DECEMBER 11, 1975

A GUIDE TO SEMICONDUCTOR RANDOM-ACCESS MEMORY COSTS/101

How parametric testing can increase pc board yield/108

For fast transient observation, try fast-transfer storage/113

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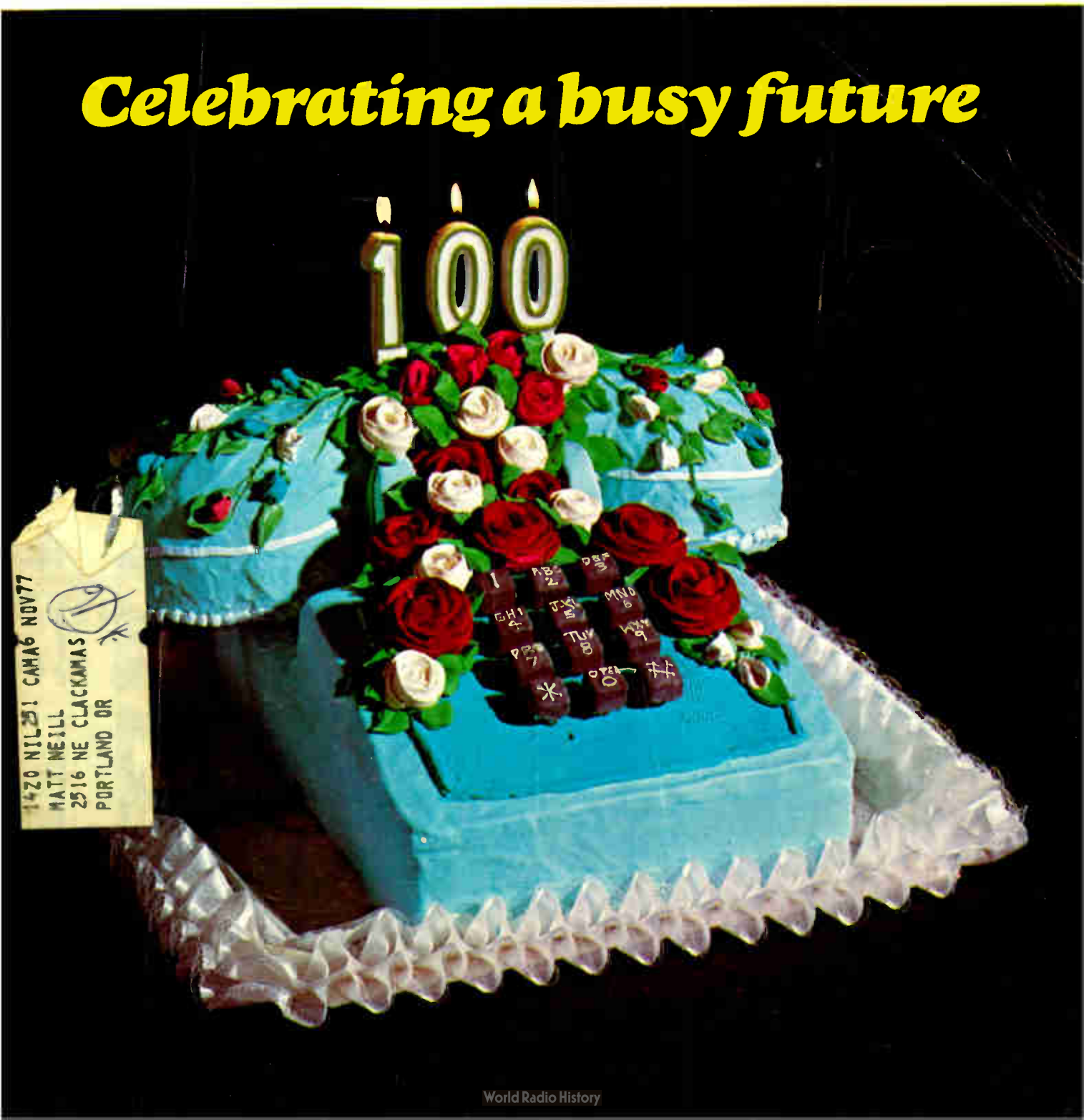

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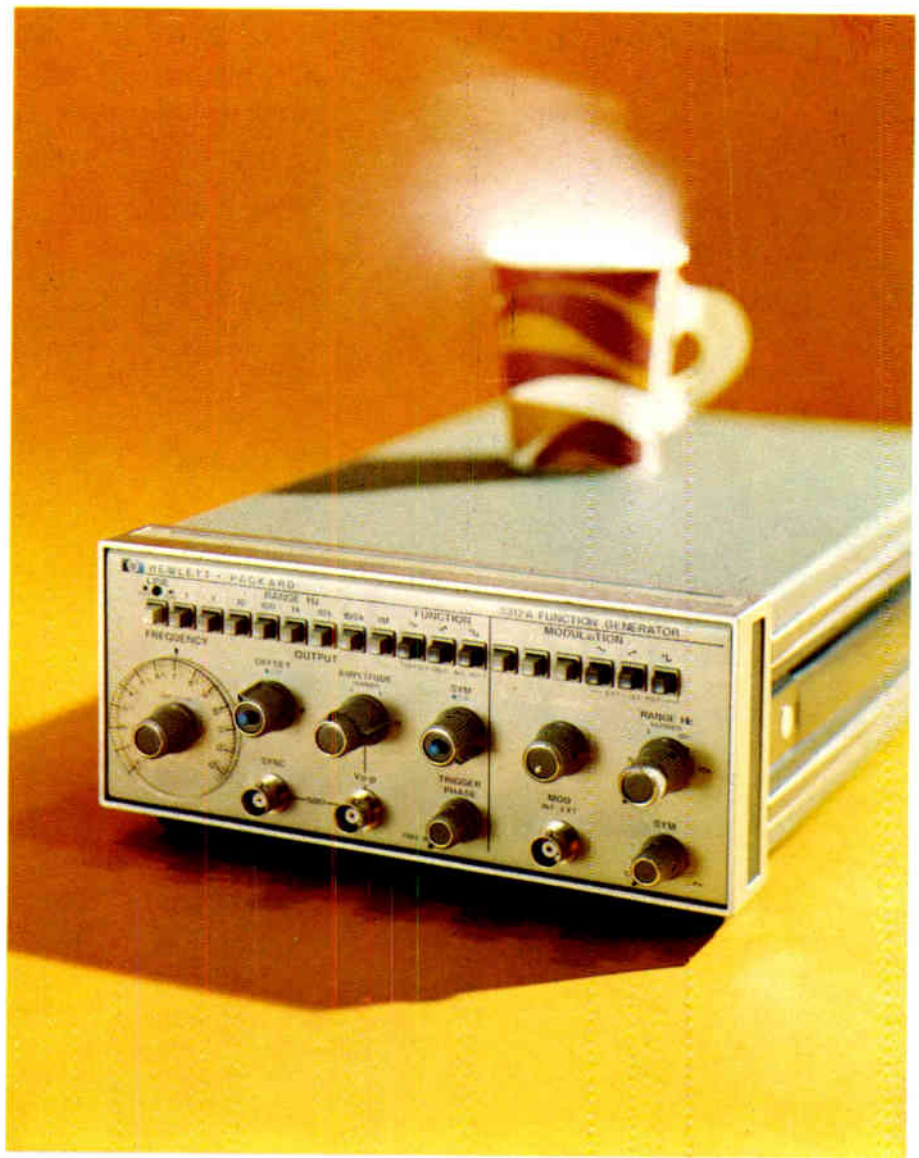

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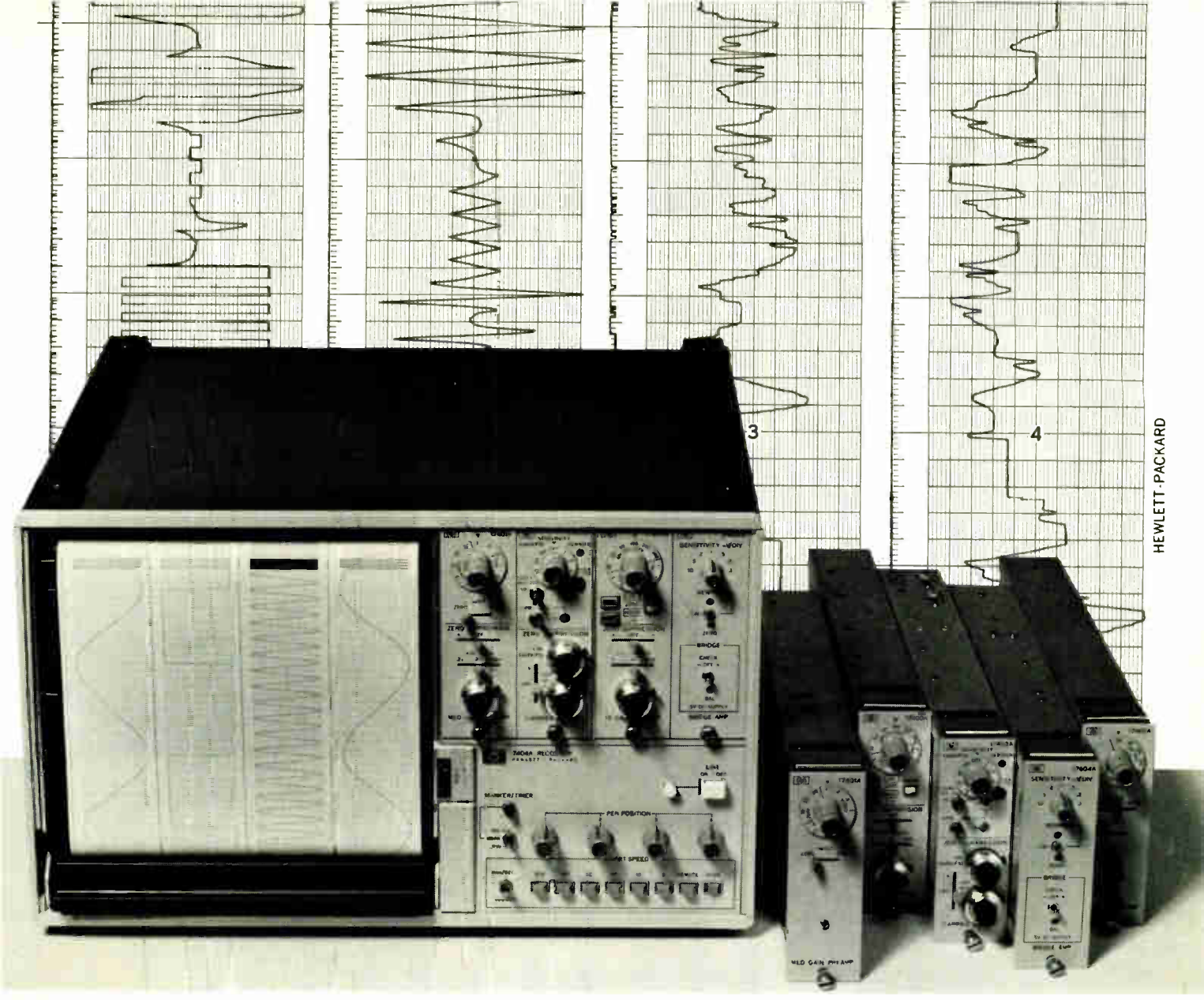

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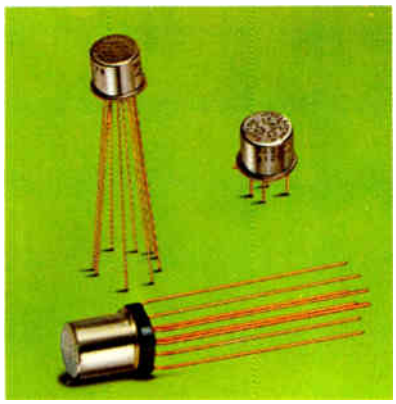

Improve shallow depth operation. Counter target decoys. Enhance rejection of false echoes. Tough goals for any torpedo acoustic guidance/control system. But Northrop did it — turning misses into hits — with a little help from Teledyne TO-5 relays.

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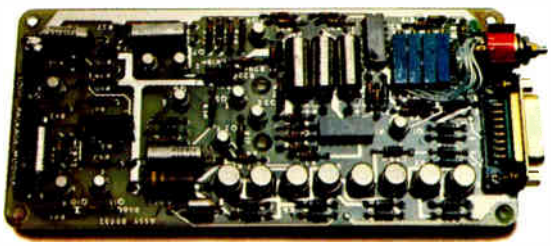

Logic Package Module for NT 37C Torpedo Guidance System (with 8 Teledyne TO-5 Relays)

NT 37C Torpedo
Courtesy of Northrop Corp.

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Electronics
The International Magazine of Electronics Technology
Vol. 48, No. 25•December 11, 1975

Highlights

Cover: At age 100 phone rings the changes, 90
On its 100th birthday, the telephone is not only doing its old job better, aided by more intelligent switching systems, but is also taking on several other roles—as a low-cost data terminal, an interface to peripheral equipment, and in radiotelephony. Promoting this versatility are the advances in large-scale integration, the spread of data communications, and FCC regulations favoring more competition in telecommunications.

Cover confection is by William and Carl Gertz of the Oven Bake Shop, Staten Island.

Can mini-maker General Automation deliver? 70
Overextended production lines, LSI problems, and a divided management plagued the California minicomputer-maker this year. But founder Lawrence A. Goshorn, now back in control, promises renewed profits soon.

How to evaluate RAM viability, 101
The memory-system designer who can estimate the production costs of chip random-access memories can check out the claims made for a new device. He need only solve a few equations to place it securely on its cost curve.

Parametric tests qualify dense chips, 108
To attain 99% yields, crowded boards must use LSI devices that are 99.99% good. Adding ac parametric testing to the standard tests raises chip quality to that level.

And in the next issue . . .
Film-carrier techniques for IC assembly, a special report . . . designing lead/lag compensation into process-control systems . . . results of the survey of EEs over 40.

Electronics

Publisher's letter

Time was when the telephone was the latest thing in technology. But that, as we make a point of in the article that begins on page 90, was a solid century ago. However, times are changing fast and, spurred by a level of competition unusual to the long-regulated telephone business, so is the telephone. Indeed, it's time to stop thinking of the "telephone" and start thinking of the "terminal" as a host of new uses and functions are being readied for Alexander Graham Bell's brainchild.

Says Dick Gundlach, our communications editor: "The advent of the push-button tone telephone, better known by its trademark Touch-Tone, and the arrival of low-cost ICs have triggered startling changes in the design and capability of the originally simple, point-to-point communications device. Examples of the new versatility range from speed dialers with memory and answering devices to crossbreeds, part phone, part calculator, and part clock. Even cordless phones have appeared, operating on radio frequencies."

It is fair to say that, even with a loosening of the regulatory strings and the entry of new companies into some peripheral telephone-equipment markets, the current ferment in telephones could not have come about without electronics technology.

What do you suppose happens when you lash together eight, or 16, or 81, or 256 microprocessors into one compact computer system. According to a number of companies that are trying it, you wind up with the performance of a large computer at a fraction of the cost. One company is even looking seriously at putting 10,000 microprocessor modules together.

Steve Scrupski, our computer editor, sums up the reasons for the interest in multiple microprocessors this way: "The key to the potential performance is that, in each system, the individual microprocessors operate more or less independently on separate parts of a problem, or even on different problems." For the story on how to get microprocessors to work together, turn to page 67.

With random-access memories turning up in more products—and taking up ever larger segments of product-design efforts—the cost of RAM chips has a significant bearing on over-all system cost. The trouble is, it's hard enough to keep track of prices and specs for current devices, let alone try to forecast those crucial parameters for the as-yet-undeveloped devices being designed into a future product.

To help system designers relate the cost of a RAM chip to the number of bits it can store, we are publishing in this issue an article that uses both statistically-based and seat-of-the-pants equations to define some important RAM relationships. One of the more intriguing equation results: it won't be as hard to bring down the cost per bit in 16-kilobit devices as it was with 4-k units, but the 32-k RAM will require some new developments to become economically viable. You'll find the details on page 101.

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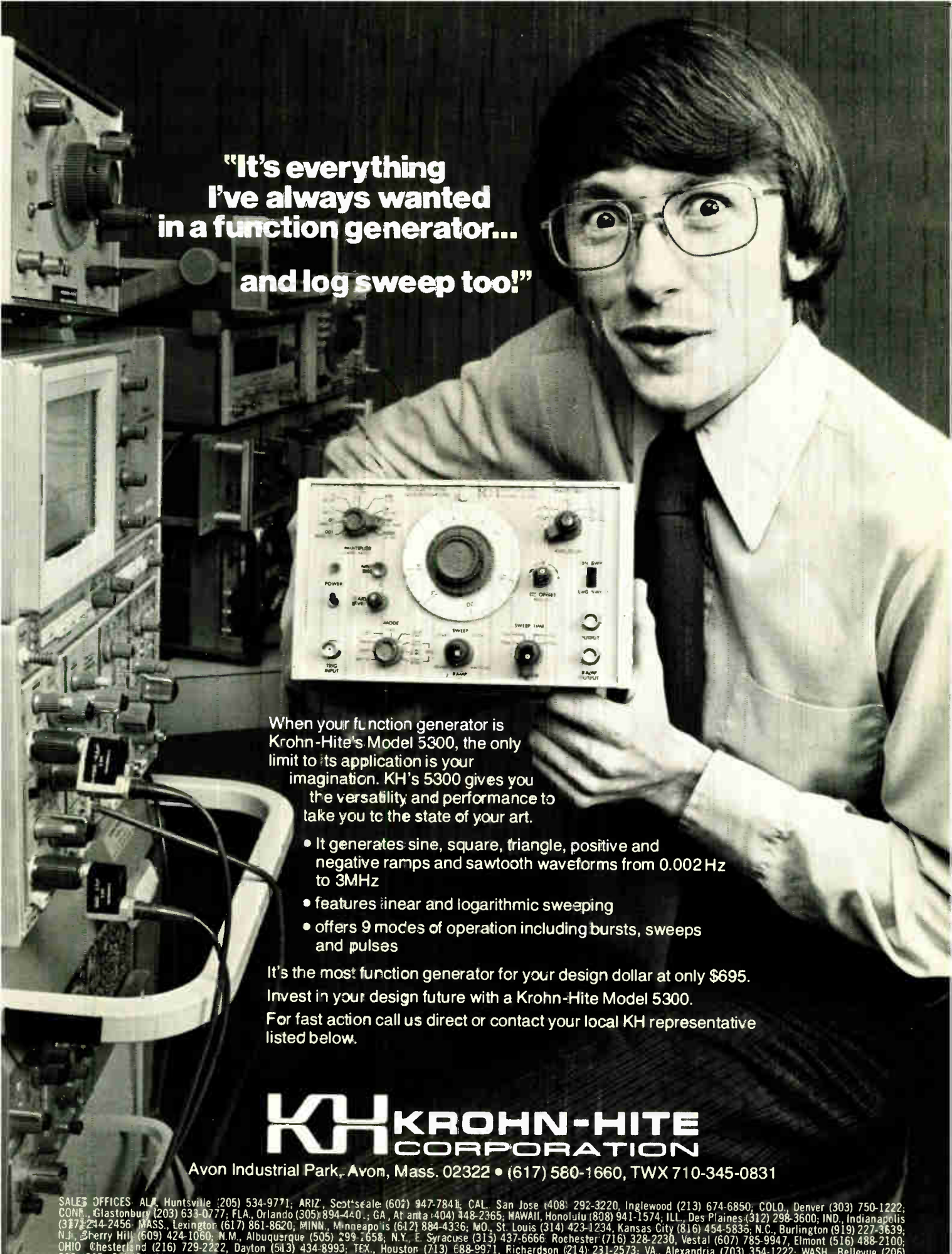

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Readers' comments

Reliability revised

To the Editor: Clarification is required on the article, "Component reliability, part 1" [Oct. 2, p. 91] regarding the graph on MOS and bipolar memory failure data (Graph 12).

Since Fairchild is the major supplier of bipolar RAMs, we have done extensive testing on this kind of product and the overall failure numbers in the article appear high as compared to results we have obtained through four years of controlled-life testing on similar products—mainly 256-bit and 1,024-bit bipolar memories.

Our data, which concerns about 14,000 devices, shows failure percentages of around 0.2 in the first 168 hours. Actually, where data was recorded, most of the failures occurred in the first 96 hours. Long-term reliability tests show failure rates at .001%/1,000 hours.

The reason for the differences becomes obvious in view of what was considered to be a failure. The article included all failures from (1) pre-burn-in test and (2) temperature and ac tests after burn-in. In the first case (pre-burn-in or retest) the failures detected are not true reliability types (time dependent) but a measure of the manufacturer's test efficiency and could have been eliminated either by a second manufacturer's screen or by tighter manufacturer sample plan. In the second case (final temperature and ac tests), these in most cases are not 100% tested prior to burn-in, so again are not reliability (time-dependent) failures but a measure of the manufacturer's product distribution and quality assurance sampling levels. These could have been eliminated by a 100% screen or by tighter test sampling plans.

Frank B. Durand
Fairchild Semiconductor
Mountain View, Calif.

To the Editor: . . . I find Table 2 misleading. It does confirm that the distribution of failure modes and mechanisms is variable between manufacturers and from lot to lot, but the statistics that are given appear faulty because the populations

HiNIL Interface

Prevent CMOS latch-ups and failures with a high noise immunity logic I/O.

CMOS systems are subject to latch-ups and failures in the field because of high voltage transients, static charge and improper field maintenance procedures. Moreover, due to their increased output impedance, CMOS is more susceptible to transient errors than corresponding bipolar logic.

A simple solution to these problems is to use Teledyne's bipolar High Noise Immunity Logic (HiNIL) as the system I/O interface. The I/O design approach shown in Figure 1 has solved these problems in applications such as business equipment, industrial controls and electronic games. The HiNIL interfaces protect the delicate CMOS inputs with a rugged bipolar "front end" not susceptible to CMOS failure modes. Also system noise immunity is maximized, and the HiNIL output devices provide direct, high current logic drive of relays, displays and long lines.

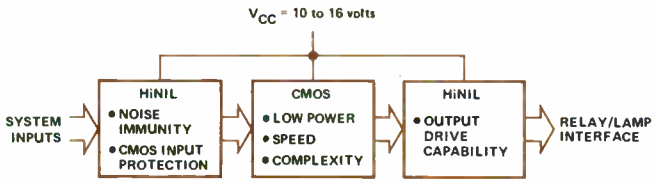

Figure 1. HiNIL input interface protects CMOS inputs while HiNIL outputs directly drive long lines and peripheral devices

The two families are directly compatible at the 10 to 16 volts V_{cc} range. The designer can take full advantage both of HiNIL's capabilities and of CMOS' low power dissipation, supply voltage flexibility and improved noise margin at higher supply voltages.

Parasitic SCR latch-up is an all too common CMOS malfunction. Large noise transients and DC input levels below ground or above V_{cc} could force CMOS input diodes into forward conduction, causing SCR action in the four-layer diodes formed by the diode and parasitic p-n substrate junctions. This condition leads to device latch-up, increased I_{cc} current and, when current is not limited, to gate destruction. Maximum protection can be obtained by using

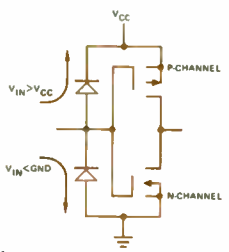

Figure 2A. CMOS latch-up causes

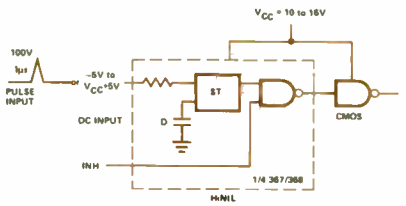

Figure 2B. HiNIL input protection

HiNIL Schmitt triggers. They prevent latch-up at DC input levels from −5 volts to V_{cc} +5 volts and suppress 100 volts transients as wide as 1μsec (Figure 2).

HiNIL inputs on plug-in cards will protect a CMOS system from problems associated with "on power" fault isolation, a widely used TTL system maintenance method. Plugging CMOS into powered connectors has led to latch-up failures because it allows inputs to see logic "1" signals before V_{cc} rises on the card. The failure is frequently catastrophic if input current is not limited.

HiNIL's lower output impedance and DC noise margin of 3.5 volts ignore large voltage noise transients that can cause CMOS logic errors. Also, static charges large enough to rupture CMOS oxide regions are often generated in dry environments by movement of materials and users. A HiNIL input gives more immunity to static and maximizes noise protection.

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 no se 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

HiNIL reliability insurance costs little since the I/O circuits—unlike filters and shielding—generally replace other logic and drive circuits. So, don't wait until your new CMOS system runs into costly problems in the field. We'll show you how to build foolproof low-power systems. Call or write today for HiNIL application notes and specifications.

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Readers' comments

are not homogeneous.

I agree, however, that the subject of the reliability of semiconductor devices is one of increasing importance as regards modern electronic systems and that cost-effective screening warrants careful and very detailed consideration.

A. H. George
British Aircraft Corp. Ltd.
Bristol, England

■ ***Editor's reply:*** *In the next issue, we will be addressing these and other comments to clarify several points that have been puzzling readers. Among other things, we will correct a mistaken assumption in the original report that affects a few of our graphs and comparisons, and we will publish revised versions of these figures.*

Others first

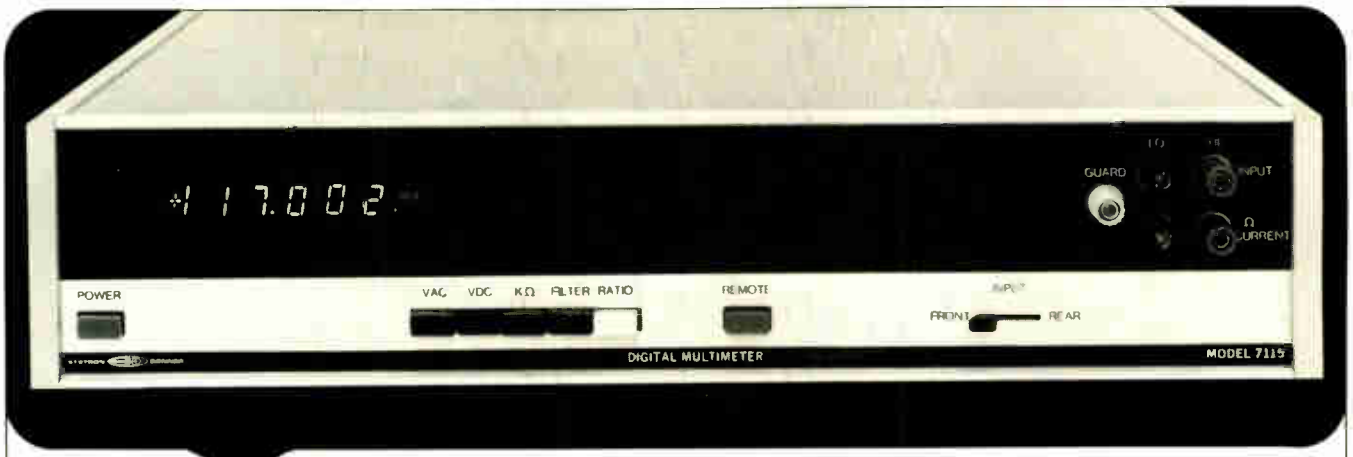
To the Editor: I just read the article in the Oct. 30 issue on Component reliability, part 2. The references on pages 91 and 92 to RCA's C-MOS reliability program presents a distorted single point of information relative to the overall industry standard in C-MOS integrated circuits.

It so happens that several of the C-MOS IC suppliers recognized the need for commercial user-oriented high-reliability programs and introduced them between the end of 1974 and the beginning of 1975. Such programs are the National Semiconductor B+ Program, the Fairchild Matrix 6, and Solid State Scientific's Solid Plus Program. I assume that other C-MOS suppliers who are not mentioned in your article or my letter also have valid, ongoing quality assurance programs.

To the best of my knowledge, RCA was a "Johnny-come-lately" to this program, so it seems strange that they were the only one mentioned in the *Electronics* article.

Would it be possible some time in the future for your magazine's editorial staff to amplify on this presently important trend among C-MOS IC suppliers?

Walt Kalin
Solid State Scientific Inc.
Montgomeryville, Pa.



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SYSTRON DONNER

Editorial

The telephone gains from competition

Despite its widespread application, the telephone led a very limited career for most of its first century. Only in the past decade or so, have pressures—market, governmental, and technological—built up for changes in the telephone's role. Now, though, the telephone can well be described as starting a new career—as a data terminal—with its basic job of handling voice communications becoming just one of many functions.

An important key to the quickening pace of change in telephone applications is a change in the marketing attitude of the giant Bell System. Where once Bell managers and designers were only concerned with streamlining and perfecting *their* system, now the needs of users is given a lot more consideration. Picture-Phone was a classic example of Bell's traditional design philosophy, and it failed initially because few users needed it. The emphasis has shifted toward making the telephone more useful—and if that translates into more profits for Bell, it goes a long way toward explaining why the change in thinking has been so rapid.

