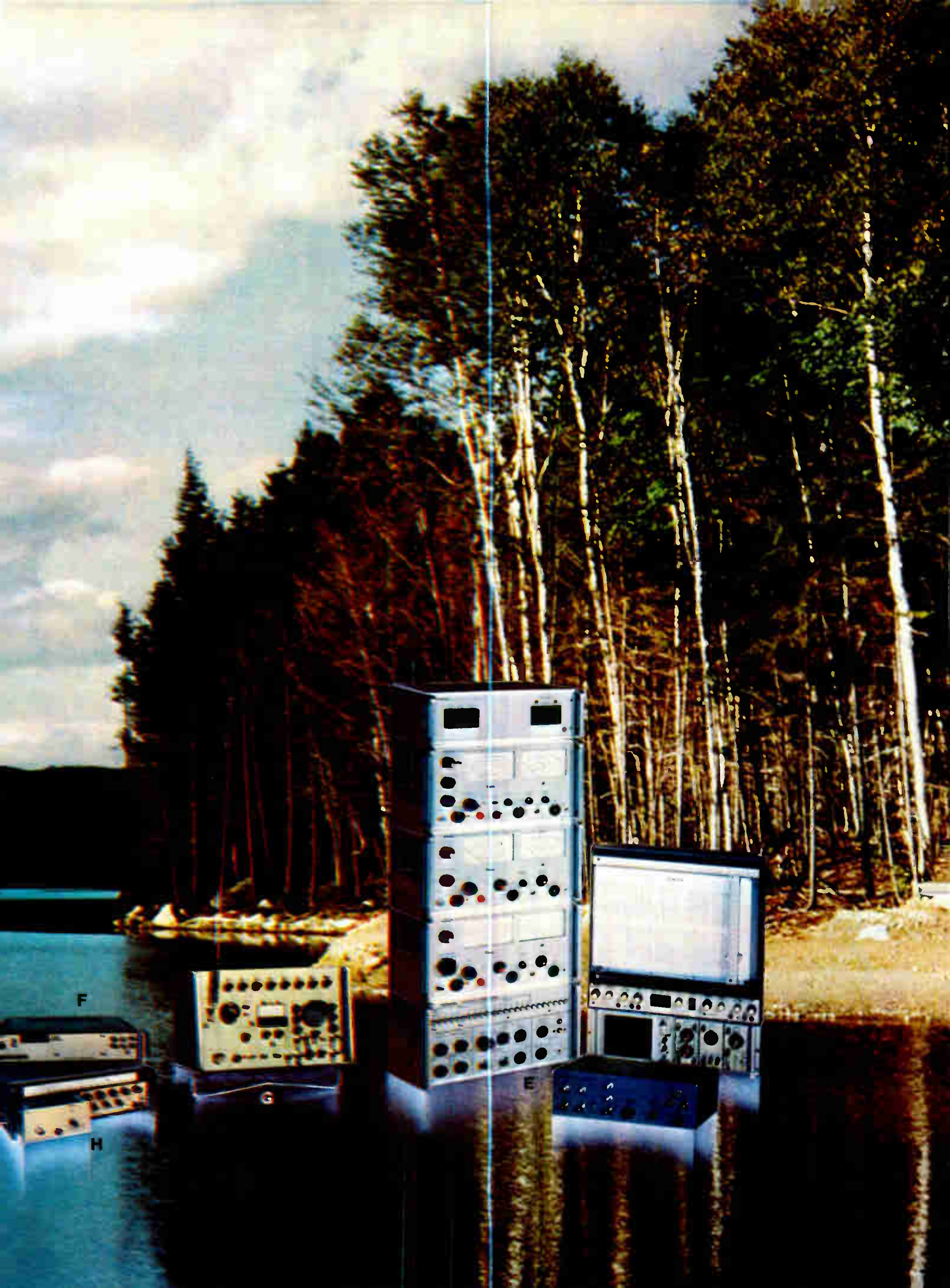
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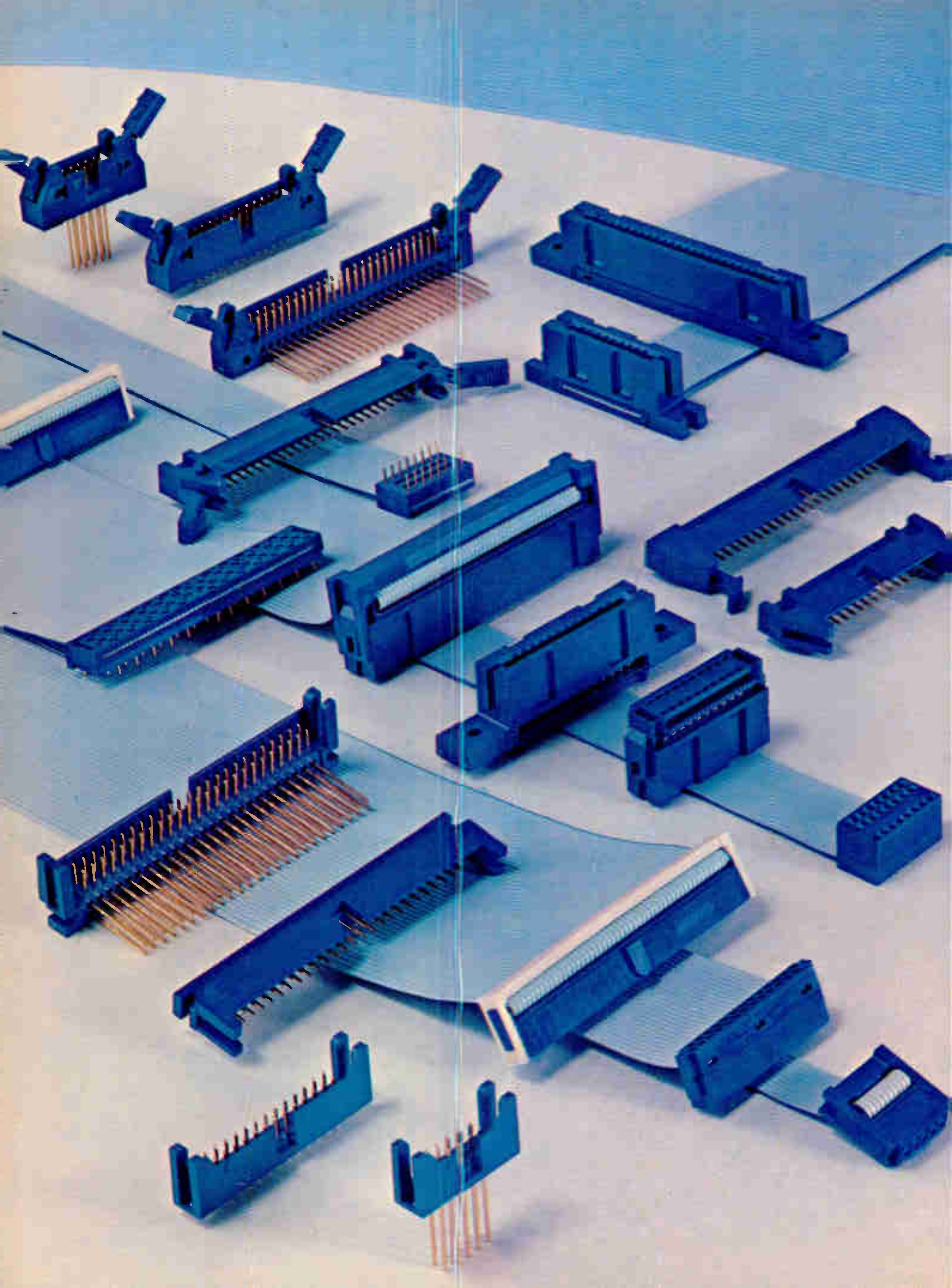

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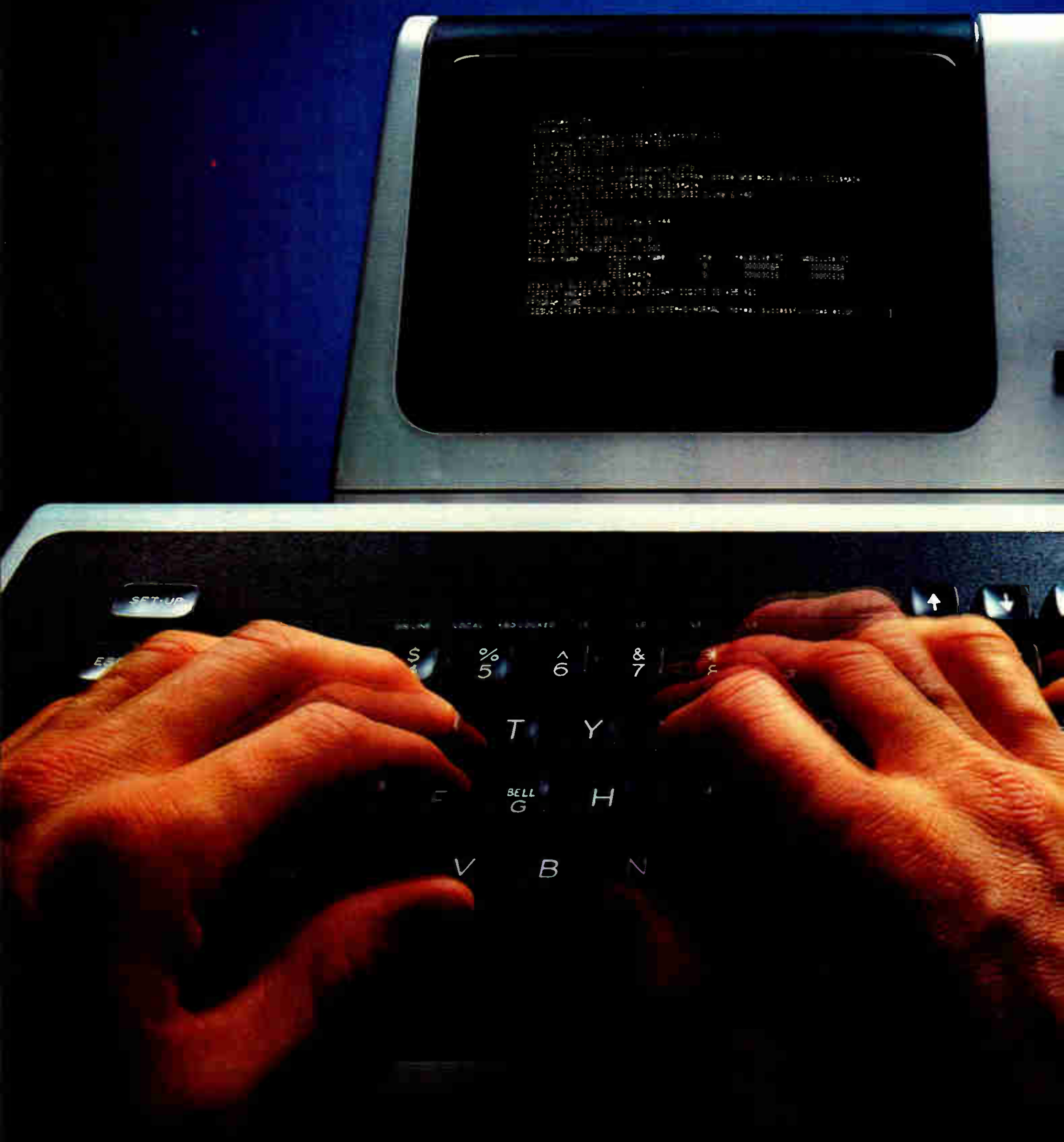

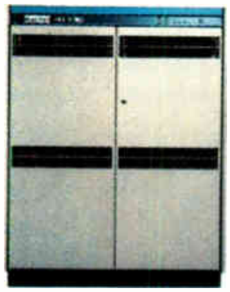

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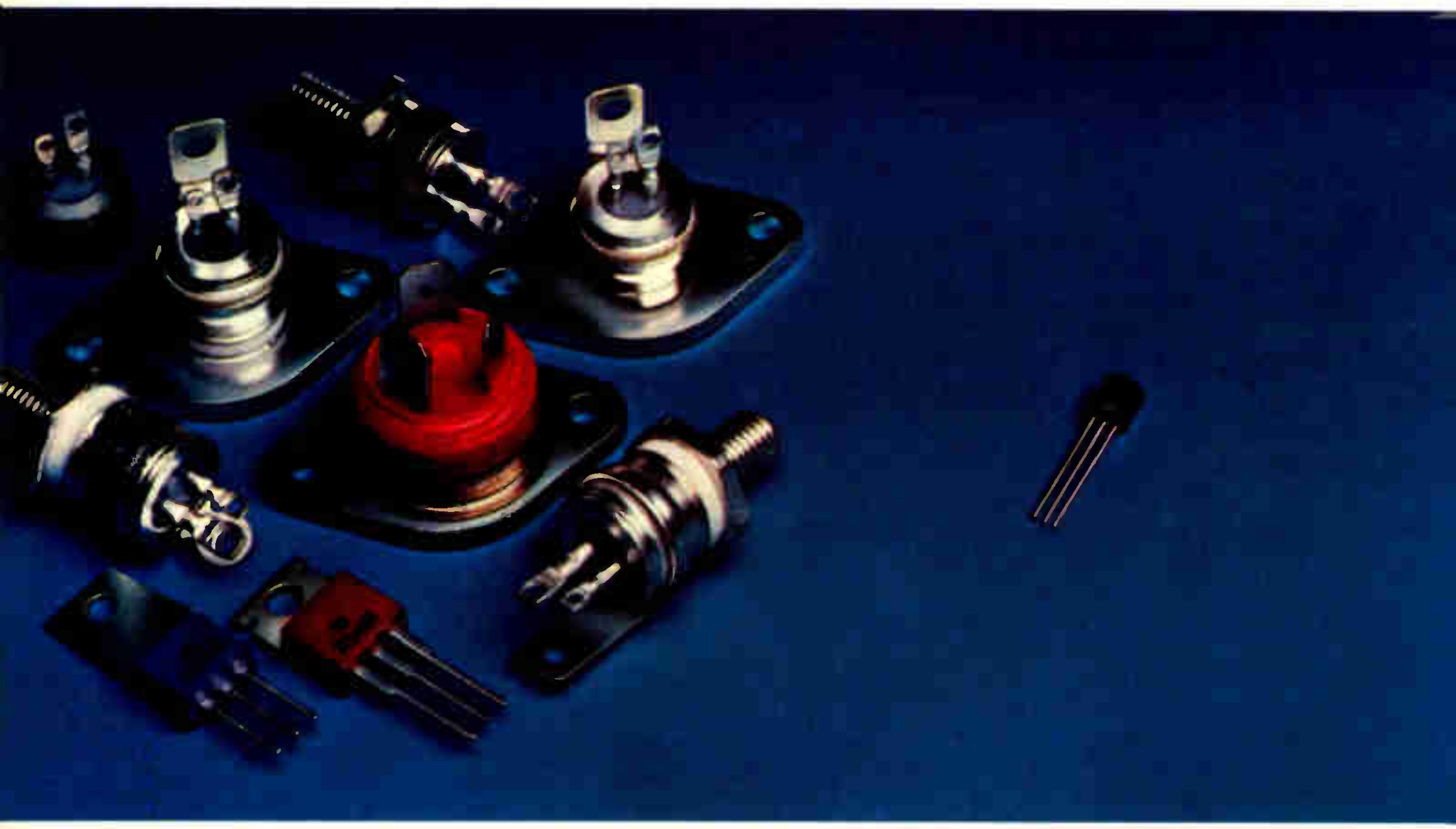

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On April 24, when the New York Coliseum's doors open on the IEEE's annual show, instruments will be competing with microcomputers and data-acquisition systems for showgoers' attention

RCA unveils first five boards in its compact, low-power computer family

Entering the market for single-board computers with a flourish, RCA Corp. will use the Electro show as a launching pad for two central-processor-unit boards, three random-access-memory boards, and an interface board. They are the first members of the CDP18S600 series, with more boards to come.

The company intends to stress the compactness of the resulting systems. The boards are only 4½ in. wide by 7½ in. long, and the liberal use of the Cosmos complementary-metal-oxide-semiconductor process gives cool-running parts that permit tight stacking of the boards and need little power.

One of the RAM boards has room for five 1.5-V batteries, enough to power a small system. Thus RCA sees a good market among users that need an isolated system, as in medical applications; a system operating at a different potential level than surrounding equipment, as in a high-voltage environment; or a sealed system, as in a vacuum.

In general, the company has its sights on the industrial control market, says Michael Caterina, product-marketing manager for microprocessor systems. The boards' compactness also make them naturals for smart peripherals, he says.

The bus structure is RCA's own, using a 44-pin edge connector on the back of the boards and a 20-pin input/output connector on the front of the CPU boards.

The processor boards, the $549 CDBP18S601 and the $475 -603, both use the company's 8-bit 1802 C-MOS microprocessor and provide 20-mA current-loop or RS-232C serial interfaces. The 601 has 20 parallel programmable I/O lines and comes with 4 kilobytes of RAM and 24-pin sockets for 4 or 8 kilobytes of read-only memory or erasable programable ROM. The 603 has 20 parallel I/O lines, 1 kilobyte of RAM, and sockets for 2 or 4 kilobytes of ROM/EPROM.

The three C-MOS static RAM boards are CDP18S620, -621, and -622, costing $395, $1,195 and $795 respectively (quantity discounts are available on all five boards). The 4,096-bit-by-8-bit 620 uses the 5101 bulk-silicon RAM chip. The other two memory boards use RCA's C-MOS-on-sapphire MWS 5114 chip, with the 621 holding 16 kilobytes

and the 622 holding 8 kilobytes. The 622 comes with four penlite batteries for backup operation, easily converted into an internal power source by adding a fifth battery to give the necessary system total of 6 V.

Finally, there is the $175 CDP18S641 interface module, which is a universal asynchronous receiver/transmitter. Also being introduced at the show are two chassis, one holding five boards and the other holding 25. Both come with wired back buses, and Caterina says other chassis introductions are planned.

More I/O boards are in the works, as are more memory and CPU boards. Among the CPU cards will be some using the 1804, the forthcoming single-chip version of the 1802. The 1804 will include 2 kilobytes of RAM and ROM, a timer/event counter, and more instructions.

Another reason for using the RCA bus structure is that it offers hardware compatibility with the company's CDP18S005 Cosmac development system, Caterina says. Thus it is possible to develop software simply by plugging boards into the 005, later plugging the same types of boards right into the final system. Coming in about 60 days will be a prototyping system (shown) based on the five-card chassis.

RCA Solid State Division, Route 202, Somerville, N. J. 08876. Phone Michael Caterina at (201) 685-6599 [411]

System acquires 250,000 samples/s

Datel Systems Inc. has broken the link between high speed and high price in data-acquisition systems. The company claims that its PDAS-250 is the first off-the-shelf unit to combine an acquisition rate of 250,000 samples/second, 12-bit resolution, and the ability to pack up to 256 single-ended or 128 differential channels into a 3.5-in. rack-mountable package at a price that starts at $3,190.

"We achieved our high speed and low price with a technique we call overlapping conversion," explains Datel's product marketing manager, Larry Copeland. The analog-to-digital converter in the PDAS-250 is fast enough by itself, with a settling time of less than 2 μs. But after conversion, rather than wait for a "data dump" instruction from a host computer, it shunts its output into a temporary storage register, freeing itself for another conversion. According to Copeland, this makes the PDAS-250 ideal for applications like signal processing, vibration studies, aircraft flight testing, process control, real-time engine diagnostics—in short, any operation where a large number of fast-changing data channels must be monitored.

In addition to the successive-approximation a-d converter, the PDAS-250 contains a high-impedance input buffer, a high-speed multiplexer, a sample-and-hold network, data-output and status registers, random-access and sequential address logic, and mode controllers. Internal logic is complementary metal oxide semiconductor (C-MOS) to minimize thermal effects and power consumption, but interface levels are transistor-transistor logic (TTL) for data-bus compatibility.

The system operates with or without computer supervision. In its internally controlled mode, it can be much faster than its rated speed of 250,000 samples/s. Although Datel will not say how much faster, it does report achieving speeds of 300,000-400,000 samples/s during tests. Under computer control, speed is limited by the host computer. With better minicomputers having direct memory access, the PDAS-250 easily reaches its rated speed. The unit is plug-compatible with Nova, Eclipse, and PDP-11 minicomputers, and a VAX-11/80-compatible model is on the way.

For hookup to a mini, the unit requires a parallel digital input/output-port module, which is available from Datel. If they wish, users can develop their own software—a handler program to control and respond to command and status bits, to supply addresses and to accept data—but this can be time-consuming and costly. As a faster and less-expensive way of getting the PDAS-250 on line, Datel suggests using one of its series of Sinetrac, 256-channel,

Our tiny new 68c* quartz crystals just made your dream product possible . . .

. . . because now you can abandon the old price and design limitations on precision oscillators.

With our new CX series low-frequency quartz crystals, you can now design ultra-accurate timing circuits that are even cheaper — overall — than LC and RC oscillators. They will fit in the smallest spaces in the roughest, toughest environments. And will give your product the prestige and glamour that accompanies the phrase "Controlled by Quartz Crystal."

CX crystals are an order of magnitude cheaper, smaller and stronger than any low-frequency crystal currently available. They come in frequencies from 350 kHz *all the way down to 10 kHz* — in the same miniature package!

Statek crystals are totally different from conventional crystals. The design is patented and they are made in California by advanced semiconductor-type processing techniques. And they incorporate everything we've learned from producing 17 million quartz crystals since 1973.

To discuss your application, write or call Jeff Upton at Statek Corporation, 512 N. Main, Orange, California 92668. (714) 639-7810.

*Prices range from 68¢ to $1.17 in 100,000 quantity. See EEM and Gold Book for details.

STATEK *Innovators in Frequency Control*

Circle 181 on reader service card

digital interface controller boards. At about $1,500 to $3,000, these are available for PDP-11, Nova, and Eclipse minicomputers.

The PDAS-250 system expands in increments of 32 single-ended or 16 differential channels, to a housing maximum of 256 single-ended or 128 differential inputs. Two housings can be stacked to reach 512/256 channels; with expansion logic, users can go to 768 channels or more. Prices rise with the number of channels: a 32/16 channel system costs $3,190 to $3,470; one with 256/128 channels goes for $5,990 to $6,165; and 512/256-channel capability has a price tag of $9,890 to $10,160, including the required second housing. As factory options, Datel also offers digital-to-analog conversion circuitry for applications like real-time data logging, and simultaneous sample-and-hold circuits that are handy for signal processing.

Although it offers speed and flexibility, the PDAS-250 has uncompromised analog specifications. At 25°C, overall system error is less than ±0.04% of full-scale range, ±2 mV for single-ended inputs; in the differential mode, the figure is ±0.05% of full-scale range, ±2 mV. Nonlinearity is within ½ least significant bit. Gain drift with temperature is typically ±40 ppm/°C over a 0-to-70°C range.

Acceptable full-scale input ranges are 0 to 5 V, 0 to 10 V, −5 to +5 V, and −10 to +10 V. Input overvoltage is ±35 V maximum, for a steady-state, no-damage condition. Differential inputs have a common-mode range of ±10 V and common-mode rejection is 80 dB from dc to 60 Hz, assuming a 1-kΩ imbalance. Digital output is available in straight binary form, in bipolar offset binary, or in bipolar 2's complement. Delivery time is 10 to 12 weeks.

Datel Systems Inc., 11 Cabot Blvd., Mansfield, Mass. 02048. Phone Gilbert Parker at (617) 828-8000 [412]

Bandpass filter has sharp cutoff

"Brickwall" is the name Rockland Systems is giving its model 751A programmable elliptic bandpass filter to be introduced at Electro79. The reason: the unit features a roll-off rate of 115 dB per octave, giving a very sharp response curve. Stop-band attenuation is at least 80 dB.

The 751A permits independent programming of low- and high-frequency cutoffs, allowing the operator to set center frequency and bandwidth anywhere in the 1-Hz-to-100-kHz band it covers. Available as options are binary-coded-decimal and IEEE-488 bus interfaces for remote programming of cutoffs and prefilter and postfilter gains.

Employing a seventh-order elliptical filter, the unit has a 0.3-dB peak-to-peak passband ripple, and 85-dB stop-band attenuation above 1.7 times the low-pass cutoff and below 0.6 times the high-pass cutoff.

Rockland expects the Brickwall to find a wide range of applications "because it is the closest approach to the ideal 'brickwall' filter allowed by the present state of the art in component design," says marketing vice president David Kohn.

Availability of the 751A is 90 days, and the base unit price is $300. The 01 BCD option adds $375, or the 02 488 option may be specified for $650.

Rockland Systems Corp., Rockleigh Industrial Park, Rockleigh, N. J. 07647. Phone David Kohn at (201) 767-7900 [413]

Operational power works six ways

The first models in a second generation of bipolar operational power supplies will be launched at Electro 79, coming from the originator of the BOP concept, Kepco Inc. The new line will feature altogether six modes of operation, whereas the first generation featured only voltage stabilization.

"Bipolar operational power supplies are unique in their ability to control a voltage [or current] smoothly and linearly through zero from a positive to negative value without discontinuity and switching," says Paul Birman, Kepco's marketing manager.

Two models will make debuts: the BOP50-2M, which is a ±50-V, ±2-A unit, and the BOP100-1M, which is a ±100-V, ±1-A unit. The slew rate for the new units is a relatively speedy 3V/μs.

To the programmable constant-voltage mode, the new generation adds five others: constant current and positive and negative boundary limits for voltage and current. To keep operation within these limits, the power supply controls the conduction of series-pass transistors, also sending a signal to front-panel

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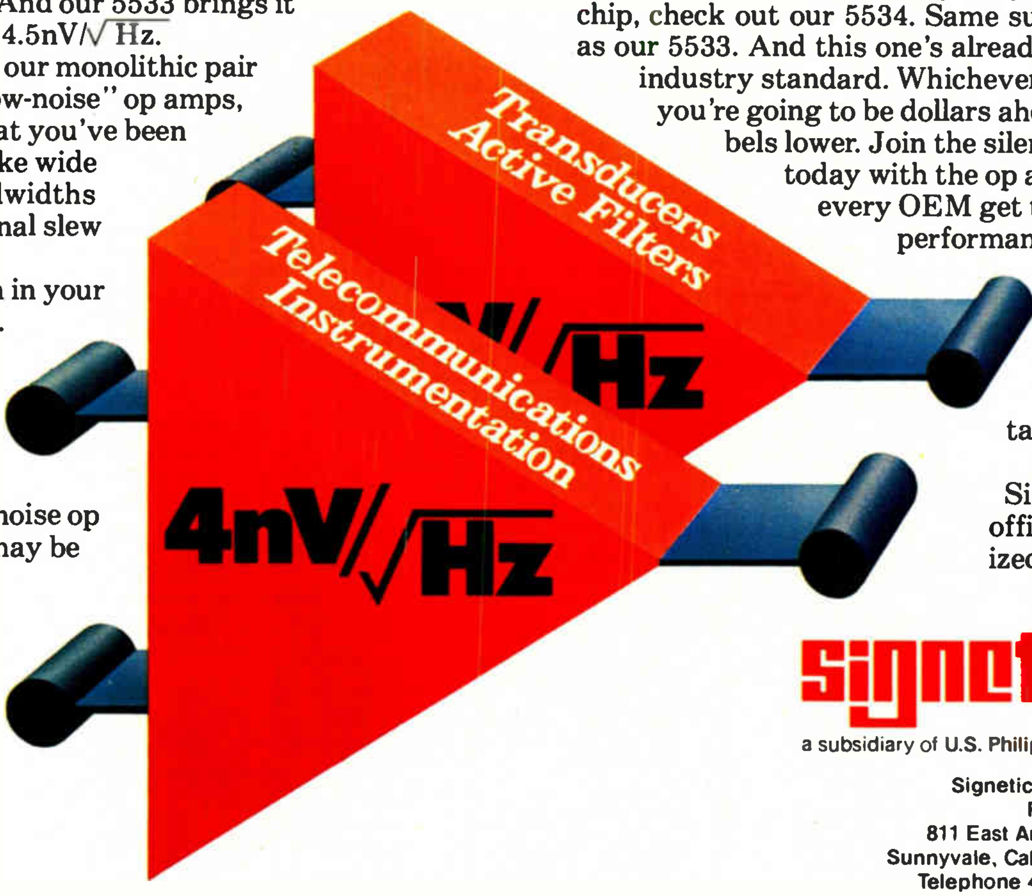

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Sunnyvale, California 94086
Telephone 408/739-7700

Signetics Dual Op Amps	
Part Number	**Key Specifications**
NE5532*	Low Noise: $6nV/\sqrt{Hz}$ (max.); internally compensated; 140kHz power BW @ 9V/μsec slew.
NE5533	Low Noise: $4.5nV/\sqrt{Hz}$ (max.); 200kHz power BW @ 13V/μsec slew.
NE/SE5530*	High Slew: 35V/μsec; internally compensated; 500kHz power BW; 3MHz small-signal BW.
NE/SE5535*	High Slew: 15V/μsec; internally compensated; 200kHz power BW; 1MHz small-signal BW.
NE/SE5538*	High Slew: 60V/μsec; compensated to gains of +5/−4; 700kHz power BW; 6MHz small-signal BW.

*industry standard pinouts

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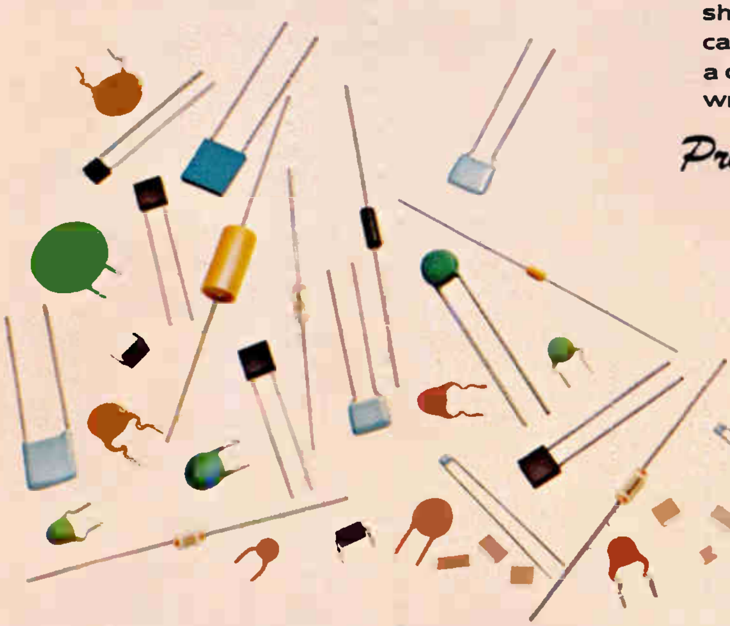

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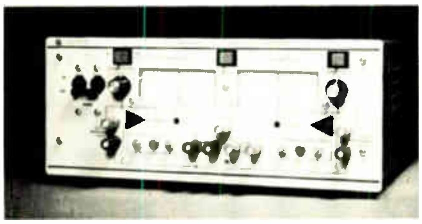


indicators and to interface connectors whenever operation pushes to one of the four boundaries.

Moreover, the new models feature four-quadrant unrestricted source-sink operation and listener compatibility with the IEEE-488 bus. Where the first generation required external amplifiers for signal manipulation, the new models eliminate the need for this extra hardware with two internal preamplifiers.

In the constant-current mode, the compliance voltage for the BOP50-2M is 100 v and 200 v for the BOP100-1M. Output noise is 1 mv typically, 3 mv maximum root mean square, and ripple is 10 mv typically, 30 mv maximum peak to peak. Output line and load regulations are 0.0005% and 0.001%. The floating output can go 500 v above and below ground.

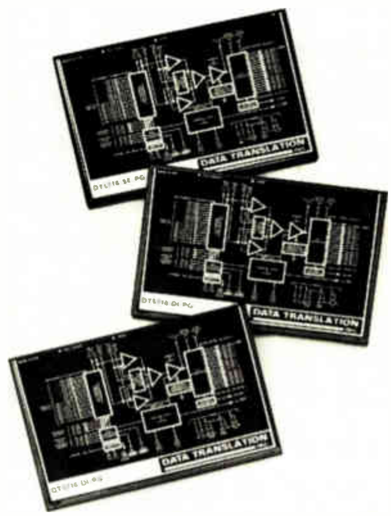
Single quantity price is $850, and availability is 90 days. Birman says the company expects the new models to follow in the steps of the first generation as power amplifiers, servo drivers, magnetic-beam steerers, and in such systems as automatic board testers, chip testers, and also avionics testers.

Kepco Inc., 131-38 Stanford Ave., Flushing, N. Y. 11352. Phone Paul Birman at (212) 461-7000, ext. 742 [414]

Acquisition unit resolves 16 bits

The number of applications for data-acquisition systems is on the rise as manufacturers broaden the dynamic ranges of their systems. Data Translation Inc. has taken the latest step forward with a new 16-bit analog-to-digital converter module for multiple analog signals. With 16-bit resolution and true 14-bit accuracy, the DT5716 accepts inputs between ±5 mv and between ±10 v.

"The DT5716 is especially good at measuring small deviations—like changes in temperature—from a central value," notes Stephen A. Connors, chief analog engineer. Fred Molinari, president of the firm, adds that "The DT5716 eliminates many of the front-end signal-conditioning costs associated with data-acquisition systems." He expects the module to be used in industrial and laboratory environments for distributed data collection, or as a signal conditioner and converter for a microprocessor or minicomputer. Other possible application areas he sees include temperature measurement systems, nuclear instrumentation, and gas chromatographs.



The DT5716 accepts data from 16 single-ended or 8 differential channels, expandable to 64 single-ended or 32 differential inputs. A resistor can be installed at each channel input to fix the gain of that channel, or the user can purchase a software-programmable variable-gain option. The user then can select a gain of 1, 2, 4, or 8 for high-level (±10-v) inputs, or a gain of 1, 10, 100 or 500 for low-level (±5-mv) signals. The module has byte-selectable, 16-bit three-state data outputs, in transistor-transistor or complementary-metal-oxide-semiconductor logic, for

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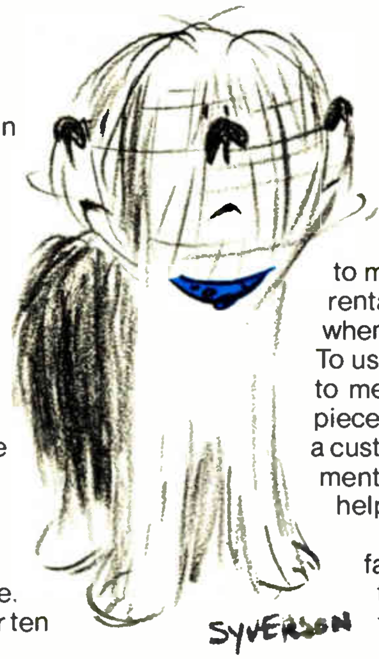

Need an oscilloscope or logic analyzer in a hurry? Do you have a short term need for a microprocessor development system? Chances are you've already discovered that renting the electronic equipment you need makes sense. But which rental company?

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But there's an even better reason to make Rental Electronics your equipment rental company. It's called service. It starts when our rental experts answer your phone call. To us, service means going that extra step to meet your particular needs—for a special piece of equipment, a tight delivery schedule, a customized rental or rental/purchase arrangement, or just straight answers and a helpful attitude.

When it comes to service we're positively fanatical. And it pays off. During the past twelve months, for example, 92% of our first-time customers have come back for more.

Next time you consider renting, consider Rental Electronics. Give us a shot at your business. We're confident we'll turn you into a repeat customer.

Test and Measurement Instruments

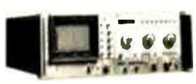
Here is just a small sampling of the test and measurement equipment available today from Rental Electronics. For a complete list, use the coupon opposite.

Hewlett-Packard 1640A Serial Data Analyzer. Identifies and locates failures to the component level; RSC 232C; 2048 characters, monitor buffer, plus 1024 characters transmit message buffer; Sync or Async.

Biomation K 100 D Logic Analyzer. 16 channels; 1024 word memory; clock rates up to 100 MHz; signal timing resolution to 10ns; built-in display and keyboard control.

Honeywell 101 Recording System. 7 or 14 tracks depending on head assembly; ½ in. (7 tracks) or 1 in. (14 tracks) tape; 8 tape speeds from 0.937 ips to 120 ips; direct bandwidth to 2 MHz (wide band) and to 600 kHz (intermediate band); FM bandwidth to 80 kHz (wide band) and to 40 kHz (intermediate band); reel size 10½ to 15 in., coaxially mounted.

Tektronix 465 Oscilloscope. BW 100 MHz; display 8 x 10; 5 mV/div to 5 V/div sens.; sweep rate 50 ns/div to 0.5 s/div; x10 magnifier; dual trace; delayed sweep; x-y operation.



Hewlett-Packard 8565A/100 Spectrum Analyzer. 0.01 to 22 GHz with internal mixer; 14.5 to 40 GHz with 11517 external mixer; 100 Hz and 300 Hz resolution bandwidth; Absolute Amplitude Calibration: −110 dbm to +30 dbm.

Brush 260 Strip Chart Recorder. 1 mV to 500 V; chart speeds 125 mm/sec. to 1 mm/min., incl. four event markers; pressurized ink; response: DC to 100 Hz.

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direct connection to 16-bit buses.

