MAY 13, 1976

COMPLEX MOS DEVICES BRING FUN AND GAMES TO TV RECEIVERS/87

Charge-transfer devices simplify moving-target indicator/98

Eight-bit multiplier chip extends processor capability/103

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Electronics®

Wide Range LCR Measurements can be this quick and easy...

Just touch and read.

The new HP 4261A Digital LCR Meter brings you the accuracy and wide range of an impedance bridge, plus the speed of an automated digital test set. Eliminating bridge balancing and dial reading reduces the chance of human error significantly. Just set the FUNCTION switch and take the reading from the auto-ranging 3½-digit LED display. HP's auto-balance circuitry eliminates the tedious knobturning and ambiguous meter reading of manual impedance bridges.

The 4261A's auto-ranging feature gives you almost instant readings: inductance from 0.1 microhenries to 1900 henries; capacitance from 0.1 picofarads to 19.00 millifarads; resistance from 1 milliohm to 19.00 megohms; and dissipation factors from zero to 1.9. And you get all this measurement capability for only $1,740.*

Options add computing power. The 4261A gives you a wide choice of optional configurations too, such as back-panel inputs and outputs that are compatible with the HP Interface Bus (conforming to IEEE 488-1975), for automated testing or data gathering under calculator or computer control. You can also order the HP 4261A with optional BCD outputs, and remote control features.

And it's versatile. The HP 4261A offers you the choice of two test-signal levels (50 mV or 1V), and internal, external, or manual trigger. You can select DC Bias levels of 0, 1.5, 2.2, or 6V (or external) and test frequencies of 120 Hz or 1 kHz. You can make two-terminal measurements for general applications and three-terminal measurements, using a guard terminal, for high impedance measurements. Or, for extremely low-impedance measurements such as a very small inductance or a large capacitance, you can make four-terminal measurements.

Contact your local HP field engineer. He can show you many additional features and benefits that the HP 4261A offers.

*Domestic U.S.A. price only.

The Useables-
new standards in component testing.

096/42

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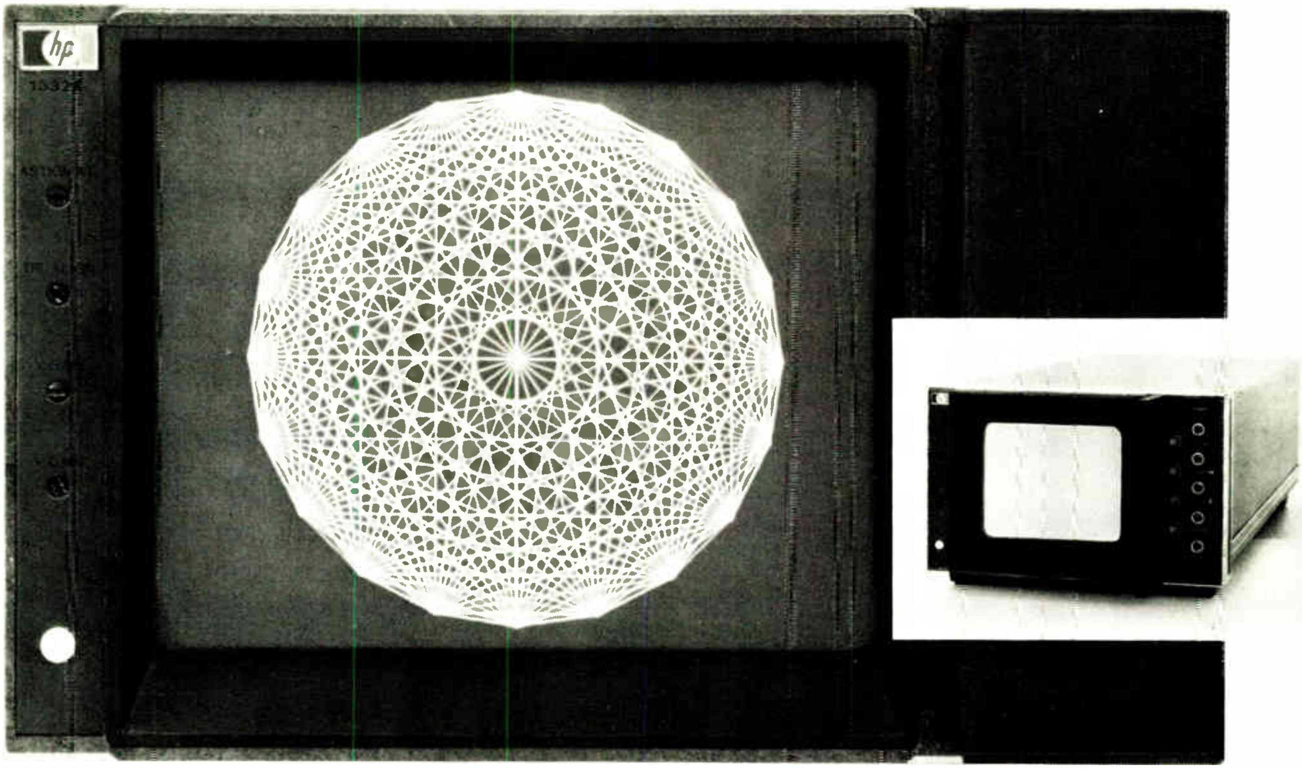
Circle 900 on reader service card

HP displays.



Because your system deserves a bright, sharp image.

You put a lot into each OEM system: good circuit design, quality components, careful testing. But end users will judge it by the information they get from the display. They expect bright, sharp images. That's why HP's 1332A, 1333A, and 1335A CRT displays make excellent choices for all types of systems—from spectrum, network, and chemical analyzers, to automatic test systems.

Each display has a very small spot size that focuses uniformly over the complete viewing area, regardless of writing speeds or intensity level. This eliminates the need to refocus at each intensity setting and assures crisp images, even around the outer edges of the screen. Fine image detail with excellent contrast and uniformity make them particularly well suited for applications involving complex graphics, especially those with alphanumeric data.

The 1335A, a variable-persistence, storage, and non-storage display, introduces a totally new CRT design optimized exclusively for information display. It offers exceptionally good resolution over the entire 8 x 10 cm screen. And the 1335A is versatile too. Any operating mode—erase, store, write, conventional, or variable persistence—can be selected with manual front-panel controls, remote program inputs, or a combination of both. Manual controls can be inhibited entirely during remote operations. The 1335A is a welcome addition to medical and instrumentation systems.

OEMs who need a larger viewing area and a brighter image at faster scan rates like the **1332A.** They appreciate its 9.6 x 11.9 cm viewing area, its superior performance, and the ease with which the 1332A, like the others, integrates into a variety of racks and cabinets.

For photographic recording of displayed data, the new **1333A** offers new performance levels. Its extremely small spot size of 0.20 mm (0.008 in.) provides the exceptional quality necessary for easy and accurate photo evaluation. And its 8 x 10 cm screen allows reproduction on Polaroid film with very little optic reduction. For convenience, all frequently used controls on all of these displays have been placed on the front panel for maximum accessibility.

Which display best fits your requirements? Let your local HP field engineer help you decide. Or write for specific details. We'll help you pick a display that makes your system look as good as it actually is.

085 9 A

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Problem

Interacting low-frequency filter adjustments.

Solution

HP's 3580A Spectrum Analyzer.

Benefit

Time saved, tuning simplified.

It's a typical problem. Your finished prototype usually contains multiple adjustments—which means you use a lot of time tuning your filter for top performance.

If you're designing filters to operate in the 5Hz to 50kHz range, you now can stop using so much time, stop being bothered by interactive adjustments. Our 3580A combines a built-in tracking oscillator, wide dynamic range, and digital storage to help speed and simplify every step of your next filter design. Follow this typical example and learn how the 3580A can help.

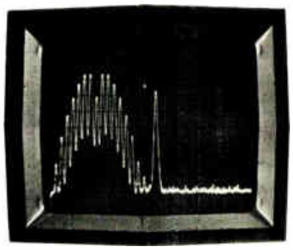
Step 1 With the 3580A, observe your spectrum and determine which frequency components to pass, which to attenuate. Decide the best type of filter to get the performance you need. Design your filter.

Step 2 Once you've selected your components and breadboarded a prototype, you can analyze your filter's performance with the 3580A. Its 80 db dynamic range gives you a clear view of everything taking place so you know exactly how your prototype is performing. Now with the tracking oscillator driving your filter, you can trim component values to optimize filter performance. Note how the tracking oscillator lets you observe the influence of each adjustment on filter performance—how it reduces the frustration you experienced before with interactive adjustments.

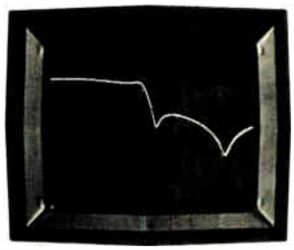
Step 3 Package and build your first production filter. Use the 3580A's digital storage to superimpose both waveforms for simultaneous viewing—a big advantage of the 3580A. Now set up and store the response of a good production filter and simply compare other production units against the good one, making adjustments as needed.

All of the capabilities in one instrument gives you extra value in your filter design and production. It's priced at $4485*. Your local HP field engineer can give you all the details. Or write for our 8-page technical data sheet.

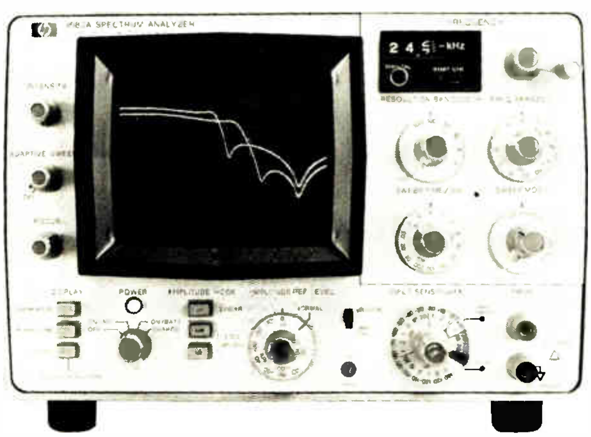
Step 1.
Analyze your spectrum.



Step 2.
Adjust your prototype's response.



Step 3.
Compare all production filters with the stored standard. Note the analog look that you get with HP's digital display.



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Electronics

The International Magazine of Electronics Technology

Vol. 49, No. 10•May 13, 1976

Highlights

Cover: 16-k RAM features single-level process, 81
Designers of a new 16-kilobit random-access memory found they could adapt the single-level silicon-gate process of today's high-volume 4-k RAMs to achieve a cell size only marginally larger than in their 16-k competitors. Potentially greater reliability may result.

Cover design is by Pat Cybulski.

Electronic watches boon to battery makers, 69
Those little cells that power electronic watches are a big area of growth for battery manufacturers. Supplies are tight—in fact, there have been shortages—so expansion plans are under way. They are fueled by predictions that the present $13 million annual sales to watchmakers and consumers will jump to between $75 and $250 million by 1980.

TV tuning is more fun with MOS, 87
Ultrasound remote channel selection is nothing new in European TV sets, thanks to MOS circuits. Now the silicon-gate technology is popping up in digital versions and in on-screen displays of channel number, time, and so on. Just over the horizon are color home video games built into the sets.

1-chip multiplier simplifies signal processing, 103
Digital signal processing makes sense for commercial applications now that an economical single-chip multiplier can handle the extra multiplications required. Booth's algorithm and a special carry-store technique are the keys.

And in the next issue . . .
A special report on the growth of distributive data-processing networks . . . what you'll hear and what you'll see at the National Computer Conference . . . a 16-bit microprocessor that fills the gap between 8-bit devices and minicomputers.

Electronics

Publisher's letter

The 16,384-bit random-access memory—which in the jargon of semiconductor people shortens up to 16-k RAM—has arrived. Indeed, some observers of the solid state field call it the big memory product for the rest of the decade.

According to Larry Altman, our solid state editor, the two companies that led in 4,096-bit RAMs, Intel Corp. and Texas Instruments, have been the quickest to introduce 16-k devices. With the publication in this issue of a technical article from Texas Instruments on its TMS 4070, *Electronics* has been the only magazine to give the full technical disclosure on both 16-k RAMs.

Significantly, both RAMs are built as extensions of proven 4-k technology, rather than as technological departures in their own right. Therefore, the "learning curve" for the new devices should show a shorter start-up period and a steeper climb toward widespread application than did their 4-k ancestors.

Nonetheless, there is little similarity between these first two 16-k RAMs. For example, Intel used a two-level structure to economize on chip real estate. TI, on the other hand, took the single-level route to keep processing from becoming too complex. For all the details on TI's new memory, turn to page 81, and if you want to compare it with Intel's 2116, check the article starting on page 116 of the Feb. 19 issue of *Electronics*.

With all the interest in advanced technology, it's a jolt to realize that there are times when the nuts-and-bolts items of electronics are what really regulate the pace of progress. A case in point is the digital watch and the battery.

Now that digital-watch sales are humming along—some 15 million this year compared with only 3 million last year—demand has soared for those tiny batteries needed to run the watches. The trouble is, the battery makers were not prepared to turn out enough batteries to power that flood of watches. In fact, it looks like the semiconductor houses are in better shape to meet the demand for timekeeping devices than are the battery makers for the power supplies to make them work.

For the story on the battery shortage, which is leading to higher retail battery prices, turn to page 69. There, our New York bureau manager, Ron Schneiderman, details an almost classic case of the kind of bottleneck that can slow the development and marketing of advanced-technology products.

And speaking of digital technology, there's a big trend in Europe toward putting digital devices into television sets. The result: a number of luxury features, ranging from remote channel selection, through on-screen channel and time displays, to built-in games. What's more, even the basic design of the tuner is being drastically altered by the inroads of metal-oxide-semiconductor devices. For a look at what's happening to television-set design in Europe, where many innovations in consumer electronics have first appeared, see page 87.

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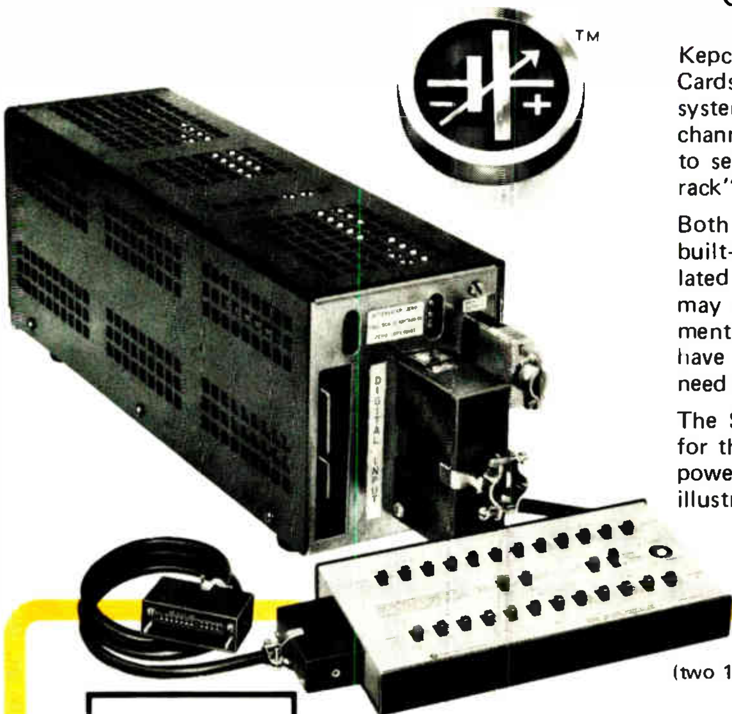
- **high speed** or **conventionally filtered** output.

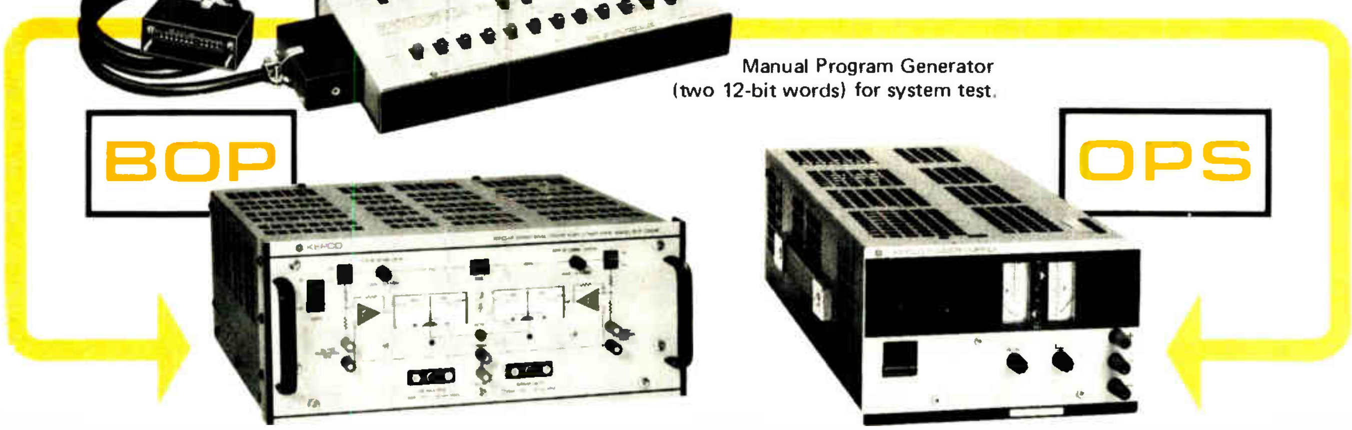


Kepco's Digital Programmers are composed of individual PC Cards that may be combined as you require to form a control system. The combination to the left provides a 12-bit, 2-range channel for voltage setting, plus an independent 8-bit channel to set a current limit. It is housed in a convenient "quarter-rack" assembly, seen here from the rear.

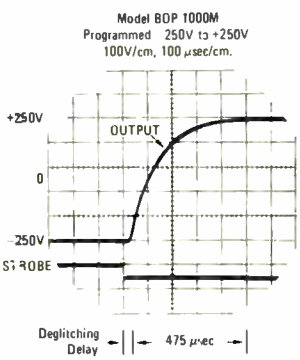
Both channels are strobe-accessed for noise immunity, have a built-in delay (10 μsec) for deglitching and are optically isolated so that either side of your power supply (up to 1000V) may be grounded. Data inputs are TTL compatible, complementary-logic with built-in storage registers. The programmers have isolated on-card a-c operated power supplies— all you need to do is plug 'em in.

The SN Programmer's outputs are d-c analog signals, suitable for the control of any of Kepco's *Operationally Programmable* power supplies, either the high speed kind (whose response is illustrated below) or conventionally-filtered models.

Manual Program Generator
(two 12-bit words) for system test.



Response character of the BOP 1000M, programmed from −250V to +250V, showing strobe and delay.



BIPOLAR VOLTAGE

The SN Programmer mates perfectly with one of the new Kepco high voltage, bipolar units, Model BOP 1000M with an SN–12R (12-bit) Card controlling voltage, and an SN–8R (8-bit) card controlling current. Your *Bipolar* output is:

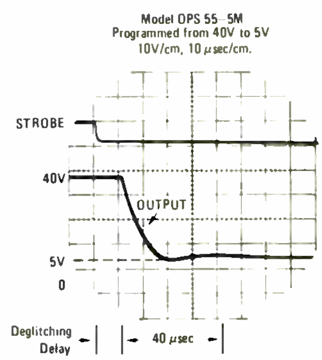
RANGE	RESOLUTION
−1000V to +1000V	244 mV
−100V to +100V	24.4 mV
−40 mA to +40 mA	0.16 mA

UNIPOLAR VOLTAGE

The SN Programmer also mates beautifully with Kepco's many high speed unipolar power supplies, for example, a Model OPS 55–5M. With the SN–12R Card for voltage control and the SN–8R Card for current control, you get a *Unipolar* output of:

RANGE	RESOLUTION
0–55V	13.2 mV
0–5.5V	1.3 mV
0–5 A	20 mA

Response character of the OPS 55–5M, programmed from 40V down to 5V, showing strobe and delay.



For complete specifications and applications notes on our full line of voltage and current regulators and digital programming interfaces, write Department FJ–14.

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Readers' comments

Resisting voltage variations

To the Editor: In the circuits shown in "Some biasing basics" [March 4, p. 110], accompanying the article on linear opto-isolator applications, the collector voltage of the current reflector's output transistor may vary considerably, thereby varying output current. A resistor in each emitter developing 0.5 volt of drop at the supplied current will decrease this effect by 90% or more.

To confirm this, we tested a matched pair of transistors, without emitter resistors, with a V_{CC} variation on the I_0 collector of 1.5 to 30 V—over 23%, potentially contributing much to nonlinearity. With 200-ohm resistors, current change due to this voltage difference was only 1.3%.

The light-emitting-diode reference circuit in the panel is slightly better on voltage change. But the circuit using the matched transistors will be better over wide temperature ranges, due to the great symmetry of a specially processed monolithic pair, like National's LM394.

Peter Lefferts
National Semiconductor Corp.
Santa Clara, Calif.

Multiply instantaneous values

To the Editor: There is an extremely important point about rms measurement barely touched upon in the March 18 pair of articles [p. 94 and p. 97]. The validity of inferring a device's power dissipation from a true-rms measurement of voltage or current alone depends entirely on the phase and linearity relationships of the voltage and the current in a given device.

Nonlinear and reactive components cannot be evaluated for power dissipation, except by multiplying the instantaneous values of voltage and current and averaging the resulting power waveform. Furthermore, the time relationship between peak-power duration and the thermal time constants of devices must be taken into account.

Warren Collins
Tektronix Inc.
Beaverton, Ore.

"No, we ordered a ten-buck DAC!"

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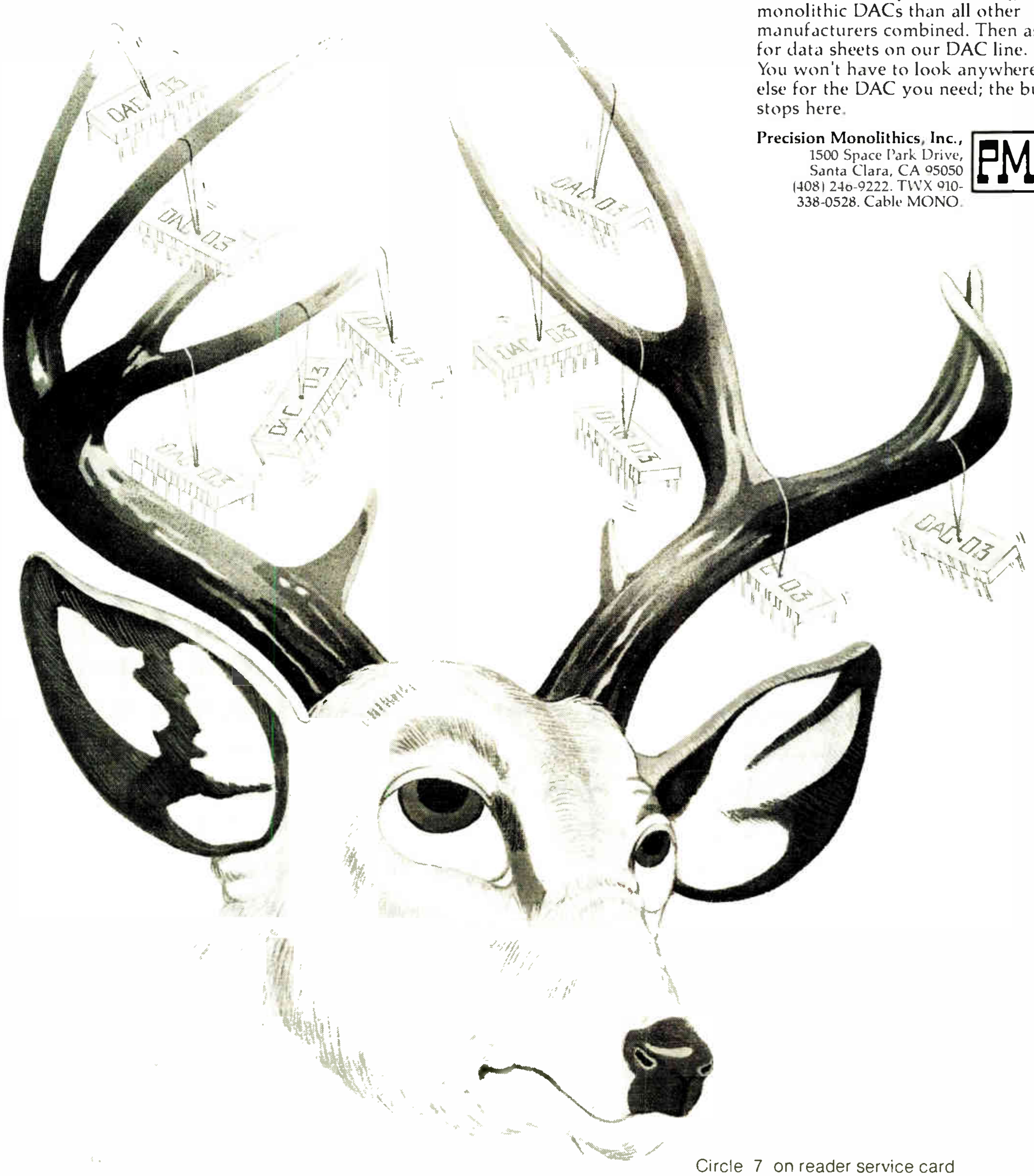

Circle 7 on reader service card

News update

■ When researchers at University College in London came up with a holographic connection system for optical cable and a multiplexing scheme that uses pressure transducers, they thought they had lowered two barriers to long-distance fiber-optic communications [*Electronics*, May 15, 1975, p. 34]. But the proof of such a system would be in the commercial world, and, so far, nothing has happened there. Some commercial interest in the idea has been voiced, but the system is a long way from being ready for the market, says Eric A. Ash, a professor in the college's electronic and electrical engineering department. There has been some progress in further development of the system, says Ash, but he won't go into detail.

■ Several aerospace firms have entered the business of energy control and at least one of them appears to be having some success. The new venture is an outgrowth of work done on their own buildings by the companies during the energy crunch [*Electronics*, March 18, p. 84]. Now, the Hamilton Standard division of United Technologies Corp. has won a $1.5 million contract from the Massachusetts Institute of Technology to design and install an energy-saving facilities-management system for MIT at its Cambridge, Mass., campus. The system is expected to cut $1 million a year from MIT's energy costs.

The computer-controlled system is to go on line by the spring of 1977. It will tie 34 buildings on the campus into a single management unit. The greatest savings are expected to come, says Hamilton Standard, through efficiency increases in heating, ventilating, and air-conditioning, as well as through electrical load-shedding. Load-shedding is a method of turning off nonessential equipment during periods of high energy use, thus limiting costly peak demands for power. And the system will include an audible and printout alarm system covering equipment failure and emergency conditions.

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DC Microamperes	0-50 (250 MV Drop)
DC Milliamperes	*0-0.5; 0-5; 0-50;* 0-500
DC Amperes	*0-5* (250 MV Drop)
AC Amperes	6 ranges from 0-5 to 0-250 with optional Model 150 Amp-Clamp adapter
DB Scale (1 MW 600 Ω Reference)	−20 to +10; −9 to +21; *−1 to +29; +11 to +41;* +19 to +49
Resistance (Standard Power)	*Rx1* (6 Ω center scale), *Rx100* (600 Ω center scale), *Rx1K* (6000 Ω center scale), *Rx10K* (60,000 Ω center scale)
Resistance (Low Power)	*Rx1* (20 Ω center scale), *Rx10* (200 Ω center scale). Max. open circuit voltage only 100 mV! Max. measuring power only 0.125 mW!
Size	5¼ x 7 x 3⅛″ (133 x 178 x 79 mm)
Weight	2.5 lbs. (1.14 kg)

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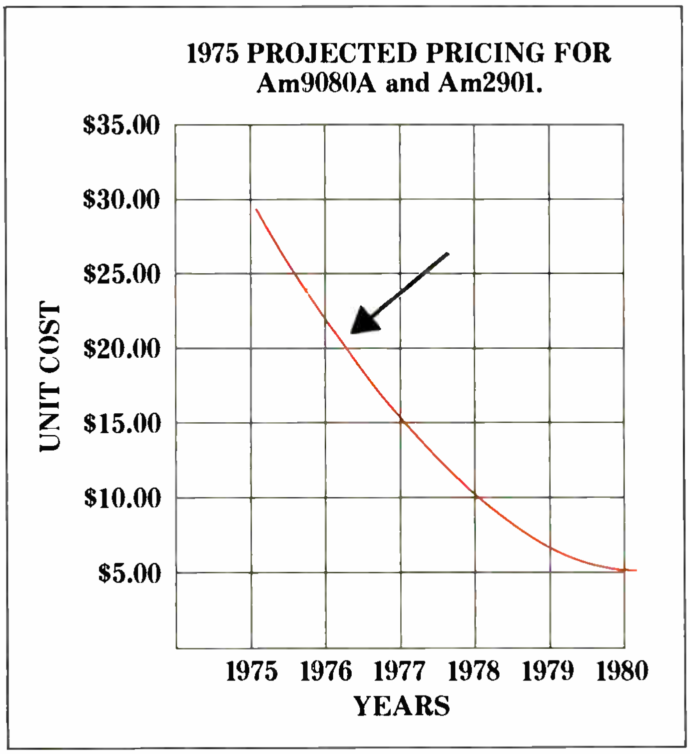
Circle 9 on reader service card

Our curve was straight.

Advanced Micro Devices announces the 100-piece price for the Am9080A and Am2901: $21.00. Just like we said.



Last year, we predicted the price would be just over $20.00. We even drew a curve. Now it's happened. And that's only the beginning. Look:

Am9080A. It's built with an advanced ion-implanted, n-channel, silicon-gate process that permits versions with speeds to 250 nanoseconds cycle time (one microsecond instruction time). Our low power (800mW maximum) gives you cooler running systems, less power drain and better reliability. The superior output drive (3.2mA @ 0.4V) gives increased design flexibility and improved margins.

Am2901. It's bipolar, for systems that rely on high speed. It can do a 16-bit register-to-register add in just 145 nanoseconds. It has 16 working registers in a cycle-saving, two-address architecture, and is controlled by nine instruction lines that permit it to do almost anything you can think of.

Another thing. Advanced Micro Devices offers a full line of support circuits for either unit—support circuits that optimize your system, not compromise it.

Whether you can best use the MOS Am9080A or the bipolar Am2901, you can now do it for less. $21.00 in 100-piece quantities.

Just like the curve said.

Am9080A System Circuits

AMD Part Number	Description	Availability
	CPU	
Am9080A/-2/-1/-4	Speeds to 250 nsec 0 to 70 C	In Dist Stock
Am9080A/-2	Speeds to 380 nsec -55 to +125 C	In Dist Stock
	Static Read/Write Random Access Memories	
Am9101A/B/C/D	256x4 Speeds to 250 nsec	In Dist Stock
Am91L01A/B/C	256x4 Speeds to 300 nsec	In Dist Stock
Am9102A/B/C/D	1Kx1 Speeds to 250 nsec	In Dist Stock
Am91L02A/B/C	1Kx1 Speeds to 300 nsec	In Dist Stock
Am9111A/B/C/D	256x4 Speeds to 250 nsec	In Dist Stock
Am91L11A/B/C	256x4 Speeds to 300 nsec	In Dist Stock
Am9112A/B/C/D	256x4 Speeds to 250 nsec	In Dist Stock
Am91L12A/B/C	256x4 Speeds to 300 nsec	In Dist Stock
Am9130A/B/C/E	1024x4 Speeds to 200 nsec	In Dist Stock
Am9140A/B/C/E	4096x1 Speeds to 200 nsec	In Dist Stock
	Dynamic Read/Write Random Access Memories	
Am9050C/D/E	4Kx1 Speeds to 200 nsec	In Dist Stock
Am9060C/D/E	4Kx1 Speeds to 200 nsec	In Dist Stock
	Mask Programmable Read-Only Memories	
Am9208/B/C/D	1Kx8 Speeds to 250 nsec	Available Now
Am9214	512x8 mask programmed Speeds to 500 nsec	Available Now
Am9216B/C	2Kx8 mask programmed Speeds to 300 nsec	Available Now
	Erasable Read-Only Memories	
Am9702	256x8 Speeds to 1.0 μsec	In Dist Stock
Am1702A	256x8 Speeds to 1.0 μsec	In Dist Stock
Am2708	1024x8 Speeds to 450 μsec	2nd Q 1976

AMD Part Number	Description	Availability
	Processor System Support Circuits	
Am8212	8-Bit I/O Port	In Dist Stock
Am8224	Clock Generator	In Dist Stock
Am8228	System Controller	2nd Q 1976
Am8216/26	Bus Transceiver	2nd Q 1976
Am25LS138	1 of 8 Decoder	In Dist Stock
Am9555	Programmable Peripheral Interface	2nd Q 1976
Am9551	Serial Communications Interface	2nd Q 1976

CPU 9080A = 480 nsec -2 = 380 nsec -1 = 320 nsec -4 = 250 nsec
Mem A = 500 nsec B = 400 nsec C = 300 nsec D = 250 nsec E = 200 nsec

Am2900 System Circuits

AMD Part Number	Description	Availability
Am2901	4 Bit Microprocessor Slice	In Dist Stock
Am2902	Carry Lookahead Chip	In Dist Stock
Am2905	4 Bit Transceiver For Open Collector Bus	In Dist Stock
Am2906	4 Bit Transceiver For Open Collector Bus With Parity Generator/Checker	In Dist Stock
Am2907	4 Bit Transceiver For Open Collector Bus With Single Data Input	In Dist Stock
Am2909	Microprogram Sequencer	In Dist Stock
Am2911	Minimicroprogram Sequencer	2nd Q 1976
Am2914	8 Level Priority Interrupt	3rd Q 1976
Am2915	4 Bit Transceiver For Three State Bus	2nd Q 1976
Am2916	4 Bit Transceiver For Three State Bus With Parity Generator/Checker	2nd Q 1976
Am2917	4 Bit Transceiver For Three State Bus With Single Data Input	2nd Q 1976
Am2918	4 Bit, 2 Port Register	In Dist Stock
Am2919	Priority Interrupt Expander	2nd Q 1976
Am2950/51	256 Bit RAM Open Collector Or Three State	In Dist Stock
Am2952	1024 Bit RAM Open Collector	2nd Q 1976
Am2954/55	16 Word By 4 Bit Two Address Register Stack Open Collector or Three State	2nd Q 1976
Am2970/71	256 By 4 PROM s With Open Collector or Three State Outputs	In Dist Stock

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Circle 256 on reader service card

Editorial

In patents, who is entitled to the rights?

Among the things that most irk engineers in the United States is the requirement in most companies that an employee sign over to the company all rights to inventions made in the line of corporate duty.

Some of the more militant engineers are trying to do something about it, and there's even a bill before the California legislature that would mandate negotiations between an inventor and an employer over patent sharing. What's more, the IEEE's U.S. Activities Board has set action on improvement in the patent rights of employed inventors as one of its 1976 goals.

In the argument over who is entitled to hold the rights to a patent, both the inventor and the employee have some very valid points to make. For example, many companies operate on the premise that they provide the labs, research equipment, personnel support, funding and the like, and that the inventions would not exist had the corporate stage not been set for their pursuit. The salary paid to an engineer covers his work in that environment, the argument goes, and whether the result of that work is patentable or not is really beside the point.

The inventor, on the other hand, can quite validly argue that the return to a company from the patent on his work often is wholly out of proportion to the amount invested in equipment, support, and salary. Therefore, some part of the "windfall profit" should be shared. After all, no amount of investment alone will spawn patentable inventions. Only the creativity the inventor brings to the job can do that.

However, it is the employer who tends to end up with all the rights, because the individual engineer has comparatively little power and, thus, very little say in the matter. To refuse to sign over patent rights as a condition of employment means to refuse the employment. Some companies carry their demands for patent rights to the extreme of including all those gathered during the term of employment, even if the research was completely unrelated to the job. This kind of demand acts more to stifle creativity than to enlarge the corporate patent base.

However, the short-term advantages to a company in preempting patent rights have clouded its perception of the long-range benefits of sharing patent proceeds with the inventors. For example, what kind of motivation does an inventor have if all he gets is a couple of hundred dollars as a bonus, the promise of weighing his achievement when promotion time comes around, or, as is mostly the case, nothing at all? Sure, the gaining of a patent is enough incentive to some inventors, but the reward of sharing in the proceeds is a vastly more potent incentive. Besides, mismanagement of creative people can lead—as it has all too often led—to the loss of key personnel.

What's needed is for more American corporations to recognize the benefits, some albeit quite selfish, of sharing patent income with the inventor. When corporate success is built on advanced technology, as it is in so many areas of electronics, a refusal to use the powerful incentive of patent-income sharing has got to be penny wise and pound foolish.

SERIES OF 76

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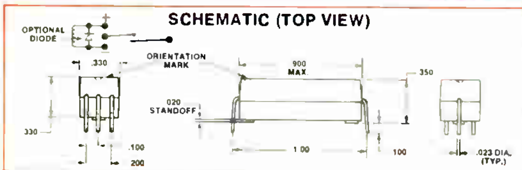
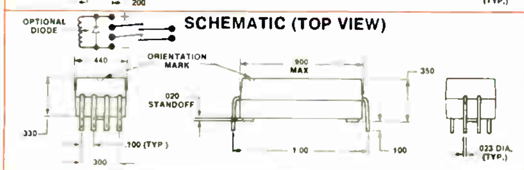
These are transfer-molded epoxy reed relays. Both switches and relays are made in the U.S.A. Popular .1x1" mounting grid—both 1A and 2A—in standard and utility grades.





Form (Std. Contacts)	Model No.	Nom VDC	Must Operate VDC	Must Release VDC	Max VDC	Coil Res. Ohms ± 10% @ 25°C	Max. Switching Watts	Max. Switching Volts	Max. Current Carry	Max. Current Switch	Max. Initial Cont. Res.	Min. Breakdown Voltage
1A	761A-05-1	5	4.0	0.5	7.5	150	10	200 VDC	1.5A	0.5A	200 Ω	300 VDC
	761A-12-1	12	9.6	1.2	15.0	575						
	761A-24-1	24	19.2	2.4	32.0	2150						
1A	761A-05-2	5	4.0	0.5	7.5	150	10	200 VDC	1.5A	0.5A	500 Ω	300 VDC
	761A-12-2	12	9.6	1.2	15.0	575						
	761A-24-2	24	19.2	2.4	32.0	2150						
2A	762A-05-1	5	4.0	0.5	7.5	80	10	200 VDC	1.5A	0.5A	200 Ω	300 VDC
	762A-12-1	12	9.6	1.2	15.0	320						
	762A-24-1	24	19.2	2.4	32.0	1500						
2A	762A-05-2	5	4.0	0.5	7.5	80	10	200 VDC	1.5A	0.5A	500 Ω	300 VDC
	762A-12-2	12	9.6	1.2	15.0	320						
	762A-24-2	24	19.2	2.4	32.0	1500						

TO SPECIFY DIODE AND OR MAGNETIC SHIELDING (INTERNAL) ADD "D" AND OR "M" TO MODEL NUMBER EXAMPLE 761A051DM

OEM REED RELAY LIST PRICES

Series	Model	1-24	25-49	50-99	100-249	250-499	500-999	1000-1999	2000-3999	4000-7999	8000-9999	10K
SERIES 76-1A-1 DRY REED RELAY	761A-05-1	$2.00	$1.90	$1.70	$1.40	$1.30	$1.10	$1.00	$ .96	$ .92	$ .90	$ .84
	761A-05-1D	2.60	2.47	2.21	1.82	1.69	1.43	1.30	1.25	1.20	1.17	1.09
	761A-12-1	2.00	1.90	1.70	1.40	1.30	1.10	1.00	.96	.92	.90	.84
	761A-12-1D	2.60	2.47	2.21	1.82	1.69	1.43	1.30	1.25	1.20	1.17	1.09
	761A-24-1	2.71	2.57	2.30	1.90	1.76	1.49	1.36	1.30	1.25	1.22	1.14
	761A-24-1D	3.31	3.14	2.81	2.32	2.15	1.82	1.66	1.59	1.52	1.49	1.39
SERIES 76-1A-2 DRY REED RELAY	761A-05-2	1.76	1.67	1.50	1.23	1.14	.97	.88	.84	.81	.79	.74
	761A-05-2D	2.36	2.24	2.01	1.65	1.53	1.30	1.18	1.13	1.09	1.06	.99
	761A-12-2	1.76	1.67	1.50	1.23	1.14	.97	.88	.84	.81	.79	.74
	761A-12-2D	2.36	2.24	2.01	1.65	1.53	1.30	1.18	1.13	1.09	1.06	.99
	761A-24-2	2.48	2.36	2.11	1.74	1.61	1.36	1.24	1.19	1.14	1.12	1.04
	761A-24-2D	3.07	2.92	2.61	2.15	2.00	1.69	1.54	1.47	1.41	1.38	1.29
SERIES 76-2A-1 DRY REED RELAY	762A-05-1	2.95	2.80	2.51	2.07	1.92	1.62	1.48	1.42	1.36	1.33	1.24
	762A-05-1D	3.55	3.37	3.02	2.49	2.31	1.95	1.78	1.70	1.63	1.60	1.49
	762A-12-1	2.95	2.80	2.51	2.07	1.92	1.62	1.48	1.42	1.36	1.33	1.24
	762A-12-1D	3.55	3.37	3.02	2.49	2.31	1.95	1.78	1.70	1.63	1.60	1.49
	762A-24-1	3.67	3.49	3.12	2.57	2.39	2.02	1.84	1.76	1.69	1.65	1.54
	762A-24-1D	4.26	4.05	3.62	2.98	2.77	2.34	2.13	2.04	1.96	1.92	1.79
SERIES 76-2A-2 DRY REED RELAY	762A-05-2	2.48	2.36	2.11	1.74	1.61	1.36	1.24	1.19	1.14	1.12	1.04
	762A-05-2D	3.07	2.92	2.61	2.15	2.00	1.69	1.54	1.47	1.41	1.38	1.29
	762A-12-2	2.48	2.36	2.11	1.74	1.61	1.36	1.24	1.19	1.14	1.12	1.04
	762A-12-2D	3.07	2.92	2.61	2.15	2.00	1.69	1.54	1.47	1.41	1.38	1.29
	762A-24-2	3.19	3.03	2.71	2.23	2.07	1.75	1.60	1.53	1.47	1.44	1.34
	762A-24-2D	3.79	3.60	3.22	2.65	2.46	2.08	1.90	1.82	1.74	1.71	1.59

D = Internal Clamp Diode

NOTE: *—1 Series Relays are max. 200 ohms Initial Contact Resistance. —2 Series Relays are max. 500 ohms Initial Contact Resistance. Consult factory for prices on magnetic shielding, non standard coil resistance or other non-standard features.*

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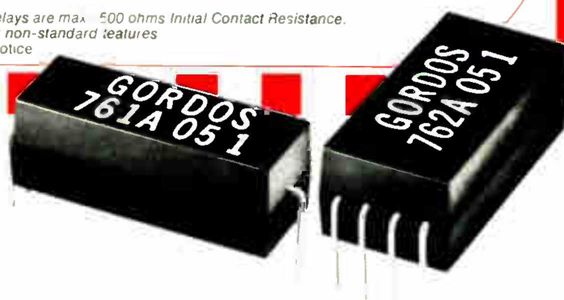

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People

Converters loom large for National's Robert Pease

Observers of the data-converter industry are remarking on the recent shift to National Semiconductor Corp. by Teledyne Philbrick's former chief engineer, 35-year-old Robert A. Pease.

Ostensibly, his month-old position as a staff engineer in the Advanced Linear Integrated Circuit department in Santa Clara, Calif., is a step down from his former one.

Way to go. Pease wants low-cost converters with high performance and few chips.

But at the loosely structured National, it's not so much a title as a person's charter that counts. And the bearded 1961 engineering graduate of the Massachusetts Institute of Technology has the charter for moving the company as quickly as possibly into its next generation of largely monolithic data converters: analog-to-digital, digital-to-analog, and voltage-to-frequency.

Serious contender. Pease's appointment is a sign that National Semiconductor is serious about expanding into the data-converter marketplace and that its initial rush to market [*Electronics*, Sept. 4, 1975, p. 136] with a family of hybrid devices was not just a flash in the pan. It was Pease, many point out, who was responsible for the design, engineering, and production of many of Teledyne Philbrick's linear and converter products using monolithic, hybrid, and discrete technology. These include the industry's first FET-input operational amplifier and the first balanced-bridge temperature-compensated transconductance multiplier.

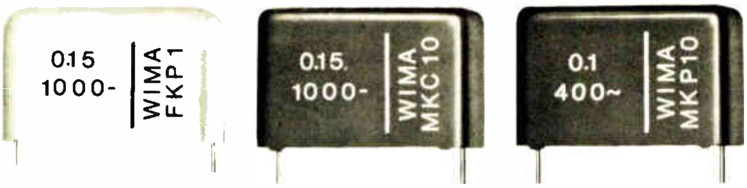
"The future, as far as data converters is concerned, lies with monolithic technology—both bipolar and MOS," says Pease. "This is a fact of life that some of the old-line converter companies accept with some reluctance, preferring to believe there will always be a place for high-performance hybrids and modules." Indeed, there will be a place, he concedes, "but that place will become smaller and smaller as monolithic devices improve."

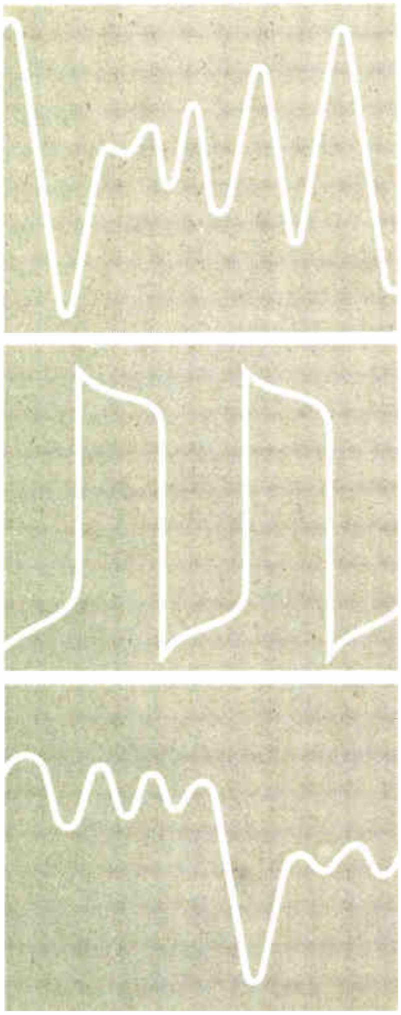
As for his design work at National, Pease says he will use "whatever does the job best at a particular moment." But more and more, he says, he will move to monolithic.

Knox, Pinto aim at n-channel products from Rockwell

For the first time, high-level officials at Rockwell International's Microelectronic Device division are admitting what others in the semiconductor industry have long known: to stay competitive, Rockwell must have a microprocessor line based on n-channel technology.

"We're late on the scene because we were busy with other products," admits Robert V. Knox, a 26-year Rockwell veteran who moved over to join the division in January as vice president, engineering, a new title. He's working in tandem with Richard C. Pinto, a veteran semiconductor-industry executive with years of experience in both bipolar and metal-oxide-semiconductor device manufacturing. Pinto, most recently vice president and general manager of the ITT Semiconductor division, became vice president for production operations at Rockwell's





microelectronic division last July.

Declares Knox: "We want to expand out to the rest of the market we haven't addressed before." He won't comment further, but an n-channel capability would make possible devices such as high-performing dynamic 16,384-bit memories and enhanced-performance 8- and 16-bit microprocessor families.

It's n-channel's speed advantage over p-channel that makes it so indispensible. "As semiconductor products belly up machine to machine, p-channel just doesn't do it," Knox says, although "p-channel is adequate for people-oriented calculator functions."

Fighting chance. Despite the tardiness, Knox believes "we have a fighting chance because of our big base." Rockwell, he points out, has delivered more than 1 million of its PPS line of microprocessors since 1972, far more than anyone else in the industry. "It's not as if Rockwell were jumping into n-channel without any background," Knox observes. "Rockwell has never been in anything but LSI."

"From a production viewpoint," Pinto points out, "n-channel is not greatly different from p-channel. We have the equipment, which is identical, and the technology, which is also similar, except for the silicon-gate process," which apparently is what Pinto is developing.

Rockwell, moreover, is relying on its own resources. A well-publicized technology-exchange agreement, made last summer with National Semiconductor Corp., has resulted in little help for Rockwell's n-channel work, according to Knox.

Tuning up. He describes his program as presently in the "engineering prototype phase where we're working on architecture and circuit design and generally tuning up the process." A pilot production operation is now "in the idle mode," and when the decision to move comes, "Dick Pinto has to expand this beachhead." The most either will say about specific products or scheduling is rather bland: "Rockwell will be increasingly active in the marketplace in 1977."

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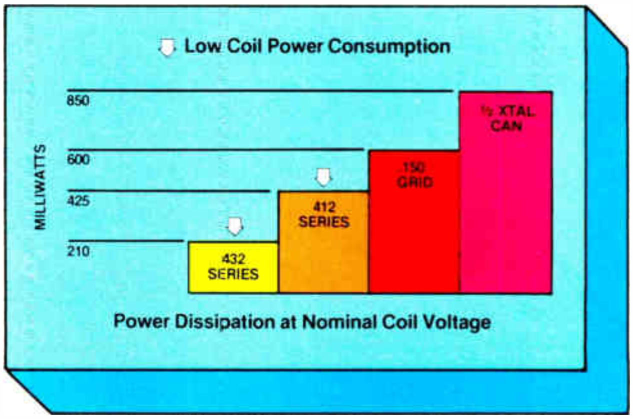
Solve your energy crisis with TO-5 relays



Subminiaturization and pc board compatibility — two obvious advantages of Teledyne TO-5 relays. But there's another outstanding advantage: low coil power consumption. This feature is best illustrated in the above graph which shows our TO-5 relay power savings compared to other miniature relays. The Teledyne 412 Series dissipates about 30% less power than the .150″ grid relay, and 50% less than the ½ crystal can. Our sensitive 432 Series is 65% less than the .150″ grid. And 75% less than the ½ crystal can.

This means you can save over 6 watts in a typical system using, let's say, ten TO-5 relays. In the end, you gain significant advantages in terms of thermal and power supply considerations that can help prevent an "energy crisis" in your system.

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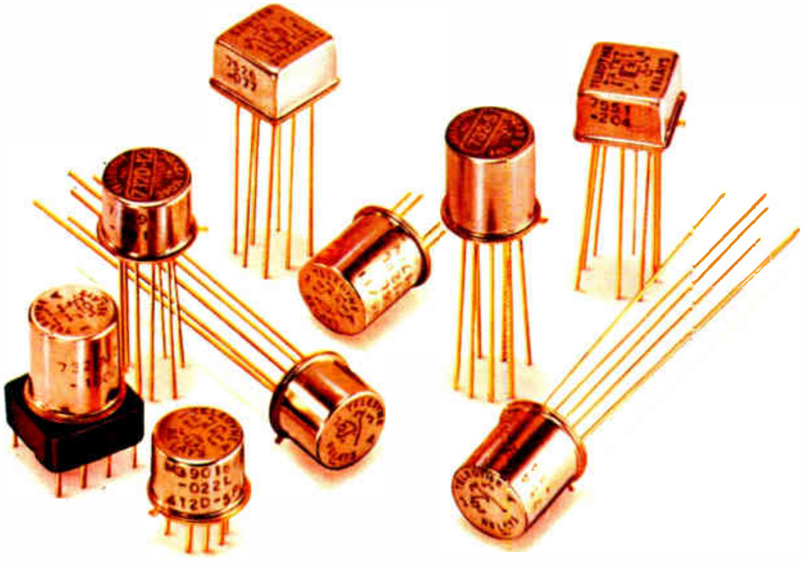

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International Symposium on Multi-valued Logic, IEEE, Utah State University, Logan, Utah, May 25–28.

Trends and Applications in Micro and Mini Systems, IEEE, National Bureau of Standards, Gaithersburg, Md., May 27.

Chicago Spring Conference on Consumer Electronics, IEEE, Marriott Motor Hotel, Chicago, June 7–8.

National Computer Conference, IEEE et al., New York Hilton, Americana Hotel, and New York Coliseum, June 7–10.

Hybrid Microcircuits Symposium, U.S. Army Electronics Command, Fort Monmouth, N.J., June 8–9.

Power Electronics Specialists Conference, IEEE, NASA Lewis Research Center, Cleveland, Ohio, June 8–10.

Electrical Insulation International Symposium, IEEE, Queen Elizabeth Hotel, Montreal, Que., June 14–16.

ICC '76 International Conference on Communications, IEEE, Marriott Motor Hotel, Philadelphia, June 14–16.

Joint MMM-Intermag Conference, IEEE and AIP, Hilton Hotel, Pittsburgh, June 15–18.

Device Research Conference, IEEE, University of Utah, Salt Lake City, June 21–23.

13th Design Automation Conference, ACM and IEEE, Rickey's Hyatt House, Palo Alto, Calif., June 27–29.

Conference on Precision Electromagnetic Measurements, IEEE, NBS, and URSI, NBS Laboratories, Boulder, Colo., June 28–July 1.

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2502	±30V/μS	HA9-2502-2	8.00	HA2-2502-2	6.75
2505	±30V/μS	HA9-2505-5	7.00	HA2-2505-5	1.85
2520	±120V/μS	HA9-2520-2	24.00	HA2-2520-2	16.50
2522	±120V/μS	HA9-2522-2	18.50	HA2-2522-2	11.60
2525	±120V/μS	HA9-2525-5	14.00	HA2-2525-5	6.75

*Suffix -2 designates −55° to +125°C temperature range.
Suffix -5 designates 0° to 75°C temperature range.

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Circle 21 on reader service card

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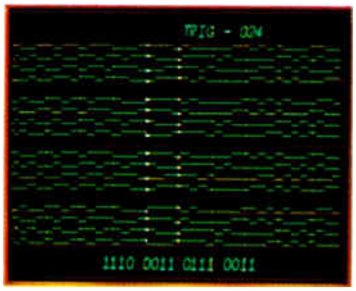


Timing and binary information together with intensified trigger marker and cursor displayed by the 7D01 Logic Analyzer. The number of sample intervals from the trigger point to the cursor appears at the top of the display; data stored at the cursor position is displayed in binary across the bottom of the crt.

New Plug-ins with Expanded Capabilities

For digital design and testing applications, you'll find that Tektronix Logic Analyzers and Oscilloscopes are literally made for each other. To expand your digital analysis capabilities, choose either the 7D01 Logic Analyzer (a new plug-in for our 7000-Series laboratory oscilloscope family) or the LA 501 Logic Analyzer and its new companion plug-in, the WR501 Word Recognizer (these two are packaged as modular TM 500-Series instruments to work with almost any oscilloscope).

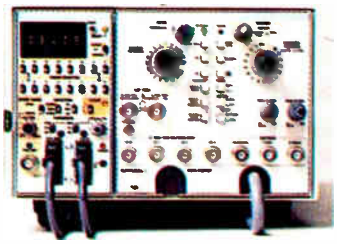
Features these analyzers have in common include:

- **16 Channel Operation**
- **15-ns Asynchronous Timing Resolution**
- **4k Memory to Store Pretrigger Data**
- **Word Recognition**
- **High Z Probes**

For versatile data acquisition, these logic analyzers let you select the number of channels and the resolution best suited to specific applications:

16 Channels, 20 MHz, 256 Memory Bits
8 Channels, 50 MHz, 512 Memory Bits
4 Channels, 100 MHz, 1024 Memory Bits

You'll like what we've done to **reduce circuit loading problems** associated with testing high-speed and high-impedance logic families. With our new P6451 active probes, which have an input impedance of **1 MΩ paralleled by 5 pF at the probe head,** you'll be able to test virtually any logic family.



LA501/WR501, Members of the TM 500 Series

Take your logic analyzer right to the problem with the LA 501 Logic Analyzer and its new companion word recognizer, the WR 501. Packaged as modular TM 500 test instruments, this pair works with any oscilloscope or X-Y monitor. Now you've got versatile logic analysis capabilities to complement the oscilloscope you probably already own.

Word recognition with digital delay gives you fast access to almost any location in the data stream.

For **channel-to-channel timing comparisons,** you can select any trace and position it next to any other. And **timing tic marks** on each channel enhance visual analysis.

No matter what your application—design, production testing, or service we've got a TM 500 logic analysis configuration for you.

On the bench, power the LA 501 and WR 501 with the TM 503 mainframe or the TM 504 mainframe (now you've got room for another TM 500 module like the DMM 502 Digital Multimeter).

In a rack, use the RTM 506—there's room enough for the LA 501, the WR 501, the SC 502 Oscilloscope, and one more module. Or you can mount the LA 501 and WR 501 in a TM 503 side by side with a 604 Monitor. The 6½-in. display is easy to read.

For **field portability,** try the TM 515 Traveler Mainframe. It's rugged and durable, yet as attractive as carry-on luggage. You can pack the LA 501, the WR 501, and the SC 502 and have a complete logic analysis system in a suitcase.

New at ELECTRO76

7D01, A Member of the 7000 Series

Turn any 7000-Series laboratory oscilloscope into a versatile 16-channel logic analyzer with the new 7D01 dual-wide plug-in. Now, gaining logic analysis capability is as simple as adding a plug-in.

With a four-compartment 7000-Series mainframe and plug-ins, you get a truly powerful logic design tool: **a logic analyzer and a real-time oscilloscope in one unit.** Use the 7D01 Logic Analyzer to locate a digital domain problem, then zero in for detailed analysis by using the 7D01's word recognizer to trigger the analog portion of your oscilloscope. Now you can do it with one instrument and display your digital and analog information on the same crt.

With the 7D01 you also get **timing and binary information displayed simultaneously** on the crt. You do it with a cursor. And because the cursor can be moved in single clock intervals, **timing comparisons are faster, easier and more error-free than visual estimates.** When the cursor is moved to a given clock position, the binary word at that point is read out across the bottom of the display.

The LA 501/WR 501 and the 7D01 Logic Analyzers will be on display at ELECTRO76. Stop by our booth for all the details and a hands-on demonstration. If you can't make it to the show, call your nearby Tektronix Field Engineer or write Tektronix, Inc., P.O. Box 500, Beaverton OR 97077.

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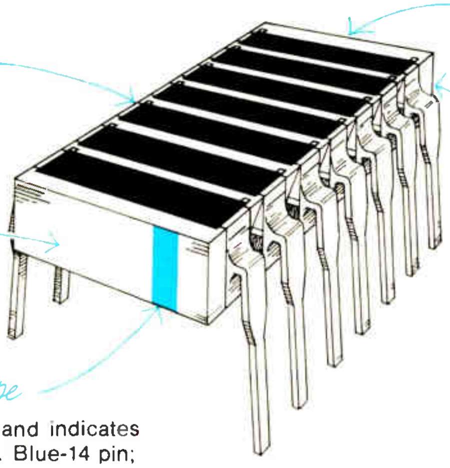

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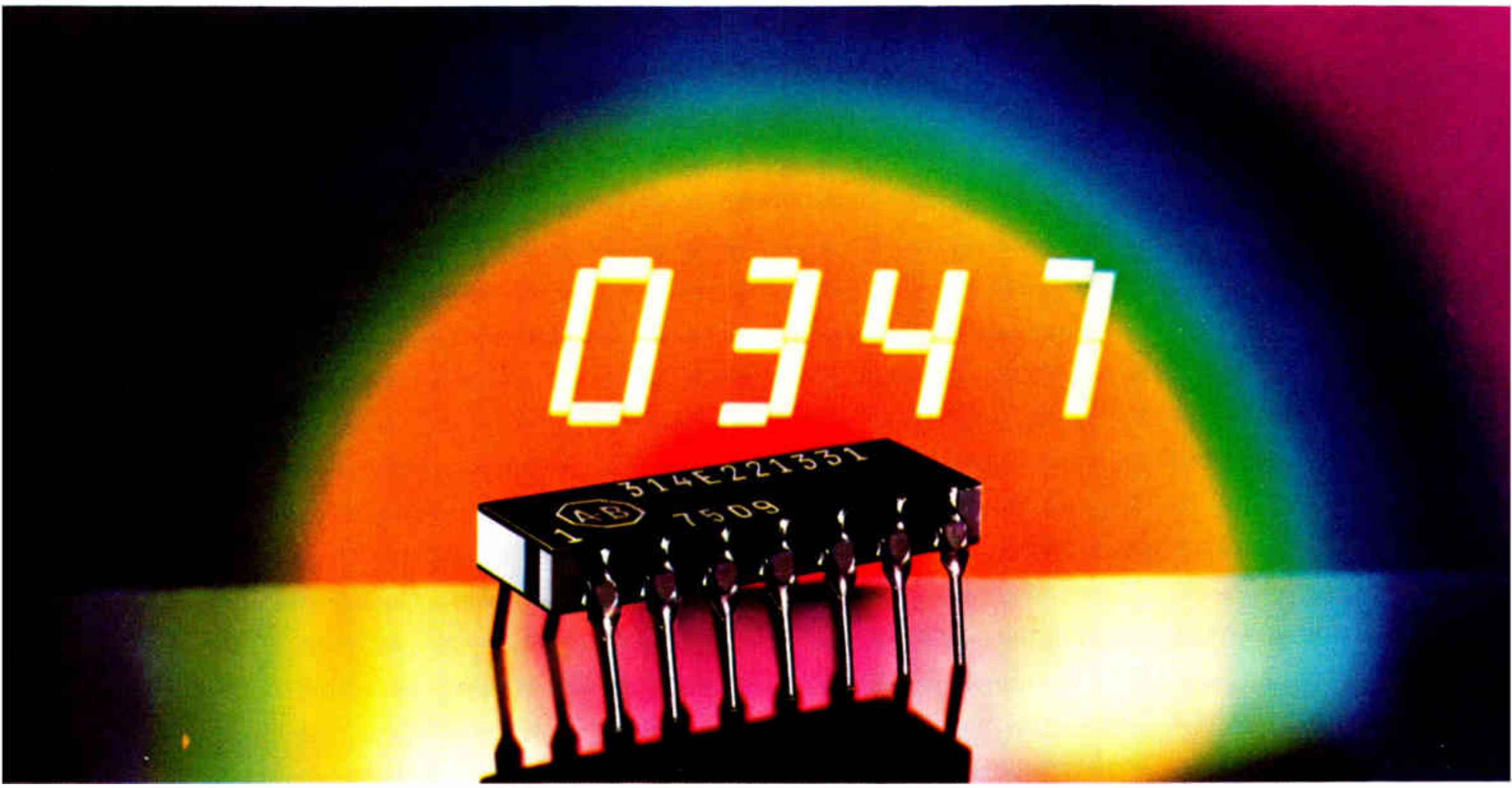

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EC111

TI lists first 4-k static RAM made with I²L

Texas Instruments will blast into the new 4,096-bit static random-access-memory market with a bombshell. Reaping the benefits of its investment in integrated injection logic, TI will begin fourth-quarter production of an I^2L 4-k static RAM **that has a maximum access time of 75 nanoseconds**—two to three times faster than all other proposed n-channel 4-k statics—and typical active power dissipation of 500 milliwatts. Moreover, the single five-volt part, the S400, is fully static and will come in the 18-pin package that houses the widely-used 2102 1-k static RAMs.

As for price, TI promises to be "extremely aggressive" in taking on the n-MOS parts. (AMD, Intel, National, SEMI, Mostek, and Motorola all have announced plans for n-MOS versions.) If chip size is any gauge of production costs, TI's use of the extremely compact I^2L process for its 4-k chip array (peripheral circuitry is Schottky TTL) results in a high density that cuts the size to about half that of n-channel 4-k static chips—well below 20,000 mil^2. TI will follow the S400 with a low-power version, the LS400, which dissipates 165 mW and has access time of 150 ns.

Meanwhile, Fairchild is developing three I^2L RAMs, a 100-nanosecond 4-k dynamic part and two static devices: a 1-k and a 4-k, both under 100 nanoseconds. Samples are to be ready by year end.

Mostek to make Zilog's Z-80

The newly introduced Z-80 enhanced 8-bit microprocessor from Zilog Corp. of Los Altos, Calif., has won new credibility **by landing Mostek Corp. of Carrollton, Texas, as a second source.** And Mostek, the firm that pioneered the use of depletion-mode load techniques in calculators and memories (see p. 65), is getting into the mainstream of the high-end microprocessor market.

One-chip C-MOS, a-d converter due from Motorola . . .

Motorola's Semiconductor Products division has developed a one-chip C-MOS analog-to-digital converter; samples are to be ready this summer. But instead of combining two technologies on the same chip, the Austin, Texas, team **is taking advantage of available n and p channels on the chip to build the linear functions.** Wafers are processed exactly like conventional digital C-MOS. The firm will follow the converter later this year with a similar dual-precision, one-shot multivibrator.

Aimed at the digital voltmeter market, the MC14433 converter delivers a 3½-digit BCD output and will do up to 24 conversions per second with an accuracy within 0.2%. A 2-volt or 200-millivolt reference is required, and no full-scale or zero adjustments are needed. The only other external components required to use the chip as a digital voltmeter are two capacitors and two resistors—which needn't be precision components—and display interfacing.

. . . along with phone-pulse converter

Motorola's Austin group also has samples available of a binary-to-phone pulse converter, the MC24408, for the telephone interconnect market. **It's designed for telephone pulse dialing where Bell's Touch-Tone is not available.** It provides an equivalent system when used with the MC14419, a keypad-to-binary-code converter.