But behind that change is a whole range of interrelated economic, social, and regulatory developments that have opened a new era of competition. The result is a new generation of user-oriented telephone equipment, ranging from computer-based private-branch exchanges to "smart" telephones that remember frequently-called numbers and the last number dialed. It has taken many years, and a large amount of foot-dragging, but now AT&T is responding to the competition of numerous independent equipment makers in the factory, instead of in the courts or the regulatory agencies.

Yet behind all of the recent changes in the telephone is a fundamental force: technology. Without the advances made in the past few years in solid-state technology, to take just one example, the whole idea of an electronic telephone, with the resultant new functions that electronics can make possible, would still be too expensive for implementation. Now, though, telephone-equipment designers all over the world are talking about the cost trade-offs of C-MOS vs n-channel MOS and I^2L and about light-emitting diodes and read-only memories.

In telephones, as in so many other areas, technology advances have sharpened the forces of competition, which, in turn, have sped the adoption of new technology. And, certainly, the improvements in service, the introduction of new functions, and the efficiency that electronics technology can bring to the staid old telephone are long overdue.

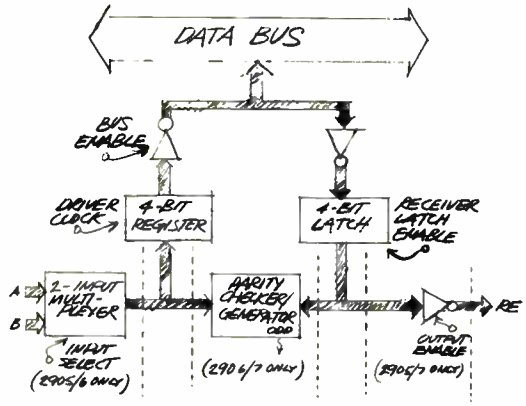
I/O To Go.

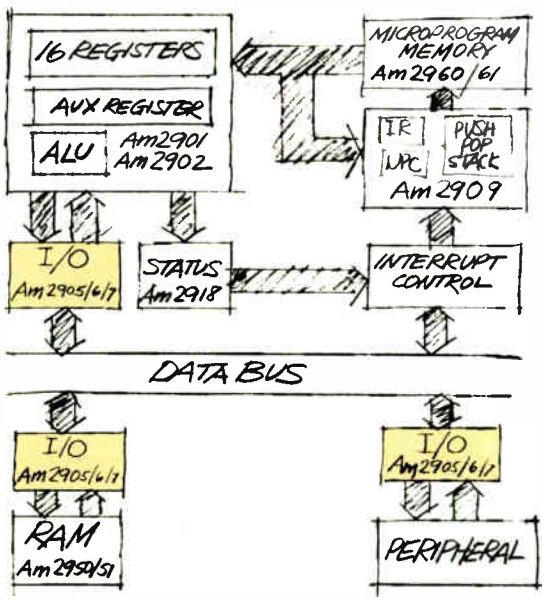
The Am2905/6/7 Bus Transceivers: High-speed I/O for your microprocessor any way you want it. Three versions of the same superb low-power Schottky LSI slice. Yours. Off the shelf. Now.

Single or dual driver input ports. With or without parity checking and generation. With or without three-state receiver outputs.

The Am2905/6/7 have open collector outputs that drive 50-ohm loads on terminated long lines. They store driver and receiver data for pipeline operation. And, with a bus-to-receiver delay of just 17 nanoseconds, they're ideal for any microprocessor, bipolar or MOS.

The Am2905/6/7 are the best microprocessor I/O's you can get. Any way you slice it.





Bye bye, MSI.

Say bye bye to your complicated, costly MSI systems. The Am2900 family is here!

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Bye bye, MSI!

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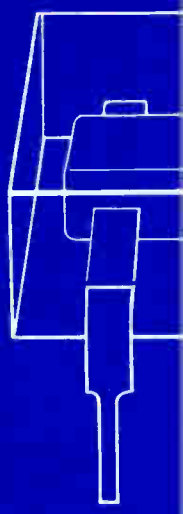
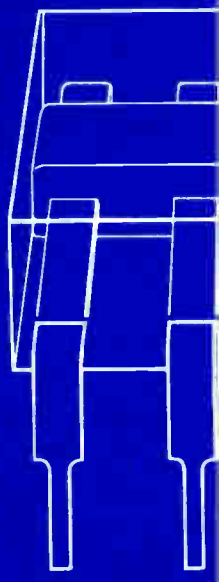
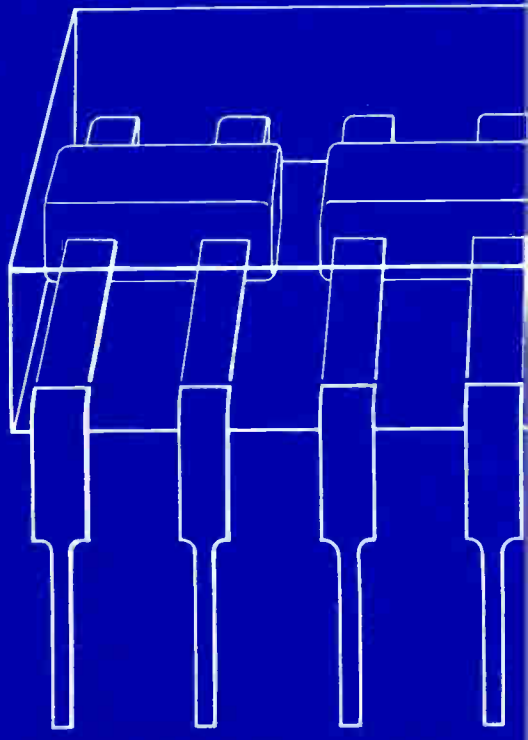


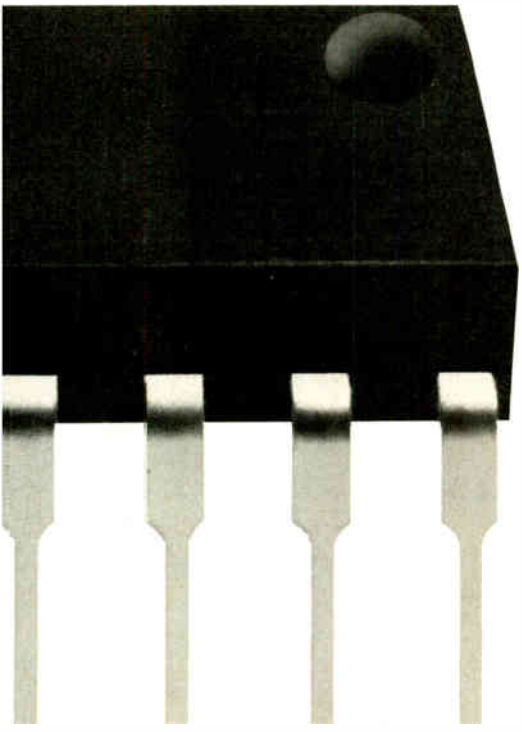
single channel



dual channel—
two independently
isolated channels



quad channel—
four independently
isolated channels



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People

Koss's Bastiaans believes the 'tailored sound' will sell

The sound from Koss Corp.'s stereo headphones these days is largely the responsibility of Cedric R. Bastiaans, recently named engineering vice president for the Milwaukee-based audio-equipment designer.

Tailor. Cedric Bastiaans wants the listener to adjust the sound to his liking.

But he's counting on whoever is using the headphones also to take a hand.

"Customer participation in obtaining the most satisfying sound is imperative," declares Bastiaans, who's charged with managing research and new product development at Koss, which considers itself the leading manufacturer in the $50 million-plus retail stereo headphone market. "So we've started putting controls on some of our products that enable the listener to alter the impression of the music."

This tailoring of sound, rather than re-creating an original sound in exact fidelity, is relatively new. This summer, for example, Koss, which grossed $16.1 million in its last fiscal year, introduced the first stereophone that allows the user to vary the frequency-response characteristics of the driver element. And earlier, it packed eight on/off switches in a hand-held programing unit that accompanies a set of quadraphonic headphones. "Each switch mechanically or electrically creates a very audible effect, a different psycho-acoustic sensation," Bastiaans explains.

New items. While he won't discuss ideas he has for further products in the highly competitive market, he admits that "in order to maintain our enviable market position, we must have new electro-acoustical properties. We'll also go more to active electrical controls, and we're developing things that work on a rechargeable 'nicad' battery, for example."

Previously chief engineer for Koss, the Dutch-born Bastiaans joined the firm two years ago from Westinghouse Research Laboratories in Pittsburgh, where he was manager of special devices research. In his 10 years there, the electrical engineer was part of the team that in 1965 demonstrated the first practical slow-scan video-disk.

Though he enjoys the "real world" of seeing his ideas become commercial products, Bastiaans still keeps an ear to basic acoustic research. He has developed, for example, a new driver for stereophones "that probably has the widest response of any dynamic driver in existence," he claims. Koss has also "supplied a few calibrated copies of the transducer to researchers working with supersonic frequencies and their application to deaf-born children."

Williams will be looking for excellence at NASA

When the National Aeronautics and Space Administration created the new headquarters job of chief engineer, it called on Walter C. Williams to fill it. A veteran of NASA's early years, Williams believes that "the chief engineer has halfway disappeared" from the Federal personnel rolls. "Instead he becomes a project manager and pretty soon his biggest concerns are costs and schedules"—and not engineering.

Changing emphasis. That's not the way it will be if Williams has his way. He returned to the space agency in October after 11 years at

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People

Chief engineer. Walter Williams at NASA hopes that mistakes won't be repeated.

California's Aerospace Corp., where he most recently served as vice president and general manager of the Vehicle Systems division. In his new assignment, Williams is responsible for reviewing the technical quality of engineering and planning for all NASA programs. He'll report to NASA chief James C. Fletcher.

An aeronautical engineer by training, Williams has already begun tracking NASA efforts like the space shuttle, visiting field installations of the agency and its contractors. Although he has yet to initiate program reviews, Williams expects his interests will reflect NASA's budget, with "the big programs getting more of my attention." Fundamentally, his rule for all engineering specialties is straightforward—lessons need to be learned and applied from past mistakes. "If you're going to make a mistake," he says, "God, let's make it a nice new original one."

Mechanical failures. Problems with electronics that the 56-year-old engineer has observed "could almost be described as mechanical—failures of piece parts, for example, often caused by contaminants, bad bonds, or connections."

More than most agencies, NASA may be prone to such difficulties, Williams says, and he acknowledges that NASA's tight budgets and few new project starts are making it difficult to maintain industry interest.

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	Part No.	Description
CPU GROUP	8080A	8-bit Central Processor Unit, 2μs cycle
	8224	Clock Generator
	8228	System Controller
CPU OPTIONS	8080A-1	1.3μs cycle
	8080A-2	1.5μs cycle
	M8080A	2 μsec cycle (−55 to +125°C)
I/O	8212	8-bit I/O Port (15 mA drive)
	8251	Programmable Communication Interface
	8255	Programmable Peripheral Interface
PERIPHERALS	8205	1 out of 8 Binary Decoder
	8210	Dynamic RAM Driver (8107B)
	8214	Priority Interrupt Control Unit
	8216	Bidirectional Bus Driver, Non-Inverting (50 mA)
	8226	Bidirectional Bus Driver, Inverting (50 mA)
	8222	Dynamic RAM Refresh Controller (8107B)
	8253*	Programmable Interval Timer
	8257*	Programmable DMA Controller
	8259*	Programmable Interrupt Controller
PROMs	8604	512 x 8, 100 ns
	8702A	256 x 8 Erasable, 1.3 μs
	8704	512 x 8 Erasable, 450 ns
	8708	1K x 8 Erasable, 450 ns
ROMs	8302	256 x 8, 1μs
	8308	1K x 8, 450 ns
	8316A	2K x 8, 850 ns
RAMs	5101	256 x 4 Static CMOS, 650 ns
	8101-2	256 x 4 Static, 850 ns
	8102-2	1K x 1 Static, 850 ns
	8102A-4	1K x 1 Static, 450 ns
	8107B	4K x 1 Dynamic, 420 ns
	8111-2	256 x 4 Static Common I/O, 850 ns

*Available 1st quarter 1976.

A dozen I/O and peripheral circuits that attach directly to the system bus make it easy to add on peripheral subsystems. Five are programmable LSI devices. These operate under software control in numerous modes and can often replace up to 75—or more—TTL packages each. For example, the Intel 8251 Programmable Communication Interface provides virtually all serial data transmission protocols in use today, including IBM Bi-Sync. Or, for easy interface to printers, keyboards, displays and motor drives, use the 8255 Programmable Peripheral Interface. You can reorganize its 24 I/O lines with software as your needs change.

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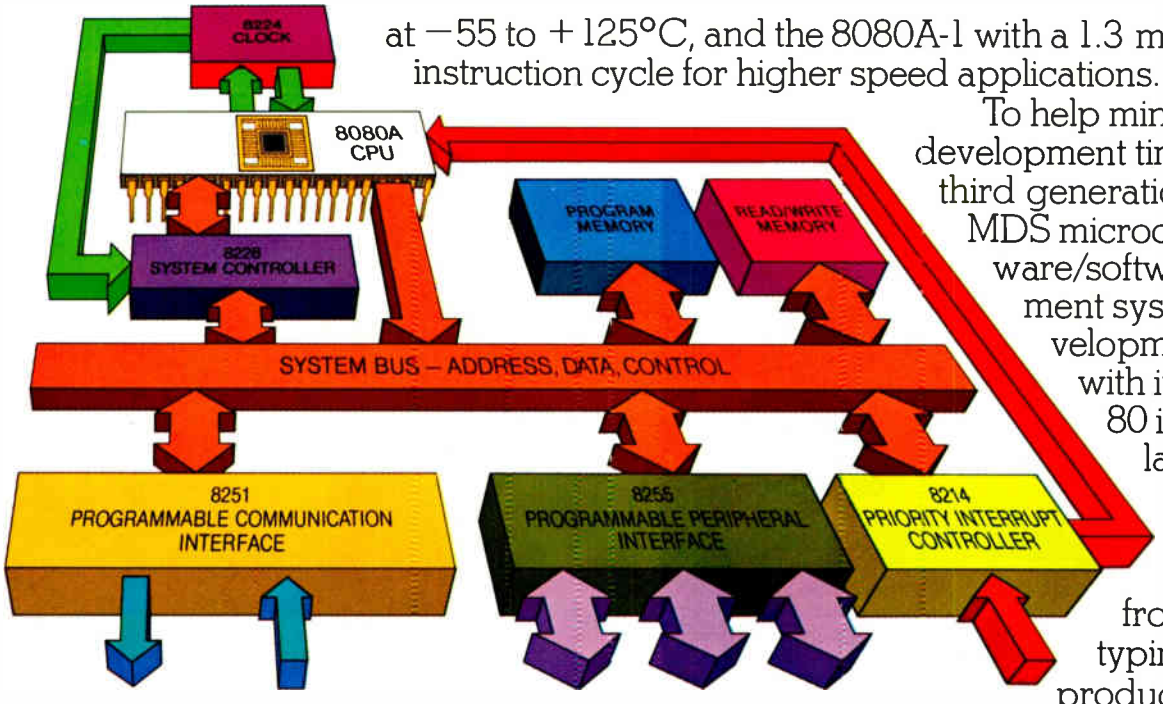

at −55 to +125°C, and the 8080A-1 with a 1.3 microsecond instruction cycle for higher speed applications.

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Meetings

Third Annual Symposium on Computer Architecture, IEEE, Hilton Inn, Clearwater, Fla., Jan. 19–21.

On-Line Systems, 1976-1986, American Institute of Industrial Engineers, Quality Inn—Pentagon City, Washington, D.C., Jan. 19–21.

Reliability and Maintainability Symposium, IEEE et al., MGM Grand Hotel, Las Vegas, Jan. 20–22.

Design and Finishing of Printed Wiring and Hybrid Circuits Symposium, American Electroplaters' Society (East Orange, N.J.), Fort Worth Hilton Inn, Fort Worth, Texas, Jan. 21–22.

Data Base Systems, American Insitute of Industrial Engineers, Quality Inn—Pentagon City, Washington, D.C., Jan. 21–23.

Power Engineering Society Winter Meeting, IEEE, Statler Hilton Hotel, New York, Jan. 25–30.

ISSCC-76, International Solid State Circuits Conference, IEEE, Sheraton Hotel, Philadelphia, Feb. 18–20.

Compcon Spring, IEEE, Jack Tar Hotel, San Francisco, Feb. 24–26.

Federal DP Expo '76 (Data Processing in the Federal Government), Instrumentation Fair Inc. (Beltsville, Md.), Sheraton Park Hotel, Washington, D.C., March 2–3.

ACM Conference on Programing Micro/Minicomputers, Association for Computing Machinery (New York, N.Y.), Delta Towers Hotel, New Orleans, March 4–6.

IECI '76—Industrial Applications of Microprocessors, Process Measurement, and Failure Mode Analysis, IEEE, Sheraton Hotel, Philadelphia, March 8–10.

Ninth Annual Simulation Symposium, Society for Computer Simulation, ACM and IEEE, Sheraton-Tampa Motor Hotel, Tampa, Fla., March 17–19.

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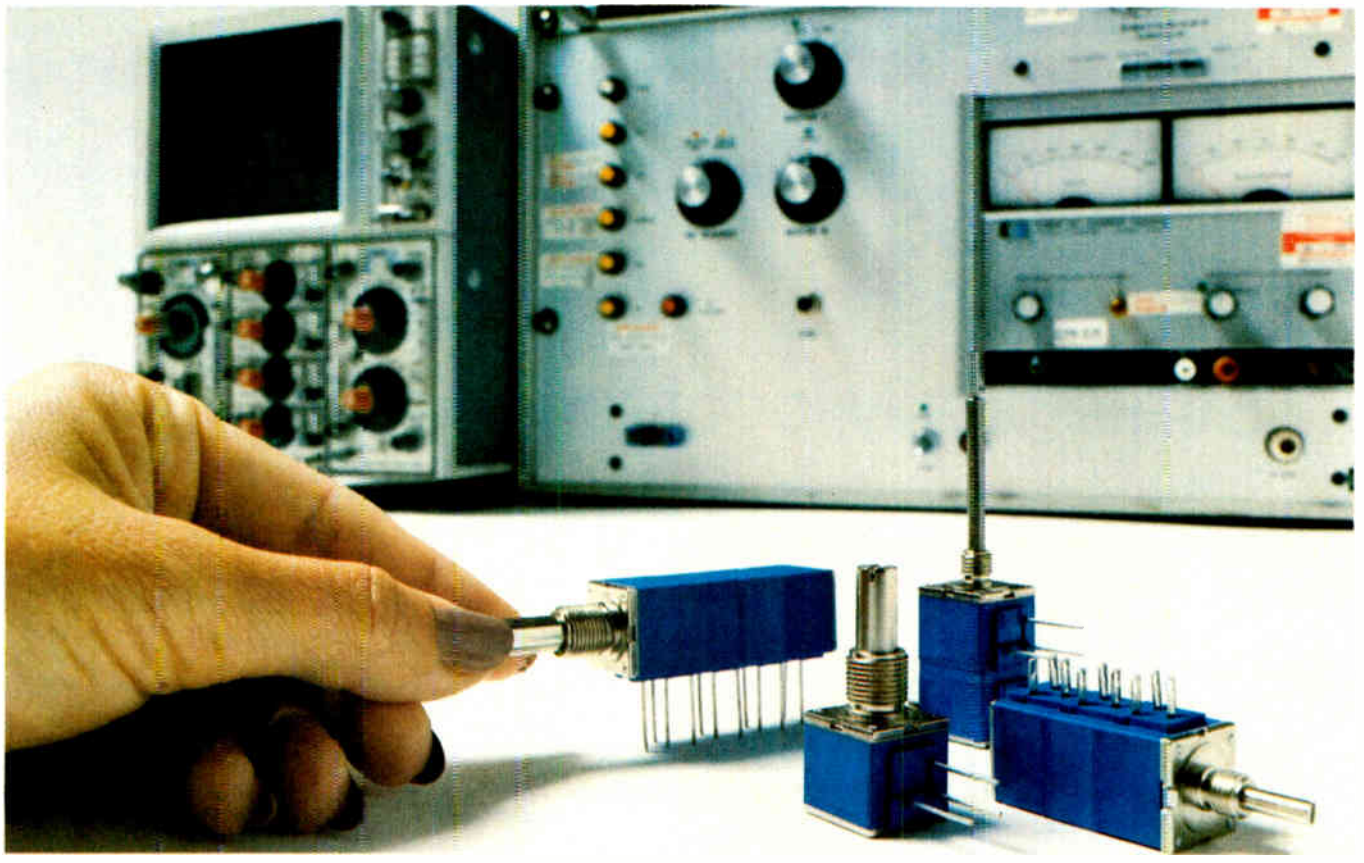

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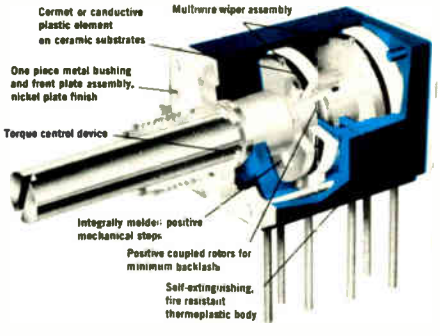

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Bourns Model 80 is available with either cermet or conductive plastic elements in virtually all linear and non-linear tapers. Element types may be mixed in multiple section units. INDEPENDENT LINEARITY IS ±5% ... offering more precise phasing of potentiometer output to panel calibration.

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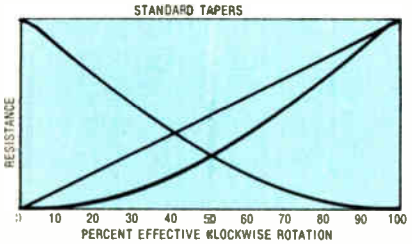

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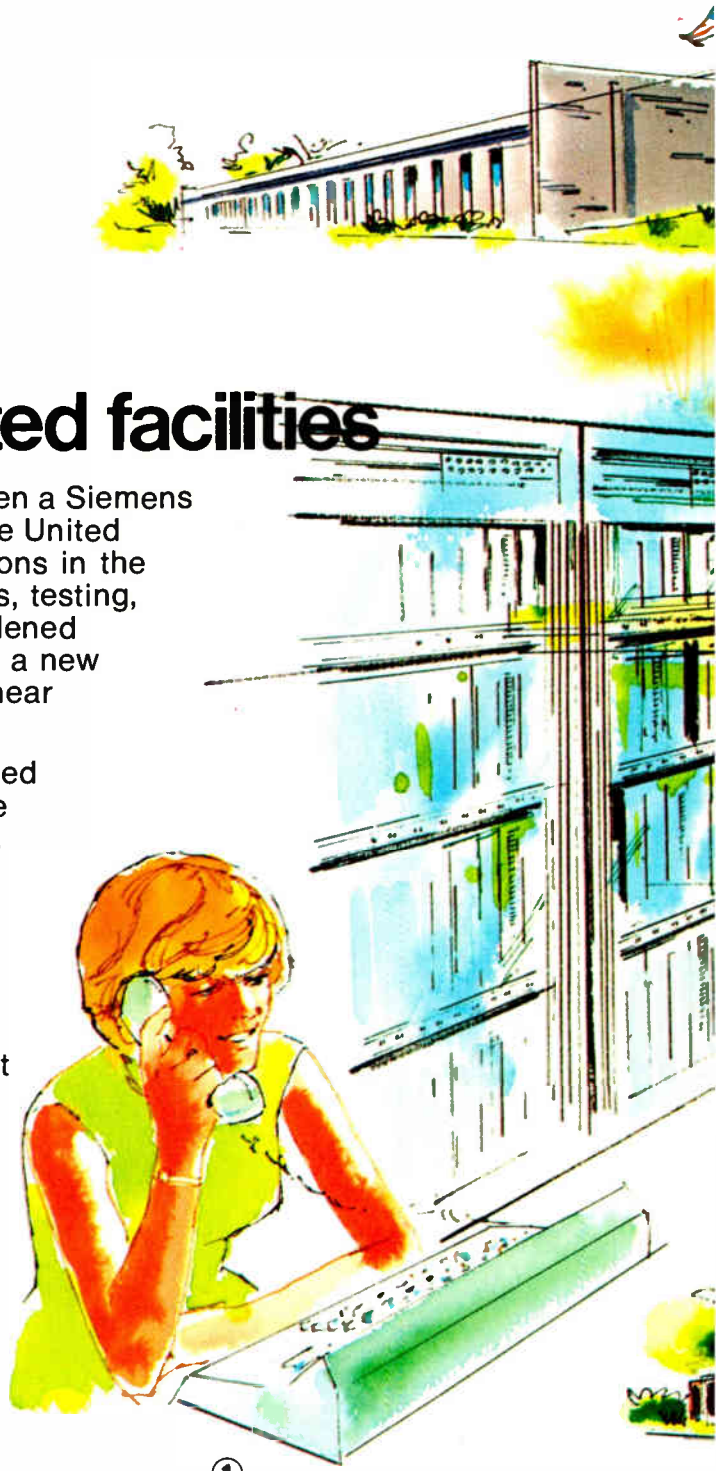

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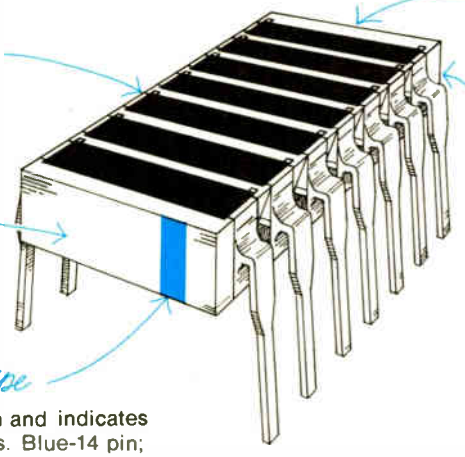

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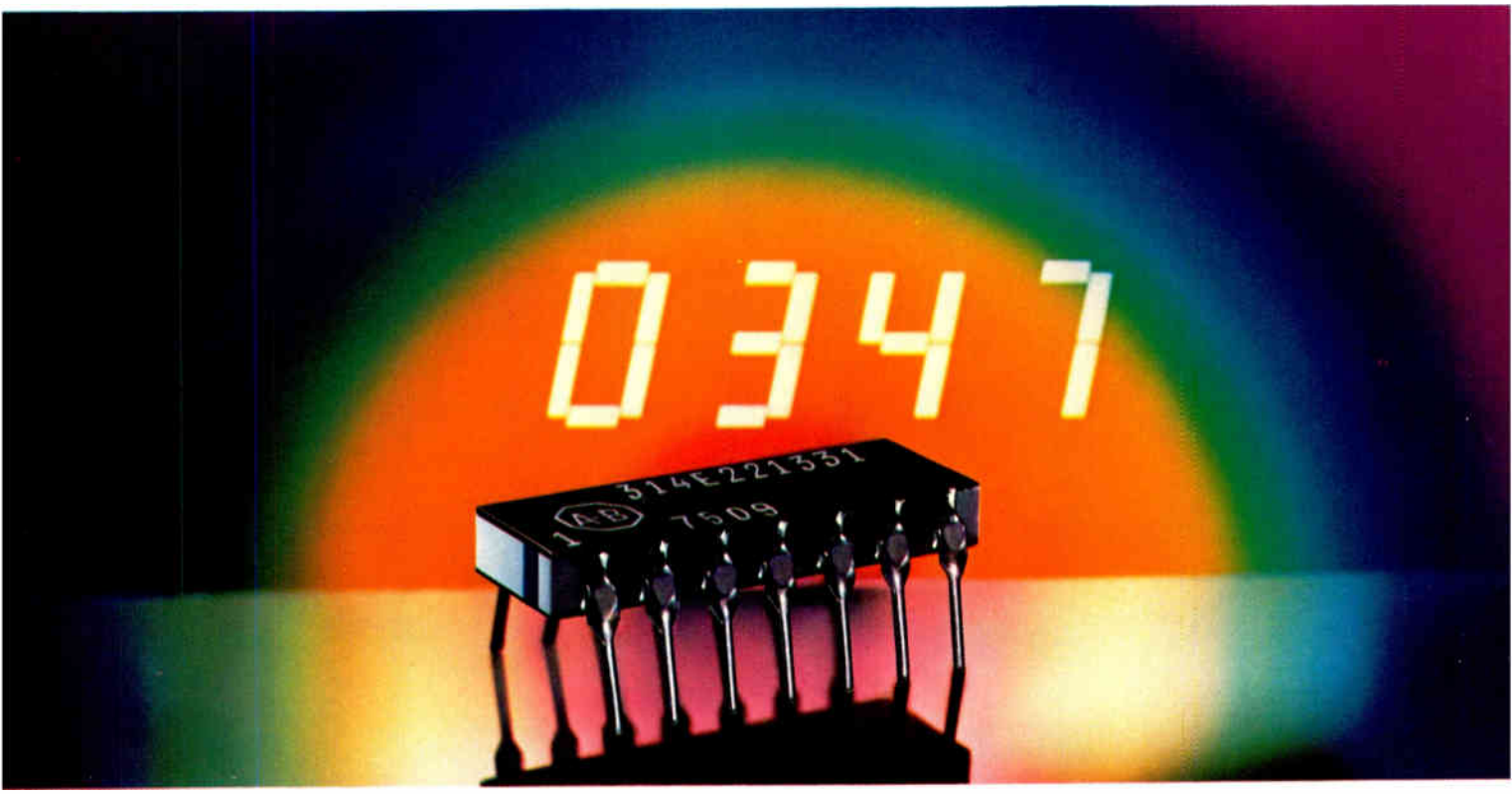

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Electronics newsletter

Fairchild predicts billings increase for semiconductors

Fairchild Camera & Instrument Corp. estimates U. S. semiconductor industry bookings will climb from about $525 million for this quarter to approximately $760 million in 1976's fourth quarter, **with billings going from $475 million to about $675 million for the same period.** Speaking at a semiconductor forum sponsored by Morgan Stanley & Co., New York-based investment banking firm, Paul Wittrock, Fairchild's manager of forecasting, projected U. S. semiconductor consumption climbing 8% to 9% per quarter next year and possibly 10% in the fourth quarter. "In total, then, we expect a little over 30% growth in 1976." Essentially, he says, Western Europe will have a no-growth year for semiconductors, and Japan will lag behind the U. S. by at least six to nine months.

