OCTOBER 16, 1975

ANNUAL TECHNOLOGY UPDATE ISSUE

Technology made major strides in 1975, led by
the availability of low-cost digital processing power / 74

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Electronics International

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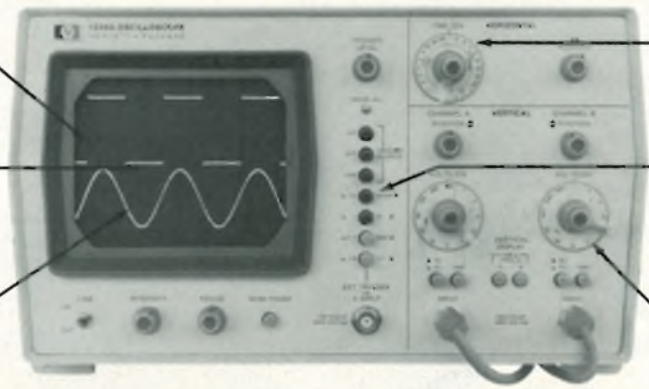

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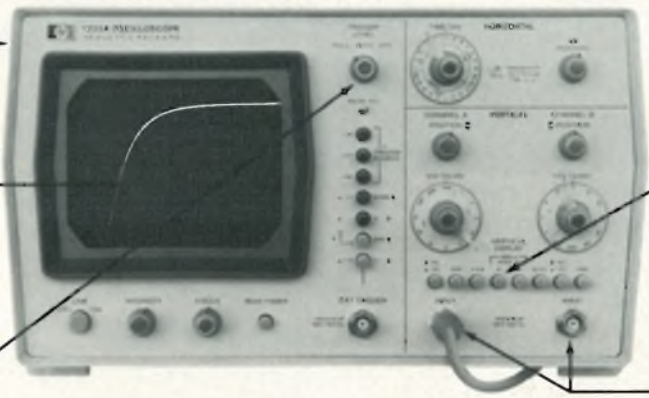

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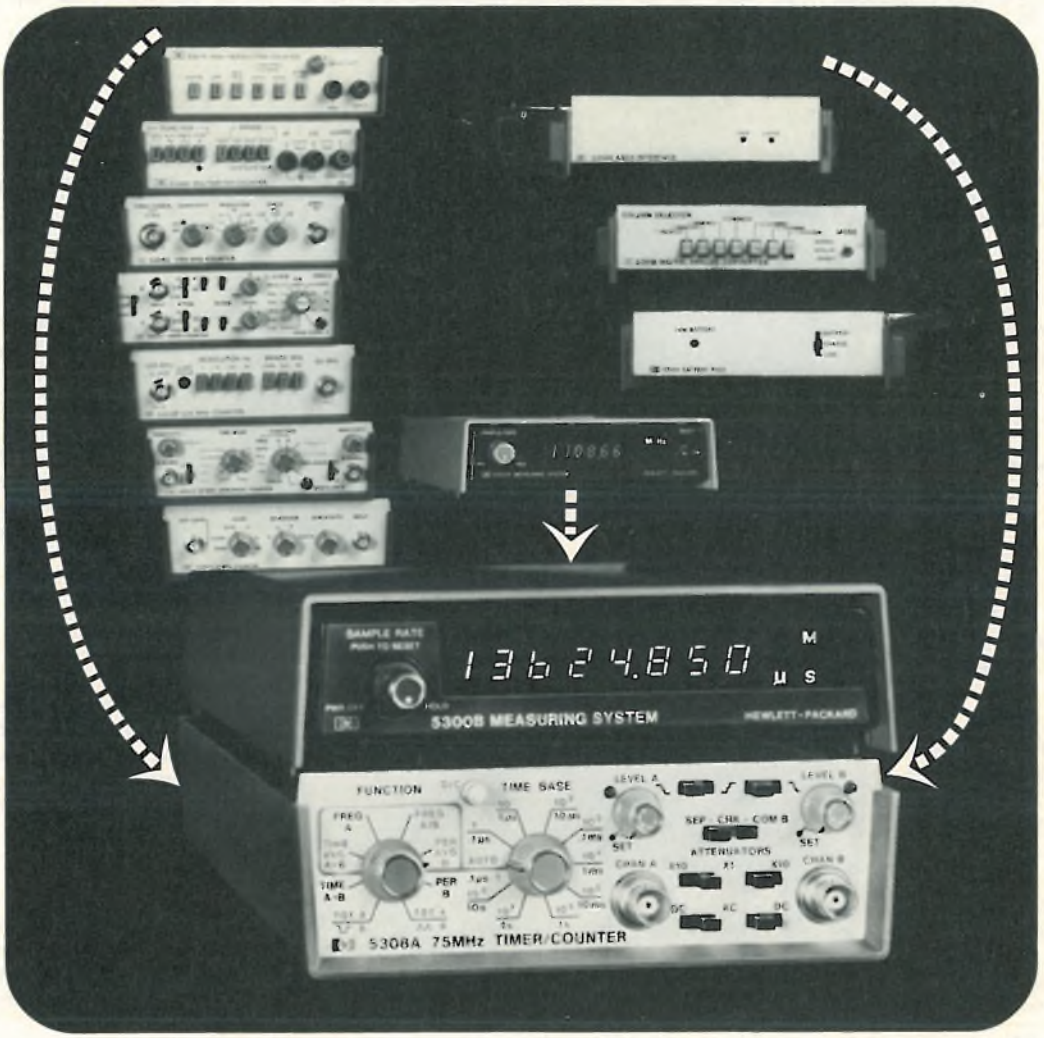

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Electronics
The International Magazine of Electronics Technology
Vol. 48, No. 21 • October 16, 1975

The cover: Award goes to I²L inventors, 66
For taking bipolar large-scale integration a big step forward, *Electronics* salutes Dutchmen Arie Slob and Cornelius Hart and Germans Horst Berger and Siegfried Wiedmann. Cover portraits are by Art Director Fred Sklenar.

Technology update, 74
Advances in LSI have made the digital approach so powerful yet so cheap that it is revolutionizing equipment and system design in almost every area of electronics.
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Consumer, 104: Digital LSI invades TV sets, cameras, air-conditioners, even stoves.
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Components, 116: Refined IC processing improves converters, op amps, couplers.
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And in the next issue . . .
Special report: how bipolar LSI is changing computer design . . . the career crisis of the middle-aged engineer . . . component reliability, part 2: users' and makers' experiences.

Electronics

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Publisher's letter

Art Erikson, managing editor international, (left) and Frankfurt bureau chief John Gosch (seated) hear about I²L's roots from Philips' Cornelius M. Hart (right) and Arie Slob.

The second annual Award for Achievement has been given to the four innovators portrayed on our cover: IBM's Horst H. Berger and Siegfried K. Wiedmann, Philips' Cornelius M. Hart and Arie Slob. Their achievement, resulting from vastly different research techniques, but publicly detailed within minutes of each other, is the bipolar-LSI concept that has come to be known as integrated injection logic, or I²L. On page 66, you'll find the intriguing story about how the two teams came up with the innovation that has given bipolar technology renewed vigor.

In the high-technology electronics industries, the spotlight is all too often on the achievements and not on the achievers. Yet it is the people in labs, offices, and universities who keep technology moving forward. We established our Award for Achievement to give recognition to those people.

And speaking of technological progress, the bulk of this special issue of *Electronics* is given over to our annual review of technology. We call it "Technology Update," and in it we round up the current trends all across the electronics industries (see p. 74).

The report covers eight major segments: computers (p. 76), communications (p.82), instruments (p.90), industrial electronics (p.96), consumer (p.104), solid state (p.110), components (p.116), and packaging and production (p.122). You'll also find, on page 126, a chronology of the major developments of the year, complete with references to when we published the details.

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Readers' comments

On Wema's wary eye

To the Editor: Regarding Bernard Cole's article, "Wema keeps wary eye on unions" [Aug. 21, p. 69], we would like to point out that the National Engineers and Professionals Association (NEPA) *is* the professional arm of the United Automobile, Aerospace & Agricultural Implement Workers of America (UAW). Therefore, the UAW effort to organize professionals is being exerted *by* NEPA. The article further stated that NEPA-UAW was helping the Engineers and Scientists of California to organize aerospace professionals at Lockheed Missiles and Space Company in Sunnyvale, Calif. The fact is, the only current organizing campaign at Lockheed is being conducted exclusively by NEPA.

Also, Mr. Cole throughout his article used negative terms like "wary, nervous, warning, fear, worrisome." We suspect that Mr. Cole is attuned to the view of industry management, and they undoubtedly do think in those narrow terms about an organization of technical professionals.

We submit, however, that there is another school of thought. The high-technology engineer or scientist is rapidly becoming the invisible person of our society. No other profession demands any higher dedication to an ever-changing technology. At the same time, the rewards have been meager.

D.R. Thomas and C.J. Paris
NEPA-UAW
San Jose, Calif. 95112

Useful addition

To the Editor: I would like to suggest a useful addition to the vlf preamplifier/isolator that I wrote about in the Designer's casebook [Sept. 4, p. 107]. The circuit can benefit from a bleeder resistor of 100 to 220 kilohms from the antenna to ground just ahead of the .002-microfarad isolating capacitor. This provides a rapid discharge path for static buildup in snow, rain, or blowing smoke particles.

Ralph W. Burhans
Athens, Ohio

HiNIL Interface

Keeping the bugs out of microprocessor systems with high noise immunity logic.

An MOS microprocessor system can be troubled by disastrous bugs unless it is protected against noise transients generated by switches, electromechanical peripherals and other nearby noise sources, such as lamps and machinery. But filters and shielding, the traditional cures, are often difficult to add to a microprocessor because of size and cost constraints.

These problems can be avoided by substituting HiNIL interface devices for conventional I/O logic. HiNIL—Teledyne's bipolar High Noise Immunity Logic—has a guaranteed DC noise immunity about 10 times that of TTL, for example (3.5 vs. 0.4V). Also, HiNIL blocks AC transients large enough to cause TTL malfunctions. Two additional advantages are superior output drive and, in low power systems, protection of CMOS memory and random logic inputs.

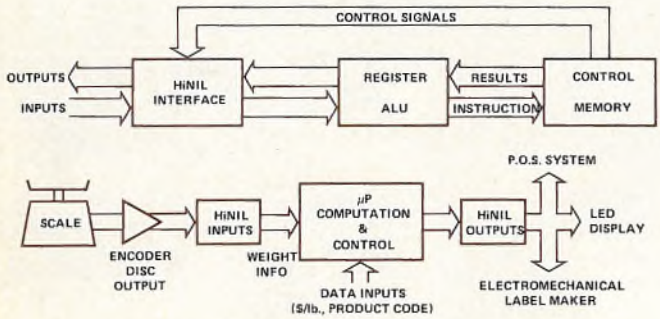

Figure 1. Use of HiNIL interfaces in POS systems with electronic scale. Top diagram shows basic microprocessor configuration.

One manufacturer of microprocessor-controlled electronic scales decided to use the configuration in Figure 1 because he was concerned about the consequences of incorrect weights and prices. The probability of errors resulting from noise transients was high because the scale would be used in a supermarket POS system, where the environment includes refrigerators, fluorescent lamps, meat grinders and electromechanical label makers.

In the system, the microprocessor receives weight codes from an encoder disc in the scale and operates a cash register interface, LED display, and relays of a receipt printer or label maker. The system designers put HiNIL interface logic on the microprocessor board to handle the I/O functions, suppress noise transients picked up along the transmission lines, and drive the peripheral devices. HiNIL output interfaces can drive long lines, relays, displays and lamps without additional components since they sink up to 65 mA and source up to 12 mA. (The new 390 buffer series will sink up to 250 mA.)

Manufacturers of systems requiring random logic are finding that HiNIL and CMOS are an ideal combination. They maximize system noise immunity and assure an excellent system function/power product. HiNIL and 54C/74C CMOS interface directly at V_{CC} voltages from 10 to 16 volts, the power supply range of HiNIL. Moreover, HiNIL protects CMOS inputs from destruction by static electricity and from harmful DC input levels that can exist before CMOS circuits are powered up.

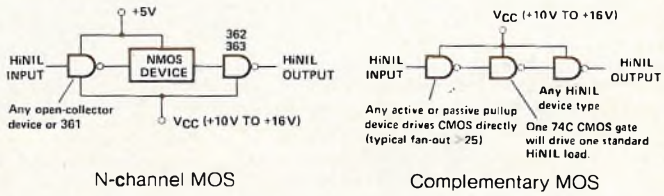

Figure 2. Typical HiNIL/MOS and HiNIL/CMOS interfaces

The rules for using HiNIL with MOS or with CMOS operating at lower voltages are simple. The pullup resistor of an open collector HiNIL device is connected to the desired high logic level voltage (see Figure 2). To use HiNIL with other bipolar logic, just plug in a Teledyne dual or quad interface circuit (see table). HiNIL is also compatible with most analog devices.

Examples of HiNIL Interface Devices

301 Dual 5-Input Power Gate 302 Quad Power NAND Gate (OC)	65mA relay or lamp driver
323 Quad NAND Gate (OC) 332 Hex Inverter (OC) 334 Strobed Hex Inverter (OC)	Input noise protection plus open-collector pullup to other logic levels
350 8-Bit Multiplexer 351 Dual 4-Bit Multiplexer	Drive longer lines than TTL with 10X noise immunity (I_{OH}=12mA)
361 Dual Input Interface 362 Dual Output Interface 363 Quad Output Interface	361 directly connects HiNIL to DTL/RTL/TTL 362 and 363 connect DTL/RTL/TTL to HiNIL
367 Quad Schmitt Trigger 368 Quad Schmitt Trigger (OC)	Suppress 100V, 1μs spikes, protect CMOS, decode switches, etc.
380 BCD to Decade Decoder 381 BCD to Decade Decoder (OC) 382 BCD to Decade Decoder 383 BCD to 7-Segment Decoder	Provide decode/drive for lamps, LEDs, gas discharge displays, etc.
390 Interface Buffer Series	250mA HiNIL driver series will be available soon

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Editorial

I^2L and technological leadership

The technological edge held by the United States in electronics is unquestioned. Certainly there are areas—such as entertainment ICs—where Europe and Japan have run faster and have outpaced the U.S. Yet across the board, American companies continue to keep a strong grip on that technological edge.

Yet the U.S. could lose that position, and lose it in a fairly short time if the subtle and delicate forces at work in politics and the marketplace become unbalanced. The last few years have seen a number of unsettling upheavals, ranging from double-digit inflation drying up traditional sources of venture capital to recessionary retrenching on the part of consumers. Yet, even these problems, serious as they are, pose less of a threat to the U.S. leadership position in electronics than does the rise of technological innovation in other nations.

Take integrated injection logic as an example. A strong weapon in the struggle being waged by backers of bipolar technology, I^2L blunts many of the major advantages of metal-oxide-semiconductor technology. This major advance was made by two teams in Europe, one at Philips in the Netherlands, the other at IBM in West Germany. True, companies around the world, American companies no exception, have taken the development and started to run with it. Yet one question can well be asked: Is the U.S. doing enough to insure that its technological leadership does not pass to other hands?

In some countries, where a clear technical need is perceived, the government is pouring hefty amounts of money into special projects, such as Japan's stoking of semiconductor and large computer development. In the U.S., however, the government is drifting. That traditional source of R&D funding, the military, is heavy on payroll and conventional weapons cost and lighter than a decade ago, say, on the kind of advanced projects that really propel technology forward. What's more, we have no program that is generating the kind of technological fallout that the space program did in its heyday.

Looked at realistically, technology knows no borders. Besides, once a breakthrough has been made, there's no need for everyone to go through all the development steps again. Anyone can jump to the new plateau and start fresh. The chances of successfully scaling new technological heights are governed more by determination, funding, and planning than by past history.

That's why it is so important for the U.S. to stop its insidious drifting in planning. As a nation, it has the determination, and, between industry and government, it has the funding to put behind meaningful projects. But the all-important planning function is the weak link.

When will Washington demonstrate a real interest, backed by substantial dollars, in applying technology, which today must include a large element of electronics for control, in mass-transportation and solar-energy technique, to name just two critical areas where Europe and Japan are setting the pace? Where is Washington's leadership in stimulating the application of technology in the little-discussed yet vital area of energy conservation? Where is the systematic balancing of the nation's scientific and technological expertise against long-term national needs that is so evident in other industrialized countries and so lacking here?

As we have said before, the American leadership position is seriously jeopardized by the lack of top-level guidance in the nation's capital. We again want to stress the need for progress toward reinstating a viable advisor to the president on science and technology. This is necessary if the U.S. is to continue to hold its leadership position.

The Am9080A: Microprocessing for the masses.

The Am9080A, a pin-for-pin plug-in replacement for the C8080/8080A is priced at $29.95 in 100-piece quantities now. Less Later.

Something is going on. Something big and important. A revolution. The Microprocessor revolution.

In the second half of this decade, microprocessors of various configurations, complexities and technologies will be sold and used in systems. But, only one will be used by the millions: The Am9080A/C8080A.

Since Intel's introduction of the 8080 and its successor—the 8080A—hundreds, perhaps thousands of designs have been committed to this general-purpose, 8-bit instruction set microprocessor. Design aids, software development systems, adequate debugging equipment, independent computerized programming systems, assemblers, compilers, cross-assemblers and systems applications materials are abundant.

The principal reason for using microprocessor-based systems is cost reduction. Unchallenged in the marketplace and hampered by an aging process technology, price decreases on the competitors' 8080 have been lagging. Until now. The Am9080A, a superior performance pin-for-pin functional replacement for the C8080/8080A, is built with an advanced ion-implanted, n-channel, silicon gate process that has enabled Advanced Micro Devices to build a chip with superior speed characteristics only two-thirds the size of the competition!

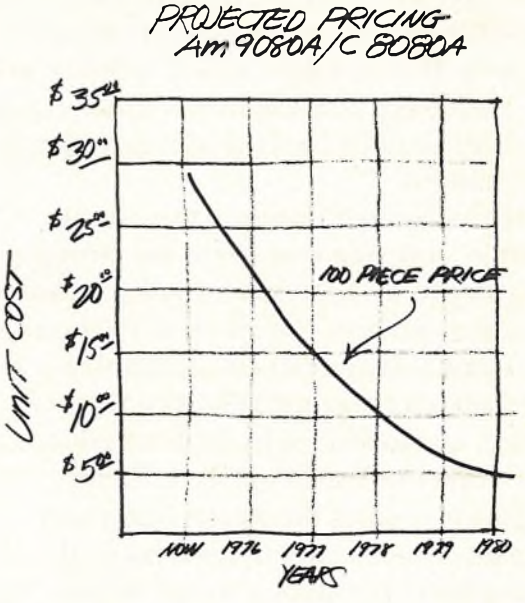
This independently developed CPU is guaranteed interchangeable in your system—or your money back. It is just like their 8080A—only better.

Like all Advanced Micro Devices' products, it is manufactured to the requirements of MIL-STD-883 at no extra charge. The $29.95 price is the unbundled price. You don't have to buy our RAM's, our ROM's or our other support circuits if you don't want to. We think you'll want to.

Advanced Micro Devices offers the broadest line of alternate plug-in replacement kit parts for your 8080-based system featuring high-speed and high-performance memories designed to take full advantage of the microprocessor's speed. We present the opportunity to optimize your microprocessor system, not compromise it.

The same engineering excellence that has made Advanced Micro Devices the price/performance leader in n-channel static RAM's is at work for you in the Am9080A microprocessor family.

Design a microprocessor-based system around the third generation *de facto* standard, the Am9080A/C8080A—the only independently multiple-sourced microprocessor from proven suppliers of high-volume n-channel silicon gate products.



Buy the microprocessor that will be sold by the millions. By the way the million-piece price is $6.00. F.O.B. Sunnyvale.

Am 9080A System Circuits

AMD Part Number	Description	Availability	8000 Series Plug-In Replacement
CPU			
Am9080ADC	0-70°C 480 nsec clock period	In Dist. Stock	C8080/C8080A
Am9080A-2DC	0-70°C 375 nsec clock period	In Dist. Stock	C8080A-2
Am9080A-1DC	0-70°C 325 nsec clock period	In Dist. Stock	C8080A-1
Am9080ADM	−55°C to +125°C 480 nsec clock period	In Dist. Stock	M8080A
Am9080A-2DM	−55°C to +125°C 375 nsec clock period	In Dist. Stock	N.A.
Static Read/Write Random Access Memories			
Am9101A/Am91L01A	256 x 4, 500 ns, 22 pins/low power	In Dist. Stock	8101
Am9101B/Am91L01B	256 x 4, 400 ns, 22 pins/low power	In Dist. Stock	N.A.
Am9101C/Am91L01C	256 x 4, 300 ns, 22 pins/low power	In Dist. Stock	N.A.
Am9101D	256 x 4, 250 ns, 22 pins	In Dist. Stock	N.A.
Am9102/Am91L02	1K x 1, 650 ns, 16 pins/low power	In Dist. Stock	8102/8102-2
Am9102A/Am91L02A	1K x 1, 500 ns, 16 pins/low power	In Dist. Stock	N.A.
Am9102B/Am91L02B	1K x 1, 400 ns, 16 pins/low power	In Dist. Stock	8102A-4
Am9102C/Am91L02C	1K x 1, 300 ns, 16 pins/low power	In Dist. Stock	N.A.
Am9102D	1K x 1, 250 ns, 16 pins	In Dist. Stock	N.A.
Am9111A/Am91L11A	256 x 4, 500 ns, 18 pins/low power	In Dist. Stock	8111
Am9111B/Am91L11B	256 x 4, 400 ns, 18 pins/low power	In Dist. Stock	N.A.
Am9111C/Am91L11C	256 x 4, 300 ns, 18 pins/low power	In Dist. Stock	N.A.
Am9111D	256 x 4, 250 ns, 18 pins	In Dist. Stock	N.A.
Am9112A/Am91L12A	256 x 4, 500 ns, 16 pins/low power	In Dist. Stock	N.A.
Am9112B/Am91L12B	256 x 4, 400 ns, 16 pins/low power	In Dist. Stock	N.A.
Am9112C/Am91L12C	256 x 4, 300 ns, 16 pins/low power	In Dist. Stock	N.A.
Am9112D	256 x 4, 250 ns, 16 pins	In Dist. Stock	N.A.
Am9130A	1024 x 4, 500 nsec	1st Q 1976	N.A.
Am9130B	1024 x 4, 400 nsec	1st Q 1976	N.A.
Am9130C	1024 x 4, 300 nsec	1st Q 1976	N.A.
Am9130E	1024 x 4, 200 nsec	1st Q 1976	N.A.
Am9140A	4096 x 1, 500 nsec	1st Q 1976	N.A.
Am9140B	4096 x 1, 400 nsec	1st Q 1976	N.A.
Am9140C	4096 x 1, 300 nsec	1st Q 1976	N.A.
Am9140E	4096 x 1, 200 nsec	1st Q 1976	N.A.

AMD Part Number	Description	Availability	8000 Series Plug-In Replacement
Dynamic Read/Write Random Access Memories			
Am9060C	4K x 1, 300 ns, 22 pins	Samples Now	8107A
Am9060D	4K x 1, 250 ns, 22 pins	Samples Now	8107A
Am9060E	4K x 1, 200 ns, 22 pins	Samples Now	8107A
Am9050C	4K x 1, 300 ns, 18 pins	Samples Now	N.A.
Am9050D	4K x 1, 250 ns, 18 pins	Samples Now	N.A.
Am9050E	4K x 1, 200 ns, 18 pins	Samples Now	N.A.
Serial Memories			
Am2812	32 x 8 FIFO	In Dist. Stock	N.A.
Am2813	32 x 9 FIFO	In Dist. Stock	N.A.
Am2841	64 x 4 FIFO	In Dist. Stock	N.A.
Am2847	4 x 80 static shift register	In Dist. Stock	N.A.
Am2896	4 x 96 static shift register	In Dist. Stock	N.A.
Mask Programmable Read-Only Memories			
Am9208B/C	1K x 8 mask programmed, 400 ns/300 ns	Now	8308
Am9214	512 x 8 mask programmed, 500 ns	Now	N.A.
Am9216B	2K x 8 mask programmed, 400 ns	Oct. 1975	8316*
Erasable Read-Only Memories			
Am9702	256 x 8, 1.0 μsec	In Dist. Stock	N.A.
Am1702A	256 x 8, 1.0 μsec	In Dist. Stock	8702A
Am2708	1024 x 8, 450 nsec	2nd Q 1976	8708
Processor System Support Circuits			
Am8212	8-bit I/O port	1st Q 1976	8212
Am8224	Clock Generator	1st Q 1976	8224
Am8228	System Controller	1st Q 1976	8228
Am8T26	Bus Transceiver	In Dist. Stock	8216**
Am25LS138	1 of 8 Decoder	In Dist. Stock	8205**
Am25LS14	8-bit Serial/Parallel Multiplier	Samples Now	N.A.
Am2905/6/7	2-Port LSI Bus Transceiver/Registers	Samples Now	N.A.
Am9555	Programmable Peripheral Interface	1st Q 1976	8255
Am9551	Serial Communications Interface	2nd Q 1976	8251

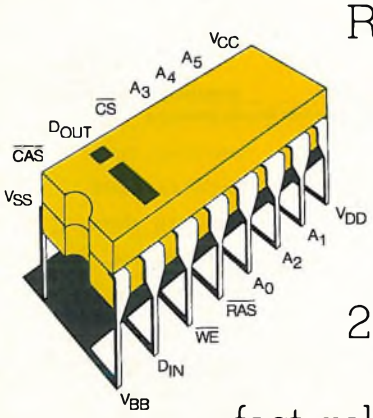
*Functional replacement only.
**Pin-for-pin replacement only. Some parameters vary

Advanced MOS/LSI

Advanced Micro Devices, Inc. France: 29 Rue du Pont, 92200 Neuilly, France, Tel: 747-4194; Germany: 8000 Munchen 2, Herzog-Heinrich-Strasse 3, West Germany, Tel: Sammel-Nr.: (089) 539588; Japan: Daini-Sayama Building, 9th Floor, 1-4, 3 Chome Nishi-Shinjuku, Shinjuku-ku, Tokyo 160, Japan, Tel: (03) 346-0363; United Kingdom: Room 322, Ebury Gate, 25, Lower Belgrave Street, London, SW1, England, Tel: (01) 730-0855

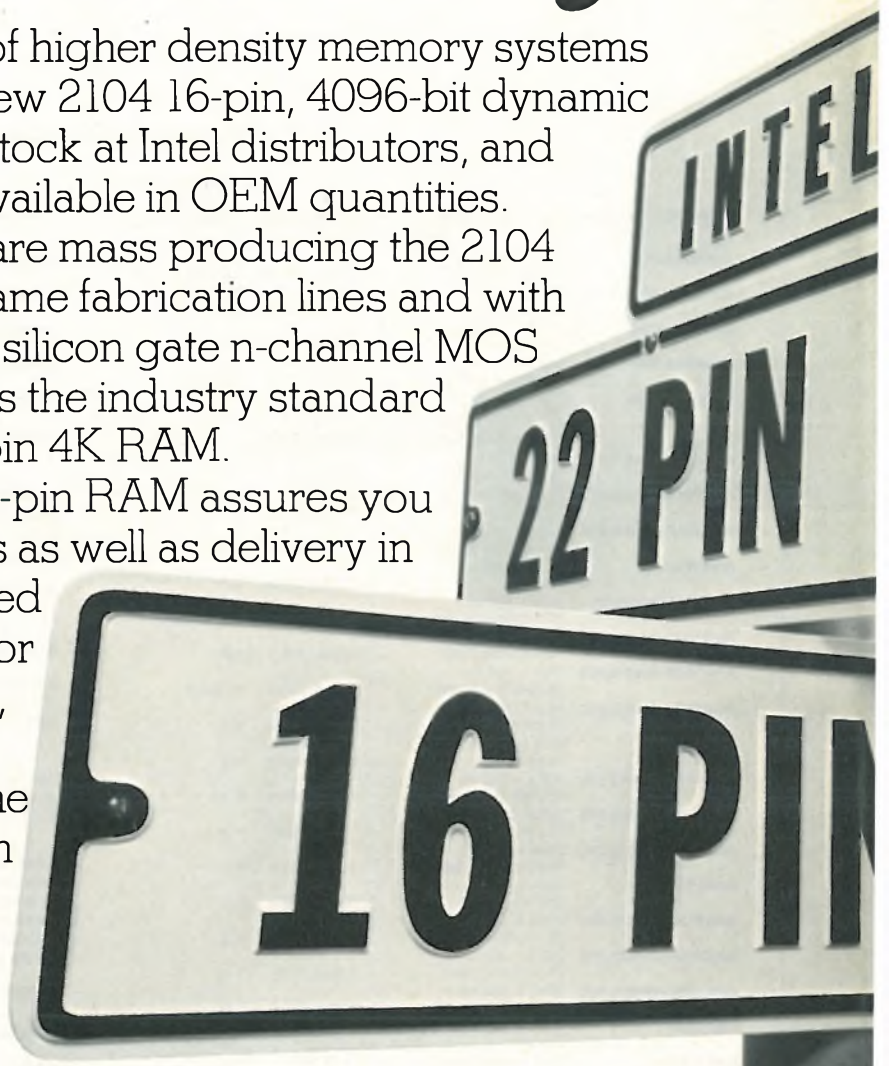
Intel is the way to

You can go into production of higher density memory systems confidently now that Intel's new 2104 16-pin, 4096-bit dynamic RAM is in stock at Intel distributors, and readily available in OEM quantities.



We are mass producing the 2104 on the same fabrication lines and with the same silicon gate n-channel MOS process as the industry standard 2107B 22-pin 4K RAM.

Intel's 16-pin RAM assures you fast, reliable parts as well as delivery in volume. The Intel 2104 is based on the proven single-transistor cell design of the Intel 2107B, the highest performance 22-pin 4K MOS RAM. Like the 2107B, the 2104 chip is much smaller than other 4K RAM chips produced today.



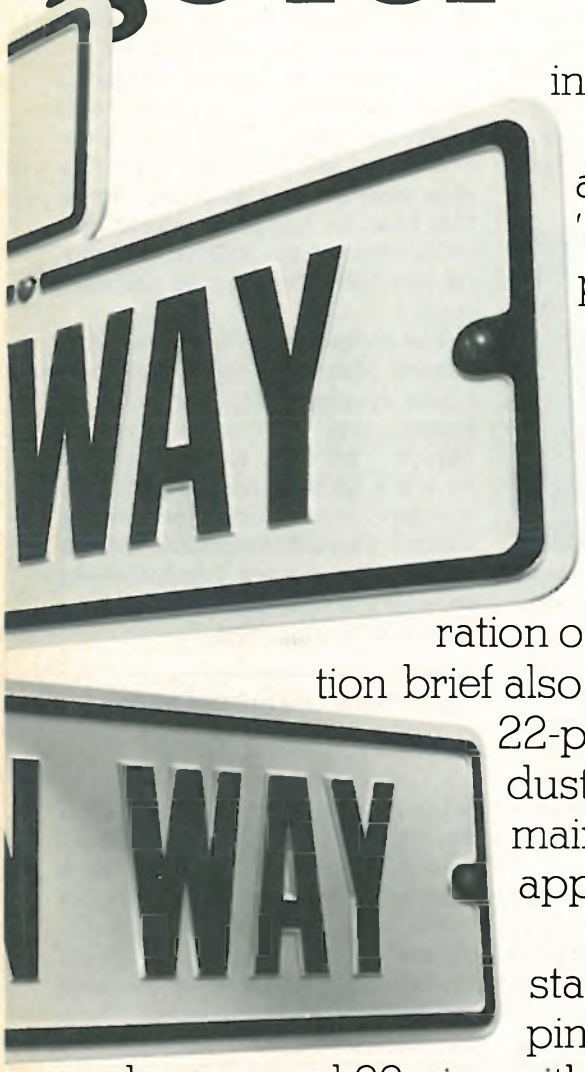
The fastest available 16-pin 4K RAMs are also in the 2104 series. Our 2104-2 guarantees an access time of only 250 nanoseconds and a cycle time of 375 nanoseconds over the full 0 to 70°C operating temperature range.

INTEL'S STANDARD 4K RAM FAMILY

Part Number	Pins	Max. Access Time (ns), 0-70°C	Min. Cycle Time (ns), 0-70°C	
			Read or write	Read modify write
D2104-2	16	250	375	515
D2104-4	16	300	425	595
D2104	16	350	500	700
2107B	22	200	400	520
2107B-2	22	220	470	680
2107B-4	22	270	470	590
2107B-6	22	350	800	960

To keep system costs low, the 2104 operates on standard −5, +5 and +12V power supplies, and TTL I/O levels. All inputs including clock

go for 4K RAMs.



inputs are fully TTL compatible.

Overall system advantages of the 2104 are detailed in a new application brief, "Which Way for 4K...16, 18, or 22 Pin?" It explains why the 16-pin 2104 is best for very compact systems such as minicomputers, microcomputers, terminals, business equipment, scientific calculators and anywhere high density is needed.

Moreover, we show how the 16-pin standard is compatible with the next generation of even higher density memories. The application brief also tells why the 2107B's simple, straightforward 22-pin design has become an industry standard for computer main memories and many other applications.

Now the industry has two standard configurations—16 pins with multiplexed addresses and 22 pins with parallel addresses. Whichever way you go, you'll find Intel ready to support both in volume production. For delivery of the 2104 or 2107B contact our franchised International distributors.

NO WAITING
24
HOUR
DELIVERY

For your copy of "Which Way for 4K..." or data sheets on any of our 4K RAMs write: Intel Corporation, 51 Rue Du Moulin A Papier-Biote No. 1, 1160, Brussels, Belgium (Telex: 24814) or Intel Japan Corporation, Kasahara Bldg., 1-6-10 Uchikanda, Chiyoda-ku, Tokyo 101, Japan.

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People

French inventor eyes U.S. automakers

French R&D and U.S. automotive electronics have had little to do with each other so far. But an ambitious Grenoble engineer hopes to create a closer bond between them with the integrated circuits he has developed for use in turn-signal indicators, with ignition cables, and in intelligent systems for driver safety.

U.S. bound. French engineer Ferdy Mayer looks forward to an American environment.

Ferdy Mayer, an outspoken, energetic specialist in contract research, plans to take his developments to the U.S. market, beginning with a limited deal with a TRW subsidiary. He has operated the Laboratoire d'Electronique et d'Automatique Dauphinois for 18 years.

U.S. partner. But, convinced that the U.S. is more suited to his hyperactive style, the lanky, gray-haired Mayer hopes eventually to cut his ties with France and move into manufacturing with U.S. partners so that he can tackle the original-equipment market. "No U.S. carmaker would buy OEM equipment from France," he says. "It is impossible to make imports economical enough."

Mayer's first entry will probably be ignition cables that suppress interference—one of his most successful developments in recent years. This month, he presents TRW Wire and Cable Co., Holyoke, Mass., with what he believes is the most advanced ignition cable yet developed, capable of attenuating interference up to 1 gigahertz. He also will show it to Chrysler Corp.

Mayer's cable improves on a 400-megahertz-limit cable that he has licensed to automakers in France and six other European countries. It works on the principle of attenuation by optimizing magnetic and dielectric losses. Ferrite shields absorb the radiation from the conductor.

"It remains to be seen whether I reach agreement on a license with TRW," says Mayer, "but if not, I expect to get into U.S. manufacturing with some partner or other." From that base, he hopes to expand into other areas of automotive electronics, like fuel economy and pollution control.

The prospect of U.S. partnerships attracts Mayer for more than economic reasons. "R&D mentality in Europe just can't keep up with change," he says. Europeans tend by habit to limit their thinking to standard, proven techniques, Mayer claims, whereas Americans have a record of achieving breakthroughs by trying new avenues, new materials, new combinations.

National's Oudewaal aims to sell modules to OEMs

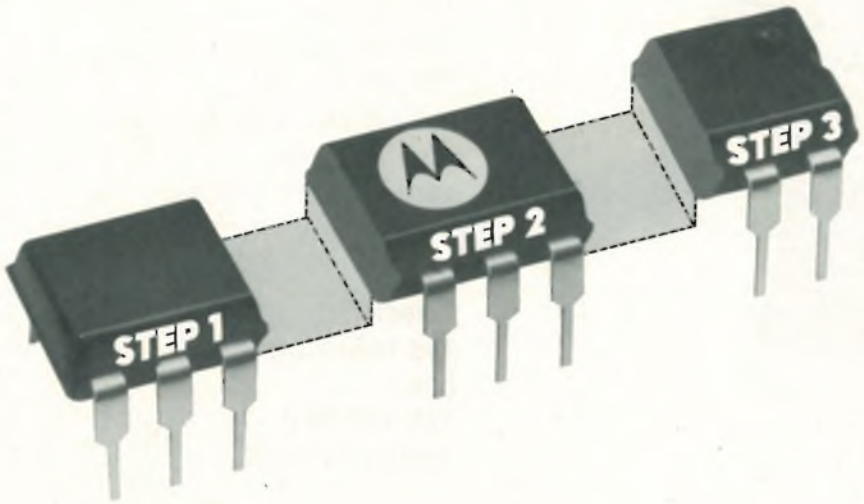
Since landing his first job as a design engineer in 1958, Martin Oudewaal has earned a reputation as a man who can start an electronics operation and move it to profitability quickly. "And no doubt that's what's expected of me with the Module Products group," says the Indonesia-born Oudewaal, director of National Semiconductor Corp.'s newest marketing effort.

The growth of National's semiconductor components in new markets is one of the important reasons

Breeder. Martin Oudewaal hopes to generate profitable new markets for modules.

3 steps toward "failure free" linear consumer plastic ICs...

Although "failure free" plastic integrated circuits are not a reality today, Motorola has taken three giant steps toward meeting that goal. During the last 18 months a stringent reliability program was undertaken to guard against field failures. The program was modified, evaluated, and modified again. Today, we feel the three step program will effectively screen out potentially defective devices and reduce costly field failures in consumer products. Here's how it works:



STEP 1. The EPIIC (Environmental Package Indicators for Integrated Circuits) Program is a dynamic audit function to provide "real time" quality and reliability assurance. It...

❶ Guards against shipment of potentially defective parts due to occasional undetected flaws in the raw materials used, or to assembly inconsistencies.

❷ Prohibits shipment of parts with marginal performance to a given specification.

❸ Provides periodic feedback at frequent intervals so that corrective action may be taken for further reliability improvement of plastic packaged devices.

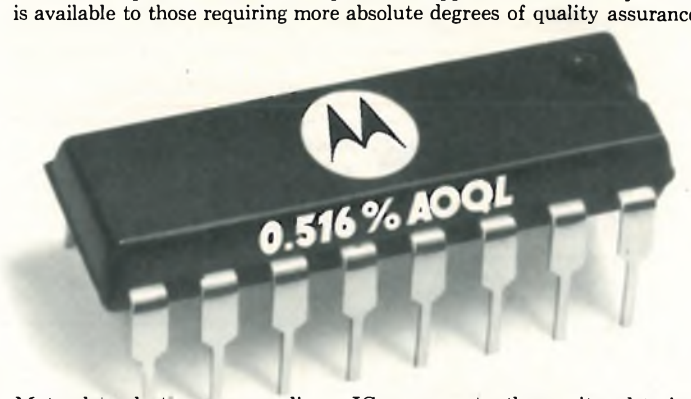
STEP 2. The Accelerated Punishment Program for Consumer Products is a periodic line audit consisting of a step stress test for failure mechanism identification and long term reliability prediction.

The accelerated testing under severely hostile environment conditions is equivalent to many years of operation under more normal conditions. The result is a program that identifies failure mechanisms and initiates corrective action to reduce failure modes. Again, this procedure is standard for consumer products and is accomplished without extra cost to customers.

STEP 3. The Consumer Reliability Program is a specialized customer-tailored program to monitor each lot of specific devices for a particular application. It is subject to extra charge and is available to those requiring more absolute degrees of quality assurance.

The industry's leading sampling plan...

In addition to the above, Motorola's outgoing QA sampling plan has been tightened up to ensure *superior average outgoing quality levels* (AOQL) in comparison to other plans utilized by the industry today. Simply stated, it offers 3/2 LTPD on all parameters combined and 0.25% AQL on function testing for a combined Average Outgoing Quality Level of 0.516%.



0 Failures a goal

Motorola's plastic consumer linear ICs are constantly monitored to improve the overall quality and reliability factors. The three step program has proven its value and is credited with higher reliability levels than has been attained in the past.

The goal is no failures at all. But in the meantime you can design in Motorola's plastic linear ICs and be confident they have passed the industry's most stringent Reliability and Quality programs.

For complete details on these advanced programs write to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036. Just ask for the Consumer Plastic Linear Reliability Assurance Program Brochure.

It will be *your* first step towards a "failure free" product.

MOTOROLA LINEAR
—A step up in Plastic IC Reliability!

People

for the formation of the Module Products group. Another, according to Oudewaal, is the hope that it will serve as a breeding ground for new OEM efforts similar to those undertaken by National's Novus consumer products division, the manufacturer of watches, calculators and electronic games.

Profitability. "The whole idea behind this module products group intrigued and excited me," says Oudewaal. "The charter for the group has virtually no limits, except to make modules. We can do them in any technology, or combination of technologies, available at National, and in any market we find interesting." The goal is to make the modules so inexpensively that manufacturers will buy rather than make them, all with an eye toward immediate profitability.

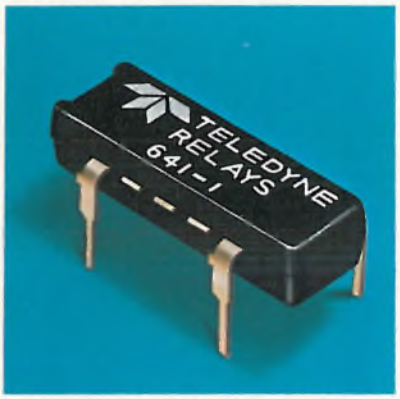
A graduate of the University of the Hague and The Utrecht Business Institute, Oudewaal came to the U.S. in 1959 and got his first intensive introduction to semiconductor technology at Transitron Corp. He moved to Fairchild Semiconductor in 1962, and by the time he left in 1966 he was managing director of the Mexican semiconductor operations he helped form. In the years following he formed two successful companies and returned for a while to the Netherlands to start a European subsidiary of an American firm.

Oudewaal points with pride to his group's first effort—a 1-by-3-inch printed-circuit-board module that he believes will enable makers of all-electronic clock/radios to break the $20-price barrier [*Electronics*, Oct. 2, p. 51]. He's not stopping there. In the works is an all-electronic clock/radio with a light-emitting-diode display for automobiles.

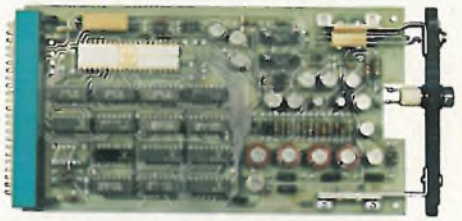
"And then there are all sorts of opportunities in telecommunications, toys, and games, as well as the standard a-d and d-a converter markets," he says. "In addition there are all sorts of module combinations using microprocessors.

"The possibilities are endless."

Did you get the message about our solid state SerenDIP relays?



International telex communication switching systems often are expected to run on a 24-hour, seven-day shift. Continuous duty like that calls for dependable, long-life component reliability — the kind RCA requires from Teledyne SerenDIP® relays used in their trunk terminator modules. These all-solid-state DIP relays provide wear-free and bounce-free switching — features you don't get with electro-mechanical or reed relays. What's more, our SerenDIP's offer high input/output isolation, low level logic input compatibility, and fast response time. And you get all of this in a low cost, low-profile TO-116 DIP package ready-made to replace any standard DIP reed relay. You also get your choice of output: bi-polar, AC (triac), or DC. There's lots more to a SerenDIP relay that you ought to know about. For detailed specs or applications help, contact the Teledyne Relays people nearest you. You're sure to get the message about our all-solid-state DIP relays.



RCA Trunk Terminator Module

RCA CCT-3 Series
Telex Switching System
(Courtesy of RCA/Camden, N.J.)

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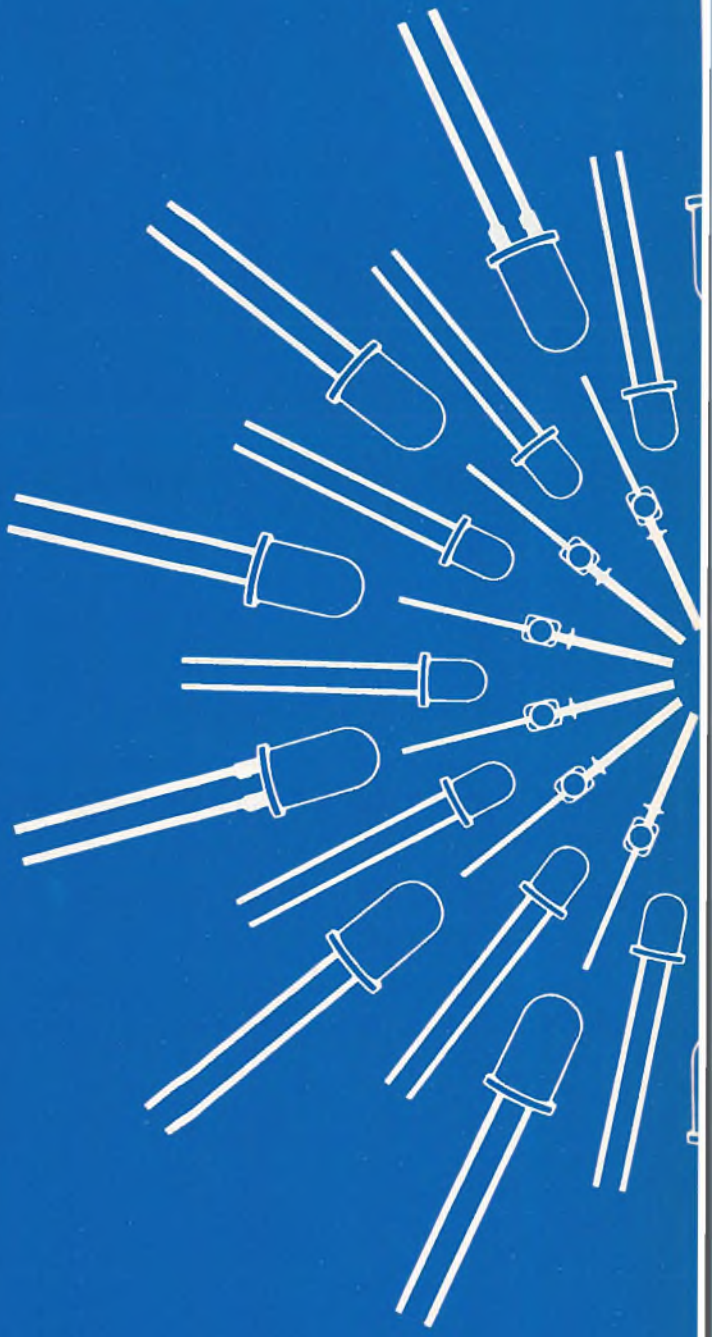
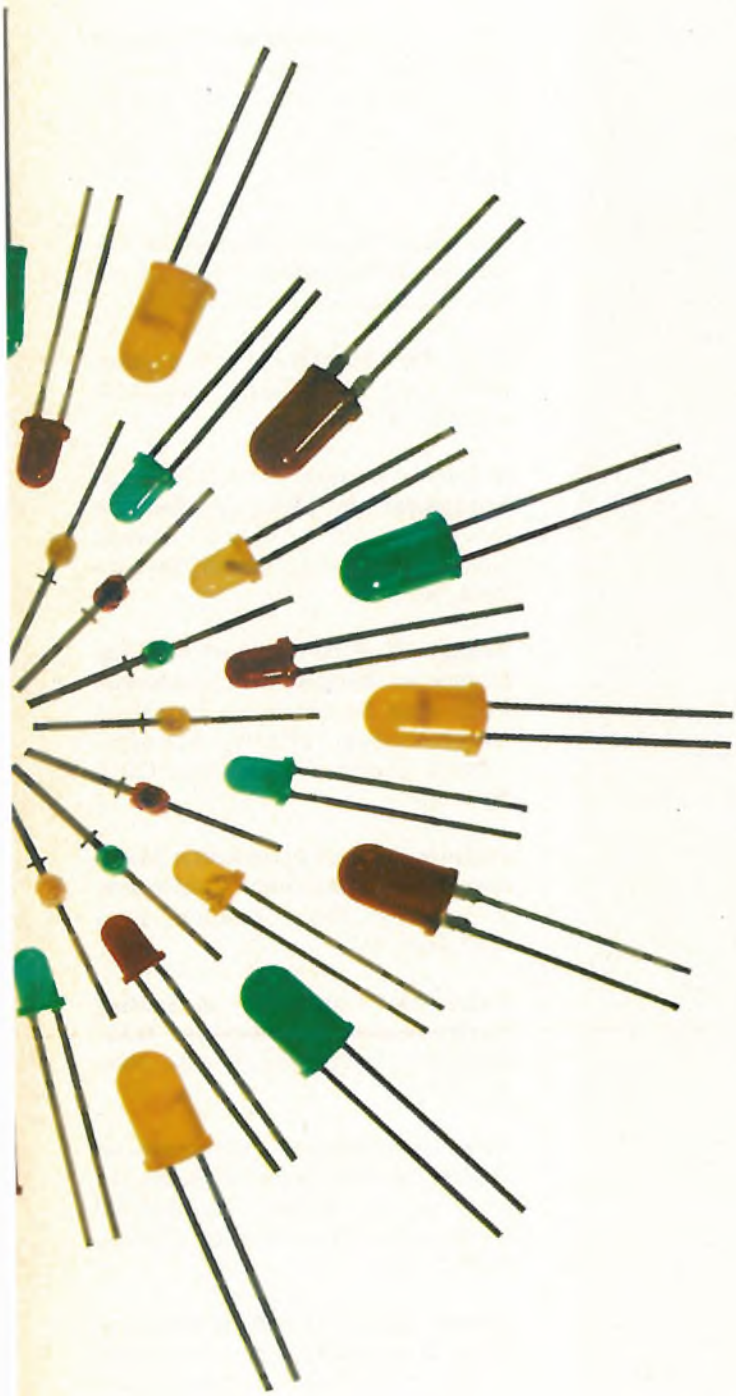
Three colors.
Three packages.

Only Litronix has them all.





All three colors in all three packages. Yellow, green or red lamps in T-1, T-1¾ or axial packages. Only Litronix has them all.

T-1¾ packages. At 0.34″ high and 0.20″ in diameter, this lamp is ideal for panel mounting. We even make available a panel mounting clip. Cost for yellow and green is just 59¢ each in quantities of 1000.

T-1 package. Our red, yellow and green lamps are available in this smaller general-purpose package that's useful not only on front panels, but on PC boards, or any place where space is at a premium. Height is 0.20″ and diameter is 0.125″. 1000-unit price for yellow and green is also 59¢ each.

Axial lead package. Our axial lead package is intended for mounting on a PC board. It's only 90 mils wide, allowing it to be inserted in standard PC board spacing of 100 mils. Price for yellow and green is just 49¢ each in quantities of 1000.

So there you are—all three colors in all three package configurations.

Now add to that the lowest published prices in the industry. The convenience of dealing with just one supplier. And the fact that the No. 1 LED manufacturer is the No. 1 safe buy. It gives you the best package deal in town.

For details contact Litronix, Inc., 19000 Homestead Road, Cupertino, CA 95014. Phone (408) 257-7910.

No wonder we're No.1 in LEDs

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Meetings

IC-QC Workshop, American Society for Quality Control, Downtowner Motor Inn, Durham, N.C., Oct. 24–25.

1975 ISHM International Technical Symposium, International Society for Hybrid Microelectronics (Montgomery, Ala.), Sheraton-Towers Convention Center, Orlando, Fla., Oct. 27–29.

Automatic Support Systems for Advanced Maintainability, IEEE, Island Inn, Westbury, N.Y., Oct. 28–30.

22nd IEEE Machine Tools Conference, IEEE, Red Carpet Inn, Milwaukee, Oct. 28–30.

Semicon/Europa, Semiconductor Equipment & Materials Institute (Mountain View, Calif.), Zuespa Convention Center, Zurich, Switzerland, Nov. 3–5.

Biocapt 75—First International Conference on Biomedical Transducers, Fédération Nationale des Industries Electroniques (Paris, France), Unesco Conference Building, Paris, Nov. 3–7.

Piezoelectric and Pyroelectric Materials and Applications Conference, IEEE, Savoy Place, London, England, Nov. 4–7.

Third Joint Conference on Sensing Environmental Pollutants, IEEE, Stardust Hotel, Las Vegas, Nov. 10–13.

Third International Conference on Digital Satellite Communictions, Intelsat *et al.*, Kyoto International Conference Hall, Kyoto, Japan, Nov. 11–13.

Electro Optics '75 and International Laser Exposition, Industrial & Scientific Conference Management Inc. (Chicago), Anaheim Convention Center, Anaheim, Calif., Nov. 11–13.

International Crime Countermeasures Conference, IEEE, Kingston, Jamaica, Nov. 13–18.

INTRODUCING THE FLUKE
SUMMA II SERIES DATA LOGGERS

The first data logger with full "microprocessor power"... As the leading manufacturer of digital voltmeters, Fluke is the industry's greatest expert on low level analog measurements.

Because Fluke is an innovator in the use of microprocessors in instrumentation, our new Summa II Series data loggers offer maximum "microprocessor power".

Top of the line is the Summa II Model 2240A. Scan 1 to 1,000 inputs, up to 60 in the mainframe with resolution to 1 microvolt and 0.1°.

Wide dynamic range (40,000 counts) and high resolution allow the user to scan faster and more economically over a greater variety of inputs.

Keyboard entry allows the user to program range, function, skip, alarm limits, time interval and fixed data from the front panel. Skip an open channel or an unused channel without disabling the entire block of channels. The data logger has several alarm scan modes which make it ideally suited to process monitoring.

Scan intervals are keyboard selectable from 1 second to 24 hours—that's 86,400 possible intervals in all. And the first interval can be different from the remaining intervals. Program the Summa II 2240A to *begin* automatically scanning any time you like. The keyboard programmable 9-digit calendar clock has resolution to 1 second.

Better Specs Across-the-Board

Because we didn't simply updata an old product, but made the microprocessor the basis for an integral design, Summa II data loggers are many ways better. The Summa II series reads all common thermocouple types better and more accurately. The LSI microprocessor lets us drastically reduce the number of IC's, lowering power consumption, thus eliminating the need for fans and vastly improving reliability.

Wide Choice of Options

Options include alarms, program memory expansion, mag and paper tape, teletype and RS232C interfaces, digital input and thermocouple conditioning.

Standard features on the Summa II 2240A include 6 digits of fixed data, complete program printout, and program storage good for *more than five years*.

An Outstanding Value

At $4295* the Summa II 2240A is the most complete data logger in a single box on the market. And it's backed by the Fluke reputation for quality and dependability that is recognized throughout the world. Other models in Fluke's Summa II Series start at $2865*

For data out today dial our toll-free number, 800-426-0361.

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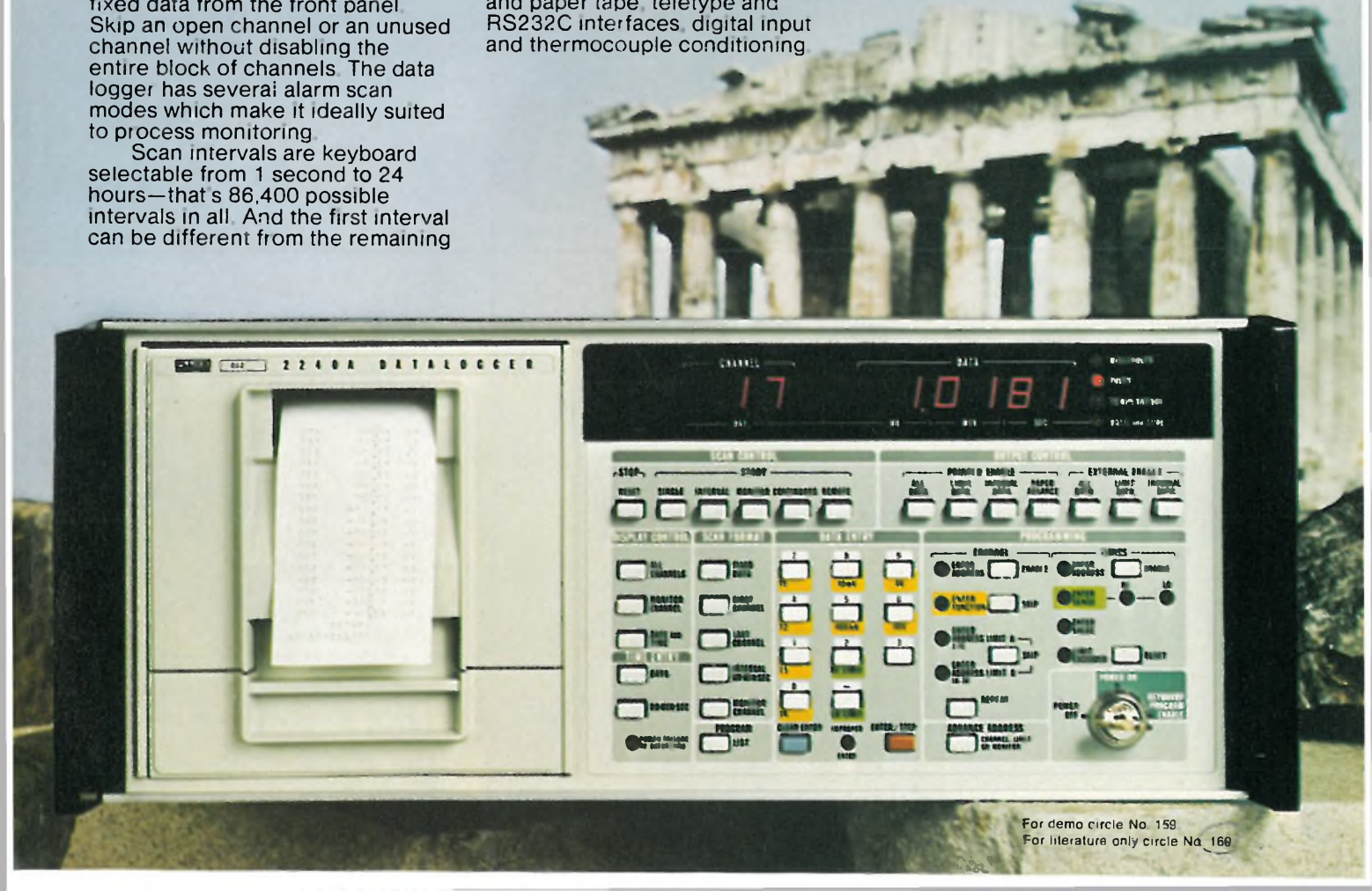

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For literature only circle No. 160

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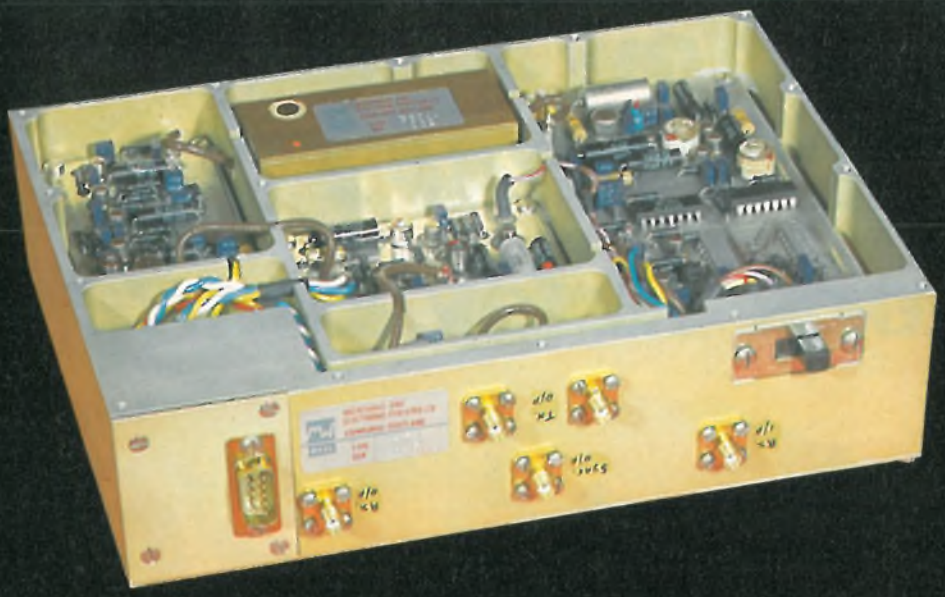

at all the noise is about?

One thing's for sure, the acoustic vibrations of SAW technology have been making a lot of noise over the past few years and their impact is being sensed in many areas.

But the message we want to circulate is implementation — applied technology, if you like — in real engineered hardware. Hardware fully qualified and already operational in airborne and surveillance radars.

MESL is committed to applied technology, and the incorporation of MESL high performance SAW pulse compression processors in today's advanced radar systems, marks a major step in this commitment.

And this is what all the noise is about.

So run a check over these spec. parameters . . .

FREQUENCY RANGE 15 MHz — 500 MHz.
TIME DISPERSION 50 μs. max.
BANDWIDTH at least 100 MHz.
TIME BANDWIDTH PRODUCT at least 500.
TIME SIDELOBE LEVEL down to – 40dB.
SYSTEM DYNAMIC RANGE typically 60dB.

And let us know if we can join your radar design team — for that's where the action starts.

MESL

on your microwavelength

Microwave & Electronic Systems Limited,
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Midlothian EH28 8LP, Scotland.
Telephone: 031-333 2000, Telex: 72384.

Just How Broad is the MAGNECRAFT Stock Relay Line?

free wall chart!

Magnecraft's stock relay line consists of 1200 versions derived from 17 categories - - - - - that is the largest and broadest line in the industry.

Oh? Did I read that correctly?

Yes, Magnecraft Electric provides 1200 relay versions in stock through our nationwide distributor network. Those 17 categories include; low profile, general purpose, power, mercury displacement, sensitive, coaxial, telephone type, air dashpot time delay, solid state, latching types, high voltage, mercury wetted reeds, dry reeds, and dip reed relays.

Magnecraft can offer you the design engineer, a quality product, local distributors, and the broadest relay line in the industry to choose from. If we don't have the relay in stock we will custom design a relay to meet your requirements.

Full color 22"x 34" relay specification chart.

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Electronics newsletter

Motorola changes second sources, lands big order

Motorola Semiconductor has landed a big order and a new second source for its 22-pin 4-kilobit random-access memory, the 6605. The order, $7 million for 1 million devices, was placed by Sperry Univac. And replacing American Microsystems Inc. is **the new second source, Intersil Inc., which shares the Univac order.** It was AMI that developed the RAM with Motorola two years ago.

The explanation, says AMI's director of standard products, Richard Conrad, is that "we felt the market just wasn't there for a three-cell device" like the 6605. Instead, AMI is staying in the 4-k RAM market with one-transistor-cell designs and has gone into production with two versions—the 22-pin 4021 and the 16-pin 4096.

The move away from Motorola **does not affect AMI's second-source deal on Motorola's 6800 microprocessor.** In fact, AMI will soon announce a 6800 hardware/software development system similar to Intel's MDS and Motorola's Exorciser.

TI chips late, Odyssey deliveries are postponed

Montgomery Ward has been forced to drop Magnavox's two new Odyssey video games from its Christmas catalogue because, in the words of a Magnavox official, "Texas Instruments has been considerably late on all shipments" of five custom-TTL chips for the games. The $79.95 Odyssey 100 uses four chips, while the $99.95 Odyssey 200 utilizes six (one chip is used twice). TI still hasn't delivered the chip that controls on-screen scoring in the 200.

Production of the 100 started last month instead of in July, and the 200 is due to start rolling off the lines in November instead of August. Although Magnavox is still marketing its original Odyssey game—it uses a plastic screen overlay and does not have sound or automatic scoring—the company will not resume production and expects to run out of that game before Christmas.

U.S. threatens to go ahead with own MLS

The U.S. is threatening to go it alone on a microwave landing system. With the Federal Aviation Administration's development program in a financial squeeze, the agency says it will deploy its own system **if the International Civil Aviation Organization delays review** of alternative programs beyond the June 1976 scheduled date.

While time-reference scanning beam has been selected as the MLS technique, Europeans favor a ground-derived system where decisions are made on the ground and relayed to the pilot. The U.S. wants to use the opposite approach. And there is some belief in the U.S. that European members are pressing ICAO to delay its decision **so that France and West Germany can have more time to develop their ground-derived systems.** If that occurs, says Frank L. Frisbie, the FAA's new MLS chief, "we will begin installing our version without ICAO approval."

Funds cut off for RADC studies

It appears that the Reliability Branch at Rome Air Development Center **will not receive fiscal 1976 funds for outside reliability studies.** RADC, the Air Force's watchdog over the semiconductor industry, has been operating without funds since July at its Griffiss Air Force Base facility in upstate New York. Expecting the worst, branch officials have

provided the Air Force Systems Command with an estimate of what it will take to fund "new starts" of such studies this year with money from the command's existing fiscal 1976 budgets.

However, five previously threatened outside study programs [*Electronics,* Sept. 18, p. 30], including a reliability study of C-MOS on sapphire, will be reinstated. Explains a RADC official: "We located some prior-year money."

Infrared CCTV system transmits video 2,000 ft

American Laser Systems Inc. of Goleta, Calif., has developed a relatively inexpensive closed-circuit-TV transmission system that **uses an infrared optical carrier to transmit the video-camera output signal to a site up to 2,000 feet away.** Duncan B. Campbell, American Laser's president, says a typical installation costs about $4,000.

Development of the system was paid for by Otis Elevator Co., which plans its first installation this week in a dog-food factory. There, the camera will be mounted on a remotely controlled materials-handling unit to check inventory numbers on stacked boxes and look for damaged packages. American Laser also has demonstrated the system to IBM Corp. for possible use at its San Jose, Calif., operation, which has buildings on both sides of a major freeway.

Allen-Bradley to use own minicomputer

To cut the price of its computerized numerical-control systems, Allen-Bradley's Systems division **has built its own microprogramed processor for the new series of machines it will announce later this month.** Built with standard and Schottky transistor-transistor logic and using 4,096-bit random-access memories from Texas Instruments, the minicomputer emulates the Hewlett-Packard 2100A used in the division's earlier series 7300 N/C machines. The new N/C series is functionally identical and software-compatible with its predecessors, but will be offered for less than $30,000—a 30% cost reduction that's mainly due to the change in processors, says a marketing official.

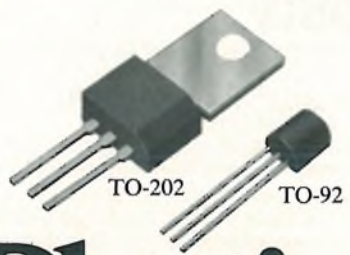
TI decides to stay out of Wema statistics

Texas Instruments has declined "at this time" to take part in the new monthly reports on semiconductor bookings to be compiled and published by Wema, the West Coast-based association of electronics companies [*Electronics,* Oct. 2, p. 53]. However, other companies are responding enthusiastically: **16 have been added to the original list of 19, and 20 others are expected to sign up before the end of the year.**

Addenda

RCA's Solid State division is about to announce plans to **second-source Texas Instruments' 4,096-bit RAM.** RCA will offer n-channel versions of TI's 4050 and 4051 18-pin devices and TI's 4060, a 22-pin part. . . . The U.S. Postal Service has taken a step toward electronic mail delivery. It has signed a $2.3 million contract with Pitney Bowes for an **experimental model of a printing and paper-handling system** to handle 4 pages a second (potentially 10 pages), format for satellite transmission, retrieve digital data, and put out hard copy at the receiving end. Subcontractors to Pitney Bowes are Lockheed Electronics and Versatec Inc.

The first packaging breakthrough in power transistors for switching power supplies:



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Devices tested: 14 and 16 pins. TTL, DTL and CMOS @ 5V.
Tests performed: Fixed pattern functional test.
Remarks: Performs 2^{20} inspections per test in from 1 to 5 seconds. No comparison with a "good" IC is necessary. 4-digit display gives absolute test results. Can also be used to check continuity of resistor network.

MODEL 1248
For demo circle Reader Service #236.
For literature only circle #237.

DIGITAL IC TESTER
$1195.

Devices tested: TTL, DTL @ 5V, HTL @ 15V, CMOS @ 5V, 10V, 15V.
Tests performed: Same as 1248.
Remarks: Interfaces with manual and automatic handlers. Multiple voltages for CMOS.

MODEL 1249
For demo circle Reader Service #238.
For literature only circle #239.

Fiber-optic system carries voice, TV and data signals

Bell-Northern Research develops analog system with 15-megahertz bandwidth; components are available

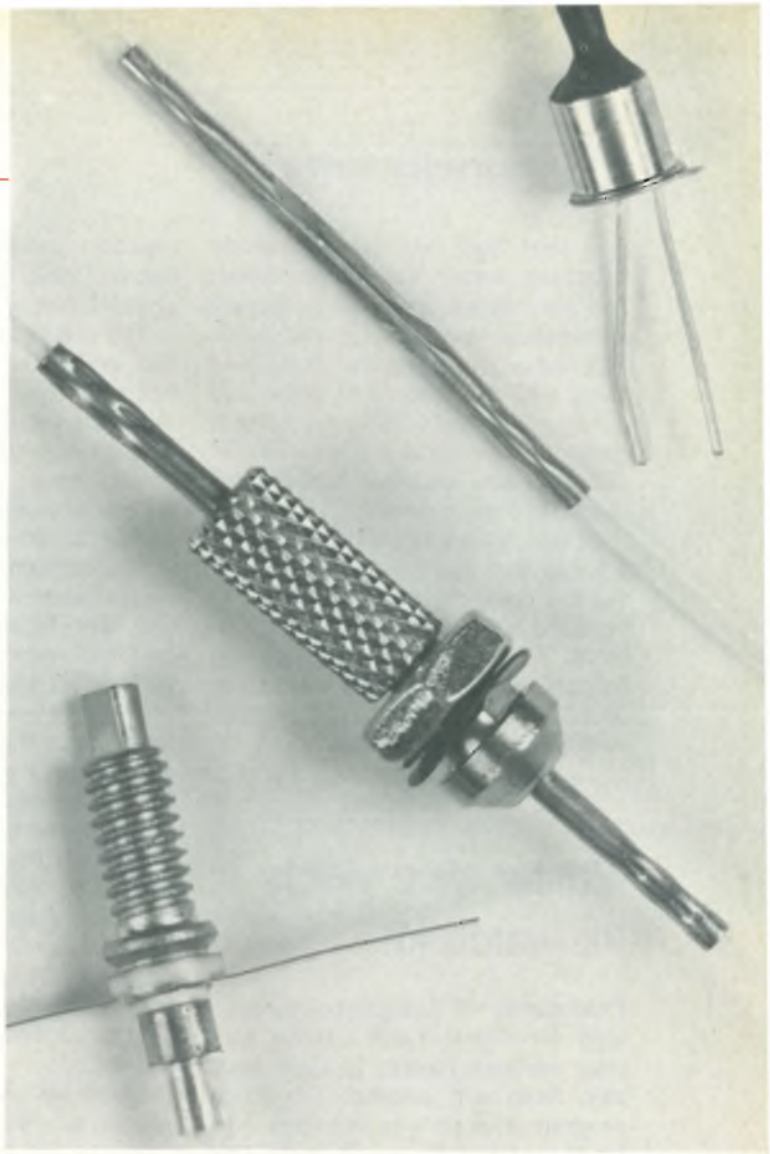
With an eye on fiber optics for providing future communications services, a research arm of Bell Canada has developed an analog system for transmitting voice, color television, and high-speed data signals.

The system was developed by Bell-Northern Research in Ottawa, and although the parent telephone company will reveal no plans of its own to implement it, BNR is willing to help interested outsiders. According to Matt Kuhn, manager of Advanced Technology Laboratories at Bell-Northern Research, "BNR will develop similar systems for specific customer applications, or will sell prototype quantities of the components" developed for the system.

Kuhn indicates that the system could be applied for paging, alarm, surveillance and entertainment in places like office buildings, shopping centers, and hospitals.

Components. The system, with its 15-megahertz bandwidth, is built of a compatible set of components developed by BNR. These include:

- A transmitter having a stud-mounted high-radiance light-emitting diode coupled to a multimode fiber. The LED, using double heterostructure gallium-aluminum-arsenide, when driven at 150 milliamperes, emits 375 microwatts of power in the 800 to 900 nanometer region. It offers good linearity and has sufficient power to meet the higher signal-to-noise ratios needed for analog transmission. It has adequate speed for data rates up to 100 megabits per second.
- A p-i-n photodiode receiver mounted in a TO-18 case and coupled to a multimode fiber. This, unlike a more expensive but high-gain avalanche photodiode, operates at low-bias voltages of 5 to 30 volts and requires no temperature compensation.
- A single-fiber splice for making a permanent low-loss fiber-to-fiber connection. Insertion loss is typically less than 1 decibel with a 100-micron core diameter. The splice is formed by butting together the fiber ends inside a stainless steel tube containing an index matching fluid. The ends of the tube are then crimped into the fiber's plastic coating. This crimp holds the fiber faces together. Kuhn says the tooling for preparing the fiber ends and crimping was developed with field use in mind.
- A single-fiber panel-mount connector that contains the splice element inside a stainless steel connector housing. This is designed for use wherever there is need to make and break the fiber cable quickly.
- Multimode fiber cable with an attenuation of 15 dB/km. (Commercially available multimode fibers, such as produced by Corning Glass Works, can also be used.)



Team. Set of fiber-optic components from Bell-Northern consists of (from bottom) LED/fiber transmitter, panel-mount connector, splice, and p-i-n photodetector/fiber receiver.

Switched transmission. With these components, BNR put together an analog system that allows switched, multiplexed transmission of studio-quality video, high-fidelity voice, and high-speed data. Since fiber-optic cables don't suffer from cross talk, low-cost solid-state switching at baseband (up to about 20 megahertz) can be used easily. The system can transmit studio-quality video over a link with an optical loss of up to 25 dB between the transmitter and the receiver. Longer distances will require a repeater—essentially a photodiode driving an operational amplifier that, in turn, drives an LED.

The system allows a user to select any of a number of video, voice, and data channels. The input selector

uses MOS logic to control a diode switching array. The voice, video, and data signals are then frequency multiplexed onto the 15-MHz band. The video is transmitted baseband along with the associated audio and occupies the first 6 MHz; the voice is multiplexed onto a 6.5 MHz carrier and the data channel multiplexed onto a 11.5 MHz carrier.

In this system any data rate up to 1.5 megabits per second is possible, but the components themselves can be used at data rates up to 100 Mb/s. The bandwidth isn't limited by cable or components, but by the speed of whatever off-the-shelf switching circuitry is used. □

Consumer

Master slice yields I²L watch kit

Proponents of integrated-injection logic for digital-watch circuits may take encouragement, if they need any, from still another I²L watch program, this time in the form of a kit of matched I²L watch parts. Out of this kit, a product of ITT Semiconductors, West Palm Beach, Fla., a manufacturer can pick and choose from among a wide range of I²L watch options—from simple four-function designs to seven-function watches that offer such things as elapsed time and time zone.

The concept is simple enough. All the major watch-circuit components—timers, frequency dividers, buffers, crystal inputs, display driver outputs—are diffused onto a single master slice. The master is then scribed into individual components and packaged to form the kit.

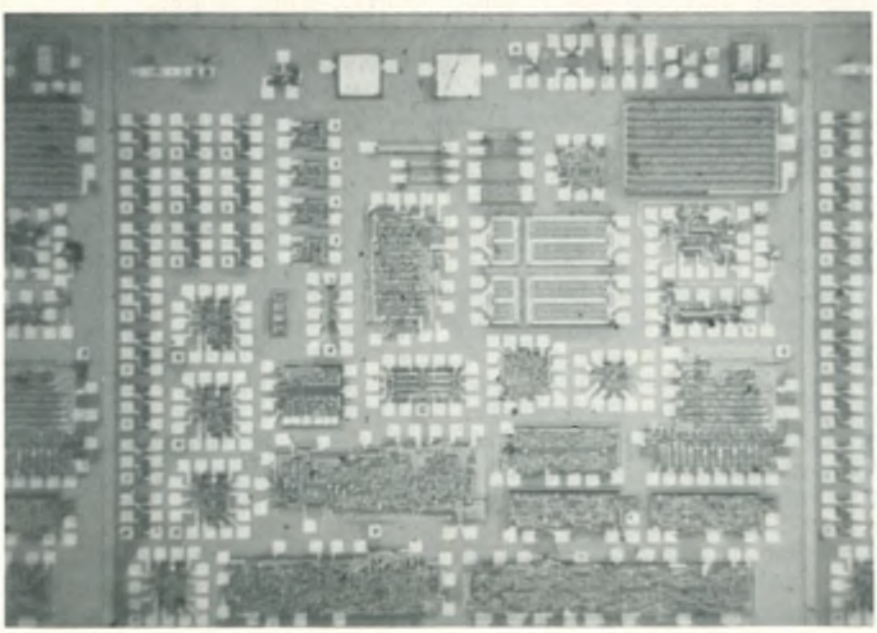
"To implement a design," says Suhael Ahmed, manager of research and development engineering, "a customer may use anywhere from 10 to 20 packages, depending on the complexity and number of features he wants. Then, once a customer works up his particular design from the kit, he can have it reduced and optimized on a single chip."

Ahmed calls I²L "the perfect technique" for fabricating watch parts because of its high-density format. This, he says, "enables us to pack a wide variety of watch components on a single slice at a very low cost. C-MOS circuits would probably be too large."

Lined up. According to Ahmed, scores of customers are already lined up for the kit, and there are several contracts for high-volume production of completed watch-chip designs.

With the kit program now two years old, ITT is planning to produce a range of standard I²L watch chips for the low-end, four-function market, to the high-end, six- and seven-function market.

Thus the war between I²L and the older complementary metal-oxide-semiconductor technology has escalated. Since the solid-state watch industry was shaken by the introduction, by Texas Instruments, of the first I²L watch chip, it soon saw other giant suppliers like Fairchild Semiconductor Corp. and Philips of the Netherlands taking the same path. And, despite their investments in C-MOS, the Motorola Semiconductor Products division and National Semiconductor Corp. are known to have developmental I²L watch programs of their own. □



Variety. Watch components such as timers, frequency dividers, buffers, and display drivers are fabricated on a single silicon slice, then cut apart and put in ITT's parts kit.

Memories

8-kilobit memory coming from AMS

With 4-kilobit dynamic memories well into production, semiconductor houses, applying the so-called "rule of four," are generally moving to develop 16,384-bit designs. But not Advanced Memory Systems of Sunnyvale, Calif. Using the same strategy that led it to develop a 2,048-bit design before it went to the 4-k, AMS is first going the 8,192-bit route.

"Our studies indicate an 8-k design is immediately cost-competitive with today's 4-k designs at the systems level on a cost-per-bit basis," asserts James Cunningham, vice president of semiconductor operations at AMS. Accordingly, the company will have prototypes of 8-k silicon-gate n-MOS dynamic random-access memories in its own memory systems by the end of this year and expects to have a standard production part by the end of the first quarter of 1976, says MOS-design manager Jerald Bernacchi.

What's more, he says, the part, designated the 7008, will have an access time of about 100 nanoseconds, two to three times faster than most 4-kilobit designs, and will consume less than 400 milliwatts.

Later. "It would appear that 1977 would be the earliest that 16-k RAMs would be available in production," continues Bernacchi.