Also on the single C-MOS chip is a re-dial function. With an extra switch, the system will re-dial the last phone number called, up to 16 digits. External logic can be added to program an on-chip hold/interrupt control, so the system—not the user—has to wait for dial tones.

Electronics newsletter

Spectra-Physics plans multichannel gas chromatograph

Spectra-Physics Inc. of Mountain View, Calif., whose Auto-Lab division dominates the single-channel gas chromatograph business, is looking to give its competitors in the multichannel market—Hewlett-Packard, Varian, Columbia Scientific, and others—a run for their money. Soon it will introduce the SP4000, a data system for gas chromatography **that uses a hierarchical, or distributed, network of Intel 8080 microprocessors** to control up to 16 channels. Price: $3,600 to $6,000 per channel.

Bally to sell electronic pinball game for home

Bally Manufacturing Corp., Chicago, a major producer of arcade games and pinball machines, has announced that it will market an electronically controlled pinball machine for the consumer market. Neither the exact date of availability nor prices was revealed, but it's understood that **the product will use an 8-bit microprocessor.** The product will look and sound very much like the commercial flipper pinball machines.

National IC for video playback replaces 4 devices

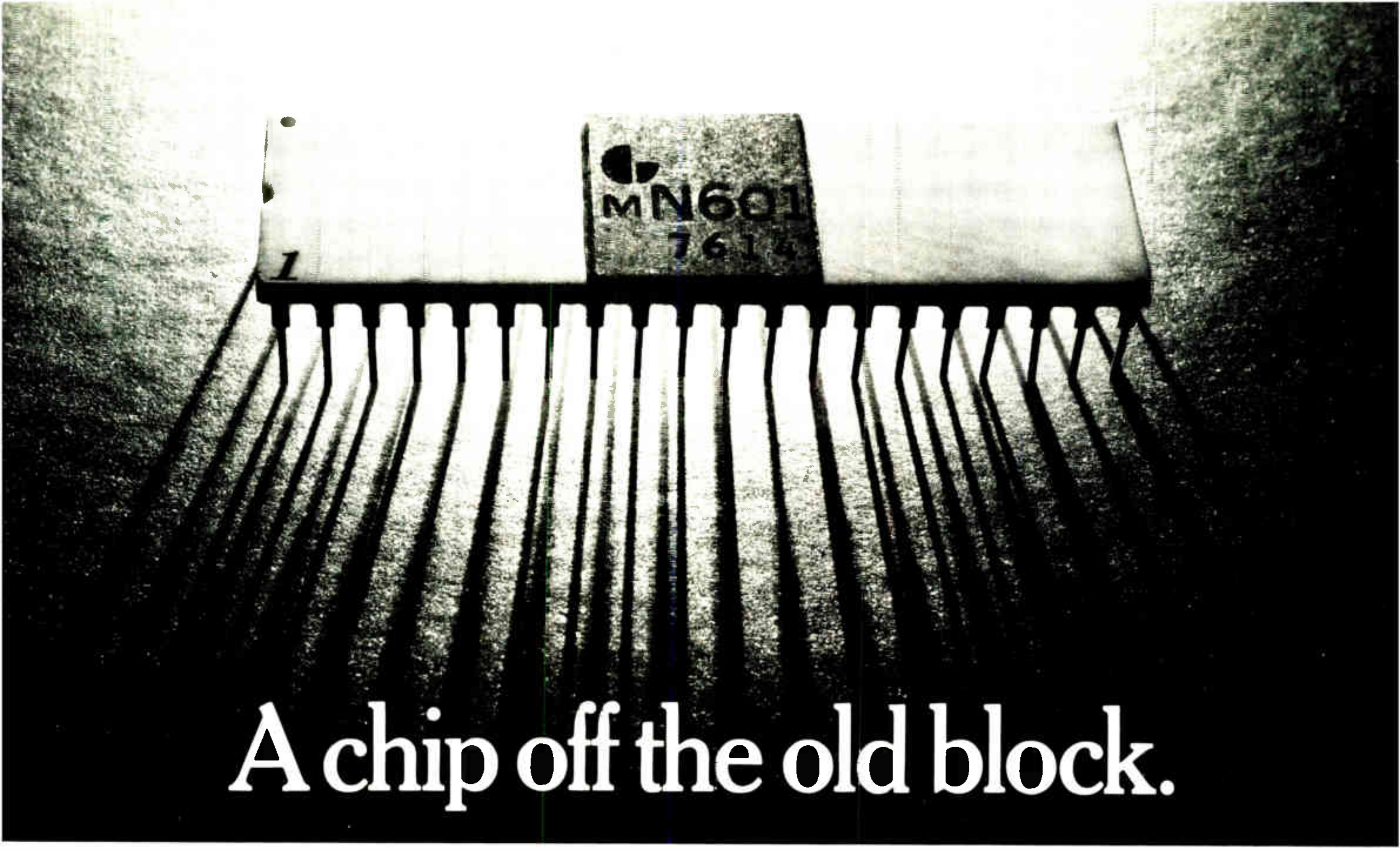
A linear IC that allows display of information from video-tape and disk recorders, games, and test equipment to be displayed on black-and-white or color-TV receivers is being offered by National Semiconductor Corp. Designated the LM-1889, the device will accept audio, color-difference, and luminance signals, and put out an rf signal to display the data on any tube of the low vhf channels. **These functions formerly required three other ICs and a transistor.** Housed in an 18-pin dual in-line package, the circuit will sell for less than $1.50 in 100,000 quantities, or about $4.50 in hundreds.

CoCom list features changes in instruments

An advance examination of the new Free World Coordinating Committee (CoCom) commodity control list reveals modifications in a number of instrumentation categories. **One of the biggest changes is in spectrum analyzers.** Where the upper limit was 1 gigahertz for nonprogramed units, it will be 12.5 GHz, with the display bandwidth upped from 12 megahertz to 125 MHz. Digital-voltmeter sampling rates also have been expanded from 10 accesses per second to 25. For nonparametric tuned amplifiers below 1 GHz, the new list shows a boost of bandwidth from 10 MHz to 50 MHz and increases the upper limit on untuned nonparametric amplifiers from 50 to 100 MHz.

Addenda

Hewlett-Packard's Data Systems division **has received a $3 million order** from Iraq for 21 HP3000 minicomputer systems plus other peripheral equipment. To be used in accounting, payroll, and production control, the first system will be installed in the ministry's headquarters in Baghdad in late summer. . . . The first hardware and software package **to permit use of the IEEE's standard interface bus with minicomputers** has been developed by Hewlett-Packard's Data Systems division. It interfaces instruments and HP's 21MX and 2100 series minis. . . . A new trade group has been formed for makers of consumer electronics products. **Its name: Association for Contemporary Electronics.** The president is Don C. Hoefler, publisher of Microelectronics News, a Silicon Valley newsletter. Among the directors are AMI chairman Howard Bobb, Atari chairman Nolan Bushnell, and Intersil chairman and venture capitalist Fred Adler. The group has scheduled a show next March in Long Beach, Calif.



As you can see, this chip is housed in ceramic and mounted in a forty pin, dual in-line package.

As you can't see, it's a NOVA® computer.

Inside that packaging sits a full 16-bit, silicon gate, NMOS microNOVA CPU. The mN601.

The mN601 is the first microprocessor designed and manufactured by a minicomputer company. And it's the highest performance NMOS microprocessor on the market. With our 160 nanosecond RAM, it has a memory cycle time of 960 nanoseconds and the fastest instruction times going. Like an Add of 2.4 microseconds. And a Load of 2.9 microseconds.

The mN601 has the 16-bit NOVA instruction set including hardware stack for easy programming. And 16-bit data for efficient memory use.

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And because the mN601 is a NOVA, it uses the most mature, field-proven software you can get with any micro. So you can cut back on development time and cost by using compatible software like our diskette-based Disc Operating System and our Real-Time Operating System.

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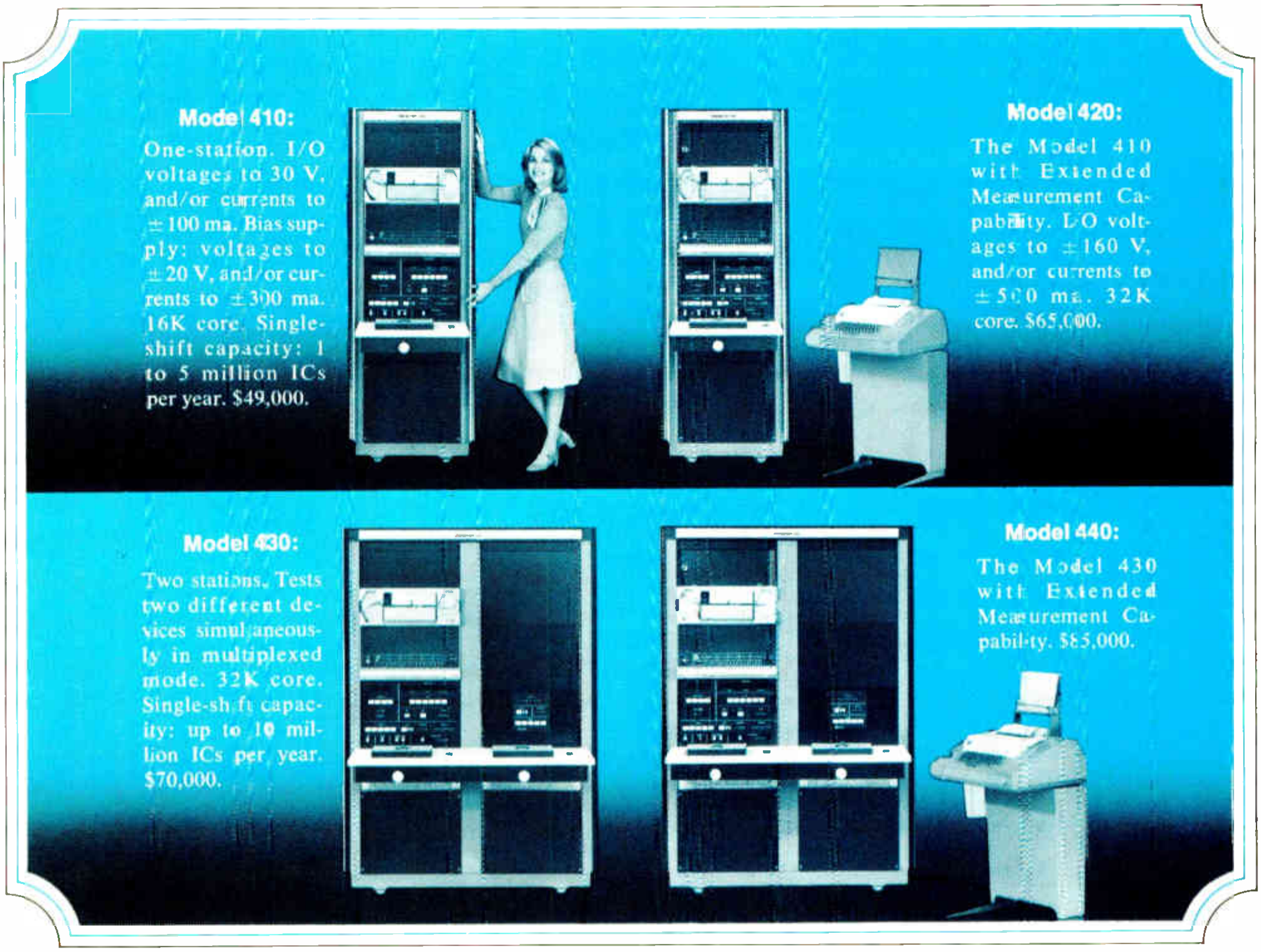

4 New Computer-Controlled IC Testers Give You Instant Access by Telephone to More Than 1000 Device Programs

Need to develop your own programs eliminated

Install a Series 400 IC tester, and we give you 50 FREE device programs. We also give you Instant Program Access (IPA). That means 1000 additional device programs are at your fingertips — instantly accessible from our Central Program Library (CPL) via a national time-sharing network.

Here's how it works

You select the device programs required to test your mix of 24-pin SSI and MSI devices. With a Teletype terminal, you then access and retrieve those programs from our CPL, over regular telephone lines. Your cost: $50 for each program and then the program is yours.

Programming expense avoided

IPA wipes out the programming expense that usually burdens computer-controlled IC tester users. There's no need for experienced programmers; no lost time developing and debugging your own device programs. But, just in case, Datatron's conversational (English language) software makes it easy for nonprogrammers to modify our programs or create new ones. It's all done via the Teletype terminal communicating with the system computer — without interrupting production testing.


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Magnetic bubbles shine brightly in flat display

Small alphanumeric units, built by Mullard Research in Britain, are yellow on a red or green background

Although many manufacturers are considering magnetic bubbles for memories, Mullard Research Laboratories is eyeing magnetic bubbles for displays. These would be better than other flat electronic displays for serial access, nonvolatility, good color contrast, small size, low drive voltage, and a need for fewer connections, the laboratories' director Kurt Hoselitz points out.

These advantages would make the displays ideal for transmitting picture information over narrow bandwidths, say the Redhill, Surrey, researchers. And a bubble display could be useful in military field and cockpit communications, as well as for police receivers.

For example, a message of 100 alphanumeric characters or a simple picture could be sent and held for later viewing. But, like bubble memories, the displays are limited by chip size to a maximum of 5 millimeters square, although magnification helps get around this problem somewhat. And making the special magnetic film for displays is easier than making it for bubble memories, Hoselitz says.

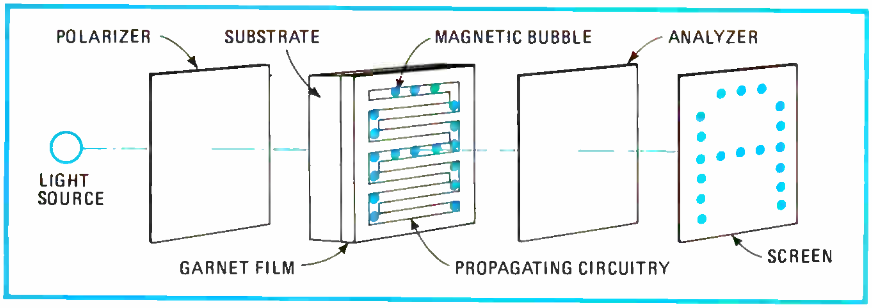
Faraday rotations. In addition to the properties of magnetic bubbles, the display is based on a special Mullard-developed magnetic material and the Faraday-rotation effect. That effect, in essence, makes the bubbles, like a series of mobile light dots, visible by sharply contrasting them against their background. This contrast is achieved by shining a linearly polarized light beam through a magnetic material. The beam's plane of polarization rotates with the direction of magnetization.

Magnetic bubbles are cylindrical magnetic domains that have their magnetization reversed with respect to an external bias field. They occur in thin films of uniaxial magnetic materials in which the balance of magnetization is parallel to the bias field. They can be easily propagated by using an in-plane rotating field and a structured permalloy film deposited onto the bubble film.

Mullard's prototype display consists of a light-bulb source, a polarizing plate of polaroid plastic, the magnetic-bubble chip surrounded by a bias magnet and drive coils, an analyzer also made from polarizing plastic, and the screen or eyepiece. The bubble chip consists of an epitaxial layer of single-crystal magnetic bismuth thulium gallium, deposited on a substrate of single-crystal nonmagnetic-gadolinium gallium garnet 500 μm thick.

Onto this epitaxial layer is deposited a nickel alloy film 3 angstroms thick in a folding-shift-register structure to form the bubble-propagation track. These permalloy elements also generate and destroy bubbles and provide stable positions for the bubbles in the display. A current conductor near the bubble generator controls the bubbles.

Color contrast. So far, Mullard has made chips with only 10 by 10 bubble positions. The bubbles appear yellow on a green or red background that varies in hue and intensity controlled by the setting of the analyzer. They form alphanumeric characters of 0.3 by 0.4 millimeter, which are easily viewed with a 10× magnifier. However, Mullard foresees a 100-character display made from 5-by-7-bubble matrixes. Driven by 200 milliwatts and operated at 10 kilohertz, it could form a picture in 1 second or less. □



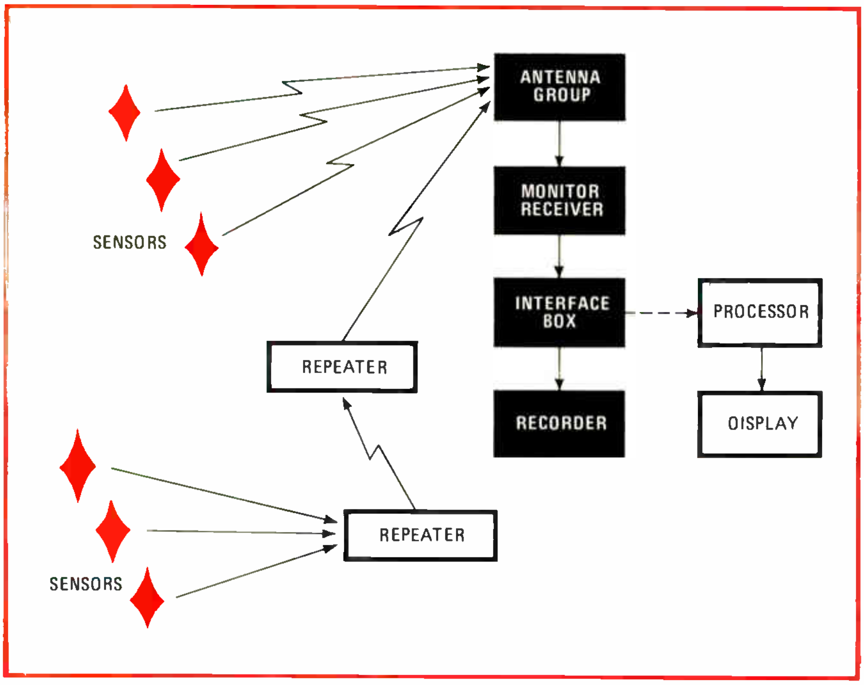
On track. Alphanumerics are formed by bubbles held in place in epitaxial garnet.

Military

Army wants more battlefield sensors

Unattended battlefield sensors proved their worth in Vietnam, particularly during the siege of Khe Sanh in early 1968, when they pinpointed where the enemy was attempting to mass and attack. And now they're being used in the Sinai to monitor the ceasefire between Egypt and Israel.

But these sensors are limited in



Battlefield ears. The Army's program for a new family of unattended battlefield sensors also calls for the development of repeaters and associated data communications equipment.

their ability to distinguish between people and vehicles, and they only operate well in warm weather. So to broaden its tactical sensor capabilities, the Army is developing three advanced sensor systems.

Rembass. The first, and most ambitious of the three, is a remotely monitored battlefield sensor system. It's intended to replace what was known in Vietnam as the "McNamara Wall," named after then Defense Secretary Robert S. McNamara, who promoted the use of ground sensors to help impede the flow of North Vietnamese military traffic across the Demilitarized Zone.

Project manager Col. Louis C. Friedersdorf at the Army Electronics Command, Fort Monmouth, N. J., says four industry contractors—Honeywell Inc., GTE Sylvania, American Electronic Laboratories, and RCA Corp.—are bidding for the Rembass program [*Electronics*, April 29, p. 25]. Two of these companies will be awarded first-phase design contracts as early as next month, but only one of the two may pick up the production contract for the program, expected to be awarded in June 1977, Friedersdorf says.

The temperature range over which the remote sensors must be able to operate has to be extremely wide. Existing sensors, for instance, use mercury batteries, which in cold weather operate poorly, if at all.

According to Maj. John P. Bulger, project officer at Fort Monmouth, the Army hopes to use long-shelf-life batteries of lithium in an organic electrolyte. "But that's another development program," he says. The sensors also must be able to distinguish between personnel, tracked and wheeled vehicles, and be deliverable by air, artillery or be emplaced by hand.

Choice of sensors. Each contractor is expected to develop or acquire the hardware for a system that may include a mix of magnetic, seismic/acoustic and infrared detectors, associated data-communications equipment, receivers, antennas, printers, displays and repeaters. The sensor technologies to be used in the program have not been chosen. This is the area, essentially, in which the four companies are competing.

"We've given them the tradeoffs," Friedersdorf says. "We're in the white-lace-and-promises stage, but it looks very good at this point." Emphasizes Bulger, "We're not trying to make any stupendous breakthroughs with the remote sensing program, but we want to meet the needs in the field and have an expandable evolutionary capability for the future."

Smaller system too. Bulger is also involved with a platoon early-warning system for limited field operations that's been developed by Delco Electronics. The company is scheduled to complete testing this summer and may go into production early next year, he says.

A third program, a field-artillery acoustic locating system, will use sound-ranging techniques to locate enemy artillery. A distributed array of acoustic sensors—sensitive to muzzle blast and shell burst, would be positioned by hand or delivered by high-speed aircraft or artillery at the forward edge of a battle area. "Enemy fire will activate the sensors, which will then transmit digital messages, through a relay if necessary" to a target processing center, says Bulger. "The received messages are time-tagged, sorted and processed, and displayed as output data that identifies the weapon position." Bulger says a request for proposals for this program may be issued within the next few days.

Friedersdorf says the Marine Corps and Navy, which continue to use the Vietnam-type sensors, are looking to the remote battlefield sensor program as its future system. The Air Force is developing its own security sensor systems for its bases, one of which is expected to take advantage of some of the Army's remote battlefield sensor effort. □

Military

Army, Navy begin tests on Boram

Developmental models of what the military hopes will become its first nonvolatile, semiconductor memory have begun operational test and evaluation. Known as Boram, for block-oriented random-access memory, three test systems from two firms use 2,048-bit metal nitride-oxide semiconductor (MNOS) memory arrays that are radiation resistant and can perform in severe military environments.

The Univac Defense Systems division, St. Paul, Minn., has delivered two Boram systems, one with 590,000 bits and one with 295,000, to the Naval Air Development Center, Warminster, Pa. A single memory board with 152 MNOS chips developed by Westinghouse Defense and Electronics System Center, Baltimore, Md., is at the Naval Air Test Center, Patuxent River, Md.

Two programs. While Univac's systems were developed under contract to NADC, Westinghouse received joint Army-Navy funding from the Army Electronics Command, Fort Monmouth, N.J. There are two development programs being funded at the same time because "we are getting refinements in the technology," says one Pentagon R&D official. The two approaches are "somewhat different in terms of system organization and packaging. We need to examine them both." Contract outlays have been low—less than $1 million for each of the two companies.

In addition to radiation resistance in a weapons system, nonvolatility, and long data retention during power interruptions and shutdowns, Boram promises cheap bulk data storage and high bit densities. Light weight and small size make it feasible for airborne and tactical field use as well. With hybrid packaging, a memory of 65,536 words plus input/output and control logic could fit into a standard air-transport rack of 10 by 7.5 by 19.5 inches.

Univac officials say the smaller of their units will undergo operational tests after integration into a flying antisubmarine warfare laboratory being developed by Boeing Co. Navy sources report that the larger Univac system is a candidate for the memory of the All-Applications Digital Computer [*Electronics*, Dec. 25, 1975, p. 52]. The Westinghouse board, which could be the basis for a module storing up to 16.8 million bits, will be tested later at Fort Monmouth for the Army's AN/GYK-12 Tacfire tactical fire control system.

Univac's Charles A. Beltz will discuss the company's Boram effort next week at the National Aerospace and Electronics Conference in Dayton, Ohio. He says Univac's production of the MNOS chips, albeit limited, has demonstrated the producibility of the devices and the viability of the MNOS technology.

Read-write on chip. The Westinghouse module—which puts 2,048 bits plus read-write circuitry on a chip measuring 154 by 170 mils—has an access time of under 30 microseconds, about 100 times faster than fixed-head drum or disk storage, according to its developers. Storage densities of 476 bits per cubic centimeter and 366 bits per gram are about one-fourth the volume and two-thirds the weight of moving-head disk systems now in military use. The firm believes costs of the MNOS memory can be made competitive.

Westinghouse says data retention times in excess of 4,000 hours are possible, while Univac says its device can retain data up to 8,700 hours but has a relatively long write cycle of 2,000 μs. But Univac's Beltz says development of a new RAM with a write cycle time of 4 μs and 5,000 hours retention is now under way at the company. The effort, he says, "represents the highest performance levels believed to be achievable in the near future." □

Displays

Bar graph uses liquid crystals

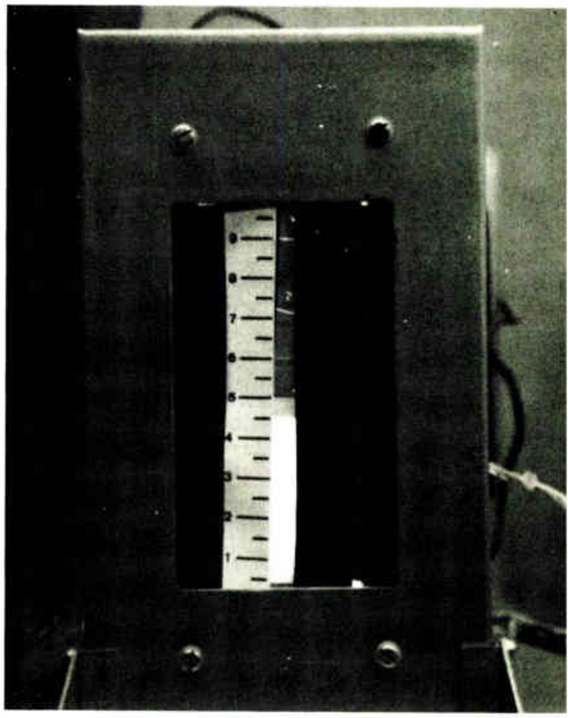
Bar-graph displays are attracting rather more attention lately from manufacturers of measurement instruments. And using liquid crystals would, at first sight, seem like an ideal way to build them (see "Bar-graph displays are easier reading"). However, in the usual scanned or multiplexed operation, voltages often fall somewhere between full-on and full-off levels, so readings may be faulty; the display may be either on or off, depending on such factors as ambient temperature and the composition of the liquid-crystal material.

To get around the instabilities of liquid-crystal bar graphs, engineers at North Hills Electronics Inc., Glen Cove, N.Y., are using two liquid-crystal layers (see figure on p. 32). These work together to transmit or block light and form the bar graph.

With the combination, matrix addressing of individual bar segments is possible, yet the voltage applied to the liquid-crystal material is either full on or full off; there is none of the "half-voltage" operation that could lead to unstable operation. Sol Sherr, vice president of research and development, described the techniques in a paper prepared for last week's Society for Information Display symposium and exhibition in Beverly Hills, Calif.

Light block. In operation, the back layer passes all light except at

Easy view. Liquid-crystal bar graph shows up brightly in model at North Hills.



the electrode that is to form the units bars—the "least significant elements" of the display. For example, to display the number 32, the bottom three tens electrodes are turned on by a saturation-level voltage; the first two units bars of the fourth electrode are also turned on by this same voltage level but it is 180° out of phase. Thus, the first 32 segments pass light; the next eight units bars are opaque because front and back electrodes are at ground. And the unwanted light that comes through the top six tens segments is blocked by the front layer. A unit with the 10 tens-and-units structure shown in the figure yields a display with a resolution of 1%. All on segments are at or above the liquid crystal's saturation voltage, and the off segments are at zero potential. No segments are in the transition region.

Panel meters using the two-layer LCDs should be ready for sale by the end of the year, says Sherr. He estimates prices will be in the $100 to $150 range.

Square-wave drive. The cells are driven by a square wave and are fully saturated at less than 20-v

Bar-graph displays are easier reading

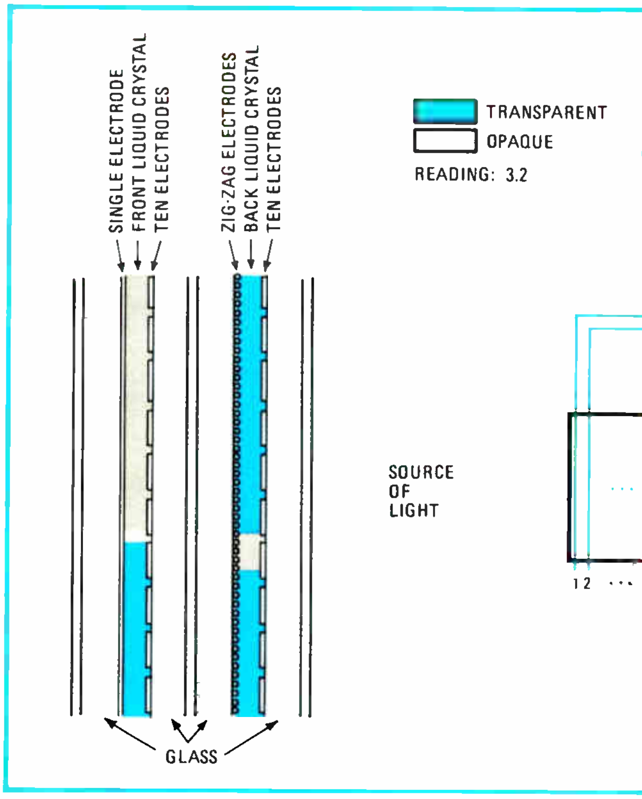
Bar-graph displays have distinct advantages over digital and mechanical analog panel meters in many applications. Like DPMs, they exhibit no overshoot when the input voltage changes, and when it comes to accuracy and resolution, especially with expanded scales, they outdo other analog meters by orders of magnitude. They also retain one major advantage analog meters have over digital types: they're easier to interpret, at least when making an approximation, and so they are superior for indicating a trend or for comparing the values of a number of measurements shown side by side on multiple bar graphs.

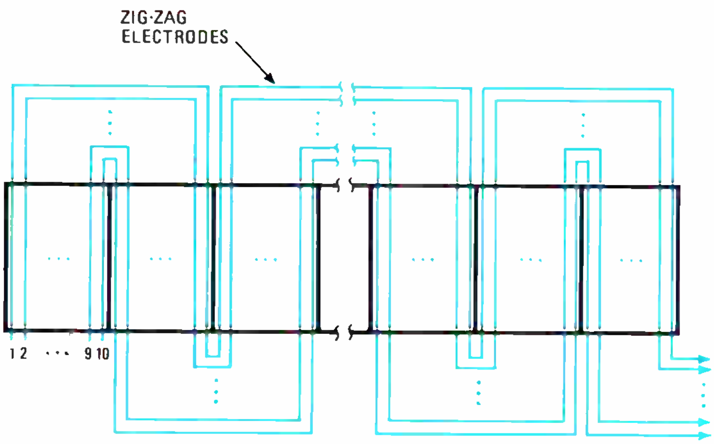
So far, there are only a handful of bar-graph displays on the market. They may be made up of light-emitting diodes, incandescent-filament bulbs, or gas-discharge cells.

A row of discrete LEDs is used to form a bar graph in Ana/Led panel meters made by Simpson Electric Co., Elgin, Ill. As with other LED displays, LED light columns offer low-voltage operation and the high reliability of solid-state design, but can be expensive and consume a fair amount of power. Power consumption is also a problem with incandescent bar-graph displays, like the aircraft cockpit units being made by Canadian Marconi. However, without a doubt, incandescents, which can operate from low voltages, are easily the brightest displays and should find applications where ambient light is high.

Gas-discharge light columns, like those made by Burroughs Corp.'s Electronic Components division, Plainfield, N.J., and those under development at Beckman Information Displays, Scottsdale, Ariz., are bright enough in ordinary ambient room lighting, but some users dislike the need for a power supply that delivers more than 150 V.

Liquid-crystal bar graphs, like those being developed at North Hills Electronics Inc., are readable in direct sunlight, consume negligible power, and do not require high voltages. On the other hand, some LCDs suffer from sensitivity to temperature changes, and the backlighting needed in low ambient light offsets the attraction of low power consumption.





Light bar. Pair of liquid-crystal layers in North Hills Electronics' developmental bar graph act in tandem to block light that's projected from the rear. The zig-zag electrode pattern superimposed over each tens segment is used to delineate the units portion of a display.

Announcing...

an important development in pulse generators from Tektronix TM 500

PG 508T (includes mainframe) . . . $1250

- 20 V, 5 Hz to 50 MHz
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- Probe compatible 1-MΩ trigger input
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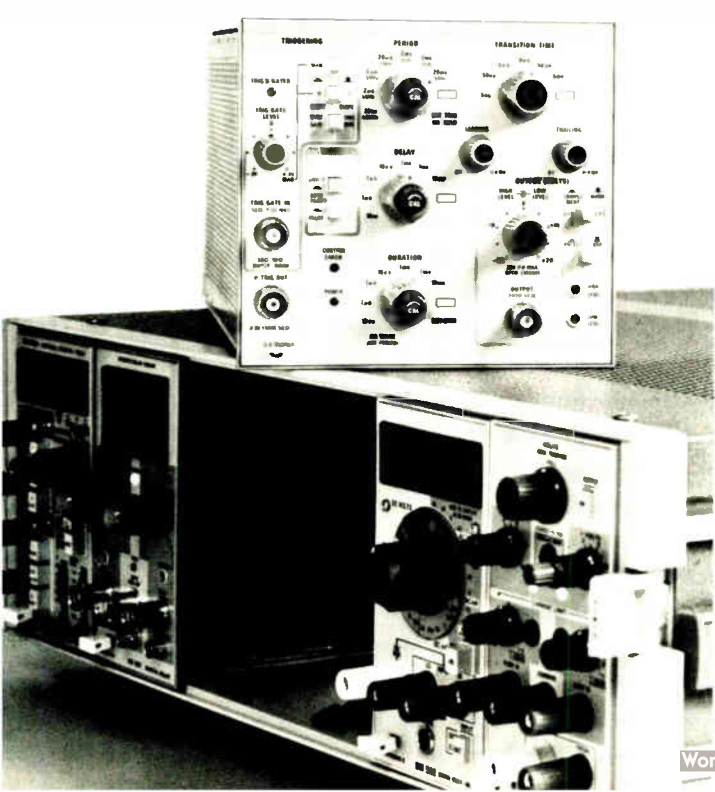

The Tektronix PG 508 50-MHz Pulse Generator is a general-purpose instrument with unique features innovated for versatility and ease of use.

It provides the high-level output required to drive MOS and CMOS (up to 20 V in a ±20-V window to hi Z and up to 10 V to 50 Ω).

A control error light helps in setting up the instrument by warning of improper switch or variable control settings of the parameters, which include period, delay, duration, and rise and fall time.

The PG 508 is the first pulse generator on the market to offer independent pulse top and bottom level control by three means: knobs, front-panel screwdriver adjustments, or external tracking. The low reactance 50-Ω output delivers clean waveforms to unterminated cables or reactive loads.

Trigger the PG 508 from your circuitry just as you would your favorite triggered-sweep oscilloscope . . . a selectable 50-Ω or 1-MΩ trigger/gate input lets you use a 1X or 10X oscilloscope probe. A three-state trigger light indicates proper external triggering.

The PG 508 will perform effectively as a pulse regenerator, sine-wave to pulse converter, or logic level translator, as well as a primary source of pulse waveforms. Use it to drive MOS, CMOS, DTL, HTL, I^2L, T^2L, or ECL.

Order the PG 508T for a self-contained pulse generator complete with mainframe/power supply. Power requirements are: line voltages from 100 to 240 V ac, line frequencies from 48 to 440 Hz.

Tektronix TM 500 is a family of plug-in modular instruments and 1, 3, 4, 5, and 6-compartment mainframe/power supplies. The unique advantage of TM 500 instrumentation is the ability of the instruments to talk to one another and work together through the rear interfacing within their mainframes . . . yet any of the plug-in modular instruments may be chosen on the merit of its performance alone as a monolithic instrument operating from a mainframe/power supply.

The PG 508, for example, can be combined with several other TM 500 Instruments to provide a basic bench setup for CMOS. One suggested lineup includes a TM 506 6-compartment mainframe, DC 505A Universal Counter, DD 501 Digital Delay for counted burst operation, PG 508 Pulse Generator, DM 502 Digital Multimeter, and PS 503A Power Supply. While this is a typical setup, many variations are possible within the TM 500 family to create the optimum instrumentation for your particular needs.

PG 508 50-MHz Pulse Generator $1100

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For further information on the PG 508 and TM 500 Instrumentation, ask for a demonstration; a Tektronix Field Engineer will contact you. Ask for literature and you'll get the comprehensive PG 508 Data Sheet and TM 500 Catalog shown below.

To write or phone: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077, (503) 644-0161 ext. 5542. In Europe: Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

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peak. "All activated areas remain fully on, which, in combination with the saturation drive, allows the maximum contrast ratio to be achieved," Sherr says. "Back lighting by means of several 8-watt fluorescent lamps is used, and contrast ratios greater than 10 are readily attained."

The electronics of the panel meter contains three programable read-only memories to decode binary-coded-decimal representations of the tens and units data into the proper format for the three patterns to be driven. □

Air-traffic control

Ground control tries new system

Planes swarm around airports even more densely on the ground than in the air. That's why the Federal Aviation Administration is readying an airport-surface traffic-control system for operational testing at Boston's Logan International Airport either late this year or early next. The system, which has just completed tests at the FAA's National Aviation Facilities Experimental Center at Atlantic City, N.J., is expected to prevent crashes on the ground and enable ground controllers to handle 25% more takeoffs and landings per hour per runway in both good and poor visibility.

The Department of Transportation's Transportation Systems Center, Cambridge, Mass., is spearheading the development—a trilateration position-fixing scheme designed to ride piggyback on Logan's existing air-traffic-control radar-beacon system. This radar-beacon system uses an airport's surveillance radar to interrogate aircraft transponders to derive position and identity information as far as 60 miles from an airport.

Speed-up. But once the aircraft has landed, the new system, dubbed TAGS for tower-automated ground-surveillance system, comes into play. It will locate and identify arriving and departing planes that are moving or standing still on the ground.

At present, local air and ground controllers depend on visual sightings to locate planes on the airport surface. Yet even when they see the planes, they can't automatically identify them by their flight numbers. Automatic identification will enhance the safety of automatic landing systems, which, as they improve, will increase the number of landings that can be allowed in limited visibility.

Interrogation. The ground-surveillance system will use the same kind of interrogation scheme as the radar-beacon system, except that it will require greater resolution because planes on the ground crowd together more closely than in the air. John O'Grady, chief of the Transportation Systems Center's Airport Surface Systems branch, says TAGS can pick out a single aircraft more than 95% of the time when only 150 feet separates its transponder from the transponder of an adjacent plane.

The TAGS systems adds a fixed antenna atop the rotating L-band airport surveillance radar. In a trilateration system, there are two transmit/receive stations and one receive-only station. The first station sends a transponder-inhibiting pulse pair that suppresses any aircraft transponders in its beam pattern for 35 seconds. A few microseconds later, the second station transmits a pulse pair to suppress transponders in its pattern, also for 35 μs. Importantly, though, each of these beams contains a steerable notch or null in which no transponder suppression takes place.

Thus, an area in which only one transponder can respond to interrogation is established at the intersection of the notches created by the first and second stations. Then 8 μs after the start of its inhibit pulse, the second station sends its interrogation pulse along the notch of its beam; only the transponder at the intersection of the notches can respond, preventing interference.

A transponder's reply is received at each of the three stations, and the plane's position is calculated by measuring the differences between its times of arrival. The plane's identity—its flight number for example—is established with the normal coded signal from the transponder. Ultimately, each aircraft will be tagged on controller displays so it can be routed safely between taxiways and runways.

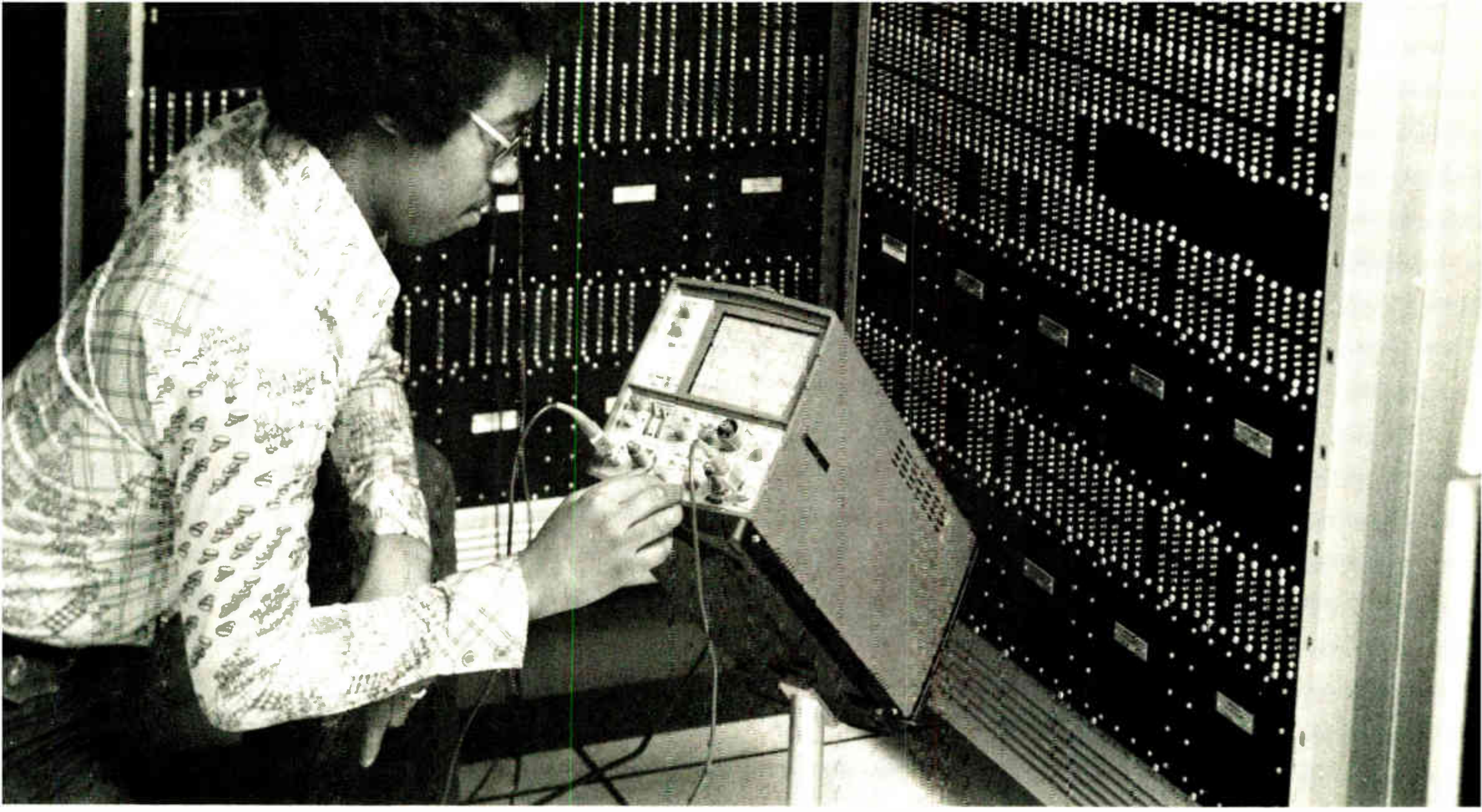
Inactive periods. O'Grady emphasizes that TAGS will be timed to function only during the airport surveillance radar's inactive periods. Thus, it won't interfere with normal operation of the radar beacon system, even though the two share the same frequencies and transponders. He looks for TAGS to be phased in operationally in 1979. □

Solid state

DEC gets its device act together

It's been a little more than a year since Digital Equipment Corp. established a semiconductor laboratory in space leased from Sprague Electric Co. in Worcester, Mass. Since then, DEC has been quietly building what amounts to a pilot production line for both silicon-gate n-channel MOS and low-power Schottky bipolar LSI devices. The facility helps fill the minicomputer maker's need for expertise in semiconductor processing, assembly and testing as it moves to integrate its component and system capabilities [*Electronics*, April 29, p. 25].

Keeping on top. The numbers pertaining to people, floor space, diffusion tubes, and delivered devices, aren't big enough to chill the hearts of semiconductor makers, and DEC will long depend heavily on outside suppliers for most of its devices. But the DEC effort suggests that the leading maker of minicomputers will not be far behind the semiconductor community in process know-how. "Our philosophy is that there's no reason DEC should be a year or two behind the semiconductor industry in creating products," says



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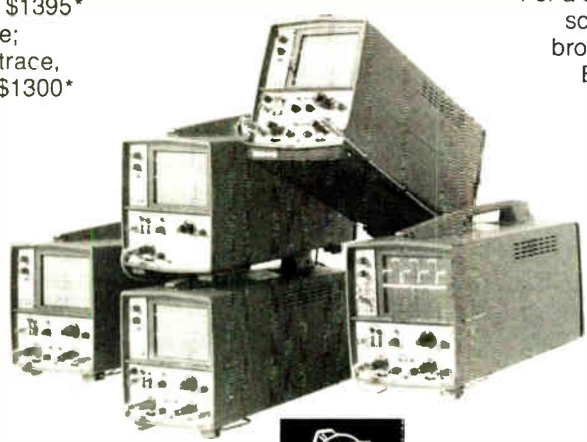

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DEC stresses device, systems awareness

To help design and fabricate its own large-scale-integrated devices, Digital Equipment Corp, Marlboro, Mass., is introducing device and systems engineers into each other's operations. And DEC is also setting up a device-test facility to go along with its wafer-fabrication operation at Worcester, Mass. Joe Chenail heads both.

Chenail says the company is particularly keen on having its device group thoroughly know systems needs and wants its systems people to be fully aware of the Worcester facility's semiconductor capability. To that end, staff meetings with systems people are held periodically to acquaint them with the semiconductor operation.

In addition, three circuit designers are doing a two-year stint in one of the systems groups. Chenail believes the synergism of having device and systems people working together will lead to still more LSI-based systems from the company.

Joe Chenail (pronounced sha-NYE), operations manager at the Worcester wafer-fabrication facility.

The plan, as outlined by Chenail, is to stay abreast of processing technology, but to farm out volume production while maintaining a growing "fall-back" production capacity. The design and processing group within DEC will also be able to develop custom LSI devices that the company wants to keep secret from the semiconductor community.

More than 100 persons are involved in semiconductor-wafer fabrication, assembly, and testing in Worcester, Marlboro, and Maynard, Mass. About 60 are concentrated in the 10,000 square feet of Worcester's wafer-processing area. That space will be doubled by July 1, as more of the assembly and test functions are concentrated there.

Progress. Chenail reports that the number of wafer starts per week is at "a nice volume" now and will be doubled by year-end. The Worcester site has eight diffusion furnaces devoted to production of the chip set for the LSI-11 microcomputer and 12 for low-power Schottky bipolar LSI devices. DEC is acting as its own second source to Western Digital Corp. for the five-chip silicon-gate n-channel MOS LSI-11 set with a process that is compatible with at least two other outside MOS manufacturers. "The LSI-11 chips are large, four-phase dynamic-logic chips," Chenail says. "And we're very proud of our yields."

The low-power Schottky process was chosen, he says, "because it offers the best speed-power tradeoff for today's random logic and also has all the earmarks to allow expansion into memory and integrated injection logic." And, although DEC has yet to build is first integrated-injection-logic device, "we've defined a program and are working on it."

Devices designed. Seven low-power Schottky LSI devices have been designed thus far and are in development. Five are custom integrated circuits that replace small-scale and medium-scale ICs that will help cut the number of circuit boards in DEC minicomputers. The other two will go into future DEC products. Chenail reveals only that one of them, to be built in both the Schottky and I^2L technologies, "pushes into the 500-gate range in complexity."

And he adds, "We were able to have a process line up and running less than three months after the diffusion-furnace gas flow and dopant profiles were established." □

Companies

Beall takes over for Williams at Rockwell

With his appointment last week as president of Rockwell International's billion-dollar Electronics Operations, Donald R. Beall continues his rapid climb up the corporation's management ladder. Since 1971 he has been earning ever more esteem at corporate headquarters in Pittsburgh for his role in turning the Collins Radio Group into a profitable operation. In his new post, he will oversee the Autonetics Group and the Microelectronic Device division (see p. 14), both in Anaheim, Calif., as well as Dallas-based Collins.

Beall succeeds Donn L. Williams, who was named to a new corporate post of vice president for electronics strategy development, reporting to Rockwell International's president Robert Anderson. But the change, says one Wall Street financial analyst who follows Rockwell closely, should be viewed as a "well-deserved promotion for Beall and in no way a demotion for Williams." Williams can make a solid contribution in his new job, the analyst believes.

Although the timing of the announcement caught everyone by surprise, sources say it is consistent with Rockwell management's policy of seeking tighter integration of high-technology electronics operations into the corporate organization. These are largely part of the old North American Aviation operations, located on the West Coast.

Beall seems an ideal choice for this mission, since he joined Rockwell itself in 1968 as executive director of financial planning before becoming second in command to Williams in 1970, the year Electronics Operations was formed. In 1971, he went to Collins when Rockwell invested heavily there, before acquiring the firm outright. Beall became president of Collins in 1974. Although Collins' financial results are not reported separately, they are said to contribute more than half the operation's profit on 40% of its volume.

Briefing. As recently as April 28, Williams briefed financial analysts in both Pittsburgh and New York on how he viewed the prospects for Electronics Operations, meetings also attended by Beall. One analyst said not a hint of the impending

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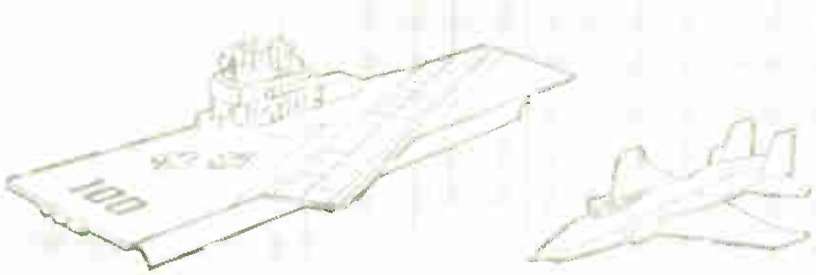

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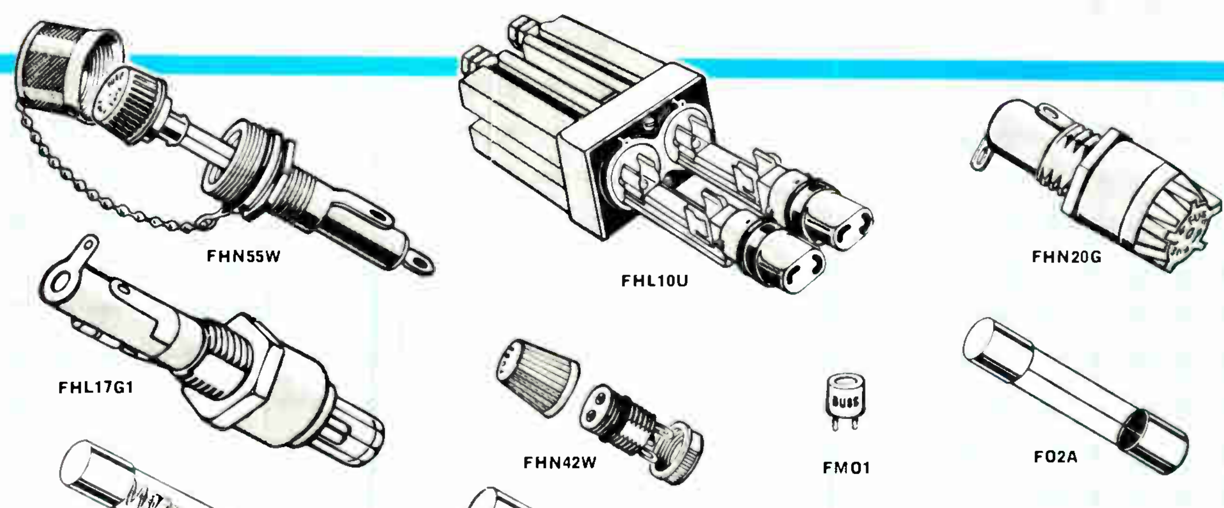

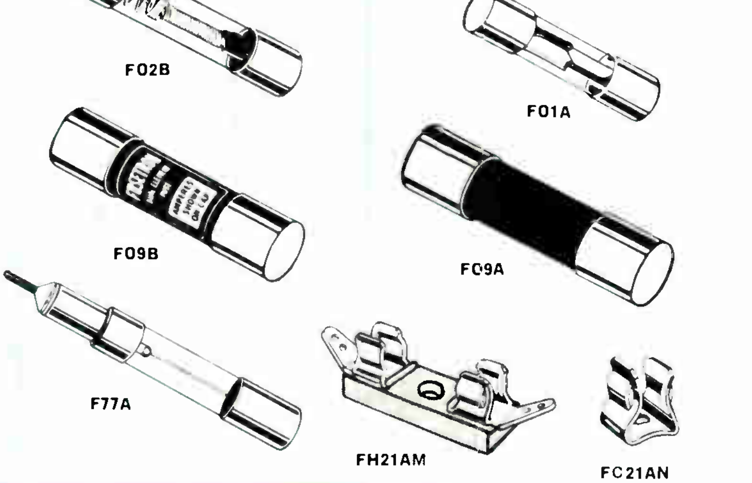

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*Military Specifications

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change was at all evident then.

At the meetings Williams predicted solid improvements for this year, with Collins up 8%, the Autonetics Group ahead by 18%, and the Microelectronic division breaking roughly even. He attributed the division's flat performance to changes in strategy, the better to serve high-volume customers, and to investments in new processes. This division has been consistently profitable, Williams said, and is an important part of the operation, even though it accounts for only 10% of total sales.

Beall will maintain offices in both Dallas and Anaheim, and Williams also will have two offices—in Anaheim and at West Coast corporate headquarters in El Segundo, Calif. □

Components

Analog Devices goes after monolithics

Undismayed by recent rumblings that the big semiconductor manufacturers are moving into monolithic-integrated-circuit data conversion, Analog Devices Inc. has taken steps to assure that "we're going to be one of the significant factors in this market," as president and chairman Ray Stata puts it.

Stata maintains that the Norwood, Mass., company has 30% of the existing $50 million data-converter market and will at least maintain its market share, as its products

News briefs

Burroughs shows new small computer system . . .

Three major main-frame makers have almost simultaneously introduced two new computers and an intelligent terminal. Burroughs introduced its B80 small computer with prices ranging from below $20,000 to about $150,000. NCR Corp. announced its Criterion 8550 and 8570 systems, aimed at medium- and large-scale computer applications. Sperry-Univac announced a new family of remote-batch and text-editing terminals.

The B80 system is built around a nine-chip, p-channel, metal-oxide-semiconductor microprocessor used by Burroughs in its TC5100 terminals and other small processor-based systems. New with the system are a flexible disk unit capable of storing 1 megabyte of information.

. . . as NCR reaches for medium and large applications . . .

NCR's microprogramable 8550 and 8570 systems, which operate as virtual machines, can run Cobol programs and others developed for the NCR Century series. The new systems are organized around a single bus, a first for systems larger than minicomputers. Circuitry is emitter-coupled logic, with memory expandable up to 1 million bytes.

. . . and Sperry Univac's intelligent terminal bows

Sperry-Univac's remote-batch terminal, the UTS 400, based on an 8080A microprocessor, is user-programable with the PL/M high-level language. Uses include data entry and processing, conversational interaction, and off-line operation. The text editor is a special version.

Illegal exports bring crackdown

I. I. Industries Inc., Sunnyvale, Calif., a subsidiary of Cutler-Hammer Inc., has been charged with illegally exporting $3 million in semiconductor-production equipment to the Soviet Union, in what may be the start of a Government crackdown on such transactions. The Federal indictment alleges that the firm, three of its officers, and three West German nationals violated U.S. law forbidding export to Communist Bloc countries of any goods that "significantly increase . . . present or potential military capability." The indictment alleges that semiconductor bake ovens, scrubbers, and etchers, among other equipment, were "falsely invoiced as commercial washing machines and industrial ovens" to an exporter.

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go increasingly monolithic in design.

Analog Devices makes, among other things, precision analog-to-digital and digital-to-analog converters in both modular and monolithic form. The monolithic capability is what Stata is bolstering as he eyes a projected $100 million market in monolithic converter products by 1980—a market that will be fueled significantly by the ever-burgeoning application of microprocessors.

To hold its market share, Analog Devices has:

- Begun to double the size of its Wilmington, Mass., Semiconductor division, which now covers 40,000 square feet.
- Hired three senior executives to fill top spots in the division.
- Established an 18,000-ft^2 IC assembly facility in Limerick, Ireland, with plans to add wafer fabrication within 15 months and eventual expansion to a total of 32,000 ft^2.
- Hired additional production workers for the Wilmington facility, with hiring continuing through Analog's current quarter.

Executives. The new Semiconductor division executives are Robert Pepper, formerly director of IC operations at Sprague Electric Co. and an authority on ion implantation, who becomes director of research and development; Charles Rawlings, previously manager of quality assurance and reliability at Raytheon Semiconductor and Texas Instruments, who will be director of quality assurance and reliability, and Gene Donovan, the new manager of manufacturing, who comes to Analog after having been manager of n-channel MOS operations at General Instrument's Semiconductor division.

The monolithic-converter market is largely responsible for the company's new-order rate, double that of last year. Stata's convinced Analog will also capture at least 30% of the monolithic market.

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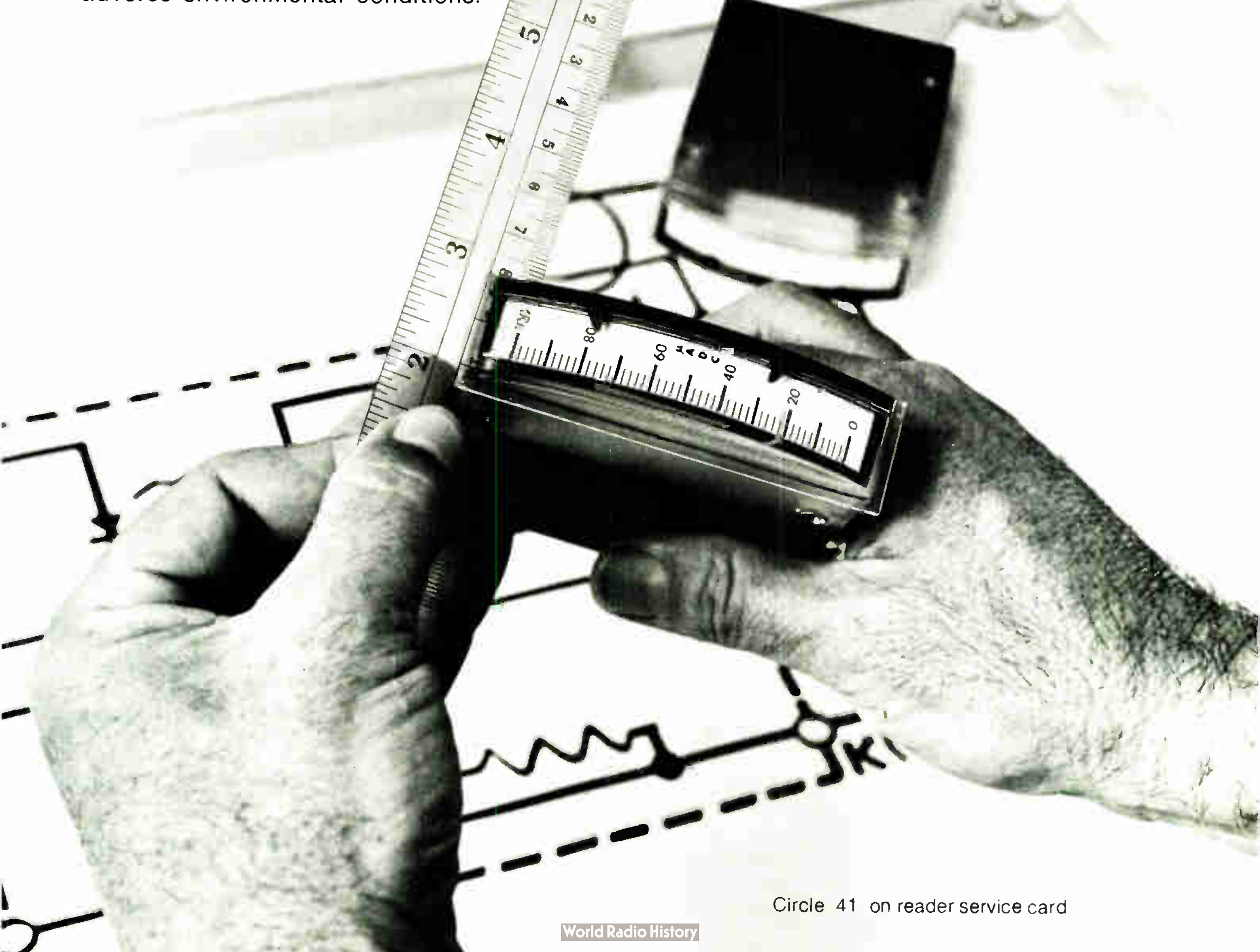

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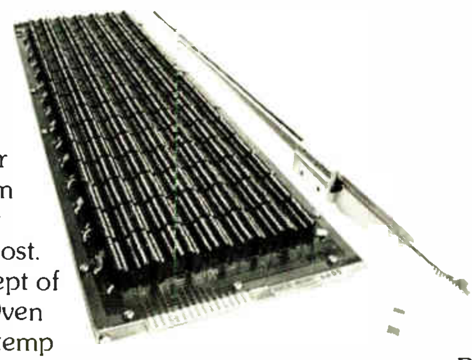

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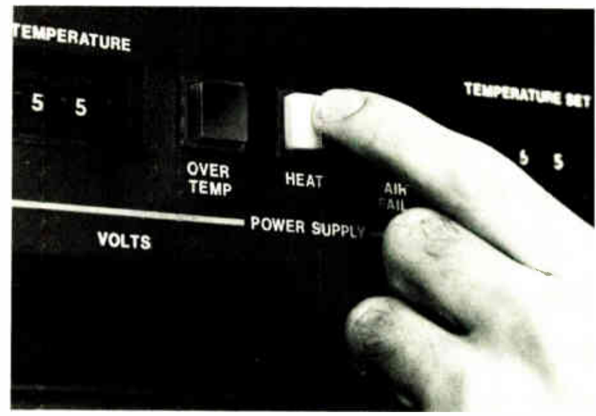

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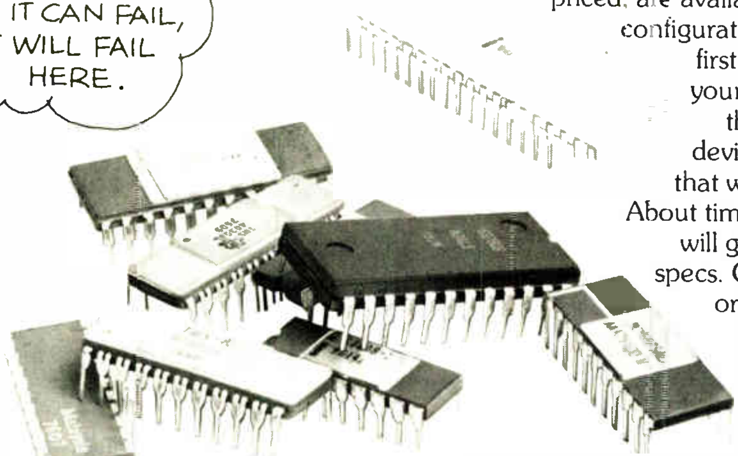

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Washington newsletter

U.S. is watching Japan's plan to 'wire city'

The State Department is alerting other U.S. agencies that Japan is planning an optical-fiber "wired city" in Nara prefecture (state) with an initial $10 million through the Ministry of International Trade and Industry. **MITI is recruiting a team of engineers for the project** from makers of computers, electrical appliances, wire, cable, and optical fibers, according to a State Department memo. Companies already identified as participating include Fujitsu, Matsushita Electric Industrial Co., and Sumitomo Electric Industries.

The engineers will be assigned to a new engineering division of the Visual Information System Development Association in Tokyo, a private foundation of 51 companies, including major broadcasters and newspaper publishers, which will direct the Nara program. It follows a one-year effort started in January in Tama New Town to develop a cable-TV system featuring special programing plus services such as automatic program repetition, a flash information service, still pictures on request, and facsimile newspapers. By using optical fibers, MITI believes it can provide the larger number of circuits necessary for a new community interactive cable TV system and permit development of lower-cost terminal equipment.

OSA sets simpler procurement rules for minicomputers

As Government purchases of minicomputers mount, the General Services Administration is simplifying its procurement regulations. **The move follows nearly a year of complaints by vendors** and a recent nudge from the General Accounting Office, the investigatory arm of Congress. Having specified that any system priced under $50,000 will be categorized as a minicomputer, the GSA is modifying procurement procedures to cut paper work and set a ceiling on orders that can be made under a single procurement. The GAO says "One major minicomputer manufacturer told us that it did not respond to Government solicitation valued under $50,000 because of the high cost to prepare a response."

FCC interconnect clarification eases terminal makers' fears

Makers of terminals for interconnection with the telephone network have had their fears allayed by a Federal Communications Commission **clarification of unclear language in its first-phase rules for registration of equipment.** The registration issue—which was stayed pending court review just prior to its May implementation—was raised by Rixon Inc., and the National Telephone Cooperative Association. Under a "grandfathering" provision, the initial rules exempted from registration equipment previously "directly connected" to the telephone network. Rixon and others questioned whether equipment had to be connected, rather than in a user's inventory, say, to qualify; and whether it might have to be modified to meet the rules if disconnected for maintenance. They also sought clarification of the FCC's definition of its phrase identifying equipment "of a type" complying with the rules.