C. Morris Chang, Texas Instruments' semiconductor group vice president, predicted the U. S. bipolar logic market would jump from $265 million in 1975 to $357 million next year, and to $447 million in 1979. **Chang also says the magnetic bubble memory device market should "well exceed" $100 million by the end of 1979** ("not including IBM"), and he estimated 1980 bubble prices at 10 millicents per bit. He also indicated that TI would begin sampling a 16-kilobit n-channel RAM within three to four months.

CCDs gain ground for dense RAM designs

With an eye on the future, Texas Instruments researchers are working on a charge-coupled cell design for random-access memories that's potentially simpler, two times smaller, and no slower than the one-transistor cell that's used in today's 4-kilobit RAMs. Significantly, the TI approach, still in early development, **uses the conventional silicon-gate RAM process with only one extra mask step.** But the cell could be built with a double-level polysilicon process with a further decrease in cell size.

What's so attractive about the TI approach is its simplicity. Each bit site consists of a single gate beneath which lie two regions—a doubly ion-implanted storage region and a transfer region. Logic is read out simply by switching the gate on and off and changing the surface potential between the storage and transfer regions. Thus, each RAM cell requires only two connecting lines (a word line and a sense line) in contrast to the three access lines required in the one-transistor version. Yet the CCD RAM could use the same voltages and clocking as the conventional 4-kilobit RAM.

This approach to RAM design is **gaining momentum as a way of achieving the next level of complexity above the soon-to-appear 16-kilobit device.** Known to have strong CCD-memory programs are Intel, Fairchild Semiconductor, and RCA in this country, as well as Philips in the Netherlands.

Motorola to sell 900-MHz land-mobile turnkey systems

Motorola's Communications division in Schaumberg, Ill., will market all the equipment necessary to operate 900-megahertz land-mobile cellular radiotelephone systems (see p. 90). Motorola will sell the equipment instead of using it **because the FCC forbids a company that makes the equipment for a mobile system to operate it.** A non-manufacturer, AT&T, will start in 1976 to operate a mobile-only cellular system.

Martin Cooper, Motorola's director of systems operation, says his company plans to provide turnkey systems, including base-station radio

and switching terminals to interface the radio and phone equipment, as well as both types of telephones. The system will be compatible with Bell's and permit users to switch from one to the other.

More firms show tomography systems

More and more firms are throwing their resources behind computerized tomography, a fledgling X-ray diagnostic technique that some companies figure may tap a billion-dollar market worldwide. Led by U.S. X-ray giant General Electric Co., **no less than a half-dozen new aspirants unwrapped their plans last week.**

Britain's EMI Ltd., which pioneered the equipment to produce cross-sectional X-ray pictures of head and body [*Electronics*, Sept. 4, p. 65], was joined by Picker Corp., Varian Associates, Philips, Syntex, Artronix, and CGR, as well as earlier entrants Siemens, Pfizer, and Ohio-nuclear. And representatives from Litton and Searle said units are in design.

AMD develops fast 4-kilobit static RAM

Look for the industry's first 4-kilobit version of the popular 2102 1-kilobit static random-access memory to be in production by Advanced Micro Devices in the first quarter of 1976. The part, which will range in speed from 500 nanoseconds to 200 ns, **is as fast as 1-kilobit statics.** It will be offered as the 9130 (4 kb by 1 bit) and the 9140 (1 kb by 4 bits). The devices operate from a single 5-volt supply and are specified at a maximum of 710 milliwatts.

While AMD is increasing static RAM density, **American Microsystems Inc. is pushing speed.** Due in next year's third quarter is a 1 kb n-MOS static RAM that will compete with Fairchild's bipolar 93415. The AMI part, designated 4025, will come in 60, 80, and 100 ns ranges. And AMD is about to start production on a 16 kb dynamic n-MOS RAM, aiming at a 32,000-square-mil chip with worst-case access times of 300 to 350 ns and a worst-case operating power of 720 mW.

TI's Toombs named head of IC division

In an apparent move to bolster its integrated-circuit capability, Texas Instruments has named Dean Toombs director of the Integrated Circuits division at its Houston facility. Toombs has been director of technology for the Semiconductor Products division in Dallas. This move will also enable Toombs **to better evaluate the relative merits of integrated-injection-logic technology and MOS technology.**

TI is known to be evaluating a 16-bit I^2L microprocessor chip and a 4-kilobit random-access memory, as well as a host of other I^2L digital products for computer applications.

Addenda

Troubled General Automation Inc. (see p. 70) surprised industry observers—and itself—last week by reporting a slim $7,000 net profit for its first quarter, ended Oct. 31. Achieved primarily by further cuts in costs, the black ink comes after three quarters of major losses. . . . Introduction of the General Electric-designed CRD-8 microcomputer will be delayed indefinitely. A technology-transfer agreement signed by GE and Solid State Scientific Inc. of Montgomeryville, Pa. [*Electronics*, Feb. 6, p. 46], calls for Solid State Scientific to convert the control processing unit of GE's CRD-8 from a TTL-MSI circuit board into a C-MOS-on-sapphire chip.

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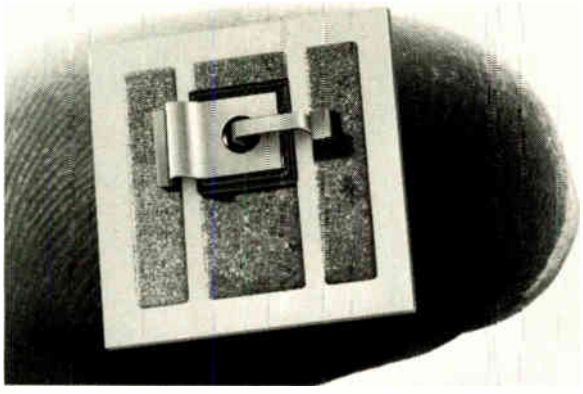

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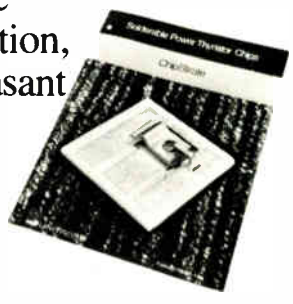

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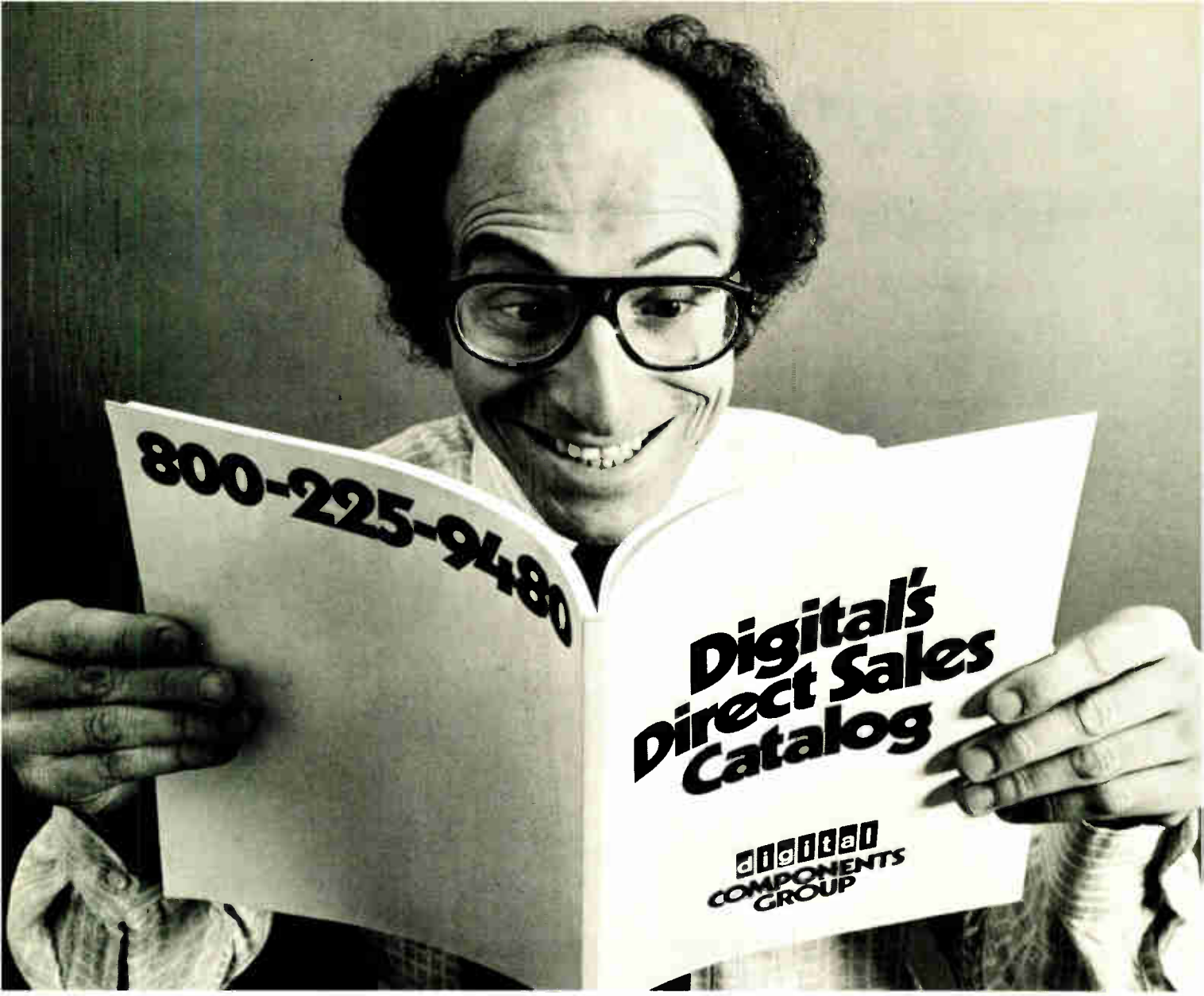

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digital COMPONENTS GROUP

Injection logic moves to production at Signetics

New 5-volt LSI devices designed for peripheral and memory applications will operate above 10 megahertz

Convinced that the high speed, low power and small size of integrated injection logic make it the technology of the next computer generation, Signetics Corp. has moved its three-year R&D effort into an on-line production schedule for a new 5-volt LSI logic family. The move follows its recent decision to drop out of C-MOS (see p. 82).

The Sunnyvale, Calif., firm joins at least three semiconductor giants with I^2L development programs in the digital area. Texas Instruments, having already announced an I^2L microprocessor—the 0400—is expected to follow with more microprocessors and memories. Fairchild Semiconductor is preparing a 4,096-bit random-access memory for sampling, and Motorola Semiconductor Products is planning to introduce a host of LSI peripheral data-processing circuits.

Signetics is also developing I^2L chips that combine analog and digital circuits for consumer, industrial timing, and instrumentation uses (see "I^2L looks good to RCA also").

Coming next year. Already scheduled by Signetics for first-quarter introduction are two I^2L peripheral devices. One is a character generator/checker, the AX-01, that is pin-to-pin compatible with Motorola and Fairchild's transistor-transistor-logic generator parts. The other is a first-in first-out shift register, the AX-03, for magnetic-tape systems. Planned for later in 1976 are a direct-memory-access chip, a 64-word-by-9-bit first-in first-out memory, a 16-word-by-8-bit last-in first-out memory, and a 16-by-16-bit multiplier.

Significantly, all of Signetics' new I^2L circuits will operate at 10 megahertz and higher. That is three to five times faster than equivalent MOS products and practically as fast as today's standard TTL devices. Also, the I^2L chips are half as large as TTL dice, pointing to lower manufacturing costs once high-volume production begins.

Stan Bruederle, advanced product planning manager, Logic division, has nothing but praise for injection logic. "From what we've seen in the development area," says Bruederle, "we're sold on I^2L for computer applications. We're already seeing speeds in the 5-to-10-nanosecond range, and potentially we think I^2L can operate down as fast as 2 ns."

Mainframe interest. Because of the high-speed LSI performance, Bruederle detects strong interest in I^2L products throughout the computer industry. "Mainframe-computer manufacturers are especially enthusiastic about I^2L for mainframe controllers," says Bruederle, "because the circuits interface directly with ECL [emitter-coupled logic] main-memory systems. Peripheral-equipment manufacturers are high on I^2L because it not only gives them an LSI function in straight digital applications like

I^2L looks good to RCA also

RCA Corp.'s Solid State division in Somerville, N.J., is developing integrated-injection-logic circuits for four major applications areas: television, time-keeping, instrumentation, and automotive [*Electronics*, Nov. 27, p. 36]. For several months it has performed what vice president and division general manager Bernard V. Vonderschmitt calls an "objective analysis between dense bulk complementary metal-oxide-semiconductors [in which RCA is the industry leader], silicon-on-sapphire and I^2L, and looking at the tradeoffs. The conclusion? I^2L "definitely will have its place and will be competition for C-MOS and eventually SOS," he says.

Although reluctant to go into detail, Richard L. Sanquini, director of bipolar integrated circuits at RCA, says a "logical use" for the I^2L linear-digital process is in the horizontal and vertical drives of TV receivers. An I^2L device could stabilize the vertical sweep in marginal TV reception areas on its own, without help from externally adjusted devices, such as potentiometers. But he's quick to note that this same function can be executed with either C-MOS or I^2L technology.

"Some interesting conclusions can be reached from the comparisons of C-MOS bipolar versus I^2L technologies," says Sanquini. "For example, when using dynamic logic, C-MOS chip area efficiency is superior to I^2L, but the I^2L linear/digital process is simpler because it requires less process steps than C-MOS/bipolar." The actual chip area required is a standoff, he says: I^2L uses 60 $mils^2$ per bit, C-MOS uses 56 mil^2 per bit.

memory controllers, but the technique can also perform analog and linear functions on a single chip."

Bruederle points to a disk drive as an example. "Analog data off the disk must be converted to digital data," he says, "and here I^2L is perfect, since one circuit process can handle the entire job."

All Signetics' I^2L devices are built with the company's standard Schottky production process. The family will also include some low-power Schottky LSI parts (for example, a controlled store switch for applications requiring very high speeds). An I^2L version of the company's 8-bit n-channel MOS microprocessor, the 2650, is currently under evaluation, as are I^2L designs for linear/digital applications. □

Solid state

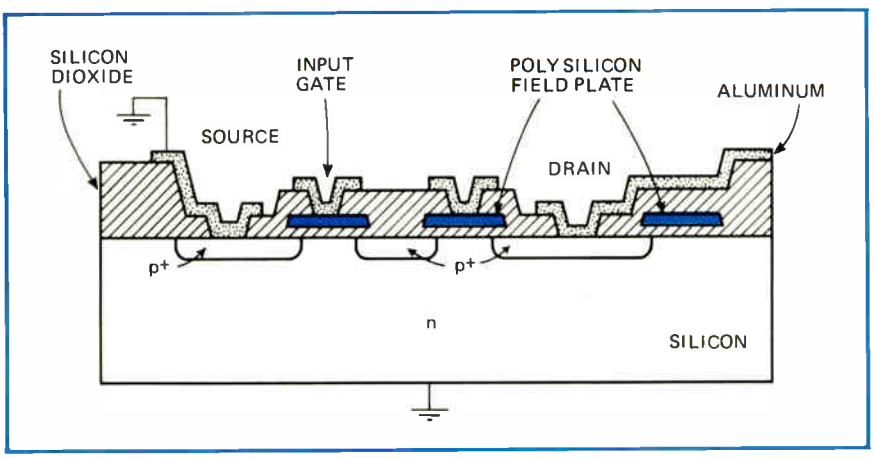
MOS switch turns on to a high 180 V

Conventional MOS integrated circuits have a frustratingly low output voltage—well below 100 volts at best. When they need a higher voltage but also need to combine it with low power and low current, they usually add aluminum gates, and other steps that complicate the metal-oxide-semiconductor process.

Now, however, a group of electrical engineers at Stanford University's Electronics laboratory in Palo Alto, Calif., has built p-channel MOS switches with drain-to-substrate breakdown voltages as high as 180 volts. And they're using standard silicon-gate technology and requiring no additional processing steps. The developers, Krishna Saraswat, James Meindl, and Josef Berger, using a variable positive-feedback technique, are able to drive 100-V MOS-switch outputs with low-level stages as far down as 5 to 10 V.

"In most of its high-voltage operations," says Saraswat, "the MOS transistor is used to drive some sort of transducer where it acts as a series switch, turning the high voltage on and off to the load." In such an operation, he says, the source is always grounded, and the drain must sustain the high voltage. "Since the maximum field intensity is at the drain-gate interface," Saraswat continues, "it is the drain-substrate junction that needs to be protected against breakdown."

Field plate. To do this, he and his coworkers have developed a new structure that combines a normal MOS transistor and a diode with a field plate (see diagram). In essence, a polycrystalline-silicon field plate negatively biased with respect to the substrate is placed above the curved edge of the pn junction. The electric field is decreased, allowing a corresponding increase of the junction reverse-bias voltage. The field plate is partly over the channel, serving as a gate and keeping the channel on because of its bias.



Voltage booster. High-voltage MOS device is obtained by combining normal transistor and diode with a "field plate" biased negatively with respect to the substrate.

To control the switching action of the transistor, another gate is placed near the source end of the channel. An intermediate p region is diffused between the two parts of the channel lying below the control gate and the field plate. "Thus, it is floating in terms of potential," says Saraswat. "That is, the intermediate p region is not connected electrically to anything except the channel."

One difficulty with such high-voltage MOS devices used as switches is that the level of signal available from the low-voltage stages is not enough to drive the output stage, thereby seriously affecting switching speed and efficiency. This difficulty, says Saraswat, is overcome by providing positive feedback—adding a voltage-variable MOS capacitor from the drain to the gate of the MOS transistor that drives the output stage.

Area reductions. In this arrangement, the amount of feedback depends on the initial gate voltages of the transistor; for 0 on the gate, feedback is almost nil, and for 1, there is heavy positive feedback. When the gate voltage is greater than the threshold voltage, the inversion layer lying under the capacitor gate physically meets the drain of the capacitor, and the MOS capacitor is connected between the transistor gate and drain.

"However, when the situation is reversed, there is no inversion, and the MOS varactor is now connected between the gate and the substrate," says Saraswat. "The only capacitance is that between the gate and the drain." This permits a controllable part of the drain voltage to drive the gate during the on condition only. □

Optics

Light valve processes images

Enhancing the quality of a picture is a cumbersome process if conventional wet-chemical film or special electronic devices are used. The pro-

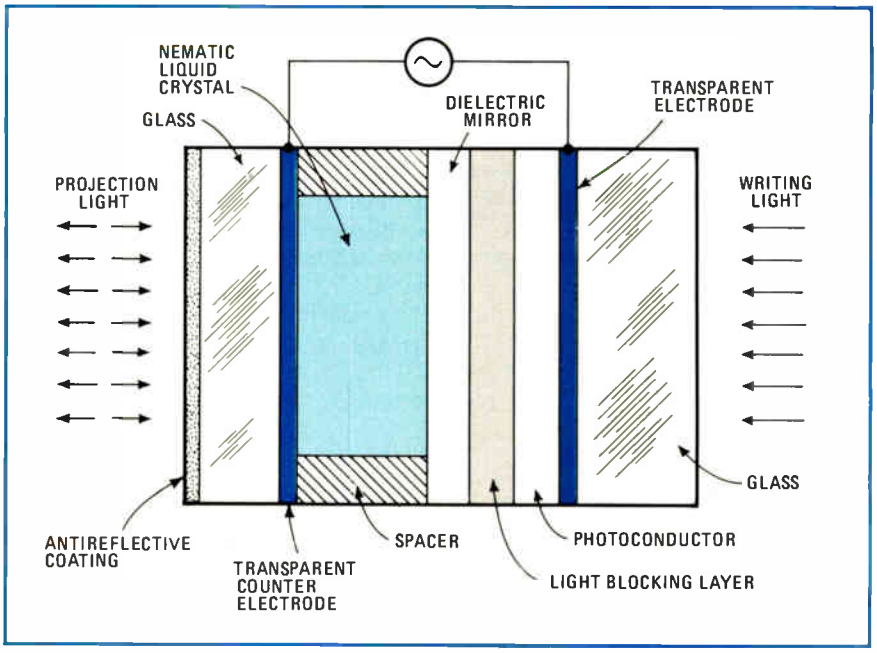
cess could be simplified if the image could be manipulated without first having to be reproduced as electronic signals in vacuum tubes or semiconductor devices or on a photographic film.

Accordingly, scientists at Hughes Aircraft Co.'s Malibu, Calif. research laboratories have been working to improve a liquid-crystal device called a light valve, with which an image can be captured, enhanced, and transmitted. Originally developed several years ago, the light valve has now reached the point where resolution and sensitivity and response tests indicate "impressive performance characteristics," says Alex Jacobson, associate manager of the Exploratory Studies department and head of the project. Intended applications include enhancing the image quality in big-screen theater-television systems, and, in the future, to provide real-time input for optical data-processing systems.

In optical data processing, the valve's real-time characteristic gives it a big advantage over the time delay required for use of photographic film for the image input. A coherent output from the valve may be obtained by using a laser as a light source to modulate it. Some authorities say optical processing could have an economic edge over digital techniques in handling such complex visual elements as analyzing large picture patterns and processing synthetic-aperture radar data.

Faster response. To begin with, Hughes looked for ways to overcome the principal limitation of the liquid crystal—the relatively slow response time. The group found that by using a different crystal fabrication technique to develop a hybrid field-effect mode, the speed could be improved by nearly an order of magnitude.

The resulting light valve is a simple, compact, solid-state low-power device that requires 6 volts rms at 10 kilohertz. Resolution is 60 lines per millimeter at a 50% modulation-transfer function and 100:1 contrast. Sensitivity at full contrast is 100 microwatts per square centimeter at 525 nanometers. Response time is 10 microseconds for excitation and 15 microseconds for extinction.



Light sandwich. Image striking cadmium-sulfide film in Hughes Aircraft Co. light valve modulates the photoconductive layer's resistivity so as to vary the voltage applied to the liquid crystal. Output image can be enhanced by varying the liquid crystal characteristics.

As the diagram above indicates the light valve has a sandwich structure that uses light-blocking layers to separate the photoconductive cadmium-sulfide film from the liquid crystal. The dielectric mirror is important, both to keep light from the liquid crystal leaking back through to the photoconductor and to serve as the reflecting element for the projection light.

Switching. Essentially, the device works by applying and switching ac voltage between the conductive electrodes. The imaging light modulates the resistivity of the photoconductor in direct relation to shades of the light's brightness. In the key operation, the valve then switches corresponding voltages to the liquid crystal to change the amount of light it transmits and produce the output image. Also, gray tone levels can be changed by varying the frequency of the power supply. This changes the threshold and slope of response of the liquid crystal. Because the films are thin and have high resistivity, little lateral spreading of the image field takes place, and good resolution is preserved.

The capability of operating at low levels of available light—10^{-3} to 10^{-4} foot candles—is why the valve may become practical in many display uses, Jacobson claims. Makers of equipment for large-screen television systems in theaters, for example, could greatly improve picture quality by processing the valve's light output to brighten weak images, enhance lines, clear up blurring, and correct focus.

NASA, which financed much of the early Hughes light-valve development, is studying the device for use as an optical-to-optical interface. And Hughes is continuing to improve the light valve's contrast, resolution, and optical qualities. □

Components

New trimmer paint improves specs

It's false economy to buy a trimming potentiometer that's low in cost but lacking in stability. Stability is important because trimmers, used

to fine-tune electronic circuitry, are often found in almost inaccessible locations inside television and radio tuners, for example, making later adjustment difficult.

Now, Centralab Electronics division of Globe-Union Inc. has developed a new carbon resistor paint for its 9-cent carbon-on-ceramic trimmers. The paint reduces several critical specs closer to those of cermet trimmers costing 24 cents each.

The Milwaukee firm started moving the new series-3000 paint into production at its El Paso, Texas, trimmer facility earlier this fall. Eventually, it will be applied across the board to all the firm's low-cost trimmer products.

In between. "The market we're aiming at with our new carbon system is somewhere between the cheap-and-dirty phenolics and the expensive cermet trimmers," says Dwayne Macdonald, marketing manager for electromechanical products. "We're offering greater stability and reliability than either phenolic trimmers or our earlier carbon trimmer and at no increase in price," he says.

Equipment makers use 70 to 80 million low-cost open-frame carbon trimmers annually. Centralab and Bourns Inc. have always asked about a cent premium for their carbon-on-ceramic versions; phenolic types, which sell for 8 to 8½ cents from domestic manufacturers, 7 cents from foreign, rely on a carbon paint screened or sprayed on a small printed-circuit board instead of on a piece of ceramic.

Centralab has dramatically improved key specs of the nine paint formulations it uses for devices ranging from 1 kilohm to 1 megohm. Typical instability of the new trimmer after exposure to 95% relative humidity, 40°C, for 300 hours is about 5%, Macdonald says, down from 12% on earlier versions. (Cermet trimmers typically exhibit about 1% instability under these conditions.)

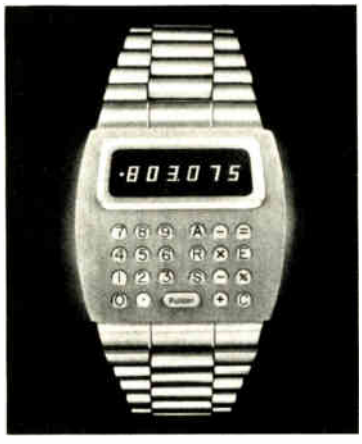
Instabilities under load and variations in the temperature coefficient of resistance (TCR) are also reduced by minimizing moisture effects. And besides using a high-alumina-content substrate to conduct temperature away from the resistive paint, Centralab cures the circuits at 200°C, well above operating temperatures.

TCR, specified at 0.04%/°C, is also reduced by proper matching of thermal expansion coefficients of the paint's constituents. TCR of the firm's earlier carbon system, as well as the best phenolic trimmers, is 0.1%/°C; cermet trimmers usually achieve a TCR of 0.01%/°C.

The reduction in contact-resistance variation to less than 2% results from the addition of conductive materials with large particle sizes to the paint. The trimmer wiper contacts the protruding particles above the surface of the resistor, Macdonald explains.

"We developed the paint for use in our hybrids and passive resistors," he says, "and have spent the last 18 months reconfiguring it for trimmer applications." □

Watch/calculator



Time Computer Inc. has introduced a solid gold Pulsar watch-calculator combination with six-digit LED display. The calculator has five functions, plus memory, floating decimal, and display overflow. Priced at $3,950, it's designed around two C-MOS chips, one each for time and calculation. The watch uses four battery cells that should last for a year for 25 calculations and 25 time readouts a day.

Consumer

Japan boosts share of TV sales in U.S.

Japan's share of the U.S. color-TV import market will set a record in 1975. According to new Department of Commerce figures, the Japanese will capture 85% of that market compared to last year's 70%.

The gain was spurred by Japanese success in capturing "an increasing share of the U.S. private label markets such as Sears, Roebuck," says the department. This increase has produced a sharp third-quarter upturn in Japan's home entertainment product shipments to the U.S. Third-quarter color TV imports from Japan rebounded to 328,000 units—more than 5% above the 312,000 sets shipped in the entire first half. Fourth-quarter Japanese shipments continue to rise while those of other foreign suppliers—in Mexico, Taiwan and Korea—decline. Unit imports in 1975 are expected to exceed the 917,000 level of 1974.