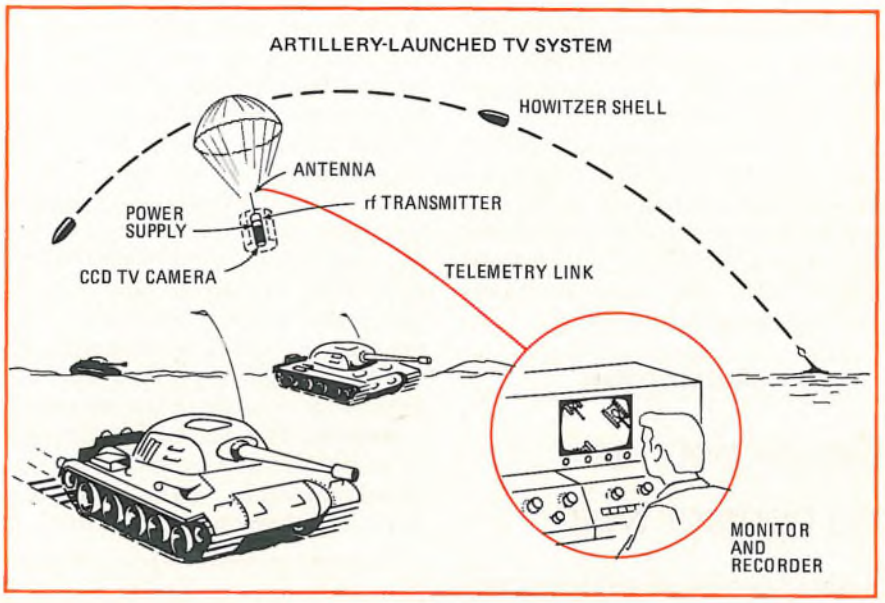
Moreover, Millard Phelps, vice president of marketing at AMS, says it will be many months before 4-k designs reach the same 100-ns performance level. Even when they do, AMS will be able to offer the same thing with twice the number of bits.

Using a one-transistor-cell design similar to that used in many 4-k RAMs, the AMS 7008 takes up about 35,000 square mils and fits into the standard 22-pin dual in-line package. "We could have made the chip at least one third smaller," says Bernacchi, "but we were aiming at a high-performance device. So we traded some extra silicon area for the extra speed and lower power."

Unique sense amps. Except for conventional dynamic one-cell circuitry, address buffers, and decoders, much of the extra chip area is taken up by a unique sense amplifier. The classical approach has been to take the information from the cell, transfer the charge to the bit-sense lines, amplify it, and pass it along to the output buffer. But before the information is handed on to the output buffer, it is refreshed, causing a delay of 40 to 50 ns.

"What we did differently is eliminate this delay," says Bernacchi. "As soon as the information is transferred to the bit-sensing lines from the cells, it is immediately latched and given to the outside world. While that operation is going on, we go back and refresh the information just coming from the cell. In order to do this, the sense amplifiers had to be made five to six times larger than the 10- to 15-square-mil structures used in 4-k designs.

To optimize the 8-k design for low power, says Bernacchi, the sense amplifiers were designed as dynamic rather than static structures so that when they are turned on, they don't draw power until they are turned off. The dynamic sensing structure draws power only when it has to recharge the capacitive storage cells, and it then turns off. All the voltages have been precharged into the capacitors, and when a bit is sensed, they are discharged. □



Seeing eye. TV camera using charge-coupled-device array could be fired over battlefield where, suspended by parachute, it would send pictures of the terrain and ground action.

Military

CCD camera to scan battlefield

A television system that will give field commanders real-time pictures of distant battlefield targets is currently under development at the Army's Picatinny Arsenal, Dover, N.J. A crucial element is a miniature TV camera in which a sturdy array of charge-coupled devices replaces the fragile vidicon tube.

Shot from guns. The idea for the system is straightforward. Essentially, the camera is to be carried inside a projectile over a target area and released at the right altitude by a timing fuse. Suspended by a parachute, it would float and send pictures of the terrain and ground action back to the command post. If necessary, the televised scenes could be video-taped.

But it's the 244-by-190-element CCD sensor array that makes the whole thing feasible, says Ernest Ohlhoff, a project engineer with Picatinny's Precision Munitions Group. "The glass in the vidicon tube couldn't take the 12,000 to 15,000 g forces exerted when the shell is fired," he explains. The Army is confident the CCD chip can.

The total system is based on an existing illumination artillery projectile—the M485 for the 155-mm gun—and uses many of its components. The camera and associated electronics would take up the space in the artillery shell normally used for the illuminating canister.

Contractor. The TV system, including the CCD array, is being developed for the project by Fairchild Camera & Instrument Corp.'s Imaging Systems division in Syosset, N.Y., under a $300,000 contract. Other key contractors in this initial phase of development are Microcom Corp. of Warminster, Pa., which is supplying the system's rf transmitter, and Honeywell Inc.'s Power Sources Center at Horsham, Pa., which is modifying an existing battery to be used with the TV system.

The Navy had experimented with a similar system at its Naval Air Test Station at Dahlgren, Va., using

a Fairchild-developed 100-by-100-element CCD array, but dropped the project early last year when it ran out of in-house funds.

For use over a battlefield, Ohlhoff says it would be possible to install a self-destruct mechanism in the system to keep it out of enemy hands. The plan is for the TV system to be flight-tested next June at Yuma Proving Grounds in Arizona. □

Automotive

Ferrite pot has no contact wear

Resistive potentiometers have a new competitor for applications in automotive electronics—a rotary potentiometer that has a longer lifetime because it is contactless. Its developer is the Licon division of Illinois Tool Works Inc., Chicago, which has been busy adapting the ferrite-core technology of keyboard switches to automobile-engine controls [*Electronics*, April 3, p. 39].

Sturdy. Highly resistant to shock and vibration, the pot will perhaps show up first as an angular-position sensor in under-the-hood systems such as air and fuel meters for carburetors. For that slot it is competing with ruggedized resistive pots—more complex synchro transmitters and rotary variable differential transformers have been rejected as too expensive.

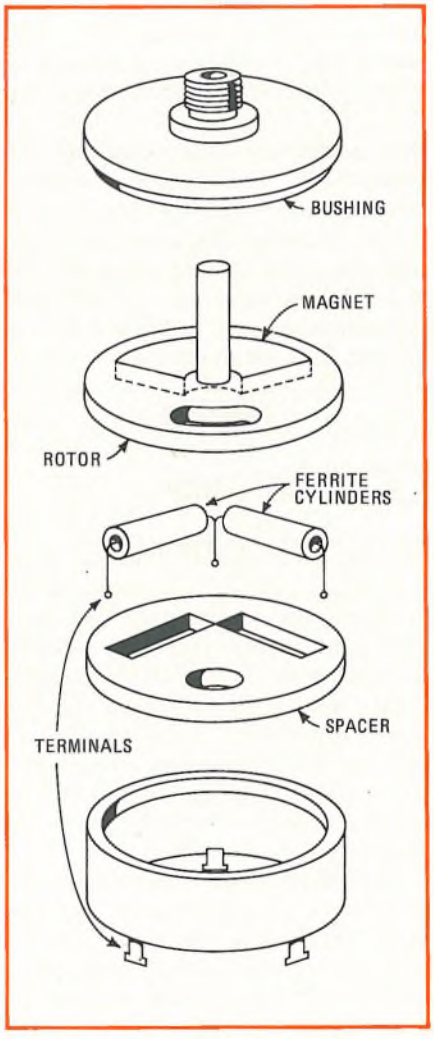
The Licon device, which will operate at temperatures up to 200°C and is the same size as a resistive pot, is being evaluated by manufacturers of engine control systems and is already being road-tested by one diesel engine builder. In addition, the firm has pocketed orders for prototypes from major auto manufacturers, says product manger William S. Barrow. He is quoting a device price of under $5 in quantities of 50,000 to 100,000 units.

Unlike resistive pots, which rely on a screened-on resistive element and accompanying wiper to vary resistance, the Licon version uses a pair of small ferrite cylinders wound as inductors with a few turns of wire, plus a permanent magnet that varies the saturation of the ferrites as it rotates. Total inductance across both ferrites is constant. But as the magnet passes above them, inductance in one increases as the other decreases, explains Edward F. Sidor, new product development manager. And the signal between the two ferrites yields a differential voltage output that is proportional to the pot's angular position and insensitive to changes in temperature.

Remote. The electronics required to complete the system can be located remotely, away from the harsh environment of the sensor. A high-frequency ac signal to drive the sensor must be generated by an oscillator stage, and a detector stage is required to demodulate the center-tap voltage to yield a dc level signal. Output of the device is extremely linear, Sidor says—to within ±1% through the rotation of the shaft, which would be connected to the value being controlled.

Licon's prototype pot will sense up to 110° of rotation, using a wedge-shaped magnet rotating over the two ferrite inductors. The inductors are positioned at right angles to each other in a package that measures just under 1 inch in diameter.

The firm has also had a few requests for a 360° sensor. "For those applications we've designed a version that uses a spiral-shaped permanent magnet and two ferrite cylinders stacked on the radius of the spiral," Sidor notes. As the magnet turns, the effective magnetic field moves in a radial direction across the two inductors. □



No contacts. In Licon position sensor, ferrite cylinders wound as inductors provide voltage output that depends on the magnet's position. The magnet in turn is attached to the automobile valve being controlled.

Computers

Data General unveils own memory chips

Data General Corp.'s Nova 3 minicomputer, formally announced on Oct. 9, means more than just a new product for the Southboro, Mass., company. It represents the payoff of its wholly-owned semiconductor facility in Sunnyvale, Calif. Although Data General will also use standard memories produced by Texas Instruments, the Nova 3 is the first minicomputer to use Data General's own 4-kilobit dynamic n-channel MOS random-access memories.

Design interaction. In-house manufacture of the memory chip, according to Nova 3 marketing manager Donald McDougall, gives the company "significant advantages in terms of tight inventory control and reliability of supply. It allowed the memory chip to be designed with close interaction between our Sunnyvale semiconductor specialists and Nova 3 system engi-

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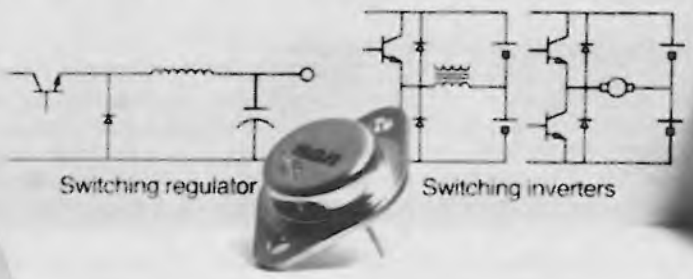
RCA



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	I_C amps	V_{CER} volts	V_{CEO} volts	V_{CEO} (sus) volts	P watts	V_{CE} (sat) volts	t_r nsec	t_s sec	t_f nsec	100+ price
2N6513	7	400	400	350	120	1.5@4A	700@4A	3@4A	500@4A	$4.44
2N6308	8	450	700	350	175	1.5@3A	600@3A	1.6@3A	400@3A	$5.09
2N6251	10	375	450	350	175	1.5@10A	800@10A	1.8@10A	500@10A	$6.84

RCA. Powerhouse in Transistors.

Circle 33 on reader service card

neers. This resulted in what we consider to be the best overall RAM-memory design that could be developed for these computers."

Memory cycle time for the MOS memory is 700 nanoseconds, and core and semiconductor memories can be mixed in any combination.

The Nova 3s, according to Data General, will compete with such computers as Hewlett-Packard's 21MX, Digital Equipment Corp.'s 11/35, and, on the low end, even with DEC's LSI-11 microcomputer.

The company expects the new mini to challenge microcomputers for some applications at the low end, and also to handle complex OEM applications. For the low end, a Nova 3/4 (a four-board computer) with turnkey front panel and 4-kilowords of semiconductor memory, will also have the chassis, power supply and interfaces that OEM systems houses often must supply when using microcomputers.

At the high end, the Nova 3/12 (12 boards) a computer with 16-k words of core or semiconductor memory can be supplemented with comparable peripherals, such as fixed and moving head disks, magnetic tape drives, line printers and CRT terminals. □

Patents

Western Electric mum on patent suit

Engineering managers at the six semiconductor companies sued this month for triple damages by Western Electric Co. don't seem worried at all by the court action. At issue is infringement of a WE patent covering basic planar diffusion techniques applicable to MOS, bipolar and discrete semiconductors.

The defendants are Intel Corp., Mostek Corp., Intersil Inc., Teledyne Semiconductor, Solid State Scientific Inc., and Stewart Warner Corp. U.S. Patent 2,802,760 expired more than a year ago, and Western Electric, in particular, won't say why it took so long to file the action. And

News briefs

House approves Navy F-18 funds
The House of Representatives early this month voted 243–173 to approve the Naval Air Systems Command's $132.2 million fiscal-1976 appropriation to develop the McDonnell Douglas/Northrop F-18 fighter. Senate approval is expected, especially as the General Accounting Office has denied LTV Aerospace Corp.'s protest of the award [*Electronics*, May 29, p. 42]. LTV's entry in the Navy's air-combat fighter (ACF) competition was a variation of General Dynamics Corp.'s F-16, which was picked earlier this year by the Air Force.

Four Intelsat V bids expected
Lockheed Missiles and Space, TRW Systems group, Hughes Aircraft and Aeronutronic Ford lead four industry teams expected to submit bids Oct. 20 for the next generation of international communication satellites, the Intelsat V series [*Electronics*, May 1, p. 40]. The Aeronutronic team, which will enter the Intelsat market for the first time, includes GEC Marconi of Great Britain, MBB of West Germany, and Mitsubishi Electric of Japan. The Communications Satellite Corp., which manages the procurement for Intelsat, will review the proposals for a possible contract award next year that could be worth more than $250 million for seven satellites with options for eight more.

IBM-Telex suits terminated
The 3½ year-old legal fight between IBM Corp. and Telex Corp. came to a surprise end this month when both companies said they were terminating their actions against each other. In the see-saw battle that first went to trial in April 1973 in Federal Court in Tulsa, Okla., Telex charged IBM with violation of the Sherman Antitrust Act, and IBM countersued Telex, alleging industrial espionage. IBM has released Telex from $18.5 million in a court-ordered damage payment. In fact, no payment of any kind will be made by either side.

Joblessness of engineers increases
The Institute of Electrical and Electronics Engineers' unemployment index rose to 4.1% in the August survey, the highest since the index was started in November 1974. It marks the first increase in unemployment since the April survey.

Dallas, Fort Worth sue LTV over Airtrans
The battle over the stalled Airtrans "people mover" at the Dallas-Fort Worth regional airport has moved to court. The two cities, plus the regional airport and eight airlines, have asked in a suit that the computerized system, built by LTV Aerospace Corp., be made operable or they want $200 million in damages. Defendants are the builder, its parent LTV Corp., and the bonding company for the Airtrans contract. Responding to the suit, Paul Thayer, LTV Corp. chairman and chief executive officer, has denied that the system was shut down because of failures on LTV's part. While the courts weigh the matter, the system has been supplanted by a fleet of buses.

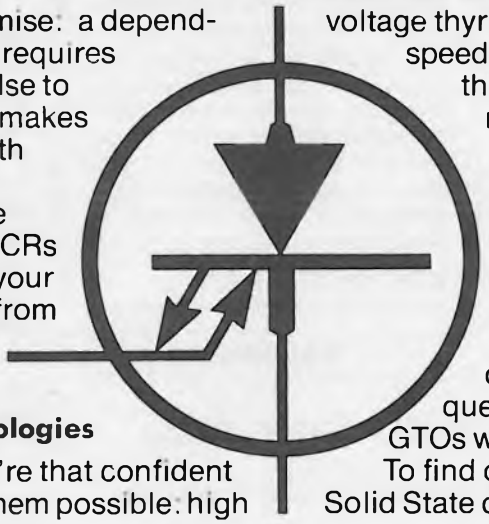
RCA introduces microprocessor family
The RCA Corp. Solid State division in Somerville, N.J., has announced the commercial availability of its CDP1800 microprocessor family, including the CDP1801 complementary-MOS 8-bit microprocessor, the Microkit hardware kit, manuals, and software-development packages. The Microkit contains the central-processing unit, 1,024 words of random-access memory, 512 words of read-only memory, space for additional memory and user-designed interface cards, input/output decoders, an I/O interface for a teletypewriter or other terminal, and power supply. The CDP1801 15-volt chips are priced at $56 each and the CDP1801C 5-V chips at $40 each for fewer than 100.

What's new in solid state...

RCA delivers the promise of GTO SCRs in an 8.5A series.

You've heard the GTO promise: a dependable, cost-effective switch that requires only a short negative power pulse to the gate for turn-off. Now RCA makes that promise. And delivers it with product.

Right now, you can choose from 18 RCA 8.5-ampere GTO SCRs available from RCA or through your distributors. At prices ranging from $4.13 to $11.47 for 1 to 99 units, from $2.50 to $6.95 at 1K.



Marriage of technologies

RCA is in GTOs to stay. We're that confident of the combination that made them possible: high voltage thyristor technology combined with high speed transistor technology. You get everything a conventional 8.5-A SCR offers: normal inrush handling capability, pulse turn-on, operating range to 125°C. Gate turn-off capability is a bonus.

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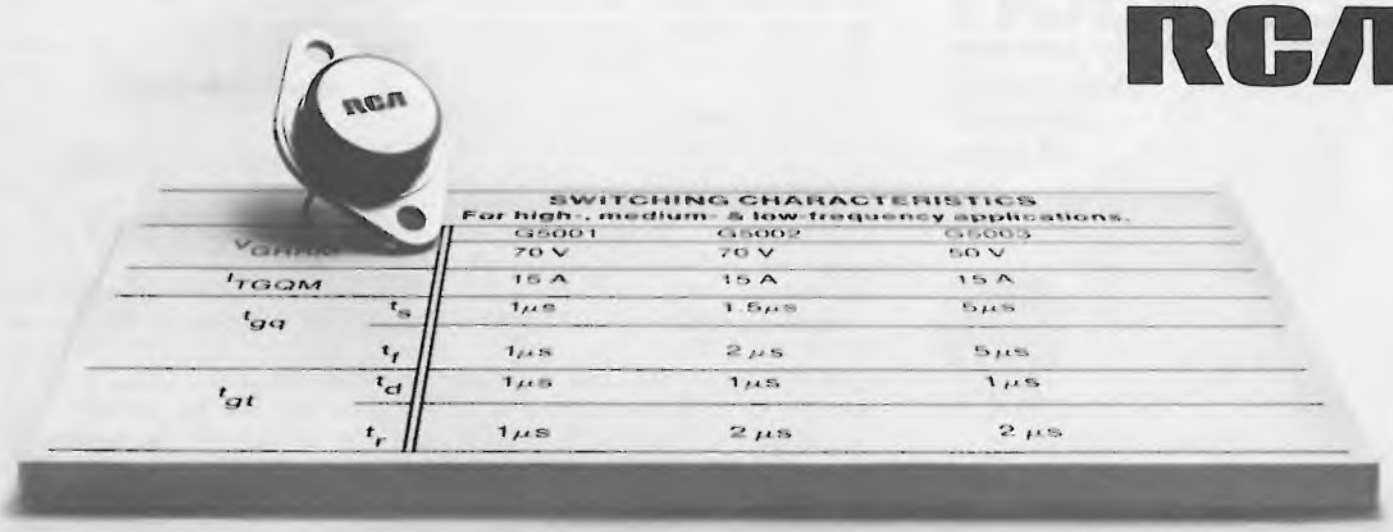

RCA. Powerhouse in Thyristors

Circle 35 on reader service card

Electronics review

the feeling among the defendants is that the suit will have little impact on the industry. □

Cooperation upswing

After years of battling, semiconductor suppliers are cooperating. In the microprocessor area, Intersil Inc. and Harris Semiconductor will each supply three versions of Intersil's new 12-bit C-MOS microprocessor, the IM 6100, input/output and read-only memory chips, and 1-kilobit C-MOS random-access memories. Coming on the heels of National/Rockwell and Motorola/American Microsystems deals, the agreement, according to Intersil president Marshall Cox, enables a supplier to share the high development costs and have a line of second-sourced parts, an advantage in the market.

Satellites

NASA laser relay bows to Air Force

An unusual conjunction of military security, budget priorities, and advances in spaceborne laser technology has put the National Aeronautics and Space Administration out of the satellite communications relay business and left the Air Force in charge.

NASA's Goddard Space Flight Center is phasing out its five-year program to develop a spaceborne carbon monoxide laser communications system. Researchers there have been told that the $15–20 million needed to flight-test their space-to-space data relay will not be available in future fiscal years.

More than that, Goddard officials say the Air Force brought increasing pressure to stop the program because the NASA charter requires it to be unclassified. The systems approach of the NASA and USAF efforts "is very similar," one NASA official explains and "too much of it is being published" in open scientific literature. The Air Force is scheduled to test its own classified 405B advanced development program for satellite reconnaissance in 1979.

Compounding NASA's problem was that development of earth sensors and small, high-data-rate computers to be carried aboard advanced earth-observation satellites has not kept pace with NASA's development of a CO laser transceiver. NASA could not in the near future make use of the laser's 300-million-bit-per-second data rate.

Military. The Air Force 405B program, led by McDonnell Douglas Astronautics Co. East, is a 1-gigabit-per-second relay system aboard a much bigger satellite that also has room for a larger data processor and a laser of neodymium and yttrium aluminum garnet. The feasibility model of the Nd-YAG laser subsystem, developed by GTE-Sylvania Inc., Mountain View, Calif., operates at 500 million pulses per second. It is mode-locked and achieves its gigabit data rate by frequency doubling, say its developers.

With its high data rate, the Nd-YAG laser in the 405B program will be capable of relaying digitized TV signals in real time between satellites for retransmission to earth. Among other applications, the Air Force is anxious to monitor Soviet intercontinental missile sites with the system, to achieve a superior early warning capability. □

Instrumentation

IR sensor protects transfer standard

By comparing the heating effect of a signal and a known dc voltage, an ac-dc transfer standard measures true-rms voltages with a high degree of precision. But the circuitry that protects the device's thermoelement not only introduces errors, preventing correlation of the standard with National Bureau of Standards voltage cells, it also has to be switched in and out of the system for every measurement, preventing use of the

devices in automated systems.

Ballantine Laboratories' new version of its model 1600A transfer standard gets around both problems with a simple, inexpensive circuit that uses an infrared-sensitive photocell like those found in fire-detection systems. The photocell monitors the color temperature of the thermoelement at a distance, without being physically linked to it.

The 1600A operates on the same principles as a conventional transfer standard. It uses a thermoelement to produce a dc voltage that is proportional to the heating value of the signal under test. A second dc voltage then replaces the signal at the thermocouple's input, and when its heating value matches the first, it is measured to determine the root-mean-square value of the test signal. The $50 to $100 thermoelement can withstand very little abuse before burning out or, at best, changing characteristics.

One run-through. Unlike its predecessors, though, the new 1600A needs only one run-through for each measurement. The earlier 1600A and other transfer standards always needed two run-throughs—one with protective circuitry turned on, and a second with it turned off after the user was confident that the input voltage was within limits. This made ac transfer measurements slow and expensive, says Raymond Gerr, chief engineer at Ballantine in Boonton, N.J.

Worse still, even when switched off, the wired-in protective circuitry often loaded down the input signal, introducing errors. In addition, earlier protective circuitry limited the range of input duty cycles and crest factors (ratio of peak to effective values) the transfer standard could handle.

In the new circuit, the silicon photocell feeds a two-stage, high-speed amplifier built around a type 747 dual-operational-amplifier integrated circuit. A three-transistor current amplifier then turns on a silicon controlled rectifier switch that in turn shuts off a transistor, removing the ground line from relays at the input to the standard. □

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The Teradyne N123 backplane test system makes quality testing affordable to manufacturers of smaller backplanes. Let us point out a few of its many advantages.

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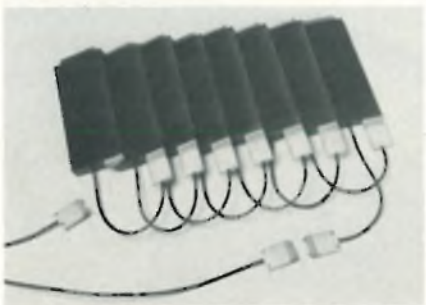
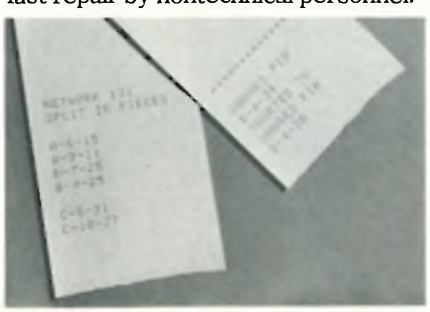


Point 2.
YOUR OWN TERMINOLOGY.

The N123 delivers error messages in your own product language. Lost time and the chance of mistakes in translation are completely avoided.

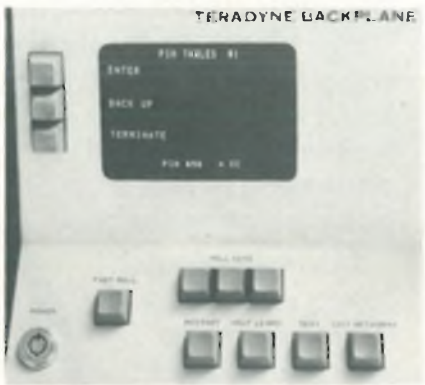
Point 3.
PRECISE DIAGNOSTICS.

Until now you might have been receiving error messages that made it seem as if you had as many faults as there were points in the network. The N123 gives you one unambiguous error message per fault, permitting fast repair by nontechnical personnel.



Point 4.
SIMPLE OPERATION.

The N123's dedicated front panel enables nontechnical personnel to learn its use in minutes. By answering a series of questions, the operator sets up the pin-naming scheme. Then the system automatically programs itself from any verified backplane.



Point 5.
EXPANDABILITY.

When you change the size or configuration of the backplanes you're testing, there's no need to invest in a completely new fixturing system. Just add or remove the necessary fixture cards.

Point 6.
RELIABILITY.

The N123 comes with Teradyne's own 10-year warranty on all circuit modules. And is built for hard use on the factory floor. What's more, all Teradyne systems are backed by a world-wide network of field service and parts stocking centers, as well as a 24-hour telephone troubleshooting service.

Point 7.
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Fast point-to-every-other-point testing, efficient fixturing, and accurate diagnostics are going to give you consistently high throughput and improved yield. Count on it.

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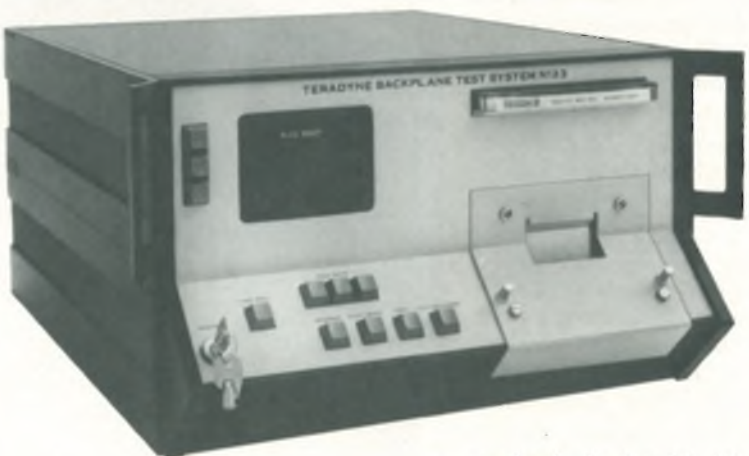

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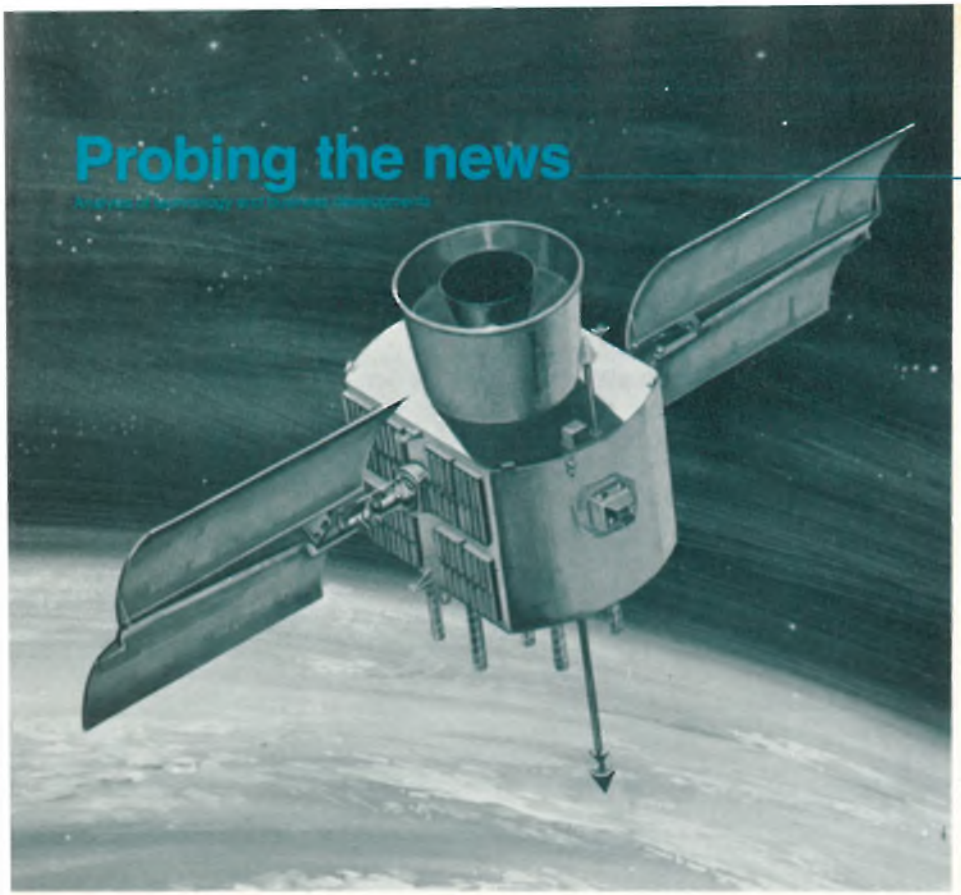

Navstar gains as sole air-navigation system

With target date of 1984, 24-satellite tri-service program could conserve spectrum space if adopted for civil aviation

by Ray Connolly, Washington bureau manager, and
Larry Waller, Los Angeles bureau manager

The idea is growing in Washington that the Pentagon's Navstar/Global Positioning System is likely to be used by the world's civil-aviation community, as well as the three U.S. military services. That prospect is producing mixed feelings as Navstar's Air Force managers proceed deliberately toward their 1984 operational target date.

Navstar is to provide worldwide real-time three-dimensional positioning information, accurate to within 10 meters, to aid aircraft, ships, ground vehicles, and troops equipped with the appropriate receivers. In full operation, 24 satellites will orbit in three 10,000-mile-high subsynchronous planes and there will be eight satellites per ring. Yet, despite that ambitious performance objective, Navstar largely will use technology thoroughly proven in previous satellite and space programs.

The likelihood of expanding Navstar's uses to include commercial airlines and general aviation delights most avionics manufacturers and military leaders. Companies can foresee an equipment market much broader than the $200 million already envisioned for Navstar military hardware—a market extending into the 1990s and beyond. Military users are hoping for development of a civilian-hardware market that would bring their equipment costs down and widen their choice of competitive suppliers. Specialists in Federal communications policy in such places as the Pentagon, the Federal Communications Commission, and the White House Office of Telecommunications Policy can visualize a third advantage: the development of the first space-based radio-navigation system that would at last conserve spectrum space because the single system would have multiple uses.

Those who are troubled by the possible expansion of Navstar's uses are airlines and general-aviation users who complain that it would require the purchase of altogether new on-board avionics for their aircraft, as well as companies with investments in developing ground-based navigation systems like Omega and Loran-C that Navstar would replace. And the Air Force itself, whose Space and Missile Systems Organization is the Navstar system integrator, fears a speedup would hurt the program. However, Navstar advocates believe that opposition could be blunted by setting a long-term transition period of five or more years for phasing out ground-based navigation aids.

Cost-effectiveness. Says Maj. Harold Shoemaker, Navstar system-engineering chief, "there is a great deal of uncertainty associated with the cost-effectiveness of large numbers of navigation and positioning systems presently in use and projected." Assuming the retention of such existing systems as Tactical Loran, Omega, Transit, and Tacan, as well as the deployment of planned systems, one Pentagon study forecasts that the 15-year direct costs of all these for a user population of 18,000 would run to $12.5 billion.

For Navstar, there are three phases: concept validation, system test and limited capability, and full operation. Phase I's space segment will consist of six autonomous satellites. First will be a Navigation Technology Satellite (NTS-2) developed by the Naval Research Laboratory for launch next year. The other five will be navigational de-

velopments satellites (NSD-1 to 5), Navstar's prototypes, to be built by Rockwell's Space division. Launches are scheduled to begin in 1977.

This six-satellite constellation, the Air Force says, will keep four in view for as long as four hours a day for testing over the continental U.S. NTS-2 will differ principally from the NDS series in that its navigational signal will be stronger to permit experiments to space-qualify advanced frequency standards using the L band. The NDS will also carry equipment for missile-tracking to help improve the accuracy of the Navy's Trident missiles. Each of the prototype space vehicles will weigh about 1,400 pounds and extend 17 feet with solar arrays.

Each of the final 24 satellite models is expected to weigh about 800 pounds, have 350 to 400 watts of end-of-life power, and a useful operational life of five years. Two different L-band signals of pseudo-random noise will be transmitted. The higher of the two frequencies will be a composite signal containing navigation data. The second frequency will permit automatic determination by the user's receiver of electromagnetic disturbances, such as ionospheric group delay.

On the ground during Phase I, Navstar will have a master control station, four widely separated monitor stations, and an up-load station. The monitors, all on U.S. territory, will passively track the satellites within line of sight, gathering ranging data from the navigation signal. This data will then be transmitted to master control for processing to correct orbits and signal transmissions.

Adding satellites. During Phase II, Navstar's space segment will be increased to nine to 11 satellites in the 1980s. In this phase, it will provide periodic three-dimensional and continuous two-dimensional capability. In the third and final production phase, Navstar will build its two-dimensional and three-dimensional capability, integrate all user ground equipment, and launch operational satellite models to meet the 24-satellite system's full potential.

Of particular interest to the communications industry is the direction and pace of developing design criteria for receiver equipment. Through its Navstar project office and associated industry contractors, Samso is already well into the work of defining these six equipment classes (see table).

In consolidating the six classes of user hardware, Samso already is facing up to cost pressures. This is possible, contends Shoemaker, "because there are two generic types of receivers—continuous and sequential tracking—and one low-cost class. The continuous-tracking receiver has a minimum of four channels, each dedicated to processing signals from a specific satellite, and the sequential receiver, which has one or more channels, sequences through the satellite-generated signals." Shoemaker and Lt. Col. Donald Henderson, Samso's deputy project manager, agree that the biggest potential market lies with Class C, or low-cost units, with their emphasis on high reliability and maintainability by use of common modular components.

Since Samso is acting as its own systems integrator, there is no prime contractor. Rather, the Air Force agency chose by competitive bidding major contractors for each separate element. Rockwell International Corp.'s Space division, Seal Beach, Calif., is responsible for satellite hardware, and General Dynamics' Electronics division, San Diego, has the charter for both user and ground-control segments. GD/Electronics, which will design and build the ground-control system, has also awarded a subcontractor role for developing three key pieces of user equipment to Magnavox Corp.'s Advanced Products division in Torrance, Calif. Samso has also picked the Air Force's Avionics Laboratory to design the best anti-jam receiver possible. Henderson plans soon to seek industry bids for this critical receiver.

Top of the line is a Hi-dynamic airborne four-channel receiver that Henderson says could serve both the A and B classes. Texas Instruments' equipment group in Dallas has a $2.9 million award from Samso to develop an alternate Hi-dynamic receiver [*Electronics*, July 10, p. 49]. The Magnavox division will also develop a Low-dynamic single-channel receiver for the C class, which Henderson calls the biggest single-user equipment application. The receiver would replace the present Tacan unit—Samso's goal is to design it to match exactly the standard Tacan's size, power, and wiring requirements. The final piece of equipment is the manpack receiver, whose optimum objective is weight of 8 pounds and size of 3 by 4 by 10 inches. An initial Magnavox study indicates that a 25-lb weight is more likely at first. TI also has a $3.2 million contract as alternate source for the manpack receiver. □

NAVSTAR GROUND EQUIPMENT

	USER CLASS	NUMBER OF USERS (EST.)	COST PER SET (IN THOUSANDS)
A	STRATEGIC	7,080	$29.5 – 28
B	TACTICAL (HI DYNAMIC)	9,796	25.6 – 17.6
C	LOW COST	9,200	26.3 – 15.2
D	SURFACE (MOBILE)	2,975	22.1 – 16.3
E	SURFACE (TROOPS)	5,860	18.2 – 16.3
F	SUBMARINES	200	25.6 – 16.3

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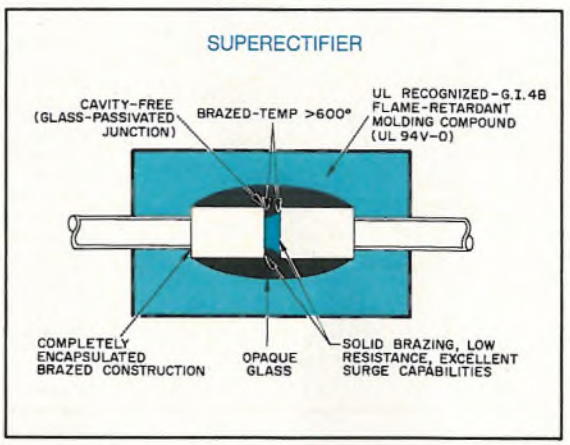

In summary, SUPERECTIFIER is the world's only rectifier with totally brazed construction, with a patented glass passivated junction, and with flame-retardant molding encapsulation.

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GENERAL INSTRUMENT CORPORATION
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Solid state

Low-power Schottky making move

Sales of standard TTL will continue to grow, but will level off as systems designed for future call for other logic families

by Bernard Cole, San Francisco bureau manager

The market for standard transistor-transistor logic has peaked. The period of big growth is over. But that's not news. The question is: How bad is the outlook for standard TTL over the next few years, and what will replace it? The answers are important, for TTL has been the keystone of the total IC market. In 1974 alone, with IC sales reaching $1.3 billion, TTL accounted for just under a third, or $377 million. No other technology came close.

The industry consensus is that while standard TTL may not bounce back after the current recession as dramatically as it did after the 1970-71 slump, it will remain a big factor in the marketplace until at least 1980, growing by about 10% a year. But most of this market will be based on systems designed two to five years ago.

In terms of designs that will be implemented in hardware two to five years in the future, standard TTL looks dormant. In some areas, particularly industrial, where low power is important, complementary-MOS equivalents are being considered. In other areas, especially computer mainframe, where speed is the prime consideration, emitter-coupled logic and custom LSI designs will predominate.

But the consensus is that the technology that will displace standard TTL in the majority of designs—first in smaller and later in LSI versions—is low-power Schottky TTL.

Nearly all components on a low-power Schottky TTL chip are smaller and have lower capacitance, resulting in a faster device. Because the components are smaller, the general chip size is smaller, particularly for MSI and LSI devices. The smaller chip size offsets need for more processing, and ultimately the selling price can be less than for standard TTL devices. In addition, the lower power dissipation means less heat generation, avoiding one of the major problems associated with TTL.

Glowing future. The obvious advantages of low-power Schottky TTL have led Thomas Longo, vice president and general manager of Fairchild Semiconductor's IC group, to predict that it will "dominate in designs over the rest of the decade for those people who are going to use TTL," and will be "the lowest cost family by the end of the decade." Robert Lanford, logic division marketing manager at Signetics Corp. in Sunnyvale, Calif., is even more optimistic. "Right now," he observes, "the devices are, on the average, about 10% to 15% more expensive than standard. By mid-1975 I think we can expect a crossover in pricing for MSI functions and 1977 for SSI."

Stephen Fry, bipolar logic product manager at Raytheon Semiconductor, reflects the views of many of his fellow managers in his estimate of the near-term market. "Depending on economic conditions," he says, "sales in 1976 for low-power Schottky TTL in SSI and MSI will be about $30 million if it's a flat market, and as much as $90 million if there is a sharp upturn. For planning purposes we are preparing for a $60 million market." David Laws, bipolar logic product manager at Advanced Micro Devices, estimates that by 1978 the market will grow to about $180 million annually. "This was the design year for low-power Schottky," says Charles M. Clough, vice president for semiconductor marketing at Texas Instruments Inc., Dallas. "Next year will be a high-volume production year."

Even as reluctant a convert as Charles Nathan, commercial TTL/DTL marketing manager at National Semiconductor Corp., who es-

timates at least "five to ten years of life left in standard TTL," believes there will be a crossover in TTL by 1980 or '81, with low-power Schottky dominating by then.

New designs. Backing up their projections with action, most of these companies are redesigning TTL circuits exclusively in low-power Schottky. TI has the largest family of such SSI and MSI devices. Also included are Fairchild, Signetics, AMD, Raytheon, and National.

Product performance of low-power Schottky falls into three categories among manufacturers: one, the original TI and Signetics devices that operate in the 10-nanosecond range; two, the new TI, National, and Signetics lines capable of speeds of 8 ns; and three, the Fairchild, Raytheon, and AMD families with speeds of 5 ns.

In terms of market, says AMD's Laws, most peripheral controller and memory designs are going with the trend. "In addition, almost every p- and n-channel MOS processor seems to be surrounded by it," he says. Adding to the list, Clough of TI points to industrial controllers and military avionics as hot new markets for SSI and MSI parts.

LSI potential. "A more important result of the smaller chip sizes and reduced power dissipation obtained with low-power Schottky," says Laws, "is that high-performance LSI TTL products become commercially practical for the first time." And even before users are into the marketplace with their improved SSI and MSI low-power Schottky versions, they are being urged to switch to LSI in their next design rounds. National Semiconductor is beginning to shift, working first on low-power Schottky MSI versions in its IMP series of microprocessors, to be followed by LSI versions.

"I think it would be safe to say that the product lifetimes of low-power Schottky versions of SSI and MSI families such as the 54/74 series will be the shortest on record," says Laws, predicting a crossover in price and share of market between low-power Schottky MSI and LSI by the mid-1980s. □

Communicators. The talk at Telecom 75 in Geneva was of stored-program-control exchanges.

Automated exchanges find markets

by Arthur Erikson, Managing Editor, International

Telephone-exchange equipment now ranks as the major single hardware investment in telephone systems throughout the world. Spending for plant this year is pegged at some $25 billion, with $10 billion of that for switching, estimates Robert Chapuis, a consultant to the International Telecommunication Union's Coordinating Committee for Telephone and Telegraph.

This heavy spending is coming at a time when computer-controlled exchanges have at long last become commercial contenders outside the U. S. and Japan. That portends a lot of foment in telecommunications markets in the rest of the world during the next few years as suppliers try to use the wedge of new technology to pry market shares from entrenched competitors. Little wonder, then, that as the public gawked at the video phones and the satellite models at ITU's Telecom 75 hardware festival that ended Oct. 8 in Geneva, switching-gear makers were pitching their stored-program-control (SPC) exchanges.

The SPC-producers, whose hardware consists largely of reed-relay or miniaturized crossbar-switching matrixes paired with special control computers, have a lot of arguments going for them. At prices ranging from roughly $300 to $450 per line, the SPC systems cost somewhat more, line for line, than conventional crossbar systems. However, the premium price for SPC hardware is amortized quickly. There's a saving of more than 50% in floor space, important for urban exchanges. Even more important, the savings in maintenance costs are enormous—SPC proponents claim only 10% the failure rate of crossbar systems.

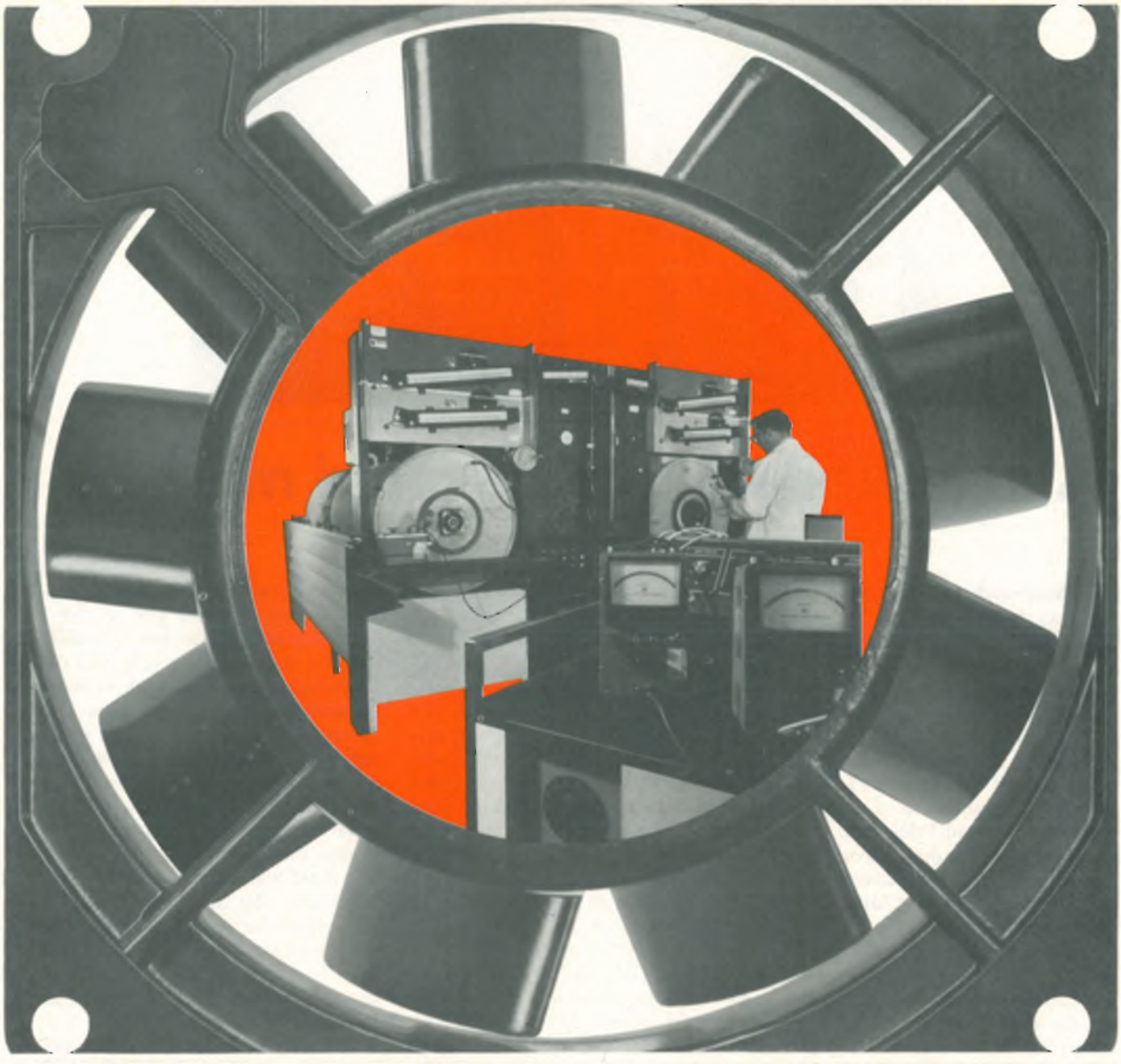
Evolution. To be sure, conventional crossbar switching will dominate the market for years to come. Björn Lundvall, president of Sweden's L M Ericsson, predicts that the late 1980s will be the earliest that the number of computer-controlled lines installed in a year will equal the number of electromechanical lines in systems outside the U. S. and Japan. By then, the annual total of lines for these systems will be about 25 million, Ericsson projects.

Lundvall hazarded these figures at a telecommunications-economics forum held by the London Financial Times and the ITU as a curtain raiser for the Telecom 75 exhibition. However, not everyone is convinced that SPC will take that long.

Everyone, though, can already appreciate that SPC is big business. General Telephone & Electronics alone has a $500 million contract to more than double the telephone network in Iran during the next three years, and GTE's No. 1 EAX systems figure heavily in that scheme. GTE, in fact, maintains that it's the leader among SPC suppliers, except for the Bell System in the U. S., which hasn't yet pushed hardware outside of North America. GTE's score so far: some 600,000 lines installed, a million on order.

Meanwhile, Northern Electric Co. Ltd. expects orders for its SP-1 switching systems to top a million lines by the end of the year, and the Canadian company hopes to write an additional 1.5 million lines into its order books next year. The International Telephone & Telegraph group has logged some 400,000 lines of Metaconta installations and has orders for another 1.4 million lines. Philips has also passed the million-line mark with contracts for its PRX hardware. The Swedish firm Ericsson's total for installed or ordered AKE toll exchanges will top 300,000 lines by year-end, the equivalent of more than 1.5 million subscriber lines.

The list will grow, too, as the SPC "world market"—excluding the U.S. and Japan, which are essentially preserves for national suppliers—zooms during the next few years, presumably passing the $1 billion-a-year mark around 1980. France's Thomson-CSF, for example, has teamed with Northern Electric to move fast into SPC. And Compagnie Générale d'Electricité, whose telecommunications subsidiary, CIT-Alcatel, is the French leader in fully electronic time-division exchanges, has paired with Nippon Electric Co. to jump into space-division SPC hardware. As one might expect, ITT's communications companies in France—LMT and CGCT—are dangling lines before the French government too, as is Ericsson's French subsidiary. □



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18513

Washington newsletter

Navy group sees reliability gain in ICs possible

Knowing precisely at which point an active semiconductor component or circuit has failed has long frustrated engineers trying to improve reliability. Now three Naval Research Laboratory (NRL) scientists believe they may have an answer with a technique employing a high-resolution electron microscope, an Auger detector and associated electronics, and a computer. The researchers—Aristotelis Christou, Wesley Weisenberger, and Howard Day—say they developed the technique for microwave transistor failure analysis, but that it can be applied as well to integrated circuits, including LSI.

The NRL technique would require an initial capital investment of about $100,000, Christou says. **It makes possible the scanning of target areas as small as 0.25 micron in diameter to identify a component's elemental constituents no more than a few atomic layers think.** The researchers say the new technique eliminates errors in failure analysis that have misled industry component designers.

FAA gives nod to ground-based collision warning

Bad news is emanating from the Federal Aviation Administration for RCA Corp., Honeywell Inc., and McDonnell Douglas Corp., who have long been at work on airborne collision avoidance (CAS) systems for aircraft. In keeping with a request by Congress for guidance, the FAA will recommend implementation of a ground-based CAS system, one designed and developed by consultant George Litchford and which will be built by Megadata Computer and Communications Corp., Bohemia, N.Y. Accordingly, **the Department of Transportation, through its Transportation Systems Center in Cambridge, Mass., will award a $500,000 contract to the Litchford/Megadata group to build two prototypes.**

A senior FAA official says the Litchford system "will make maximum use of existing transponders" and will add a large ground-based computer to sort out interrogations and predict possible collisions based on the timings of transponder responses. Delivery of the first prototype is tentatively scheduled for January, with flight tests to begin in next spring.

Communications, EDP upgraded by USAF in reorganization

Designers of Air Force computer and communications systems have a new high-level voice in the AF Office of the Chief of Staff with an internal reorganization just completed. **In the shuffle, the new job of assistant chief of staff for communications and computer resources was created, and Maj. Gen. Robert L. Edge was named to the post.** Reporting to Edge will be the directorate of command control and communications, which he headed when it was part of the office of the deputy chief of staff for programs and resources. Edge also will oversee the directorate of data automation, previously part of the USAF comptroller's office.

CML may file Domsat plan by year's end

Watch for CML Satellite Corp. to file its domestic-satellite-system plan with the Federal Communications Commission before year's end now that a third partner has been found for the $165 million venture. Aetna Life & Casualty plans to join IBM Corp. and Comsat General Corp. as a one-third partner in CML to comply with the FCC's February order

calling for a "balanced CML" in which no partner can own a controlling interest.

Aetna, with its heavy communications requirements for insurance, real estate, and hotel businesses, is expected to become an early user of CML's satellite system, which industry sources believe will use the 11–14 gigahertz spectrum rather than the 4–6 gigahertz of competing systems.

Report is out on TV-radio makers' productivity

Productivity of U.S. radio and television makers declined 9.3% in 1974 compared to the output per employee man-hour a year earlier, according to new data compiled by the Office of Productivity and Technology (OPT) in the Bureau of Labor Statistics. **The recession was cited as the primary reason—a 17.3% drop in unit sales in 1974, or a $500 million decline.** The analysts say industry didn't lay off employees rapidly enough in the face of falling demand, and many industry officials agree. "We try to retain our skilled employes a little longer [than necessary] because particular skills in our industry are hard to get," notes an RCA official. Despite the downturn in orders, the industry hired 2.4% more non-production workers such as salesmen and executives. OPT says home entertainment electronics was the only U.S. industry to increase non-production employee payrolls during a drop in output.

EFT study report may be another two years away

Because of a year-long delay by the White House in nominating its representatives, **the deadline for a full report of the National Commission on Electronic Funds Transfer will likely be extended by Congress for one year, to October 1977.** The White House finally nominated its 14 representatives to the 26-member commission this month, and none of the nominees, including the 12 named by Congress, is considered a specialist in data processing or communications. The commission will be responsible for studying system standards and proposing legislation on changes in existing policies that will govern the burgeoning EFT business [*Electronics*, July 24, p. 79].

Early decision on automated broadcast transmitters seen

A market for automated transmitters for commercial television and radio broadcasters may materialize early next year when the FCC is expected to sanction their use. FCC Chairman Richard Wiley strongly supports the automation move, long promoted by station engineers and the National Association of Broadcasters [*Electronics*, Oct. 3, 1974, p. 88]. **The FCC has received "numerous responses, almost all positive" to its proposed plan, a commission source says.** An NAB official adds, "It's a shoo-in, but we wonder how the FCC will be able to type-certify all those add-on monitors." Chairman Wiley leans toward standardization of monitor parameters to ease FCC certification staff overloads.

McDonnell Douglas gets guidance pact on cruise missiles

McDonnell Douglas Corp., St. Louis, has won the competition to develop the guidance and navigation system that will be used on both the Navy and Air Force cruise missiles. **McDonnell is getting an initial $12.8 million contract, defeating E-Systems Inc. of Garland, Tex.,** in the competition directed by the Naval Air Systems Command [*Electronics*, Oct. 2, p. 39].

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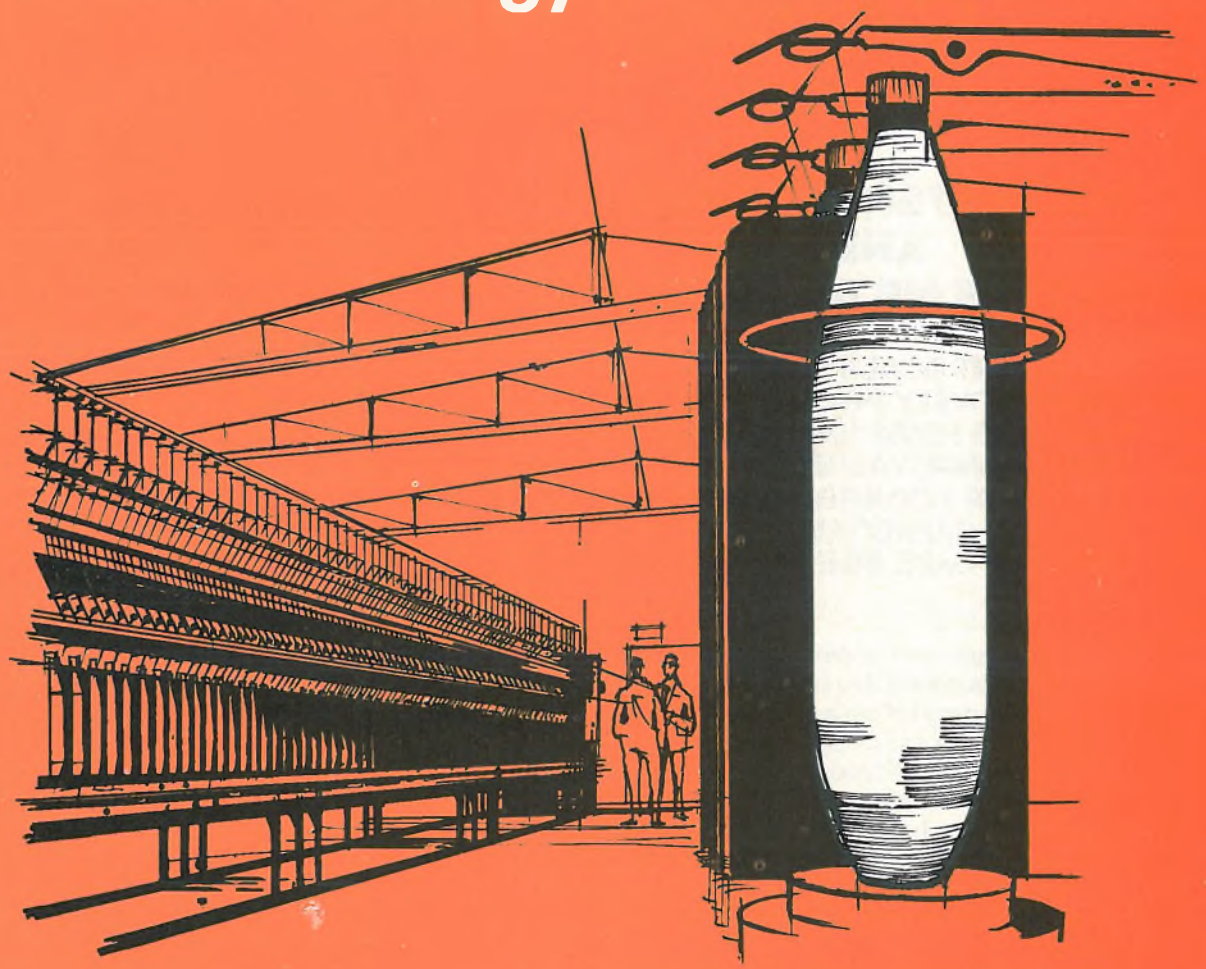


To maintain a constant thread tension in spinning machines it is necessary to convert minute deviations from nominal mechanical values into analogous electrical variables.
Magnetosensors are ideally suited to such tasks. These are devices whose electrical properties are changing with the magnetic field: Magnetoresistors alter their resistance, Hall generators produce a Hall voltage as a function of the control current and magnetic flux. In this way, many supervision and control tasks can be solved more efficiently than with conventional sensing or switching elements and potentiometers.
No contacts, no wear.
This is why magnetoresistors and Hall generators already have a wide variety of applications: In automobiles they control the ignition, in film cameras the sound synchronization. In high-speed computer printers they supervise the print hammers and paper feed, in conveyor systems they assure accurate destination control. They are used in machine tools and construction machines, in locomotives and electric vehicles. Even welding seams on pipelines are checked with their aid.

It's worth knowing the facts about these versatile devices.

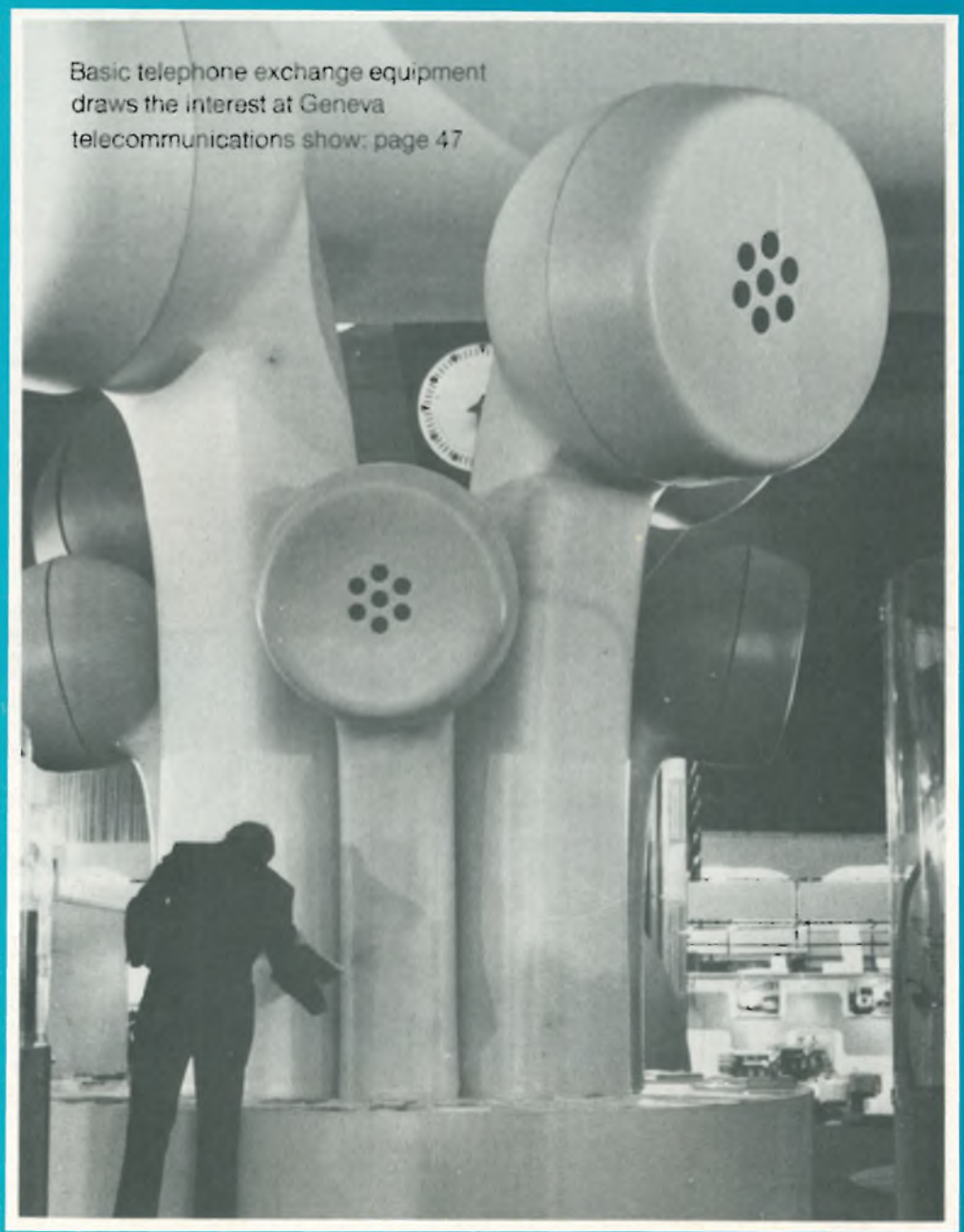
Magnetoresistors and Hall generators from Siemens

B 33/7510/101

Oct. 16, 1975

Electronics International

Self alignment yields improved vertical FETs: page 7E



Basic telephone exchange equipment draws the interest at Geneva telecommunications show: page 47

International newsletter

Siemens wins pact to make TWTs for U. S. military . . .

A focusing system that cuts energy consumption and weight of a traveling-wave tube was the major factor in the award of a TWT development contract by the U. S. Navy and Air Force to West Germany's Siemens AG. The device, intended for aircraft and ship communications via satellites, is being tested by both U. S. armed forces. Its so-called periodic-permanent-magnet focusing system, built around samarium-cobalt magnets, cuts tube weight to only 6 kilograms, compared with the 15 to 20 kgm of TWTs that have solenoid focusing systems. The TWT, fitted with a single-stage collector, has a typical saturation power of 1.5 kilowatts and efficiency of 30%. It attains output power of 1 kW at continuous-wave frequencies of about 38 gigahertz.

. . . and will supply satellite monitor to Bundespost

Monitoring of radio-communications by the West German Bundespost is to be extended to satellite traffic in the spring of 1977. Siemens AG has won a $5 million contract to build the monitoring system, to be served by two unmanned antenna systems. One will have four logarithmic-period antennas to cover from 130 megahertz to 1.3 gigahertz. The other, which will have a cassegrain antenna 12 meters in diameter to cover from 1.3 to 13 GHz, will have an azimuth-tracking speed as high as 16° per second to follow even fast-orbiting satellites.

Coating optical fibers enables communications use

A major advance has been made toward the practical use of optical fibers in communications links, claim researchers at GEC's Hirst Research Centre in the UK. **To prevent the fibers from breaking when they are led around corners, the researchers have developed a process to coat the multimode silica-based fibers with a polyurethane-based resin loaded with black carbon.** Several coats of the resin, each 3 micrometers thick, are applied to the fiber, 120 μm in diameter, as it emerges from the graphite-tube resistance furnace and before it gets to the pulling drum. For optical-fiber telephone links, GEC plans to loosely bind six of the resilient fibers with color-coded covering in a cable supported internally by several steel support wires.

Mullard shrinks gates to increase packing density

A minor addition to the conventional photoetch process produces still denser MOS static shift registers and high-frequency discrete components by shrinking the width of transistor gates and interconnections, say researchers at the UK's Mullard Research Laboratories. **An additional boron-diffusion step is what reduces these widths by a factor of 10 to only 0.3 micrometer, although the separation of the gates remains at the normal 3 μm.**

In the process, lines are defined in the conventional manner with a masking layer on top. Then, boron is diffused into the edge of the polysilicon layer so that the width of the line is determined by the depth of diffusion. **The line width is determined by diffusion from only one edge, rather than both edges, as in other methods.** The fine boron-doped line is left after the masking layer is removed, and the undoped region of polysilicon is selectively etched away.

International newsletter

Nippon to supply STC phone exchange in New England

Japan's Nippon Electric Co. has won a $2 million order for a 10,000-circuit electronic stored-program-control telephone exchange from Southern New England Telephone Co. **Service is to start in March 1977 for the exchange, to be installed in New Canaan, Conn.** NEC has developed its electronic exchanges for export around exchanges it had developed for and under the guidance of the Nippon Telegraph & Telephone Public Corp.

Fast n-channel RAM from Japan needs minimal power

A latecomer to the semiconductor-memory business, Japan's Toko Inc., has leapfrogged other competitors with a high-speed n-channel 4,096-bit random-access memory with minimal power consumption. Production is to begin in December on the KM 8680, which has a typical access time of only 70 nanoseconds, a cycle time of 160 ns, and power drain of only 350 milliwatts. Standby drain is a mere 3 mW.

These high-performance characteristics are achieved by using n-channel silicon-gate single-transistor memory cells with silicon-gate dynamic complementary-MOS peripheral circuits. The C-MOS circuits are laid out in n-well, rather than the more common p-well configuration, and are made by the Locos (local oxidation of silicon) method. The KM 8680, mounted in a 22-pin ceramic package, measures 3.5 by 3.9 millimeters, smaller than most 4-kilobit RAMs. Price of samples, to become available next month, will be less than $20 each. In quantity, the price will be about $13.

Multitone to make bleepers for British paging network

Multitone Electric Co. has won a contract for somewhat less than $2 million to supply 10,000 bleepers to the British Post Office for a London-area radio-paging network. **The London company is thought to have beaten out Motorola, Philips subsidiary Pye, and Redifon, a licensee for Martin-Marietta pagers.** Although Multitone has options to supply 9,000 more units and therefore has the edge in future buys, the Post Office may strike a balance among competing paging systems when it enlarges the network and begins the national system.

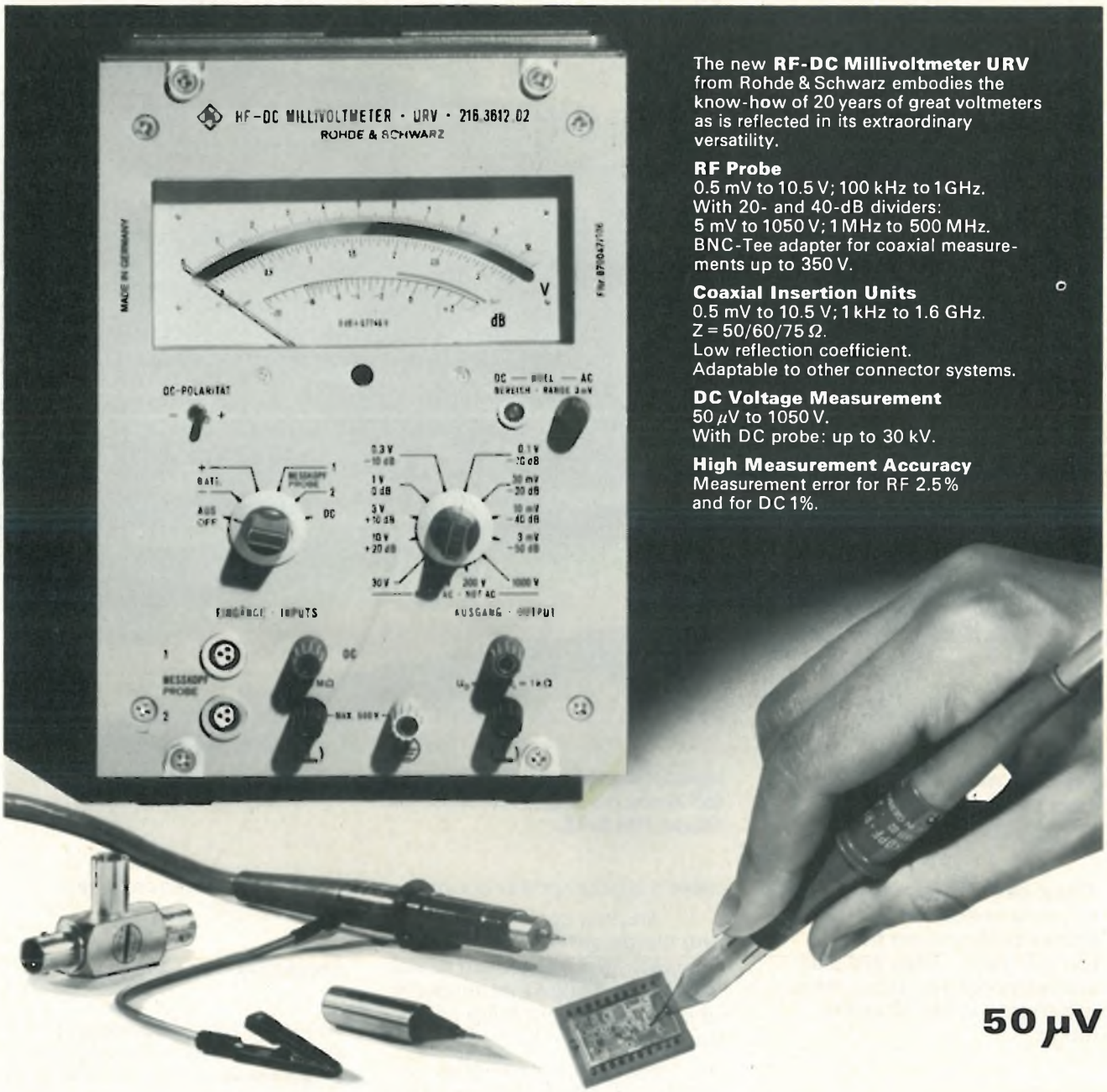
Meanwhile, for the London system, Redifon will supply the transmitters and Motorola the central control station in separate contracts totaling less than $1 million. In the bleeper buy, the Post Office halved its original order.

C-MOS synthesizers to displace crystals in CB transceivers

The crystal shortage plaguing manufacturers of citizens' band transceivers should be relieved next year as Japanese and American set makers rush to market phase-locked-loop synthesizers that contain fewer crystals. **The use of these complementary-MOS LSI synthesizers in the estimated six million to nine million CB transceivers to be produced next year may be limited only by delivery of the devices.** Most Japanese companies will supply single-chip synthesizers, but Motorola plans to begin this year supplying a two-chip system.

Nippon Precision Circuits Ltd., a subsidiary of watchmaker Seiko, is now selling one-chip synthesizer circuits at $5 to $6 in volume, but competition is expected to cut that price in half. Shipments are to begin next month. The customer has a choice of six part types containing a 6.4- or 10.24-megahertz crystal and an 8- or 9-bit programable counter.

High-performing Millivoltmeter DC – 1 GHz



The new **RF-DC Millivoltmeter URV** from Rohde & Schwarz embodies the know-how of 20 years of great voltmeters as is reflected in its extraordinary versatility.

RF Probe
0.5 mV to 10.5 V; 100 kHz to 1 GHz.
With 20- and 40-dB dividers:
5 mV to 1050 V; 1 MHz to 500 MHz.
BNC-Tee adapter for coaxial measurements up to 350 V.

Coaxial Insertion Units
0.5 mV to 10.5 V; 1 kHz to 1.6 GHz.
$Z = 50/60/75\ \Omega$.
Low reflection coefficient.
Adaptable to other connector systems.

DC Voltage Measurement
50 μV to 1050 V.
With DC probe: up to 30 kV.

High Measurement Accuracy
Measurement error for RF 2.5% and for DC 1%.

The very fine tip of the small-sized, easy-to-handle RF probe (right) permits measurements to be made on the printed circuit of a thin-film broadband amplifier for 10 to 1100 MHz for example.
The new URV has two measuring-head inputs for convenient four-terminal measurements, a floating RF-leakage-proof DC input and a calibrated DC output for connection of a recorder or DVM.
Last but not least: completely off earth and independent of AC supply (battery operation: 5000 hrs from 6 single cells).
The URV is a general-purpose instrument for use in laboratories, test departments and service workshops. In addition to DC measurements, it permits measuring RF voltages in broadband amplifiers, across oscillator circuits, narrowband amplifiers and filters, at IF outputs and transmitter power stages as well as on other coaxial line systems.

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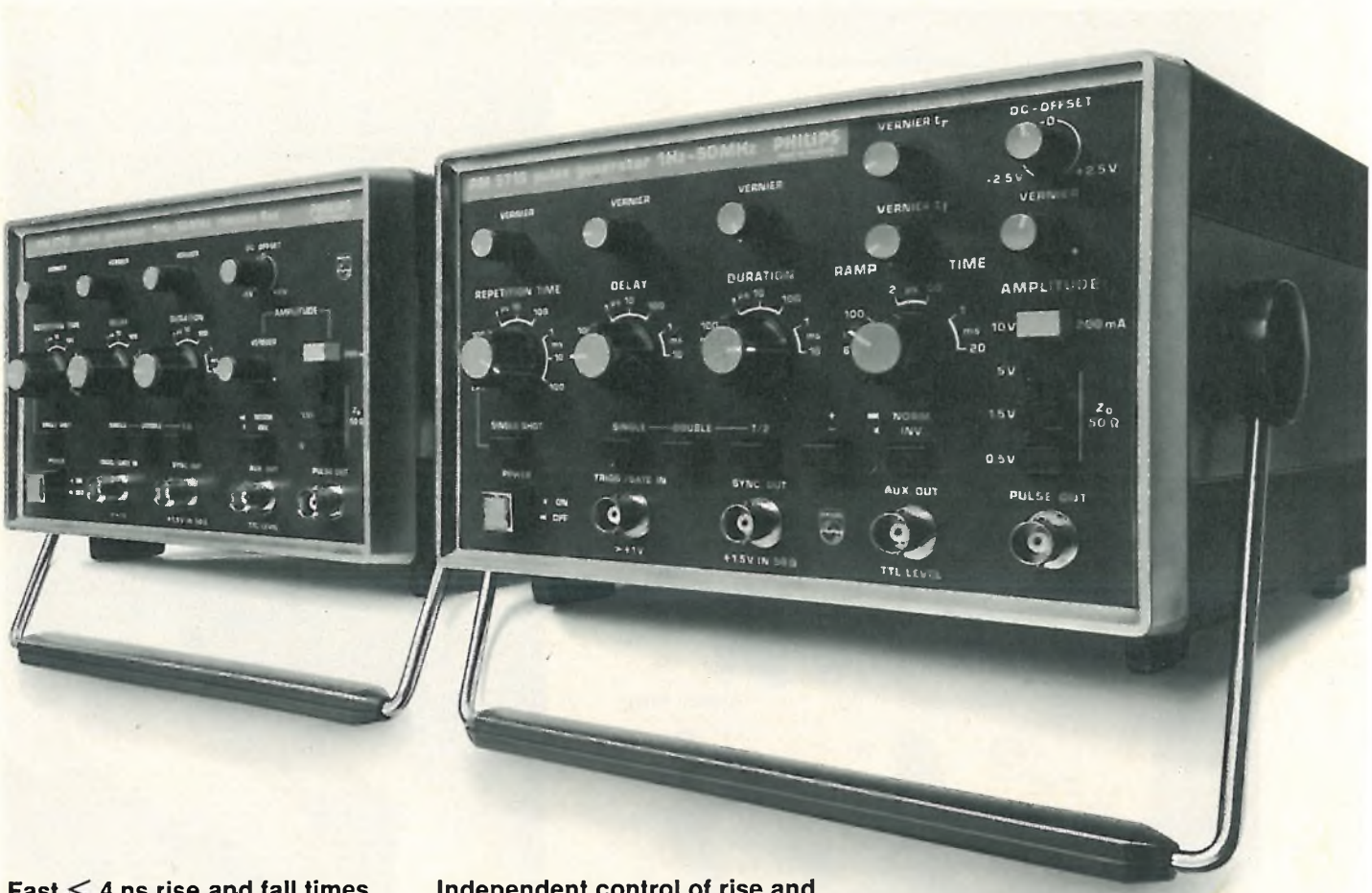


Fast ⩽ 4 ns rise and fall times from 1 Hz to 50 MHz. Model PM 5712.

Independent control of rise and fall times from ⩽ 6 ns to 500 ms. Model PM 5715.

These generators meet virtually all pulse needs up to 50 MHz. Moreover they meet them economically. They are also complemented by three more generators in the 100 MHz range.

Economy

Economy is achieved by cutting costs, not performance. For example the PM 5704 has a built-in, crowbar-protected + 5 V TTL power supply. So for TTL breadboarding you rarely need a special power source.

Another saving that this and the model PM 5705 share comes from the engraved scales. This feature allows parameters to be reset without tying up an oscilloscope.

Instead of the built-in power supply, the '05 has a high 15 V output which is very unusual in this price class. The generator is therefore ideal for MOS and HNIL circuitry, as well as TTL.

The PM 5704 and '05 can thus be used for a very wide range of applications - very economically.