The DT5716 acquires 16-bit channel data in 300 μs and converts it in 100 μs. System accuracy is within 0.0075% of full-scale range for gains between 1 and 10. Throughput rate is 2.5 kHz, with 1 μV rms of input noise. The operating temperature range is from 0° to 70°C.

The module contains a multiplexer, a precision instrumentation amplifier, a charge-compensated sample-and-hold amplifier, a high-resolution successive-approximation a-d converter, and control logic. The a-d converter has a temperature coefficient of linearity of ±2 ppm/°C, and a temperature coefficient of gain of ±15 ppm/°C. For the instrumentation amplifier, the gain tempco is ±10 ppm/°C.

Housed in a 3-by-4.6-by-0.375-in. package, the DT5716 sells for $1,195 in quantities of one to nine. A version with 14-bit resolution and accuracy, the DT5714, is available for $795 in the same quantities. The software-programmable option for high-level inputs costs $175; for low-level signals, the price is $100. Delivery is within five days after receipt of order.

Data Translation Inc., 23 Strathmore Rd., Natick, Mass. 01760. Phone Fred Molinari at (617) 655-5300 [415]

Low-cost units test Z80s, 8085s

The hunger for more efficient ways to debug bus-architectured systems can hardly be satisfied, even by the number and variety of logic analyzers coming onto the market daily. Sophisticated, expensive units catering to the programming gourmet not only monitor what is happening on the address and data lines but take control of the processor, too. But Pro-Log has taken a McDonald's approach to analysis and developed a pair of low-cost, portable analyzers that sample address and data information passively.

Designers of "take-out" instrumentation have to grapple with the problem of how much capability they can pack into a box before they compromise the ease of use, compact size, and light weight needed in the field. "Despite their light weight and low cost, these two products allow users to analyze the address and data lines of either the Z80 (model M 824) or the 8085 (model M 825) incrementally or at full system speed and they offer much help in hardware and software debugging," says Shay Adams, director of international marketing for Pro-Log. The 824 and 825 are priced at $1,250 each, about the same price as the personality modules required by more complex analyzers.

Each analyzer clamps onto its particular microprocessor with a DIP clip that terminates an interconnecting cable. The user traps data by setting the desired address on a rotary switch and putting the analyzer in the data-latching mode. When that address appears on the address bus, the byte on the data bus is latched and displayed both in hexadecimal and 8-bit binary formats.

Users can step through a processor's program either by instruction or by machine cycles and can add 0 to 100 cycles of delay to an address before the desired data is latched. Addresses are displayed on a four-digit hexadecimal readout. Incremental control of the processor is obtained by operating on its WAIT line, according to Adams.

An oscilloscope-synchronizing output allows users to examine address and data lines for noise and glitches on an external scope. "When a user has isolated the problem down to a few instructions," explains John P. McDonald, the design engineer whose approach this is, "he can dial up those addresses one at a time and, as each one of them comes up, it will trigger the scope." Both products will be available for delivery in June, Adams declares.

Pro-Log Corp., 2411 Garden Rd., Monterey, Calif. 93940. Phone (408) 372-4593 [416]

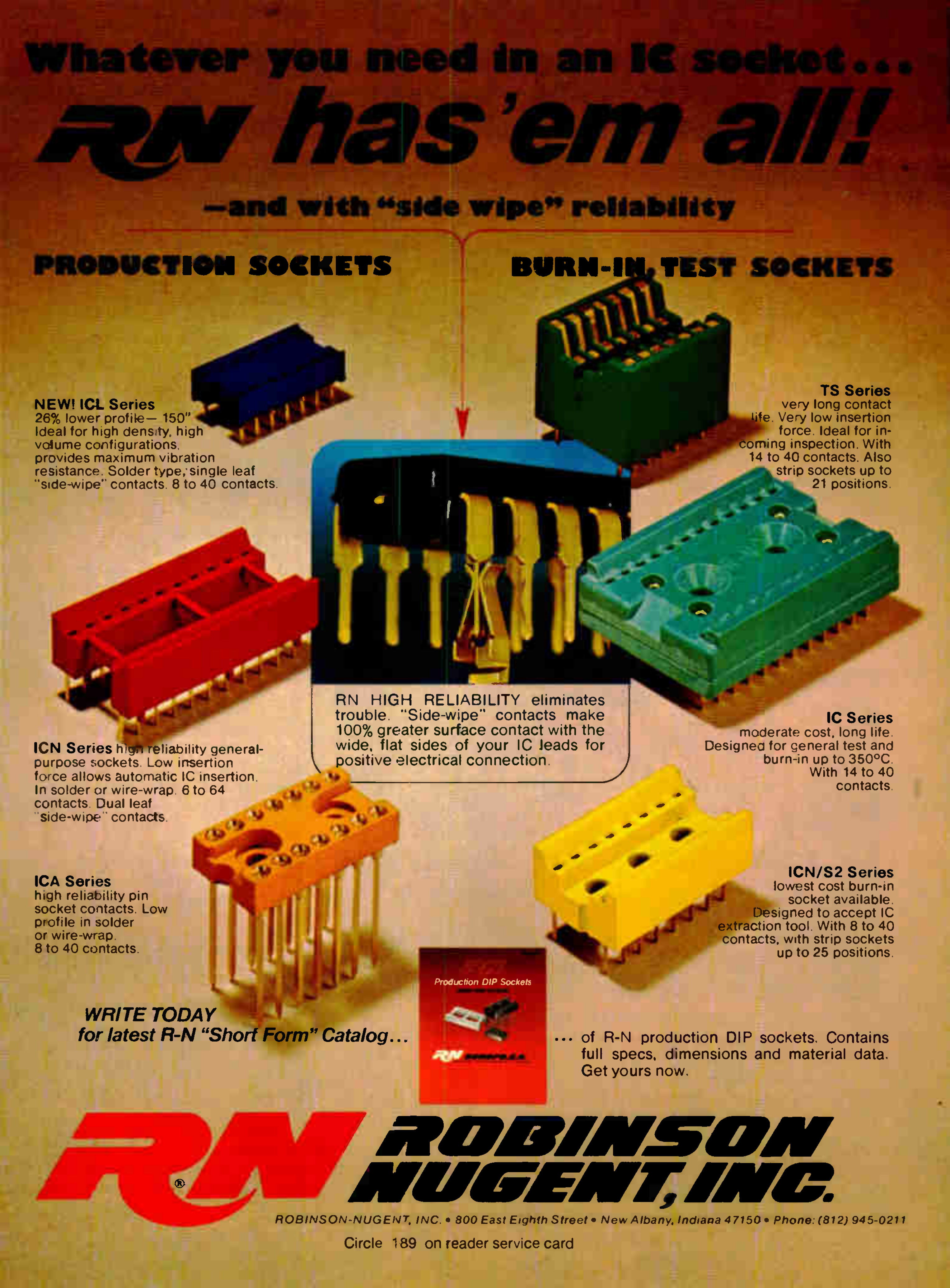
V-f units have small footprints

The days when fast voltage-to-frequency converters had to have large footprints on printed-circuit boards is past; Teledyne Philbrick is unveiling a high-reliability 1-MHz converter housed in a standard hybrid package.

Designated the 4735, the 24-pin unit is only 0.8 in. wide by 1.39 in. long and therefore requires only one quarter the area that a typical 2-in.-square module would.

The highest-frequency member of the family of converters introduced early last month [*Electronics*, March 1, p. 160], the 4735 resembles its relatives in its specifications. Like them, its operation is fully described over the temperature range from −55° to +125°C. "It is the only 1-MHz hybrid V-f converter with such a wide temperature range on the market," claims Wah Fea Ng, the company's product specialist for linear and nonlinear voltage-to-frequency converters.

Changes in output at full scale due to temperature variation are guaranteed to be within ±50 ppm/°C and



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typically they are ±30 ppm/°C. Temperature has little effect on the offset voltage, too; it is stable to within a guaranteed ±50 μV/°C and typically to within ±15 μV/°C.

Accepting power supply voltages between ±9 V and ±18 V, the 4735 is guaranteed linear to within ±0.015% of full scale (typically, within 0.005% of full scale). The dynamic range of the converter is 100 dB guaranteed (126 typically) and the common-mode rejection ratio is a guaranteed 60 dB (70 dB typical) with the common-mode voltage at 10 V. Overrange is typically 100%, and 50% is guaranteed.

The 4735's output is compatible with transistor-transistor or complementary-metal-semiconductor logic levels. The output pulse width can vary from 0.1 to 0.3 μs, and the output impedance is 6.8 kΩ ±20% when the pulse goes high.

Some applications for the converter are high common-mode voltage isolation, two-wire digital transmission, analog-to-digital conversion of up to 20 bits, and optical data links. Wah Fea Ng suggests that "it can act as the voltage-to-frequency end of a data link. Teledyne Philbrick should have a 1-MHz frequency-to-voltage converter very soon."

The 4735 costs $145 each for one to nine units. It is fully screened to meet MIL-STD-883. Also available is the 4735-83 at $185 (for one to nine); screened to MIL-STD-883 as well, it has additional burn-in and temperature cycling. Delivery is in 6 to 10 weeks for both.

Teledyne Philbrick, Allied Drive at Rte. 128, Dedham, Mass. 02026. Phone Wah Fea Ng (pronounced Eng) at (617) 329-1600 [417]

THD analyzer is easy to use

For such important and widely used instruments, distortion analyzers have had very little human engineering expended on them. Typically they are difficult to operate and require technicians to spend a good

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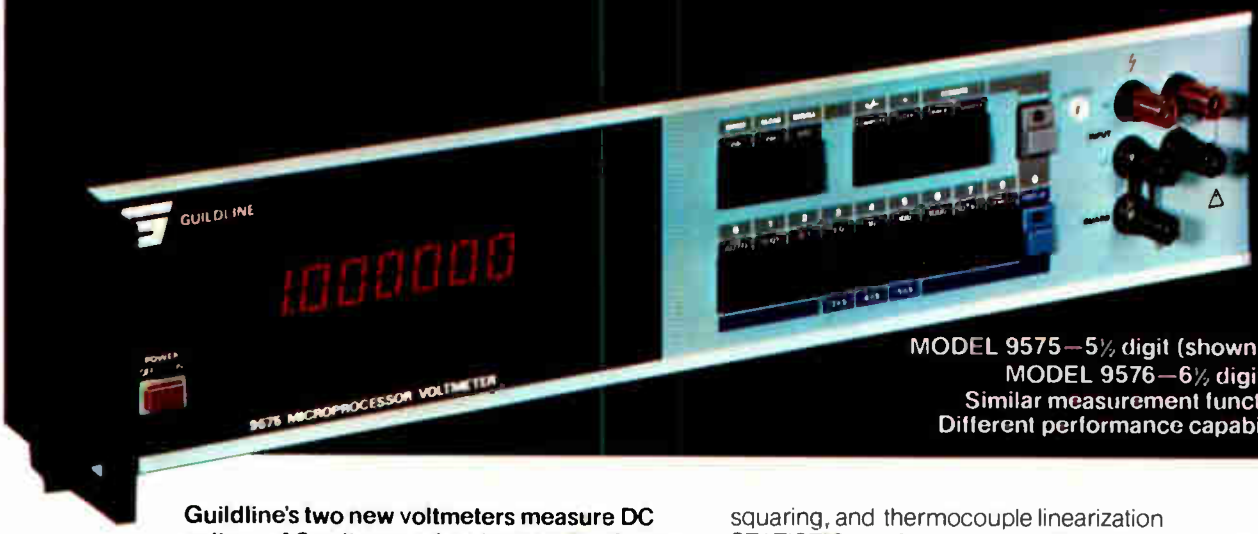

MODEL 9575—5½ digit (shown above)
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PLUS

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Electro/79 Booths 1627 & 1629

deal of time on learning how they run. Now, for all those firms making audio-band equipment, from operational amplifiers to active filters and consumer sound gear, there's Krohn-Hite Corp.'s model 6800 automatic distortion analyzer. The instrument measures percent total harmonic distortion (THD) quickly and accurately and does not require the skills of a piano player to operate.

Further, the price is right at what, for this market, is a very low $1,500.

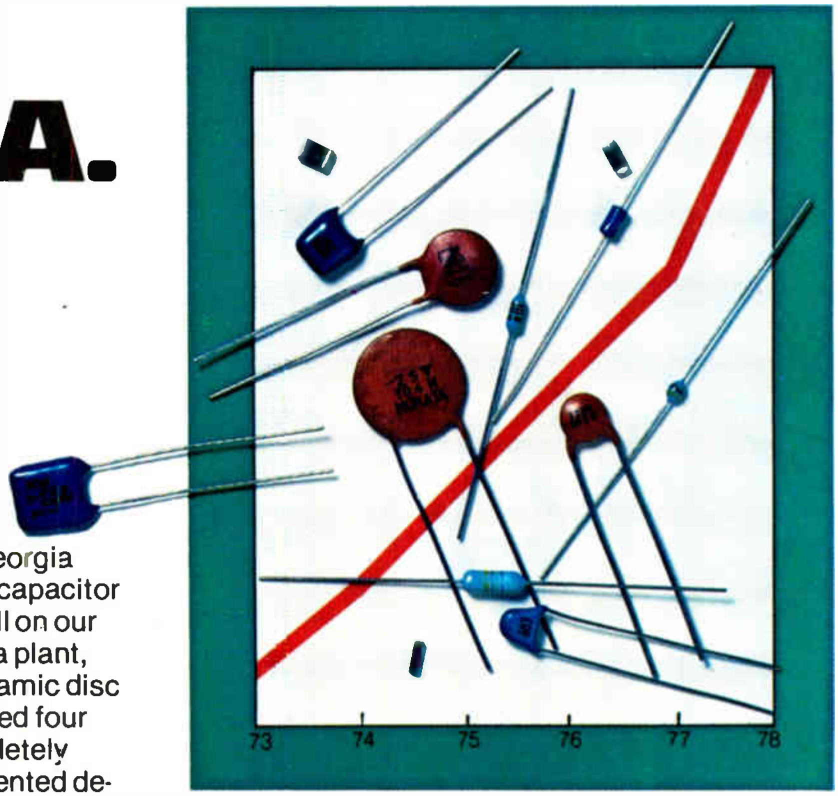
The 6800's front panel is simple compared with those of competing units. There is a 3½-digit planar plasma display and, nearby, a mode switch with one position for ac-voltage measurements and a second for distortion analysis. The only other important control is a set of push buttons for frequency-band selection.

Unlike most competing units, the 6800 is fully automated. Some analyzers require that parameters like amplitude, frequency, and phase be set manually; others automate one or two of these functions. The 6800 manages everything.

Its "autonull" circuitry homes in on the frequency of the test signal and matches it in phase by using a twin-T circuit built with photosensitive resistors, switched capacitors, and—to complete the loop—light-emitting diodes to control the resistors. Amplitude, also, is a hands-off parameter. The 6800 accepts inputs from as low as 100 mV to as high as 130 V. Using a combination of dropping resistors and variable-gain amplifiers, the 6800 amplifies or attenuates the input until it reaches the unit's 2.7-V internal working level.

Thus about all that the user need do is select the gross band of interest from among the following: 1–10 Hz, 10–100 Hz, 100–1,000 Hz, 1 kHz–

It's no coincidence that Murata-Georgia is the fastest growing ceramic capacitor manufacturer in the U.S.A.



In 1973, we made a decision: Murata-Georgia would create an unsurpassed ceramic capacitor capability and we'd do it fast. We're well on our way. Since 1974, our Rockmart, Georgia plant, already one of the most automated ceramic disc facilities in the world, has been expanded four times. We're presently building a completely automated plant to meet the unprecedented demand for monolithic glass, epoxy and chip capacitors in Douglasville, Georgia. Our corporate headquarters in Marietta, Georgia ties it all together with one of the most sophisticated data processing systems in the industry for inventory control and customer service.

Combine Murata-Georgia's rapidly expanding production capability with a line of ceramic discs, monolithics and high voltage units based on over 30 years of ceramic capacitor experience, and it's easy to understand why Murata-Georgia is the fastest growing manufacturer in the field.

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New products

10 kHz, or 10 kHz–110 kHz. If an input is outside the preset range, the digital display will flash until the operator presses the correct range button.

The display reads THD directly in percentage with resolution to 0.001%. Actual distortion measurement capability is close to this figure, but K-H spokesmen are sticking with an admittedly conservative specification: 0.005% residual distortion.

Because the effects of noise, hum, and electromognetic interference are very great when measuring such small amounts of distortion, K-H has included a pair of filters. A high-pass filter rolls off low-frequency artifacts like hum and noise at 12 dB per octave below 1,000 Hz and is typical of the instrument breed. Atypical is the 6800's low-pass filter that tracks the input fundamental frequency and rolls off information above its fifth harmonic at 6 dB per octave; this is an automated feature once switched in.

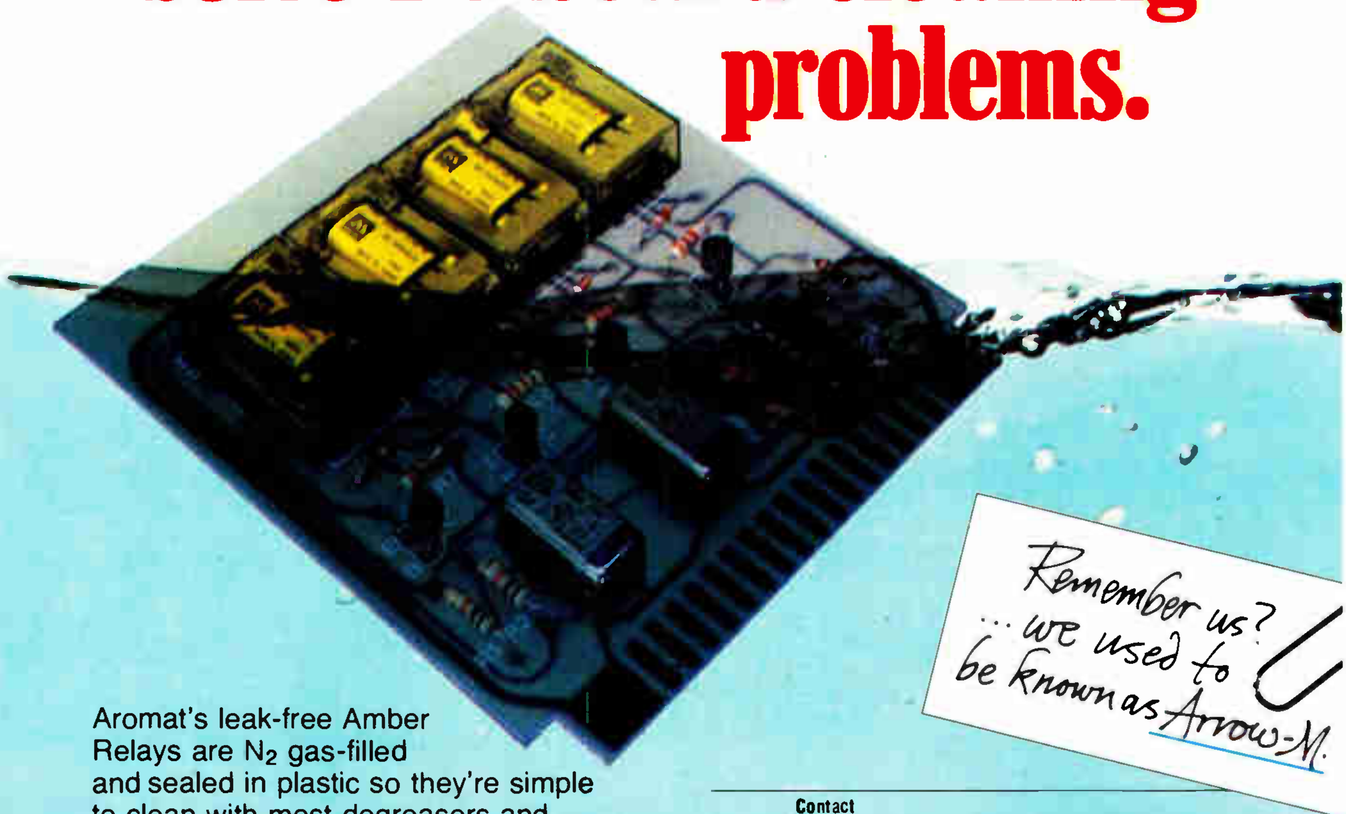
The 6800 also functions as an ac voltmeter with a frequency range that extends from 110 kHz all the way down to 1 Hz. As in the analyzer mode, the voltmeter works with voltages from 100 mV to 130 V rms. Measurement uncertainty is ±(2% of reading + 1 count) for voltages between 1 V and 130 V, regardless of frequency. For voltages of 100 mV to 1 V, measurement uncertainty above 40 kHz increases to ±(2% of reading + 3 counts). Below 40 kHz, the accuracy is the same as for the higher voltages.

The input impedance of the 6800 is fixed, regardless of mode: 110 kΩ shunted by less than 100 pF.

The 6800's $1,500 price cannot include everything. One of the things it excludes is a multifrequency oscillator. The oscillator in the Krohn-Hite instrument is a fixed-frequency unit that runs at 1 kHz with no more than 0.001% distortion. It is supplied mainly for system test and calibration. However, because so many audio measurements are referred to 1 kHz, it turns out that the built-in oscillator is all that many users will need. For those who really need

Aromat Amber Relays

solve PC board cleaning problems.



Aromat's leak-free Amber Relays are N_2 gas-filled and sealed in plastic so they're simple to clean with most degreasers and detergent cleaners, without affecting the maximum contact reliability of the relays.

In addition, Aromat's vacuum annealing production process completely outgasses all plastic parts, thereby completely eliminating any possible contact contamination.

Aromat can help you substantially reduce your labor costs! Just use Aromat Amber Relays on your PC board in conjunction with automatic wave soldering.

The total savings are even greater when you use Aromat Amber Relays. Aromat Amber Relay prices are right in line with standard non-seal types.

Aromat Amber Relays. When you want maximum reliability and maximum savings. And only Aromat makes them.

Series	Contact Form	Rating	Style	Size
RS	1 Form C	1 Amp	Half size	(.787Lx.394Wx.394H)
NF2E	2 Form C	2 Amp	Flat pack	(1.165Lx.772Wx.425H)
NF4E	4 Form C	2 Amp	Flat pack	(1.165Lx.953Wx.425H)
K2E	2 Form C	2 Amp	Cradle type	(.929Lx.748Wx1.181H)
K4E	4 Form C	2 Amp	Cradle type	(1.157Lx.748Wx1.181H)
K6E	6 Form C	2 Amp	Cradle type	(1.370Lx.748Wx1.181H)
HC1E	1 Form C	5 Amp	General purpose	(1.097Lx.827Wx1.280H)
HC2E	2 Form C	3 Amp	General purpose	(1.097Lx.827Wx1.280H)
HC4E	4 Form C	2 Amp	General purpose	(1.097Lx.827Wx1.280H)

Contact Your Aromat Representative or Distributor Today.

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Suite 1
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(312) 593-8535

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Relays for Advanced Technology

Aromat
Member of Matsushita Group

multifrequency operation, the company recommends its 4000 series broadband oscillators.

Small in price, the 6800 is also light in weight—only 10 lb, or a tenth the weight of some competitive units. It is also light on power consumption, requiring a mere 15 W.

Delivery time is 30 days.

Krohn-Hite Corp., Avon Industrial Park, Bodwell Street, Avon, Mass. 02322. [418]

Handheld meter race gets tighter

It's beginning to look like a track meet in the 3½-digit handheld multimeter market. Fluke's $169 8020A was challenged recently by Data Precision's look-alike model 935 [*Electronics*, Feb. 1, 1979, p. 150], which is priced at $149 and by Beckman Instruments' $130 model 3010 and $170 model 3020 [*Electronics*, March 15, 1979, p. 168]. Now, Fluke plans to use Electro79 to vault back into contention with its $129 model 8022A.

With this new meter, Fluke is trying to catch the competition between its improved 8020A and the new instrument. "We're using higher-precision references and input dividers in the 8020A now," says Charles B. Newcombe, product marketing manager, "and it now matches the 0.1% accuracy spec of the 935 and the 3020." Other added

features include an extra year's warranty (two years now) and the carrying case (formerly a $10 option).

The 8022A does not have the unusual conductance mode of the 8020A, nor does it match the improved meter's accuracy. It does have five functions: ac and dc voltage to 2,000 V, ac and dc current to 2 A, and resistance to 20 MΩ. Its basic dc-voltage–measurement uncertainty is ±(0.25% of reading + 1 count) and its ac bandwidth is 450 Hz (compared to 5 kHz for the 8020A model).

Low-power operation in the 8022A is provided by both its custom complementary-metal-oxide-semiconductor circuit and its liquid-crystal display. Because these components consume little power, the meter can operate for up to 150 hours on an ordinary 9-V battery or 200 hours using an alkaline battery. (The Beckman units, however, get 2,000 hours from the same size and type power sources.)

Reliability is enhanced by the meter's small number of parts (only 47) and its built-in overload protection. The instrument can safely withstand overloads of 1,000 V in its voltage modes, 500 V in its resistance mode, and 2 A in its current modes.

Both the 8022A and the new version of the 8020A will be available with 30-day delivery times.

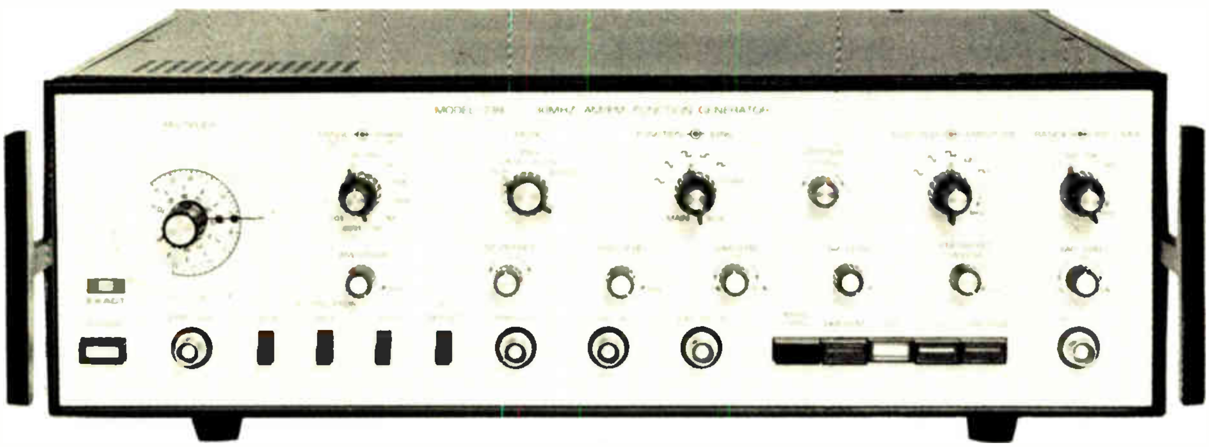
John Fluke Manufacturing Co., P. O. Box 43210, Mountlake Terrace, Wash. 98043 [419]

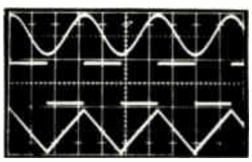
Single-step board speeds debugging

Debugging systems built with Mostek's Micro Design series (MD) series of inexpensive microcomputer boards will be faster with the latest addition to the Z80-based line.

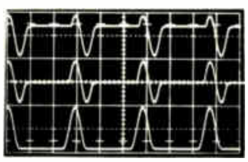
Designed for use with the line's MDX-CPU1 and MDX-DEBUG boards, the new MDX-SST will allow users to step through programs one instruction at a time and display the

WHY NOT USE A 30 MHz FUNCTION GENERATOR FOR YOUR AM/FM REQUIREMENTS?

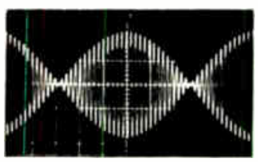




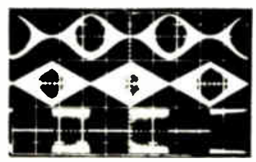
1. **30 MHz Top Frequency** for standard sine, square, triangle, and pulse waveforms.



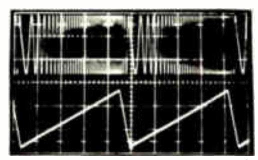
2. **Variable Phase Control** permits varying the start/stop point 180° in trigger, gate, pulse, and burst modes.



3. **Amplitude Modulation** from 0% through 100% to double-sideband suppressed-carrier using AM Level and Carrier Level.



4. **Multi-waveform AUX** generator provides square, triangle, and sine AM/FM modulating frequencies variable up to 1 MHz.



5. **Variable Symmetry** Control allows symmetry ratio adjustment from 19:1 to 1:19. Great for linear sweeping.

more reasons why the Exact Model 739 is the most AM/FM function generator ever sold.

TWO GENERATORS IN ONE. The Model 739 is two complete and separate generators in one box. Both generate sine, square, and triangle waveforms. The Main generator frequency range is 0.0001 Hz to 30 MHz. The AUX generator frequency range is 0.01 Hz to 1 MHz.

WIDE BANDWIDTH. The carrier can be frequency modulated by the AUX generator over a 3 decade frequency band. It can also be swept over a 1000:1 range manually, or with an external or internal ramp.

INTERNAL AM/FM SOURCE. The AUX generator can frequency modulate, sweep, gate, trigger, or amplitude modulate the Main generator. It can also amplitude modulate an external carrier. The AM modulation is adjustable from 0% through 100% to double-sideband suppressed-carrier.

TRIGGER/GATE (Internal and External). The Main generator can be triggered (single cycle) or gated (multiple cycles) either manually or by an external signal when GATE or TRIG modes are selected. The AUX generator is internally connected to gate or trigger the Main generator when BURST or PULSE modes are selected.

VARIABLE SYMMETRY. Variable symmetry controls for each generator allow the symmetry of the selected waveform to be varied from 19:1 to 1:19. When the AUX generator is internally connected to the Main generator, this provides linear frequency sweeping at a rate 19 times the retrace time.

SIMULTANEOUS AM/FM. The Model 739 provides increased flexibility by allowing simultaneous amplitude and frequency modulation. Examples are: AM/frequency shift keying using squarewave modulation, linear AM/FM using triangle or ramp modulation, and sinusoidal AM/FM using sinewave modulation.

SEPARATE AM, FM, AND CARRIER LEVELS. The Model 739 has separate level controls for FM width, AM carrier, and AM modulation. The 30 V P-P open circuit (15V P-P into 50Ω) output can be attenuated up to 80 dB. 60 dB is in fixed 10 dB steps and a variable amplitude control provides 20 dB. The modulation percentage is not affected by the attenuator settings. Approximately 40 dB additional attenuation is available by using the carrier level control when in the AM mode.

RUGGED ALL-METAL CASE. Die castings, extrusions and sheet aluminum combine to make a rugged instrument 43 cm wide, 13 cm high, and 35 cm deep. With the optional rack mounts it uses only 5¼" of vertical space in a standard 19 inch RETMA rack.

PRICED RIGHT. Compare all of these Model 739 features with those of any other combination AM/FM function generator available today. Then compare the price of the Model 739 at *$1295.00 FOB Tillamook, Oregon. There is no contest!

*Domestic U.S.A. price only

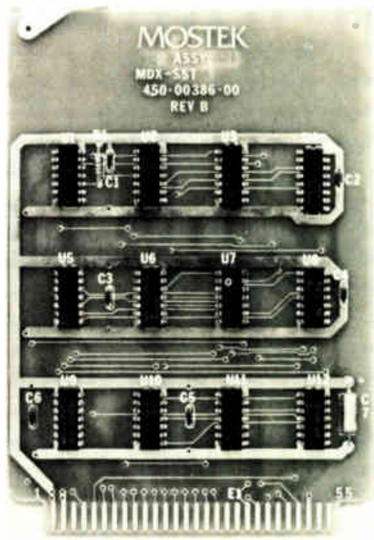
BOX 347 TILLAMOOK, OR 97141 Tel. (503) 842-8441
TWX 510-590-0918

EXACT electronics, inc.

contents of all the CPU1's registers after each instruction. Under keyboard control, the SST employs the CPU1's nonmaskable interrupt and DEBUG-resident firmware to supply users with enhanced debugging capabilities.

With the SST, users may specify a number of instructions to be stepped and the starting location in the program. All 18 of the CPU1's 8-bit registers and its four 16-bit registers can be displayed or printed out after each instruction cycle.

Like other cards in the low-priced series, the SST measures 4.5 by 6.5 in. and slips into the STD-Z80 bus designed jointly by Mostek and Pro-Log. Mostek expects that it will be used most frequently with the MDX-



PROTO, a prototyping package that includes the CPU1, DEBUG, DRAM8 (an 8-K-by-8-bit dynamic-memory board), and card cage.

With a $1,095, single-quantity price, the PROTO package is offered primarily as a low-cost tool for hardware and software evaluation, says Harold Webb, microcomputer systems manager. Development work is possible with the PROTO kit alone; the DEBUG board contains a 10-kilobyte software package in read-only memory with assembler, text editor, loader, and debugger. So as Webb explains, "We saw fit to

Why fool around?

Our Snap-Lock makes your tough little connector decisions easy. It's the rugged, make-sure miniature circular connector to call for when you just don't want to fool around.

It has the right quality features: metal housing, high contact density, moisture-proof, can be pressure resistant and/or hermetically sealed.

And you can choose from enough sizes and options to make designing-in Snap-Lock as easy as it is dependable: 2 to 19 contacts, reversible, and crimp removable or soldered — plus a variety of mounting styles, back shells and potting boots.

Positive, vibration-proof locking.
You can hear it snap into place. It won't shake loose. But release is easy with a squeeze of the metal ring.

Need a quick, pull-the-cable disconnect?
We have it: Pull-Lock. Friction holds the connector together, but a firm yank on the cable pulls it apart.

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enhance the PROTO by introducing the SST to take advantage of existing firmware."

For really extensive development projects, Webb recommends the dual-disk AID-80F program development system. But for smaller tasks he foresees the PROTO-SST combination as providing a fast solution.

The MDX-SST is available now at a price of $150 in single quantities and $100 in lots of 100 or more.

Mostek Corp., 1215 Crosby Rd., Carrollton, Texas 75006. Phone (214) 242-0444 [420]

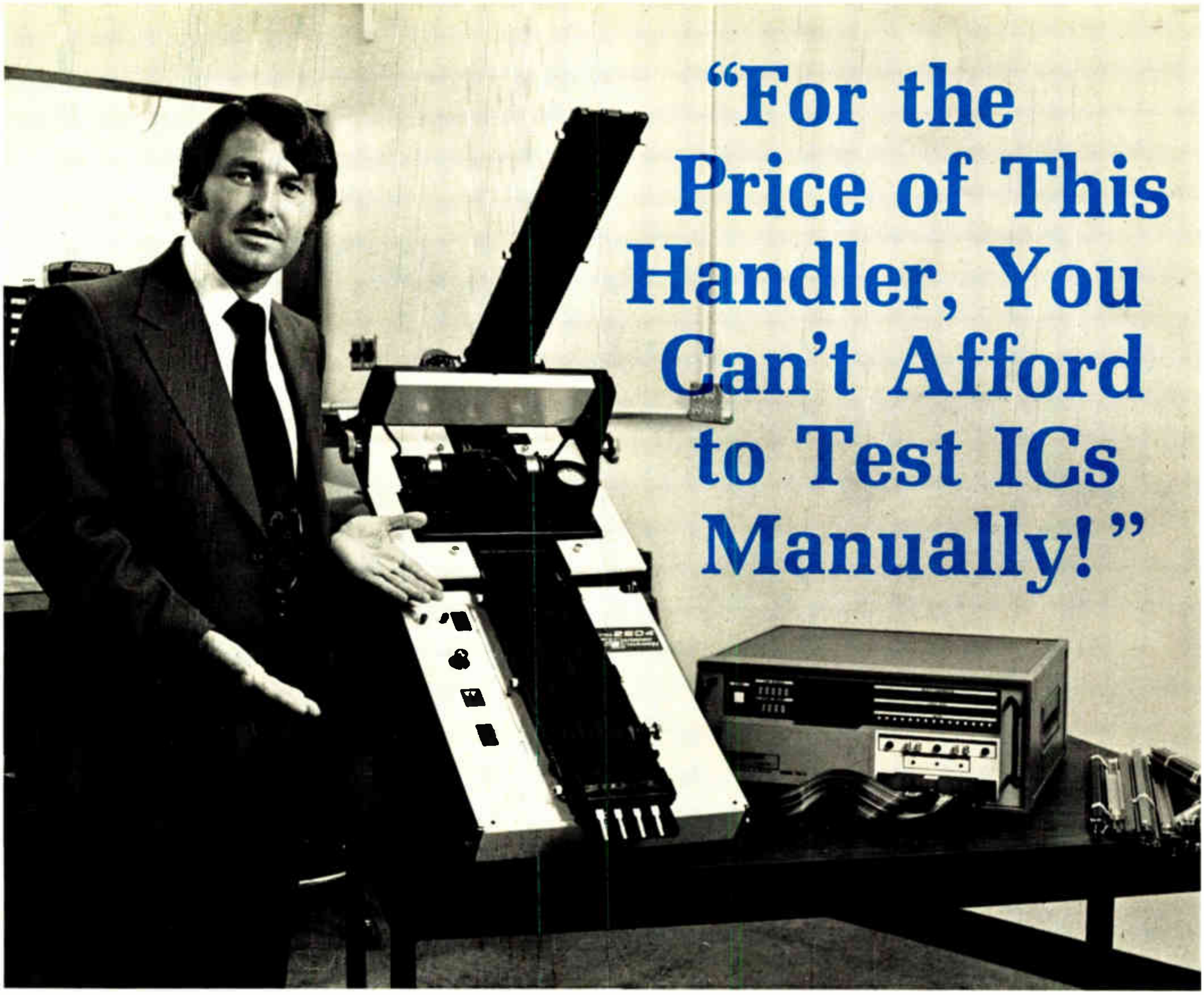
Cinch gets into flat-cable market

The crowded market for flat-cable connector systems gains a new competitor this month with the introduction of TRW Cinch Connectors' new three-part system. Grid socket connectors, pin headers, and dual in-line package (DIP) plugs from TRW "basically look just like the others," concedes a TRW official, but the company is counting on its worldwide distribution chain to become an off-the-shelf supplier of the connectors. Prices will range from 60 cents to $2 depending on the exact size of the connector.