The Japanese third-quarter surge in color-TV sets is in sharp contrast to the trend in imports of home-entertainment audio and video products from all sources from January to September. These dropped by $358 million to $1.07 billion—about 25% below the $1.42 billion worth imported in the first nine months of 1974. Imports of color sets from all foreign sources fell by 25% to 765,000 sets in the first nine months from 1.02 million in the same 1974 period. □

Consumer

Dial-up games play on home terminals

Scott B. Guthery calls it the "greatest thing to happen to games since the invention of the ball." But then it was his idea. Guthery, a specialist in probabilities and statistics at Bell

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Telephone Laboratories' Applied Statistics department in Holmdel, N. J., has formed Computer Recreations Inc. to develop a library of over 300 computerized amusements that can be played by anyone equipped with a keyboard printer terminal or keyboard cathode-ray-tube alphanumeric-display terminal and a telephone.

Thinkers. Computer-based "thought" games as opposed to TV "action" games like ping-pong and tennis are nothing new, of course. But Guthery hopes to commercialize them and bring them into the home on a big scale, starting in the New York and New Jersey areas. To do this, Guthery needs a computer, and he recently advertised an offering of 50,000 shares of common stock, at $5 per share. With the $200,000-plus proceeds from the sale of stock, Guthery says the company plans to purchase a computer system that will accommodate up to 32 simultaneous users, acquire games and programs, maintain and operate the time-sharing system, and develop its marketing program.

Although most terminals capable of interfacing with remotely located computers range in price from $500 to $1,500, Guthery says they're dropping in price. In the meantime, he believes there are enough terminal owners in the New Jersey area alone to warrant making Computer Recreations a reality now.

Initially, users will have to pay the regular telephone rate for all calls made to the computer. Eventually, however, Computer Recreations, based in Cliffwood, N. J., may provide more economical access by renting dedicated telephone lines or inward wide area service (IN-WATS) numbers. Guthery says that, based on projected operating costs for the 32-port computer system and assuming an average revenue of $3 per user hour, the company would have to sell 1,334 hours a month to break even. "Assuming a 20-hour-a-day, seven-day-a-week operation, 1,334 hours per month would represent 7% of the maximum capacity of the system," notes Guthery.

In addition to such games as chess, Solitaire, Blackjack, football, and golf, plus word and math games for children, Guthery says Computer Recreations will be able to "talk" subscribers through the diagnosis and repair of malfunctioning home appliances. Also, at times subscribers may feel like just watching games rather than getting directly involved themselves. Guthery calls this "electronic kibitzing." □

Displays

Plasma display attains new heights

For years, the search has gone on for a smaller, flatter substitute for the time-tested cathode-ray tube used in military display systems. Plasma-display technology long has seemed a promising approach, except that above 8,000–10,000 feet the displays burst from internal pressure.

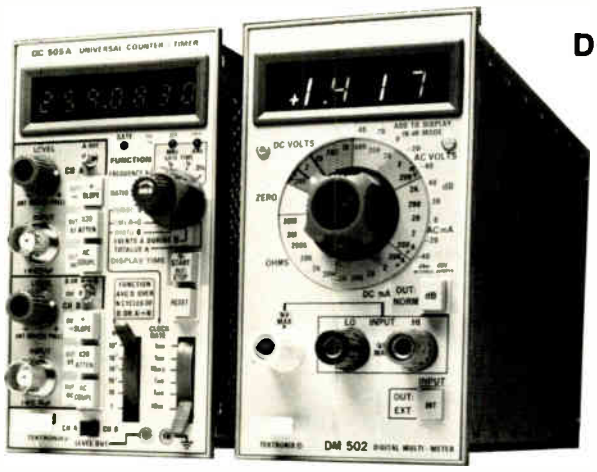
Now, the Government Electronics division of Motorola Inc. in Scottsdale, Ariz., has developed a way to make plasma displays operate at altitudes to 30,000 feet. The result is a plasma-panel display terminal, developed for the Navy, that provides interactive alphanumerics and graphics. This terminal, designated the AN/UYQ-18 (V), has been delivered to Collins Radio Group of Rockwell International Inc., Dallas, Texas, for flight-testing early next year. It is intended for use in C-130 aircraft in a Navy program that will rely on satellites and airborne C-130s to relay very-low-frequency messages to submerged submarines.

The terminal works on the principle of exciting, or illuminating, the neon plasma gas on a selective basis over a 262,144-dot matrix.

Packaging protection. Under development only since February of this year, the display effort presented few technology problems once the mechanical packaging that protects the plasma display itself had been designed, reports George

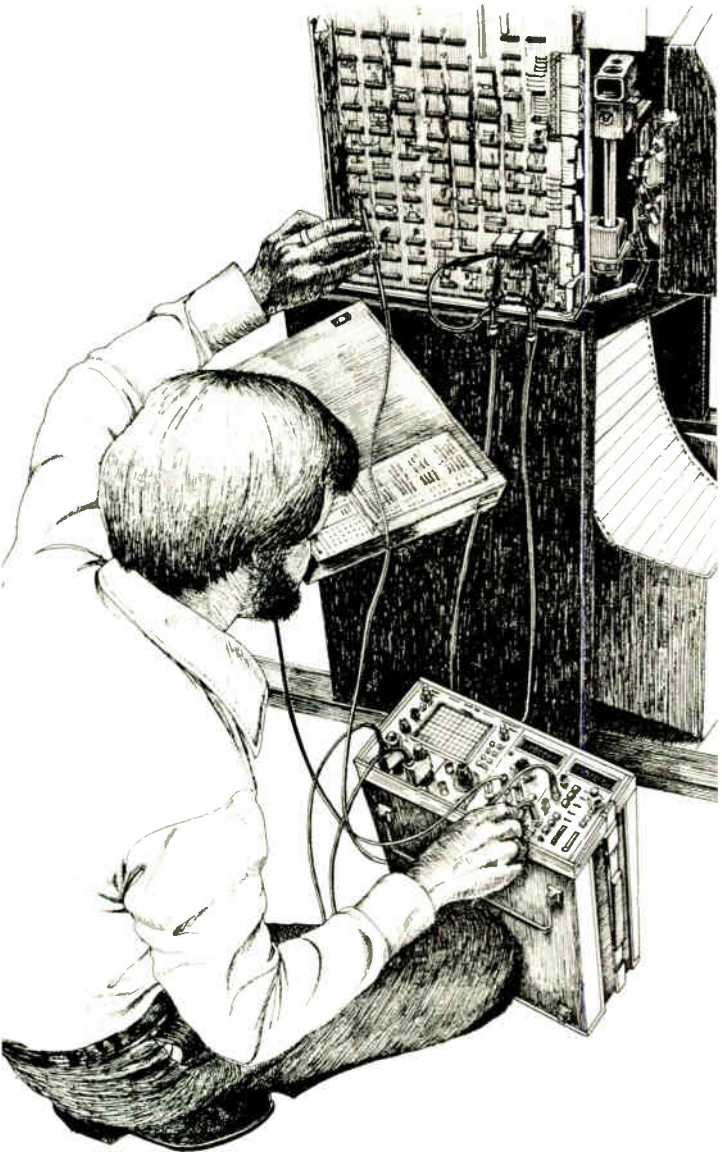
Flatter. Motorola's plasma-panel neon-gas display terminal has less depth than CRT terminal. Mechanical design allows operation to altitudes of 30,000 feet for the first time.

Get Tektronix TM 500 versatility in a counter/DMM combo



DC 505A / DM 502 for only $1900

When you plug in a TEKTRONIX DC 505A Universal Counter alongside a DM 502 Digital Multimeter, you get more than a 225 MHz counter and a full-function DMM. The TM 500 Mainframes that receive these plug-in modular instruments feature a common interface circuit board, allowing the instruments to work together and with other instrumentation. For example, with the interface connections set up, you can read counter trigger level on the DMM at the touch of the INT (internal) pushbutton. Touch INT again, and you have separate and simultaneous universal counter and DMM capability. Among other examples: A TM 500 counter/DMM combo can work with the TEKTRONIX 31/53 Programmable Calculators for applications such as obtaining data from mechanical measurements.



The 10 nanosecond clock rate of the DC 505A Universal Counter ($1395) means you get single shot resolution to 10 nanoseconds in period or time interval measurements . . . and resolution to 100 picoseconds on repetitive events when you set the averaging to 10^5 cycles. A single function switch selects FREQUENCY (channel) A, PERIOD (channel) B, RATIO A/B, TIME A→B, WIDTH B, EVENTS A DURING B, and TOTALIZE A. Flip the slide switch on the front panel to CH A or CH B to read channel A or B trigger level on an adjacent TM 500 digital multimeter connected through the rear plug-in interfacing, or on other instruments, such as an oscilloscope, through the tip jacks on the front panel. The DM 502 Option 2 Digital Multimeter ($325) measures ac and dc voltage and current, dBm, dBV, and resistance. Temperature ($125 more) can be read in °F and °C. A single front panel switch selects all ranges. A pushbutton called *dB* provides dB readout of ac functions in lieu of ac voltage or current, and the INT pushbutton selects the input available at the rear plug-in interface (trigger level from an adjacent DC 505A counter or any other voltage routed to that point). But the DM 502 is even more versatile: Internal jumpers provide readout in dBm or dBV and FET input $>$ 1000 MΩ or 10 MΩ input on the two lowest dc voltage ranges. And the temperature probe lets you check for abnormally operating components in tightly packed circuitry.

The TM 500 Product Line includes mainframes with 1, 3, 4, 5, and 6 compartments. Plug the DC 505A and DM 502 into a TM 504, 4-compartment mainframe ($180) for the equivalent of a monolithic instrument offering exceptional capabilities . . . the DC 505A/DM 502 Combo $1900. Utilize the additional compartments for later expansion, selecting from the total TM 500 line of more than 30 plug-in instruments including signal sources, power supplies, oscilloscopes, and more.

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Robert Kaelin, senior staff engineer who directed it.

Supplied by Owens-Illinois Inc., Toledo, Ohio, the display panel is a glass sandwich a half-inch thick filled with neon gas at an internal pressure of less than 1 atmosphere. Although the structure is inherently rugged, at above 10,000 ft it becomes a pressure chamber instead of a vacuum, degrading the display and affecting its safety.

But by devising a package to surround the panel, Motorola ensures reliability to the 30,000-foot altitude, according to Kaelin. He declines to describe the packaging because the company is seeking a patent on the design.

Small. In this initial phase of the program, the plasma display terminal is already shallower and lighter than CRT units, according to Kaelin. The present configuration, for example, is 15.7 inches deep, compared to 19 inches for Motorola's own Totalscope CRT display terminal. Weight is about 100 pounds, against 130 for the CRT.

For the sake of expediency, this first plasma-display terminal borrows the internal processor and electronics from the Totalscope terminal. The next terminal will have large-scale integrated circuitry and a microprocessor that should reduce the size and drop the weight eventually to about 70 pounds, says Kaelin. He believes an ultimate goal of one third the present size is possible.

Kaelin predicts the terminal could eventually be applied in such restricted-space applications as submarines, aircraft cockpits, and even displays that a soldier could carry for tactical field use. In production, costs should be reduced to one third as much as a CRT, he adds.

Addressable matrix. The display has a viewing area of 8.54 by 8.54 in. with an addressable matrix of 512 by 512 lines. An internal processor provides complete text-editing through a keyboard, as well as message formatting and control. With a font of 5-by-7-dot-matrix characters, the writing rate is 1,302 characters per second, and screen-erase time is 16 microseconds. □

Government

Cutbacks seen in FAA R&D

The Federal Aviation Administration's electronics research and development budget for the fiscal year beginning Oct. 1, 1976, is expected to be cut by one-quarter to $50 million. A senior FAA official said as much following November hearings before the House Science and Technology subcommittee on aviation and transportation R&D—areas in which FAA activities have generated severe criticism. "No program is sacred at this point," the source indicated. "We've got to cut back and maybe eliminate some programs."

While precise numbers have yet to be determined, FAA's R&D slice from the Airport Trust Fund that covers most of the agency's electronics effort is expected to drop to $50 million next fiscal year from the present $70 million level, officials say. As a result, the agency's total R&D budget, including non-electronic items, was cut to $80 million by Congress from the $96 million sought by FAA for fiscal 1976.

Analysis. To cope with the expected cutback, the FAA has begun a cost-benefit analysis of its entire R&D effort, officials report. The action stems from criticisms within Congress and from aircraft-industry user groups.

Although the Air Transport Association of America and the Air Line Pilots Association were, in general, supporters of the FAA program, general-aviation representatives were scathing in their criticism.

"There is no need for further pursuit of a full MLS microwave landing system," noted the Aircraft Owners and Pilots Association, taking a shot at the FAA's biggest R&D program, budgeted at more than $20 million for next year. AOPA is in favor of an interim MLS concept, currently denied FAA funds. The Air Transport Association, on the other hand, supports MLS.

But Jefferson W. Cochran, FAA's associate administrator for engineering and development, claims that $50 million a year isn't enough. He wants to do a better job of selling R&D programs to the user groups. "We're going to try to work closer with them," he says.

Of the FAA's R&D programs, aeronautical satellite (Aerosat) development is under the most pressure. Faced with almost total apathy from the Air Transport Association and other user groups, and with intense Congressional scrutiny, it is losing friends fast. The resignation of deputy associate administrator David R. Israel in October may have meant the loss of its only strong supporter in the FAA, industry officials say. All Cochran will say is that the Aerosat program is one of the many programs under review.

The Air Transport Association as well as general-aviation interests also wonder what the FAA will do with the discrete-address-beacon project, which could be used as a surveillance and collision-avoidance system as well as a digital data link for interference-free ground-to-air communications. "I'm convinced that DABS has value as an improved surveillance link," Cochran says. "It needs work, though, for a data link." □

Memory

Domain memory tops 2 megabits

A three-year development effort at West Germany's BASF has resulted in a prototype magnetic-domain memory unit that, like cores and magnetic bubbles, has no movable mechanical parts.

Hermann Deichelmann, one of the developers of the Mados (for magnetic domain storage) at BASF's laboratories in Ludwigshaven, places the equipment's performance between that of high-speed disk-storage devices on the one hand and expensive semiconductor or core memories on the other. Relying on

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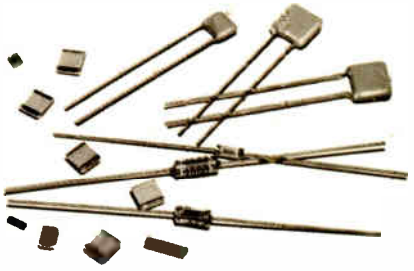

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SCIENCE/SCOPE

The first in a series of six new satellites Hughes is building for the 91-nation International Telecommunications Satellite Organization was launched September 25 and has passed all tests successfully. Intelsat IV-A, which has two-thirds more capacity than the present Intelsat IVs, provides 6,250 telephone circuits, plus two television channels, and serves more than 40 earth stations as the Atlantic primary satellite. Its new spot-beam antenna concentrates its signals on major business centers and makes more efficient use of the frequency spectrum allotted for satellites.

The U.S. Marine Corps has a new position locator system which pinpoints individual men, units, and vehicles. The Hughes-built engineering development model of the PLRS (Position Location Reporting System) includes a commander's mobile master unit and 17 user units, which can be man-packed or mounted in vehicles and aircraft. PLRS uses "time of arrival", burst-transmission, and spread-spectrum techniques. It does its job faster, more accurately, and in greater volume than older methods such as sight and sound reporting, radio triangulation, or even radar.

A high-speed, 16-bit microcomputer that can operate throughout the military-applications temperature range is being tested at Hughes. The AN/UYK(XN-1) has a capability of up to 500,000 operations per second -- 10 times greater than top state-of-the-art compact systems just months ago. Speed and flexibility were achieved at low cost through use of commercially available LSI microprocessor chips. The AN/UYK was developed for a Naval Air Systems Command digital missile autopilot R&D program. Other potential applications include mobile ground and helicopter fire-control systems, digital scan converters, and various distributed processor systems.

Hughes' Conographic^{tm} graphic display terminal, which displays curvilinear information by conic curve generation rather than by x-y plotting, is now available in a low-cost version, the Conographic-9 terminal. With a package price of $9,750, the new fully interactive unit offers high resolution, selective erase, high light output, built-in serial interface, and other features of higher-priced terminals without requiring additional hardware options. Conographic process generates smooth curves with considerable reduction in data required, resulting in more cost-effective telecommunications.

Hughes needs manufacturing and equipment design engineers. Responsibilities include designing specialized manufacturing equipment and fixtures, efficiency analysis, implementation of reductions. Requirements: BS in ME or Industrial Manufacturing and five years' related experience, preferably in hybrid circuit assembly. Forward your resume and salary history to: Pat Schneider, Hughes Aircraft Company, 500 Superior Avenue, Newport Beach, CA 92663. An equal opportunity M/F employer.

A lightweight amplifier for satellite earth terminal transmitters, developed by Hughes, provides 35 watts minimum RF output power in the 6 GHz satellite uplink frequency band. It has solid-state circuitry for low power consumption and a rugged metal-ceramic traveling wave tube derived from the space-qualified TWTs Hughes builds for communications satellites. It operates from 115- or 230-volt AC or 48- or 24-volt DC input power. The unit measures 3½" x 19" x 16" and weighs 20 lbs. For information, write: Hughes Electron Dynamics Division, 3100 West Lomita Blvd., Torrance, CA 90509.

the principle of controlled propagation of magnetic domains, the memory has a capacity of about 2.1 megabits, a minimum internal-block-access time of 35 microseconds, and a data-transfer rate of 0.275 megabyte per second. Deichelmann says initial application for Mados will be in peripheral memories for process computers. He ex-

News briefs

TI drops microprocessor prices
By slashing the prices on its version of the Intel 8-bit 8080 microprocessor, Texas Instruments has signaled an aggressive move into the microprocessor market. The cuts—by more than 75%, to $21.15, for 100 to 999 pieces, and by 40% to 60%, to $34.25, on 1 to 24 pieces—follow on the heels of TI's entry into the 16-bit microprocessor market with its 9900. Others are likely to follow suit. "It's pretty evident we'll go down," says William H. Davidow at Intel Corp. By how much he won't say, however. At Motorola Semiconductor Products, Durrell Hillis says small quantities don't mean much: "The real business is negotiated from 100 up," where, he says, Motorola will continue to be competitive.

Israel expands R&D subsidy
Israel's Ministry of Commerce and Industry has received a $5 million loan from the World Bank to be used exclusively to boost from 50% to as much as 85% the Israeli government's contribution for industrial R&D projects performed in the country. Joseph Vardi, North American director of Israel's Investment Authority, says the incentive is designed to attract more foreign companies to the country, especially those in electronics industries. "If we want to increase our penetration of electronics markets, we have to come up with new products, and we can only do that over the long term by expanding R&D in our country," says Vardi.

Hickey named board chairman of General Instrument
Frank G. Hickey, president and chief executive of General Instrument Corp., New York, succeeds Moses Shapiro as GI's chairman of the board. Shapiro, who turned 65, was named vice chairman of the board, a new post. At the same time, Edgar A. Sack, head of GI's Microelectronics group, and William L. Slover, head of the company's Defense and Engineering group, were named corporate vice presidents.

Tandem Computers introduces first product
Tandem Computers Inc., Santa Clara, Calif., has introduced its first product—the Tandem 16 Nonstop system, designed to meet the fail-safe system demands of transaction-oriented businesses that can't afford any computer down-time. The system, consisting of two to 16 interconnected 16-bit processors, will be aimed specifically at such organizations as banks, airlines, insurance companies, and hotel/motel chains. James Treybig, president of the company, says the requirement for a redundant system with standard operating-system software, such as the Tandem 16, should find a comfortable niche in a market he estimates will run to $800 million a year by 1980.

Motorola and Hitachi sign microprocessor agreement
Motorola Inc. and Hitachi Ltd. have signed nonexclusive worldwide cross-licensing agreements making Hitachi's Electronic Devices group a comprehensive second source for producing and marketing the M6800 n-channel MOS microprocessor family. The arrangement between the two companies also allows for future mutual sourcing of MOS microprocessor families made by both companies. It covers software, firmware, and Exorciser programing apparatus, as well as products. With the announcement, Hitachi joins American Microsystems Inc. in second-sourcing the M6800.

Domain tips—a bit better than bubbles?

Domain-tip memories resemble magnetic-bubble memories. In both memories, magnetized areas of the material are moved, presence or absence designates 1 or 0, and both are nonvolatile. However, in the domain-tip system, the magnetization is greater—by about a factor of 100—and the direction lies in the plane of the material.

In magnetic bubbles, the magnetization is smaller and perpendicular to the plane of the material. Workers say that the materials required for domain-tip memories are much easier to produce than the garnet commonly used with bubbles, and, because the magnetization is so much larger, output signals tend to be higher. Moreover, since bubbles have perpendicular magnetization, domains could probably be packed much more closely for potentially higher bit densities.

pects first production models from BASF around mid-1977.

Collaboration. The principles underlying the new memory have been worked out jointly by BASF and Cambridge Memories Inc. of Bedford, Mass., with which the German company has a technology-exchange agreement. Cambridge Memories, however, is aiming at smaller-capacity systems for use with microprocessors and controllers. It has recently introduced systems with capacities between 32,000 and 400,000 bits at prices below 0.5 cent per bit.

Basic to the Mados design is the so-called DOT (domain-tip) memory element. It consists of a glass plate 0.3 millimeter thick coated with a vapor-deposited aluminum layer 30 nanometers thick. Etched into this layer is a meandering pattern of channels. In a second vapor-deposition step, the whole surface is covered with a nickel-iron-cobalt layer 100-nm thick that has ferromagnetic properties.

External magnetic fields set up isolated magnetic domains in the channel structure. The direction of magnetization is opposite the polarity in the surrounding ferromagnetic material. The data stored as the presence or absence of domains can be moved through the channel structures by varying these external magnetic fields.

In contrast to magnetic-storage devices such as disks or tape, but like magnetic-bubble memories, there are no mechanical forces involved. And the memory element can be operated either synchronously or asynchronously so that operation is not limited to a particular data-transfer rate.

Memory groups. The memory portion of Mados is divided into 16 groups of planes, each with eight double planes. These contain the DOT elements, each of which has a capacity of 3,648 bits. Each group of planes has eight directly addressable selector areas, and within each selector area are six directly addressable information blocks. Each such block has a length of 2,736 bits or 342 bytes. The total number of blocks is 768. Because of the serial-block arrangement, the external block-access time is a minimum of 165 microseconds and a maximum of 4.9 milliseconds.

Deichelmann concedes that the memory's price-per-bit ratio is rather high at 0.23 to 0.28 cent per bit. But for peripheral data storage there are several compensating advantages, he points out.

One is the quick block access—about 100 times faster than that of existing fixed-head disk memory devices. And since the equipment has no moving parts, maintenance is negligible. □

Air Force seeks 'realism' in testing

Avionics in particular and military electronics in general perform far worse in the field than laboratory tests predict. A concerned Air Force

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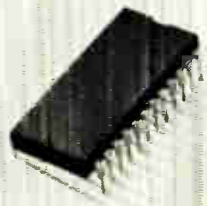

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Reader Service No. 201

Electronics review

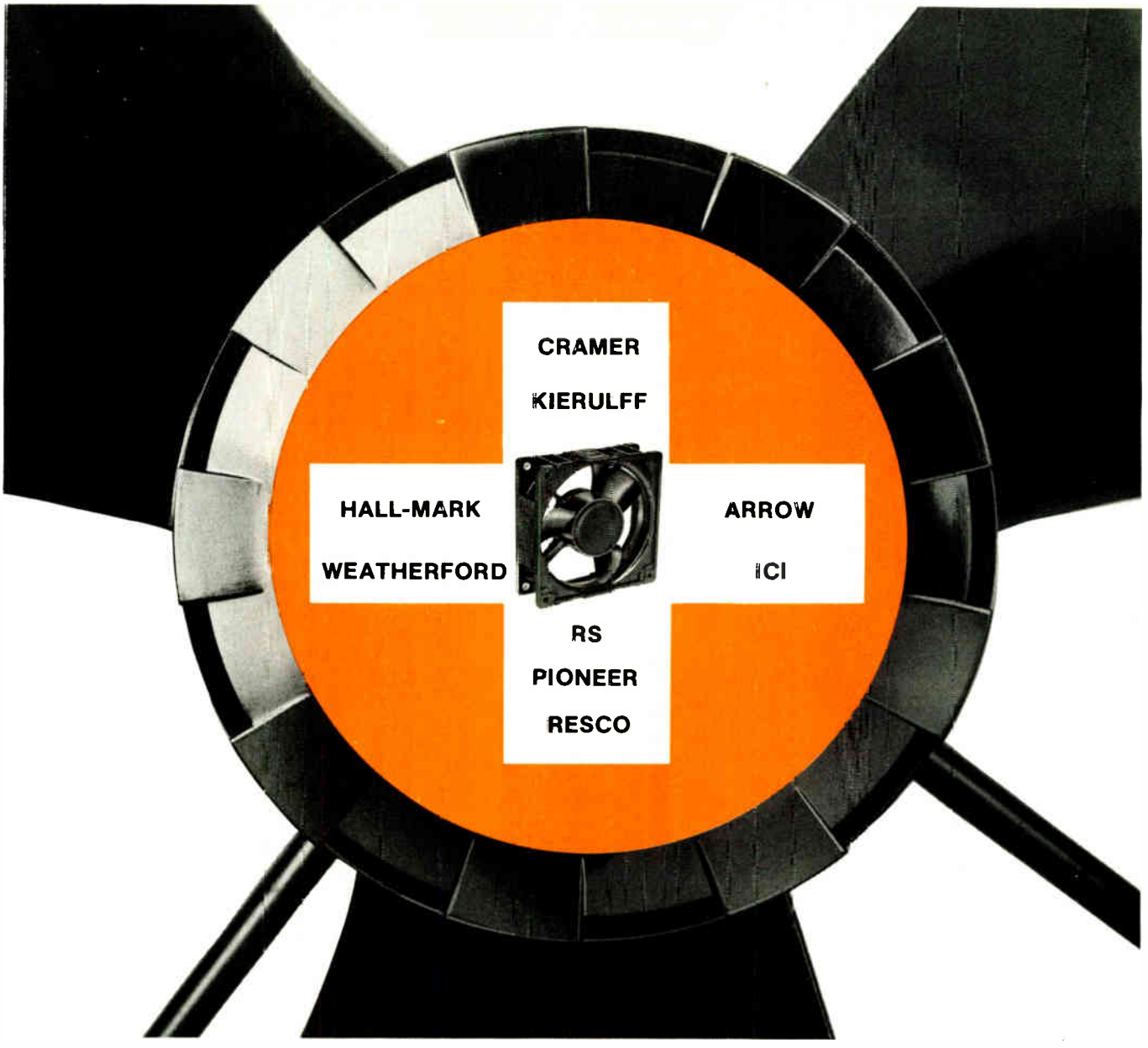
is moving to correct the difference by developing a new testing program called CERT, for combined environment reliability test.

The present "poor correlation" between field operation and existing standards is "leading to release for production of operationally unreliable equipment," warned Demetrius Zonars and Richard E. Colclough of the Air Force Flight Dynamics Laboratory at Wright-Patterson Air Force Base, Ohio, late last month in Washington. They made the disclosure before a meeting of the Government- and industry-sponsored Radio Technical Commission for Aeronautics.

The need is for more realism in duplicating a system's operating environment. The environment studied annually accounts for $360 million or 30% of military maintenance costs. Zonars and Colclough say their conclusions derive from multiple military studies on reliability and maintainability, including the Defense Department's Electronics-X study and others.

Radar tests. In the first CERT effort at Wright-Patterson, the Air Force team tested the terrain-following radar of the F-111 interceptor for 600 hours and found a mean time between failure of 55 hours. The figure "compares very favorably" with the radar's field failure rate of once every 35 to 46 hours, Zonars and Colclough reported. But it was far below the 196 and 252 hours of failure-free performance projected in laboratory tests under MIL-STD-781 and Military Handbook 217B, respectively. The higher figures, according to the Air Force study, correspond more closely to the MTBF found for the part of the system that ran for 200 hours on a laboratory bench.