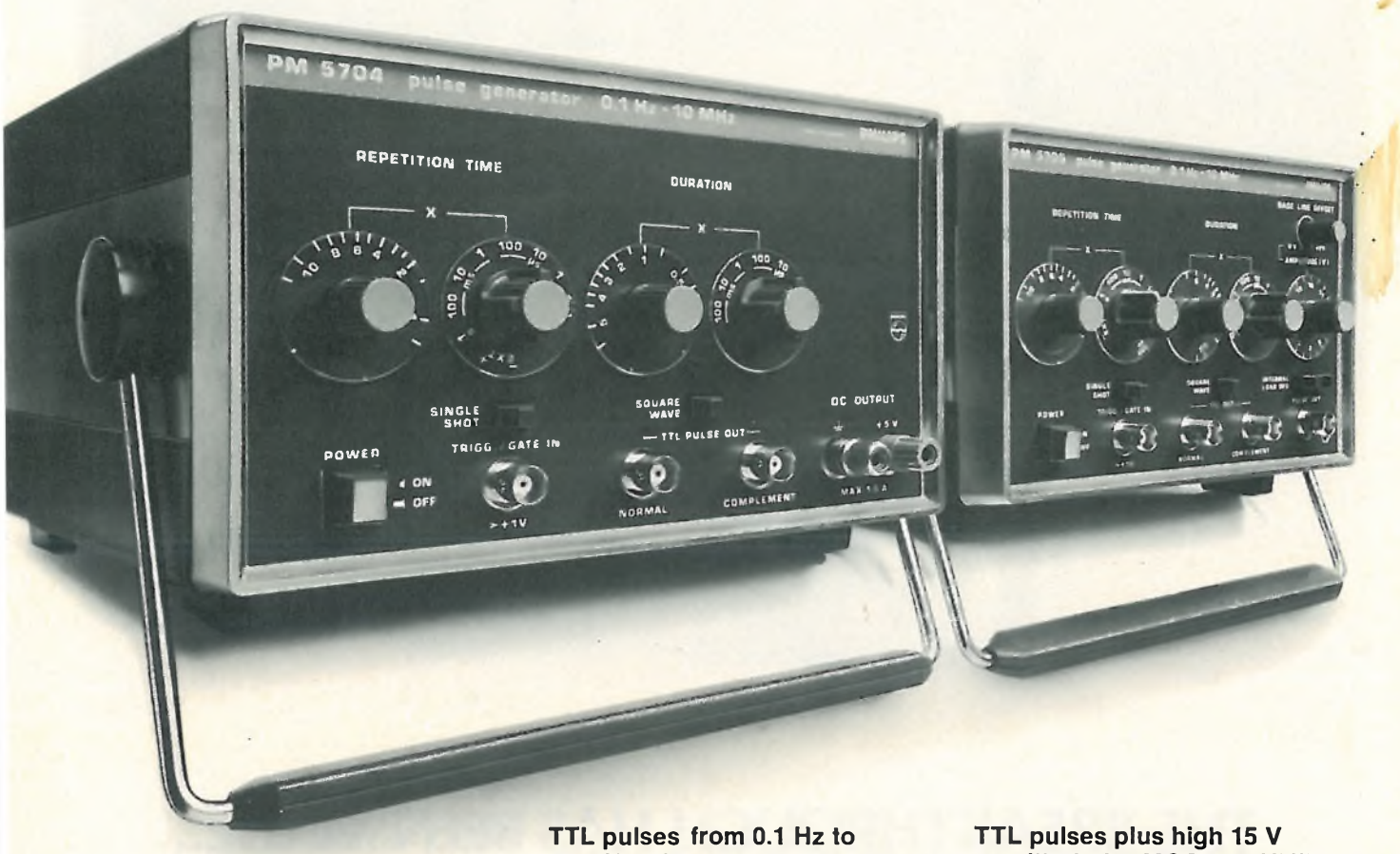
Versatility

At higher frequency ranges Philips again provide a choice of pulse parameters. The PM 5712 features a fast, fixed rise and fall time of ⩽ 4 ns making the instrument ideal for advanced high-speed digital circuitry.

When reponses to both fast and slow transition times are needed the PM 5715 fits the bill by providing independent

PHILIPS

versatile pulses



TTL pulses from 0.1 Hz to 10 MHz plus built-in TTL voltage supply. Model PM 5704.

TTL pulses plus high 15 V amplitude for MOS and HNIL applications. Model PM 5705.

fine control of rise and fall times from $\leqslant$ 6 ns to 500 ms.

Common features of both these generators include the 10 ns to 100 ms pulse delay/duration, and the facilities for external triggering, synchronised gating, single shot operation, pulse shaping, double pulse and square wave operation and a synchronising output.

Rest of the range

For more advanced applications the range includes three 100 MHz models.

The PM 5771 gives very fast, variable transition times from 2.4 ns to 100 μs and has sufficient output for lower speed DTL circuitry.

An even faster fixed rise/ fall time of 1 ns is provided by the PM 5775. This generator is therefore ideal for testing advanced logic circuitry such as ECL.

When bipolar pulses are needed the PM 5576 is employed, which has an identical specification to the '75 with the exception of the second output, which can be independently adjusted with respect to DC offset, amplitude, polarity and normal/inverted position. The '76 is thus ideal for pulse code modulation applications.

For more information on Philips pulse generators contact your local Philips organisation or write to :

Philips Industries
P.O. Box 42099 S-126.12
Stockholm - Sweden.

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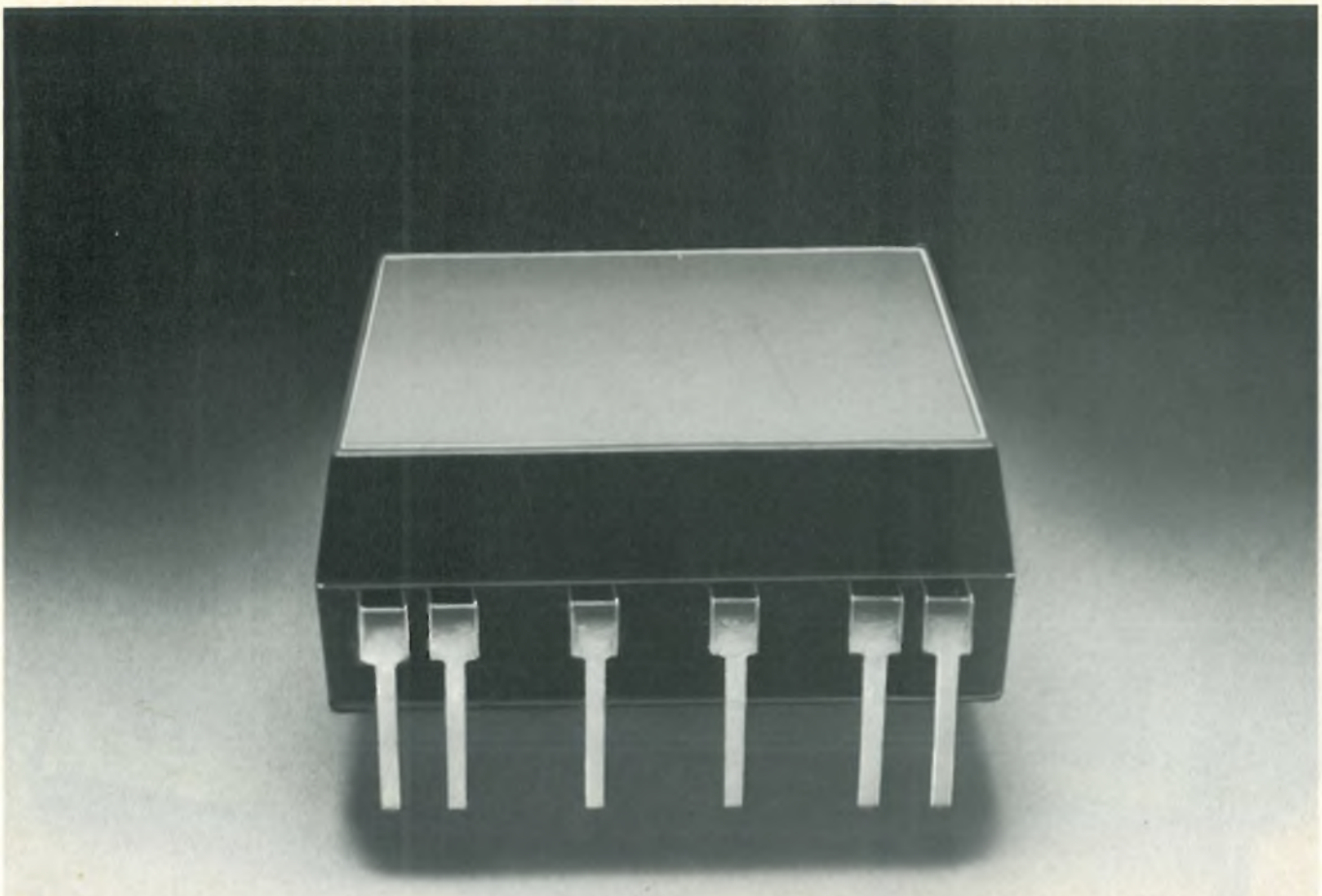

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Reliable The heart of both the MHMG and HGJ series is a Clare manufactured hermetically sealed glass capsule. Contact switching is mercury-to-mercury. So there is no contact wear, no contact bounce, constant ON and OFF impedances - every operation. The mercury-film contact surfaces are constantly renewed, thus assuring reliable and consistent operation. Clare mercury-wetted relays are rated for billions ($> 10^9$) of operations.

Flexibility The HGJ2MT version is specifically designed for low-level analog multiplexing and data logging applications in high common mode environments. The MHMG series are compact packages with up to 5 separate contacts.

Please use the magazine reader reply card to request a copy of the Clare Catalog 800 and the Technical Application Reference brochure on mercury-wetted relays.

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Self-alignment process yields improved vertical FETs

Planar structure used at Toshiba has resulted in two audio devices and 900-MHz uhf unit

Vertical field-effect transistors have been used mainly in deluxe stereo amplifiers where their transfer characteristics, which are similar to triode vacuum tubes, make for lower distortion and higher speaker damping, compared with bipolar devices. They have found few other jobs, however, for several reasons. For one, source-to-drain series resistance tends to be high, making for low efficiency. What's more, input capacitance is high, making them unattractive in high-frequency applications. Then, too, their cost is high.

However, a planar vertical FET structure developed at the Research and Development center of Tokyo Shibaura Electric Co. promises to greatly both expand the range of applications and ease the fabrication of the devices. The structure exhibits greatly reduced source-to-drain series resistance and input capacitance. And, it can be easily fabricated with bipolar transistor production techniques, which should bring prices down.

Trio. The company has disclosed details of three types of prototype devices. One is suitable for audio-output, one for audio-driver, and one for 900-megahertz uhf-amplifier applications. The devices are made by the same general fabrication process, which achieves a high level of precision—maximizing the source-to-gate junction breakdown voltage—without the need for accurate mask alignment.

A 5,520-channel power FET is fabricated on a 4-millimeter-square chip. It has an output impedance in the range between 3 and 15 ohms, and an amplification factor of approximately 5. Two of these devices in a push-pull class-B amplifier can deliver an undistorted output of 50 watts to an 8-ohm load. A prototype driver transistor is fabricated on a 1.3-mm-square chip. It has a voltage amplification factor of about 10 and good input-output linearity.

Fabrication starts with a p-type epitaxial layer grown on the p^+ substrate. Then the surface of the wafer is oxidized and both the gate diffusion window and the source contact holes are made in the silicon dioxide layer. This is followed by deposition of an Si_3N_4 film. A masked plasma etching technique is used to remove the silicon nitride film in the area of the gate diffusion window only. After diffusion and oxidation, the silicon nitride on the source contact holes is etched off.

Windows. The precision of this self-alignment method is dependent only on the precision of a single mask, and not on mask-alignment operations. Removal of silicon nitride on the gate diffusion windows need not be a precise process. It need only be good enough to completely remove the film over the diffusion windows while leaving film near and over source contact windows undisturbed. This process guarantees that breakdown voltage will be maximized by locating source contacts midway between gate regions. If location is not midway, the shorter distance determines breakdown punch-through voltage.

In the next step, the device surface is completely covered with a polycrystalline film heavily doped with boron. The film, in effect, forms a continuation of the source region and makes ohmic contact with it while eliminating contact between the high-field region of the source and the aluminum wiring. A masked plasma etch, used to remove excess polysilicon film, is followed by a standard aluminum metalization and etch to form ohmic contacts, wiring, and pads for bonding external leads.

A uhf device with a finer pattern is fabricated on a 0.4-mm-square chip. This device uses an n^+ source for reduced source resistance. In tests at 900 MHz, an output power of 1 W with 3 decibels of gain and an efficiency of 30% was achieved. □

West Germany

Electric-car control system uses magnetic potentiometer

Passengers on Volkswagen's new line of battery-operated pick-up trucks are in for a much smoother ride than is typical of most electric vehicles. The big German automaker is using a novel scheme of

brake and accelerator control on such vehicles, long noted for their often-abrupt starts and stops.

Replacing the conventional potentiometers, which are normally employed at foot pedals for delivering motor control currents, are so-called field-plate potentiometers. These devices, from Siemens AG, contain semiconductor resistors that, thanks to operation in a magnetic field, furnish stepless control currents from 0 to 20 milliamperes over a 30° angular range.

Because the semiconductor resistors are suspended in an air gap, the control device operates without friction, in contrast to wire-wound potentiometers and their pick-off arms. The absence of wear and the practically unlimited life that the new device offers should prove a big advantage, especially in dense city traffic where vehicles have to speed up and slow down more often than under normal conditions. Besides, unlike conventional potentiometers, the device operates steplessly, enhancing both riding comfort and safety.

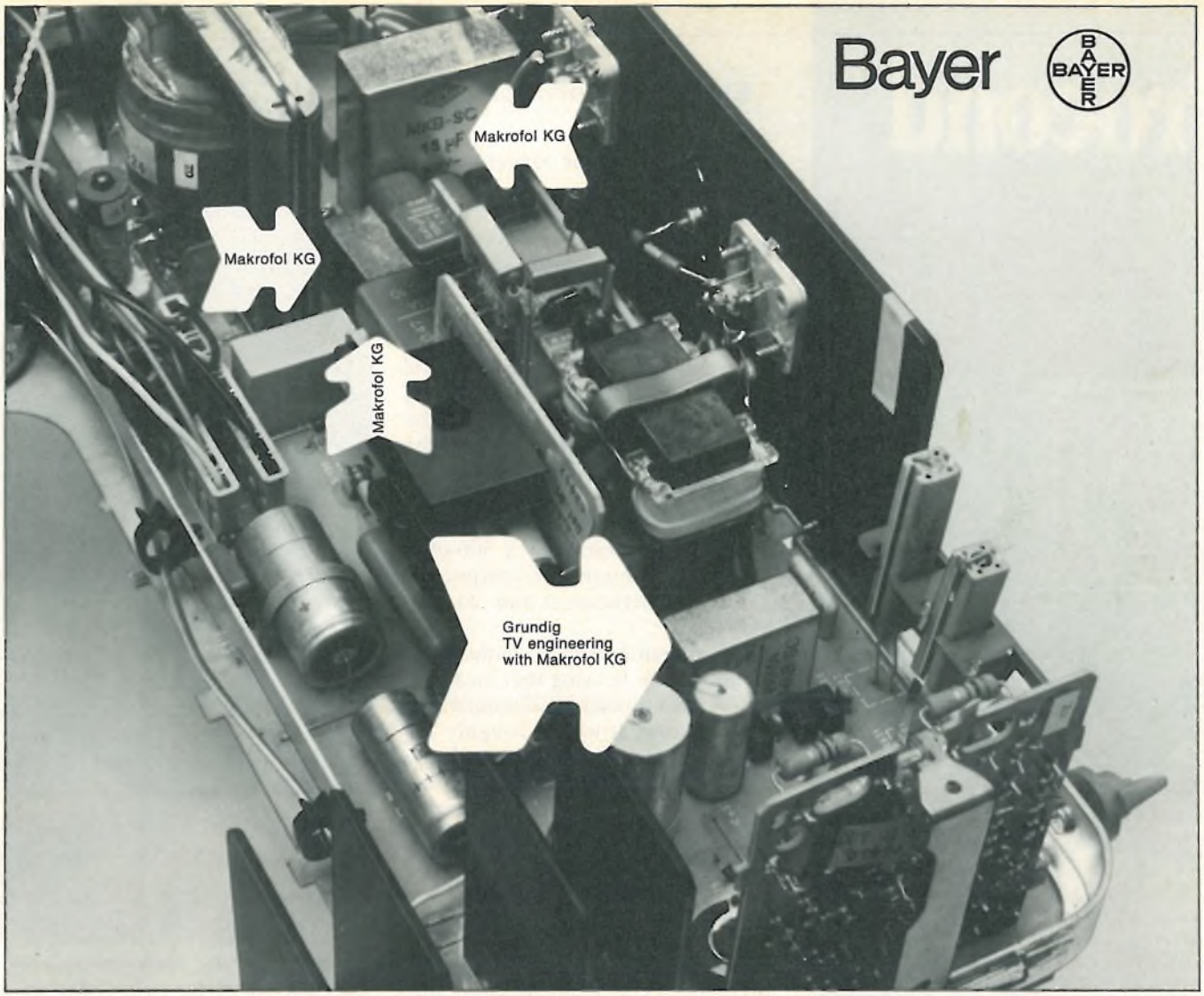
The controls are appearing first on 20 VW electric pickup trucks operated by the German city of Essen for maintenance jobs. They are being run as part of Volkswagen's large-scale program aimed at testing and evaluating future vehicle drive systems.

Old concept revived. The operation of the field plates is based on the magneto-resistive phenomenon where some materials sharply change their resistance in a magnetic field. Although it has been known for more than a century, this phenomenon was little exploited until Siemens researchers seriously began investigating it for practical applications.

Recent advances in semiconductor materials technology, however, have led to new crystal combinations that considerably extend the range of resistance variation and at the same time simplify the manufacture of field plates.

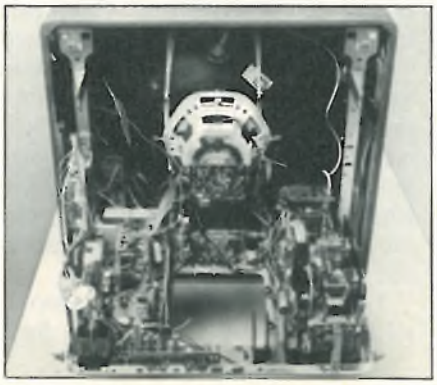
The semiconductor material that Siemens uses for such plates is indium antimonide. Embedded in it are needle-shaped conducting regions consisting of nickel antimonide that are spaced only a few micrometers apart. When no magnetic field is applied, current traverses these regions along the shortest possible path. The plate's resistance is then at its minimum.

Under the influence of a magnetic field, however, the current paths between the conducting regions are deflected. The nickel antimonide needles constitute equipotential lines along which the current path jumps. What results is a zigzag conduction course and an increase in



At the critical points: maximum operational safety through Makrofol KG

The substitution of electron tubes by semiconductors has resulted in an improvement of the operational safety of TV sets by reducing the heat build-up – apart from the fact that the diodes, transistors and thyristors last much longer than tubes. The most significant change, compared with earlier sets, occurred in the line deflection stage.



Grundig employ a 12 µF storage capacitor for the thyristor line deflection stage, which is made of metallized ®Makrofol KG by WIMA-Westermann. The outstanding thermal properties of Makrofol KG, and in particular the low shrinkage in the transverse direction, are the basic requirements to ensure a satisfactory and reliable contact for the capacitor, which in this case has to withstand a power load of up to 18 amp peak-peak. The low tan δ of Makrofol KG ensures a slight intrinsic temperature rise of the capacitor, in spite of the prevailing impulse circuitry.

The following demands present no problem for Makrofol KG:

1. Safe contacting under high power load as is usual with television sets fitted completely with semi-conductors.
2. Low tan δ.
3. Good capacity constancy, even at varying temperatures.

These properties are demanded of capacitors which are used to adapt the pulse shape of the line deflection voltage to the curvature of the tube, also known as the "S correction".

Capacitors made of metallized Makrofol KG by Wilhelm Westermann meet these requirements and have already proved successful in practice.

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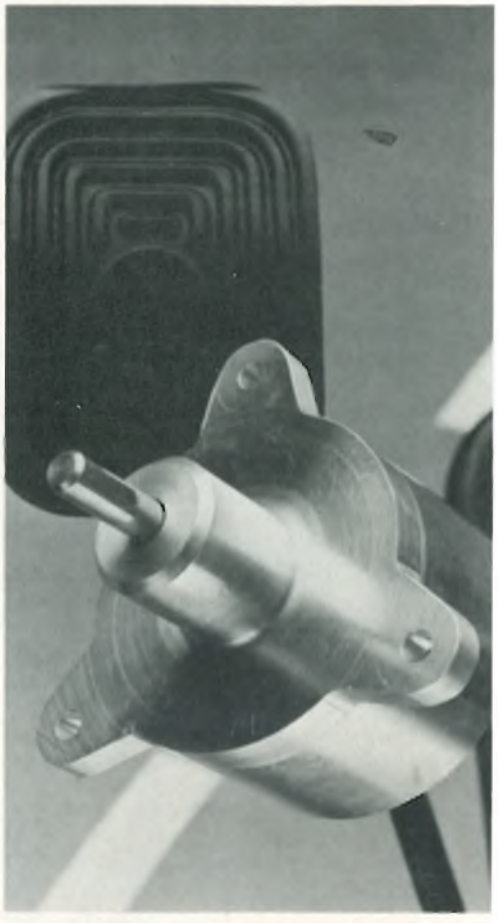
resistance due to the longer current path.

In the Siemens field-plate potentiometer FP310L100 used in the new VW vehicles, two field plates—each is about 3.5 by 2.5 millimeters in area and roughly half a millimeter thick—are subjected to the flux of a permanent magnet. An eccentric disk cuts into and out of the air gap between the magnetic poles thereby varying the flux distribution in the plates. The resistance change is evaluated by an amplifier, which is built into the potentiometer housing. With 15 volts and a 500-ohm load, the potentiometer's output signal varies between 0 and 20 milliamperes.

The potentiometer is contained in an aluminum housing that measures about 5 centimeters in diameter and 5.25 cm long. It weighs roughly 180 grams. By changing from an aluminum to a plastic case, Siemens can cut the weight by about 50 grams.

In the VW application, the shaft that turns the flux-controlling disk is connected via a linkage system to the drive and brake pedals. The currents that are generated are used to control a dc regulator containing thyristors. The controls—also supplied by Siemens—are designed so that the braking power recharges the vehicle's batteries. □



Transducer. A key component in a new electric-vehicle control system going into a line of Volkswagen pick-up trucks is a field-plate potentiometer, which has magneto-resistive action.

West Germany

AEG-Telefunken in microprocessor second-source pact with Rockwell

It didn't take Rockwell International long after cementing a domestic second-source agreement on microprocessor products and technology know-how to make a similar move in Europe. AEG-Telefunken and Rockwell's Microelectronic Device division announced a mutual second-source arrangement for microprocessors just a month after National Semiconductor Corp. and Rockwell reached such an agreement [*Electronics*, Sept. 18, p. 38]. There are strong indications, too, that Rockwell will enter into a similar deal with a Japanese semiconductor manufacturer soon.

The cross-licensing agreement, signed by Rockwell in California late last month and counter-signed by AEG-Telefunken in Frankfurt in early October, makes it possible for the two firms to exchange their technical know-how and product programs in microprocessors, a field in which both companies are among the leading producers on the respective continents.

The agreement won't stop short at microprocessors, however. Says

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Charles V. Kovac, vice president of the Rockwell division: "Its terms are broad and flexible enough to eventually include bipolar circuits as well."

But there's little doubt among German industry observers that Rockwell is strongly considering drawing on AEG-Telefunken expertise in integrated circuits for consumer applications, particularly for color-TV sets, now that it has acquired of the American TV producer Admiral. In circuits for entertainment applications, Rockwell has found itself a powerful partner. Elmar Windhorst, an AEG-Telefunken board member and manager of its components group, puts his firm's position on the West German market for TV circuits, for example, in the No. 2 spot behind Philips.

At present, though, the agreement centers on microprocessors, and the two firms won't be dragging their heels in putting it to work. There will be an exchange of engineers before the end of this month, points out D.P. Del Frate, vice president of marketing for the Rockwell's Microelectronics division.

German process and applications specialists will shortly be sent to California and a team of their U.S. counterparts to AEG-Telefunken's Heilbronn plant to acquaint themselves with each other's know-how in the field. Each company's technology will then be used by the other in microprocessor manufacture. Kovac expects such manufacturing to be underway early in 1976 and the first products to hit the market during the year.

What AEG-Telefunken offers its partner is its CP3F, developed last year [*Electronics*, Dec. 12, 1974, p. 33], the first truly European-made microprocessor. Originally custom-designed for the AEG-Telefunken subsidiary, Olympia Werke AG, an office equipment and calculator producer, the CP3F is proving to be a winner on the European market. It has, meanwhile, found other customers in the office-equipment field. Despite Europe's economic slowdown, "several million deutschmarks worth of our microprocessors

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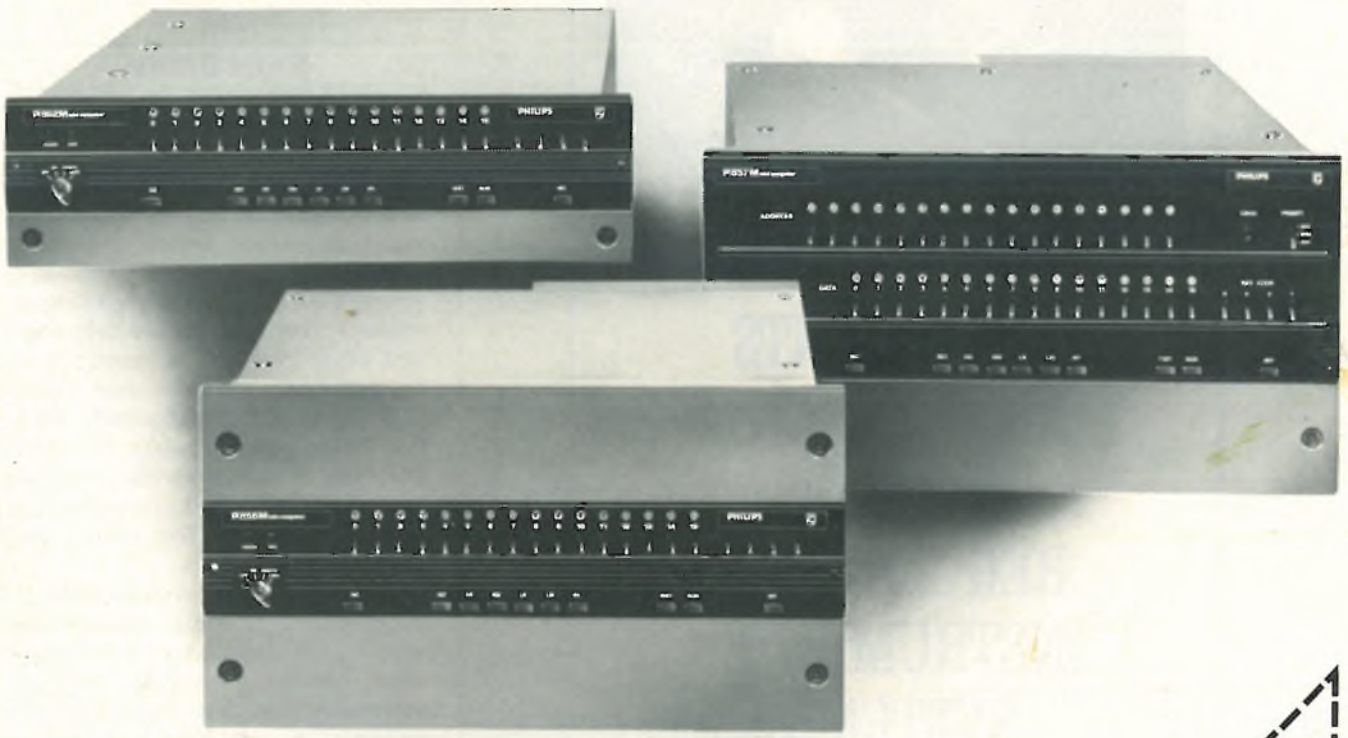

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have already been produced," Windhorst says.

What should benefit AEG-Telefunken, on the other hand, is Rockwell's well-established PPS-4 and PPS-8 microprocessor families and the company's large experience in the field. The agreement is not restricted to the two firms' present microprocessors. "Each company has a right to the other's products when announced," Del Frate says. This arrangement allows each firm to use the other's know-how in making follow-up families right from the start. □

Great Britain

CCTV optical link uses analog signals

Many optical-fiber communication systems use high-speed digital techniques, which for cable television and other "wired city" applications are needlessly complex and, therefore, expensive. Consequently, Plessey Telecommunications Research Ltd. has come up with a simple analog fiber-optic TV system that looks promising for cable and closed-circuit TV.

The field-tested system, with 7-megahertz bandwidth, already can meet closed-circuit-TV specifications, according to Peter H. Fell, senior engineer, who announced the system at the first European Optical Fibre Communication Conference in London, last month. Because about 70% of subcribers would be within a few kilometers of the transmission source, the LED-fed system could be designed as a straight, direct-shot link without the need for any repeaters to step up power.

The system directly modulates the output intensity of a specially developed light-emitting diode by a baseband video signal. Two TV sound channels are transmitted as frequency-modulated signals, one on a 6-megahertz carrier in line with broadcasting standards, and the other 10.7 MHz. Since these are standard frequencies, ceramic filters and

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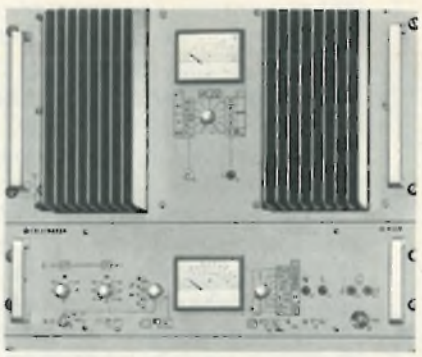

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integrated circuit demodulators are commercially available.

The receiver consists of a p-i-n diode, which can operate well in the small-bandwidth, high-signal-noise system, and a receiver-amplifier, which drives a baseband picture monitor and a filter where the two sound channels are split out and fed to audio amplifiers and speakers.

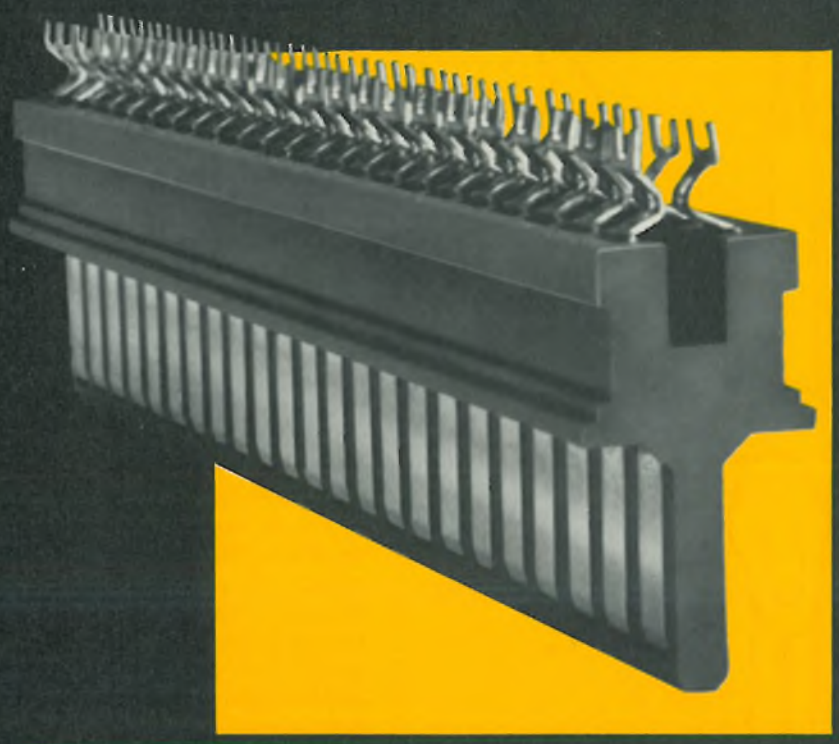
Plessey has run the link for more than 1,000 hours "mostly during the Australian test cricket match and British golf championships," since it was installed last January, says Fell. The K factor, an arbitrary measurement of quality based on wave-form distortion, has been 0.5%, about eight times better than the CCTV standard, he says.

Tests. Plessey's experimental underground ducted link runs 740 meters on a bending path at the research grounds in Taplow, Berkshire. The link also is being used to test a proprietary design of flat-cable construction, by British Insulated Callender's Cables Ltd., which carries two optical fibers enclosed in a cladding in between two steel wires, all of which are housed in a polyethylene covering. The high-silica step-index fibers from Corning have 85-micrometer cores and a numerical aperture of 0.18.

The high-radiance LEDs, made of gallium arsenide and emitting at 900-nanometers, are mounted in the output stage of a simple feedback amplifier, so that the standing diode bias current of about 100 milliamperes is modulated linearly to a depth of 50% by the video input signal, Fell explains.

To obtain the best possible performance from the p-i-n diode, the group has been developing a low-noise amplification system. A preamplifier features a field-effect-transistor, cascode input stage with overall feedback by a high-value resistor, which acts as a photodiode load, Fell says.

The low-noise amplifier is coupled via a variable attentuator to a conventional fixed-gain video amplifier, capable of giving a 1-volt peak-to-peak output into a 75-ohm load, he continues. Thermal prob-



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lems are eliminated by using ac coupling, and the low-frequency response extends down to about 1 hertz. Coupling loss through a collared coupler design is less than 1 dB, which means an input light level of 500 nanowatts is adequate.

Overall, the weighted signal-to-noise ratio is 59 dB in the 5.5-MHz band, or better than the 50 dB needed to meet CCTV specs. The second fiber in the two-fiber system is for viewer program selection, data, or some of the other applications a two-way link makes possible.

The present link uses preset gain control, but either the amplitude of the sound carrier or the pulse height of the TV sync signal could be used to control the overall gain of the receiver. An optical feedback circuit would be needed to bring the system up to regular TV broadcast standards, Fell says. This move would require splitting part of the output light signal, which, as an electrical signal, would then modulate the input to the light source. □

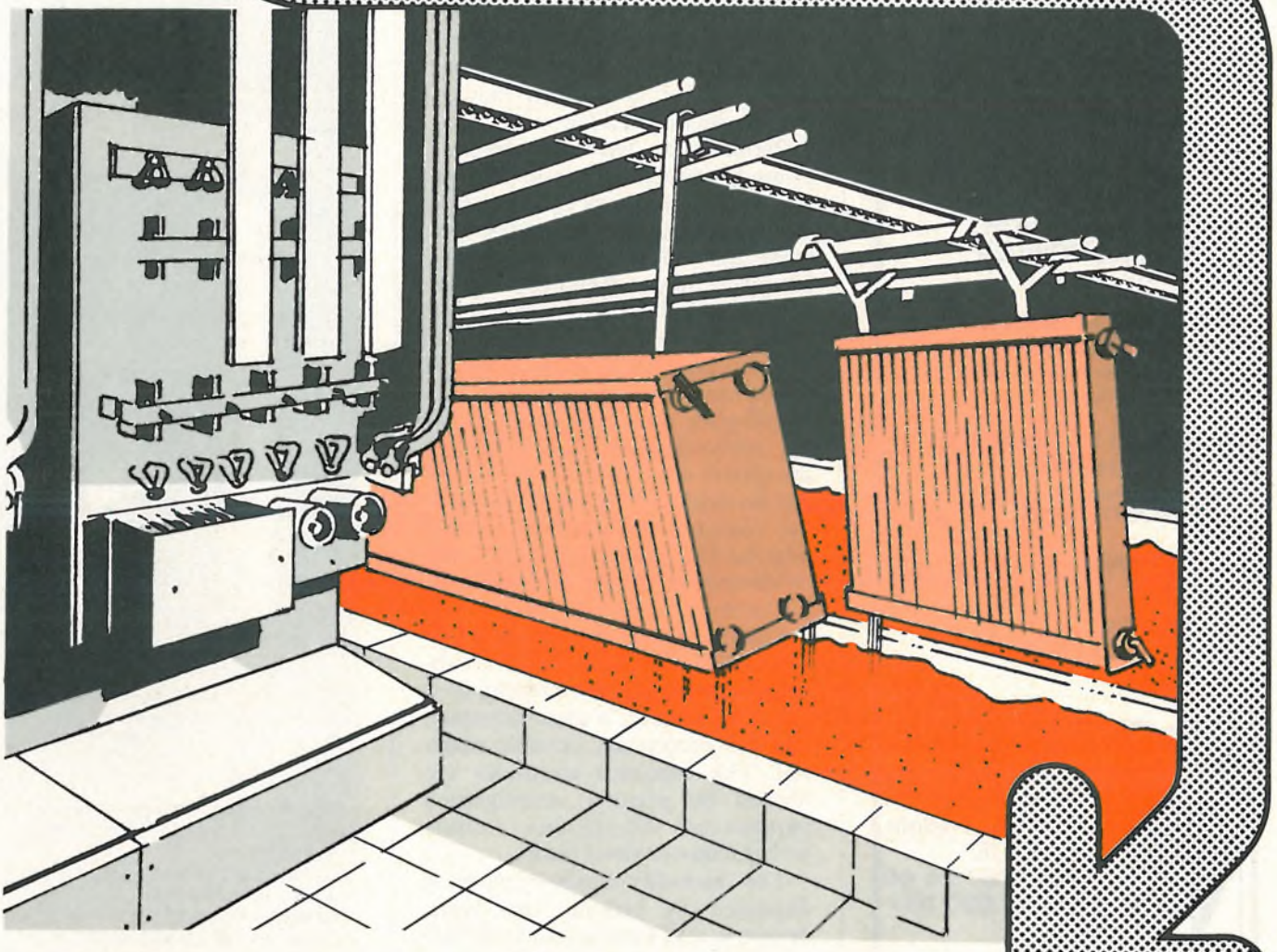
Dielectric boosts sensor efficiency

Many humidity sensors are unsatisfactory because the dielectric in their transducers changes resistance as water vapor is absorbed. Finding a dielectric that absorbs little water yet allows a quick reading and is free from accuracy-degrading contamination is a tough job. Then too, because transducer output is logarithmic, discriminating circuitry is needed to produce a more-readable linear response.

Now, most of these shortcomings have been eliminated by a new dielectric that has been developed and built into a British thick-film humidity sensor. The transducer, based on alumina particles embedded in a proprietary ceramic-dielectric substrate, was developed by the Barnwell Components division of Holsworthy Electronics Ltd., of Holsworth, Devon.

Thanks to thick-film processing, says Peter Barnwell, company man-

Heavy currents under control



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ager, the sensor is cheaper than conventional devices. Competitive sensors can cost $125 plus another $300 or more for the electronic circuitry to read out the results, Barnwell says, while his sensors and circuitry will beat that level when they go into production in a few weeks.

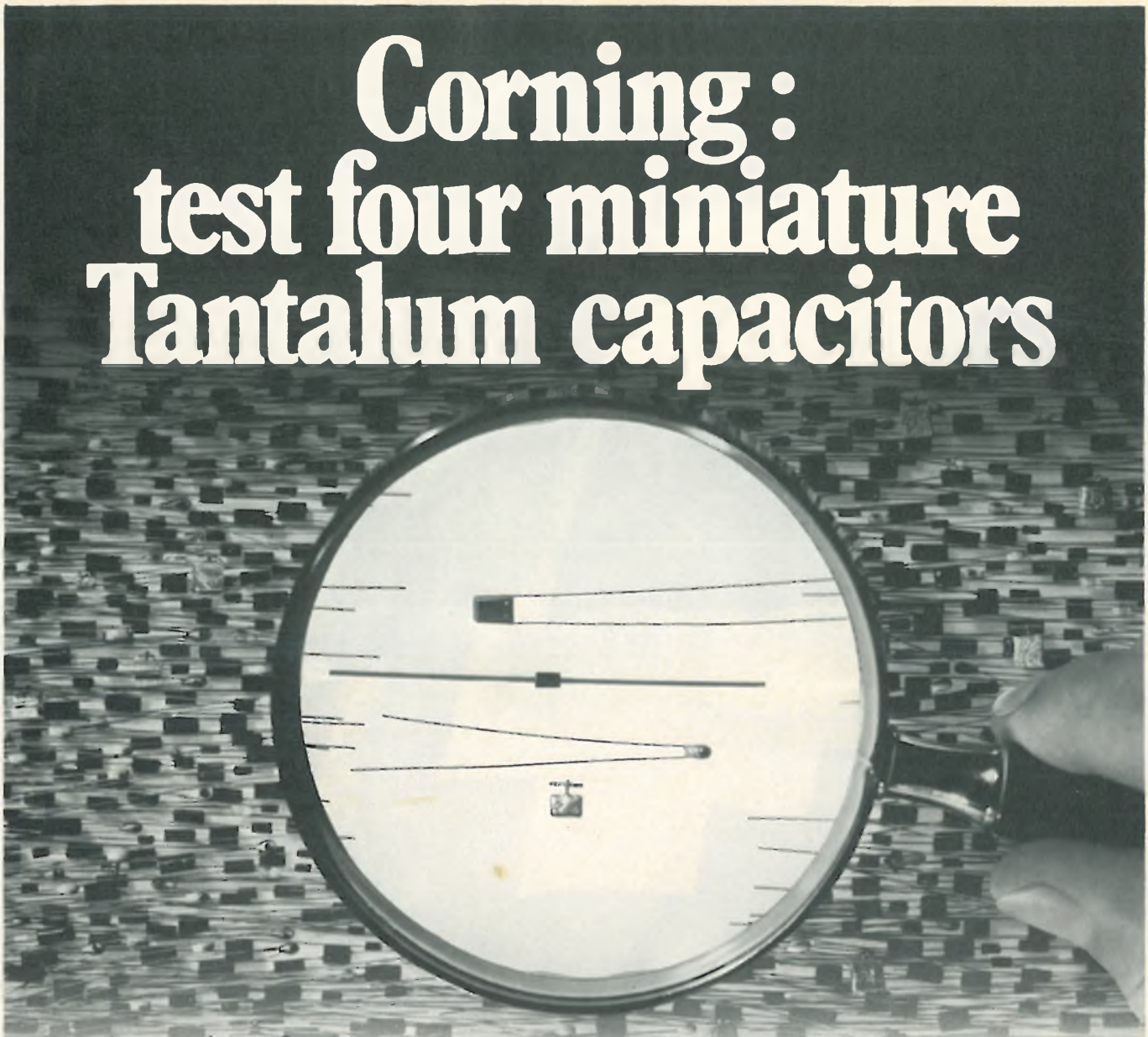
Performance. The sensor boasts a 2-second response time to changes in humidity, accuracy of about 98%, and has a practically linear response from 25% to 95% relative humidity, Barnwell says. Potential applications include climate control for the manufacture of chemicals, paper, and pharmaceuticals, as well as food-processing and packaging. Meteorologists, especially those studying micro-climates, may also find the system useful because the sensor can be deployed far from the readout circuitry, Barnwell last month told the Conference on Hybrid Microelectronics at the University of Technology, Loughborough.

The transducer, measuring 0.5 to 1 by 0.025 inch, consists of a substrate containing an interdigitated electrode pattern, a glass substrate, and the proprietary ceramic material. The capacitor electrodes are formed by printing interdigitated patterns on a 96% alumina substrate with palladium-silver paste.

The humidity-sensitive paste is deposited by printing one layer, drying it, and then printing another to give a total fired thickness of about 40 micrometers. The transducer is completed by soldering the substrate edge connectors to pads that have been left exposed through the dielectric layers.

This dielectric can absorb water throughout its bulk so that the nearby interdigitated electrode patterns can efficiently measure changes in capacitance caused by humidity. Barnwell claims that the glass-ceramic material that holds the coated inert alumina particles together is superior to solid-glass ceramic because it gives more surface exposure, allows about 10 times faster absorption throughout the dielectric, and has a high porosity because the particles don't melt together during processing. □

Corning: test four miniature Tantalum capacitors



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HEF4070P	Quad exclusive-OR gate
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HEF4072P	Dual four-input OR gate
HEF4078P	Eight-input NOR gate
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HEF4085P	Dual two-wide two-input AND-OR-invert gate
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HEF4099P	Eight-bit addressable latch
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HEF4514P	One-of-sixteen decoder/demultiplexer with input latch (HIGH)
HEF4515P	One-of-sixteen decoder/demultiplexer with input latch (LOW)
HEF4518P	Dual BCD up-counter
HEF4519P	Quad two-input multiplexer
HEF4520P	Dual binary up-counter
HEF4539P	Dual four-input multiplexer
HEF4555P	Dual one-of-four decoder with active HIGH outputs
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Not a bad achievement, considering that the advanced P6006 equipment has been produced only since early 1974.

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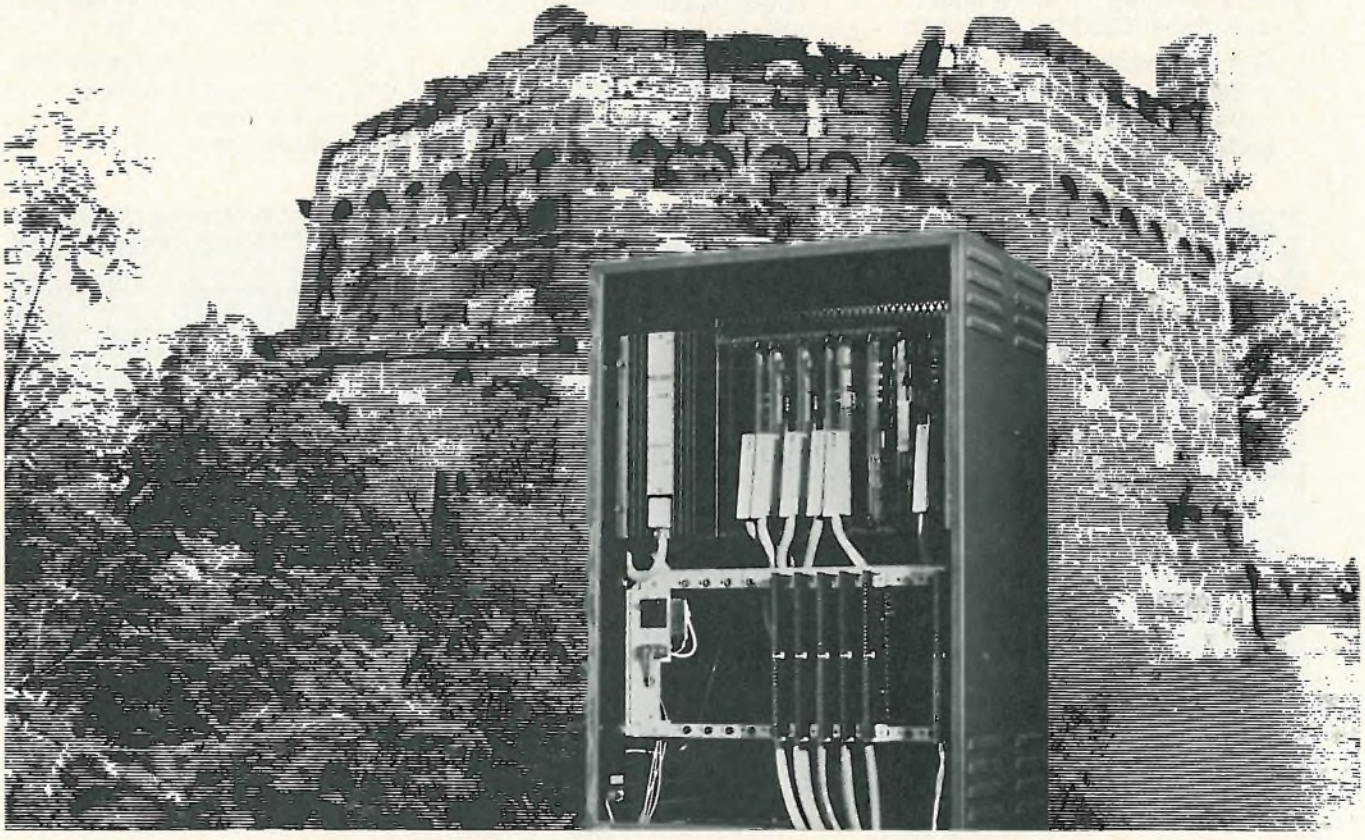
We started 8 years ago in Vicenza - when we already had to our credit remarkable achievements in other fields - with the remote control systems for the municipal distribution network.

Then, while on the one hand we continued our activity in the distribution field, on the other hand we carried out computerized systems for the acquisition of data in thermoelectric power plants. In these days of energy restraint we feel particularly engaged to analyse the problems of automation, together with electricity authorities, and to thus contribute with our equipment towards a safer and economically convenient production and distribution of the electric energy.

Naturally, our activity in the automation field is not restricted to the electrical sector and we can offer, particularly to municipal authorities, our experience in other remote control applications such as gas and water systems. Complete automation systems can also be supplied for numerous other sectors.

All these systems are based on advanced equipment such as our P3010 and P4010 process computers, a vast range of terminals (among which the P2656 colour video units) and the already mentioned P6006 remote control stations, all entirely designed in our laboratories and incorporating particular functional and technological features.

To these must be added, as an essential component of the Pignone systems, the expert work of our team of system analysis and application software specialists.



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* the option of use in ultrasonic or boiling-emulsion processes.
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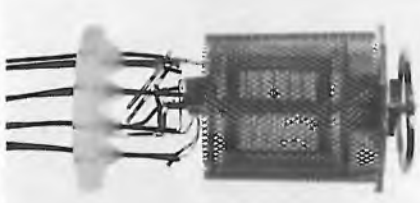

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ICI Mond Division, P.O. Box No. 13, The Heath, Runcorn, Cheshire, England.

Monitor. Once the operator specifies the kind of analysis desired, Cosynus system prints out details of the type and level of radiation emission in 6 or 7 minutes.

Computer-run modular system monitors reactor emissions

by Richard Shepherd, McGraw-Hill World News, Paris

Schlumberger's Cosynus is expected to further Camac-module acceptance in industrial controls

There is little that the nuclear power industry fears more than radioactivity on the loose. So when France starts up the first in a new series of American-designed light-water reactors next summer, the plant will be monitored day and night by a computer-controlled radiation-measuring system said to react faster than most competing systems. Built by the Nuclear department of Schlumberger in France, the equipment had special significance for delegates to the second international symposium on Camac in Computer Applications in Brussels this week.

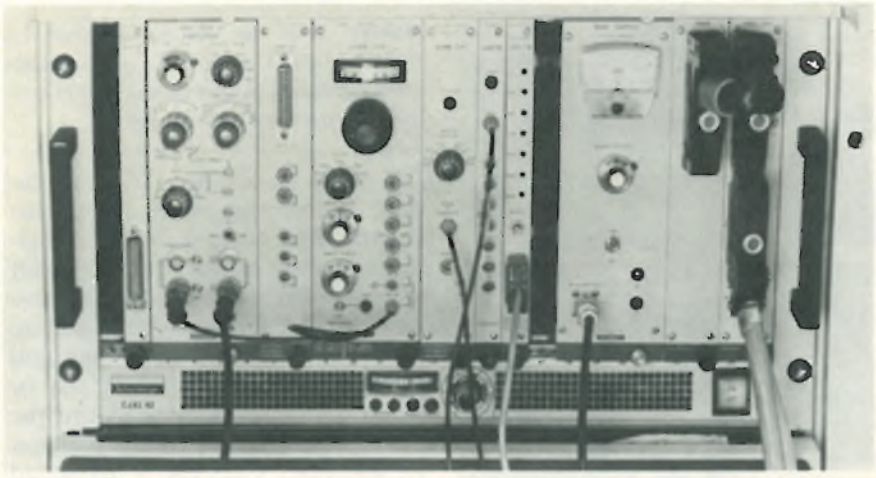
Camac and NIM (nuclear instrumentation module) are standardized modular data measurement systems that originated in nuclear research laboratories, and close to two-thirds of the current investment in Camac-standard instrumentation is confined to nuclear physics applications. As nuclear power programs take on new importance in the wake of the oil crisis, however, nuclear instrumentation for power plants and uranium enrichment and reprocessing facilities is becoming an industrial market in its own right.

Schlumberger won orders for its Cosynus-γ system from the utility, Electricité de France, for two nuclear power complexes in eastern France. The company's sales engineers figure it came out top in a stiff international contest for the business because the machine is able to print out details of both type and level of radiation in about six or seven minutes, about one third the time taken by most other systems. In addition, Cosynus is equipped with a 64-unit keyboard that enables unskilled operators to trigger a particular analysis by a single touch, rather than by complicated computer instructions channeled through a conventional teletypewriter.

Like most radiation detectors, Cosynus analyzes gaseous or liquid emissions by measuring the energy content of each particle with a germanium-lithium detector that converts the energy into an electric signal. And since each particle or isotope, such as cobalt, has a specific energy value, an analysis of ambient radioactivity can be done simply by adding up the numbers of identical values.

Conversion. In the Cosynus systems, that analysis is done automatically by converting the measuring task into a spectrum analysis. The electrical signals are displayed to show the number of identical values on a vertical axis and the varying values along the horizontal base line. The peaks on the display thus correspond proportionally to the different radioactive isotopes emitted from the radiation source.

Fast spectrum analysis of a 4,000-channel display, with as many as 30 peaks at one time, is handled by a Digital Equipment PDP-11/05. Each peak is measured in terms of time, surface, height, energy value, resolution, background noise and Gaussian shape, and input is compared to a memory stocked with standard isotope data. Complete results can be flashed on the screen in real time. Once that job is done, the



Custom fit. Camac modules are shown in lower half of Cosynus cabinet (front panel removed). Camac standard modules originated in nuclear instrumentation laboratories.

crucial question of whether the radiation is at a dangerous level can only be answered by another analysis to determine the rate of emission of each isotope. As one engineer explains it, the first part of the job is to find out what is leaking and the second is to determine how much it is leaking.

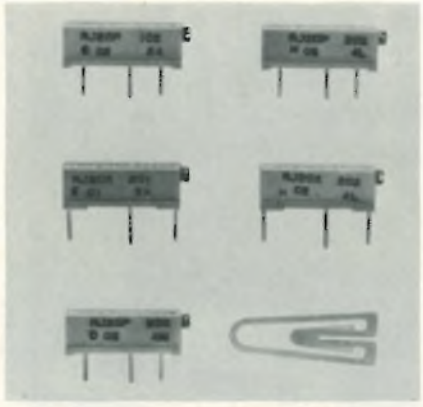
Results can be badly distorted because of the geometry of the detector and because the volume and surface of the sample under analysis is too small. The efficiency of the detector fluctuates with the energy emitted by each isotope or particle. So Schlumberger has had to devise compensating computer programs to obtain true and comparable results. A similar correction has to be made for variations in the energy value readings on the display grid by plotting a sequence of 10 reference-point values in kiloelectronvolts, to make them comparable with data fed in from the detector system. Cosynus-γ can carry out separate and more detailed analyses of individual peaks without interrupting the regular monitoring procedures.

There are plenty of other special jobs that nuclear installation operators may want to do that also go beyond the day-to-day routine of monitoring for leaks. But Schlumberger explains that the modular organization of the Cosynus-γ hardware gives it the multifunction capability for which the Camac concept of standard sizes and configurations was originally developed.

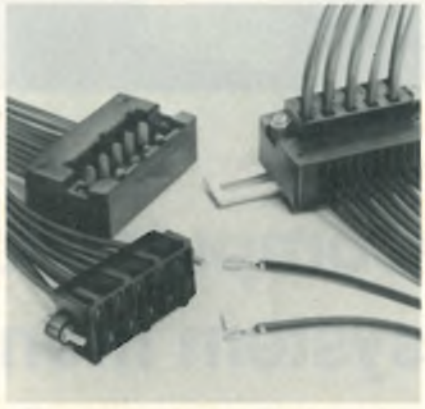
At $55,000 to $65,000 per system, Schlumberger will not be needing mass-production techniques to meet market demand. France will have only 40 to 50 nuclear installations around the country by the end of the century, and each will need no more than four or five systems like Cosynus, especially since each system can handle input from a number of sources or detectors simultaneously. But Cosynus will push the Camac concept more firmly into the industrial marketplace, where it has made relatively slow progress in the last year or so. Prospects are brightening now, however. Both IEEE and ICE regulatory and standards organizations have recognized Camac chassis and module norms this year.

Well-timed. More practical help will come from Schlumberger, which will soon acquire a license to build microprocessor control modules developed by the electronics laboratories at the Commissariat à l'Energie Atomique. The timing is good because Camac systems' builders point out that intelligent distributed systems, essentially systems that decentralize computing power, are making strong headway now in industrial process control, where complete systems from minicomputer makers have tended to outrun Camac systems.

Schlumberger Nuclear Department, 56, rue de Paris, Bagneux, Paris, France [441]



Cermet multiturn trimming potentiometer, series RJ20, offers range from 10 ohms to 5 megohms ±10%. Power rating is 0.5 watt at 70°C; temperature range, −55°C to +120°C; temperature coefficient, 100 ppm/°C. Resista, 83 Landshut, Ludmillastr. 23/25, West Germany [443]



Right-angled, 10-position connectors, called the AMP 250 Fastin-Faston series, can be used with high-speed crimping machines. Rated at 20 A, 500 V ac, they have an insulation diameter of 2 to 4.4 mm. AMP (Japan) Ltd., 7-15-14 Roppongi, Minato-ku, Tokyo 106, Japan [444]

Self-latching reed relay can be mounted on a circuit board like an IC. The miniaturized unit weighs 1.6 grams. Rhodium contact-plating provides stable performance, even at low energy levels. Fujitsu Ltd., 2-6-1 Marunouchi, Chiyoda-ku, Tokyo 100, Japan [445]

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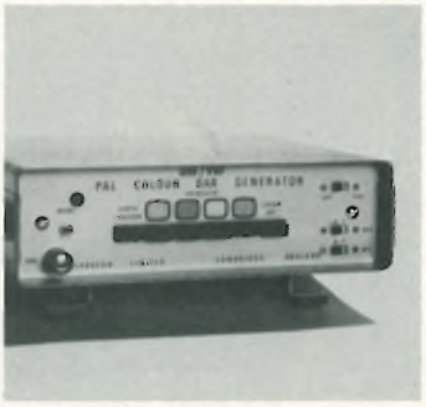
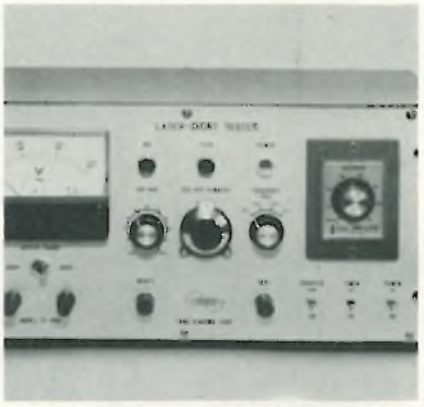
New products international

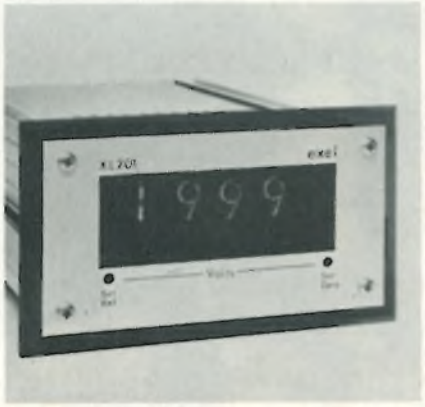
A thin, strong, coaxial cable, type 2419, has a characteristic impedance of 50 ohms, ±10%, and an attenuation constant of 0.2dB/m at 10 MHz. The conductor is piano-wire wound with copper wire. Azuma Cord Co. Ltd., 3-17-6 Higashi-oi, Shinagawa-ku, Tokyo 140, Japan [446]



A uhf/vhf PAL color-bar generator, the CM6052/CB, has all the characteristics of Labgear's 6037 plus color-difference signal outputs and an external variable-tuning capability to simplify the adjustment process. Labgear Ltd., Abbey Walk, Cambridge CB1 2RQ, England [449]



Model TL-600 tester detects internal short circuits in transformers, choke coils, motors, and solenoids. Sensitive unit can detect short-circuiting of a single turn when used for testing a 15,000-turn coil. Tama Densoku K.K., 6-15-6 Honmachi, Hoya-shi, Tokyo 188, Japan [452]



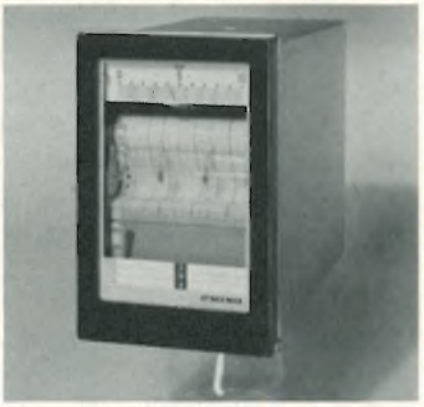
Digital panel meter, the XL201, offers a 3½-digit Nixie-type display and overrange to 2999. Sensitivity ranges from 20 mV to 200 V full scale. Reading accuracy is within 0.05% ±1 digit. Exel Electronics Ltd., Wolterton Rd., Branksome, Poole BH12 1LR, England [447]

The Cor 75 series of reed keyboard switches offers a plunger design that ensures minimum lateral play and long life. Other features are low plunger-friction and minimum absorption of moisture. Contraves AG, Industrie-Werbeabteilung, Postfach, CH-8052 Zurich, Switzerland [450]

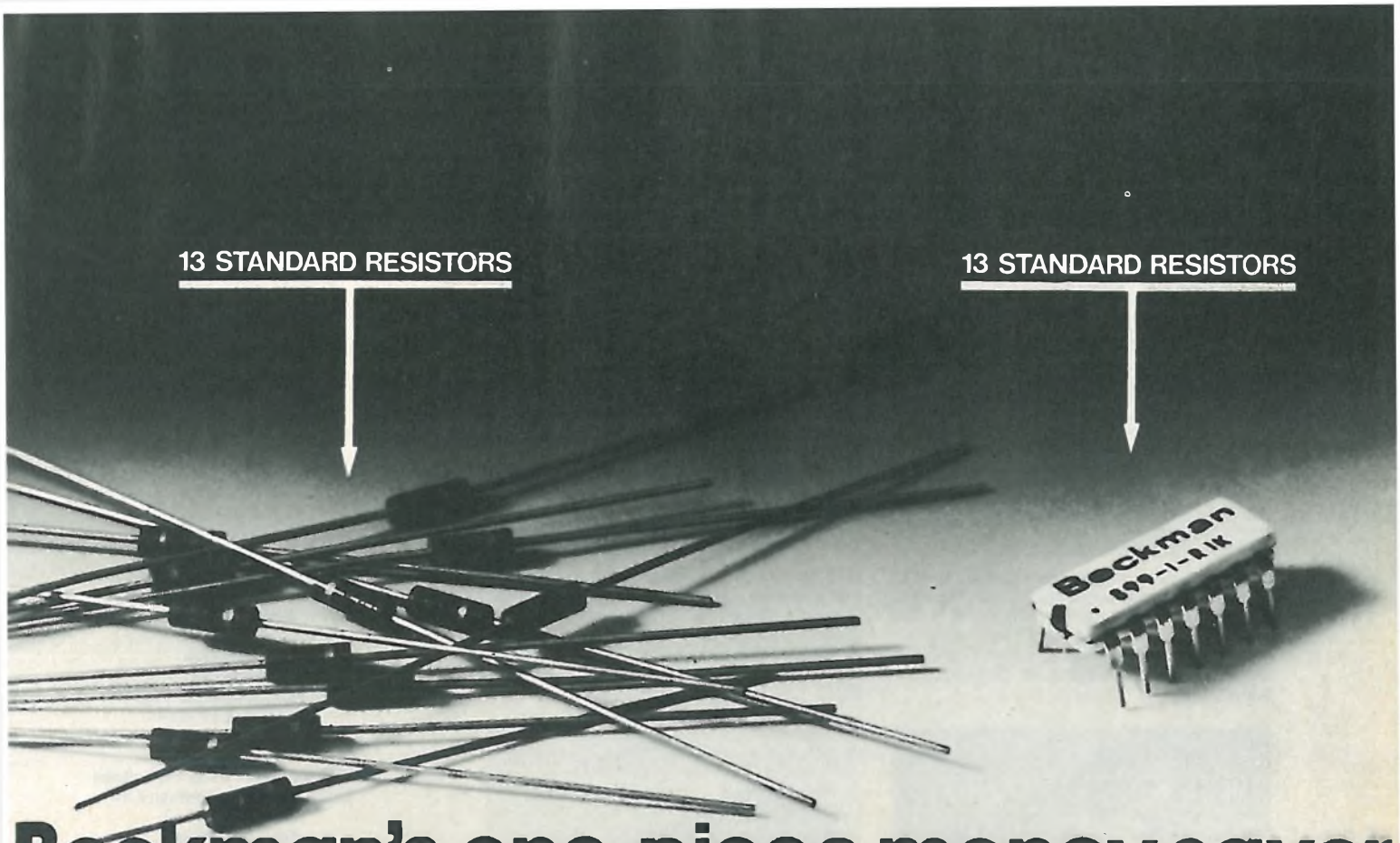
Development of a high-speed hybrid IC is the key to design of a pulse generator, the model TR-4240, with a 2-GHz bit rate. Rise and fall times of the unit are less than 200 picoseconds. Takeda Riken Industry Co., 1-32-1 Asahi-cho, Nerima-ku, Tokyo 176, Japan [453]

Matrix printer, model 6330, has a 132-column capability, operates at up to 150 characters per second, and uses fanfold paper. A microprocessor executes instructions stored in the printer's memory. Data Recording Instrument Co., Staines, Middlesex, England [448]

A highly ruggedized version of the HP 8640B signal generator, the model 8640M, delivers phase-locked test signals from 500 kHz to 550 MHz. Applications are in flight-line and field-testing. Hewlett-Packard Co., 7, rue du Bois-du-Lan, CH-1217 Meyrin 1 Geneva, Switzerland [451]



Miniature electronic recorder, model ES, provides charts of chemical and other industrial processes on folding-type paper that is 60 mm wide. Unit measures 96 by 144 by 214 mm. Chino Works Ltd., 1-22-8 Nishi-ikebukuro, Toshima-ku, Tokyo 171, Japan [454]



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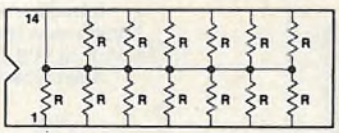
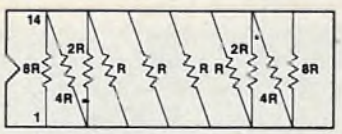


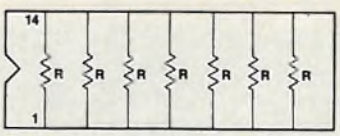
MODEL SERIES 899-1
Resistance Values 78 Standard versions available 22Ω to 100K.

Common Applications: Digital pulse squaring; MOS/ROM pull-up/ pull-down; "wired OR" pull-up; power driver pull-up: open collector pull-up; TTL input pull-down; TTL unused gate pull-up; high-speed parallel pull-up.
Standard Tolerance: ± 2.0%



MODEL SERIES 899-2
Resistance Value (ohms): 10K
Common Applications: Inverting operational gain; potentiometric gain; differential gain; noninverting gain; gain adjustment.
Standard Tolerance: ± 2%

16 pin versions available
Ask for Series 898



MODEL SERIES 899-3
Resistance Values 78 Standard versions available 22Ω to 100K.

Common Applications: Line termination; long-line impedance balancing; power gate pull-up; ECL output pull-down resistors; LED current limiting; power driver pull-up; "wired OR" pull-up; TTL input pull-down.
Standard Tolerance: ± 2%

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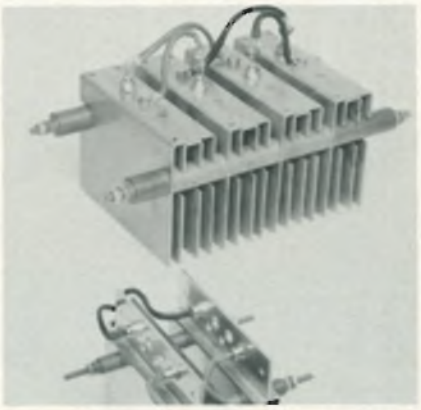
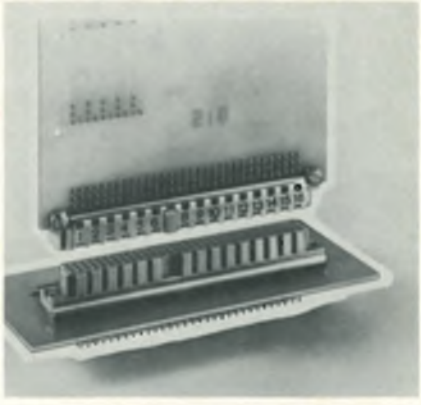


Medium-power silicon-bridge assemblies, the S series, are compact and air-cooled. Current ratings are 35 to 330 A dc at 200-1,400 V. Single- and 3-phase versions are available. Semiconductor Division, Westinghouse Brake and Signal Co., Wiltshire SN15 1JD, England [458]

Phase-sequence indicator called the Cirtest-Dran can be used with up to 660 V. Warning lamp glows in one transparent probe when sequence is wrong, one phase is missing, or there's a wrong connection. Taco-Tafel GmbH, 73 Esslingen, P.O. Box 792, West Germany [456]

An addition to the Bulgin DS-1000 switch line has an illuminated or unlighted button with push-on, push-off action. Rated 5 A at 250 V, the switch has rear-projecting contacts for wiring, and several can be grouped on a panel. A.F. Bulgin & Co., Barking, Essex, England [459]

Laminar-flow work station, type GH, provides dust-free atmosphere. Mean air velocity is 0.45 meters per second, and velocity is adjustable. Illumination intensity in work area is up to 2,000 lux. VEB Elektromat, 808 Dresden, Karl-Marx-Str., East Germany [457]



Printed wiring connectors, called the FO68 series, come in two versions: with contact pins measuring 0.6 by 0.6 mm for currents up to 2 A at 70°C (FO68-I); and 1-by-1-mm contact pins, 4 A at 70°C (FO68-II). Philips, P. O. Box 523, Eindhoven, The Netherlands [460]

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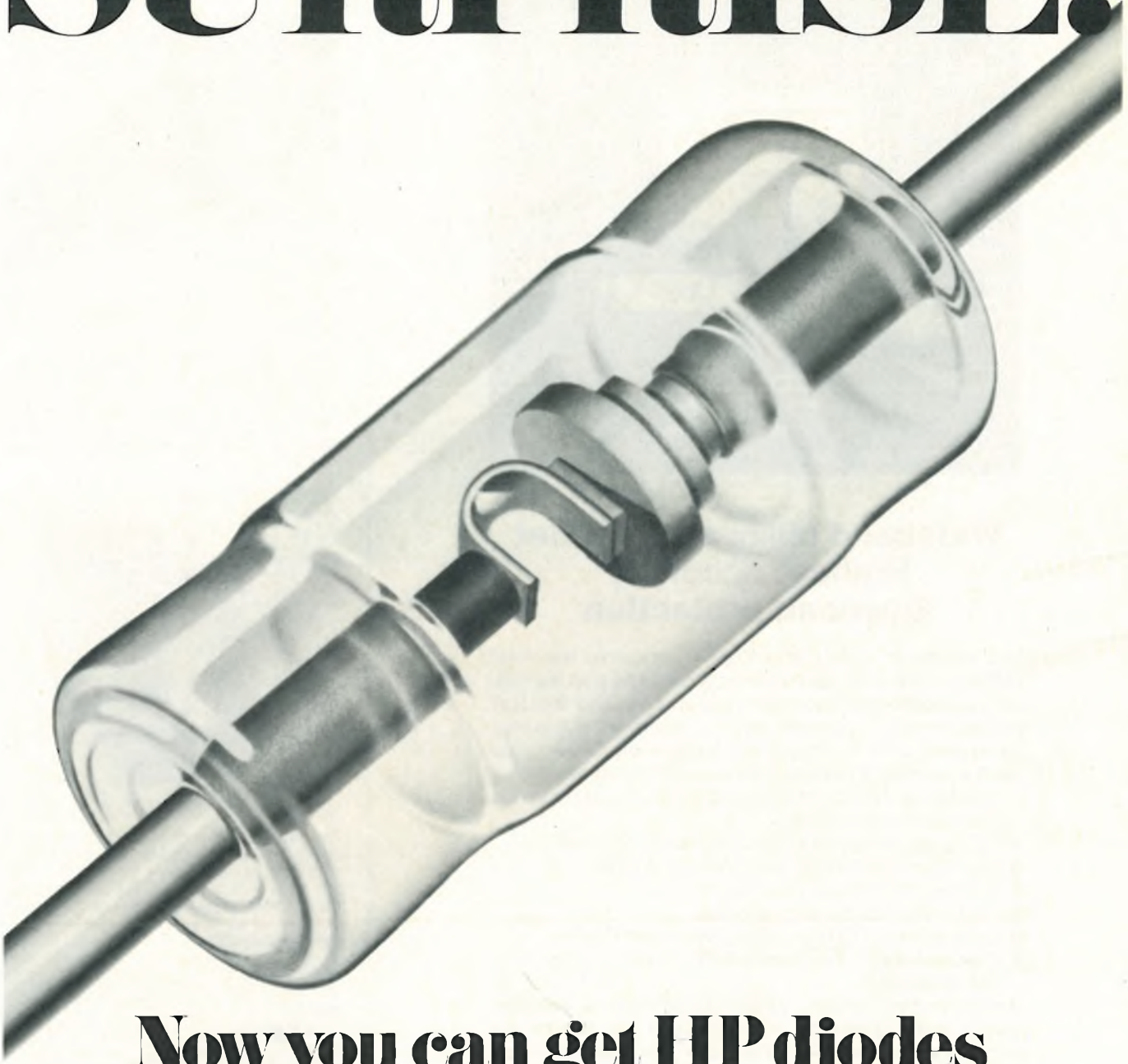

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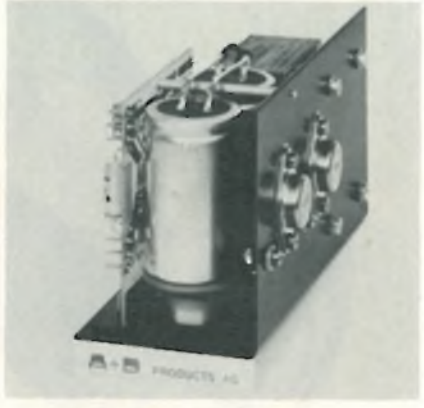
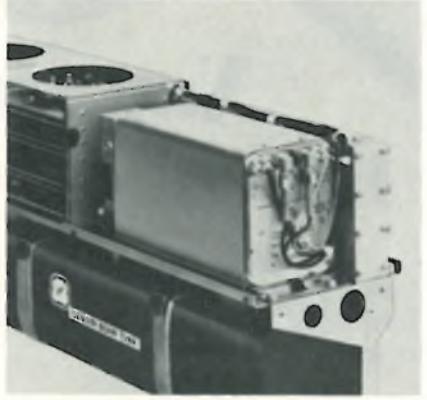


The first in a line of low-cost modular dc power supplies for OEMs, the LCM 5-5 has an output voltage from 4.75 to 6.25 V. Output current is 5 A, and the unit has electronic short-circuit protection. A + D Products Ltd., P.O. Box 1113, CH-2501 Bienne, Switzerland [462]



A 5-MHz cesium oscillator for OEMs (above) is a compact unit that can be powered by a 24-volt dc source. Applications include communications and navigation systems that use a cesium source. Ebauches Ltd., 1, Fbg. de l'Hôpital, CH-2001 Neuchatel, France [463]

PS/MAC 7000 Nuovo Pignone electronic instrumentation

The PS/MAC 7000 series of electronic instruments for industrial process control, was created by General Electric and has been developed by Nuovo Pignone through an extensive experience of applications in many types of plants. The line is complete, so that it can satisfy any design configuration, both for general use and for intrinsic safety, in accordance with U.L., P.T.B. and other international authorities' regulations.
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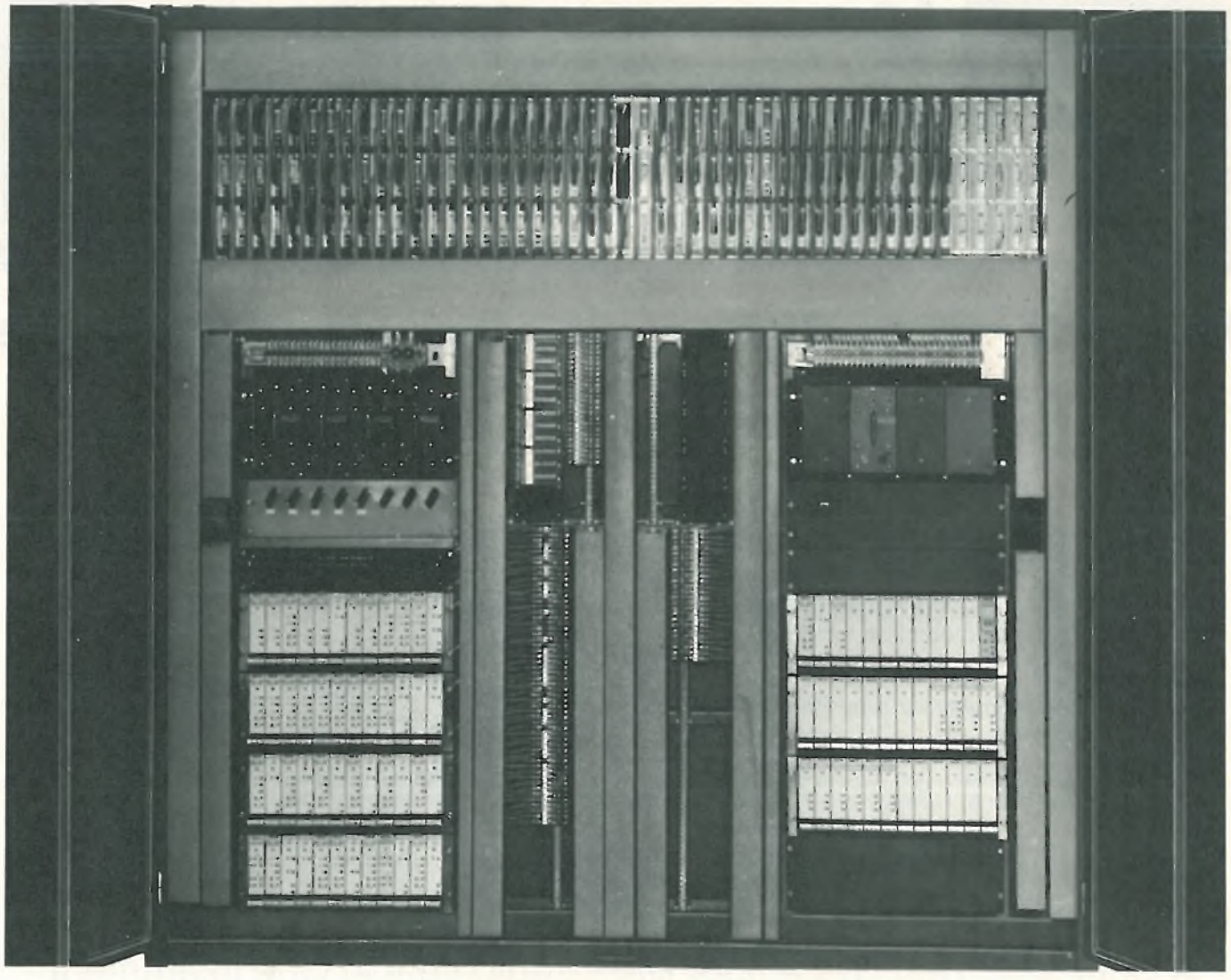
Rack instruments are available in preassembled and prewired modules.

The panel mounted and rack instruments of the PS/MAC 7000 line can be divided into seven functional groups - rack units for input and output interfacing - analog computing units - controllers - recorders and indicators - alarm units - stabilized power suppliers - calibration and test units.

All the circuits of the PS/MAC 7000 line make wide use of intergated components, which lead to an excellent thermal stability and to high input impedance of the receiving instruments. Their connection in parallel is thus possible without signal alteration.
The rack instruments and accessories are mounted in modular containers so as to obtain preassembled and prewired functional blocks of easy transportation and installation. This new system eliminates the traditional wiring design and connection work.