Seven sizes of grid socket connectors are available, and strain relief is an option. Up to 50 terminations are possible, with two contact points per position. With locking latches in the cover, the socket connectors can be compact in design: connector spacing is 0.250 in.

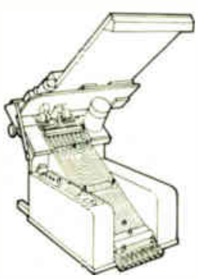
Six-pin headers for interconnecting printed-circuit boards with flat-cable sockets are available in straight and right-angle configurations, with two solder tail lengths (0.092 or 0.155 in.) and a 0.610-in wire-wrap tail. Four DIP plugs can be either permanently soldered to a printed-circuit board or inserted into standard integrated-circuit sockets. Delivery time for the products is six to eight weeks.

TRW Cinch Connectors/Electronic Components Division of TRW Inc., 1501 Morse Ave., Elk Grove Village, Il. 60007 [339]

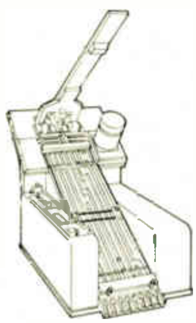


"For the Price of This Handler, You Can't Afford to Test ICs Manually!"

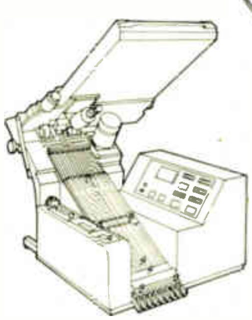
. . . It's MCT's Model 2604



Model 2608M
8,500 DPH
Expanded Input
DIP Handler



Model 2608
10,000 DPH
DIP Handler



Model 2608E
7,000 DPH
Elevated Temperature DIP Handler

Why test ICs manually when we make efficient, reliable automatic DIP handling available at such a reasonable price?

Our MCT* Model 2604 is the DIP handler designed and priced for users cycling a moderate volume of devices. Its 5000 DPH speed and four-track output assure efficient throughput for normal operation as well as peak load conditions. Its low price generates a fast return on investment even if your work load only requires that you run your handler part time.

The Model 2604 offers the ruggedness of more expensive handlers at a reasonable price. Its quality components, wear-resistant materials, long contact life, and 'leads up' handling of devices reduce downtime and insure trouble-free operation. The Model 2604's proven reliability means that it will be earning its keep long after other handlers are down for repair.

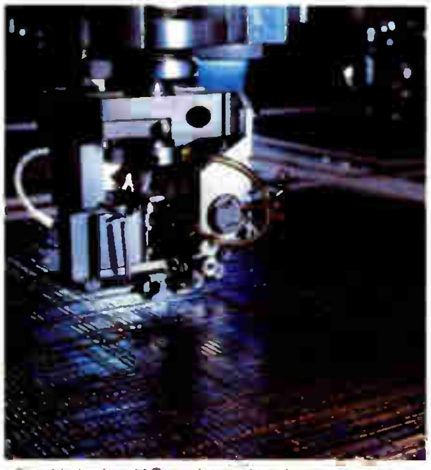
The Model 2604 is just one of our many fine IC handlers. It is fully supported with installation, service and operator training programs. Find out for yourself why we're the leader in IC handling equipment.

For more information on the Model 2604, contact Micro Component Technology, Inc., P.O. Box 43013, St. Paul, MN 55164 or call (612) 482-5170.

MCT™

*MCT is a trademark of Micro Component Technology, Inc.

With Multiwire, startups come fast.



®Multiwire is a U.S. registered tradename of Kollmorgen Corporation

Product life cycles are shrinking dramatically. Every design phase must be shortened drastically.

Under such pressures, Multiwire® is a far better high-density system for interconnection than multilayer to have on your side. As we will note, it has advantages over wirewrapping, also.

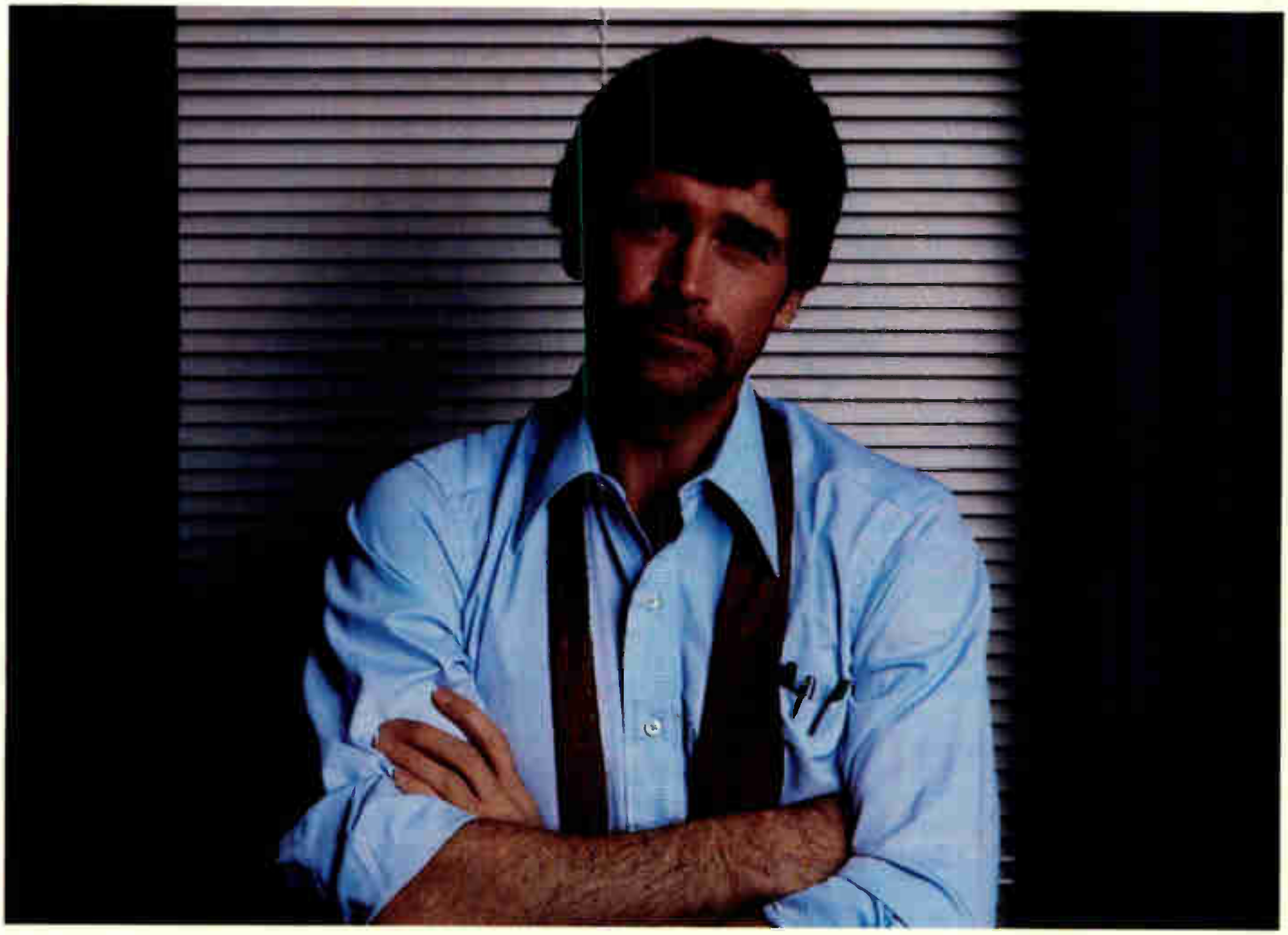
With Multiwire, startups come much faster. Multiwire board design requires power and ground artwork only. It eliminates all the steps in creating multilayer board artwork.

Development of Multiwire wiring paths is fully computerized. Beginning with your point-to-point interconnection list, Multiwire software programs do all the wire routing. You get fast, early documentation of the design from actual-size graphic printouts showing all wiring paths and connections.

The same software package generates the magnetic disk that controls our Multiwire machines. As a result, the manufacturing cycle is fully defined the moment you approve your graphic printout.

Multiwire machines lay down extremely dense patterns of insulated wire with precise line spacing between lines and between cross-overs. Your chance for malfunction of boards because of unpredictable manufacturing problems is virtually nil.

With multilayer, you've got to wait.



What about design changes? Most wires are accessible in the typical Multiwire board, so circuit paths can be interrupted and new paths patched in by hand in minutes. Opportunities for doing this with success are far less in multilayer.

Making new boards with changes is extremely fast with Multiwire. There's no wiring artwork to correct or start from scratch. We simply input your changes into the computerized net list. Computers do the rest.

Compared with wirewrapping, Multiwire boards are, of course, much thinner. Wirewrapping is typically used for prototyping before multilayer production, leading to switchover problems, Multiwire is both a prototype and production system.

Multiwire also has significant advantages over larger complex two-sided printed boards. Too often, the routing paths on these printed boards can't match the component loading. Not so with Multiwire. Its inherent ability to crossover solves the routing problem.

Multiwire is proven as the way to meet the time pressures of today. And you will get a pleasant bonus. Because your time frame to start up can be condensed by Multiwire, your development costs will be lowered.

To provide you with even faster service, Multiwire manufacturing centers are now on each coast.

Our new Multiwire guide will show you how easy it is to use Multiwire. For more information and location nearest you contact Multiwire, 31 Sea Cliff Ave., Glen Cove, NY 11542, (516) 448-1307

MULTIWIRE

Circle 154 on reader service card

procedure, but the least efficient because of the need for repeated communication between array processor and host. The user can purchase the optional Fortran compiler and write his own high-level programs which are then converted to assembly language—a more efficient scheme. Those users who must have the maximum throughput may work in assembly language and squeeze more of those simultaneous operations into the 64-bit words.

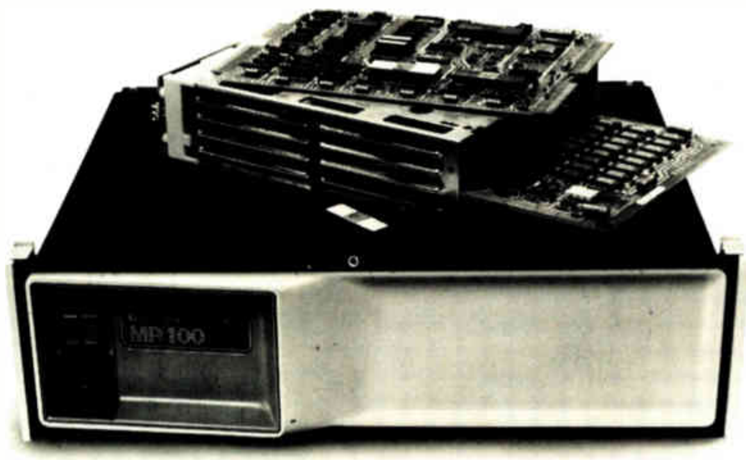
A Fortran software package, Apsim, allows a user to simulate the action of the FPS-100 on his host so new programs can be developed and tested without tying up the actual array processor.

In situations where input/output operations are better handled directly by the array processor than through the host, optional I/O processors can be fitted to the FPS-100. One is used for interfacing to fixed-protocol peripherals such as display terminals. The other, which is programmable, has dual processors, one for I/O control and another for format control. The latter processor features a 32-word writable control store. It converts fixed formats into floating point or one format of floating point into another; it can also be used to pack or unpack data. There are 70 formatting routines in Floating Point's routine library.

In addition, there are over 250 computational routines available from its math library. Housed in its 18-inch-wide, 10.5-inch-high and 24.4-inch-deep chassis, the FPS-100 can accommodate up to 15 plug-in boards, enough for its floating-point arithmetic unit, integer controller, all memories, plus one optional I/O processor. Extra I/O processors are housed in an expansion chassis, but the power supply in the main box can supply both, Strelchun says. Host computer interface hardware, which also fits in the main chassis, is available to link the FPS-100 with Digital Equipment Corp.'s PDP-11 systems and Data General's Nova series. First delivery of the FPS-100 is slated for last quarter of 1979.

Floating Point Systems Inc., 11000 SW 11th St., Portland, Ore. [340]

ANNOUNCING THE LOW-COST 16-BIT MICROCOMPUTER, MP/100.



THIS IS HOW FAR YOUR MONEY CAN GO.

Function and economy. Those are the two reasons we packed more features in our new 16-bit microNOVA® MP/100 than anyone would have thought possible. And at a price lower than anyone would have thought possible.

Available at chip, board or box level, the MP/100 is based on the new Data General designed and manufactured 16-bit mN602 NMOS microprocessor. This is where the true functionality begins. Our single, 40-pin package includes the full NOVA® 16-bit architecture and multifunction instruction set, hardware stack and frame pointer, 16-bit multiply and divide, realtime clock, multiple addressing modes, standard and high-speed data channels (2M byte/sec), 16-level priority interrupt and dynamic RAM refresh. It's capable of supporting up to 64KB of RAM/PROM/EPROM memory in standard applications and up to 128KB in special application requiring additional memory.

The MP/100 gives you the mN602 microprocessor, an asynchronous interface with full modem control, automatic program load, power/monitor/auto restart and soft control panel all on a single 7½" x 9½" board.

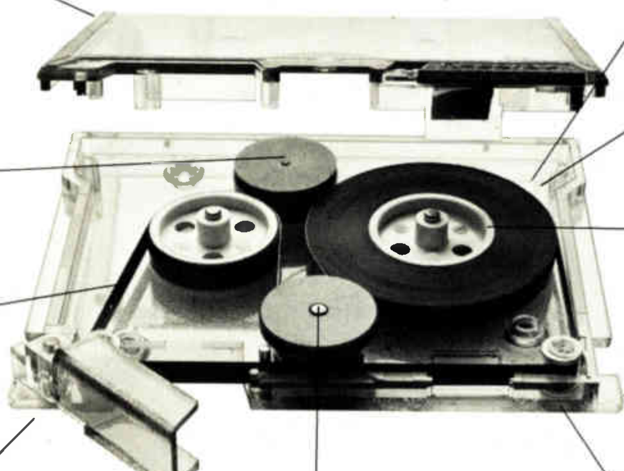
All microNOVA computers are available in a compact, modular 5¼" eight-slot chassis featuring a single board power supply for increased reliability and maintainability. Plus a low cost four-slot card cage for product OEMs.

Our new 16-bit microNOVA MP/100. It can take you a long way on a small amount of money. Most important, the MP/100 is not only compatible with other members of the microNOVA family but also within the entire Data General family of NOVA and ECLIPSE computers. It's a smart way to grow.

Why Verbatim® re-invented the wheel.

Our patented "Belt Driven Floating Roller" is the key engineering design element in the TC-150. The Verbatim TC-150 offers at least ten improvements over the other design.

TC-150 mini data cartridge, shown actual size.



1. Our **unitized construction**, consisting of symmetrical shell halves, provides structural stability and the strength of advanced polymer. Construction is simpler and less expensive, yet the entire shell has thermal consistency. No differing rates of expansion to stress critical tape paths.

2. Our simplified Floating Roller design, employing fewer moving parts, **reduces variability** caused by environmental changes, age and use.

3. Our TC-150 mini data cartridge uses Verbatim's unique **gamma ferric oxide digital** tape. This special formulation has been extensively field proven to have long life and low head abrasion.

4. Each cartridge is **completely certified** after final assembly to be 100% error free before packaging.

5. Our Floating Roller design, which eliminates the unstable function characteristics of corner rollers, **improves recording quality** by producing repeatable tape tension across the read/write head.

6. Our metal-free advanced polymer shell design **resists static buildup**. A metal baseplate can cause damage from static electricity as the cartridge is inserted into the system. Synthetic carpets can build up big charges.

7. The Verbatim TC-150 mini data cartridge has a **broad operating temperature range.**

8. The tape hub material was formulated to produce a rate of thermal expansion that exactly matches the tape's. This **prevents "pack shift"** and uneven tape wear.

9. **Less power is consumed** when driving our Floating Roller cartridge because the elimination of corner rollers dramatically lessens friction.

10. Since we have **eliminated the corner rollers**, we don't need the metal baseplate which is subject to warping, dents and burrs.

Any resemblance between the Verbatim TC-150 mini data cartridge and the old fashioned 3M DC-100A and HP 9162-0061 cartridges it replaces, ends with the form factor. We completely re-engineered this useful byte-oriented data cartridge, for the good reasons noted above. You'll want to test our improvements, which happily result in a lower cost. Call any of the Verbatim distributors listed on the facing page.

Special Limited Offer: Buy a sample order of at least five Verbatim TC-150's and our distributor will give you, on delivery of your order, a coupon redeemable for one of our mini data cartridges **free.** This offer is only available through participating Verbatim distributors and is void where prohibited by law. Limit one coupon to each customer.

Our distributor will also be delighted to supply you with quality Verbatim diskettes and cassettes.

Verbatim Corporation.
323 Soquel Way, Sunnyvale, CA 94086.
(408) 245-4400.
TWX: 910-339-9381.

"Nothing on a computer isn't important."

PEOPLE WHO PLAY THE COMPUTER

Specify Verbatim.

Circle 214 on reader service card

New products

Components

Triac driver is driven by logic

Optically coupled unit with zero-crossing detector has isolation rating of 7.5 kV

To be able to switch 115-V ac loads using a logic-level signal, with no adverse effects on nearby circuitry, has been a difficult goal to realize. Motorola's MOC3030 triac driver achieves that goal and provides a few extra features at the same time.

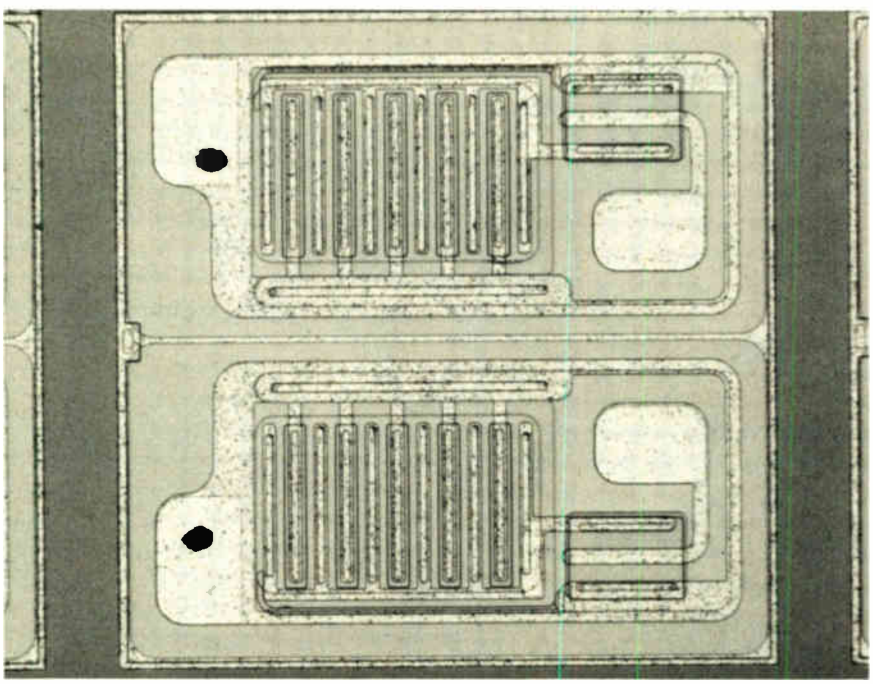
The device consists of an infrared-light-emitting diode optically coupled with a bilateral detector. The detector, which includes a zero-crossing sensing circuit, is a monolithic unit. Both components—the IRED and the detector—are housed in a six-pin dual in-line package.

The use of optical coupling gives the MOC3030 an input/output isolation-voltage rating of at least 7,500 V ac. A breakdown-voltage rating of at least 250 V for the output switch provides a comfortable safety margin for switching the 115-V root mean square line. At the same time, to drive most triacs, the driver circuit can deliver a gate current of 100 mA.

The zero-crossing feature prevents optical excitation from triggering the device when the instantaneous line voltage differs from zero by more than ±20 V. This not only greatly reduces electromagnetic interference, but also extends the lifetimes of certain load devices, such as incandescent lamps, by preventing sudden inrush currents.

Motorola implements its zero-crossing detector with a pair of phototransistors, each shunted by a field-effect transistor whose gate is connected to the phototransistor's collector. As a result, when the voltage on the collector exceeds the threshold voltage of the FET, the base current is shunted to ground, greatly decreasing the output signal. Consequently, the triac driver can only be triggered when the voltage across its output terminals is less than the threshold voltage of the FET—about 20 V.

The FET also acts as an active dv/dt suppression network, since it clamps much faster than most transients can rise. The MOC3030 can therefore be used in circuits with inductive loads with no need for an



external snubber network.

Power dissipation for the driver is 330 mW. It comes in two versions: the 3030 requires 30 mA of IRED drive for the output to latch up; the more sensitive 3031 needs only 15 mA. Each has a holding current of 100 μA for both polarities.

In lots of 100 or more pieces, the 3030 sells for $1.80, whereas the 3031 is priced at $2.37. Samples are available now with production quantities coming in the third quarter.

Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Ariz. 85036. Phone (602) 244-3965 [341]

Detector and amplifier share the same can

Housed in an eight-pin T0-5 can, the UDT-455 consists of a silicon photodiode that can be connected for either photovoltaic or photoconductive operation and a monolithic operational amplifier with junction-field-effect-transistor input.

The amplifier's typical offset and input bias currents are low (3 and 30 pA, respectively), as are its offset temperature coefficient and typical offset voltage (0.5 μV/°C and 1 mV, respectively). Slew rate is a minimum of 40 V/μs.

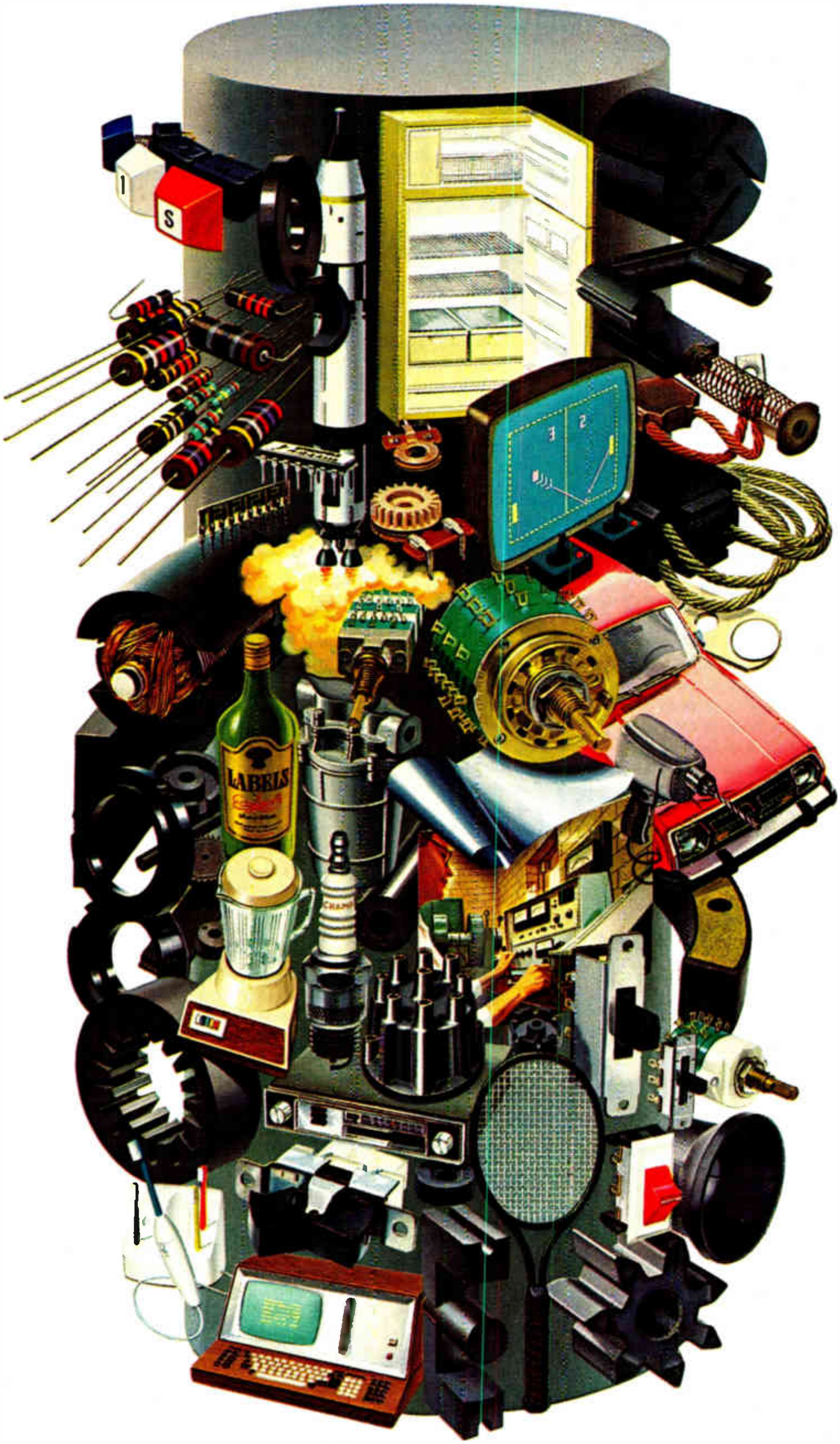
In single quantities, the hybrid 455 costs $57 and delivery time is 30 days.

United Detector Technology Inc., 2644 30th St., Santa Monica, Calif. 90405. Phone (213) 450-8585 [345]

Avalanche rectifier ensures safe trip for microprocessors

The MR2525 is a 25-A avalanche rectifier diode designed to protect sensitive electronic circuitry such as microprocessors and memories from high-voltage surges. The device serves particularly well in automotive applications, for example, where 200-to-500-ms transients with peaks of 80 to 120 V can occur when a battery being charged by an alternator is disconnected — a situation

What is a Stackpole?



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New products

known as a load dump.

To provide protection, the unit uses a chip of more than 38,000 square mils; previous avalanche rectifiers had chip sizes of less than 120 square mils. The greatly increased size allows the 2525 to withstand nonrepetitive forward-surge currents of up to 600 A and repetitive reverse-surge currents of 62 A. Breakdown voltage for a reverse current of 40 A (with a pulse width of 10 ms and a duty cycle of 2%) is a maximum of 40 V.

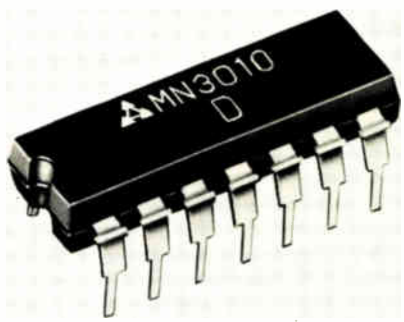
The unit is available in a stud-mounted case with standard polarity (cathode to case) or reverse polarity for $2.50 in lots of 100 or more. It also comes in an axial-lead mount priced at $2.44 in like quantities. Delivery is from stock.

Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Ariz. 85036. Phone (602) 244-6900 [343]

Bucket-brigade device keeps the buzz out of echos

Intended for audio and other analog signal-delay applications, the BBD3010 is a bucket-brigade device in a 14-pin dual-in-line package that introduces a noise level of only 210 μV. The unit contains two segments of 512 stages that can be combined in series to provide a delay of up to 51.2 ms or else used separately to retard signals by as little as 0.52 ms.

The unit works with clock frequencies of from 10 to 200 kHz, responds to frequencies in a wide range approximated by 0.3 times the



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Circle 219 on reader service card

clock frequency, has a signal-to-noise ratio of about 85 dB, and typically distorts signals by only 0.4%. Also typical is its 0-dB insertion loss.

The BBD3010 is the tenth in a series, extending the choice of devices to create reverberation, vibrato, chorus, double-voicing, and similar effects in electronic musical instruments, and to produce time compression and delay in voice-communication systems. In 1,000-piece lots, the units are priced at $8.95 apiece.

Panasonic Inc., One Panasonic Way, Secaucus, N. J. 07094. Phone Bill Bottari at (201) 348-7276 [346]

Op amp plus transistors equals 20-W output

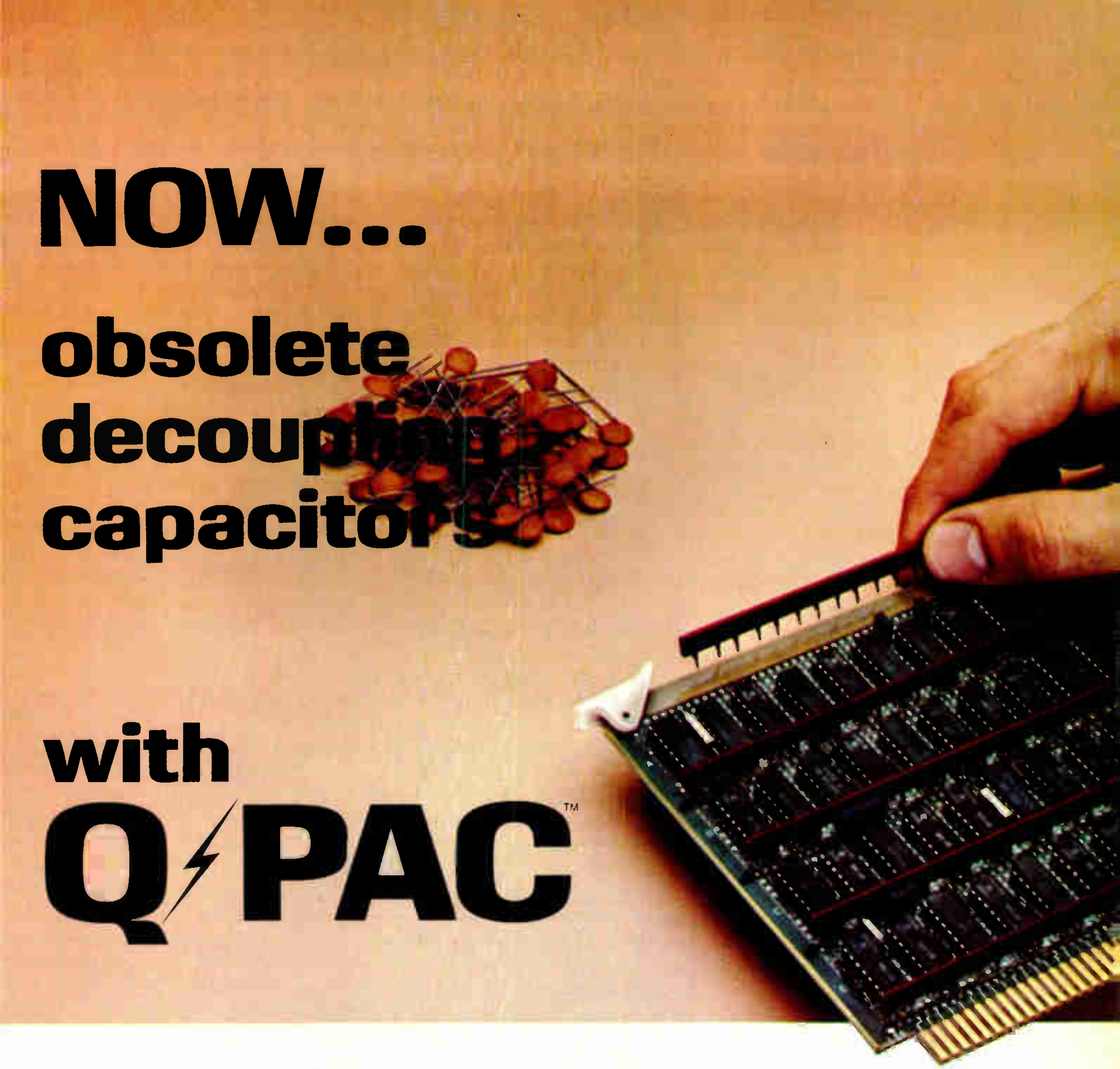
By adding power transistors to a 741C operational amplifier, designers of the PA-011 have come up with a bidirectional class-B linear-power amplifier providing a peak power of 20 W for 10 seconds working from a ±24-V supply. The amplifier can deliver 1 A, peak power, and 5 W continuously.

The PA-011 has a maximum absolute differential voltage of ±30 V dc and a maximum common-mode voltage of ±12 V dc. Its common-mode rejection is 90 dB, its input-offset temperature coefficient is 6 μV/°C, and its input bias current is 0.5 μA. Differential and common-mode impedances for the PA-011 are 300 kΩ and 2 MΩ, respectively. Full-power response for the unit reaches to 5 kHz.

The unit is designed for operation in environments whose temperatures range from 0° to 65°C. Its molded housing measures 1.2 by 2 by 0.6 in. and its pins are designed for spring-loaded contacts. Among its recommended uses are relay driver, sound amplifier, servo valve, solenoid, and motor applications.

The PA-011 costs $52 in single quantities and delivery takes two weeks.

Torque Systems Inc., P. O. Box 588, 225 Crescent St., Waltham, Mass. 02154. Phone (617) 891-0230 [344]



New, high capacitance Q/PAC* power distribution elements are the exciting, revolutionary way to eliminate decoupling capacitors from printed circuit boards. Rugged Q/PAC elements are easy to install and increase system reliability through reduced part count.

Q/PAC elements are available in capacitance values up to 0.05µf per inch in lengths up to 16 inches. Configurations allow for either vertical mounting or horizontal installation under DIP packages.

Patent Applied For

Q/PAC elements eliminate the need for on board power traces and extra board layers. They maximize packaging density and minimize signal interconnection problems.

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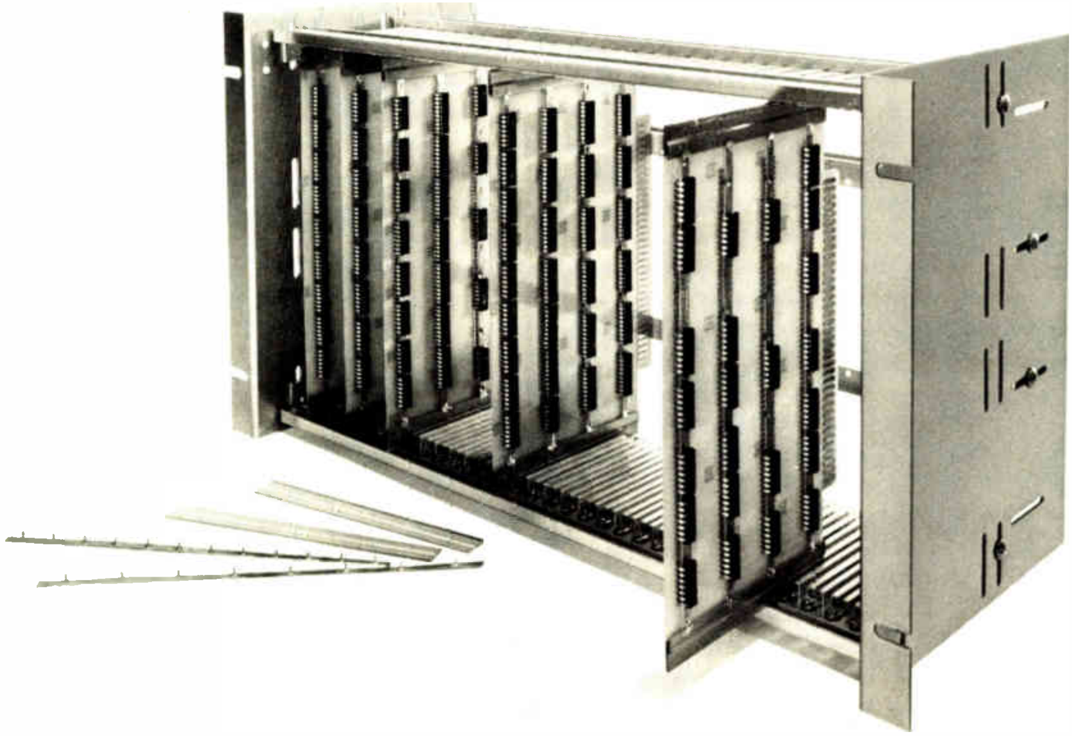
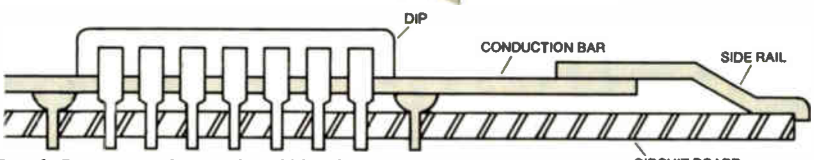
For information only circle #221

Why IERC's new heat dissipation system for .300" DIPs is more efficient, simpler and costs less than alternate technologies.