In a Flight Dynamics Laboratory test facility for CERT, equipment is operated in simulated ground and flight missions in Arctic, desert and tropic environments. Hardware is also run through what the Air Force calls a "dynamic time history for environments" of pressure, temperature, humidity, air flow, vibration, shock, and electrical spikes. □



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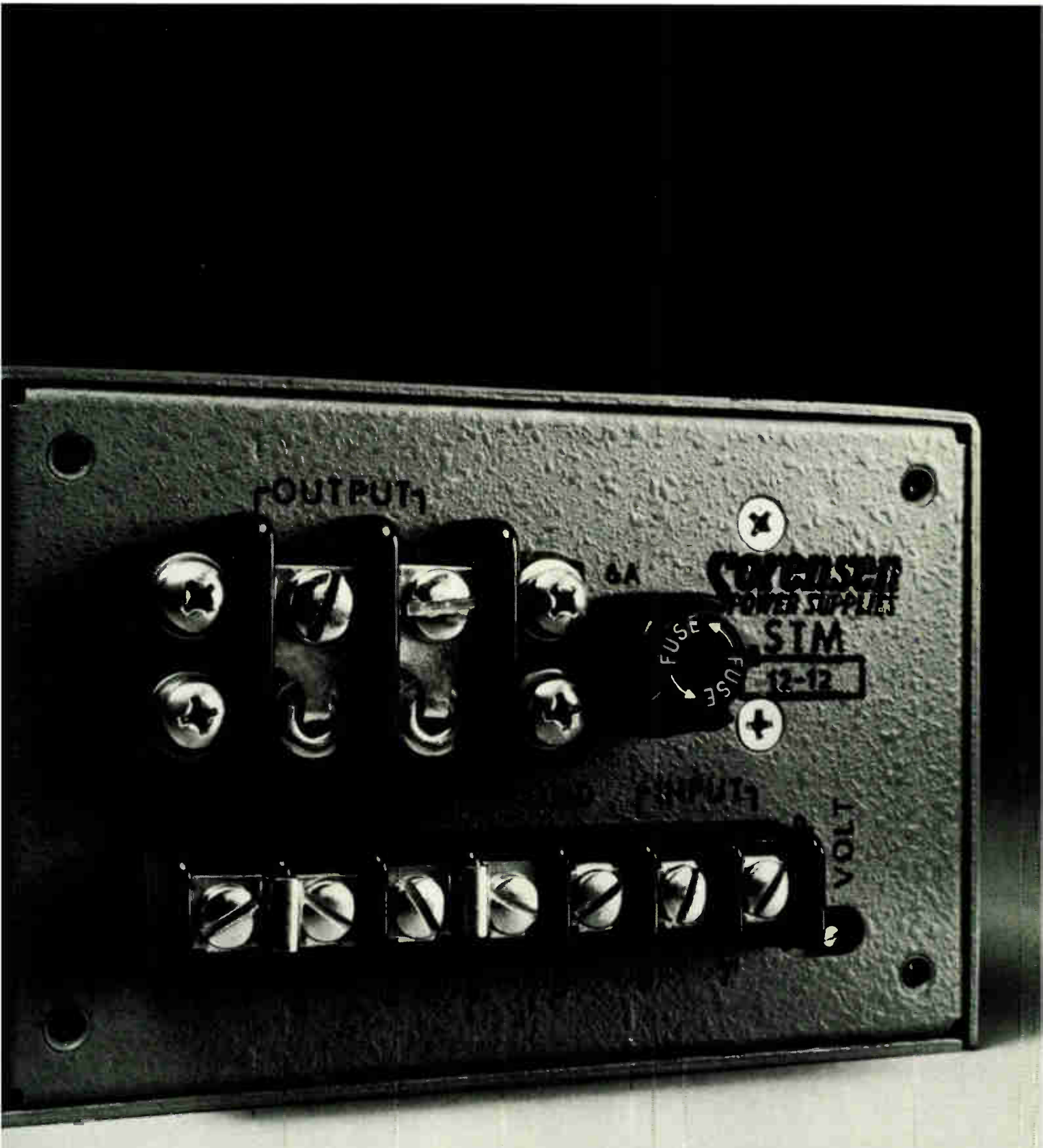

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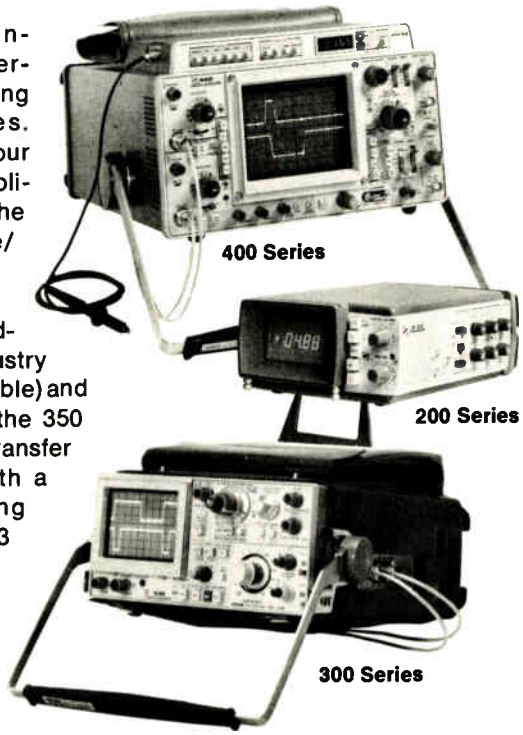

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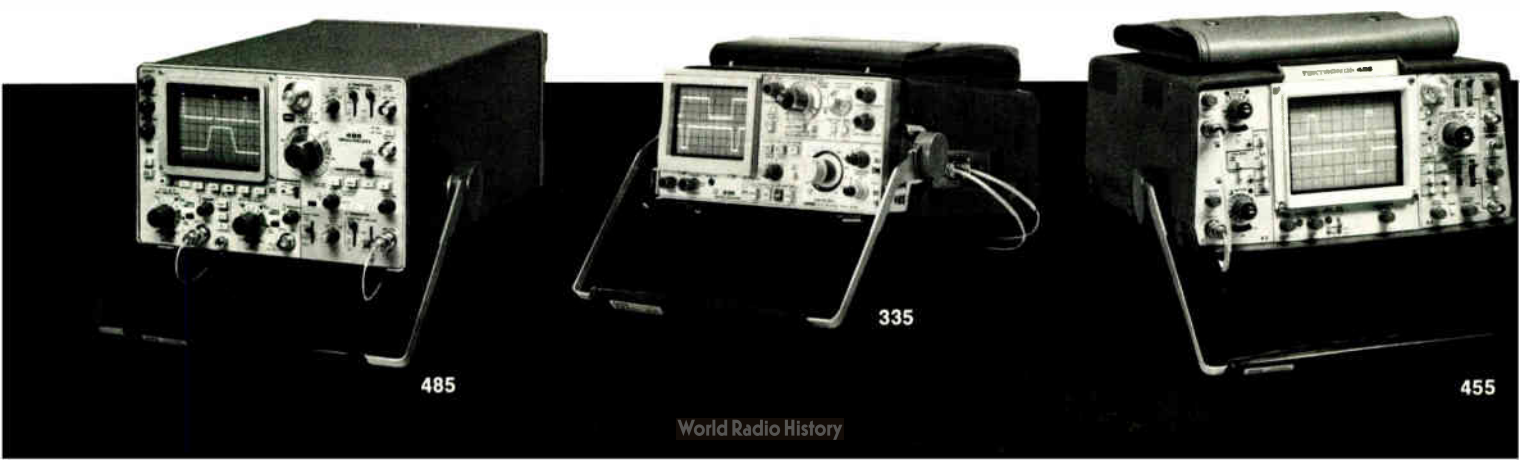

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	434	25 MHz @ 10 mV/div	yes		20 ns/div	Split screen storage	$2900
	314 **(NEW)**	10 MHz @ 1 mV/div	yes		10 ns/div	Only 10.5 lbs.	$1995
	214	500 kHz @ 10 mV/div	yes		1 μs/div	Only 3.5 lbs.	$1200
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	475	200 MHz @ 2 mV/div	yes	yes	1 ns/div	Highest gain-BW in a portable	$2900
	465	100 MHz @ 5 mV/div	yes	yes	5 ns/div	Cost effective for 100 MHz BW	$2095
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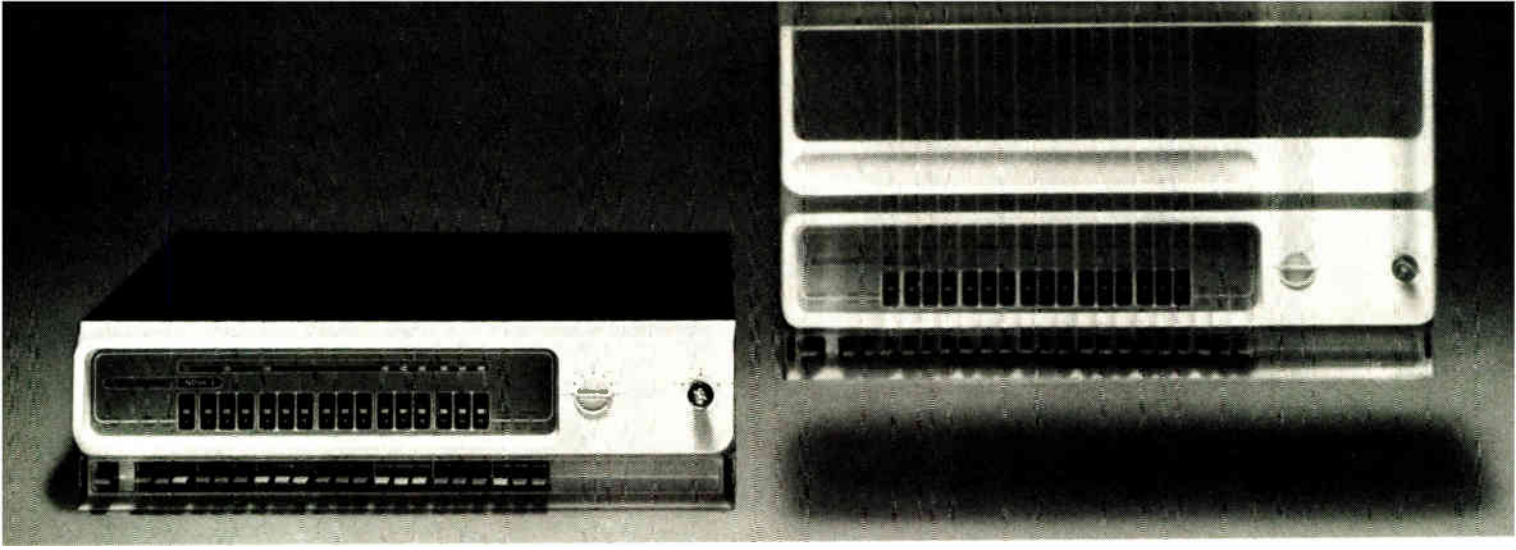

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Washington newsletter

Japan moves to increase dominance in the CB market

Japan's Sanyo Electric Co. and Sharp Corp. are aiming to enlarge their share of the U.S. citizens-band-radio market with significant plant expansions, according to a cable from the American embassy in Tokyo to the U.S. State Department. **Japan already controls 70% to 80% of the CB market in America, which, according to industry sources, will total 4 million units this year.**

A Sanyo plant expansion at Osaka has more than doubled the facility's monthly CB output—from 30,000 radios to 70,000—while Sharp has set up CB production lines at its Hiroshima plant for a monthly output there of 30,000 units, according to the cable.

Congress hears call for FCC, AT&T breakups

Congress has been told the Federal Communications Commission should be split in two—one part to handle radio and TV broadcast issues, the other to deal with telecommunications—while American Telephone & Telegraph Co. should be restructured and made subject to the Public Utility Holding Companies Act. The recommendations were made by the Computer Industry Association (CIA) in a statement to the House Interstate & Foreign Commerce Communications subcommittee, which is examining Federal telecommunications policy [*Electronics*, Nov. 27, p. 40].

The FCC's long and laborious efforts to inject competition into the telecommunications market while trying to control AT&T shows that it "lacks the tools" for the job and should be reorganized as a stronger body, according to A.G.W. Biddle, CIA president. If the Public Utility Holding Company Act were applied to telecommunications, Biddle said, "We would create locally owned-and-operated telephone company switching systems, connected by several competitive long-lines or intercity transmission systems and supplied by independent, competitive equipment companies." CIA, which has 35 member companies with annual revenues of more than $1.4 billion, believes the convergence of telecommunications and data-processing technologies "raises a fundamental question of whether monopoly control of telecommunications" is necessary or desirable.

Army gets new armaments role for all services

Two Army organizational changes that will affect developers and makers of electronic fuses and related armaments are to be implemented in mid-1976. First, the Army will set up a new office at its Rock Island, Ill., arsenal that will be responsible for all U.S. military buys of conventional ammunition, including that used by the Air Force, Navy, and Marines. Details of the action are still being worked out with the other services. Second, the Army will establish **a new armament development center in Picatinny Arsenal, N.J., where management of all its armament research, development, and acquisition will be consolidated.**

Addenda

Competitive USAF contracts for advanced strategic air-launched missile guidance technology have been awarded to the Missile Systems divisions of Rockwell International, Columbus, Ohio, and Raytheon Co., Bedford, Mass., for $1.2 million and $1.5 million, respectively . . . John Freeman is the new overseer of solar and geothermal development projects at the Federal Energy Administration, where he has been named deputy assistant administrator for energy projects. Freeman had been with the Department of Housing and Urban Development.

Washington commentary

The case for promoting John Eger

A good man nowadays is just as hard to find as he was when Ethel Merman first began shouting that show tune line on Broadway. And the shortage of good men throughout the Federal bureaucracy makes the few there are seem even more outstanding.

John M. Eger, acting director of the White House Office of Telecommunications Policy since last year, is a case in point. As the argument over America's lack of a national telecommunications policy moved to Capitol Hill in mid-November, Eger's precise presentation and fresh perspective on how to overcome the Federal Communications Commission's past failures to evolve a policy drew praise from several diverse quarters.

As the chairman of the House communications subcommittee, Torbert Macdonald, told Eger after his testimony: "I hope this won't redound to your disadvantage [at the White House], but OTP has turned out more and better work in the past year or two than it ever did before." That personal commendation of Eger is made stronger in view of OTP's lack of clout throughout the Federal superstructure because of its weak and limited mandate [*Electronics*, Sept. 18, p. 50].

John Eger deserves President Ford's nomination as permanent head of OTP for some very practical reasons.

For instance, it would resolve the White House problem of finding a respected and qualified chief for OTP outside of Government. There are such persons, of course, but none of them is likely to abandon present commitments for a job with an Administration whose continuity beyond January, 1977, is in doubt.

The plus side

The politically sound reasons for an Eger nomination, however, do not do justice to the positive qualities of the candidate himself. Those were best demonstrated by Eger's superior overview of the nation's telecommunications problems before the Macdonald subcommittee, and his view of how they might be resolved.

After detailing the history of FCC's delay in developing interconnection standards in the seven years since the landmark Carterfone decision and the resulting stagnation in the U.S. interconnect equipment market, Eger came on strong for full and fair competition in telecommunications. In a balanced presentation, he struck out against AT&T's argument that competition for special services would force up local exchange rates to offset losses. "Some of the speculation about potential injury have been grossly exaggerated," Eger declared. "The portion of Bell System revenues which is even vulnerable to competition is only about 5% of its gross."

Yet Eger is also able to sympathize with some AT&T charges, as he did when noting that "what we have today is not so much market competition as regulated competition, which is another way of describing Government-imposed allocation of the market."

Competitive guidelines

John Eger's proposal for accelerating full and fair competition contains eight points, the highlights of which call for: shifting the burden of proof that new market entries will be detrimental to the opponents from the advocates, that is, to established interests rather than small and often struglling new organizations. Additionally, Eger wants more deregulation by the FCC of things like terminal equipment and services lacking "any appreciable attributes of 'natural monopoly.'" Then there is the need, he says, for new and better principles of cost allocation by multiservice firms like AT&T to better control cross-subsidization and predatory pricing. Nevertheless, Eger would also allow open competition for new services, provided established carriers set up separate corporations, accounts and records for them.

Eger's detailed citation of these options for the FCC leave no doubt that the man has done his homework on a set of problems where, he acknowledged, "final solutions will not come easily or instantaneously." Yet OTP's acting director has demonstrated once more that he deserves to have the "acting" designation—and all the uncertainty it implies—removed from his title so that his views will command wider attention and greater respect. They might even motivate the White House itself to give the telecommunications regulatory dilemma the Federal resources it requires for timely resolution. **—Ray Connolly**

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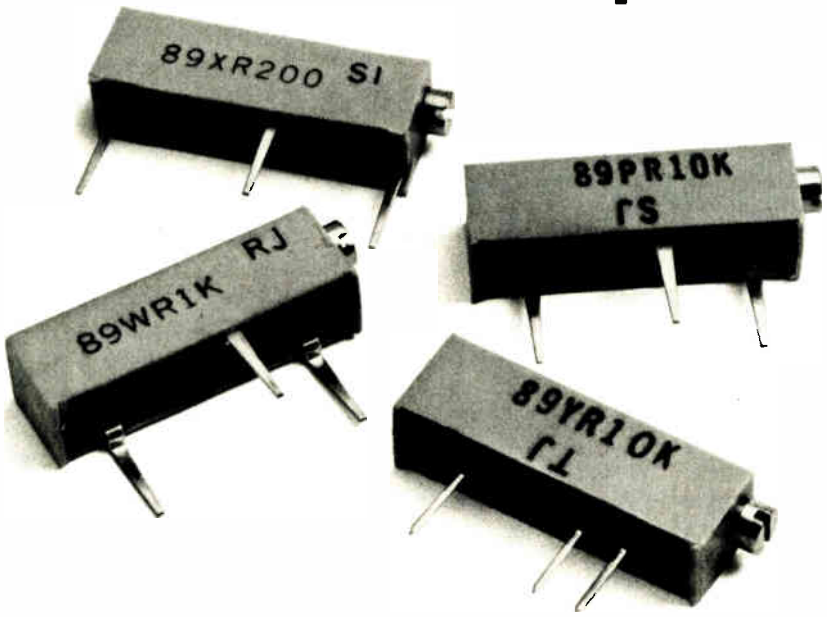

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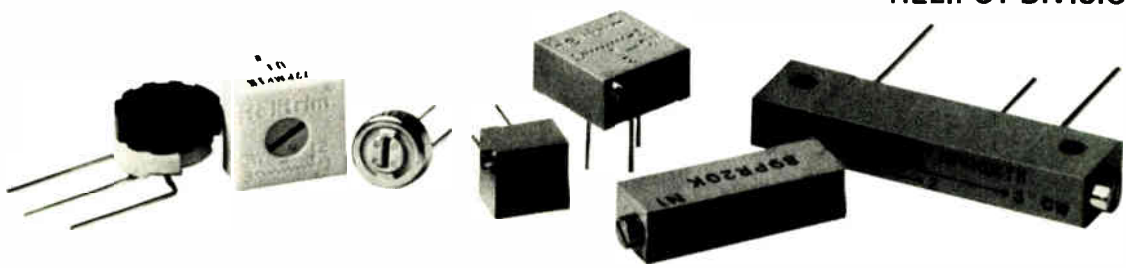

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Philips modular air-traffic-control system is aimed at civilian use

A modular air-traffic-control system for civilian planes in emerging nations is the first weapon Philips N. V. is deploying in a new campaign to capitalize on its solid reputation in military radars. The so-called Mini-ATC, made by Philips' Hollandse Signaalapparaten B. V. in the Netherlands, is designed for both long- and medium-range operations in Africa, Latin America, and Southeast Asia.

The Mini-ATC is built around the LAR 2 radar, which is based on new L-band radar technology. The system can be made as sophisticated as necessary for any application, Philips says. The LAR 2, which employs frequency-coded pulse-compression techniques, uses a surface-acoustic-wave filter and a traveling-wave tube instead of the more conventional magnetron or klystron.

A new 23-inch alphanumeric "bright" display permits viewing in normal light, and the system contains a sophisticated minicomputer derived from Philips' military versions. With an optional video extractor, the new bright display can show a completely synthetic picture of computer-generated symbols.

The performance is impressive: the LAR 2 has a range of 1,000 meters to 200 nautical miles and 120,000 feet in altitude. Resolution is 1.7° in azimuth and 90 meters in range. Besides the transmitter, the system includes an aluminum horn-fed parabolic antenna and a double superheterodyne receiver with a low-noise-transistor amplifier as a radio-frequency preamplifier.

The nearest equivalent to the Mini-ATC is believed to be the Automated Radar Terminal System (ARTS-2), now under development by the U. S. Federal Aviation Administration. A British radar company executive says that the new Philips radar has better accuracy and is more versatile than its competitors. Especially noteworthy is "the SAW delay line for pulse-shaping, and chirping [pulse-compression] is a new trick in civil radars."

Expensive. Technology is expensive, however. The system is priced between $1.5 million and $4 million, depending on whether or not a secondary surveillance radar is added. The price could rise to more than $10 million for an equivalent to the highly automated SARP-2 being installed at Schiphol airport.

Aiming for high reliability, good clutter-suppression, and a range that accommodates both terminal areas and long distance, Signaal chose a Raytheon TWT. A TWT, which is more coherent and more stable than a magnetron, has a larger instantaneous bandwidth, provides higher gain and is easier to handle than a klystron. The transmitter puts out a healthy 180 kilowatts peak power for long-range performance and a mean power of 4.1 kW, low enough to avoid the need for a pressurized waveguide.

The TWT sends long pulses of 4 to 8 microseconds, unacceptable for performance at minimum range. Signaal turned to pulse-compression techniques to reduce the pulse to the necessary 0.6 μs needed for precise target detection. Essentially, a second 0.1-μs pulse, transmitted immediately after the longer pulse, is processed separately in the video processor to get the best minimum-range performance. □

Around the world

Molybdenum floating gate aids alterable ROM

Though molybdenum gates have been abandoned for main memories, they have found a new vitality in special designs. A molybdenum floating gate has improved the speed and cut the power requirements of a new electrically alterable read-only memory developed by Sanyo Electric Co. in Japan. The two prototypes are applicable mainly to the specialized electronic equipment. One prototype memory, 256 words by 1 bit, is for use in programable calculators, control equipment, and the like. The other, a matrix of 16 by 18 bits, is more suitable for programable television tuners and citizens'-band transceivers. Both have write and erase times of 1 millisecond and a read time of 3 microseconds. Their power-supply configuration can be simple because the Earom needs only 1-ns pulses of −30 volts for writing and −20 v for erasing. The memories, which are fully decoded on the chip, can survive more than 10^4 write-erase cycles. Retentivity of 10 years is achieved by a relatively thick oxide layer.

Oscillator phase shift locks receiver in data net

Digital telecommunications networks require an oscillator circuit to precisely lock the receiver into the transmitted signal. However, this action can create problems because electronically shifting the oscillator's frequency can upset its stability.

Now, J.D.H. Alexander, senior lecturer at the department of engineering, University of Aberdeen, Scotland, has developed a logical phase-controlled oscillator that acts like a differential gearbox to match the phases between the transmitter's oscillator and the receiver's oscillator circuit.

Alexander's oscillator circuit, built around 74-series transistor-transistor-logic chips, has been used in a master-slave clock system to experimentally correlate pseudorandom number streams. In the data receiver, one of the oscillator's eight phases is matched to the incoming signal.

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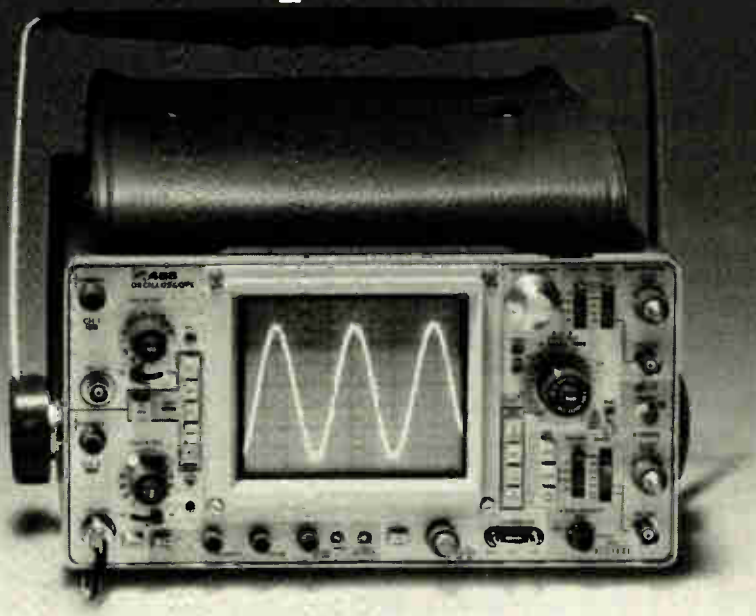

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International newsletter

Japanese fax set can send page in two minutes

A facsimile transceiver can process a letter-size page in two minutes by **means of vestigial-sideband transmission of amplitude-modulated signals to achieve handwidth compression.** What's more, the new machine from Matsushita Graphic Communications Systems Inc. can operate at slower speeds with a-m and fm machines, including those made in the U. S., that send pages in four and six minutes. The company, which is selling the transceiver in Japan at about $5,250, **plans to produce 500 units a month for domestic and export markets, particularly the U.S.**

Vestigial-sideband transmission is similar to the technique used for bandwidth compression in television broadcasting. A five-position switch on the front panel can select transmission to or reception from sets using standards of the Nippon Telegraph & Telephone Public Corp., as well as from commercial sets made by Matsushita, Nippon Electric Co., Toshiba, Minnesota Mining and Manufacturing Co., and Xerox Corp. **Writing density in the two-minute a-m mode is 2.6 lines per millimeter; in the four-minute fm mode, 2.5 lines/mm; and in the six-minute fm mode, 3.8 lines/mm.** The four-minute speed is commonly used for NTT-standard a-m signals on local lines and six-minute speed on long-distance lines.

French seek to increase share in computer firm . . .

Even though Honeywell Information Systems has agreed to French domination of jointly owned CIT-Honeywell-Bull even before its formal establishment in the near future, the French want even more. **The U.S. share is soon to be cut from 66% to 47%, and the French want to cut that to a token amount.** The French interests, which are counting on U. S. technology to wrest the lead in computer sales in France from IBM Corp. by 1980, are the government and Compagnie Internationale pour l'Informatique.

Top government-industry planner Hughes de l'Estoile, who boasts that "the French are more inventive than the Americans," is telling computer customers that domination "is the guarantee of the computer policy we have chosen." De l'Estoile is following the same strategy he is using in the nuclear-power industry, where he is pushing Westinghouse to agree by year-end to slash its 45% share in reactor-builder Framatome to 15%.

. . . as U. S. partner launches computer and floppy disk

Meanwhile, France's U. S. partner, Honeywell-Bull, is launching the smallest computer in the 61 series, the general-purpose 61/40, and a floppy-disk data-entry system, the KDS 7255. The floppy-disk system provides intelligent data entry to any computer in the 61 series. The diskette-oriented 61/40 computer, priced from $53,000 to $108,000, **operates in mono- or multiprogram mode with two or three processors.** The central processor has 16 kilobytes of read/write memory and 12 kilobytes of read-only memory. One processor controls communications in multistation configurations. A microprocessor controls data entry and the console disk capacity is 18.4 megabytes.

Hitachi OCR reads hand-written alphanumerics

An optical character reader developed in the Central Research Laboratory of Japan's Hitachi Ltd. can recognize hand-written English alphanumerics and, with the aid of software, Japanese katakana syllabary. The machines read faster and are listed at about half the price of the IBM 1287, which can read only machine-written alphanumeric characters. Unlike other

methods, the Hitachi system handles characters written in rectangular format. **The speed is 500 hand-written characters or 1,000-machine-printed characters a second.** In tests of alphanumeric written by the researchers, the rejection rate was one in 1,000, and the error rate was 1 in 5,000.

Four of 10 units ordered are now in operation and are to be delivered in about six months. Initial applications are intended for computers, and Hitachi does not plan to export the OCRs until it begins exporting computers. **Two models are available—one for on-line operation with computers and one stand-alone.** In operation, writing is scanned by a flying spot, the patterns are thinned, line segments are coded for one of eight directions and topologically classified, and then they are matched against nonlinear patterns in the memory.

British firm wins pact for Mideast computer network

British Petroleum's computer-services subsidiary, Scicon, has bagged a $50 million contract to supply huge turn-key integrated communications and computer network in an undisclosed Mideast country. When asked if the network was for military use, the company declined comment. **About half the cost of the five-to-seven-year project will cover hardware and installation costs,** and the rest will go for software and training.

NEC hits milestone for 1-megabyte bubble memory

An experimental bubble memory developed by researchers at the Central Research Laboratory of Nippon Electric Co. indicates that the Japanese have reached a major milestone in their quest for a 1-megabyte auxiliary memory. The memory, to be completed by 1977, requires bubbles to circulate at a rate of 1 megahertz for the government's pattern-information-processing computer.

The interim memory, which has a capability of 128 kilobytes, produces an average access time of 1.62 milliseconds from bubbles circulating at a rate of 100 kilohertz. Each of the four chips, 6 millimeters square, stores 16 kilobits in bubbles that are 7 micrometers in diameter. In the full system, 72 chips of the same size would be enclosed in a package 20 by 20 by 5 centimeters. **The thrust of the research is to reduce the bubble size, to 2-μm diameter so that each chip can store 128 kilobits—16 kilobytes—for a total capacity of 1 megabyte.** The loops on the chips will be redesigned, and researchers are not predicting what the final access time will be.