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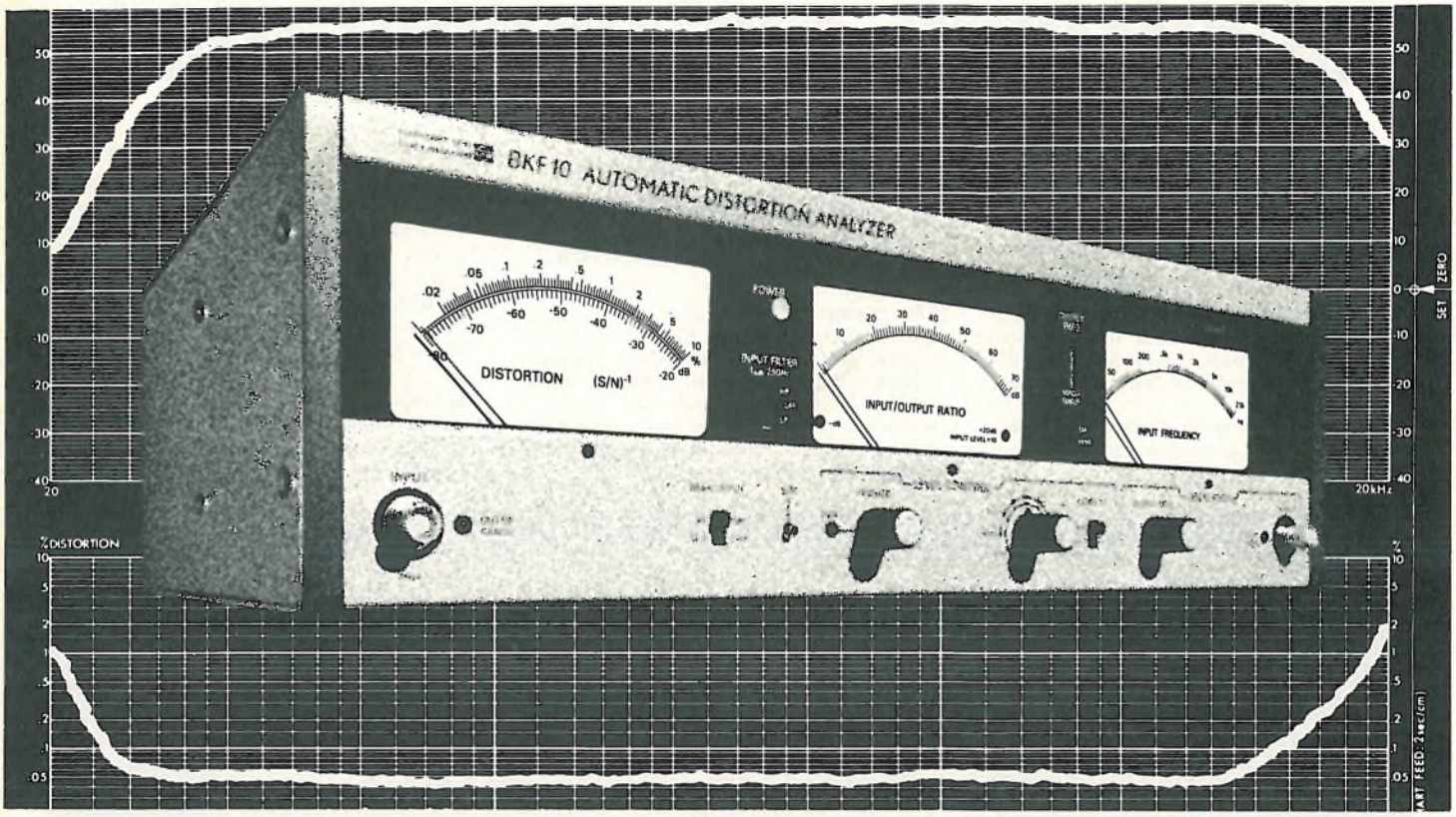

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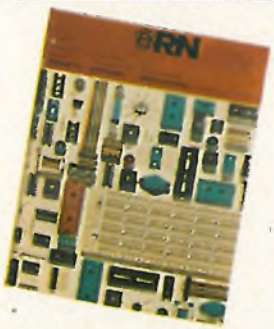

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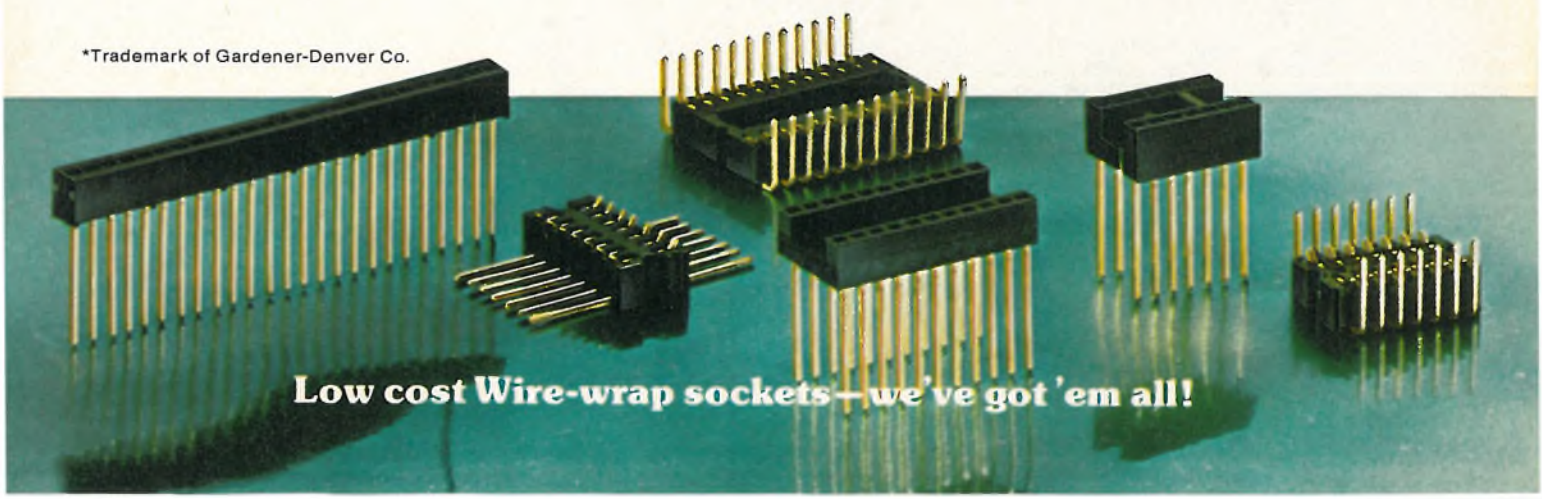

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Fig. 1

Fig. 2

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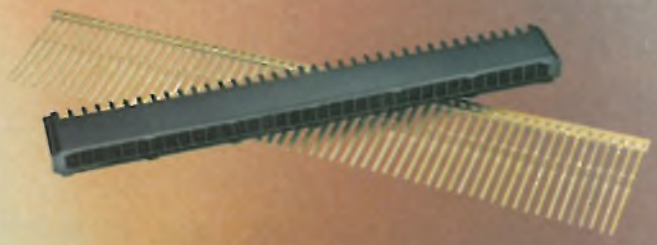

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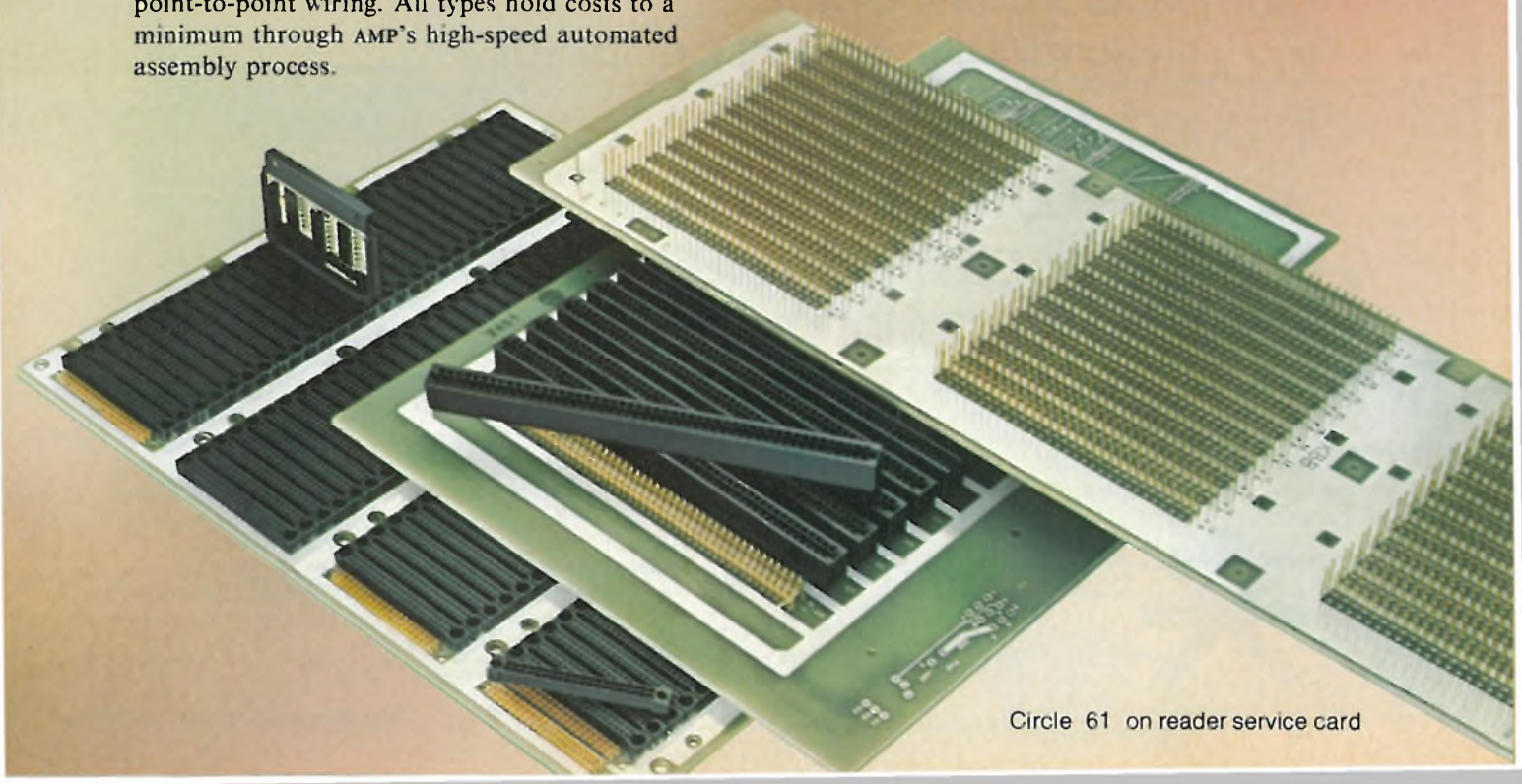

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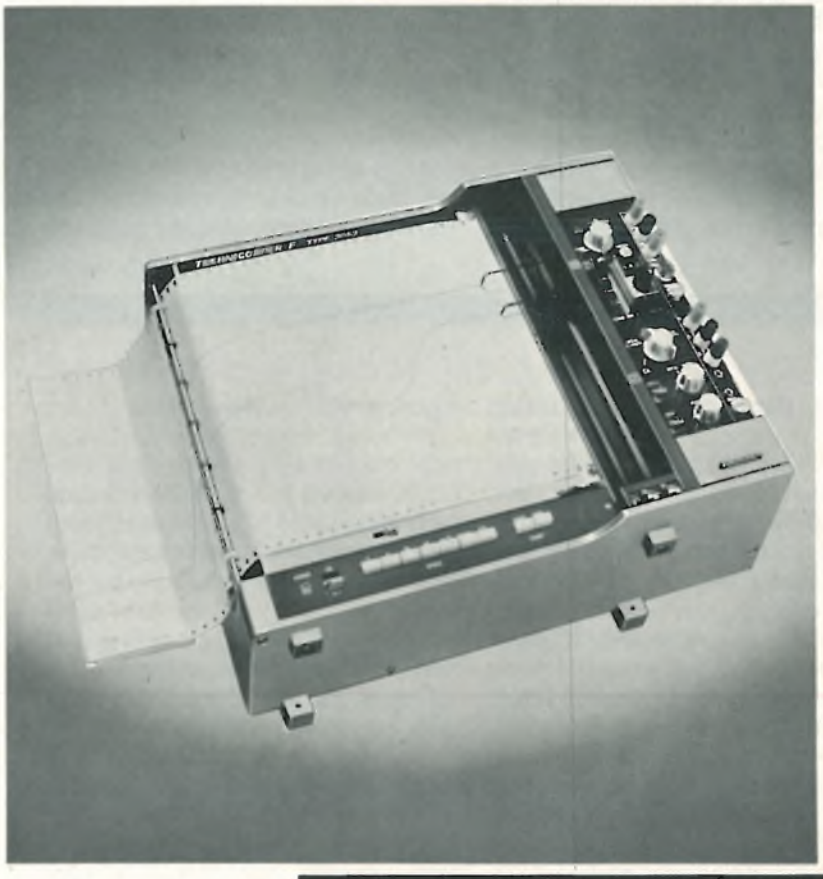

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Max. Sensitivity: 0.5°C/cm or 10°C/20cm
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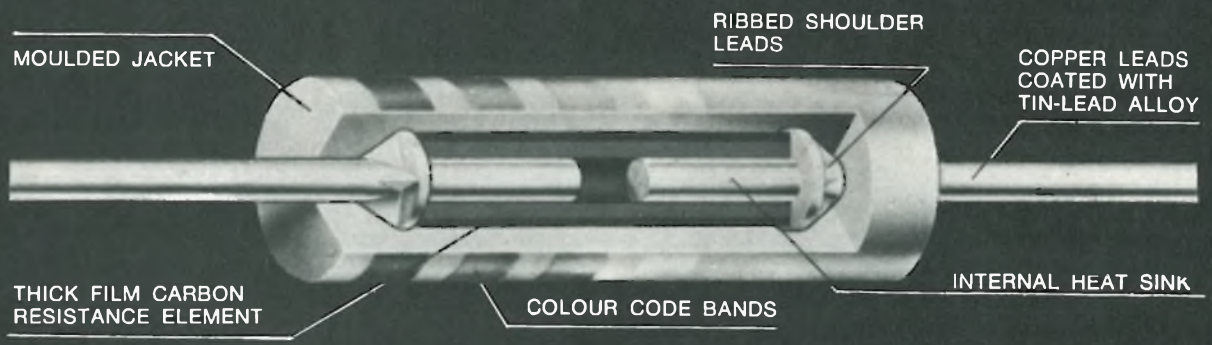

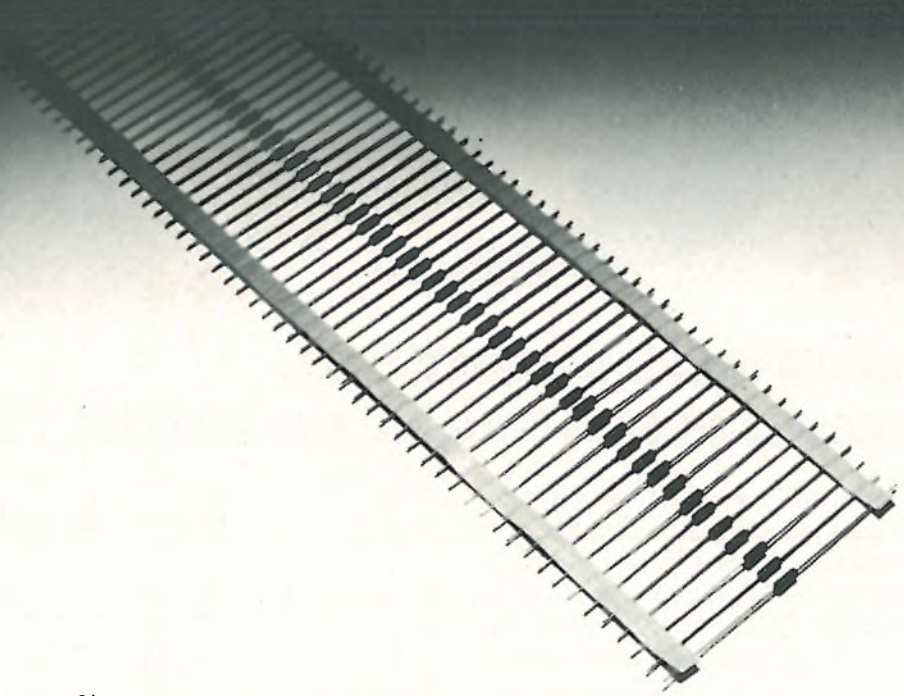

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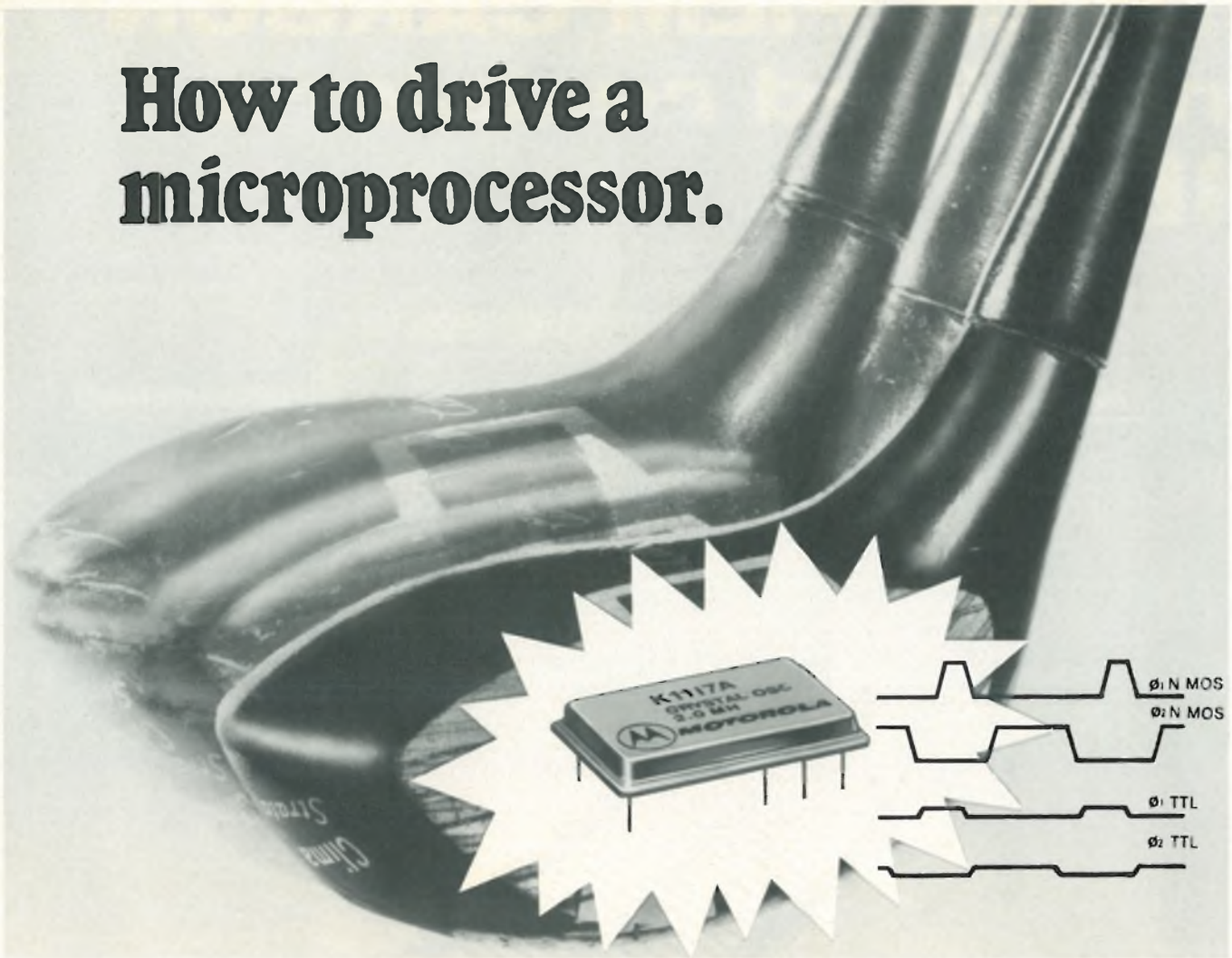
How to drive a microprocessor.



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1-4	33.00	33.00	36.00
5-9	27.60	27.60	30.00
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Technology

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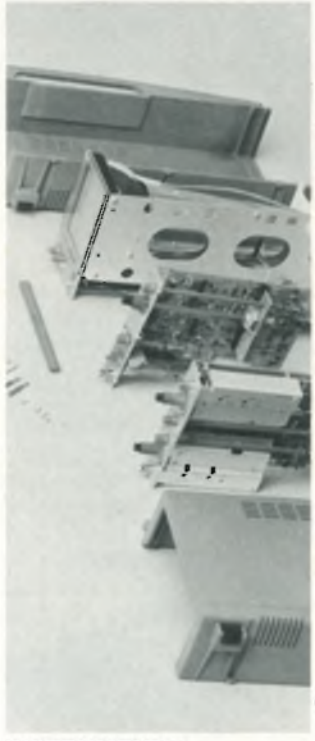

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Update

The most significant technological trend to emerge in 1975 is the availability of low-cost digital processing power. The theme crops up again and again in the various sections of this, our second annual technology update issue. It sounds simple enough—even trite—but it is a development of profound significance.

A series of remarkable improvements in semiconductor technology has culminated in cheap and powerful microprocessors, larger and faster memories, and the replacement of hard-wired by programable logic. All of these are extending the reign of digital processing into instruments, communications, industrial controls, and even appliances for the home.

Many of the details of these developments are shown in this report, but their implications are only just beginning to emerge. One thing remains certain, however: at this stage, the possibilities of electronics are still limitless.

Processors moving from computer room

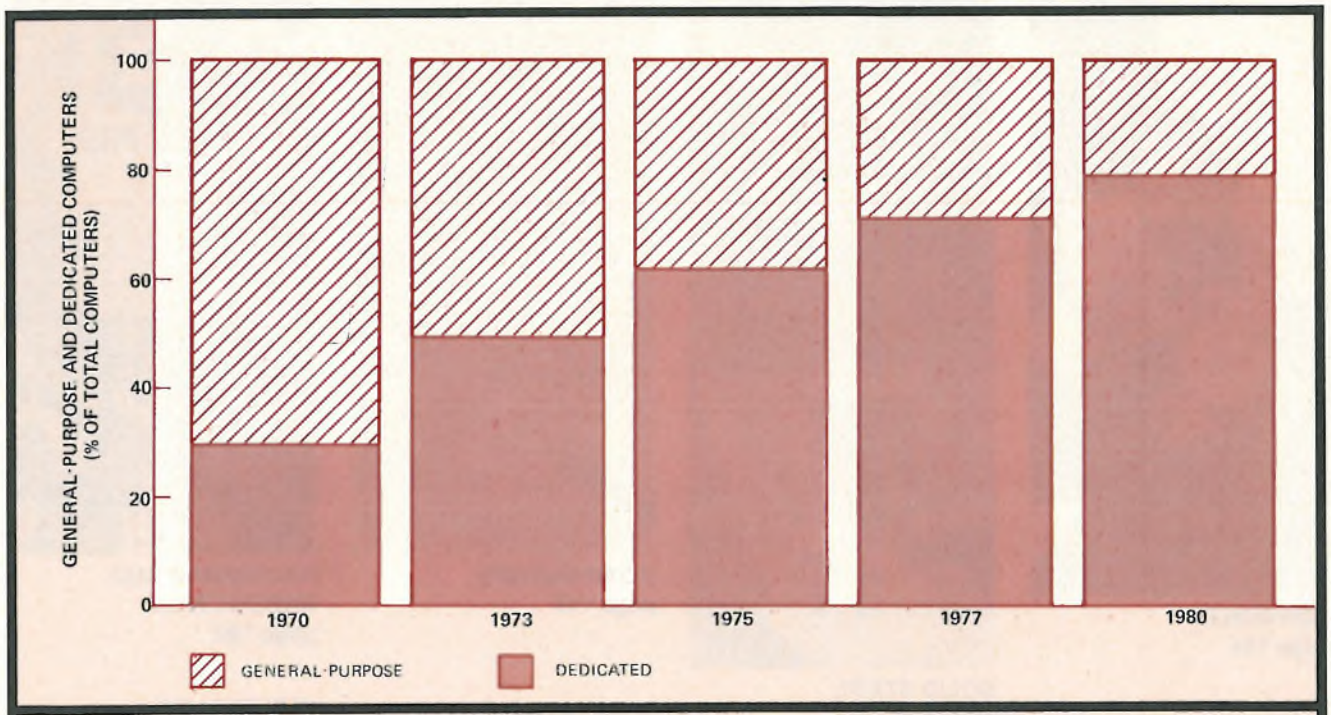
☐At a recent technical meeting on computers, one session was titled, "Are big machines necessary?" The ensuing discussion could not have been more significant than the question itself, for it reckoned with the most discernible trend in computer technology today—the shift toward distributed processing, the scattering of computer power among numerous points in the system rather than its continued centralization in the typical computer room.

Spurring the trend toward distributed processing is the semiconductor industry—still ground zero for computer technology. Armed with the ability to produce dense, high-speed LSI circuits with such technologies as Schottky TTL, integrated-injection logic, and advanced n-MOS techniques, the semiconductor manufacturers are changing the way computer designers work. Tomorrow's central processing units, memories, architecture, and even software will be related directly to what's happening in the diffusion furnaces today.

Microprocessors, of course, continue to open up more areas for computer technology throughout society and industry, bringing distributed processing to new types of equipment. In the meantime, other developments are also to be noted. Among them:

- The next generation of large main-frame central processing units are being designed using emitter-coupled logic—today's ultimate in high-speed large-scale integrated circuits.
- Mass-storage systems are getting larger in anticipation of the need for a hierarchy of speeds and capacities in large data bases. It is these data bases that will allow a system's distributed intelligent terminals to interact as they process transactions with the data base.
- Intermediate mass storage systems are under devel-

by Stephen E. Scrupski, *Computers Editor*



The number of dedicated minicomputer-based systems in use over the next five years will grow enormously compared with the number of general-purpose systems. By 1980, minicomputers will comprise about 80% of all systems.

Laser writer. IBM's new 13,360-line-per-minute printer, model 3800, uses a low-power laser to form character images on a rotating drum, which picks up ink-like powder and transfers images to paper.

opment to span the access-time gap—the difference in access time between fast main memories and large rotating magnetic memories.

Microprocessors

In the past year, the number of available microprocessor types just about doubled (see the table on p. 78). In MOS, new 4-bit families were introduced for low-end, stand-alone controllers requiring little memory. Full 16-bit single-chip microprocessors are available to handle as many as 64-k words of memory, while new 8-bit systems offer users more intelligence for peripherals. Finally, bipolar bit-slice systems built with Schottky TTL or integrated-injection logic can handle the highest level CPU and control jobs.

If 1975 was the year of the microprocessor CPU, 1976 will be the year of the interface or peripheral control circuit. Most semiconductor makers will now attempt to cash in on their design investments, adding interface circuits to allow the CPU to serve many applications.

Almost all microprocessor manufacturers are also working on prototype development systems. For example, Intel Corp., Santa Clara, Calif., introduced its Intellec Microcomputer Development System (MDS) to aid designers using the 8080 MOS and the 3000 bipolar chips [*Electronics*, May 29, p. 91]. The key element in the system is the in-circuit emulator module, which substitutes for the microprocessor by plugging into the 40-pin socket that will eventually hold the device. In its first version, the MDS uses assembly language, but Intel plans to add a high-level language compiler to allow programs in the company's PL/M language.

The ease of the microcomputer design process depends to a great extent on the level of programing language used. Assembly language, while making efficient use of memory, is tedious, but high-level languages are easier to use. National Semiconductor has been working on a language called SM/PL, which will be ready next year. Others are working on variations of Basic.

Microprocessors will continue to offer designers an alternative to low-end minicomputers, and most minicomputer companies will be designing microprocessor-based computers, of which DEC's LSI-11 is perhaps the best example [*Electronics*, Feb. 20, p. 114]. The LSI-11, with chips made by Western Digital Corp., is word compatible with DEC's PDP-11 series and uses much of the same software. A 16-bit computer, it has 8,096 words of random access memory on its 9.5-by-10 inch board along with four MOS LSI and several TTL circuits.

Minicomputers

Minicomputers, for the most part, have not yet felt the impact of the new LSI logic circuits. True, microprocessors are appearing in low-end machines, such as the LSI-11, but most minicomputer CPUs today are being produced with MSI-level low-power Schottky TTL. Minicomputer manufacturers are designing bigger machines, moving up to compete with the low end of the main-frame manufacturers. The primary emphasis for such machines is on memory (and most minis now are being designed with semiconductor memories rather than magnetic cores, which will only be offered as options) on mass-storage, and on input-output equipment (most mini makers are beginning to manufacture their own peripherals, like CRT terminals and printers).

However, the next generation of minicomputers, perhaps appearing on the market by the end of 1976, will probably use LSI-level low-power Schottky TTL. These parts are being produced in bit-slice formats by, among others, MMI, Advanced Micro Devices, Intel, Fairchild, and TI. While not yet available in production quantities, their existence is causing computer designers to look again at computer architectures that could make maximum use of the parts. The first minicomputers using the parts will probably reproduce the old architecture, but subsequent generations will be different.

Most minicomputers are being designed with 4-kilobit random-access memory chips, and 16-k chips should start to appear next year. The 4-k chips have been declining steeply in cost while improvements have been made in reliability and in speed—from about 300 nano-

AVAILABLE MICROPROCESSORS

Type No.	CPU Bits (bit slice size)	Address Capacity	Comments* Developing Manufacturer**
p-MOS			
LP 8000	8	2-k	General Instruments
4004	4	4-k	Intel
4040	4	4-k	Intel
8008-1	8	16-k	Intel
5065	8	32-k	Mostek
GPC/P	4	100	BS, MP, National
IMP-4	4	4-k	MP, MC, National
IMP-8	8	64-k	MP, MC, National
IMP-16	16	64-k	MP, MC, National
PACE	16	64-k	MP, MC, National
PPS-4	4	4-k	SV, Rockwell
PPS-8	8	16-k	SV, Rockwell
PPS-4/2	4	128	CC, SV, Rockwell
TMS 1000	4	8-k	SV, MP, Texas Instruments
SC/MP	8	64-k	CC, SV, National
n-MOS			
EA 9002	8	64-k	SV, Electronic Arrays
F-8	8	64-k	CC, Fairchild
CP-1600	16	64-k	MP, General Instruments
8080	8	64-k	Intel
6501	8	64-k	SV, MOS Technology
M6800	8	64-k	SV, Motorola
CMP-8	8	64-k	National
2650	8	32-k	SV, Signetics
TLCS-12	12	4-k	MP, Toshiba
MCP-1600	16	64-k	MP, MC, Western Digital
PFL-16A	16	64-k	MC, Panafacom
C-MOS			
COSMAC	8	64-k	SV, RCA
6100	12	4-k	SV, CC, Intersil
Bipolar			
3002	2	512	BS, SV, MP, Intel
RP16	4	64-k	BS, ECL, MC, SV, Raytheon
6701	4	64-k	BS, SV, MP, Monolithic Memories
SBP0400	4	64-k	I^2L, CC, BS, SV, MP, Texas Instruments
1601	4	32-k	BS, MP, Transitron
2901	4	64-k	BS, MP, Advanced Micro Devices
10800	4	64-k	BS, MP, CC, ECL, Motorola
9400	4	64-k	BS, MC, MP, SV, Fairchild

*NOTES. BS – Bit slice
MP – Microprogramable
ECL – Emitter coupled logic
I^2L – Integrated injection logic
SV – Single voltage
MC – Multi-chip cpu
CC – Clock on chip

**Second sources not listed

seconds access time a year ago, to about 200 ns today. Improvements aside, reliability has been one of the major problems in the devices, and most minicomputers have therefore incorporated error-correction schemes for use with the semiconductor memories. Single bit-error correction has increased reliability by as much as 400 times.

In read-only memories, IBM set a new high in bit density with a 48-kilobit n-channel MOS chip used in its new 5100 portable computer [*Electronics*, Sept. 18, p. 29]. ROMs translate keyboard commands (Basic or APL) into machine language. Standard commercial ROMs only go as high as 16-k, a level that will probably hold steady throughout next year.

Main-frame computers

The next generation of main-frame CPUs will probably use some form of LSI emitter-coupled logic for higher speeds. One example is Amdahl Corp.'s 470 V/6 system, introduced this year to compete with such top-of-the-line hardware as the IBM system 370/168.

Amdahl uses an LSI version of ECL for a 30-ns CPU cycle time, while the main memory has up to 8 megabytes of MOS memory. A high-speed buffer memory of 16 kilobytes uses bipolar memory chips. CPU speed, according to Amdahl, is two to three times faster than the competition, while size is about one-third.

Although it may not represent any single advance in technology, IBM's General Systems division's System 32 must be recognized as setting a new direction in applying computing technology to low-level applications. It uses floppy disk for input, a fixed-disk memory, a CRT, a matrix printer, and a set of prepackaged programs for specific applications. IBM also introduced a communications option to the S/32, which effectively turned it into an intelligent terminal.

The major computer mainframe makers are all working on the distributed network concept. Burroughs Corp., for example, introduced the TC5100 series of intelligent terminals. The terminal uses MOS LSI circuits in the CPU and can call a group of microinstructions into its 16-kilobyte semiconductor memory from storage (such as a floppy disk or magnetic cassette) to run a program written in one of several languages.

Avionics

In avionics computers, too, the trend is toward distributed processors. And more functions are being handled digitally simply because smaller computers are available. Also, with the microprocessor looming as the basis of the next generation of military computers, the military is acutely concerned about the possible chaotic results from a plethora of different computers. Computers that are completely standard—all using the same parts—of course would help reduce the logistics of spare-parts inventories, but the first level of standardization for the military is being confined mostly to computer instructions, so that differently constructed computers at least will be able to work together.

Few military computers are still being designed with magnetic cores—the exceptions being in cases where nuclear radiation hardness is the prime need. Most memories are semiconductor, and here the military is following commercial practice, hoping to cash in on the declining price of semiconductor memories. Although some militarization of the chips will be required—temperature specs, packaging, and the like—few new memory chips will be developed expressly for military applications.

Disks

In the magnetic disk storage business, the present technologies of magnetic media thickness, head-to-media spacing, and magnetic head gap have been just about pushed to their limits. IBM's adoption of fixed disks and built-in heads in the new 3350 units allowed the company to increase capacity from 200 megabytes per spindle in the older 3330 units to 317.5 megabytes per spindle. The extra storage was achieved because, with the recording heads built directly into the drive, the relatively wide mechanical tolerances demanded for reliable operation with removable disks could be reduced, and track densities and linear bit densities could be increased.

Another company, Storage Technology Corp., Louisville, Colo., raised the capacities of their disk systems by raising the linear bit density by 50%, to about 6400 bits per inch, by means of higher frequency recording. The company's model 8850 raised the total unit capacity to 1,270 megabytes, a 50% improvement over the previous 880's capacity. Track density involves more difficult tolerances but remains at 238 tracks per inch. In Anaheim, Calif., however, California Computer Products Inc. has announced a 400-megabyte per spindle unit with a much higher density—perhaps as high as 700 tracks per inch.

Attention to disk storage will probably concentrate next on thinner magnetic coatings, perhaps by sputtering magnetic materials as thin films. Also coming are deposited-film magnetic heads, which will allow closer tolerances on the head gap. Taken together, such improvements could result in a ten times increase in storage capacity.

While no single company has a monopoly on technological improvements or innovations, one of the unwritten rules in assessing computer technology is to study any development from IBM very carefully. When IBM puts a stamp of approval on a product or a format, it tends to become a de facto industry standard. Even when IBM compatibility calls for lesser performance, as sometimes happens, equipment builders will demand it in order to hit as wide a market as possible. This is particularly true in the floppy-disk field, where disks are categorized as IBM compatible and non-IBM compatible, and the latter may have greater density.

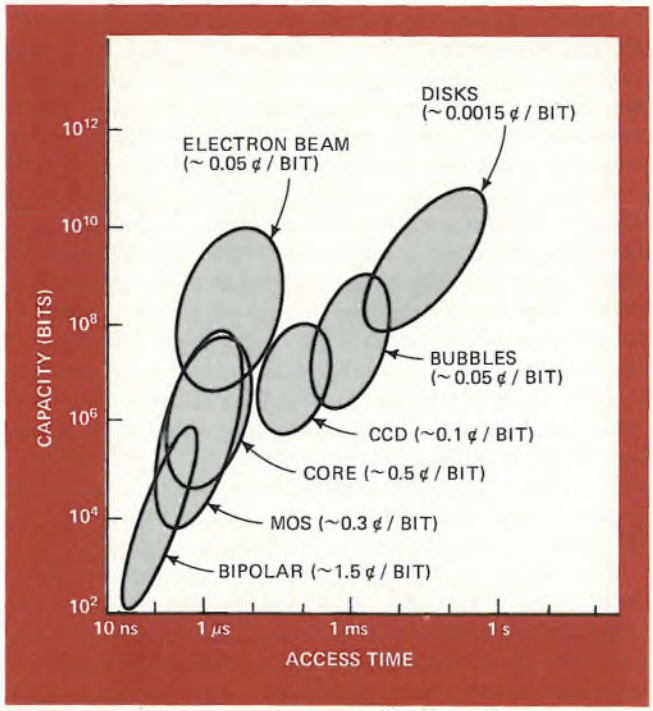
Although some "double-density" drives today allow recording on both sides of the disk, the disk must be flipped. Manufacturers now are working on recording on both sides of the floppy disk simultaneously.

In printers, improvements are showing up in several areas: speed, print quality, ease of operation, ambient noise level, multiple copy capability, maintenance, and interfacing. Serial printer speeds range from 30 characters per second to above 120 characters per second, while line printers range from below 300 lines per minute to about 2,000 lines per minute. Since speed is so closely related to mechanical design, most printer development will be in the area of building in more intelligence to give the devices more capabilities. Adding a microprocessor, for example, could enable on-board control of letter spacing, allow graphical plotting, and relieve the computer of much of the burden of instructing the printer. As for electromechanical improvements, they will be aimed at lower cost and better reliability.

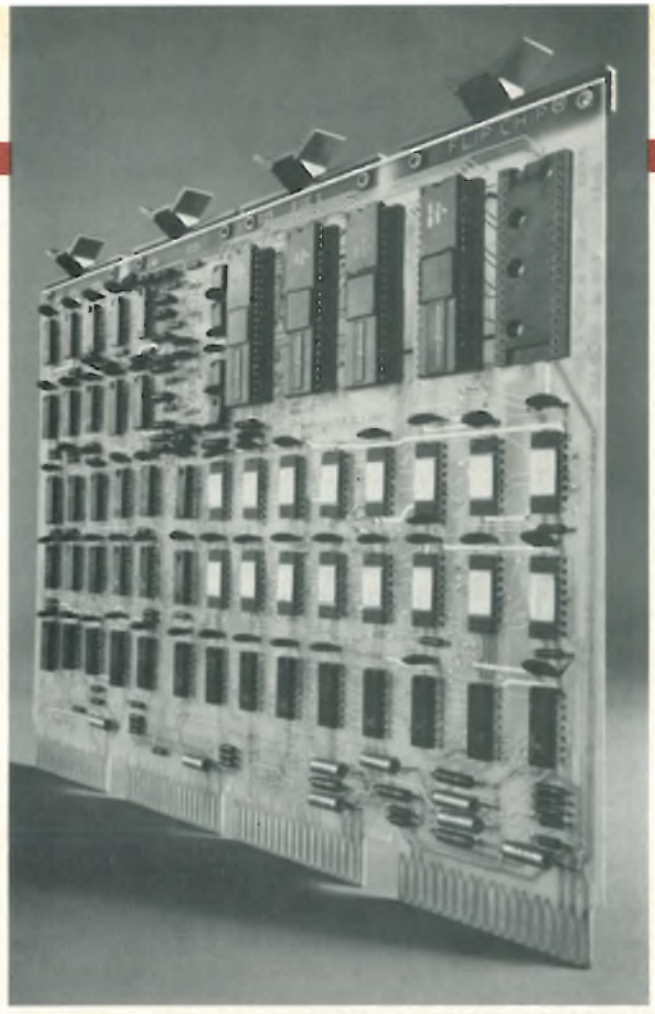
IBM set a new standard in line printers when it announced its model 3800, which uses a laser to "write" text on a photoconductive drum. The drum then picks up charged particles for transfer to paper, where the image is fixed as in an electrostatic copier. The printer operates at 13,360 lines per minute (45,000 characters per second), which is nearly six times as fast as IBM's previous line printers. The new printer, which will not be delivered until late 1976, also can use almost any type paper, a real plus in a world of high-cost paper.

Magnetic bubbles and CCDs

Magnetic bubbles continue to hold out the promise of high-density storage that could possibly be competitive with magnetic disks. Working bubble memories could



Memories. Memory technologies offer varied combinations of capacities and access times. Costs per bit are estimated for mid-1976 for complete memory systems.



Microcomputer. The LSI-11, introduced by Digital Equipment Corp. in early 1975, is typical of microprocessor-based machines that are upward compatible with existing minicomputers.

come in 1976 using bubbles that are 4 microns in diameter formed into 64-kilobit chips. IBM's Thomas J. Watson Research Center, Yorktown Heights, N.Y. has disclosed work on a concept called bubble-lattice storage, which could increase capacity by more than 5 times compared with present bubble technology. (The name comes from the fact that bubbles are packed together in a manner similar to a crystal lattice.) Bubble-lattice storage, rather than using the presence or absence of a bubble to represent a logic 1 or 0, uses the direction of magnetization on the boundary region of the cylindrical bubble domain to represent 1s and 0s. In some bubbles the rotation of magnetization is the same around the circumference, while in others the direction of rotation reverses from clockwise to counterclockwise. The two types can be generated without difficulty, while detection involves deflecting the path of one type with respect to the other. The ultimate density could be in the range of about one billion bits per square inch (a potential density 10 times greater than present CCD chips).

Meanwhile, the Memory Systems division of Intel Corp. Sunnyvale, Calif., now is supplying custom CCD memories for such things as a high-resolution CRT display, and as a replacement for a small disk memory. The disk replacement application has sub-millisecond latency time, which puts the CCD into the access-time gap. As a standard product, Intel has introduced a 1-megabit memory on a single board [*Electronics*, Aug. 21, p. 109], but that is probably intended to demonstrate capability, while later applications will probably turn out to be custom.

Fairchild Semiconductor, Mountain View, Calif., is also making CCD memory chips, having this year introduced a 9-kilobit version arranged into nine registers, each holding 1,024 bits for a 9-bit-wide serial register. More is coming in the form of a line-addressable random access memory (Laram) which will comprise four blocks of 4-kilobits each for a total of 16-k. Next year will probably bring a 32-k chip and a 64-k chip may not be far behind. Costs per bit are projected to be at 0.02 cents by the end of the 1970s.

Electron-beam memories

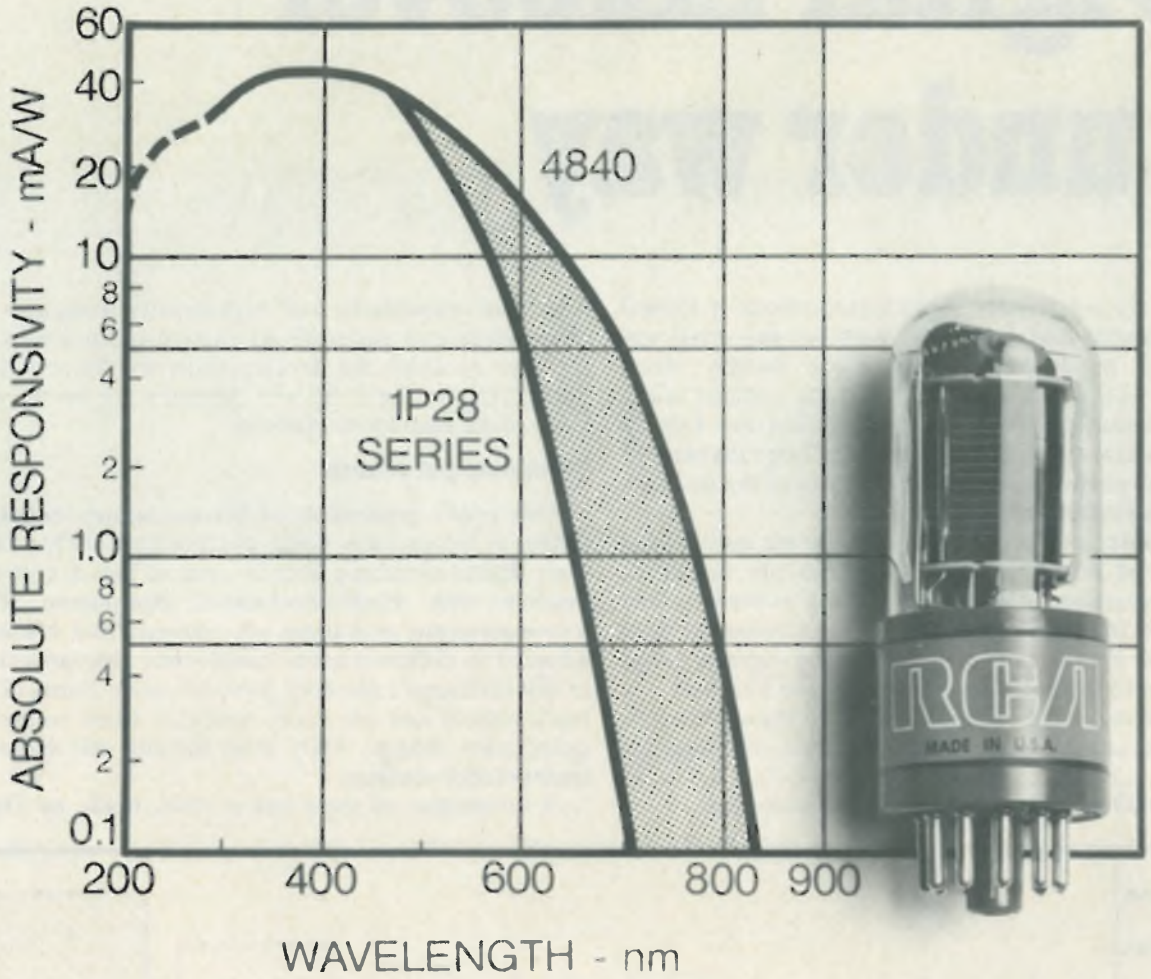
Also aiming at the access-time gap is the electron-beam memory. General Electric Research and Development Center, Schenectady, N.Y., Micro-Bit Corp., Lexington, Mass., and Stanford Research Institute, Menlo Park, Calif., have developed such units. GE's Beamos (beam-addressed metal-oxide-semiconductor), for example, cuts the millisecond-level access times for rotating mass memories by a factor of 1,000—from about 30 milliseconds to 30 microseconds. The first GE units have stored 32 million bits, with transfer rates of 10 million bits per second. Beamos uses four MOS chips as a target and the electron beam is aimed at the cells to generate a stored charge. Reading is performed by allowing the electron beam, by proper biasing of the chip, to generate electron-hole pairs; the holes are repelled from the stored charges to produce a readout pulse.

Micro-Bit Corp. has shipped a prototype electron beam memory to Control Data and expects to have a commercial product available next year. The unit will use 16 tubes with capacities of 8 megabytes each. The company is working on a new tube that will store 128 megabytes, but this will not be available for at least another year.

Electron-beam memories may be closer to commercial usage than the casual observer may think. Supporting technology, such as computer-aided design of the electron optics and the semiconductor technology, is already available. For the same reason, the cost of the modules themselves should be quite low. The major costs, according to GE, will be in the external formatting and control electronics. GE projects the cost of a 32-million-bit Beamos memory as between 0.02 cents and 0.1 cent per bit by 1977, depending upon quantities and performance.

Mass storage systems have been announced by IBM (the 3850) and Control Data (the 38500). Each uses small magnetic tape cartridges that are automatically extracted from a honeycomb-like structure and transported to a read-write station. IBM's system can store about 50 million bytes on one cartridge, and CDC's about 8 million bytes. Over-all, the IBM system stores from 35 billion up to 472 billion bytes—more than a trillion bits. Starting with a minimum of 16-billion bytes, CDC's system can be expanded to similar levels. □

Improved responsivity at 800 nanometers.



RCA's Multialkali Side-On PMT. The new RCA 4840 offers 100 amperes/lumen anode responsivity *minimum* and 50 microamperes/lumen cathode responsivity *minimum*. Just plug it in the socket using any of the 1P28 series and reap the benefits of high responsivity to beyond 800 nanometers. And — the 4840 is a direct replacement for the HTV R446.

This new 9-stage side-on detector with a UV-transmitting glass window also has a "Red-to-White" ratio of 25% minimum with C.S. 2-62 filter; 10% typical with V-R 68 filter; Cathode Radiant Responsivity of 43 mA/W typical at 375 nm; and Typical Current Amplification of 2×10^7. You get performance superiorities plus domestic manufacture, delivery and in-depth engineering support.

With the addition of the multialkali 4840, RCA now provides high gain, low noise side-on PMTs covering the spectral range from 165 to beyond 800 nanometers. For more information on the entire line or on the new 4840, see your local RCA Distributor or write: RCA Limited, Electronic Components, Sunbury-on-Thames, Middlesex, England or RCA International Marketing, S.A., 118 rue du Rhone CH1204, Geneva, Switzerland.

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Digital takeover is under way

☐The thrust everywhere in communications is toward greater capacity and versatility. Both big and small networks can handle more calls more flexibly when equipped with the new digital switching systems under stored-program control. Some telephones are turning into interactive terminals, and only the huge investment in existing systems is delaying the arrival of the more efficient digital equipment.

Meanwhile, transoceanic phone calls are multiplying as improved communications satellites are launched, and high-capacity inter-office trunking is seen as one application for the rapidly maturing technology of fiber optics. The newest radars, in processing signals, adapt on the spot to jamming and changes in the weather.

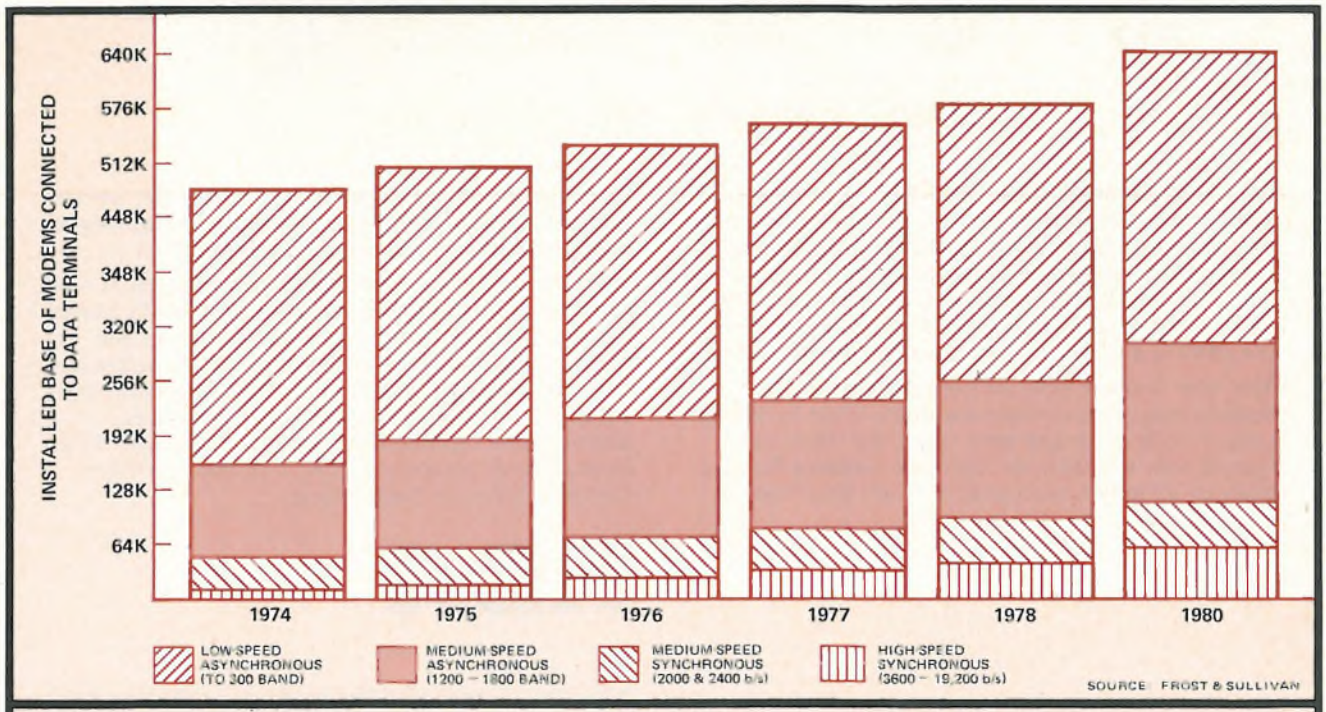
The driving force behind many of these developments is, of course, large-scale integration—the logic arrays, microprocessors, and high-density memories that outperform and undersell alternative technologies. But the pace at which the developments will be actualized, particularly in the U.S., will depend a lot on the decisions of the regulatory agencies.

by Richard Gundlach, *Communications & Microwave Editor*

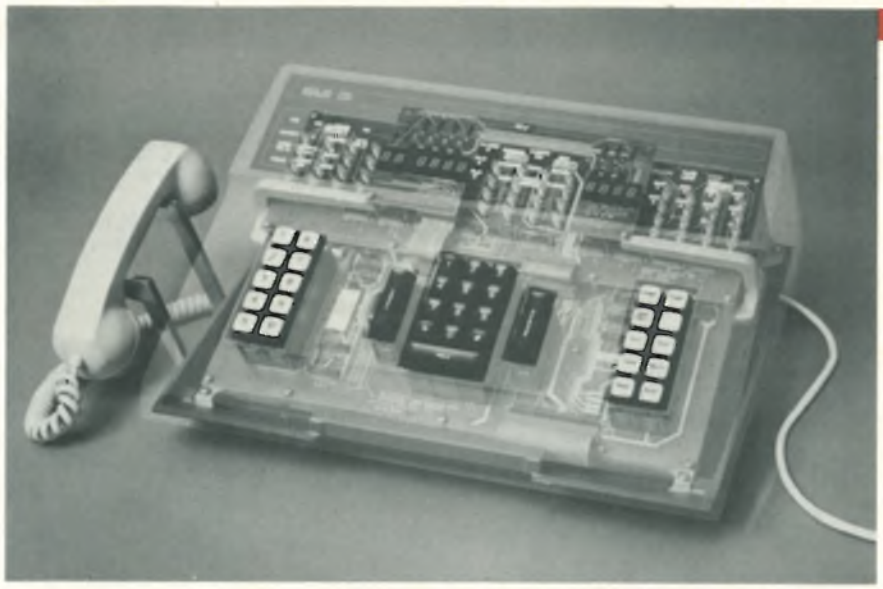
Terminals get smarter

This year's generation of private-branch exchanges (PBXs) is increasingly using microcomputers to control their digital-switching circuits—and at last is cost-competitive with electromechanical equipment. These stored-program exchanges are compact and are easily adapted to different users' needs since programs stored in the exchange's memory provide varied forms of network control and are easily rewritten when control requirements change. They even include self-diagnostic maintenance routines.

A forerunner of these newer PBXs, made by Digital



High-speed data traffic will increase more rapidly from 1977 on, but still will account for less than 6% of the total installed base of modems connected to data terminals. More than half of these modems will still be low-speed asynchronous devices by 1980.



Inside look. Visible through the "ghost" impression of the cover of the attendant console of Rolm's all-digital PBX console are LEDs, digital ICs, and LSI circuits.

Telephone Systems, San Rafael, Calif., is built round a 40-pin custom p-channel MOS LSI circuit. This chip converts voice-frequency inputs into a delta-modulated digital format before switching and then decodes the signals again before they are sent to the station. One of the stored-program PBXs introduced this year is from Rolm Corp., Cupertino, Calif. The processor in this unit routes calls in the way that will keep their cost to a minimum, sets limits on toll calls, and also keeps track of all outgoing calls automatically. Tele/Resources of White Plains, N.Y., has updated its programable PBX System 32 by adding microprocessor logic to collect data about outgoing calls. The new unit can then either print out the data continuously or store it on a digital cassette for later processing by the company. Another exchange, microprocessor-controlled and developed by Chestel Inc., of Chester, Conn., uses a programable read-only memory, so that new subroutines that satisfy different users' needs can be inserted without disturbing main ROM circuits.

Since these are just a few of the stored-program PBXs available or soon to be available, a real tug of war seems likely to develop between Bell with its microprocessor-based PBX, the Dimension System, trying to retain its foothold in this market, and a long line of other manufacturers, offering computer-controlled highly flexible PBXs at attractive prices.

From telephone to terminal

Telephones, as well as telephone exchanges, are becoming more talented—witness Bell's latest addition to its Transaction Telephone family of interactive terminals for use in check verification, credit authorization and electronic funds transfer. Scheduled for operation in April 1976, the Transaction II will serve as a regular business telephone and also, like its predecessor, read ABA magnetic stripe cards, place a call to the central data base automatically, and when the call is completed, transmit all the stored information. Unlike the earlier model, Transaction II also has an eight-character, seven-segment display for presenting either local keyed-in information or frequency-shift-keyed data messages received through its data receiver. It can operate in a voice-only or data-oriented system.

Although data is a very small portion of the traffic over communications networks of all kinds, it is the most rapidly growing segment. And the demand for still faster and cleaner transmission is another incentive for conversion to purely digital networks. The digital switching systems now coming on line will encourage the spread of the digital format in central offices and also in local distribution systems and will begin to affect the nature of the transmission plant (see table detailing the existing and planned facilities for voice, data, and video transmission).

The all-digital switching office going into service in Chicago this January will be the first in Bell's new high-capacity toll network, and several more will open later that same year. This electronic switching system (No. 4 ESS) is the largest one operational to date—it has a capacity of 107,000 trunks and, through its stored-program control, can switch 350,000 calls per hour.

With digital switching gaining momentum, it's important to consider how best to integrate both transmission and switching functions, which in the past have progressed quite independently from each other. Digital radio systems are being developed to offer lower-cost transmission of both digital data and digitized voice and will eventually force all users to consider them on the basis of cost per unit of information, particularly as LSI brings down system cost.

Meanwhile, Bell is working to upgrade in a cost-effective way its huge investment in 4- and 6-gigahertz radio systems, which carry about 65% of all phone traffic. Using improved linear-amplifier technology, it has developed an amplitude-modulated, single-sideband 6-GHz radio system that will put 6,000 voice circuits over the same 30-megahertz fm radio channel that at present provides only 1,800 circuits. With this new system, very little of the older setup must be changed.

An altogether different way of exploiting the limited space of the electromagnetic spectrum is to make re-

EXISTING AND PLANNED FACILITIES FOR VOICE, DATA, AND VIDEO TRANSMISSION

Service	Characteristics	Local Connections	Long-Distance Connections	Remarks
Dial				
Voice	Many transmitters (telephones), many receivers (telephones) Private, two-way connection	Well established[1] (twisted-pair)	Well established[1] (T-carrier, microwave radio, coax cable)	Strong emphasis on digital techniques 18-GHz radio (1978) Millimeter waveguide (1980's) Glass fibers (1980 – 85) Local facilities to be augmented by 900-MHz cellular mobile radio (1978)
Data				
Low-speed < 9.6 kB/s	Many transmitters (terminals), few receivers (computers) Increasing use of two-way, interactive connections	Established[1] Data speeds up to about 1.2 kB/s carried reliably on local loop Reliability for 2.4, 4.8 and 9.6 kB/s depends on age of equipment	Established[1,2] Reliability of Telco network depends on speed	Public data networks provide reliable, cheap service using message switching and data packets
Medium speed 50 kB/s	Some transmitters (RJE terminals, data banks, etc.) few receivers (computers)	Established[1,2] Special connection and/or conditioning required	Established[1,2] Data-under-voice (DUV) network Private networks	Switched data connections offered between major cities by Bell, Datran, Western Union
High speed > 1 MB/s	Few transmitters (computers), few receivers (computers)	Experimental[1,2]	Experimental[1,2]	Limited demand Possible with coaxial cable, optical fiber, microwave radio, domestic satellite, etc
Video				
Television	Some transmitters (TV stations), many local receivers (TV sets), few long-distance receivers (network stations)	Broadcasting well established One-way cable well established Some very limited two-way experiments (Broadcast TV, CATV)	Terrestrial cable[1,2] system used by networks Special events carried by satellites	Satellite distribution of pay-TV proposed Local two-way services may develop on cable, but not as fast as previously believed

1 – Established common carriers 2 – Specialized common carriers

Source: GTE Laboratories

peated use of the same frequency, essentially by making multiple low-power transmissions from multiple geographical locations. This is the basis for AT&T's cellular concept, which the Federal Communications Commission has now blessed for use by all qualified common-carrier cellular developers—not just AT&T—in the recently opened 40-MHz slot in the 900-MHz region.

The cellular approach

The goal is to develop a fully interconnected, mobile radiotelephone network. The means are partly the new allocation of spectrum, which makes more channels available, partly the reusability of channels so that literally millions of callers can be accommodated, and partly the advances in electronic switching, which make it possible to tie all the base stations and mobile units together into an integrated network.

Other types of mobile-radio systems have been limited in capacity, because they use one high-powered base station to transmit in all directions over a large area. The cellular approach is different. It divides that same area into smaller segments or "cells" packed together in such a way that radio channels used in one cell can be simultaneously reused in various other cells spaced far enough apart to avoid radio interference. A conversation is carried over wire lines to the base station in the cell through which the mobile unit being called is passing. The path between the called and calling parties is completed via a low-power directional antenna at the base station or cell site. And as the mobile unit travels from cell to cell, the call is automatically and without interruption given over to the appropriate base station by the computer-controlled mobile switching office.

Bell plans to start field trials of its cellular concept in Chicago in 1978 using equipment supplied by OKI Electronics of America, Fort Lauderdale, Fla., and E. F. Johnson Co. of Waseca, Minn. It proposes to divide the allotted 40-MHz bandwidth in half, using one 20-MHz channel to receive and one to transmit. Each of the 30 kilohertz channels could carry 666 voice conversations, which with frequency reuse would increase tenfold.

Although most manufacturers will emphasize equipment to operate in 900 MHz, the stress in other fm land-mobile bands has been on coded communication equipment for such jobs as automatically keeping track of vehicle status at headquarters. By now, digital techniques are finding their way into mobile radio, where they eliminate the need to go through voice identification and acknowledgment processes with a base station. The digital approach is also faster and more secure and makes more efficient use of the spectrum. Moreover, it provides more slots to accommodate more mobile users. The next step is, again, an all-digital network that will let the mobile radio access a computer directly.

Citizens' band radio, too, is becoming very popular,

EXISTING AND PLANNED SATELLITE COMMUNICATIONS NETWORKS

COUNTRY OR REGION COVERED	OPERATIONAL DATE	REMARKS
USSR – Molniya 1	1967	TV
USSR – Molniya 2	1972	Telephony, telegraphy and TV
U.S. – RCA Satcom	1973 (via Anik)	Telecommunications for Alaska and U.S. (RCA will launch own satellite in 1976)
Canada – Telesat	1973	Telephony, message service and TV
U.S. – Westar	1974	Private-line video and telecommunications
U.S. – Amsat	1974 (via Anik)	Wideband data, military; commercial video and PL
USSR – Intersputnik	1974	Soviet Union, Poland, Czechoslovakia and Cuba
Algeria	1975	Telephony and TV
Brazil	1975	TV
India	1975	ATS-6 educational TV
Malaysia	1975	Telecommunications
Atlantic/Pacific – Marisat	1975	Initial ops for U.S. Navy
Nigeria	1975	Telecommunications
Norway	1975	Telephony to gas and oil platforms
Atlantic/Pacific – Intelsat IV	1976	Transoceanic communications
Indonesia	1976	Telephony and TV
U.S. – AT&T Comstar	1976	Supplement long-haul network
Canada and U.S. – CTS	1976	Communications technology
Arab League	1977	Telephony
Western Europe – OTS	1977	Pre-operational telecommunications tests
Japan	1977	Broadcast and telecommunications (2 satellites)
Atlantic/Pacific – Aerosat	1978	Transoceanic communications
U.S. – CML Satellite Corp.	late 1970s	Digital Data Communications

SOURCE: ARTHUR D. LITTLE INC.

now that the FCC is increasing the number of CB channels to 40 and has dropped the cost of a license from $20 to $4. In fact, license applications are coming through the FCC at so fast a rate—around 200,000 a month—that manufacturers of CB transceivers think the 1976 market may be four million units. This is for Class D citizens' band 23-channel 4-watt-output base and mobile units, only—walkie-talkies are not even included.

A major problem for CB manufacturers is getting enough crystals. Twelve to 14 are needed for each 23-channel set, and several companies are looking to digital and phase-locked-loop synthesizer techniques to minimize the number of crystals used in their new designs.

A decade of technological progress

Transoceanic phone calls take a more sophisticated technology than CB, and indeed they were launched into the space age by the Early Bird satellite as long as 10 years ago. For one such call made in 1965, more than 10 are being made today, and the annual total exceeds 150 million. Today there are six Intelsat IVs in orbit (see table, "Existing and Planned Satellite Communications Networks"), yet their successors, the IV-As, are being built with nearly double the IV capacity to handle the more than 200 million transoceanic calls forecast for 1980.

In addition, this year's Marisat launch for the first time gave ships on the high seas high-quality communications services on a full-time basis. Telesat Canada, too, launched its third Anik satellite last May.

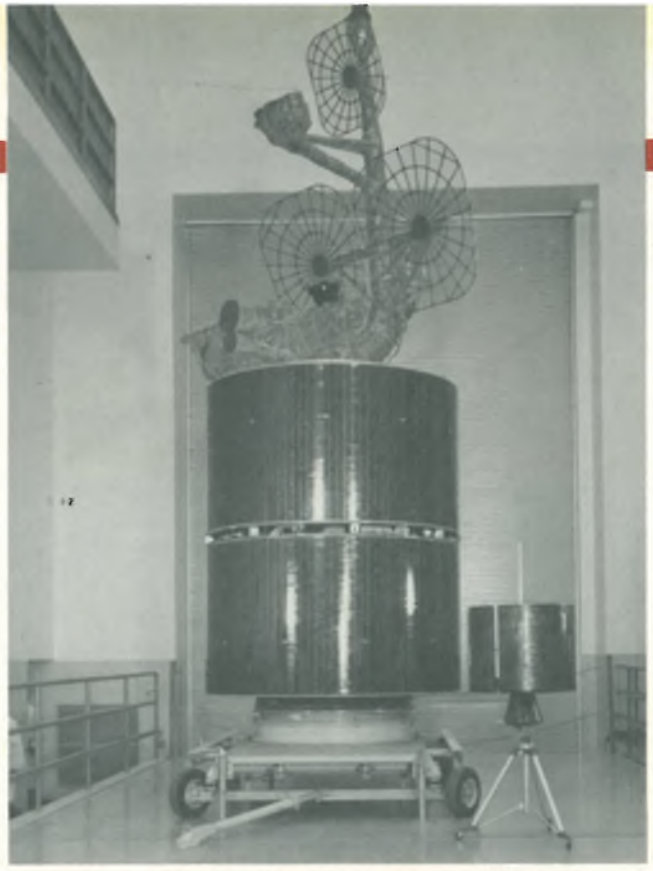
The first Intelsat IV-A is scheduled for launch this fall, and RCA's domestic satellite should go up early next year. Both make use of several technological innovations for frequency reuse such as dual polarization and antenna beam-shaping and -isolation techniques.

Sharing the spotlight in satellite communications are the newer earth terminals. They have smaller, inexpensive antennas and need a good deal less equipment, thanks to advances in device technology and modulation techniques.

Economy is pushed to the limit in a ground unit developed for satellite routes that have only light traffic. Introduced this year by Digital Communications Corp., Gaithersburg, Md., the stand-alone channel unit (STAC) is self-sufficient and replaces the large amounts of equipment common to multiple-channel installations. The approach, which adapts existing single-channel-per-carrier technology, keeps startup costs low and still permits expansion when called for.

Fiber optics moves ahead

Stimulated by a $500 million estimate for the 1980 market in fiber-optic communications systems (excluding major telecommunications markets), the technology is reaching maturity a lot faster than at first envisioned. The root cause is a growing demand for faster, higher-capacity transfer of information. The systems are being looked at for interoffice telephone lines, for data busing, and for video distribution both between cities and



Evolution. The Intelsat IV-A dwarfs its predecessor in both physical size and channel capacity. The tiny Early Bird, the first synchronous commercial satellite, went into operation 10 years ago with 240 two-way channels; IV-A can handle 11,000 channels.

within the same building. And since fiber-optic and copper cable may soon cost about the same, the two leading telecommunications companies are readying fiber-optic systems for field trials early next year. Both systems, which will use electronic/optical interfaces, are being considered as eventual high-capacity replacements for interoffice trunking.

GTE Laboratories, Waltham, Mass., plans to use fibers with a loss of 5 decibels per kilometer so that runs of up to 15,000 feet between repeaters will be possible. This compares favorably with the 6000-ft spacing now needed for twisted-wire pairs. One of the things Bell Laboratories wants to find out from its tests is the quality of transmission with 5- or 6-mile spacing between repeaters. Besides reducing the numbers of repeaters, Bell would like to get the units out of the manholes and into offices, where they should be less costly to maintain. In fact, the company conjectures that it may be less costly overall to run fiber cables between several central offices, instead of only one cable along a more direct route between two offices and with repeaters along the way.

Attenuation in the fiber keeps coming down. Under laboratory conditions, Bell Labs has reported only 0.9 dB/km at 1.06-micrometer wavelength. But more importantly, optical communications technology has moved out of the lab and into the real world. Bell, for instance, has reported a new splicing technique that prepares fiber in one step instead of three. Corning Glass Works, Corning, N.Y., and Deutsch's Electronic Components division in Banning, Calif., have jointly produced the first practical single-channel-per-fiber connector with less than 0.3 dB of mating loss. And several other companies such as ITT Cannon, Bell Northern Research, and the American division of Thompson-CSF are selling practical components.

Radar looks to distributed processing.

Over the past several years radar systems have gotten deeply into software and data processing and by now are evolving along with developments in these areas. Currently, the move is away from central processing to distributed processing, based on relatively low-cost microprocessors coupled with LSI random logic and memory. Very soon, the need for more computational capability is going to produce systems sprinkled throughout with microprocessors.

Signal processing has already achieved greater adaptability to real conditions—much too complex a luxury in radar before the maturity of digital LSI. Signal thresholds, gain settings, and so on need no longer be adjusted at the factory but are controlled by the processor as the need arises when the equipment is in operation. When it is raining or if jamming is present, for instance, the processor will automatically adapt thresholds and other parameters to avoid false targets. Digital processing also provides its customary bonus of greater communications security.

In radar systems overall, the trend is to phased arrays, which are ideally suited to tracking multiple targets. Though not a new idea, the approach still needs several technological breakthroughs before it becomes cost-effective. The software for very sophisticated real-time programing and beam steering, for example, is still a major stumbling block, and array elements such as phase shifters must drop to half of today's $100 price tag. Moreover, higher-power, greater-efficiency rf power sources are a must, though low-cost Impatt diodes and low-loss combiners may be the answer.

As all this suggests, radar technology is still seen as a growth area that warrants a significant continuing R&D commitment. George H. Heilmeier, new director of the Defense Advanced Research Projects Agency, cites four areas that require further study.

First, there's a need for a small remotely piloted vehicle carrying either a millimeter-wave designator for all-weather weapon delivery or a radar illuminator (not necessarily narrow-beam) for all-weather missions. Second, an approach to target acquisition and battlefield surveillance is required that locates the transmitter in a sanctuary area, centralizes the processing to keep costs down, and uses low-cost data links to transfer critical radar information from receiver to processor to users. Third, frequency-hopping techniques, random pulse repetition frequencies, and long pseudorandom-noise-coded pulses could be used to counter the time-of-arrival and antiradiation missile threats. Finally, adaptive processing for antenna-beam sharpening and selective null placement should be developed to eliminate discrete interference sources, and digital filters could be replaced by charge-coupled devices and surface-wave acoustic filters. □

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Two-way 0°						
PSC 2-1 ZSC 2-1 ZMSC 2-1	0.1-400	25	0.4 above 3dB split	1	0.1	$ 9.95 (6-49) $24.95 (4-24) $34.95 (4-24)
PSC 2-2 ZSC 2-2 ZMSC 2-2	0.002-60	40	0.3 above 3dB split	1	0.1	$19.95 (6-49) $34.95 (4-24) $44.95 (4-24)
PSC 2-1W ZSC 2-1W ZMSC 2-1W	1-650	25	0.5 above 3dB split	3	0.20	$14.95 (6-49) $29.95 (6-49) $139.95 (6-49)
PSC 2-1-75*	0.25-300	25	0.4 above 3dB split	1	0.05	$ 9.95 (6-49)
MSC 2-1	0.1-450	30	0.4 above 3dB split	1	0.1	$16.95 (6-24)
Two-way 180°						
PSCJ 2-1** ZSCJ 2-1	1-200	33	0.6 above 3dB split	2.5	.15	$19.95 (5-49) $34.95 (5-49)
Two-way 90°						
PSCQ 2-90	55-90	30	average of coupled outputs less 3dB 0.3	3	1.0	$ 19.95 (5-49)

Model No.	Freq. range (MHz)	Isolation between outputs (dB) typical	Insertion loss (dB) (typical)	Unbalance φ (deg)	Unbalance Amp. (dB)	Price (Quantity)
Three-way 0°						
PSC 3-1 ZSC 3-1 ZMSC 3-1	1-200	30	0.4 above 4.8 split	2	0.1	$19.95 (6-49) $34.95 (4-24) $44.95 (4-24)
PSC 3-2 ZSC 3-2 ZMSC 3-2	0.01-30	40	0.25 above 4.8 split	2	0.1	$29.95 (6-49) $44.95 (4-24) $54.95 (4-24)
Four-way 0°						
PSC 4-1 ZSC 4-1 ZMSC 4-1	0.1-200	30	0.5 above 6dB split	2	0.1	$26.95 (6-49) $41.95 (4-24) $51.95 (4-24)
ZSC 4-2 ZMSC 4-2	0.002-20	33	0.45 above 6dB split	2	0.1	$64.95 (4-24) $74.95 (4-24)
PSC 4-3 ZSC 4-3 ZMSC 4-3	0.25-250	30	0.5 above 6dB split	2	0.1	$23.95 (6-49) $38.95 (4-24) $48.95 (4-24)
Six-way 0°						
PSC 6-1	1-175	30	0.75 above 7.8dB split	4	0.2	$59.95 (1-5)
Eight-way 0°						
PSC 8-1	0.5-175	30	0.8 above 9dB split	3	0.2	$59.95 (1-5)

COMMON SPECIFICATIONS FOR ALL MODELS: Impedance all ports, 50 ohms. *Except 75 suffix denotes 75 ohms VSWR:1.1-1.2 typical Nominal phase difference between output ports, 0° **Except J suffix denotes 180° Q denotes 90° Delivery from stock; One week max.

For complete product specifications and U.S. Rep. listing see MicroWaves' "Product Data Directory," Electronic Designs' "Gold Book" or Electronic Engineers Master "EEM"

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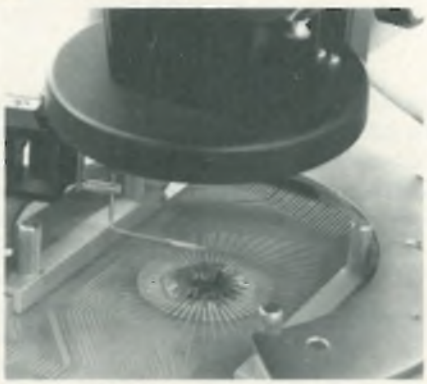

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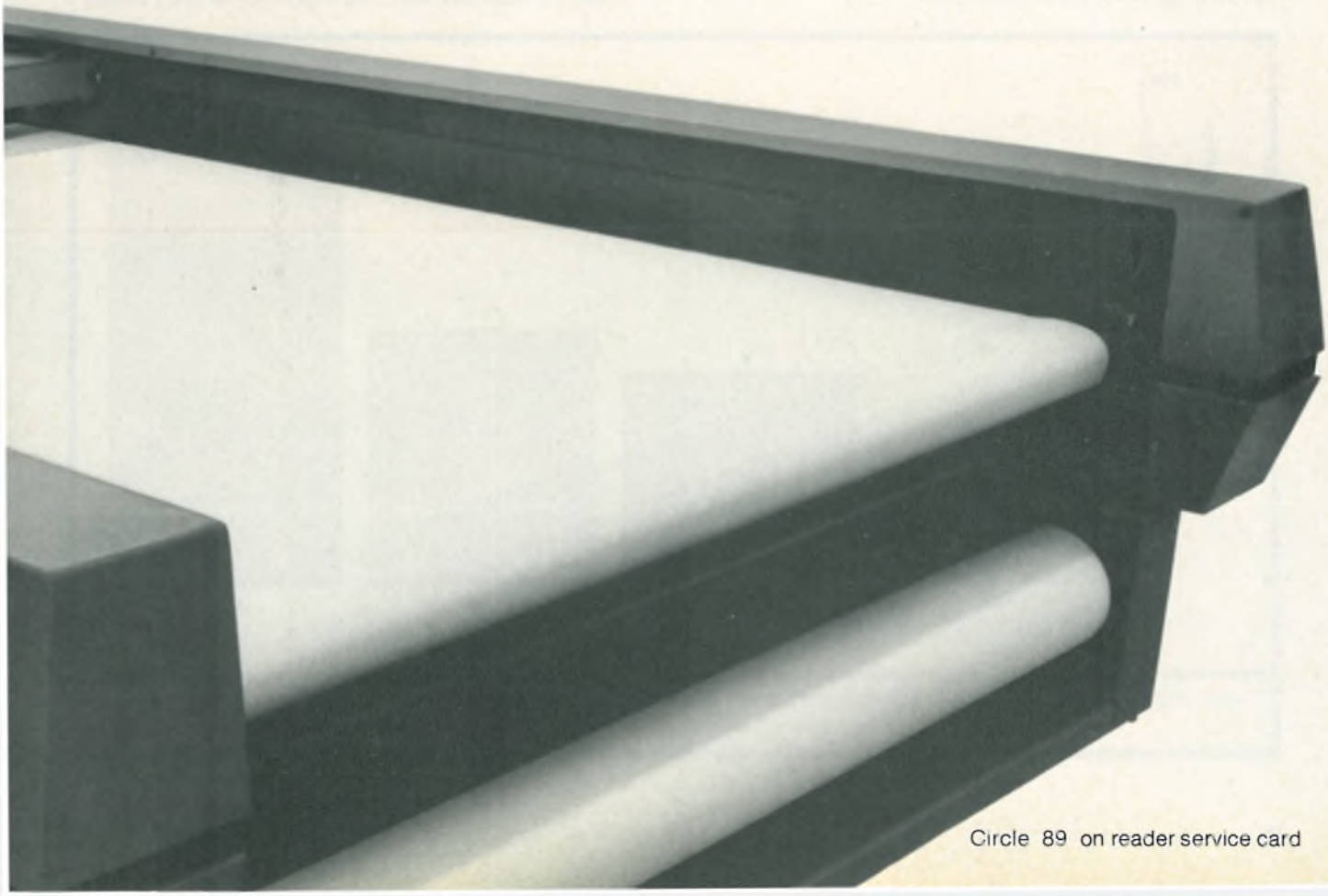


Circle 89 on reader service card

Smarter, cheaper gear is more versatile

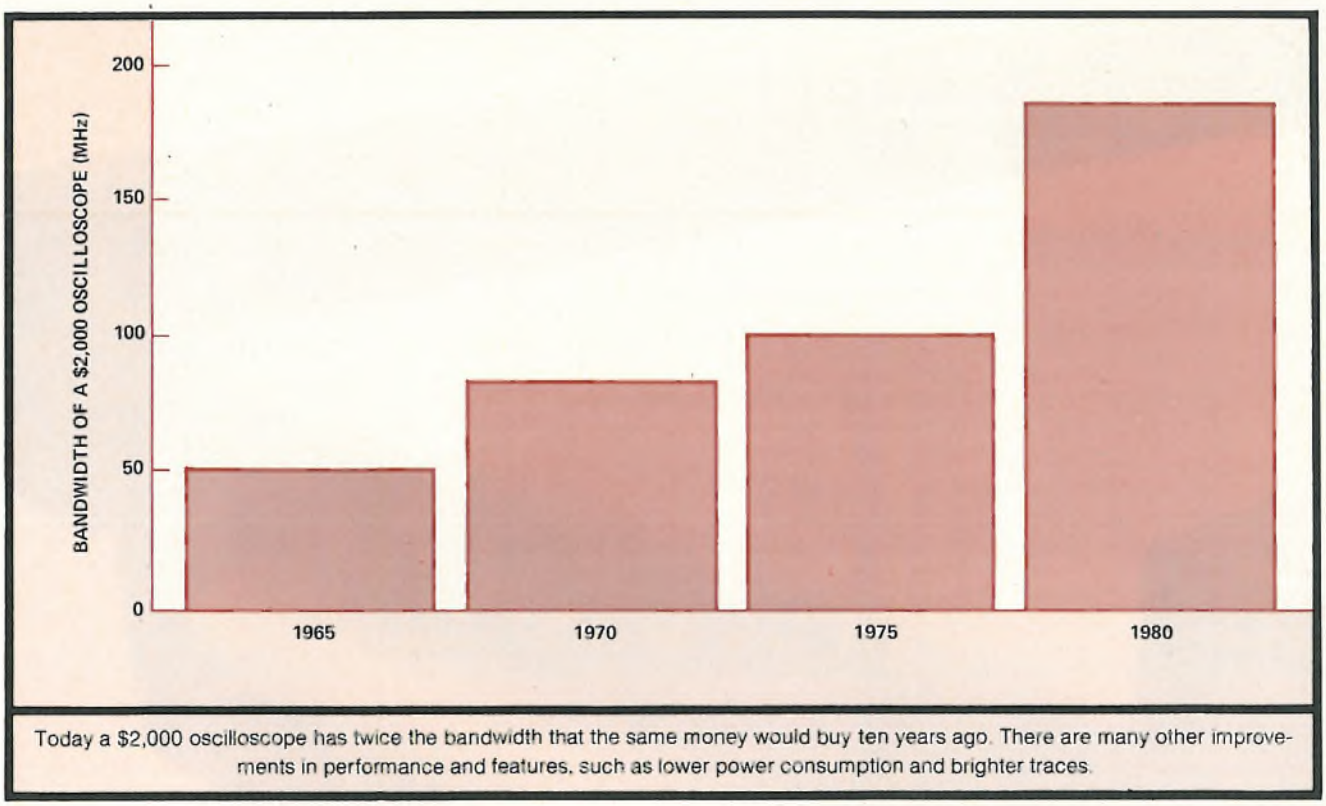
☐Performance criteria in test and measuring equipment have been taking second place to cost criteria more frequently since the onset of the long economic doldrums. This has meant a move toward lower-priced instruments—the better to appeal to a soft demand.