The IERC system provides significant thermal transfer for better thermal balance as well as an efficient thermal interface from DIPs to card holder.



Standoffs raise conduction bar .020" above circuit board to accommodate metal traces between the standoffs, and to permit removal of solder residue.

The Problem

The thermal management of large numbers of dual-inline packages on a single PC board can be a problem, particularly in telecommunications and logic networks. Single DIPs rarely dissipate as much as one watt, but a board full of them can add up to 15-25 watts. IERC's system of conduction bars and side rails provides a simple, inexpensive, off-the-shelf solution to the problem.

Some Expensive Solutions

Ladder networks will do the job. Of course there is the cost of fabrication, and the difficulty of epoxying the networks to the boards, which makes assembly and repairs a nightmare.

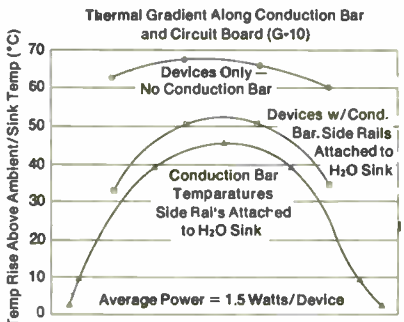
Another approach is to plate heat-dissipation strips directly onto the board. A good idea for some applications, except the cross-sectional dimensions of plated strips (and hence their dissipating efficiency) is limited by the plating process. Also, plated strips require valuable board space and often introduce capacitance and induction problems into your design.

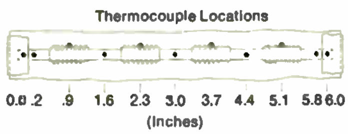
Boards with heat-dissipating metal cores require extremely careful engineering, and are costly and very difficult to make.

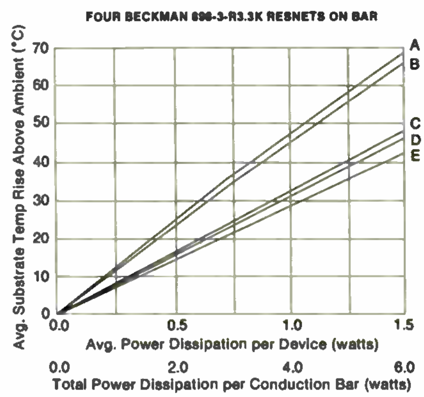
IERC's Better Solution

IERC's heat dissipation system consists of conduction bars and side rails, both of which are made from high-thermal-conductivity copper (solder plated) and are available in practically any length. The conduction bars can be wave-soldered into place along with other board components. The IERC system permits quick fabrication of a custom heat-dissipating network for .300" DIP systems, with no restrictions on the distance between DIPs or rows of DIPs. Call or write today for more information.

IERC's conduction bar system lowers substrate temperatures 30% — 40%.





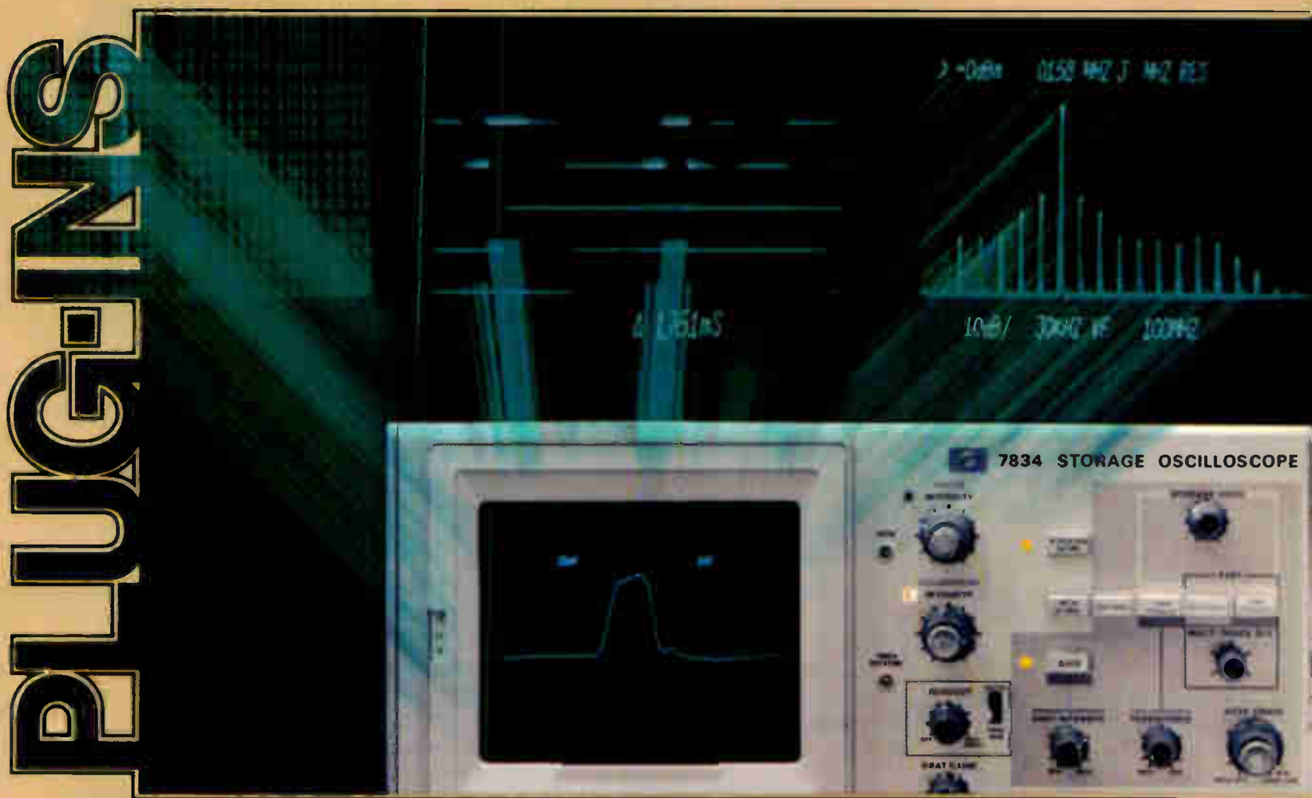


A – Device only, natural convection, horizontal board;
B – Device only, natural convection, vertical board;
C – Device with conduction bar, natural convection, horizontal board;
D – Device with conduction bar, natural convection, vertical board;
E – Device with conduction bar, side rails attached to infinite heat sink.

IERC

International Electronic Research Corporation, 135 West Magnolia Boulevard, Burbank, California 91502 (213) 849-2481

FLEXIBILITY



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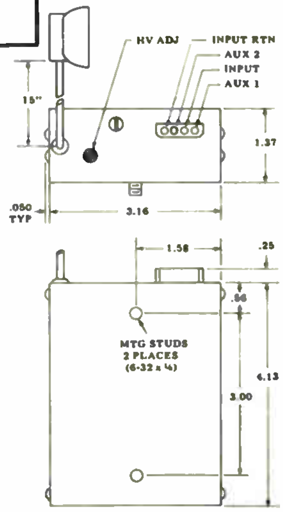

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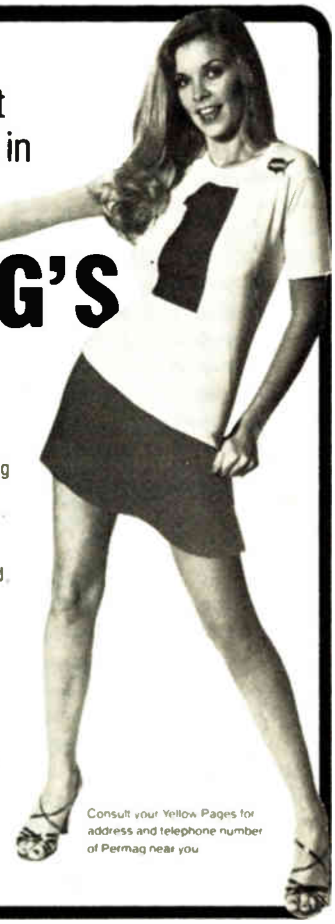

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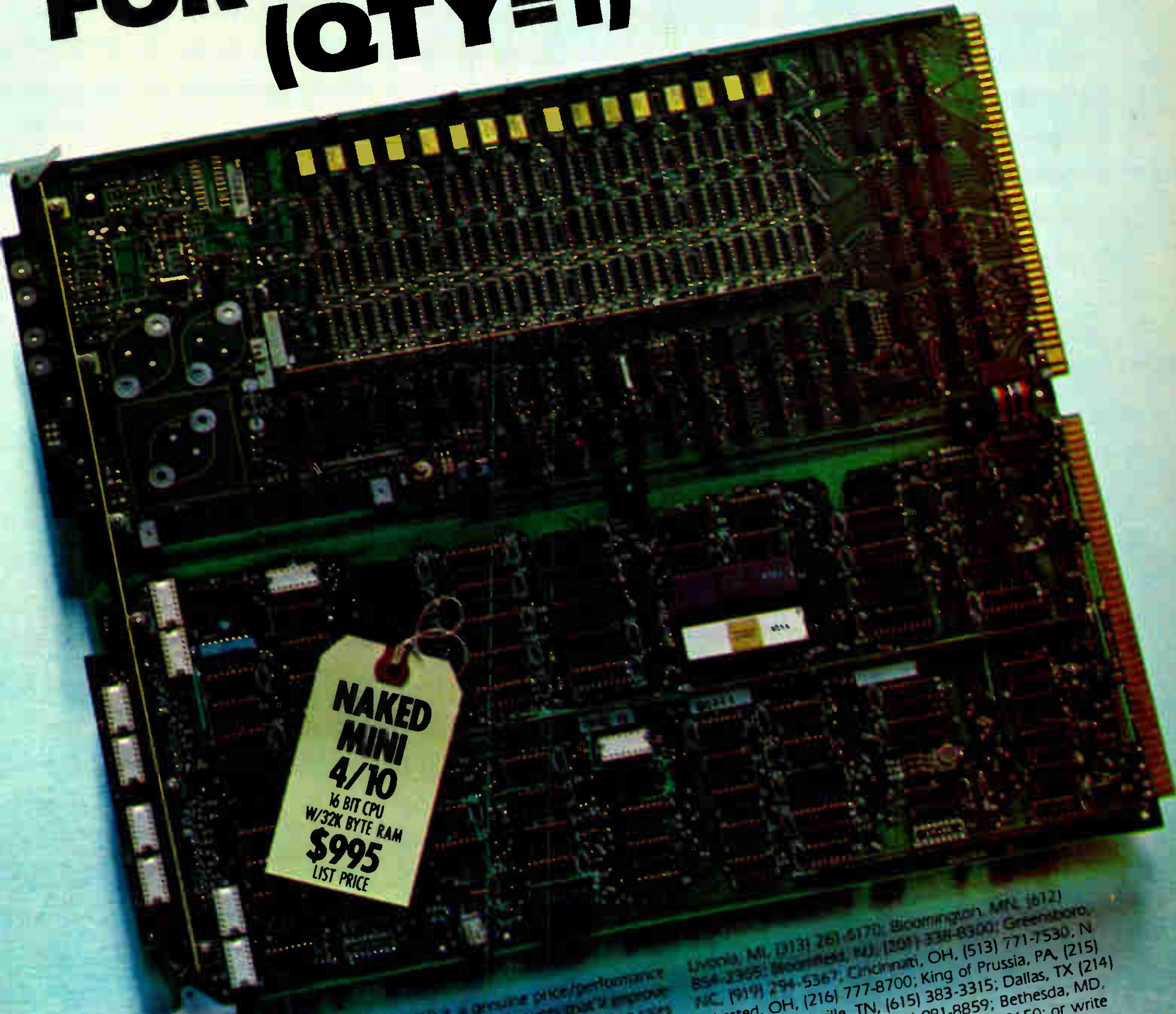

Circle 225 on reader service card

Instruments

LCD thermometer computes, too

Unit measures and stores temperature in three scales and figures rate of change

In a marketplace already overcrowded with portable digital thermometers, why would a company introduce another one?

"Because people need one that is not only convenient and accurate," replies Tracy L. Varnum, general manager of Caspar Integrated Systems, "but is also able to do computations for them." Consequently, CIS is introducing a microprocessor-based handheld model that it claims offers significantly better performance than benchtop units costing several times more.

The DPT 600 measures temperature over a wide range—−192° to +407°C—and shows the result on its 4-digit, 0.5-in.-high liquid-crystal display. Celsius, Fahrenheit, or Kelvin scaling can be selected and platinum resistance temperature probes are offered for any of four types of measurement: immersion, surface, surface-piercing, or gaseous.

To ensure accuracy, the thermometer's 8048 microcomputer uses an algorithm, based on DIN RTD standards, that corrects inputs to within 0.05°C. The chip is also programmed to correct for circuit nonlinearities, so total system error does not exceed ±0.2°C from −150° to 407°C and ±0.3°C down to −192°C.

Busy chip. Taking full advantage of the 8-bit microcomputer, CIS incorporated additional switch-selectable functions: storage and recall of minimum and maximum temperatures, computation of rate of temperature change, and latch-in display of temperature extremes.

Minimum and maximum temperature readings are automatically captured and stored in memory locations no matter what functions the unit is performing. They are updated three times every two seconds and, at the press of a switch, can be recalled

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Fotoform and Fotoceram materials are being applied in many new high technology products such as wire guides in several new dot matrix impact printing systems, and magnetic recording heads used in computer disk memory units. This photograph shows an enlarged section of a cell sheet used in a gas discharge display.

Three different materials are available, Fotoform glass, Fotoform Opal glass-ceramic and Fotoceram glass-ceramic.

We've prepared a special technical package, "Materials for the Design Engineer," that will give you the specs on Fotoform and Fotoceram materials—and more. We're the Fotoform Products Group, part of the Materials Business. MS-123A, Corning Glass Works, Corning, New York 14830.

CORNING

Circle 227 on reader service card

New products

five frequency bands, keeping them accurate to within 1 MHz over the instrument's tuning range of 1 MHz to 22 GHz.

With the aid of front-panel push buttons and a type 2147 4,096-bit read/write random-access memory, the operator can store signals and perform various other operations. An immediate benefit of digitally stored and refreshed signals is the complete absence of flicker, even at very low scan rates, notes Joseph P. Engeman, product line manager. Moreover, punching the HOLD button freezes the signal in the memory so that it may be closely studied for an unlimited length of time.

The normal display mode of the analyzer uses only 1,024 bits of the memory. By punching the SAVE button, the operator can store the signal in another 1-K segment, without disturbing the displayed signal. He may later recall that signal, or he may punch the SIGNAL-INPUT button, thereby feeding to the display the difference in amplitude between the stored signal and the real-time signal at the analyzer input. Yet another button allows the live signal and the stored signal to be displayed simultaneously for comparison, a handy feature when making production-line adjustments in filters and the like, Engeman says.

Digital output. The 757 also provides an on-screen readout of six important parameters: center frequency, reference level, vertical scale, scan width, scan time, and intermediate-frequency filter bandwidth. Moreover, these six parameters and the 1,024 horizontal points of the displayed waveform feed to rear-panel outlets for connection to a computer, printer, or storage device.

Another aid to semiautomatic testing is the 757's ability to step across the selected frequency band in response to a remote signal. This capability was optional on the preceding model 727, but is standard on the new instrument.

Like its predecessor, the 757 has a 100-dB dynamic range, a low-end sensitivity of −125 dBm, and a high-end sensitivity of −90 dBm. (The sensitivity figures apply with a 1-kHz

One day, the pencil factory started producing pencils with erasers at both ends,

because the machine that put the erasers on went haywire,
because the computer gave it the wrong message,
because one of its printed circuit boards malfunctioned,
because one of the I.C.s was in backwards,
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Division of USM Corporation, Elliott Street, Beverly, Massachusetts 01915

An **EMHART** Unit

i-f bandwidth.) Moreover, the new unit's height has been cut from 12.5 to 8.75 in., and its weight has been pared about 25 lb to 65 lb.

Scheduled to be available by the end of the quarter, the 757 will sell for $19,975—about $2,200 more than the earlier model. However, besides the benefits of digital processing, it offers, as standard, three features that formerly were extra-cost options: the semiautomatic response to remote-signal tweaking, a preselector-filter bypass that can increase sensitivity by 10 dB when the filter is not needed to reduce noise, and a local-oscillator output.

Ailtech Division, Cutler-Hammer Inc., 2070 Fifth Ave., Ronkonkoma, N. Y. 11779. Phone Charles Sheetz at (516) 528-3600 [353]

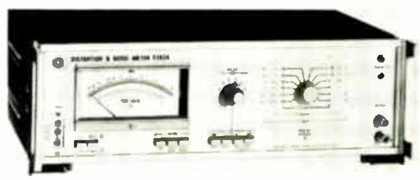
Automatic meter measures audio distortion and noise

Tuning the fundamental rejection frequency across the frequency range of interest is one of the most time-consuming parts of making a manual distortion measurement. The model F242A performs the tuning automatically, both saving time and eliminating operator error.

With its frequency range of 20 Hz to 20 kHz, the meter is suitable for testing all sorts of audio gear, including amplifiers, oscillators, tape recorders, line equalizers, and filters. In addition to distortion, it can measure audio gain, frequency response, and signal-to-noise ratio.

Input circuit configurations include both unbalanced and balanced circuits either terminated in 600 Ω or bridged. When terminated in 600 Ω the F242A has a residual noise of less than −110 dBm. It sells for $2,425; delivery time is 60 days.

Marconi Instruments, 100 Stonehurst Court, Northvale, N. J. 07647. Phone (201) 767-7250 [355]



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Microcomputers & systems

Micro-company uses big bubbles

Portable microcomputer with ¼-megabit memories weighs only 20 lb

While titans IBM and Bell Labs publicly discussed their newest bubble technologies at Indian Wells, Calif., last month, a tiny Los Angeles company had something to say about bubbles, too.

"We are now marketing the first microcomputer that uses ¼-megabit bubble devices," announced Michael Wurmbrand, vice president of nine-person Findex Inc.

Called the Findex 128, each typewriter-sized computer contains four of the first ¼-megabit production parts delivered by Rockwell Inc. In addition to the basic 128 kilobytes of mass storage that these devices provide, the 20-lb unit includes 48 kilobytes of dynamic random-access memory, 1 of static RAM, and 8 of read-only memory expandable to 32 kilobytes.

Storage and RAM can also be expanded, and users can pack 500 kilobytes of bubble memory and 128 kilobytes of RAM into the single housing or expand them to 2 megabytes each with an additional chassis. Presiding over all this is a Z80 processor that can ship out data over four serial or 46 parallel lines or on an S-100 bus. Where more I/O is needed, a further 64 parallel lines can be added.

To keep the unit's weight and volume down, Findex engineers chose a scrollable gas-discharge display rather than a bulky cathode-ray tube. Users can put up to six lines of 40 dot-matrix characters in upper and lower case while scanning the system's data base. For hard copy, there is an integral tape printer: an external printer can also do the job using the bus or I/O lines.

Getting their first product to market was not an overnight project, according to Wurmbrand. The company's four engineers began designing the computer some 3½ years ago, building their own driver circuitry based on Rockwell's original single-loop design. Then, when Rockwell changed to a multiple-loop structure last April, it was back to the design board. "It's the price you pay if you want to deal with new technology," Wurmbrand warns.

But fast-acting Findex was ready when Rockwell started delivering the parts last February. As they come in on a 45- to 60-day schedule, Findex is able to plug them in, test, and ship

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out the product 90 days or less after receipt of order. The company can currently produce 20 to 30 units each month.

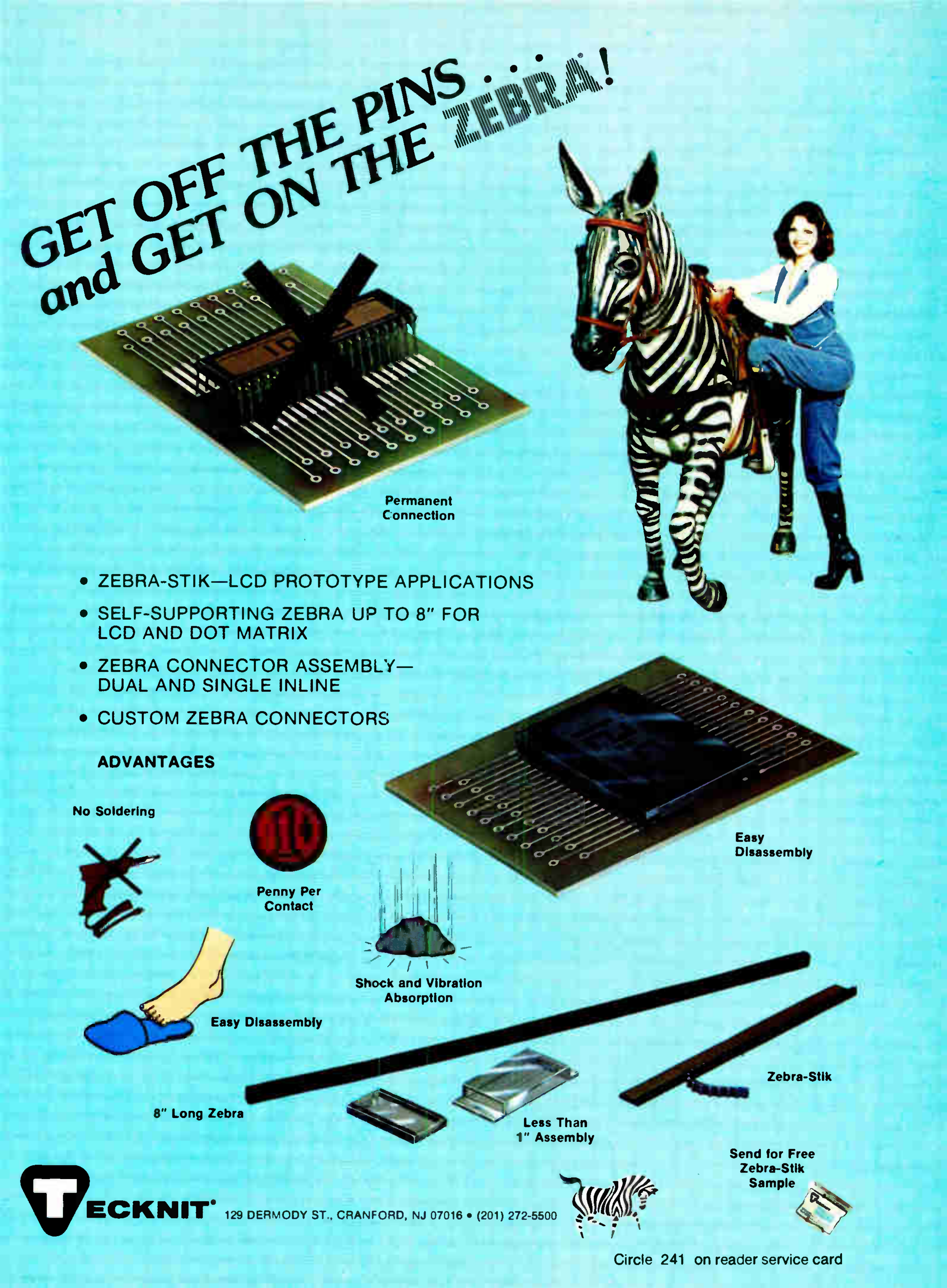
The 128 comes programmed in business Basic, but also supports Fortran and Cobol. With minimum memory, it can be purchased for $8,230 or leased for $250/month. Additional bubble increments of 128 kilobytes cost $3,000.

Findex Inc., 1625 W. Olympic Blvd., Los Angeles, Calif. 90015. Phone Claudine Muller at (213) 734-6339 [371]

Z80 emulator frees MDS by taking on test chores

Along with other tasks, trouble-shooting and production-line test chores are often assigned to micro-processor development systems. But rather than tie up an MDS—priced at $4,000 up—for those jobs, engineers working with Z80-based systems can turn to a less expensive device, the EZ-80.

Designed to emulate that popular processor, the $2,295 unit can be plugged into the Z80 socket of the system being evaluated, providing program control and system diagnosis without restricting memory addressing or programming technique. Data in memory, in microprocessor registers, and at input/output ports can be displayed in hexadecimal form on the EZ-80's front panel and altered as required. Front-panel keys let users step through a program one instruction at a time or run it at full processor speed. Moreover, a trace memory will capture 255 machine cycles for later display; hardware-implemented breakpoints can be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used to stop the program at a specific address whenever it occurs or only when it occurs after another specified address.

Nine diagnostic routines, including scope loops, are built into the emulator. These routines repeatedly access a designated memory location or I/O port while disabling memory refreshing to simplify signal tracing by oscilloscope. In addition to built-in routines, system-defined diagnostics can be performed by plugging a programmable read-only memory containing user-generated tests into a front-panel socket.

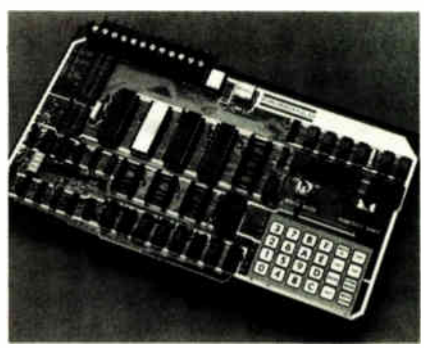
Delivery of the EZ-80 is from stock to six weeks.

Applied Microsystems, 11064 118th Place N. E., Kirkland, Wash. 98033. Phone Robin Knoke at (206) 827-9111 [373]

Low-cost board breeds F3870 family familiarity

Engineers who would like to familiarize themselves with the F3870 family of microcomputers can now buy a prototyping, evaluation, and programming board, called PEP for short, for $450. The unit provides real-time in-circuit emulation of the various family members (F3870, F3872, F3876, and F3878) through a 40-pin umbilical cable.

In addition to an on-board keypad and six-digit hexadecimal display, the system includes 2 kilobytes of static read/write random-access memory, expandable to 4, which simulates the read-only memory and RAM of the various microcomputer models. A separate 128-byte RAM provides workspace in which to examine the contents of the comput-



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in multiple-line statements, are supported by the new language.

The program is available from stock on cassette with a user's manual for $39.95. A source listing is not available, but a disk version that runs under the Flex DOS will be available shortly.

Technical Systems Consultants Inc., Box 2574, West Lafayette, Ind. 47906. Phone (317) 463-2502 [377]

Boards for S-100 bus built around 16-bit 8086

Users of the S-100 bus systems have had to be content with 8-bit processors while the rest of the world heads rapidly toward 16 bits. No longer, however, need that be the case; a three-board system meeting the proposed IEEE 16-bit protocol for that bus based on the 8086 has been developed.

Appropriately named the 8086/S-100, the system is composed of a 4- or 5-MHz central processing unit, an appropriate-speed read/write random-access memory board with 16 kilobytes of RAM, and a card combining a programmable read-only memory monitor and serial and parallel input/output ports.

The serial output port works with RS-232 or current-loop devices and the 24 lines of parallel I/O can be programmed in groups of eight for either input or output. Memory is expandable in accordance with the proposed protocol up to 1 megabyte.

Most S-100-bus peripherals currently available can be joined to the S-100/8086 without degrading the system's performance and assembly language software from existing 8080 systems can run on it.

The CPU board is priced at $895 and the PROM-I/O card sells for $495 with monitor PROM or $350 without. The 16-kilobyte memory board, strappable for data widths of 16 or 8 bits, costs $495. Discounts are available for original equipment manufacturers.

Tecmar Inc., 23414 Greenlawn Ave., Cleveland, Ohio 44122. Phone (216) 382-7599 [375]

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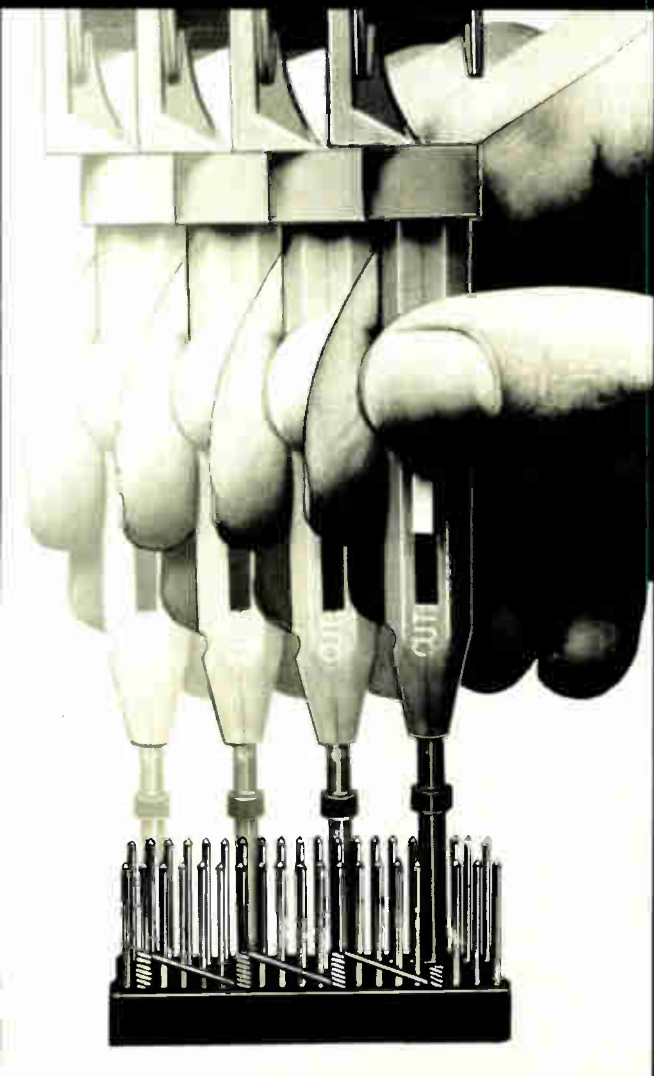

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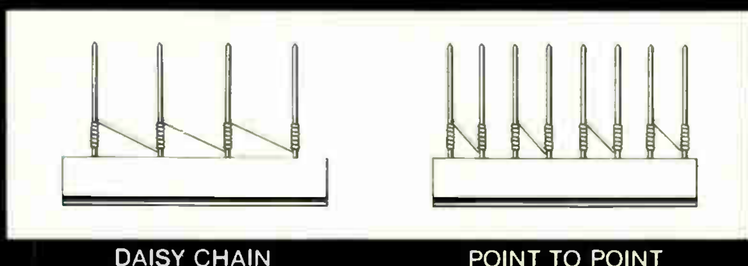

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Data acquisition

Z80-based system offers flexibility

Real-time computing unit uses modular approach to serve differing needs

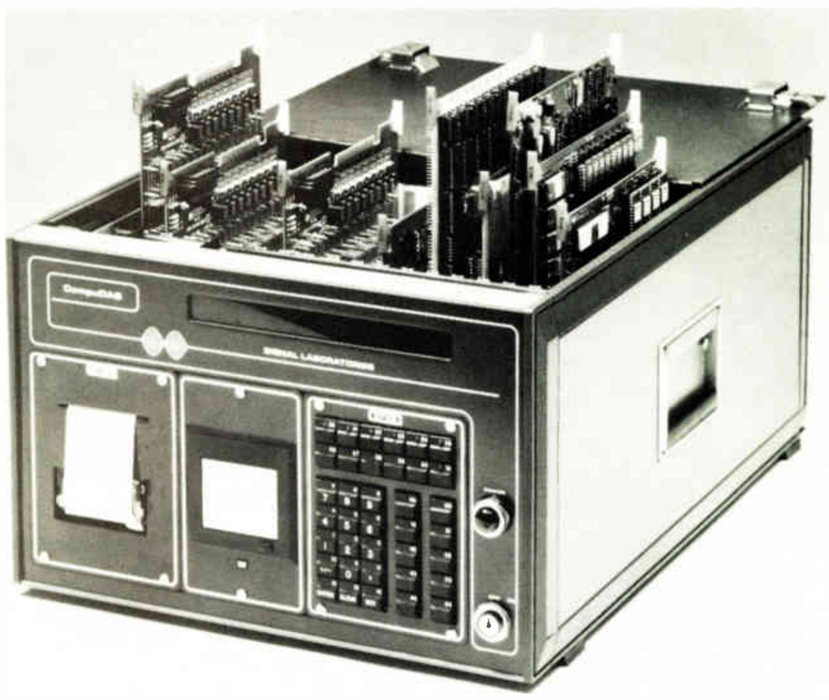
Flexibility should be the cornerstone of any product aimed at a broad market. That was the philosophy of engineers at Signal Laboratories when they designed CompuDAS, a real-time computing data-acquisition system intended for a wide variety of industrial measurement and control applications.

"CompuDAS fills the gap between limited-capability data loggers and costly minicomputer systems," explains Allen Roth, the company's vice-president of engineering. "Since this is such a wide gap, we made the instrument completely modular, allowing users to tailor systems to their particular applications." Such applications, according to Roth, include process control, testing in research and development laboratories, and data collection either with or without connection to a host computer.

The basic unit, built around a portable or rack-mountable chassis with an 18-slot card cage, contains: a Z80 microcomputer board; 16 kilobytes of random-access read/write memory; the programming language Dabil 1, an easy-to-learn subset of Dartmouth Basic, housed in read-only memory; one RS-232-peripheral port; and all necessary power supplies. A real-time clock is included in software; a more accurate battery-powered clock is optional.

The user can increase the processing power of the instrument by adding another 16 kilobytes of RAM and a high-speed arithmetic processing card that contains an array of commonly used arithmetic and trigonometric functions. To customize CompuDAS to the application, the user adds dedicated plug-in circuit cards, all with integral signal conditioning, from one or more of the following functional groups.

For electrical measurments, a digital input/output board provides software control over 64 discrete transistor-transistor-logic input or output lines. A low-level board containing a multiplexer, an analog-



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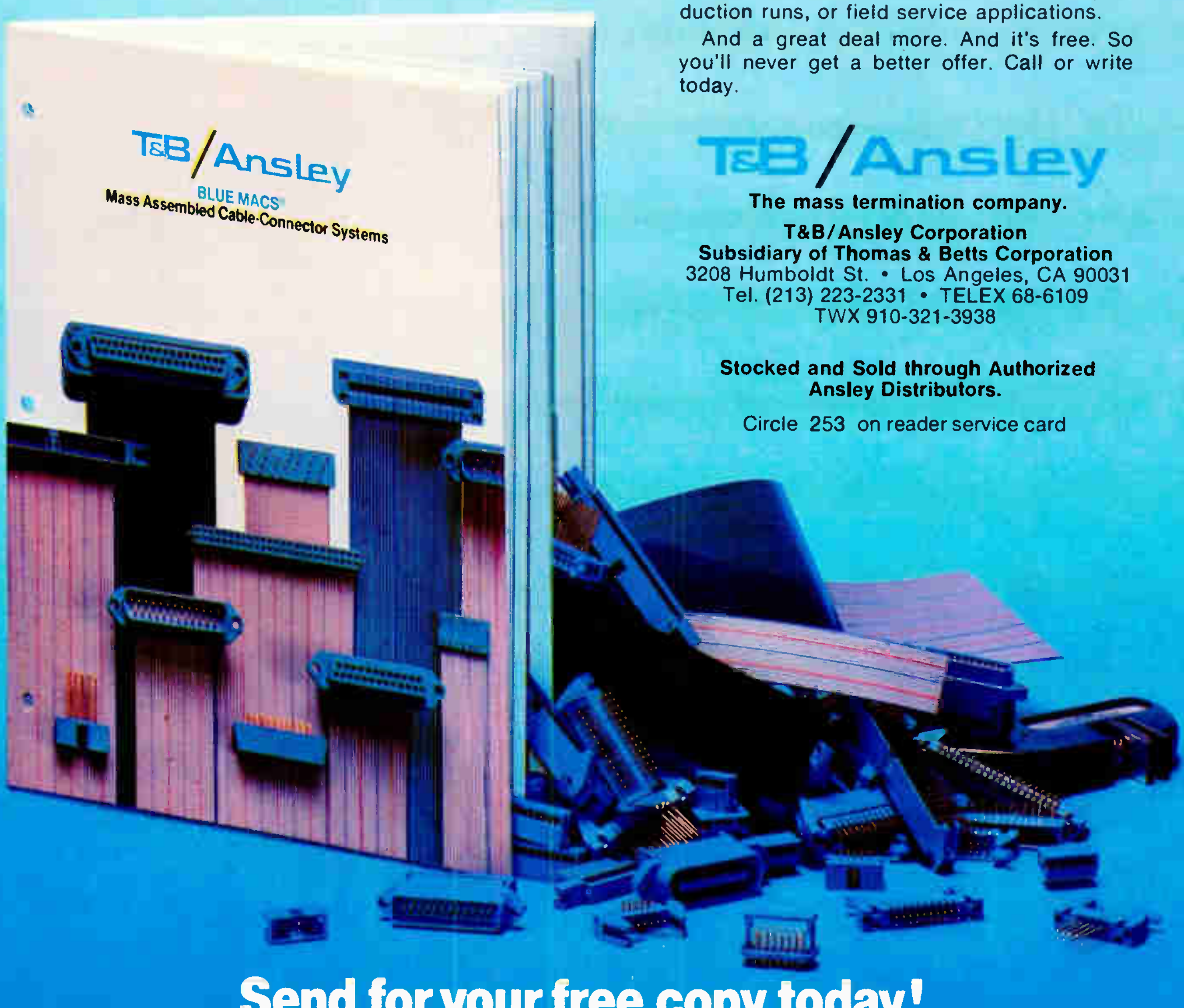

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A resistance interface board provides excitation, bridge completion, balance, and calibration for eight variable-resistance transducers like strain gages and resistance temperature detectors. A counter-timer board lets CompuDAS measure eight channels of time intervals, events per unit of time, and frequency. Further, an isothermal interconnect tray enables ambient-temperature compensation of thermocouples in 10-channel groups.