The FCC said "grandfathering" may apply to the same models of equipment already provided for interconnection but not yet "directly connected." Moreover, it indicated equipment removed for refurnishment may be reconnected provided "components are replaced with comparable components" by the manufacturer or his authorized agent. "Use of the language 'of a type' generally means the same model of equipment made by the same manufacturer," the FCC said. "It does not refer to a generic description, or to an industry-wide generic type designation."

Some unanticipated costs of Federal computers

Computer usage in the Federal Government is threatening citizens with more than an invasion of their privacy—it is also costing them, as taxpayers, a great deal of money, reports the U.S. Comptroller General. The problem is the use of computers to automatically process payment authorizations, bills, and requisitions without review.

It's not the hardware that's at fault—even though the general public likes to blame such problems on the machine—but the systems' software and the people who write it. In calling for improving management of automated computer decision making, Comptroller General Elmer Staats apprised the Congress late last month of the dimensions of the problem: "At a minimum," he said, "Government computers issue annually" some $26 billion in unreviewed payment authorizations or checks, excluding payroll; another $10 billion in unreviewed bills, plus $8 billion in unreviewed requisitions, shipping orders, repair schedules, and disposal orders for Government material.

DOD's horror stories

A review of the situation by the General Accounting Office headed by Staats turned up one Army program to control inventory and save money on overseas shipments by guaranteeing all material for Europe went from East Coast depots while West Coast depots inventoried only material for the Pacific. But the use of outdated software in at least two depots and, worse yet, the failure to implement it in others permitted shipments of materials across country. The GAO says the Army Audit Agency figures the cost per year ran to $1.3 million in increased inventory investment or pipeline costs plus another $900,000 in unnecessary transportation.

On the Navy side, an automated program to monitor and initiate overhaul and repair of aircraft parts spent $145 million in one year on hardware valued at about $797 million. The Naval Audit Service figured that software foulups cost untold "millions of dollars in unnecessary and premature overhaul costs."

At the Pentagon, the response to Staats from DOD Controller Terence McClary is, in effect, leave it to us and we can fix it ourselves. McClary, who is as sly as he is able, suggested that "the report be issued as a study [rather than a GAO investigation], retaining the findings and conclusions but deleting the recommendations and substituting the following: 'Each Federal agency should review its internal regulations and procedures for management [automatic decision-making systems] to assure protection of mission effectiveness and Government resources from system errors' . . ."

Needless to say, Comptroller General Staats did not buy DOD's neat dodge, which would probably have given the GAO study the lip service of distribution and not much more. Instead, Staats' office wants the Office of Management and Budget to "act immediately" and order each agency to (1) determine which of its computer operations are involved in automatic decision making, (2) review each operation to find where errors are being made and correct them as quickly as possible, and (3) use the sum of its knowledge to implement programs that will prevent new mistakes before any new applications programs are undertaken.

Fundamentally, though, the GAO is counting on the National Bureau of Standards for new technical guidelines to be used throughout Government for program analysis and review. NBS, as an arm of the Commerce Department, is responsible for computer technology within the Government except in weapons systems.

No panacea

The Staats recommendations are far from instant solutions to a costly problem. Of course, there are none. Errors will continue, and the stories describing them will continue to get wide distribution. They make more interesting reading than the proposed solutions. Even the computer industry, which also writes most of the software for the machines it sells to the Government, is "astonishingly indifferent" to the problem of erroneous payments, according to one GAO official.

One troublesome question about the Comptroller General's looking to the issuance of NBS technical guidelines as a key to resolving the problem is: can the NBS do it? Compared to many of the agencies with which it will have to deal—like the Pentagon and HEW—the resources of the Bureau of Standards are limited indeed. If the NBS is given the task—and there seems to be no one better qualified—then it must also get sufficient money and competent people with which to do it. **—Ray Connolly**

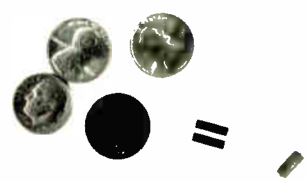
Monday -

John -

Suggest you investigate & get sample of GE's new 13¢ varistor

See attached →

Sen



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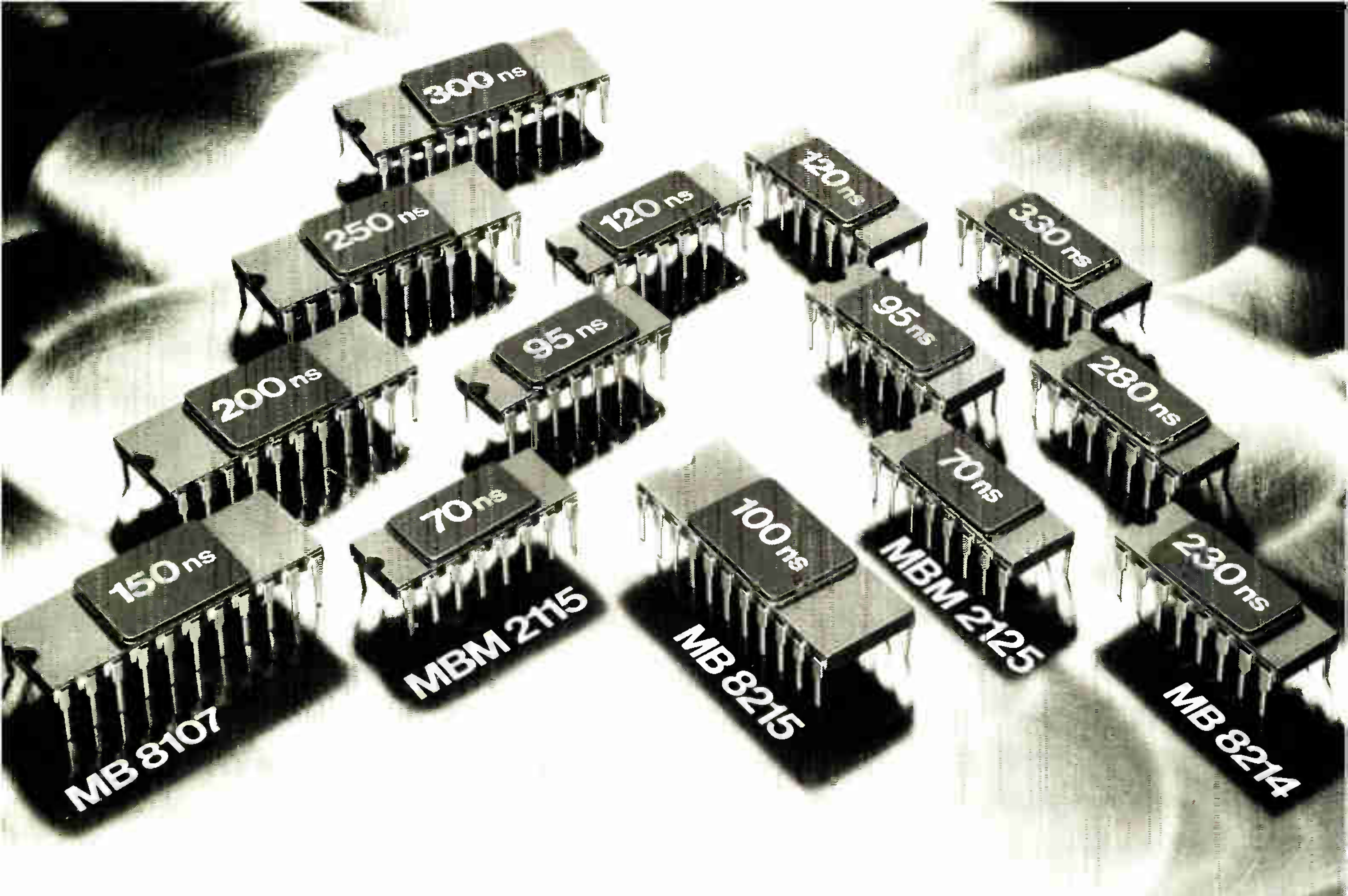

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Circle 50 on reader service card

Japanese develop telemeter capsule that samples liquids in intestines

Physicians soon may be able to sample liquids in patients' intestines by means of a telemetering device developed in Japan, which can also release medicine in the stomach or intestines at any point desired. The telemeter capsule, jointly developed by Jikei Medical University and Dai-Ni Seikosha, is swallowed by the patient and controlled from outside of the body.

Already in experimental use are telemeters that are swallowed to measure pH and temperature of the intestine, but the intestine-sampling device is said to be the first of its kind in the world. The 6-gram, chromed brass/polycarbonate capsule, 0.4 inch in diameter and 1.1 in. long, is divided into battery, electronic circuitry, and sampling compartments. The capsule holds a 60-cubic-millimeter sample.

The motion and position of the capsule telemeter are monitored by X-ray fluoroscopy. When the capsule reaches the target area in the intestine, transmissions from outside the body switch on the capsule's electronic circuit, and the battery heats the filament to 150°C to 160°C.

The filament melts a polypropylene thread that holds a lever bar in place against the spring in the sample chamber. As the thread is severed by the filament heat, the lever bar is released and the holes on the hull of the sample chamber, 1 mm in diameter, are uncovered by spring action, which pushes out the capsule head.

The liquid sample flows into the chamber through the uncovered holes. The capsule is discharged from the body about 24 hours later.

The transmitter operates at 35 kilohertz and dissipates 0.2 watt. It is designed with a loop antenna 3.3 feet in diameter, which can be slipped over the patient if necessary. The capsule's electronic circuitry consists of a oscillating circuit with an MOS integrated circuit and a one-shot switching circuit with two transistors.

The oscillating circuit and switching circuit are placed on a round substrate 0.3 in. in diameter. The capsule has two silver-oxide batteries with a combined output of 3 volts. The device is expected to be marketed as a nonreusable capsule that will sell for less than $1. □

West Germany

Grundig color-TV line offers digital tuning and on-screen channel display

While most of West Germany's television producers suffered setbacks during last year's recession, Grundig AG, the country's largest set maker, scored significant gains. Color-receiver sales for the company soared 28% in 1975, and now better than one out of every four color sets sold in West Germany comes off the firm's production lines. The com-

Around the world

Computer aids French nuclear body scanner

Paris-based Informatek is marketing a nuclear body scanner that uses a computer to process the output of a gamma-ray camera to avoid degrading its resolution. Internal body scans are displayed on a 19-inch video terminal in a matrix 256 dots square, and a scale allows selection of 256 levels for the color assigned each isotope. After as many as three isotopes at a time have been injected into the patient, the gamma-ray output is transferred from the camera to a Mitra-15 minicomputer made by CII.

Aided by a disk file, the Semis 3 can display multiple smaller images simultaneously—as many as 16 in a matrix 64 dots square. For dynamic studies, images also can be cycled in rapid sequence. The Semis 3 is now being used in 30 European hospitals and five in the U.S. to test for heart lesions and record cerebral blood flow. Informatek late last year established an assembly plant and sales office in Birmingham, Ala.

Ferranti offers amplifier for IR thermal image

Samples of an ultra-low-noise amplifier, primarily designed to fill the increasing need for high sensitivity in infrared thermal-imaging systems, are being offered by Ferranti Ltd. in the UK. The chip, the ZN 459, combines an unusually high gain-bandwidth product of 15 gigahertz with an exceptionally low noise of 1 nanovolt per root cycle (1 $nV/Hz^{1/2}$).

The amplifier yields fast signal response with the exceptional noise sensitivity needed for IR thermal imagers using cadmium-mercury-telluride (CMT) detectors and serial charge-coupled-device storage, explains tne Electronic Components division. Essentially, the device amplifier buffers signals from the CMT detectors for the charge-coupled devices, which "shift out the information as you need it." The division developed the chip under a Ministry of Defence contract.

Although confident that the circuit will have a wider usefulness, probably for sonar applications and a 10.7-megahertz intermediate-frequency amplifier for frequency-modulated communications, Ferranti is sticking with military and commercial imaging applications for now.

Tuning aids. Digital ICs provide this Grundig portable Super Color 77 TV set automatic search with fine tuning either by feather-touch or IR remote control.

pany is still pressing its advantage.

Grundig, in Nuernberg, does it mainly by keeping ahead of its competitors in receiver design. The company pioneered modular construction back in 1972, for example. Last year it stayed the front runner with sets having on-screen display of the time, the channel number, and a channel-tuning scale. Now it expects to step out even further with a new line of sets it calls Super Color 77. These sets offer more operating conveniences and improved picture quality, but are priced no higher than their predecessors.

The main new features are automatic station search, infrared remote control, and extremely sharp picture resolution. Larger sets in the 30-model line incorporate all these features; portables and smaller sets are somewhat less elaborate.

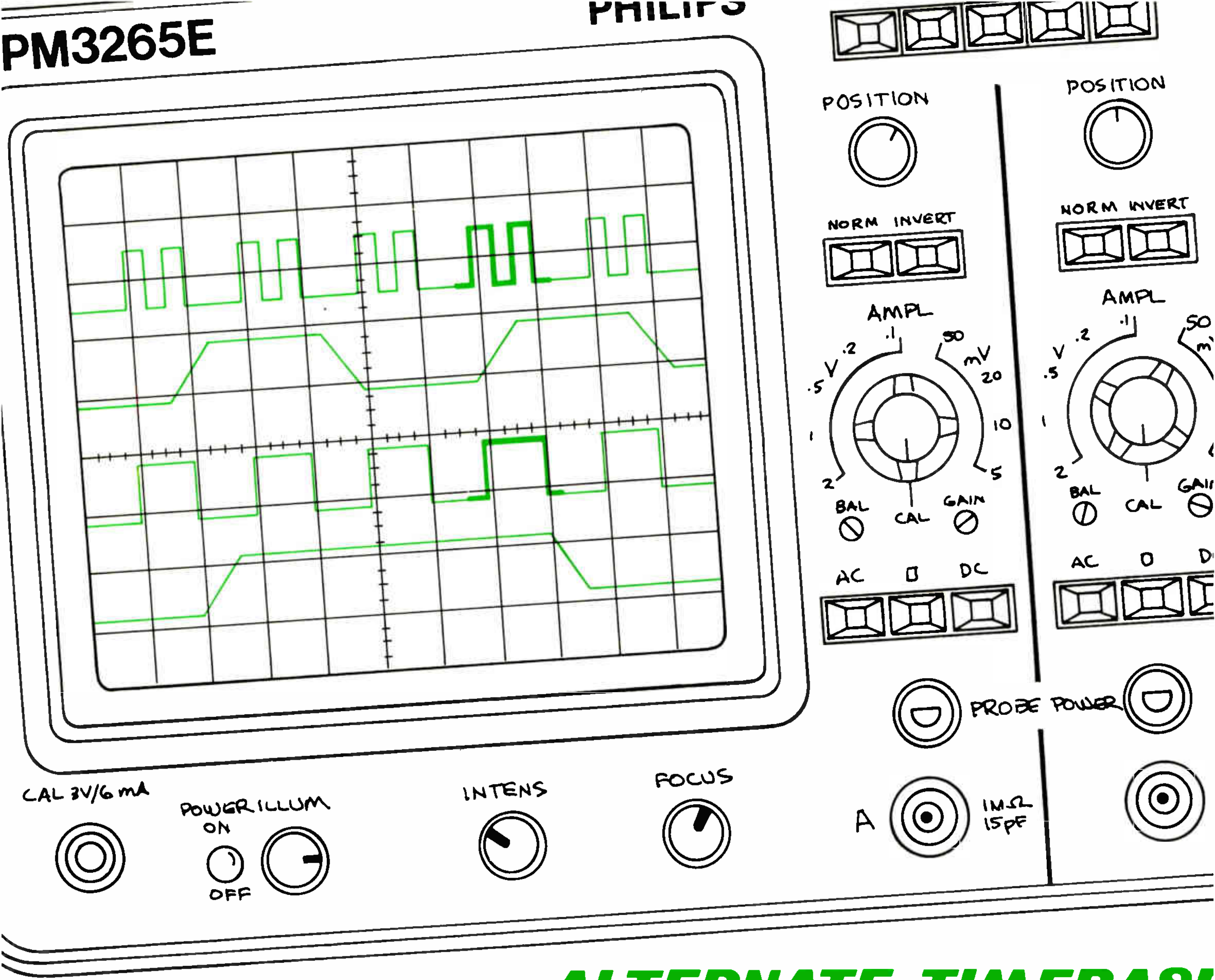
Tuning. Grundig developed its new automatic-search circuitry together with Texas Instruments. The digital system is built around five custom MOS packages and stores the location of selected stations as well as finding them. The search for stations within range of the receiver, in fact, is generally made once and for all when the set is installed.

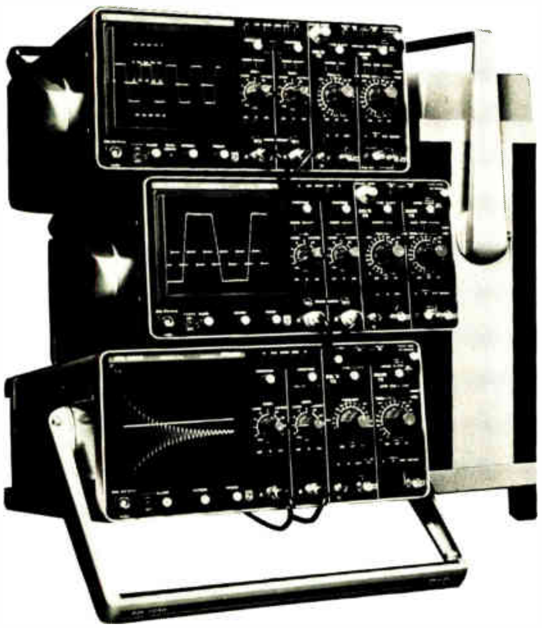
Started by pushing a button, the search begins fast, but goes into a slow afc, or fine-tuning, mode when a TV signal is encountered. The search ends when the channel is tuned to optimum sharpness. To facilitate finding stations, a green line moves from left to right across the screen during the search process.

When a station is selected, its setting is entered into a digital memory by push buttons. After that, it can be retrieved automatically either by on-set controls or a remote control. Whatever the means, the afc always remains active during station selection. This prevents detuning that might otherwise result from frequency drift caused by temperature changes or aging of components.

Light control. For the infrared remote-control system, the company paired off with Motorola Semiconductor. The key integrated circuits here, one for the hand-held transmitter and one for the on-set photodiode receiver, are custom n-channel MOS designs. They take considerable advantage of Grundig's experience. The transmitter generates control signals at ultrasonic frequencies and modulates them onto the 950-nanometer infrared beam. After demodulation, the coded control signals perform their assigned functions. Big sets in the line have units with 21 control functions for handling up to 12 channels; smaller sets (screens to 66 centimeters) have control units with a capacity of eight channels and six operating controls.

To improve picture quality in the Super Color 77, the color-difference output stages have been replaced by a red-green-blue drive-circuit module with three complementary push-pull stages. Operated in class B, these output stages have a low distortion factor, and since they consume little quiescent current, they dissipate only a small amount of power. As a result of the low distortion factor, phase errors are minimized, and picture resolution is improved. Even fine differences in color shades that are clearly discernible to the viewer. □





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PHILIPS

Siemens acoustic filter can replace discrete networks

Siemens AG has started production on a surface-wave filter that can replace filter networks of discrete capacitors and coils in entertainment-electronics equipment. **What makes the West German company's new filter attractive even for nonprofessional applications is an economical fabrication process involving an inexpensive, yet extremely dense, low-porosity piezoceramic material.**

The ceramic, made of lead, zirconium, and titanium, has certain additives that ensure a low-temperature sensitivity of the filter's mechanical parameters and help reduce the ceramic's permittivity. Designated the B39936, the Siemens surface-wave filter is suitable especially for intermediate-frequency stages in television receivers. With the new filter, detuning cannot occur, the company says. And stray fields don't hurt picture quality.

Microprocessor in OCR enables price slash

A small microprocessor-based optical character reader that could cost as little as $5,000, or only 10% as much as available units, has been developed by Mullard Research Laboratories of the UK. **The model, which reads single lines of printed alphanumeric characters at the rate of 50 characters per second, is designed for large accounting departments** where a clerk could punch in the amount of payment while the OCR reads the bill number.

The basis for the unit is a conventional solid-state reader, a simple paper transport, extensive large-scale integration, a fast microprogramed processor for character recognition, and an Intel 8080 microprocessor to complete the recognition and control the overall system. The read-only memories can be reprogramed to store different character fonts. Parent Philips, which has left data processing, is pondering the commercial possibilities.

Swiss watch has built-in charger for its batteries

A Swiss watchmaker has come up with a highly promising solution to the problem of battery charging in electronic watches. At the late-April Basel Watch and Jewelery Fair, Sicura Watch Co. turned up with a "hybrid" watch—a self-winding mechanical movement with hands combined in the same case with a digital electronic module having a light-emitting-diode readout.

The electronic module is powered by **a 1.2-volt nickel-cadmium battery kept charged by a miniature alternator built into the rotor of the mechanical movement's self-winding mechanism.** The alternator output—Sicura won't say what its level is—is rectified and regulated by a special integrated circuit. Jacques Stephan, the Sicura executive responsible for technology developments, says the company plans to adapt the rotor/alternator for use on straight digital watches.

Canada buys gear for sorting mail from Telefunken

AEG-Telefunken of West Germany has won a contract to supply $8 million worth of computer-controlled mail-sorting equipment to the Canadian post office. The order is for 23 sorters, of which **15 are being built by AEG-Telefunken's Canadian affiliate Bayly Engineering Ltd. in Ajax, Ont., Canada. The remaining eight will come from the company's facilities in West Germany.** The machines are designed to handle, not only normal, but also large-format mail, which is more widely used in North America than in Europe.

International newsletter

UK firm develops efficient amplifier for radio beacon

A new maritime multifrequency radio beacon built around a special output circuit is 50% more efficient than conventional circuits. The system is being launched by England's Redifon Telecommunications Ltd., the world's largest supplier of radio beacons. The key is the first use of a push-pull class D amplifier for a unit with a 125-watt power-output rating.

The increased efficiency means low power consumption and a four-to-one reduction in internal thermal dissipation. There's no need for cooling fans because the output transistors operate at low temperatures. The circuit also handles mismatched loads caused by a faulty antenna. The approximately $4,000 solid-state BK125M beacon is to guide coastal ships and direct helicopters onto oil rigs in bad weather.

German electronics hurt by shortages of components

Components shortages, even of passive types, are beginning to plague West Germany's electronics industry, and the sector that's feeling the pinch most is consumer equipment. Kurt Huebler, head of the passive components group in the Electrotechnical Industry Association, says delivery problems exist, especially with ceramic capacitors and certain ferrite-based devices.

Commenting on West Germany's market for passives, Huebler notes that this year's sales are expected to rise by about 10% to 15% over those last year. **The 1975 production volume of passive devices is pegged at about $400 million, which is roughly 30% less than the 1974 level.** Domestic sales last year declined by 20% to 25% below the 1974 mark.

France to control ITT and Ericsson phone-gear groups

France's Thomson-CSF has moved to the forefront among the country's telecommunications suppliers by agreeing in principle to purchase an International Telephone and Telegraph subsidiary and a subsidiary of Sweden's Ericsson Group. The takeovers comply with the government's policy that telecommunications should be under French control. Since LMT owns 40% of Lignes Télégraphiques et Téléphoniques, Thomson-CSF will control LTT, too.

Putting ITT's Le Matériel Téléphonique and the L M Ericsson subsidiary under French control is **one of the last steps in France's program to expand the telephone system, operated by the post office, by an additional 20 million lines over the next five years.** President Valéry Giscard d'Estaing is expected to give formal government approval by mid-May for the move.

Tokyo show pushed back to October

The Japan Electronics Show, to which the Audio Fair will be added this year, has been pushed back to Oct. 22 through 27 in the hope of better weather. The original dates of Sept. 16–25 are often excessively hot. **The October date became available when this year's motor show was cancelled.**

Solar cells power pocket calculator from German firm

A pocket calculator powered by solar cells has been introduced at this month's Hanover Fair by West Germany's Triumph-Adler group, an affiliate of Litton Industries in the U.S. **Dubbed the Solar 1980, the new calculator has a liquid-crystal display and is only 1 centimeter thick.** The calculator, to sell for about $120, offers floating decimal point, square root, memory for positive and negative input, and single or total clearance.

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11/04 can now manage 28K of core or 28K of MOS memory.

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The 11/34 comes in the exact same sizes as the 11/04. 5¼" x 19" x 25". Or 10½" x 19" x 25". It's the same color, has the same number

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Addressing Space: 32K words
Memory:
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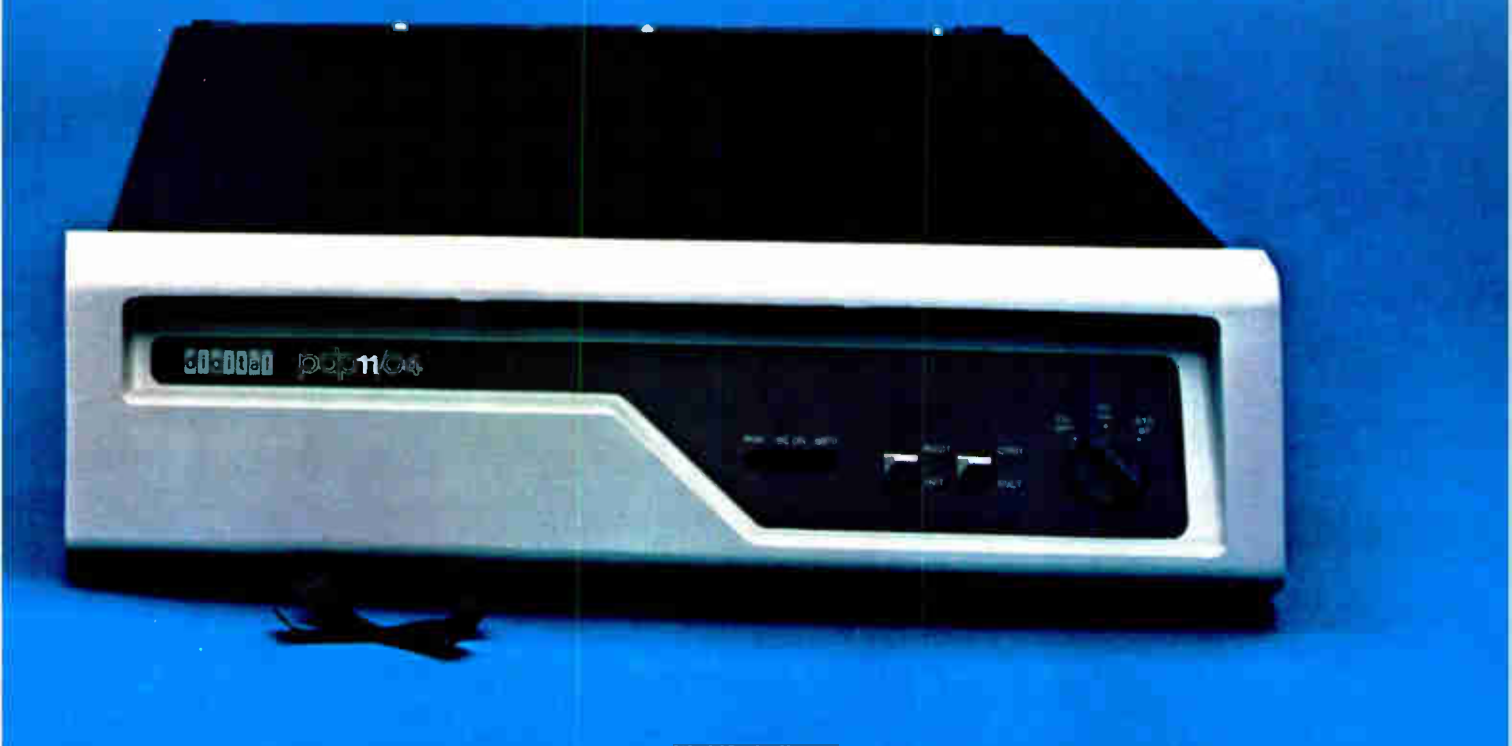

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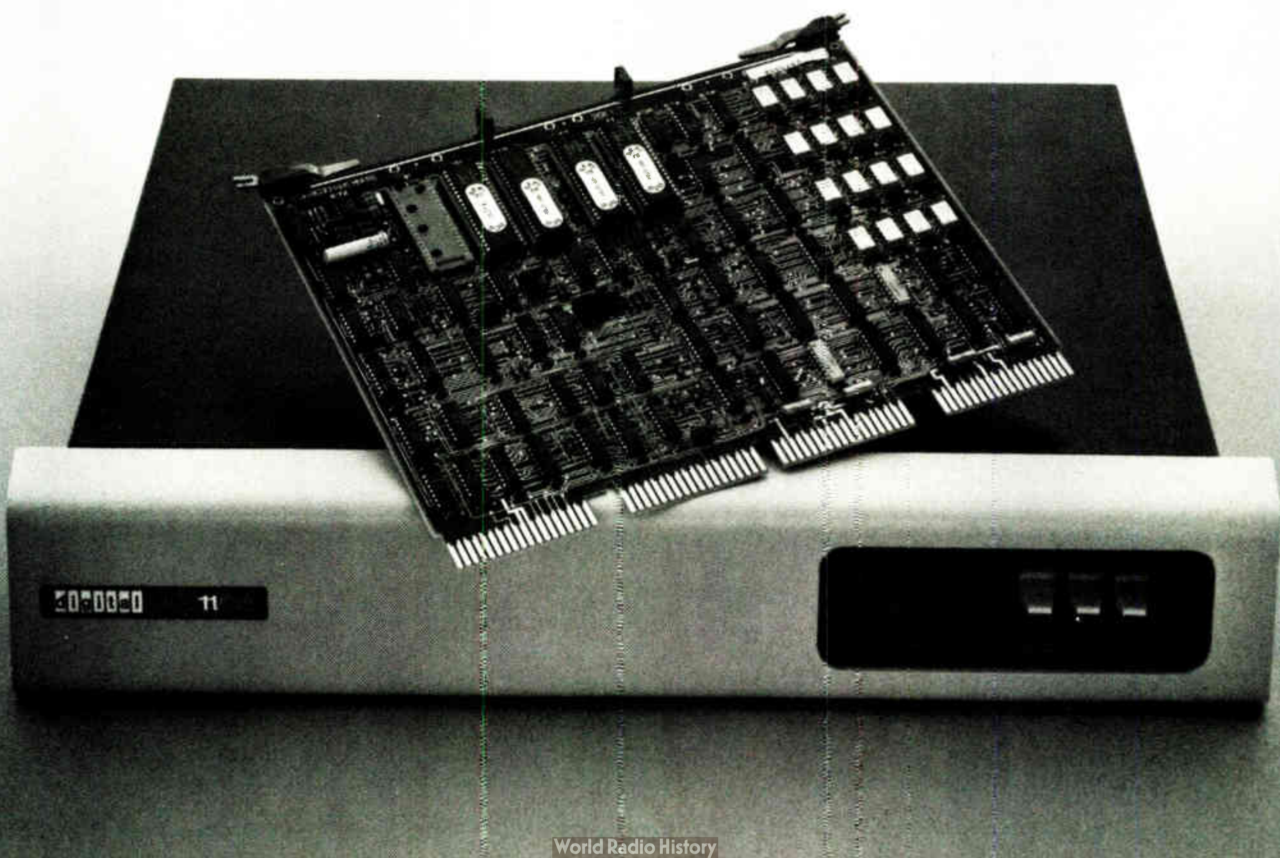


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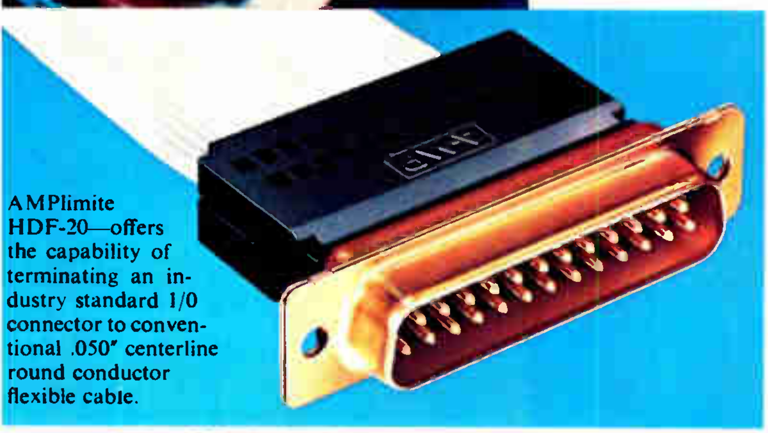

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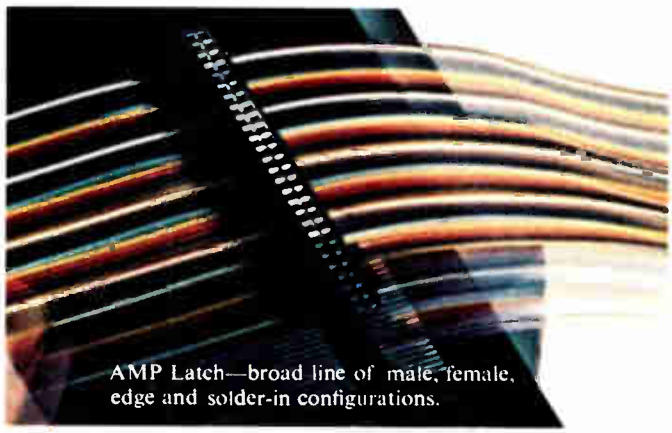

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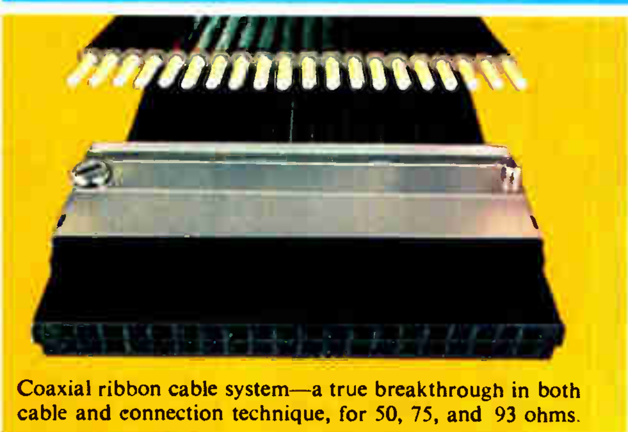

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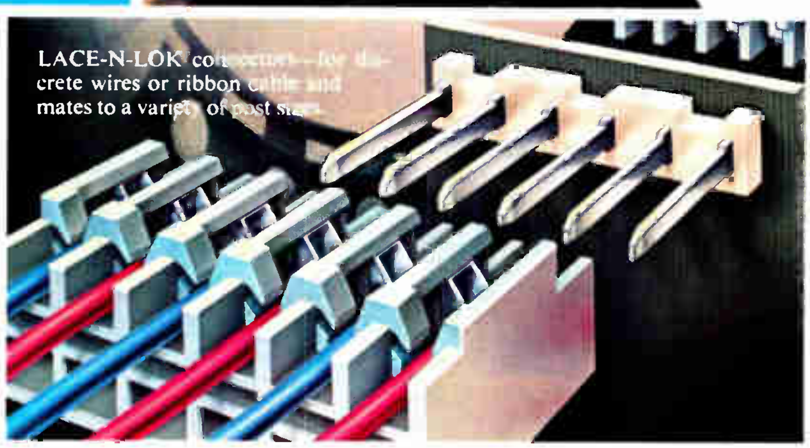

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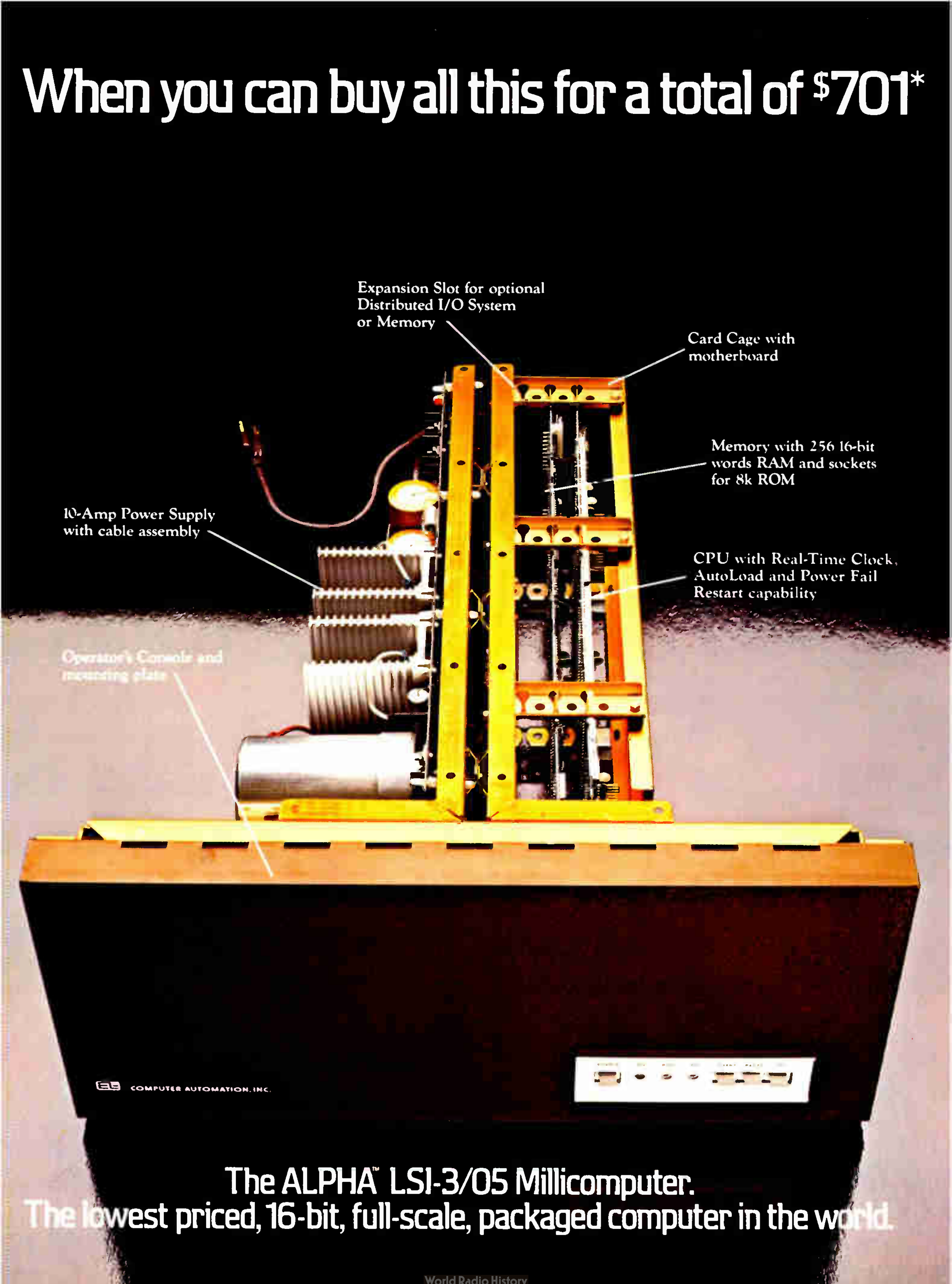
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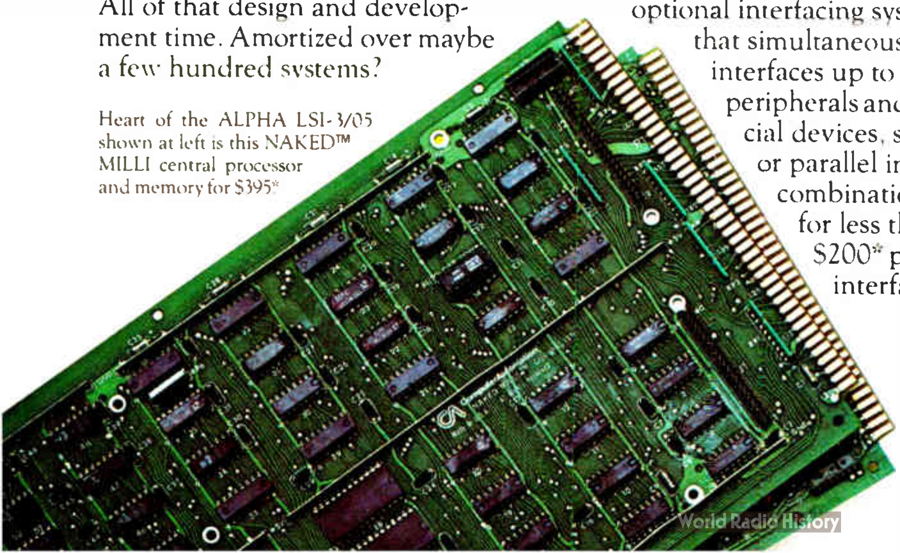

Heart of the ALPHA LSI-3/05 shown at left is this NAKED™ MILLI central processor and memory for $395*

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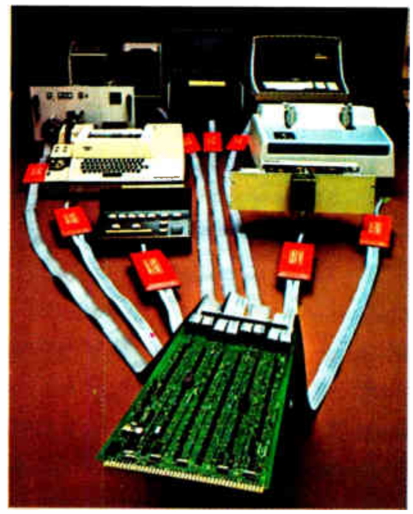

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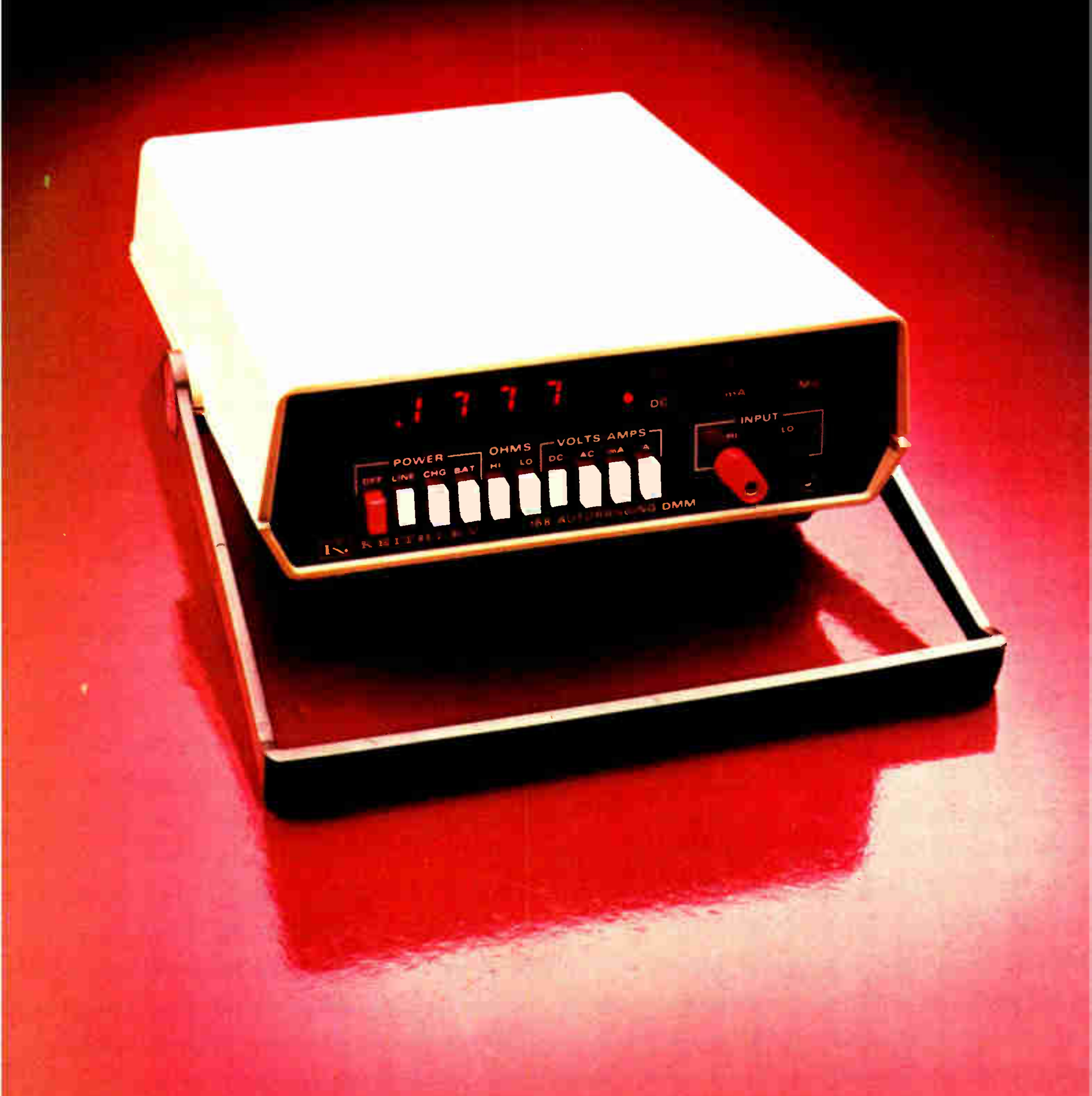

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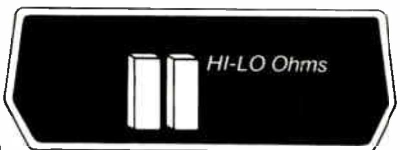

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Depletion mode shrinks CPU chips

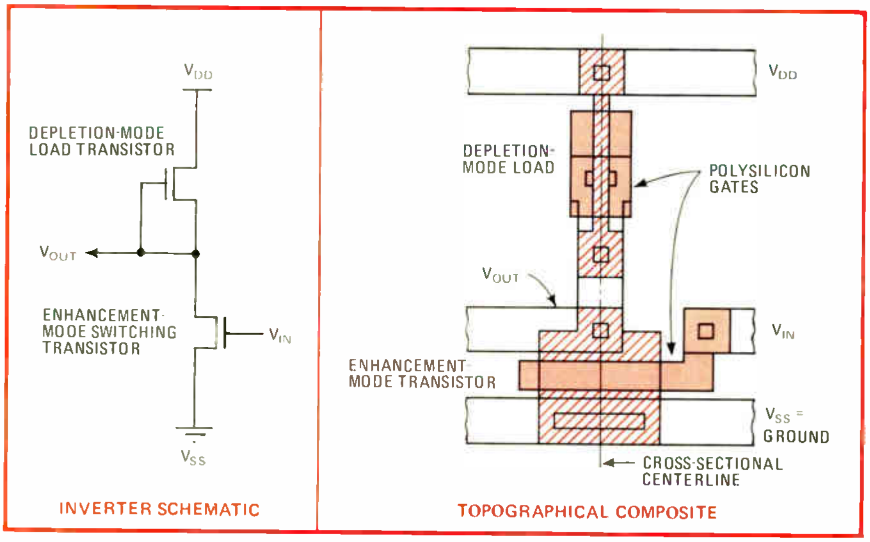
MOS microprocessors, by adopting technique used in calculators and memories, are also approaching microinstruction times of bipolar Schottky devices

by Bernard Cole, San Francisco bureau manager

Depletion-mode load techniques, used for four years in one-chip calculators and memories, are now improving microprocessor density and performance to a startling degree. Applied selectively as early as 1974 as load devices in portions of the Intel 8080 and other enhancement-mode processors—those with high threshold voltage and three power supplies—depletion loads have raised the performance level by about 30% to 40%. Cycle times of 500 nanoseconds and instruction-execution times of 2 microseconds have been reduced to 350 to 400 ns and 1.3 μs, respectively.

Within the past six to eight months, new second-source versions of the 8080 from companies like Advanced Micro Devices Inc. of Sunnyvale, Calif., have made even more extensive use of depletion-mode loads to halve chip size and increase speeds by another 30% or 40%. Expected in a year or so are other multiple-power-supply n-channel MOS processors with cycle times between 100 and 200 ns—or well within the microinstruction cycle time of several Schottky bipolar 2-bit and 4-bit designs. (Indeed, at least one semiconductor company is reportedly developing a depletion-load n-MOS version of either Intel's 3000 2-bit bipolar slice series or AMD's 2900 low-power Schottky 4-bit slice family.)

Meanwhile, since the beginning of the year, several depletion-load designs with low voltage thresholds have appeared that combine a single 5-volt power supply with 1.5 to 2-μs instruction-execution times and have tripled or quadrupled the density of the 8080.



Boosting performance. By adding a depletion-mode load transistor to the conventionally operating enhancement-mode switching transistor, left, AMD boosts cycle time and cuts power dissipation. Nevertheless, inverter size is not increased, as shown right.

Many advantages of this circuit technique derive from the initially on state of the depletion device. With enhancement, no current flows with zero gate-to-source voltage, and in fact, a voltage greater than threshold must be applied to initiate conduction. But at zero gate voltage in depletion-mode transistors, appreciable drain current flows, and a voltage more positive than pinchoff (+5 V typical) must be applied.

Two-faced look. As a result, a depletion load looks like a constant current source at the power supply and like a nonlinear resistor at the output terminal. The major difference in operation between the two loads is that the gate of the depletion device is connected to its own source while the gate of the enhancement load must be connected to a voltage that is more negative than the drain supply voltage.

By far the most common implementation of depletion-mode devices in microprocessors has been as the load resistor in an enhancement-mode driver, says Federico Faggin, president of Zilog Inc., of Los Altos, Calif. There, the characteristics of the circuit technique approach the ideal situation for static logic gates. The constant current effect, for example, minimizes the chip's power requirements and allows much greater densities, but without much loss in speed.

Using such techniques, he says, Zilog developed its Z-80, which features 1.4-μs instruction-execution time. A 5-V depletion-mode system in which the central processor contains the equivalent of 8,200 devices on a 203-by-205-mil chip, the Z-80 is only 12% larger than the 8080A, which has 4,500 transistors. Also:

- Electronic Arrays engineers, using

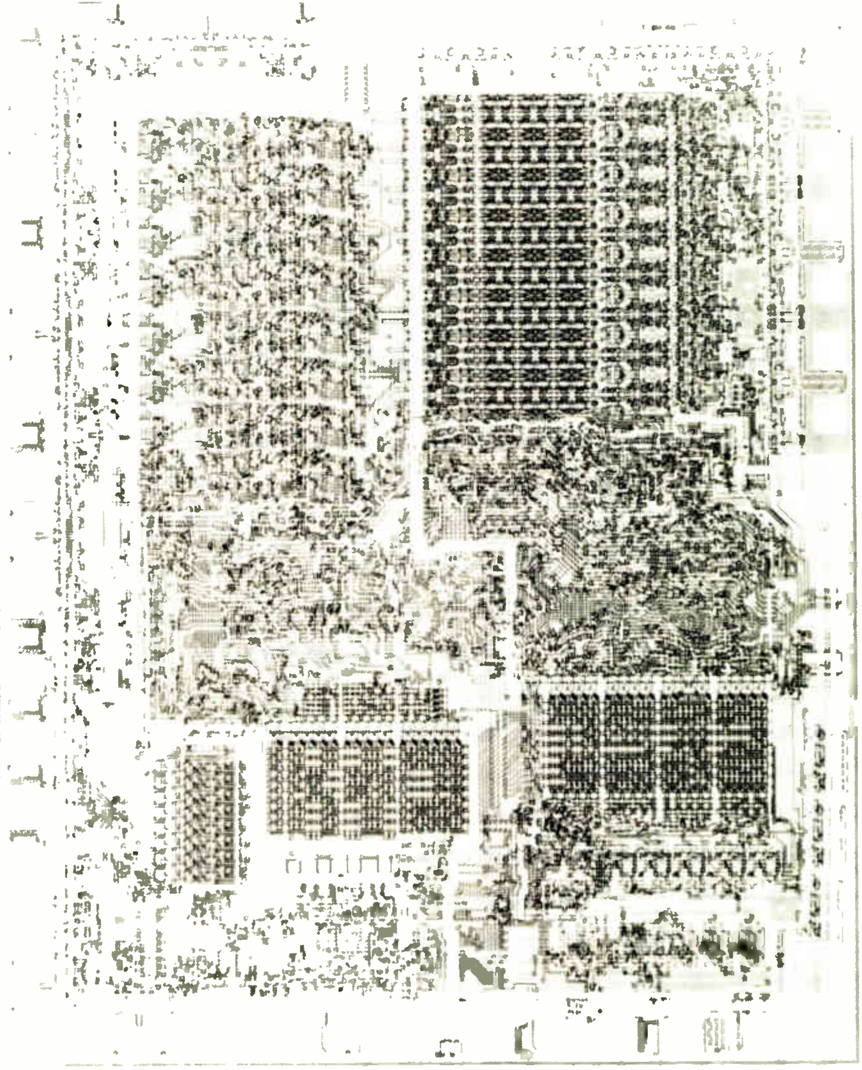
similar techniques, have developed the 5-V, 2-μs EA9002, with the equivalent of 10,000 transistors on a single 200-by-201-mil chip.

- Texas Instruments Inc. has been shipping its 16-bit n-MOS TMS 9900 microprocessor with depletion loads since early this year. TI also is planning to bring out an n-channel version of its one-chip 4-bit TMS 1000 microcomputer on a chip, five times faster than its p-MOS version, which is specified at 10 to 15 μs.
- Signetics engineers are at work on the redesign of a depletion-load version of the n-MOS 2650, specified at 1 to 1.5 μs.
- At National Semiconductor, a move is under way to upgrade its p-channel PACE microcomputer system to depletion-load n-MOS.

Even more intriguing are moves toward truly one-chip, 8-bit microcomputers with the speeds and capabilities of current multichip designs. At Intel, engineers are developing a depletion-load, 5-V, single-chip device called the 8048. It packs enough read-only, programable read-only, and random-access memory, as well as I/O capability, onto the same chip as the central processor to form a minimal computing system.

Motorola Semiconductor is also reported to be developing a similar one-chip, 8-bit microcomputer. Steve Sparks, manager of microprocessor design at Motorola, declines to discuss details, but says that "n-channel depletion load will be the technology of the next few years—at least for us," and foresees a doubling in speed for Motorola's microprocessor line.

High speed. According to Andrew Allison, MOS microprocessor product manager at Advanced Micro Devices, manipulation of the ratio of enhancement- to depletion-load devices allows marked improvement not only in chip density but in speed as well. For example, when the drain supply on depletion-load/enhancement switching driver combinations is set at –5 V, the gate supply at –15 V and threshold at –5 V, the ratio is 5. A factor of 10 is easily reached when the enhancement load is operated in saturation at higher voltages.



A la depletion mode. Am9080A-4 microprocessor from AMD, made with depletion-mode load techniques, is fast and dense. It executes instructions in 1 microsecond and contains the equivalent of 7,000 to 9,000 transistors on a chip that measures only 131 by 169 mils.

This is somewhat altered, however, by the degrading effect that the substrate has on the characteristics of the depletion-load element. So, depending on the bias conditions, improvement can be anything from twice to 10 times over the enhancement-load current.

Retaining a three-power-supply approach, AMD engineers have been able to manipulate the substrate bias and various other performance parameters, says Allison, so that its most recent version of the 8080 (the Am9080A-4) not only executes instructions in 1 μs, but contains the equivalent of about 7,000 to 9,000 transistors on a 131-by-169-mil chip that is 45% smaller than the 8080A chip. And in the near future, he says, the number of supplies could be reduced to two, with further improvements in performance. Ultimately, says Gary Prosenko, senior engineering specialist at Electronic Arrays, the use of on-chip substrate biasing techniques (such as those used on Intel's 2115, a 70-ns static 1,024-bit n-MOS RAM) will mean single 5-V, one-chip microcomputers with instruction-execution times under 1 μs are a distinct near-term possibility.

Interestingly enough, it is rumored that Intel is redesigning an enhanced 8-bit follow-on to the 8080 called the 8085. Like Zilog's Z-80, it will contain the equivalent of 8,000 to 9,000 transistors on a central processor chip not much larger than the 8080, allowing the incorporation of peripheral interface devices now on separate chips. But in the first design go-around, it is reported, multiple power supplies will be retained and Intel will go all out for instruction-execution time of less than 1 μs. □

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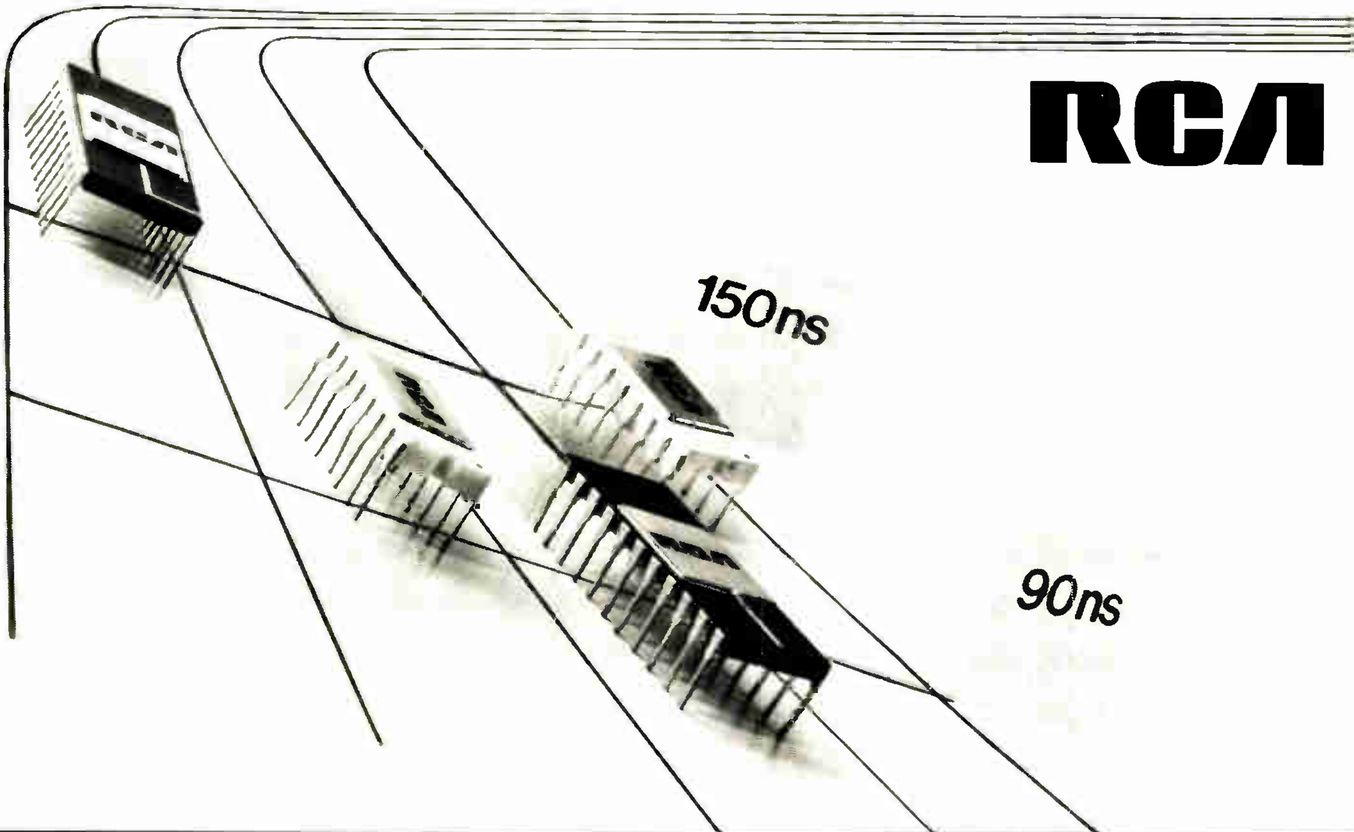

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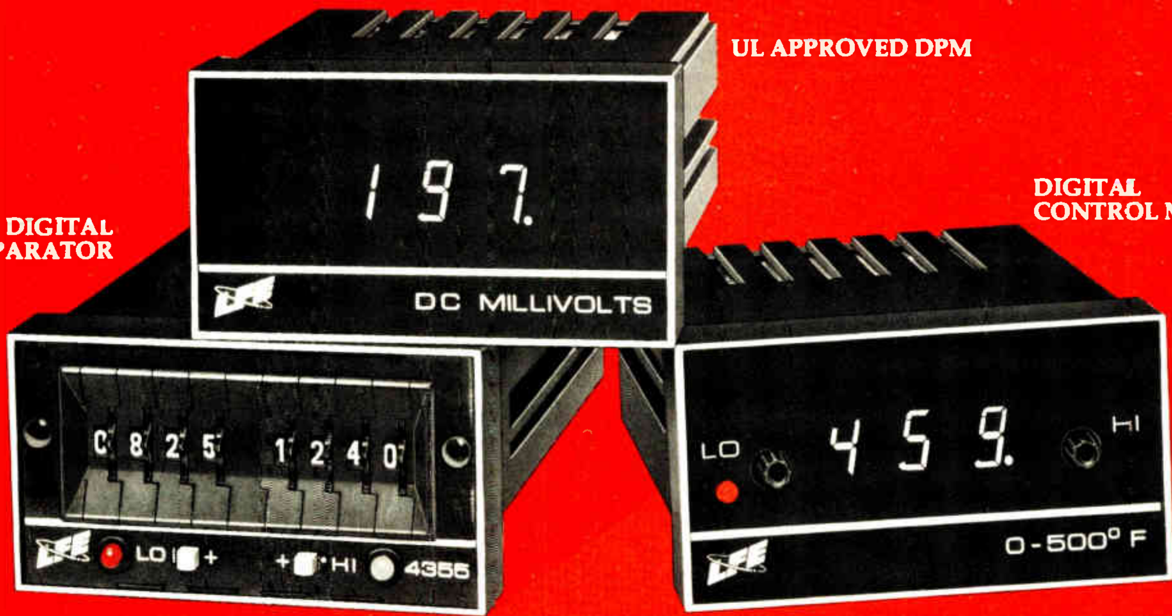

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Components

Battery boom is on

Makers of button cells for digital timepieces rush to add capacity as demand tightens supply

by Ron Schneiderman, New York bureau manager

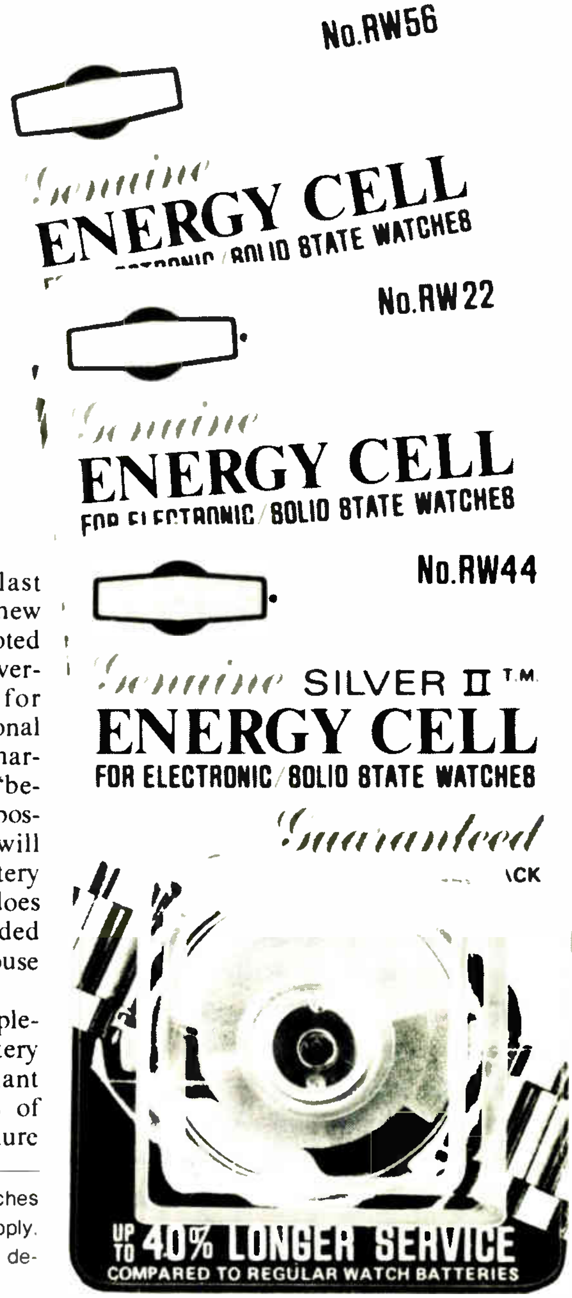
Battery makers may be getting the biggest charge out of the digital-watch revolution. Worldwide production of digital watches this year is estimated at 15 million units—about 12 million more than were produced in 1975. Most watches need two batteries, but as a rule of thumb, each watch actually needs six—two in the watch, two on the shelf, and two in the pipeline. This adds up to plans for more production capacity by the major makers of those batteries—the Ray-O-Vac division of ESB Inc., Union Carbide Corp., and P.R. Mallory & Co.—now already working near capacity. And it also means a tight supply picture until those new production lines are up and running.