Among the few recent advances in instrumentation technology, perhaps the most important is actually an advance in semiconductor technology, namely the microprocessor. This is an item being used more often and with greater sophistication in interface, control, and computation in instrumentation and medical diagnostic equipment. At the same time the growing understanding of the special problems of testing microprocessors and microprocessor-based systems has led to new test gear designed specifically for digital products.

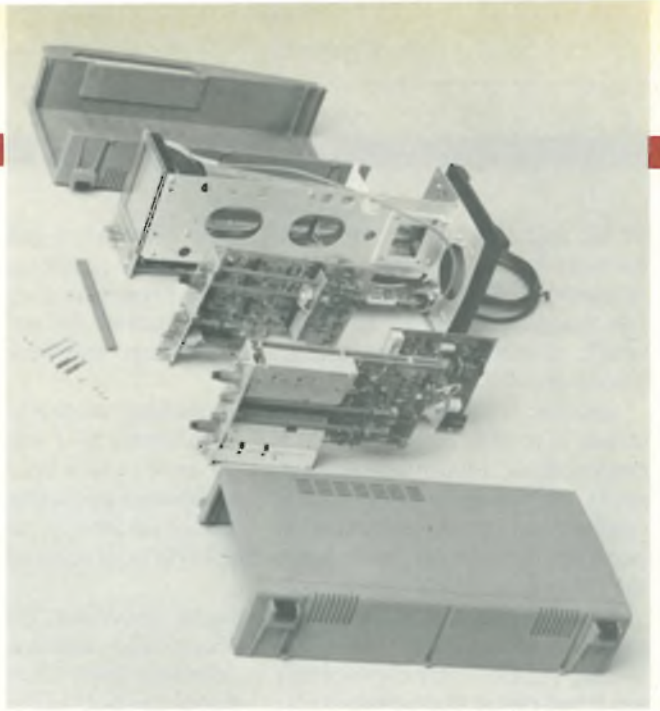
A brief summary of these and other significant developments in instrumentation would look like this:

- Lower-priced instruments. Instrument makers, by concentrating more on packaging and production, have lowered the cost of a wide variety of test instruments.
- Microprocessors. In such traditional gear as oscilloscopes, voltmeters, signal generators, and counters, microprocessors are finding an important range of applications. While microprocessors generally take over functions formerly done by fixed logic, instrument makers are learning new tricks, like storing linearization curves and offsets in built-in instrument memories.
- Clinical diagnosis simplified. In medical instruments, where unit prices are higher and users less familiar with electronics, microprocessors are being used to lower the cost of diagnosis while speeding the sample-testing process. Microprocessors are being used here even more fully than in other types of instruments.
- Standard interface bus. Microprocessors are playing a

by Andy Santoni, *Instrumentation Editor*



Today a $2,000 oscilloscope has twice the bandwidth that the same money would buy ten years ago. There are many other improvements in performance and features, such as lower power consumption and brighter traces.



Cost cutting. Improved packaging techniques, like mounting most components on plug-together pc boards to minimize hand wiring, can lower the cost of instruments.

role in popularizing the universal instrument interface bus. Because they make re-formating digital data a relatively simple operation, microprocessor-based instruments can have a variety of interface options, including the IEEE standard.

- Microprocessor testing. A major stumbling block with microprocessors is the problem of testing the devices themselves and the boards and systems that use them. Automatic test systems that operate at high enough speeds and test methods that promise a high enough confidence level are just now becoming available.
- Digital troubleshooting. Manual methods for troubleshooting on multi-line digital systems are becoming more sophisticated. An understanding of the differences between troubleshooting analog and digital systems has led to a new class of testers.
- Safety. Most instrument makers are improving the safety of their products. Part of the reason is the Occupational Safety and Health Act, which mandates less dangerous equipment in places of employment.
- True-rms measurements. Nonsinusoidal signals like those produced by digital circuits and power switching systems are becoming more common, and the increased demand for instruments that measure such signals has led to new techniques for extracting true-rms values.

The economy prescribes

Gloomy, confusing economic conditions have kept most buyers' capital budgets tight. The reaction of instrument makers has been to design for more favorable price/performance ratios rather than push for state of the art. As a result, much of the new technology being applied to instruments involves packaging techniques that lower the cost of assembly, not circuit designs that improve electrical performance. The T900 series of portable oscilloscopes from Tektronix, Inc., Beaverton, Ore., is a good example.

The top-of-the-line dual-trace model T935 has a bandwidth of 35 megahertz, vertical sensitivities from 2 millivolts to 10 V per division, and dual time bases. This is hardly startling, especially when compared with the industry-standard model 465, which has 100 MHz bandwidth at 5 mV/div. But the T935 is adequate for many scope users, and is priced more than 40% lower than the 465—$1,250 compared with $2,095.

Such advances are in the form of manufacturing improvements. The T900 scope uses single-sided pc boards instead of the more-expensive double-sided or multilayer variety. As many components as possible—including front-panel switches—are mounted on the boards to minimize time-consuming point-to-point wiring. In fact, there is almost no hardware on the unit's rear panel.

Pulse generators are also coming down in price for a given level of sophistication. With pulse generators, "better" has usually meant higher repetition rates or shorter rise times. But as the product matures and becomes a fixture on more circuit designers' test benches, the next direction is toward lower cost.

Here again, designing a lower-priced product requires careful attention to packaging, says Bernie West, chief engineer at E-H Research Laboratories Inc., Oakland, Calif. Putting as many functions as possible on a single printed-circuit board is just one of the techniques needed to minimize production costs. The goal is simplicity, or what West calls "spartan architecture."

While pulse generators are becoming less expensive in their present "bench-top" configuration, increased demand is also spurring suppliers to provide products more appropriate for system uses. More pulse generators that are digitally programable are becoming available for use in test systems that examine the parametric behavior of devices and systems by measuring their response to a step-input stimulus.

Lower-cost techniques

Along with lower-cost instruments, lower-cost measurement techniques are being devised. A prime example is the oscillator calibration system developed by the National Bureau of Standards, Boulder, Colo. The system uses phase comparison with network-broadcast color subcarrier signals to perform oscillator calibrations with resolutions of a few parts in 10^{11} [*Electronics*, March 20, p. 107].

All that's needed to implement this system is a color

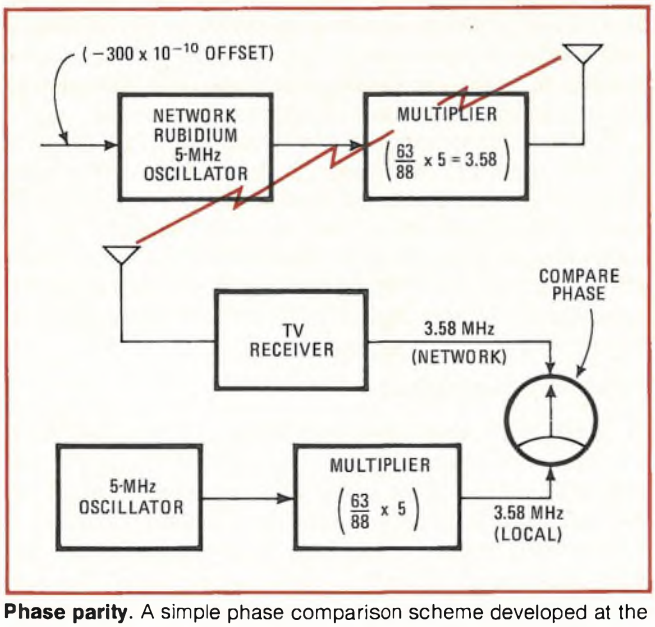
TV set and a simple comparator circuit. The circuit can be built from parts that cost less than $50; a wired instrument version is available from the Dynatron Co., Los Angeles, for $100. In effect a few hundred dollars' worth of equipment can replace a rubidium reference priced at nearly $8,000.

Another way to lower the cost of making measurements is to take advantage of the capabilities of a microprocessor. Instrumentation makers have in fact been applying microprocessors to make equipment operation simpler and less time-consuming—and therefore less expensive—rather than to improve the basic operation of the instrument itself.

In the model 6011A synthesized signal generator, for example, John Fluke Mfg. Co., Mountlake Terrace, Wash., applies a microprocessor to interface both manual front-panel and automatic rear-panel controls to the signal-generating circuitry [*Electronics*, Sept. 18, p. 138]. The microprocessor performs a number of bookkeeping functions: keeping track of control positions to flag invalid modes, directing signals between circuits, memorizing sets of frequency and amplitude data for later recall, and formatting data for display.

But the microprocessor does little to improve the basic performance of the generator. A frequency range from 10 Hz to 11 MHz and a maximum open-circuit output voltage of 28.28 V peak-to-peak would have been possible without the microprocessor.

Instead, the microprocessor makes the model 6011A less expensive to use. By storing nine sets of frequencies and amplitudes that can be recalled by pushing one button, the 6011A can speed repetitive tests that require a series of different outputs. And by allowing an operator to program amplitudes in terms of decibels referenced to a stored level, the 6011A simplifies tests such as frequency response and linearity.



Phase parity. A simple phase comparison scheme developed at the National Bureau of Standards permits high-resolution oscillator-frequency calibration using a TV signal as a reference.

Where technicians are less well-trained in electronics, as in medical and chemical laboratories, the ability of microprocessors to simplify testing is greatly appreciated. Microprocessors are especially well-suited to the needs of medical testing labs because the high prices for medical electronic equipment can support the costs of microprocessor hardware and software design.

Simpler clinical tests

At Union Carbide Corp.'s Clinical Diagnostics department, Rye, N.Y., Intel microprocessors have been applied to a system than automates radioimmunoassay (RIA) procedures. Physicians use RIA to determine the concentration of specific molecules in serum or plasma by using antibodies and radioactive labeled molecules as reagents. The methods used up to now are tedious, involve many critical manual steps, and require considerable skill to achieve maximum reproducibility.

Using microprocessors to automate the pipetting, incubating and separating steps can reduce potential error, says Ed Cohen, systems manager. At the same time, throughput has been increased from 100 or 150 tests per day to as many as 800 per day.

Another way to lighten the load and offset the shortage of trained hospital staff is to use a computer to manipulate data taken from patient monitors. A system from Siemens AG, Munich, keeps tabs on such body functions as heart beat, blood pressure, respiratory function and body temperature; it analyzes the measured values, and signals critical conditions on a visual display at a nurses' station or in the doctor's office.

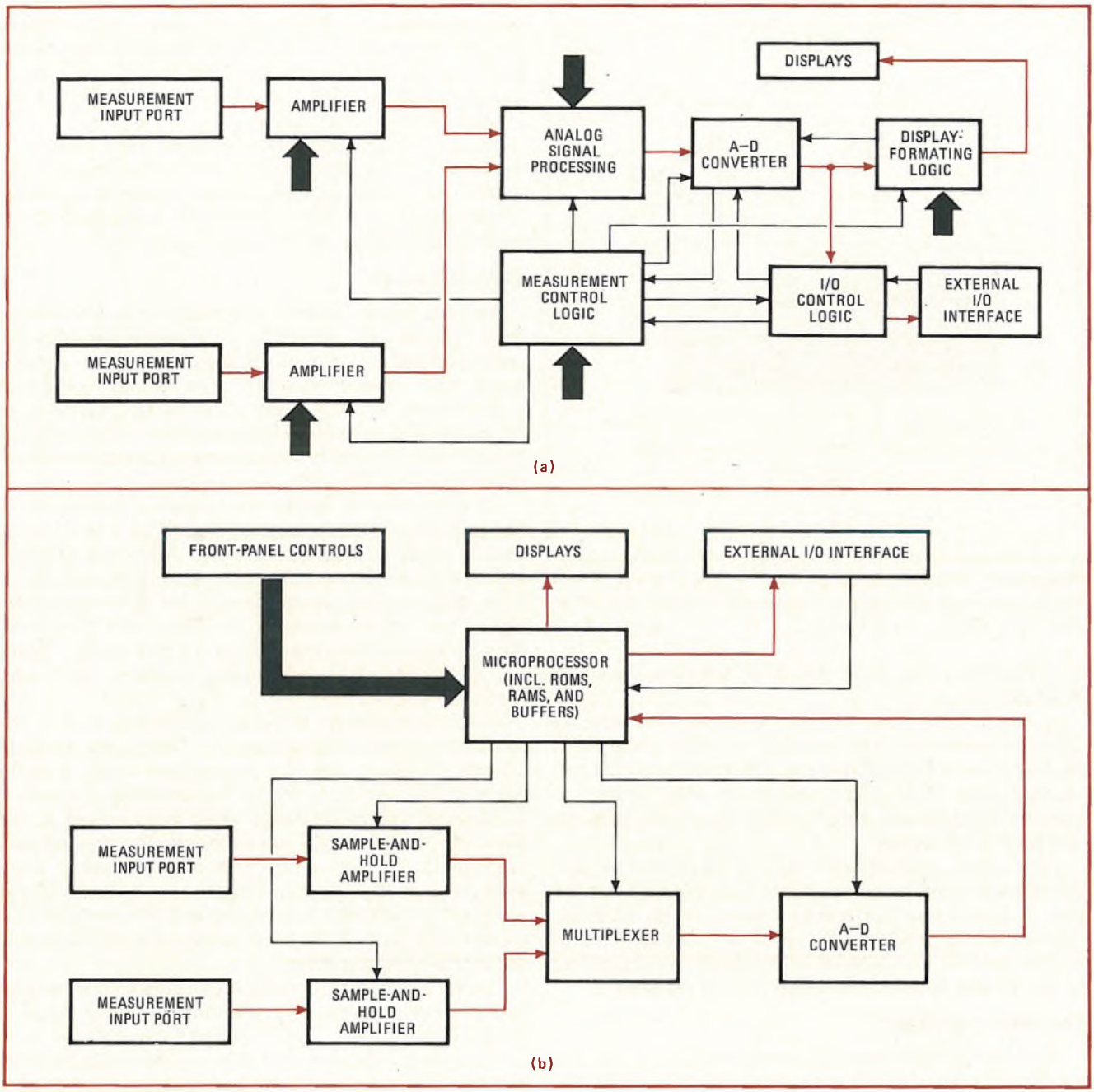
Easier interfacing

Counter/timers, multimeters, and many other instruments can use microprocessors to simplify making a variety of interface options available. The microprocessor can change the format of digital data within the instrument for convenient connection to instrument systems. In the 6011A synthesizer, to cite one example, a Fluke-defined parallel ASCII interface is standard, and either IEEE-488 or RS-232C interfaces are options.

Other instruments with microprocessors to increase input/output flexibility include the series 9000 counter/timers from Dana Laboratories, Inc., Irvine, Calif. [*Electronics*, Sept. 4, p. 129]. Four interface options are available: IEEE-488, a serial ASCII-2 interface that allows use of a teletypewriter as a printout device, BCD, and a high-speed computer interface that permits a higher transfer rate than the IEEE bus.

The microprocessors in these instruments also perform calculations and permit keyboard entry of manual commands so that signal-carrying wires to front panels can be eliminated. Says Marvin Wilrodt, staff engineer at Hewlett-Packard's Santa Clara division, such designs will help suppliers hold the line on costs while adding things like wider frequency ranges and programable offsets and linearization for special applications.

At the same time, counters that can handle higher

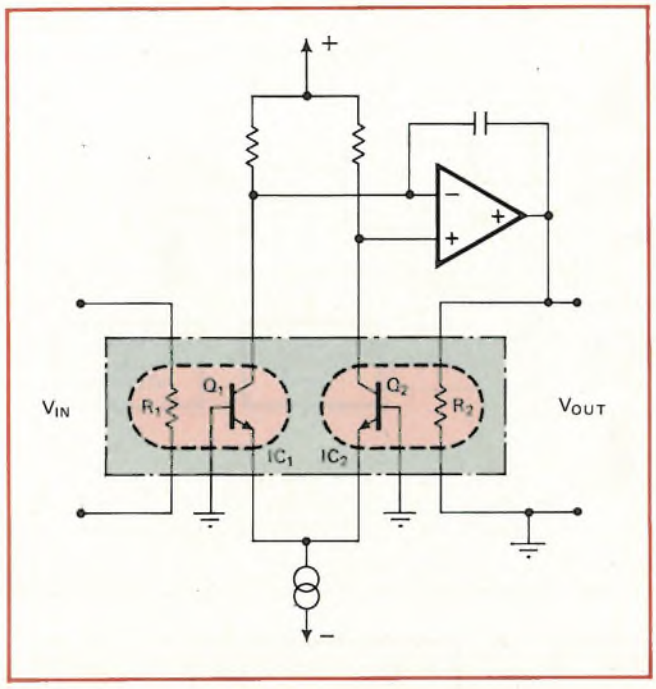


Instrument architecture. Unlike typical digital-readout instruments, which handle signals in analog form (a), microprocessor-based products (b) convert to digital further ahead in the processing chain. In both diagrams, signal paths are in color and control lines in black.

frequencies are becoming available for use in communications applications in the 900 MHz band. And the use of such low-power circuitry as C-MOS will help lower the cost of using counters while permitting battery operations for field service needs.

Counters have also been featuring more and more digits, notes Wilrodt. In some cases this may mean that the counter's resolution exceeds the stability of its time base. For relative measurements taken within a short time period—examining the change in output frequency of an oscillator with changes in some circuit parameter, for example—all the counter's digits may be meaningful. But users must be careful when making absolute measurements of frequency.

The increasing popularity of microprocessors in instruments should help make the IEEE standard instrument interface more common. The standard, initiated by Hewlett-Packard Co., Palo Alto, Calif., has been accepted for ballot by the International Electrotechnical Commission for worldwide use. It has already been applied to instruments from HP, Fluke, Wavetek Inc., San Diego, Calif., Dana and its subsidiary Exact Electronics



True value. Using the definition of true-rms, this circuit, used in a Philips multimeter, automatically compares the heating value of an input signal with that of a dc voltage.

Inc., Hillsboro, Ore., and Rohde & Schwarz Sales Co., Fairfield, N.J.

In fact both Dana and Rohde & Schwarz are offering modules that convert the interface on given instruments in their lines to the IEEE system. The Dana units use microprocessors under either PROM or ROM control to simplify tailoring the units to the instruments they are designed to work with.

Here again, performance takes a back seat to cost. The interface bus standard, while expected to lower the cost of assembling instrument systems, is far from the fastest method available. But in those systems where it can be applied, it should be substantially less expensive to implement than do-it-yourself interface circuitry.

The testing problem

Yet for all their benefits, microprocessors are not without drawbacks. One is the difficulty of training engineers to program them. And more important, perhaps, is the problem of testing microprocessor chips and systems so that proper operation can be guaranteed.

The first question is whether it is sufficient just to test a microprocessor's functions—does the right set of inputs elicit the right set of outputs?—or is it necessary also to examine parametric behavior? Second, microprocessor users must determine whether they can rely on tests performed by the supplier or tests performed at incoming inspection instead of testing completed assemblies for proper operation.

Even then, there are choices to make between various testing methods. Microprocessors can be compared with other, similar units that are assumed to be good, or can be compared with a written test specification. Either random input patterns or a fixed series of data words can be used. And the necessity for testing at the maximum operating speed that the microprocessor will see in use has not yet been proven.

There's no question, however, that some method is required to track down a fault once it has been determined that a microprocessor-based system is not functioning properly. Here, test equipment designed to operate in the data domain becomes invaluable.

Making it safer

Another factor becoming more important to instrument makers—and one that will increase rather than decrease instrument costs—is the need to design test equipment with safety in mind. The impact of OSHA requirements, and the desire of instrument suppliers to protect their customers, is becoming clear: longer design cycles, more expensive components, and more personnel to monitor safety-related procedures.

To guarantee the safety of equipment used in factories and offices, OSHA requires testing by a third party such as Underwriters' Laboratories. And UL is attempting to meet the demand for safety testing of instruments by writing a safety standard—UL 1244. Instruments designed to conform to safety standards—like the model 60 volt-ohm-milliammeter from Triplett Corp., Bluffton, Ohio—are already becoming available, and more are in the works.

New techniques for true-rms conversion, such as the stochastic-ergodic method used by Norma Messtechnik GmbH, Vienna, and the automated ac-dc transfer method used by N. V. Philips' Gloeilampenfabrieken, Eindhoven, the Netherlands, have been added to the thermal conversion and calculating methods previously employed. The new techniques promise higher accuracies over wider ranges of frequencies and crest factors because they depend less on the transfer linearity of a thermoelement or have fewer stages of amplification in the signal-handling chain.

Norma's stochastic-ergodic measuring technique uses probabilistic principles in converting an analog signal to a digital pulse train. The pulse train can then be measured by logic circuitry that does not have the linearity and dynamic range limitations of analog circuits used in earlier products [*Electronics*, July 24, p. 86].

The Philips circuit applies the basic definition of rms voltage—the value of the dc voltage which will produce the same amount of energy in the same time. Philips uses an operational amplifier as a control element to balance the heating effect of the input signal on one transistor with a dc signal that heats another transistor.

The dc voltage generated in this fashion, which has the same value as the true-rms value of the input ac signal, can be measured by relatively simple dc voltmeter circuitry. One application is in a digital multimeter that measures the true-rms value of ac voltages from 20 millivolts to 600 V full-scale and from 30 hertz to 100 kHz with 3½-digit resolution (see page 137). □

The Harris Report.

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HM-7603 (three-state)	256	32 x 8	16	40ns	50ns	$2.95	$5.95
HM-7610 (open coll)	1024	256 x 4	16	60ns	75ns	$4.95	$9.95
HM-7611 (three-state)	1024	256 x 4	16	60ns	75ns	$4.95	$9.95
HM-7620 (open coll)	2048	512 x 4	16	70ns	85ns	$9.95	$19.95
HM-7621 (three-state)	2048	512 x 4	16	70ns	85ns	$9.95	$19.95
HM-7640 (open coll)	4096	512 x 8	24	70	85ns	$19.95	$39.95
HM-7641 (three-state)	4096	512 x 8	24	70	85ns	$19.95	$39.95
HM-7642 (open coll)	4096	1024 x 4	18	70	85ns	Available January '76	
HM-7643 (three-state)	4096	1024 x 4	18	70	85ns		
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INDUSTRIAL

Controls save energy, refine processes

☐Spiraling costs of materials and energy are forcing massive changes in industrial companies. Pressured to save where once they had wasted, manufacturers are now pushing to tighten control of processes and decrease their energy usage.

Increasingly sensitive and reliable sensor and analytical instruments, frequently tied to computer controls, are chopping waste by narrowing process tolerances. For even more economy, manufacturers are boosting system performance with advanced control techniques. The microprocessor is part of this trend, making complex control feasible for even the smaller process loops.

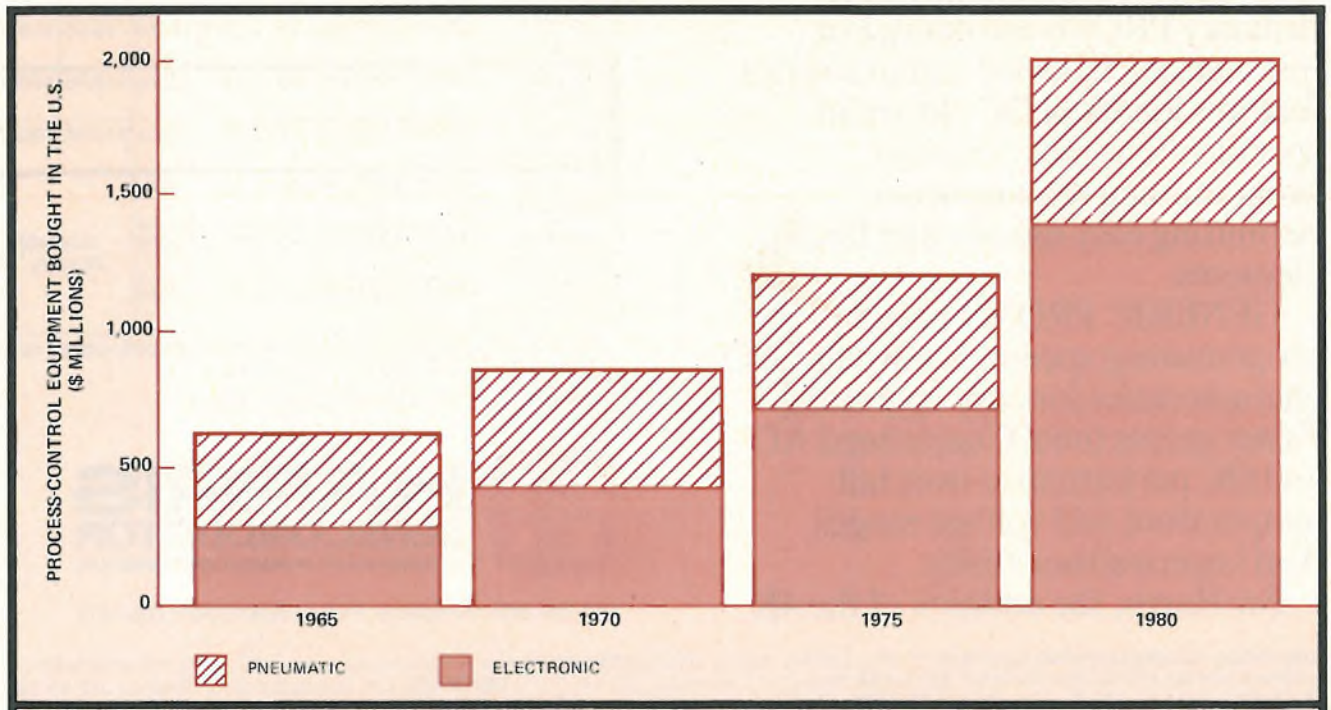
While improved sensor and microprocessors can help save materials, energy is being conserved by a technology that has remained relatively dormant for years—power-demand controls. Cost savings through alternate energy sources, however, still remains merely a subject for discussion. Solar energy, for example, is at least a decade from practical large-scale application.

by Margaret A. Maas, *Industrial Editor*

Microprocessors star in industry

The microprocessor, touted as a major control tool for 1975, is living up to the brightest predictions. Microprocessors are controlling rolling mills in the metals industry, helping supervise pipelines in the petroleum industry, interpreting measurements of analytical instruments, and controlling processes in all sorts of industries. Expansion of these applications will continue as falling costs make the device more attractive than ever to designers. Although the major drawback in adapting microprocessors continues to be the lack of high-level languages, there will be significant additions during the coming year.

Microprocessors are also accelerating the trend



In controls, electronics has been steadily gnawing away at pneumatics technology. It passed pneumatics about 1971 and by the end of the decade will dominate control in chemical, petroleum, metals, and other process industries.

toward distributed control. Distributed systems have long been operating at the minicomputer level. Now, microprocessors are assuming similar tasks. In West Germany, for example, a distributed system designed by Philips is controlling vehicular traffic in cities. Philips is putting a microprocessor at each intersection, and the number of intersections controlled can be expanded as and when needed.

In the processing industries, the microprocessor enables distributed control on an individual loop basis. The device can provide, at the loop level, cascade, feedforward, and other advanced control techniques. As an added benefit, the independent loops are capable of functioning even when the main computer fails.

Tightening processes

In the process industries, there is a strong trend to reducing plant capacities. Although the total plant may be larger than before, storage capacities within the system are decreasing. The change is brought about largely because of rising costs both for the structure and for the inventory it holds. At the same time, companies are boosting system throughputs in order to increase productivity. Higher production speeds demand control systems that respond faster, and faster response, in turn, can set up system transients. Large tanks and pipes serve as capacitances and tend to dampen process transients, but smaller ones do not. Although traditional feedback systems don't handle transients very well, feedforward systems do.

But implementation of feedforward control requires a model, in the form of an algorithm, that describes how the process responds to operating conditions. If analog circuits were used to construct this model, it would be essentially inflexible.

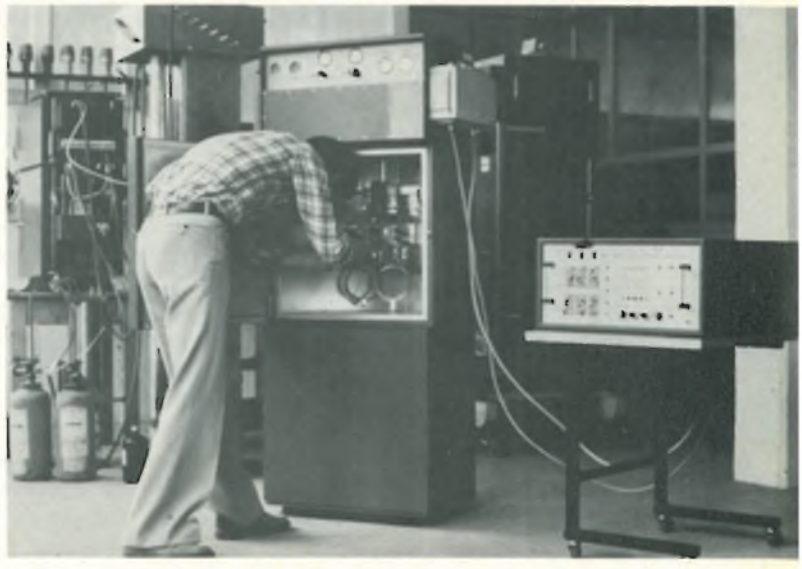
Yet, today's computer-stored models may be changed frequently because they are often developed in the course of controlling the process. A form of control algorithm is developed, applied, and the results measured. Then these results are compared to the predicted results, and the algorithm is corrected or refined. When models are stored in computer memory, they can be readily altered by changing the stored values. Even the entire control algorithm may be restructured without any changes in the system hardware.

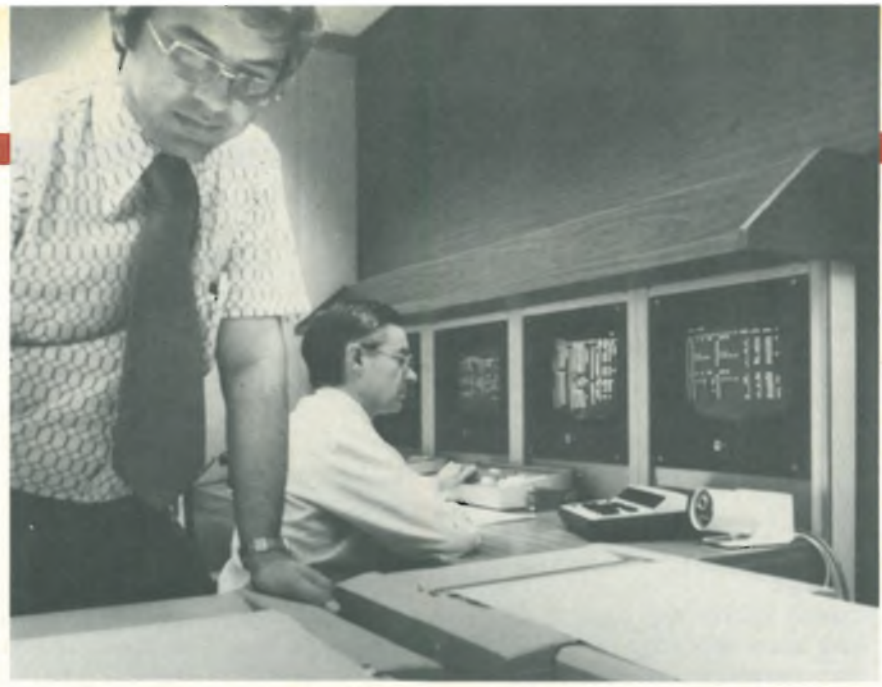
For example, the Westinghouse Electric Corp. Industry Systems division, Pittsburgh, Pa., uses this technique to handle the complex interrelationships in a steel-rolling mill. The system calculates settings on all the rolling stands according to the type of alloy, its thickness, and desired reduction. As the strip passes through the first stand, a thickness gage measures the material and compares it with the target thickness for that stand. If the thickness does not meet the target, all the stands downstream are reset automatically to correct for the error. Corrections are timed to begin when the off-gage strip arrives at a stand. At the same time, the system adjusts the first stand to bring incoming material closer to the initial target.

Adaptronics, McLean, Va., carries mathematical modeling a step further by not only deciding how variables interrelate, but also whether or not they are significant to the model. Adaptronics handles its modeling through software, but it is also building a hardware/software version in which modular computing elements perform the repetitive arithmetic required for modeling, but at much higher speeds.

When interconnected, the modules will form a spe-

Process chromatograph. In designing this unit for hazardous environments, Beckman Instruments included digital timing controlled by a quartz oscillator as well as advanced safety features.





Condensed information. CRT displays, such as this console designed by TRW Controls, monitor petroleum pipelines.

cial-purpose computer under control of a central-processing unit that performs the nonrepetitive calculations. Adaptronics is investigating possible applications of its techniques in machine tools in the hope that they can infer the surface finish of a part while it is being machined. This result is to be predicted by listening to and analyzing the sounds of the cutting tool against the surface.

Generating the necessary inputs

Control, regardless of the strategy, is ineffective without reliable and accurate inputs from the multiple sensors dedicated to the process. In the traditional measurements of temperature, flow, and pressure, recent sensors have been mostly improvements to existing concepts, rather than new techniques.

However, the silicon pressure transducer has been changed extensively. Since its introduction by National Semiconductor Corp., Santa Clara, Calif. [*Electronics*, Dec. 4, 1972], its pressure ranges and packaging have been greatly expanded. Initially, there was only one device with a one-atmosphere pressure range and no packaging around it. Some models now extend down to one pound per square inch and others reach up to 5,000 lb/in.^{2} An extensive amount of packaging has been added so that the transducer can be connected into a variety of applications.

Basically, the transducer consists of a Wheatstone bridge arrangement of four piezoelectric resistors diffused into a silicon chip. The center of the chip is etched to create a diaphragm which is exposed on one side to a vacuum reference cavity. The other side is exposed to the pressure to be measured.

The silicon pressure transducer is an actively trimmed hybrid with integral signal-conditioning, regulated power supply, amplification, and temperature compensation. Some have temperature controls—a built-in thermostat and heater. This approach will be carried even further by combining a microprocessor and transducer on one chip. The transducer has to be actively trimmed, to ensure that the microprocessor has the desired outputs.

In temperature measurement, on the other hand, few improvements have been made. Except for the silicon temperature transducer that came on the market a couple of years ago, no devices have appeared. And the silicon transducer itself remains the same.

In flow meters, the newest device is the vortex-shedding meter. The device is based on a phenomenon that results when a sharp-edged blunt body is placed in the path of the flow. As fluid flows around it, vortices are shed from alternate edges of the blunt body. The rate of vortex formation is proportional to the flow.

There are different ways of measuring this vortex formation and producing an electrical output. Corning Glass Works, Bradford, Pa., relies on the high-temperature coefficient of its temperature-sensitive nickel film in its temperature-sensitive resistors. Two elements of this film are placed downstream from the blunt body so that they are affected by the vortices that are generated from its alternate sides. The vortices alternately cool one film, then the other, causing a change in their resistances. The strips are connected as two legs of a Wheatstone bridge so that the frequency of resistance change is detected as a voltage change at the bridge output.

In a flow meter from Fischer & Porter Co., Warminster, Pa., on the other hand, a flexible "tail" is placed downstream from the blunt body. As the tail wags under the influence of the alternating vortexes, a strain-gage bridge mounted in the tail translates the oscillations into a measure of flow.

Among promising new technologies being explored as potential sources of process data are sound and color changes. If properly analyzed, sound signatures might yield important clues that could, in turn, be used to control a process. Color changes, too, could be related to variations in processing conditions.

Moving on line

Still another technique that is tightening control is the development of on-line analytical instruments. Many of the analytical instruments formerly used only in the laboratory are now being moved out into the field. This transfer eliminates the time required to col-

lect samples and take them back to the laboratory for analysis. It also allows for immediate corrections of a process based on the results of on-the-spot analysis.

The on-line instrument most in demand is the gas chromatograph, an instrument that determines the chemical constitutents and their concentrations in production. Outputs of the chromatograph can be tied directly into a computer-controlled system that is operating a refinery or supervising the process loops within a chemical plant.

But rather than weigh the process computer down with tasks such as peak analysis, timing between peaks, and other instrument outputs, it is better to dedicate a microprocessor to the job so that the microprocessor and analytical instrument form an independent control loop. And indeed, at least one manufacturer is now field-testing an on-line chromatograph built around a microprocessor. Other microprocessor-based analytical instruments will be emerging during the year.

Conserving energy

Although many industries would not consider power demand control before the energy crisis occurred, these controls are now proliferating, as evidenced by the four-fold growth in the number of suppliers during the past four years.

Power-demand control helps users avoid the stiff surcharge inflicted by many utilities when a company's power usage exceeds a predetermined level during its contracted time interval. When a plant is in danger of exceeding its prescribed power-consumption limits, the control can warn operators not to bring additional equipment on line until the next time interval, or it can shed loads to keep power usage below the critical limit.

Although techniques of power-demand control vary, basically, the equipment operates from the two pulses supplied, upon request, by the electric utility—a kilowatt-hour pulse and an end-of-demand-interval pulse, which resets the calculation. One manufacturer, Leeds & Northrup Co., North Wales, Pa., accumulates the incoming kWh pulses and compares them to the desired kWh limit. The difference between the two is divided by the time remaining in the demand interval to produce a running average. This figure, in turn, serves as the setpoint for the controller and is compared with the number of kilowatts actually purchased, as calculated from the accumulated kWh pulses. When the error signal is large enough, the system begins shedding loads.

There are various ways to shed loads. Common methods are first on-first off and fixed sequence. Each user has his own requirement as well as his own interface needs for the particular equipment he is controlling. Because of this diversity, systems are still being made of discrete components. But most manufacturers have taken advantage of some component developments to keep system costs down. For example, they are using inexpensive digital-to-analog converters, digital registers, and programable controllers that add a large number of outputs at relatively low cost.

Although the microprocessor has not yet appeared in power-demand controls, it will if utilities go to time-of-the day metering (charging more for power during periods of peak usage) and load-shedding sequences have to be varied according to the time of the day.

Solar energy: the big question mark

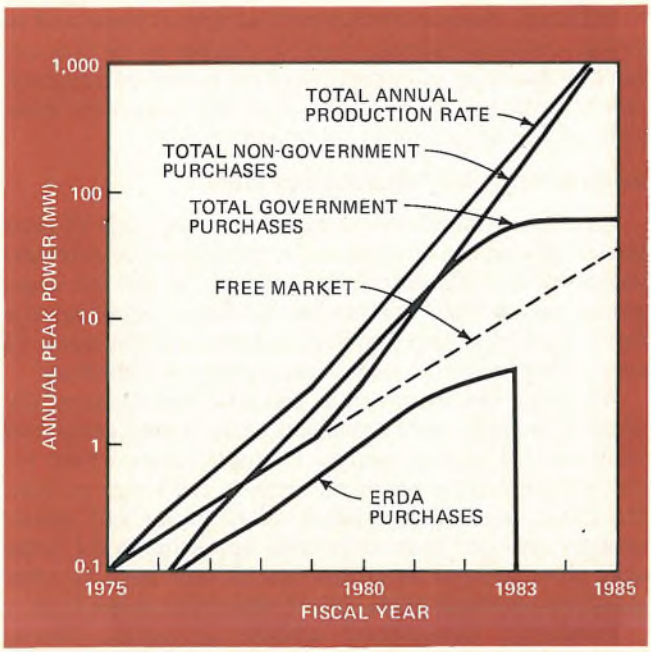
Any discussion about energy invariably leads to solar power. Numerous companies are pursuing this potential plum—some with petroleum money, as the oil companies realize their commodity is energy, whatever the form. However, the practical industrial application of solar energy remains some distance over the horizon.

Although the silicon solar cell has been successfully applied in space, more practical earth-bound usage has been limited almost entirely to applications where replacing batteries is far more costly in the long run than the initial exorbitant expense of the solar cell. Interestingly enough, most terrestrial applications for solar cells have been in countries that do not have the tremendous electrical grid network that exists in the U.S.

Terrestrial applications include navigation buoys, communications systems where they are used in remote repeater stations and offshore platforms, and cathodic protection against corrosion of pipelines. In the pipeline, the solar panel develops a voltage to counteract the electrical field that a flowing fluid normally generates around a buried pipe.

Three major materials are competing for the solar-cell limelight—the oldest and most developed is the silicon cell, followed by cadmium sulfide and gallium arsenide. Silicon is the leading contender—at least as far as

Monitoring power. In its power-demand controller, Leeds & Northrup Co. calculates a running average on energy consumption and adjusts the setpoint for shedding loads accordingly.



Photovoltaic goals. Government funding will spur solar-energy development, but the free-market purchases will lag Government purchases. Total production by 1985 is estimated at 1,000 MW.

the Government is concerned—and is the technology on which the Energy Research and Development Administration is betting its money.

Silicon technology has the advantage of space-program development behind it, and it has logged literally years of successful space operation. But unfortunately, three to five years of operation for a custom-made device designed for space can't be extrapolated into 20 to 30 years of terrestrial application for a mass-produced unit. Silicon is stable and reliable, but its big hangup is that it's very expensive, a drawback of all the solar-energy contenders.

A silicon cell is formed from a crucible-grown ingot which is then sliced, chemically etched to remove work damage, and doped with a material such as phosphorus to form a pn-junction semiconductor. The price is affected greatly by differences in production technique—for example, the method of doping, and the way contacts are put onto the cell. A cell for space application will cost $200 to $300 per watt, although its terrestial counterpart costs a fraction of that amount, but still $20 to $30 per watt.

Efficiency of the silicon cell has been increased only about 1% during the past five years to 12% today. But the Heliotek division of Textron Inc., Sylmar, Calif., predicts that efficiency will reach 14% within the year. The company also projects a price of $5 per watt by 1980. But that is still far above the range of 15 to 50 cents that is considered essential for large-scale applications. A typical space cell of 2 by 2 cm delivers 56 milliwatts. Open circuit voltage is 0.5 v.

Mobil Tyco Solar Energy Corp., Waltham, Mass., to bring down costs, has been working on mass production by growing silicon ribbons instead of wafers. The technique is based on the company's efforts with sapphire-crystal growth. Continuous crystals are grown directly from the melt and, unlike in other production techniques, can be grown in almost any shape with continuous replenishment of the raw material during growth. Less than a year ago, Mobil Tyco was producing ribbons a maximum of six feet long. However, the company, using pulling equipment and wrapping the material around a mandrel, is now producing ribbons up to 80 ft long.

The cadmium-sulfide solar cell, being developed by the University of Delaware at Newark, Del., is attractive because it can be made by thin-film techniques, lends itself to continuous production, is potentially quite economical, and can be made quite large. Unfortunately, however, the cells have a typical efficiency of only 5%, and the material is plagued by degradation when exposed to water or oxygen.

The search for that failure mechanism is one of the main thrusts of the research at the University of Delaware. Once the failure mechanism is understood, the researchers are confident that the problem can be solved by proper encapsulation.

The last entry into the energy fray is gallium arsenide, which has been widely publicized because of the high-efficiency claims for the material of 15% by Jet Propulsion Laboratory, Pasadena, Calif., and 21% by Varian Associates in Palo Alto, Calif. [*Electronics*, May 29, p. 41]. The JPL cell consists of a layer of gallium-arsenide 5 micrometers thick, topped by a 70-angstrom gold film. The Varian cell, on the other hand is made of aluminum-gallium-arsenide.

To make the cells, a liquid-epitaxial layer of n-type material is grown on top of n^+ gallium arsenide. On top of this, an aluminum-gallium arsenide layer is grown and doped with p-type material such as zinc, to produce the pn junction across which the photovoltage apperas. The heterojunction confines the electrons so that the velocity of surface recombination is low, which yields high efficiency.

On the credit side, a large body of knowledge applies toward adapting the material to solar-cell development because light-emitting diode displays are made of gallium arsenide. On the debit side, the material is expensive, the cells are small, and concentrators, which are relatively large and also expensive, are required to focus the radiation onto the cells. The cost of these concentrators, which must be steerable so that they can follow the sun, adds to the total cost of the cells.

Which of these materials—if any—wins the solar-cell derby will depend on cost-effectiveness. It is too early, however, to project any meaningful cost figures. Even the efficiency of these materials, especially cadmium sulfide and gallium arsenide, are not very good determinants of their worth. But if research and mass production can beat the costs down into the right ball park, one of these solar-cell types is likely to become the main power source of the future. □

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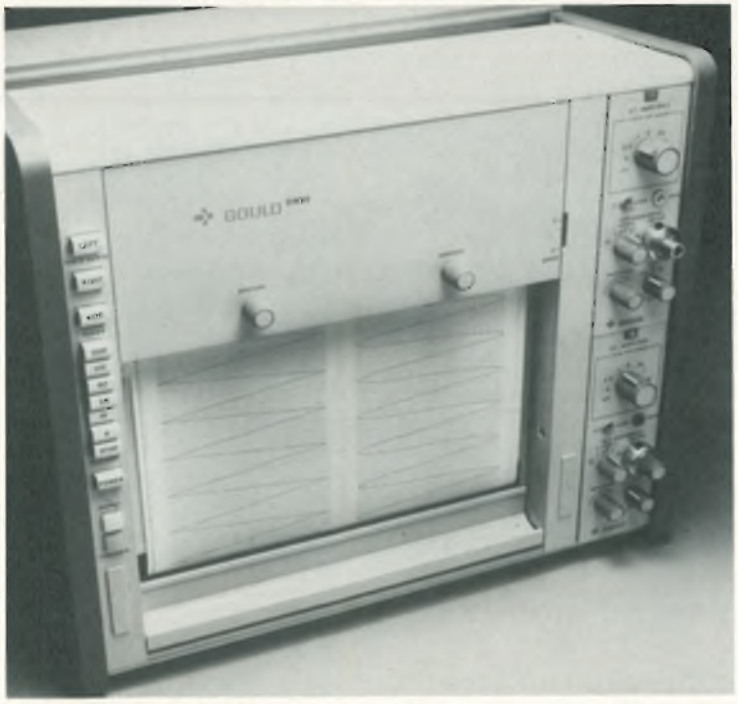

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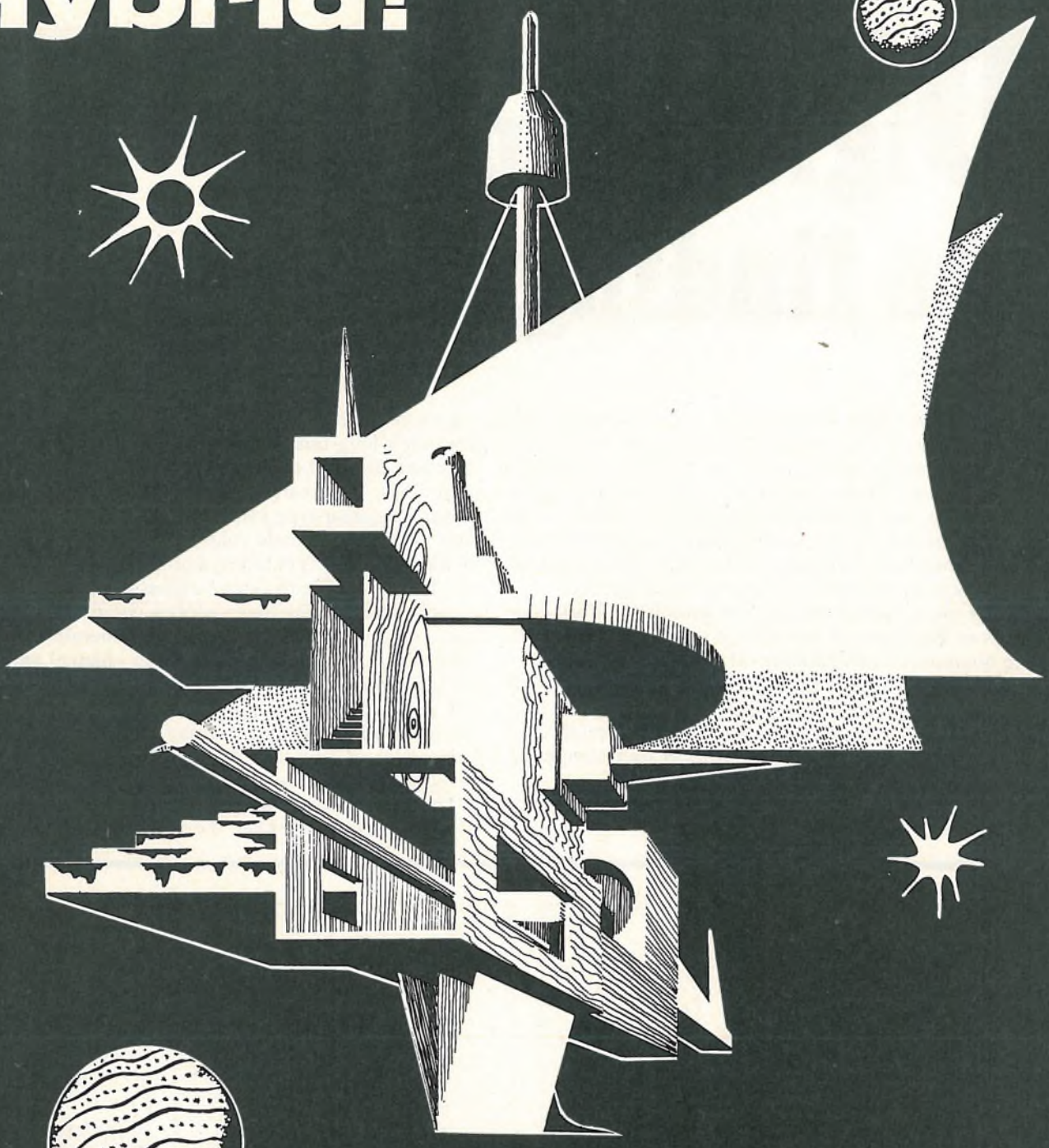

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CONSUMER

Digital controls are finding homes

☐Digital electronics is becoming part of today's life style at home and at play, as well as at work. This year's color-television receiver, with its digitally addressed tuner, the automated camera, the multifunction digital wrist watch, not to mention the digital controls to be found in kitchen ranges, sewing machines, and automobiles, all owe their new capabilities to the declining cost and increasing versatility of large-scale integration.

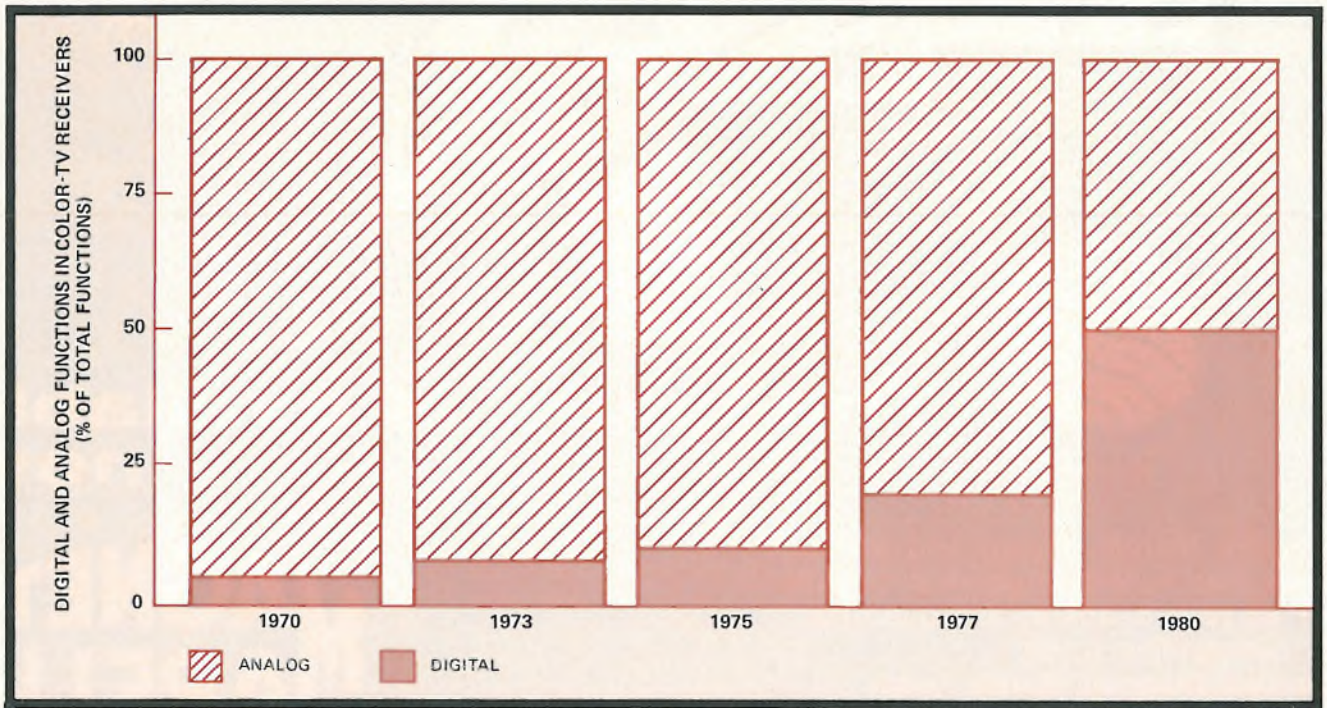
Even more radical changes are promised. Work continues on flat-panel TV sets and on ways of turning them into domestic communications terminals.

Closest to actually entering the home, however, is an analog development. Video-disk systems may be available in the U.S. by the end of next year, though consumers' bewilderment over the three or four competing technologies could damp sales.

by Gerald M. Walker, *Consumer Editor*

Last year, television-receiver manufacturers switched from their long-time pursuit of ever-brighter pictures to installing all-solid-state chassis in any model that still used tubes. This year, the focus has shifted to electronic tuning. Varactor-type tuners, though more or less standard on German-made color receivers, are much rarer in American sets. Yet today, European and U.S. designers alike are racing to extend digital controls to varactor tuners, especially the tuner-address circuits, and, in a related move, to include character generators for on-screen display of channel number or channel and time. In fact, Grundig AG of Germany is making six color-TV sets that display program number and time on screen, not to mention a channel-tuning scale that aids service technicians in adjusting the receivers' automatic channel-selection circuitry.

The two standard ways to design the tuner-address systems are to use either the new frequency-synthesis



Low-cost digital techniques, using MOS or I²L circuits, are allowing TV manufacturers to add digital functions to traditionally analog set designs. This year, 10% of the circuitry is digital, in 1978 30% will be digital and by 1980 about half will be digital.

Video-disk entry. One video-disk system due on the market by the end of 1976 is this RCA capacitance-based player. It will compete against an optical system, due about the same time from MCA/Philips, and Teldec's already available mechanical system.

(phase-locked-loop) method or the more familiar voltage-synthesis (capacitance-address) method. In the first approach, a local-oscillator frequency is generated to correspond to the channel selected, and in the second, a variable dc voltage corresponding to the channel selected is applied across the varactor diodes. Both methods have followers—frequency synthesis because of its inherent stability and flexibility in use, and voltage synthesis for its low cost and simplicity.

The frequency-synthesis method can also be handled in two ways—the so-called birdie count used in the Magnavox STAR tuner announced last year, and direct countdown favored by tuner designers this year. Essentially the IC in the birdie count system counts down outputs from a synthetic spectrum generator to obtain a frequency that matches the uhf or vhf channel selected. Requirements are the production of 6-megahertz harmonics, plus added processing because of some awkward allocation of the TV frequency spectrum, plus rf processing that cannot readily be integrated.

In direct countdown, on the other hand, the output of a voltage-controlled oscillator is amplified and fed into a programable divider. The divider is programed to divide by a number that, when multiplied by the frequency from a reference oscillator, results in the desired channel frequency. The only rf processing required is a wideband amplifier consisting usually of two transistors, two varactor diodes, and one switching diode.

A third type of digital address system was developed this year by the F. W. Sickles division of General Instrument Corp., Chicopee, Mass. It's based on a nonvolatile nitride-coated MOS (MNOS) memory that can store 82 channels of vhf and uhf information. The three other chips in the system are an n-channel MOS control-logic chip, which transfers channel selection to the memory, an n-MOS display driver, and a complementary-MOS digital-to-analog converter to transfer the memory output to the varactor tuner.

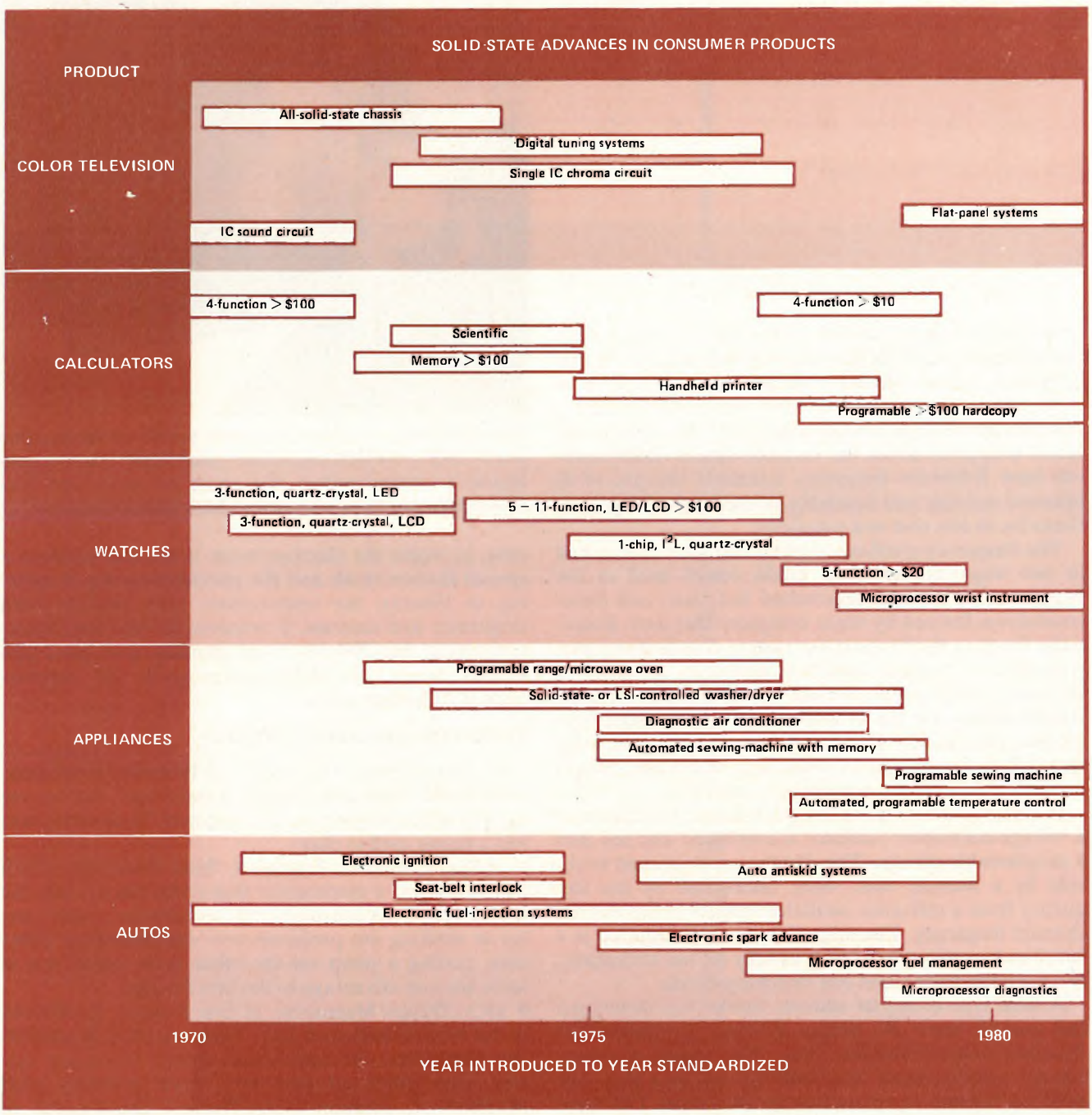
Development in TV-picture tubes a year ago focused on the in-line gun, which costs less than a delta gun to assemble into a set, needs fewer dynamic tolerance-compensation circuits, and substitutes factory-set convergence for dynamic convergence-setting components on the tube neck.

Nor has the pursuit of brightness ended. In Japan, Hitachi Ltd. has introduced a mask-focusing picture tube, in which the electron beam is focused between a special shadow mask and the phosphor-screen. According to Hitachi, the wide-necked tube doubles both brightness and contrast. It requires 20–30% less deflection power, has 70% less mask doming, and has a 20% smaller beam spot than conventional 110° narrow-necked deflection tubes.

Video-disk uncertainty remains

A clash between the makers of competing and noncompatible video-disk players is imminent, but no one can tell which will win most consumers. Each contestant has a strong card to play:

- Teldec GmbH in Frankfurt, West Germany, which has developed a mechanical skid-stylus player, was the first to reach the consumer market, despite a year's delay in working out problems over disk-handling. However, getting a jump on the other firms seems not to have been an advantage to the firm in sales.
- MCA/Philips/Magnavox, of Los Angeles, Eindhoven in the Netherlands, and New York, are joint developers and marketers of a laser-based optical video-disk system. They point out that their player provides great flexibility of operation—it can freeze a frame, speed up or slow down, and attach an indexing number to a frame to make it easy to find again, all without wear on the record surface. Laser life, on accelerated tests, is estimated at 8,000 to 10,000 hours, worst-case, to about 20,000 hours of normal use.
- RCA of New York, developer of a capacitance-sensing video-disk system, claims that its player design gives it an intrinsic reliability and makes it easy and cheap to mass-produce because none of the components requires precision in manufacturing. The stylus arm itself stabilizes signal timing—essential in playback through TV receivers, in which circuitry for synchronizing horizontal scanning is relatively slow. But neither stopping the



disk nor running it in slow motion is a practical option.

Thompson-CSF in France and Zenith in the U.S., jointly working on a laser optical system rather like the MCA/Philips concept, have kept a lid on their planning, obviously waiting to see what happens to the others.

Despite the uncertainty, the list of competitors is not getting any shorter. CBS has confirmed an interest in video-disk development and disclosed that the CBS Technology Center, Stamford, Conn., is keeping an eye on present systems and may enter the field if economic conditions become favorable.

And from Japan, Hitachi's laboratories have quietly impressed the technical world with the development of a holographic video-disk player. Disks are 30 centimeters in diameter, play 30 minutes of color pictures and sound, and contain 54,000 holograms each. Luminance, chrominance, and sound are superimposed in an area just 1 millimeter in diameter. Because of this high density, the disk needs to rotate only six times a minute. A laser focuses the holograms on three solid-state sensor arrays, which reconstruct the image. Their output is processed and displayed on a TV monitor.

As for TV's future, researchers continue to play with ideas for expanding the role of the television receiver in

the home. It seems likely that the TV set will inevitably become a communications terminal. In England, alphanumeric data is already being telecast experimentally to receivers that use a digital memory to store the data for replay on the TV screen.

Eventually, such data might be received on an inexpensive monochrome receiver equipped with a decoding and memory module. The signal carrying the information could be part of the TV signal, but it could also be broadcast on a special narrow channel or even the telephone line, creating an entirely new information network not unlike the home facsimile system proposed some years ago by RCA.

Watch displays improve

No longer either high-priced novelties or cheap toys, digital-display watches have been solidly accepted. The two types of displays—light-emitting diode and liquid crystal—continue to face off in the marketplace, and developments this year have been aimed partly at compensating for their deficiencies and partly at adding more functions from increasingly complex LSI chips. Price declines have been taken for granted.

The display has always been the weak part in these watches, but some of the new models mitigate the nuisance factors—the invisibility of LCDs in the dark, the dimness of LEDs in bright light, and the need to turn a LED display on and off to save battery power. Now, some LCD types have tiny incandescent back lights, to be turned on only when needed—though of course this adds another button switch and a lamp that could break down. Some manufacturers have even mounted the LED display on the side of the watch where it is shielded from bright light and therefore is easier for the wearer to read.

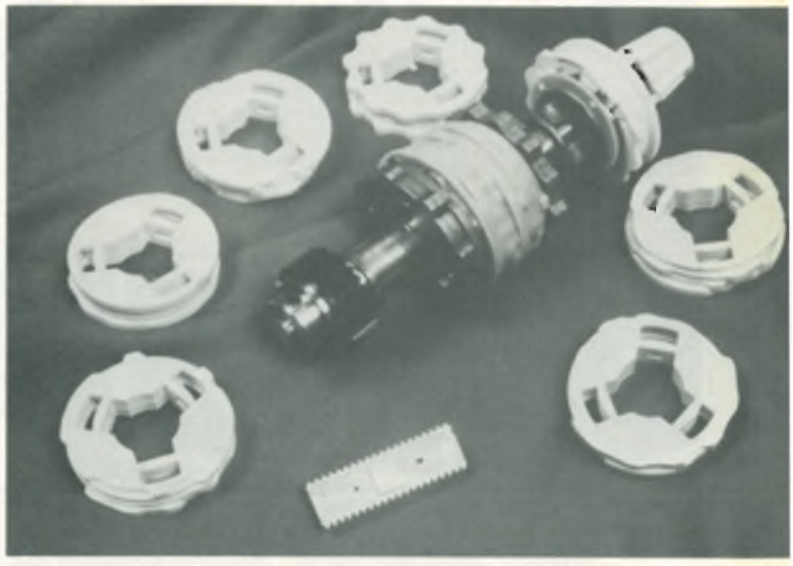
Cameras also are getting electronic controls. One of the most advanced is the Contax RTS (real-time system) camera developed jointly by Yashica in Japan and Carl Zeiss of Oberkochen in West Germany. Besides automatically computing, storing, and controlling shutter speed with far more accuracy than is possible with electromechanical controls, the electronic circuits display shutter speeds alongside the viewfinder and even check the battery output.

Microprocessors head for the home

Because of the narrow cost window in home appliances, solid-state controls have been slow in gaining entry. But as their costs decline, alert firms are getting a head start with ideas that are noteworthy less for their sophistication than because they are unique.

An outstanding example is the central-air-conditioning system that Heil-Quaker Corp., Nashville, Tenn., majority-owned by Whirlpool Corp., began shipping this spring. The system keeps watch over its own operation and diagnoses problems by means of a hybrid analog and digital package that includes a custom hardwired computer module.

The module responds to electrical problems by shutting the system down until the situation returns to normal. It also alerts the owner to three different temperature conditions, all critical to the performance and life of the air conditioner. They are the "freeze" condition, when there is no indoor evaporation and the air conditioner could turn into a block of ice; when the outdoor unit overheats, and when the air conditioner fails to cool. In each case the module shuts down the system until repairs are effected.



Sew much neater. On Singer's Athena 2000 sewing machine, a MOS memory handles complex stitch-pattern control. Without electronics, the job would need 350-plus mechanical parts.

Another IC application in the forefront of the home-appliance industry is the new Athena 2000 sewing machine from Singer Co., New York. Stitch patterns are automatically controlled by a 6,000-bit read-only memory. This p-channel MOS LSI chip is the equivalent of a mechanical control requiring over 350 individual parts and a confusing array of complex operating procedures—the firm tried both approaches.

Frigidaire is building electronic temperature controls in two top-of-the-line kitchen ranges. A variation of the concept has been introduced by Amana Inc., Amana, Iowa, for a microwave oven, the Radarange model RR-6W. This "Touchmatic" oven contains a single MOS chip that controls all timing functions, the critical parameter when cooking by microwave.

The IC controls three separate cycles, depending on the oven's use—defrost, cooking, and slow cooking. The homeowner can cook a frozen roast by touching various buttons on a panel to program the oven with the proper defrosting and cooking times, activating the unit, and leaving it to follow orders. In the slow-cooking mode, the oven automatically delays the rate of cooking to handle sauces and other recipes for which microwave ovens are normally too fast. A four-digit LED display on the front panel indicates time of day and counts down remaining time of cooking after the system has been programed and the oven activated. □

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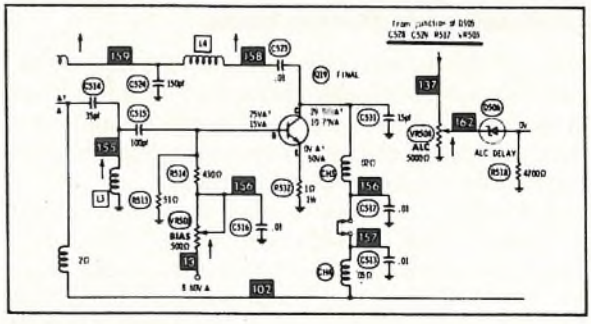

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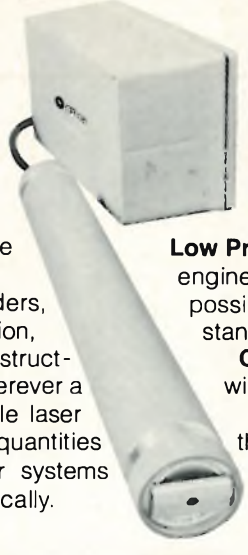

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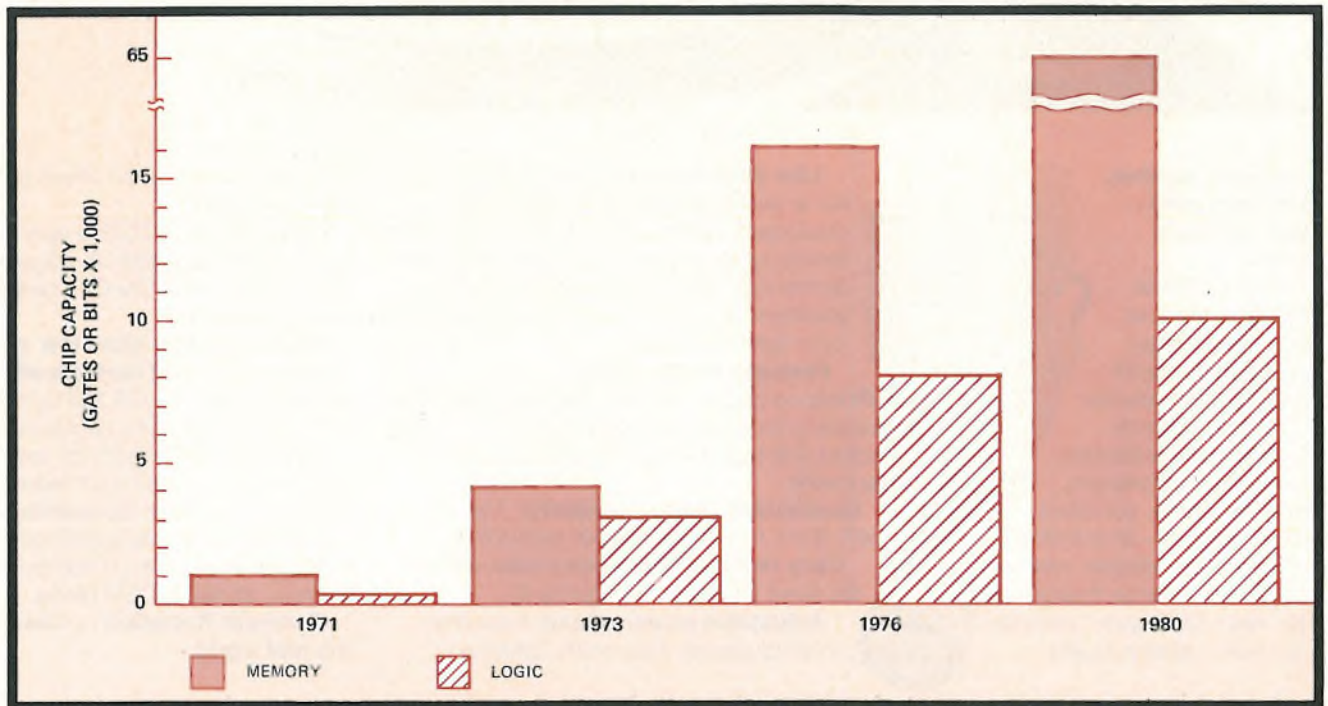
LSI multiplies design options

☐A record-breaking abundance of new circuits showered down upon equipment designers in the last 12 months. In digital design, injection logic established itself as a commercial reality, while metal-oxide-semiconductor performance was boosted by new n-channel processes and complementary-MOS designs. Suddenly the traditional boundary between the two competing technologies began to blur, and it was no longer a case of MOS for low cost, bipolar for high speed. Moreover, as mixed bipolar and MOS linear circuits took shape, new analog/digital capabilities became available for the fast-moving areas of data acquisition, analog control, and industrial processing.

In the digital product area, integrated injection logic has been the pace-setting technology. It was the real start of bipolar large-scale integration and began paying off as designers got their hands on the first sampling of I^2L products. Texas Instruments Inc. of Dallas went to market with its 4-bit microprocessor slice, which operates at a speed between those of today's n-MOS and TTL products, and at the same time readied an advanced I^2L process capable of TTL performance. Motorola Semiconductor Products Inc., in Phoenix, Ariz., began introducing a new family of I^2L programable logic circuits, called Megalogic, while Fairchild Camera & Instrument Corp.'s Bipolar Memory division in Mountain View, Calif., began sampling the industry's first 4,096-bit bipolar RAM—an injection logic design capable of access times of less than 100 nanoseconds.

I^2L watch chips proliferated throughout the industry, competing with C-MOS designs for the attention of watch manufacturers. I^2L watch modules from TI and Fairchild, to be joined soon by others from Motorola, ITT Semiconductors, perhaps National Semiconductor

by Laurence Altman, *Solid State Editor*



The relentless march toward greater chip densities is what forces semiconductor IC costs down over the years. By 1980, chips with 65,000 bits of memory or 10,000 gates of logic will have become standard products throughout the industry.

Getting the call. New opportunity for semiconductor manufacturers is the telephone industry. Improved n-MOS and I²L circuitry can add new features to telephones, as in this German pay telephone.

Corp., Philips Gloeilampenfabrieken, and others, will begin to take over the LED watch market and may start being designed into LCD watches as well.

Answering the I²L challenge in digital circuit design is a newly developed n-MOS process that borrows from charge-coupled-device technology. By folding each gate over itself, and by introducing a buried layer of polysilicon as an additional interconnection, n-channel memory circuit designers can do one of two things: they can either push the access time of 1,024-bit RAM designs down to 50 ns or boost single-chip bit densities into the 16,384-bit range while maintaining the traditional 200- to 300-ns access times. TI, Intel Corp., Santa Clara, Calif., and perhaps Motorola and Mostek Corp. in Carrollton, Texas, are expected to be test-marketing 16,384-bit parts soon, while Intel's very fast (50–70-ns) 1,024-bit random access memory, the 2115, has already become available.

MOS microprocessors are also profiting greatly from the steady improvements being made to n-channel processes. Both Intel and Motorola have already developed upgraded versions of their 8-bit microprocessor systems, offering instruction times down to 1 microsecond. Moreover, as the rest of the industry starts introducing their versions of 8-bit systems, the widest possible choice of processor capabilities will become available. In addition, second sources are multiplying, as other suppliers group themselves around the 8080 Intel design or the 6800 Motorola design or the National/Rockwell p-channel MOS families.

Designers of low-power digital systems got their first taste of complementary-MOS LSI products in 1974, and increasing emphasis on C-MOS LSI is forecast for the next year. RCA Solid State division, Somerville, N.J., has put the final touches on its C-MOS microprocessor design, an 8-bit parallel processing system, while Intersil Inc., Cupertino, Calif., introduced the industry's first 12-bit C-MOS microprocessor, a system that can operate with the readily available PDP-8A software package. Motorola began making available a host of new LSI functions aimed primarily at the communications-equipment industry—such products as tone encoders, bit-rate generators, phase-locked-loop circuits, and universal asynchronous receiver/transmitters (UARTs).

Moreover, designers of terminal memory systems grew more interested in the faster n-MOS components, with their less-than-100-ns access times, and have also begun evaluating the new C-MOS 1,024-bit static RAMs. A silicon-on-sapphire version is produced by RCA and is in development at Solid State Scientific Inc., Montgomeryville, Pa., while the more conventional silicon-gate designs are made by Intel and Intersil.

Finally, in the area of the highest LSI performance, new versions of bipolar microprocessor chip families made their appearance for computers and other high-speed data-processing and process-control applications. Four-bit processor slices built with a revamped low-power Schottky TTL technology thrust microprocessor designs into the highest regions of TTL performance. New families from Fairchild and Advanced Micro Devices, Sunnyvale, Calif., plus others expected shortly from TI and National, are offering designers 100-ns instruction-cycle speeds in low-cost compatible chip sets. Motorola, on the other hand, maintaining its technological lead in emitter-coupled logic, will offer the first ECL 4-bit slice. The device can manage the specifications of the largest mainframe systems—instruction cycle times of less than 50 ns and ECL pipeline throughput capability.