For control, a digital-to-analog output board with four 12-bit d-a converters permits control of proportional valves and outputs to strip-chart recorders and analog displays. The board can be strapped for five different output-voltage ranges, or for a 4-to-20-mA current loop. A relay output board gives the user 16 relays for controlling external loads up to 1 A each, with manual-override capability.

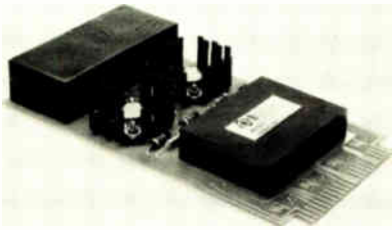
For communications, the user can purchase several front-panel options that allow CompuDAS to function as a stand-alone unit. These include a 20-column thermal printer, a microcassette recorder, an interactive 40-character alphanumeric dot-matrix display, and a 37-key keyboard with 15 dedicated-function keys and eight light-emitting diodes for indicating operating modes. To expand the unit's communications capability beyond the one RS-232 port provided, the user can add a four-channel serial input/output board that allows interface with four additional RS-232 peripherals like display terminals, printers, floppy-disk drives, and host computers.

Depending on the configuration, CompuDAS costs from $11,900 to $25,000. It measures 10.5 by 16.5 by 22.5 inches and weighs about 60 lb. Delivery takes 60 to 90 days from receipt of order.

Signal Laboratories Inc., 202 N. State College Blvd., Orange, Calif. 92668. Phone (714) 634-1533 [381]

D-s converter drives three torque receivers

Board modules of the 14-bit digital-to-synchro converter series can drive up to three size-11 torque receivers in parallel, keeping accuracy within ±6 min. The converters accept transistor-transistor-logic–level binary input signals, transforming them into three-wire synchro or four-wire resolver outputs of 90 or 11.8 V rms line to line at frequencies of 60 or



400 Hz, depending on the model.

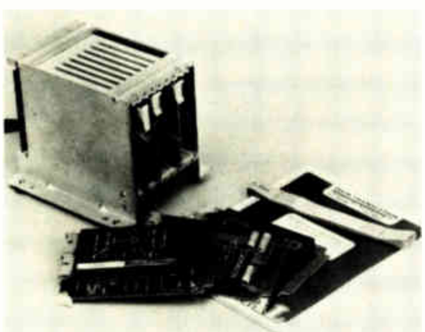
Outputs are short-circuit–protected and current-limited. Standard output power is 5 VA. The modules measure 4½ by 9¼ by 1 in. and come in industrial and commercial temperature versions. In reasonable production quantities, the converters cost less than $475 each and delivery time is four to six weeks.

Computer Conversions Corp., 6 Dunton Ct., East Northport, N. Y. Phone (516) 261-3300 [383]

12-bit analog input cards board STD bus at low fare

Original-equipment manufacturers designing low-cost 12-bit data-acquisition systems can now consider using Mostek's MD series or Pro-Log's 7000 series microcomputers, thanks to the introduction of four analog-input boards. The STD-bus–compatible DT2720 series consists of cards that range in price from $225 to $325 in lots of 100.

For systems requiring isolation of slowly varying signals in noisy environments, the model 2725 at $325 offers four differential channels that can withstand voltages of up to ±250 V. Absolute full-scale input ranges of 10 mV to 10 V and unipolar and bipolar input modes are resistor selectable.



The card uses a multiplexer and an integrating a-d converter that can provide throughput rates of 20 conversions/s for random channel addresses and 40 conversions/s for sequential. Conversions are accurate to within 0.03% of full-scale range at 10 V and 0.1% at 10 mV. Resolution is within ½ least significant bit. And each $325 model 2735 expands the number of isolated differential channels by eight; as many of these cards can be added as the processor allows.

For faster, nonisolated applications, the $275 model 2724 lets users choose 16 single-ended or eight differential channels. Input configurability and system accuracy are the same as for the 2725. The 2724's multiplexer, sample-and-hold amplifier, and successive-approximation d-a converter provide throughputs of 32 to 270 μs per channel depending on full-scale range. The $225 expander card for the 2724, the 2734, provides 24 additional single-ended or 12 differential channels.

All boards are available from stock to five days.

Data Translation Inc., 4 Strathmore Rd., Natick, Mass. 01760. Phone (617) 655-5300 [384]

S-d unit in a single module converts two-speed inputs

The model SDC-361 is a single module measuring about 2.6 by 3.1 by 0.8 in. It converts the input from a two-speed (1:36) synchro into digital outputs in Type II servo loop format. Working in the 47-to-1,000-Hz range, the unit consumes 2 W and can replace bulkier, dual-module systems.

The s-d converter accepts all standard synchro or resolver inputs and can track at rates of 1,000°/s for a 400-Hz carrier and 250°/s for a 60-Hz carrier. The 361 requires no field adjustments and features a control transformer algorithm that makes it inherently more accurate than other systems, according to the manufacturer.

The converter meets the specifications of MIL-STD-202E and is sold in versions that work from 0° to 70°C and −55° to +105°C. In single quantities it is priced at $695 and delivery is from stock to 90 days.

ILC Data Devices Corp., Airport International Plaza, Bohemia, N.Y. 11716. Phone (516) 567-5600 [385]

Fast 18-bit d-a converter sells for under $500

Will engineers want an 18-bit digital-to-analog converter that provides 16-bit accuracy? At Analog Devices—they believe the answer is definitely yes, so they are bringing their DAC1137 with them to display at this year's Electro at the Coli-

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seum in New York City.

A low-end version of the laboratory-quality DAC1138, the unit's current output settles to within ½ least significant bit in just 10 μs for a full-scale-input step. And its long-term offset and gain stability is within ±2 ppm over a 1,000-hr period. Furthermore, the high-quality converter sells for less than $500.

"People will use a product like this in a non-lab environment," Robert W. Glines, senior marketing specialist for modular converter products, proposes. "It gives them security; they are not going to need field service people to fiddle with it constantly."

The integral and differential nonlinearity temperature coefficients for the module are ±0.5 ppm/°C. The unit will operate over a temperature range of 0° to 70°C, and its gain tempco is ±8 ppm/°C.

The converter gives either current or voltage outputs (jumper connection of the internal amplifier to the current output will give the voltage output). Output ranges of 0 to 5 v, 0 to 10 v, ±5 v, or ±10 v are user-selectable by jumpers. The voltage settling time to ±½ LSB for a full-scale step is 250 μs.

Housed in a 2-by-4-by-0.4-in. package, the converter requires ±5 v dc and +15 v dc power. Acceptable inputs are transistor-transistor logic-level-signals.

Applications for the DAC1137 are abundant, according to Glines. He can rattle off a long list that includes data-distribution systems, high-resolution cathode-ray-tube displays, automatic semiconductor testing, typesetting, frequency synthesis, and nuclear reactor control. "There are two main sets of customers for this converter," Glines summarizes. "Those who need linear resolution for analytical instrumentation and servo systems will use the DAC1137; it will also be excellent for the 16-bit marketplace."

The DAC1137 sells for $460 in quantities of 1 to 9. Delivery is stock to four weeks.

Analog Devices Inc., Rte 1 Industrial Park, Norwood, Mass. 02062. Phone Bob Glines at (617) 329-4700 [382]

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Optical waveguides. Thin film memory. Liquid crystal displays. Wherever today's breakthroughs are shaping tomorrow's world, you'll find EM Laboratories as a source for fine chemicals.

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Circle 259 on reader service card

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The last symbol in our list stands for GUARANTEED SPECIFICATION. To us at TELEDYNE PHILBRICK, it's every bit as precious as platinum, gold, or silver. That's because our customers know that when we guarantee a performance parameter, the guarantee is as good as gold.

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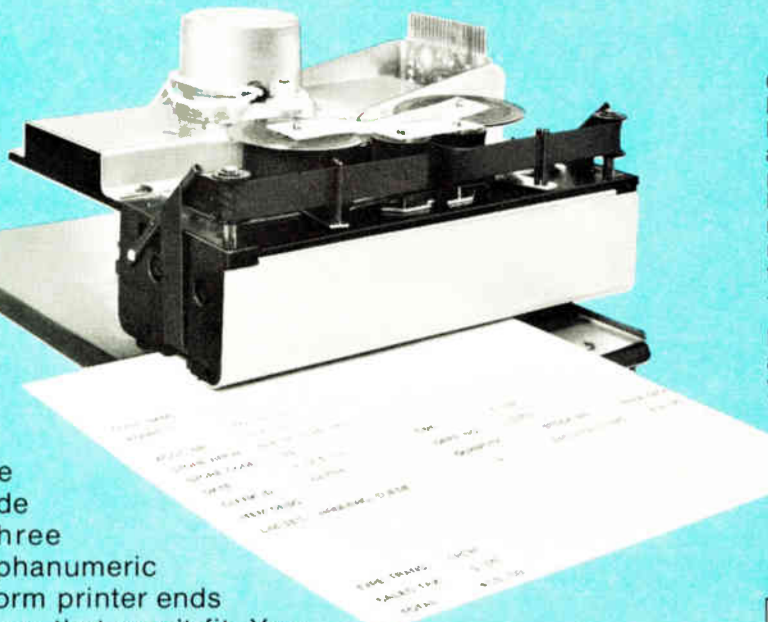
No One Does It Better Than Philbrick

TELEDYNE PHILBRICK DATA CONVERTERS, V/F/V CONVERTERS, LINEARS, NONLINEARS, POWER SUPPLIES
Allied Drive at Route 128, Dedham, Massachusetts 02026
Tel: (617) 329-1600 TWX: (710) 348-6726 Telex: 92-4439

Circle 703 on reader service card

Feed all your forms to our wide-open printer

The OEM impact printer wide open on 3 sides



Consider the advantages! Programmable character pitch, heavy-duty construction and an extra long-life dot matrix printing head means real durability. Its exceptionally long needle stroke turns out crisp multiple-copy printings on thicknesses from .003" to .015" — without adjustment.

Its easily replaceable ink rollers and self-reversing ribbon gives you a 10 million character life.

ALL THAT, YET STILL ECONOMICAL — ONLY $269 IN 100's.

With an edge guide sensor on one side and the other three sides open, our alphanumeric DMTP-8 impact form printer ends worries about forms that won't fit. You can easily insert from bank checks to out-size pages, single sets to multipart reports... any forms where you need to print up to 50 characters per 4" line.

P A PRACTICAL AUTOMATION, INC.
Trap Falls Road
Shelton, Conn. 06484
Tel: (203) 929-5381

Circle 260 on reader service card

What makes Northern Ireland work for the electronics industry?

More than 40 firms in the industry are at work in Northern Ireland today. Companies headquartered in the U.S., Europe, and Great Britain are engineering everything from appliances to sophisticated components.

The industry is long established. Support services are in place for research and development as well as for manufacturing. And there are special grants available to help you turn R&D into profitable products.

There is no shortage of skills in the work force of Northern Ireland. American companies who have come here find that people bring to work not only experience, but also a deep sense of company loyalty, a good labor relations record, and positive attitudes toward attendance and productivity.

New arrivals also find transportation links and first-class telecommunications that make it easy to do business in the Common Market or anywhere else. And nowhere in the EEC is there a better overall package of incentives to help a new venture succeed.

Find out how the people and the province can work for you. Get the facts from Reg Browne or George McLaren at the Northern Ireland Industrial Development Office in New York. They can quickly tailor an offer of assistance to suit your plans. Call (212) 593-2258. Or write: NIIDO, British Consulate-General, 150 E. 58th Street, New York, NY 10022.

Kieran Fitzpatrick works. An apprentice for the past year, he's building a career in electronics with Grundig.

Northern Ireland works.

Circle 261 on reader service card

LOW BOUNCE!

Low level switching for dry circuits

For years, EAO Series 01 and 31 Lighted Pushbutton Switches have been supplied for applications in control panels, instrumentation, telecommunications, computers and medical electronics.

Now both the 01 and 31 Series are available with low level switching elements that can handle the dryest of dry circuits . . . from micro-volts and micro-amps up to a maximum of 100 mA at 60 volts. This is made possible by our unique contact design . . . 4 gold plated contact fingers of different length . . . contact bounce less than 100 micro-seconds.

This low level, low bounce switch is perfect for direct interface with today's requirements of electronic circuitry. With 5 million operations and a price no higher than our standard 01, 31 units.

Low level lighted pushbuttons come with round, square and rectangular bezels, momentary or maintained action with universal terminals for soldering, P.C. board mount, or quick connect termination.

The original and still the finest Series 01 and 31 from EAO SWITCH CORPORATION.

EAO Switch, you can feel the difference.

EAO SWITCH CORPORATION

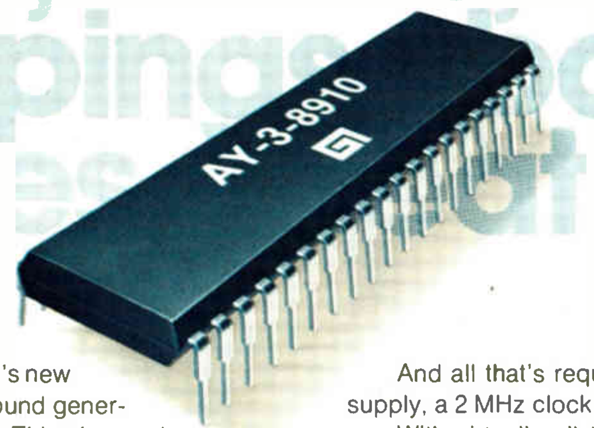
255 Cherry Street/Milford, CT 06460/(203) 877-4577/TLX-EAO SWITCH MFRD 964347

ELECTRO/79 Booth 3604

GIMINI Cricket

The chip that chirps...

or cheeps, bleeps, hums, peeps, buzzes, dings, rings, roars, beeps, toots, blips, bongs, h nks hoots hi pings oom whist



The point is, if you need a sound, GI's new "GIMINI Cricket" programmable sound generator, the AY-3-8910, can produce it. This gives a designer practically unlimited possibilities because, under full software control, the chip can generate complex sounds or combinations of sounds — music to soothe, rings and buzzes to alarm, and just about anything in between.

The AY-3-8910 is a natural for any products using microprocessors, interfacing easily to most 8- and 16-bit MPU's. In addition, it readily connects to most single-chip microcomputers — our PIC series, for example. The low-cost, AY-3-8910 has three independently programmed sound channels, an analog envelope generator, and two general purpose 8-bit I O ports.

And all that's required for operation is a single 5V supply, a 2 MHz clock and a microprocessor controller.

With virtually all the hardware necessary to meet most audio needs, the AY-3-8910 has immediate application for a wide variety of systems and products providing audible signals, synthesized music and unique sound effects, to name but a few. The "GIMINI Cricket" chip is available in quantity and ready to chirp, cheep, beep — or whatever you decide to program into your product.

For more information on the AY-3-8910 and a free copy of our 1978 Product Guide, write to General Instrument Microelectronics, 600 West John Street, Hicksville, New York 11802, or call (516) 733-3379.

We help you compete.

GENERAL INSTRUMENT CORPORATION
MICROELECTRONICS

Industrial

Weighing system displays 5 digits

Load-cell digitizer with 40,000-count resolution sells for $295 in 100s

Load-cell digitizers are constantly breaking fresh ground in industrial weighing applications as companies seek the advantages of electronic over mechanical scale systems. Analogic Corp. is meeting this market need with a five-digit microprocessor-based digitizer able to drive four 350-Ω load cells.

The AN5315 digitizer offers tool-operated tare switch, center-of-zero indicator light, switch-selectable pound or kilogram display, and a light-emitting-diode readout up to 99,990 with polarity indication. The internal count resolution is 40,000, whereas the display's full-scale increment totals are selectable by internal switch as any multiple of 1,000 from 1,000 to 10,000. The center-of-zero requirement of a 4:1 minimum ratio of internal-to-display resolution accounts for the 10,000 display maximum. Display multipliers are also internally selectable.

The dead-load zero offset has a normal maximum of 30 mV (2 mV/V), which is adjusted in three stages. The coarse adjustment is by means of a DIP switch. The medium adjustment is made by an internal potentiometer, and the fine adjustment uses a front-panel potentiometer. This method allows the overall temperature coefficients to meet the U.S. and OIML regulations of 20 and 5 ppm/°C, respectively.

The display, which is updated every 400 ms, has a jumper-selectable decimal point for each digit. In case of overload (more than 102% of full scale) it goes blank.

An important error-reducing feature of the AN5315 is its push-to-acquire tare function. A tool-operated switch allows the unit to acquire the gross weight display as the tare value. This value is automatically converted into the appropriate pound or kilogram value depending upon the position of the lb/kg front-panel switch. Therefore, no error can be caused by changing

from kg to lb, or vice versa, as can happen in weighing systems that employ a thumbwheel switch to enter the tare value.

The AN5315 comes in table-top and panel-mounting versions. Its water-sealed front panel uses pressure switches. The unit's specified operating temperature range is −10° to +50°C.

Available options include automatic zero tracking (to compensate for minor variations in climatic and other oprating conditions), binary-coded-decimal output, and a printer interface. The interface includes a motion detector to inhibit the printer if the output is not stable and also in case of overload or negative gross weight.

Paul F. Coughlin, marketing manager for the industrial digitizing systems product group, believes the AN5315 will find its greatest use in the retrofitting of mechanical scales, although platform scales and tank weighing will be close in market applicability. "We'll be able to automate mechanical systems and, we hope, make them more precise," he observes. "The advent of the microprocessor has allowed us to offer features not available before at a reasonable price."

The AN5315 sells for $295 in hundreds and has a delivery time of four weeks.

Analogic Corp., Audubon Road, Wakefield, Mass. 01880. Phone Paul Coughlin at (617) 246-0300 [401]

Process-control system performs hardwired logic tasks

The WP6000 is a microprocessor-based process control system that lets the instrumentation or original-equipment manufacturer establish the logic, time, and control requirements for a small process without reconfiguring any hardwired logic. By means of branching functions in its 79-step program, the WP6000 can perform the work of a hardwired logic system requiring several thousand steps.

Selling for under $400, the controller has eight front-panel control functions, five programmable input signals (including a predetermining counter), and four control relay outputs. At present the WP6000 can accommodate four input/output channels, and expansion kits will be offered at a later date to handle greater I/O needs.

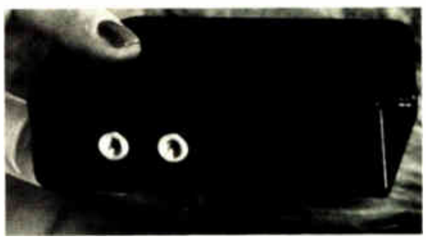
Once a system's requirements have been defined, users may purchase a chassis version of the WP6000 without programming switches that contains the controlling program in read-only memory. Based on volume and program complexity, the WP6000 will drop from under $400 for a single development unit to $100 each for some chassis packages. Delivery is from stock for both the programmable system and the chassis.

Minarik Electric Co., 232 E. Fourth St., Los Angeles, Calif. 90013. Phone Blair Randle at (213) 624-8876 [403]

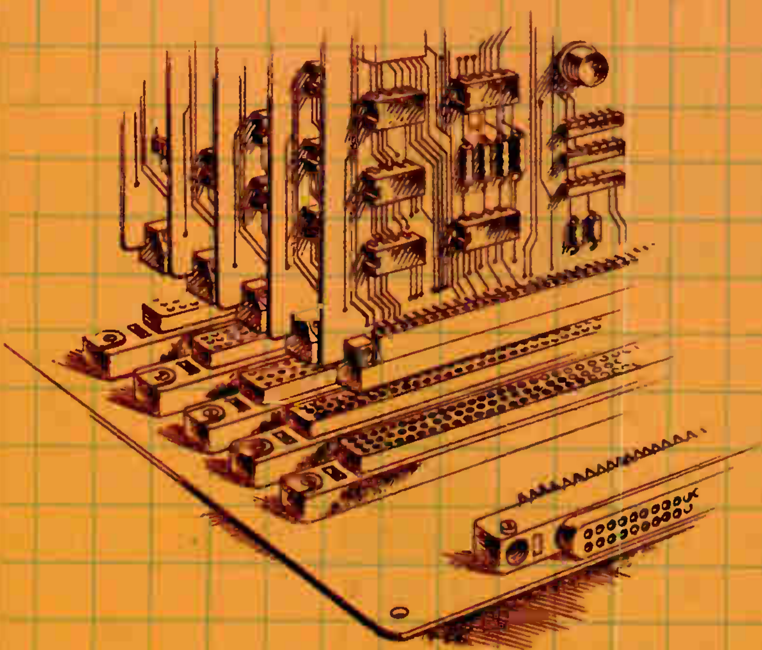
LED photoelectric scanners come with complete package

Designed for a wide range of motion-control applications, each miniature photoelectric scanner in the Trim Scan series has as its active elements a light-emitting-diode source, a sensor, a power supply, an amplifier, and an output relay. These devices are enclosed in small housings that can be easily mounted for different configurations. The series consists of three retroreflectors operating over distances to 20 ft and one reflector with a 12-in. range.

Weighing only 5.5 oz the model MCS-164 has a control response time of 30 ms and a scanning rate of 1,000 per minute and does not need an external lens. In addition to the MCS-164, the −161-1, −162-1,



PCB Simplicity with Bendix Brush Connectors.



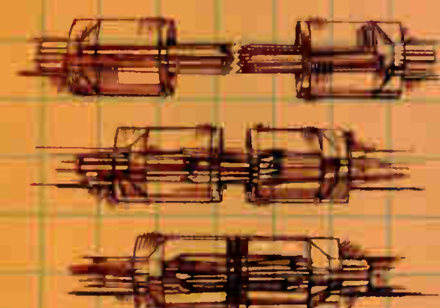
Bendix Brush Connectors can streamline your printed circuit board designs. They don't require the extra board support necessary with conventional, higher mating force connectors and they eliminate the need for secondary actuation systems or procedures used with zero-insertion force connectors. Here's how:

Bendix Brush Connectors increase circuit count per board.
- Reduce number of boards by allowing more circuits per board.
- Greater board effectiveness by providing exact circuit counts up to 400 contacts in only one connector!

Bendix Brush Connectors reduce mating force 70% to 90%.
- Less complex board supports.
- Secondary actuators eliminated.
- Extended mechanical life. Up to 20,000 mates/unmates.
- Fewer damaged boards.
- One connector instead of multiple, fixture-mounted connectors.

Bendix Brush Connectors—a broad product line.
- Mother Board, Daughter Board, Input/Output, PC receptacle body styles.
- 2, 3 and 4 row configurations.
- 90° and straight PC, solderless wrap, crimp removable terminations with multiple lengths and plating options.

Bendix Brush contacts improve electrical characteristics.
- Highly redundant contact sites with multiple electrical paths and wiping action.
- Gold plated wire bristles mesh together intimately with gas-tight junctions.
- Stable contact resistance even after extreme mechanical durability abuse to 20,000 matings.



For full information, call (607) 563-5302, or write The Bendix Corporation, Electrical Components Division, Sidney, New York 13838.

Bendix

We speak connectors.

Circle 269 on reader service card

New products

and −163-1 all operate in the infrared region and have a life expectancy of 100,000 hours at −20° to +60°C. For these models, response time is 20 ms and scanning rate is 1,500/min. Delivery is from stock.

Warner Electric Brake & Clutch Co., 449 Gardner St., Beloit, Wis. 53511 [404]

IR thermometer measures 2,500°C target temperature

The 1600WR infrared thermometer can measure target temperatures from 0° to 2,500°C with an error of less than 1% of the indicated temperature. The instrument uses two IR sensing heads that each measure 2 in. by 2 in. by 7 in. and weigh less than 2 lb.

Using radiometric techniques, the 1600WR is zeroed continuously with respect to background temperature to ensure drift-free performance in environments up to 40°C (105°F). Optional water-cooled enclosures for the sensing heads permit measurement in surrounding environments up to 150°C (300°F).

The IR sensing heads can be fitted with various sighting accessories and also can be used as handheld thermal survey instruments. Minimum

resolution is 1.5 mm (0.06 in.). The emittance response can be adjusted by using a 10-turn potentiometer located on the front panel of the indicator-amplifier unit. Response time may be varied from 1 to 5 s. Two set-point alarm relay outputs are accessible on the amplifier's back panel. An optional rechargeable nickel-cadmium battery supply is available for portable operation.

Capintec Instruments Inc., 136 Summit Ave., Montvale, N. J. 07645. Phone (201) 391-3930 [407]

The Cook-able Computer

Introducing a ruggedized version of Intel's iSBC* 80/10A Single Board Computer

From Cryogenics to Hades

Our ruggedized SECS 80/10A likes it hot — or cold. It shrugs off shock, vibration, moisture. And thrives on dust, dirt and grime.

Meets MIL-E-5400, 16400, 4158 — and more. This makes our SECS 80/10A perfect for military systems and tough industrial applications — petroleum, steel, oceanography, communications.

In fact, anywhere a rugged microcomputer is needed.

Functional counterpart of Intel iSBC 80/10A

Exclusively licensed by Intel, our SECS (Severe Environment Computer System) is a functional counterpart of the standard iSBC 80/10A board. Even uses the same development system software.

*Trademark of Intel Corporation

The difference is in the packaging

Our SECS 80/10A, which uses rugged Intel 883B chips, is mounted on a 9″ by 6″ shock and vibration resistant, full ATR compatible board. Conduction cooled, it operates from −55°C to +85°C. Add our numerous support modules and you end up with a versatile severe environment microcomputer system at a fraction of the development cost.

Other SESCO products

We also have a complete line of MIL SPEC core and semiconductor memories. New products include D-DAS, a digital data acquisition system for the 1553 bus, and SETS, a compact digital tape recorder with 23 megabit capacity.

When you're faced with a tough environment, "buy SESCO... it works!"

SECS 80/10A

EMM SESCO
Severe Environment Systems Company
A Subsidiary of Electronic Memories & Magnetics Corporation

20630 Plummer Street • P.O. Box 668 • Chatsworth California 91311
Telephone: (213) 998-9090 • Telex: 69-1404

The Microcomputers you should take seriously.

The C3 Series is the microcomputer family with the hardware features, high level software and application programs that serious users in business and industry demand from a computer system, no matter what its size.

Since its introduction in August, 1977, the C3 has become one of the most successful mircocomputer systems in small business, educational and industrial development applications. Thousands of C3's have been delivered and today hundreds of demonstrator units are set up at systems dealers around the country.

Now the C3 systems offer features which make their performance comparable with today's most powerful mini-based systems. Some of these features are:

Three processors today, more tomorrow.

The C3 Series is the only computer system with the three most popular processors— the 6502A, 68B00 and Z-80. This allows you to take maximum advantage of the Ohio Scientific software library and the tremendous number of programs offered by independent suppliers and publishers. And all C3's have provisions for the next generation of 16 bit micros via their 16 bit data BUS, 20 address bits, and unused processor select codes. This means you'll be able to plug a CPU expander card with two or more 16 bit micros right in to your existing C3 computer.

Systems Software for three processors.

Five DOS options including development, end user, and virtual data file single user systems, real time, time share, and networkable multi-user systems.

The three most popular computer languages including three types of BASIC plus FORTRAN and COBOL with more languages on the way. And, of course, complete assembler, editor, debugger and run time packages for each of the system's microprocessors.

Applications Software for Small Business Users.

Ready made factory supported small business software including Accounts Receivable, Payables, Cash Receipts, Disbursements, General Ledger, Balance Sheet, P & L Statements, Payroll, Personnel files, Inventory and Order Entry as stand alone packages or integrated systems. A complete word processor system with full editing and output formatting including justification, proportional spacing and hyphenation that can compete directly with dedicated word processor systems.

There are specialized applications packages for specific businesses, plus the vast general library of standard BASIC, FORTRAN and COBOL software.

OS-DMS, the new software star.

Ohio Scientific has developed a remarkable new Information Management system which provides end user intelligence far beyond what you would expect from even the most powerful mini-systems. Basically, it allows end users to store any collection of information under a Data Base Manager and then instantly obtain information, lists, reports, statistical analysis and even answers to conventional "English" questions pertinent to information in the Data Base. OS-DMS allows many applications to be computerized without any programming!

The new "GT" option heralds the new era of sub-microsecond microcomputers.

Ohio Scientific now offers the 6502C microprocessor with 150 nanosecond main memory as the GT option on all C3 Series products. This system performs a memory to register ADD in 600 nanoseconds and a JUMP (65K byte range) in 900 nanoseconds. The system performs an average of 1.5 million instructions per second executing typical end user applications software (and that's a mix of 8, 16 and 24 bit instructions!).

Mini-system Expansion Ability.

C3 systems offer the greatest expansion capability in the microcomputer industry, including a full line of over 40 expansion accessories. The maximum configuration is 768K bytes RAM, four 80 million byte Winchester hard disks, 16 communications ports, real time clock, line printer, word processing printer and numerous control interfaces.

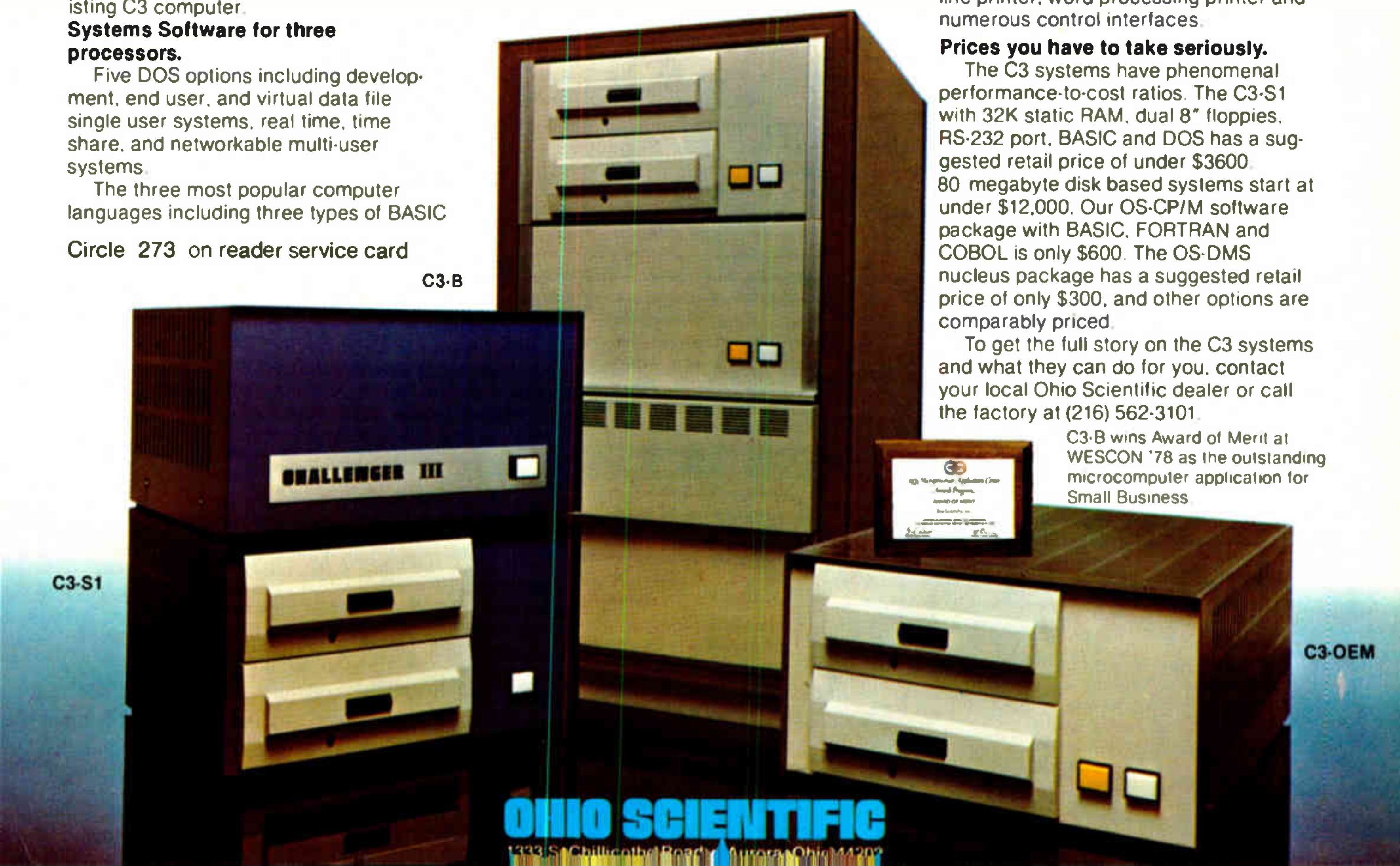
Prices you have to take seriously.

The C3 systems have phenomenal performance-to-cost ratios. The C3-S1 with 32K static RAM, dual 8" floppies, RS-232 port, BASIC and DOS has a suggested retail price of under $3600. 80 megabyte disk based systems start at under $12,000. Our OS-CP/M software package with BASIC, FORTRAN and COBOL is only $600. The OS-DMS nucleus package has a suggested retail price of only $300, and other options are comparably priced.

To get the full story on the C3 systems and what they can do for you, contact your local Ohio Scientific dealer or call the factory at (216) 562-3101.

The C3 Series from Ohio Scientific.

Circle 273 on reader service card



C3-B wins Award of Merit at WESCON '78 as the outstanding microcomputer application for Small Business

New products

Computers & peripherals

System grows to fit big picture

Modular graphic system puts 20,000 vectors on screen, uses adaptive timing

An increasingly competitive graphics market is forcing designers to put together quality systems with both performance and price matched to a particular application. Realizing this, Megatek is unveiling two modular vector-refreshing families dubbed Whizzard.

"This building block concept is especially important to the systems designer and original-equipment manufacturer," stresses Peter Shaw, director of marketing. "It gives them the opportunity to satisfy sophisticated application requirements at the lowest cost—they are not locked into one expensive configuration." This opportunity is provided by the Whizzard 5000 and 7000 series, whose members range from boards to stand-alone systems.

Units in the 7000 series are capable of drawing over 20,000 short vectors, from point to point, on 4,096-by-4,096-element screens refreshed at a rate of 30 Hz. The end points of two different vectors can come within 0.005 in., seeming to the unaided eye to touch neatly, and their intensity is uniform.

These effects are accomplished by a technique in which the electron gun is brought up to speed by being made to trace a loop starting at a vector's beginning coordinate before the beam turns on. To optimize drawing time, loop size and drawing speed are less for smaller vectors, and beam intensity is adjusted so that all vectors are equally intense—a process called adaptive timing.

Bits and prices. For $18,000, designers can purchase the basic 7000 processor unit, which includes the processor board with a 32-bit microprocessor tailored from 2901 bit-slice parts, a vector-generator board, a 62-kilobyte refreshing memory built from 4116-type RAMs dynamic and expandable to 128 kilobytes, a power supply, and a chassis. With monitor, it is priced at $24,000.

The system interfaces not only with popular hosts like the PDP-11, NOVA, and Eclipse, but also with the IBM Series/1, the VAC 11/780, and minicomputers from Varian, Hewlett-Packard, Interdata, and Prime, to name a few.

Graphics data within the system travels over a 32-bit bus while peripherals use a 16-bit bus. Rather than waste the host's processing time by letting it track a cursor, the system's joystick, data tablet or digitizer, and keyboard can be interfaced to an intelligent peripheral controller that records cursor locations; it supplies them to the host only on demand.

An additional $6,000 buys a hardware clip, rotating, scaling, and translating unit that animates two-dimensional pictures in real time and, for an extra $2,000, performs the same chore for three-dimensional graphics as well.

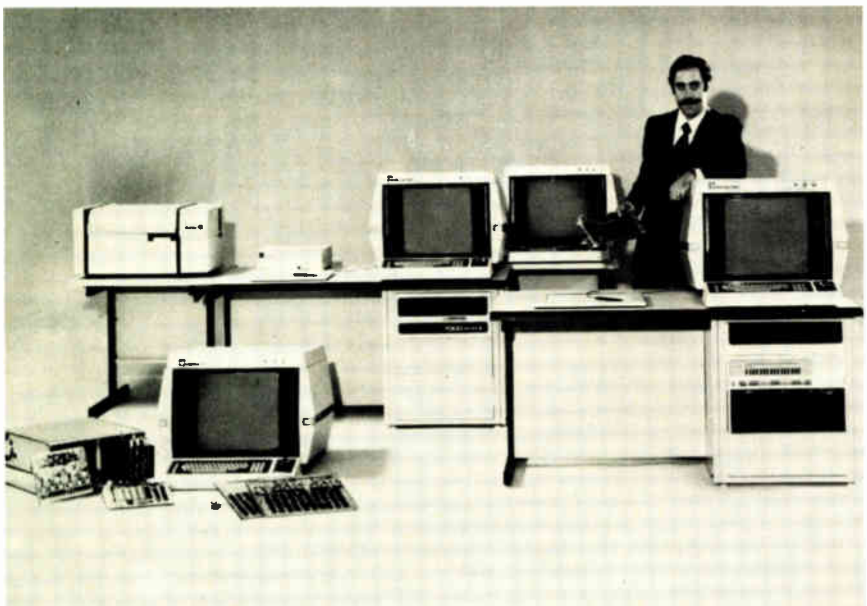
When hard copy is needed, a Rastorizer will pull data from the memory rather than the screen, format it, and plot it on a 4,000-point-line electrostatic printer in 8 to 15 seconds. The board shares the vector generator's microprocessor and is priced at $3,000.