Electronic watches now consume about $13 million worth of batteries, says James Magid, an analyst with Drexel Burnham & Co., New York City. "Should the number of battery-operated watches sold in the U.S. rise from 7 million or 8 million units in 1975 to only 35 million watches per year in 1980 (a conservative estimate), replacement battery sales would approximate $75 million. That would imply over 40% annual growth of replacement watch batteries," he says.

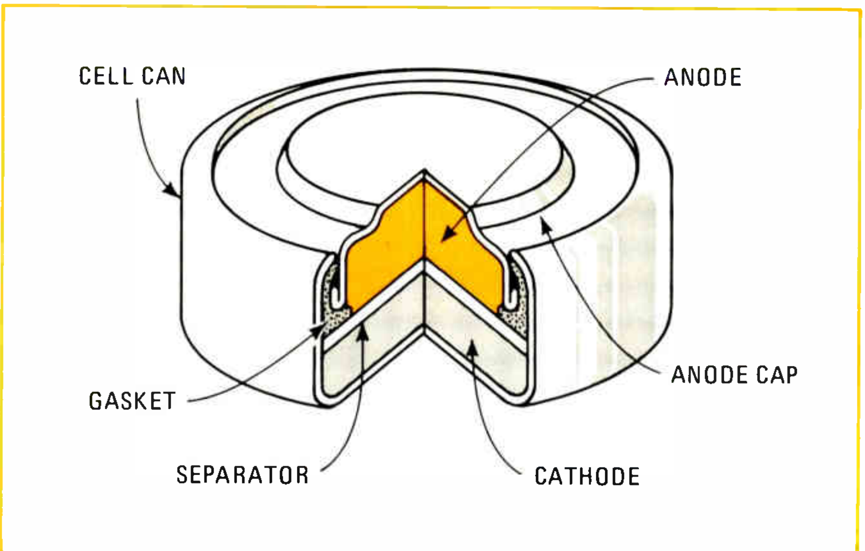
Mallory's David Sweeney, manager for watch batteries, predicts total watch-battery sales of 6 million units in 1975 will jump to 31.5 million this year, helped along by the new $30-and-under digitals with light-emitting-diode displays. "If our projections are correct," says Sweeney, "the replacement market alone in the U.S. this year will be $55 million, climbing to $250 million in 1980."

In recent developments:

- Ray-O-Vac broke ground last month in Portage, Wis., for a new plant, most of which will be devoted to the production of divalent silver-oxide button-cell batteries for watches. Harold Coakley, national sales manager for electronic markets, says the company plans to "become as vertically integrated as possible." He says Ray-O-Vac will either acquire makers of battery components that the company does not now produce, such as molded metal parts, or develop the in-house capability to make them.
- P.R. Mallory is pushing completion of its own $6.7 million battery plant in Lancaster, S.C. The plant represents almost three fourths of the company's capital-expenditure



Charged up. Button cells for digital watches like Ray-O-Vac's (top) are in short supply. Schematic diagram shows construction details of a silver-oxide button cell.



Probing the news

budget for this year. Sweeney, whose post as manager for watch batteries is a newly created one (until recently, watches were an additional duty of the hearing-aid-battery specialist at Mallory), says "a lot" of the new plant's capacity will be made available to product button-cell watch batteries.

- Union Carbide is "significantly" increasing the manufacturing capacity of its button cells at existing U.S. facilities, says Hugh Keating, director of market development at the company's Battery Products division. The company also is building a plant in Switzerland to supply the European electronic-watch market.
- Bulova has a working agreement with Varta AG, in Frankfurt, West Germany, to market Varta's digital-watch batteries in the U.S. A Bulova spokesman says details of the agreement may not be disclosed until later this month.
- Burgess Inc. in Freeport, Ill., which makes general-purpose batteries, is considering production of miniature button cells for the digital-watch market. "We're studying this now," says national sales manager Gene Dobra, "and expect to make a decision soon."
- Japan's National Mallory Battery Corp., owned 40% by Mallory and 60% by Matsushita Electric Industrial Co., is expanding button-cell marketing in the U.S. It will also soon begin retail distribution.

"Catalyst." Although several different types of batteries will be produced at the new Ray-O-Vac facility, which is expected to be in operation by the end of this year, Coakley says that the digital-watch market "was the catalyst" for building the plant. The new plant in Portage, which is also the site of Ray-O-Vac's current button-cell manufacturing facility, will cover an estimated 50,000 square feet with new production lines, testing equipment, and storage, aging, and packaging facilities. Ray-O-Vac currently supplies watch cells to over 100 watch companies worldwide, and emphasizes its divalent silver-oxide battery, which the company claims offers up to 40% more life than ordinary silver-oxide batteries provide.

P.R. Mallory expects digital-watch production to jump to more than 100 million by 1980, but analyst Magid, who follows the company, admits it is difficult to apply past trends to projections.

Does the rapid growth of the digital-watch market mean possible shortages this year or in the future? Mallory's Sweeney remarks, "It's going to be tight, but we think we can handle our market now." Ray-O-Vac's Coakley says shortages experienced by the company late last year and early this year are "behind us now, although there may be some short-term shortages in a few areas."

However, Texas Instruments Inc., which has been using Ray-O-Vac batteries exclusively, is introducing several digital models priced below $30 and isn't taking any chances. Hector Cardenas, engineering manager of TI's Time Products department, says the company also has supplier agreements with Union Carbide and Mallory. Jim Diller, National Semiconductor Corp.'s director of special products operations, says he hasn't experienced any shortages, and William K. Weakland, general manager of Hughes Aircraft's Solid State Products division, calls the battery situation "tight, but we can get them."

In Weakland's view, the ideal allocation of watch batteries is for distributors, who service the after-sale market, to get twice as many as manufacturers. Now, he says, the opposite is true, because manufacturers have greater purchasing leverage. (Hughes' Newport Beach, Calif., division claims it produced about 1 million modules in 1975—almost a third of all digital-watch modules made worldwide—and expects to make 3 million this year.)

Also, prices may remain at a high level, both for the OEM and retailer. Although the suggested retail price of a typical digital-watch battery is $1.85, most watch and battery makers expect the over-the-counter prices to be higher—up to $3.50. Fine jewelry stores in particular believe they can command the higher price because they maintain service centers, where they change batteries and reset watches for the many customers who can't do either. □

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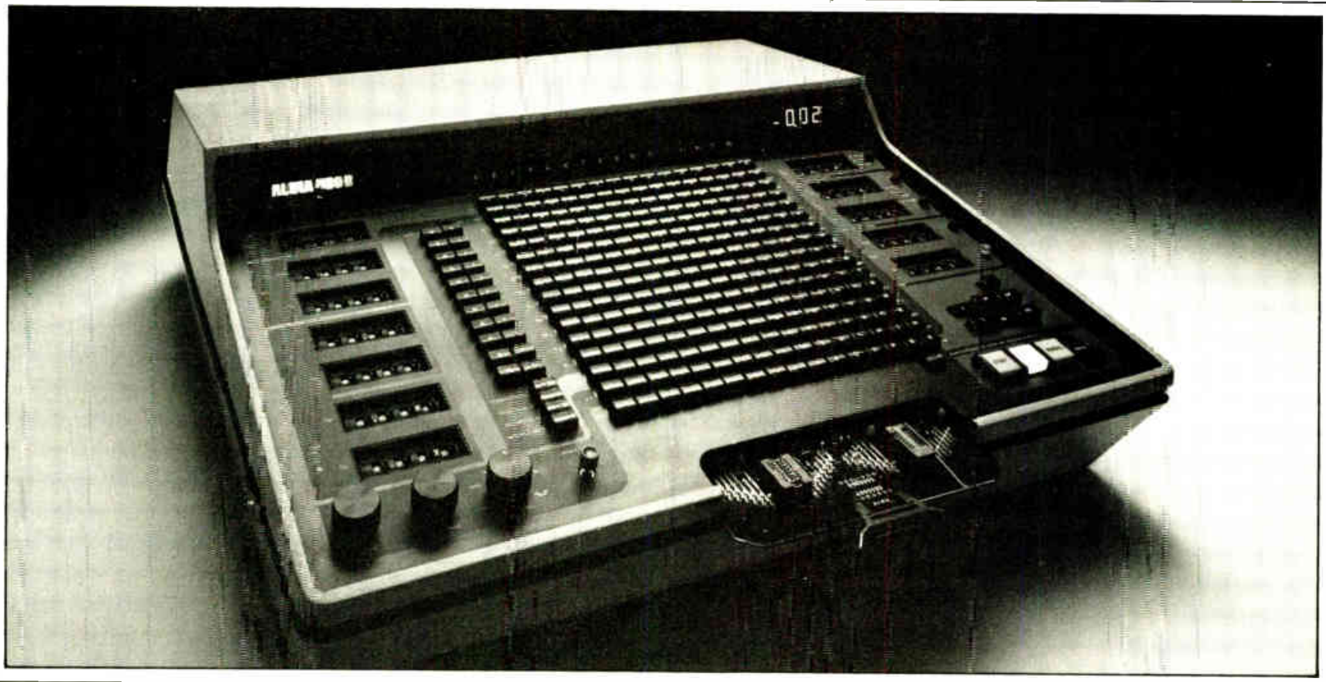

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Patents

Proposed law raises reform hopes

Most companies still consider inventions all in a day's work, but California measure would mandate profit sharing with inventors

The stern corporate resolve that salaried engineers and scientists have no right to share in royalties from their inventions is under attack. While efforts by militant engineers and the IEEE to liberalize customary patent attitudes are too new to have had any impact, a bill just introduced in the California legislature may prove more persuasive.

The measure at present reposes in the State Senate's Judiciary Committee for hearings. It takes the attitude that an invention belongs to the inventor and the right to compensation for it "can't be taken away by contract," says John Sutton, the attorney who drafted the bill. He refers to the agreement required of almost all technical employees assigning rights of any invention to their employers. The bill is not specific about remuneration, providing only that an employee may patent his invention unless his employer establishes interest in it within four months. In that case, the two parties must agree on payment; if they can't, says the bill, "remuneration shall be fixed by a court of competent jurisdiction."

Opposition has been quick to form. Initially, it is coming from General Electric Co. and the Association of Motion Picture and Television Producers.

Early backers include the California Society of Professional Engineers and the American Chemical Society. As for the IEEE, James Nawrocki, chairman of the Santa Clara County Chapter's Professional Activities Committee, says the patent bill "is not the greatest piece of legislation ever written" and doubts that it will get out of committee. Meanwhile, the Santa Clara committee is itself seeking a means of broadening patent benefits for engineers, while the IEEE is also seeking to spur changes (see "IEEE seeks better deal for inventor"). And a patent-reform bill has passed the U.S. Senate and now awaits House hearings.

Back in Santa Clara County, semiconductor company spokesmen are understandably unhappy about the California bill. Gale Woodward, patent counsel at National Semiconductor Corp., says his major objection is that the measure tells a company how to do business. He points out that engineers with a résumé of patents should be paid more than others anyway in anticipation of further inventions.

Enunciating a perhaps more common company attitude, Alan MacPherson, patent counsel at Fairchild Camera & Instrument Corp., observes, "It's not clear to me that the people hired to invent are being financially disadvantaged." He emphasizes that they are doing what they are hired to do and any accomplishments will be noted when the employee's performance is evaluated. Furthermore, MacPherson believes that the movement among engineers for patent rights "reflects a misunderstanding about which factors go into an invention"—such as the capital.

Paternalism. That promise to "take care" of deserving employees rankles with militants, to whom it smacks of paternalism. Besides, they

The IEEE seeks better deal for inventor

The IEEE's U.S. Activities Board has decided that one of its 1976 tasks is "to obtain improvement in the patent rights for employed inventors." A task force of volunteers, staff, and legal counsel is to investigate: the patent laws, armed services regulations, current industry practice, patent-law provisions in other countries and practices in industry there, and what must be done to change the U.S. law and armed services regulations. The activities board is to make a policy decision by September.

Meanwhile, in Santa Clara County, Calif., the local chapter's professional activities committee is taking a slightly different tack. James Nawrocki, committee chairman, says, "We're looking for a narrowing of the inventions an employer has a right to." Nawrocki notes, for example, that most companies even forbid employees from using their own time to invent products that might relate to their 9-to-5 work; he would like to see that changed. But, he says, "where the company actually paid to have the guy invent something for it," the invention should go to the company.

What the committee will do is draft a model employment contract to replace the present company-takes-all versions. It would:

- Specify which types of inventions belong to the company.
- Require the company to relinquish rights to the invention if it did not act within a certain period of time—also a provision of the patent-rights reform bill that has been introduced in the California legislature.
- Find a more generous means of compensating employed inventors.

point out, it relieves the company of the legal obligation to do anything.

Texas Instruments Inc. in Dallas meets this criticism by considering patents earned an important ingredient in its key personnel analysis.

Other companies have adopted a bonus system. At National, it takes the form of a two-stage payment: $100 when a patent application is filed and $200 more when the patent is issued. Motorola Inc. in Phoenix, which also requires an employee to sign over his patent rights when he joins the company, follows the same system. The company won't say how much it awards at the time of filing and when the patent is awarded, but the amounts don't differ from employee to employee.

On the East Coast, Raytheon Co. in Lexington, Mass., and GTE Sylvania in Waltham, Mass., give employees $200 when a patent application is filed. In addition, Raytheon awards $140 each if a group of developers is involved. And in France, where it's practically unheard of for a salaried engineer to get royalties, Thomson CSF sometimes rewards an outstanding invention with a bonus.

Two ways. IBM has two bonus and incentive programs. One provides payments based on points accumulated for patent applications or awards. The other involves cash payments, starting at $2,500, for outstanding inventions. And at IBM Germany, there is a system of royalty percentage payments for outstanding inventions.

But the overriding attitude is still that engineers are expected to work for the company. They receive a salary so whatever they develop on company time and with company equipment belongs to the company.

Jean R. Chognard, general counsel at Hewlett-Packard Co., says there's another reason for not awarding royalties. "There may be hassles between supervisors and engineers over who was the inventor," he says. Often, he explains, a supervisor will suggest a development, and the engineer will work on it, leaving a question as to which is the winner. Not only that, but one component of a successful product may be patented, but may not necessarily contribute to its success. □

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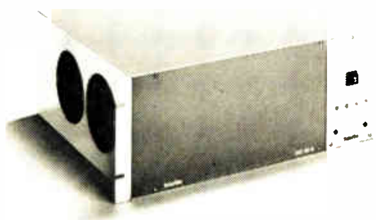

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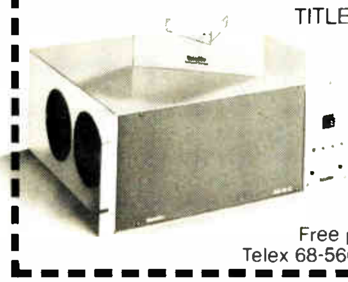

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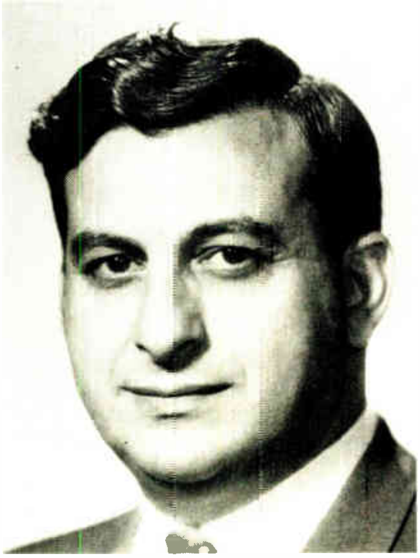
Longo: computer makers want I^2L



Dovetailing technology and application has been Thomas Longo's specialty at Fairchild Semiconductor for the past seven years. First he developed bipolar technology for high-speed computer memories; then he salvaged Fairchild's sagging MOS operation, making it into a profitable memory and microprocessor product line.

Now, as vice president and director of technology of Fairchild Camera & Instrument Corp., he must have one of the most educated opinions around on how the industry is taking its next big hurdle—LSI circuits for the next generation of big computer applications. Longo discussed the subject recently with the editors of *Electronics.*

Q. You've been involved in building high-performance circuits for the computer industry since before 1960, so you know that, except for some main memory, n-MOS hasn't made much impact on large- and medium-sized computer design. What are the prospects for large-scale ICs' meeting the needs of these mainframe computer manufacturers?

A. Right off, let me say that integrated injection logic is the only viable high-performing LSI technique suitable for main computer applications. And it's already happening, much to the surprise of a lot of people in this industry who said I^2L was a dud. I'm talking about 500-gate-and-up logic operating in the 1-to-5-nanosecond range and main memory below the 100-ns range. That's why we've aimed our whole I^2L effort at high-performing applications and not messed around like some others trying to make I^2L designs compete with our own MOS effort. It was these early nonproducts that gave I^2L a bad name—like the 4-bit processor slice that can't compete with anything.

Q. What do you say to the allegation that I^2L isn't a memory technology?

A. That's ridiculous. While our competitors were saying things like that, we were looking at an I^2L 4-k dynamic memory that operates in the 100-to-150-ns range with a chip no larger than MOS 4-k RAMs. Watch out for the self-serving statements. Companies that made their name in MOS say I^2L isn't good for anything, while big bipolar companies say I^2L will take over the world. Both are wrong—the two technologies have their place.

Q. How about in main memory? Why do some say that I^2L RAMs will never make it in the main memory because they'll be too expensive?

A. I can't understand why they'd say anything so ridiculous. With I^2L you can design as simple a 4-k dynamic cell circuit as with MOS. Then with Isoplanar you get the chip size down and the performance up.

Q. What price range are you talking about—$20 to $30?

A. No way—I'm talking about significantly less than $10 in volume production. That's a very small premium to pay over today's MOS devices when you consider the performance.

Q. What kind of demand in the computer industry do you see for I^2L?

A. We see a tremendous demand. There already are major applications for less than 150-ns I^2L parts and many more for under-100 ns. And I'm not talking about the small buffer- or cache-memory systems that always went to bipolar designs. I'm talking about volume memory for add-on and other high-performance main-memory designs. If you project the speed requirements over the next five years, you'll be amazed at the number of potential applications for sub-100-ns memory.

Q. What about logic?

A. It's a natural for microprocessors. I'd be a fool not to be working on combining I^2L with Isoplanar for microprocessors. You can create a very exciting 16-bit processor out of this technology.

Q. Turning to MOS, what are the prospects for pushing that technology into the TTL performance range—the under-5-ns speeds required for main computer designs?

A. I think V-MOS has promise in this area, but it requires considerably more process complexity. Whether it gives you a significant advantage over I^2L bipolar processing is still not clear. Certainly, it's worth investigating. But overall, I don't think that MOS will ever achieve the price-performance level that's possible with injection logic that's built with Isoplanar circuit technology. Again, with MOS you must so encumber the process to get the performance that you lose the low-cost MOS advantage. □

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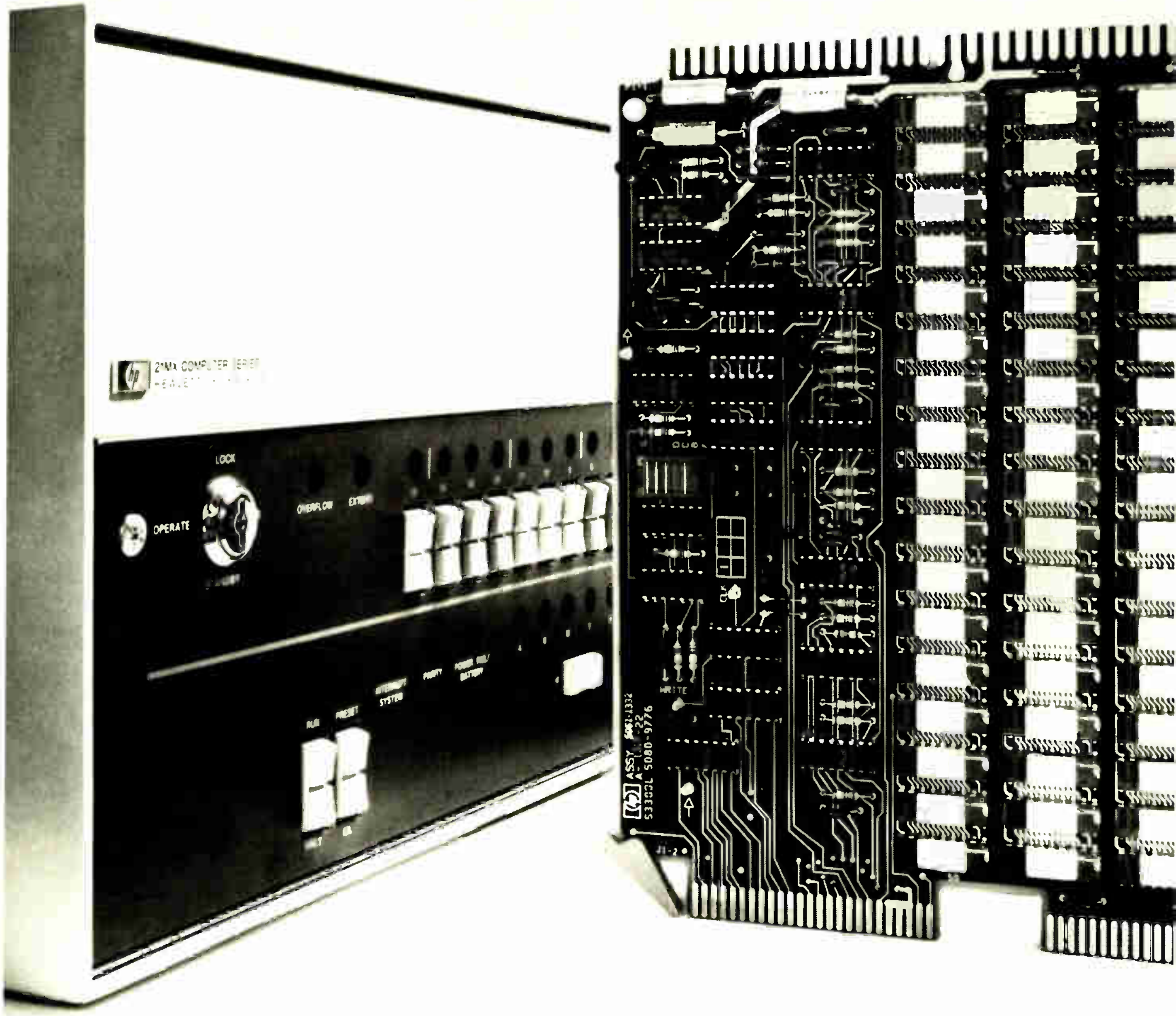

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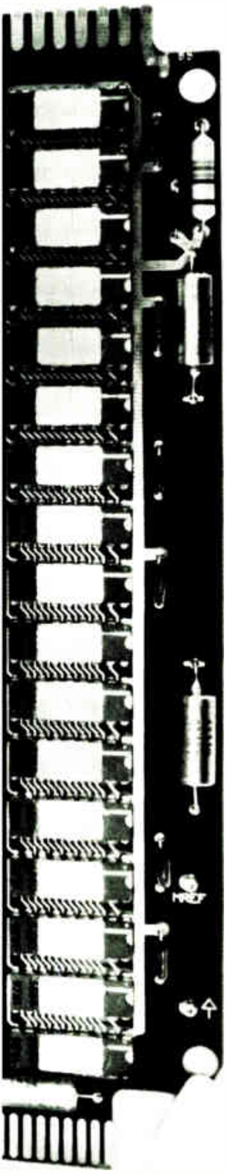

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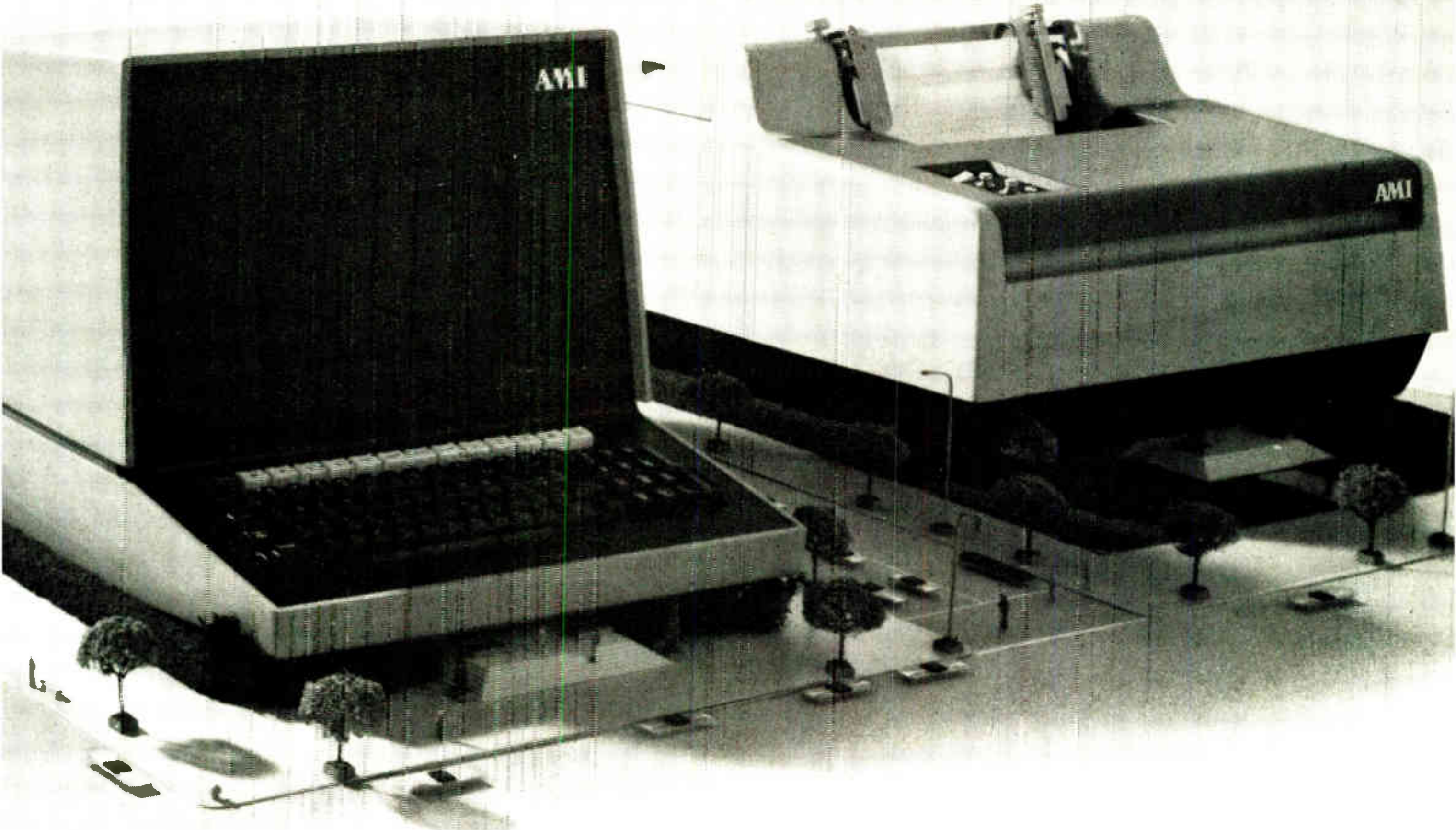

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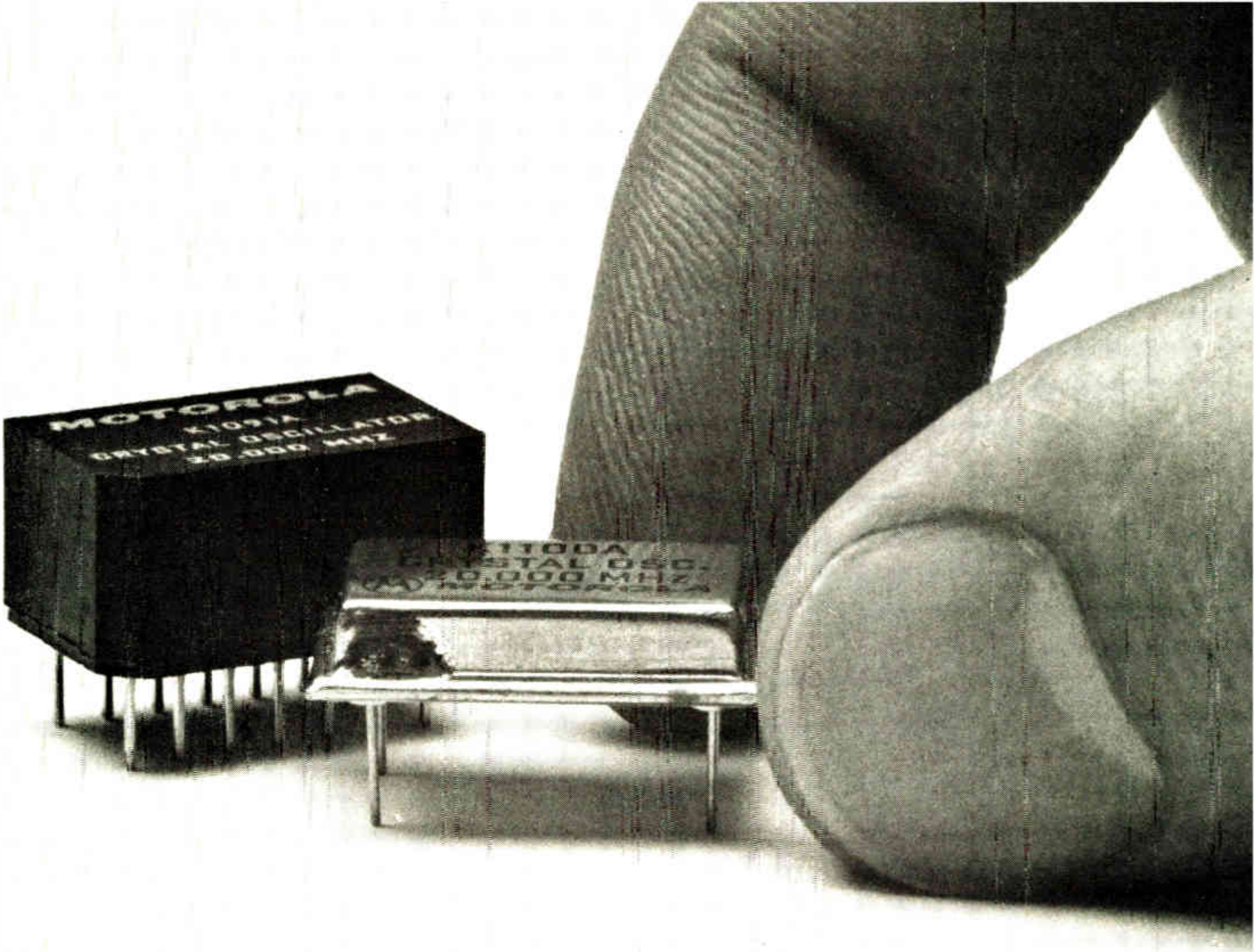
Circle 78 on reader service card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16-k RAM built with proven process may offer high start-up reliability

Designed with single-level polysilicon process, chip has 350-ns maximum access and power dissipation of no more than 550 mW

by Clinton Kuo, Nori Kitagawa, Deene Ogden, and John Hewkin, *Texas Instruments, Dallas, Tex.*

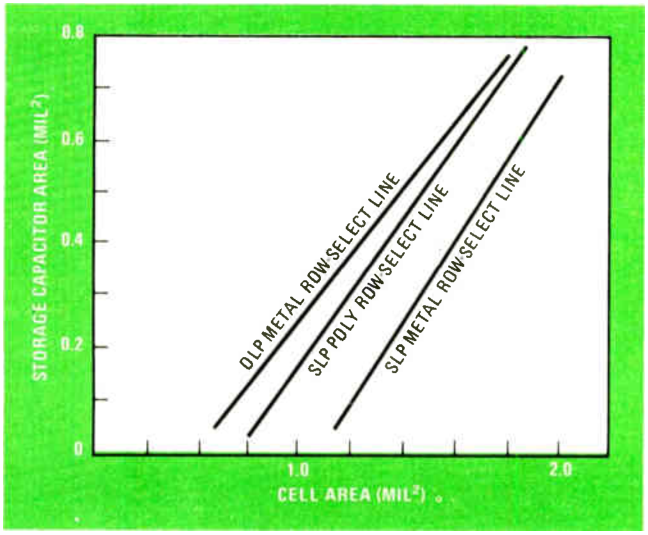
☐ Shunning the two-level process that most manufacturers feel is *de rigueur* for achieving 16-kilobit dynamic random-access memories, a 16,384-bit RAM employs the simpler single-level technique that's used in today's high-volume 4-k devices. With only slight refinements, this 5-mask n-channel process has produced a cell only marginally larger than those in the more complex 16-k designs, assuring reliable, volume production that presages steadily decreasing manufacturing costs.

The 16-k-by-1-bit TMS 4070 will be supplied in a standard 16-pin dual in-line package that's fully compatible with transistor-transistor logic—including clocks—and operates with multiplexed addresses. Thanks, also, to a more sensitive low-power sense amplifier and a power-saving chip organization, it dissipates only 550 milliwatts of power, no more than most 4-k RAMs. Memory boards using the new devices can readily replace those built with any 16-pin 4-k memory, without any increase in power-supply requirements for the system.

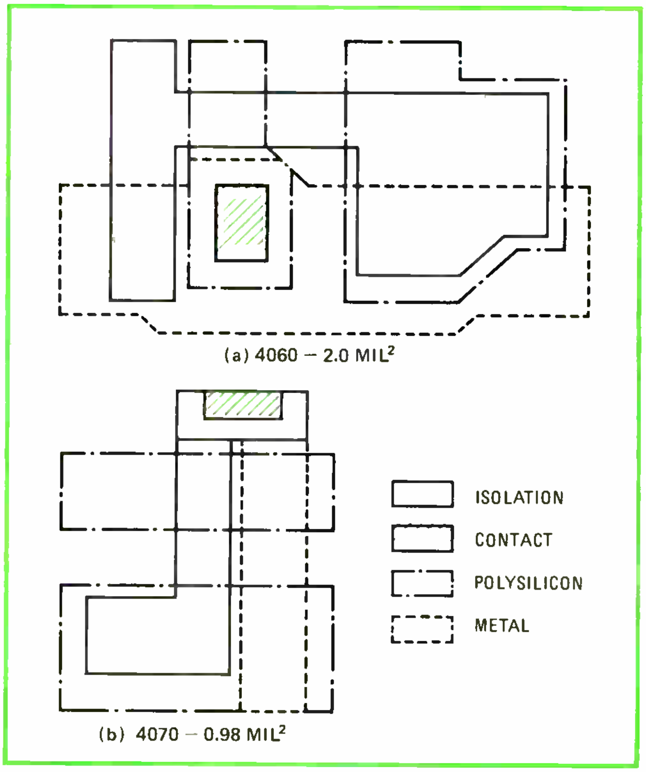
For the chip to fit into a standard 300-mil-wide package, the memory-cell size must be on the order of 1 square mil or less. There are two types of n-channel silicon-gate processes that will meet this requirement: single-level polysilicon and double-level polysilicon. [See *Electronics*, Feb. 19, p. 116, for details of these processes.] The DLP process can be used to lay out a one-transistor cell 10–15% smaller than one built by SLP, but this advantage comes at the expense of the more complex process.

Single-level works

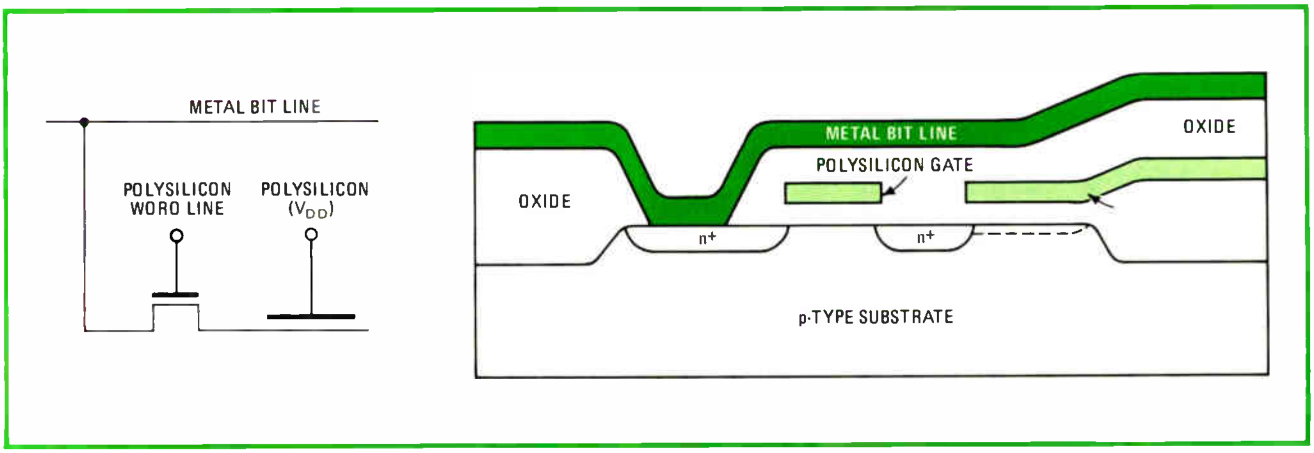
The TMS 4070 was designed with the simpler SLP process and polysilicon row-select lines. Figure 1 shows cell areas versus storage-capacitor size for the two processes, including two SLP cell layouts, one using metal row-select lines and the other using polysilicon lines.



1. Cell sizes. Double-level polysilicon gives a considerably smaller cell size than the single-level process, but it is a more complex technique. However, if polysilicon select lines are used with the SLP process, the difference in cell area is significantly reduced



2. Cell layout. The memory cell of the 16-k RAM is less than half the size of present 4-k RAM cells. The smaller size is principally due to a smaller cell capacitor as well as to tighter geometrics. Moreover, the 16-k cell has a lower-loss poly digit line.



3. Single-level polysilicon. Since only one level of polysilicon is required, the same 5-mask process that's used with today's 4-k RAMs can be applied to 16-k RAM design. This simpler process should have the advantage of better reliability compared to the double-level 16-k RAMs.

With these polysilicon lines, the cell size attained is only 0.98 mil^2, less than half the present 4-k RAM cell-size in production. And since the new device is fabricated with the same process as these 4-k memories, it benefits from proven production experience and reliability.

Figure 2 compares cell layouts of the TMS 4070 16-k and the TMS 4060 4-k devices, while Fig. 3 shows a cross section of the one-transistor cell of the 4070. Its size is achieved by a smaller storage-capacitor, which is made possible by a smaller digit-line capacitance and a higher-sensitivity sense amplifier.

Besides the higher density and potential savings over the 4-k devices, the 16-k chip also should have better reliability. Random, single-bit, "hard" failures related to thin-oxide defects make up 85–90% of the 4-k failures. Thus, as a first approximation, RAM failure rates can be assumed to be proportional to the total thin-oxide area, which is only 67% more in the 4070 than in the 4060. Therefore, significant reliability improvement on a per-bit basis is predicted for the 16-k RAM.

The organization is symmetrical

The device is organized for the best combination of high speed, low power dissipation, and maximum signal sensing. It is divided into two symmetrical arrays of 8,192 bits each (Fig. 4). To detect a cell's output, each array is serviced from its middle by 128 balanced sense amplifiers. Each sense amp handles only 32 memory cells, which minimizes amplifier loading and maximizes signal detection.

Moreover, when a bit is to be addressed, only one 8-k array is selected (through address bit A_6). This saves chip power, since only 128 of the 256 amplifiers are active at any time. Finally, locating the row decoder between the two 8-k arrays minimizes the length of the row, thereby minimizing the resistance-capacitance time delay of the polysilicon row-select lines.

To improve signal sensing still more, each 8-k array is subdivided into four 2,048-bit arrays. Each subarray's 32 sense amplifiers share an intermediate output buffer with those of another subarray. When the appropriate addresses (A_{12} and A_{13}) are activated to select a bit, only one of the subarrays need be addressed. Thus the selected devices are effectively isolated through the intermediate output buffer, further minimizing loading effects on the sense amplifier. It all adds up to a highly reliable switching and detection operation with 200 millivolts of sensing signal provided to the sense amp.

The sense amplifier: it's critical

Perhaps the most critical circuit element on a 16-k RAM chip is the sense amplifier: it must be sensitive enough to detect the fairly-low 200-mv signals characteristic of 16-k memory-cell operation, yet efficient enough to operate reliably while dissipating power in the low milliwatt range. With 256 sense amps on each 16-k chip, even a slight increase in power dissipation could be detrimental to overall performance of the chip.

As shown in Fig. 5, the sense amplifier in the TMS 4070 is a balanced flip-flop with a multigrounding path. Each side of the sense amplifier is connected to its row of 32 memory cells and to a dummy cell that provides a reference voltage for logic 1 and 0 signal detection.

During sensing, the selected memory cell dumps charge onto one end of the sense amp via the digit or bit line. This condition is shown in Fig. 5, where a storage cell, Q_X and the dummy cell, Q_D', are selected. At once the flip-flop goes into its unstable stage, with the switching direction determined principally by the difference between the flip-flop currents I_D and I_D' in transistors Q_2 and Q_2'.

Clearly, for the amplifier to detect the 200-mv signals coming from the storage cell, a high sensitivity is required. Using a standard measure of amplifier sensitivity, $(I_D - I_D')/I_D$, at a given time, t_0, then:

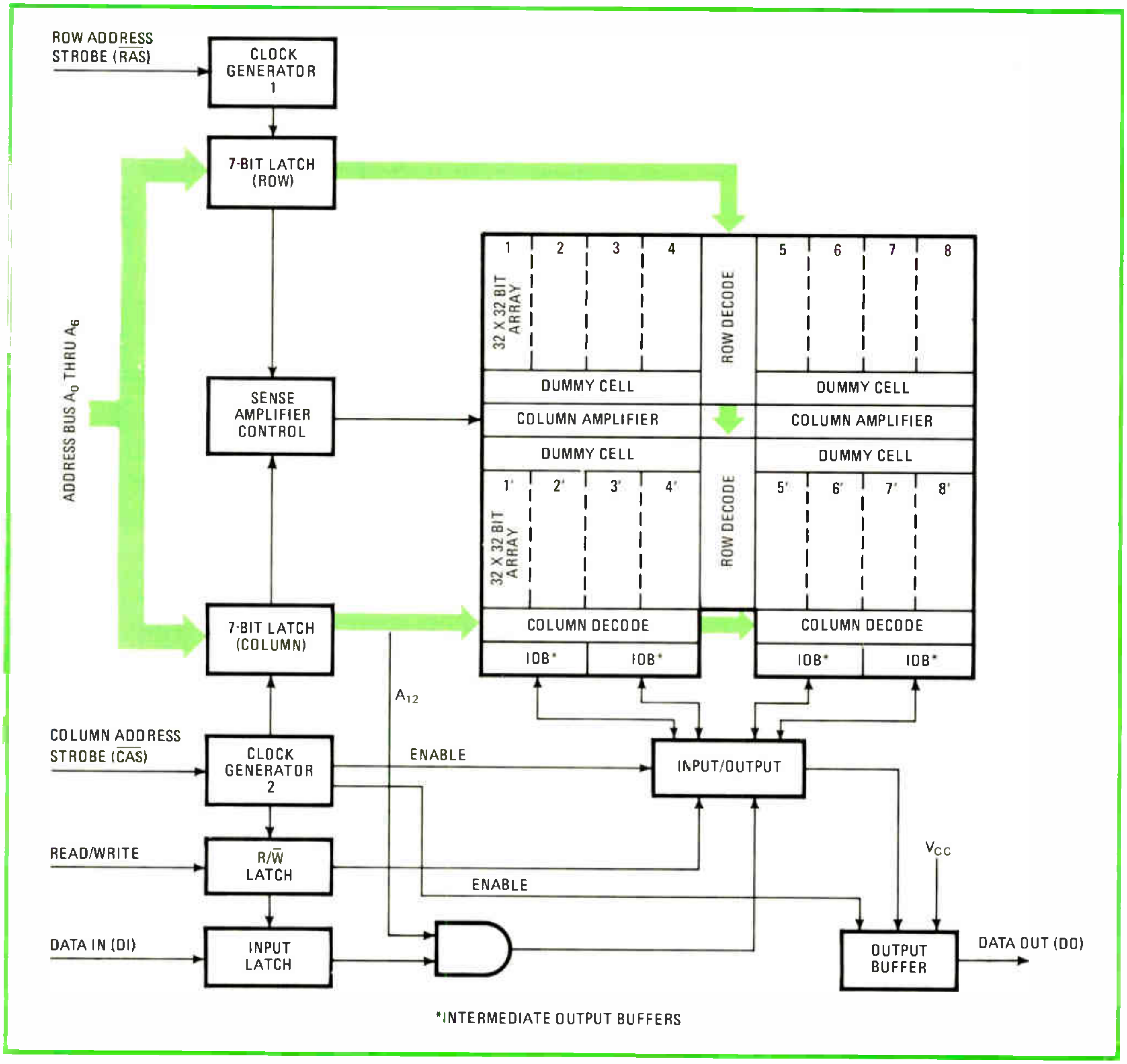
$$S\Big|_{t=t_0} = (I_D - I_D')/I_D\Big|_{t=t_0}$$

$$= \frac{K'(W/L)(V_D - V_0 - V_T)^2 - K'(W/L)(V_D' - V_0 - V_T)^2}{K'(W/L)(V_D - V_0 - V_T)^2}\Bigg|_{t=t_0}$$

or $$S\Big|_{t=t_0} = 2\Delta V/(V_D - V_0 - V_T)\Big|_{t=t_0} \qquad (1)$$

where $\Delta V\Big|_{t=t_0} = V_D - V_D'\Big|_{t=t_0}$

and W and L are channel width and length for Q_2 and Q_2', K' is the transistor constant, and V_T is the threshold voltage.



4. Organization. The chip is divided into two 8-k arrays, each connected to 128 balanced sense amplifiers in the middle of the array. For bit selection, address A_6 selects the right or the left array. Each array is further divided into four 2-k subarrays to improve signal sensing.

It is apparent from equation (1) that the higher is the differential output voltage V_O, the higher is the sensitivity. Moreover, a maximum value of V_O also will result in the lowest value of power dissipation in a sense amplifier, as shown in this approximation:

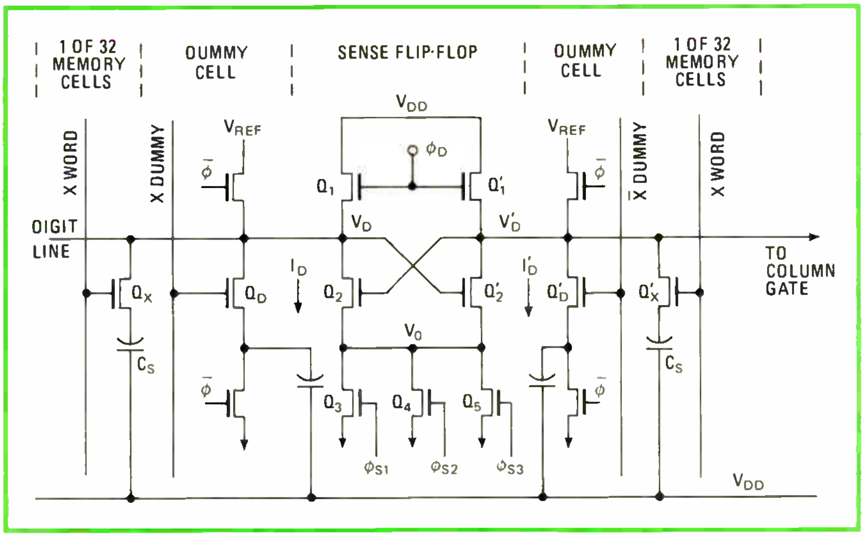
$$P_S = V_{DD}K'(W/L)(V_D - V_O - V_T)^2 \qquad (2)$$

A multiple grounding path that includes transistors Q_3, Q_4, and Q_5 achieves the highest value of V_O during sensing. During initial sensing, only Q_3 is turned on to provide the low output resistance needed to assure high V_O. After some delay from Q_3, transistor Q_4 is turned on to further enhance the signal by lowering V_O. After sensing is accomplished, Q_5 is switched on to provide a solid ground path, and therefore, good output signals.

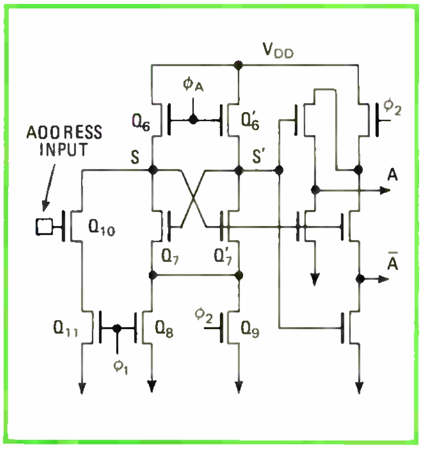
The power dissipation of the TMS 4070 is greatly reduced by switching off the sense-amplifier load devices Q_1 and Q_1' in all the nonselected 2-k arrays before the grounding transistor Q_4 becomes conductive. The high V_O made possible by the multigrounding path also adds reliability. It tends to prevent the precharged digit line of logic level 1 from dipping low during the initial sensing, thereby minimizing the time that Q_1 and Q_1' must be on to restore the bit line to its proper voltage level.

A new input buffer

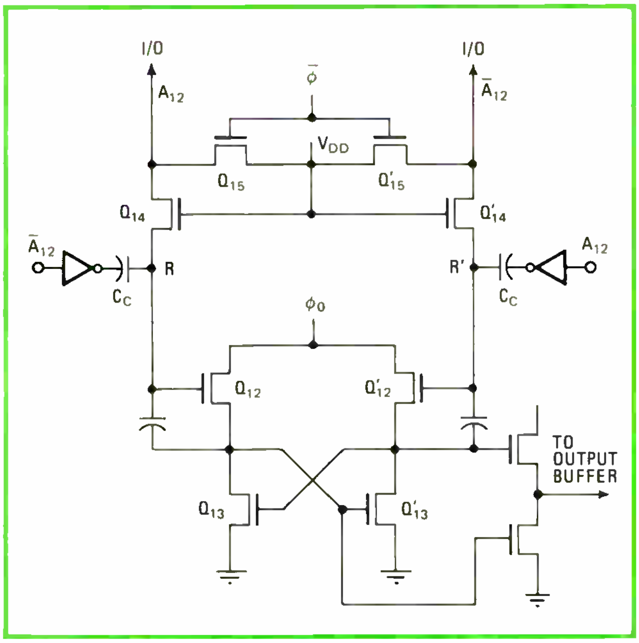
To make it easier to use the memory in a system, the TMS 4070 presents a purely capacitive load to all transistor-transistor-logic inputs, as well as possessing the required sensitivity for detecting standard TTL signals. This input compatibility, a feature absent from many 4-k RAMs, is made possible by a new input buffer design (Fig. 6). In that circuit, transistors Q_7 and Q_7' have



5. Multigrounding path. The sense amplifier achieves high sensitivity and low power dissipation by turning on grounding devices Q_3, Q_4, and Q_5 in sequence. This gives initial high grounding resistance for high sensitivity of differential voltage.



6. Easy interfacing. The input buffer also uses a differential sense amplifier with multigrounding path to reduce power dissipation. Transistors Q_7 and Q_7' have slightly different sizes for proper 1 and 0 detection.



7. Intermediary. It's the intermediate output buffers that allow each 8-k half to be divided into four 2-k arrays to improve signal sensing and to speed up signal transition. They are balanced flip-flops with the switching direction determined by Q_{12} and Q'_{12} voltages.

slightly different sizes to bias the flip-flop for detecting both 1 and 0 levels. Input 1 levels are detected by pulling node S toward ground through Q_{10} and Q_{11}. 0-level detection is guaranteed by the built-in preferred switching direction, which pulls node S′ toward ground through Q_7' (which is slightly larger than Q_7). Input signals are latched internally to simplify system timing.

The scheme for the multigrounding path in the sense amplifier is also in the input buffer circuit (Q_8 and Q_9 in Fig. 6) to reduce power and improve sensitivity. The design of the input buffer, involving purely capacitive circuitry, guarantees the absence of clock-related transient currents, which simplifies system design.

Output signals from the selected 2-k array are detected and amplified by intermediate output buffers that speed up signal transitions and add to the overall fast-access time of the device. Each buffer and the 2-k array it serves in the selected 8-k half are connected through the A_{12} and A_{13} decoding addresses (Fig. 4).

The intermediate output buffer

A schematic of the intermediate output buffer is shown in Fig. 7. Like the sense amp, it is a balanced flip-flop, but here the switching direction is determined by the voltage at the gates of the load transistors Q_{12} and Q_{12}'. The gate on the nodes R and R′ are charged high through Q_{15} and Q_{15}', with the voltage on the unselected side reduced by capacitive coupling through C_C to provide a reference voltage for logic-1 signal detection. If the $\bar{A}_{12}$ array is selected, and the data is logic 0, the Q_{12}' gate voltage will be lower than the Q_{12} gate voltage, causing the flip-flop to send a 0 to the output buffer. If the data from the $\bar{A}_{12}$ array is a 1, then, because of the capacitive coupling, the Q_{12}' gate voltage remains higher than the Q_{12} voltage and detection of the output signals is assured.

The clocked supply voltage Φ_D to the flip-flop, which is decoded by A_6 and A_{13} (Fig. 4), activates only the selected one out of four intermediate output buffers. Φ_D is delayed from the sense amplifier's load clock Φ_D to assure the proper timing sequence.

Because the output comes off the complementary side of the flip-flop, data from the A_{12} array will always be inverted by the intermediate output buffer. To provide the correct polarity, the data stored in the array is inverted before writing by the exclusive-ORing of the data input and address A_{12}.

Using the RAM

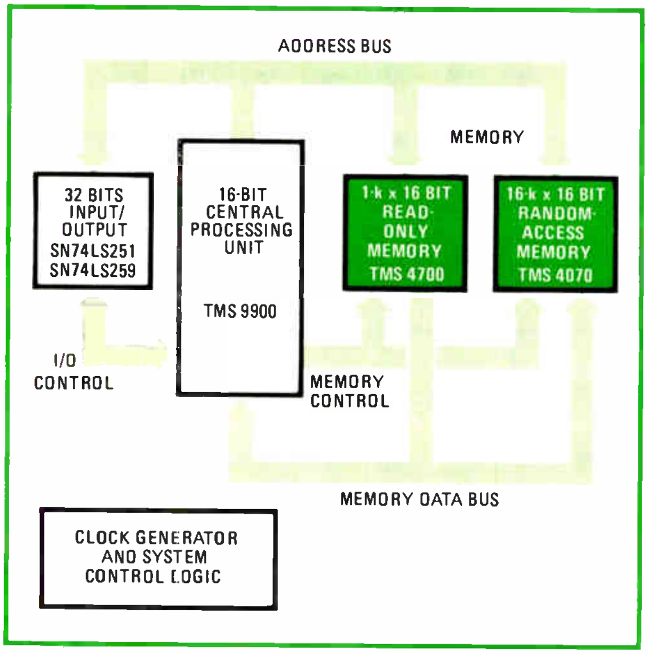
Fitting the TMS 4070 to the standard 16-pin format requires multiplexed addresses. This is accomplished with the leading edge of the row-address-strobe ($\overline{RAS}$) clock strobing in seven addresses, which are latched internally. The column-address-strobe ($\overline{\text{CAS}}$) clock handles the seven column addresses and serves as chip-select control to activate and deactivate the data input and output buffers. This function allows $\overline{\text{CAS}}$ to be used efficiently for a multichip memory board design, as will be discussed later.

The chip has a maximum access time of 350 nanoseconds from $\overline{\text{RAS}}$ initiation and a minimum cycle time of 550 ns. The typical active power dissipation at room temperature is only 550 mW, with a typical standby power consumption of only 8 mW. The fully-TTL-compatible input signals have typical maximum permissible 0 levels of 0.6 V and minimum permissible 1 levels of 2.2 V, thus guaranteeing a comfortable 200-mV dc noise margin in both 1 and 0 states when used with typical input and output devices.

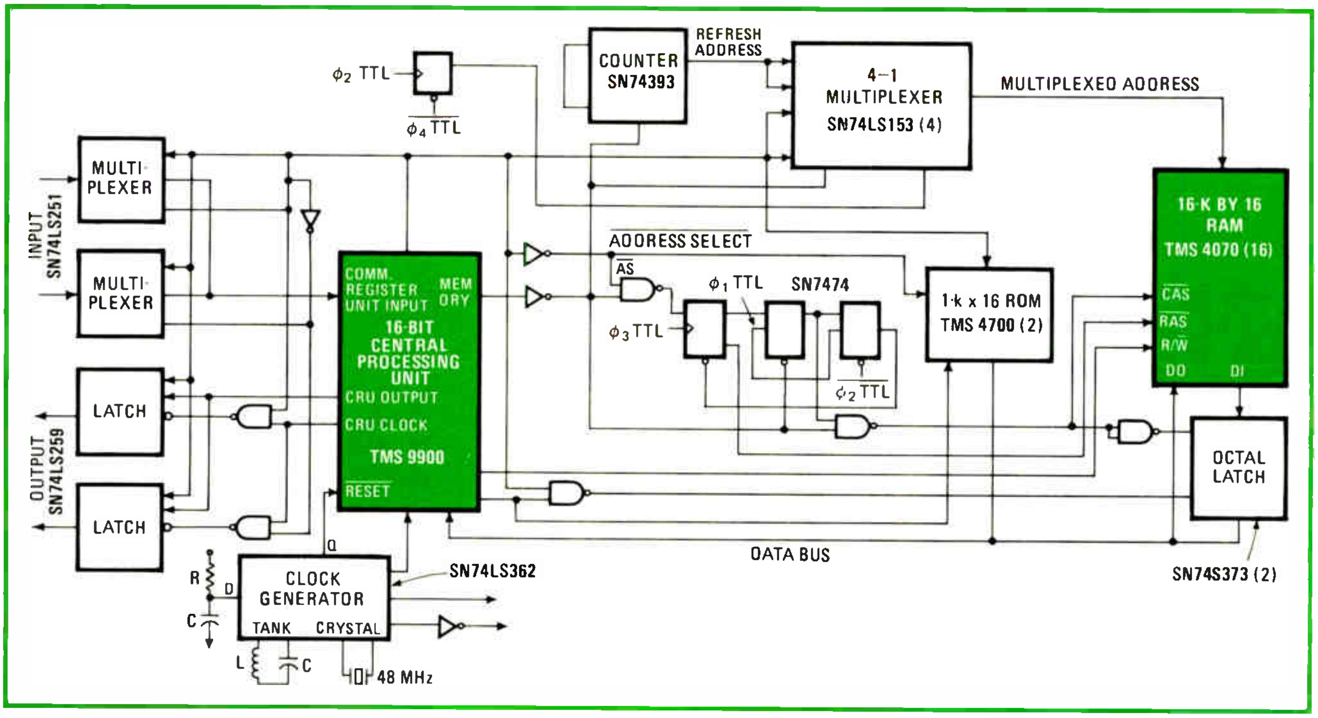
Unlike other proposed 16-k RAM designs, the output buffer of the TMS 4070 is nonlatched and assumes a high impedance state when either $\overline{\text{CAS}}$ or $\overline{\text{RAS}}$ is inactive. Nonlatched outputs allow the device to be wire-ORed in a typical memory system by using the $\overline{\text{RAS}}$ as chip enable and the $\overline{\text{CAS}}$ as chip select control. Thus data output is valid only during the time both clocks are active, and each memory cycle can be maintained as a separate entity. Latched outputs, on the other hand, hold the data output valid into the succeeding memory cycle and need an extra $\overline{\text{CAS}}$ cycle to clear the latch, thus adding to the cycle time of the memory system.

The unlatched output also facilitates transparent refresh techniques, particularly beneficial in larger memory systems. Usually a refresh operation must be performed at least every 2 ms to retain data. With the 4070, this may be accomplished internally, using the $\overline{\text{RAS}}$-only mode of 128 refresh cycles. Since $\overline{\text{CAS}}$ is inactive in this mode and the output is in the high impedance state, there can be no output during refresh, which eliminates the need for disabling circuitry.

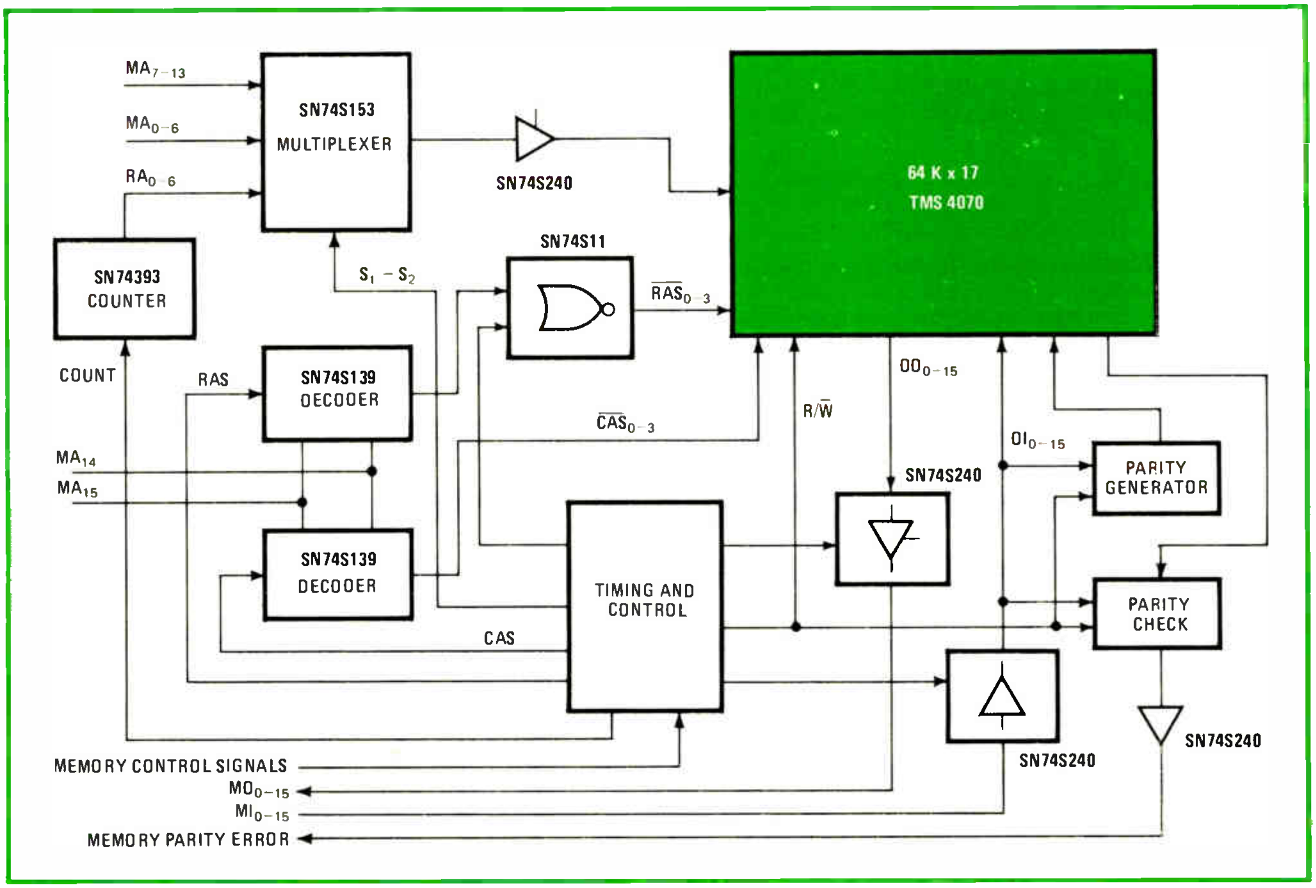
Fig. 8 is an example of a microprocessor system using the new device. Here a TMS 9900 16-bit microprocessor system consists of a block of 1,024-by-16-bit read-only memory, a block of 16-k-by-16-bit RAM, and 32 bits of input/output logic. This is a typical configuration for equipment where a large, high-speed data buffer is re-



8. Microprocessor system. The microprocessor, using a 16-bit TMS 9900, has a 16-k-by-16 RAM and a 1-k-by-16 ROM. This minimum system, which also includes 32 bits of input/output, requires only 36 logic packages; but it emulates minicomputer performance.



9. Logic diagram. The dynamic RAM interface to the TMS 9900 includes a SN74393 refresh counter, SN74LS153 address multiplexers, SN74S373 octal latches, and miscellaneous logic gates. The entire microcomputer system is implemented in only 36 packages.



10. Minicomputer memory. The 16-k random-access memory allows minicomputer engineers to design memory systems with a memory capacity of 64-k-by-16 bits on one printed-circuit board. (An additional bit is furnished for parity check.)

quired such as in a word-processing or data-concentration system.

Here the TMS 4070 could best be used in the transparent refresh mode. A refresh always occurs during the first nonmemory cycle following a memory access (each cycle consists of two clock periods). The worst-case condition of the lowest frequency of refresh cycles is during the DIVIDE instruction—five cycles during the 41.33-microsecond execution time, or an average of one refresh every 8.3 μs. So the longest complete refresh of the chip will require only 1.06 ms (128 refresh cycles x 8.3 μs), which is well below its minimum refresh rate of 2 ms. This allows the TMS 9900 to run at the guaranteed frequency of 3 megahertz with no overhead time required for memory refresh.