From the user's viewpoint

The chart on page 12 illustrates the performance ranges of the various technologies and shows just how much overlap exists in the three main-line LSI technologies. It plots the performance ranges of the principal MOS and bipolar technologies that are available in today's new products.

Clearly, I²L and n-MOS devices will compete strongly for that middle range of fast stored-time and slow real-time applications typically found in most stand-alone

controllers. On balance, I^2L devices appear to have the advantage at this range's high end, since they more easily achieve the necessary gate propagation delays of 25 to 50 ns and also consume only moderate power. For example, I^2L microprocessors will easily accommodate the 0.5-microsecond and 500-milliwatt specifications characteristic of many process-control and real-time systems.

On the other hand, the more established n-MOS devices will be cheaper and more suitable for the 1–2-μs speeds needed in most stored-time systems. That's why today's MOS microprocessor systems are being utilized in a variety of control applications, such as programable calculators, business-machine data sorting, food processing, and traffic-light controls.

For fast real-time computer control applications, low-power Schottky TTL processor families appear to be the designer's best choice. Even so, the improved I^2L designs that will soon be available from TI and Fairchild, for example, and probably from Motorola, too, are expected to offer alternatives in this region. IBM's Federal Equipment division in Owego, New York, is already evaluating an advanced I^2L design for this purpose.

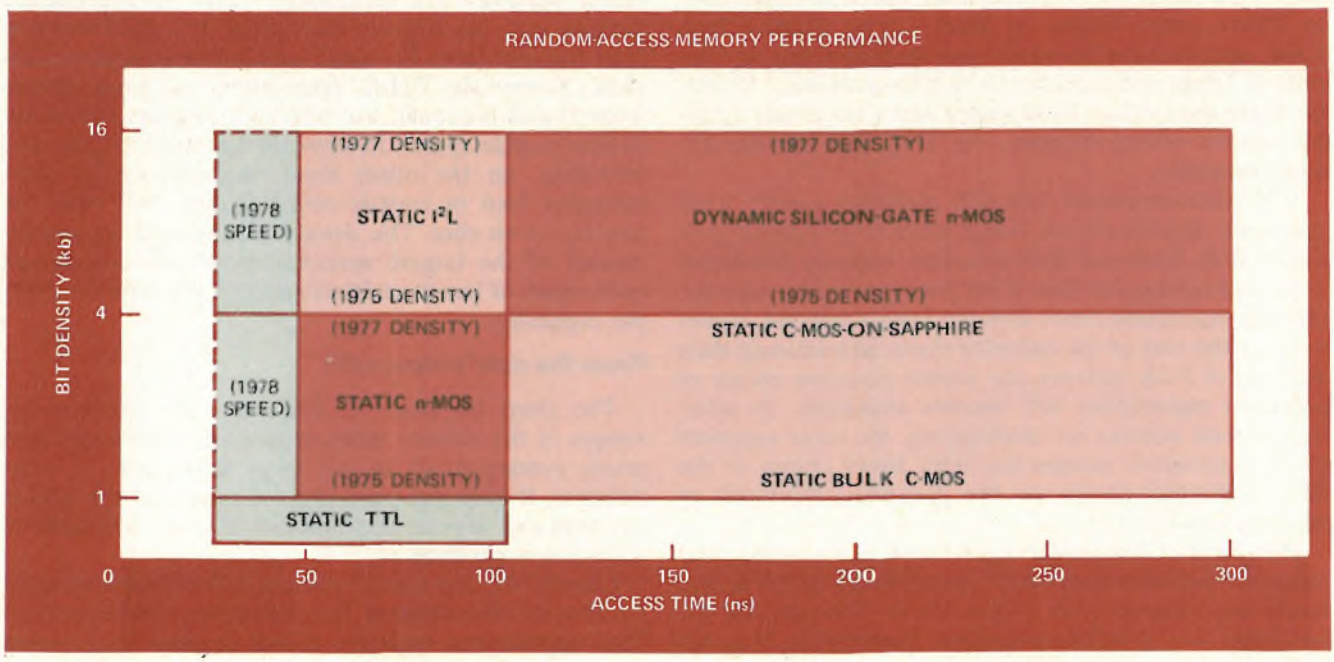
However, still unanswered is the question whether injection logic can reach the 5–10-ns gate speed needed for the bulk of real-time applications. Schottky TTL already operates in this range, and in fact, it's this kind of performance that is beginning to turn computer designers on to these new low-power Schottky LSI families.

And an LSI technology undoubtedly will eventually revolutionize computer design. That's evident from the cost savings inherent in mainframe control logic built with high-density programable logic. For example, typical control circuitry for a 64-kiloword minicomputer memory system requires approximately 200 hardwired TTL packages containing about 5,000 gates. Yet, with today's Schottky LSI chip sets, which average 300 to 400 gates per chip, the same logic can be built with a total of less than 15 circuits packaged on a single printed-circuit board. And this is only the beginning. Chips with 5,000 to 10,000 gates and with the needed performance could easily come along in the next five years.

Moreover, the same economies are also available to the designer of process controls. He now has a choice between a general-purpose minicomputer, which in many cases offers him more design flexibility than he needs, and designing his own control logic with one of the Schottky LSI families. Here he may be able to perform a dedicated function with much less hardware—the job that needed a general-purpose minicomputer, with its 200 to 300 ICs would maybe take half as many packages and an efficient software system. Indeed, Schottky LSI suppliers are finding the process-control manufacturers, such as Honeywell, Foxboro, and others, to be potentially the greatest users of these circuits.

As for technological advances over the next 12 months, both n-MOS and injection logic are expected to make significant advances in speed-density capability. The accompanying table, which compares the parameters of the four principal technologies, shows that I^2L will be approaching the 10-ns gate delay region without the use of Schottky diodes, and may be pushed down into the 5-ns range when Schottky diodes are used.

Likewise, with the new n-channel process, MOS gate speeds may well get below 10 ns. The idea for this improved process was borrowed from CCD technologies, where the emphasis is on packing as many storage sites as possible onto a single chip. It produces a split-gate configuration, so called because a single gate is built from two elements that overlap one another. Unlike in conventional technologies, in which storage and junction capacitors are fabricated separately, the gate con-



trol element is formed by folding one half of the gate over the other half, so that one bit line accommodates both elements. Each gate, viewed vertically, occupies only half the area it would in a conventional RAM, and twice as many gates can be served with a single bit line.

What's more, a layer of polysilicon underneath the folded-over gates adds another level of interconnection and once more doubles the number of cells that will fit in a given area. In all, density is just about quadrupled, roughly two from the folded-gate procedure and two from the buried polysilicon layer.

To describe the process steps in order, a bit line is first diffused into the substrate, followed by a pass gate, which is then insulated by a layer of polysilicon. Next comes an oxide layer, a second insulating layer, and last of all the normal metalization process.

All this means that system designers who are already using either n-MOS or I^2L devices in today's equipment can readily update them over the next few years with higher performing components. Here, the advantage over low-power Schottky becomes apparent, because now a much simpler manufacturing process (four masks and two diffusion steps for I^2L and five masks and three diffusion steps for MOS) will result in the same high performance as the Schottky products. In short, the cost and performance advantages of I^2L and n-MOS over TTL may well override the initial design costs required to introduce new technology into products.

Memory: in all directions at once

Like their counterparts in logic-system design, memory-system designers are getting a host of new device types that are changing the traditional cost-performance relationships between the LSI technologies. Indeed, new RAM devices are expanding all sides of the memory component universe.

COMPARISON OF DIGITAL LSI DEVICE PARAMETERS

Parameter	Silicon gate n-MOS	Bulk C-MOS	I^2L	Low-power Schottky TTL
3-wide gate area (mil^2)	3.5	8.0	2.5	20
Gate delay (ns)	10 – 50	50	10 – 50	1 – 10
Speed-power product (pJ)	10	4.0	0.1 – 1.0	10 – 20
Number of photomasks	5	6	4 – 5	7
Number of diffusions or implants	3	3	2 – 3	4
Density (gates/mil^2)	200	100	300	50

Soon to be available are 16,384-bit RAMs that will increase the density and lower the cost of medium-speed dynamic designs for main memory and microprocessor storage systems. Faster, fully static n-MOS designs are revitalizing the small, fast buffer memory systems as they replace some of today's bipolar products. Likewise, 4,096-bit I^2L RAMs will be built into main memories—territory that till now has belonged to MOS devices. Finally, low-power C-MOS RAMs, as they become denser, faster, and cheaper than the old products, become more suitable for a wide range of terminal and microprocessor designs.

The star event of the next 12 months, of course, will be the appearance of the big 16-k devices and the emergence of the 4-k I^2L RAM. Sample 16-k devices are already being tried out, while Fairchild has prototypes of the 4-k I^2L chips out, and TI has—or is very close to having—them out as well.

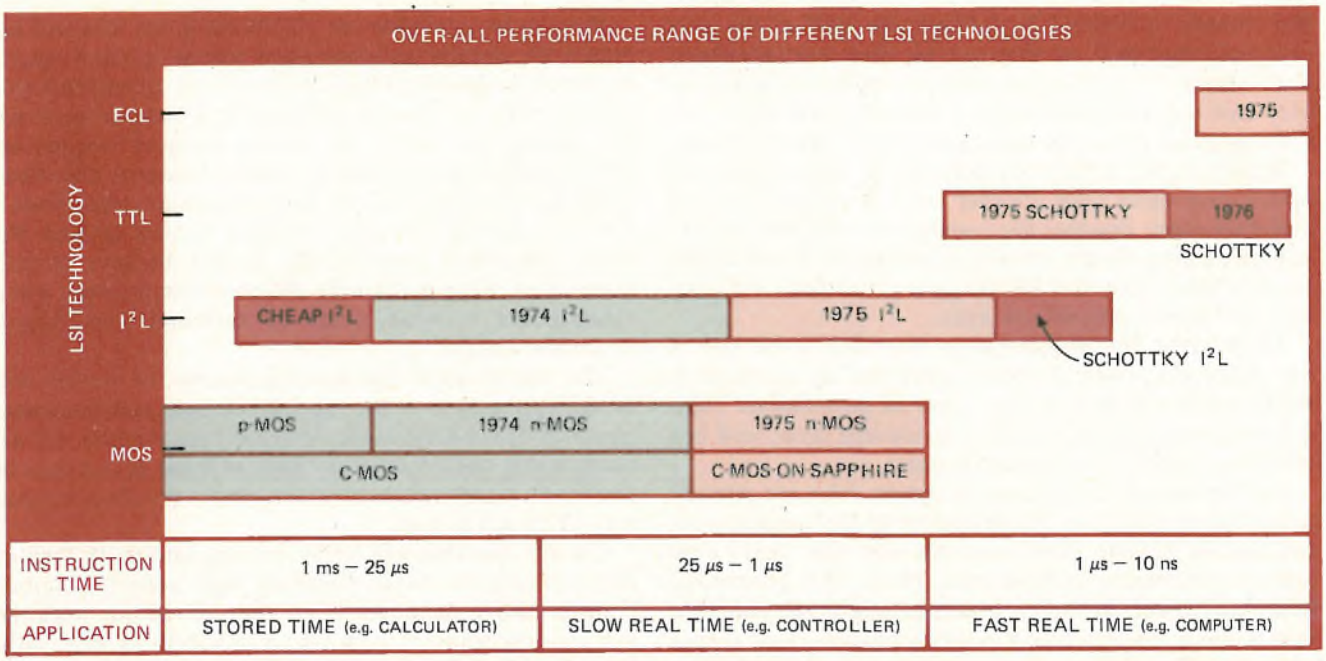
Clearly, the 16-k will begin moving into main memories as designers begin planning high-density memory boards. Many suppliers hope that its 16-pin package will ease the transfer from 4-k to 16-k devices, especially for those who already use 16-pin products. But no 16-k component is device-for-device replaceable with any 4-k component—separate boards will have to be designed. And whether it has 16, 20, or 22 pins (publicly, TI is still undecided), any type of 16-k RAM chip that becomes available in quantity will undoubtedly be gobbled up because of its potential low cost per bit.

Today's 4-k RAMs sell for about $6 and are working towards $4. By the time the 16-k comes around in volume, it could sell for as much as $15 per package and still be cheaper than the 4-k types. Then, as it races down the price curve the 16-k will simply wipe out most mainframe demand for the smaller size—it could happen as soon as 1977-78.

Again, the improved n-MOS process already described can be used to optimize memories both for density or for speed, or for both together. For example it can pack four times as many bits as before onto a chip of a given size or it can double access speed at the 1,024-bit chip level.

Two manufacturers developed this process long enough ago for their memories to be operational in systems today. Mostek pioneered this type of structure with its metal-gate buried-polysilicon design for a 4-k RAM and has now recently adapted it into a full-scale silicon-gate design for 16,384-bit designs. Intel also used the split-gate process in its 8,192-bit programable read-only memories. More recently, a very fast (50-70-ns) 1,024-bit RAM, the 2115, has become available from Intel, and both Intel and TI expect to be test-marketing 16-k parts by the end of the year.

Just where the new I^2L memories fit is less clear. In the mainframe area, their impact will depend mostly on their cost. If the cost is high compared to dynamic MOS types, they will not see much mainframe usage (except in ECL controller systems). But they could replace much of the fast static bipolar and new n-MOS products in



buffer systems since at the 4-k level I²L should be cheaper than the 1-k designs.

However, injection logic designs may not be costly to build, since they require fewer manufacturing steps than conventional TTL memories. If it turns out cheap enough, the 4-k I²L RAM, operating at a 50-ns access time and dissipating about 100 mW per package, could have a big impact even on the mainframe MOS world.

CCDs vs the disk and drum

Also noteworthy is the recent availability of charge-coupled memory systems as solid-state replacements for disks and drums. (Remember, CCD memories are neither random-access nor read-only in type but serially accessible by either line or block.) Although the devices have been in development for about five years, mass-memory applications remained out of their reach until the chips reached a high level of density. Only then could moderately fast (5-MHz) very low-cost arrays be built that would match the disk and drum costs of less than 0.1 cent per bit.

The break-even point was the single 50-package memory board containing in the region of 1 million bits and so requiring a chip density of 16 kilobits and up. Meeting this requirement are the first two entries from Intel and Fairchild, both of them 16-k CCDs. When mounted with auxiliary circuitry on the standard-sized printed-circuit board, these chips provide a serially accessible memory array of 1.1 million bits—the first semiconductor option for mass-memory applications.

In architecture, the CCD memory differs from the familiar ROM or RAM so radically that it deserves further discussion. The new devices basically simulate the operation of rotating drums. For example, the Intel 16,384-by-1-bit chip is organized so that it can combine serial and random-access functions.

The devices are arranged as 64 256-bit shift registers in which four-phase clock signals simultaneously shift the data. Each shift register can be thought of as representing a single track in a conventional drum, and each track can be thought of as being divided into 256 sectors, corresponding to the 256 CCD data storage cells in each line. The "rate of rotation" of this semiconductor drum therefore is controlled by the four-phase clock.

Each of the 64 tracks contains its own driver buffer interface and is randomly accessible for read-write operation. Two basic addressing modes are possible: by sector (clock addressable) and by track (line addressable). To access a word in the block-addressable mode, the cylinder is shifted until the sector containing the word reaches the read/write buffer. The word is then accessed one bit at a time by addressing the appropriate track. Conversely, in the track-addressable mode, a word is placed sequentially around the cylinder in a given track and then accessed by appropriate clock shifts.

CCD memories have clear advantages over existing high-speed drums. They are an order of magnitude faster, despite the fact that their data is accessible only by block or line. At present, any line is accessible in 100 microseconds, and that time is expected to decrease significantly over the next few years.

CCD memories also have no need for high-speed mechanical movements and should therefore be much more reliable and last longer than today's drums with their extremely fast rotating mechanical assemblies. This makes CCDs particularly attractive in small associative memory systems, where the overhead of drive motors, sense heads, and other peripheral devices needed for conventional drums is excessively high. Estimates are that a simple five-board CCD system could be only half the cost of a 5-million-bit rotating system.□

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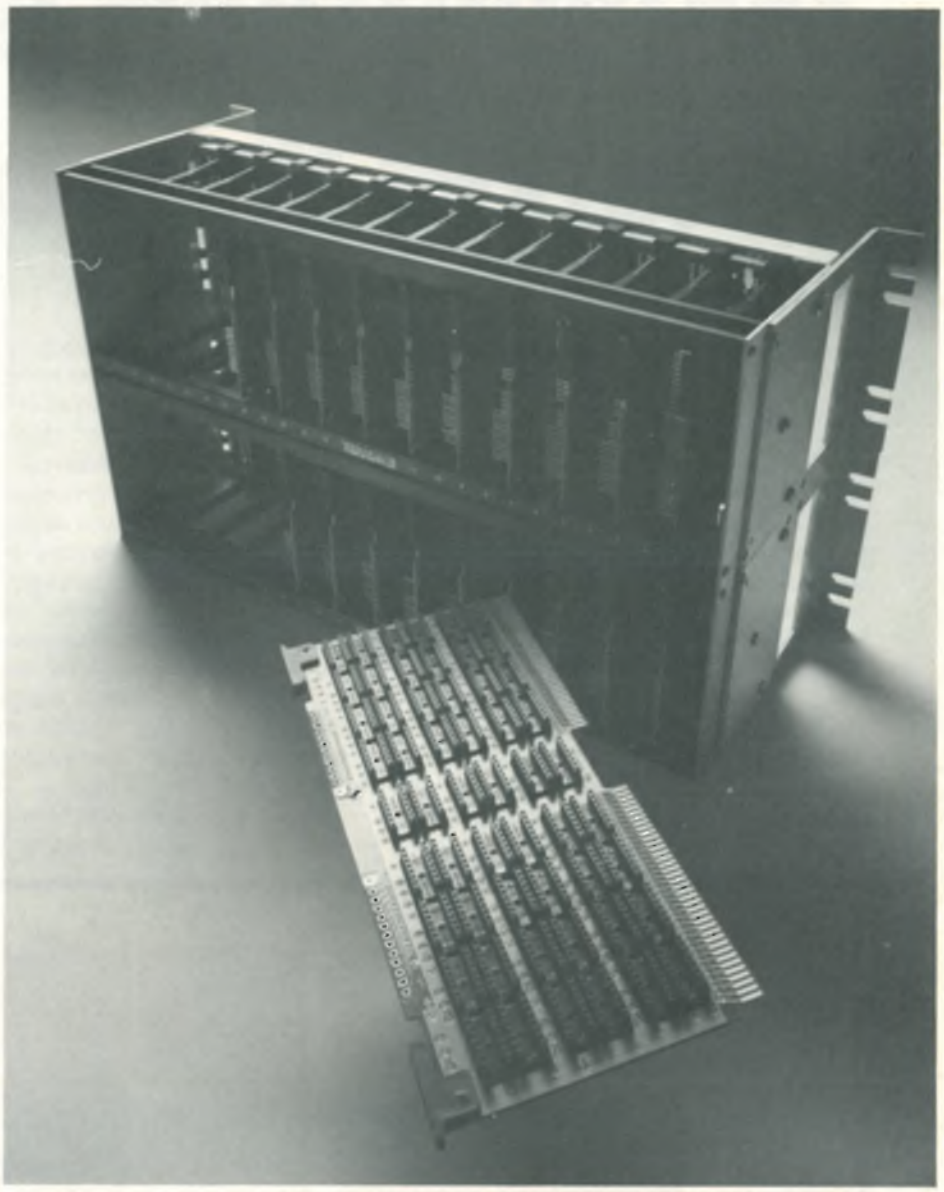

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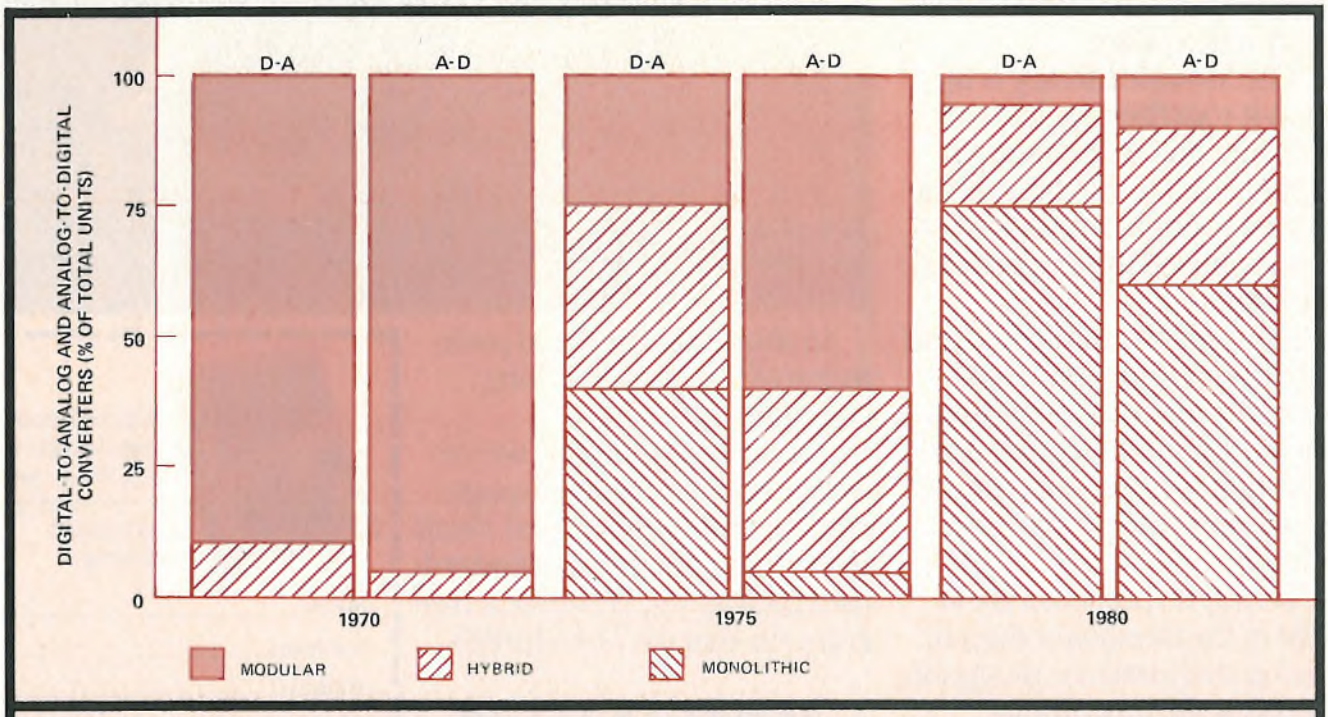
Monolithics mature, passives improve

☐ As in many areas, the major developments in components of late are due largely to improvements in integrated-circuit technology. There is, for example—to cite probably the most notable achievement of the past year—the first complete monolithic analog-to-digital converter. Without ion implantation and other refinements in IC technology, this component would not be available. To a great extent the same is true of other data converters, as well as operational amplifiers, resistor networks, and virtually the whole gamut of active and passive components.

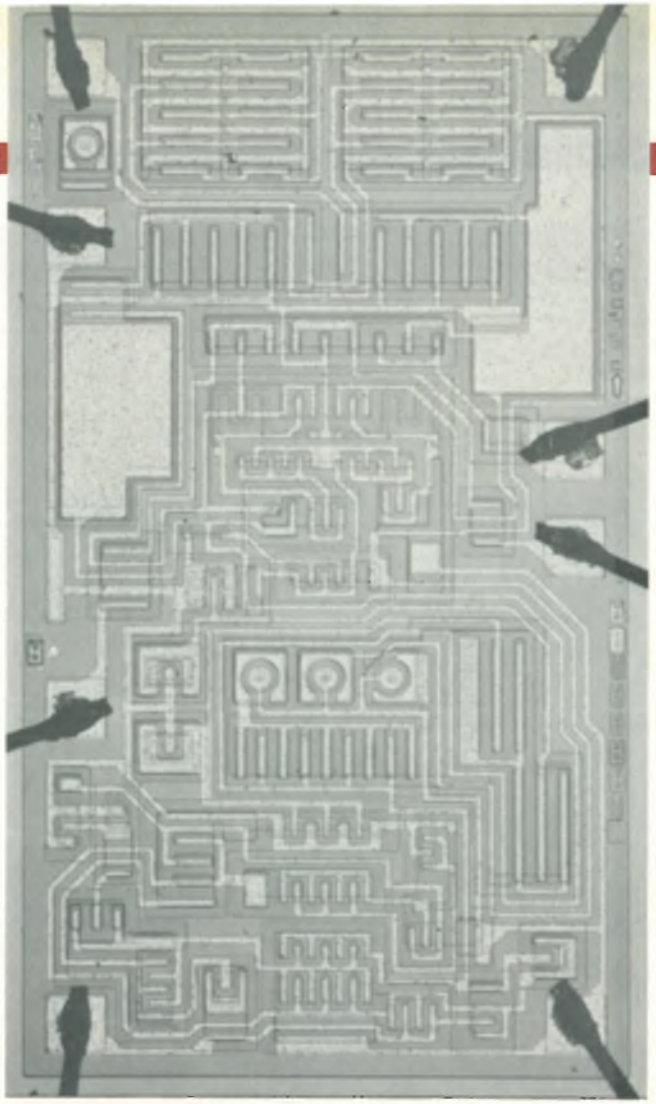
Whatever the driving technology may be, today's state of the art in components is impressive:

- Data converters. Hybrid digital-to-analog and analog-to-digital converters are being greatly integrated, so that units requiring no outboarded devices for operation are becoming more common. Monolithic data converters having 8- or 10-bit resolutions are now readily available. Most, however, require one or more associated external components.
- Operational amplifiers. The combination of mixed linear processing and ion implantation is producing FET-input units that have better characteristics.
- Power and microwave semiconductors. Voltage and current ratings for power semiconductors are up, operating speeds are higher, and prices are lower. For microwave devices, efficiency and gain levels are improving as power outputs and operating frequencies climb.
- Optical couplers. Current transfer ratios and operating speeds are increasing. For phototransistor and photoDarlington couplers, minimum transfer ratio can be as high as 100% to 200% for inputs as low as 1 milliampere. New types of couplers are on the way, particularly those intended for analog signal isolation.

by Lucinda Mattera, *Components Editor*



By 1980 more than half the data converters sold will be monolithic, a quarter or so will be hybrid, and 5% to 10% will be encapsulated modular units. Unlike what happened with op amps, market dominance by monolithics will be considerably slower to develop.



Good performer. Ion-implanted op amp from National Semiconductor has bipolar output and matched input J-FETs. Because of the matched input, the device's input characteristics are excellent.

- Resistors and capacitors. The prices of thin-film networks are plummeting and for the first time these devices are being supplied in plastic packages. Chip ceramic capacitors are no longer strictly fixed-value devices. And prices for both chip and packaged ceramic capacitors are falling dramatically as base metals substitute for precious metals.
- Relays and switches. Electromechanical relays in low-profile packages are compatible with today's high-density boards, and many of them can even be driven directly by logic ICs. And the pervasiveness of the dual-in-line package has now reached slider switches.

Converters proliferate

Technological advances in data converters have been snowballing for several years and this year has been no different, particularly for hybrid and monolithic devices. There are now many more of both types from which to choose (see converter table) and at least a couple of new hybrid vendors, namely National Semiconductor Corp. of Santa Clara, Calif., and Datel Corp., of Canton, Mass. Both entered the hybrid arena just last month with state-of-the-art devices.

Prices for complete hybrid digital-to-analog converters—ones that include an internal precision reference as well as an output amplifier—are down to under $10 for 8-bit units (from National) and under $30 for 12-bit units (from Datel). Despite the low prices, performance is commendable, with settling time running from about 10 microseconds for an 8-bit hybrid to about 3 μs for a 12-bit device. Additionally, Burr-Brown of Tucson, Ariz., has an unusual d-a hybrid—a 16-bit current-output device that provides 14-bit accuracy in a 24-pin dual-in-line package. Settling time to within ±0.003% of full-scale range is 50 μs.

Similarly, complete 12-bit hybrid analog-to-digital converters (from Datel) now sell for about $80 each, and conversion time can be an amazing 8 μs. Hybrid complementary-MOS units (from National) are available for as little as $35, although they require an external register and clock, and conversion rate is typically 20 kilohertz.

Complete monolithic converters, both d-a and a-d, having 12-bit resolutions still seem to be something in the not-too-distant future. However, there is now a whole array of 10- and 12-bit monolithic analog and digital building blocks available for making either a-d or d-a conversions. They include successive-approximation registers, quad switches, and precision current sources.

Some monolithic 10-bit d-a converters are complete, while Analog Devices Inc. of Norwood, Mass., has a 12-bit C-MOS unit that requires an external reference and output amplifier. This company also offers a 10-bit C-MOS d-a device whose inputs are double-buffered for direct interfacing with IC microprocessors.

At this time there is only one completely monolithic a-d converter—it's an 8-bit device made by National Semiconductor with ion-implanted p-channel MOS technology. Conversion time is around 18 μs. Selling price is on the order of $10. There is also a 10-bit monolithic C-MOS a-d converter from Analog Devices, but it requires an external reference clock and a comparator.

Modular converters—the epoxy-encapsulated variety—continue to offer the ultimate in performance. For example, conversion time for a 12-bit modular a-d converter is now down to 2 μs. Not only that, complete data acquisition systems have become available in modular form. These units, low-profile packages smaller than a human hand, are multiple-channel systems, containing a-d converters, sample-and-hold circuits, multiplexers,

A QUICK SURVEY OF DATA CONVERTERS

Technology	Resolution (Binary Bits)	Digital-to-Analog Converters			Analog-to-Digital Converters*		
		Settling Time	Notes	Approx. Small-Qty Price**	Conversion Time	Notes	Approx. Small-Qty Price**
Monolithic	8	85 ns – 1.5 μs	All units require ext. ref source and op amp	$10 approx.	18 μs approx.	All complete	$12 approx.
	10	250 ns – 1.5 μs	Some complete; others need ref source and/or op amp	$25 – $90	40 μs approx.	All require ext. clock and comparator	$70 approx.
	12	500 ns approx.	All require ext. ref source and op amp	$32 approx.	–	–	–
Hybrid	8	10 μs – 23 μs	All complete	$10 – $40	1 μs – 60 μs	All complete	$60 – $195
	10	23 μs approx.	All complete	$60 approx.	As low as 2 μs	Some complete; others need ext. register	$35 – $110
	12	3 μs – 23 μs	Most complete; a few need ext. op amp	$30 – $150	8 μs – 50 μs	Most complete; a few need ext. ref source and/or register and clock	$22 – $275
	16	100 μs approx.	All complete	$120 – $150	20 μs – 50 μs	Integrating types only	$75 – $250
Modular	8	25 ns – 20 μs	Both current- and voltage-output types	$12 – $255	800 ns – 250 μs	All complete	$60 – $475
	10	25 ns – 5 μs	Both current- and voltage-output types	$20 – $190	1 μs – 300 μs	All complete	$80 – $485
	12	50 ns – 20 μs	Both current- and voltage-output types	$35 – $180	2 μs – 350 μs	All complete	$115 – $585
	14	1 μs – 250 μs	Both current- and voltage-output types	$260 – $840	10 μs – 50 μs	All complete	$200 – $700
	16	750 ns – 250 μs	Both current- and voltage-output types	$110 – $1,500	5 μs – 400 μs	All complete	$1,400 – $3,000

*Principally successive-approximation types **For commercial-grade products

and sometimes even programable logic.

Like last year, mixed linear processing continues to influence monolithic operational amplifiers. With its ion-implantation technology, National Semiconductor has succeeded in producing a line of op amps (see figure) that have bipolar outputs and matched junction-FETs at their inputs. National, which calls its new process Bifet, is also using the technique for a line of analog switches and analog multiplexers. The op amps offer input offsets of 3 picoamperes and 1 millivolt, and an offset drift of only 3 microvolts/°C.

Quad op amps, offering the advantages of low cost and high functional package density, can now provide performance comparable to single units. Input bias currents are down around 500 nanoamperes, and output slew rates are slightly greater than 1 volt/μs. Frequency performance is impressive too, with small-signal bandwidths being 1 megahertz or more and large-signal bandwidths ranging from 20 to 40 kilohertz. What's more, chip designs have been improved so that crossover distortion is no longer a problem when the op amps must drive a grounded load while operating from a split supply.

Voltage-to-frequency converters, which can be used to make analog-to-digital conversions, have been available in component form for only two or three years. Yet modular versions already are down in price, ranging from about $200 for a unit providing an output frequency as high as 5 MHz to less than $35 for a 10-kHz unit. Linearity error can be as good as ±0.005% to ±0.1%.

This past August, furthermore, the first monolithic voltage-to-frequency converter was introduced by the Semiconductor division of Raytheon Co., Mountain View, Calif. The unit contains a voltage comparator, a one-shot, and a precision switched current source, and sells for only $3 each in quantities of 100. The full-scale frequency is resistance-programable over an operating bandwidth of 10 to 100 kHz, and linearity error ranges from ±0.05% to ±1%, depending on whether an external integrator is used.

Another component area studded with significant technical advances in 1975 is power semiconductors (see ratings table). Ratings for a single switching transistor

RATINGS FOR POWER SEMICONDUCTORS				
Power Class	Type of Device	Description	Voltage Range (V)	Current Range (A)
Moderate power	Diodes	Rectifier	50 – 5,000	0.5 – 100
		Zener	5 – 200	(1.5 – 60-kW surge capability)
		Schottky	up to 40 – 45	up to 50 – 60
	Transistors	Switching	50 – 800	1 – 35
		Darlington	40 – 600	1 – 15
		High-voltage	1,200 – 3,000	1 – 12
	Thyristors	SCRs and Triacs	30 – 800	1 – 60
High power	Diodes	Rectifier	50 – 4,000	100 – 3,000
	Transistors	Switching	50 – 500	50 – 200
		Darlington	100 – 700	40 – 200
	Thyristors	SCRs	50 – 4,000	60 – 1,900

are up to 750 volts at several amperes, with turn-off time on the order of 1 μs. Darlington transistors are getting faster, too. Their turn-off time is around 2 to 3 μs, and ratings can run up to 600 V at 15 A.

In thyristors, new types of devices, particularly gate-turn-off units, are reducing commutation times and problems. Voltage ratings of up to 600 V are commonplace, while current handling capability can be on the order of 50 A. Although silicon-controlled rectifiers are by far the most widely used thyristor, applications for triacs are growing because of their improving performance. A new family of triacs from Hutson Industries of Dallas, for example, are monolithic structures, but they function as though they were two discrete SCRs, permitting them to be easily gated and commutated.

High-power devices grow

Progress has been slow but steady in high-power rectifiers and SCRs for industrial applications. Wafer size is getting bigger and the largest single devices now have diameters of 2 to 2.5 inches. Peak reverse-voltage rating for these giants is currently around several thousand volts, while continuous current capabilities range from 1 to 3 kiloamperes. For smaller devices, operating speed is getting faster with no degradation of voltage and current ratings. Turn-off time for a 1,200-V SCR capable of handling a root-mean-square current of 750 to 850 A is down to 18 to 30 μs.

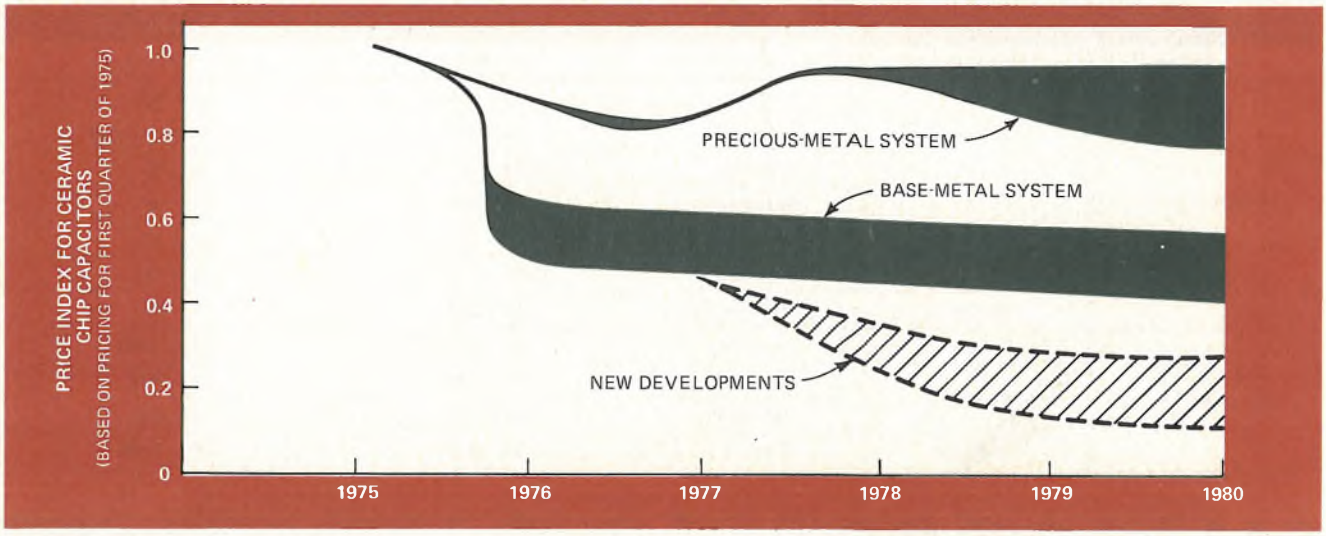
Power-output levels are also increasing for microwave discrete semiconductors. For silicon bipolar transistors, continuous-wave outputs now range from 35 to 1 W for frequencies of 1 to 10 gigahertz. Efficiency and gain levels are remaining high, with the former spanning 15% to 65%, and the latter 4 to 10 decibels. Currently in development are both silicon and gallium-arsenide field-effect transistors capable of providing sizable power outputs. At 1 GHz, better than 4 W can be obtained from a silicon device, with a gain of over 6 dB. GaAs FETs operating at frequencies of up to 9 GHz can develop outputs of up to 1 W at a gain of around 4 dB and efficiency of 16%.

Similarly, the power and efficiency levels of microwave diodes are improving as operating frequencies climb. In Gunn devices, ratings range from approximately 2.5 W at 8 GHz and 10% efficiency to around 50 milliwatts at 94 GHz and 0.7% efficiency. GaAs Impatt diodes can now develop up to 4 W in continuous-wave operation at 10 GHz with 18% efficiency, or up to 15 W in pulsed operation at 9 GHz with 25% efficiency. And the power output of silicon Impatts can be over 1 W at 50 GHz or so, with an efficiency of 12%.

In optical couplers, performance seems to be leveling off. Manufacturers are concentrating more on refining technologies. For an imput current of only 1 mA, minimum current transfer ratio can be guaranteed at 100% for a phototransistor coupler, and at around 200% for a photoDarlington coupler. The maximum data rate of logic-gate couplers is typically around 5 MHz, but speeds of up to 10 MHz can be realized with optimum circuit conditions. Guaranteed minimum isolation voltage for a single device in a dual-in-line package can be as high as 5 kilovolts.

Coupler prices should continue to decline for the next several years, dropping eventually to the $1 level for high-performance devices that now fetch $2 or more. New types of coupler are also beginning to emerge—ones whose switching threshold can be programed by means of external resistors, and multichannel ones intended for analog applications. In the near future, there may be couplers having a phototriac output, or couplers whose input and output remain linearly proportional to each other.

Discrete light-emitting diodes, available in several colors for the past year or two, can now be bought in ultra-miniature form with a body size only slightly larger than the head of a pin. These devices can develop a brightness of around 1,000 foot-lamberts at drive levels of 10 mA or so. A components application that could impact display technology in the years ahead is the use of LEDs in analog-type indicators that have no moving parts. The indicator, being proposed by Germany's Siemens AG, could be used as a car radio dial or as a temperature or liquid level indicator. From a linear array of LEDs, an IC selects a specific diode and turns it on and



Price projection. Base-metal system developed by USCC/Centralab for ceramic chip capacitors dramatically lowers prices over precious-metal units. During next five years, base-metal parts may be up to 60% cheaper. By 1978, other developments will mean still lower prices.

off, depending on the analog value to be represented.

Although LEDs continue to dominate the readout market, liquid-crystal displays have made some notable technical gains. No longer, for example, are they strictly edge-mounted devices. At least one manufacturer, Liquid Xtal Displays Inc. of Cleveland, has developed a dual-in-line configuration facilitating wider conductive patterns and therefore less susceptibility to opening. Recently this company has equipped its dual-in-line devices with special substrate clips that permit the displays to be plugged directly into pc boards in order to mount them.

Prices for passives dropping

Thin-film resistor networks traditionally have been fairly expensive, selling for $3 to close to $40 each, even for off-the-shelf standard parts. This year, prices nosedived. By applying the high-volume automatic processing techniques that are used for ICs, the Resistor Products division of Analog Devices is producing thin-film resistor networks in hermetic packages that in some cases sell for half as much as previous devices and with no degradation in performance.

Furthermore, National Semiconductor this year announced a line of thin-film resistor networks packaged in plastic that are intended to compete with standard thick-film networks in ceramic packages. National, which aims to get prices down to less than 35 cents each in lots of 100,000, feels the traditional ceramic package for thin films is overkill. For most circuitry, claims National, ceramic exceeds the need to guard thin films against moisture, and the customer is paying for this overprotection.

Ceramic capacitors, both chip and packaged versions, have been the fastest growing segment of the capacitor industry for a few years now. Prior to 1975 unpackaged ceramic chips were strictly fixed-value devices. Now Vitramon Inc. of Bridgeport, Conn., has a line of ceramic chips whose capacitance can be adjusted incrementally without adversely affecting device performance.

Another significant step in ceramic capacitors was the successful transition from a precious-metal system to a base-metal system by USCC/Centralab of Los Angeles. The company is using a nickel alloy to make the internal electrodes and the terminations for its capacitors, permitting price recuctions (see graph) of at least 30%, and even 50% in many instances.

Others looking

Likewise, manufacturers of other components that have a relatively high precious-metal content are looking for suitable base-metal substitutes. In its family of Flexlok connectors, the Components division of Burndy Corp., Norwalk, Conn., is using a gold-free specially shaped contact to make gas-tight high-pressure connections to flat cables and flexible circuits. The connectors are directly pluggable, obviating the need for special assembly, soldering, or welding equipment. The contact is composed of a copper alloy plated with a tin alloy.

Packages for electromechanical devices like relays and switches continue to evolve in forms that are compatible with ICs. A number of relays are now available in low-profile packages, for example, that have heights ranging from 0.34 to 0.45 in., making them ideal for applications where the vertical spacing between boards is only 0.5 or 0.6 in. Some of the new low-profile units can be driven directly by bipolar logic ICs and a few even by C-MOS devices.

Similarly, rocker-type switches can be supplied in dual-in-line packages, with as many as 10 single-pole single-throw switches to a 20-pin package. Slide-type switches have also been put in miniature dual-in-line packages by the Minelco division of General Time, Thomaston, Conn. The switches come in 16-pin DIPs, which measure only 0.3 in. wide by 0.55 in. long by 0.33 in. high. □

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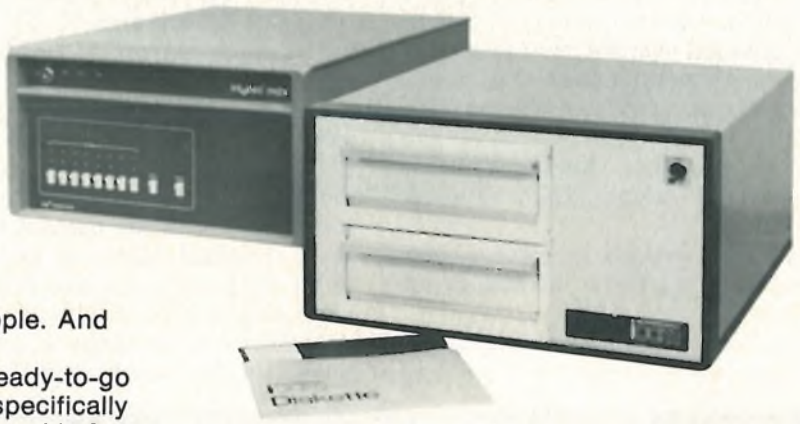

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Film carriers win productivity prize

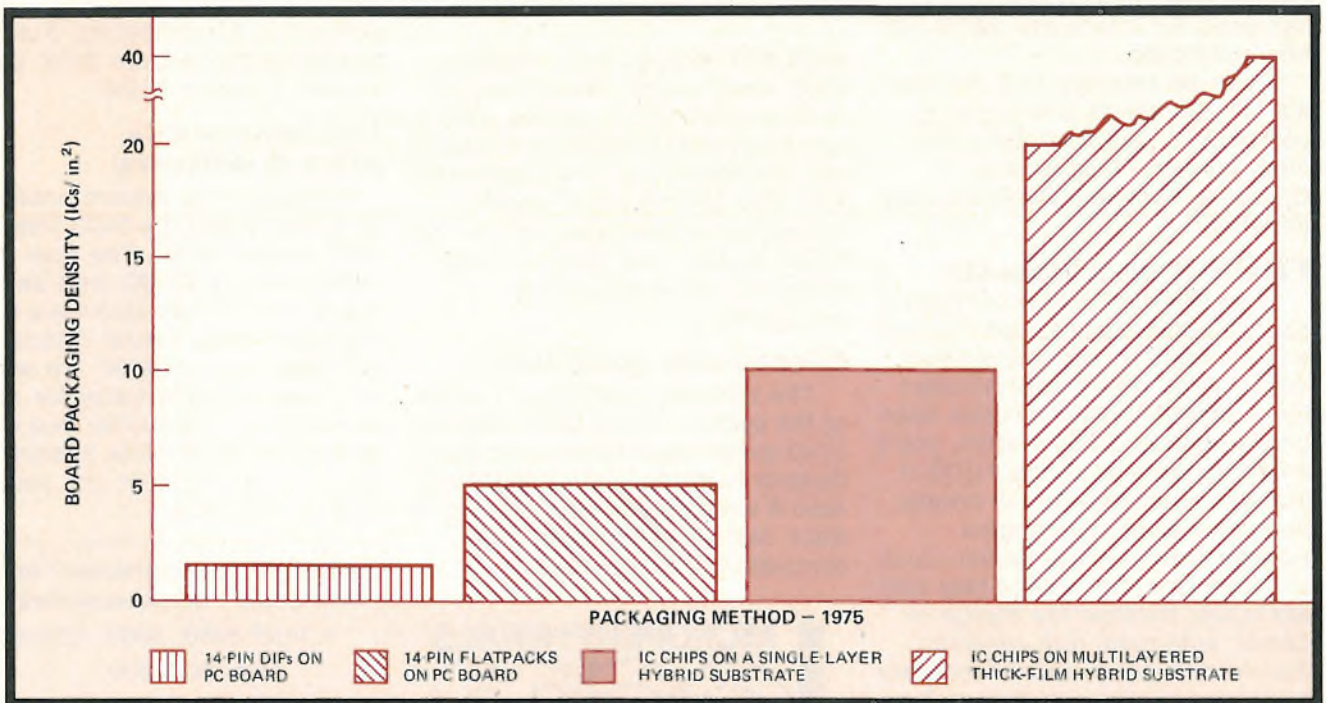
☐ The coming-of-age of the film-carrier technique of gang-bonding integrated circuits must rank as the most important production advance in the past year. As evidence, each of the film-carrier (or tape-carrier) machines now in commercial operation is turning out at least 1,000 monolithic IC devices per hour, and that figure is expected to be doubled over the next 18 months. By comparison, a high-speed automated wire bonder may produce 600 ICs an hour, while a manual machine may produce only 60.

While perhaps not as impressive, other technical innovations recently coming to the fore also have important implications, including:

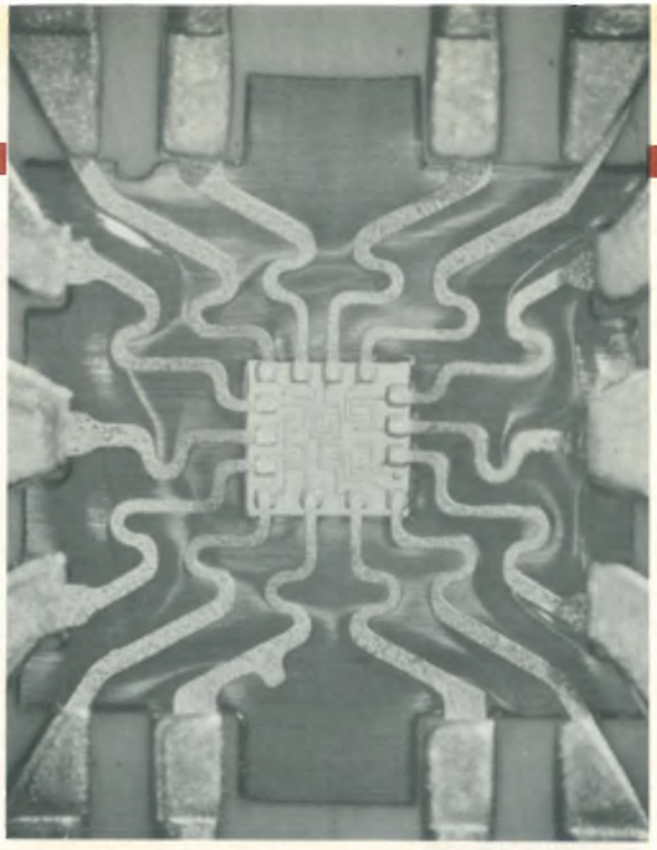
- A new resistless additive process in printed-circuit production and a radically improved method of die-stamping printed circuits.
- The emergence of four competitive techniques for automated wiring, each with its own distinct advantages.
- A speed-up of the trend toward increased packing density in thick-film hybrids through multilayering and computer-aided design.
- The expanded use of elastomeric materials for general interconnection purposes.

Still, the preeminent achievement is the film-carrier technique. Originated by the General Electric Co. in 1971, shortly before GE took itself out of the IC business, the film-carrier process was conceived as a way to stay competitive with the manual IC wire bonding done off shore. Dubbed Minimod by GE [*Electronics*, Feb. 1, 1971], the process was also designed to produce greater IC reliability. It was held back, however, by a number of circumstances, including a couple of economic recessions. But there were technical reasons as well. Tapes

by Jerry Lyman, *Packaging & Production Editor*



Multilayering and computer-aided design between them have produced thick-film hybrids that have a packaging density almost an order-of-magnitude larger than competitive techniques such as DIPs or flatpacks mounted on printed-circuit boards.



ICs on film. A familiar sight from now on will be the gang-bonded IC chip, like the RCA unit shown here on a frame of 9-mm film.

and gang-bonding equipment were not generally available, and new techniques were needed to develop the metallic IC bumps required for a bond interface to the lead frame of the film carrier.

As shown in the table of IC manufacturers using the film-carrier method, the technical problems have been overcome, and there are now companies in the U.S., Europe, and Japan producing ICs with the tape-carrier technique.

The Minimod process consists basically of lead frames etched from a copper strip and laminated onto a sprocketed 35 mm polymide film. The film and a string of chips then come together and, with the film serving as a support for the chips, the lead frame and chip leads are bonded.

When GE dropped the IC business in 1971, it sold the fast-bonding process to Texas Instruments, which continues to use a refined version of it today. TI and other companies that were experimenting with similarly conceived ideas have since divided into two schools over the film-carrier technique. One school uses a three-layer film in standard cinematic sizes (8, 16, 35, and 70 mm), while others have adopted a specialized standard of 11 mm film having two layers.

The two-layer film uses 0.5-mil-thick rolled copper on a polyimide film, using no adhesive, and its partisans say it has higher temperature resistance and lower costs for tooling and materials. Three-layer film, on the other hand, is built up out of electrodeposited copper, adhesives, and polyimide film. Users say it offers an excellent dielectric barrier with low electrical leakage between the metal lead pattern and the normally hydroscopic film, making it suitable for both bipolar and MOS ICs.

Whether two-layer or three-layer, the output figures are about the same. Moreover it is not inconceivable that production rates of 10,000 devices per hour will be seen by 1977, by which time further refinements of the film-carrier process may have combined optimally with automatic inspection and automatic testing.

Other predictions foresee the virtual extinction of other ways of bonding ICs. "Since the dynamic limits of automated wire bonding have just about been reached, and the cost of foreign labor is going up," says Thomas Angelucci, "American IC manufacturers will have all switched over to the tape-carrier/gang-bonding method by 1977." Angelucci is president of International Micro Industries, a producer of film carriers and gang-bonding equipment in Cherry Hill, N.J.

A not-quite-so-sweeping view is taken by Dick Santilli, division vice president for bipolar ICs and special products of RCA Solid State division, Somerville, N.J. "In two years," Santilli predicts, "all major IC manufacturers will go either to the tape carrier or automatic wire bonding for cost effectiveness and reliability. However, full automation is further down the line."

The pc story

Until this year, practically all printed-circuit processes were based on patterns produced with screened or film-resist materials that limit the action of chemical processes to sharply defined areas. Normally these patterns are formed on screened resists (at 3 to 4 cents per sq. ft.) for low cost medium and low-density boards, or photo-imaged on liquid (12 to 15 cents per sq. ft.) or dry film (35 cents per sq. ft.) for more expensive high-density boards.

Then came a photo-imaging additive pc process, called Photoforming, from Photocircuits division of Kollmorgen, Glen Cove, N.Y. Photoforming needs no resists and provides conductor definition as good or better than that of additive boards using dry film resists. And the cost is comparable to that of a liquid photoresist process. Duke Danzig, Photocircuits marketing manager, says, "Probably within two to three years Photoforming's price will approach that of a screened resist board, making the process suitable for both high- and low-density pc work."

With the new method, conductors 1.36 mils thick with spacing as close as 3 mils have been successfully fabricated. Since a catalytic image is formed photographically, line definition is potentially as good as the qual-

MAJOR IC MANUFACTURERS USING FILM CARRIERS			
Company	Relative U.S. Output	Film Width (mm)	Film Type
Texas Instruments	1st	35	3-layer
National Semiconductor	2nd	11	2-layer
Fairchild	3rd	16	3-layer
RCA	4th	11	2-layer
Motorola	5th	16	3-layer
Honeywell Bull	–	35	3-layer
Siemens	–	8	3-layer
Philips	–	16	2-layer
NEC	–	35	3-layer
Mitsubishi	–	35	3-layer

ity of the line work used on the photographic negative.

Photoforming is currently in the pilot-line phase at Photocircuits and at its licensees. Danzig anticipates the process will be in full production in about two years.

Stamping out pcs

One of the more timely developments in the manufacture of printed-circuit boards has been the emergence of die-stamping as a possible replacement for chemical etching. Timely because guidelines posted by the Environmental Protection Agency have put a cloud over the future of chemical etching.

Chemical etching is a process in which the dielectric and a copper foil are sandwiched, and the circuit pattern is imaged on the copper with a material that is resistant to etching chemicals (the resist). The copper, which is not intended to be part of the circuit, is then removed by chemical etching. There have already been instances in the U.S. where local authorities have forced pc manufacturers to either shut down chemical etching operations or install pollution-control systems.

Since about 1958 a process for mechanically die stamping pc boards has been available that would solve the ecological problems of chemically etched boards, but it was suitable only for low-density boards with relatively thick line widths and spacing. Several years ago, however, the Stampede division of Jerobee Industries Inc., a subsidiary of Rocket Research Corp., Redmond, Wash., developed a chemically milled die that could result in boards with 0.01-inch-wide conductors on center spacings at 0.032 to 0.022 inch intervals. R. J. Stryer, marketing manager of Stampede, says, "As a rule of thumb, any commercial pc board that is currently being etched can now be die-stamped."

At the present time, Stampede will supply dies to anyone willing to use the die-stamped pc process. The Rogers Corp. of Rogers, Conn., will supply die-stamped boards to a customer's specifications.

The advantages of mechanically produced printed circuits include material savings (no etchants or inks), repeatability, high production rates, lower labor costs, increased equipment life, and salvageable scrap copper. Disadvantages are that the die is expensive (although this can be written off over a long production run) and there is currently no satisfactory way to produce a two-sided die-stamped board with plated-through-holes (PTH). Stampede is working on several methods of producing PTH die-stamped boards and feels that an adequate solution is not too far off.

MLBs go commercial

Multilayer pc boards are often thought of as an expensive and rather complex way to solve high-density packaging problems. But for some time now, multilayer boards (MLBs) have been expanding from the military/avionics world into commercial uses. Here these boards are used not so much to increase packaging density but to improve logic speed, cut electrical crosstalk, and control circuit impedances. For example, emitter-coupled logic and Schottky TTL need buried ground and power planes to operate properly. This can be accomplished with a relatively simple four-layer MLB having two external patterns and two buried conductive layers. Since the buried layers have no pattern, a board of this type is easier to design and manufacture than a complex aerospace type. Digital Equipment Corporation (DEC), Maynard, Mass., and Cambridge Memories, Bedford, Mass., are examples of companies using this approach. DEC has been using 8-by-17-inch four-layer boards for high-speed bipolar logic since 1972. Since bipolar logic types are becoming more prevalent, design engineers will have to get away from the use of two-sided pc boards for many applications. But multilayer boards are not, of course, the only alternative.

There are three automatic wiring techniques that compete effectively with pc boards, especially multilayer pc boards. Two of them are patented processes called Wire-Wrap and Multiwire, and the other is called stitch wiring. A comparison of the three is shown on the table on page 125.

The well-established Wire-Wrap process was originated by the Gardner-Denver Co., Grand Haven, Mich., and is backed up by a full range of specialized automatic and semi-automatic machines. Basically it consists of tightly winding the stripped end of a solid wire five to seven times around a square-edged post so that the post and the wire are formed into a gas-tight bond. A competitive method that produces the same type of intimate bond, but which is less widely used, is called Termi-Point. A development of Amp Inc., Harrisburg, Pa., Termi-Point has been confined mostly to backplane applications.

The Multiwire process, developed in 1970 by Photo of Glen Cove, N.Y., involves a customized pattern of insulated wires laid down on an adhesive-coated substrate. While successful, Multiwire's availability has been confined to Photocircuits and a few licensees.

Multiwire competes with multilayer boards in two areas—packaging density and as an inter-connection method for high-speed bipolar logic. One Multiwire board with an etched ground and powerplane and signal layers on each side is the equal of a six-layer MLB.

RATING AUTOMATED WIRING TECHNIQUES						
Method	Two-Dimensional Packaging Density	Repairability	Cost of Artwork	Programing Costs	Mfg. Costs (Prod. Quantities)	H-F Performance
Multilayer pc	Highest (1)	Poor	High	None	Lowest (1)	Excellent
Multiwire	High (equal to 6-layer MLB) (2)	Fair	Low	High (1)	Low (3)	Good
Stitch wiring	High (3)	Good	Low	Medium (2)	Highest (4)	Good
Wire-Wrap	Medium (4)	Excellent	Low	Medium (2)	Low (2)	Good with special panels

And by adding other signal layers, equivalents of a 12-layer MLB can be had. A more graphic example is cited by Jack Staller of Staller Associates, a Norwood, Mass. consulting firm. "An MLB designed for a fast-Fourier transform system analyzer had an artwork cost of $10,000," says Staller. "Using Multiwire for the same 300-IC board only required a $2,500 programing cost."

The third alternative to multilayer boards—stitch wiring—is used primarily in the military/avionics/space field because of its very high reliability. The chief commercial drawback, until this year, was the absence of a low-cost manual machine (comparable to a hand-held Wire-Wrap gun). But now APAC has come out with a manual stitch-wirer for $995, and commercial interest has increased. Furthermore, boards with standardized or customized patterns are becoming available for potential stitch-wirers.

So the next couple of years should see a sharp increase in the use of stitch-wiring, as well as Multiwiring. At the same time, the growth of Wire-Wrap and multilayer boards will remain steady.

Dense digital hybrids

While most attention concerning packing density has been focused on monolithic ICs (ROMs, RAMs, microprocessor sets), the thick-film industry has quietly slipped into the large-scale digital hybrid field. Thick-film hybrids normally are thought of as relatively simple analog circuits on relatively small substrates, like a quarter inch square, but this is a misconception. Many thick-film hybrid manufacturers now are turning out large-scale digital hybrids in units as large as nine inches square and containing upwards of 220 chips. These units, aimed at the military/avionics/space field, are possible because of the development of multilayering in thick-film hybrids and the greater use of computer-aided design and manufacturing.

An example of this technology is a 16-bit missile computer designed by Algorex, Syosset, N.Y., which packs 75 monolithic chips plus discretes on a 10-layered 2-by-2-inch substrate. A comparison of packaging density of DIPs, flat-packs, and hybrids is shown in the table heading this section.

Conductive elastomeric materials, formed from a rubber made conductive by incorporating a metallized filler or carbon, seem bound for growing success. Originally used for gasketing against electromagnetic and radio-frequency interference, recent large-scale production of digital watches has opened up a large new market for conductive elastomers as connectors for the liquid crystal readouts. As opposed to metals, the elastomers filled a need for high-contact density, shock-proof, springy, reliable connectors. Leonard Buchoff, technical director of research and development for Technit, Cranford, N.J. observes that, "almost all of the digital electronic watches made in the United States today use the conductive button in a frame approach, or the layered connector technique as the means of connecting to the LCD."

The elastomeric connection

In the first and earliest approach, conductive rubber buttons are molded through holes in a glass-filled nylon frame. A later approach, called Zebra [*Electronics*, September 19, 1974, p. 122], consists of a rectangular bar of alternate layers of laminated conductive and non-conductive silicone rubber.

A Technit competitor, Chomerics Inc. of Woburn, Mass. has just come out with a product with similar properties. Chomerics' elastomeric connector, Cho-Strel, is made by molding conductive paths into a silicone base. Cho-Strel differs from Zebra in that its alternate conductive and nonconductive paths do not run all the way through.

The next large field for elastomeric materials will probably be in the field of connectors for ICs. A scheme using a square Zebra as a solderless connector for a leadless IC carrier [*Electronics*, July 10, 1975, p. 38] is about a year off, according to Steve Cifani, Tecknit's vice president of marketing.

Meanwhile, a development expected late this year may see elastomers used on test probes and IC probers. Another development that elastomeric researchers are only thinking about is to actually bond an IC chip to a lead frame with elastomeric materials eliminating the wire and epoxy bonding schemes used now.

Finally there are thin elastomer sheets available that have a matrix of conductive dots in the Y direction (the Zebra normally makes connection along an edge). These materials have been proposed as very-high-density connectors to LSI or hybrids (at the chip level). □

Chronology

OCTOBER 1974

- 12-bit digital-to-analog converter from Analog Devices is first to be built from a pair of custom LSI chips *Oct. 3, 1974, p. 139*
- First C-MOS single-chip microprocessor, a 12-bit unit from Intersil, can reduce cost and power consumption of processor-based control systems *Oct. 17, 1974, p. 26*
- The 100-nanosecond access-time barrier for n-MOS 1,024-bit RAMs is broken by Intel's 2105 static RAM *Oct. 31, 1974, p. 20*
- 4-trillion-bit mass-storage system, IBM's 3850, automatically extracts magnetic-tape cartridges from honeycomb frame and transports them to station where data is recorded on the tape as helical stripes *Oct. 31, 1974, p. 28*
- First digital 4-function watch chip built by TI with I^2L makes bipolar circuits competitive with low-power C-MOS for digital watches *Oct. 31, 1974, p. 30*

NOVEMBER 1974

- First commercial application of thin-film sapphire substrates for watches is RCA's C-MOS-on-sapphire 4-MHz timing chip, which allows use of smaller, more accurate high-frequency crystals *Nov. 14, 1974, p. 25*
- Field-programable logic arrays from Intersil and Signetics offer designers unprecedented flexibility *Nov. 14, 1974, p. 26*
- First zener made in chip form, a voltage reference from National, outperforms most conventional zeners *Nov. 14, 1974, p. 26*
- New family of TI Schottky TTL microprocessor parts rushes in era of high-performance programable-logic design techniques *Nov. 14, 1974, p. 29*
- Tightened n-MOS processes at TI and Intel yield 4-kilobit RAMs that operate under 200 nanoseconds *Nov. 14, 1974, p. 30*
- RCA develops thin liquid-crystal coating that reveals design faults in ICs *Nov. 14, 1974, p. 32*
- C-MOS RAM reaches the 1,024-bit level, expanding the range of applications for low-cost, low-power memories *Nov. 14, 1974, p. 42*
- First 16-bit single-chip microprocessor from National, built with silicon-gate p-MOS technology, becomes cheapest available 16-bit processor *Nov. 28, 1974, p. 35*

DECEMBER 1974

- Mixed linear processing from National builds relay drivers having C-MOS front ends and Darlington outputs for high-drive capability for telecommunications *Dec. 12, 1974, p. 30*
- Mask-focusing color-TV picture tube from Hitachi of Japan has double the brightness and contrast of other 110° deflection tubes and reduced power requirements *Dec. 26, 1974, p. 7E*
- Competition heats up in high-board-density RAM market with introduction of 18-pin 4-kilobit devices from TI and National *Dec. 26, 1974, p. 20*
- Frequency-synthesis digital tuner-address systems for color TV sets are introduced, one by Plessey and National jointly and a second by Fairchild *Dec. 26, 1974, p. 26*

JANUARY 1975

- First monolithic 10-bit analog-to-digital converter is built by Analog Devices' C-MOS technology *Jan. 23, 1975, p. 137*

FEBRUARY 1975

- Measurement packages continue to shrink in size as Tektronix integrates DMM and miniscope *Feb. 6, 1975, p. 123, and Feb. 20, 1975, p. 81*
- 16-bit microcomputer with 4,096-word memory complete on one board, Digital Equipment Corp.'s LSI-11, uses four n-MOS LSI chips and is compatible with DEC PDP-11 computers *Feb. 20, 1975, p. 114*
- Technical Wire Products' Zebra-strip (alternate conductive and nonconductive elastomer layers) is dense, low-cost interconnection for digital watches, etc. *Feb. 20, 1975, p. 132*

MARCH 1975

- Universal instrument interface standard is adopted by IEEE *March 6, 1975, p. 10*
- Rockwell International prepares a 10-bit p-MOS microprocessor with a keyboard-equipped emulator-control module for automotive applications *March 6, 1975, p. 36*
- High-power plastic package capable of dissipating 65 W at 100°C is developed by TI for its medium-current power transistors and thyristors *March 20, 1975, p. 40*
- First microprocessor-controlled synthesized signal generator is introduced by Fluke *March 20, 1975, p. 101, and April 3, 1975, p. 3*

Significant advances in electronic technology reported over the past year in *Electronics*

APRIL 1975

- Chrysler Corp. develops electronic spark-advance system that provides a lean-burn clean-emission auto and promises increased gas mileage *April 3, 1975, p. 38*
- New additive printed-circuit process from Photocircuits division of Kollmorgen Corp. requires no film or screened-on resist *April 3, 1975, p. 44*
- Japanese facsimile system sends letter-size pages in 3 seconds *April 3, 1975, p. 58*
- Expandable mass-storage system from Control Data Corp. stacks 100-billion-bit magazines, each consisting of 2,052 64-million-bit cartridges *April 17, 1975, p. 26*

MAY 1975

- Tri-metal process from RCA brings hermeticity to plastic-packaged ICs *May 1, 1975, p. 29*
- Algorex produces computer-designed thick-film multilayer hybrids with up to 30 chips per square inch instead of four or five *May 1, 1975, p. 30*
- Logic-state analyzers introduced by Hewlett-Packard feature state-map format to simplify troubleshooting in the data domain *May 1, 1975, p. 75, and May 15, 1975, p. 103*
- Telephone exchanges in France adopt electronic switching *May 15, 1975, p. 9E*
- First low-loss multichannel fiber-optic cable for commercial uses, from Corning, can handle six channels at once, with maximum attenuation of 20 dB/km per fiber *May 15, 1975, p. 121*
- Rolm Corp. announces a computer-controlled stored-program PBX *May 29, 1975, p. 38*

JUNE 1975

- FCC effectively wraps up its proceedings under docket 18262, which calls for land-mobile communications to be developed within the 115 MHz allocated at 900 MHz *June 12, 1975, p. 50*
- First 4,096-bit RAM to be built with the I^2L technique, from Fairchild, has two to three times faster access than competing n-MOS products *June 26, 1975, p. 25*
- Second-generation I^2L at TI attains speed in 10-ns TTL range *June 26, 1975, p. 25*

JULY 1975

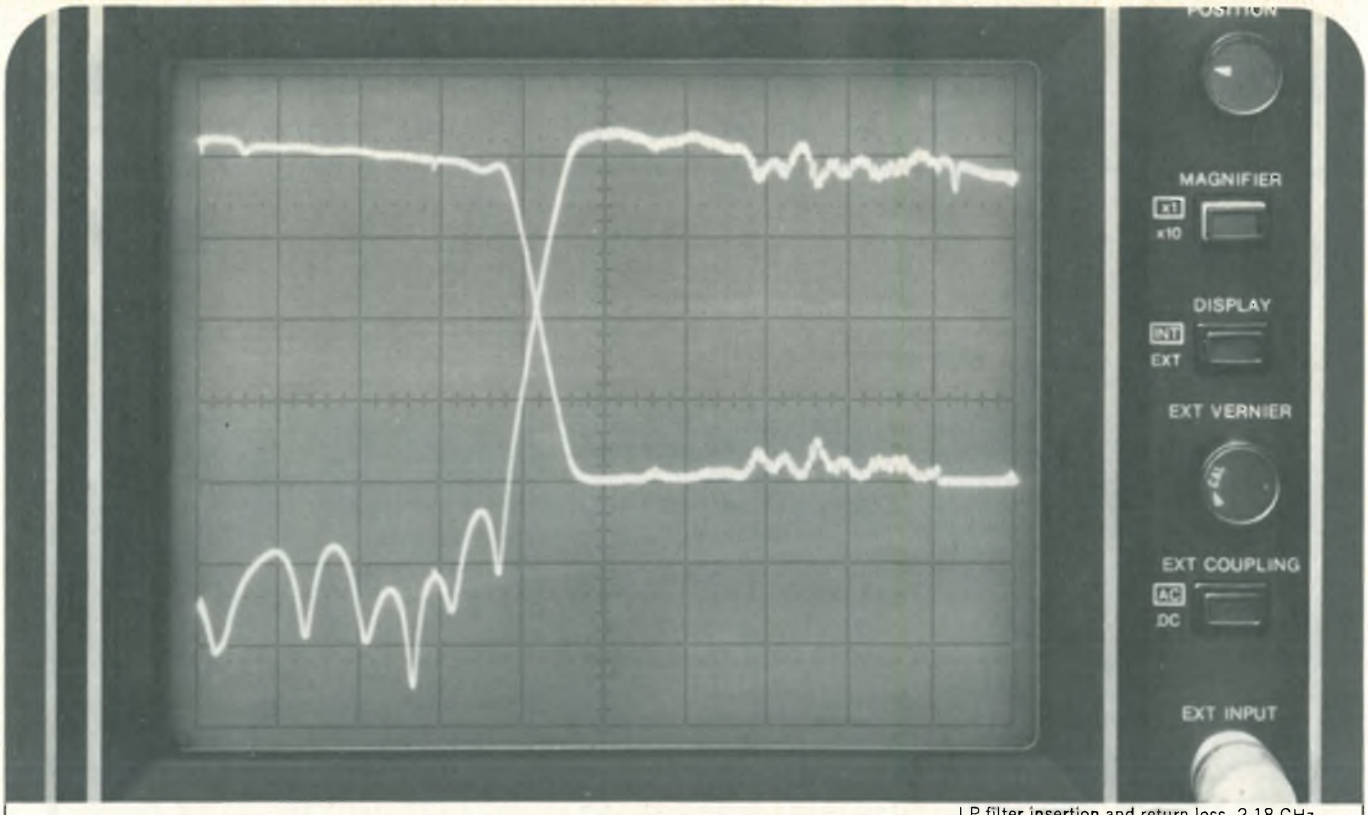
- First 1,024-bit C-MOS-on-sapphire RAM is announced by RCA *July 10, 1975, p. 25*
- New type of thyristor, fabricated as a seven-layer monolithic structure by Hutson Industries, is designed to replace the conventional triac *July 10, 1975, p. 122*
- Color-TV receivers from Loewe Opta GmbH of West Germany feature infrared audio transmission from a diode array on the set to a photodiode mounted in a headset worn by the viewer *July 24, 1975, p. 5E*
- New class of signal-measuring instruments from Austria's Norma Messtechnik uses probabilistic principles *July 24, 1975, p. 86*

AUGUST 1975

- AT&T proposes to cooperate with other equipment makers in developing protective interconnection module *Aug. 7, 1975, p. 63*
- First practical multichannel single-fiber-per-channel connector is produced by team of Corning and Deutsch for optical communications systems *Aug. 21, 1975, p. 29*
- Philips, Intermetall, and Plessey develop digital electronic tuning systems for European TV market, and Grundig designs on-screen display for channel, time, and tuning scale *Aug. 21, 1975, p. 59*
- 1-megabit CCD memory system from Intel is first commercial semiconductor device to compete with disks and drums for associative computer applications *Aug. 21, 1975, p. 109*
- First monolithic voltage-to-frequency converter, developed by Raytheon, offers linearity within ±1% and bandwidth of 100 kHz *Aug. 21, 1975, p. 112*

SEPTEMBER 1975

- Integrated-injection-logic LSI circuits are developed by Bell Labs for new terminal equipment, bringing low-cost processing to the telephone industry *Sept. 4, 1975, p. 21*
- Fiber-optic system for computer interface is developed by IBM *Sept. 4, 1975, p. 25*
- First commercially available charge-coupled analog delay line for video-tape recorders, from Fairchild, replaces expensive conventional delay components *Sept. 4, 1975, p. 36*
- First microprocessor-controlled counter/timer is unveiled by Dana Labs *Sept. 4, 1975, p. 129*
- Model 5100 portable computer, introduced by IBM, uses 48-kilobit ROMs to interpret keyboard commands written in Basic or APL languages *Sept. 18, 1975, p. 29*



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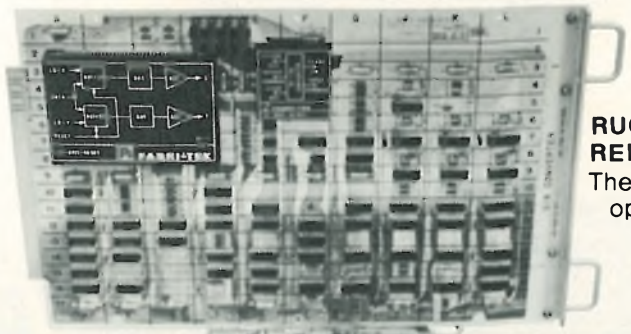

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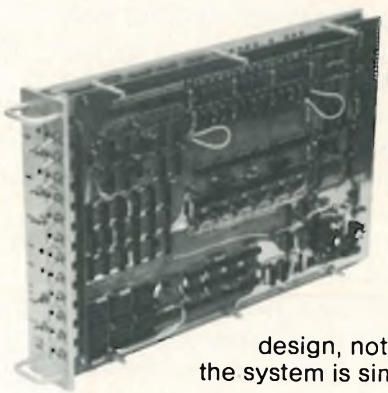

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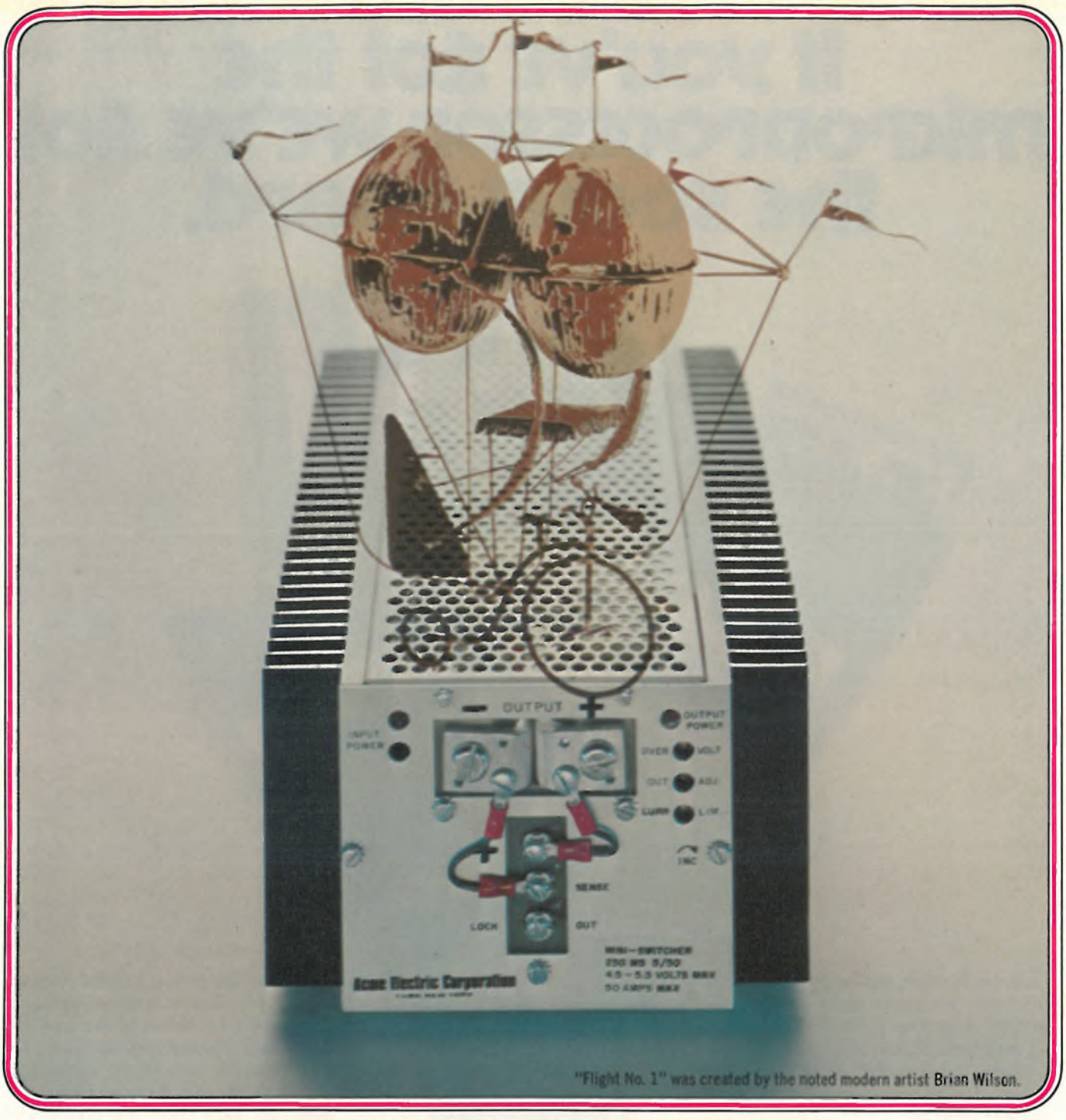

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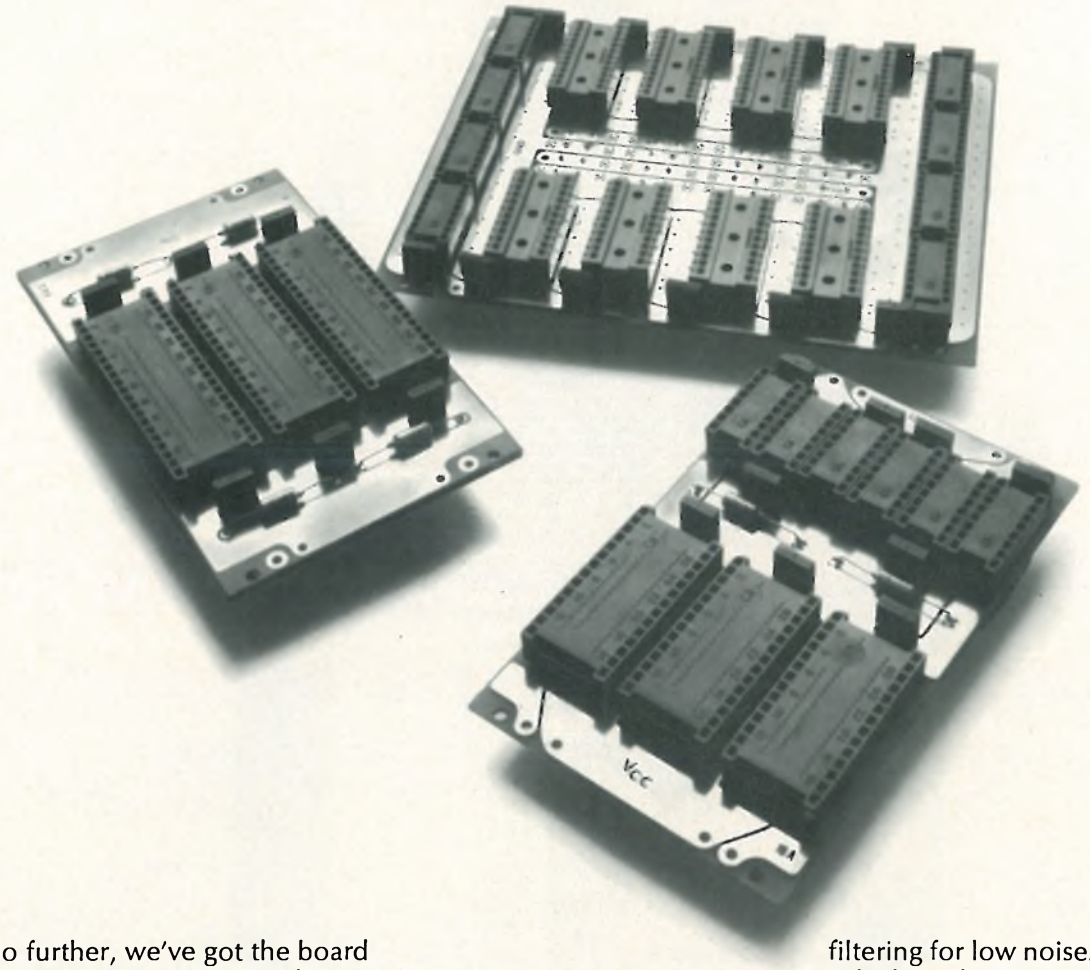

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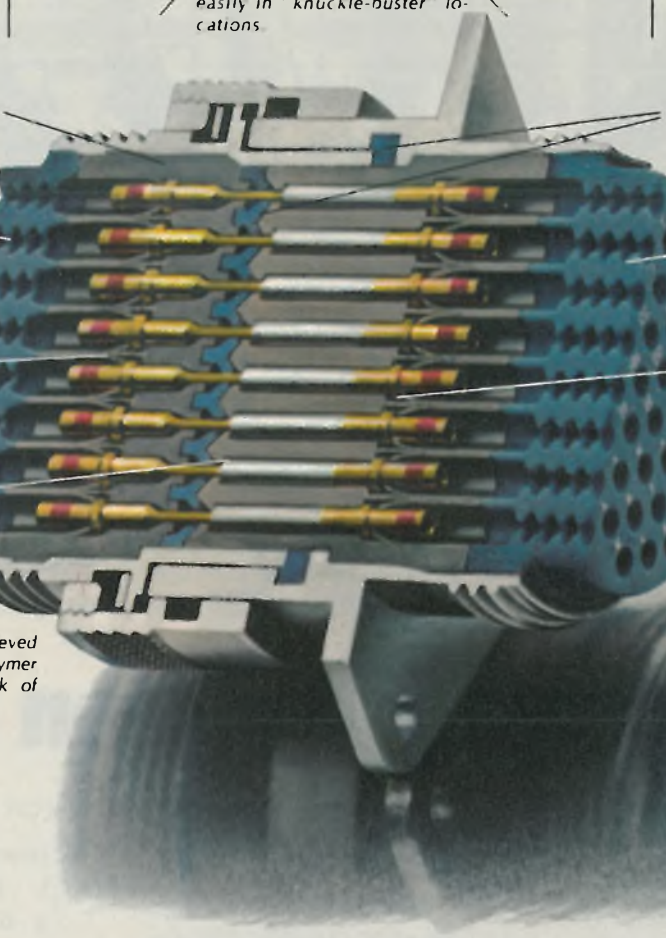

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Interfacial mating seal and static peripheral shell seal. Assure system integrity.