Japanese form second group to develop VLSI

A second group of Japanese manufacturers has set up a joint venture to coordinate development of very large integrated circuits and computers to take advantage of VLSI capabilities. The new company, **Computer Development Laboratories Ltd., is being formed by Fujitsu Ltd., Hitachi Ltd., and Mitsubishi Electric Corp.** The participants share equally in the $1 million capitalization of the new company, to begin operation Dec. 15. The president is Satoshi Kojima, who also retains his position as president of Fujitsu Laboratories Ltd., Fujitsu's research arm.

The other computer-development company, NEC-Toshiba Information Systems Inc., was set up in 1974 to coordinate development planning for VLSI and advanced computers, as well as the present generation of computers from the two parent manufacturers, Nippon Electric Co. and Toshiba.

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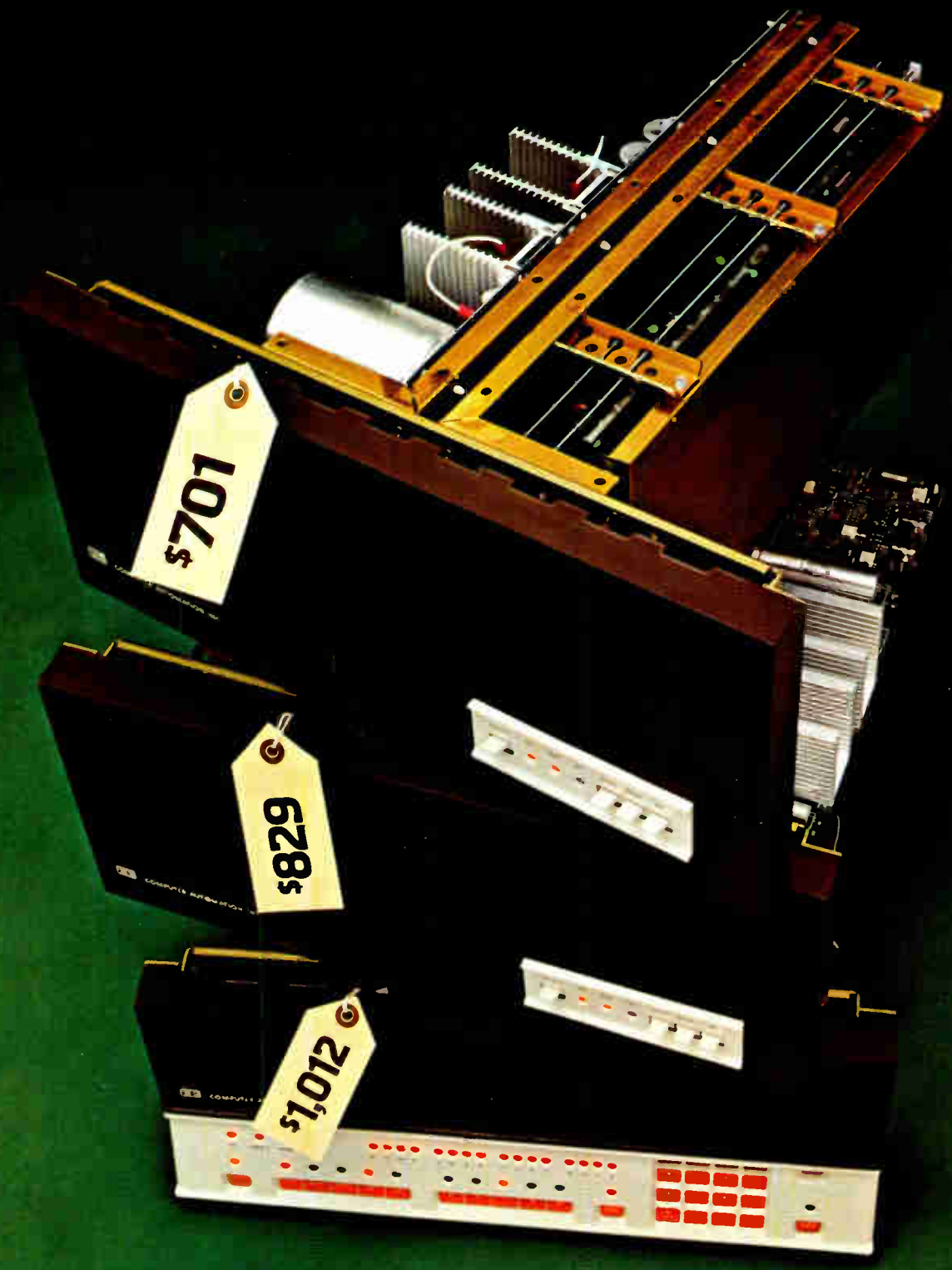

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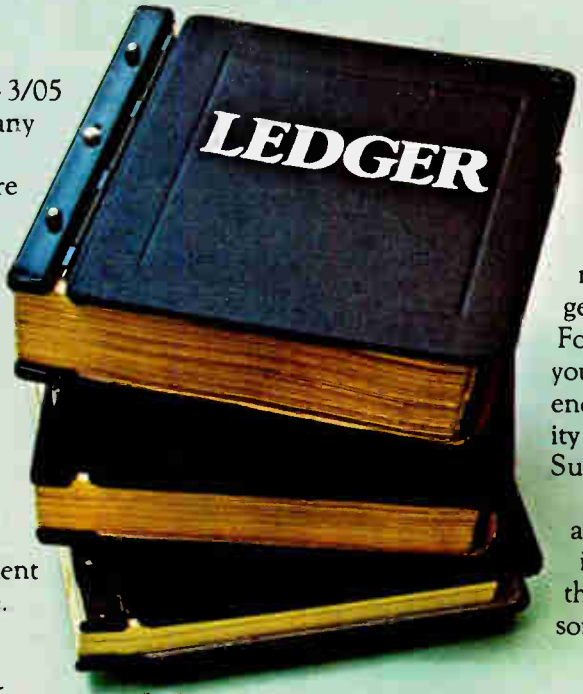

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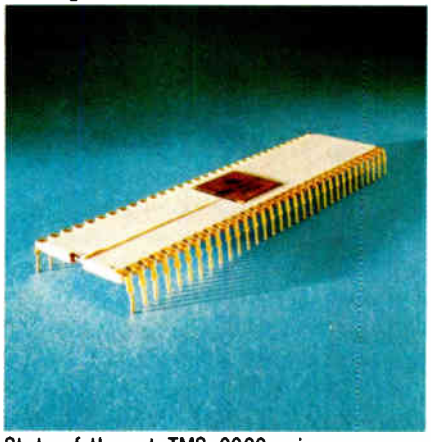

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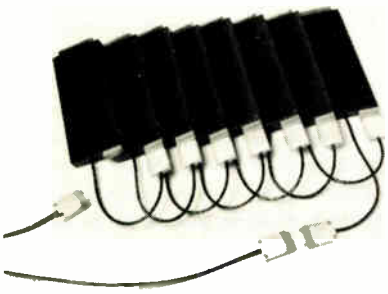

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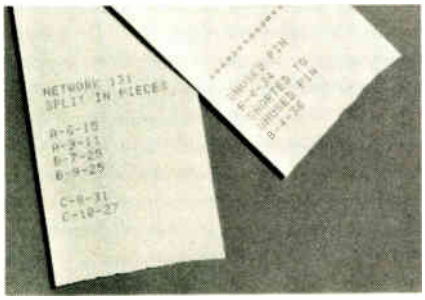

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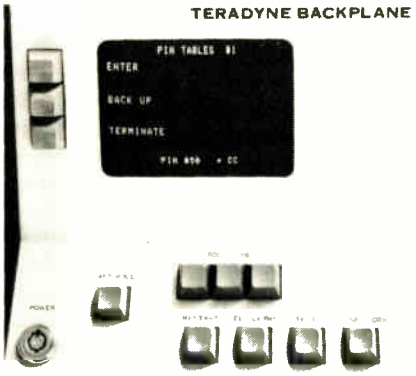

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Coming: cheap, powerful computers

One-chip microprocessors, combined with semiconductor memories, promise to compete with expensive mainframes

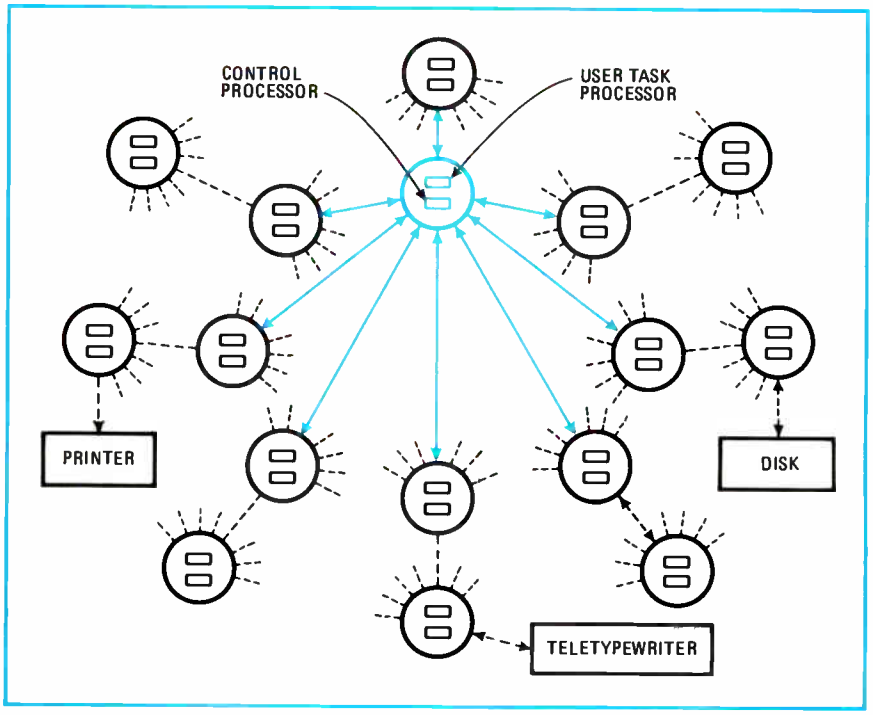
by Stephen E. Scrupski, Computers Editor

It was bound to happen. Given the compact processing power and storage capability of single-chip microprocessors and semiconductor-memory chips, someone had to put together a large array of microprocessor-memory modules designed to rival the performance of large mainframes at a fraction of the cost. However, it may not be that simple—some experts warn that producing power entails far more than simply hooking together a number of processors.

At least three companies on both sides of the Atlantic are working on this next-generation concept: Grumman Aerospace of Bethpage, N.Y.; IMS Associates Inc. of San Leandro, Calif.; and a French firm, Realisations Etudes Electroniques. Both IMS and REE are basing their systems on Intel 8080 n-channel MOS chips, while Grumman is going for higher speeds with Intel's 3000 series bipolar chips.

IMS assembles the 8080s in a structure called a Hypercube, in which each processor communicates with eight others directly connected to its input/output ports (see illustration above). IMS plans to build three system sizes ranging from 16 to 256 processors. REE's immediate plans are much more modest: only eight interconnected 8080s.

But Grumman, on the other hand, says it intends to use the microprocessors to solve large problems that take many hours on a 370-168. Robert McGill, head of the Computing Sciences branch of the Research department says, "We are actively, seriously, looking at interconnecting as many as 10,000 microprocessor modules."



From California . . . In the array planned by IMS Associates, which it calls a Hypercube, each processor can communicate with eight others, or a maximum of 256.

Grumman plans to build one module and replicate it 10 or 20 times to improve performance two to three orders of magnitude over the level of IBM's 370-168.

The key to the potential high performance is that, in each system, the individual microprocessors operate more or less independently on separate parts of a problem or even on different problems. This approach differs from previous multiprocessor architecture, which has a great degree of parallelism. The giant Illiac IV, for example, designed at the University of Illinois and now installed at NASA's Ames Research Center, Moffett Field, Calif., had 64 processors, but each operated in synchronism from a single controller, performing the same instruction in parallel on separate data words.

D.R. Slotnick of the University of Illinois, who recalls that he "picked out the parts for the Illiac IV 10 years ago," notes that there would be much fewer electronic problems with the 8080s. The Illiac IV was based on emitter-coupled logic and it was difficult to control noise in the high-speed circuits.

Trade-offs. As attractive as such independent processing may seem, however, it's not quite so simple to multiply individual processor power, points out Gene M. Amdahl, founder and chairman of Amdahl Corp., Sunnyvale, Calif., and the

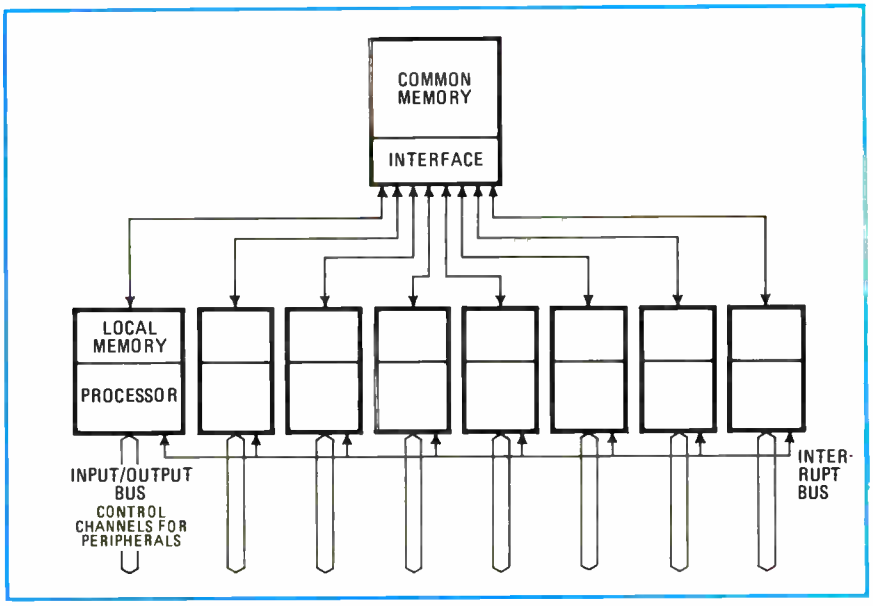
principal designer of the IBM System/360 computers.

In 1967, Amdahl says, he analyzed the potential of parallel processing and concluded that even a small percentage of sequential processing can drastically reduce the gain in processing power. For example, even if as little as 5% of the instructions must be run sequentially, 64 parallel processors would have their over-all power reduced to the equivalent of only 15 independent processors. With the same percentage of sequential processors, 16 processors would behave like 11.

Grumman's McGill acknowledges Amdahl's warning, but says that the "difficulty is mainly at the algorithmic level." He says that completely new algorithms are needed to take advantage of the new computing systems "because the opportunity to do things with a high degree of concurrency is coming upon us very fast." He is encouraged by results he has seen in developing these new algorithms, he says.

Skepticism. Another point that some skeptical observers make about microcomputer-multiprocessors is that, although there's no doubt that one microcomputer based on one 8080 is a good thing, it's not at all clear that n microcomputers will be n times better. For example, how does one go about programing a system containing many 8080 microcomputers? For a large system with a single central processing unit, a program is written and then fed into a compiler to obtain the machine code that actually directs the computer operations. Can something similar be done in these multiprocessor systems?

Yes and no. REE plans a system, the Micral-M, with a single location of a program from which each of the eight 8080s draws its instructions. The Micral-M is based on REE's one-board microcomputer, the Micral-S. With eight such microcomputers, the system can handle 512,000 words of memory and perform 3 million instructions per second. Each processor has its own memory, but also shares part of a common memory, which holds the program. Similarly, each processor can draw on the resources managed by another.



. . . to France. In the version by Realisations Etudes Electroniques, the key is a custom Schottky-TTL LSI hard-wired logic circuit that determines priority of access to the memory.

The key to the system is a custom-designed Schottky-TTL LSI hard-wired logic circuit that sets the priority of access to the common memory, and resolves any simultaneous accesses of equal priority.

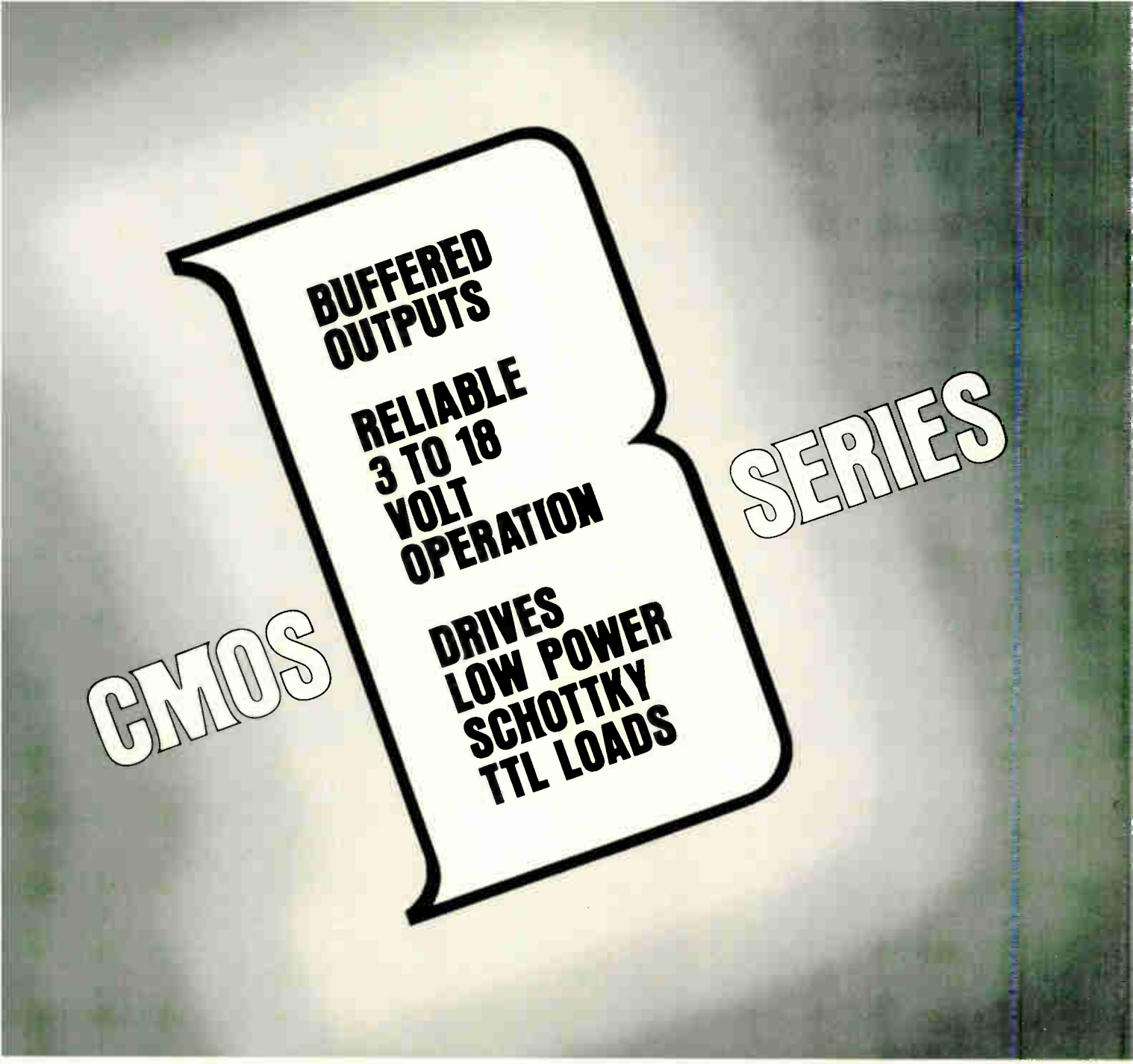
Distributed program. In the IMS system, the plan is for a user to write a distributed program in low-level assembly language for each 8080 in the system. The basic operating unit in the IMS Hypercube is a subsystem containing two 8080A chips, plus memory and interface circuits, mounted on a pair of 8-by-22-inch printed-circuit boards. Each subsystem is located at a node of the Hypercube and connected to eight other subsystems in adjacent nodes. One of the 8080As executes the user's program while the other handles the overhead and communications tasks and the operating-system software.

With the 8080A's direct-memory-access capability, one subsystem can access another's memory while the subsystem at another node is performing its own calculations. In use, some of the nodes would be assigned the responsibility of processing input or output data, or interfacing with a printer, keyboard, or disk-storage unit, and they would make data available to other nodes.

Users would program each node to perform its function, and the operating system built into each node would take over internodal communications. This makes programing not much more difficult than successive programing of single 8080As, according to IMS.

Each node has an instruction rate of 1 million instructions per second, direct-memory-access capacity of 2 megabytes per second, and 16 kilobytes of user-program memory, expandable to 64 kilobytes. The smallest system IMS is building, the Hypercube II, has an aggregate execution rate of 16 million instructions per second, capacity of 256 kilobytes of user-program memory, and capability to perform 2 million memory-to-memory additions a second, the firm says. Housed in a single 72-inch-high cabinet and consuming 1,280 watts, the Hypercube II will sell for about $80,000. A Hypercube III will sell for about $400,000, about 10% of the price of an IBM 370-168.

The company now is completing construction of a Hypercube II, which will soon be taken out for "show-and-tell" sessions. IMS marketing director William Millard says military and government agencies have already expressed great interest in Hypercube for use in telemetry and simulation systems, in maintaining large data bases, and in data-communications networks. □



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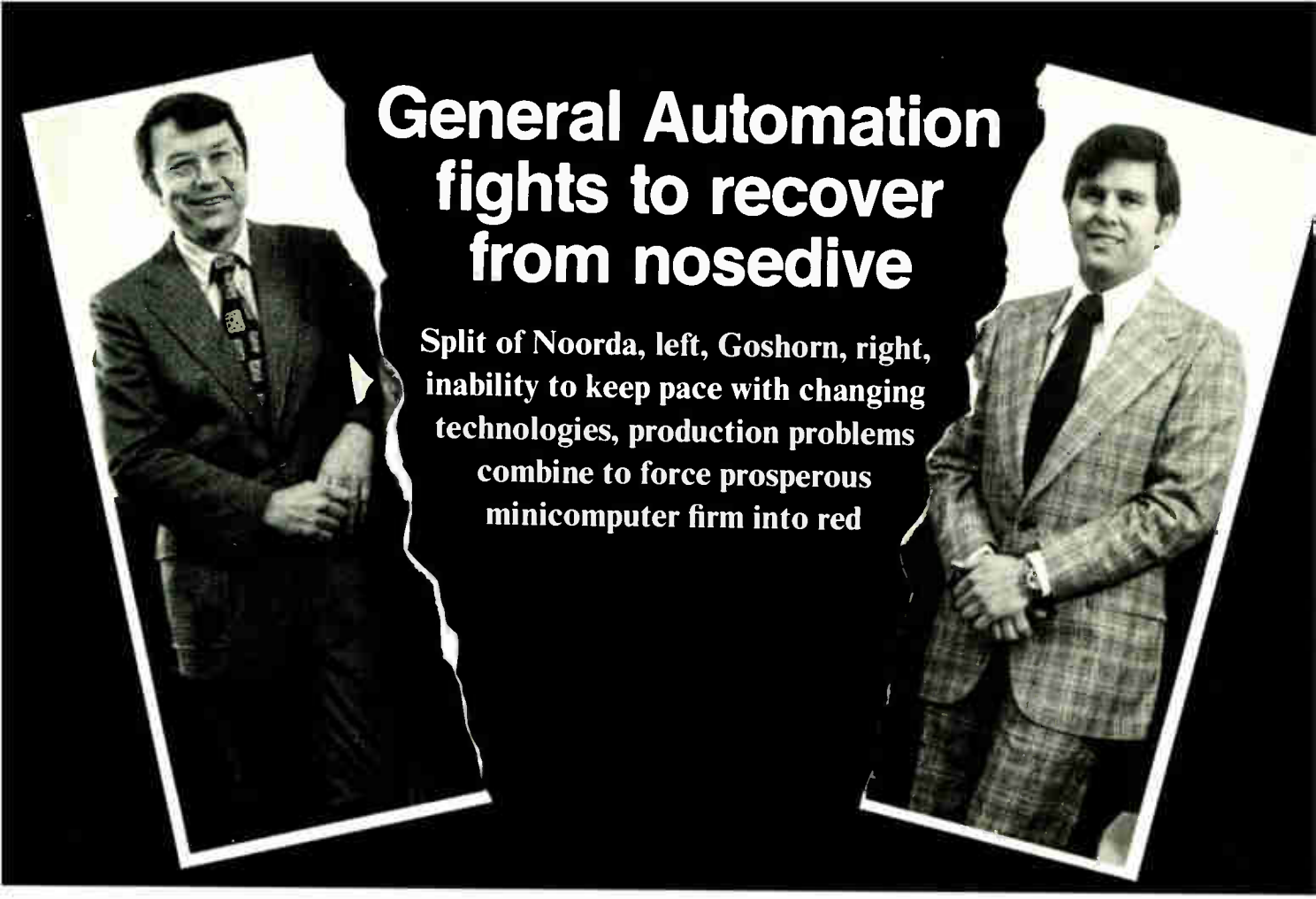

General Automation fights to recover from nosedive

Split of Noorda, left, Goshorn, right, inability to keep pace with changing technologies, production problems combine to force prosperous minicomputer firm into red

by Larry Waller, Los Angeles bureau

As recently as mid-1974, General Automation Inc. was a high-flying minicomputer company chalking up solid profits. Since then, the picture for the Anaheim, Calif., firm has changed completely: it has skidded into sales, overhead, and production problems, big losses, and a future dominated by the need to straighten out the curve by getting production and delivery schedules of its new MOS machines under control.

What went wrong at GA?

Basically, the combination of internal struggle and the lack of clear-cut lines of authority caused troubles to multiply. In the dynamic minicomputer field, buffeted by fierce competition and rapid technological improvement, delays and wrong decisions proved costly.

Much of the damage at GA resulted from a long-simmering struggle between two management factions for control of the firm. On one side (the winning side, as it turns out) were founder, board chairman, and controlling stockholder Lawrence A. Goshorn and his associates. On the other, the four outside board members lined up solidly behind president Raymond J. Noorda, who joined the firm in 1970. The strife surfaced explosively in August of this year when Noorda and his four backers on the board resigned and Goshorn emerged as the undisputed boss of a company that had enjoyed zooming growth for most of its life since he founded it in 1967.

Flop in SOS. While a good part of the slide also may be blamed on its much-publicized failure to introduce an advanced silicon-on-sapphire (SOS) microcomputer line, that debacle seems to have been more a symptom than a basic cause. Such an attempt to leapfrog competition with the use of unproved technology is, to Noorda, an illustration of Goshorn's ill-fated "flair for the dramatic."

That failure, and GA's current problems, grew out of a weakening competitive position. Both Goshorn and Noorda now agree that it was apparent even before 1973 that the company had to update its standard SPC-16 minicomputer line with new LSI circuitry.

Noorda says that in 1972 he told Goshorn and Michael Ford, then vice president of marketing, that GA had to have systems incorporating two new technologies. "We needed microprocessors in machines at the bottom of the line and a microprograming extension of our SPC-16. These would be upwardly compatible machines with sophisticated architectures," he recalls telling them. Goshorn took responsibility for developing these products, Noorda says, and in fact kept full control of product planning throughout.

In connection with these plans, a pivotal announcement was made in December 1973 that GA would build a low-cost microcomputer based on an SOS chip to be manufactured by the Microelectronic Device division of Rockwell International Corp. Since this development would give GA higher-speed minicomputers with lower power requirements than anything else then offered commercially, the company and Goshorn

became the center of industry attention. As events unfolded, the chips proved uneconomical to produce because of yield deficiencies, and Noorda was forced to announce the termination of the program a year later. (Rockwell says its contract, signed by Goshorn, was for "feasibility studies" only, from a design supplied by GA.)

Claims no role. Goshorn now disavows any connection with the SOS affair. As he tells it: "About that time, I left the company for personal reasons. I'm not sure we could have made SOS work even if I had stayed. But we would have known sooner. . . . I would have kept Rockwell more committed and raised a lot more hell."

Furthermore, it was later in 1974 after he was gone, according to the GA chairman, when the "basic mistake" took place that knocked the company "out of control." During fiscal 1974's fourth quarter, running from May through July, management pushed sales to a record $20 million. Among other effects, this decision "sucked out all the backlog, caused overhead to explode, and drove the company into instability." It raised production to unsustainable levels and led to the write-offs and operating losses that have plagued GA since the second quarter of fiscal 1975.

Goshorn claims that from late 1973 until well into 1975 he was outside the decision-making process. Although he declines to blame anyone, it is clear that in his mind the Noorda regime made the key mistakes.

"His plans." As might be expected, Noorda disagrees with Goshorn's version of events. "He was not gone—he never left the company except for a five-week vacation in early 1974. The SOS program was Goshorn's entirely, he was the only one who met with Rockwell for the first six months," Noorda says, adding: "I was operating the company according to plans he gave me. He never gave up the chief executive officer's role. He was fully responsible for all decisions."