The operation of this memory system is extremely straightforward. A memory-enable signal from the TMS 9900 indicates a valid memory cycle and is used along with address select, $\overline{AS}$, to initiate the flip-flop timing chain. These flip-flops generate $\overline{RAS}$ and $\overline{CAS}$. The enable signal is used also to increment the refresh counter and to control the address multiplexer, which selects refresh address, row address, or column address.

Figure 9 presents a detailed logic diagram of the system. The logic in the memory controller is all that is required to interface the 4070 to the 9900 memory buses. The other components include a 32-bit input/output interface, a SN74LS362 clock generator and driver, and a SN74S373 octal latch, both for providing high-impedance buffering when the data bus contains write data and for holding the 4070 output data during a data cycle. The entire system contains only 36 packages.

Minicomputer/mainframe applications

The 16-k RAM also is attractive in minicomputer and mainframe applications. It can provide greatly improved board densities compared to current 4-k designs. As an example, a circuit board that supports 16-k words of 16 bits of 16- or 18-pin 4-k RAMs will easily support 64-k words of 16-bits using the TMS 4070.

Figure 10 is a block diagram of a system of 64-k by 16 bits with an extra bit for parity check that would work with a typical 16-bit minicomputer. A multiplexer, SN74S153, is used to select a row or column address for the RAM array. Optional buffers are shown for data-inputs DI_{0-15} and data outputs DO_{0-15}, although the 4070's output can drive two TTL loads, adequate for many minicomputer systems.

The timing and control block interfaces with the memory control bus and provides row address and column address strobes, $\overline{RAS}$, $\overline{CAS}$, as well as a refresh access (RFACCR) signal. The SN74S139 decoders generate the signals to the array from $\overline{RAS}_0$ to $\overline{RAS}_3$ and $\overline{CAS}_0$ to $\overline{CAS}_3$.

To generate $\overline{RAS}$for refresh cycles to all arrays, SN74S11 gates are put between the SN74S139s and the RAMs. The complete system with parity check takes only 85 packages. □

MOS technology brings fun and games to TV sets

Digital integrated circuits take over ultrasonic TV-tuning functions, as well as display of channel numbers and time; an IC in the receiver provides games like soccer, volleyball, and steeplechase in color

by Marijan Lorkovic, *ITT Intermetall GmbH, Freiburg, West Germany*

☐ Within a relatively short time, European manufacturers have turned to complex MOS integrated circuits to provide de luxe features for color-television receivers. Among these conveniences are remote channel selection and on-screen displays of channel numbers and time.

Although bipolar technology originally dominated TV applications, MOS circuits now outnumber them, chiefly because of the low power requirements of MOS and the ease with which new features, such as TV games, can be added. Silicon-gate technology makes possible higher packing density than bipolar parts can offer to make these features economical. In fact, some IC functions in TV receivers would be impossible to implement efficiently without MOS technology.

Although the trend toward MOS enhancements started in Europe about two years ago when ultrasound remote channel-selection controls were introduced, ultrasound control is now being used in most large-screen sets now being produced in West Germany and about a third of those manufactured in all of Western Europe. Also coming on fast are digital electronic tuning and elaborate on-screen displays.

Happily, viewers may soon be able to play video games at home by virtue of MOS circuits designed to fit inside the receivers. And now that conventional tuning methods are being replaced by techniques based on MOS voltage- and frequency-synthesis tuning, even basic receiver design is undergoing an evolution.

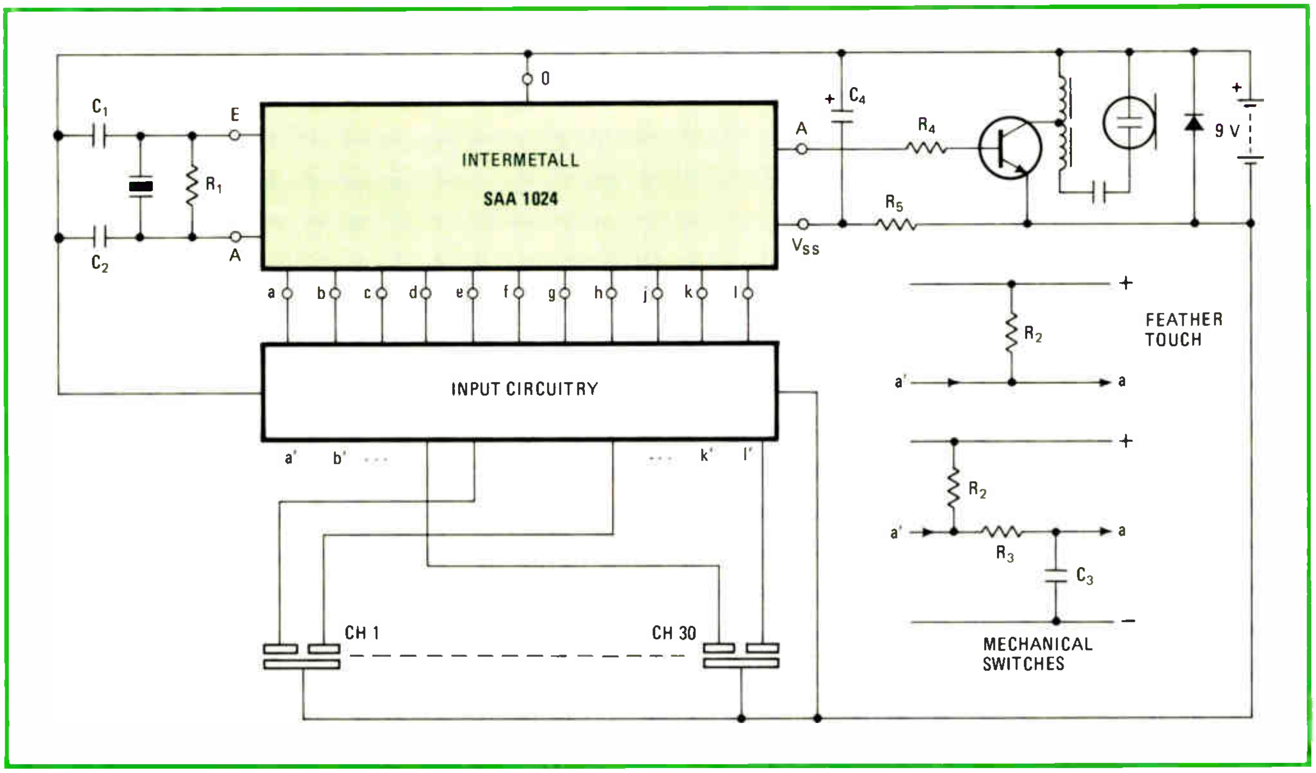
1. Remote connection. A recent use of MOS technology for television receivers is the hand-held ultrasonic transmitter unit designed for remote control of channel selection, picture tuning, and volume control. This unit can handle up to 30 commands if needed.

Remote ultrasound clicks for channel selection

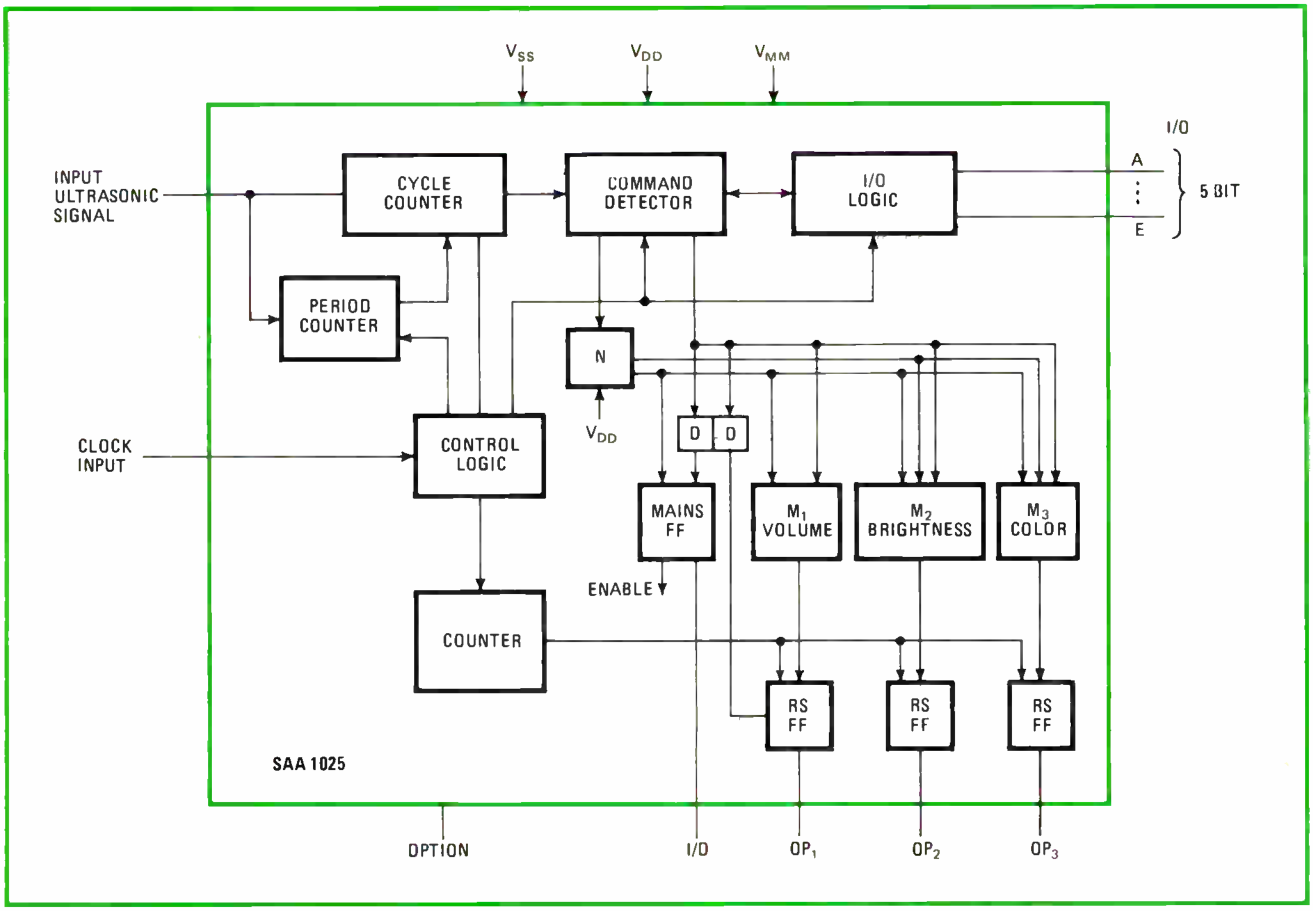
The ultrasound channel selector contains two key MOS devices, a transmitter and a receiver, although the system may also provide additional functions. A typical basic system can handle 30 different commands.

The 30-command transmitter (Fig. 1) contains a complementary-MOS device to generate the ultrasonic signals and process them for transmission to the receiver IC inside the TV set. In standby, this circuit need never be turned off because it normally consumes only about 10 microamperes from a conventional 9-volt battery, which can power it for about a year.

The Intermetall SAA 1024 transmitter contains an oscillator, an adjustable frequency divider, an integrated decoder, and an error-protection logic circuit. The divider produces any of the 30 ultrasonic frequencies from the 4.4336-megahertz quartz-crystal stabilized oscilla-



2. Sending the message. The ultrasonic transmitter unit is built around this MOS integrated circuit, which consists of an oscillator, an adjustable frequency divider, an integrated decoder, and an error-protection logic circuit which prevents wrong signals from being processed.



3. Receiving end. The ultrasonic receiver IC is an MOS device that processes the ultrasonic commands coming from the transmitter unit. Frequency of the received signal is counted twice to ensure that the correct one is processed.

tor. The appropriate dividing factor is selected by an input code.

By pushing a key on the hand-held transmitter, the viewer selects two input lines—one in the group designated A to E, and the other from f to l (Fig. 2). These two-pole key switches may be mechanical or touch-type.

The device in the ultrasound transmitter unit enables selection of any of 16 TV channels. Assigned to each channel is an ultrasound frequency that is generated by an adjustable frequency divider in the IC. Much the same technique is used for the analog functions—brightness, volume, and color saturation. There are two buttons and two ultrasound frequencies for each of these functions—one for increasing the setting and the other for decreasing it.

When one of the buttons is pressed, a code word is produced at IC input pins A to E and f to l. This code word consists of 11 bits, only two of which represent a logic 1, so that push buttons need only two contacts.

In the IC, the command is converted into 5-bit words. Each command then changes the output frequency by changing the divider factor of the adjustable frequency divider. When the button for, say, raising the volume, is pushed, the 8.99-kilohertz pulse at output OP_1 of the ultrasound receiver IC (Fig. 3) is converted into 30 steps. Going through the entire volume range takes about 5.5 seconds if the button is kept depressed that long. The pulse train is rectified and fed to the sound circuits of the TV set.

The integrated decoder converts the key-selected signals into 5-bit words and feeds them to an adjustable frequency divider, where the desired ultrasound-command frequency is produced by blanking principles. Another fixed divider reduces the jitter that is unavoidably produced in the adjustable divider.

The ultrasonic frequency range of the command signals extends from about 33.8 kHz to 44.16 kHz, and adjacent frequencies are separated by a space of about 346.6 Hz. If a key erronously sends more than one signal to the A-to-E or f-to-l inputs, the error protection logic circuit recognizes the fault and switches the oscillator off.

Transmitting the commands

The transmitter output is a rectangular signal that controls a switching transistor. A coil in the transistor's collector circuit, acting as an autotransformer, produces a sinusoidal voltage of about 200 V, which drives the ultrasonic transducer, a capacitive-type loudspeaker. In parallel with the coil is a diode that furnishes the required 100-V dc bias for the loudspeaker.

The IC at the heart of the ultrasound receiver in the TV set (Fig. 3) is a silicon-gate MOS device that processes the ultrasonic commands coming from the transmitter. To ensure that only the signals from the ultrasound transmitter are processed, the received signal frequency is measured twice. For one measurement, a 4.4336-MHz oscillator provides the time base, and the other is a period-measuring process.

The signal is processed further only if the two frequency measurements produce the same result and only if the period measurement confirms that the signal's period corresponds to the desired frequency in the 33.8 to 44.16-kHz ultrasonic range. If all requirements are met, the signal is converted into a five-word code and fed to the outputs of the receiver integrated circuit.

The selected channel number, in the form of a binary-coded word about 23 milliseconds long, appears at the appropriate output between A and E. Outputs of OP_1, OP_2, and OP_3, derived from three 5-bit up/down counters M_1, M_2, and M_3, are 8.99-kHz rectangular signals for controlling volume, brightness, and color saturation. The duration of these signals can be varied in 30 steps of about 200 milliseconds each.

Amplifying the ultrasonic signal

In the outboard circuitry of the receiver IC, the preamplifier boosts the ultrasonic signal picked up by a microphone to an amplitude of 0.5 V. This preamplifier should be designed for a gain of about 70 dB for transmission distances of 6 to 10 meters. It should also have bandpass characteristics to eliminate the effects of stray signals, such as the second and third harmonic of the TV set's line frequency that could otherwise interfere with the operation of the receiver IC.

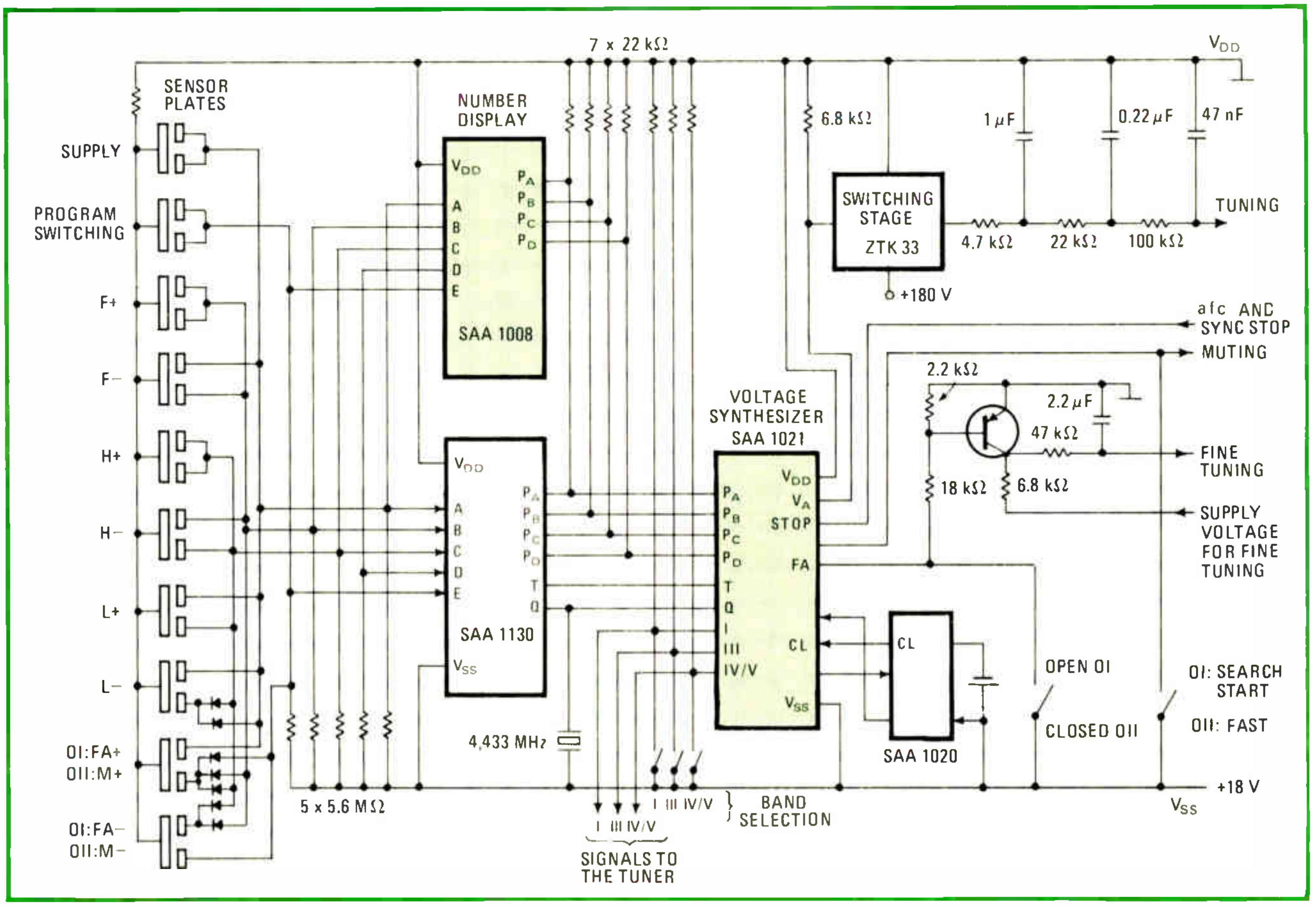
In addition to selection of channel number and control of volume, brightness, and saturation, the system also provides for a number of other settings. Color saturation and brightness can be set to their normal or mean levels by a command called "normalization." Another command switches off the sound. When the set is turned on again, the same sound level is maintained.

What's more, receiver-IC input/outputs A to E can come as direct commands from either mechanical or touch-type contacts on the set. In the direct mode, inputs are coded in a matrix and applied to pins A to E.

There, the microampere-level input commands have their impedance reduced to get the low ohmic values needed to drive decoders. The decoder converts the signals to select the channel numbers. The direct analog commands for volume, brightness and saturation, which are also present at pins A to E, produce the appropriate changes at outputs OP_1, OP_2 and OP_3. Channel-selection commands can be entered directly either between the IC and the external decoder or between the decoder and channel-memory circuits.

However, the versatility of this device is overshadowed by a new 30-channel silicon-gate MOS ultrasound receiver IC being offered in an 18-pin plastic package (Fig. 4). This chip has the capability to adapt to future ultrasound-controlled TV receivers, as well as several other advantages. A major improvement is elimination of external memory needed in the earlier system to store channel-number data. The new chip stores that data in an integrated memory, and it is available in static form at outputs P_A to P_D so that the IC can directly drive both a channel-number-display IC and a voltage-synthesizer IC.

Although the process is similar to that of the earlier device, the new one also permits finer adjustment of the analog controls because it is implemented in 61 steps instead of 30. The analog commands for volume, brightness, and color saturation change the pulse/interval ratios at the analog outputs in the same way. Channel-selection commands can be entered directly and se-



4. Television pickup. The receiver IC for this channel-selection and tuning system can directly drive an IC to display the channel number and a voltage-synthesizer IC. This setup eliminates the external channel memory required in previous units.

quentially. In addition, the oscillator circuit is integrated so that only one external component—a quartz crystal—is needed.

Another innovation for which MOS technology is also suited is on-screen display of channel numbers, preferably near the edge of the screen. For such displays, the digits must be large enough and have enough contrast to be readable from a distance against either a black-and-white or color picture. The display should be visible only for 2 to 4 seconds and should appear automatically as channels are switched.

An integrated circuit that meets this requirement, the SAA 1008, is being offered in an 18-pin dual in-line plastic package (Fig. 5). The MOS silicon-gate circuit consists of a decoder, a display memory, and a shift register. The 2.2-MHz clock frequency, which is produced internally, can be fine-tuned by means of only one external resistor divider. The clock frequency determines the width of the dots that make up the digits and the distance of the background field from the left edge of the screen. An external resistance/capacitance network sets the duration of the display. The vertical and horizontal flyback pulses synchronize the signals to produce a stationary display.

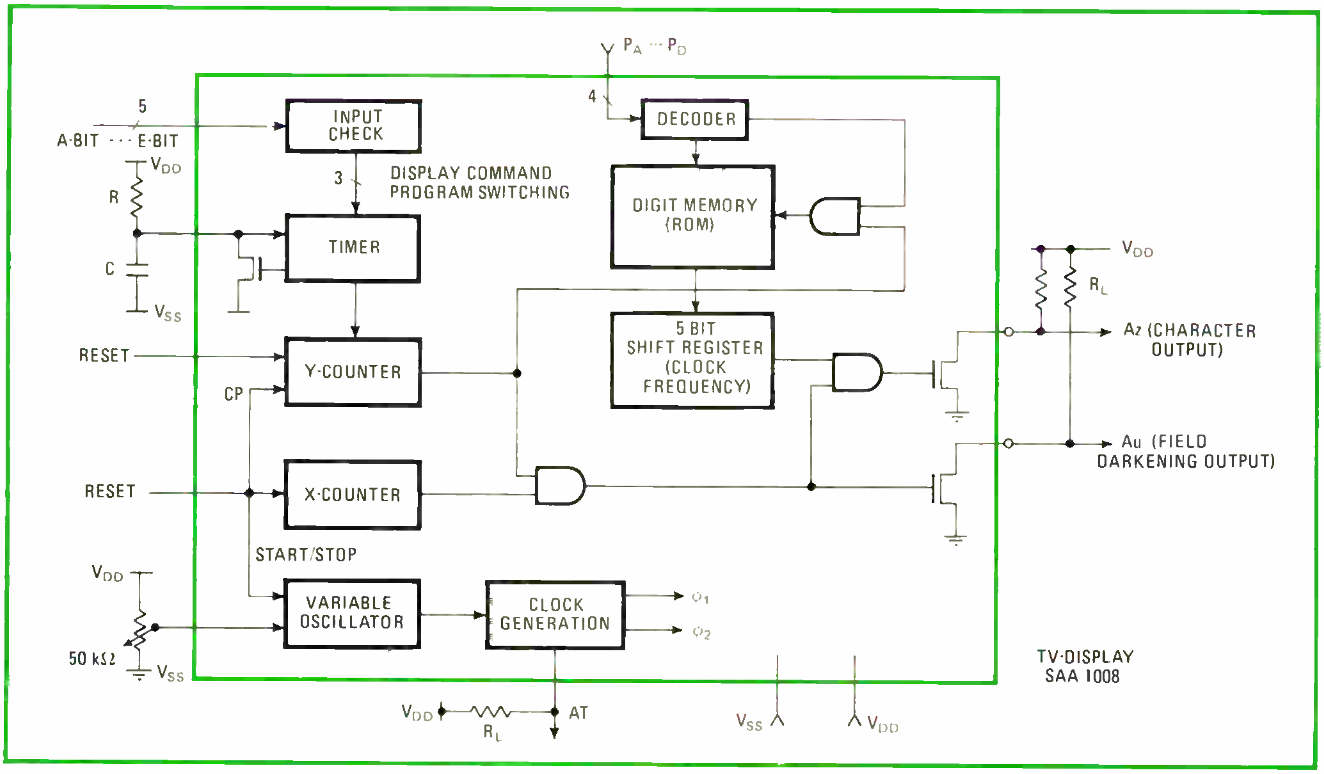
Single-digit channel numbers are formed by a 5-by-7 dot matrix against a dark 7-by-9 dot background, and double-digit numbers appear on a 2-by-7 dot matrix against a dark 4-by-9 dot background. Each dot is made up of six TV-line segments, 0.4 microsecond in duration. The background field starts 114 lines from the upper edge and about 86 dots from the left edge (Fig. 6).

Also under development is another version of the display IC that, in addition to providing the channel number, will display on a 12-by-7-dot field in the upper left-hand corner of the screen the letters F, H, and L (for the German words meaning color saturation, brightness, and volume) as well as a plus or minus sign behind each letter to indicate which way these settings are moving.

To display the F, H, and L, a 5-bit word is entered at the dynamic inputs of the receiver. The device will also display the tuning voltage and indicate the band and channel numbers. And by adding an IC, the time of day can also be displayed. This display can also be turned on and off by ultrasound commands.

The channel number is displayed whenever 4-bit channel information from the ultrasound receiver IC is changed, when the channel-switching or recall commands are recognized, or when the digital tuning information is present. The channel number symbols, shown at the left edge of the screen about half-way from the top, consist of a 4-by-5 matrix of nearly square dots.

To represent the tuning voltage, the externally coded band data and the digital tuning voltage data are evaluated. The TV-band number appears as a Roman numeral I or III or as the letter U for ultrahigh-frequency bands IV and V in the field where the three letters are



5. Display it again. The on-screen display IC consists of a decoder, a display memory, and a shift register. The clock frequency determines the width of the dots that make up the digits and also determines the distance of the background field from the left edge of the screen.

usually shown.

Right below it is a rectangular, vertically positioned field that's divided by horizontal lines into five equal sections. The upper and lower sections display the number of the channels at the upper and lower limits of the band. In band I, these limit channels are 4 and 2; in band III, they are 12 and 5, and in the uhf band, they are 69 and 21.

To indicate time, there are two character fields—one for hours and the other for minutes—made up of 4-by-5-dot matrixes. Seconds are indicated by a flashing colon between the hours and minutes.

Voltage synthesizer also goes MOS

Another new MOS product for TV receivers is a set of voltage-synthesizer ICs that constitute a digital-to-analog converter and memory for tuner control. These ICs can replace the potentiometer arrangement now used for setting and storing the dc voltages corresponding to the various TV channels. ICs have two advantages over potentiometers: channels can be selected by an automatic search, and more channels can be stored.

The voltage-synthesizer IC set, designed to handle 16 channels, is fully compatible with the ultrasound receiver and display ICs, as shown in Fig. 4. The set consists of a control circuit and a memory circuit. The former supplies band-switching signals in uncoded form and also a 558.67-Hz pulse-modulated output voltage from which the dc-tuning voltage is obtained after an integration process. This voltage is then fed into the tuner varactor diodes. Both the tuning voltage and the band-switching signals for all 16 channels are stored in the memory IC.

The control IC, which is a silicon-gate MOS device in a 24-pin plastic dual in-line package, can be driven directly by the ultrasound receiver IC, which supplies the channel number in coded form. Available at pin T on the receiver IC are either 20-microsecond or 23-millisecond pulses at 138-ms intervals, which determine the circuit's control functions. The IC can be used with or without automatic frequency control. In the afc mode, channels are found by automatic-search tuning, and the dc voltages corresponding to the stations are stored in a separate memory IC. By means of pulse-width modulation, the 558.67-Hz output voltage for driving the tuner is varied in 3,968 steps. It is then smoothed by a simple RC network and applied to the TV tuner.

The speed of the automatic search adapts to the slope of the tuner's voltage/frequency curve in the individual bands. This search, which starts with zero voltage at the output of the IC when a button on the TV set is pushed, proceeds in one direction. When a channel is found, an automatic-frequency-control signal stops the search.

To restart, the button must be pushed again. When the highest voltage level is reached, the output signal jumps back to zero, and, after an 80-ms delay, the search is resumed. Each output signal can be fine-tuned in both directions in seven small steps via ultrasound remote control or by push buttons on the set.

In the non-afc mode, the fine-tuning output is connected directly to the 18-V V_{SS} line (Fig. 4). In tuning, the output voltage can be made to go in either direction, either by a combination of discrete steps and continuous slow variations or by continuous fast variations. The discrete steps and slow variations can be controlled by two ultrasound commands. About 0.6 second after a

6. Channel 15. The channel display for double-digit numbers is a 2-by-7 dot matrix against a dark 4-by-9-dot background. Each dot is made up of six TV-line sections, each 0.4 microsecond in duration.

key is pushed, a step changes into a slow variation. Fast variations, on the other hand, can be started only at the TV set through direct input to the control IC.

The memory IC in the voltage synthesizer is a low-threshold C-MOS static shift register that requires a voltage supply of 1.2 to 2 V. It contains 16 memory addresses of 18-bit words, each with 12 bits for tuning information, 3 bits for fine-tuning, and 3 bits for band information. This device connects to the control IC via three lines—one each for the first and last shift-register stages, and the third for clock signals.

Built-in games are coming

Intermetall is developing an IC that will become the heart of on-screen game circuitry. Installed in the receiver, the IC makes possible games like soccer, steeplechase, volleyball, and table tennis. On color sets, the games can be shown in different colors. The device eliminates the need for very-high-frequency signal transmission via antenna cables between the TV set and the game-control deck. Instead, the receiver and the control box are connected via cables that transmit dc signals only. Intermetall is also working on a transmission system for TV games that uses digital ultrasonic commands to execute the functions performed by conventional potentiometers.

The game IC integrates a 1-MHz clock oscillator with an external quartz crystal. The basic 1-MHz frequency provides the vertical and horizontal synchronization pulses used for driving the television receiver. The screen shows the playing field, the lines representing the goals, the "players," and the "ball," as well as the score for each player.

For input in the games of soccer, steeplechase, volleyball, and table tennis, the IC needs such information as the player movements, action of the ball, and playing direction. This IC supplies red-green-blue or color-difference signals, as well as tone signals, to produce a sound when a player and the ball touch each other.

Depending on the player's role at the time, the IC recognizes the relationship between the ball and offensive players, defensive players, the table, the net, and the goals, or the hurdle in steeplechase. The IC also advances the counters for the scoreboards.

In the soccer game, the field is represented on the screen, and there is a potentiometer for each player. The offensive player varies the vertical position of the ball, while the defensive player varies the vertical position of the goalie. The IC automatically switches between the offensive and defensive roles. The ball, which is always at the same distance from the upper edge of the screen as the active player's goal, travels at a horizontal speed that decreases as a function of a constant base of the logarithmic system.

The movement of the ball changes direction when it touches the defensive player's goal, goal posts, goalie, or boundary line. When the ball touches the goal, the "ball" signal is blended out for as long as it takes it to reappear at the mid-line of the field. Should the ball touch the boundary line, the signal is blended out until the ball is in line with the goalie.

Since the ball's vertical position corresponds to the vertical position of the goalie, it emerges from the goal keeper as though it had been kicked off. When the ball hits the active player's own defense, it goes right through and is kept in play. Ball speed can be adjusted by a potentiometer. With a variable resistor, the ball's horizontal dimension can be changed to adapt to the size of the screen.

In the steeplechase game, the runner is controlled by controlling the same circuitry as that used for controlling the ball in soccer. When a capacitor is charged from a constant-current source instead of a resistor, the runner moves at a constant speed. For volleyball, the on-screen field appears as a side view so that the players observe the ball's altitude. For table tennis, the control circuitry is the same as that for volleyball, although certain inputs of the signal-generating circuitry must be switched. Triggering then occurs with a vertical synchronization pulse, since the players move vertically. □

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Circle 93 on reader service card

Potentiometer and timer control up/down counter

by Frank Gergek
Weston, Ont., Canada

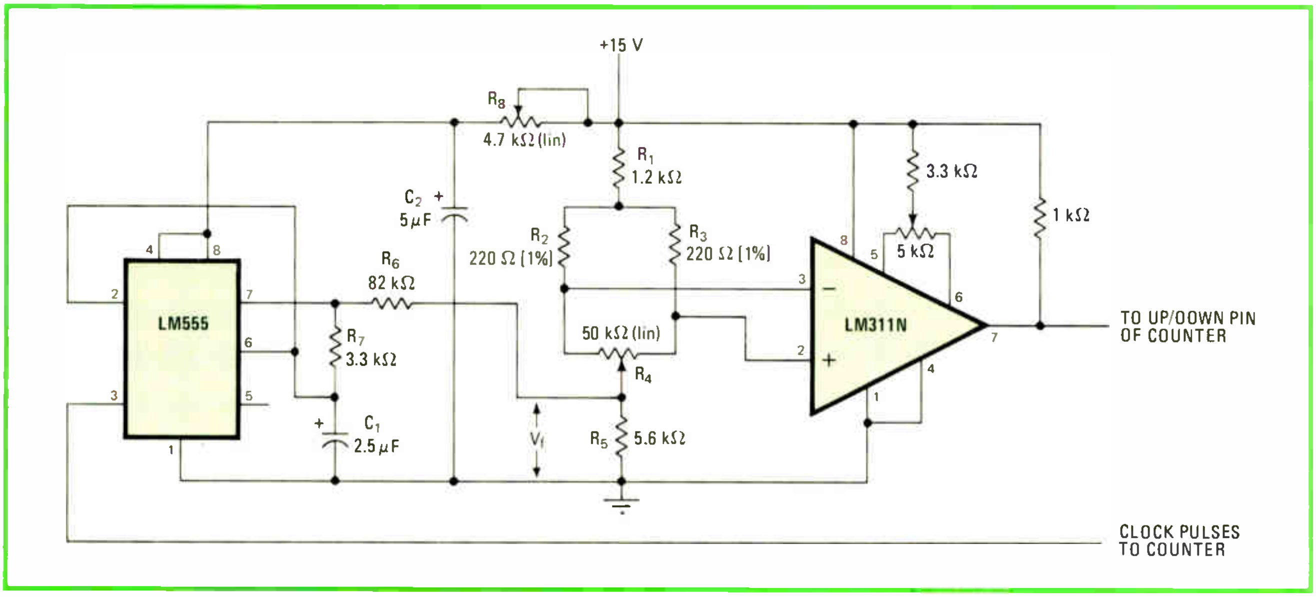
A single potentiometer in an astable multivibrator circuit can replace the clocks and push buttons necessary for setting an up/down counter. It provides a variable clock frequency and the correct logic states.

The same circuit (Fig. 1) can be used in such varied applications as manually adjusting a tool through a stepping motor, rolling a script up and down on a video terminal, and in video games.

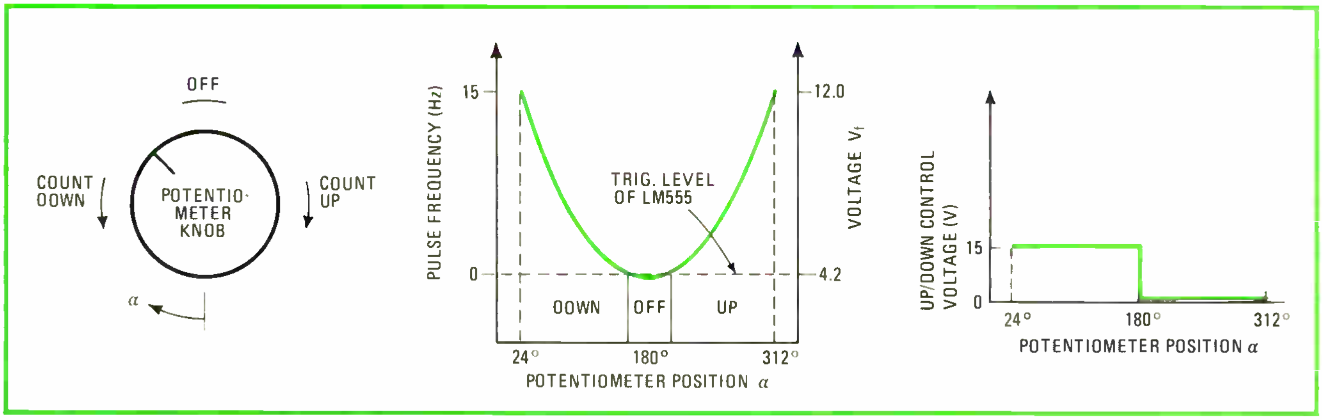
With a three-decade up/down counter that has display but no direct preset capability, a clock feeds pulses into the counter input. To reach the number 615, say, 615 pulses are needed. Two clocks speed up the process: a fast one for rough setting, then a slow one for fine setting. There is a push button for each clock. If the setting is to be reached from both lower and higher numbers, two more push buttons are necessary.

A potentiometer and a 555 timer simplify setting. The pot lets clock pulses be applied quickly for fast setting, then more slowly as the counter gets close to the desired setting. It also holds one pin of the counter at a high or low logic state, depending on whether the counter is to go up (low logic) or down (high logic).

The clock frequency is changed with potentiometer R_4. When R_4 is at its midpoint, the 555 is below threshold for triggering, so the clock rate is zero. When



1. Up or down. Circuit for setting an up/down counter has two outputs. Output from multivibrator delivers clock pulses; clock frequency increases exponentially from zero as potentiometer is turned away from middle position. Output from comparator is either high or low so that counter counts either down or up; output is high counterclockwise from off position of potentiometer, and low clockwise from it.



2. Slow or fast. The LM 555 timer IC operates as a voltage-controlled oscillator, with frequency of clock-output pulses controlled by voltage V_f. The relationship of V_f to the position of the wiper of R_4 is parabolic, even though R_4 is linear.

the potentiometer is turned clockwise or counterclockwise, the 555 generates pulses at a frequency that increases exponentially (Fig. 2). For the component values shown, the maximum frequency is 15 hertz.

Resistors R_2 and R_3 sense whether the potentiometer is clockwise or counterclockwise from its midpoint off position. They cause the comparator to produce either a high or low logic state. The comparator output is high when R_4 is counterclockwise from off, and low for clockwise rotation. This output, also shown in Fig. 2, tells the counter whether to count down or up.

The circuit is adjusted initially by setting R_4 to its midpoint, and then setting R_8 so that the 555 is just below its threshold of oscillation. □

IC timer circuit yields 50% duty cycle

by Frank N. Cicchiello
Geometric Data Corp., Wayne, Pa

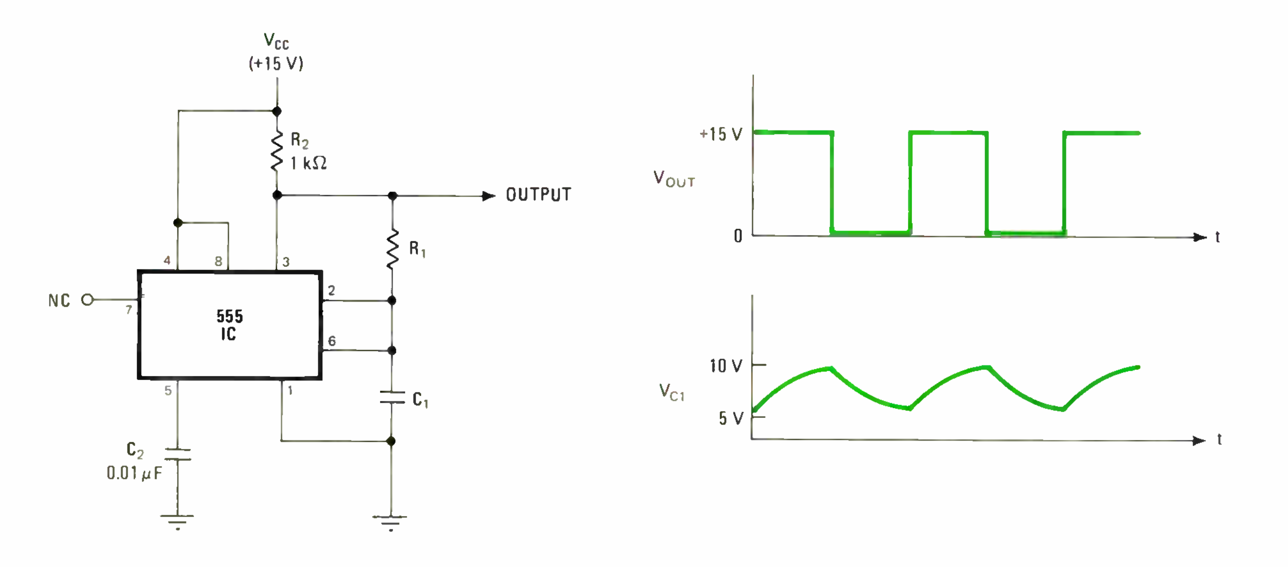
When a 555 timer is operated as an astable multivibrator, it normally produces a pulse-type digital output waveform that has a limited duty cycle. Circuit arrangements that allow the 555 to operate with a 50% duty cycle square-wave output may be rather complex, and many are unstable. However, the simple circuit shown here produces a stable square wave with a duty cycle of 50% ±1%. This circuit has no tendency toward hesitant starting or latch-up.

As a start, assume capacitor C_1 to be uncharged. When this is so, a zero-volt signal level is applied to the IC's internal comparator (as seen at pin 6) when power is first turned on. This, in turn, means that the digital output (pin 3), to which resistor R_1 is returned, is at V_{CC}. Therefore, C_1 charges exponentially toward V_{CC} through resistor R_1. When the voltage across capacitor C_1 reaches a value of 2/3 V_{CC}, as seen at pin 6, the IC's internal comparator triggers its internal flip-flop, causing the output (pin 3) to switch to 0 V or ground level.

Now capacitor C_1 discharges toward 0 V through resistor R_1 until the voltage V_{C1} drops to a level of ⅓ V_{CC}, as seen at pin 2, the IC's internal trigger circuit. At this point, the IC's internal flip-flop causes the digital output to switch back to the V_{CC} level, reestablishing the circuit's original conditions for charging C_1.

Connecting the trigger to the threshold inputs (pins 2 and 6) produces continued free-running or astable operation of the multivibrator, since these two circuits alternately control the IC's internal flip-flop/output circuit. It also means that the charging cycle need not start with 0 V across capacitor C_1 as previously explained, but may just as well begin its operation on the negative-going slope of C_1's waveform.

Resistor R_2 is a pull-up resistor, which ensures that the digital output voltage level at pin 3 closely approximates V_{CC}. Without it, the TTL-compatible output of the circuit may drop below this desired value. Capacitor C_2 is a bypass capacitor on the IC's unused voltage-control



f (DESIGN) (kHz)	C_1 (µF)	R_1 (CALCULATED) (kΩ)	R_1 (ACTUAL) (kΩ)	f (ACTUAL) (kHz)
0.1	0.05	144.3	150	0.0962
1	0.01	72.2	75	0.962
5	0.01	14.4	15	4.81
50	0.001	14.4	15	45.3

All squared away. Free-running multivibrator built around 555 IC has 50% duty cycle because time constants for both charge and discharge are set by R_1C_1. Conventional discharge terminal (pin 7) is not connected in this arrangement. For values of supply voltage V_{CC} anywhere in the range from 5 to 15 volts, the actual output frequencies will not vary from those shown in table by more than 1%.

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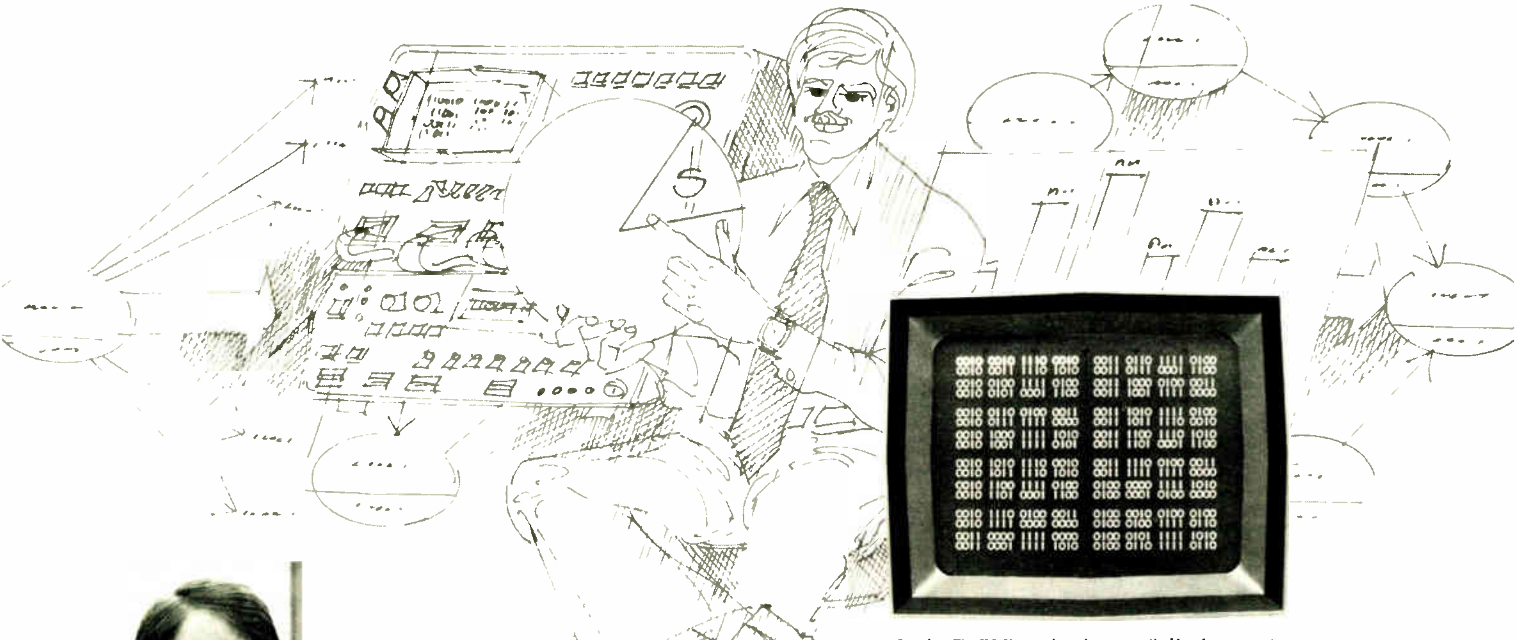

In the TABLE mode, the 1600S displays up to 16 32-bit words. These words could be combinations of addresses, instructions or states of the control lines.

If you're like me, you get nervous when you see your best designers grouped around your most promising digital development program. To a manager, that often spells trouble. Bugs in the design that mean more development money...costly delays in getting the product into production... perhaps even a weakening of your competitive position in the marketplace.

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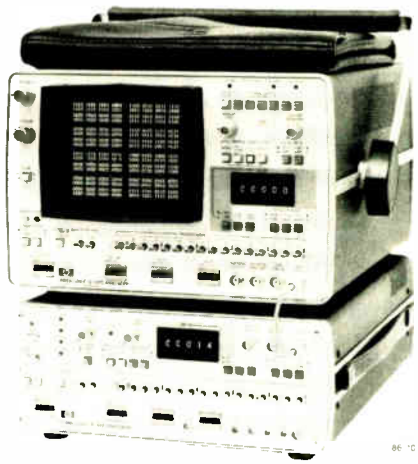

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Sales and service from 172 offices in 65 countries input. Circuit operation follows the formula:

$$t_1 = t_2 = 0.693\ R_1C_1$$
$$T = t_1 + t_2 = 1.386\ R_1C_1$$

so t_1 and t_2 are each equal to half of the period of the output, and T is the period.

The resistance of R_1 should be at least 10 times the value of R_2 but otherwise can be varied without upsetting the duty cycle. Transients occur in circuits that discharge C_1 rapidly, but they don't in this circuit. □

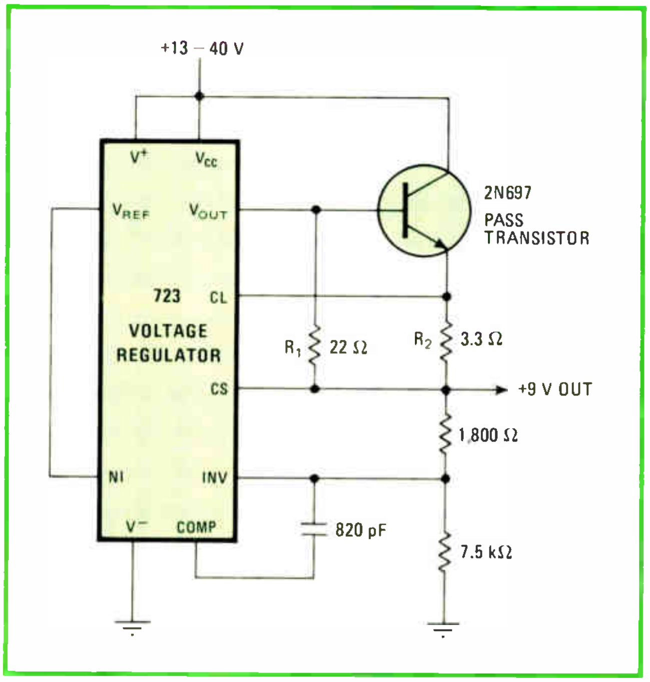
Extra resistor helps regulator share load with transistor

by Dale Hileman
Sphygmetrics Inc
Woodland Hills, Calif.

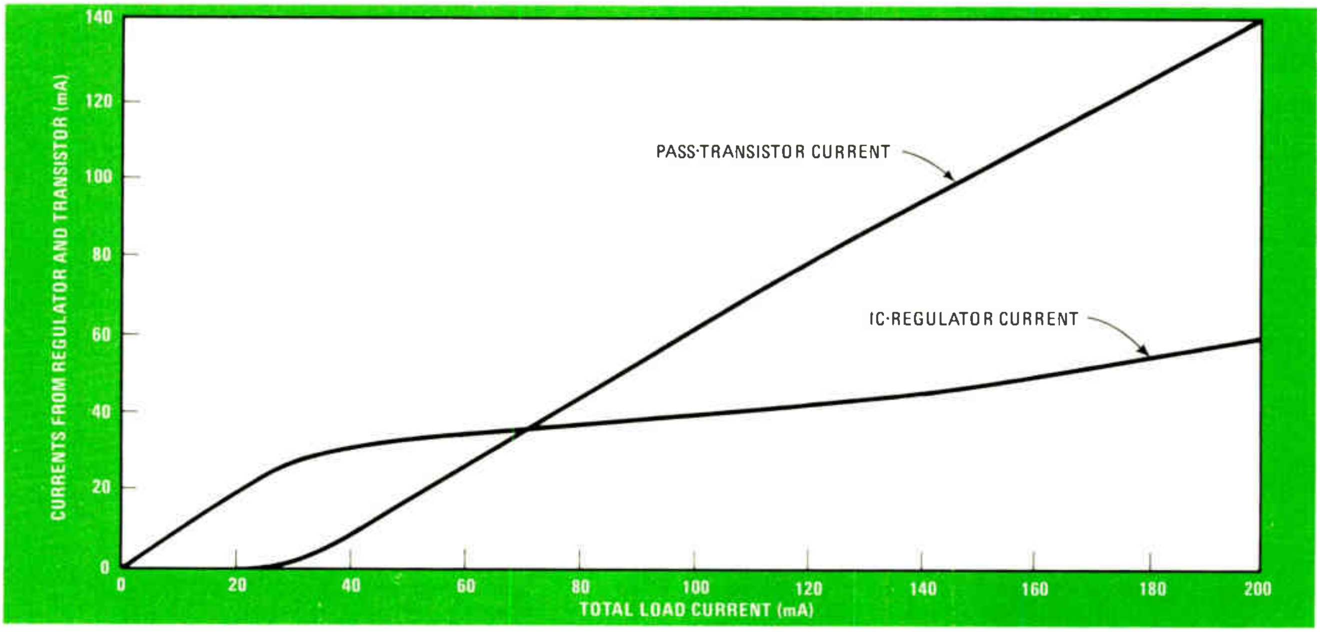
A pass transistor is used with an IC voltage-regulator circuit when the load current required is greater than the integrated circuit can handle. But the capability of the IC is then wasted because it has to furnish only a small base current to the transistor. The addition of a single resistor allows the IC to share the load with the pass transistor. By increasing the total output-current capability of the circuit, this simple change makes it possible to use a smaller transistor for a specified load.

In the schematic diagram shown as Fig. 1, resistor R_1 is added to a typical type-723 IC regulator circuit between the output terminal of the IC and the load. The extent to which the IC then shares the load current with the pass transistor is a function of the current level.

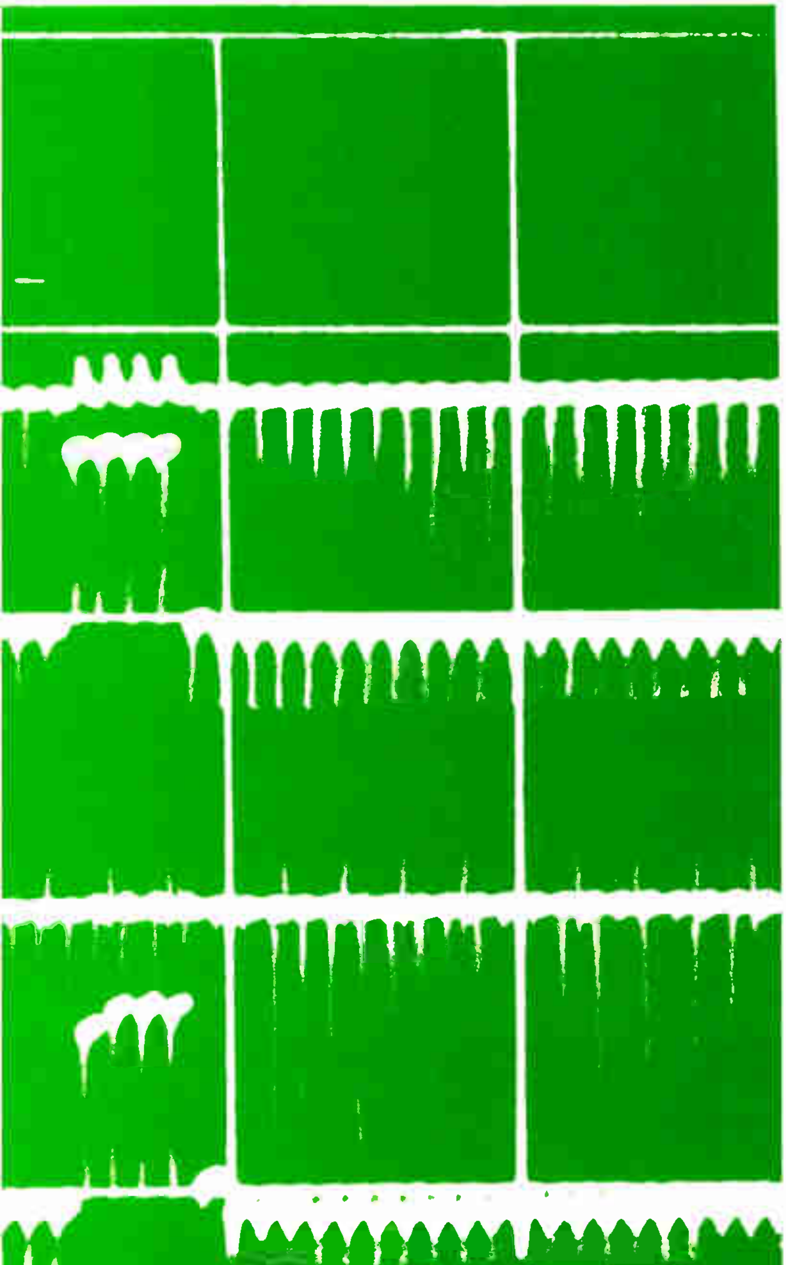
At low current levels, the IC carries the entire load, as shown by the graph in Fig. 2. However, the transistor begins to share the load when the current is high enough for the voltage across R_1 to exceed the base-to-emitter junction voltage, which is about 0.6 V for a silicon transistor. □



1. Add an R. . . Resistor R_1 is added to voltage-regulator circuit so that the IC can deliver some of the load current in addition to driving the base of the external pass transistor.



2. . . . to share the load. Small load currents are drawn entirely from the integrated circuit. The pass transistor takes on an increasing base-to-emitter junction voltage. This arrangement permits a given circuit to deliver more current or use of a smaller pass transistor for a given load requirement. The total load current is the sum of the currents through resistors R_1 and R_2.



Charge-transfer devices replace conversion in moving-target indicators

by David Ludington and Helmut Lobenstein,
General Electric Co., Aircraft Equipment Div., Utica, N.Y.

☐ In the new high-performance radar systems, charge-transfer devices will often prove more satisfactory than conventional analog-to-digital conversion circuitry. These radars, having switched over to digital signal processing for the sake of its stability, are now forced to use complex and expensive a-d conversion circuitry. But in a number of applications, the use of charge-transfer devices as low-cost analog sampled-data processors can eliminate the need for a-d and d-a conversion entirely. At the least, used in a preprocessor, they will reduce the cost of subsequent a-d conversion to the more economical realm of low-bit, high-speed technology.

Charge-transfer devices, a designation which covers integrated versions of both bucket-brigade shift registers and charge-coupled devices, are basically delay lines and sampled-data memories [*Electronics*, Aug. 8, 1974, p. 91 and Nov. 14, 1974, p. 113].

The input analog signal is sampled as in digital systems. The samples, however, are not digitized but are stored and processed as discrete analog packets of charge (see "What happens in charge transfer"). Hence, the devices utilize a continuous range of amplitudes and can be designed to have a large dynamic range.

An ideal application for CTDs in a radar system is in a moving-target-indicator filter. Such a filter rejects the relatively narrow doppler spectrum of sea or ground clutter while enhancing higher-velocity targets that otherwise would be lost.

Before digital implementations, MTI filters depended on ultrasonic quartz delay lines. These had many basic deficiencies—in particular, a delay dependence on temperature. They therefore required encasing in temperature-controlled ovens, with the attendant weight, volume, and power penalties. Worse yet, for high-performance dual-delay cancellers, it became necessary to establish system timing by sending a pilot pulse through one delay line and then slaving the second delay line to the first.

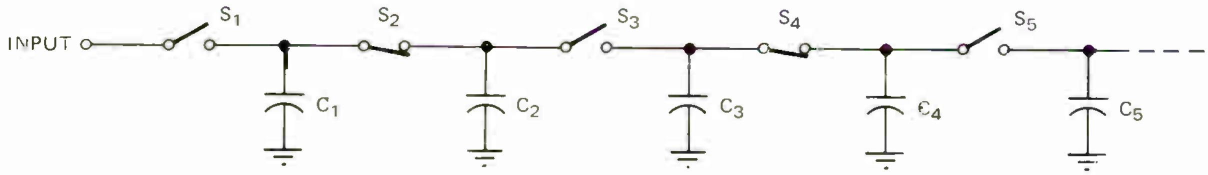
In contrast, CTD storage, like digital shift-register storage, is solely dependent on the stability of the clocking oscillator. Using a crystal clock assures good short-term stability, and temperature-compensating only this one device is much cheaper. In addition, the master clock generates the requisite system timing, automatically tracking all timing functions. For the pulse-repetition intervals commonly used in radar systems, the required storage may extend from several hundred microseconds to milliseconds.

From idea to reality

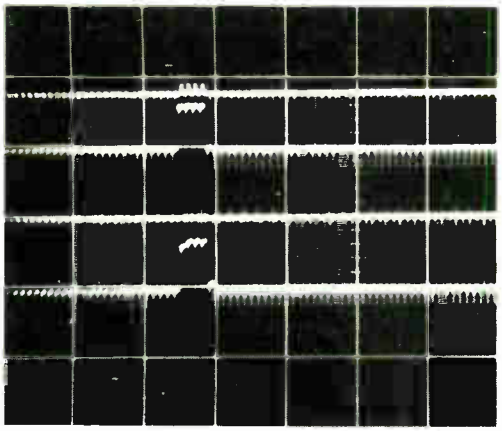
The single-delay canceller in Fig. 1 is basic to all kinds of moving-target indicators. The circuit allows a radar return that has been delayed by the duration of one pulse repetition interval to be subtracted from an incoming return. Thus it cancels out all information that has not changed from one return to another—for instance, the kind received from stationary targets. The extent to which good cancellation can be maintained over the full video bandwidth of the system is determined by the characteristics of the delay line.

To show that charge-transfer devices would work as moving-target indicators, a filter was built with identical

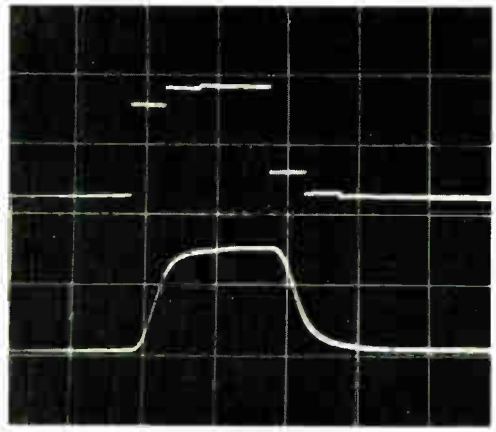
What happens in charge transfer



(A) SIMPLIFIED EQUIVALENT CIRCUIT



(B) TRANSFER EFFICIENCY



(C) SIGNAL RECOVERY

The bucket-brigade charge-transfer device is best characterized as an analog sampled-data delay line. The equivalent circuit shown in Fig. A consists of capacitive storage elements separated by switches (the actual charge-transfer mechanism depends on the type of charge-transfer device). When switch S_1 is closed, capacitor C_1 charges to the input signal level. Then S_1 is opened, S_2 is closed, and the input sample is transferred to C_2. As the switches alternately open and close, the analog charge samples pass down the device. Samples are isolated because all odd-numbered switches are operated together and so are all even-numbered switches.

The time it takes to transfer analog information through the bucket brigade is determined by the digital clock period, which for a given number of stages (switch and capacitor pairs) works out as:

$T = N/2f_c$

where T = delay, N = number of stages, and f_c = clock frequency. Thus, the delay can be varied either by changing the number of stages in the device or by changing the clock frequency. (Charge-coupled devices provide the same function except that instead of capacitors being filled, charge packets are transferred to adjacent storage sites by clocked voltage gradients, much as the water level in a canal lock is raised or lowered to transfer barges to the next stretch.)

In practice, the bucket-brigade switches may use bipolar, MOSFET, or J-FET semiconductors. They also may be fabricated in monolithic integrated circuits to increase circuit density. The capacitors are an integral part of the monolithic structure and have a value on the order of a few picofarads.

There is never a complete transfer of charge from one storage element to the next, and this limits device bandwidth at high clocking or sampling rates. At low clocking frequencies, the bandwidth is determined by the Nyquist sampling requirement described in the main story.

To analyze the effect of cascading a large number of delay sections, the first step is to assume that the transfer of charge from one storage capacitance to another can be roughly modeled by a simple RC low-pass filter. The transfer function is given by:

$T(s) = 1/(1 + sCR)$

where s = the complex frequency variable, C = the capacitance of the stage, and R = the resistance of the switch. The 3-decibel bandwidth of a single stage is given by:

$BW_1 = 1/(2\pi RC)$

Next, assume that the time sequential transfer of charge through n sections can be modeled by cascading n isolated RC sections. The overall transfer function is then given by:

$T(s) = [1/(1 + sCR)]^n$

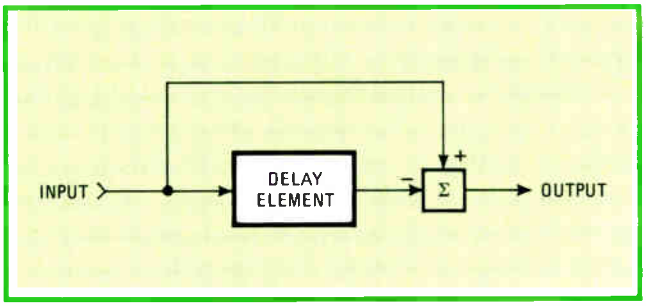
and the 3-dB overall bandwidth is given by:

$BW_C = (2^{1/n} - 1)^{1/2} BW_1$

which, for large n, becomes

$BW_C = (0.83/n^{1/2}) BW_1$

Figure B shows how a MOSFET charge-transfer device limits bandwidth. When a signal is picked off after the 12th stage, the pulse reproduction is very good. But when the signal is picked off after the 108th stage, the limiting effect is clearly evident—the samples at the leading edge of the pulse are reduced in amplitude and the charge left behind by earlier, incompletely transferred charges builds up as spurious samples at the trailing edge. Analog signal recovery is typically accomplished by means of a sample-and-hold operation plus low-pass filtering (Fig. C).



1. Delayed. The basic moving-target-indicator filter delays a radar return pulse before being subtracted from the next incoming radar return. In this way target information that hasn't changed from one return to another is cancelled.

characteristics to an existing acoustic delay-line canceller (see table) and was integrated into a radar system. Now, in operating radar systems, the input is sometimes split into two channels (in-phase and quadrature) so that the information may be processed at baseband (0–1 megahertz) instead of at higher intermediate frequencies while preserving both the phase and the amplitude characteristics of the signal. When this is done, the 1-MHz i-f bandwidth requirement is reduced to 500 kilohertz for each of the I and Q channels, but each channel now needs its own double-delay canceller. Two single-delay cancellers of the type shown in Fig. 1 can be cascaded to achieve the required cancellation.