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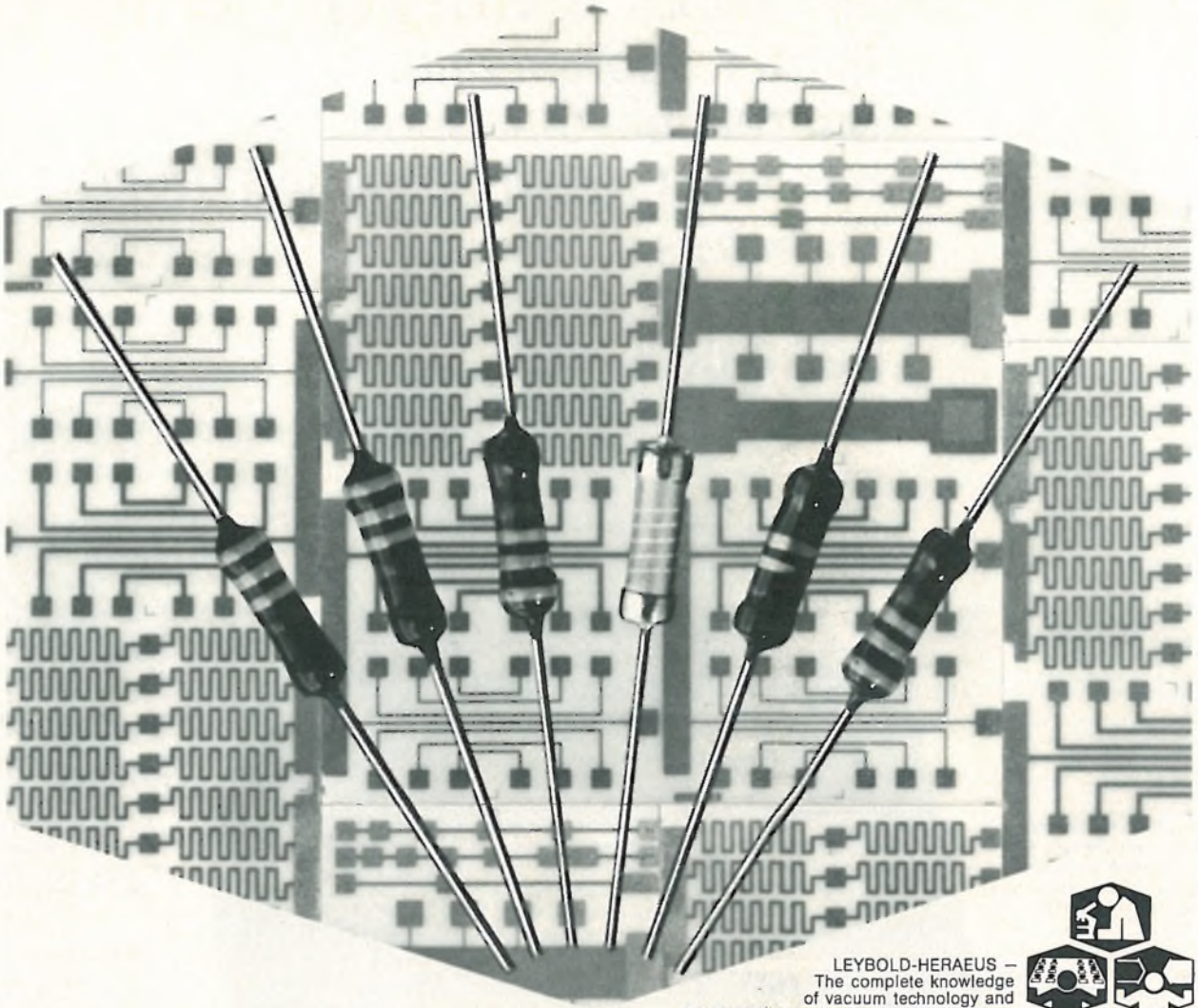

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Using our standard evaporation plant A 700 Q, up to 40 000 resistors (Ø 2 · 5 mm) can be coated within 60 minutes.

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Multimeter measures 2 gigohms

True-rms instrument resolves 4½ digits on dc, 3½ digits on ac; autoranging dc-coupled DMM has basic accuracy to within 0.05%

by John Gosch, Frankfurt bureau manager, and Michael J. Riezenman, New Products Editor

In the opinion of the instrument makers at Philips in the Netherlands, today's digital multimeters can "handle 90% of the jobs for 80% of the people." More specifically, users who need to measure true-rms voltages and currents, or who need to measure resistances above about 20 megohms, have to buy special-purpose instruments to complement their general-purpose DMMs.

To serve these users, the Dutch company has come up with a 4½-digit (20,000-count) autoranging instrument that provides dc-coupled true-rms ac measurements of both voltage and current up to 100 kilohertz, that measures resistances up to 2 gigohms, that can resolve currents down to 100 picoamperes dc or 1 nanoampere ac, that can resolve dc voltages down to 100 microvolts, that can measure ac voltages up to 700 megahertz with an optional probe, and that will sell in the U. S. for about $1,600. In addition, the PM2527 has a second optional probe that measures temperatures from −60°C up to +200°C.

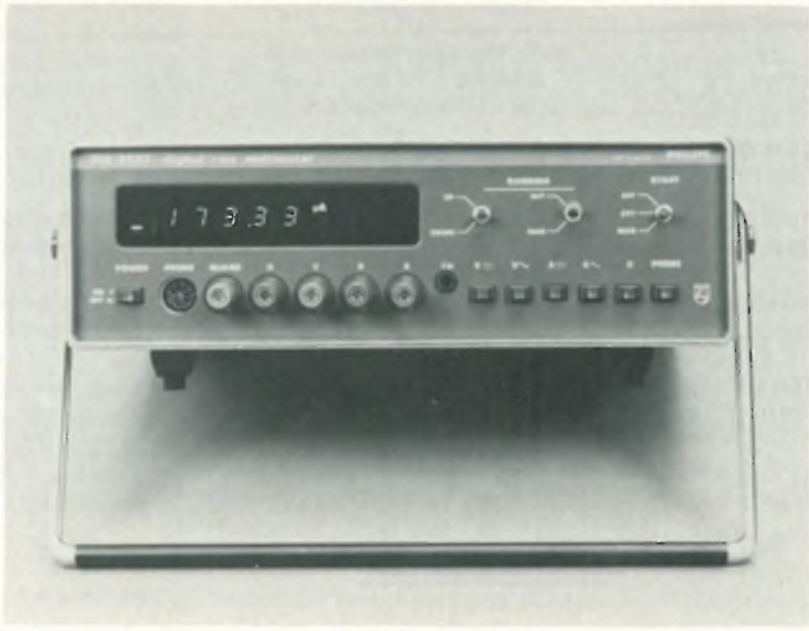
Like many other 4½-digit instruments, the PM2527 is less accurate on some ranges and for some functions than others. Instead of merely mentioning this fact in the instruction book, the Philips people have designed the meter to blank its least-significant digit in those measurement situations for which the digit would have no meaning. Thus the meter only shows 3½ digits for the 200-megohm and 2-gigohm resistance ranges and for all ac voltage and current measurements.

Although designed primarily for laboratory applications, the instrument's usefulness extends to service and field jobs, particularly at remote weather stations, tracking facilities, radar sites, and similar installations. It is in these field applications that Henk Onstee, a product manager in the Philips Industrial Equipment Division, feels that users will particularly welcome the meter's true-rms capability—that is, its ability to measure true-rms values without any additional equipment.

In most cases, he points out, special-purpose meters designed specifically for the measurement of true-rms values have been used when this capability has been needed. The ability of the PM2527 to make true-rms measurements by itself, "together with wider ranges and a high resolution, makes for a simple measuring setup and provides a cost-effective solution to a measuring problem," Onstee says.

The instrument uses a new Philips-developed true-rms-to-dc converter to make its ac measurements. Essentially, the converter compares the power dissipated by a dc voltage with the power dissipated by the input signal (both working, of course, into equal resistances). The converter then adjusts the dc voltage until the powers are equal. (A diagram of the converter circuit appears on p. 94.)

No range switch. Five push buttons on the multimeter select the parameter to be measured, be it ac or dc voltage, ac or dc current, or resistance. A sixth push button is activated when an external probe is used. To select the range, one can either put the ranging switch into its automatic position or choose a manual mode in which a separate up/down selector switch is employed to step the meter through its various ranges. The user then consults the meter's readout to



Pocket-sized elephants!

For really phenomenal memory capabilities, consider THOMSON-CFS's new, improved scan-converting image-storage tubes. Featuring enhanced resolution, these tubes are second-to-none in the market.

Let the figures speak for themselves!

Tube	Size	Resolution at 50% modulation
TME 1238 A	1"	1400 TV lines/dia
TME 1239 A	1 1/2"	1900 TV lines/dia
TH 8803	2"	2700 TV lines/dia

- With continuous readout, at least 15 minutes of undegraded output image is available.
- All the gray-levels of a standard TV test chart can be reproduced.
- When switched off, the last recorded image is stored for at least 1 month.

That's really elephantine (or should we say pachydermatous) memory!
And a complete picture can be recorded or totally erased in just one TV image (30ms)!

Applications currently encountered exploit TV frame-freeze, slow-scan TV, data recording and storage, scan conversion and integration of low-level signals, contour enhancement, image comparison and subtraction, etc.
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2419

see what range the unit is on. Overloads are indicated by a reading of "..00". The meter's light-emitting-diode displays are 7 millimeters (0.275 in.) high.

Possessing all of the usual features associated with modern high-quality DMMs, the PM2527 has an input resistance of 10 megohms in parallel with 100 picofarads, a basic dc-voltage error of no more than ±(0.02% of reading + 0.02% of range), and a high degree of overload protection. The resistance ranges, for example, can withstand dc voltages as high as 250 V and ac voltages as high as 350 V peak.

The meter's measuring ranges and maximum errors are as follows: Dc voltage ranges are 200 millivolts, 2 volts, 20 V, 200 V, and 1,000 V full scale with 4½-digit resolution. Ac voltages to 100 kHz are measured to 3½-digit resolution with full-scale ranges of 20 millivolts, 200 mV, 2 V, 20 V, 200 V, and 600 V. Maximum error on the three lowest ranges, for frequencies from 30 hertz to 100 kHz, are ±(0.2% of reading + 0.2% of range). For the upper three ranges, the maximum error stays the same up to 1 kHz, but increases to ±(0.4% of reading + 0.2% of range) from 1 kHz to 100 kHz. The rf probe gives ac voltage ranges of 20 mV, 200 mV, and 2 V full scale. It is 3 dB down at 1 gigahertz and falls off in a Gaussian fashion beyond that point.

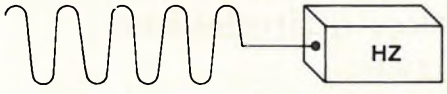
Seven ranges. There are seven ranges of both dc and ac current: 2 microamperes, 20 μA, 200 μA, 2 milliamperes, 20 mA, 200 mA, and 2 amperes. Maximum dc error is ±(0.1% of reading + 0.05% of range). The ac error will not exceed ±(0.3% of reading + 0.2% of range) from 30 Hz to 1 kHz. The dc measurement is made to 4½-digit resolution while the ac is to 3½-digits.

The accuracy of the resistance-measuring ranges varies greatly from range to range. Its extremes are ±(0.05% of reading + 0.05% of range) for the 200-ohm range, and ±(1% of reading + 0.5% of range) for the 2-gigohm range.

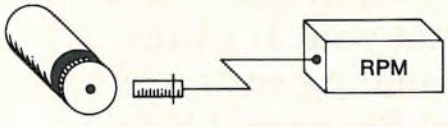
Philips N. V., Industrial Equipment Div., Eindhoven, P. O. Box 523, the Netherlands [338]

Measuring flow rates, draw, ratio, rpm, totals, speeds or time periods?

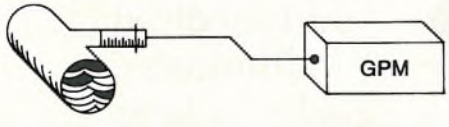
DigiTec's **new** 8100 Series of factoring Counter/Timers consists of 3 different models that operate from the output of any pulse transducer, and can be used to measure an infinite variety of parameters.



Featuring programmable normalization for direct reading in any unit, each model in the series uses an internal crystal clock for precise measurement, and has an input frequency range beyond 100 KHz.

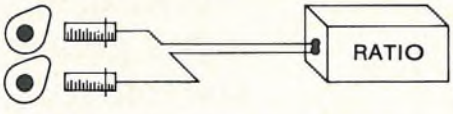


All units are attractively styled to compliment any instrument panel and have a large, full 5 digit, non-blinking, LED display. Once programmed, these counter/timers help eliminate errors and delays by becoming a "Hands Off" readout usable by non-technical personnel.

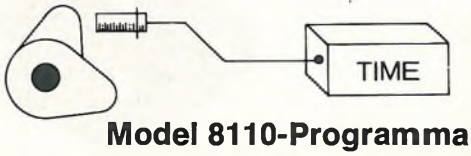


1.89"H x 4.39"W x 4.50"D

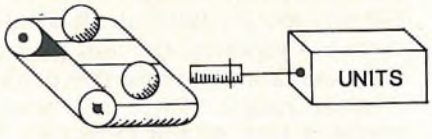
Although all models have a basic input sensitivity of 10mV RMS, the input can withstand up to 120V RMS, without damage.



One of DigiTec's HT Series (High Technology) instruments, the 8100 family, utilizes state-of-the-art, plug-in components & LEDs for reliability and easy maintenance. Each model operates from 115/230 VAC, 50 to 400 Hz.



Optional stored BCD output for use with limit detectors, recording peripherals and computer interface is also available.



To see a DigiTec Model 8110 Programmable Factoring Counter, Model 8120 Programmable Factoring Totalizer or Model 8130 Programmable Factoring Timer, and obtain OEM quantity discounts, contact your nearest DigiTec representative or write United Systems Corporation.

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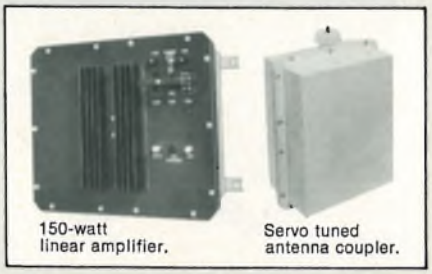
These instruments available under GSA Contract GS-005-27741



12 reasons why this 150-watt, automatically tuned, solid-state SSB system is the leader in its class:

1. More performance, more reliability. The new CA-38 SSB from CAI has highly innovative solid state circuitry that enables its 150-watt power to be used to utmost advantage. The system makes long distance SSB communication more dependable and far easier than ever before.

2. Pre-programmed channels. The fully solid state 20-watt transceiver has 12 pre-programmed channels. They can be spread across the entire 2-18 MHz frequency range, or grouped in any band without restriction. A back-lighted display window shows channel selected.

3. Operation is extremely simple. Turn it on and select a precisely tuned channel. The rest is automatic. There are no band selectors, no tuning knobs, meters, manual squelches or voice clarifiers. Channels can be programmed for SSB, compatible AM, or telegraph (CW) modes. In short, it doesn't require an experienced operator.

4. Expandable to 24 channels. The CA-38 is also available with 24 channels and semi-duplex capabilities. This may either be specified or installed in the field at a later date. Display window is easily changed to show the additional channels.

5. Amplifier protected against burnout. The separate 150-watt linear amplifier is solid state and completely broad-banded. It enables any 2-18 MHz frequency to be programmed without adjustments or modifications. Overload circuits protect it against high VSWR loads, excessive heat, and damaged antennas.

6. Continuously tuned in any environment. The companion servo tuned antenna coupler automatically and continuously fine-tunes the antenna to the exact frequency being used. It also compensates for changing weather conditions and movement of nearby metal objects.

7. Exceptional stability. Precisely controlled crystal ovens provide ±20 Hz or better frequency stability and optimum clarity of communication. Six automatically switched low pass filters provide −62dB harmonic suppression. It's also available with a highly effective automatic noise compensated squelch.

8. Easily re-tuned in the field. Most transceivers have separate coils for each channel, but the CA-38 uses electronically tuned circuits over its entire frequency range. This means channel frequencies can be re-tuned with minimal test equipment in a few minutes. Its integrated solid state circuitry means lower maintenance costs.

9. Obsolescence proof. Because channel changes are easily accomplished and its 12 channels can be placed anywhere on any band, the CA-38 cannot be made obsolete by changing frequency regulations. The system exceeds most international requirements.

10. Three power supplies available. The CA-38's separate amplifier/power supply unit is available for either 12 VDC, 24-32 VDC, or 115/230 VAC operation.

11. A rugged, go-anywhere system. Components are housed in tough, lightweight Lexan® Cabinets. The CA-38 is flexible. It's designed to be a base station, land mobile, marine, or portable SSB station. It provides dependable long distance communications in any environment. There's a 20-watt SSB—the CA-39—for applications that don't require 150-watts. The CA-39 (which is identical to the CA-38's transceiver) can function independently, or be part of a CA-38/39 network.

12. The SSB only CAI could build. The system was created by Communication Associates, Inc.—the world's most respected name in SSB. For performance, easy operation, simplified maintenance and reliability, the CA-38 establishes a new standard of comparison. Like all SSB from CAI it comes with a 3 year guarantee. For more information and the name of a nearby dealer, write:

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Tel: (516) 271-0800/TWX: 510-226-6998

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Circle 232 on reader service card

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Testers tailored to use

In-house designs spawn a series of units for checking logic, boards, and cables

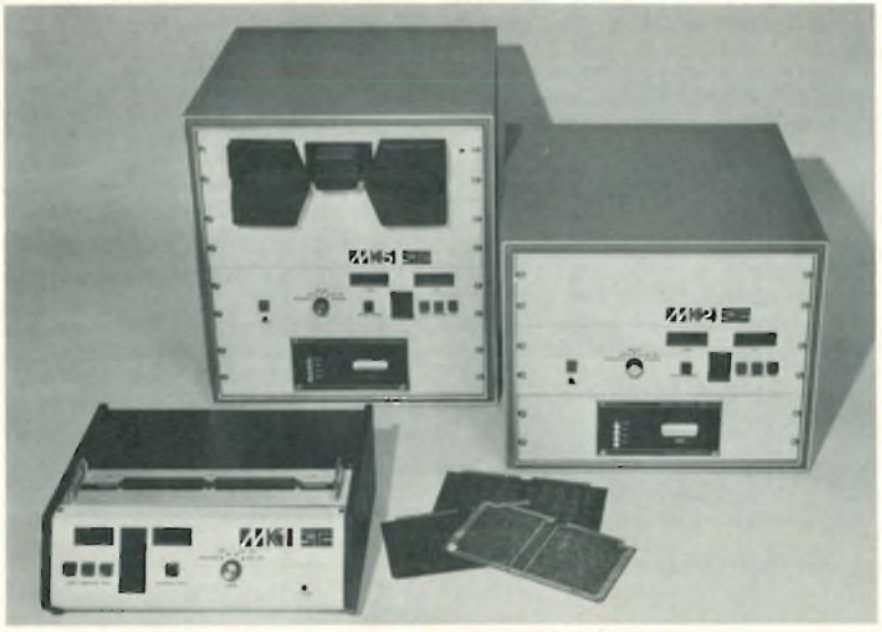
by Andy Santoni, Instrumentation Editor

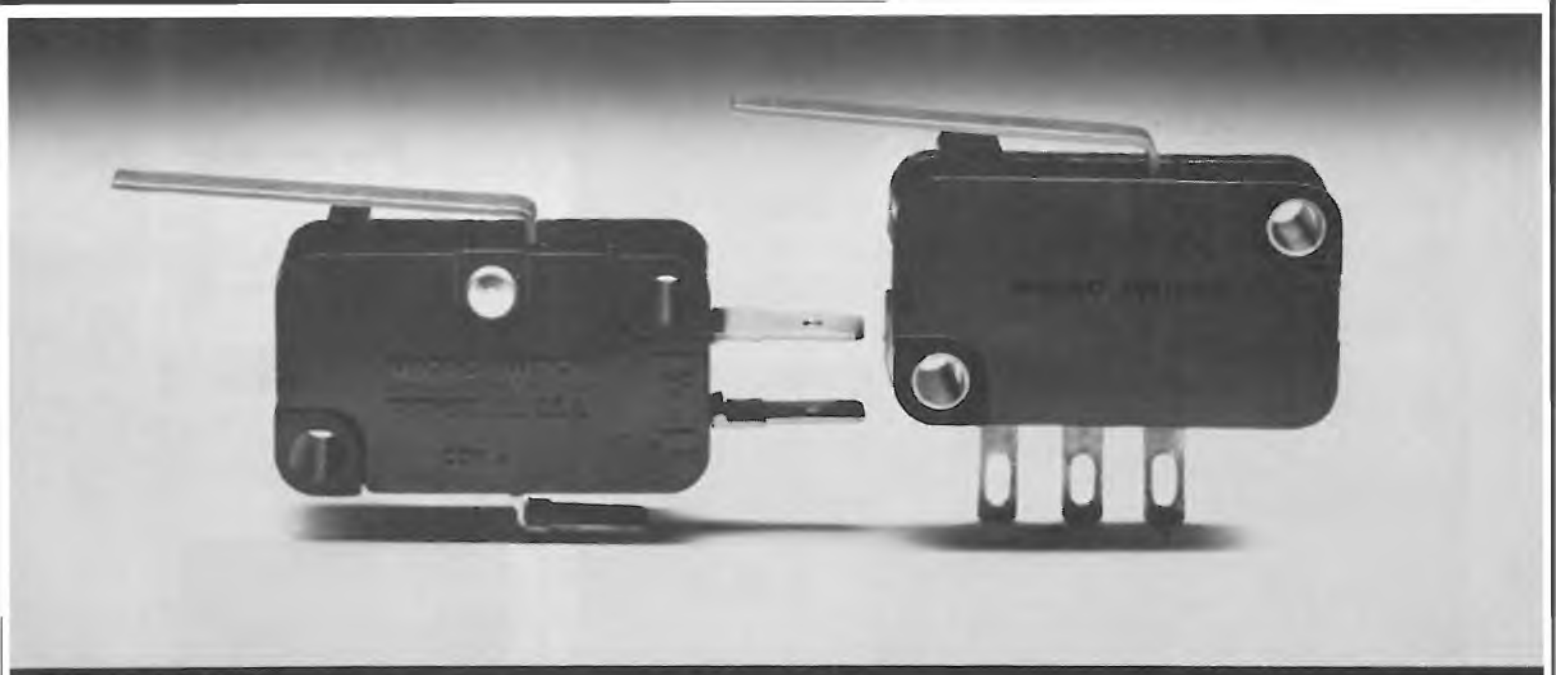
Performing the wide variety of tests required by different printed-circuit board users demands an equally wide variety of testers, from short and continuity testers for bare boards to loaded-board and system test equipment, and at almost every level of confidence.

Like many firms, Storage Technology Corp., a Colorado manufacturer of computer peripherals, has that sort of range of testing needs within its own operations and, again like many other firms, has built much of its own test equipment. Now the company is entering the instrumentation field by making its in-house designs available as commercial products. While this is also not unheard of, it has rarely been done with such a broad line of equipment.

Storage Technology's entries include a current-path indicator, priced at $149.95, which can track faults on a digital logic board directly to the bad gate, even in wired-OR circuits. Another benchtop instrument, called the Short Stop, is priced from $795 and is designed to weed out those bare pc boards that contain open or shorted leads by testing them from the card edge. The third product introduced at this time is a more sophisticated benchtop tester, the Mark 1, that can check out a bare board or cable for shorts and opens by being connected to either a card edge or an external fixture.

Already on the drawing boards and scheduled for introduction by the end of this year are additions to the Mark series with more test points and program input/output options, the Star series of custom-designed testers using standard modules, and another series of dig-





One of these is a new solid state switch. It's important that you can't tell which one.

The switch on the left is the V3. A mechanically-actuated snap-action switch the size of a postage stamp. It was an industry first when MICRO SWITCH introduced it in 1943. And it's gone on to become the industry standard, with hundreds of millions in use worldwide.

The switch on the right looks like the V3. Mounts like the V3. It's even actuated like the V3. And that's exactly where the similarities end. Because it's all solid state inside.

Designed around a Hall-effect integrated circuit perfected by MICRO SWITCH, the XL has been made to provide every benefit of true solid state design without the necessity of getting out of mechanical control.

Because the XL is all solid state, there are no contacts to bounce or become contaminated. And the Hall-effect integrated circuit has been performance tested through over 12 billion operations without a single failure. Unlike standard mechanical switch designs, the XL can also interface directly with other solid state components. Its 20MA output eliminates the need for amplifiers, in most applications. And you can order it with either current sinking or current sourcing outputs.

It needs very little force for actuation—down to 10 grams. Even less with a lever. And the choice of actuator styles is the same as for the V3: over 500 different actuators in all. Including simple pin plunger, straight lever, simulated roller or roller lever.

Power supply requirements are also flexible. 5 VDC or 6 to 16 VDC with built-in regulator, over a temperature range of −40°C to +100°C.

So the XL obviously offers some unique advantages. It's just one of a wide range of MICRO SWITCH solid state designs that do. Including a complete range of magnetically operated solid state position sensors, like the ones pictured here.

If you'd like more information on the XL, or any of the other MICRO SWITCH solid state switches, call your nearest MICRO SWITCH Branch Office or Authorized Distributor. Or write for literature.

We'll tell you the advantages of solid state design in your particular application.

And about a switch that looks very familiar. But works like nothing you've ever seen.

Products shown are actual size.

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New products

ital circuit-board test equipment.

The current-path indicator (see photo above) is a dc microvoltmeter that measures the approximate value and direction of current flow on printed wiring. Voltage drops as low as 1 microvolt can be displayed on its zero-center meter.

The instrument is most useful in digital testing. There it can localize such faults as a signal path stuck at ground by tracing current to the failing pin, even when several gate outputs are tied together.

Housed in a 5½-by-6-by-2½-inch case, the current-path indicator operates from batteries with an estimated life from 500 to 2,000 hours, depending on type. An optional battery charger is priced at $11.95.

Designed as a production test or engineering tool, the current-path indicator will be available by mail order.

The Short Stop printed wiring and cable tester (photo on p. 146) is a statistical device. That is, since it examines a board only from its edge connector—up to 250 points—it cannot track down all shorts and opens. But for a low price—$795 plus $45 to $70 for each adapter for each board type to be tested—it will catch more than 30% of the bad boards it tests and cut the expense of repairing them later on in the production cycle.

The Short Stop uses C-MOS cir-

A new champion—the clean-punching laminate from Norplex.

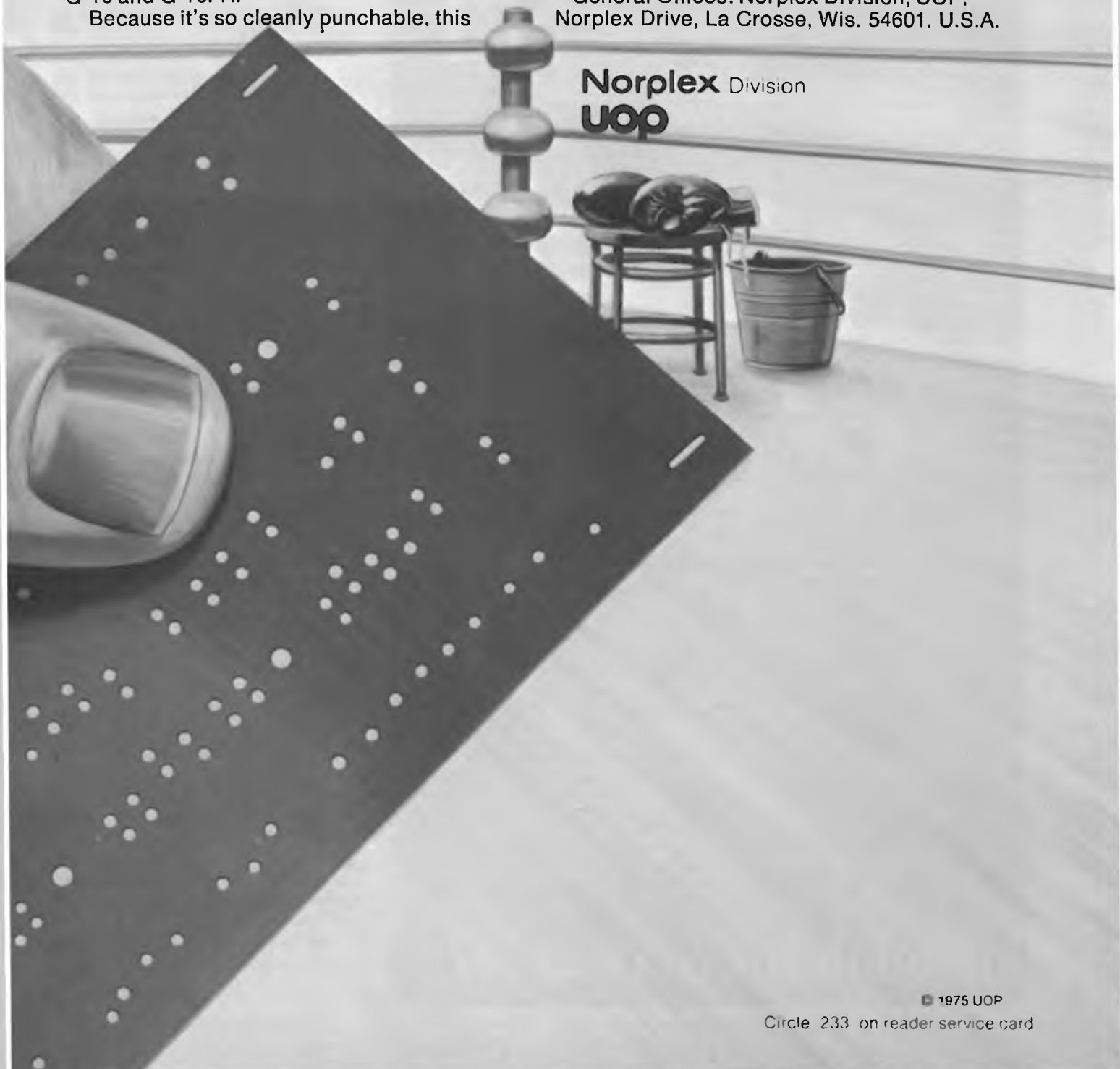
Score another technical knockout for UOP, leading developer of championship-caliber laminates.

Now there's NP-424—a new *punchable* laminate for printed circuitry that gives you cleaner holes for reliable through-hole plating. And NP-424 is less expensive than G-10 and G-10FR.

Because it's so cleanly punchable, this versatile UOP laminate can lower your cost-per-board over drilled holes without sacrificing end-product quality. NP-424 is available in rigid, double and single-clad stock—all meeting UL 94V-0 requirements.

This tough, machinable laminate will still be going strong under rigorous punching when its rivals are hanging on the ropes.

In Europe, UOP laminates are produced and sold by UOP Bisterfeld & Stolting GmbH, 5291 Egerpohl, Wipperfurth, West Germany. Phone: 2281-781—an operating unit of UOP • Norplex Division Representative: Martin Icough, 17, Bennet Close, Alton, Hants GU34 2EP, England • (Far East Representative: Katsumi Nozawa, 19-3-Chome, Hachiman-Dori, Shibuya-Ku, Tokyo, Japan, Phone: 461-5291) • General Offices: Norplex Division, UOP, Norplex Drive, La Crosse, Wis. 54601. U.S.A.



Norplex Division
uop

Circle 233 on reader service card

cuitry to learn and store the proper responses from a known-good pc board or cable. The instrument will indicate pass or fail and either open or short and the node number for faulty boards. Programing and test time are each about 1½ seconds.

The unit can be operated from batteries or from ac-line sources, and a variety of power supplies is available for different line-voltage and frequency combinations.

The Mark 1, shown in the lower left of the photo on p. 142, is the first in a series of testers that use C-MOS and low-power Schottky TTL circuitry to exercise all paths on a blank pc board or cable. Priced from $2495, the Mark 1 can handle up to 500 points via the same plug-in modules used in the Short Stop, or via a connector that can interface with a bed of nails fixture.

An optional printer is available for all Mark series testers for read-out of failures, nodes, and tests.

The Mark 2, Mark 5, and Mark 10 units, which can test up to 10,000 points, will be available by the end of the year. These units, which are assembled from standard rack-mount modules, may contain optional paper-tape readers, cassette tape recorders, and teletypewriter interfaces for input and output.

Also planned for early next year is a series of low-cost digital logic testers that include a first-fail comparator circuit to determine which element within a feedback loop failed and caused erroneous responses at other points. Storage Technology also expects to handle custom test system assembly for end-users and OEMs.

Storage Technology Corp., 2270 South 88 Street, Louisville, Colo. 80027 [339]

If you're worrying about Gallium, you haven't heard the news.

A large stable supply of gallium is now available.

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Gallium is found in bauxite. And Alcoa has extensive reserves of bauxite in Arkansas. So Alcoa will be extracting gallium from Arkansas bauxite for a long time to come.

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Temperature transducer is monolithic

50-by-50-mil chip includes sensor, zener voltage reference, and op amp; National device will sell for $1 in hundreds, 50 cents in thousands

by Bernard Cole, San Francisco bureau manager

Despite built-in linearity, the monolithic temperature transducer/sensor has had hardly any impact on the high-volume, low-cost market dominated by discrete thermistors and nickel-plate resistance thermocouples. At $2.50 and up, the integrated-circuit approach has cost too much.

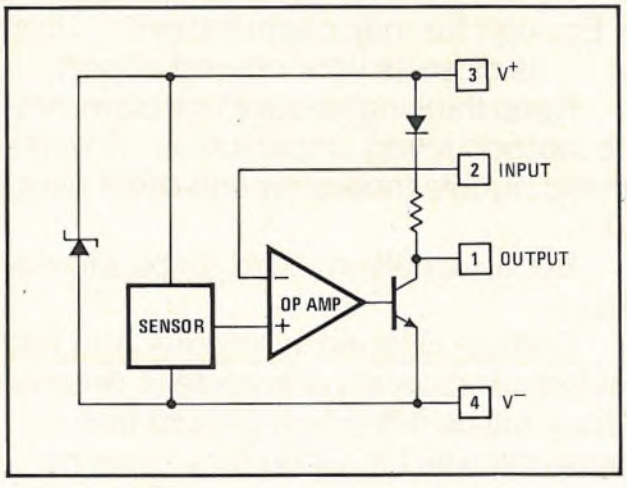
Now, however, National Semiconductor Corp. is introducing a device priced at $1 each for 100 to 999 and about 50 cents each in quantities of several thousand. This compares favorably with the over-all cost of the discrete setup—a 25–30-cent thermistor plus a 25-cent voltage reference and a 45–50 cent operational amplifier. The last two are usually added to correct the thermistor's nonlinearity—its output typically fluctuates from 30–40 millivolts per degree at 0°C to 300–400 microvolts/°C at 100°C.

National's device is fabricated on a 50-by-50-mil chip and includes the same three functions: a temperature sensor, a stable zener voltage reference, and an op amp.

The transducer is designed for use from −25 to +85°C and, when it's shipped, has an uncalibrated accuracy of within ±10°C. But, with the addition of an external potentiometer, the user can calibrate it so that the accuracy is within ±0.5°C.

In addition, says Robert C. Dobkin, director of advanced linear-circuit development, the LM3911 has a linear output of 10 mV/°C over the entire range. "The LM3911 uses the difference in emitter-base voltage of transistors operating at different current densities as the basic temperature-sensing element" says Dobkin. "If the collector current ratio is controlled, there will be a very predictable difference of emitter voltage. Further, this voltage varies with temperature in a known and predictable manner. And since this output depends only on transistor matching, the same reliability and stability as present op amps have can be expected."

The internal op amp provides a consistent, very light loading of the sensor output. Using a feedback terminal pin allows gains to be controlled from unity to 100 or so. Without it, an open-loop gain of several thousand is possible. Pnp input transistors, integral to the device, allow the op amp to function as a comparator over a large range of inputs. The zener and the op amp form a shunt regulator with a typical impedance of 3 ohms, so that any temperature scale factor is easily obtained with the addition of external resistors of the proper value or a potentiometer. When the op amp is connected as a comparator, the output will switch as the temperature transverses the set point, says Dobkin, making the monolithic device useful as an on-off temperature controller.



An active shunt that is part of the unit is connected across the power leads to provide a stable 6.8-V reference for the sensing system. This allows the use of any power supply voltage with suitable external resistors. The input bias current is low—35–45 nanoamperes typically and 150 to 250 nA maximum—and relatively constant with temperature, ensuring high accuracy when high source impedances are used. Further, says Dobkin, the output collector can be returned to a voltage higher than 6.8 V, allowing the LM3911 to drive lamps and relays running from a supply voltage of up to 35 V. Output linearity is ±0.5% typical and ±2% maximum. Long-term stability is ±0.3° a year. Long-term stability of the voltage reference is 6 mV per year. Op-amp voltage gain is typically 15,000 V/V, the company says.

The LM3911 is available now in three package styles—a metal-can four-lead TO-5 configuration, a metal-can TO-46, and an eight lead epoxy mini-DIP. Other packages are expected to follow.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara Calif. 95051 [340]

New from Potter & Brumfield

The lowest profile 3 amp relay we've ever offered!

The P&B T10 Series relay is lower than many other circuit board components. Only 0.375" high, it's ideal for high-density applications. Permits pc boards to be mounted on 0.5" centers!

T10 relays provide 0.1 to 3 ampere switching @ 30VDC. Coil ratings are 6, 12, 24, and 48VDC. Permissive make, gold-flashed silver contacts are noted for low contact bounce, long operating life. Bifurcated contacts for low level switching are available on special order.

Designed for low cost general purpose applications, the T10 is ideal for use in tele-communications, copy and reproduction machines, computer and peripheral equipment.

For additional information, contact the Potter & Brumfield sales representative or authorized distributor nearest you, or write Potter & Brumfield Division AMF Incorporated, Princeton, Indiana 47671. Telephone 812 385 5251.

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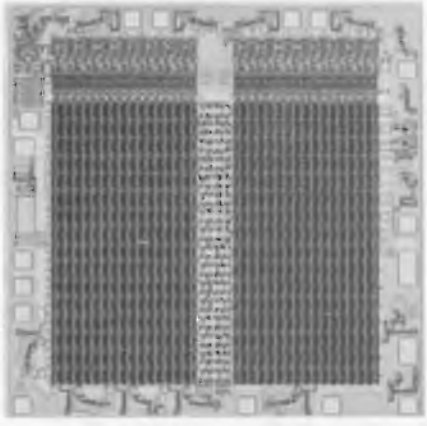
Circle 149 on reader service card

Semiconductors

1-k MOS RAM fast as bipolar

Fully static Intel family is interchangeable with Fairchild's bipolar parts

The standard bipolar random-access memory has come under direct fire. Intel Corp.'s latest n-channel metal-oxide-semiconductor 1,024-bit memories not only rival the TTL RAM's speed but are the first MOS



RAMs to be fully static at that speed. What's more, the devices are pin-for-pin and functionally interchangeable with Fairchild Semiconductor's 1-k bipolar static RAM family, the 93415/93425.

Until now, high-speed computer main memories, control buffer storage, and other systems with access times less than 100 nanoseconds have been built either with bipolar RAMs or quasi-static MOS RAMs. The quasi-static devices cost less than bipolar types and require less power, but need long cycle times of 200 ns or more.

But because they are fully static, the new Intel devices need no internal refreshing so that cycle time equals access time. For the user, this means speed comparable to that of bipolar memories.

According to Don Bryson, the memory products manager, Intel's family—the 2115-2 and -4, and the 2125-2 and -4—can operate as fast as their bipolar counterparts, at the same +5-volt supply and logic levels, but with 290 milliwatts less maximum operating power.

The Intel parts come in three speed ranges:

- The 2115-2 and 2125-2, with a maximum access time of 70 ns and a typical time of 60 ns.
- The 2115 and 2125, with 90 ns and 70 ns.
- The 2115-4 and 2125-4, 120 ns and 90 ns.

Not only are Intel's parts pin-compatible with the Fairchild parts, says Bryson, but their logic operation is the same, again because they are fully static. They also drive transistor-transistor logic directly, operate at TTL logic levels, and use a single 5-V power supply—the TTL standard.

By contrast, previous MOS RAMs capable of system speeds approaching 100 ns have differed significantly from bipolar RAMs, says Bryson. They are logically different, requiring clocks and refreshing (dynamic MOS RAMs) or strobing (quasi-static charge-pumped MOS RAMs). They operate at high voltages, requiring as much as 15 to 30 V across the chip, and are not TTL-compatible, requiring special interface circuits, such as level translators, sense amplifiers, and drivers. They also need three or four system power supplies (special MOS supplies and TTL supply).

"As bipolar RAM replacements," says Bryson, "these parts make it practical for system manufacturers to reduce all major system costs simultaneously—power supply, cooling, and packaging, as well as components cost." This is because the 2115/2125 family has a maximum power dissipation of 525 mW per RAM, compared to 815 mW for standard 1-kilobit bipolar RAMs, he says. This improves the speed-power product by a third or more at equal speeds, so the power supply can be smaller and less costly. Also, since lower-power circuits generate less heat, the Intel RAMs, says Bryson, require less cooling and can be

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Vactec's latest development is a new Blue Enhanced Silicon (BES) photodiode with exceptionally low dark current for efficient response in the blue region (200 - 400 nm). Made in Missouri, U.S.A., it performs equally well in an expensive Japanese SLR camera or in an American-made colorimetric analyzer as well. And you'll like the price, which could be as big a breakthrough as blue sensitivity.

Vactec also introduces a new line of PIN photodiodes that operate at high voltages, low noise levels, and fast rise times, with about half the blue sensitivity of the BES photodiode. For larger areas, Vactec offers a complete range of Blue Enhanced Silicon photovoltaic cells up to 1⅛" diameter.

Vactec now supplies the broadest line of photodetectors in the industry, including:

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- hi-speed/low-leakage silicon cells
- NPN phototransistors
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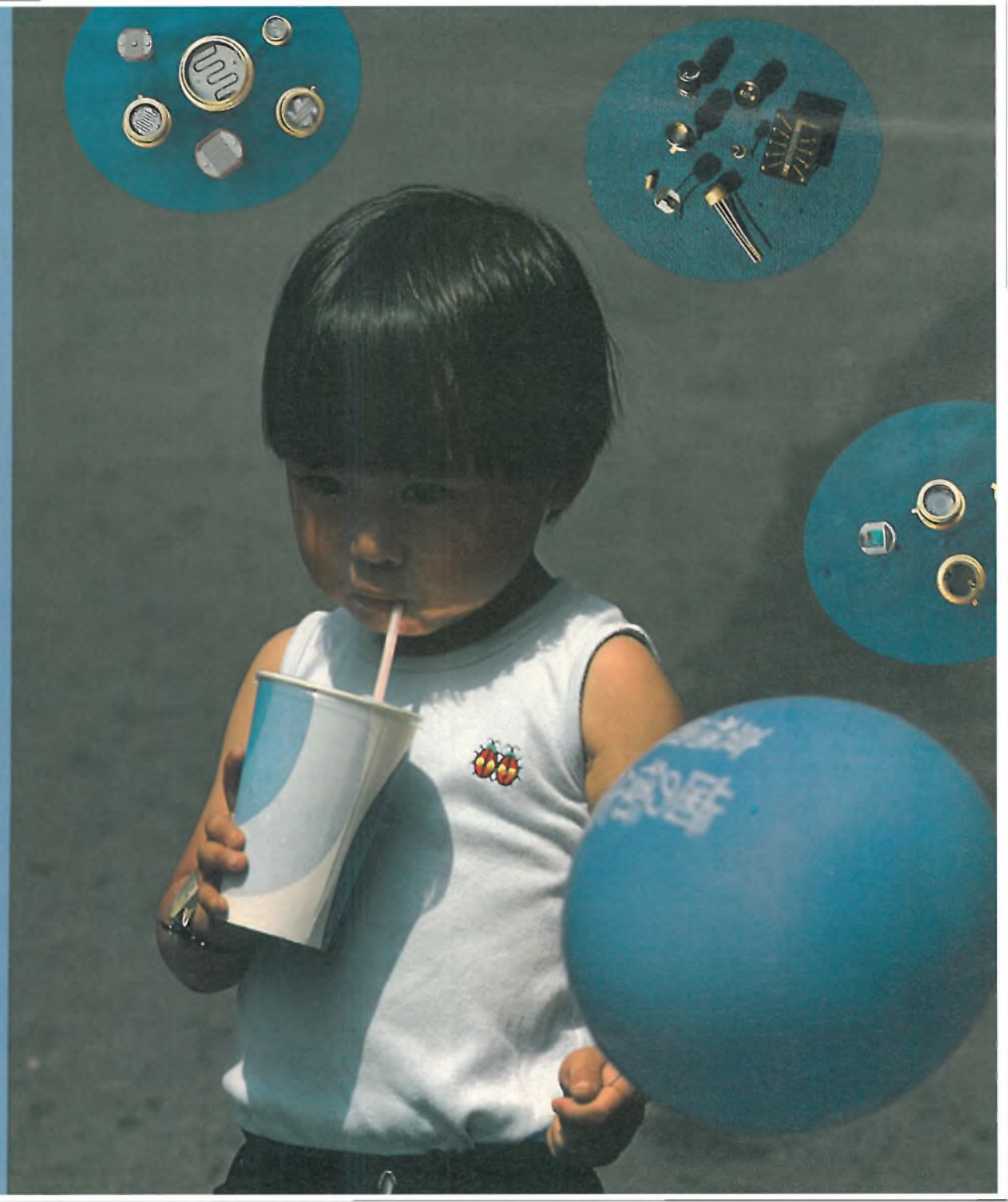
- CdS & CdSe photoconductors
- CMOS & bi-polar custom ICs
- opto-couplers
  a) LED/photoconductor
  b) LED/phototransistor or darlington
  c) lamp/photoconductor
- selenium photovoltaic cells

Call or write today:

Vactec, Inc.
2423 Northline Industrial Blvd.
Maryland Heights, Mo. 63043
(314) 872-8300

Circle 151 on reader service card



packaged more compactly.

Available now in standard 16-pin dual in-line packages, the price of the devices in quantities of 100 to 999 is $14.20 each for the 90-ns 2115/2125, and $12.90 each for the 120-ns 2115-4/2125-4.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051 [411]

Six-decade counter includes display driver

The MK 50395N is a presettable, synchronous, six-decade, up/down counter with compare registers and storage latches. It comes equipped

with multiplexed seven-segment and BCD outputs that can be used to drive displays. Able to count at frequencies up to 1 megahertz, the device interfaces directly with standard C-MOS families. The MK 50395N sells for $14 in 1,000-piece quantities. It is available through distributors.

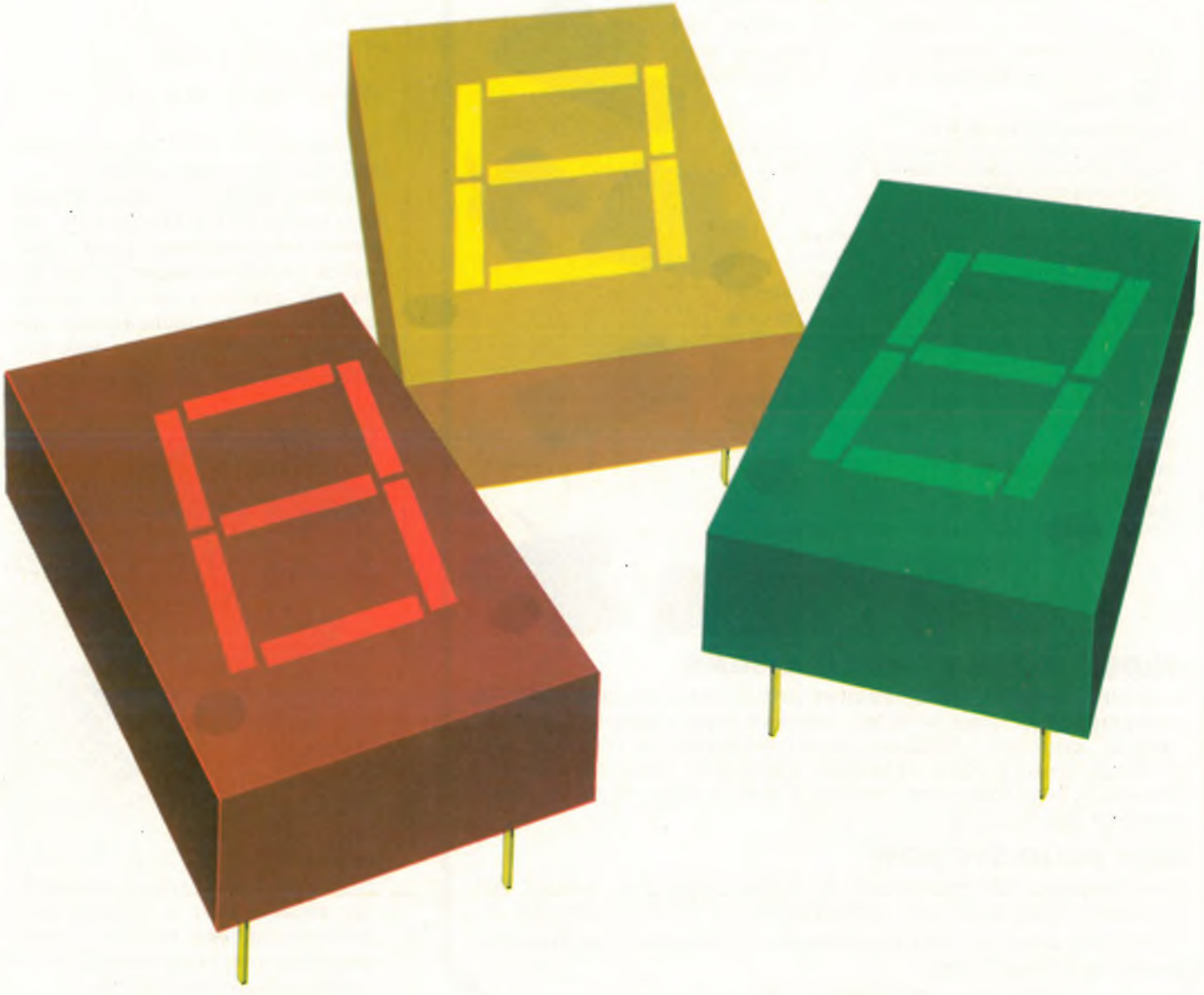
Mostek Corp., 13300 Branch View Lane, Dallas, Texas 75234. Phone (214) 620-2454 [414]

High-power SCR can switch at 10 kHz

Rated for continuous operation at up to 1,200 volts and 500 amperes, a series of silicon controlled rectifiers can switch as fast as 10 kilohertz. With turn-off times as low as 10 microseconds, the 500BPQ family is believed to be the fastest commercially available SCR series. Forward voltage drop at 500 A is only 1.3 volts—about 20% lower than conventional units. The improved speed and forward drop are the result of a new geometry that distributes the gate over the surface of the silicon strip in an interdigitated arrangement instead of placing it at a single point at the periphery of the silicon strip.

Pricing ranges from $83.60 to $206.43 each, for lots of 10 to 99 pieces, depending upon the device's

SURPRISE!



HP's 5 times brighter display!

At 20mA our new High-Efficiency red display is 5 times brighter than our standard red displays. Just 3mA per segment gives you all the brightness you need and makes it ideal for battery powered applications. These large .43" displays are offered in High Efficiency Red, Yellow, or Green and are readable up to 20 feet. The 5082-7650 (High-Efficiency Red), -7660 (Yellow), -7670 (Green) are available in standard DIP packages with left-hand d.p. and common anode configuration. Just $3.95* each in quantities of 100. Contact Hall-Mark, Schweber, Wilshire or the Wyle Distribution Group (Liberty/Elmar) for immediate delivery, or write us for more information and our new application note on contrast enhancement.

01503 *Domestic USA price only.

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Circle 153 on reader service card 153

New products

voltage and current ratings.
International Rectifier Corp., Semiconductor Division, 233 Kansas St., El Segundo, Calif. 90245. Phone (213) 678-6281 [413]

1-inch LED display consumes at most 760 mW

Visible 60 feet away, a single-digit light-emitting-diode display has a character height of 1 inch. Housed in a 14-pin dual in-line package, the device has a maximum power dissipation of 760 milliwatts. Typical luminous intensity is 250 microcandelas at 20 milliamperes per segment. Each segment uses two series diodes, so the voltage drop is

approximately 3.3 V per segment. Priced at $4.35 each in hundreds, the displays have a large-quantity delivery time of 60 days. Small quantities are being offered at reduced prices for prototyping.
Industrial Electronic Engineers Inc., 7740 Lemona Ave., Van Nuys, Calif. 91405. George Daniels, (213) 787-0311 [415]

4-k n-MOS static RAM has 225-ns access time

A TTL-compatible 4,096-bit n-MOS static RAM has a complete cycle time of 400 nanoseconds and a worst-case access time of 225 ns. Consuming less than 150 milliwatts when operating, the Semi 4200 can have a

Almost anyone can build an automatic board tester.

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So if anyone can build the hardware, what makes one board test system better than another?

Answer: the software. Which is one very important reason you should look at what we've got to offer.

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And the savings.

General Radio, GR Test Systems Division, 300 Baker Ave., Concord, Mass. 01742, 617-369-8770.

The difference in software is the difference in testers.

Circle 155 on reader service card

New products

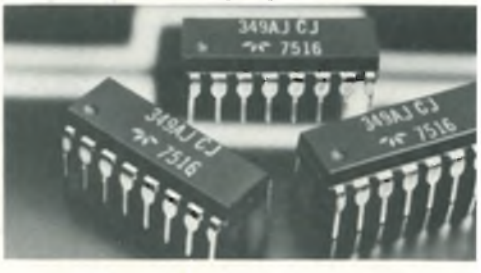
standby power consumption of less than 2 microwatts per bit. It achieves this low figure by having its drain supply reduced from 12 to 4 volts, which can be done without risk of losing stored data. Housed in a 22-pin DIP, the Semi 4200 sells for $24 each in hundreds. Delivery is from stock.

Semi Inc., 3883 N. 28 Ave., Phoenix, Ariz. 85107 [416]

Dual pulse stretcher can be retriggered

The latest addition to Teledyne's family of high-noise-immunity logic (HiNIL) is the HiNIL 349 dual retriggerable pulse stretcher, a device that can be used to stretch both positive and negative pulses to indefinite durations. The circuit uses an external resistor and capacitor to determine the fixed pulse-stretching time that will be added to the duration of the input pulse. This time interval can be anywhere from 100 nanoseconds to 0.5 second. Longer durations are easily achieved, however, simply by retriggering the device before it times out. Each of the circuit's two outputs can deliver up to 5 milliamperes or sink up to 20 mA. Housed in a 16-pin plastic dual in-line package, the HiNIL 349 sells for $1.96 in hundreds. A ceramic-packaged unit is priced at $2.30.

Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94303. Allan Colby, (415) 968-9241 [417]



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For example, Telonic *sweep generators* are used in well over 5,000 labs and production lines internationally. With a 20-year history of specialization in sweeper design, we invite any comparison with our newest solid-state 1200-Series. They offer you a broad choice of frequency ranges to 1.5 GHz, selectable band widths, precise frequency marking, and real-time dependability.

To make your test results even more visible, we also provide large-screen X-Y *display oscilloscopes* in single and dual trace versions, Models 121 and 122. Their sensitivity and stability make them well suited for the design bench or the production area. And for the OEM who wishes to incorporate a display in his own system, we even supply a naked display (Model 4060) – no case – just a basic chassis, interfaced to your specifications.

In the *filter* business, our customers in instrumentation, radar, E.W. and communications make up the top 100 of the electronics industry. The product line extends from low pass and band pass tubulars to cavities, interdigitals, combline, subminiature, and tunables, up to 12 GHz in some models. In addition to fine performance, these filters offer the user two other significant advantages – low price and fast delivery.

Our *attenuators* are another first choice by major instrument manufacturers. We use thick film substrates for precision and extra long life. We keep them small to minimize panel space. We design them for handling high power to simplify circuitry. We even modify them to meet your requirements.

And that 5th thing we do well is to *back up our products* – like our 5-year warranty on filters. With over 36 offices nationally, and 35 distributors overseas, Telonic has a man close at hand to assist you with application know-how, replacement parts, and service.

The information number below will provide a short form catalog, but if you need information on specific products right now, phone or write our Marketing Department directly.

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Circle 157 on reader service card

Subassemblies

Low-cost source has 1-mV error

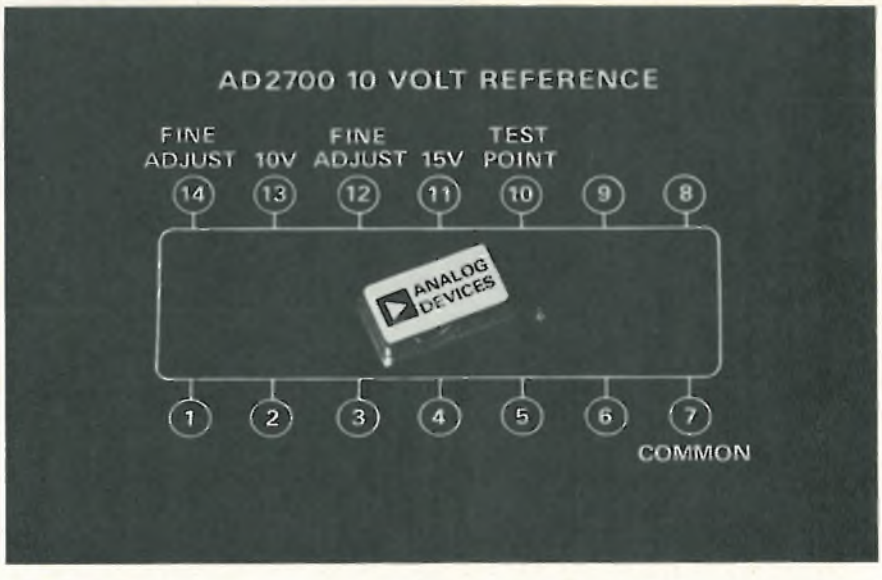
Actively trimmed, stable 10-volt reference uses thin-film techniques

High-performance data conversion components, like 12-bit analog-to-digital and digital-to-analog units, are only as good as their precision voltage references. This external component can be fairly expensive, costing up to $45 (depending on specifications and operating environment) for a purchased unit or as much as $16 in parts alone for an in-house design.

Now a 10.000 ±0.001 volt reference, the AD2700, priced as low as $10 in quantities of hundreds and with a long-term stability of 50 parts per million per year, has been introduced as the first active product from the Resistor Products division of Analog Devices. The AD2700 is a precision 10-V source, rated at 20 milliamperes and housed in a 14-pin DIP. The unit is a functionally laser-trimmed thin-film hybrid assembly using thin-film resistors (the main product of this division of Analog Devices) in combination with linear IC chips. Tom Parello, marketing manager for the division, says this is the first of a series of active hybrid references from his group.

The reference source is available with an environmental range of either 0°C to 70°C (AD2700/L) or −55°C to 125°C (AD2700/U) and with optional screening to MIL-STD-883A (AD2700/U/883). All three versions guarantee output error limited to ±0.01% at 25°C, 50 μV peak-to-peak noise, ±0.01% load regulation. For a supply voltage of 12 to 18 V, input-regulation/power-supply-rejection is 0.0004 maximum. Short-circuit protection is standard on all three versions. Total maximum error over the specified temperature range is ±0.03% for the AD2700/L, ±0.05% for the AD2700/U and AD2700/U/883. No external components are required. Offset adjustments are provided for optional use if accuracy of better than 1 mV is needed.

The AD2700/L is priced at $20 each for one to nine and $10 in hundreds; the AD2700/U costs $25 each for one to nine, $14 in hundreds; and the AD2700/U/883 requires a minimum order of ten and is priced at $30 in 10 to 24 quantities, $20 in hundreds. The small size, low cost, high performance, and hermetic seal of these references make them suitable for both military and commercial application



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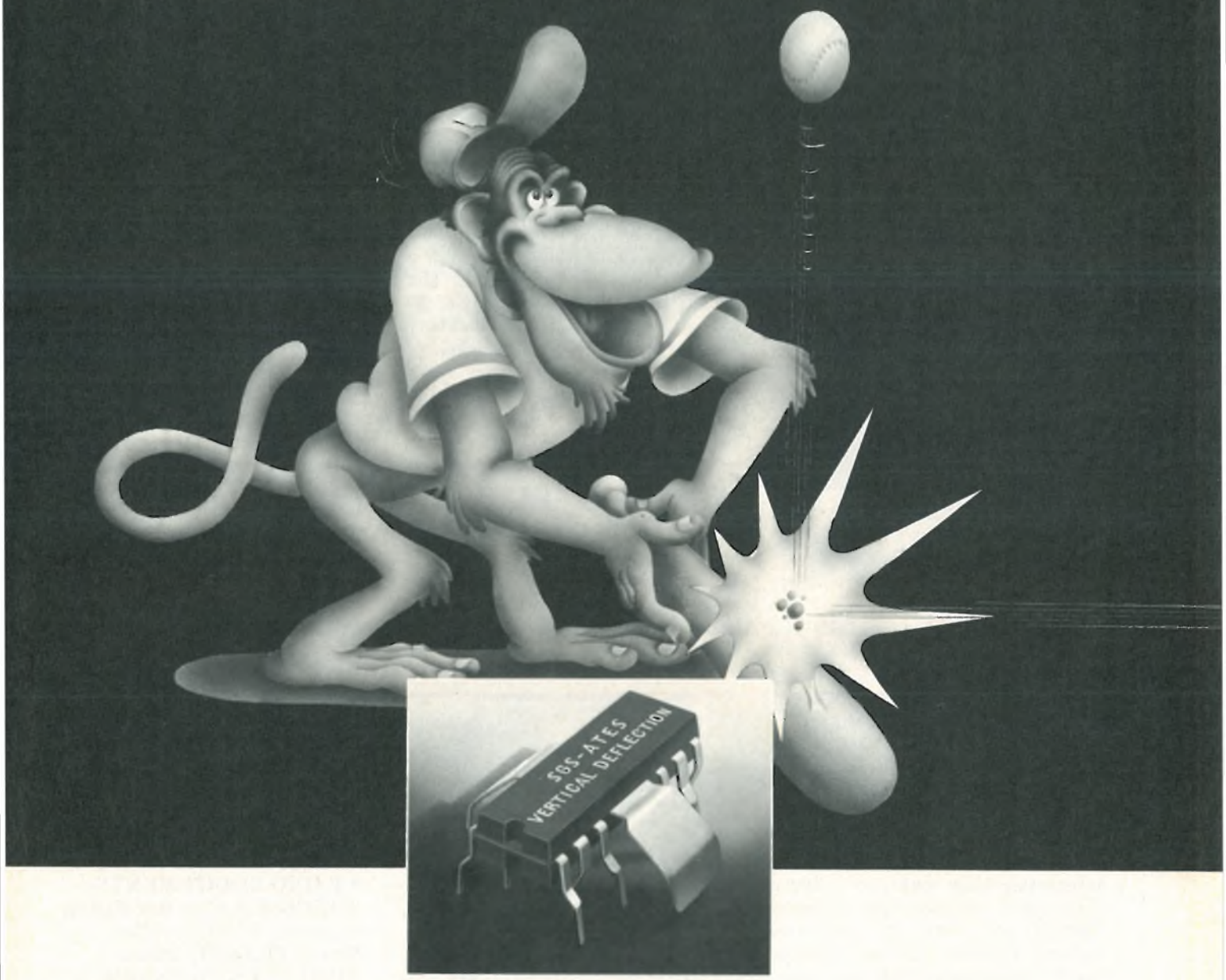


TDA 1170/1270 vertical deflection systems

The TDA 1170 and TDA 1270 are integrated vertical deflection systems for B & W and colour TV sets.

Both are mounted in a FIN DIP package and integrate the functions of oscillator, voltage ramp generator and high gain power amplifier with 1.5 A output current.

Their main features are:

- independent frequency, linearity and height controls
- few external components
- very low oscillator and ramp generator bias current
- high frequency stability
- positive or negative sync input

The TDA 1270 is for colour sets. When its own output current is inadequate the addition of a low-cost complementary transistor stage will solve the problem.

The supply voltage can be up to 40 V.

The TDA 1170 incorporates the flyback generator and provides the complete vertical deflection section for B & W sets. Maximum supply voltage is 27 V and the peak flyback voltage is 58 V.

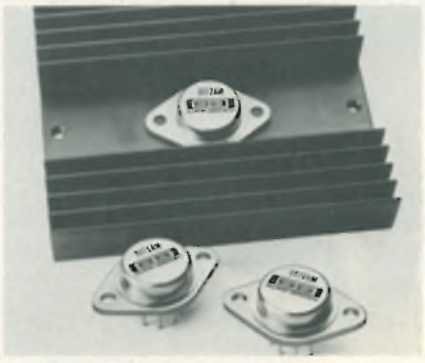
Circle 711 on reader service card

requirements that have formerly been met with bulky supplies or elaborate oven-compensated zener diodes, the company says.

Analog Devices, Inc., P.O. Box 280, Route 1 Industrial Park, Norwood, Mass. 02062 [381]

Hybrid op amps deliver up to 60 watts at 16 kHz

A pair of laser-trimmed, FET-input operational amplifiers from Burr-Brown are hybrid devices that can put out 60 watts at frequencies as high as 16 kilohertz. The model 3572 is rated at 60 W continuous, 150 W peak, while the 3571 has a continuous-power rating of 30 W and a peak-power rating of 60 W.



Small-quantity pricing on the two units is $65 for the 3572 and $60 for the 3571. In hundreds, these prices drop to $42 and $38.50, respectively. The amplifiers have differential input impedances of 10^{11} ohms shunted by 10 picofarads. Input bias current is −100 picoamperes, and minimum open-loop gain is 94 decibels with a 5-ohm load. The amplifiers, which must be mounted on substantial heat sinks to achieve their rated outputs, have built-in thermal protection. A protective network removes the output-stage biasing when the substrate temperature reaches approximately 150°C. For convenience in mounting, their cases are electrically isolated from the internal circuitry.

Burr-Brown, Box 11400, Tucson, Ariz. 85734. Dennis Haynes (602) 294-1431 [383]

Log converters operate on input ratios

The outputs of two new modules are proportional to the logarithm of the ratio of two input voltages. Able to accept positive input voltages from 10 millivolts to 10 volts, the units have scale factors of 1 volt per decade, so an input ratio of 1,000:1 yields an output of 3 V, while an input ratio of 1:1,000 results in an output of −3 V. Both units have an offset temperature drift of 100 microvolts/°C for temperatures from 0°C to 70°C and have output bandwidths of 20 kilohertz. The model LR101 has a maximum output error of 15 millivolts and a small-quantity price of $55. The LR102 has a maximum error of 10 mV and a price of $70. Delivery time for both units is four weeks.

Intronics Inc., 57 Chapel St., Newton, Mass. 02158. Arthur G. Pfaelzer (617) 332-7350 [385]

10-bit a-d converter can run at 1 MHz

The model 2800 is a 10-bit analog-to-digital converter with a maximum conversion time of 1 microsecond and a small-quantity price of

"This is the year for the 16K bipolar ROM."

Yes, it's 16K bits, organized 2K x 8. Yes, it's bipolar. Not only did we make it bigger, we made it faster, with 110ns max. access time over temp and voltage; yet it consumes less than 55 μw/bit.

If you're doing space-critical systems, you need the 16K's density. If you're doing speed-critical stuff, you need bipolar performance. In both cases, this is the ROM you'll want. It's available from Monolithic Memories in commercial and Mil Spec versions, open collector and three state. It's organized 2K x 8, and it's pin-compatible with our 1K x 8 bipolar ROM. Now you can upgrade your system without modification and enjoy the speed/power/density benefits of our new 16K ROM.

Remember, it's bipolar. Needs only one 5V power supply. Provides faster access time for microprocessors. Improves system reliability and it requires fewer peripheral circuits than MOS. The 16K ROM is a great way to store microcode and fixed programs. It's perfect for high resolution look-up tables or character generation of complex fonts. Lots of applications; what's yours?

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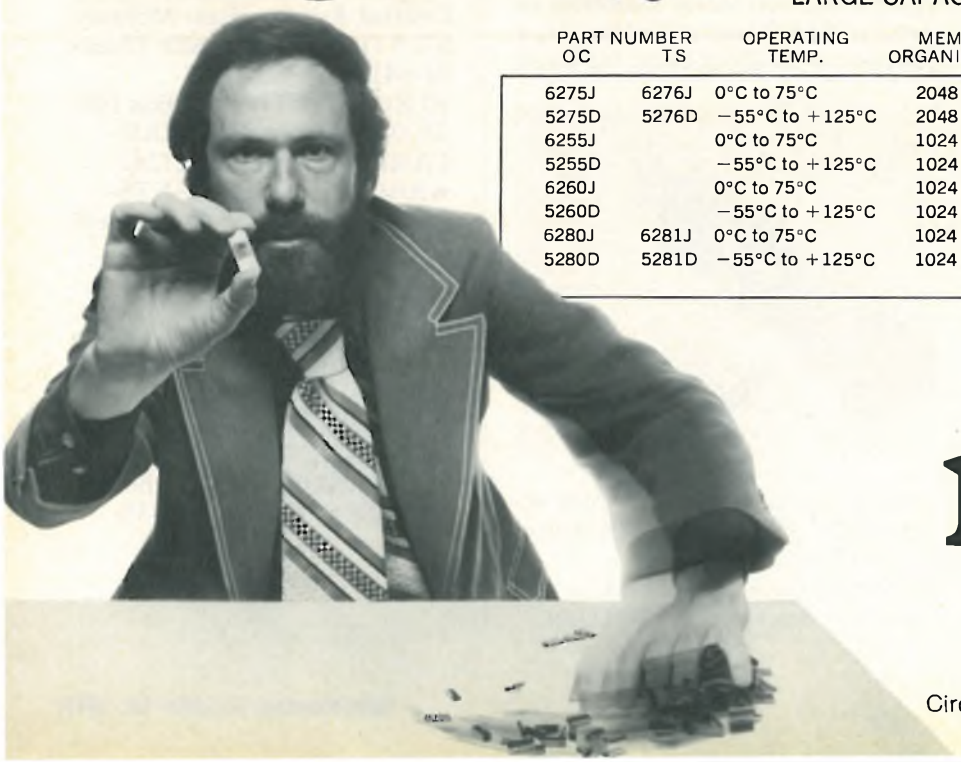
LARGE CAPACITY MMI BIPOLAR ROMS

PART NUMBER OC	PART NUMBER TS	OPERATING TEMP.	MEMORY ORGANIZATION	MAX. POWER DISSIPATION/BIT	MAX. ACCESS TIME (nsec)	PRICE (@ 100 QUANTITY)
6275J	6276J	0°C to 75°C	2048 x 8	55 μw	110	$ 67.50
5275D	5276D	−55°C to +125°C	2048 x 8	57 μw	120	$155.00
6255J		0°C to 75°C	1024 x 10	77 μw	150	$ 49.50
5255D		−55°C to +125°C	1024 x 10	81 μw	150	$ 99.00
6260J		0°C to 75°C	1024 x 9	85 μw	150	$ 45.00
5260D		−55°C to +125°C	1024 x 9	90 μw	150	$ 99.00
6280J	6281J	0°C to 75°C	1024 x 8	109 μw	150	$ 36.00
5280D	5281D	−55°C to +125°C	1024 x 8	114 μw	175	$ 70.00



mmi

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Circle 161 on reader service card

$365. Housed in a module that measures 2 by 4 by 0.375 inches, the successive-approximation unit has a typical differential nonlinearity of a quarter of a least significant bit. The unit is pin-compatible with Datel's ADC-G and H units and with Teledyne Philbrick's 4131. Delivery time is two weeks.

Dynamic Measurements Corp., 6 Lowell Ave., Winchester, Mass. 01890. Peter Scholl (617) 729-7870 [384]

15,000-volt supply is regulated within 0.25%

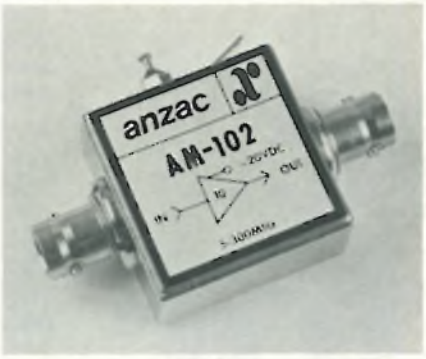
Intended for use an an accelerator-voltage supply for cathode-ray tubes, the model 409 is a 15,000-volt unit with a current rating of 200 microamperes and no-load to full-load regulation within 0.25%. Ripple is 0.05% maximum. Housed in a compact package that measures 2 by 4 by 6 inches, the supply also has outputs of 1,000 v at 1 milliampere,

and −100 v at 2 ma. These latter voltages are regulated within 5% and can have as much as 0.5% ripple. The 409 requires an input voltage of 15 v dc. It sells for $235 in small quantities and has a two-week delivery time.

Emco High Voltage, 2444 Old Middlefield Way, Mountain View, Calif. 94043. W. Doherty (415) 969-3056 [387]

Compact amplifier has 10-dB gain from 5 to 300 MHz

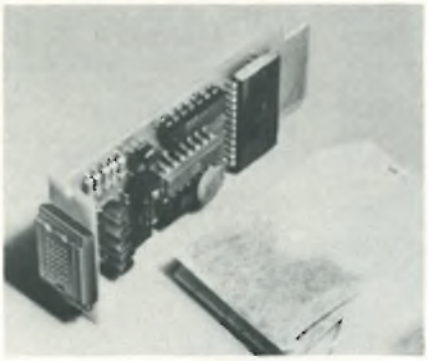
The model AM-102 amplifier has a fixed gain of 10 decibels from 5 to 300 megahertz, an output power rating of +15 dBm, and a noise figure rating of 5.5 dB. Its intermodulation distortion is low: with two −10-dBm signals at the output, third-order intermod measures only −60 dBm. The amplifier costs $95 in small quantities; delivery is from stock.



Anzac Electronics, 39 Green St., Waltham, Mass. 02154. Arthur L. LeMay (617) 899-1900 [388]

Dot-matrix display includes ASCII generator

A 0.3-inch-high 5-by-7-dot-matrix light-emitting-diode display generates 64 ASCII characters. The model 740-0018 alphanumeric display is a gallium-arsenide-phosphide device that produces bright red characters for such devices as calculators, data terminals, test equipment, and status indicators in general. The character displayed is a function of six input lines; the seven



rows of the display are scanned sequentially. Pricing for 1,000 pieces is $36.72 each.