Whoever guided GA, it was foundering so badly by August that management emotions reached the flash point. While the precise sequence of events remains murky, the battles in the August board meetings ended with Goshorn solidly in control as chairman and president. The four outside board members' attempt to gain unchallenged authority for Noorda could not prevail against the almost 40% of common shares held by Goshorn and his associates. The four and Noorda resigned.

Noorda's view of what went wrong differs dramatically from the chairman's. "Goshorn would not face up to facts. Our two main products were going obsolete, and the company fell apart from bad production and business decisions and failed to remain competitive. . . . On the low end, he tried to use unproved technology to leapfrog competition. On the high end, total failure. We just had nothing to sell."

What now? With executive infighting and the intrigue settled, what is GA's competitive situation now? And what are the chances it will regain its momentum? The chief executive officer is optimistic, basing his optimism on the new three-product MOS line. "They offer twice the performance of Digital's product," he claims, referring to Digital Equipment Corp.'s LSI-11 minicomputer. Indeed, the preliminary industry assessment of the GA line seems to be that the models 110, 220, and 330 are soundly designed computers, wholly compatible with the firm's previous products. The top-of-the-line 440 is also state of the art with its low-power MSI Schottky circuitry.

Stacking up. According to one knowledgeable industry source, the $531 price of the one-board 110 is competitive with DEC's $534 LSI-11, but the 110 has only 1 kilobit of memory as opposed to the LSI-11's 4 kilobits. However, the 110's execution speed is 2 microseconds; the LSI-11's is 3.5 μs. On the high end, says the source, the 440 appears to be a competitive medium-performance computer.

The major question currently concerns production problems with the three models (the 440 has been delivered in limited quantities since June). One informed Wall Street source says flatly that GA's "production is out of control." Reacting, Goshorn chooses his words carefully: "A little harsh, maybe, but fairly correct. It's coming under control gradually." He estimates that by the end of January, production should be "back under acceptable control."

For the near term, Goshorn estimates another GA loss in the first quarter, breaking even or better in the second, and improving profitability for the remainder of the fiscal year.

Religious question. Aside from production, there is the question of what, if any, is the effect on the company of Goshorn's fundamentalist religious beliefs. Those are the subject of speculation and rumors in Southern California industry circles and received national attention in an article in Time magazine. Noorda claims they hampered GA and represented a final reason for his resignation. It was too much, Noorda says, when Goshorn told him of a divine message that "appointed, annointed, blessed, and set me apart" to direct GA.

Goshorn asserts that such convictions lend strength to his company and himself. "I'm both a Christian and a patriot, and not a fanatic," he states. "The strongest leadership is to tell people what you believe and take a stand—in this case, the ultimate one. I'm not trying to convert anyone." □

Downturn

December 1973: GA announces $500 SOS microcomputer.
May 1974: Announces second SOS computer.
Fourth quarter 1974 (July 31): Reports $20 million sales; $61 million for year.
First quarter 1975 (Oct. 31, 1974): Sales drop 30% for quarter, profits slump.
December 1974: Noorda announces failure of SOS program.
First half 1975 (Jan. 31): GA reports losses on $2.5 million inventory write-down, high overhead, and production problems.
August 1975: Noorda and all four outside directors resign; Goshorn renamed president.
Fiscal 1975 (July 31): Goshorn reports $4 million loss for year.

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Sony: market dilemma

Director Iwama seeks to firm up sales in smaller U.S. cities and push VTR in color-saturated Japan

One of Japan's and the world's most innovative consumer electronics firms entered 1975 under a cloud of recession and uncertainty. Sony Corp.'s domestic sales were down, net income had slipped, the worldwide economic decline dampened overseas sales, and the climate for new products was unfriendly.

In the previous fiscal year, Sony's net sales had increased 26% to $1.3 billion, but net income had dropped 2% to $83.3 million. Like all Japanese consumer electronics producers, the company was forced to cut back production to ride out the economic storm. But the recession hit Sony at a precarious time: it had begun a strategy of promoting high-priced, console-type color-TV receivers for the domestic market and was just about to begin a serious effort to market home video cassette players—both moves that called for a strong, free-spending economy. But after the oil crisis, consumers were more inclined to buy low-priced, economy products.

As Sony nears the end of fiscal 1975, what is happening to its markets? How has it been managed during the recession? For the answers, *Electronics* interviewed Kazuo Iwama, corporate deputy president and chairman of Sony Corp. Here are excerpts from that interview.

Q. Sony has a reputation for doing things differently from other consumer electronics firms. Have you done anything differently in trying to recover from the recession?

A. We are putting more and more money into development of products, but there have been no big changes in marketing—in this sense you might say we are doing things differently by not reducing effort. Sony has been strong in the major cities in Japan and in the U.S. Now we are attempting to increase our activity in the smaller cities and rural areas.

Q. How has Sony performed in 1975, compared to 1974?

A. Recovery began in January and February. In June and July we were in a very good inventory position, so production was up. Sales for the year will be up, but profit is the problem. Profit margins may be down. In the United States total color-TV sales went down, but Sony increased sales and increased its share of U.S. market. In America, people were buying for the Sony quality reputation despite our higher prices. The Japanese consumer, however, does not want a high-priced TV set. He wants a 13-inch and 14-inch set at very reasonable prices.

Q. What is the condition of the color-TV market in Japan today?

A. Price competition has been very sharp. There has been no change in the number one market share position, but there have been almost monthly changes in the market share of second, third, and fourth positions. We expect a total of about 5.5 million sets to be sold this year in Japan, compared to 5.14 million in 1974.

Because the Japanese market has reached saturation, growth will not be the same as in the past. Still, we do not expect a shakeout of TV manufacturers.

Q. What is the outlook in the "post-color" market, now that saturation in Japan has passed 90%?

A. We expect that what we in Japan call video systems—VTRs in the U.S.—will gradually open a wide consumer market as the prices come down. It's a new industry, so we have to educate the people in how it is of value in the home. With radio and TV sets, people have programs available, therefore the hardware makers need only to produce good

products and that's enough. Video systems need another effort to make them profitable.

It will take a long time, but the kickoff of Betamax [Sony's high-density video-tape cassette system] last May was good. We are selling more than we can make at present. Sony is marketing a new console-type video-TV in Japan in which the Betamax video deck is combined with an 18-inch Trinitron color-TV set equipped with a built-in timer. The total price, 449,800 yen [$1,499] is still high, but there is a market for this system. [The same combination, but with a 19-inch receiver, has since been introduced in the U.S. for $2,295.]

The video deck is priced at 229,800 yen [$766]. The selling price will continue down, because at 100,000 yen [$333] there is an enormous market. This low price is not our aim now. We want to bring along the market for a few years. Low-price talk now will only mislead the public. We are not in a hurry.

Q. What about the arrival of the video-disk players? Won't they hamper tape players?

A. The same is true for the video disk and video cassette as was true for the audio disk and audio cassette—coexistence. So I'm not so afraid of the video disk. I'm more and more confident of the Sony video product because we have accumulated so much experience and technology in the video field. We will sell Betamax in many ways—as a stand-alone unit, with a TV set, with and without tuner, or built into a console. The video disk will help sell the video cassette. The disk needs software, but if the people want to record, they will buy the cassette.

Q. But hasn't the lack of standardization among the video player systems held back growth and confused consumers?

A. Yes. Lack of standards originally restrained the market for audio players, but then some of the competitors folded and those remaining prospered. Now there are many video formats, but we believe that Betamax will be the final format.

Q. Japanese consumer electronics companies are subdued and uncertain about the future. Have the Japanese lost their confidence?

A. Yes, to some extent, because in Japan since the oil crisis, there is no confidence in obtaining material resources at low price. We have no natural resources. We can't raise wages and we can't raise prices or we will lose export competitiveness. To realize full employment with no natural resources, we must export in order to import.

From Sony's point of view, we want to export quality products to make profits and keep our overseas strength. Domestically, we must stimulate industry by creating new markets. Right now the Japanese consumers are reluctant to spend, but another feature, like the video cassette, will be different.

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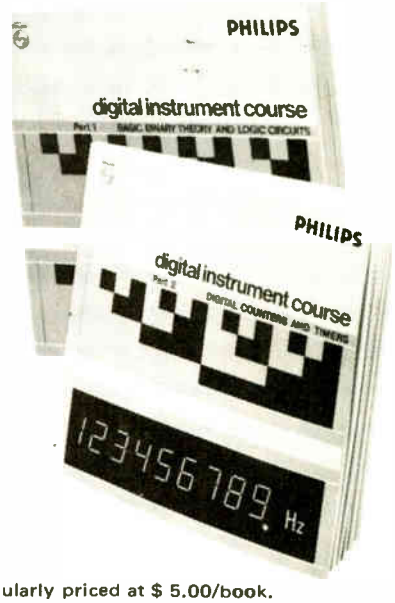

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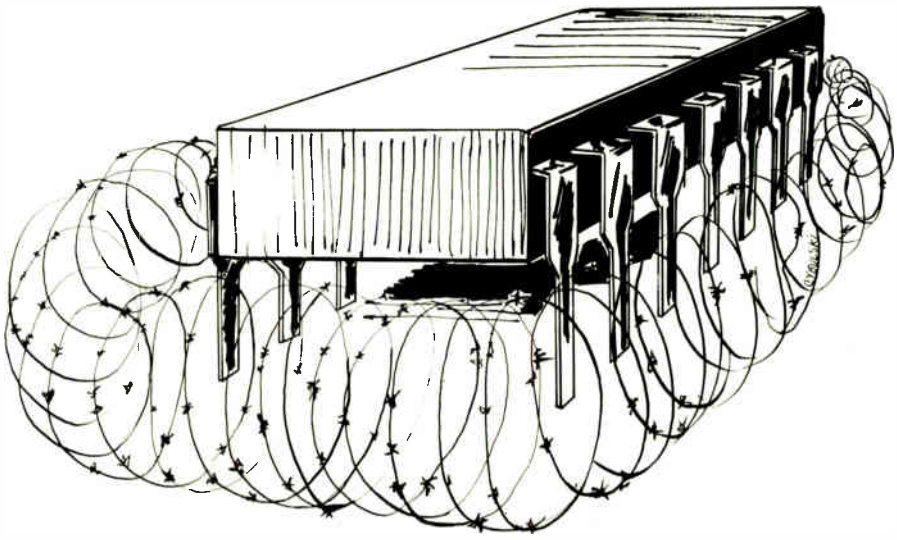

Patents

Recession spurs infringement suits

Royalty and licensing revenues look good to semiconductor companies as they take to the offensive on patent protection

by Howard Wolff, Associate Editor

Battles over patents always have been part of the hurly-burly of the semiconductor industry. But in recent months there has been an upsurge in protective zealousness, culminating in the suit by Western Electric Co. against six semiconductor firms [*Electronics*, Oct. 15, p. 34]. Among other active suits are General Instrument Co. vs Mostek Corp., Motorola Inc. vs MOS Technology Inc., and Bowmar Inc. vs Texas Instruments Inc. There are several reasons for the activity.

For one thing, the suits may indicate that the semiconductor industry is maturing. Robert B. Shapiro, General Instrument Corp.'s director of legal affairs, says, "When you first start out, it's a life-and-death struggle. All you're concerned about is having the right product and selling it—you don't have time to worry about patents. Now, the patent process has become a normal part of doing business."

In addition, when business is bad, threatening suit to obtain income from royalties or from cross licenses is an enticing prospect. Furthermore, a company with an extensive licensing program—none in the industry is more extensive than Western Electric's—often goes to court "to maintain the viability of its program," says the patent attorney for one Silicon Valley manufacturer. Another manufacturer believes Western Electric has something else in mind: "They're looking for income," he says.

Protection. While the cost of a legal action can run to a quarter of a million dollars, royalties usually are pegged from 0.1% to 6% or 7% of sales—and that includes back royalties. At Bell Laboratories, where 80 attorneys labor full-time over patent matters, the major consideration is protection of licensees who would be understandably upset if competitors were permitted to pirate the technology that they pay for. Bell also uses its patents to obtain cross licenses to make sure that its parent, Western Electric, has access to the latest technology.

The attorney for one major semiconductor house points out that patents may be used either offensively or defensively. Offensively, "a company will use a patent solely to generate revenue" or to protect its technology. Defensively, the patent holder can use its position to exchange information with other companies—frequently without charge to either one.

The same lawyer agrees that patent litigation may be on the upswing because of the recession: "Revenues are down, and people start looking for ways to make money." But he says that Western Electric is more concerned about protecting its paying licensees. "It's hard to collect royalties if other people are infringing the patent."

He also notes that Western Electric has little to lose by filing a suit based on its expired patent (there is a six-year grace period for such action). If the court somehow decides Western's patents are invalid, the company would not have lost all that royalty from years back. Western Electric itself won't comment.

Licensing. Discussion of when to act defensively and license and cross license patents occupies a good deal of time in executive suites. Some patent holders, such as Bell, are liberal with licenses; others, such as Mostek Corp. of Carrollton, Texas, aren't. "It hasn't been our corporate philosophy to actively seek licenses or cross licenses," says executive vice president Berry Cash, although Mostek "has developed a patent

portfolio for use whenever necessary in cross-licensing negotiations." But the use of patents defensively—to obtain cross licenses—is a valuable business ploy.

The classic licensing agreement, says Vincent Rauner of Motorola Inc., grants only the right to make and sell a semiconductor product. Rauner, the company's vice president for patents, trade marks, and licensing, is based at the Semiconductor Products division in Phoenix. Although most existing deals leave the licensed company on its own to come up with the technology needed to make a product, he says, a trend is developing for agreements to include technology.

At TRW Electronics in Los Angeles, which does a brisk business in licensing its transistor-transistor-logic patents, Albert Coakley, senior legal counsel and vice president, says licensing never includes processing or how-to information. That, along with masks, test equipment, and directions, comes under the heading of "trade secrets," he says. Sums up Roger S. Boravoy, vice general counsel at Intel Corp.: all a license gives the licensee "is the freedom from getting sued."

Weapons. Since patents can be used either as weapons or to gain knowledge, or be ignored until some advantage can be gained from enforcing them, just what is the value of a semiconductor patent? TRW's Coakley contends that it's worth only what the company holding it makes it worth. "On its own," smiles Coakley, "a patent certificate is just a pretty thing to keep up the spirit of engineers."

How does a company decide when to go to court? Motorola's Rauner says that litigation most often takes place after the failure of negotiations on licensing or if a dispute about patent applications can't be settled. Such a dispute is one of the legal points in Motorola's suit against MOS Technology, he says. Another important factor, adds Rauner, is timely action. Not acting promptly in filing a patent-infringement suit hurts recovery prospects in the patent courts, he says. □

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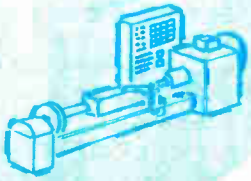

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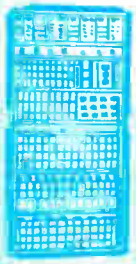

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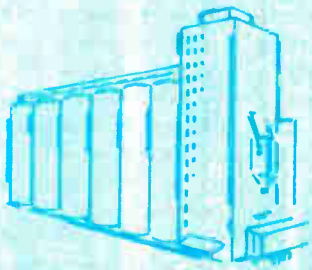

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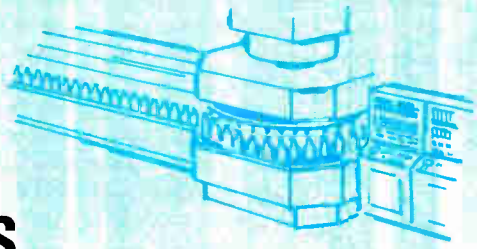

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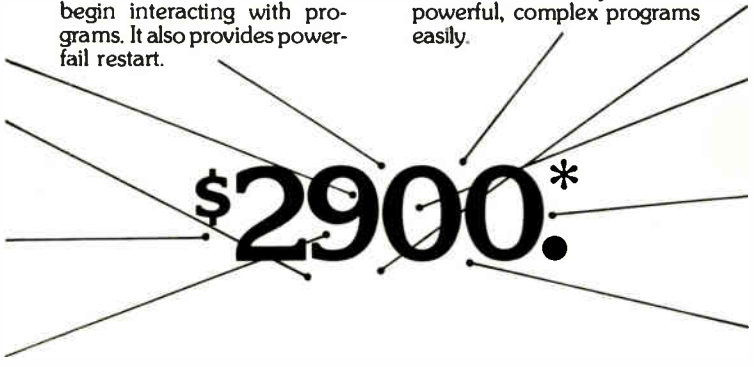

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Solid state

Don't count out C-MOS yet

That's what makers say, despite bad 1975; design activity and interest by large-computer manufacturers are increasing

by Ron Schneiderman, New York bureau manager

The best that most C-MOS suppliers can say about 1975 is that it is almost over. Indeed, while RCA's Solid State division, which claims 44% of the market, and several smaller makers of RCA's standard 4000 series were licking their wounds and planning for better days, Signetics Corp. of Sunnyvale, Calif., last month unceremoniously dropped its entire line of standard C-MOS products (see p. 29).

Citing Signetics' late entry into "a market that has not developed as anticipated," Robert Lanford, Logic division marketing manager, notes that the 1975 C-MOS market total was projected to be as high as $200 million. However, "the actual will be less than $120 million, with the standard domestic market around $75 million."

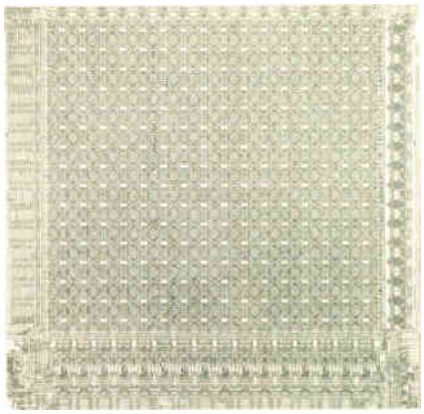
Signetics followed Siltek International Ltd., a Canadian-based supplier with a reputation as an aggressive pricer, which priced itself right out of the market only a few months earlier. But does all this mean that standard C-MOS is no longer a growth market?

Looking up. Not yet, say suppliers, adding that things are beginning to look up. Philip R. Thomas, RCA's division vice president for MOS products at Somerville, N.J., says, "We're seeing a steady increase in demand, month to month, starting about three months ago." Bob Bennett, C-MOS marketing manager at National Semiconductor Corp. in Santa Clara, Calif., says that many of the small and medium-size C-MOS user companies that were hit hardest during the recession are starting to buy again, and prices are stabilizing. "Shippable bookings are high, and total C-MOS bookings even higher, which means long-term business is also improving." And despite a significant drop in both sales and earnings during the first nine months of the year, Solid State Scientific Inc. of Montgomeryville, Pa., insists that it is now "faring quite well," and maintaining a 14% market share.

What happened to the C-MOS market during 1975, in the opinion of Wolf Loescher, manager of C-MOS marketing for second-ranking Motorola Integrated Circuit division, Austin, Tex., is that it has been delayed for one year—mostly by economic factors. He expects 1976 growth to hit the mark previously anticipated in 1975. "In fact, we expect a 45% growth in dollar sales in 1976 to around $200 million," says Loescher.

None of the C-MOS makers feels threatened by advancing technology in logic families, such as programable LSI circuits or microprocessors. At least, not yet. "In terms of numbers of units and new designs, C-MOS is still early in its growth curve," says Bennett. A number of major companies, such as Control Data, NCR, and Hewlett-Packard are starting to turn to it, mostly for use in terminals. "Previously, the market has been the smaller companies." He adds that "programable LSI circuits are not a significant factor."

One of the growth applications for C-MOS, says Bennett, is in peripheral-interface circuits for microprocessors, and an active development program is underway at National. In addition, National is expanding its standard C-MOS-logic family through second-sourcing of RCA and Motorola designs.



Alive and kicking. Don't think of C-MOS as a dormant technology, caution its makers. They point to renewed design activity.

Competitor coming. Both Bennett and Loescher contend that the only competitor that might dent the C-MOS market—but not replace it—is low-power Schottky technology. "But not for at least three years," says Loescher. Meanwhile, he says, the two will "co-exist peacefully," while C-MOS LSI picks up speed. "The problem with LSI," says Loescher, "is that it was introduced into the teeth of the recession, with little system-design activity."

Signetics, meanwhile, is shifting its emphasis to microprocessors and low-power Schottky devices. RCA has already announced its 8-bit C-MOS microprocessor Microkit, and is pushing C-MOS-on-sapphire, calling it "clearly an LSI technology."

In addition to its existing SOS line in New Jersey, Thomas says that RCA will begin production in Palm Beach, Fla., just as soon as the demand for C-MOS-on-sapphire justifies such a move. □

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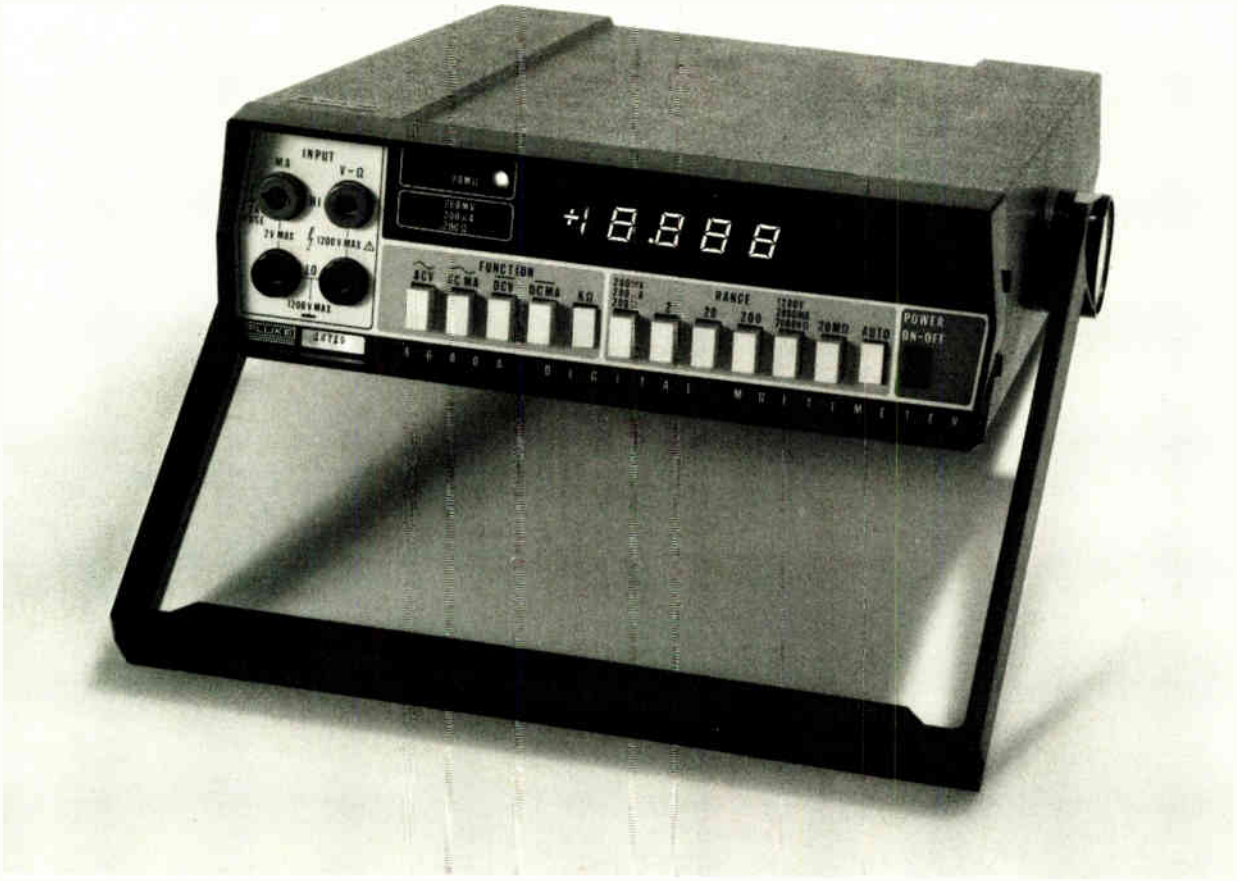

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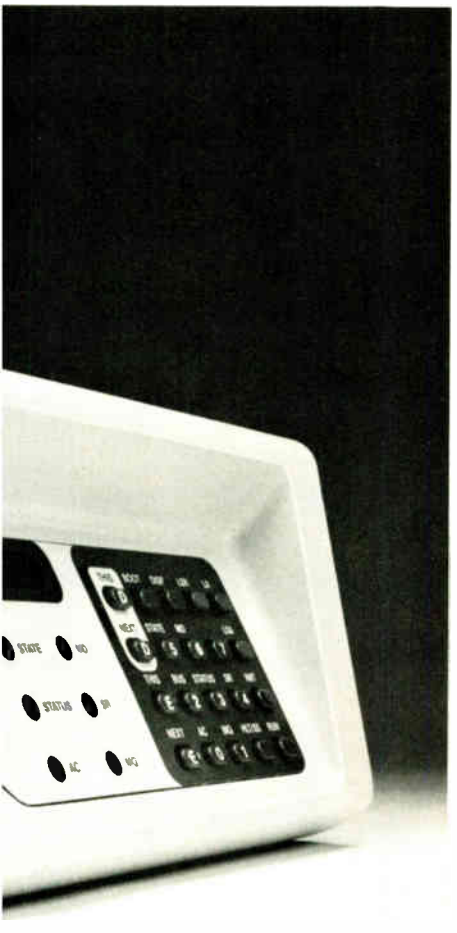

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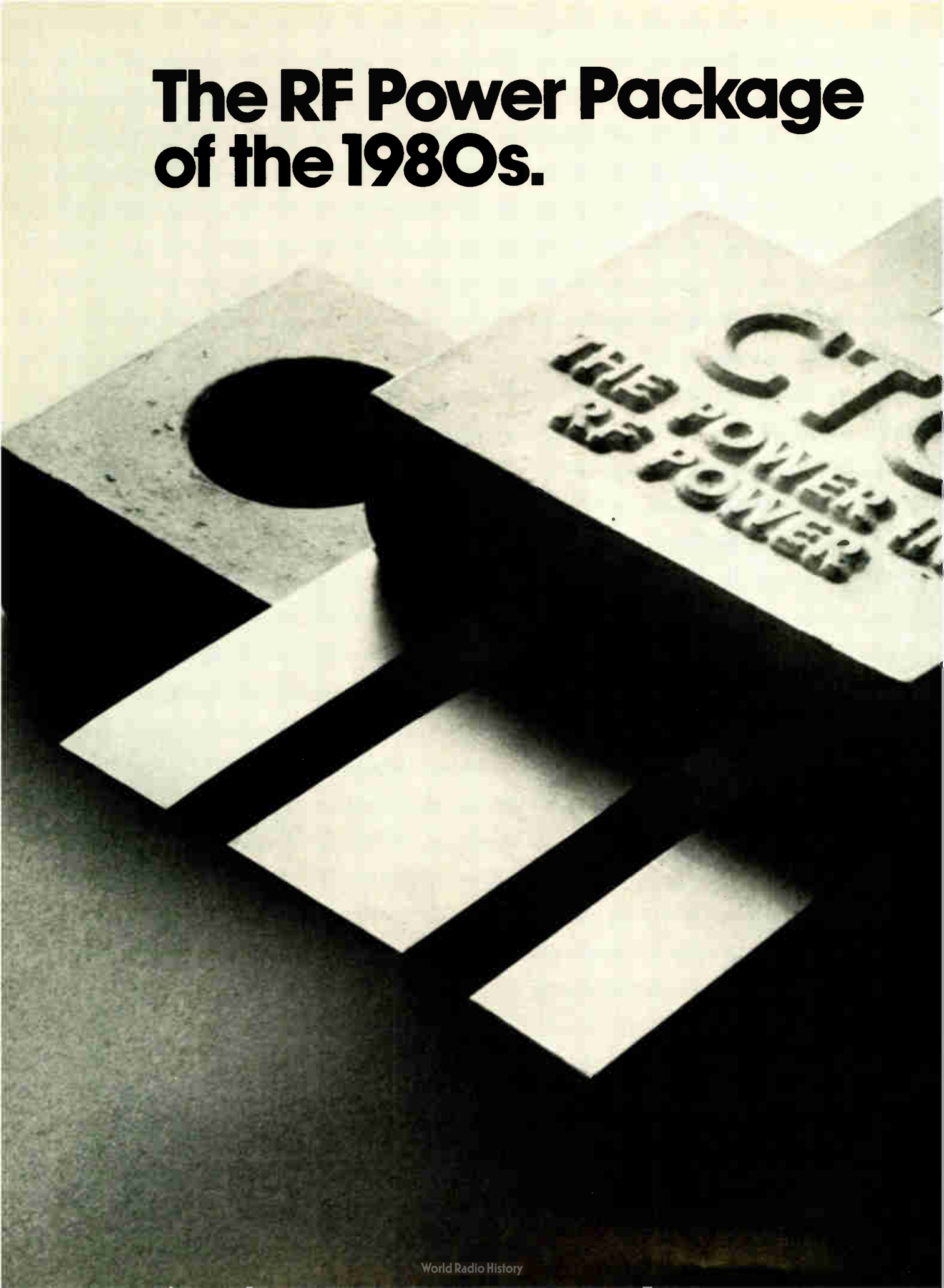