The number of stages required for each of the single-delay cancellers can be determined as follows. The Nyquist theorem states that the sampling frequency must be at least twice the bandwidth of the signal for proper reconstruction of the analog signal from the samples. In practice, the input signal is usually sampled somewhat above the Nyquist rate, and in this instance a sampling frequency (f_s) of 1.6 MHz was chosen for both the I and the Q channels. Combining this sampling rate with the specified delay of 250 microseconds yields the number of needed CTD stages:

$$N = 2f_s \times delay$$
$$= 2(1.6 \times 10^6)(250 \times 10^{-6})$$
$$= 800\ stages$$

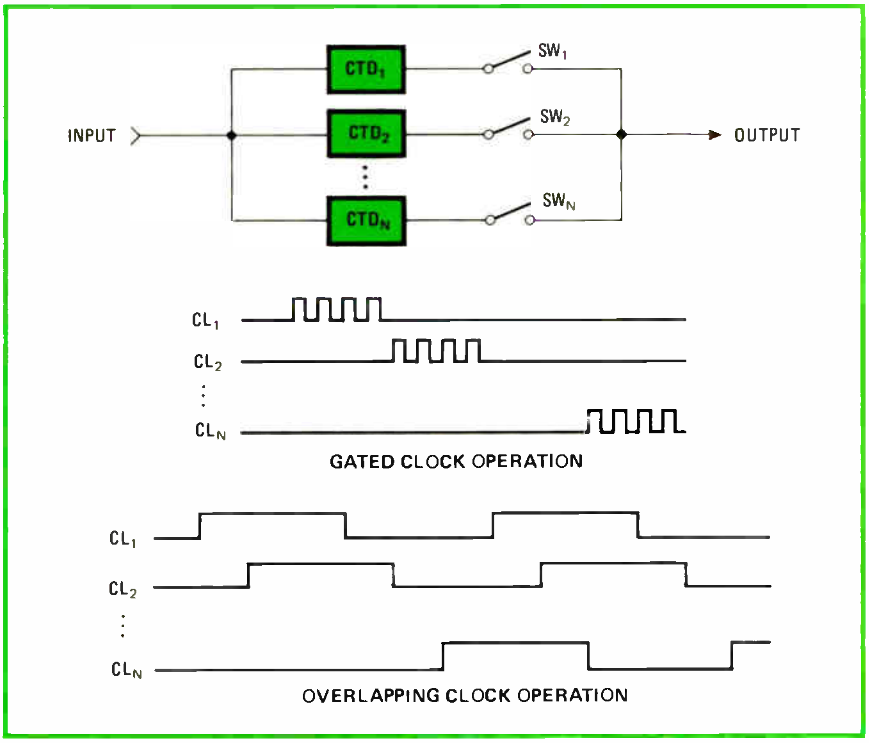
The simplest method of providing the 250-microsecond delay would be to use a single charge-transfer device with 800 stages. However, available p-channel metal-oxide-semiconductor bucket brigades had a charge-transfer efficiency of only 99.9% per transfer.

Devices in parallel

This prohibited the use of a single serial device since 1/1,000 of the signal is lost per stage, and for 800 stages 80% of the signal would disperse and spread into neighboring stages before it reached the output. Circumventing this problem requires the multiplexing of several shorter parallel charge-transfer devices—in this instance, eight (Fig. 2).

The CTDs used were developed at General Electric's Corporate Research Center. They are p-channel metal-oxide-semiconductor bucket-brigade delay lines in a 14-pin dual in-line package that needs only −10 volts and a simple two-phase clock. (Bucket-brigade devices are much easier to operate than the faster charge-coupled devices, which require more than one bias voltage as well as more complex clocking.)

There are two methods of clocking charge-transfer shift registers in a multiplexed setup (see Fig. 2). Either the registers could each be clocked at a sampling rate of 1.6 MHz for a portion of the pulse-repetition interval, or they could be operated in an overlapping or skewed-clock mode.



2. Multiplexing modes. In the gated clock mode, clocks to each register are turned on and off sequentially, rather than run continuously but shifted in time as in the overlapping mode.

Clocks in series

In the first method, after enough samples to fill the first bucket-brigade register are taken, its clock is turned off. Then the clock to the next register is turned on.

The process continues until the entire memory is full. Each register is clocked for a period equal to the pulse-repetition interval divided by M, the number of bucket-brigade registers in parallel. During the next pulse-repetition interval, the sequence is repeated with the signal samples automatically multiplexed at the output of the registers.

Although this scheme has the advantage of keeping all samples in sequence, thus making the processing easier, there are several disadvantages. When the clocks to each register are turned off, the leakage of the storage capacitors from site to site is not uniform and therefore imposes a pattern noise on the stored signal. Also, each bucket brigade must be clocked at 1.6 MHz, which gives little time for the transfer of charge.

A second method, and the one used in the present system, is to reduce the clocking rate by operating the registers in an overlapping or skewed-clock mode. In this mode, the clocks to the bucket brigades are each run continuously at $f_c = f_s/M = 200$ kHz, but to maintain an actual sampling rate at 1.6 MHz, they are staggered between adjacent devices so that only one device samples the input at a time.

Enough transfer time

This skewed-clock mode of operation provides adequate time for charge transfer to occur. Also, because the clocks run continuously, the pattern noise that would result from turning off the bucket brigade during part of the pulse repetition interval is eliminated.

Of course, for each of these methods, the gain and dc balance between each of multiplexed channels must be maintained. Otherwise their levels could differ and show up as spurious signals.

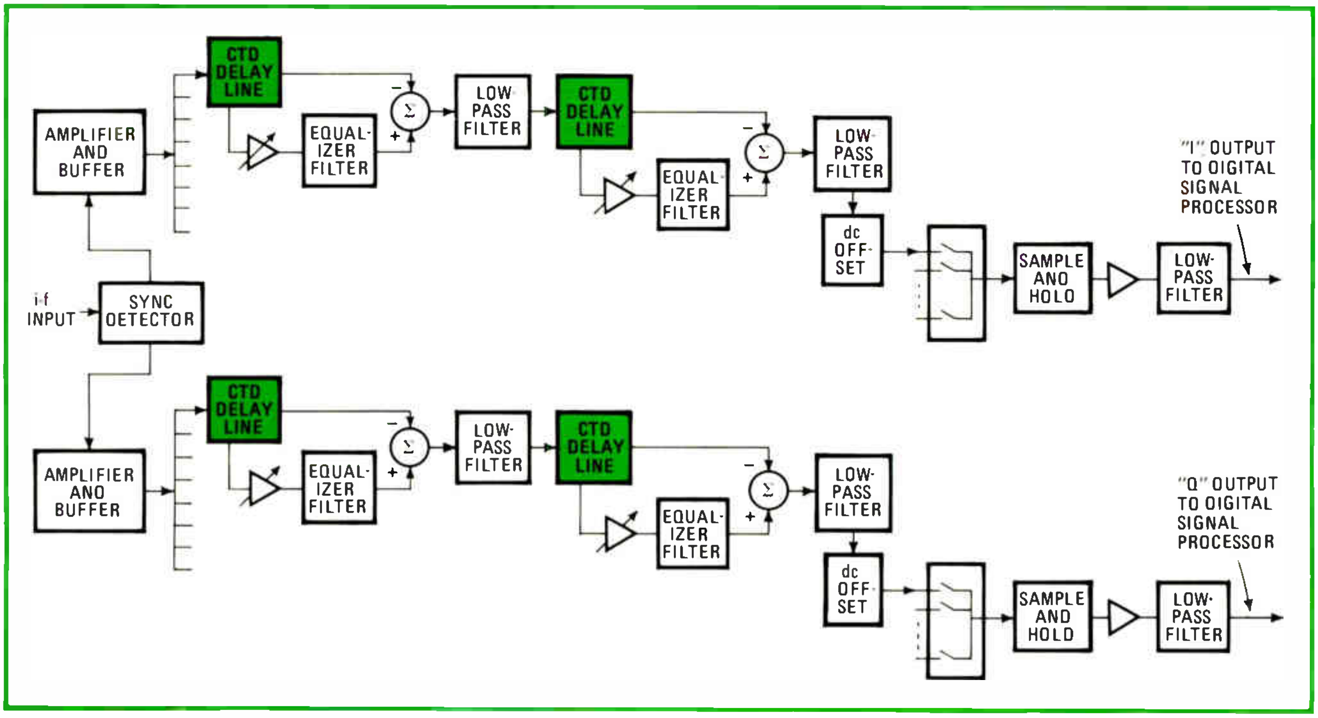
A small fraction of charge is, as usual, left behind in each CTD stage, and this charge-transfer inefficiency has two effects on the performance of the bucket-brigade version of a moving-target indicator. Since a direct signal is subtracted from a delayed signal in the summation circuit, the signal paths should have nearly identical characteristics for good suppression of unwanted clutter. Therefore, to ensure that the frequency responses of both paths are well matched, the direct signal is first passed through a bucket-brigade stage and then through a simple resistor-capacitor equalization filter (as shown in Fig. 3).

PARAMETERS OF MOVING-TARGET INDICATOR	
Type	Three-pulse vector canceller
Cancellation	50 dB
Dynamic range	>50 dB
System waveform	Multiple burst, 250-μs pulse-repetition interval
Pulsewidth	1 μs
I-f bandwidth	1 MHz
Input format	In-phase (I) and quadrature (Q) baseband video

Another problem results from the occurrence of charge-transfer inefficiency in a multiplexed structure. At the output of each bucket-brigade shift register, the fraction of the k^{th} signal charge packet that's been dispersed because of charge-transfer inefficiency will not appear in the reconstructed train of signal samples until the $(k + m)^{th}$ sample. Thus the effect of charge-transfer inefficiency is to generate an extraneous signal that is displaced in time by the number of parallel CTDs multiplied by the period of the sampling frequency. If the ghost signal is part of the clutter returns, it bears a precise relationship to the clutter patch itself and will be cancelled in the second stage of the canceller. But, in the case of a desired target, the extraneous signal will show up in the radar display as a second target slightly displaced from and smaller than the actual target (30 decibels down).

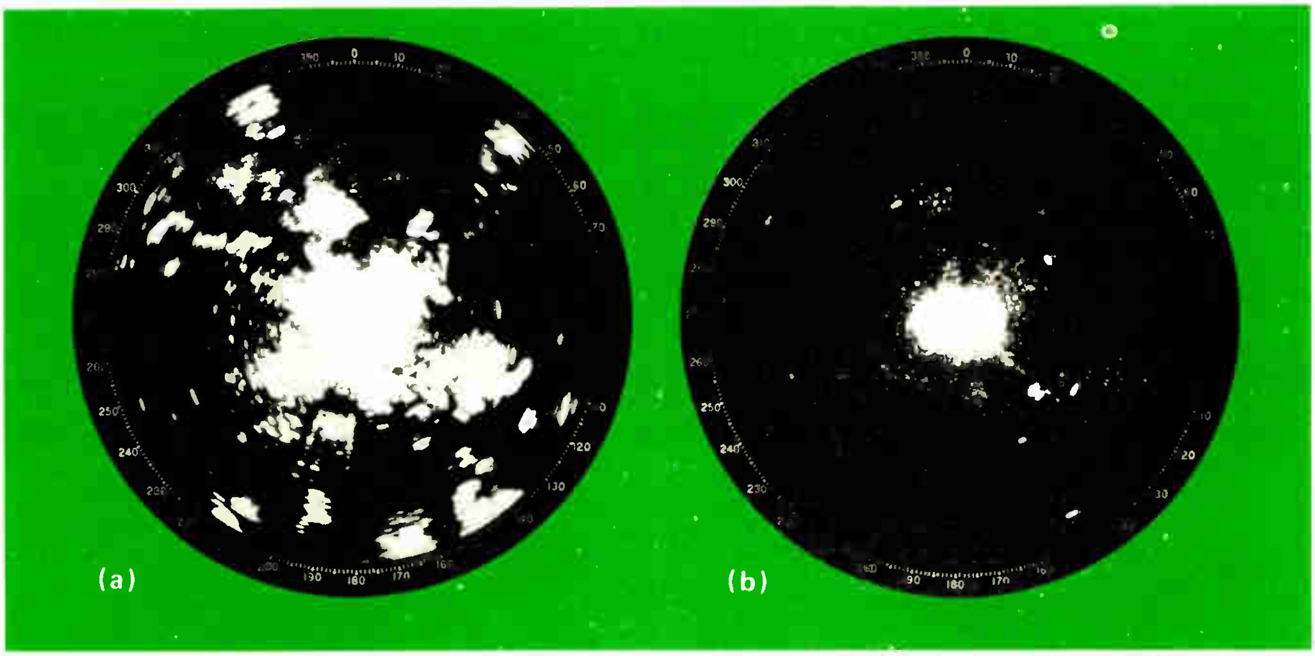
Individual double-delay channels (Fig. 3) achieved

3. Multiplexed. Individual double-delay channels using paralleled charge-transfer devices are multiplexed to avoid the extensive signal loss per stage that would occur with single, serial charge-transfer device. Either a gated- or an overlapping-clock scheme may be used.



58 decibels of cancellation. But because of multiplexing noise and residual unbalances between channels, the multiplexed-system performance fell to 51 dB.

Figures 4a and 4b demonstrate actual system performance without and with activation of the moving-target-indicator circuit. Note, for instance, that the radar return from a hill shown in Fig. 4a although almost 60 decibels above noise, is barely visible in Fig. 4b. □



4. Cutting through clutter. With the moving-target-indicator circuit bypassed (a), a hill located 5–8 miles away at a 335–355° bearing is 60 dB above noise. In the MTI mode (b), the same hill is barely visible, and several targets (at 60°, 120°, 150°, etc.) that were previously lost in the clutter can now be easily seen. Also several discrete returns due to site location plus a rain storm are eliminated. The double return at 132° and 6 miles is due to a combination of a large target and the transfer inefficiency of charge-transfer devices.

What's available in CTDs

Although charge-transfer-device technology is only six years old, several companies have available off-the-shelf devices, and some firms will modify custom devices.

Fairchild, for example, has developed a dual 455-element buried-channel shift register/delay line, complete with input and output circuitry, that requires only two external clocks. The CCD 321 has a 4-to-5-megahertz bandwidth and a dynamic range of about 55 decibels. The output signal of one register can be directly connected to the input terminal of the other to obtain a 910-element delay, all in a standard 16-pin dual in-line package, priced at $50 each in 1,000 quantities.

Also available from stock is a 130/260-bit charge-coupled analog delay line/shift register packaged in an 18-pin DIP. The CCD 311 sells for $27 in 1,000 quantities [*Electronics*, Sept. 4, 1975, p. 36].

At GEC Semiconductor Ltd. in Great Britain, a new 120-element charge-coupled device, CD 128 adds buried n-channel technology to the two-year-old 100-element surface-channel device it replaces. Also available is the CD 200, a 1,024-element surface-channel device that costs $185 in quantities of 30 or more. The devices have a 99.995% charge-transfer efficiency, 1-millisecond storage time at 25°C, operating temperatures of from 0°C to 60°C, a minimum dynamic range of 60 dB, and a 1-to-10-kilohertz clock frequency.

The firm makes its devices for imaging, shift register, and signal processing applications, but it also is one of the companies that will make custom devices if the order is large enough.

Reticon Corp.'s dual 512-stage bucket-brigade device for serial analog delay, SAD-1024, has two independent arrays of 512 storage elements within the same 16-lead ceramic DIP. Both sections may be independently clocked and inputted or connected in sequence to provide 1,024 elements of delay.

The dynamic range is 75 dB, signal bandwidth is greater than 100 kHz, sampling frequency is from 1 kHz to 2 MHz, and delays in excess of one second are possible at room temperature. The SAD-1024 costs $8 in 1,000-piece quantities.

Panasonic has a dual 512-stage bucket-brigade device, MN 3001, with independent input, output, and clock terminals. The frequency response is 0.3 times the clock frequency, which has a range of from 10 to 800 kilohertz. The signal-to-noise ratio of the Panasonic device is 70 decibels.

Thomson-CSF's tube division in France is making available samples of its THX 1105, a 256-element charge-transfer delay line. The dynamic range is 50 dB with signal-bandwidth capability up to 10 MHz. Price is not firm, but, according to company sources, it should be in the $200 to $300 range.

The Philips Elcoma division in the Netherlands has developed a 512-stage bucket-brigade device that can provide delays from 51.2 milliseconds to 0.512 ms. The TDA 1022 has a typical attenuation of 3.5 dB and can be used with clock frequencies from 5 to 500 kHz over an ambient temperature range of −20°C to 55°C [*Electronics*, Aug. 21, 1975, p. 55].

Single-chip multiplier expands digital role in signal processing

The many multiplications in such systems are handled by implementing Booth's algorithm and by storing the carries temporarily in a flip-flop

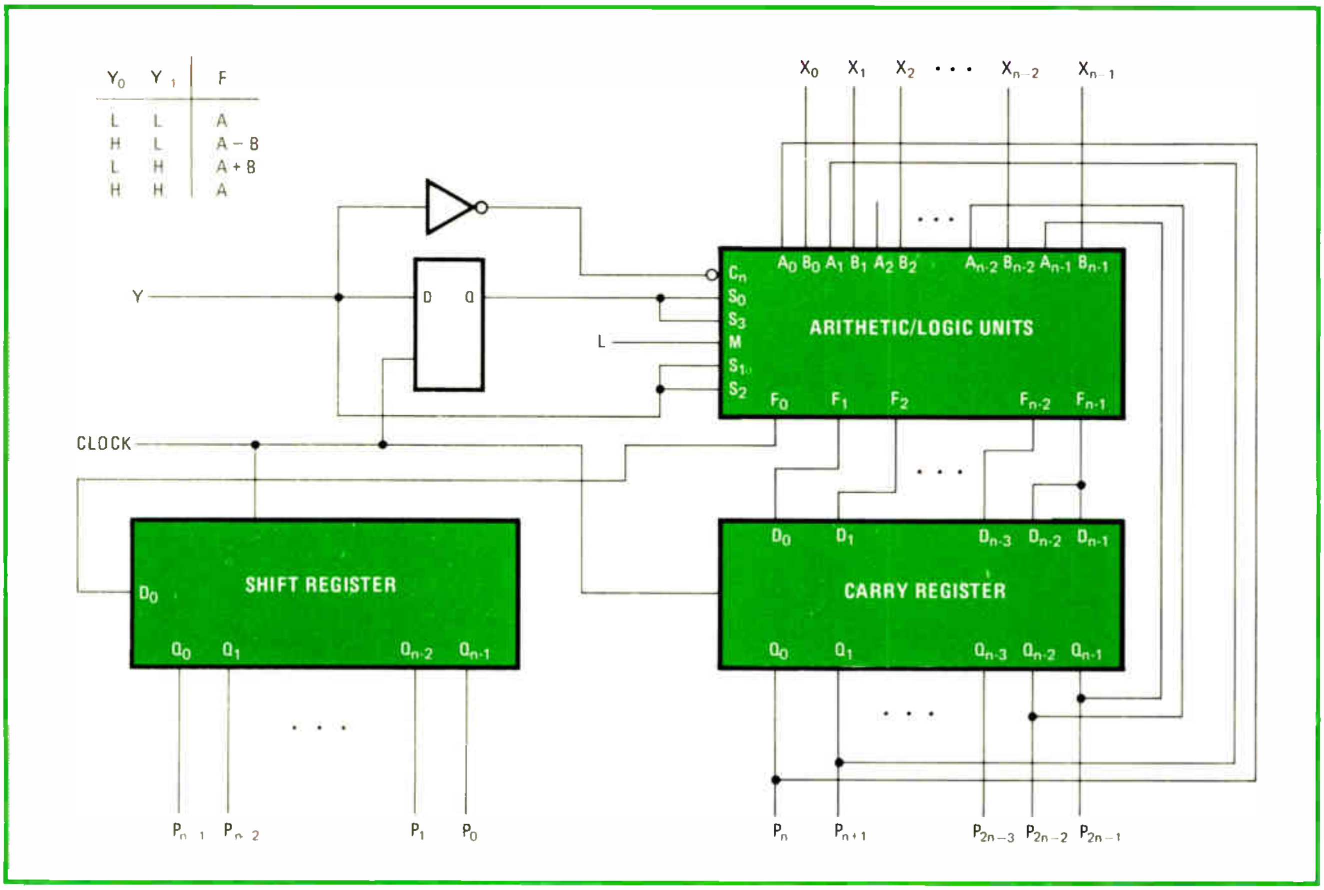
by John R. Mick and John Springer, *Advanced Micro Devices, Sunnyvale, Calif.*

☐ With their precision, stability, and programability, digital processors have been steadily usurping the roles of analog circuits in such signal-processing functions as frequency analysis, correlation, and filtering. However, in this role they must perform many more multiplications than usual, and the number of integrated-circuit packages required to perform them has been economically feasible only for military uses.

A single-chip multiplier could open up many new areas in commercial digital-signal processing systems as well as in minicomputers based on large-scale integration. Such a chip would be most economical if it could fit into a 14- or 16-pin package, could handle 8-bit numbers, and could be cascaded easily with similar packages to handle larger numbers. Such a chip is possible if the multiplication is based on a simple algorithm (the so-called "Booth's algorithm") and if the carries are stored by a special technique.

This has been accomplished in a new 8-bit serial-parallel multiplier, which requires only a quarter of the best previous design's IC packages for a 16-bit-by-16-bit multiplication. The Am25LS14 uses advanced low-power Schottky transistor-transistor-logic technology in a 16-pin package. It handles unsigned numbers as well as negative, 2's complement, numbers.

The requirements for an easy-to-use good general-



1. Multiplying with MSI. Booth's algorithm for multiplying two binary numbers, X (parallel input) and Y (serial input), can be performed with an ALU to form the partial-product bits and two shift registers to assemble the final product.

purpose IC multiplier that would fit into commercial applications are:

- Low cost.
- Fast operation.
- Adaptability to any word length.
- Ability to handle signed numbers in 2's complement notation without correction.

Early designs of digital multipliers operating in parallel on binary words were slow in propagating the carry signal across the bits of the multiplicand as the word length increased. So two types of circuits evolved: higher-speed carry and look-ahead multipliers that required costly external logic devices and a type that compromised speed for cost. The third and fourth requirements limit the multiplication method to an algorithm that works in 2's complement notation and handles all bits in the same manner, so that the sign bit is treated identically with the other ones.

The Am25LS14 takes in the whole multiplicand in parallel and then uses a single bit at a time from the multiplier to form partial products in an integral register. Digital-signal processing can make good use of the mixed serial-parallel processing because the multiplication frequently involves a constant withdrawn in parallel from a read-only memory and a variable stored serially in a shift register. The chip's output is a serial bit stream representing the product of the parallel multiplicand word and the serial multiplier word.

Add-and-shift multiplying

Disregarding signs, multiplication can be performed by summing a series of partial products, each of which is formed from one bit, y_i, of the multiplier word Y times the entire multiplicand word X times the weight, 2^i, of the Y multiplier bit. That is,

$$XY = \sum_{i=0}^{n-1} y_i X 2^i$$

where n is the number of bits in Y.

BOOTH'S ALGORITHM

Y_i	Y_{i-1}	Function	Partial Product
0	0	Do nothing	S + 0
0	1	Add X	S + X
1	0	Subtract X	S − X
1	1	Do nothing	S + 0 = S − 0

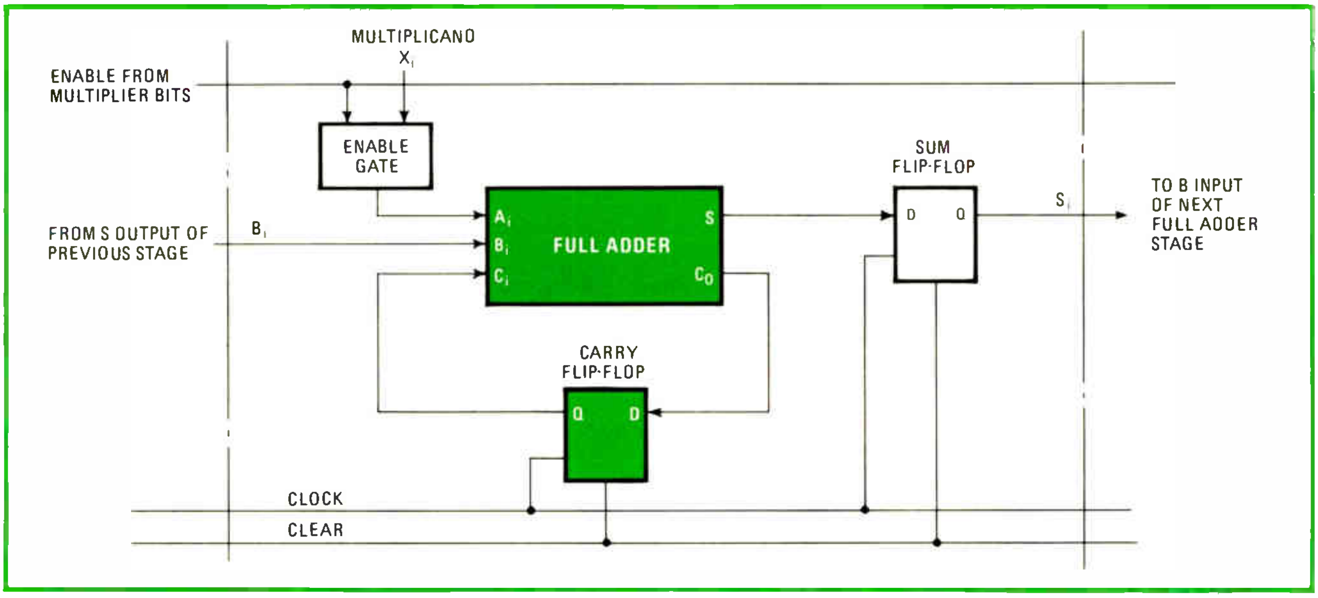
The algorithm, usually designated "add and shift," is performed simply with logic circuits by ANDing y_i with each bit of the X value, giving a result of x_i, or 0, that is added to the previous partial product to generate a new one. The least significant bit of the new partial product represents one bit of the desired overall product. The new partial product is then shifted one place toward the LSB to shift it out of the register. (This shift operation is equivalent to multiplying by 2^i.) The process is repeated for each bit of Y.

One binary number can be subtracted from another by adding its 2's complement—its negative representation—to the other number and ignoring any final carry in the result beyond the original most significant bit. The 2's complement is formed by changing all the 1s to 0s and vice versa and adding 1 to the least significant bit.

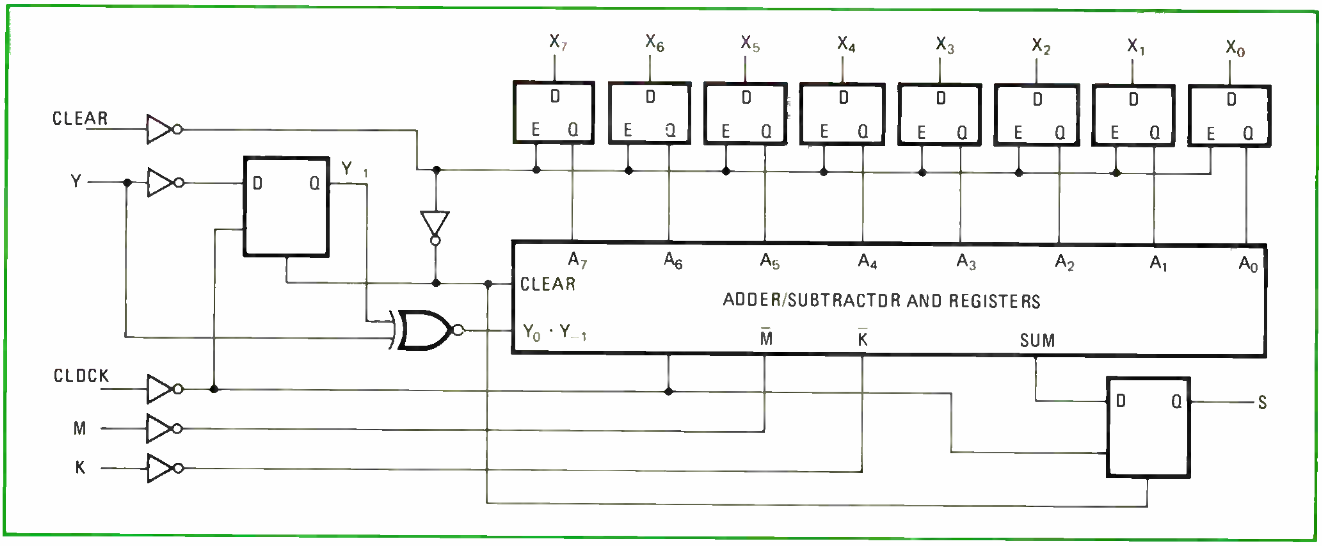
This algorithm will work for 2's complement values of Y, if for the MSB of Y (the sign bit) subtraction rather than addition is performed. A subtraction is required because the MSB of a 2's complement effectively carries a negative weight.

Booth's algorithm

The number of operations in this add-and-shift technique can be reduced if Booth's algorithm is used. It operates on the principle that a string of 0s in Y requires only shifting—no additions—and a string of 1s in Y run-



2. Carry-save cell. The carry flip-flop stores, for one clock cycle, the carry signal generated in the adder and then reinserts it into the adder on the next clock cycle. This eliminates the need for carry-out and carry-in pins on the multiplier package.



3. The multiplier. The AM25LS14 multiplier has a storage register to hold the parallel-entry multiplicand X, adder-subtracter logic tc form partial products, logic operating on the serial-entry multiplier Y and other logic to alter multiplicand X to unsigned notation.

ning from bit weight 2^r to weight 2^s (s greater than r) can be treated as $2^{s+1} - 2^r$.

For example, if Y is 001110 (14), then $r = 1$ and $s = 3$, and $2^4 - 2^1 = 14$. Thus XY = X(001110) or X(010000 - 000010). The use of the add-and-shift algorithm for this example would require three additions (one for each of the 1s in Y), but Booth's algorithm requires only two operations: an addition at weight 2^{s+1} and a subtraction at weight 2^r.

More generally, Booth's algorithm involves the following steps:

1. Examine the multiplier bit by bit, beginning with the least significant bit.
2. Subtract the multiplicand X from the partial product (zero initially, of course) when finding the first 1 in a string of 1s, add the multiplicand to the partial product when finding the first 0 in a string of 0s, and do nothing when the bit is identical to the previous bit.
3. Shift the partial product toward its LSB, relative to the multiplicand, and repeat the process.

The significant features of the algorithm are that:

- While, in the worst case, it could require as many operations (compare, add/subtract, shift) as Y has bits (alternating 0s and 1s), it usually requires fewer.
- It works for X in 2's complement, because the logic circuitry required for addition and subtraction is identical for unsigned numbers and 2's complement numbers.
- It works for Y in 2's complement, because when Y ends in a string of 1s (toward the MSB) the last operation will have been a subtraction at the appropriate weight.

The basic algorithm as developed by Booth is as follows: X is the multiplicand, y_i is the i-th most significant bit of an n-bit multiplier representation, y_0 is the LSB, and y_{n-1}, the MSB, is the sign bit. Starting with $i = 0$, each y_i and y_{i-1} are compared:

1. If $y_i = y_{i-1}$, add nothing
2. If $y_i = 1$ and $y_{i-1} = 0$, subtract X from the partial products (add the 2's complement).
3. If $y_i = 0$ and $y_{i-1} = 1$, add X to the partial product. The table opposite summarizes these rules.

It is easy to implement this algorithm in hardware using existing discrete components: registers to store the partial product, a flip-flop to store the previous multiplier bit y_{i-1}, and arithmetic/logic units to perform the arithmetic (Fig. 1).

At each stage of the adder in the ALU, a bit of the multiplicand is added to or subtracted from a partial-product bit and an incoming carry bit (taken from the next lower-order adder stage). This action generates a new partial-product bit, which is shifted to the next lower weight, while a carry signal may be passed to the next more significant stage of the adder. When the partial-product bit reaches the LSB position, it is sent to the shift register to be assembled into the final product of the multiplication.

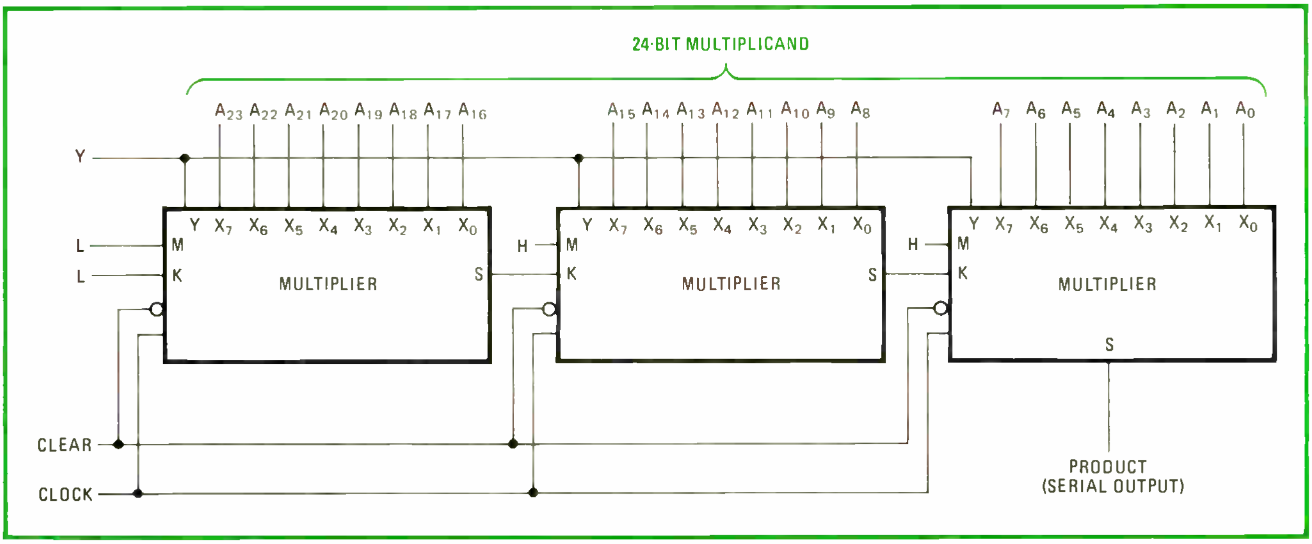
The left-hand register in Fig. 1 thus assembles the lower half of the bits of the resulting product by taking the LSB output of the ALU on each cycle and shifting it. The right-hand device is a parallel-entry register that assembles the higher half of the product, with the shift accomplished by the staggered, hardwired connections from the ALU.

However, this implementation suffers from several problems: the longer the multiplicand word length, the longer the time required per cycle, since a carry must propagate across the entire adder chain of the ALU. The system also requires a large number of devices—at least two 16-pin packages and one 24-pin package for every four bits in the multiplicand.

All on one chip

A single monolithic chip will solve these problems. It will contain an adder/subtracter, a partial-product storage register, and a y_{i-1} flip-flop, along with the appropriate control logic. If a reasonable length—8 bits—is chosen, the device requires eight parallel multiplicand inputs, a serial multiplier input, an output, a master reset, a clock input, and two power pins for a total of 14 pins.

But such a circuit is not expandable to a word length longer than 8 bits without adding an input pin to receive the partial-product output from the more signifi-



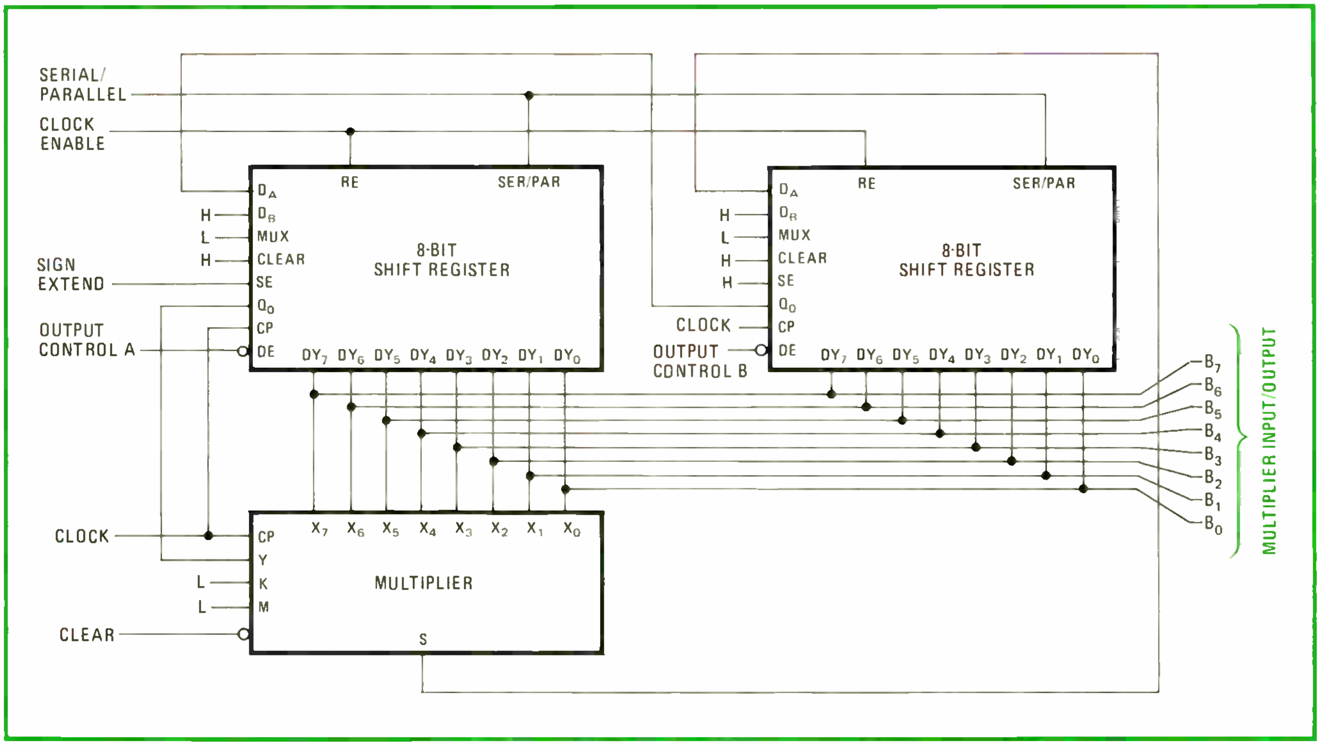
4. Cascading. Three multiplier chips may be cascaded to handle 24-bit words. The serial output terminals S of the intermediate multipliers are tied to the K input, the sum-expansion input of the next lower-order multipliers. Clock and clear terminals of each chip are tied together.

cant device (for storage in a shift register) and a carry-in pin and a carry-out pin for the adder/subtracter (to be applied to the LSB and MSB, respectively). This would bring the total pin count one above the desired number of 16. Moreover, the circuit would suffer from the delays caused by the carry and look-ahead propagation over long fields. What is required is some different way to handle the carry signals that are generated in the monolithic chip.

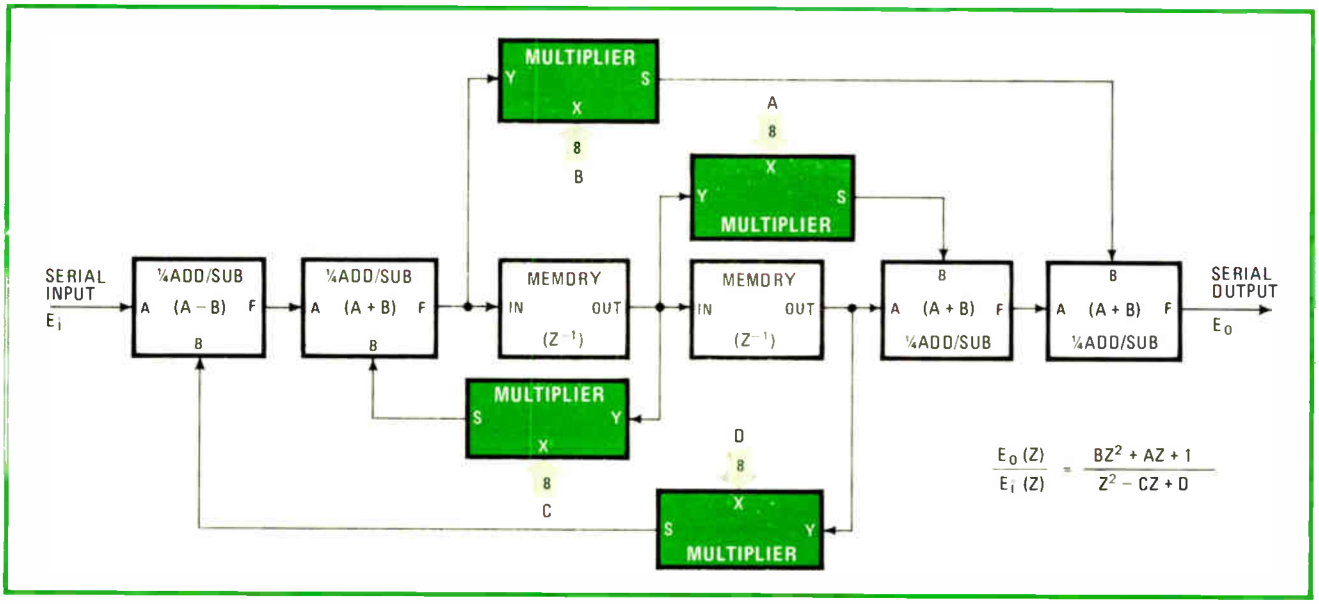
In the arithmetic/logic unit, at any given time, only the output of the least significant adder/subtracter stage need be correct for entry into the shift register. Therefore, the carries that are generated at the various intermediate stages need only be added into the partial product at any time before the partial product is finally shifted out of the device.

For example, suppose stage s_i generates a carry signal, which should be added to the next highest stage, $s_i\Omega_1$. In the next time period, partial-product bit $s_i\Omega_1$ will be shifted into s_i. Thus, instead of sending the carry generated at s_i up to the next stage, it can be saved in a flip-flop and added back into the same adder during the next clock time. For easy reference, such a scheme can be called "stored carry-save multiplication."

This technique of storing the carry-out of each bit and feeding it back on the next clock cycle eliminates



5. Eight by eight. A single 8-bit bus can handle the input multiplier and multiplicand and the 16-bit product in the form of 2 bytes. The shift registers hold the multiplier word for input to the multiplier chip and then store part of the product.



6. Digital filter. Four multiplier chips can be used to build a two-pole, two-zero, recursive filter. The additions and subtractions are performed by sections of four serial adder/subtracters, and two shift registers are used to hold the intermediate results.

the need for carry-out and carry-in pins. It also makes the cycle time of the system independent of the size of the multiplier. Thus, each bit of the multiplicand is processed in an identical cell consisting of a full adder, a carry-save flip-flop, a flip-flop to store the partial product, and some input control logic to carry out Booth's algorithm (Fig. 2).

But the circuit must perform subtraction as well as addition, and so may be generating borrow signals as well as carry signals. If a single carry-borrow-save cell is used, the question is how the circuitry will determine sign of the cell's contents. The answer is simple when Booth's algorithm is used. Addition and subtraction always alternate in time, so if a multiplier bit is 1, then the last operation was subtraction, and if it is 0, the last operation was addition. Also, a carry or borrow at a given cell i can occur only if $x_i = 1$, and then the saved carry's sign depends on the last operation.

The multiplier chip

The result of applying the technique of stored carry-save multiplication to the design process is the Am25LS14 multiplier (Fig. 3). It has four parts:

- A storage register to hold the 8 parallel bits of the multiplicand X.
- Adder/subtractor logic containing a partial-product register and a carry-borrow register.
- A flip-flop and gate operating on the serial multiplier string Y to provide a control signal to the adder/subtracter logic.
- A simple logic control to alter the multiplicand from signed to unsigned notation.

The adder/subtracter logic consists of seven identical cells and a slightly different eighth cell that incorporates the multiplicand sign logic. The K input is the sum-expansion input and allows the cascading of devices. Mode input M is used in cascading to determine the most significant bit of the multiplicand.

In the typical operation of the multiplier, multiplicand data is presented to the X inputs and the clear input is pulsed low. This loads the X latches with the new multiplicand and resets all internal flip-flops. Then the least significant multiplier bit, y_0, is presented to the Y input. On the clock low-to-high transition, the first product bit s_0 appears at the S output and the second multiplier bit y_1 is presented to the Y input. This clocking process is repeated until all the S product bits have been developed.

The chip has a typical maximum clock frequency of 40 megahertz. Using an 8-bit-shift register an 8-bit-by-8-bit multiplication typically can be performed in 450 nanoseconds, assuming 10 clock cycles. Similarly, a 16-bit-by-16-bit multiplication typically can be performed in 850 ns, assuming 34 clock cycles for the total multiplication.

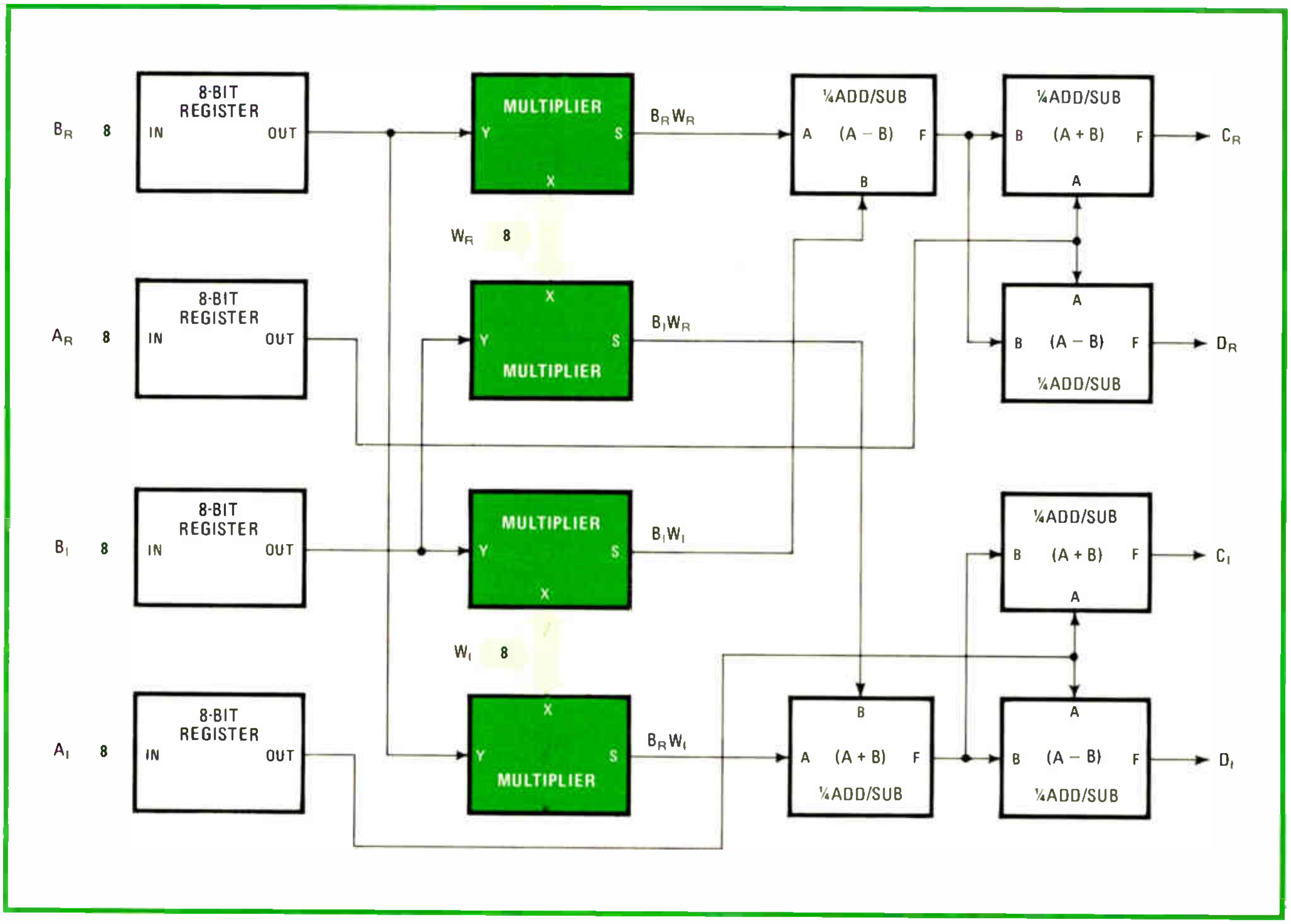
One Am25LS14 handles 8-bit-long words, but it can be cascaded easily with duplicate chips to handle larger words. In cascading them (Fig. 4), the clock inputs are connected together, as are the clear and Y inputs. Each device accepts 8 bits of the total multiplicand, and the S outputs are connected to the next lower-order K inputs. For a 2's complement multiplicand, the most significant device M input is tied low. On the other devices, M is tied high.

An 8-bit-by-8-bit multiplier with a parallel, bus-organized input/output capability (Fig. 5) accepts an 8-bit multiplicand and an 8-bit data bus. It will return a 16-bit product (8-bit upper and lower bytes) using the same 8-bit bus.

Applications

The Am25LS22 is an 8-bit register designed to perform various functions with the Am25LS14. It can be used initially to hold the multiplier word, perform the sign-extend function, and then hold part of the product. It has separate serial I/O capability as well as shared parallel input/outputs.

The serial-parallel capability means the multiplier is



7. Butterfly. The butterfly network used in the fast Fourier transform can be assembled with four multiplier chips. A, B, and W are complex numbers with 8 bits each in the real and imaginary parts, and C and D, the outputs, also are complex numbers.

particularly well suited to digital-filter and fast-Fourier-transform applications. In a typical canonical, two-pole, two-zero, recursive digital filter (Fig. 6), four multipliers are used with two memory registers and four serial adder/subtracters. (A new device, the Am25LS15, has been developed to handle this add/subtract function with four separate adder/subtracters.) The 8-bit coefficients A, B, C, and D determine the pole and zero locations of the filter. Thus it can be used as a high-, low-, or band-pass digital filter and as a two-pole building block in more complex designs, such as Butterworth or Chebyshev filters.

The multipliers also can be used in a butterfly network that is required for when performing fast-Fourier transforms (see Fig. 7). Input quantities A, B, and W are complex numbers:

$$A = A_R + jA_I$$
$$B = B_R + jB_I$$
$$W = W_R + jW_I$$

where R and I designate real and imaginary parts and the outputs C and D are evaluated as:

$$C = C_R + jC_I$$
$$= (A_R + B_R W_R - B_I) + j(A_I + B_R W_I + B_I W_R)$$
$$D = D_R + jD_I$$
$$= (A_R - B_R W_R + B_I W_I) + j(A_I - B_R W_I - B_I W_R)$$

The four BW multiplications can be performed easily with four serial-parallel multipliers (using the appropriate number of bits, of course), while the additions and the subtractions can be performed with four serial adder/subtracters.

Only the basic data flow is shown in the figure. The circuits for binary weighting of the numbers, rounding, truncation, and so on must, naturally, be included to come up with a workable, practical system.

In Fig. 7, the input variables A, B, and W are assumed to be represented by 8 bits for both the real and imaginary parts. Input B is first loaded in parallel into an 8-bit shift register and then shifted out serially for appliation to the Y input of a multiplier.

The W inputs are loaded in parallel into the multiplier's X inputs. Input A is similarly converted to a serial stream for application to the adder/subtracter networks. The final outputs appear as serial streams on the C and D lines.

These applications, of course, while numerous and valuable in themselves, hardly exhaust the capabilities of the Am25LS14. In the future, this device and other digital-signal-processing monolithic chips will find useful roles to play in many cost-effective commercial systems: process control, data compression before transmission, spectrum analyzers, medical electronics, and special-purpose instrumentation. □

Diode or transistor makes fully linear thermometer

by Cameron J. Koch
Ontario Cancer Foundation, London, Ont., Canada

An electronic thermometer circuit that uses a semiconductor diode or a transistor as its sensor can produce an output voltage that varies linearly with temperature. The voltage across the diode or the base-to-emitter junction of the transistor changes at −2.2 millivolts per degree celsius if the current through the junction is held constant. Previous circuits with such sensors have been nonlinear at low temperatures [*Electronics*, March 20, 1975], but this difficulty is easy to overcome.

The trick is to use a bipolar power supply so that the sensor's amplifier is not forced to operate near its V− supply voltage. The thermometers described here use this kind of supply, and both are linear and accurate to within 0.05°C. Self-heating of the sensors is extremely small, because they operate at about 50-microwatt power levels.

In the transistor-sensor circuit (Fig. 1a), the potential of the noninverting input of the op amp is set by resistor divider R_4 and R_5 between ground and B−. The output of the amplifier then drives the R_1-R_2 divider and the base of the sensing transistor via R_6. As a result, enough current flows through emitter resistor R_3 to make the potential at the emitter (and hence at the inverting input of the amplifier) the same as the potential at the noninverting input.

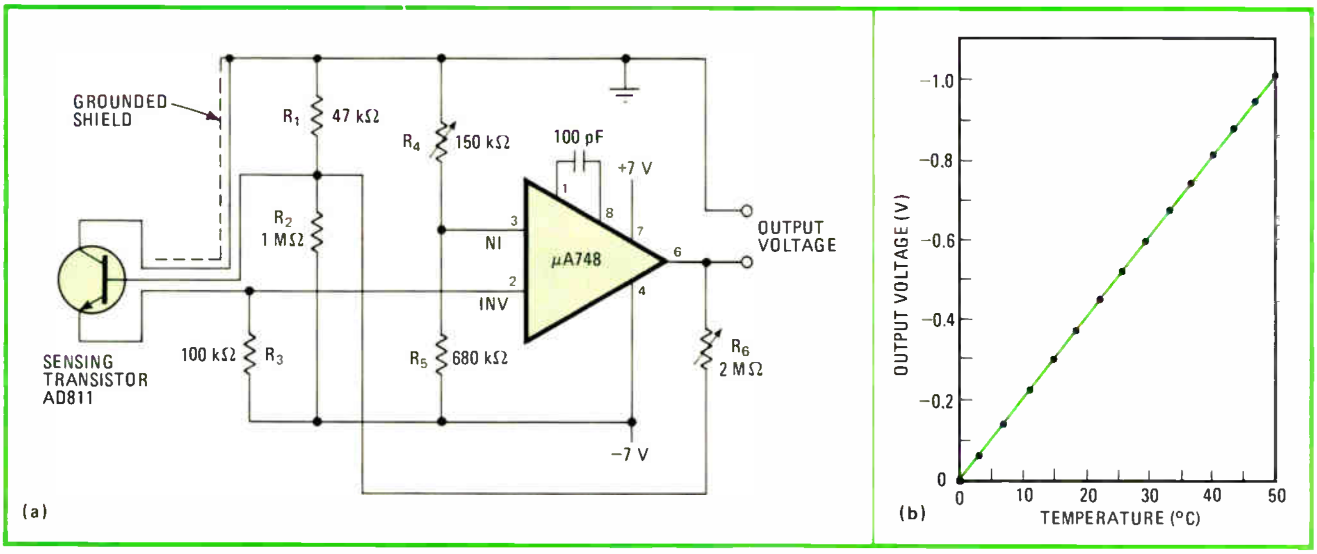
The operation of the circuit depends on the necessity for the emitter current I_E to remain constant in order to provide a constant potential at the inverting input of the amplifier. The base current I_B is just $I_E/(1+h_{FE})$; since I_B is constant, the base-to-emitter voltage depends only on the temperature of the transistor. Hence the output, which is proportional to the base-emitter voltage, is in turn proportional to the absolute temperature.

Neither the temperature variation of h_{FE} nor the collector-to-base leakage current affects the operation of the thermometer circuit significantly. The value of h_{FE} varies very slowly with temperature, and I_{CBO} is much smaller than the forward base-emitter current. The Analog Devices AD811 transistor used for the sensor has extremely low leakage.

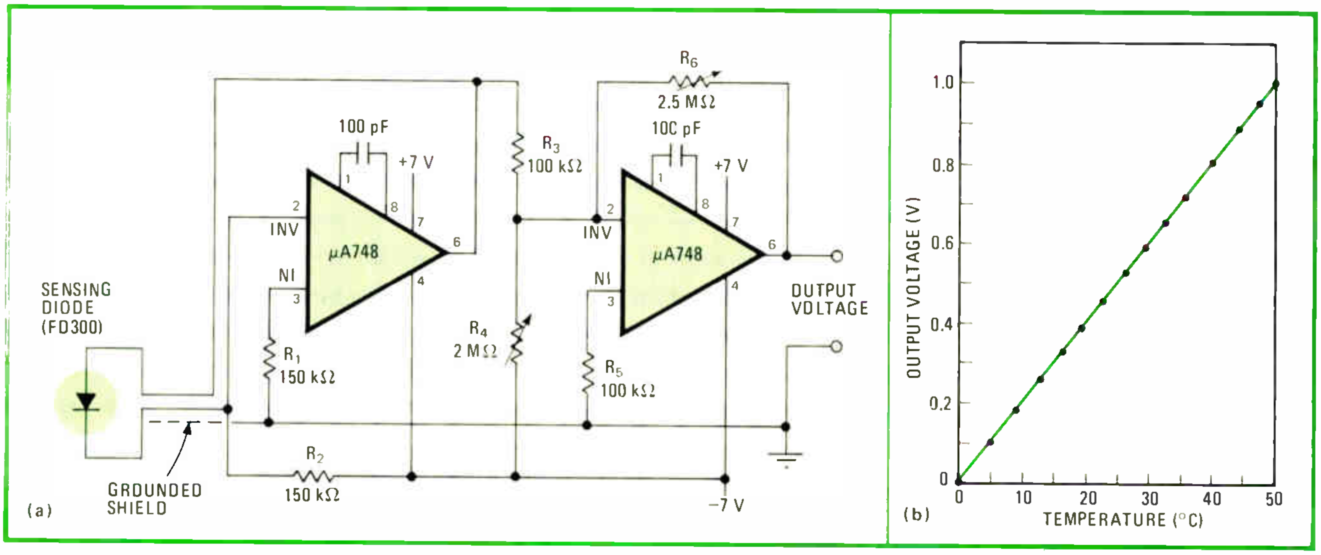
The zero point is set by potentiometer R_4 and the gain by potentiometer R_6. Since the two adjustments interact somewhat, two or three iterations of the calibration are necessary. At the slight expense of an increased output impedance, it's possible to remove the interdependence of zero and gain controls by using a fixed feedback resistor for R_6 and connecting a 10-kilohm potentiometer between the output of the amplifier and ground. Then the overall circuit output becomes the wiper and ground terminals of the pot.

Figure 1b shows the output voltage as a function of ambient temperature at the transistor. The calibration adjustments were set for an output of −1 volt at 50°C. The line connecting the experimental points was drawn with a straight edge.

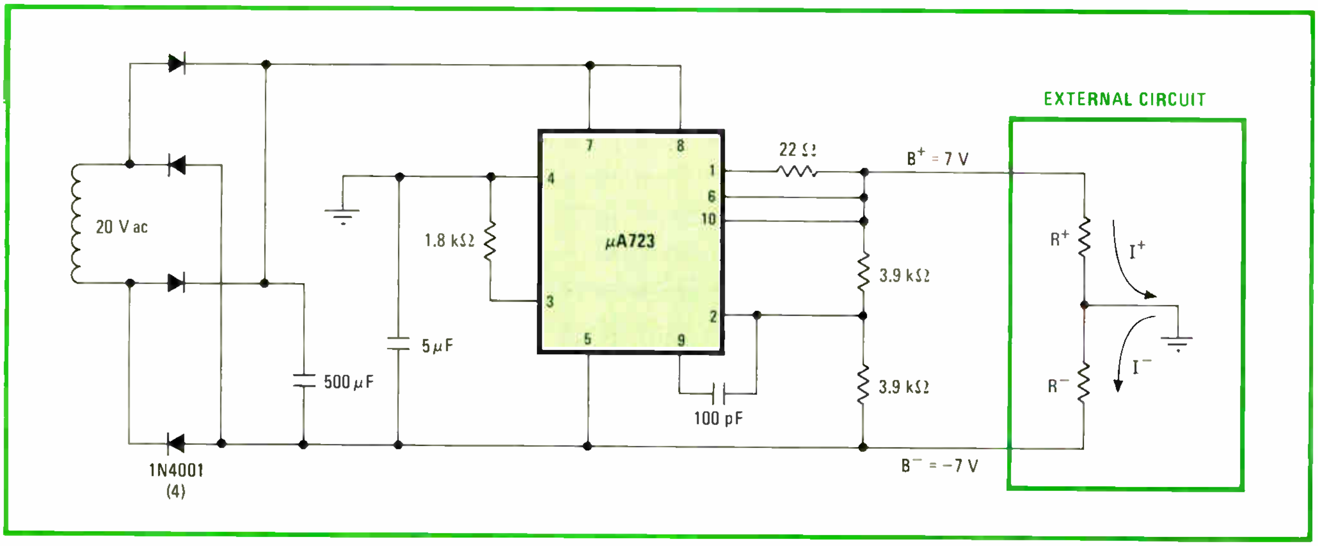
The sensor is fabricated by sealing the transistor—preferably along with a little dessicant—into thin stainless steel tubing with silicone rubber. Both the tubing and the collector are grounded. The unit operates satis-



1. Transistor sensor. Electronic thermometer circuit (a) uses a low-leakage transistor to produce an output voltage that varies linearly with temperature. The fixed voltage applied to the noninverting input of op amp is matched by the constant emitter-current drop through R_3. Output voltage varies with temperature-dependent junction voltage to hold emitter current constant. Zero point is set by R_4 and gain by R_6. Response curve (b) is linear to within the 0.05°C accuracy of calibrating thermometers.



2. Diode sensor. In thermometer circuit with diode (a), constant diode-junction current through R_2 keeps inverting terminal of first op amp at same potential as grounded noninverting terminal. Output voltage varies with temperature-dependent diode drop to hold current constant. Second op amp allows zero adjustment through R_4 and gain control through R_6. Response curve (b) is linear within measurement accuracy.



3. Supplying power. Precision voltage regulator IC is heart of this ±7-V power supply for low-current instrumentation circuits. The −7-V line is a stable reference for the thermometer circuits because it is just the reference voltage of the integrated circuit, with no temperature-dependent elements to reduce stability; the +7-V stability is limited by the temperature dependence of the output transistor in the device.

factorily, even in boiling water.

In the diode-sensor circuit (Fig. 2a), the first operational amplifier acts as a simple constant-current source for the diode. The noninverting input is grounded through R_1, so the output always moves sufficiently positive to keep the inverting input at ground potential as well. Thus the current through R_2 is set at about −50 microamperes by the ground-to-B^- reference voltage (−7 V/150 kilohms). The input current requirement of the amplifier is very small (less than 50 nanoamperes), so virtually all of this (constant) current flows through the diode. Therefore, the voltage drop across the diode depends only on temperature, and hence the output of the first amplifier is proportional to the absolute temperature.

Since most temperature measurements are made in the range of 270 to 370 K (0–100°C), a second amplifier is used to offset the diode voltage to whatever temperature range is desired and also to provide gain. Potentiometer R_4 between the input of the second amplifier and ground sets the output at zero for whatever temperature is chosen (i.e. 0°C), and feedback resistor R_6 sets the gain. The input resistor to this stage, R_3, is 100 kilohms, so the maximum gain is about 25. Figure 2b shows the voltage-vs-temperature curve for a circuit adjusted to give 1 V at 50°C.

Compared to the transistor, the diode sensor is a little harder to fabricate and shield effectively by using commercial high-quality devices like the Fairchild FD300 because the cathode is only at virtual ground in the circuit. However, the diode circuitry does have two advantages. The zeroing and gain potentiometers are completely independent, resulting in a simple calibration procedure, and since both the diode input current and zeroing current are set by the −7-V reference voltage, any slight changes in these currents caused by reference voltage changes tend to cancel. Thus the overall circuit is about half as sensitive to reference changes as the transistor-sensor circuit.

If the diode is sealed entirely within a thin piece of grounded tubing, the shielding becomes just as effective as in the transistor sensor. However, the time constant of the sensor is several times larger because of the reduced heat flow between the diode and the external environment. Even so, this time constant is not much greater than that of a typical mercury thermometer.

In both of these electronic temperature-sensing circuits, the current requirements of the outputs are very low because the operational amplifiers need only drive a high-impedance readout device such as a recorder, digital voltmeter, or microammeter. Therefore a bipolar power supply and extremely stable reference can be achieved inexpensively with a single μA723 (Fig. 3).

With this type of power supply, two conditions must be satisfied. The external circuit resistances (labeled R^+ and R^-) must be such that the current always flows out of the reference (i.e., $I^- - I^+$ must be positive). Also, to comply with the specifications of the integrated circuit, this current must be less than 5 milliamperes. The easiest way to ensure that I^- is greater than I^+ is to set up the external circuit under maximum I^+ conditions, then measure the two currents and make I^- greater than I^+ by connecting an appropriate resistor between ground and B^-.

The second condition can be met wherever the total change in $I^- - I^+$ (caused by output current variations) is less than 5 mA, as in these circuits. □

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.