Even cheaper. For really low-cost entry to the Whizzard group, users can buy a 5000 series graphics-processor and vector-generator set for only $6,400. Adding a monitor, keyboard, and hardwired character generator to the two 15½-by-15½-in. boards boosts the price to around $14,000. And as a complete stand-alone system, with dual floppy-disk drives and Data General minicomputer, it costs about $33,500.

By means of its Emutek software, the 5014 version emulates a Tektronix 4014, accepting software routines from it and letting programmers generate new, animated two-dimensional graphics.

Both families use Megatek graphics software based on Fortran and offering a wide variety of display formats. Delivery time is 60 to 90 days.

Megatek Corp., 3931 Sorrento Valley Blvd., San Diego, Calif. 92121. Phone Peter Shaw at (714) 455-5590 [361]



Auxiliary storage unit makes video terminals smarter

The 232 series of data stations can boost the abilities of intelligent cathode-ray-tube terminals or educate


The worldwide switch is at hand.
Manufacturers of computers and computer peripherals throughout the world use C&K switches. Producers and designers of test instrumentation, panel boards, word processing, and telecommunication equipment are switching our way too.
And here's why. Our line of mini, submini, and microminiature switches is literally hundreds of thousands of models long. Quality is incredibly high because we specialize exclusively in switches and have developed our own specialized engineering techniques. C&K switches are readily available, at highly competitive prices and with no minimum order requirements.
If you're not with us yet, start switching. Send for our complete new catalog and see for yourself. We give you more to switch about than anyone in the world.
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ELECTRO/79 Booths 2725-2727
Circle 3 on reader service card

New products

dumb ones. The data stations are auxiliary storage/retrieval peripherals that are controlled by 16-bit microcomputers.

The peripherals come in versions with up to 16 kilobytes of read-only memory and 64 of random-access, as well as one or two tape transports that accept DC 100A tape cartridges. Each unit connects to a terminal's computer and to a peripheral, printer, or plotter through an RS-232 interface. Communication rates of 100 to 9,600 b/s can be selected by switch.

The stations read and write at 30 in./s and search at 60 in./s. Files may be packed toward the front of the cartridge to minimize search time, and they can be edited an unlimited number of times.

A single-cartridge data station with 3 kilobytes of ROM and 2 of RAM sells for $2,495; a dual-cartridge one for $2,995. Delivery time is under 60 days.

Digital Datacom Inc., 17951 Skypark Circle, Suite K, Irvine, Calif. 92714. Phone (714) 549-8943 [364]

Terminals dash off hard copy in both directions at 180 c/s

The TP2 series of Dasher terminals, consisting of two receive-only printers and two send-receive units with keyboards, prints 180 characters per second, three times faster than earlier versions. Combined with a 1,000-word random-access memory, this speed makes the bidirectional units efficient at continuous rates of up to 1,200 bits per second without any data loss.

Half- and full-duplex transmission

can also be handled at rates selectable up to 4,800 b/s. The terminals (at whose core is the time-tested 16-bit processor of the first microNova generation) use a nine-wire printing head to print upper- and lower-case letters in a seven-by-nine-dot matrix; a 96-character ASCII set is provided. The TP2s also can write user-designed characters and symbols, employing a software feature called down-line loading, and can plot graphic data.

Normal or double-width characters may also be chosen by switch or software, and densities of six or eight lines per inch can be set by switch. Models of the 132-column units are available that print condensed characters, too, at a pitch of 16.5 characters to the inch.

The receive-only printers, the 6075 and the condensed-print 6076, are priced at $3,550 and $3,700, respectively. The keyboard terminals, the 6077 and the condensed-print 6078, sell for $3,750 and $3,900, respectively. Delivery time for all units is 90 days.

Data General Corp., Route 9, Westboro, Mass. 01581. Phone (617) 366-8911 [363]

Unit lets Harris terminals generate printouts and plots

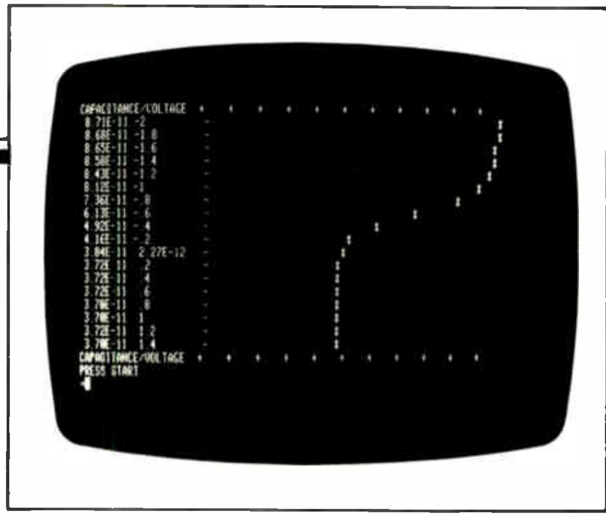
Owners of Harris 1600 remote batch and job entry terminals can now generate electrostatic plots and printouts on any of 18 Versatec printers, thanks to development of a remote plotting controller.

With Versaplot software on the host computer, input data is processed and compressed, then transmitted over data communications lines in encoded raster format to the Harris terminal and thence to the remote plotting controller. Independently, the controller decompresses the data and prints or plots it.

The controller accepts input over RS-232 lines at rates of up to 9,600 b/s and includes self diagnostics. It sells for $6,000; prices for Versatec plotters begin at $6,200.

Versatec, a Xerox company, 2805 Bowers Ave., Santa Clara, Calif. 95051 [365]

THE 200 MILLISECOND C/V CURVE



MEANS THE HIGHEST THROUGHPUT AVAILABLE

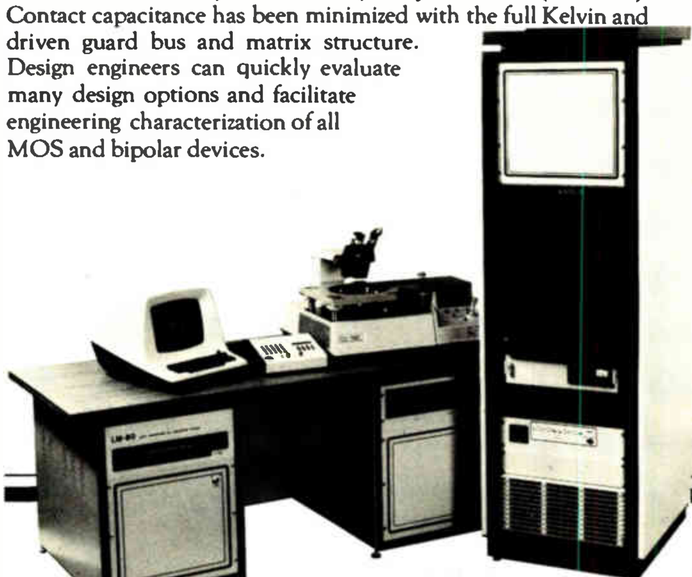
The LOMAC LM25/LM80 Production Process Control and Electrical Wafer Test System gives you:

THROUGHPUT. Lomac production test systems are ten times faster than any other automated testers available, which means remarkable increases in productivity when the LM25/LM80 system replaces your manual curve tracers.

VERSATILITY. The LOMAC systems are *full DC function* testers that perform a wide variety of parametric tests for process control evaluation. In addition to C/V measurements, you can test voltage or current using any combination of up to 96 pins. Other capabilities include ultra-low current measurements, providing 0-100 pA full scale on the most sensitive range.

EASE OF USE. The LM25 and LM80 are easy to use. These Z80 microcomputer-based systems using an enhanced form of Basic, called LOMAC TEST LANGUAGE, allow turnkey operation for immediate testing and data acquisition under full software control.

FLEXIBILITY. The LM25 and LM80 fit the engineering environment as well as the production line. All measurements can be made routinely to an accuracy of 1 part in 4000 (full scale). Contact capacitance has been minimized with the full Kelvin and driven guard bus and matrix structure. Design engineers can quickly evaluate many design options and facilitate engineering characterization of all MOS and bipolar devices.



LM80 with host computer.

EXPANDABILITY. If your needs are modest, you can start with a single, low-cost LM25, which offers the same high throughput of the more sophisticated LM80. The LM25s continue to be an integral part of your system as you expand since each LM80 will coordinate up to four LM25 test systems.

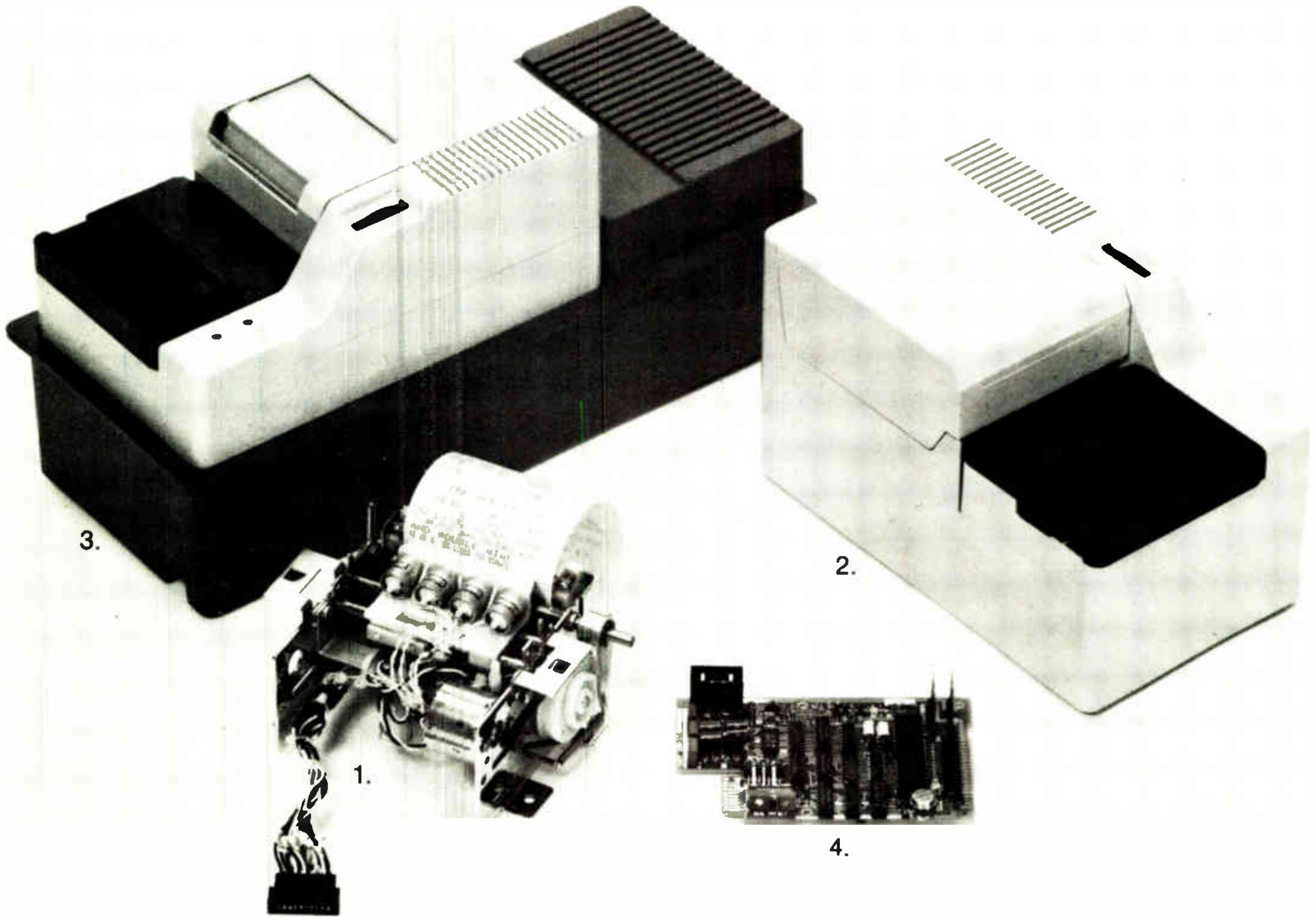
COMPATIBILITY. The LOMAC system will continue to expand to meet your needs, with a wide range of peripheral equipment available for the system, including printers, floppy discs, hard discs, tape drives and smart probers. Available software programming allows up to eight LM25/LM80s to be controlled by a host computer enabling program and data transfer to or from the host in background mode. Supported host computers include those made by Digital Equipment Corporation, Hewlett-Packard Corporation, and Data General Corporation.

LOMAC has been the leader in design and production of systems for process control and electrical wafer test for over six years. Nationwide distribution and service, along with a full one year system warranty, has made LOMAC the leading supplier to all of the major semiconductor manufacturers in the United States.

For more information, write or call Ms. Rosanna McClure at (408) 984-5982.

LOMAC CORPORATION
2118 Walsh Avenue, Santa Clara, CA 95050

Have it your way

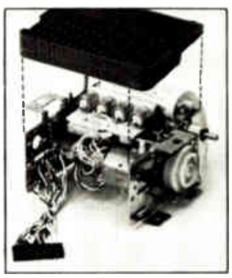


The only 40 column printer with NCR reliability now available almost any way you want it.

1. DIET SPECIAL — Mechanism only (low cost, field proven, available in quantity) add your own electronics.
2. TO GO — Cabinetized Version — comes in a handsome, well finished, gray case, for only a little extra lettuce.
3. BIG MECH — Mechanism (in a finished case) with its own power supply, with or without NCR electronics, packaged as a complete unit.
4. ON THE SIDE — NCR driven electronics, available with any selection.

For delivery information, prices, or literature, please contact:
NCR Engineering and Manufacturing
OEM Marketing
P.O. Box 627, Ithaca, New York 14850
(607) 273-6066.

Compare our ingredients and note the extra value of every unit served.



- Works as printer and/or plotter because of unique single wire design
- Multiple copy capability
- Prints up to 120 lines per minute
- Disposable ribbon cassette is operator changeable
- No messy spools or tricky threading

NCR
Engineering and Manufacturing — Ithaca

Circle 11 on reader service card

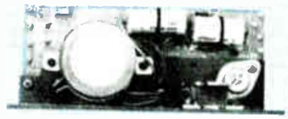
Circle 18 on reader service card →

L-179

LAMBDA INTRODUCES LSS SERIES SUB-ASSEMBLIES

A new solution to your regulated DC power requirements

The LSS Series sub-assemblies provide rectification filtering and regulation.


LSS-80 SERIES


LSS-70 SERIES

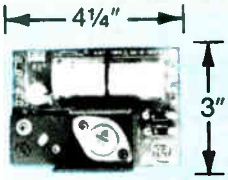

LSS-60 SERIES


LSS-50 SERIES

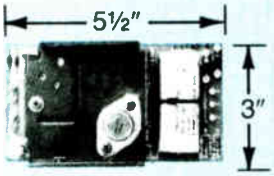
It solved ONTEL's DC power requirements for their intelligent CRT Terminal.

λ LAMBDA ELECTRONICS

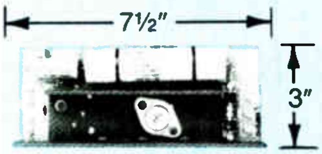
The LSS Series provides a practical solution to your regulated DC power requirements



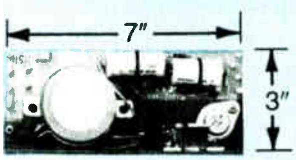
LSS-50 SERIES



LSS-60 SERIES



LSS-70 SERIES



LSS-80 SERIES

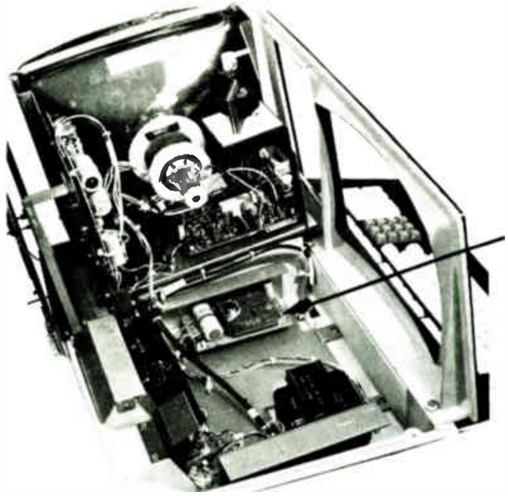
Now you can meet all your regulated DC power system requirements by using Lambda's LSS Sub-Assemblies. The LSS Sub-Assembly consists of rectification, filtering and regulation sections. All you do is provide the AC input and some heat sinking for the LSS Sub-Assemblies and you solved your single or multiple DC regulated power system requirements. Lambda provides data for transformer and heat sinking designs on the pages that follow.

RATINGS AND PRICES

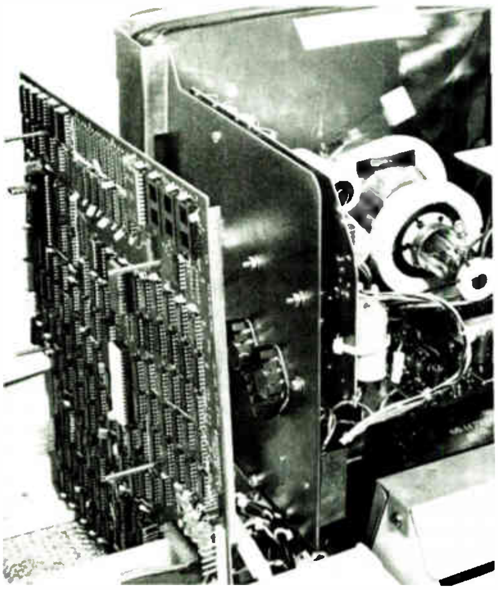
	V_O VOLTS	MODEL	MAX I_O AMPS	COMPLETE ELEC & MECH SPEC. PG.	1 Pc. PRICE	UNIT PRICES* 100 Pc. MIX	500 Pc. MIX	1000 Pc. MIX
5 VOLTS	5±2% FIXED	**LSS-50-5**	1.5	5-6	$33	$21	$19	$13
	5±5% ADJ	**LSS-80-5**	10.0	11-12	$80	$53	$48	$45
5-6 VOLTS	5-6ADJ	**LSS-50-01**	1.5	5-6	$35	$23	$21	$18
		LSS-60-01	3.0	7-8	$39	$26	$23	$20
		LSS-70-01	5.0	9-10	$60	$40	$36	$32
6 VOLTS	6±5% ADJ	**LSS-80-6**	10.0	11-12	$80	$53	$48	$45
9-15 VOLTS	9-15 ADJ	**LSS-50-02**	1.5	5-6	$35	$23	$21	$18
		LSS-60-02	3 0	7-8	$39	$26	$23	$20
		LSS-70-02	5.0	9-10	$60	$40	$36	$32
12 VOLTS	12±2% FIXED	**LSS-50-12**	1 5	5-6	$33	$21	$19	$13
	12±5% ADJ	**LSS-80-12**	8 5	11-12	$80	$53	$48	$45
15 VOLTS	15±2% FIXED	**LSS-50-15**	1.5	5-6	$33	$21	$19	$13
	15±5% ADJ	**LSS-80-15**	8.0	11-12	$80	$53	$48	$45
20-28 VOLTS	20-28 ADJ	**LSS-50-03**	1.5	5-6	$35	$23	$21	$18
		LSS-60-03	3.0	7-8	$39	$26	$23	$20
		LSS-70-03	5.0	9-10	$60	$40	$36	$32
24 VOLTS	24±5% ADJ	**LSS-80-24**	7.5	11-12	$80	$53	$48	$45
28 VOLTS	28±5% ADJ	**LSS-80-28**	7.0	11-12	$80	$53	$48	$45

*PRICES ARE FOR MIX QUANTITIES. A MIX CAN CONSIST OF 100 OF THE SAME UNIT AS WELL AS DIFFERENT MODELS.

LSS sub-assembly solved Ontel's DC power requirements for their intelligent CRT terminal OP-1/R



Arrow indicates Lambda's LSS sub-assembly mounted.



Lambda's LSS sub-assembly provides a reliable power source to complex circuitry.

Finished Ontel OP-1/R unit.

OP-1/R

The OP-1/R is the lowest cost Ontel intelligent terminal system and the first truly user programmable intelligent terminal in its price range.

A memory capacity of up to 40K and the ability to run all Ontel software, including high level languages, make this design most suitable for use in the cluster and distributed data processing market. Individual software programs may be executed in a multi-task environment while sharing the data base of a cluster or host computer

The OP-1/R display microprocessor features a set of 128 upper and lower case characters and provides line-drawing capabilities. Asynchronous communications from 110 to 19,200 baud and a parallel Centronics interface are also available.

Software

The key to Ontel's many successful installations is a broad range of complete system and application programs fully supported by their software and systems groups.

Operating Systems:

A versatile operating system is available which provides a strong base upon which sophisticated software systems can be designed and developed. Some of its features are:

Dynamic allocation and de-allocation of disk space

Private and shared user file catalogs

Sequential and random file access with lockout protection facilities

Wide range of utilities for file design and manipulation

Device-independent I/O support system

Device drivers for hard disk, diskette, magnetic tape, and matrix or character printers

Word Processing

Ontel's Word Processing System is the result of many years of hardware and software development. The terminal's unique design combines a display which is easy to read with special hardware which enables fast screen manipulations. It is highly suitable for a secretarial environment.

Easy to operate, the WORD system provides the ability to produce original dictation, form letters, forms, contracts, mailing lists and financial statements.

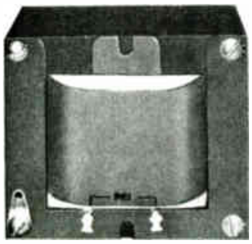
Ontel's system, since it is intelligent, provides users with a word processing plus capability...the plus being stand-alone accounting, high speed communication and message switching.

(Information on this page furnished by Ontel Corporation, 250 Crossways Park Drive, Woodbury NY 11797.)

30 reasons why you should me
using Lambda's Sub-Assemb

1 All circuit engineering provided by Lambda power supply engineers

2 Transformer design data provided by Lambda Engineering



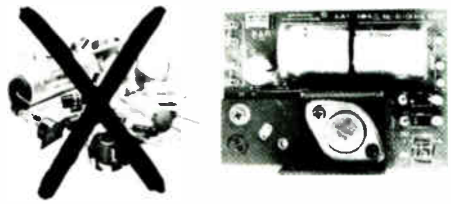
3 Thermal requirements provided by Lambda Engineering

θ_{RAD} (°c/w)

7 **Total control of mechanical packaging configuration**

8 One day delivery of Lambda sub-assemblies cuts inventory and reduces inventory complexity

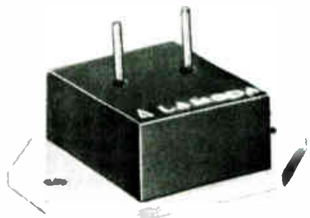
9 Building-Block concept provides greater production flexibility



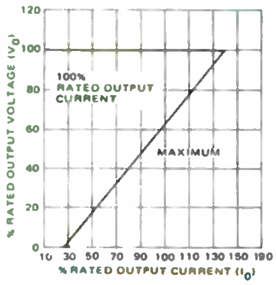
13 Sprague electrolytic capacitors

14 Adjustable outputs available

15 Overvoltage protection component available as accessory



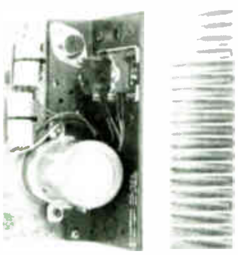
19 Foldback current limiting



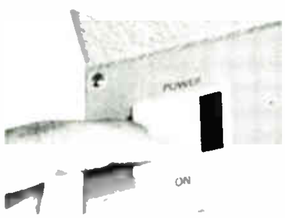
20 CC4* printed circuit board with plated thru-holes, fungus inert, flame retardant

21 Thick, 1/8" aluminum sheet metal thermal interface Finish: Grey, Fed Std. 595 No. 26081

25 Can be mounted for convection cooling or forced air cooling



26 Resultant design provides no overshoot on turn-on, turn-off, or power failure



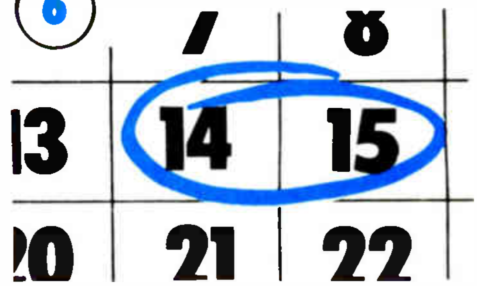
27 **Standard AC line of 50, 60 and 400 cycles or DC input**

et your DC power requirements
y, building block approach.

4 Because of Building-Block concept, future design changes can be made at minimum cost

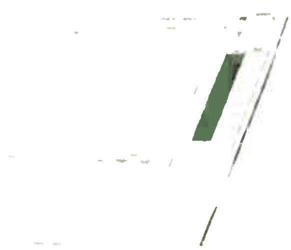
5 Complete reproduceability—Lambda Quality Control

6 Minimal time if design changes are required

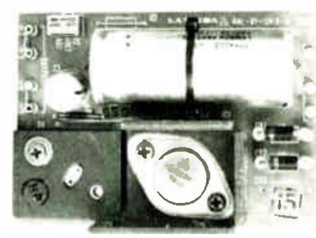


10 **Building-Block concept eases repairs and shortens mean time to repair**

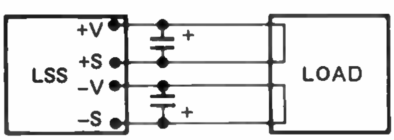
11 Building-Block concept reduces number of parts to purchase



12 Only 8-12 parts for maximum reliability and minimum repairs



16 Remote sensing overcomes DC line voltage drop



17 Only Lambda IC regulators utilized

18 Series regulator provides fast transient response

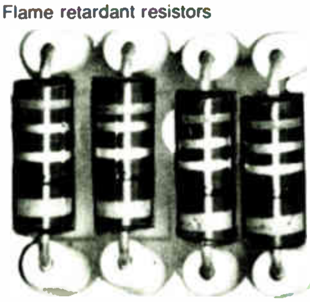
22 **Lambda's International Distribution Centers**

McAllen, Texas
High Wycombe, Bucks, England
Orsay, France
Achern, W. Germany
Montreal, Canada
Tokyo, Japan
Tel Aviv, Israel

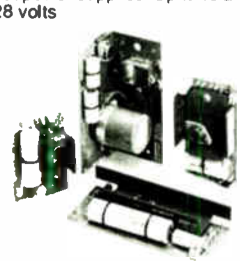
23 Texas/Mexico twin plant border production facility can handle any single order up to 250,000 sub-assemblies

24 Worldwide direct factory field sales force to serve you

28 Flame retardant resistors



29 4 power packages, 18 models provide wide selectivity for building single or multiple output power supplies. Up to 10 amperes, up to 28 volts



30 You can build you own power supplies with Lambda quality

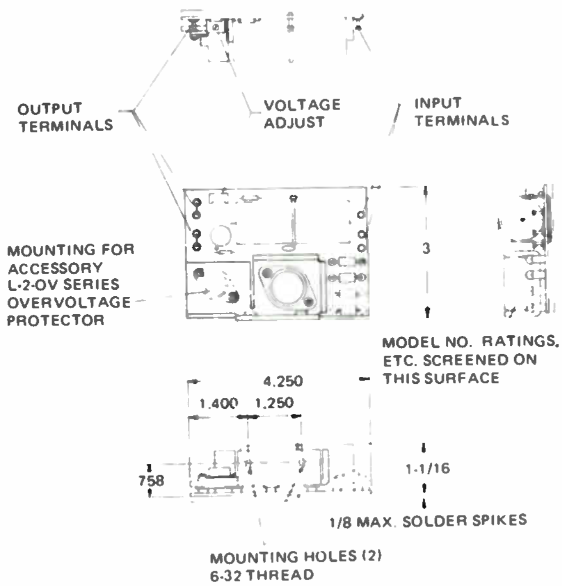
PERFORMANCE SPECIFICATIONS
LSS-50 SERIES

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	MAX
INPUT VOLTAGE	$V_{IN}DC$	$I_o = 1.5A$	$V_o + 3.4V$	SEE TABLE I
	$V_{IN}PKAC$	$I_o = 1.5A$	$\frac{V_o + 3.9V^{(1)}}{.85}$	SEE TABLE I
OUTPUT VOLTAGE	V_o		5V	28V
OUTPUT CURRENT	I_o			1.5A
CURRENT LIMIT KNEE	I_K	$V_{IN} = V_o + 5V$		2.8A
SHORT CIRCUIT CURRENT	I_{SC}	$V_{IN} = 20V$		1.8A
STANDBY CURRENT	I_Q	$V_{IN} = V_o + 5V$		10mA
STORAGE TEMPERATURE	T_S		-40°C	+85°C
AMBIENT OPERATING TEMPERATURE	T_A		0°C	65°C
LOAD REGULATION		$V_{IN} = V_o + 5VDC$ $\Delta I_o = 1.5A$		0.6% V_o
LINE REGULATION		$I_o = 1.5A$ $\Delta V_{IN} = 5$ VDC		1.0% V_o
PROGRAMMING RESISTANCE	R_P			200Ω/V
PROGRAMMING VOLTAGE	V_P			IV/V
TEMPERATURE COEFFICIENT	T.C.	$V_{IN} = V_o + 5$ V $I_o = 100mA$		0.03% V_o/°C
RIPPLE AND NOISE				SEE FIGURE 3

(1) ASSUMES 60Hz INPUT LINE FREQUENCY AND A RECTIFICATION EFFICIENCY (V_{CF} AVG/V_{SEC}PK) = 85%

TABLE I

MODELS	$V_{IN}DC$ MAX	$V_{IN}PKAC$ MAX (NO LD.)	INPUT CAP (µf)
LSS-50-01	16.5V	18.5V	3.9K
LSS-50-5	16.5V	18.5V	3.9K
LSS-50-02	25.5V	29V	2.5K
LSS-50-12, 15	25.5V	29V	2.5K
LSS-50-03	40V	40V	1.5K



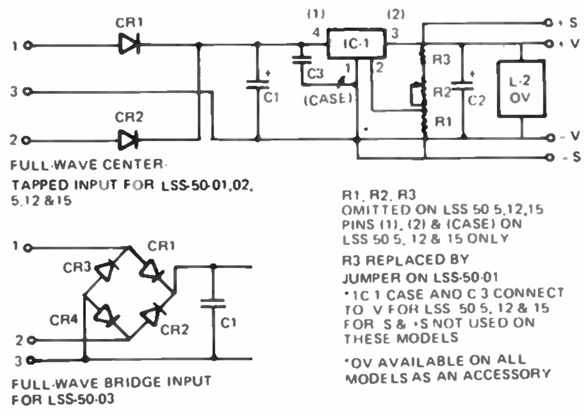
OUTLINE DRAWING

DESIGN EXAMPLE

Requirements: $V_o = 12V$ @ 0.5A
$T_A = 60°C$
Input Line Voltage = 117V_{RMS} ±10%, 60 Hz

1. For 12 volts at 0.5 AMP choose LSS-50-12. (or LSS-50-02)
2. From specification table, V_{IN} peak minimum =
   $\frac{Vo + 3.9}{.85} = \frac{12 + 3.9}{.85} = 18.7V$
   [Note that this assumes a rectification efficiency $\left(\frac{V_{AVG}}{V_{PEAK}}\right)$ of 85%]
3. From the transformer design, calculate V_{IN} peak maximum at high line. For this example, assume that V_{IN} peak maximum is 25.0 volts. Therefore $V_{AVG}MAX$ = 25 x .85 = 21.25V.
4. Compute the voltage differential (V_D) across the module as follows: $V_D = V_{AVG}MAX - V_o$
   $V_D = 21.25 - 12 = 9.25V$
5. From Design Curve (Fig. 1) at $V_D = 9.25V$, $I_o = 0.5A$ and T_A=60°C, power dissipation (P_D) = $V_D \times I_o$ = 4.625W and the thermal impedance of the required heat sink (θ_{RAD}) is 10.75° C/W. This corresponds to an absolute heat sink temperature of 107.5°C.

Note: For DC input in the above example, V_{IN} minimum would be V_o + 3.4V (from specification table) and $V_{AVG}MAX$ would be $V_{IN}MAX-1$.