Dialight, a North American Philips Co., 203 Harrison Pl., Brooklyn, N. Y. 11237 [389]

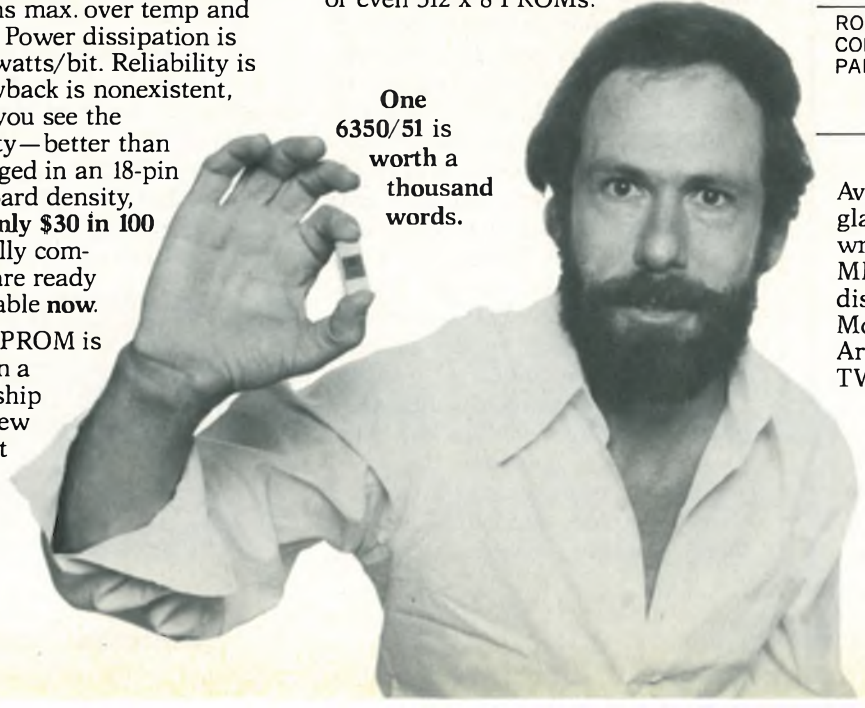
"This is the year for the 60ns 1K x 4 PROM."

MMI has always set the trends in bipolar memories. The first 1K, 2K and 512 x 8 4K PROMs had MMI stamped on them. Now we offer the designer another first: a 4K PROM configured 1K x 4, the way you've told us you want it.

We've drawn on our vast experience in making PROMs coupled with our proven Schottky process, and here it is: Speed is 60ns max. over temp and voltage ranges. Power dissipation is only 150 microwatts/bit. Reliability is improved, growback is nonexistent, and wait until you see the programmability—better than 90%. It's packaged in an 18-pin DIP for best board density, and **priced at only $30 in 100 quantities.** Totally compatible ROMs are ready for your truth table **now.**

Our newest 4K PROM is only the latest in a series of leadership moves. MMI grew to be the largest manufacturer of bipolar memories in the world by finding what the industry wanted and delivering better devices. Our new 1K x 4 PROM is better because its 18-pin package allows you four times the packing density of 1K PROMs. It's available in both commercial and mil spec versions. And it clearly offers you the opportunity of upgrading from 1K, 2K or even 512 x 8 PROMs.

One 6350/51 is worth a thousand words.



1K x 4 MMI PROMs

	COMMERCIAL	MIL SPEC
OC	6350J	5350D
TS	6351J	5351D
TEMP. RANGE	0°C to 75°C	−55°C to +125°C
MAX. ACCESS TIME OVER TEMP. RANGE	60 nsec	75 nsec
PRICE (@ 100 QUAN.)	$30	$55
ROM COMPATIBLE PART NO.		
OC	6250J	5250D
TS	6251J	5251D

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Circle 163 on reader service card

New products

Data handling

Low-cost CRT displays graphics

Tektronix terminal is priced like alphanumeric units, offers same screen capacity

Design engineers must usually pay a premium for CRT terminals capable of displaying graphics. But Tektronix Inc. is marketing a graphics terminal that is price-competitive with many CRT terminals that display only alphanumerics. Not only that, its screen capacity is equal to that of most alphanumeric models.

The unit is the model 4006-1, and it is offered by the company's Information Display Products division. The desktop display is small—12 by 15 by 27 inches, weighing only 42 pounds—but its cast-aluminum construction makes it sturdy.

Data rates up to 4,800 bits per second are available, and are selectable in eight steps: 75, 110, 150, 300, 600, 1,200, 2,400, and 4,800 bits per second. The 4006-1 has 1,024 by 780 viewable points, and its screen capacity is 2,590 alphanumeric characters.

The 4006-1 has two principal operating modes: alpha (alphanumeric) and graf (graphic display). The graf mode controls input of data that causes vectors to be written on the 7.5-by-5.6-in. screen. In the alpha mode, the 4006-1 has a 5-by-7 dot matrix, 63 printing characters, and 35 lines with at least 74 characters per line. In the graf mode, it has 1,024 by 1,024 addressable points, with 780 in the Y dimension viewable on the screen. The 4006-1 provides continuous lines in the vector mode between any two selected points.

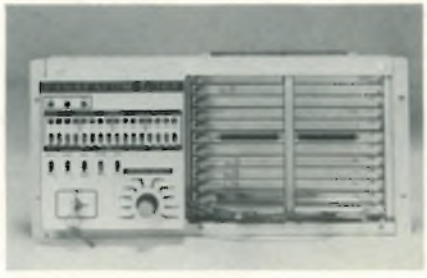
A newly developed interactive graphic package enables the nonprogramer to generate on-screen single- and multiple-line graphs, bar charts, log plots, and calendar plots. Other features include automatic sealing and interactive labeling.

Hard-copy compatibility is included in the 4006-1, using the Tektronix 4631 hard-copy unit. Off-line storage can be provided by the company's 4923 digital cartridge tape recorder. An option for the 4006-1 is a half-duplex data-communications module, which extends the capability of the standard integral interface to include half-duplex normal and half-duplex with supervisory-channel operation. The 4006-1 is compatible with EIA RS232A, B, and C (CCITT-V24) interfaces. Available this month, a single unit costs $2,995, with a lease price of $150 per month on a two-year basis.

Information Display Group, Tektronix, Inc., P.O. Box 500, Beaverton, Ore. 97005 [361]

Microcomputer designed around three MOS circuits

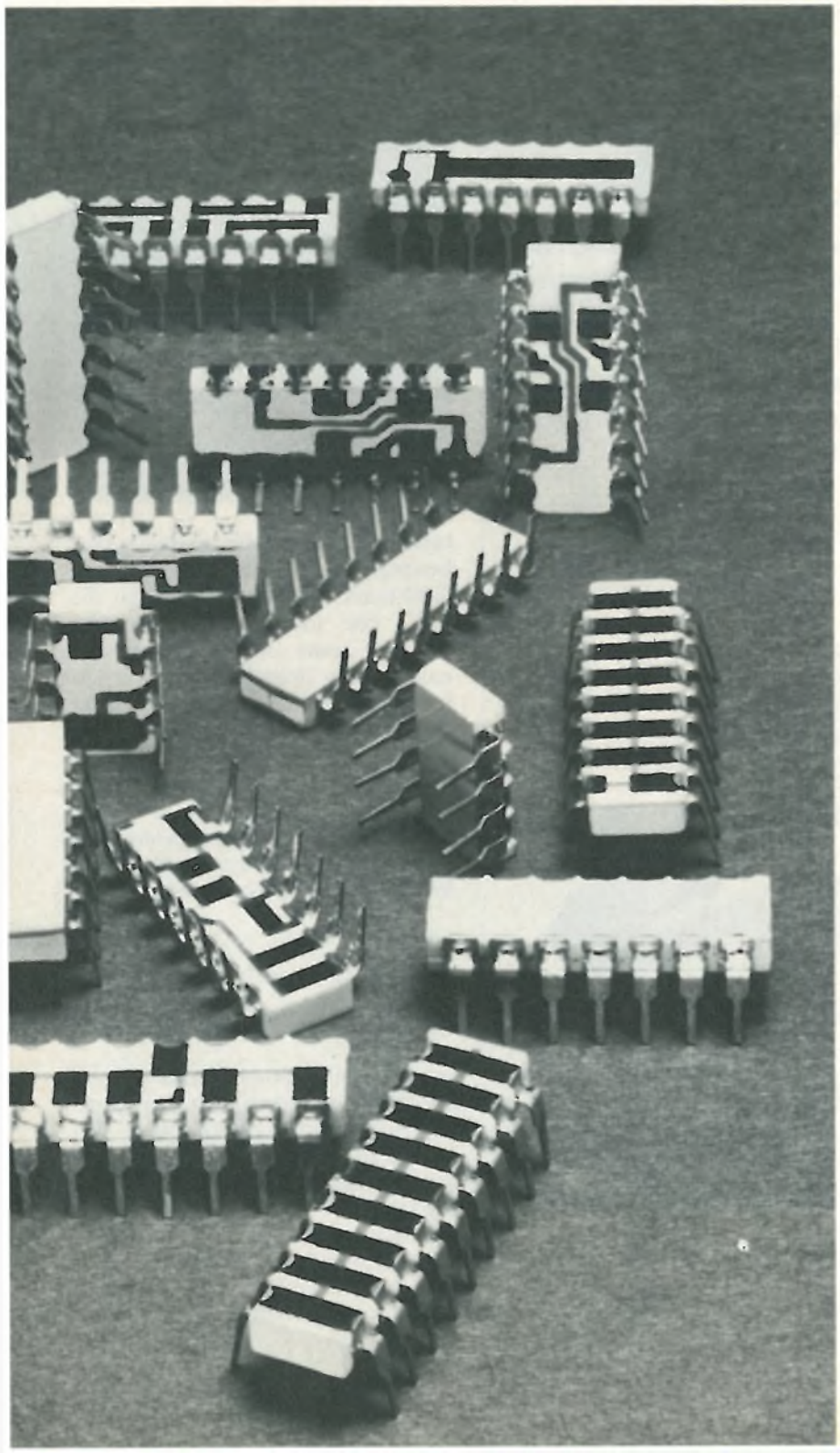
Aimed at industrial and commercial applications, a 16-bit microcomputer is designed around three n-channel MOS LSI circuits. Designated the PFL-16A, the system has minicomputer-like features such as a variable instruction set and 16-bit parallel processing scheme. The CPU

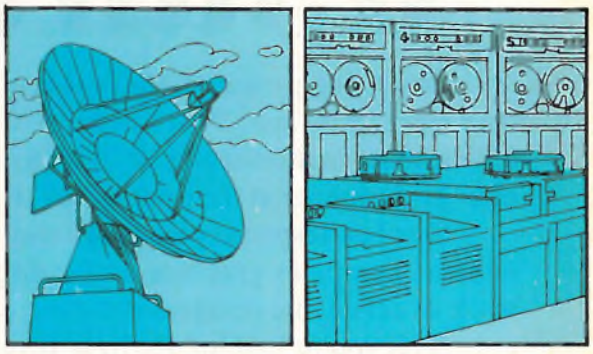


For PBX, computer memory and instrument power supply applications

turn to CTS

for cermet resistor networks





Save Space. Money. Time. It's easy with CTS Series 760 DIP Cermet Resistor Networks. Four popular packages . . . 8, -4, -16 and -18 lead styles . . . provide an infinite number of circuit combinations.

Compact, low profile design puts the squeeze on PCB space. Cost cutters, too. All designs eliminate lead forming and lead trimming for low cost automatic insertion along with IC's and other DIP components. Time saving? One 18-lead CTS 760 Series package can replace up to 32 separate components.

Available without organic cover coat, so you can trim for circuit balance. Precision .100" leads; rated up to 2 watts on 18 lead style; 5-lbs. pull strength on all leads.

Immediate delivery on standards. Custom designs to specifications. Be a saver. Turn to CTS of Berne, Inc., 406 Parr Road, Berne, Indiana 46711. Phone: (219) 589-3111.

Circle 165 on reader service card

CTS CORPORATION
ELKHART, INDIANA

A world leader in cermet and variable resistor technology.

circuit performs 16-bit parallel operations in 3 microseconds. The subchannel adapter circuit along with the direct memory-access-channel controller provides an input/output transfer rate up to 1 million bits per second.

Inquiries Manager, Panafcom Ltd., P.O. Box 4637, Mountain View, Calif. 94040 [364]

Printer/plotter offers speed, high accuracy

By means of an electrostatic printing technique, the model 5200 printer/plotter can produce and plot graphics and alphanumerics in computer-aided design and manufacturing, medical research including brain-scanning, geophysical exploration, and other applications. The 5200 is accurate within 0.2% in plotting graphics and can vary the character spacing within each line so that it approximates a true graphic-arts output. The manufacturer's own specially coated paper becomes electrically charged and fluid-toned as it travels through the unit. The toner adheres to the charged areas of the paper and emerges dry from the machine. Direct interfaces are available for most computers and minicomputers. In addition to basic software, special packages are offered, the company points out.

Marketing Services Manager, Gould Inc., Instrument Systems Division, 3631 Perkins Ave., Cleveland, Ohio 44114 [365]

Microprocessor's instruction cycle takes 200 nanoseconds

An 8-bit microprogramable processor-on-a-board has an input/output-oriented architecture designed to reduce system cost, interfacing, and development time. Designated the Wintex 200NS, the product has an instruction time of 200 nanoseconds, 16-level priority-vectored interrupts, a 16-level stack for interrupt and subroutine returns,

...a few ways Belden can help you protect your bottom line.

Wire and cable usually cost less to buy than install. And poor performance can cut into profitability deeper than potential penny-per-foot savings on an initial buy.

Here's how Belden can help protect your bottom line performance...

BROAD LINE: We can help you meet toughest environmental and application requirements from an exceptionally broad line of standard wire and cable configurations, or design a special for you if stock answers won't work.

UNIQUE PUT-UP CAPABILITY: Ask about Belden's UNREEL™ packaging concept. A dispensing system that eliminates the reel. And time robbing snarls, backlash, and tangle problems. We have a number of ways to put-up wire that can save you production time and money.

ENGINEERING HELP: There's a Belden Electronic cable specialist near you. He's backed by factory engineering specialists and a Technical Research Center. You won't find a better source for solving cable problems.

HOT-LINE ASSISTANCE: Need a "right now" answer to a cable requirement. Call 317-966-6681. It's a direct-line to Belden's cable engineering facility. A way to get immediate assistance on problems that won't wait.

DESIGN KIT: If you're looking for design help, we have a kit that covers most of the nitty-gritty aspects of performance characteristics, costs, and material capabilities. Send for your kit, today.

GREAT DELIVERY: Belden has increased production capabilities and offers shorter lead times on most cable configurations. Check it out.

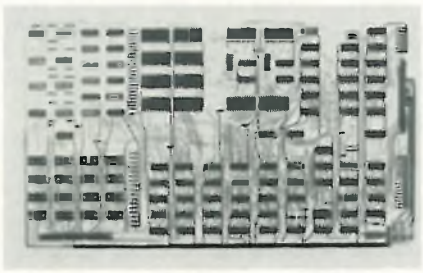
Profit protection is part of the Belden cable package. But, find out for yourself: Write: Belden Corporation, Electronic Division, P.O. Box 1327, Richmond, Indiana 47374. 855

...new ideas for moving electrical energy

BELDEN

Circle 167 on reader service card

New products



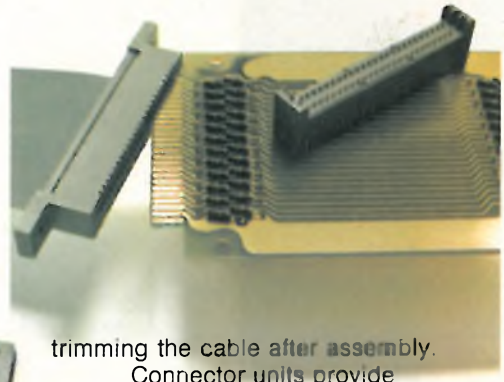
and 16 general-purpose registers. The processor acts both as a device controller and as a microcomputer by using firmware for the control functions and the interpretation of higher-level languages. The processor is available on a board measuring 11 by 10¼ inches, or on an 11-by-18-in. board with sockets for 1,024 bits of control memory. Price is $587 each in OEM quantities.
Wintex Computer Corp., 544 Lunt Ave., Schaumburg, Ill. 60172. Nelson Wong (312) 529-3080 [366]

Low-cost terminal provides remote-batch capabilities

Built to provide entry-level low-cost remote-batch capabilities, the Harris 1606 terminal is for small- to medium-volume batch users requiring emulation for IBM 2780/3780 protocols. The 1606 has a 16-bit, byte-oriented processor, a synchronous communications interface that handles 2,000 to 4,800 bits per second, a 64-character-set chain printer running at 300 lines per minute, and a

reader with a capacity of 150 characters per minute. In the standard configuration, the terminal costs $820 a month, including maintenance, on a 12-month lease. The 1606 includes provision for the IBM protocol, synchronous data link con-

Design with the complete flat cable/connector system.



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.

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

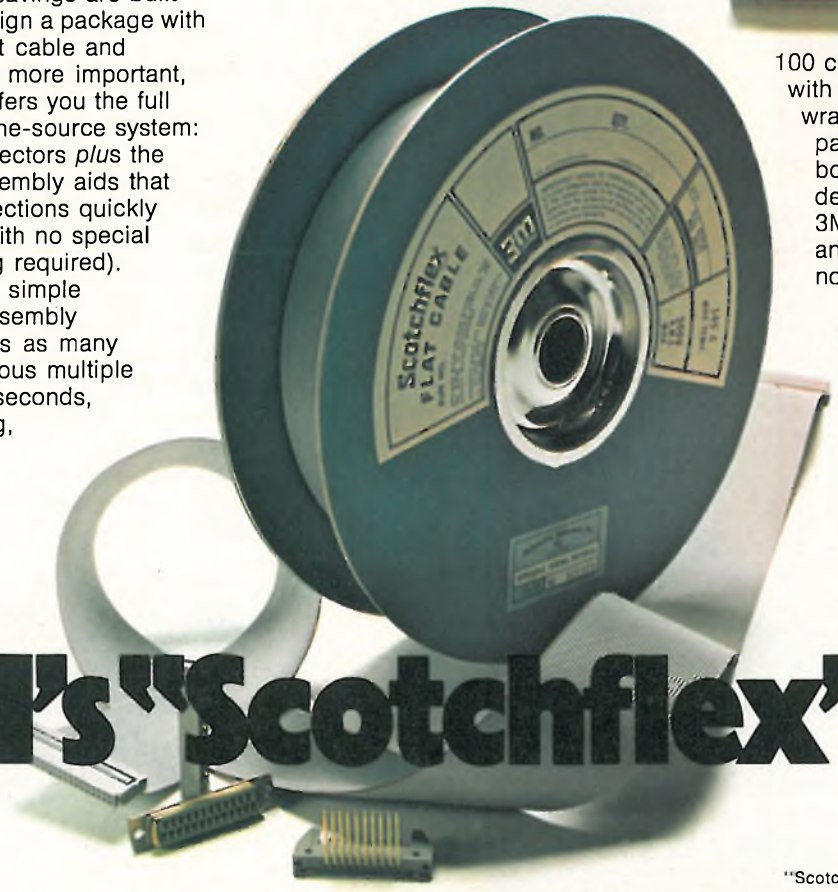
With cable, connectors and assembly tools from one design and manufacturing source, you have added assurance the connection will be made surely, with no shorts or "opens."

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

The 3M DELTA pin and socket connector.

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.

3M COMPANY



3M's "Scotchflex" line.

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

Circle 169 on reader service card 169

trol, to be designed into its hardware.

Harris Corp., Data Communications Division, 11262 Indian Trail, P.O. Box 44076, Dallas, Texas 75234 [367]

Cassette recorder operates up to 120 inches a second

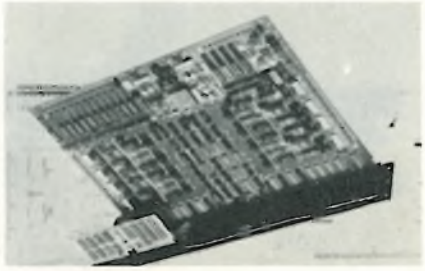
The requirements of mini- and microcomputers, intelligent terminals, and other data-transfer devices are satisfied by a cassette recorder, the model 763, in which the transport uses a servo system to maintain constant tape speeds of 20 to 120 inches per second. The unit meets the specifications of most standard recording formats. The two-channel recorder provides a symmetrical system that can be operated entirely by digital control at TTL levels, once the cassette has been inserted. Digital inputs run, control direction, and select from two-tape speeds. Price is under $400 in quantity.

Memodyne Corp., 375 Elliot St., Newton Upper Falls, Mass. 02164 [368]

Core memory doubles capacities of two PDP-11s

Pin-compatible with both the PDP-11/15 and 11/20 computers, the model LM-820 is a core-memory system that fits within the available chassis space in the computers. It stores 8,192 words of 16 bits each. Cycle time is 650 nanoseconds, and access time is 280 ns. The system board has 86-pin edge-type connectors.

Litton Industries, Memory Products Division, 360 North Crescent Dr., Beverly Hills, Calif. 90210 [369]



It's like finding money.

Reliability testing at up to 300°C with Ekkcel™ can cut time by 70% and up yield almost 1/3!

Whether you are a *manufacturer* of semiconductors or a user of IC chips and discrete devices, you can be dollars ahead when you do process control testing at 250° to 300° C . . . using Ekkcel injection molding resins for burn-in sockets and carriers.

For a user, it can mean 30% increase in yield, due to elimination of marginal devices not discovered at 125° C.

For a manufacturer it can mean greatly reduced testing time: from 168 hours at 125° C, down to 16 hours at 280° C . . . which could save from 22¢ to 40¢ per unit, and greatly improve throughput on existing test facilities.

Where silicone or ceramic carriers and sockets develop brittleness with high temperature use, Ekkcel is unchanged in long term 300° C service. Best of all, Ekkcel can be molded in sections down to .004 in. (.010 CM) in thickness, and it's easily plated.

We'd like to help with your existing test programs, and work with you developing answers to your future needs. We can help you cut costs. And that's like finding money.

Carborundum Plastics, Inc.
Ekkcel Division
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Atlanta, Georgia 30341
(404) 455-6127

CARBORUNDUM

Circle 171 on reader service card

Our bright engineers are turning us into a bunch of order takers.

Everybody should have our problems.

Ordinarily, a salesman's life isn't easy. You're really working for your money. Then along comes ASTRO. The Universal Interface Chip that's an Asynchronous/Synchronous Transmitter/Receiver. Our bright engineers put it all into one chip. One chip, mind you. And everybody wants some. So we're busy writing and filling orders. But for all management knows, we're out there hustling.

ASTRO. It's not just a better mousetrap.

Actually, it's a link that's been missing all this time. State-of-the-art. One chip that helps computers and terminals talk to each other. **32 ASTROS can be addressed on a bus.** And our ASTRO is IBM bisynch compatible. Has transparent mode and full duplex capabilities. It can replace as many as 50 chips in one computer-based system. And just think how many of those are being designed today. It's mind-boggling.

Seems there's no letup.

Not to leave well enough alone, our engineers came up with the MCP 1600. A 3-chip set for microprocessors, originally designed by Western Digital and used in Digital Equipment Corporation's LSI-11 program. You can use the set to interface with all kinds of peripherals. Build it up so it bridges the gap between micros and minis. Another missing link. And that means more orders.

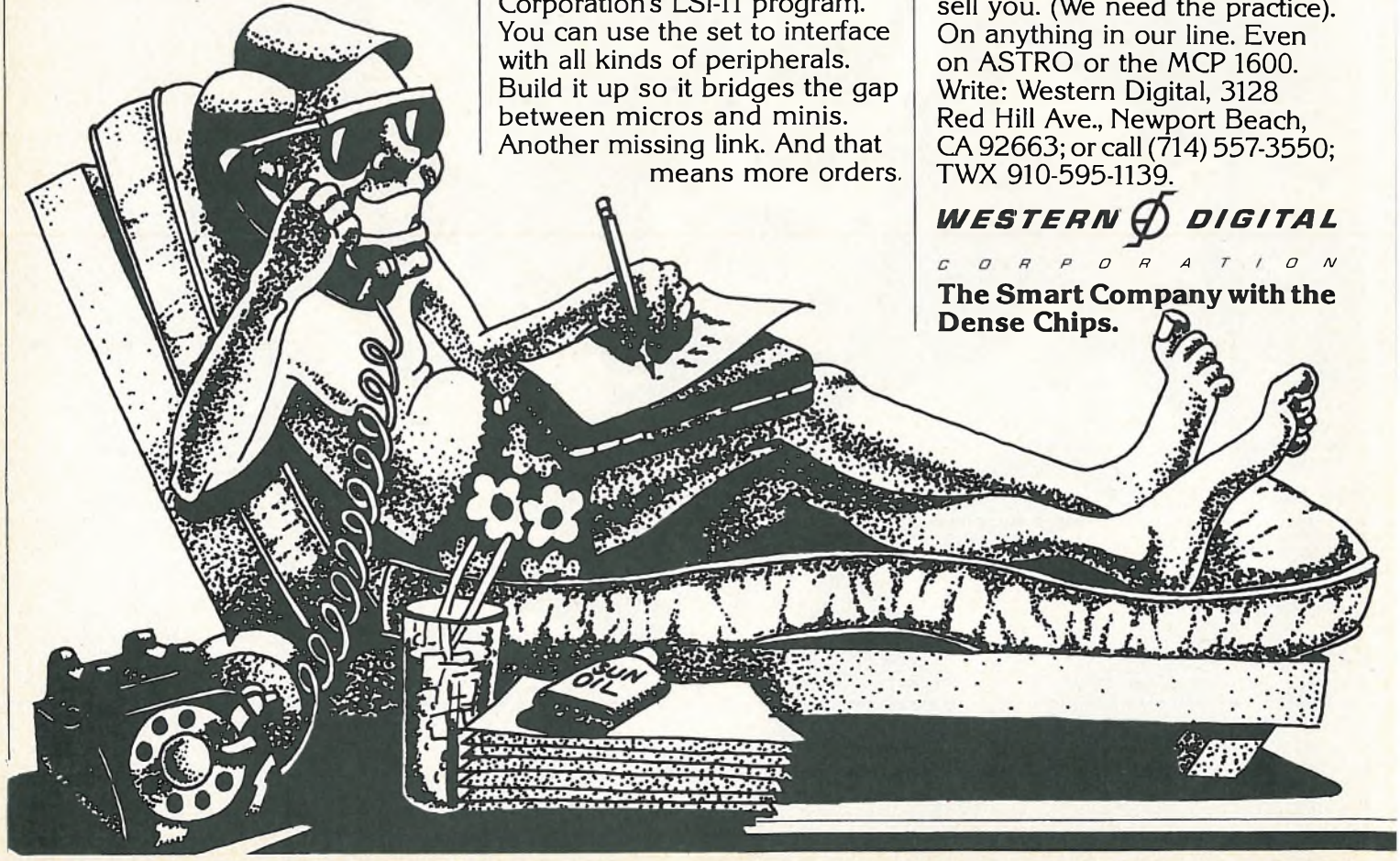
Now our engineers are talking about something else. Only a couple of months away. They claim it's management that makes them do it. Whoever is behind those schemes is doing something right. It sure beats knocking on doors.

Keep those cards and letters rolling in.

As usual, we in sales take the brunt of it all. Maybe one of these days, our engineers will get tired and design a me-too chip. Then we'll be out there selling again. In the meantime, we're filling orders. Probably yours, too. But if you're not convinced, give us a chance to sell you. (We need the practice). On anything in our line. Even on ASTRO or the MCP 1600. Write: Western Digital, 3128 Red Hill Ave., Newport Beach, CA 92663; or call (714) 557-3550; TWX 910-595-1139.

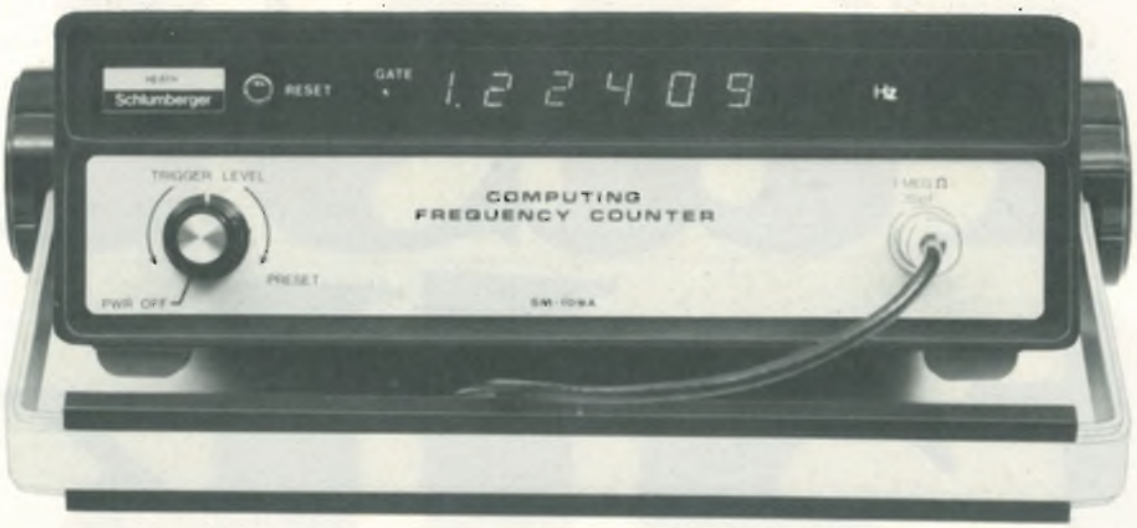
WESTERN DIGITAL
CORPORATION

The Smart Company with the Dense Chips.



Circle 172 on readerservice card

Our frequency counter is smarter than your frequency counter.



The new Heath/Schlumberger SM-109A Computing Frequency Counter is probably the lowest-priced "smart" test instrument available today. With its exclusive Heath-designed circuitry, it is possible to make fast, accurate, high resolution low frequency measurements that cannot be obtained with a conventional frequency counter.

How does it work? The SM-109A measures the elapsed time for a number of periods of the input waveform, then computes the frequency. And it does this in much less time than would be required for a conventional counter. For example, a resolution of 0.00001 Hz can be obtained for a 1 Hz input frequency with a total measurement time of 1 second. A standard frequency counter would require 27.78 hours for the same measurement!

Range of the SM-109A is 0.1 Hz to 20 MHz with sensitivity as low as 20 mV. The display provides 6-digit resolution with automatic decimal point placement and range indication. The front panel trigger control adjusts the input amplifier level above the zero crossing point to insure an accurate count in the presence of noise or signal distortion. Time base can be switched for a choice of 1 second or 0.1 second gate time. A fast count switch permits the display to be updated more often when working with higher frequencies.

Because of the 1-megohm input impedance, a standard oscilloscope probe can be used as a voltage divider. Other features include display of either Hertz or counts per minute...oscillator input for use with an external frequency standard...reset switch to reset counter to zero. All for only $595*.

Smart? You bet it is. Send for our latest catalog and see how the SM-109A can help solve your frequency measurement problems. That's *really* smart.

A complete line of counters for today's measurement problems

...is described in our latest catalog. We have one of the most complete frequency counter lines available, offering the performance and features that you really need. Our SM-118A is the lowest-priced autoranging counter available—anywhere. Its 30 MHz range, 10 mV input sensitivity and 1 Hz resolution make it an outstanding value for only $250*. The autoranging SM-128A & SM-128B are the ideal way to add a high performance counter to your lab. They offer a 110 MHz range, 15 mV sensitivity and a choice of oscillator stabilities. Our 180 MHz SM-110A provides accuracy and stability to meet the most exacting design and testing applications. The 600 MHz SM-110C has an extremely stable TCXO (±1 ppm/yr.) and complete remote programming capability .

Our complete frequency counter line is described in the latest Heath/Schlumberger Assembled Instruments Catalog. Send for your free catalog today. You'll see why there are no better buys than frequency counters from Heath/Schlumberger.

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Heath/Schlumberger Instruments
Dept. 510-100
Benton Harbor, Michigan 49022

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EK-460A

Fast talk

Here they are at last—high-speed communications interfaces on a single chip.

Our new S2350 Universal Synchronous Receiver/Transmitter and S6850 Asynchronous Communications Interface Adapter make it easy to link your word-oriented controller or microprocessor with a serial transmission line. They're both N-Channel, use single 5-volt power supplies, need no TTL, and are bus compatible.

And they're fast. The USRT transmits and receives at a rate of 500 KHz. The ACIA at 800 KHz (making it the fastest Asynchronous R/T going).

Both circuits will fit right into most synchronous or asynchronous communications systems. But they're especially valuable as part of a system using the AMI S6800 microprocessor family.

They both have interrupt logic and they're both double buffered. This lets the MPU operate much more efficiently, because it's not a slave to its family.

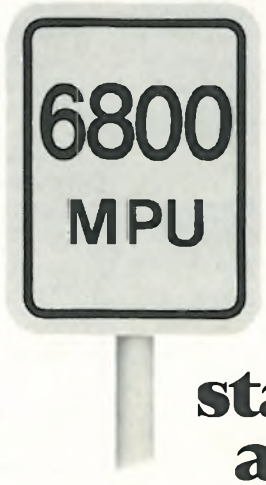
These two chips are the latest additions to our growing list of communications circuits. It now includes the S1757 UART (CMOS compatible), the S1883 UART, the S9544 CRC and the S6860 Modem.

Features of the S6850 ACIA

- 8 bit bidirectional data bus for communication with MPU.
- False start bit deletion.
- Peripheral/modem control functions.
- Double buffered receiver and transmitter.
- One or two stop bit operation.
- 7 or 8 bit characters with odd, even or no parity.
- Parity, overrun and framing error checking.
- Programmable control register.
- Optional ÷ 1, ÷ 16, and ÷ 64 clock modes.
- Up to 800,000 bps transmission.

Features of the S2350 USRT

- 500 KHz data rates.
- Internal sync detection.
- Fill character register.
- Double buffered input/output.
- Bus oriented outputs.
- 5-8 bit characters.
- Odd/even or no parity.
- Error status flags.
- Single power supply (+5v).
- Input/output TTL compatible.



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AMI, 3800 Homestead Road, Santa Clara, CA 95051. Phone (408) 246-0330.

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AMERICAN MICROSYSTEMS, INC

Packaging & production

Memory-board tests are fast

Technique using RAM spots bad ICs in a single pass, shows them on an error map

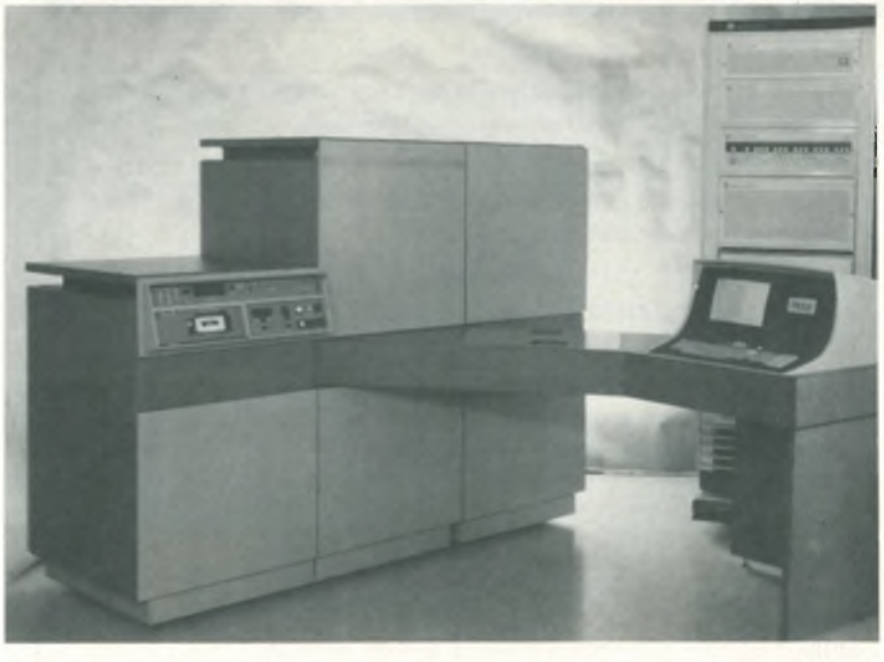
Testing a memory board that turns out to be defective is often a lengthy business. To shorten the process, Adar Associates Inc., Burlington, Mass., has developed what it calls memory-board error-mapping (BEM) as an option to its DR12/20 memory test system. With BEM it takes no more time to test a board with faults than one without faults.

Only a single pass is required to find all faulty chips, unlike the stop-on-first-failure method, in which a board must be recycled through repair and retest for each fault. BEM is also unlike software error-mapping, in which faults are translated into geographic locations and stored in memory, the test program is changed to "mask" the failure, and testing is begun again. Adar contends that both of these methods are slow, and that BEM can speed up memory-board testing by an order of magnitude in most cases.

BEM is built around a high-speed bipolar random-access memory, with error-data and write-error-line inputs and an assignment register. During testing, information on errors is sent from the DR12/20 to the appropriate bit position in the RAM through the assignment register. Failures are detected and their locations recorded at full speed. The RAM has 768 bits; if one chip under test has more than one error, all are given to a single bit position. At the end of the test sequence, the RAM's contents are read into the DR12/20's core memory, formatted, and displayed as an error map. When several tests are performed, the BEM can be set to display errors after each test or to accumulate and display them at the end of the sequence.

Adar says the BEM can handle any type of semiconductor memory with speeds of up to 8 megahertz (a 125-nanosecond cycle time). This will accommodate most large stores, all MOS memories, and all but the fastest bipolar memories. Memory is tested by the line in formats ranging from 32,000 words that are 72 bits wide to 256-k words that are 6 bits wide.

The user can choose an address



for the chips using both X and Y positions of board coordinates and individual package coordinates (chip-select and bit position). Chips can be located visually by displaying a facsimile of the board layout and identifying the defective device within it.

Price of the board-error-mapping option is about $10,000. Price of the DR12/20 is $50–60,000. Delivery time is 60 days.

Adar Associates Inc., 11B North Ave., Northwest Park, Burlington, Mass. 01803 [391]

Table-mounted system tests logic boards

A family of relatively inexpensive test systems for digital-logic printed-circuit boards uses microprogramed control hardware instead of a minicomputer to keep costs down and to keep speed up. The 505 series of testers has clock and pin-change rates of up to 500 kilohertz, and sells for $20,000 to $30,000, depending upon configuration. The compact, table-mounted systems use both programed and pseudorandom test patterns to test boards with up to 223 edge pins. Programs are generated outside of the tester; they can be developed on a time-shared terminal, on a minicomputer used for other purposes, or they can be purchased from Mirco.

Mirco Systems Inc., 2106 W. Peoria Ave., Phoenix, Ariz. 85029 [393]

ECL boards use three-layer power-distribution scheme

Designed for the proper packaging of high-speed emitter-coupled logic circuitry, two series of circuit boards use a three-layer, low-impedance, power-distribution system. The commercial version of the ECL boards uses a standard two-sided board with a laminated third plane. The military version is of true multilayer construction. Signal routing is by means of standard wrapped-

wire interconnections. Prices range from $1 to $2.50 per IC position. Delivery is from stock for standard configurations and from four to six weeks for custom units.

Garry Manufacturing Co., 1010 Jersey Ave., New Brunswick, N. J. 08902. Harry A. Koppel, (201) 545-2424 [394]

Automatic system checks analog circuit boards

The L125 Circuit Diagnostic System uses a guided-probe technique to diagnose problems with analog printed-circuit boards on a production-line basis. The system characterizes analog signals by such simple criteria as dc offset, ac peak-to-peak value, and rectified dc average value, thus making extensive measuring capability and memory unnecessary. Single-point impedances to ground are also used. No circuit analysis enters into the system programing. Instead, comparative diag-

nostic data is taken from boards on the production line. The basic analog system, which can handle boards with up to 228 input/output pin, sells for $96,500. A digital-only version is priced at $65,750. Delivery takes from 12 to 16 weeks.

Teradyne Inc., 183 Essex St., Boston, Mass. 02111. Bob Sigsby, (617) 482-2700 [395]

Wire-loaded elastomer seals out both moisture and emi

Elastomet is a silicone elastomer material that contains uniformly dispersed convoluted monel wires. Each wire is completely surrounded by silicone rubber, except at the tip, so no moisture channels are formed. Produced in strips as thin as 30 mils

and in rectangular strips and rings, the material is an effective shield against electromagnetic interference.

Technical Wire Products Inc., 129 Dermody St., Cranford, N. J. 07016. Phone (201) 272-5500 [396]

Metric packaging panels introduced by Augat

A family of integrated-circuit packaging panels, made to European metric standards, has been introduced by Augat Inc. The panels, called the 8136-VG series, are offered in two sizes: 100 by 160 millimeters and 160 by 233 mm. The single boards contain 35 integrated-

New products

circuit patterns while the double ones can hold 85 ICs. Patterns for 14- and 16-pin ICs can be provided. Depending upon size, variations, and quantity, the panels are priced anywhere from $31 to $170 each. Delivery time is two weeks.

Augat Inc., P. O. Box 779, 33 Perry Ave., Attleboro, Mass. 02703 [397]

Solder-Wrap process speeds prototype wiring

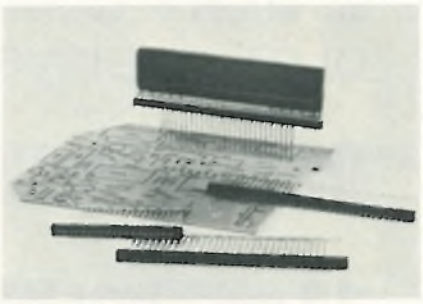
A hand-wiring process known as Solder-Wrap uses a wiring wand to dispense cartridge-loaded, heat-strippable insulated wire around and between component leads mounted on a special circuit board. Once the wire is routed and wrapped around the leads, the connections are heated to strip away the insulation and solder them. A special hobbyist kit sells for $11.95. It contains the pencil-shaped wiring wand, a cartridge with 200 feet of 34-gauge wire, a circuit board with 15 IC positions, 10 insulating channels, and instructions. Extra boards and wire are available.

Applied Manufacturing of Texas, P. O. Box 50273, Dallas, Texas 75250 [398]

Display connector stays where put

Anxious to lop every possible penny off their bill of materials, manufacturers of cheap (and not so cheap) consumer products such as desk-top calculators and digital clocks often use floating contacts for their digital displays. This works fine as long as the product is not subjected to sufficiently rough handling or vibration to cause contact disalignment. When that happens, intermittence results. Methode's answer to this problem is a family of connectors with stamped, tin-plated, beryllium-copper contacts ultrasonically welded into a two-piece thermoplastic body. Offered in versions with from 17 to 52 contacts (for direct interface with 8 to 16-digit display de-

New products



vices) the connectors cut labor costs by speeding assembly.

Methode Manufacturing Corp., 1700 Hicks Rd., Rolling Meadows, Ill. 60008 [399]

Low-profile fan moves 200 cubic feet/minute

The IMCool 600 Tubeaxial fan is a 400-Hz blower specifically intended for the cooling of high-density electronic assemblies. With a typical operating point of 200 cubic feet per minute at a pressure of 0.18 inch of water and its low acoustic noise level, the fan is especially well suited for computer-room use. Measuring only 2 inches deep by 6.75 in. in diameter, the compact unit can be mounted in any position, and can be oriented as an intake or an exhaust fan. The device meets specifications of MILB 23071/B.

IMC Magnetics Corp., Eastern Division, 570 Main St., Westbury, N. Y. 11590. Gene Egan (516) 334-7070 [400]

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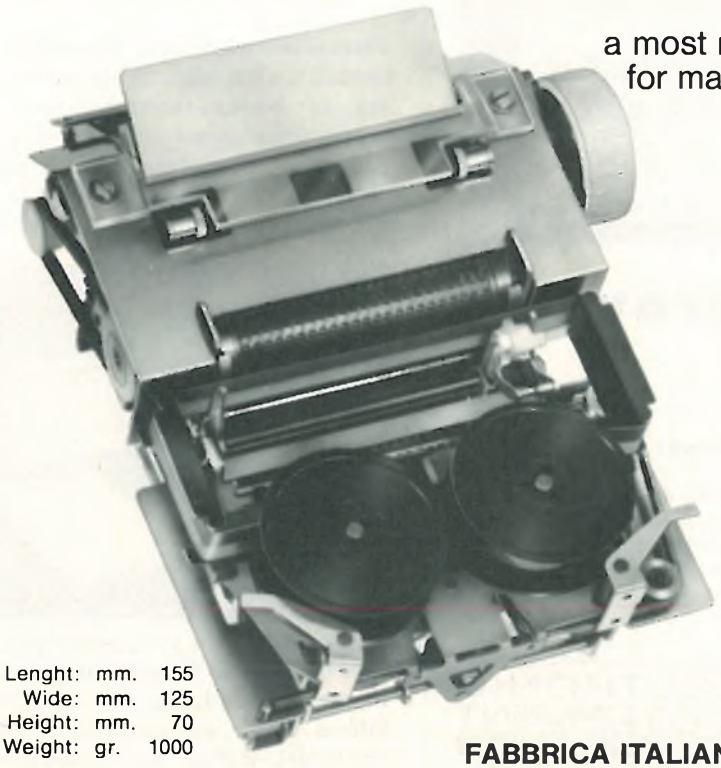

high capacity serial flying printer • two-colour printing • large and easily readable figures • standard paper roll and ribbon • noiseless: motor runs only if printing-patented sturdy construction-highly compact

Lenght: mm. 155
Wide: mm. 125
Height: mm. 70
Weight: gr. 1000

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inzadi SpA

Circle 268 on reader service card

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16 POSITIONS

INTERSWITCH now offers two new 16-position thumbwheel switches – the Type H front mounting switch and the Type P rear mounting switch.

Each switch module measures only 10-mm wide and is available with a multitude of options which INTERSWITCH offers on all of its thumbwheel switches.

Available from stock and local distribution. Write or call today for complete information.

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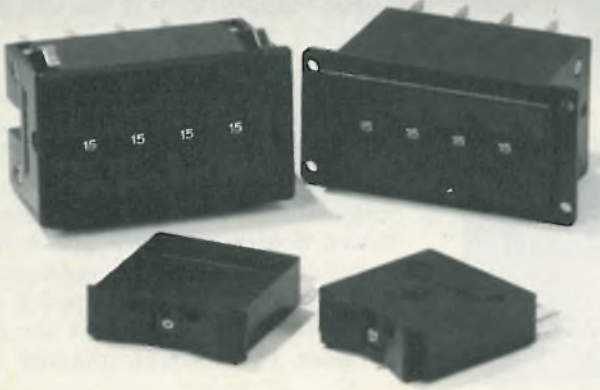

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811 E. ARQUES, SUNNYVALE, CALIF. 94086

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New products/materials

Zirconium-oxide setter plates are intended for the high-temperature firing of barium-titanate-based ceramic components such as ceramic capacitors, thermistors, and various piezoelectrics. Zirconium oxide is the only setter-plate material that

can survive firing at temperatures in excess of 1,288°C without reacting with barium titanate. The calcia-stabilized plates are available as flat rectangles, wafers, and two-rail rectangles. Two types are offered: No. 1247, which is recommended for initial testing, and No. 9123, which has a finer grain size.

Zircoa, P. O. Box 39217, Solon, Ohio 44139 [476]

Single-crystal tin with purities of 99.9999% are available in standard diameters of 0.25, 0.5, 0.75, 1.0, and 1.5 inches and in standard lengths of 1, 2, 4, and 6 in. Normally supplied with random crystal orientation, the crystals can also be furnished with specific orientations of (100), (110), and (111) within 3° of the major axis at extra cost. Pricing is typified by a one-inch crystal of 0.25-in. diameter that sells for $150. Typical delivery time is four to five weeks.

Aremco Products Inc., P. O. Box 429, Ossining, N. Y. 10562 [477]

A soldering wax for use in continuous-flow soldering operations will not smoke on heating up to 550°F. Used to prevent oxidation and scum formation on the surface of molten solder, Solderwax 550°F also helps to maintain a uniform temperature in the solder machine. Supplied in flaked form, the white wax should be used in sufficient quantity to

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SIZE SYMBOL	DIMENSIONS WITH TOLERANCE, mm		
	Ext. dia.	Int. dia.	Height
K61x24x13	61 ± 1.5	24 ± 0.6	13 ± 0.1
K72x32x10	72 ± 1.5	32 ± 0.7	10 ± 0.1

Other dimensions of the "3.1 BA" Annular Ferrite Magnet are available. V/O Electronorgtechnica, 32/34 Smolenskaya Sennaya, Moscow 121200, USSR. Telex: 7586.

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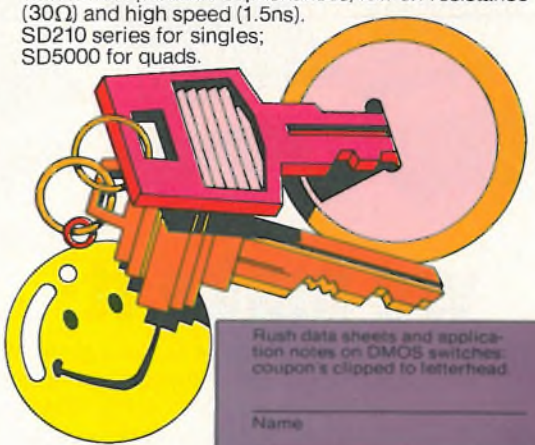

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Circle 189 on reader service card

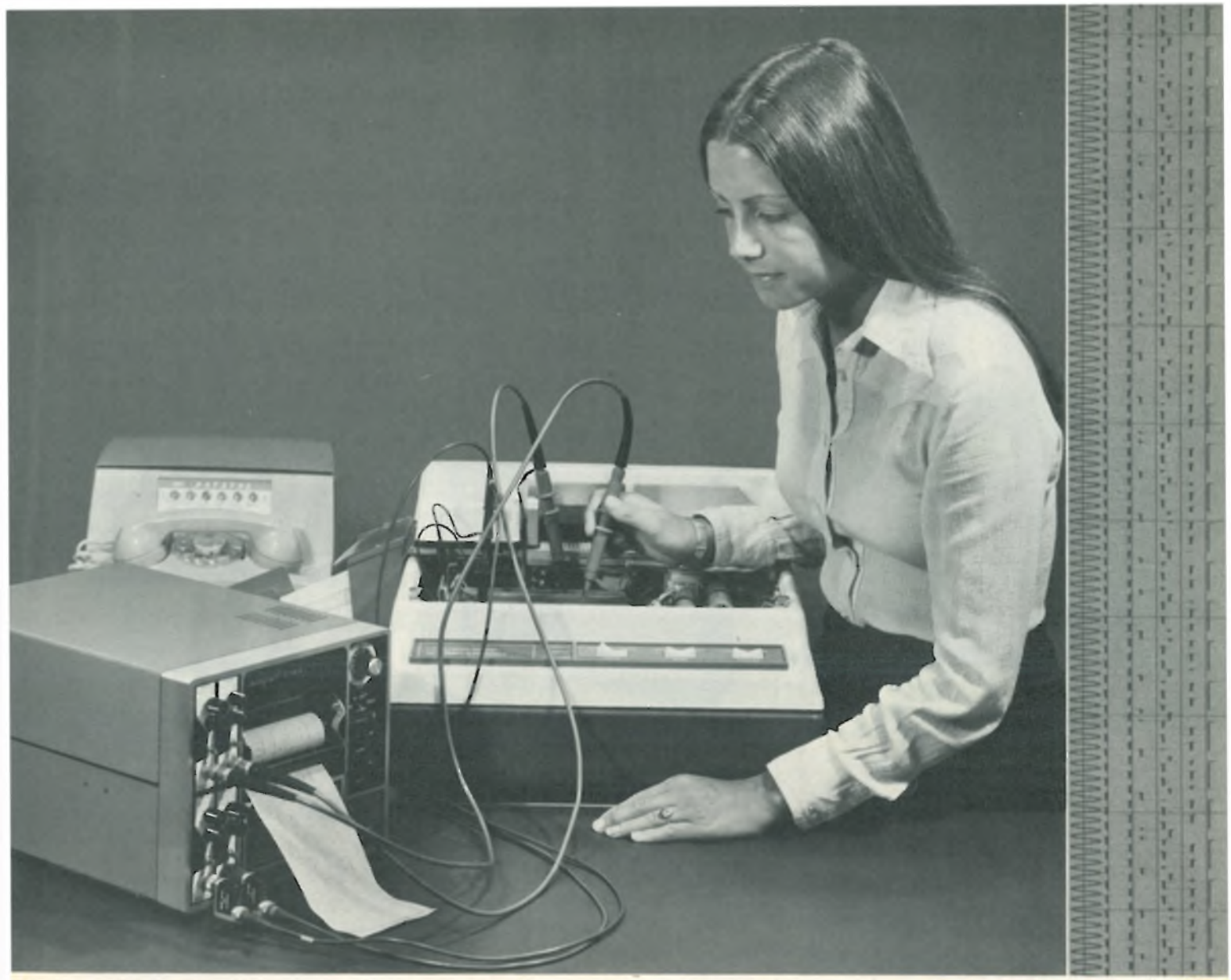
New products/materials

form a layer from 0.25 to 0.5 in. thick.
Solderwax Chemical Co., 16 Catalpa Lane, Valley Stream, N. Y. 11581 [478]

Thick-film conductor paste EX2310, after firing in a nitrogen atmosphere, yields a copper film with a sheet resistivity of 2 milliohms per square and good solderability. The base-metal material can also be bonded by ultrasonic and thermal-compression techniques. Adhesion is good with a peel strength of 4 to 5 kilograms per 2.5-mm square pad. Sample quantities of EX2310 sell for 89 cents a gram. The price drops to 41 cents per gram in large quantities.
Electro-Science Laboratories Inc., 1601 Sherman Ave., Pennsauken, N. J. 08110. Phone (609) 663-7777 [479]

Thin dielectric films of pure polysulfone with thicknesses as low as 2 micrometers (0.08 mil) have a matte finish on one side to promote good windability. The uniaxially oriented films are homogeneous and can be operated at temperatures up to 150°C. Called Kimfone polysulfone film, the material is offered in thicknesses up to 12 micrometers (0.48 mil). Applications include the fabrication of high-voltage capacitors, wire insulation, and the manufacture of semiconductor devices.
Schweitzer Division, Kimberly-Clark Corp., Lee, Mass. 01238 [480]

Two flame-retardant resins for potting and encapsulation are designed to meet Underwriters' Laboratories requirements. Scotchcast XR-5234 is a beige-colored material that meets UL flammability requirement 94 V-O. It has a gel time of 10 minutes at 120°C (248°F) and a cure time of two hours at the same temperature. The cure time increases to about 3½ hours at 90°C (194°F). The filled resin system is said to have excellent thermal and mechanical shock resistance. Scotchcast XR-5237 is a liquid that cures at room temperature and is able to operate at 130°C.
3M Co., Dept. IEP5-7, P.O. Box 33600, St. Paul, Minn. 55133 [341]



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Bell & Howell's Datagraph® Model 5-144 recording oscillograph. Probably the most convenient test instrument you'll ever use.

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Circle 191 on reader service card

New literature

Motors. A reference source for users of fractional-horsepower motors and controls—The B & B Binder—contains catalogs of the top manufacturers of these motors, as well as gear motors, clutches,

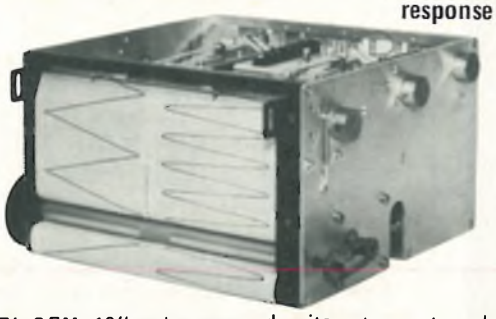
brakes, counters, controls, and related products. The binder is available free to qualified buyers and users. To obtain a copy, write to Sales Manager, B & B Motor and Control Corp., 96 Spring St., New York, N. Y. 10012. The letter should be on company stationery and should describe intended applications.

Using Impatt diodes. A 12-page application note discusses the physics, structure, characteristics, and operation of double-drift Impatt diodes. Aimed principally at users who want to use Impatts as high-power continuous-wave microwave sources, AN 962 includes circuit-design information and a list of references for further study. The note is obtainable from Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. Circle reader service number 422.

Computer printers. A 1,000-page analysis and evaluation of computer printers is both a buyer's guide and a tutorial analysis of the printer market. Priced at $495 per copy, the report identifies 96 OEM manufacturers of printers, and discusses the characteristics of 298 systems. Ap-

WIDE CHART RECORDERS

up to three 100 mm channels with 50 millisecond full scale response



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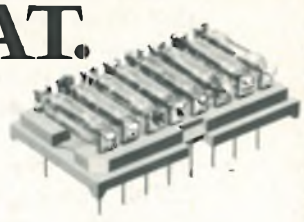

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Circle 193 on reader service card

New literature

plications-oriented comparisons are included. For further information, contact S. P. Davis and Co., P. O. Box 1469, Los Altos, Calif. 94022. Scott Davis or Tom Tracy, (415) 941-3482 [423]

Cooling semiconductors. Tech Tips 1-5 is an application note that includes step-by-step instructions for reclamping disk-type semiconductors onto air- or water-cooled heat exchangers. For a copy, write to Semiconductor Division, Westinghouse Electric Corp., Youngwood, Pa. 15697. Phone (412) 925-7272 [424]

Marketing in Germany. The Directory of American business in Germany is a 672-page handbook that lists the German representatives of American firms. It contains two alphabetical lists—one of the German firms and the other of the American. The price of the directory is 65 Deutschmarks plus postage. The handbook, which is printed in both German and English, can be ordered from Seibt-Verlag, D-8000 Munchen 80, Anzinger Strasse 1, Germany [425]

Code conversion. A handy chart that shows equivalent code expressions in ASCII-7, ASCII-8, EBCDIC, EBCD, Field Data, six-bit Transcode, Selectric, and Baudot is offered by Atlantic Research Corp., 5390 Cherokee Ave., Alexandria, Va. 22314. Phone (703) 354-3400, Ext. 621 [426]

OSHA summary. A quick-look, six-page summary report outlining the Federal safety standards mandated by the Occupational Safety and Health Act (OSHA) has been published by Soltys Associates, 1741 N. Ivar Ave., No. 106, Los Angeles, Calif. 90028. The report sells for $3.50 and may be ordered from the publisher.

Electronics catalog. Various components, tools, instruments, educational materials, and other electronics equipment are included in a 12-page catalog put out by Woas Elec-

The standard power supply is a minor consideration... until it fails.

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If reliability is worth more to you, send for a bulletin, or call your North Standard Power Manager at 419/468-8874.

Listed here are the more popular models—many other voltages are available.

MODEL	11000	12000	13000	14000	15000	16000	17000	18000
VDC	AMPERES							
5.0	35	5.2	11.2	13.0	20.0	32.5	44.0	92.0
12.0	28	4.2	8.8	10.5	15.0	23.0	36.0	56.0
15.0	24	3.7	7.5	9.5	14.0	20.8	27.0	44.0
18.0	21	3.3	6.9	8.9	13.0	18.9	26.0	40.0
24.0	15	2.8	4.2	7.6	11.0	15.9	21.0	33.0
36.0	14	2.4	4.0	6.3	9.0	14.0	20.0	29.0
48.0	12	2.0	3.1	5.6	8.0	11.0	14.0	23.0
48.0	9.5	1.8	2.6	4.2	6.0	8.9	13.0	18.9

MODEL	10000
VDC	AMPS
5.0	2.10
12.0	1.25
15.0	0.85
18.0	0.66

DUAL OUTPUT SUPPLIES	
MODEL	N00052
VDC	AMPS
±15.12	400MA
MODEL	N00052
VDC	AMPS
±15.12	1.0A

NORTH ELECTRIC COMPANY

North Electric Company / Galion, Ohio 44833 / A United Telecom Co.

SP-20

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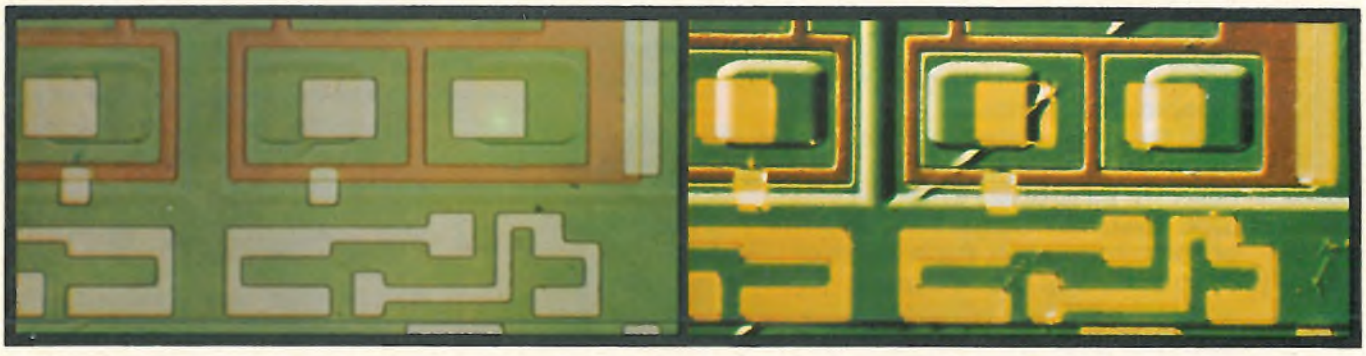

If this is all you're seeing, this is what you're missing.

The AO DICV Series 10 Differential Interference Contrast Microscope can make a big difference. A standard brightfield microscope reveals only what is shown in the specimen on the left.

Now look at the specimen on the right. With this ability to reveal significant detail in outstanding relief in black and white or color, the AO DICV Series 10 can help you spot surface irregularities, inclusions and faults.

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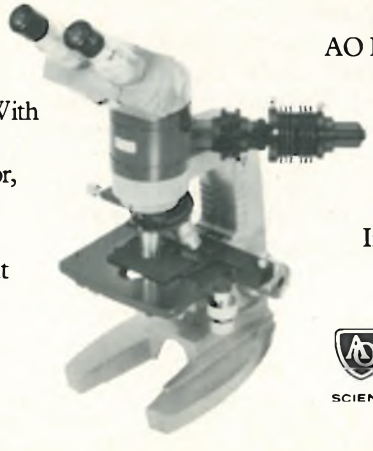


AO DICV Microscopes convert quickly from interference contrast to brightfield. So if you can't afford to miss something, you can't afford to overlook the AO DICV Microscope. For details, write American Optical Corporation, Scientific Instrument Division, Buffalo, N.Y. 14215.

AMERICAN OPTICAL CORPORATION

SCIENTIFIC INSTRUMENT DIVISION • BUFFALO, N.Y. 14215

Circle 195 on reader service card

New literature

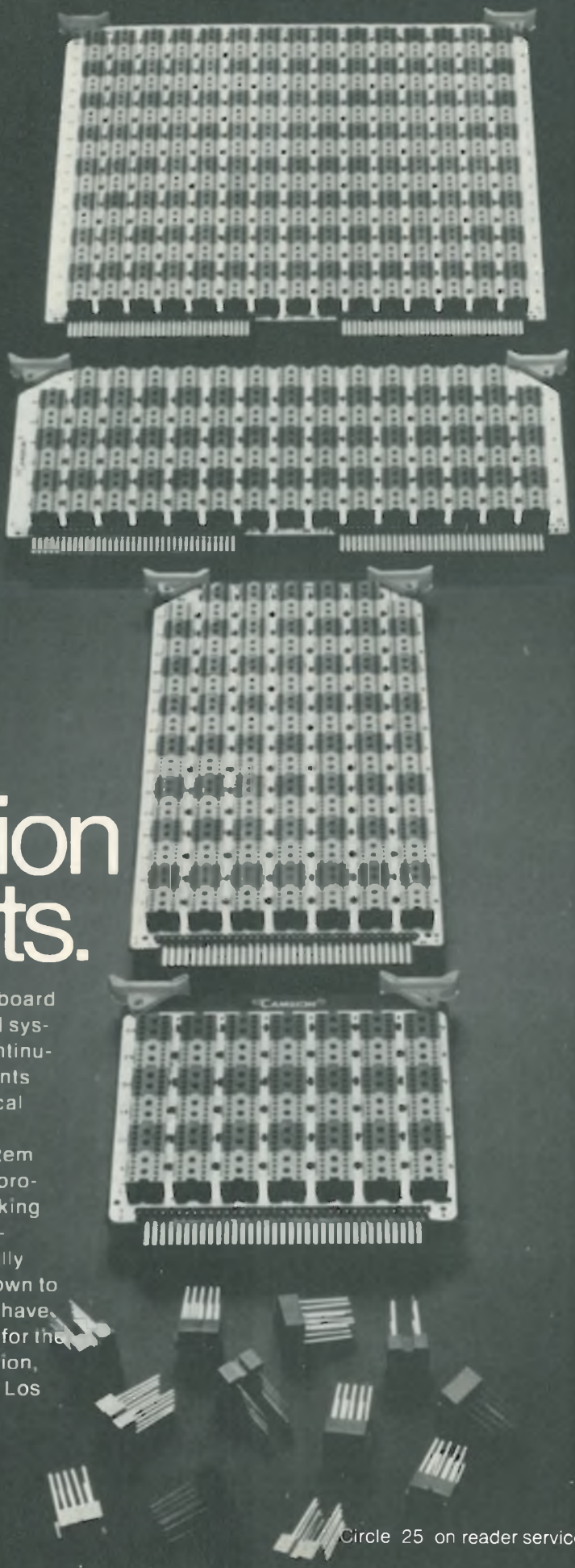
tronics, P. O. Box 2637, El Cajon, Calif. 92021. Each catalog is supplied with an ordering form and complete ordering information. [427]

Subminiature lamps. General Electric's subminiature lamp catalog, which lists 177 lamps with diameters of 0.25 inch or less and contains outline drawings and technical data on each of them, also includes useful information on lamp failure modes and other applications data. This catalog (No. 3-6252R1), as well as an index of all lamps made by GE's Miniature Lamp Products Dept. (No. 3-6255R), can be obtained from the GE Inquiry Bureau, Nela Park, Cleveland, Ohio 44112 [428]

Static electricity. A four-page brochure on a line of products for the elimination of static electricity includes data on personnel wrist and heel grounders, seat covers, tote boxes and trays, conductive sheeting and covers for work surfaces and floors, antistatic liquids and sprays, and similar items. A feature of the product line is that its resistivity is high enough to avoid creating painful or possibly explosion-producing sparks, but low enough to effectively drain away static potentials. The publication, No. CP-775, is available from The Simco Co., Inc., 920 Walnut St., Lansdale, Pa. 19446. [429]

Relays. A line of relays including latching, reed, solid-state, time-delay, frequency-sensitive, power, and

Total IC packaging systems build faster with Cambion components.



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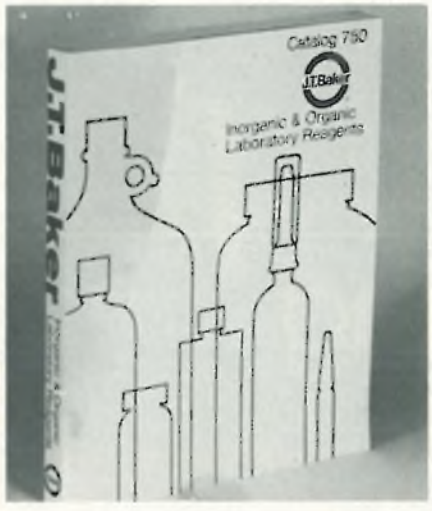
New literature

other types is described in a 32-page catalog put out by Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343 [430]

Pure chemicals. Containing data on more than 3,000 products for the laboratory, the Baker Catalog 750 includes a new section on the com-



pany's Ultrex line of ultrapure reagents as well as research material distinguished by greater purification and extensive analytical characterization. The catalog is offered by J. T. Baker Chemical Co., 222 Red School Lane, Phillipsburg, N. J. 08865 [431]

Plastic lenses. An illustrated brochure from Combined Optical Industries explains recent advances in the production of plastic lenses and outlines their advantages for industrial applications. The 15-page handbook lays particular stress on aspherical lenses, which are easily fabricated in plastic but which create formidable problems if they are to be made from glass. The publication can be obtained from Combined Optical Industries Ltd., 200 Bath Rd., Slough, SL1 4DW England [432]

Teflon carriers. A line of Teflon wafer and mask carriers capable of handling wafers up to 5 inches in diameter and masks up to 4 inches square is described in a four-page brochure from The Fluorocarbon

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New literature

Co., Process Systems Division, 1432 S. Allec St., P. O. Box 3640, Anaheim, Calif. 92803 [433]

Shielding for electron microscopes. Technical literature on shielded rooms for electron microscopes—to eliminate both magnetic and vibration-induced distortions—can be obtained from Keene Corp., Ray Proof Division, 50 Keeler Ave., Norwalk, Conn. 06856. The special rooms exclude interference from power-line feeders, elevators, fluorescent lighting, and other magnetic-field sources. [434]

High-voltage capacitors. A line of high-voltage capacitors for light-and heavy-duty energy-storage/discharge applications includes rating charts and size information on every covered type of capacitor. The 32-page catalog is available from Aerovox Industries Inc., 740 Belleville Ave., New Bedford, Mass. 02741 [435]

Ceramic capacitors. A 300-page handbook on the manufacture and application of ceramic capacitors has been published by Viclan Inc., P. O. Box 81403, San Diego, Calif. 92138. The text, which was written by Donald W. Hamer, includes reproductions of catalog pages of many manufacturers in the field. Priced at $25, the handbook may be ordered from the publisher.

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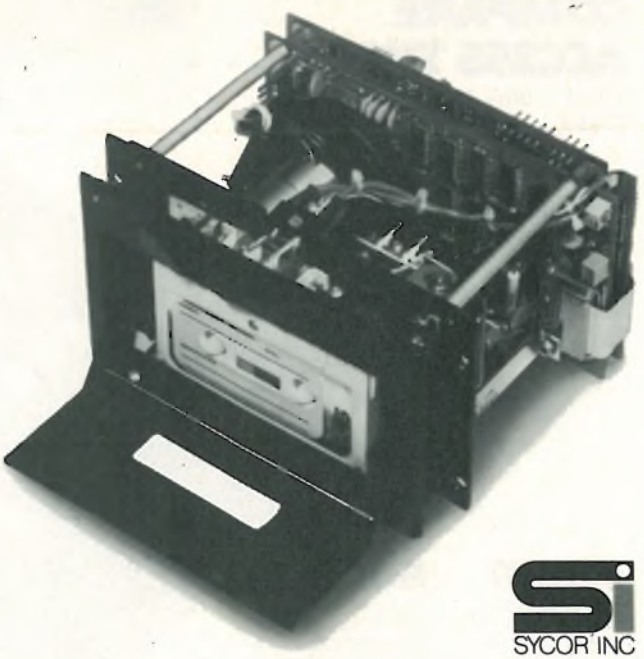

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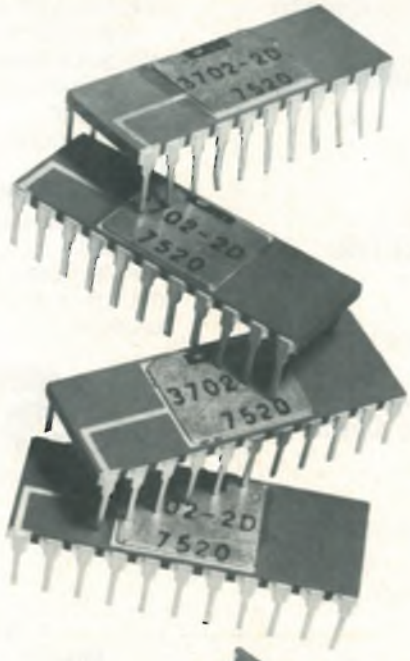

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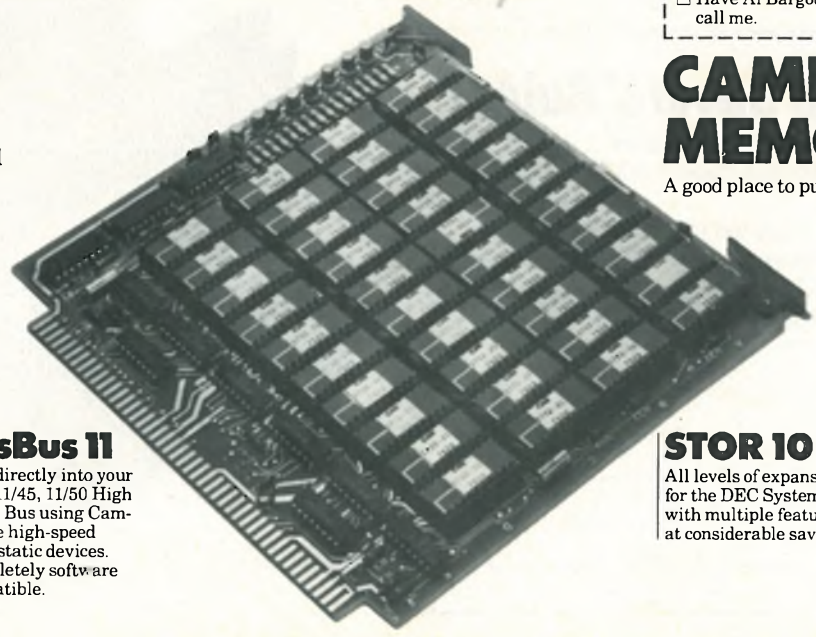

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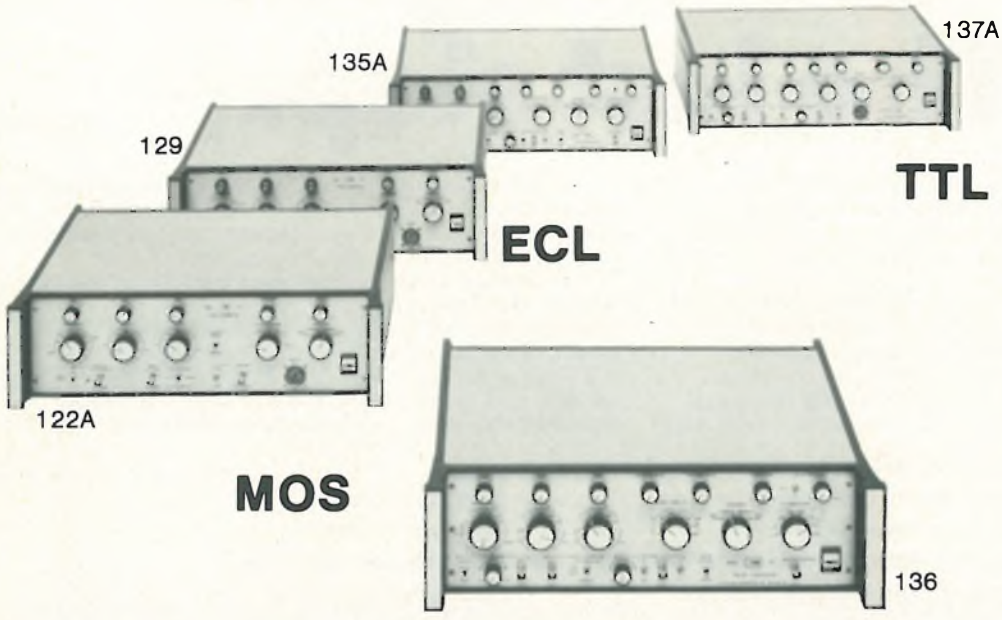

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New books

Charge Transfer Devices, Carlo H. Séquin and Michael F. Tompsett, Academic Press, 309 pp., $16.00.

Charge-transfer devices date only from 1969, the year in which Bell Laboratories announced its development of the charge-coupled type. But already a significant body of knowledge exists about how to use them and design with them.

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Most readers would do well to read the last chapter, "Conclusions," first. It presents a quick overview of the basic technology and the applications. On image sensors, for example, the authors say that uncooled image arrays that contain 500 by 500 elements and compete with Plumbicon tubes are feasible but will require "sustained development effort." However, less demanding requirements for commercial surveillance cameras or consumer video recorders will "probably be met fairly rapidly." In signal processing, applications appear to be a little further off, although the fact that the devices can now provide accurate clock-controlled delays of a few hundred nanoseconds to several seconds suggests they could replace bulky passive delay lines. In memories, of course, commercial 16-kilobit devices now are available, while the ability to design peripheral circuits on the same chip will help the CCDs compete with magnetic bubbles.

The first two chapters, which introduce the devices, demand only an understanding of the basic concepts of solid-state physics, such as energy band diagrams and interface potentials. Two more chapters cover device structures and—more important to the user—device limitations under such headings as signal-handling capabilities, transfer inefficiency, noise, linearity, dark current, and power. From this point, the

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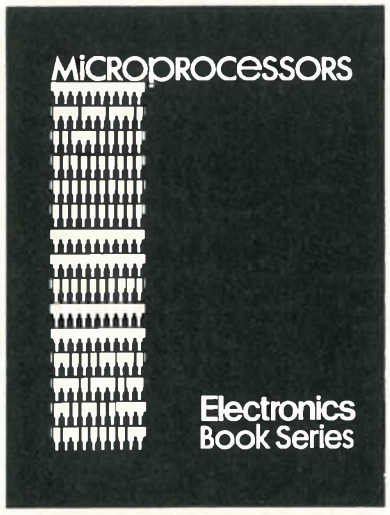

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The chapter on image sensing, at 60 pages, is the longest of the three and covers linear and area sensors as well as infrared image sensors. Under signal processing, the authors deal with delay circuits, multiplexers, and recursive and transversal filters. Under memories, three basic organizations are described—serial-parallel-serial, electrode-per-bit, and serpentine.

Of particular use to those readers who want to delve further into the subject will be the extensive, 25-page-long list of references. It's unusual to find a book with such up-to-date references—several are as recent as 1975.

The authors have already contributed much to the area with their own work. Now they have produced a well-written summary of the complete field. —Stephen E. Scrupski

Recently published

Random Point Processes, Donald L. Snyder, John Wiley & Sons, 485 pp., $24.95.

Magnetic Materials and Their Applications, Carl Heck, Newnes-Butterworths (Borough Green, Sevenoaks, Kent, TN158PH, England), 770 pp., 18.45 pounds.

Stability of Motion, E.J. Routh, Halsted Press, 228 pp., $19.95.

Fundamentals of Automatic Control, Robert C. Weyrick, McGraw-Hill, 397 pp., $13.50.

Quantum Electronics, 2nd ed., Amnon Yariv, John Wiley & Sons, 570 pp., $20.95.

Operational Amplifiers: Theory and Servicing, Edward Bannon, Reston Publishing, 195 pp., $13.95.

Computer Interfacing and On-Line Operation, J.C. Cluley, Crane, Russak & Co., 181 pp., $14.50.

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New books

cesses, William S. DeForest, McGraw-Hill, 269 pp., $16.50.

Digital Filters and the Fast Fourier Transform, Bede Liu, ed., Halsted Press, 423 pp., $30.00.

Digital Principles and Applications, Albert Paul Malvino and Donald P. Leach, McGraw-Hill, 437 pp., $11.95.

Advanced Applications for Pocket Calculators, Jack Gilbert, Tab Books, 304 pp., $8.95 (hardback), $5.95 (paper).

Data Communications Via Fading Channels, Kenneth Brayer, ed., IEEE Press, 503 pp., $17.95.

Nonreciprocal Microwave Junctions and Circulators, J. Helszajn, John Wiley & Sons, 349 pp., $20.95.

Semiconducting Temperature Sensors and Their Applications, Herbert B. Sachse, 380 pp., John Wiley & Sons, 380 pp., $22.95.

Circuit Theory: A Computational Approach, Stephen W. Director, John Wiley & Sons, 679 pp., $18.95.

Process Quality Control, Ellis R. Ott, McGraw-Hill, 379 pp., $14.95.

Computer Programming Handbook, Peter A. Stark, Tab Books, 506 pp., $12.95 (hardback), $8.95 (paper).

Integrated Circuits Guidebook, Ken Tracton, Tab Books, 195 pp., $8.95 (hardback), $5.95 (paper).

Transistor Theory for Technicians and Engineers, Andy Veronis, Tab Books, 224 pp., $5.95 (paper).

Electronic Integrated Circuits: Their Technology and Design, John Allison, McGraw-Hill, 139 pp., $12.50.

A Flick of the Switch: 1930-1950 [radio-TV equipment and program nostalgia], Morgan E. McMahon, Vintage Radio (Box 2045, Palos Verdes Peninsula, Calif. 90274), 311 pp., $9.95.

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