Touch switch enters data without extra components

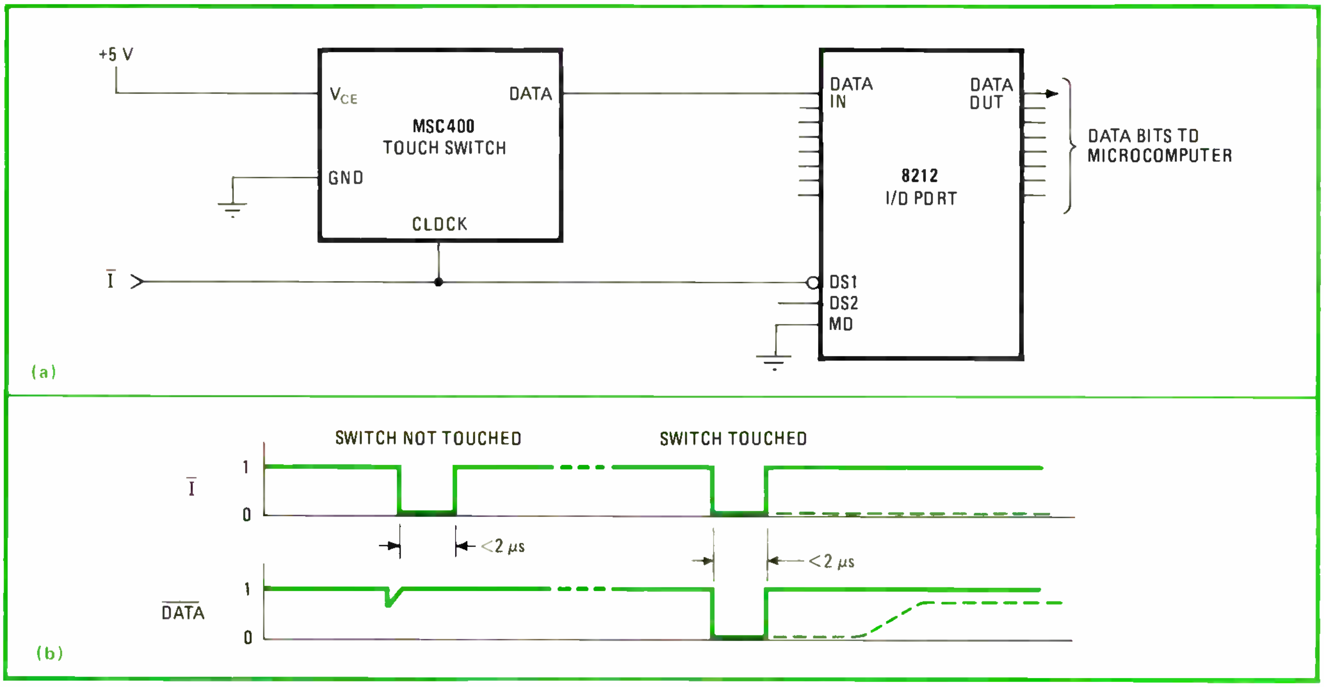
by Kim Rubin
University of California, Berkeley, Calif.

A clocked touch switch provides a convenient way to enter data into a microcomputer because no additional circuitry is required. And, since touch switches don't bounce, debounce software routines are unnecessary. If a finger is on the switch when it is clocked, the switch produces a short output pulse. No pulse is produced if the switch is not being touched.

A microcomputer receives data through an input instruction that typically entails the use of a negative-going input pulse $\bar{I}$. This pulse strobes the latch that connects the data bus or data source to the computer. When the data source is the clocked touch switch, the $\bar{I}$ pulse can be used to clock the switch. The output data pulse from the switch has a duration of about 2 microseconds, which is long enough for the computer to accept the data.

The figure shows a touch switch interfaced to a microcomputer through an Intel 8212 latch. While the switch is touched, the strobe pulse appears on the data line as a logic 0. When the switch is not touched, no pulse appears on the data line in response to the strobe, so a logic 1 is read in.

Although an Intel 8212 I/O port is shown, a Motorola MC6820 peripheral input adapter or an Intel 8255 programable peripheral interface may be used. □



Data at a fingertip. Clocked touch switch feeds logic 1s or 0s into computer through I/O latch (a). Strobe that enables latch also clocks the touch switch and appears on data line as a logic 0 if switch is touched (b). Dashed line indicates what happens when the strobe stays low.

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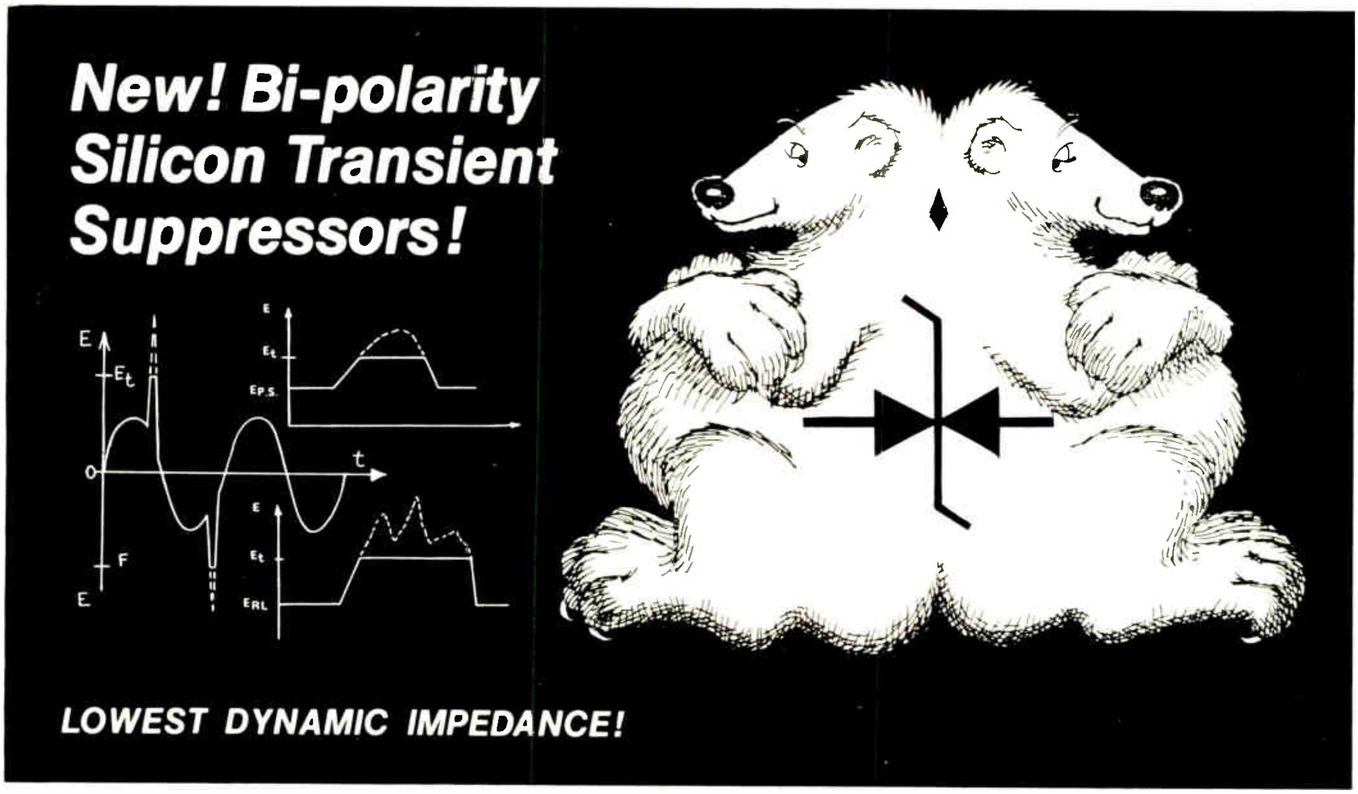

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Temperature Coefficient of (VBR): .05 to .11%/°C
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Peak Pulse Power

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Peak Surge Current (Ism): 136.4 to 5.2A
Temperature Coefficient of V(BR): .05 to .11%/°C
Case Size (Max.): .180" D x .165" L

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Circle 113 on reader service card

Engineer's newsletter

How to turn an erasable PROM into a ROM simulator

If suppliers made erasable PROMs that fitted into the same sockets as nonerasable programable read-only memories, designers of microprocessor-based equipment would have a lot less to complain about. As it is, they need an expensive ROM simulator to debug a program before they dare commit it to masks. Well, John R. Shotliff of Electronic Associates Inc., West Long Branch, N.J., took the bull by the horns—he **used plyers, saw, and soldering iron to turn an Intel 2704 (a PROM that is erasable with ultraviolet light) into the equivalent of an Intel 3624 PROM.**

To be more specific, he modified a standard socket for the 3624 so that it could hold the 2704. The two 24-pin devices have only four functionally different pins, so Shotliff began by temporarily removing the corresponding four from the 3624 socket. Next, he cut a notch in the socket side and a hole through the socket bottom, beginning the latter just beyond the empty pin sites and extending it roughly two thirds of the way across. He then refloored the socket with a piece of perforated Veroboard. That done, he reinserted the pins, folded them over flush with the socket base, and soldered them firmly along their length to the outside of the board. Finally, he wired the pins from the other side of the board—through the board perforations—to an external bus, passing the wires through the notch and flush with the upper rim of the socket. This assembly held an erasable PROM but plugged into the standard PROM socket.

GE is hot on trail of why batteries 'remember' . . .

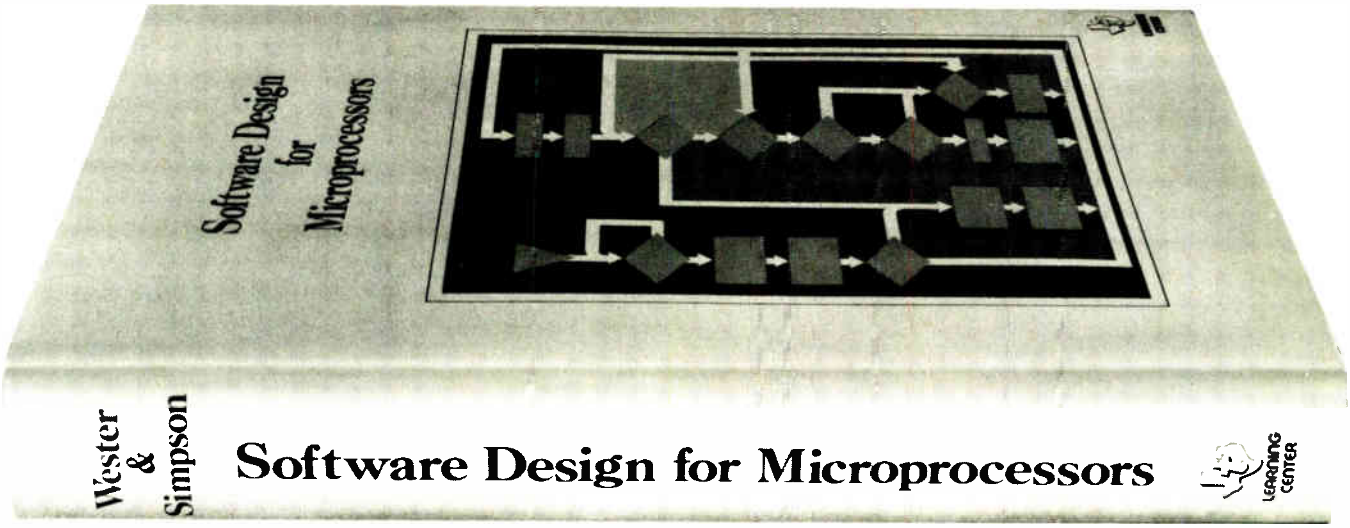
Perplexingly, a relatively new nickel-cadmium battery occasionally begins to lose capacity, but as users know, it can be returned to full capacity by being given a full dead discharge and then a full recharge. Popularly called "memory," this loss of capacity seems to happen after repeated short cycling, where the depth of discharge is shallow and identical for each cycle.

But GE's battery department in Gainesville, Fla., may have defined the mystery. Under a scanning electron microscope, the plates in test batteries showed physical changes that suggest **an explanation in terms of decreased voltage discharge rather than an actual reduction in battery capacity.** Another discovery: "memory" is more difficult to induce in applications that vary any of the battery environment parameters—discharge depth, discharge rate, temperature, or recharge time.

. . . and here are two worth remembering

And if you're designing power supplies using rechargeable nickel-cadmium batteries for portable equipment like calculators, cameras, and watches, you'll want to check out a couple of foreign products now being sold in the U.S. From SAFT American, a French affiliate, comes a 1.2-volt unit with a hefty 430 milliampere-hour rating. It's the size of a book of matches, only twice as thick, and **its big selling point is that it can be recharged in six hours—that's about as fast as possible.** A safety valve prevents pressure from building up dangerously during recharge. Also, Frankfurt-based Varta AG plans to market watch batteries in the U.S. through Bulova (p. 65). **—Laurence Altman**

New from Texas Instruments: An authoritative guide to understanding microprocessor software...from the beginning. Only $12.95.



A working knowledge of microprocessor software is essential to mastery of microprocessors. And acquiring such knowledge is now simplified with TI's new text, *Software Design for Microprocessors.*

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61002

A microcomputer for industrial use

Low-cost, low-power modular line is tailored to harsh environments; system with full ASCII keyboard, CRT display is priced below $1,000

by Stephen E. Scrupski, Computers Editor

In designing a microcomputer for industrial use, close attention must be paid to the special requirements of the industrial environment. The microcomputers frequently must work in dirty, corrosive surroundings and thus are often installed in sealed boxes where they can cook themselves to death. For such applications, power dissipation must be kept to an absolute minimum. A new one-board microcomputer based on the 8080A microprocessor makes extensive use of C-MOS technology to reduce power dissipation to about half that of other microcomputers.

Two boards. Designed for instrumentation and machine-control applications, the Superpac 180, priced at less than $1,000, includes a full ASCII keyboard and a 5-inch cathode-ray-tube display—a combination offered at lower cost than many CRT displays alone, according to the maker, Process Computer Systems. The Superpac 180 basically uses two boards: the microcomputer module and a keyboard interface and CRT control module, which has circuits for memory refresh, timing, character generation, for 16 lines of 16 or 64 characters, programable cursor blink, and reverse video.

Basic to the 180 line are the 1806 and 1810 microcomputer modules. For less than $300, the 1810 includes power fail/automatic restart and battery backup that can support its 256 bytes of C-MOS random-access memory for up to 10 days. It also includes a crystal-controlled clock, 16 3- to 30-volt digital inputs, 16 30-volt, 500-milliampere digital outputs, an RS232 serial port, an external interrupt, five interval timers, provisions for 7,168 bytes of read-only memory, and direct-memory-access capability. Users can build onto this basic one-board microcomputer system by adding memory and input/output as well as peripherals and communications options.

The 1806 module, a standard microcomputer in the 180 package, is for applications where battery backup is not important and where more memory is required on a single board. It comes with 1,024 bytes of random-access memory, eight transistor-transistor-logic inputs, and eight outputs. Otherwise, it is similar to the 1810.

An additional advantage offered by C-MOS for industrial applications is its noise immunity. But this technology has a capacitance problem and low drive capability, which slows it down coming on and off a bus, so the 180 systems use tri-state bus ports to improve load handling and speed.

The 1806 also will be offered with a basic four-slot chassis for under $500. I/O modules can be added as needed by the customer. The four-slot chassis is also available in a 19-inch rack-mount configuration with power supply and 1806 module. At a slightly higher cost, the 1810 module can be supplied in place of the 1806. In the 19-inch configuration, the four-slot chassis/1806 combination is available as a complete package that includes a front panel with on/off and status switches for about $700. The system version for rack-mounting, the Micropac 180, has front-panel status indicators and sells for $695.

Process Computer Systems, 5467 Hill 23 Drive, Flint, Mich. 48507 [338]

Connectors aimed at CB market

Line designed for applications in citizens' band radio equipment includes no-solder, field-crimp type and units for high-volume automatic termination

by Ron Schneiderman, New York bureau manager, and Larry Armstrong, Midwest bureau manager

Hoping to take advantage of the exploding market in citizens' band radio, Bunker Ramo Corp.'s RF division in Danbury, Conn., has developed a family of fast and easy-to-terminate PL-259-type uhf coaxial connectors for both OEMs and end users.

The new 83-58FCP (for field-crimp plug), designed for solderless terminations of RG-58 A/U cable, is available in OEM quantities or from distributors in both off-the-shelf (bagged) form or in blister packs for point-of-sale display racks at $1.18 each. In OEM quantities, the 83-58FCP price ranges from 80 cents for one to 24 pieces to 50 cents each for 1,000 to 2,499 pieces. Lee E. Eichenseer, the division's marketing vice president, says performance of the 83-58FCP (shown at right) equals that of the company's standard communications connector, the Amphenol 83-LSP.

No special tools. To complete connector-to-cable termination of the 83-58FCP, the user simply strips the coaxial cable and pushes the connector parts onto the center conductor and braid. The contact is squeezed at the tip to secure the center conductor. Or, if desired, the contact can be soldered. No braid soldering, combing or cable braid, special crimping tools, or adapters are needed, adds Eichenseer.

The 83-58FCP connectors have a frequency range of 0–300 MHz, and a voltage rating of 500 V peak. Thermal limits are −67°F to +300°F, and the connectors are not waterproof. They have standard ⅝-24 threads and mate with standard uhf receptacles and adapters.

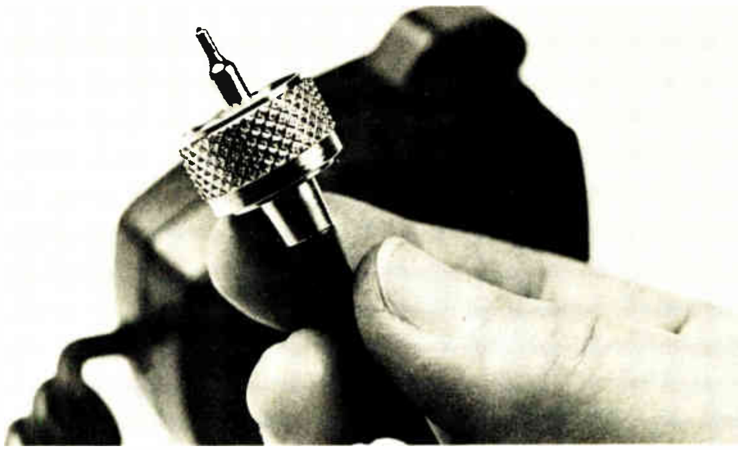
In addition to the 83-58FCP, three new crimp/solder Amphenol PL-259-type uhf connectors are now available. However, unlike standard PL-259-type connectors that require soldering of both the center contact and outer ferrule to the cable braid, Eichenseer says the new connectors require a simple crimp termination of the outer ferrule to the cable braid, reducing assembly time and lessening the hazard of damage from overheating during soldering.

Each of the new connectors is designed to accommodate a variety of specific RG/U coaxial-cable types. Amphenol model 83-8SP, priced at 53 cents each in OEM quantities of 1,000 to 2,499, is designed for RG-8, -11, -149 and -213/U; model 83-58SP (52 cents each) for RG-58 and -141/U; model 83-59SP (also 52 cents each), for RG-59, -62, -140, and -210/U.

These connectors can be crimped with a semiautomatic pneumatic crimping tool for high-volume applications. Also, separate sets of crimping dies are available to accommodate various cable diameters.

The SP series connectors have the same frequency range and voltage ratings as the 83-58-FCP. Their nominal impedance is 50 ohms.

Another new Amphenol PL-259-type connector with crimp termination of both the outer ferrule and center contact to eliminate soldering operations entirely, is designated the 83-58SCP. Designed for high-volume applications, it can be crimped with either a semiautomatic pneumatic crimping tool or Bunker Ramo's Twin Hex hand-

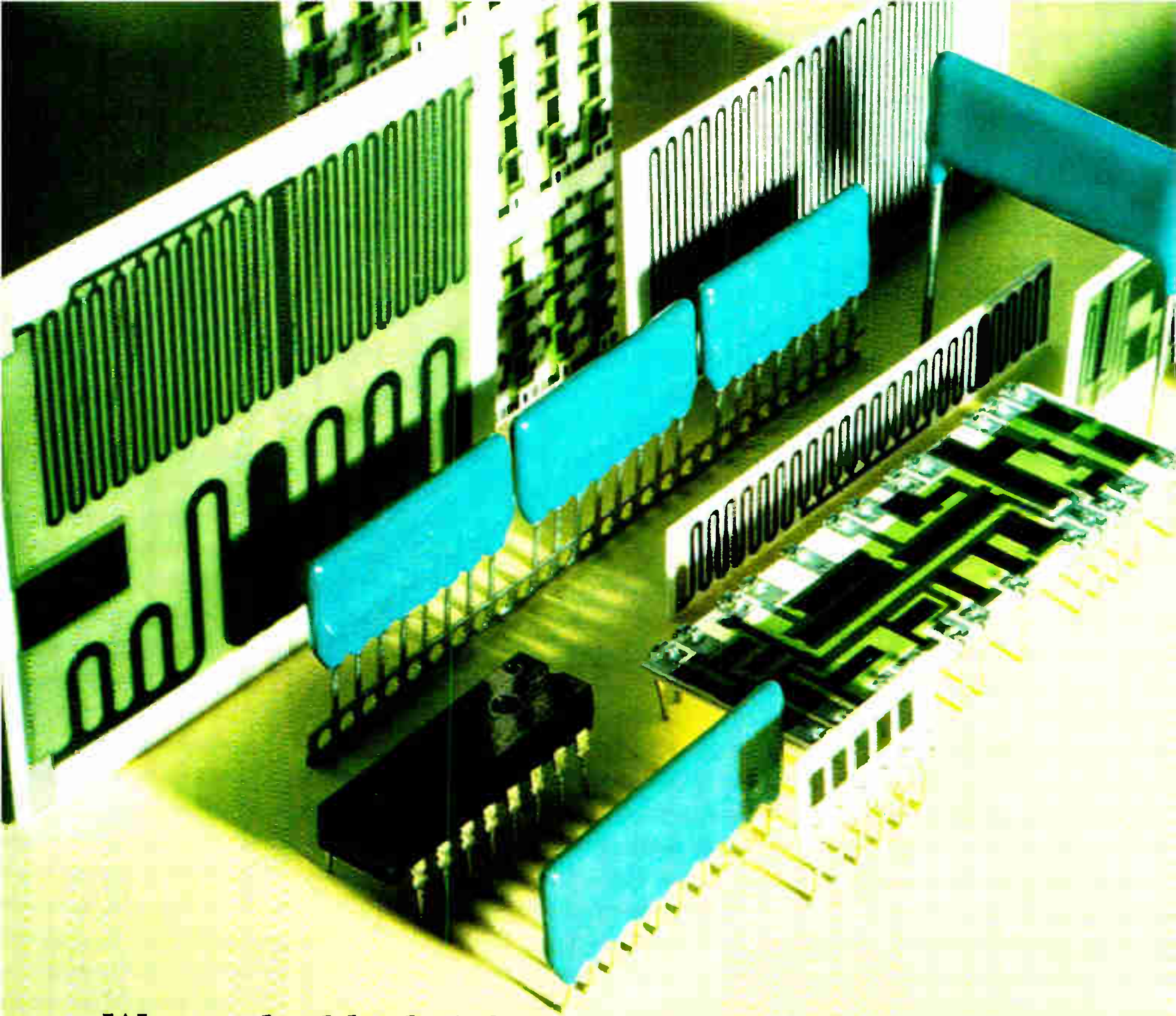


crimping tool.

The Twin-Hex tool has a universal tool frame with interchangeable crimping dies that are selected according to the cable and connector being assembled. The tool can be used for both crimping operations—the outer ferrule to the cable braid, and the center contact to the center conductor of the cable.

The 83-58SCP is priced at 51 cents each in OEM quantities of 500 to 999.

Bunker Ramo RF division, 33 E. Franklin St., Danbury, Conn. 06810 [339]



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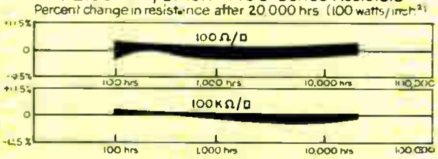

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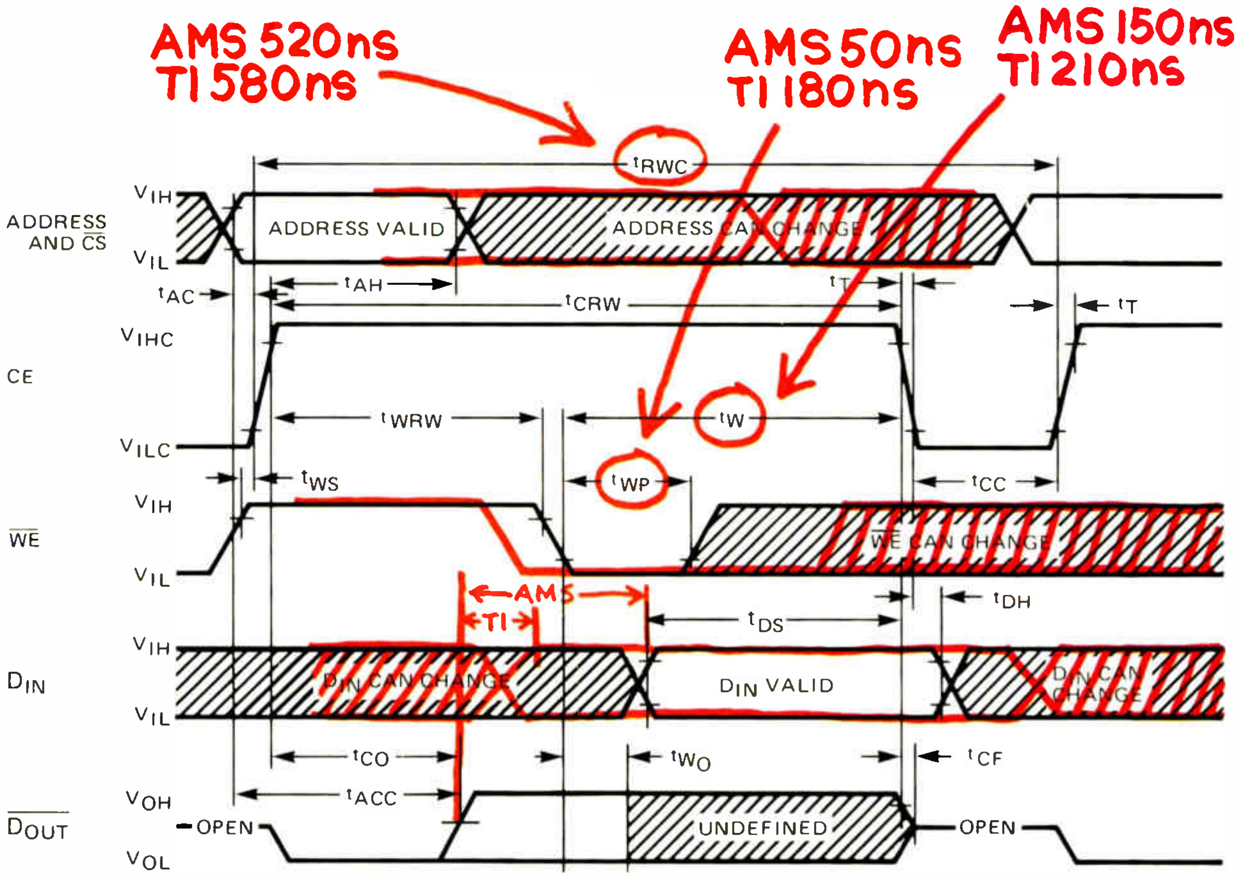

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Pick a spec.

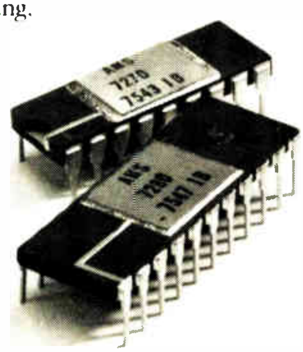
These are only highlights, but you can readily see how TI ends up in the red.

		22 pins		18 pins	
		AMS 7280	TI 4060-2†	AMS 7270	TI 4050††
t_{AH}	Address & CS Hold Time	50	150	50	150
t_{WP}	$\overline{WE}$ Pulse Width Time	50	180	50	180
t_W	$\overline{WE}$-to-CE OFF Time	150	210	200	210
t_{DH}	D_{IN} Hold Time	0	40	0	40
t_{DS}	D_{IN}-to-CE OFF Set Up Time	150	210*	150	210*
min RMW cycle		520	580	580	600
t_{mod} @ min cycle		20	20	80	20
t_{mod} @ TI's min cycle		(580 ns) 80	20	(600 ns) 100	20

*data must be valid on $\overline{WE}$ going low
†pin-for pin compatible
††not pin for-pin compatible

Pick a winner.

The 7280 or 7270 from Advanced Memory Systems. With the devices you need, in production quantities, and with the experience to support you in performance, reliability, delivery and pricing.



4K OK

AMS 7280 22 pin
4096 X 1 NMOS Dynamic RAM
Max Access 200 ns
Min Cycle 400 ns
Single High-Level Chip Enable
TTL Compatible
P_{diss} 480mW typ.
Capacitive inputs
On-Chip Address Registers
Pin-for-pin with TI 4060
Ceramic DIP

AMS 7270 18 pin
Same as 7280 with
Special Tri-Share Port*

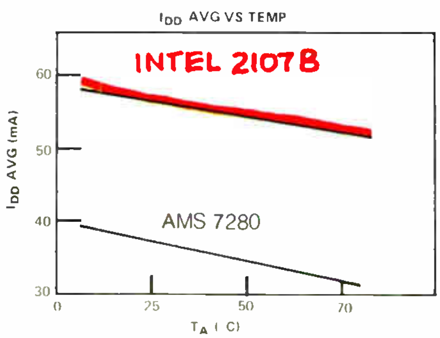
*Tri-Share is a registered trademark of National Semiconductor Corporation

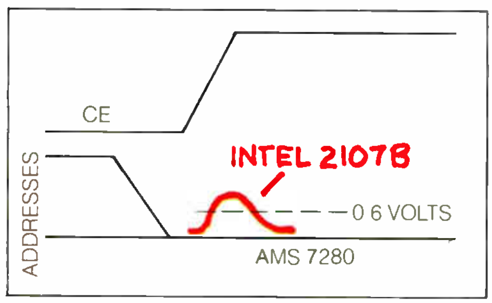
Intel delivers if you have power to burn and a fistful of capacitors.

Intel's 2107B consumes one third more power during a read or write cycle than our 7280. It's even worse during read/modify/write. Note the chart of I_{DD} Avg. to your right.

To observe the glitch in the far right graph, hang a probe on an address line of an Intel 2107B board. Watch it shoot above 0.6 Volts. And watch it go away with 7280s.

Supply noise? You can silence Intel with a fistful of capacitors. Or, more simply, you can replace the 2107Bs with our 7280s. No power problem. No clock watching. No trade offs. No kidding.





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Packaging & production

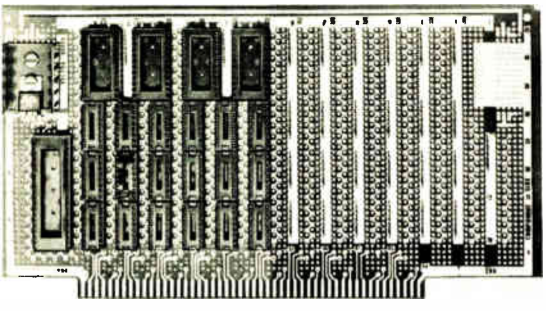
Pc board aids system design

Universal card helps develop breadboards based on any microprocessor

A universal microprocessor board with an area of 53.13 square inches and 100 input/output contacts is designed to give users flexibility in putting together breadboards of microprocessor-based systems. The model 8800V board, produced by Vector Electronic Co., handles any commercial microprocessor, allows memory expansion, implements peripheral interface hardware requirements, and accommodates such I/O circuits as converters, multiplexers and relays.

"The large area is important," says Floyd Hill, vice president of marketing, "because the board has to be big enough for quantities of microprocessor packages and other required electronics, and still be versatile enough in bus arrangement to hook up all these things."

The model 8800 board is prepunched with 0.042-inch-diameter holes on 0.1-inch centers so the user can place dual in-line packages in any location. Typically, the board holds two 40-pin DIPs, eight 24-pin DIPs, and 36 14- or 16-pin units. As an alternative, it can accommodate 52 14- or 16-pin DIPs, or 10 40-pin and eight 24-pin DIPs—or any combination of these. This adaptability is particularly useful, Hill says, with the larger memory devices that may have 18-, 20-, 22- or 28-pin packages.



Without modification, the designer may use any DIP device, with space for discrete components and for ribbon-wire connectors. Column and row DIP-zone coordinates as well as hole designators are etched into the laminate.

Power and ground planes on opposite sides of the board, which also give distributed decoupling capacitance, send power to each DIP location. Additional capacitors may be located adjacent to the DIPs.

For regulators, the board has two copper heat-sink positions on the component side, with one position pre-wired and drilled for 7800 series regulators in a TO-220 case. The second regulator position is uncommitted, with provision made to cut power conductors for special applications. One low-profile, finned heat sink is supplied with each board.

The 5.313-by-10-inch boards are manufactured of FR-14 expoxy-glass material 0.06 in. thick. Two-ounce 0.0028-inch-thick copper cladding has solder plating for conductors and gold-flashed nickel plating for connector contacts. One hundred connector fibers, 50 to a side, are spaced on 0.125-inch centers. Holes are provided for card ejectors.

Boards are priced at $19.95 in 1–4 quantities, off the shelf. Furnished with each board are layout sheets showing hole and bus locations. Solder-tail and wrapped-wire mating sockets are also available, as well as associated sockets, terminals and tools.

Vector Electronic Co. Inc., 12460 Gladstone Ave., Sylmar, Calif. 91342. Phone Floyd Hill at (213) 365-9661 [391]

Board tester does go/no-go testing and fault isolation

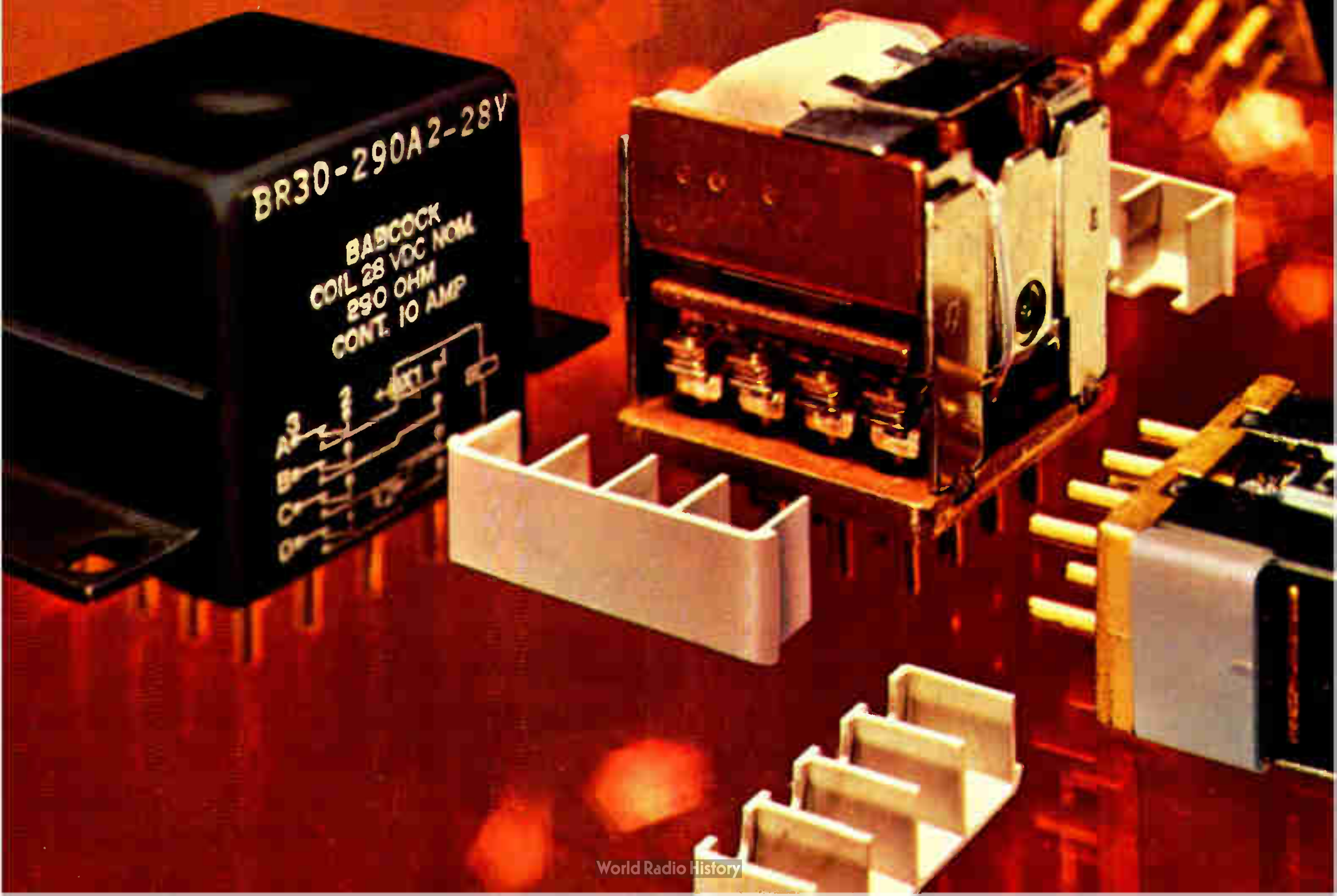
Designed both to provide high throughput when testing digital logic boards on a go/no-go basis and to perform rapid fault isolation

by means of a guided-probe, the DTS-70 digital test system is a computer-controlled assembly that can handle from one to three test stations. Digital-test-product manager Eric Isacson says the system can test a typical large logic assembly in only a few seconds. Fault isolation, typically down to the level of one integrated circuit, usually takes less than a minute, he says. Fault isolation is done both with stored fault signatures and by system-directed probe measurements.

The system consists of a controller, the HP 9640, and from one to three HP 9571A test stations. The controller is made up of an HP 2112 computer with 32 kilowords of memory, an HP 7905A 15-megabyte disk subsystem, and an optional line printer for program preparation.

Test programs are prepared using Testaid III, a software package that includes logic-simulation and automatic pattern-generation capabilities. The software package, says Isacson, eliminates much of the tedium associated with the production of good digital-test programs. The logic simulator operates concurrently with one test station, allowing the user to prepare new test programs while one station is operating.

The 9571A can handle large logic assemblies of most commercial logic families, up to approximately 200 MSI-type ICs. As many as 360 pins can be provided at each station, and each can be programed to act as either a driver or a sensor. A 60-pin station sells for less than $25,000, and three such stations can be controlled by a controller that is priced at approximately $42,000. Deliv-



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290 OHM
CONT. 10 AMP

eries will start in July of this year.

Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [393]

Unit programs Intel 4-k and 8-k memories

A versatile, low-cost programer for the Intel 2704 (4,096-bit) and 2708 (8,192-bit) erasable PROMs requires only 70 seconds to program and verify one of the 4-kilobit memories and only 140 seconds for an 8-k device. Verification is done automatically by using an internal random-access memory. The RAM may be loaded manually by using eight data

switches and an octal address switch or automatically from a master ROM, a ROM simulator, or a minicomputer. With the minicomputer, the programer serves as a 1-k-by-8-bit RAM for the minicomputer system until the prospective erasable PROM contents are debugged. Eight status lamps on the model PR-2708 programer allow visual verification and adjustment of the contents of the erasable PROM. Designed for either laboratory or production use, the PR-2708 is housed in a 16-by-10-by-4 inch metal case. It sells for $998.

Curtis Electro Devices Inc., Box 4090, Mountain View, Calif. 94040 [394]

Pc connector for vertical boards uses no gold

A single-sided printed-circuit connector for interconnecting vertical boards with backplanes, Qiklatch

provides high-reliability connections without using gold on either the connector or the mating component. The device uses Burndy's patented GTH principle of high-pressure deformation to make a gas-tight connection in a soft, base-metal target. The result is a low-cost, corrosion-free interconnection system. Available on 0.156-inch centers in sizes from eight to 24 contact positions, the Qiklatch connector series is designed to accommodate 0.062-in. component boards and can be used with either a 0.062-in. or 0.093-in. backplane.

Burndy Corp., Norwalk, Conn. 06852. Phone (203) 838-4444 [395]

Pick-and-place machine cuts hybrid-circuit costs

The model SP 42 semiautomatic placer greatly reduces the cost of producing hybrid circuits by picking and placing components at rates of up to 1,800 pieces per hour. Programed by means of holes in a program board, the SP 42 can place components in the orientation in which they are received from their respective magazines, or it can rotate them by ±90° or ±180°. The machine places components such as resistors, capacitors, diodes, thermistors, SOT-23 transistors, and SO-8 integrated circuits to a tolerance within 3 mils. Bonding methods include solder paste, conductive epoxy, or solder-tinned circuits with components held in place with nonconductive epoxy. The SP 42 sells for approximately $7,000.

Deval Industries Inc., 5335 McConnell Ave., Los Angeles, Calif. 90066. Phone R. Atchley at (213) 390-6291 [397]

Communications

Fiber-optic cable family offered

Production quantities of five types ready; each made by different glass process

Although fiber-optic cables seem destined to compete with conventional signal conductors within the next decade, widespread acceptance has been prevented by high costs, difficulties in obtaining consistent quality, interconnection problems, and poor availability. Certainly, no single cable configuration yet offers the best and most cost-effective solution for all applications. However, Galileo Electro-Optics Corp. manages to circumvent many of these problems and to cover a wide range of applications with just five distinct cable types.

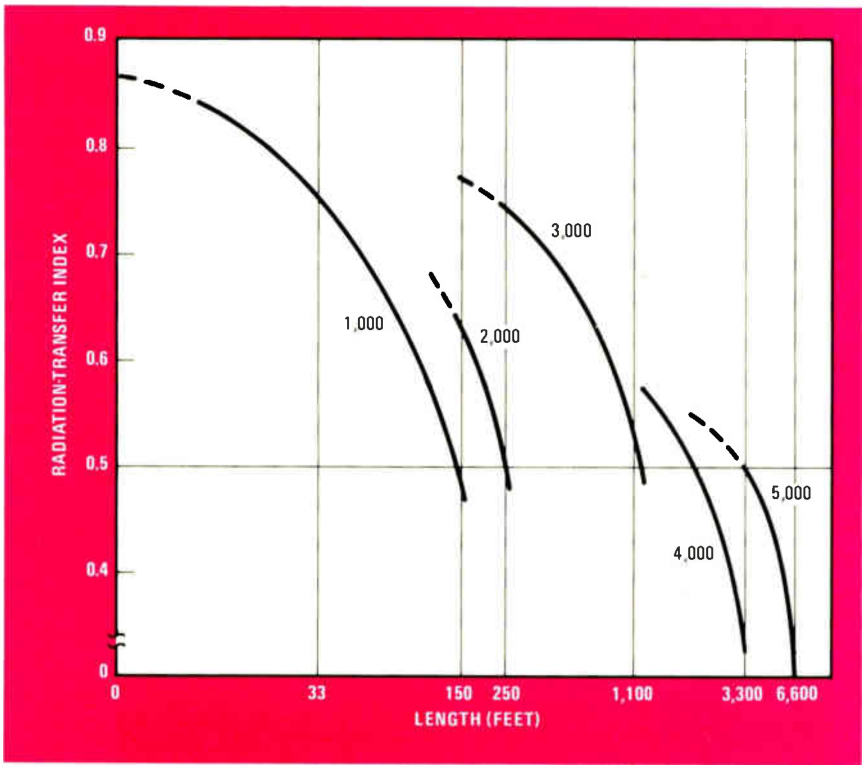
The Galileo line of optical communications fibers is now available off the shelf in production quantities. To achieve optimum performance within a determined length and for specific applications, the company uses five completely different glassmaking processes, giving users their choice among a broad range of stock fibers.

The graph below, using the radiation-transfer index as a figure of merit, helps in making the choice. This figure of merit is a combination of propagation loss, coupling loss, and operational cost.

Galileo's first entries are five different step-index fibers ranging from 30 cents to $4.50 per foot in lengths to 500 feet. All types are available in 1, 2, 7 and 19 fibers sheathed in polyvinyl chloride or Trefzel, a Du Pont material, and some are available in a strengthened jacket. The family of initial entries consists of:

- Galite 1000, the lowest-priced type, with the highest numerical aperture and thinnest cladding, which combine to minimize coupling losses when used with inexpensive light-emitting-diode sources. Tailored for applications that require maximum transmissions of 150 feet, it's particularly suited for internal communications links such as computer wiring, monitoring of hospital patients, high-voltage monitoring, and interface communications with areas needing rf isolation. The cable is supplied in lengths of up to 4,900 feet.
- Galite 2000, designed for short-range (150 to 250 ft) data-distribution systems, avionics controls, shipboard communications and high-voltage monitoring.
- Galite 3000, especially suited for data transmission over maximum distances of 1,100 feet. The processing minimizes scattering losses at the core/clad interface.
- Galite 4000, a plastic-clad fused-silica fiber that has superior radiation hardness and minimal loss in the near-infrared region. It is suited for such communications applications as computer-to-terminal links, remote military communications centers, cable television, and telephone exchanges.
- Galite 5000, the most costly member of the family, being doped to a specific index of refraction for use in long-distance communications at bandwidths as high as 100 megabits per second.

Galileo Electro-Optics Corp., Galileo Park, Sturbridge, Mass. 01518 [401]



Communications counters offer superior sensitivity

To extend its family of portable communications counters into the lower-cost and higher-performance regions of the market, Systron-Donner's Concord Instrument division is introducing the models 6242A and 6243A at Electro/76.

According to product manager Gail Dishong, the 6242A in essence replaces the model 6252 in the range of 100 MHz to 512 MHz, but at $795 costs about $400 less. The model 6243A is also less expensive, about $995, but has a wider range—from 100 MHz to 1,250 MHz.

Both counters offer a superior sensitivity of 10 millivolts rms, eight-digit readout, and an oscillator

Alabama still has room for profitable growth.

For the third straight year, capital investments announced for new and expanding industries in Alabama were over one billion dollars. (Only one other southeastern state has ever announced new capital investments exceeding the billion-dollar mark in a single year.)

The fact is, industries and businesses still find Alabama a profitable environment in which to locate, expand and grow.

Alabama has a labor training program that can supply you with qualified workers—at no cost to you for the state-supported training service. In 1975 alone, some 5,000 people were trained to meet industrial needs.

Chances are good that whatever else your needs might be— energy sources, available land, or navigable waterways—Alabama has that, too.

And Alabama Power will help you find it.

Just write G.T. Nelson, Vice President, Alabama Power Company, Industrial Development Department, Box 2641, Birmingham, Alabama 35291. Tell us what you need. We'll help you find it. Because Alabama wants you.

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with an aging rate of ±2 parts in one million per year. Higher stability oscillators are optionally available, says Dishong.

They also incorporate a novel phase-locked/multiplier technique that permits high resolution, high-speed direct-reading measurements of low-frequency tone signals with resolution to 0.001 Hz in 1 second. Resolution is 0.1 Hz to 1 kHz in decade steps. Direct gate time is 10 seconds to 1 millisecond in decade steps. Prescaled gate times are 40 seconds to 4 milliseconds on the 6242A and 160 seconds to 16 ms on the 6243. In the direct mode, the counters' input impedance is 1 megohm shunted by 25 picofarads.

Crystal frequency is 10 megahertz. The 0.4-inch eight-digit display features in-line readout with off-scale indicator for overflow. An automatic leading zero-suppression display holds readings between two samples. Operating temperature is 0 to 50°C. Power is 110/115 or 200/230 volts (±10%), 48 to 440 MHz. Measuring 3.5 by 8.5 by 13.5 inches, both models weigh about 10 pounds.

Systron-Donner, Concord Instrument Division, One Systron Drive, Concord, Calif. 94518 [402]

Data-communications tester operates up to 64 kilobits/s

Intershake II is a fully programable data-communications monitor and interactive tester. It can handle all codes and line disciplines at speeds

up to 64 kilobits per second with its internal clock or 256 kb/s with an external clock. In addition, the tester provides for all aspects of half- and full-duplex testing, even calculating the block check character for such common computer communications protocols as bi-sync and synchronous data-link control (SDLC). With its CRT option the instrument can display a full-duplex data stream.

In the hands of a relatively unskilled operator, Intershake II can perform up to 15 protocol diagnostic routines at the touch of a button. A skilled operator can structure his own routines from a library of 100 test steps including jump and branch (decision) instructions and loop (repeat) instructions for computer-like test programing. In addition to its main use in a communications center, the instrument is expected to find applications in the development of new communications equipment, in production testing, in field installations, in the diagnosis of difficult service problems, and in performance degradation analysis.

Atlantic Research Corp., 5390 Cherokee Ave., Alexandria, Va. 22314. Phone (703) 354-3400 [403]

Notch filters permit accurate noise measurement

The 585 series of narrow-band notch filters are specifically designed to permit accurate measurements of noise on telephone message circuits. These active filters have band-reject characteristics so sharp that they virtually eliminate test or holding tones from the input of noise-measurement equipment. The −3-dB and −50-dB bandwidths of the 585 series conform to Bell System specifications. The filters are offered in two standard models. Model 585-1 has 50 dB of attenuation from 995 hertz to 1,025 Hz to eliminate test tones, 1,004-Hz holding tones, and the 1,020-Hz tones that are often used for phase-jitter measurements. The model 585-2 has 50 dB of attenua-

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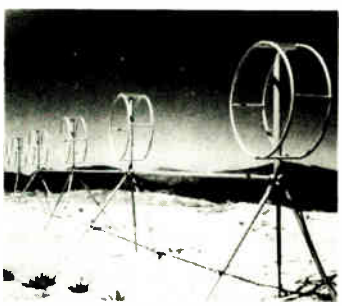
CONTINENT —

DIFFERENT LATITUDES
DIFFERENT CLIMATE

64°N

42.5°N



32.5°N

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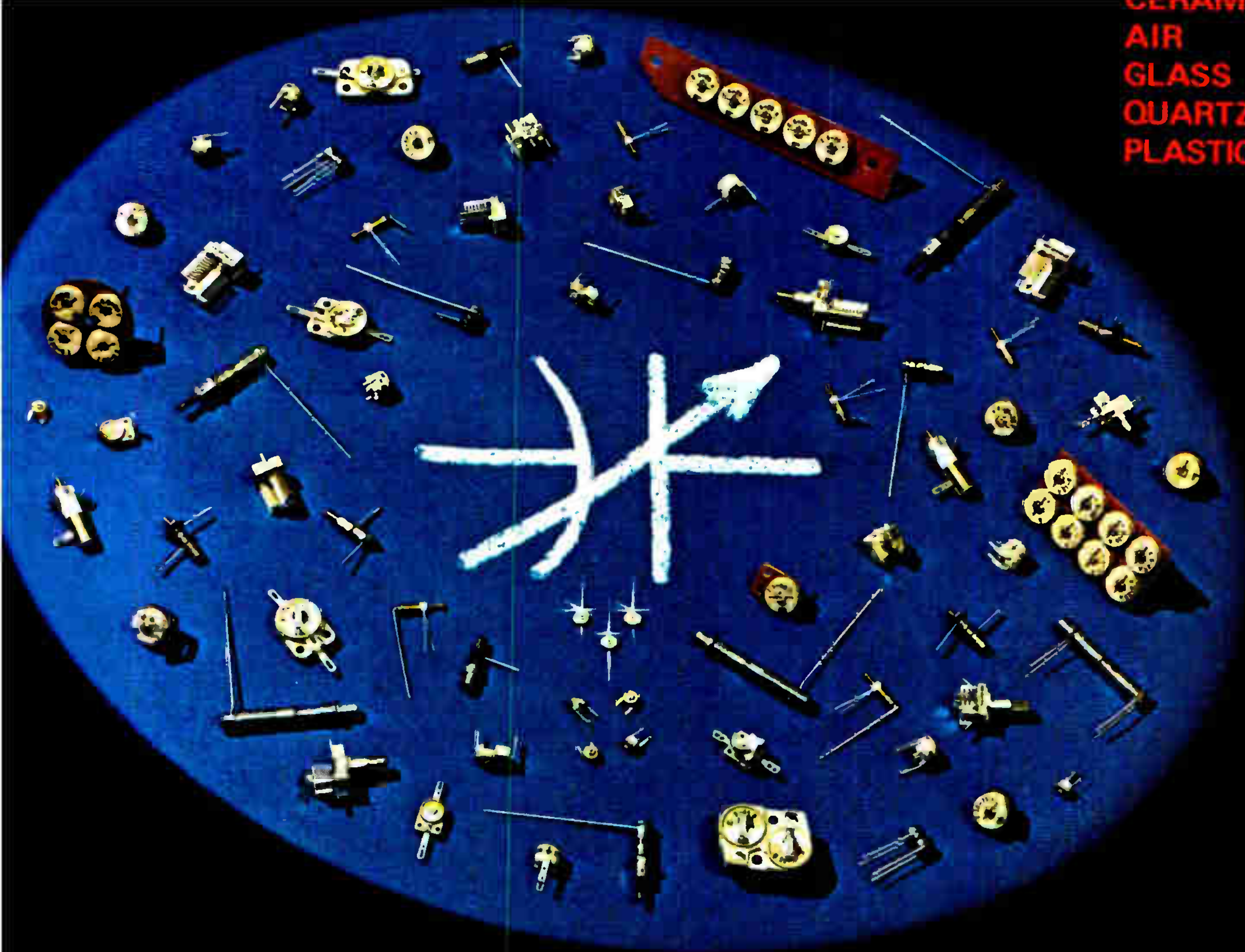
tion from 2,785 Hz to 2,815 Hz to eliminate the 2,800-Hz holding tone that is commonly used in telephone systems for line-noise measurements. Housed in standard low-profile modules that measure 2 by 2 by 0.4 inch, the filters sell for $85 in small quantities. In hundreds, the price drops to $57. Delivery is from stock for small quantities; four to six weeks for 100 pieces.

Frequency Devices Inc., 25 Locust St., Haverhill, Mass. 01830. Phone (617) 374-0761 [404]

Thick-film amplifiers operate up to 400 MHz

A line of six thick-film rf amplifiers built using proprietary multi-layer construction techniques operates up to 400 megahertz with noise figures as low as 4 dB. Packaged in plug-in TO-12 transistor packages (four-leaded TO-5 cans), the single-stage amplifiers are offered with three output-power ratings. The AH-403/463 has a typical output power of 15 dBm at its 1-dB compression point. Minimum gain is 9 dB, and typical noise figure is 7.5 dB. The AH-402/462 has a typical output power of 6 dBm, a gain of 13 dB, and a noise figure of 6 dB. The lowest-power units are the AH-401/461 which have typical output powers of −2 dBm, minimum gains of 13 dB, and noise figures of 4 dB. The AH-461, AH-462, and AH-463 differ from the other three units in that they require external input, output, and bypass capacitors to establish

CERAMIC
AIR
GLASS
QUARTZ
PLASTIC



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Erie, Pennsylvania 16512

their low-frequency roll-off characteristics. All six units sell for $25 in small quantities.
Optimax Inc., P. O. Box 105, Advance Lane, Colmar, Pa. 18915. Phone (215) 822-1311 [405]

Transmission test set is battery-powered and rugged

The model TTS 44 transmission test set is a battery-operated portable unit constructed to withstand the rigors of field and central-office use. Able to run for seven hours on its rechargeable gel cell batteries, the instrument can also run on line power. It measures signal level, noise level, and frequency and displays them on a large digital readout. Dual send/receive channels with single-switch control simplify testing to loop-around and code 104 equipment. With its frequency range of 35 Hz to 60 kilohertz, the TTS 44 can handle the transmission test requirements of nearly all telecommunications circuits in common use, including voice, program, and data circuits to 50 kilobits per second. The TTS 44 is priced at $1,750.
Northeast Electronics, Airport Rd., Concord, N. H. 03301. Phone (603) 224-6511 [406]

Carrier noise analyzers check microwave emitters

Designed for rapid characterization of noise from microwave energy sources, carrier noise analyzers called the CNA series test sets can measure a-m, fm, and phase-modulation noise levels of microwave emitters over a wide range of input-frequency and power levels, carrier-frequency deviations, and video bandwidths. The basic test set consists of an a-m detector, a phase bridge, and a frequency discriminator. The set is available for the microwave bands from 9.7 to 10.3 GHz and from 15.0 to 16.0 GHz.
Raytheon Company, Microwave and Power Tube Division, 190 Willow St., Waltham, Mass. 02154 [407]

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Amplifier-per-channel or differential multiplexing. System 620 now gives you a choice.

Choosing the best multi-channel analog data acquisition system has always been a trade off between the high performance of an amplifier-per-channel or the lower cost of differential multiplexing. Now System 620 offers both! And whichever you choose you'll have a complete analog to digital package ready to plug into your computer, with specified end-to-end accuracy.

Amplifier-Per-Channel Series 100

Amplifier-per-channel is the recognized superior technique for the acquisition of low-level signals because of signal isolation, low noise, high speed channel sampling, high accuracy, and low crosstalk.

In just 4 short years, our Series 100 has become the industry standard. With features such as low pass active filters having selectable cutoff frequency, computer programmable input sensitivity, and continuous analog outputs. And four versatile differential input amplifier configurations: low level, high level, simultaneous sample and hold, and ± 300 volt common mode.

The price is right, too. About $200 per channel. And the system is compact — 64 channels plus control in 7 inches of cabinet space, expandable to 256 or 2048 channels.

Differential Multiplexer Series 400

For high performance at a low price, you can't find a better differential multiplexer than our Series 400. It has programmable input sensitivities from 5 millivolts to 10 volts, 10 kHz channel sampling rate, and 120 dB crosstalk rejection.

The solid state CMOS/FET differential input switches are preceded by a 2-pole low pass filter for each channel which reduces undesired signal frequencies and superimposed noise. Time and temperature drift is eliminated by auto-zero circuits in the programmable amplifier.

Series 400 is perfect for either small or large installations, with expansion to 2048 channels. Cost is about $55 per channel and 256 channels require only 7 inches of cabinet height.

Signal Conditioning Series 300

You asked for it. Now here it is. A companion 620 unit which provides transducer excitation and signal conditioning. Series 300 has constant voltage and constant current excitation. Plug-in mode cards make it easy to configure a channel for a particular bridge, thermocouple, resistance temperature device (RTD) or other types of transducers. Programmable calibration is standard and shares computer interface with either the amplifier-per-channel or differential multiplexed System 620.

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Today, a high speed data acquisition system is only as good as its computer interface. System 620 offers standard interfaces to most computers, some with Direct Memory Access, for high speed data transfer. Or, if you choose to design your own, our TTL logic simplifies the task by including most necessary interface functions right in the system.

For the whole 620 story — amplifier-per-channel, differential multiplexer and signal conditioning — contact Neff today. If you have an immediate requirement, request our System 620 Users' Manual — 30 pages of down-to-earth facts and figures.

NEFF
Instrument Corporation
1088 E. Hamilton Rd., Duarte, CA. 91010
Telephone: (213) 357-2281

Circle 136 on reader service card

Semiconductors

4-k static RAMs give fast access

Clocking technique in AMD units permits standby mode, reducing power dissipation

With an eye on the burgeoning memory market for computer terminals and other peripheral equipment, makers of 1,024-bit static random-access memories requiring a single 5-volt supply are moving up to 4,096-bit units that also can be powered by a single supply. Advanced Micro Devices Inc., joining Intel, National, and Semi Inc., is now producing in volume a pair of 4-k static n-channel MOS RAMs.

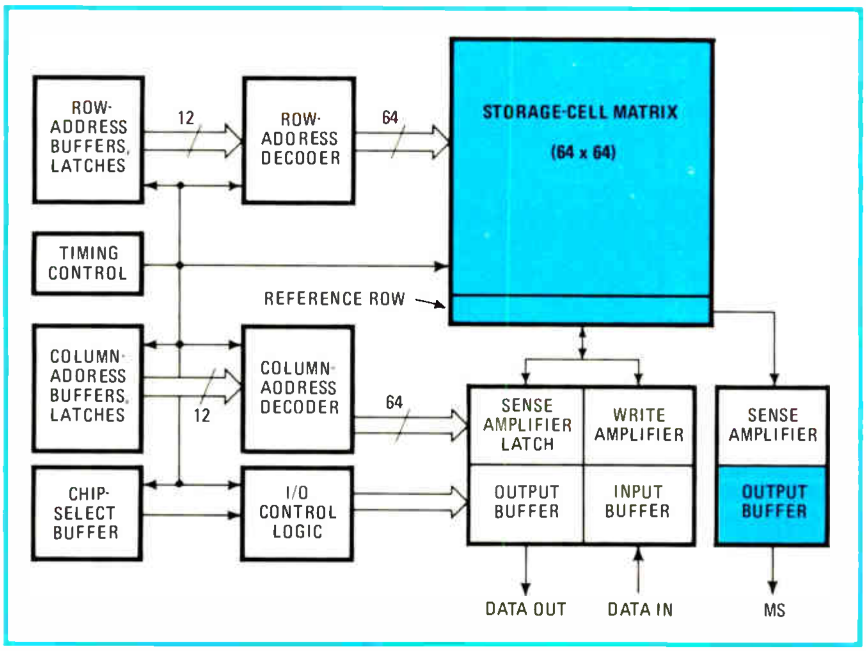
Designated the Am9130 (1-k words by 4 bits) and the Am9140 (4-k by 1-bit, shown below), the devices in a standard 22-pin package require a single 5-volt supply, and power dissipation is down to 350 milliwatts while operational access time is 150 to 200 nanoseconds. The two parts also have a new "memory-status" mode that allows them to be used at their actual, rather than worst-case, access and cycle times. This mode provides a system speed of 100 to 150 ns in some cases.

Fully static in the sense that refresh is not required, the decoding and sensing circuitry uses a clocking technique more common to dynamic memories to allow the devices to be deselected into a dc standby mode that reduces dissipation by 80%, down into the 70-to-100-mW range.

Jeffrey M. Schlageter, AMD's manager of MOS memories, says that enhancement and depletion-load channel n-MOS silicon-gate processing, combined with AMD's proprietary Linox technique, allows use of a six-transistor cell that occupies less than 5.3 square mils on a chip of 192 by 197 mils.

The combination of fast access and low power is achieved by using static storage and pipelined circuit techniques often found in dynamic RAMs. Chip-enable initiates and controls all memory operations. When it is low, all cells are deselected, and the bit and data lines are equalized to an intermediate voltage. When the chip-enable is high, the address and chip-select inputs are latched into on-chip buffers.

The selected row decoder is then clocked by an internally generated timing signal, and the selected cell



begins to discharge the heavily capacitive bit and data lines. A timing and control signal is generated from a reference row of cells to energize a latch used to assist the cell that is discharging. The data-line voltage is then detected and presented to the output buffer by a differential feedback amplifier that is compensated for variations in process, temperature, and voltage.

Schlageter explains that the average operating speed of memory systems can be improved significantly by the new RAMs because the memory-status-output signal, which simplifies the timing and improves performance, communicates three basic units of information.

The rising edge of the signal indicates that chip-enable may be brought to low so that the memory-preset period may begin.

The falling edge of the memory-status signal indicates, he says, that memory reset is complete and a new cycle may begin. The use of this information allows the memory to be used at its actual rather than worst-case specifications. Furthermore, since the inverted memory-status output is simply the chip-enable required for any given part, the 9130 and 9140 can be "self-timed" and do not require external clocks.

Parts specified over the commercial temperature range are $24 each in quantities of 100 for 500-ns speeds and $36 each at 200 ns. Over the military range, the price is $70 each in lots of 100 for 500-ns parts and $90 each for 300-ns parts.

Advanced Micro Devices, 901 Thomson Pl., Sunnyvale, Calif. 94086 [411]

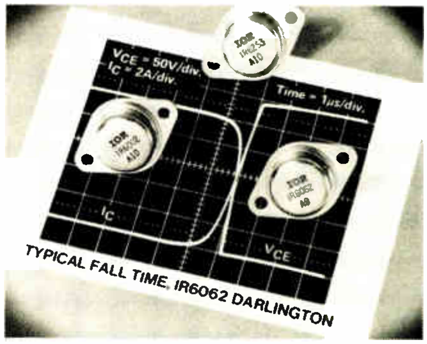
IC controls and protects switching power supplies

The SL442 is a monolithic integrated circuit that provides all of the control and safety functions required by a switching power supply or inverter. It includes an oscillator that can be synchronized with an external signal, if desired; it puts out variable-ratio space/mark pulses for controlling an active series or parallel element; it provides adjustable dynamic current limiting with an overload trip, and it contains provision for overvoltage protection. The SL442 is a soft-start device—that is, the output voltage of a supply it controls increases at a predetermined rate to the required level. Known as a switch-mode power-supply control circuit, the unit operates at frequencies up to 40 kilohertz and can withstand short circuits between adjacent pins and ground. The IC is housed in a 16-pin dual in-line package: plastic for operation from 0°C to 55°C or ceramic for operation up to 65°C. The device, in plastic, sells for $6.60 in hundreds.