SCHEMATIC DIAGRAM

OPERATIONAL DATA
LSS-50 SERIES

FIG. 1 POWER DISSIPATION VS VOLTAGE DIFFERENTIAL (V_{AVG}-V_o)
POWER DISSIPATION VS RADIATOR THERMAL IMPEDANCE FOR VARIOUS OUTPUT CURRENTS

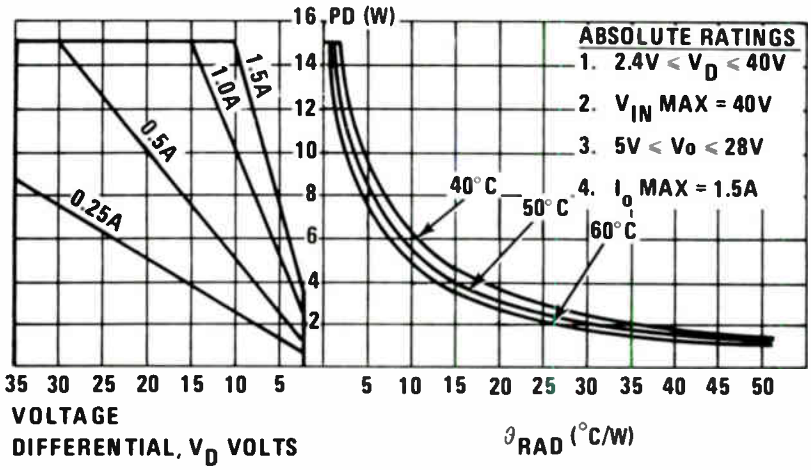


FIG. 2 OUTPUT RIPPLE AS A FUNCTION OF OUTPUT VOLTAGE WITH 3V PK-PK INPUT RIPPLE @ 120 Hz

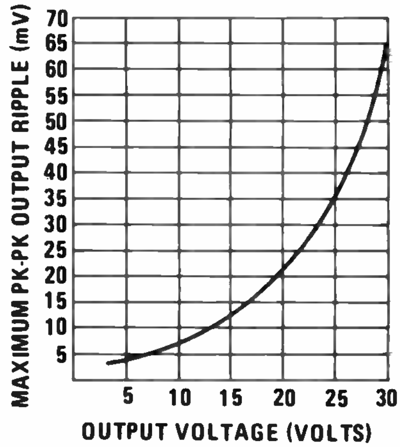


FIG. 3 POWER DERATING AS A FUNCTION OF RADIATOR TEMPERATURE

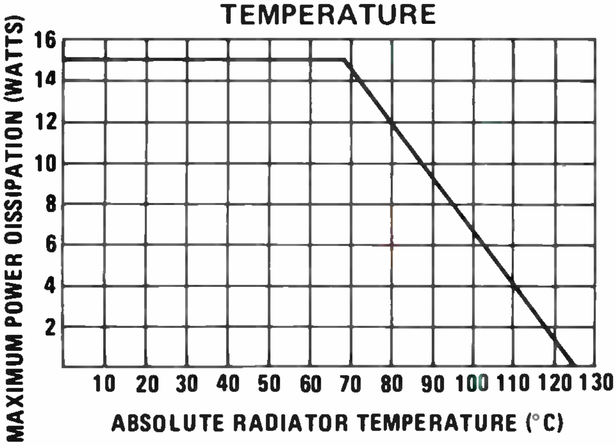


FIG. 4 D.C. SAFE OPERATING AREA AS A FUNCTION OF RADIATOR THERMAL RESISTANCE AT 40°C AMBIENT TEMPERATURE

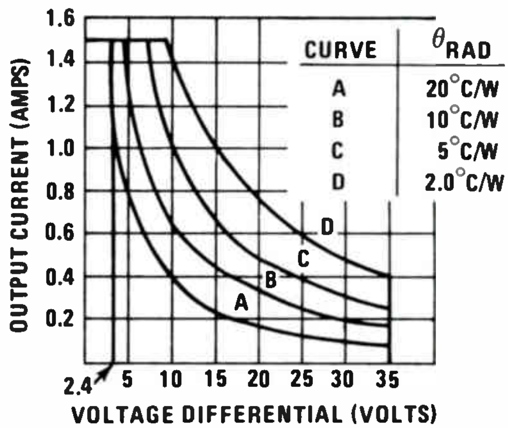


FIG. 5 D.C. SAFE OPERATING AREA AS A FUNCTION OF HEATSINK TEMPERATURE

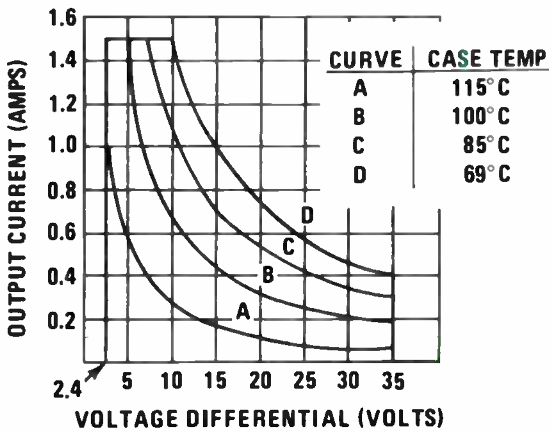
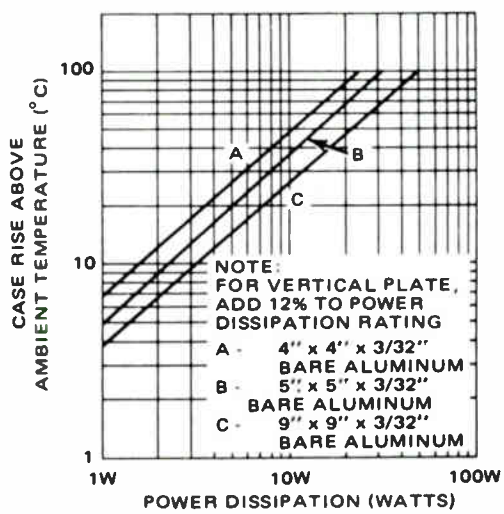


FIG. 6 TYPICAL HEAT SINKING DATA FOR HORIZONTAL PLATE



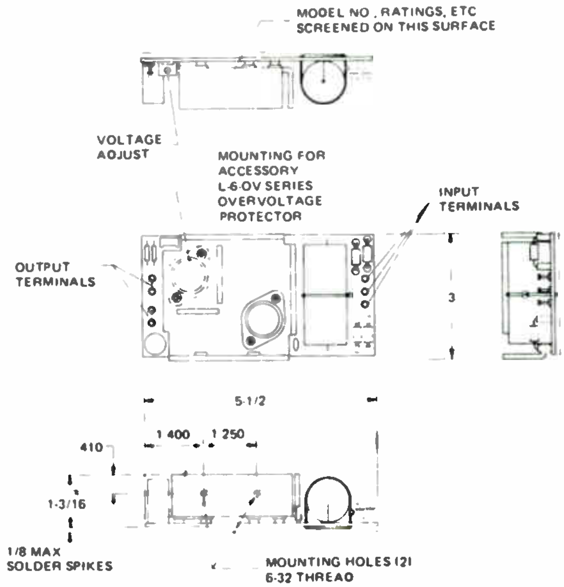
PERFORMANCE SPECIFICATIONS
LSS-60 SERIES

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	MAX
INPUT VOLTAGE	$V_{IN}DC$	$I_o = 3.0A$	$V_o + 3.3V$	SEE TABLE I
	$V_{IN}PKAC$	$I_o = 3.0A$	$\frac{V_o + 3.8V^{(1)}}{.85}$	SEE TABLE I
OUTPUT VOLTAGE	V_o		5V	28V
OUTPUT CURRENT	I_o			3.0A
CURRENT LIMIT KNEE	I_K	$V_{IN} = V_o + 5V$		4.5A
SHORT CIRCUIT CURRENT	I_{SC}	$V_{IN} = 25V$		2.0A
STANDBY CURRENT	I_Q	$V_{IN} = V_o + 5V$		25mA
STORAGE TEMPERATURE	T_S		-40°C	+85°C
AMBIENT OPERATING TEMPERATURE	T_A		0°C	65°C
LOAD REGULATION		$V_{IN} = V_o + 5VDC$ $\Delta I_o = 3.0A$		$0.6\% V_o$
LINE REGULATION		$I_o = 2A$ $\Delta V_{IN} = 3.5 VDC$		$1.0\% V_o$
PROGRAMMING RESISTANCE	R_P			200Ω/V
PROGRAMMING VOLTAGE	V_P			IV/V
TEMPERATURE COEFFICIENT	T.C.	$V_{IN} = V_o + 5V$ $I_o = 5mA$		$0.03\% V_o/°C$
RIPPLE AND NOISE				SEE FIGURE 3

(1) ASSUMES 60Hz INPUT LINE FREQUENCY AND A RECTIFICATION EFFICIENCY (V_{CF} AVG/V_{SEC}PK) = 85%

TABLE I

MODELS	$V_{IN}DC$ MAX	$V_{IN}PKAC$ MAX (NO LD.)	INPUT CAP. (µf)
LSS-60-01	16.5V	18.5V	6.6K
LSS-60-02	25.5V	29V	4.4K
LSS-60-03	40V	40V	2.8K



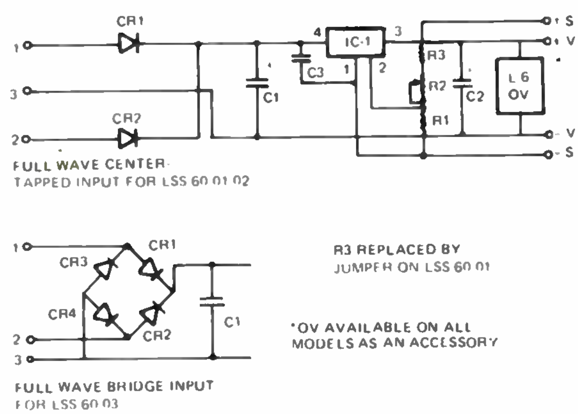
OUTLINE DRAWING

DESIGN EXAMPLE

Requirements: $V_o = 15V$ @ 1.0A
$T_A = 40°C$
Input Line Voltage = $117V_{RMS}$ ±10%, 60 Hz

1. For 15 volts at 1 AMP choose LSS-60-02.
2. From specification table, V_{IN} peak minimum =
   $\frac{V_o + 3.8}{.85} = \frac{15 + 3.8}{.85} = 22.1V$
   [Note that this assumes a rectification efficiency $\left(\frac{V_{AVG}}{V_{PEAK}}\right)$ of 85%]
3. From the transformer design, calculate V_{IN} peak maximum at high line. For this example, assume that V_{IN} peak maximum is 29.0 volts. Therefore $V_{AVG}MAX$ = 29.0 x .85 = 24.7V.
4. Compute the voltage differential (V_D) across the module as follows: $V_D = V_{AVG}MAX - V_o$
   $V_D = 24.7 - 15 = 9.7V$
5. From design curve (Fig. 1) at $V_D = 9.7V$, $I_o = 1.0A$ and $T_A = 40°C$, power dissipation (P_D) = $V_D \times I_o$ = 9.7W and the thermal impedance of the required heat sink (θ_{RAD}) is 6.5°C/W. This corresponds to an absolute heat sink temperature of 105°C.

Note: For DC input in the above example, V_{IN} minimum would be $V_o + 3.3V$ (from specification table) and $V_{AVG}MAX$ would be $V_{IN}MAX$-1.



SCHEMATIC DIAGRAM

OPERATIONAL DATA
LSS-60 SERIES

FIG. 1 POWER DISSIPATION VS VOLTAGE DIFFERENTIAL ($V_{AVG}-V_O$)
POWER DISSIPATION VS RADIATOR THERMAL IMPEDANCE
FOR VARIOUS OUTPUT CURRENTS

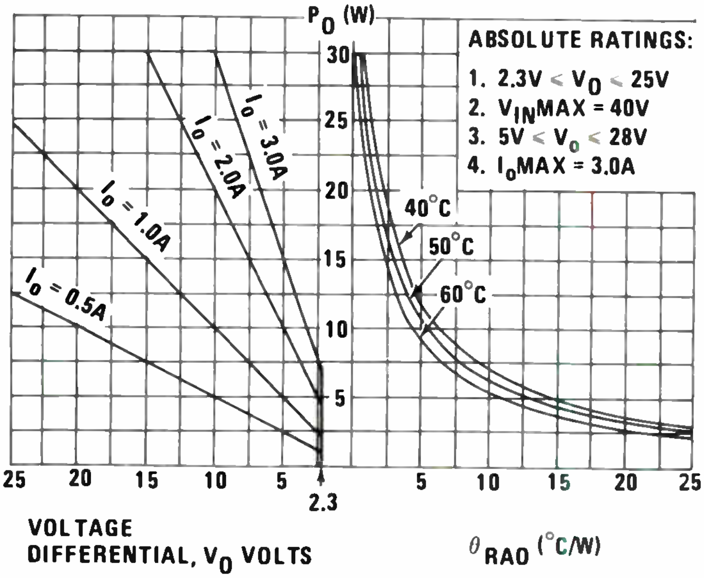


FIG. 2 POWER DERATING CURVE AS A FUNCTION OF HEAT SINK TEMPERATURE

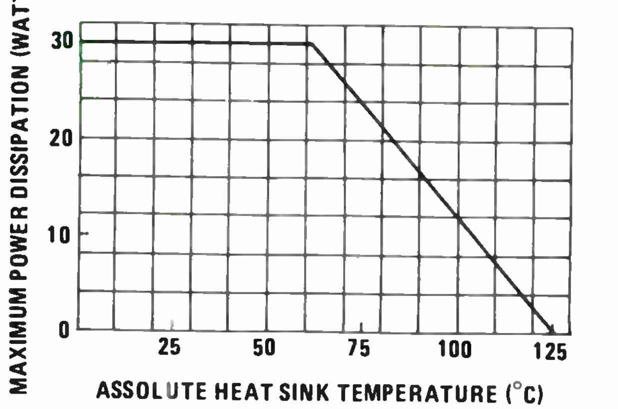


FIG. 3 OUTPUT RIPPLE AS A FUNCTION OF OUTPUT VOLTAGE WITH 3V PK-PK INPUT RIPPLE @ 120 HZ

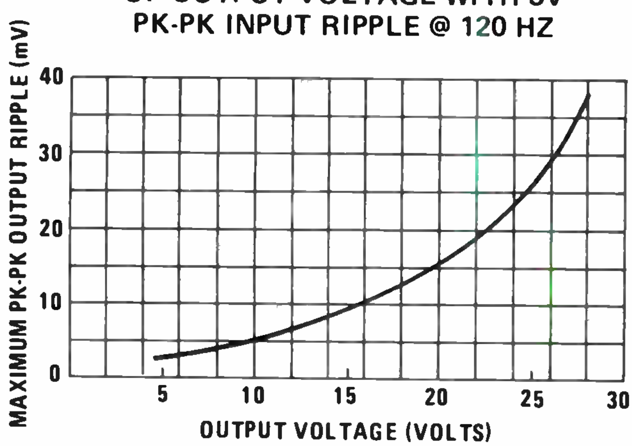


FIG. 4 DC SAFE OPERATING AREA AS A FUNCTION OF HEAT SINK THERMAL IMPEDANCE TO AIR AT 40°C AMBIENT TEMPERATURE

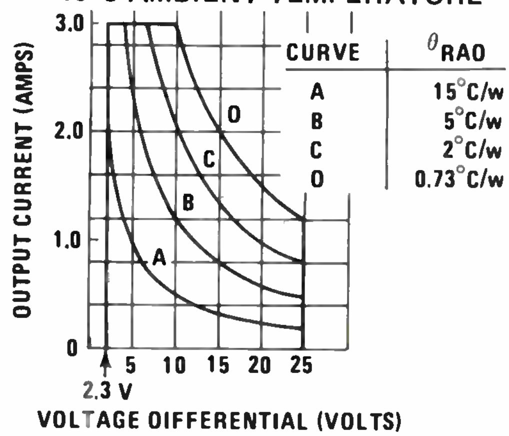


FIG. 5 DC SAFE OPERATING AREA AS A FUNCTION OF HEAT SINK TEMPERATURE

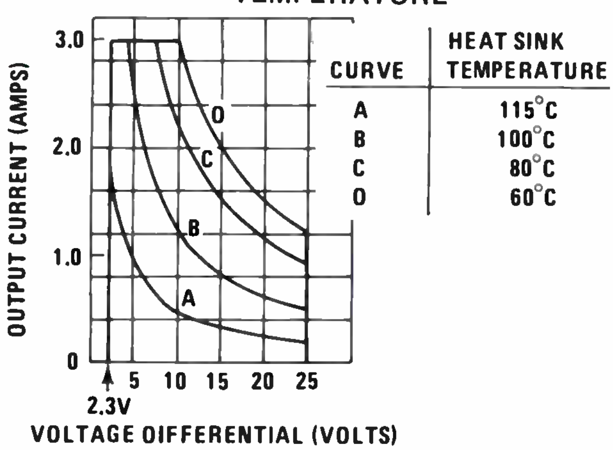
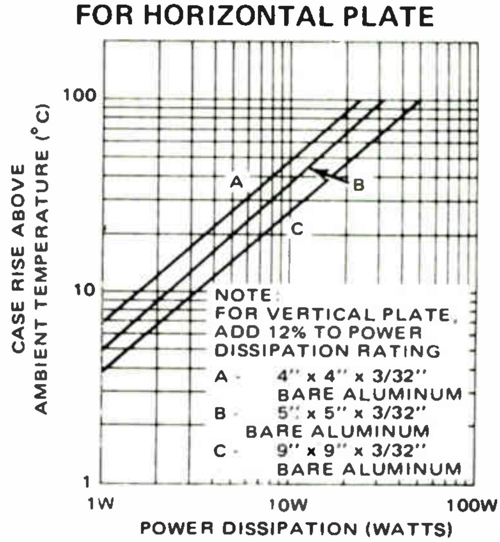


FIG. 6 TYPICAL HEAT SINKING DATA FOR HORIZONTAL PLATE



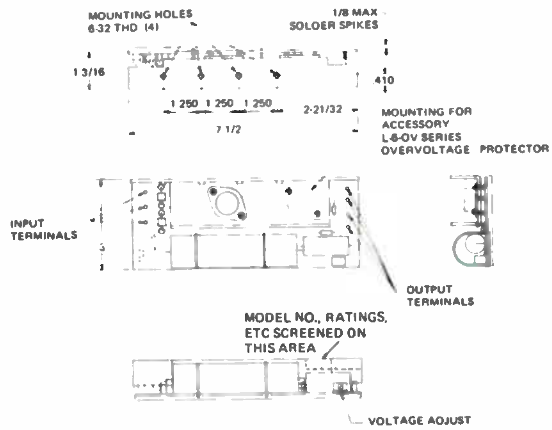
PERFORMANCE SPECIFICATIONS LSS-70 SERIES

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	MAX
INPUT VOLTAGE	$V_{IN}DC$	$I_O = 5.0A$	$V_O + 3.6V$	SEE TABLE I
	$V_{IN}PKAC$	$I_O = 5.0A$	$\frac{V_O + 4.1V^{(1)}}{.85}$	SEE TABLE I
OUTPUT VOLTAGE	V_O		5V	28V
OUTPUT CURRENT	I_O			5.0A
CURRENT LIMIT KNEE	I_K	$V_{IN} = V_O + 5V$		6.5A
SHORT CIRCUIT CURRENT	I_{SC}	$V_{IN} = 25V$		2.0A
STANDBY CURRENT	I_Q	$V_{IN} = V_O + 3V$		25mA
STORAGE TEMPERATURE	T_S		-40°C	+85°C
AMBIENT OPERATING TEMPERATURE	T_A		0°C	65°C
LOAD REGULATION		$V_{IN} = V_O + 5VDC$ $\Delta I_O = 4.95A$		0.6% V_O
LINE REGULATION		$I_O = 5.0A$ $\Delta V_{IN} = 4.5VDC$		1.0% V_O
PROGRAMMING RESISTANCE	R_P			200Ω/V
PROGRAMMING VOLTAGE	V_P			IV/V
TEMPERATURE COEFFICIENT	T.C.	$V_{IN} = V_O + 3V$ $I_O = 100mA$		0.02% V_O/°C
RIPPLE AND NOISE				SEE FIGURE 3

(1) ASSUMES 60Hz INPUT LINE FREQUENCY AND A RECTIFICATION EFFICIENCY (V_{CF} AVG/V_{SEC}PK) = 85%

TABLE I

MODELS	$V_{IN}DC$ MAX	$V_{IN}PKAC$ MAX (NO LD.)	INPUT CAP (μf)
LSS-70-01	16.5V	18.5V	15K
LSS-70-02	25.5V	29V	10K
LSS-70-03	35V	35V	5.2K



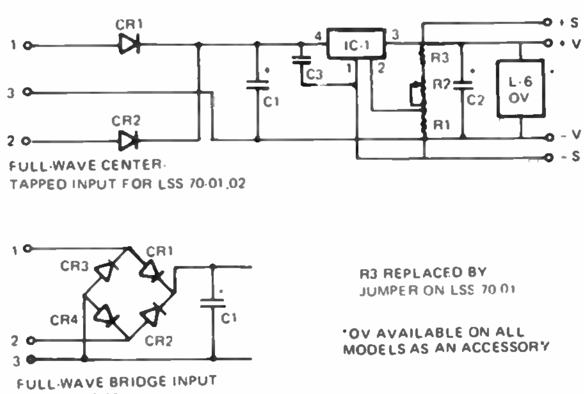
OUTLINE DRAWING

DESIGN EXAMPLE

Requirements: $V_O = 9V$ @ 2.0A
$T_A = 60°C$
Input Line Voltage = 117V_{RMS} ±10%, 60 Hz

1. For 9 volts at 2.0 AMPS, choose LSS-70-02.
2. From specification table, V_{IN} peak minimum =
   $\frac{V_O + 4.1}{.85} = \frac{9 + 4.1}{.85} = 15.5V$
   [Note that this assumes a rectification efficiency $\left(\frac{V_{AVG}}{V_{PEAK}}\right)$ of 85%]
3. From the transformer design, calculate V_{IN} peak maximum at high line. For this example, assume that V_{IN} peak maximum is 21.0 volts. Therefore $V_{AVG}MAX$ = 21.0 x .85 = 17.85V.
4. Compute the voltage differential (V_D) across the module as follows: $V_D = V_{AVG}MAX - V_O$
   $V_D = 17.85 - 9 = 8.85V$
5. From design curve (Fig. 1) at $V_D = 8.85V$, $I_O = 2.0A$ and $T_A = 60°C$, power dissipation (P_D) = $V_D \times I_O = 17.7W$ and the thermal impedance of the required heat sink (θ_{RAD}) is 2.35° C/W. This corresponds to an absolute heat sink temperature of 100.5°C.

Note: For DC input in the above example, V_{IN} minimum would be $V_O + 3.6V$ (from specification table) and $V_{AVG}MAX$ would be $V_{IN}MAX-1$.



SCHEMATIC DIAGRAM

PERFORMANCE SPECIFICATIONS
LSS-80 SERIES

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	MAX
INPUT VOLTAGE	$V_{IN}DC$ $V_{IN}PKAC$		$V_o + 6.2V$ $\frac{V_o + 4.0V^{(1)}}{.85}$ (3)	SEE TABLE I SEE TABLE I
OUTPUT VOLTAGE	V_o		4.75V	29.4V
OUTPUT CURRENT	I_o			10.0A
CURRENT LIMIT KNEE (4)	I_K		9.8A	13.5A
SHORT CIRCUIT CURRENT (4)	I_{SC}		2.1A	3.0A
STANDBY CURRENT	I_Q			31mA
STORAGE TEMPERATURE	T_S		-40°C	+ 85°C
AMBIENT OPERATING TEMPERATURE	T_A		0°C	65°C
LOAD REGULATION		V_{IN} = CONSTANT $\Delta I_o = 10A$		0.2%
LINE REGULATION		$I_o = 10A$ $\Delta V_{IN} = V_{IN}MAX - V_{IN}MIN$		$0.01\% V_o/\Delta V_{IN}$
PROGRAMMING RESISTANCE	R_P			200Ω/V
PROGRAMMING VOLTAGE	V_P			IV/V
TEMPERATURE COEFFICIENT	T.C.			$0.015\% V_o/°C$
RIPPLE AND NOISE ATTENUATION			60dB (2)	

(2) 54dB MINIMUM FOR 24V AND 28V MODELS

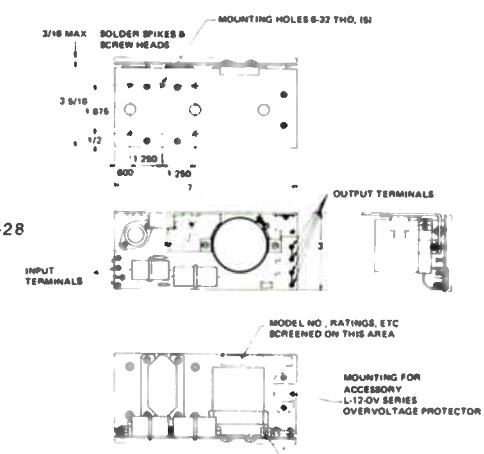
(3) $V_{IN}PKACMIN = \frac{V_o + 6.7V}{.85}$ FOR LSS-80-24 AND LSS-80-28

(1) ASSUMES 60Hz INPUT LINE FREQUENCY AND A RECTIFICATION EFFICIENCY $(V_{CF}AVG/V_{SEC}PK) = 85\%$

TABLE I

MODELS	$V_{IN}DC$ MAX	$V_{IN}PKAC$ MAX (NO LD.)	INPUT CAP (μf)
LSS-80-5	16.5V	18.5V	20K
LSS-80-6	16.5V	18.5V	20K
LSS-80-12	25.5V	29V	14K
LSS-80-15	25.5V	29V	14K
LSS-80-24	40V	40V	10K
LSS-80-28	40V	40V	10K

(4) MAX VALUE APPLIES TO LSS-80-5; MIN VALUE APPLIES TO LSS-80-28



OUTLINE DRAWING

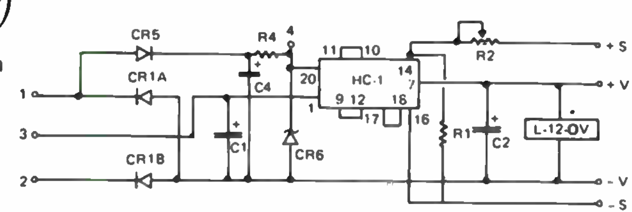
DESIGN EXAMPLE

Requirements: $V_o = 24V$ @ 4.0A
$T_A = 40°C$
Input Line Voltage = $117V_{RMS} \pm 10\%$*, 60 Hz

1. For 24 volts at 4 AMPS, choose LSS-80-24.
2. From specification table, V_{IN} peak minimum = $\frac{V_o + 6.7}{.85} = \frac{24 + 6.7}{.85} = 36.1V$
   [Note that this assumes a rectification efficiency $\left(\frac{V_{AVG}}{V_{PEAK}}\right)$ of 85%]
3. From the transformer design, calculate V_{IN} peak maximum at high line. For this example, assume that V_{IN} peak maximum is 40.0* volts. Therefore $V_{AVG}MAX$ = 40 x .85 = 34V.
   [Note that the maximum input voltage is 40V]
4. Compute the voltage differential (V_D) across the module as follows: $V_D = V_{AVG}MAX - V_o$
   $V_D = 34 - 24 = 10V$
5. From design curve (Fig. 1) at $V_D = 10V$, $I_o = 4A$ and $T_A = 40°C$, power dissipation $(P_D) = V_D \times I_o = 40W$ and the thermal impedance of the required heat sink (θ_{RAD}) is 1.8°C/W. This corresponds to an absolute heat sink temperature of 150°C.

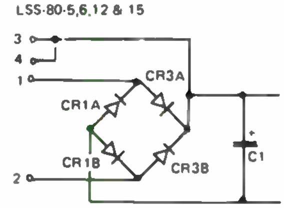
Note: For DC input in the above example, V_{IN} minimum would be V_o +6.2V (from specification table) and $V_{AVG}MAX$ would be $V_{IN}MAX$-1.

*Note that this value of peak input voltage requires restricted line swing



FULL-WAVE CENTER-TAPED INPUT FOR LSS-80-5,6,12 & 15

R4, C4, CR6, CR5 OMITTED ON LSS-80-24,28



FULL WAVE BRIDGE INPUT FOR LSS 80 24,28

* OV AVAILABLE ON ALL MODELS AS AN ACCESSORY

SCHEMATIC DIAGRAM

OPERATIONAL DATA

LSS-70 SERIES

FIG. 1 POWER DISSIPATION VS VOLTAGE DIFFERENTIAL ($V_{AVG} - V_o$)
POWER DISSIPATION VS RADIATOR THERMAL
IMPEDANCE FOR VARIOUS OUTPUT CURRENTS

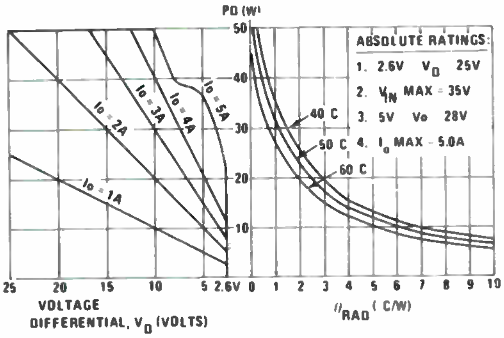


FIG. 2 POWER DERATING
CURVE AS A FUNCTION OF
HEAT SINK TEMPERATURE

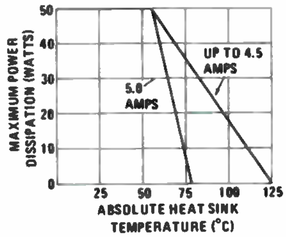


FIG. 3 OUTPUT RIPPLE AS A FUNCTION
OF OUTPUT VOLTAGE WITH 3V
PK-PK INPUT RIPPLE @ 120 Hz

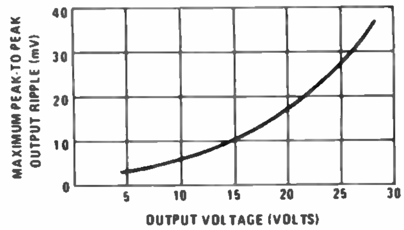


FIG. 4 DC SAFE OPERATING AREA AS A FUNCTION
OF HEAT SINK THERMAL RESISTANCE
TO AIR AT 40°C AMBIENT TEMPERATURE

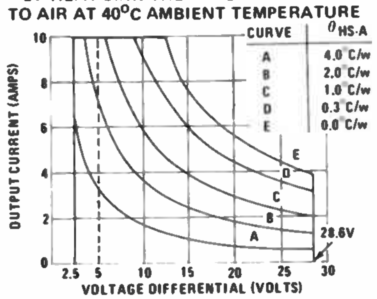
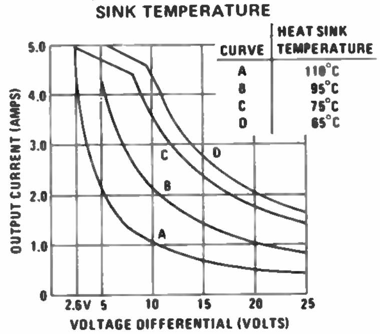


FIG. 5 DC SAFE OPERATING AREA
AS A FUNCTION OF HEAT
SINK TEMPERATURE



LSS-80 SERIES

FIG. 2 POWER DERATING
CURVE AS A FUNCTION OF
HEAT SINK TEMPERATURE

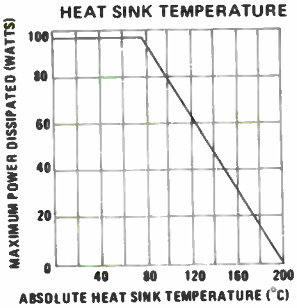


FIG. 3 DC SAFE OPERATING AREA AS
A FUNCTION OF HEAT SINK TEMPERATURE

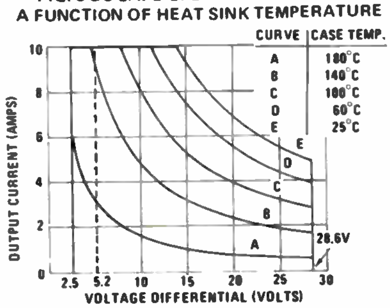


FIG. 4 DC SAFE OPERATING AREA AS A
FUNCTION OF HEAT SINK THERMAL
IMPEDANCE TO AIR AT 40°C AMBIENT
TEMPERATURE

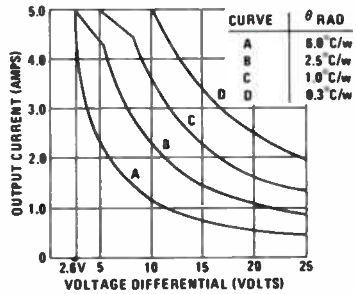
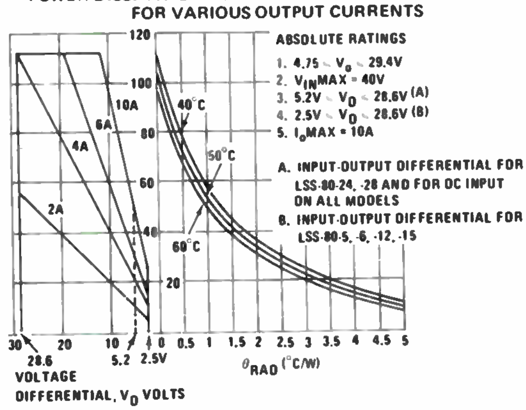


FIG. 1 POWER DISSIPATION VS VOLTAGE DIFFERENTIAL ($V_{AVG}-V_o$)
POWER DISSIPATION VS RADIATOR THERMAL IMPEDANCE
FOR VARIOUS OUTPUT CURRENTS



FOR TYPICAL HEAT SINKING DATA FOR HORIZONTAL PLATE FOR LSS-70 AND LSS-80. SEE FIG. 6 FOR LSS-60

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2420 East Oakton St., Unit Q
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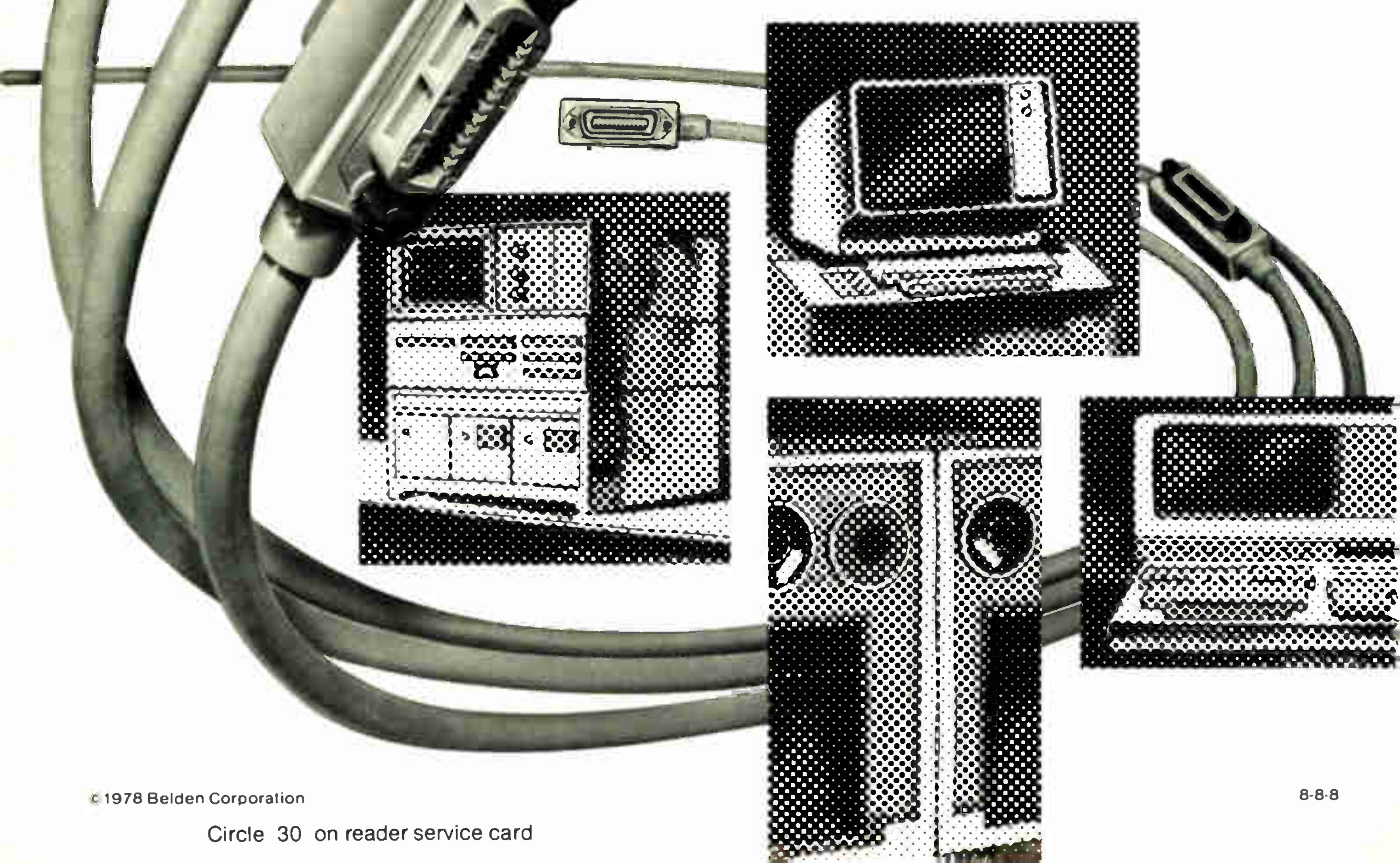

8-8-8

Circle 30 on reader service card

Products newsletter

Impact printer doesn't hit OEMs in the pocketbook

Taking up only 1.37 ft^2 of space, a fast impact printer for original-equipment manufacturers is priced at $995 in single quantities. It is called the Paper Tiger, and it rips through copy at rates of **100 to 198 characters/s, depending on which of the four pitches—8.3, 10, 12, or 16.5 characters/in.—a user selects.** Controlled by a Motorola M3870 microcomputer, it can recognize the last seven-by-seven-dot-matrix character on a line and immediately return to start a new one, making possible 400-line/min speeds. It prints a 96-character set, has an RS-232 interface, and comes from Integral Data Systems Inc. of Natick, Mass.

Compact unit tests memories at 25 MHz

Dubbed "The Colt," the latest memory tester from Pacific Western Systems of Mountain View, Calif., is a 25-MHz machine that sells in the $50,000 to $60,000 bracket. **Intel Corp., Santa Clara, Calif., is slated to get first crack at the tester, which is designed to check out both static and dynamic semiconductor memories at both the wafer stage and at final test.** The Colt is small enough to slide under the table that houses the prober or device handler. It is software-compatible with Pacific Western's Mustang-2 test system, already used by Intel for testing erasable programmable read-only memories and the new 2920 analog microprocessor.

German learning aid for 8085 processor to be sold here

Good sales on European markets have prompted Munich-based Advanced Micro Computer GmbH (AMC) to introduce its ECB85 microcomputer learning aid to the American market. The system, intended to familiarize users with 8085-based microcomputer applications [*Electronics*, Dec. 21, 1978, p. 4E], **comprises a single-board computer built around an 8085 and a host of peripherals.** It will be available for $825 from Advanced Micro Devices in Sunnyvale, Calif. U. S. deliveries are expected to begin "within a few months," says Erich Gelder, head of AMC in Munich.

How to capture random events

What makes digital-system troubleshooters turn prematurely gray is the random event that always occurs when no one is around. Hewlett-Packard's way of fighting aging is option 003 for its 1741A variable-persistence storage scope. **With this $75 feature, such random signals are automatically stored, redisplayed, and photographed by the model 197B camera ($1,100).** The 1741A scope goes for $4,250.

Eclipse computer gets militarized

Data General's Eclipse computer is now available in a fully militarized version from Rolm Corp., Santa Clara, Calif. Designated the MSE/30, **the rugged computer is aimed at military C^3 data-base management and logistics markets.** It supports AOS—Data General's advanced operating system—along with the data-base–oriented file-management system Infos, ANSI standard Cobol, Fortran, and PL/1.

4½-digit DMM measures 20 A

Keithley Instruments Inc., Cleveland, Ohio, has added a 20-A current-measuring range to its model 179 digital multimeter and dubbed the result the 179-20A. **Priced at $349, the 179-20A is claimed to be the only 20-A 4½-digit DMM available.** It can make continuous measurements on ac and dc currents up to 15 A and periodic measurements up to 20 A.

New products/materials

Titanium and palladium etchants are for use in semiconductor and microelectronics applications. The titanium etchant, TFT, is useful from 20° to 50°C and can etch at a rate of 2.5 mil/min at 25°C. The clear material is compatible with negative and positive photoresists and is rinsed with water. TFP, the palladium etchant, has a temperature range from 40° to 60°C and can etch at a rate of 11 nm/s at 50°C. The aqueous solution is compatible with a variety of photoresists, including KPR, KMER, KTFR, and Riston, and can also be rinsed with water.

Shelf life for TFT is a year and for TFP six months. The latter etchant sells for $18 for 1 gallon and $15 each for 4 gallons. The former one sells for $22 per quart, $60 per gallon, and, in quantities of 4 gallons, $50 per gallon.

Transene Co. Inc., Route One, Rowley, Mass. 01969 [475]

An aerosol solvent removes grease or grime from electronic and electrical components and circuits. This trichlorotrifluoroethane compound, Contour Number 40, can be applied as a heavy wet spray. Evaporating quickly and leaving no film to retain dust or oil, it is suitable for such devices as switches, motors, precision

instruments, film equipment, and tools. It is packaged in a 16-oz can and a free sample is available when requested on company letterhead.

Contour Chemical Co., Special Products

The Quick Test.

Next.

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Quick and simple to operate, the Series 50 features easy self-programming from a known good board, extensive self-diagnostics, rapid "go-no-go" inspection, complete numeric or alpha numeric hard copy error messages and full memory storage on magnetic tape or diskettes.

Next. The Series 50 is modular and expandable. Choose the capability you need today; add additional capability as you require it. Low equipment and operating costs, modular design, easy operation and high test speeds make the Series 50 Family ideal for a variety of applications. You can test bare boards, back-planes, ceramic substrates and cable assemblies. Quickly, easily, accurately. Next time you think about throughput, think about the Series 50 Circuit Verifier line. By ATEC, an Everett/Charles Company.

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E/C EVERETT/CHARLES, INC

Division, 3 Draper St., Woburn, Mass. 01801 [476]

A dielectric recording paper for use with electrostatic printers, measuring equipment, and facsimile systems, will operate in an environment with from 0 to 100% relative humidity. According to Matsushita Electric Corp., this surpasses the performance of most other papers, since they are effective only in an area with 40% to 70% relative humidity.

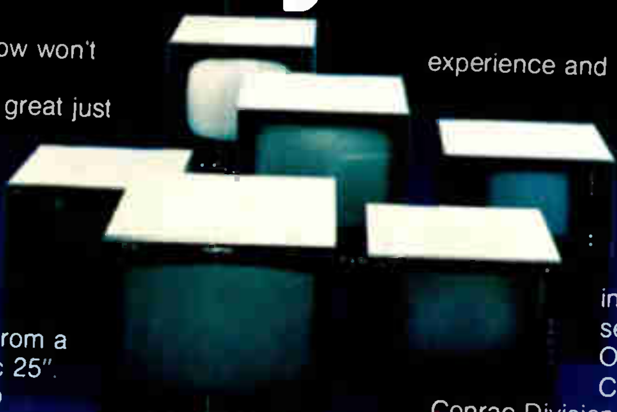
The recording sheet is made up of a base paper, a 6-to-7-μm-thick conductive layer, and a 4-to-5-μm-thick dielectric layer. The dielectric layer is essentially a thin film of resins that can be easily charged when placed in contact with electrodes in the computer terminal, measuring device, or facsimile system. The conductive layer acts as an opposing electrode to hold the charge pattern on the dielectric layer. To form the images deposited by the electrodes, the sheet is passed

through an electrostatically charged toner. The images are then fixed on the paper either by heat or pressure. The image recorded on the paper will not fade or discolor with age.

Specifications for the paper are a resistivity of 10^7 ohms regardless of ambient humidity, a recording voltage of 300 to 700 V, a recording speed of 0 to 500 kHz, and a resolution of more than 8 lines/mm.

One roll of paper 20 in. wide by 328 ft long sells for approximately $36 to $39. Delivery time is scheduled for the beginning of the summer.

Matsushita Electric Corp. of America, One Panasonic Way, Secaucus, N. J. 07094 [477]



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Circle 40 on reader service card

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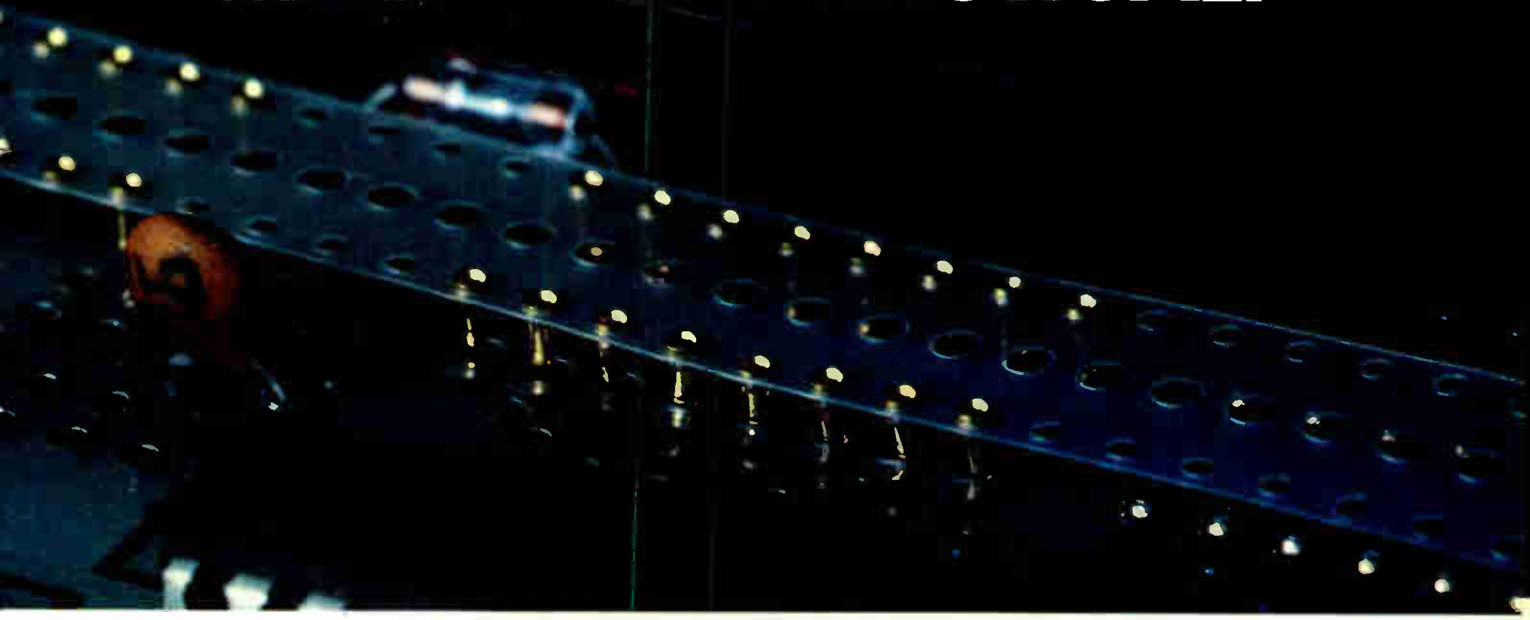

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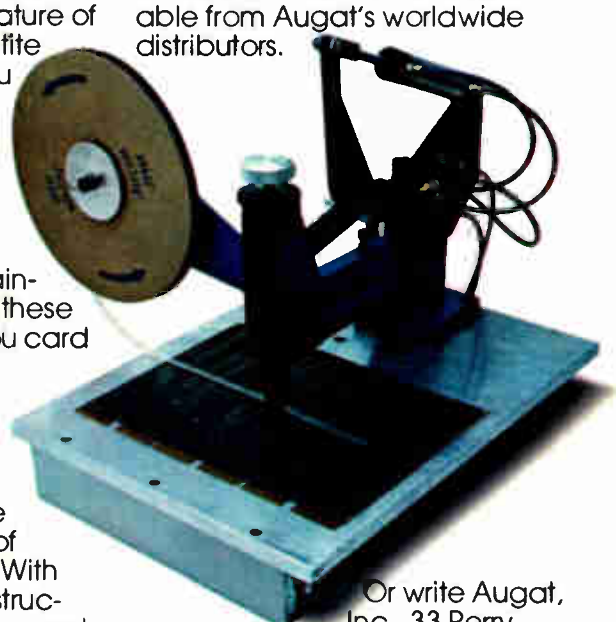

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Circle 41 on reader service card

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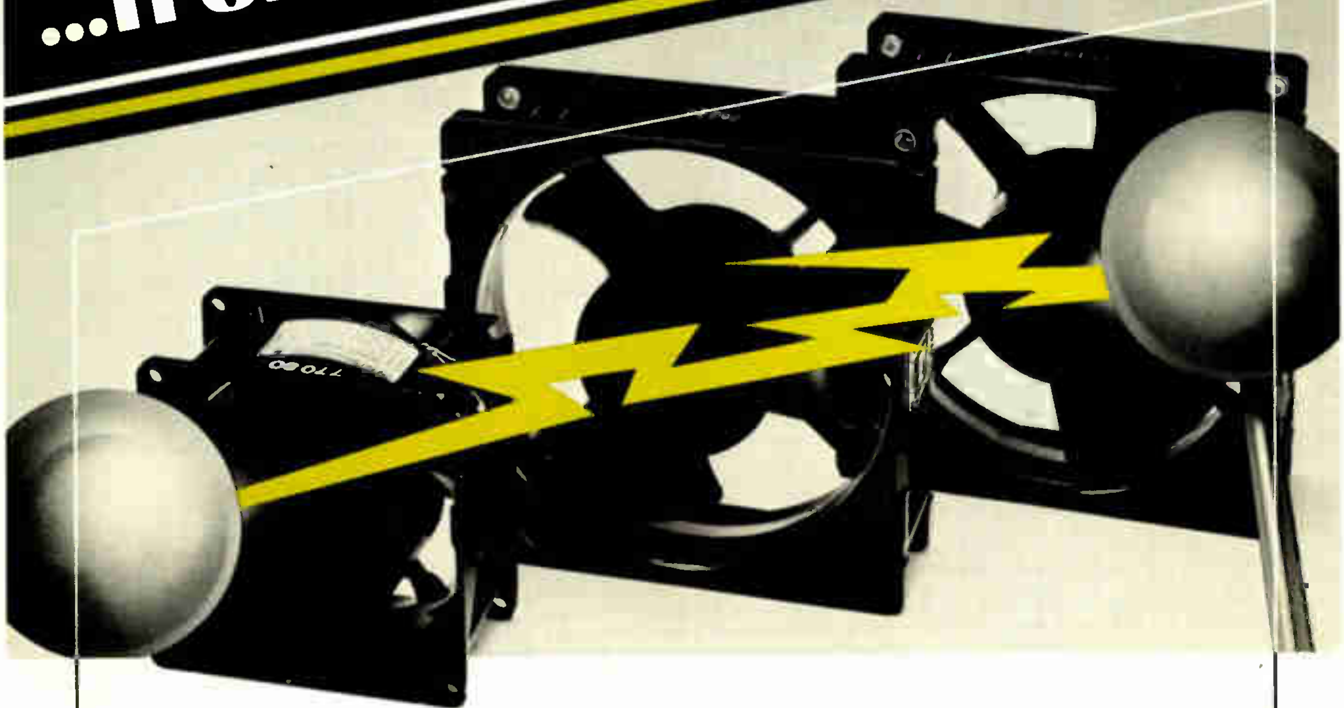

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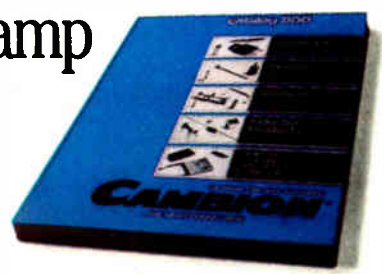

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New literature

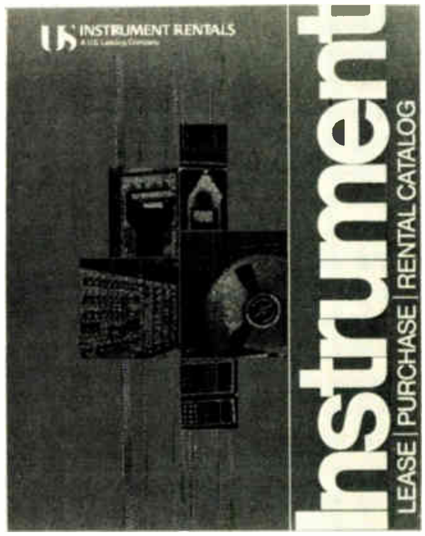
Test accessories. "1979 Electronic Test Accessories" catalogs dozens of new patch cords, cable assemblies, test socket adapters, test leads, banana plugs, phone jacks, and connecting cords. The 100-page booklet also outlines step-by-step procedures for putting together BNC cable and triaxial cable assemblies and provides tables for metric and temperature conversions. ITT Pomona Electronics, 1500 E. Ninth St., Pomona, Calif. 91766. Circle reader service number 421.

Frequency converters. A 15-page catalog of frequency-to-voltage converters includes application notes covering the converters' operation with standard optoisolated inputs and magnetic pickups. It also discusses their use in simple control applications. Prices for the devices are provided. D-B-Developments, 7709 Kilbourne Rd.,. Rome, N. Y.13340 [422]

Component subassemblies. A 70-page catalog describes a diverse line of attenuators, directional and hybrid couplers, oscillators, diode switches, tuners, and other devices. Specifications and prices are accompanied by drawings and photos. Engelmann Microwave, Skyline Drive, Montville, N. J. 07045 [424]

Converters and encoders. A 34-page catalog of synchro converters, displays, and encoders contains clear diagrams along with complete specifications and application information. Products not previously listed include synchro-to-digital converters and programmable solid-state limit switches. Computer Conversions Corp., 6 Dunton Ct., East Northport, N. Y. 11731 [426]

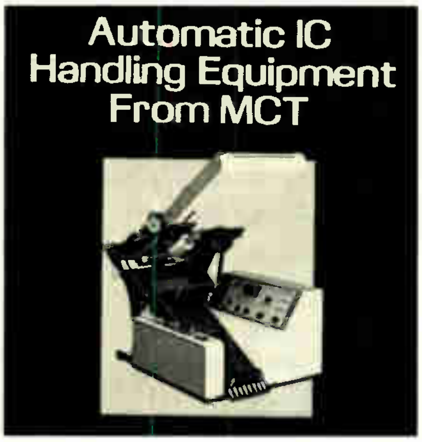
Rent, lease, or buy. This instrument catalog goes into the whys and wherefores of renting, leasing, or buying the equipment. It lists and



explains Idiom, a computer service for getting reliable up-to-date information on product availability, price, and delivery. The catalog discusses microprocessor development systems, programmable read-only memory programmers, amplifiers, analyzers, calibrators, component testers, counters, generators, oscilloscopes, and receivers. Write U. S. Instrument Rentals, 2121 S. E. Camino Real, San Mateo, Calif. 94403 [425]

Measurement systems. A line of instruments and systems for the analysis of audio-frequency spectra, distortion, frequency response, and very low-frequency phenomena is covered in a 16-page catalog. The products range from one- and two-channel real-time spectrum analyzers to advanced systems and fast-Fourier-transform analyzers for digital signal processing. Spectral Dynamics, a Scientific-Atlanta subsidiary, P. O. Box 671, San Diego, Calif. 92112 [427]

IC handlers. Five different integrated-circuit handlers are compared and their primary features discussed in a booklet. They include



ambient and elevated temperature dual in-line package types, an expanded-input DIP model, and a single in-line package (SIP) unit. Micro Component Technology Inc., P. O. Box 43013, St. Paul, Minn. 55164 [428]

Power supplies. More than 350 encapsulated ac-dc and dc-dc power-supply descriptions, specifications, prices, and photographs are included in a 20-page catalog. A glossary of terms also is provided. Wall Industries Inc., 175 Middlesex Turnpike, Bedford, Mass. 01730 [429]

Bubble memory. The TI0203 bubble-memory data manual includes an eight-page discussion on the operational fundamentals and advantages of the 92-kilobyte device. Specifications go beyond the bubble package to include integrated circuits it interfaces with. These are function-timing generator SN74LS361, sense amplifier SN75281, function driver SN75380, and coil driver SN75382. Thermistor TSP102 and Schottky-diode bridge VSB53, needed for bubble-memory system design, are also covered. Texas Instruments Inc., Inquiry Answering Service, P. O. Box 225012 MS-308 (Attn: LCC4430), Dallas, Texas 75265 [432]

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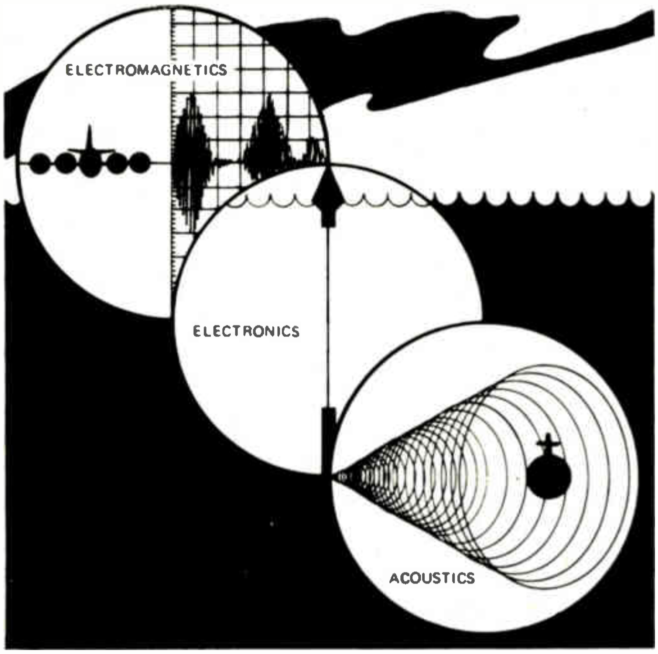

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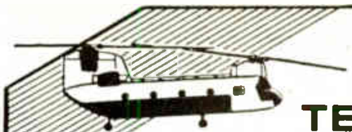

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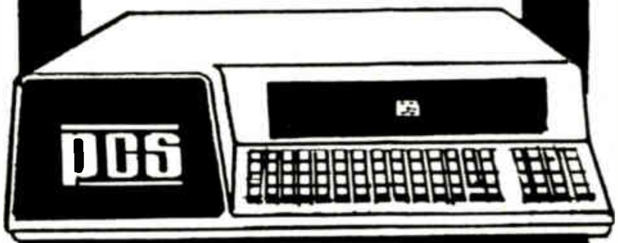

Equal Opportunity Employer M F

CONTROL DESIGN ENGINEERS

D-M-E, the world leader in basic tooling for the injection plastics and die casting industries, has an outstanding opportunity for you.

Our electronic products group needs enthusiastic, creative individuals (degree preferred with 3-5 years experience) who want to work on the development of process control systems used in the plastic injection molding industry.

To be considered, applicants should possess some background in the following areas:

- design of digital and analog circuitry
- software programming (assembly and high level languages with real time programming experience)
- familiarity with micro processors or other computer systems
- "hands-on" experience with design and prototyping
- seasoned troubleshooting capabilities
- experience with machine tools or industrial controls and instrumentation

We offer a very competitive salary (including an incentive program), a strong benefits package and a challenging, professional environment in which to grow. To explore this opportunity further, send your confidential resume and salary history to:

MANAGER OF EMPLOYEE RELATIONS

D-M-E COMPANY
29111 Stephenson Highway
Madison Heights, Michigan 48071
(313) 398-6000

Equal Opportunity Employer M F

Tennessee Eastman Company's Research Laboratories in Kingsport, Tennessee, needs an experienced electronics engineer for a broad range of "hands-on" and developmental engineering. The work is related to the performance, reliability, and improvement of electronic instrumentation used for chemical and physical analyses and for the processing of materials. Duties include servicing scientific instrumentation, designing instrument-computer interfaces, and developing micro computer applications for automation.

Candidates should have a B.S. degree in Electrical Engineering and "hands-on" experience with instrumentation and computers. The ideal candidate will enjoy the challenges of analyzing instrument failures and restoring optimum performance as well as developing electronic systems for automation. Please send resume to: **Mr. M.F. Lowe, P.O. Box 511, Tennessee Eastman Company, Kingsport, TN 37662.**

An Equal Opportunity Employer

The Engineer's Index

Systems Engrs.
Data Processing
Electronics

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Manufacturing Engrs.
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Companies Assume Our Fees.
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THE ENGINEER'S INDEX
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SCHOOLS

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FACULTY POSITIONS VACANT

Physics/Earth Sciences Anticipated Position—Assistant Professor, Full-time, 10 month position, Salary: $14,850, Fall 1979. Responsibilities: Teach Electronics for Physics and Pre-Engineering Students; Computer Electronics including integrated circuits, microprocessors, and interfacing techniques. To develop computer assisted instructions in Physics courses and develop courses in computer hardware to enhance computer science program. Qualifications: Ph.D. strongly preferred, will consider M.S. with appropriate experience or Engineering background. Resumes forwarded to: Dr. James A. DellaValle, Chairperson, Physics/Earth Sciences Dept., Central Conn. State College, New Britain, Connecticut 06050. Please include three(3) letters of recommendation. Deadline for application: June 1, 1979. EOE/Minorities, Females, Handicapped persons encouraged to apply.

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Therefore, the people we're looking for must be familiar with today's processes and still be innovative enough to develop tomorrow's systems.

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Background should include succeessful performance as Logic Engineer, experience with the conceptual design and implementation of large scale central processors working closely with the systems architecture staff. Requires 5 years experience in the design of large scale processors with architectural exposure. Experience in the design of microprogrammed processors using latest technologies, (TTL, ECL, etc.) is very desirable. BS/MS or equivalent is desired also.

The roads lead in many directions in today's world. If you're ready to take one that will be the most beneficial to you, send your resume with salary requirements in complete confidence to:

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Manager, Recruitment & Placement
P.O. Box 6000
Mail Station Y-18
Phoenix, AZ 85005

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The Advanced Energy Systems group of Exxon Enterprises, Inc., the new business development arm of Exxon Corporation, is seeking engineers with experience in all aspects of solid-state power conversion. We're a unique and dynamic organization with attractive opportunities and highly visible positions. Presently our needs include:

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You'll be working on the development of advanced power conversion equipment with primary application to variable speed AC motor drives. Responsibilities include overall system design and the coordination of electronic design engineers. The successful candidate will have a working knowledge of variable speed motor controls, multi-variable feedback systems, and power semiconductors. Design experience with analog IC's and digital logic is required. Familiarity with microprocessor controllers a plus. You should have a minimum of 8 years experience and demonstrated a high level of achievement with minimum supervision. BS degree in EE required, MS desirable.

Electronic Design Engineers

We seek creative engineers with extensive hands-on experience developing power transistor switching circuits, dedicated analog and digital feedback control circuits, or microprocessor based real-time controllers. You will be working on the development of state-of-the-art inverter circuits and systems in small project teams, working under minimum supervision. Familiarity with electromagnetic machine fundamentals and computer-aided design is also desirable. BS degree in EE and minimum of 5 years experience is required, MS desirable.

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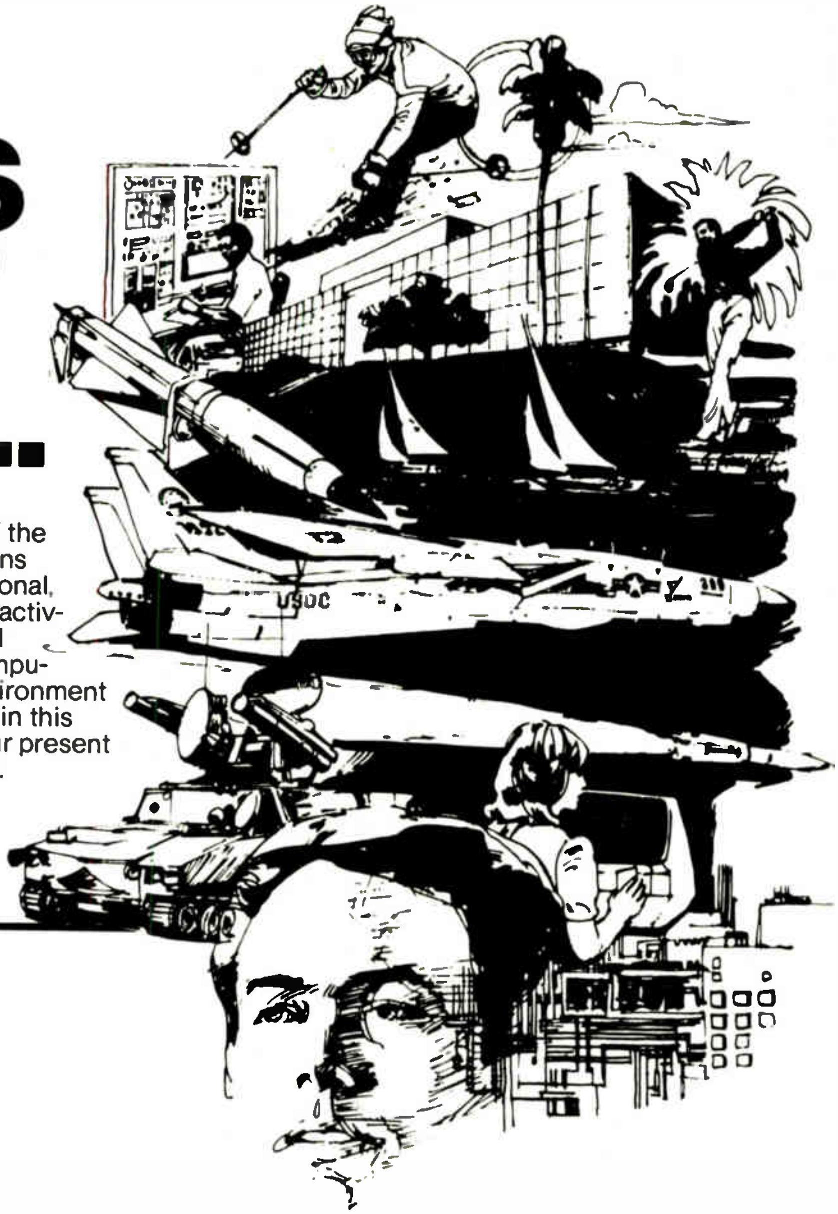

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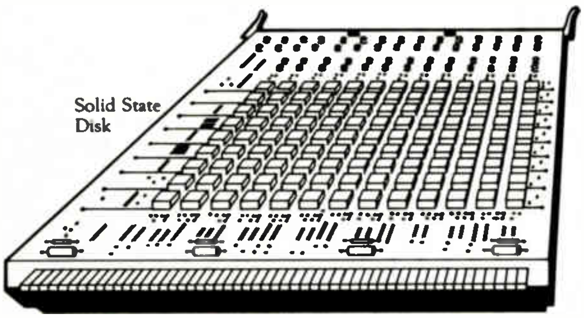

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BLOCK MULTIPLEX 1/0 DESIGN ENGINEERS
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TELECOMMUNICATIONS FIELD ENGINEERING SPECIALISTS
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Dept. E/4-12
MD-13

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B.S. degree and minimum 5 years experience.

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Experience in design of Power Supply Systems for communications operating facilities. Hands-on experience in design, preparation of specs and estimates for installation of power switchboards, rectifier/battery systems emergency power, UPS, HVAC lite & Pow. distribution and controls for earth stations, microwave & central office. Mechanical and construction experience a plus.

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MERCK & CO., INC.
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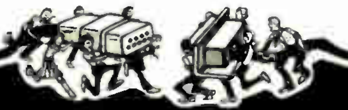

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As a key member of a product development team, you will have significant responsibilities for system and circuit design of high bit rate PCM equipment. This equipment will utilize State-of the-Art techniques including high speed digital circuits and microprocessors, and will be used with fiber optic and microwave radio systems. Applicants should have a minimum of 4 years digital design experience, preferably including ECL, and a BSEE degree. A background in PCM telecommunications equipment design is desirable.

PCM TERMINALS ENGINEERS

Responsible for circuit design of PCM voice/data channel bank equipment from concept to factory production. Position requires BSEE degree and experience in analog design. Prefer some digital experience or desire to learn digital design. Openings at all skill levels.

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For a Stored Program Digital Telecommunications Switching System. Should have a BS or MS degree in one or more of the following areas: Telephone Call Processing, Structured Software Design, Real Time Systems Design, Systems Diagnostics, PL/M.

TEST EQUIPMENT DESIGN ENGINEER

Position requires experience in digital and analog circuit design, preferably in the area of test equipment. Some programming background/TTL and ECL experience desirable. Ability to convert engineering test requirements into finished production test equipment.

Projects involve the design of test equipment for digital and analog carrier systems, microwave and digital radio systems, as well as microprocessor based products. Work includes design of calculator controlled and microprocessor based automatic and semi-automatic test systems as well as dedicated hardware test sets. BSEE or equivalent experience required. (Reply specifically to Job #JC1)

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Position requires a BSEE with 2-5 years experience in power electronics and power processing. Knowledge of solid state components, power electronic circuits and power magnetics is required.

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BS/MS or PhD in Electrical Engineering to develop custom integrated circuits in Bipolar and N-Mos technologies. Analog and/or digital design and computer simulation desirable. Willing to train Engineer with solid experience in discrete circuit design. You will have full responsibility for the development of your telecommunication circuit.
Need Electrical Engineer to generate IC modeling test pattern and to develop automatic programs for high speed test systems. Solid background in linear or digital circuit analysis and aptitude in programming required.
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Must have knowledge of electro-mechanical packaging and/or printed circuit board layout for proprietary products. No degree necessary.

GTE Lenkurt offers excellent salaries and a comprehensive benefits package including Paid Vacations and 11 Paid Holidays; Medical/Dental/Life/Disability Insurance; Stock Purchase; Savings & Investment Program; 100% Tuition Refund; Pension Plan; Employee Store and Credit Union, and Relocation Assistance. We are an Equal Opportunity/ Affirmative Action Employer.

Please send your resume or a brief letter outlining your qualifications to DICK NELSON, Employment Manager, GTE Lenkurt, 1105 County Road, San Carlos, CA 94070. (415) 595-3000.

GTE LENKURT

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GTE Sylvania Inc.
Johnston Street
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NOTICE TO EMPLOYERS:

Why we can recommend our readers for the top jobs

The subscribers to this magazine have qualified professionally to receive it. They are also paid subscribers—interested enough in the technological content to have paid a minimum of $15 for a subscription.

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Electronics

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POSITIONS VACANT

Electrical Engineer/Instructor— Qualifications: Electrical Engineer, Bachelor's Degree, Master's Degree preferred. Three years of applied experience in the application, design or maintenance of electrical power. Control equipment, motor controls, or similar current consuming devices is required. Solid state and logic systems as they apply to electrical controls are desirable. Salary range: depending upon training and experience. To apply send resume, transcripts and salary requirements in confidence to: Edward R. Maclosky, Springfield Technical Community College, One Armory Square, Springfield, MA 01105. An Equal Opportunity Employer.

Electronic Engineer, Sun Belt, excellent opportunity, salary & benefits. Murkett Assoc., Box 527, Montgomery, AL 36101.

POSITIONS VACANT

Electrical Engineer/Instructor— Qualifications: Electrical Engineer, Bachelor's Degree, Master's Degree preferred. Three years of applied experience in the design or application of engineering principles on electronic equipment or equal. Solid state and computer background as they relate to the communications field is desirable. Salary range: depending upon training and experience. To apply send resume, transcripts and salary requirements in confidence to: Edward R. Maclosky, Springfield Technical Community College, One Armory Square, Springfield, MA 01105. An Equal Opportunity Employer.

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Junior Faculty And Research Positions In Semiconductor Device Technology Applications are solicited for junior faculty and research staff positions in the Department of Electrical Engineering and Computer Science at M.I.T. in the general area of semiconductor-device and integrated-circuit technology. Faculty duties include teaching at the graduate and undergraduate levels, research, and supervision of theses. Research staff duties are primarily in research, with opportunities for teaching or thesis supervision when appropriate. As part of an expanding M.I.T. program in semiconductor device and integrated circuit technology, a new faculty or staff member will be expected to become a collaborative member of one or more existing research programs, and to develop original research programs in such areas as semiconductor device fabrication; characterization and modeling of submicrometer structures and devices; physical device limitations; design technologies for device and integrated circuits; or novel devices, integrated circuits, and integrated systems. Prior industrial experience will be helpful. Applicants should have an interest in working with groups at M.I.T. that seek to develop integrated circuits and systems for a wide range of disciplines, such as computer technology, signal and image processing, biomedical engineering and communications, and should be interested in developing working relationships with industrial organizations. Applicants should provide a resume and the names and addresses of three or more references. Applications should be sent to: Professor Stephen D. Senturia, Room 13-3010, Massachusetts Institute of Technology, Cambridge, Mass. 02139. Indicate citizenship and, if not a US citizen, describe your visa status. M.I.T. is an equal opportunity/affirmative action employer.

Applicants are invited for a faculty position in The Electrical Engineering Dept. at South Dakota State University, Brookings, SD to begin Aug. 16, 1979. Rank and salary are commensurate with background and ability. Acceptance of applications until position is filled. Contact Dr. V. Ellerbruch Head, or call 605-688-4526. An equal opportunity/affirmative action employer.

Anticipated faculty position in Bachelor of Technology Program Fall 1979. Teach courses in areas of digital electronics micro-processors, and computer interfacing. Ph.D. required for assistant professor appointment; industrial and teaching experience desired. Send resumes to: Dr. George DePuy, Director of Technology Programs, School of General Studies, SUNY-Binghamton, Binghamton, New York 13901. An equal opportunity employer.

3 Tenured Track Faculty positions available in the Department of Electronics and Computer Technology. Fall 1979. Send resumes to: Richard Lyons, Department of Electronics and Computer Technology, School of Technology, Indiana State University, Terre Haute, IN 47809. Applications received after June 1, 1979 cannot be assured consideration. Equal Opportunity/Affirmative Action Employer.

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Wang's growing diagnostic Software Development Department is looking for highly motivated individuals with a minimum of 3 years hardware/software experience to fill intermediate through senior level openings to design, code, debug, evaluate and release diagnostic programs for hardware systems and subsystems, ranging from a microprocessor-based subsystem to a medium sized general purpose virtual memory system.

The applicant should be versed in assembly language programming, knowledgeable of diagnostic testing strategy for subsystems, including CPUs, memories, and peripheral devices, acquainted with hardware/software compromises to obtain levels of hardware visibility that will ensure a product that we can test, diagnose and maintain.

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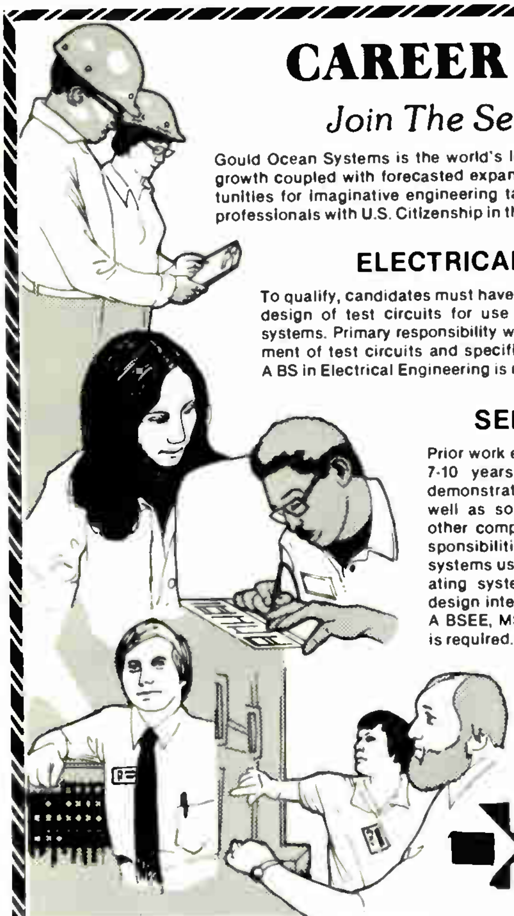

Gould Ocean Systems is the world's leading pioneer in the field of oceanic technology, and is continually striving to stay #1. Significant growth coupled with forecasted expansion and a solid commitment to new product development has created exciting professional opportunities for imaginative engineering talent with Gould's fast-moving Ocean Systems Division. Immediate openings are now available for professionals with U.S. Citizenship in the following areas:

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To qualify, candidates must have at least 5 years experience in the design of test circuits for use in complex digital and analogy systems. Primary responsibility will involve the design and development of test circuits and specifications for performance testing. A BS in Electrical Engineering is required.

SENIOR ENGINEER

Prior work experience should include at least 7-10 years of power control engineering demonstrating strong leadership abilities as well as solid experience in Fortran IV and other computer aided analysis. Areas of responsibilities will include analyzing power systems used for undersea propulsion, generating system requirements and overseeing design integration and evaluation processes. A BSEE, MS or PhD in Electrical Engineering is required.

ELECTRICAL ENGINEER

For consideration, candidate must have experience in either hardware design or test program development, plus a background in automatic test equipment. Primary responsibilities will involve the analysis and synthesis of circuits for prototype development, the development of software and hardware test programs, as well as the generation of engineering documentation. A BS in Electrical Engineering is required.

ELECTRICAL ENGINEER

For consideration, candidates must have 0-3 years electronic experience in either hardware design or test program development, plus a solid background in automatic test equipment. Primary responsibilities will involve the analysis and synthesis of circuits for prototype development and the development of software and hardware test programs, as well as providing liaison with other departments to expedite realization of hardware and software products. A BS in Electrical Engineering is required.

If you're up to the large scale challenges and the exhilarating growth pace that have established Gould as an integrated technology company . . .you'll be rewarded with an exceptional salary, a full benefits package and highly-visible advancement opportunities. Submit letter or resume in confidence with earnings history and salary requirements to:

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Ocean Systems Division

GOULD OCEAN SYSTEMS DIVISION
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- **Mini-Computer Technology**
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- **Airborne Instrumentation**
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- **Electronic Circuit Design**
- **Micro-Processor Technology**

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W. B. Kellenberger, Section Manager
Professional Employment
Department E-04 • P. O. Box 516
St. Louis, Missouri 63166

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CORPORATION

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RCI is a technical search firm with an outstanding reputation representing a broad base of nationwide clients serving the Electronics Industry. If you are interested in advancing your career, call us or send your resume or a brief hand written description of your background including present salary and geographic preferences, in confidence to:

Tony Ray, Search Director-Room J
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Automatic test equipment design including analog measurement, analog stimulus and digital subsystems. Requires BSEE/MSEE and 2-5 years design experience. Analog design background preferred.

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