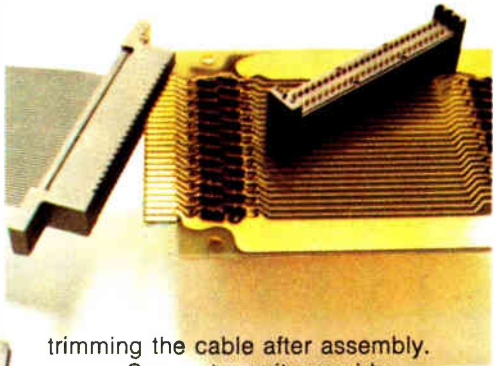
Plessey Semiconductors, 1674 McGaw Ave., Santa Ana, Calif. 92705. Phone Dennis Chant at (714) 540-9979 [413]

Monolithic power Darlingtons have short turnoff times

Because they include an internal speed-up diode, a series of monolithic power Darlington transistor pairs can achieve fall times as short as 400 nanoseconds. The three transistors have current ratings of 15, 20, and 25 amperes at a voltage of 500 volts. Designated the IR6000, 6060, and 6250, the devices are glass-passivated for low leakage and good stability. The 15-A IR6000, which can dissipate 100 watts at a case temperature of 25°C, has a minimum dc current gain of 140 at 3 A. The 20-A model IR6060, which can dissipate 125 W, has a gain of 150 at 5 A. The 25-A 6250 is also rated at 125 W; it has a gain of 100 at 10 A. Prices for the Darlingtons, in hun-



Design with the complete flat cable/connector system.



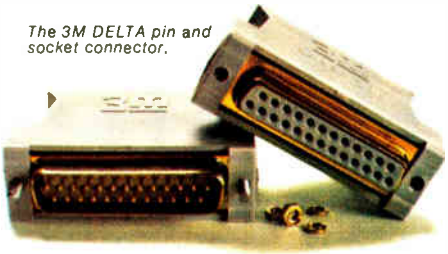
Assembly-cost savings are built in when you design a package with "Scotchflex" flat cable and connectors. But more important, 3M Company offers you the full reliability of a one-source system: cable *plus* connectors *plus* the inexpensive assembly aids that crimp the connections quickly and securely (with no special operator training required).

The fast, simple "Scotchflex" assembly sequence makes as many as 50 simultaneous multiple connections in seconds, without stripping, soldering or trimming the cable after assembly.

Connector units provide positive alignment with precisely spaced conductors in 3M's flat, flexible PVC cable. The connector contacts strip through the insulation, capture the conductor, and provide a gas-tight pressure connection.

With cable, connectors and assembly tools from one design and manufacturing source, you have added assurance the connection will be made surely, with no shorts or "opens."

And "Scotchflex" now offers you more design freedom than ever. From stock you can choose shielded and non-shielded 24-30 AWG cable with 10 to 50 conductors, and an ever-increasing variety of more than 100 connectors to interface with standard DIP sockets, wrap posts on standard grid patterns, printed circuit boards, or headers for de-pluggable applications. 3M's DELTA "D" type pin and socket connectors are now also available. For full information, write Dept. EAH-1, 3M Center, St. Paul, MN 55101.



The 3M DELTA pin and socket connector.

3M COMPANY

See our catalog in EEM 2-1034.

3M's "Scotchflex" line.

"Scotchflex" is a registered trademark of 3M Co.

dreds, range from $4.65 to $9.75. Delivery is from stock.

International Rectifier Corp., Semiconductor Division, 233 Kansas St., El Segundo, Calif. 90245. Phone (213) 678-6281 [414]

8080A-type device has 250-ns cycle time

Designated the Am9080A-4, an eight-bit fixed-instruction-set microprocessor is essentially the same as standard 8080A devices except for its faster cycle time, lower power dissipation, and slightly better noise margin. The Am9080A-4 has a cycle time of 250 nanoseconds which yields an instruction-cycle time of 1 microsecond. Power dissipation is 1.1 watts compared with the 1.3 W of 8080A devices. And an input logic 1 is 3.0 volts—0.3 V higher than standard units. Available off-the-shelf from distributors, the Am9080A-4 sells for $55 in hundreds.

Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086. Phone (408) 732-2400 [415]

SCR switches peak current of 1,600 A at 10 kHz

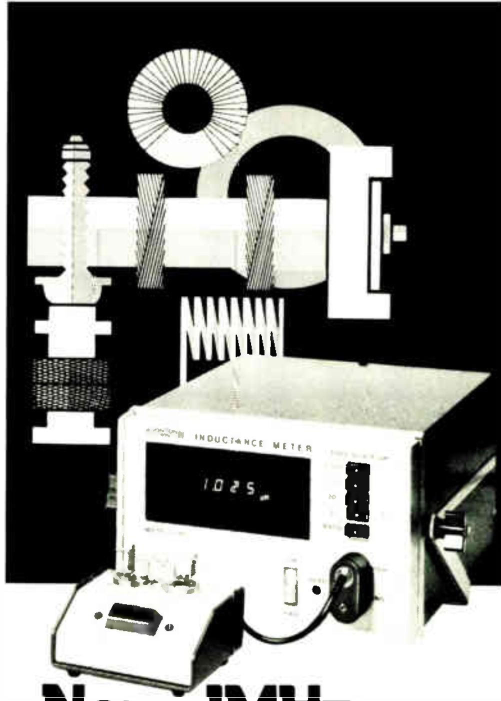
A distributed-gate SCR, the model Q220A, is capable of switching sinusoidal pulses with a peak value of 1,600 amperes at a rate of 10 kilohertz. The interdigitated device, which is housed in a standard 1-inch hockey-puck case, can dissipate 1,425 watts at a case temperature of 71°C. Intended for use in power inverters, uninterruptible power supplies, and in modulators for radars, lasers, and navigation aids, the Q220A can handle 10-kHz square waves with a peak amplitude of 1,100 A and a rate of rise of 100 A per microsecond. Critical dv/dt for the 1,200-volt device is 1,000 V/μs. In small quantities, the thyristor sells for $195.

Westcode Semiconductors, P.O. Box 159, Richford, Vt. 05476. Phone (514) 263-1028 [416]

New devices make MCS-40 systems more versatile

Intel Corp. has enhanced the versatility of its MCS-40 microcomputer systems—those based on its 4-bit 4004 and 4040 microprocessors—with the development of two software-programable devices. These devices, the 4269 programable keyboard/display unit and the 4265 general-purpose programable input/output unit, will allow MCS-40 systems to operate with many more types of peripherals and, in most cases, to be built with fewer components. In addition, the 4265 provides a convenient interface between MCS-40 systems and MCS-80 systems, the latter being built around Intel's 8080A 8-bit microprocessor. The 4269 can be thought of as a general-purpose interface and control unit for man-machine communications devices such as keyboards, displays, switches, lamps, and indicators. The 4265, on the other hand, is perhaps best described as a general-purpose machine-machine interface device. It provides four software-configurable I/O ports (16 I/O lines) and a variety of control capabilities. A particular feature of the 4265 is that it lets MCS-40 systems use MCS-80 peripherals. Among the add-ons that can be thus interfaced with an MCS-40 system are the 8251 programable communications interface, the 8253 programable interval timer, and the 8214 priority interrupt control unit.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051. Phone Howard A. Raphael at (408) 246-7501 [417]



Instruments

Pulse generator aimed at n-MOS

Unit designed to work also with C-MOS devices; clock range is 1 Hz to 10 MHz

Intended for use with n-channel and complementary metal-oxide-semiconductor devices, the model G725 pulse generator has a high-level output adjustable from -5 V to +25 V and a low-level output adjustable from -25 V to +5 V. The earlier model G720, which is intended primarily for use with p-MOS devices, has a high-level output that can be varied from -5 V to +12 V and a low-level output with a range from -35 V to 0 V.

The new unit's internal clock can be adjusted over the frequency range from 1 hertz to 10 megahertz. Pulse widths from 50 nanoseconds to 500 ns allow it to be used as a single-phase driver for shift registers and other logic arrays. For multiphase operation, two buffered trigger outputs allow several of the pulsers to be connected with precise phase relationships. The G725 can also be driven by an external clock at any rate from 0 to 10 MHz, and it accepts DTL/TTL data inputs from word generators.

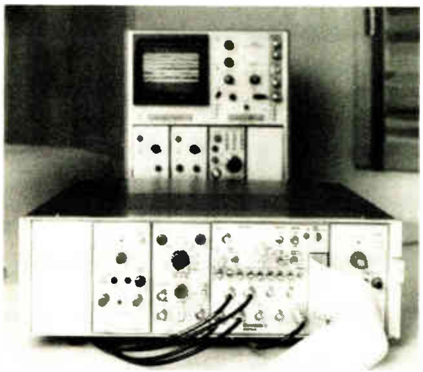
Two remote probe units, for normal and complementary inputs, allow the pulser to be connected directly to a wafer prober, a test fixture, or a test circuit. The probes, says Dominic Norcia, product manager, will drive a capacitive load of 100 picofarads at a rise time of 1 ns per volt. Average output current is limited to 20 milliamperes for probe protection. Delays up to 500 ns and widths from 50 ns are fully adjustable.

The G725, which is being introduced at Electro/76 this week, will sell for about $600 to $700, according to Norcia.

E-H Research Laboratories Inc., 515 Eleventh St., Box 1289, Oakland, Calif. 94604. Phone (415) 834-3030 [352]

Logic analyzer has hard-copy output

Although there are a dozen or so logic analyzers on the market, until now none of them has had the capability to produce a hard-copy record of a timing diagram. The Logicorder-8 from Scanoptik Inc., rectifies this omission. Designed to fit into a Tektronix TM-500 series mainframe where it occupies a dual module space just like Tektronix' own LA-501 logic analyzer [*Electronics*, Sept. 18, 1975, p. 138], the unit is an eight-channel instrument with a built-in miniature chart recorder. It has a 10-megahertz sample rate on eight channels with a storage capacity of 256 bits per channel, 8-bit triggering, and three triggering modes—pre, mid, and post. This last feature means that the analyzer can show the 256 bits immediately preceding the trigger word, those immediately following it, or those surrounding it. For examining high-speed data, the Logic-



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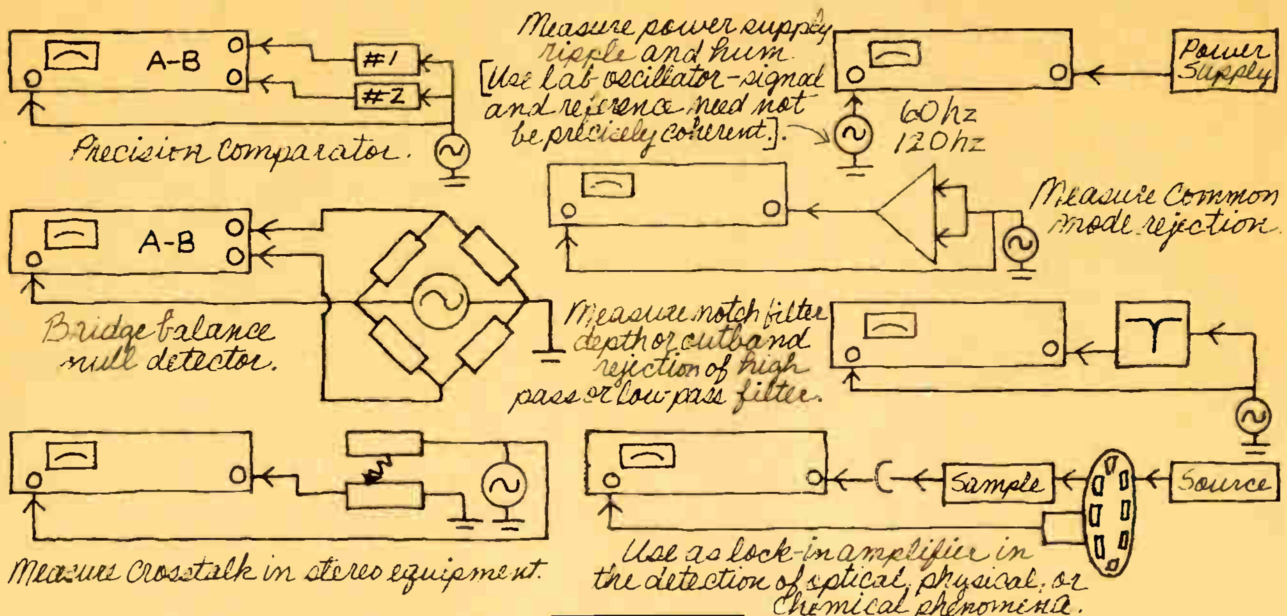
New Dynatrac® narrowband voltmeter.

Now you can be sure you are measuring what you think you are measuring. This important new engineering tool will measure the signal at the exact frequency you tell it to look at, and that's all it will look at. There's no drift in either amplitude or frequency, even at bandwidths as low as .03 Hz.

The diagrams below show Dynatrac narrowband voltmeters in some typical design engineering and quality control applications.

For further information or to arrange a demonstration, contact John Hanson at Ithaco, Box 818E, Ithaca, New York 14850. (607) 272-7640. TWX 510-255-9307.



ITHACO

Circle 143 on reader service card

order-8 has a mode in which it operates two channels at a 40-MHz sampling rate with a storage capacity of 1,024 bits per channel. The instrument is equipped with a scope output. The $4,000 analyzer has a delivery time of 30 days.

Scanoptik Inc., P. O. Box 1745, Rockville, Md. 20850. Phone Jerry L. Shumway at (301) 977-9660 [353]

Portable DMM is extremely stable

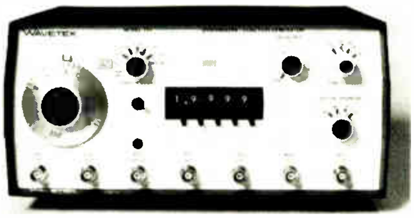
The 4½-digit model 4600 digital multimeter is a portable instrument that maintains its basic dc-voltage accuracy of ±(0.01% of reading + 1 digit) for six months without recalibration. This maximum-error specification is maintained over the temperature range from 20°C to 30°C and for relative humidities up to 80%. The autoranging meter measures ac and dc voltages from 2 millivolts full scale to 1,000 V, resistance from 2 ohms full scale to 20 megohms, and ac and dc current from 2 microamperes full scale to 2 amperes. The meter combines an input filter with an integrating conversion scheme to achieve 80 decibels of normal-mode rejection during dc-voltage measurements. A potentiometric input provides an input resistance of 10,000 megohms on the two lowest voltage ranges. The model 4600 uses 0.43-inch yellow LED displays for easy readability. It sells for $549 and has a delivery time of 30 days. Extra-cost options include parallel BCD data output ($150), a rechargeable battery pack ($125), and various special-purpose probes.

Dana Laboratories Inc., 2401 Campus Dr., Irvine, Calif. 92713. Phone Chris Everett at (714) 833-1234 [355]

Function generator offers synthesizer accuracy

Combining the accuracy, stability, and spectral purity of a frequency synthesizer with the multiplicity of waveforms, dc offset, and manual sweep of a function generator, the model 171 synthesizer/function generator covers the frequency range from 0.1 hertz to 2 megahertz and sells for only $795. In its synthesizer mode, the instrument is accurate within 0.005% and drifts less than 0.0001%/°C for frequencies from 1.000 Hz to 1.999 MHz. It has 4½-digit resolution in six decade bands.

In the function-generator mode, the 171 can be swept manually by means of a front-panel dial or by



means of an externally applied voltage ramp. The dial has a maximum frequency error of 3% of full scale. Sine, square, and triangular waveforms are available from two output ports: one has a 50-ohm impedance, the other has an impedance of 600 ohms. Up to 80 dB of output attenuation is provided—20 dB of continuously variable attenuation plus 60 dB in 20-dB steps. Delivery time for the generator is 30 days.

Wavetek, P. O. Box 651, San Diego, Calif. 92112. Phone John Roth at (714) 279-2200 [356]

DPMs have 0.7-inch liquid-crystal displays

Digital panel meters offer advantages over their analog counterparts in accuracy and resolution, but they are often more difficult to read, especially from long distances. Now Ballantine Laboratories is taking aim at this problem by offering displays 0.7 inch high as a standard feature in 3½-digit meters.

The 8305B series of DPMs uses field-effect liquid-crystal displays to produce back-lighted white-on-black numerals and signs. The series

includes models with five voltage and eight current ranges. The highest resolution is 10 microvolts or 0.01 nanoamperes.

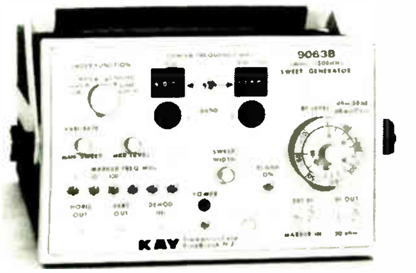
In large quantities, the panel meters are priced at about $76, the same as for the earlier 8305A series, which used 0.5-in. displays. The smaller displays are an option on 3½-digit models, and are standard on the firm's 2½- and 4½-digit units.

The 8305B series offers accuracies to within ±(0.03% of reading + 0.02% of full scale) for one year without adjustment over a temperature range of 0 to 45°C. Power consumption is under 1.5 watts with the standard transmissive display and nominally 0.95 W with an optional reflective display. Power requirement is 117 V ±10% at 60 hertz.

Ballantine Laboratories Inc., P.O. Box 97, Boonton, N.J. 07005 [357]

Sweeper goes from 1 MHz to 1,500 MHz in two bands

The model 9063 half-rack sweep generator covers the frequency range from 1 megahertz to 1,500 MHz in two overlapping bands: 1 to 900 MHz and 800 to 1,500 MHz. For ease of frequency setting, the unit includes a digital display of the center frequency of the sweep. Maximum output of the unit is 0.5 V rms with up to 80 decibels of continuously variable attenuation available. Built-in leveling keeps the output flat within 0.5 dB over-all. The sweep rate of the 9063 can be varied from 1 to 100 hertz or it can be



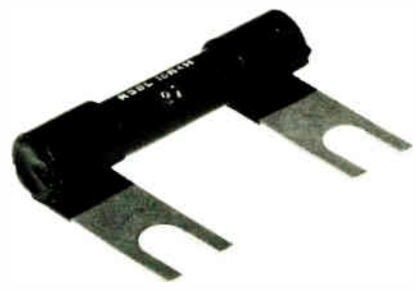
locked to the power-line frequency. Alternatively, provision is made for sweeping the output manually. The instrument sells for $1,590 and has a delivery time of 30 days.

Kay Elemetrics Corp., Pine Brook, N. J. 07058. Phone Jim Connors at (201) 227-2000 [358]

Primary-standard resistor is accurate within 0.05%

Designed especially to fill the need for a low-resistance primary-standard resistor, the model R38L resistor is an oil-filled, hermetically sealed unit with a maximum absolute error of 0.05% and a drift of no more than 0.01% per year. Offered in resistances from 1 to 100 ohms, the unit has a temperature coefficient of 5 ppm/°C from 0°C to 65°C. Because of its special design, the R38L is able to keep all thermally induced transient effects, such as self-heating, Seebeck, and Peltier, to less than 0.0005% at the rated power dissipation of 2.5 watts. The resistor measures 2.35 inches long by 0.475 in. in diameter; lug spacing is 1.625 in. between centers.

Julie Research Laboratories Inc., 211 West 61st St., New York, N. Y. 10023. Phone (212) 245-2727 [359]



Components

Reed switches shrink in size

Compact design yields devices with increased sensitivity, less bounce

Reed switches are relatively simple devices—just a pair of reed blades sealed in a glass envelope—and yet the way they are formed greatly influences both their electrical performance and physical size. Because of a new design implemented with a fully automated process, Morex Inc. is now able to make units that are smaller than conventional reed switches and offer improved operating characteristics.

Called Accuswitch, the new device represents the first innovation in the design of reed switches in years, says William F. Orr, vice president. Their cross-sectional area, he claims, is one third that of comparably rated conventional switches.

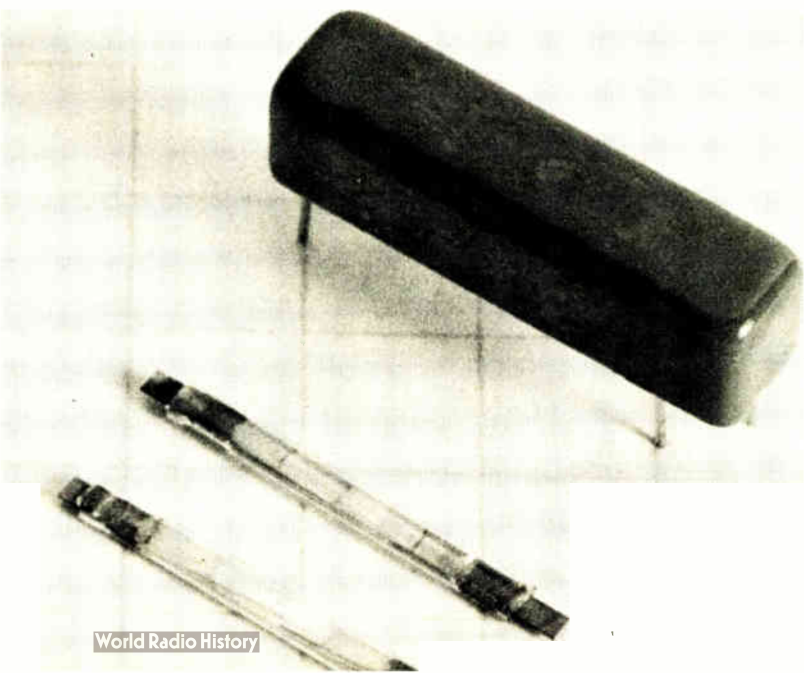
Morex fabricates the Accuswitches with an automatic seal-and-anneal machine, capable of producing 35,000 units an hour, compared with 1,200 devices per hour from most rotary machines, says Orr. Every Accuswitch glass envelope is dimensioned precisely to fit the blades closely and to position them accurately with respect to each other. In the open position, the blades rest against the glass, so that chattering upon release is virtually eliminated, Orr adds.

At present, Morex is marketing two models, the MRB-3 and the MRB-4, which are intended for use in keyboards and in dual in-line reed relays. For resistive loads, both have contact ratings of 10 volt-amperes maximum—100 V dc or peak ac, at 0.5 A switched or 1.5 A carry-only. Each model is a single form A switch (single-pole single-throw, normally open contact arrangement).

The glass envelope for the MRB-3 measures 0.04 by 0.07 by 0.61 inch; for the MRB-4, 0.04 by 0.07 by 0.685 in. Both models have axial flat leads—0.385 in. long for the MRB-3, 0.35 in. long for the MRB-4. A third model with axial round leads suitable for bending and direct insertion into printed-circuit boards will soon be available.

The small size of the Accuswitch capsules means that the energizing element can be brought very close to the reeds themselves, resulting in greater power sensitivity, says Orr. The two new devices, he also notes,

Twice as many. Two tiny form A reed switches built by Morex Inc. fit in a standard relay housing that could previously accommodate only one conventional device.



fit in the relay package that usually houses only one. Furthermore, since unit-to-unit dimensions are uniform, Accuswitches can simplify the automatic assembly of products in which they are a component, he adds.

The reeds are made of rhodium. Initial contact resistance is 100 milliohms maximum, contact-to-contact capacitance is typically 0.2 picofarad, and operating frequency can be as high as 1 kilohertz. Life expectancy is 100 million operations at signal levels of 5 V dc and 10 milliamperes or 5 million operations at 28 V dc and 125 mA.

Currently, Accuswitches sell for 17 to 55 cents each, depending on quantity and operating range. However, as volume production is reached, Morex plans to lower prices, says Orr.

Morex Inc., 48 Progress Parkway, Maryland Heights, Mo. 63043. Phone (314) 434-0311 [341]

Planar plasma display aimed at replacing CRTs

Aimed at replacing cathode-ray tubes in alphanumeric readout panels, the model SII0640PD2 Self-Scan display from Burroughs is a low-cost planar plasma panel and driver assembly capable of displaying the equivalent of six lines, each consisting of 40 five-by-seven dot-matrix characters with two blank columns between characters.

On display at Electro/76, the assembly is priced at $500 each for the evaluation units now available. Production units will be priced at $290 for small quantities and $170 for larger orders after the first of next year. These prices compare with

$512 for the 256-character panels currently in production.

The lower price is made possible by lower-cost manufacturing methods. In the newer units, for example, silk-screened conductors replace the hand-wired electrodes of the earlier models.

Burroughs Corp., Electronic Components Division, P. O. Box 1226, Plainfield, N.J. 07061. Burroughs ECD International, 11-15 Betterton St., Drury Lane, London, WC2h 9BS, England [342]

Potentiometer and dial fit inside knob

The model K200 combines a knob, a dial, and a wire-wound potentiometer in a single package. The pot, which can dissipate 1 watt at 40°C, has a minimum life expectancy of 10,000 turns. It is linear within 0.7% and has a maximum temperature coefficient of 70

ppm/°C. Priced at $4.23 each in thousands, the unit is offered in black, gray, and red. Tighter linearity and nonstandard colors are available on special order. Delivery time for the standard units is three to four weeks.

Panel Components Corp., 2015 Second St., Berkeley, Calif. 94710. Phone Robert D. Wersen at (415) 548-1966 [343]

Solid-state relay sells for $6.90

Capable of switching 1.5 amperes ac with the aid of its integral heat sink, or up to 7 A ac with an external heat

New products

sink, the series 226 solid-state relay sells for $6.90 each, but drops to $3.80 in quantities of 1,000. Believed to be the lowest-price solid-state relay currently available, the series 226 is an optically isolated device that can be activated by standard TTL gates. Because its integral heat sink is in the shape of a TO-3 can, the many standard heat sinks developed for power transistors packaged in TO-3 cans can be used on the relay for additional heat dissipation. The relay has an isolation-voltage rating of 2,500 V rms and an isolation resistance of 10^{12} ohms.

Sigma Instruments Inc., 170 Pearl St., Braintree, Mass. 02184. Phone Robert E. Cullen at (617) 843-5000, Ext. 344 [344]

Miniature arc lamp puts out 500,000 beam candlepower

An extremely compact xenon arc lamp puts out more than 500,000 peak beam candlepower while consuming only 300 watts. Measuring about 2.25 cubic inches, the model VIX-300 illuminator produces up to 2 W of ultraviolet (200 to 400 nanometers), 16 W (4,000 lumens) of visible light, and more than 30 W of infrared radiation (800 to 2,100 nm). Because the lamp's ceramic body, parabolic reflector, tungsten electrodes, and single-crystal sapphire window are formed into an integral structure, the rugged unit never needs optical alignment. Cooled with forced air, the VIX-300 has a maximum operating temperature of

150°C. Potential applications range from surgical lighting and photographic projection to military systems, and the duplication of sunlight for materials research.

Varian Eimac Division, 301 Industrial Way, San Carlos, Calif. 94070. Phone Dave Wilson at (415) 592-1221 [345]

Wire-wound resistors are hermetically sealed

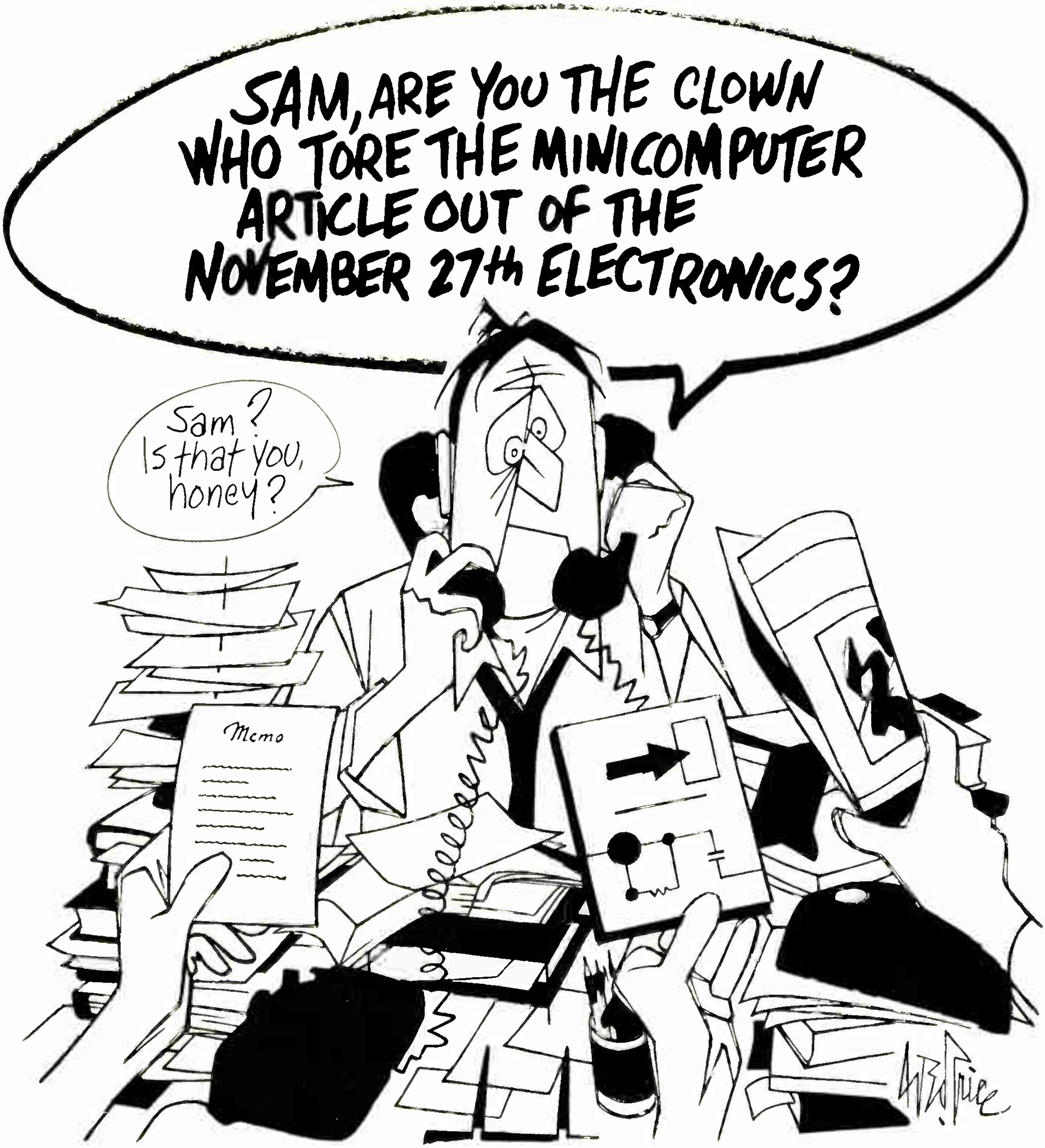
A line of precision wire-wound resistors with values from 1 ohm to 1 megohm is offered in hermetic TO-5 transistor cans. The subminiature units can dissipate 150 milliwatts and are rated for operation from −65 to 125°C. Maximum voltage is 250 V. Standard tolerance on the resistors is 1% and standard temperature coefficient is 10 ppm/°C. Other tempcos are available as are tolerances to within 0.01%. Delivery of the resistors is from stock.

RCL Electronics Division of AMF Inc., 195 McGregor St., Manchester, N. H. 03102 [349]

TOPICS
Components

Macromatic Inc., Chicago, Ill., is offering potential users of solid-state timers a 90-day free trial for the line of timers it acquired from Intermatic Inc. in early 1975. . . . **Douglas Randall division of Walter Kidde & Co., Pawcatuck, Conn.,** announces that its entire line of ac solid-state relays has been recognized under the component-recognition program of Underwriters' Laboratories Inc., File No. E60556, CC No. NMFT2. . . . **Industrial Electronic Engineers Inc., Van Nuys, Calif.,** is producing a pair of directly viewed incandescent displays, the models DA-2000 and DA-2010, which are direct replacements for RCA's DR2000 and DR2010 Numitrons. . . . **Burroughs Corp., Plainfield, N.J.,** has announced price reductions of up to 35% on its Self-Scan bar-graph panel displays.

Circle 198 on reader service card



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Electronics
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New products/materials

Thick-film-resistor compositions for the manufacture of cermet trimmers and potentiometers are low-cost formulations with temperature coefficients of resistivity of less than 250 ppm/°C. The 4500 series compositions are offered in eight resistivities from 1.5 ohms per square to 1 megohm per square. Noteworthy for

their stability in humid environments, resistors made with the 4500 series compositions typically show changes of less than 1% after 1,000 hours at 40°C and 90% relative humidity.

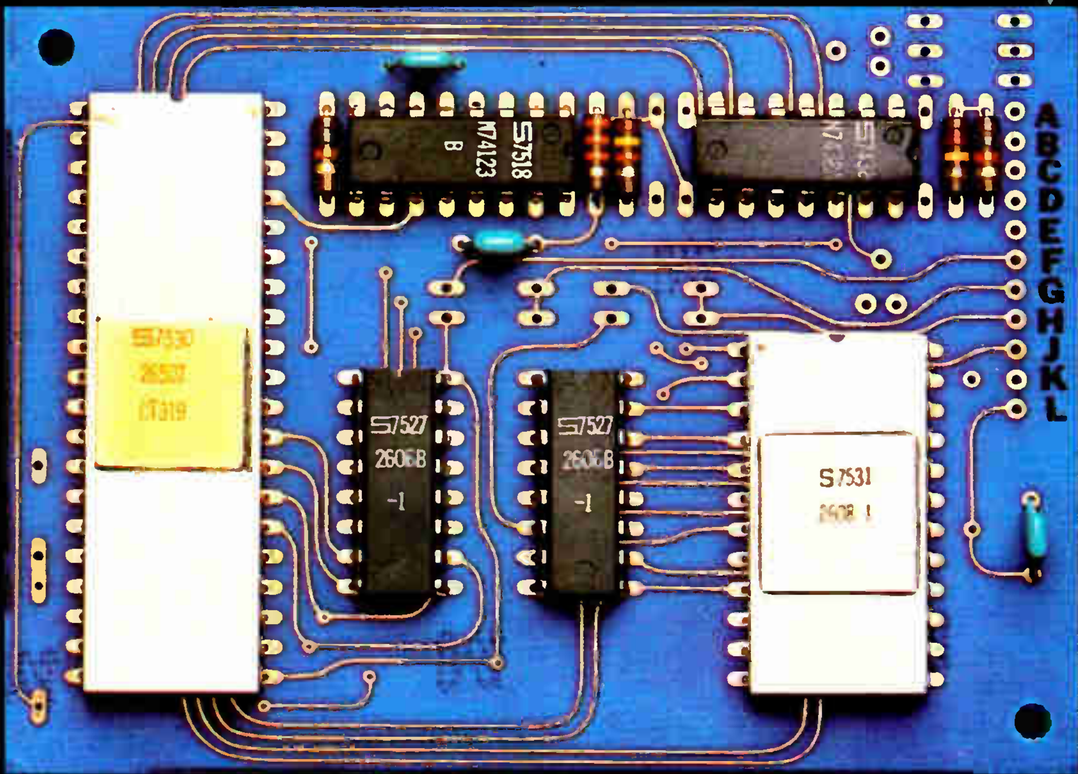
Electronic Materials Division, Du Pont Co., Wilmington, Del. 19898 [476]

Epoxy adhesive hermetically seals electronic components that are subject to thermal cycling. Nordbak 4-32 epoxy resin is an unfilled, two-component materials system that cures material with excellent resistance to thermal shock. The material has a tensile elongation of 35% and a dielectric strength of 500 volts per mil. Before curing, the low-viscosity mixture has a working time of about an hour at 72°F. Gel time is about an hour and a half.

Specialty Chemicals Division, Rexnord Inc., 4300 North 127 St., Brookfield, Wis. 53005. Phone (414) 781-5204 [477]

Glass rectangles coated with tin oxide are available up to 4 by 12 inches for use as a front plate in liquid-crystal and gas-discharge displays. The transparent, electrically conductive coating can be applied

The easiest-to-use microprocessor



(Photograph approximately 2x actual size.)

The single-chip 2650 is easiest-to-buy, too. Now only $21.50 (100-up).

Full support of customer and product is the key to ease of development with the 2650. Applications engineers in the U.S. and abroad are at your beck and call at every stage. Software for almost anyone's requirements and machines. Development hardware is versatile and inexpensive. All circuits are multi-sourced.

Flow Chart: How to travel safely and quickly from spec sheet to your μC.

1. Applications Engineers — in the field now, more coming. Specific assistance to you is available around the USA, and in Belgium, Holland, Germany, France, Sweden, Britain, Italy, etc.

2. Multi-sourced 2650 — available in any quantity from Signetics, at the unprecedented low price of $21.50. Also available from AMS and Philips, and from Signetics' authorized distributors.

3. Development Software — includes the PL μS, an extremely efficient High Level Language (compiler) that reduces programming effort and cuts development time. ANSI standard Fortran IV executes on most machines without alteration. 2650AS1000/1100 Assembler and 2650SM1000/1100 Simulator are available in both 32- and 16-bit, on GE and NCSS time-sharing.

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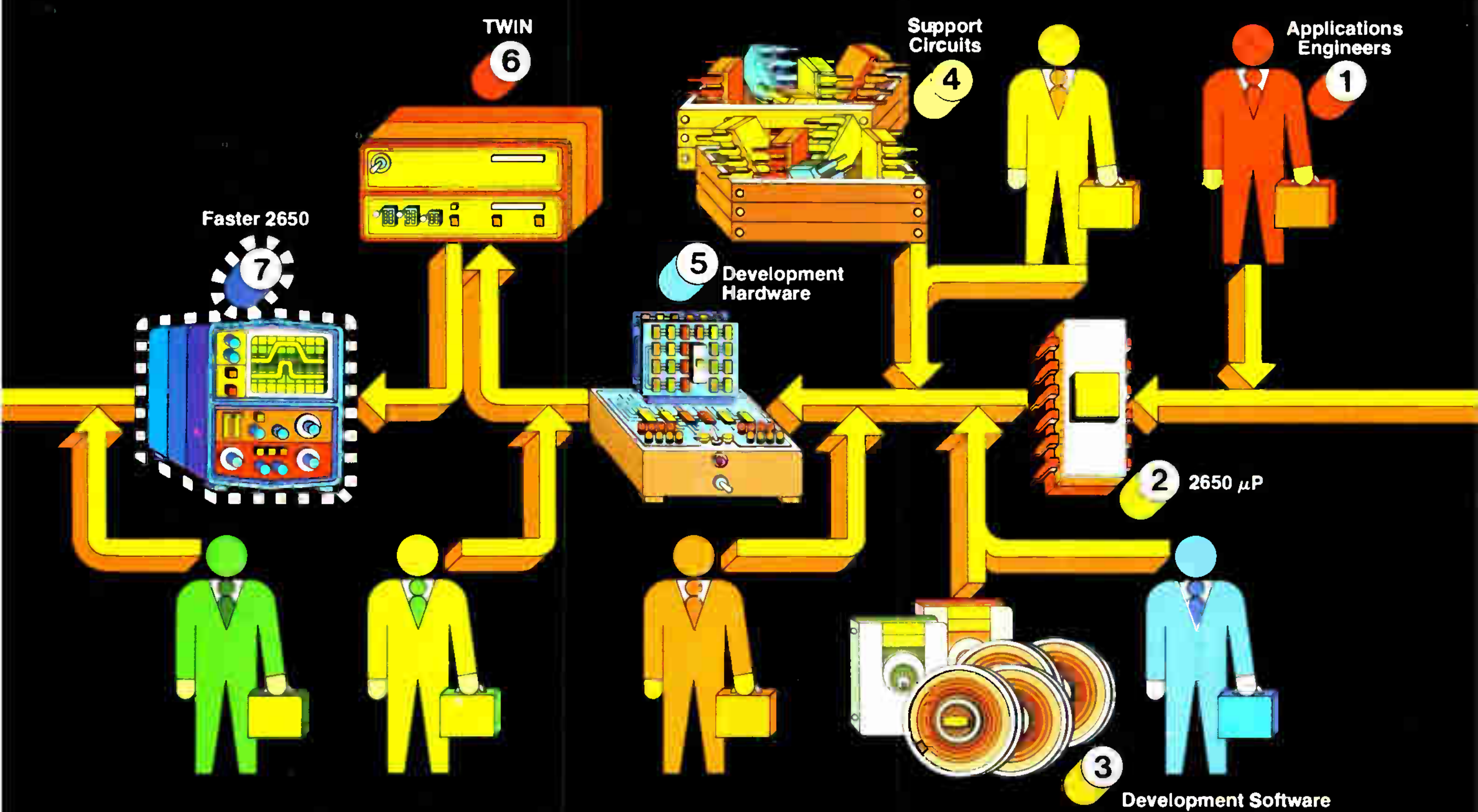

makes the easiest-to-develop microcomputer.

5 Development Hardware — Design/develop/prototype with a variety of cost/capability levels of hardware support. Including prototyping cards and kits, smart typewriter demo card, 4k-byte RAM card, and more. Applications help if you need it.

6 TWIN With Floppy Disks — "crashproofs" your system checkout. With DOS, Resident Assembler, and Text Editor. You develop programs and circuits together in an actual system environment with TWICE (*T*est*W*are *I*n *C*ircuit *E*mulator). PROM programming, too.

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to the entire sheet of glass uniformly or in patterns. Larger sizes are planned for the near future.

Equipment Applications Engineering, Watkins-Johnson Co., 440 Mt. Hermon Rd., Scotts Valley, Calif. 95066. Phone (408) 438-2100 Ext. 217 [478]

Metalized ceramic substrates of alumina and beryllia are claimed to have a ceramic-metal interface strength 50% stronger than most others. Useful as heat sinks, microwave collectors, and platforms for solid-state relays, as well as hybrid circuits, the metalized ceramics are offered with platings of nickel, copper, or gold. Typical prices range from 15 cents each to $20, and delivery times from four to eight weeks.

Ceradyne Inc., P. O. Box 11030, Santa Ana, Calif. 92705. Phone (714) 549-0421 [479]

Electrical contact tape consists of a precious-metal surface on a base-metal backing. Offered in a variety of cross-sectional configurations, the tape comes in many sizes, shapes, and metal combinations.

Matthey Bishop Inc., Malvern, Pa. 19355 [480]

Developed specifically for die-stamping techniques in semiconductor-chip bonding operations, a two-component silver epoxy adhesive enables users to deposit highly uniform films on flat and protruding surfaces. Called Epo-Tek H20S, the solvent-free epoxy has silver powder dispersed in both its components. Pot life after mixing is four days minimum at room temperature. One-ounce trial kits are priced at $22, FOB factory.

Epoxy Technology Inc., 65 Grove St., Watertown, Mass. 02172 [371]

A water-removable organic soldering flux known as Organo-Flux No. 935NS minimizes sputtering of flux during soldering. It is said to provide highly stable foam in foam-fluxing, excellent wetting of component leads and printed-circuit surfaces, and easy residue removal.

London Chemical Co., 240 Foster Ave., Bensenville, Ill. 60106 [372]

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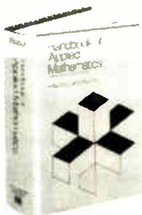

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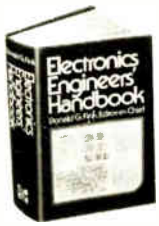

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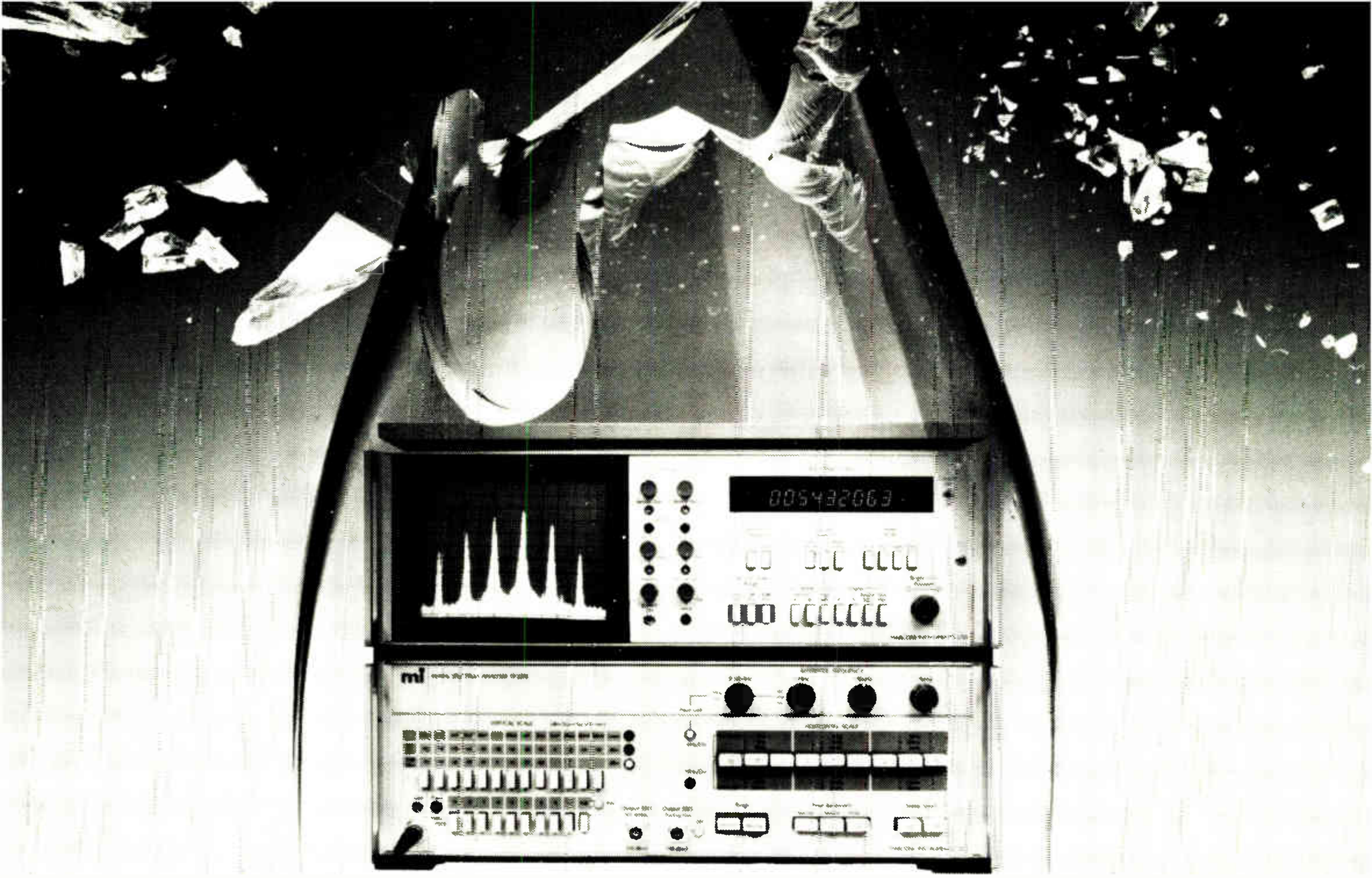
Driving Beckman displays. A six-page application note, entitled "Display Power Supply Requirements," describes power-supply configurations for driving Beckman planar gas-discharge displays. Calculations and diagrams for the determination of voltages and waveforms are presented. Copies of the note are available from Beckman Instruments Inc., Information Displays Operations, Marketing Dept., P. O. Box 3579, Scottsdale, Ariz. 85257. Circle 421 on reader service card.

Stripline components. A catalog of microwave stripline components such as couplers, combiners, mixers, and dividers contains data on standard items for applications from 100 megahertz to 18 gigahertz. The catalog can be obtained from Merrimac Industries Inc., 41 Fairfield Pl., West Caldwell, N.J. 07006 [422]

Ultraviolet facility. A user guide to the National Bureau of Standards' synchrotron ultraviolet radiation facility (SURF II) describes the properties and characteristics of synchrotron radiation as well as the instrumentation available at the facility. For a copy of the guide write to Dr. Robert P. Madden, Chief, Far Ultraviolet Physics Section, Room A251, Physics Bldg., National Bureau of Standards, Washington, D.C. 20234 [423]

Wire terminals. The metallurgical and geometric characteristics of crimp-type terminals are covered in a 12-page booklet from AMP Inc., Harrisburg, Pa. 17105. The booklet also deals with the terminology of wire terminals and illustrates application tooling. [424]

Semiconductor guide. GTE Sylvania has published a supplement to its 1975 ECG semiconductor replacement guide and catalog. The supplement, which sells for 35 cents, includes 8,000 entries—industry part numbers cross-referenced to the company's line of solid-state devices. The guide itself, which sells for $2.95, cross-references 114,000 domestic and imported semicon-



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Thick-film products. A line of materials for thick-film fabrication is described in a catalog put out by the Methode Development Co., a subsidiary of Methode Electronics Inc., 7447 West Wilson Ave., Chicago, Ill. 60656. The catalog includes such materials as resistive and conductive pastes, glasses and insulators, dielectric materials, optoelectronic materials, solder pastes, and packaging polymers. [426]

Resistor reliability. The results of a three-year program of reliability tests on a total of 740 high-performance film resistors are summarized in a 12-page report compiled by Caddock Electronics Inc., 3127 Chicago Ave., Riverside, Calif. 92507. Tests include temperature cycling, overload, 2,000-hour load-life, moisture resistance, low-temperature, and shock and vibration. [427]

Rental instruments. General Electric's 76/77 Instrument Rental Catalog, which contains descriptions of more than 5,000 instruments, can be obtained by writing to Manager, Instrumentation & Communications Equipment Service, General Electric Co., Bldg. 28, Room 450, One River Rd., Schenectady, N. Y. 12345. The 60-page document cross-references the instruments alphabetically and by manufacturer. [428]

Audio Indicators. A wide variety of solid-state audio indicators with sound-pressure ratings from 70 dBA to 100 dBA are described in a 16-page catalog available from Projects Unlimited Inc., 3680 Wyse Rd., Dayton, Ohio 45414. Catalog 176-70M includes 32 devices that typically draw a maximum of 10 to 35 milliamperes. Models are available in the frequency range from 400 Hz to 3,700 Hz. [429]

New Books

Introduction to Microcomputers and Microprocessors, Arpad Barna and Dan I. Porat, Wiley-Interscience, 108 pp., $10.50.

Thermodynamic Theory of Domain Structures, I. Privorotskii, Halsted Press, 129 pp., $22.50.

Data Processing Contracts—Structure, Contents, and Negotiation, Dick H. Brandon and Sidney Segelstein, Van Nostrand Reinhold, 465 pp., $34.50.

Management Systems for Profit and Growth, Richard F. Neuschel, McGraw-Hill, 365 pp., $12.95.

Handbook of Electronic Testing, Measurement, and Troubleshooting, Matthew Mandl, Reston, 287 pp., $16.95.

Spread Spectrum Systems, R.C. Dixon, Wiley-Interscience, 318 pp., $22.50.

Computer Systems Organization and Programing, Harry Katzan Jr., Science Research Associates, 459 pp., $14.95.

Dimensional Methods in Engineering and Physics, E. de St Q. Isaacson and M. de St Q. Isaacson, Halsted Press, 220 pp., $22.50.

Introduction to Quantum Electronics, P.A. Lindsay, Halsted Press, 202 pp., $19.75.

Ion Implantation in Semiconductors, Science and Technology, Susumu Namba, ed., Plenum, 742 pp., $49.50.

Energy Storage, Compression, and Switching, W.H. Bostick, V. Nardi, and O.S.F. Zucker, eds., Plenum, 537 pp., $35.00.

Assembler Language with Assist, Ross A. Overbeek and W.E. Singletary, Science Research Associates, 372 pp., $14.95.

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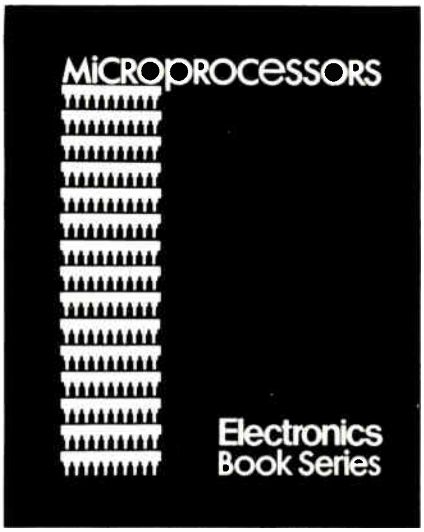

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Microwave Transistors, Edward D. Graham Jr. and Charles W. Gwyn, eds., Artech House, 570 pp., $25.00 (paper).

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Electronic Scanning Radar Systems (ESRS) Design Handbook, Peter J. Kahrilas, Artech House, 372 pp., $28.00.

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Introduction to Medical Electronics for Electronics and Medical Personnel, second edition, Burton Klein, Tab Books, 320 pp., $9.95, $7.95.

Microprocessor/Microprogramming Handbook, Brice Ward, Tab Books, 294 pp., $9.95, $6.95 (paper).

Modern Applications of Linear ICs, Editorial staff, United Technical Publications Inc., Tab Books, 276 pp., $12.95, $9.95 (paper).

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The Nature and Properties of Engineering Materials, second edition, Zbigniew D. Jastrzebski, Wiley, 633 pp., $19.95.

Handbook of Physical Calculations, Jan J. Tuma, McGraw-Hill, 370 pp., $14.95.

Selected Papers in Digital Signal Processing, II, IEEE Digital Signal Processing Committee, ed., IEEE Press, 582 pp., $17.95.

IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Std 242-1975), IEEE Industry Applications Society, IEEE Press, 312 pp., $19.95.

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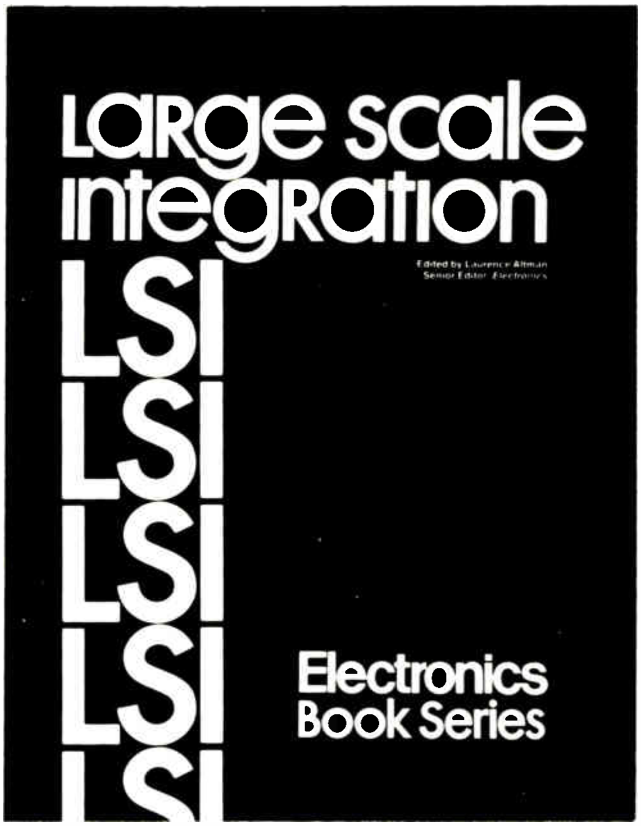

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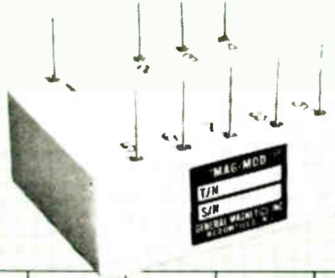
Solid State Sine-Cosine Synchro Converter



This new encapsulated circuit converts a 3-wire synchro input to a pair of d-c outputs proportional to the sine and cosine of the synchro angle.

- Complete solid state construction.
- Operates over a wide temperature range.

UNIT	DMD 1436-1	DMD 1430-1	DMD 1403-2	DMD 1361-6	DMD 1361-4	DMD 1193-4	DMD 1361-8	DMD 1446-1	DMD 1193-5	DMD 1193-6	DMD 1361-10	DMD 1472-2
L · L SYNCHRO INPUT (VRMS)	11.8	90	95	90	11.8	11.8	11.8	11.8	11.8	11.8	11.8	90
FREQUENCY (Hz)	400	400	60	400	400	400	400	400	400	400	400	60
FULL SCALE OUTPUT (VDC)	±10	±10	±3	±3	±3	±10	±10	±10	±10	±10	±10	±10
OUTPUT IMPEDANCE	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<10Ω	<1Ω	<1Ω	<1Ω	<1Ω
L · L INPUT IMPEDANCE	>10K	>30K	>5K	>30K	>5K	/5K	>5K	>5K	>5K	>5K	>5K	>5K
REFERENCE VOLTAGE (VRMS)	26	115	115	115	26	115	26	115	115	115	26	115
ACCURACY SIN/COS (+25°C)	±6MIN	±6MIN	±6MIN	±6MIN	±6MIN	±6MIN	±6MIN	±0.5%	±6MIN	±6MIN	±6MIN	±6MIN
FULL TEMPERATURE RANGE ACCURACY SIN/COS	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±15MIN	±0.5%	±15MIN	±15MIN	±15MIN	±15MIN
D.C. SUPPLY (VDC)	±15	±15	±15	±15	±15	±15	±15	±15	±15	±15	±15	±15
D.C. SUPPLY CURRENT	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA
BANDWIDTH	>10Hz	>10Hz	external set	>20Hz	>5Hz	>10Hz	>10Hz	>10Hz	>2Hz	>40Hz	>5Hz	external set
SIZE	1.1x3.0 x1.1	2.0x2.25 x1.4	1.1x3.0 x1.1	1.5x1.5 x0.6	1.85x0.85 x0.5	2.01x2.25 x1.4	0.85x1.85 x0.5	2x2.25 x1.4	2x2.25 x1.4	2x2.25 x1.4	2.15x1.25 x0.5	1.1x3.0 x1.1
NOTES	–	dual channel unit	–	–	–	dual channel unit	–	dual sine output	dual channel unit	dual channel unit	–	–
TEMPERATURE RANGE	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C

High Precision Analog Multipliers

PRODUCT ACCURACY (MCM 1519-1) ± ½% OF ALL THEORETICAL OUTPUT VALUES OVER FULL MILITARY TEMPERATURE RANGE OF −55°C TO +125°C. ZERO POINT ERROR FOR ANY INPUT COMBINATION IS ± 2MVRMS

Features:

- No external trims required
- Distortion free AC output over entire dynamic range
- Linearity, product accuracy and zero point virtually unaffected by temperature
- All units are hermetically sealed and are not affected by external fields
- High analog product accuracy and wave quality allows dual multiplier assemblies to be matched with 1% of point over the specified temperature range
- Full four quadrant operation
- Package size, power supply requirements and other specs. may be altered to your exact requirements at no extra cost.

Specifications:

- Transfer equation: Eo=XY/10
- X & Y input signal ranges: 0 to ±10V PK
- Maximum zero point error (X=0; Y=0 or X=±10; Y=0 or X=0; Y=±10): 2MVRMS
- Input impedance: Both inputs 20K min.
- Full scale output: ±10V peak
- Minimum load resistance for full scale output: 2KΩ
- Output impedance: 1Ω
- Short circuit duration: 5 sec.
- Frequency response characteristics (both inputs) 1% amplitude error: DC to 1200 Hz (min.) 0.5 DB Amplitude error: DC to 3500 Hz min. 3 DB point: Approx. 10K hz Roll off rate: 18 DB/octave
- Noise Level: 5MV PK-PK @ 100K Hz approx.
- Operating temp. range: See chart
- Storage temperature range: -55°C to +125°C
- DC Power: ±15V ±1% @ 30MA
- Dimensions: 2" x 1.5" x .6"

Type No.	Product Accuracy	Operating Temperature Range
MCM 1519-1	±0.5%	−55°C - +125°C
MCM 1519-2	±0.5%	−25°C - +85°C
MCM 1519-3	±0.5%	0°C - +70°C
MCM 1520-1	±1.0%	−55°C - +125°C
MCM 1520-2	±1.0%	−25°C - +85°C
MCM 1520-3	±1.0%	0°C - +70°C

Precision AC Line Regulator

Total Regulation 0.15% Max.

Features:

- Low distortion sinusoidal output
- Regulation control better than ten times superior to commercial AC voltage regulators transformer product lines
- No active filters or tuned resonant circuits employed resulting in immunity to line frequency changes
- 6.5 watt output level
- Small size
- Output set to ±1% accuracy — this includes initial set point plus line, load, frequency and temperature changes
- Foldback short circuit protection provided resulting in protection against overloads and short circuits of any duration
- Low profile package with straight pins makes the unit suitable for PC board mounting (unit is hermetically sealed)
- Transformer isolation between all power inputs and the outputs.

*Other units available at different power levels. Information will be supplied upon request.

Specifications Model MLR 1476-2:

- AC input line voltage: 115V RMS ±20% @ 400 Hz ±20%
- Output: 26V RMS ±1% (for any condition)
- Load: 0 to 250 MA, RMS
- Total regulation: ±0.15% maximum (any combination of line, load or frequency)
- Distortion: 2% maximum
- AC input line current: 100 MA. max. at full load
- DC power: ±15 V DC ±5% @ 15 MA. max.
- Phase angle: 1° max.
- Temp. Range: -40°C to +85°C
- Case Material: High permeability nickel alloy
- Terminals: Glass to metal hermetic seal pins

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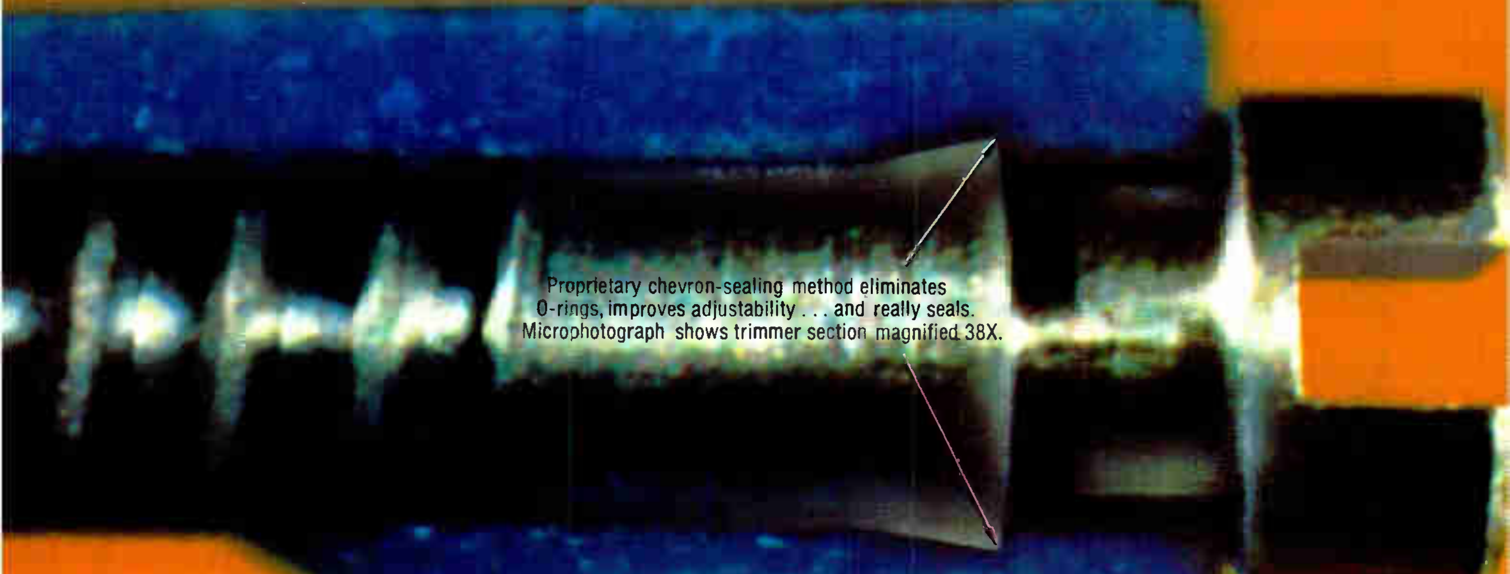
Circle 178 on reader service card

Better trimmer adjustability from a better way to seal . . .



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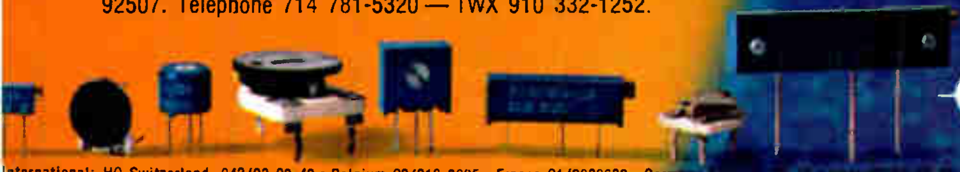

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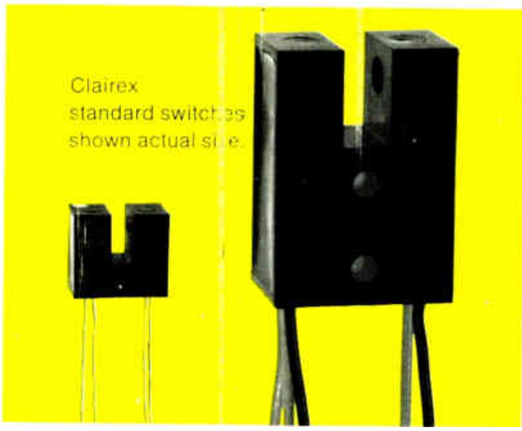

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