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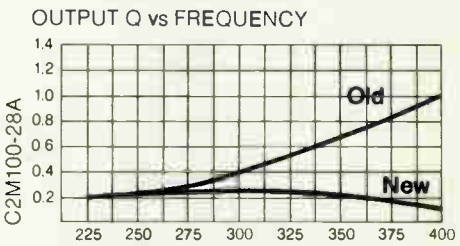

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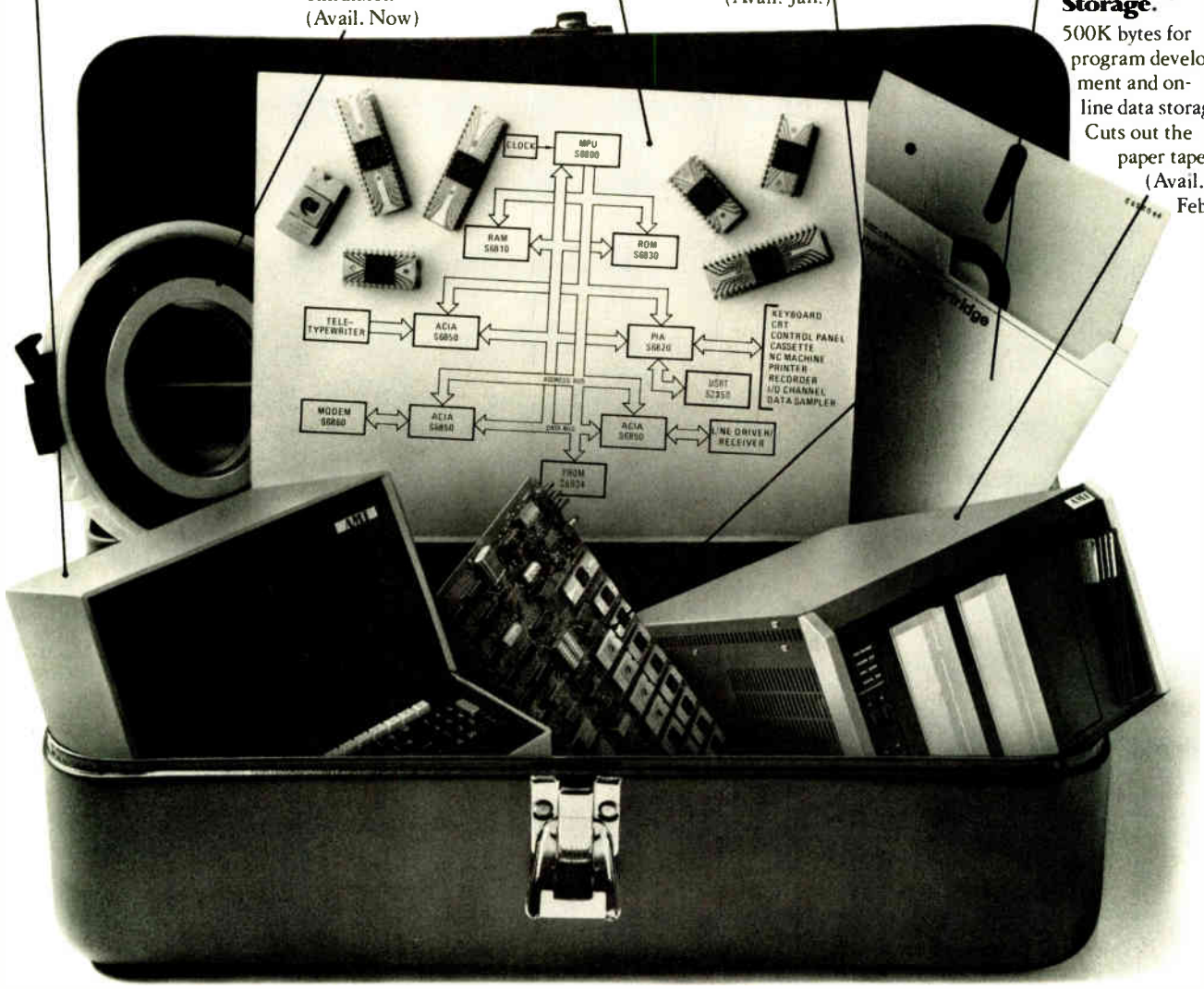

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Transformed by technology for new functions

by Richard Gundlach, *Communications Editor*

☐ The telephone is celebrating its 100th birthday with an astonishing outpouring of new capabilities and services. Constrained for its first 90 years or so by its strictly electromechanical nature, it owes most of its new versatility to its use of large-scale integrated circuitry and computer technology.

The all-electronic telephone is unlikely to be an economical proposition for some time, but the partially electronic push-button tone phone handles data as well as voice traffic—which the rotary-dial phone could never do—and promises eventually to turn into a low-cost data terminal. Equipped with memory, it stores a list of most often called numbers, and only slightly more elaborate versions serve as point-of-sale terminals or funds transfer systems.

To move out from the phone itself, all-electronic equipment that switches calls under stored-program control can supply each office with a unique set of services, indicating busy lines and waiting calls and storing forwarding numbers. And the nationwide radiotelephone network that's in the offing tracks mobile phones from computerized base stations.

To these technological advances must be added the effect of Federal Communications Commission decisions. The opening up of a 40-megahertz slot in the 900-MHz region for use by all qualified common-carrier system developers has given the mobile and portable radiotelephone a new boost. And the recent decision to permit AT&T customers to interconnect to telephone lines without an AT&T interconnection module will allow for more competition between the Bell System and independent manufacturers. The resultant much freer use of interconnects—whether answering devices, data modems, or display terminals—adds still further to the telephone's usefulness.

The new telephones and telephone services could not have been developed without the prior development of the more efficient and versatile electronic switching systems (ESSs) which, in the 1960s, also began incorporating software for greater flexibility. These stored-program electronic systems, as they are called, do away with the need for physical rewiring and instead use programing techniques to reroute circuitry. This made it more practical for telephone companies to offer a customer such services as automatic call transferring and speed dialing of selected numbers stored in memory at the switching center.

More recently, as the Bell System realized it was installing more digital plant, as data traffic grew in volume, and as higher-speed integrated circuits became available, AT&T evolved a new all-digital electronic switching system, called No. 4 ESS. The first of these systems will go into operation in Chicago next month for toll switching. It can handle 550,000 long-distance phone calls every hour, or five times as many as the current No. 4 crossbar-type toll-call switcher.

Nor is the No. 4 ESS the last word. Soon after it becomes operational, Bell plans to introduce what it calls common channel interoffice signaling (CCIS), a high-

speed, high-capacity system for linking electronic switching offices across the nation. By separating the voice and signaling paths, CCIS will greatly reduce the time it takes to set up and take down long-distance calls.

Programed exchanges make light work of doing business by phone

Private branch exchanges have come a long way since 1904, when the first 80-line, 15-trunk No. 4 PBX with its manual cord-type switchboard was installed. Since then they have moved from manual through electromechanical to electronic switching and finally to dedicated computer control of electronic switching.

What has made the stored-program PBX possible is the low cost of microprocessor, logic, and memory ICs. This year, in particular, has bred processor-controlled PBXs that are easily as sophisticated as the needs of today's businessman. Features can be added or subtracted almost at will, residing as they do either in software or partly in custom memory circuits and partly in programable read-only memory that tailors the machine to a specific application. Such a PBX often has no need of key telephone stations, with their buttons that give access to extra lines, and just four wires connect all the phones to the much smaller PBX equipment cabinet.

As a result, the customer gains a number of new services. A tone alert lets someone on the phone know another call is waiting, and several calls can be put on hold without the aid of a bulky key phone. A person who plans to be away from his desk can use his own phone to place into memory the number where he can be reached—a feature called forwarding. Three-way conferencing is easy, and no longer must time be wasted waiting for a wide area telephone service (WATS) line, since outgoing trunk queuing will automatically place a call on the next free outgoing trunk.

Automatic call accounting even turns these new PBXs into a management tool for cost control, and some PBX makers are already talking of extending that capability to collect and process information other than details of outgoing telephone calls—for example, to report alarms, time spent with a client, the number of pieces processed from the floor of a manufacturing facility, defects in those products, and so on.

American Telephone & Telegraph Co.'s newest system, with the trade name of Dimension, is perhaps the most powerful of these PBXs to hit the market (Fig. 1). By the end of 1976, it will handle 400 lines and be offering users altogether 200 distinct features. Its main memory has the various feature programs loaded into it by a magnetic-tape cartridge. A secondary or backup memory containing several million bits carries off-line programs for diagnostic routines and to revise information for a particular installation.

In Europe, International Business Machines Corp. is marketing a switching system called the 3750. Besides the normal PBX functions, it allows a user to interrogate

The beginnings in Boston

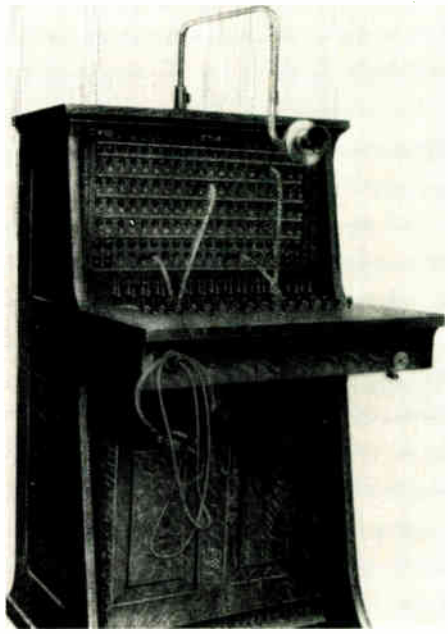
It has been a hundred years since a faint but momentous sound was made by Thomas Watson when he plucked a reed of a rudimentary transmitter. But that sound traveled over wire and was heard in another room by Alexander Graham Bell, who happened to be holding a similar reed-and-diaphragm apparatus to his ear. This was the first telephone signal.

Later, on Feb. 14, 1876, Bell filed for the now famous patent on the apparatus that he and Watson had been working on—just three hours before one Elisha Gray filed a *caveat* with the Patent Office, declaring that he was working on a similar device but had not yet perfected it. Had the timing been different, we now might have a "Ma" Gray instead of Ma Bell.

The first telephone patent was issued to Bell on March 7, 1876, three days before the historic moment when the first intelligible human voice was transmitted over the new telephone. Bell, after spilling acid over his clothing, had called out, "Mr. Watson, come here. I want you!" Next year the first commercial telephone went into service when a Boston banker leased two instruments, each consisting of a simple wooden box that contained both transmitter and receiver (see figure below). The user had to alternately talk and listen.

According to the records, the seed idea for the Bell System was planted when a merchant named Thomas Sanders made a verbal offer to Bell to finance the telegraphic experiments. They reached a tentative agreement, and shortly afterward a lawyer named Gardiner G. Hubbard made Bell a similar offer. The three put into writing an agreement dated Feb. 27, 1875, and later signed a deed of trust, dated July 9, 1877, forming the Bell Telephone Company, Gardiner G. Hubbard, Trustee.

On Feb. 12, 1878, New England Telephone Co., the forerunner of the Bell System's associated companies, was formed to serve the New England area. To provide service outside New England, a corporation was formed on July 30, 1878, called simply the Bell Telephone Co. The national character of telephone development was officially recognized on Feb. 17, 1879, when these two companies merged to form National Bell Telephone Co. Then in 1880, a certificate of incorporation was filed for the American Bell Telephone Co., but it wasn't until Feb. 28, 1885, that the American Telephone and Telegraph Co. came into being.



1. **More than a switch.** The first standard PBX in the Bell system, an 80-line, 15-trunk machine manufactured in 1904, was designed to serve as the standard switchboard. The newest PBX, introduced this year under the trademark Dimension, is an electronic, stored-program switching system that handles 400 lines and offers a myriad of features that can be changed simply by changing the software.

a computer with his standard push-button tone telephone.

Remember the old movies where the high-powered executive always had a dozen phones and lines all over his desk? It was the key telephone that eliminated all that. A key phone is an individual telephone console containing a set of manually operated key buttons that can be used for intercom and signaling and also enable the user to access more than one telephone line to the central office. Typically only a few of the keys actually bring in extra lines—the rest are used to put calls on hold, for conferencing, or for signaling. The culmination of all this was the call director used by secretaries.

A PBX in miniature

Key telephone equipment has now evolved into almost a "mini" PBX. Such a unit offers direct-trunk selection, dial-up intercoms, plus selective retrieval of calls put on hold—a capability that few PBXs have.

Aimed at smaller businesses' needs, for instance, is a Bell product (Fig. 2) that will handle 16 stations and four central-office stations. It offers the subscriber key-system capability without a cabinet full of equipment or an attendant's console. Trademarked COM KEY 416, the system offers standard services such as multiple-line pickup, hold, line-status LED indicators, intercom, and tone ringing. Multiline conferencing can be done, loudspeaker service with volume control is built in, and recall is provided—this has the same effect as replacing the handset and lifting it again for a dial tone.

GTE International is also working on an all-electronic key set. Its new 8000 system (Fig. 3) has 25 extensions, five trunk lines, and five central-office lines and can handle five simultaneous conversations. The 8000 uses four p-MOS MSI chips made by GTE Laboratories, Waltham, Mass., which will shortly also begin testing and evaluating the first 15 machines now being shipped over from GTE's Belgian facility.

The creative touch

The advent of the push-button tone telephone, better known by its trademark Touch-Tone, and the arrival of low-cost ICs have triggered startling changes in the design and capability of the originally simple, point-to-point communications device. Examples of the new versatility range from speed dialers with memory and answering devices to crossbreeds, part phone, part calculator, and part clock. These instruments permit telephone conversations and calculations to go on at the same time and display the exact time in hours, minutes, and seconds when the calculator portion is not in use. Even cordless phones have appeared, operating on radio frequencies. And that's not to mention the wild variety of decorator phones that now grace shopwindows and phone marts.

Still, telephone engineers had no easy task getting all the needed functions onto chips. They had to provide for voice-level regulation, tone generation, polarity-reversal protection, and sufficient cancellation of sidetones, as well as such newer features as speed dialing.

A major problem is the range of voltages involved. For instance, when the telephone has been ringing and is taken off-hook, the 90-volt rms ringing voltage may remain for 100 milliseconds or so. At the same time, all the circuitry used must function at low voltage. On very short loops from telephone to central office, the battery

voltage from the central office at the telephone set never exceeds 12 V, but on longer loops it could drop below 4 V. What's more, the battery voltage from the central office can be of either polarity during operation.

Despite these problems, solid-state memories are already finding their way into a telephone terminal device called a repertory dialer. This device stores in memory the numbers most frequently dialed by a user, who can dial any one of them simply by pushing a button. The dialer also stores the last number dialed manually, so that if the connection was not made, the user only needs to push one button to place the call again.

Studies show that 95% of the phone numbers dialed from a given telephone are contained within a 25-name repertory. A Touch-Tone dialer would need only 1,024 bits of memory to store such a repertory and could cut the 12 or 14 seconds of dial-code transmission time of a rotary dial system to less than 2 seconds, thus greatly reducing the load on the telephone switching system's holding time.

One problem for repertory dialers is that memories are volatile and must be protected against power outages that would wipe out all the stored telephone numbers. Until nonvolatile n-channel metal-oxide-semiconductor and magnetic-bubble memories become available, complementary-MOS memories that need only microamperes to keep refreshed are being favored.

That problem did not arise with the first repertory dialer, which was introduced in 1961 and used perforated plastic cards to store the numbers. Later, though, Bell switched to large-scale ICs for the memory and in its current repertory dialer uses p-channel MOS logic and memory. It is evaluating an all-C-MOS approach or a combination of C-MOS logic and nonvolatile bubble memory for their relative cost-effectiveness. If the C-MOS memory were chosen, central-office batteries would trickle-charge a small battery to keep it alive for over a year should power fail.

Another example, a repertory dialer telephone being developed by General Telephone & Electronics Corp., employs two C-MOS chips—a memory and tone generator—to store and dial nine 16-digit numbers plus the last number dialed. The 16 digits are to cope with international calls, and at 4 bits a digit a 64-bit memory is adequate. The tone generator uses a 3.58-MHz crystal (the type used in color-television subcarrier oscillator circuits) as the master frequency standard which is then appropriately divided down. Both chips are powered by local-office batteries, or about 4 V at the phone.

"The biggest problem we had was making a high-frequency dividing system operate reliably with a maximum of 3 V," comments Lee Davenport, president of GTE Laboratories. And since some switches in some older central offices cut off voltage to a telephone for about 300 milliseconds during dialing, a capacitor is used to store the voltage for that short time. "We thought of using nonvolatile n-MOS memory, but we just couldn't afford it," says Davenport. "We have talked with Texas Instruments about I^2L [integrated injection logic], but we'll stick with C-MOS for now because of its lower price."

Bell's repertory model, the Touch-A-Matic, which stores 31 numbers plus the last number dialed, has a dial-tone detector that features one-touch dialing. To make the set go off-hook the user just pushes a button instead of lifting the handset. Then the set automatically dials the stored telephone number, and, once the connection is made, the user may pick up the handset for privacy or just talk in the direction of the telephone. Bell plans to offer a 16-number model for home use.

2. New tool. The control cabinet of the Dimension PBX contains a maintenance panel into which a "craftsperson," as he or she is called today, can key information necessary to change a customer's services. The panel also helps in diagnosing PBX troubles.

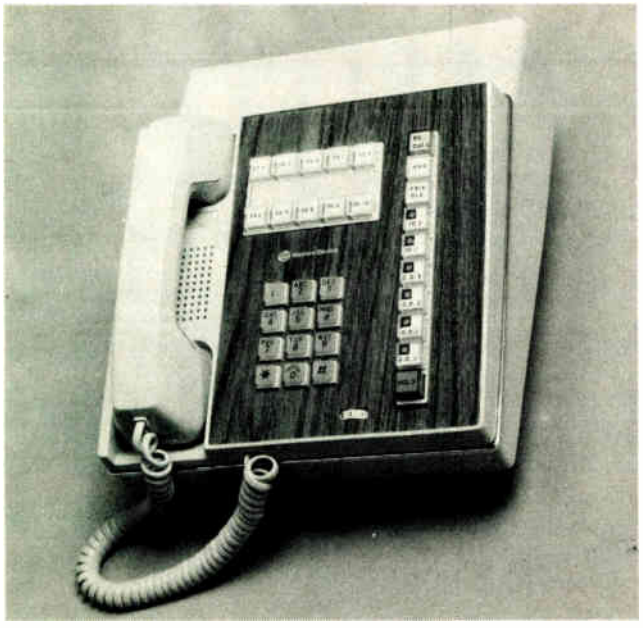
The multinational telephone

Did you know that there are more telephones in Washington, D. C., than people? And as of Jan. 1, 1975, there were almost 144 million telephones in use in the United States? Or that if you lived in Tokyo and wanted a telephone installed, you'd have to pay about $667? Or that in France there is a 15-month wait to have a phone installed? And that even then it costs about $250 to get connected?

The number of telephones in use worldwide increased by 23.4 million to over 336 million during 1974, a gain of some 7.5%. The U.S. retains the lead with 138.3 million, Japan follows with 38.7 million, the UK with 19.1 million, the Federal Republic of Germany with 17.8 million, and the USSR with 14.3 million. The largest individual growth, 24.4%, occurred in Taiwan. Altogether, 41 countries now have more than 500,000 telephones each.

All-electronic phones as yet lack economic appeal

Although electronics has made many improvements in the telephone, telephone companies are in no hurry to convert all the existing telephones into electronic



3. Stand alone. Bell's new key telephone system, (left) COM KEY 416, serves businesses needing up to four central-office lines and 16 telephone sets. The system consists only of the telephone sets shown and the cables required to link them, eliminating the present need for bulky wall-mounted key-service equipment cabinets. GTE's electronic key set is just going into final evaluation testing. The 8000 system can handle up to 25 extensions and five central-office lines. Its nonholding push buttons light when pushed.

models. Such a move would, of course, be a boon to the semiconductor industry, but the telephone companies lack the kind of cash flow needed to replace the several hundred million main-line telephones now in use.

The more recently built units do contain some electronics. Tone ringing circuits, as well as dynamic-type microphones and solid-state amplifiers in both the transmitter and receiver, can be found in Bell's G-46 handset for rural areas, for example. A fully electronic telephone, though, would completely eliminate all electromechanical parts—a tone ringer would replace the bell, a push-button generator and keypad the rotary dial, memory would be needed for storing and rapidly dialing frequently used numbers, and a LED display would have to be included for communicating with data systems to order merchandise by phone or check out a bank balance. Such an all-electronic telephone could also be made much smaller and in almost any shape.

But as far as making a significantly cheaper telephone with modern-day electronics, Lee Davenport of GTE Labs speaks for most telephone companies when he says, "The electronic telephone still awaits even lower-cost solid-state devices, and with hundreds of millions of telephones in service, most telcos can't afford any price increases." James W. Fitzwilliam, executive director, Station Systems division at Bell Telephone, agrees, pointing up the fact that so far, no one has found a way to make a tone ringer circuit and a speaker that's cheaper than the old reliable bell ringer.

Ken Nixon, manager of telephone apparatus at Bell Northern Research, Canada, thinks that people's attitude toward the telephone must change before the telephone set will change, but adds, "If someone comes along with an electronic phone every company in the business must have one ready to compete—and everyone does." This may be true, but most companies are playing their cards close to the chest.

ITT is an exception. In conjunction with Jutland Telephone Co. in Denmark, ITT's Standard Electric A/S is talking about readying an all-electronic telephone (Fig. 5) in 1977, using its version of push-button dialing. According to Frank Palen, who is in charge of technical matters for station apparatus for ITT worldwide, ITT's new set will include an optional automatic dialer, plus a LED display of alphanumerics and an extra row of buttons that turn the phone into a low-cost data terminal.

A relatively small Canadian company, however, plans to introduce an all-electronic phone much sooner. Mitel Corp., Kanata, Ontario, feels there is a market for a premium type of telephone that would reduce the clutter on an executive's desk, and it plans to back this feeling sometime in mid-1976 with a one-piece electronic phone that should sell in the $300 range.

Coupled with the size reduction possible with electronics, Mitel plans to offer better transmission quality, regardless of loop length, and a pleasant tone quality instead of the harsh bell sound. The phone therefore has a warbling tone that starts softly and builds up slowly to a tolerable degree of loudness so that there is no need for a volume control. After the third ring it's loud enough to be heard at a distance. The speaker in the mouthpiece will double as the speaker for the ringing tone. The earpiece is not used for this purpose, because there would always be the possibility of getting a blast in the ear if ringing had not yet stopped, or if the button were pushed for automatic redialing.

"On the whole we'll use I^2L LSI and thick-film technology with bipolar op amps and a metal oxide varistor for surge protection," says Mike Cowpland, Mitel's president. I^2L's attractions are its density and ability to operate at low phone-line voltages of 4 V or less that finally reach the set from the batteries located at the telephone companies' central office. A LED display will be used, and a calculator-type keyboard.

Nationwide radiotelephone networks will link people on the move

Next best thing to a telephone extension is to take the phone with you. Portable phones are here now, mostly on wheels, and more are on the way, including phones that could be tucked into a pocket.

With the Federal Communications Commission's recent allotment of the 900-MHz region for land-mobile use, along with the Bell Laboratories' introduction of the cellular concept, a fully interconnected, nationwide, mobile radiotelephone network seems imminent. The cellular concept reuses the allocated land-mobile frequencies many times within a given area [*Electronics*, Oct. 16, 1975, p. 84].

That area is subdivided into "cells," and the radio channels used in one cell can be simultaneously reused in various other cells that are far enough away to avoid radio interference. A caller's conversation is carried over wire lines to the base station in the cell through which the mobile unit being called is passing. A base-station directional antenna completes the path between the calling and called parties. As the mobile unit travels from cell to cell, the call is automatically and uninterruptedly given over to the appropriate base station by the computer-controlled switching office.

AT&T plans to start field trials of the mobile cellular concept in Chicago in 1978. But the smaller, handheld kind of portable telephone, which does not need a vehicle to carry it around, could come to some geographic areas sooner than 1978. At least, that's the view of Motorola Inc.'s Communications division, Schaumberg, Ill., which introduced the first such portable telephone gear in 1973 [*Electronics*, April 12, 1973, p. 50].

Martin Cooper, Motorola's director of systems operations, claims that "with today's technology, the vehicle isn't necessary." He points to advances in battery technology combined with silicon-gate MOS and I^2L technology that need very low power. "The design of a new handheld radiotelephone capable of full-duplex operation at 900 MHz is easier to do now because coils and cavities get a lot smaller at that frequency," says Cooper. "However, variable control of the power output will be needed to assure that the minimum amount of power required is transmitted," he adds.

The radio portion of the new portable telephone is relatively straightforward. But for the digital portion Motorola had to develop a synthesizer that could handle the 666 channels that are available with the cellular approach. Cooper claims something in excess of 30,000-device complexity was required just for the logic that controls supervisory functions, such as on-hook, off-hook, and dialing.

However, Motorola doesn't plan actually to operate a cellular system because the FCC prohibits a company from both manufacturing the equipment needed for a mobile system and operating it. According to Cooper, his company will offer those interested in gaining FCC approval as common carriers all the equipment necessary to operate a 900-MHz cellular system for communication over both portable and mobile telephones.

Motorola's plan is to provide a turn-key system that would include a base-station radio and switching terminals to interface the radio and telephone equipment, in addition to both types of telephones. The system would be compatible with Bell's and would allow a person to travel freely from one to the other.

Take it along

Cordless extension telephones are another form of portable phone that is useful if expensive. They operate like standard telephones but provide unrestricted mobility up to 300 feet from a stationary base unit. The base unit plugs into a telephone jack and is ac-powered from the 115-V 60-Hz power line. The portable unit is a standard phone equipped with rechargeable batteries and a telescoping antenna. The price is about $400.

One of the newest models on the market comes from Tel-Tech Inc., Milwaukee, Wis. Called Handifone, both parts have separate narrow-band fm transmitters and receivers using tone-decoder chips. The base unit transmits at 1.7 MHz and the portable telephone transmits on any one of six channel-frequencies in the 27-MHz citizens' band. Output power is about 100 mW. Six nickel-cadmium batteries power the telephone for about eight

Birth of the interconnect industry

With its 1968 Carterfone decision, the Federal Communications Commission changed the face of the U.S. telephone industry. That decision essentially opened up the telephone network to non-Bell communications devices and for the first time put the Bell System in direct competition with independent manufacturers, who could now sell communications products to Bell System subscribers. Later, the decision was replaced with the one that currently requires all "foreign attachments" to be linked to telephone lines via a connecting arrangement from the telephone company.

Then this year, in October, the commission established a certification plan that will allow Bell customers to directly interconnect data terminals (but not private branch exchanges, key telephones, or coin telephones) to local telephone lines as of next April 1. Terminal users will then be able to avoid paying installation and rental fees for an AT&T protective module. The FCC holds the view that none of the device types initially excluded from its registration program can harm the telephone lines, and it has set a Dec. 11 deadline before which interested parties must file comments on their planned inclusion.

According to a New York Public Service Commission report of last April, interconnect equipment should account for about 37% of an estimated $1 billion market in the New York Telephone service by 1984. By then, the same report predicts, N.Y. Telephone will have lost 16,800 PBX-Centrex and 46,000 key-system customers to interconnect companies.

4. An electronic future. Being readied for 1977, ITT's electronic telephone, about the size of a desk-top calculator, will feature operation without removal of the handset, automatic dialing, and a LED display that turns the phone into a low-cost data terminal.

hours of average use or for up to 20 hours on standby before recharging.

When an incoming call is present, the 90-V rms ring voltage from the central telephone office fires a neon lamp in the base unit. This is sensed by a photocell, which turns on a 2-kHz oscillator to frequency-modulate the 1.7-MHz carrier. The portable receiver, which is always on, demodulates the fm signal, and a tone decoder, responding to the 2-kHz tone, causes a buzzer to signal the incoming call. When the portable telephone handset is taken off-hook, it disconnects the buzzer, transmitter, and the 5-kHz oscillator used to modulate the 27-MHz carrier. This establishes the two-way link.

To place a call from the portable unit, the procedure is reversed. Lifting the handset turns on the transmitter section, and during dialing, the 5-kHz oscillator is pulsed by the interrupter contacts of a conventional telephone relay at the standard 10 pulses per second. A relay in the base station follows the same duty cycle, producing outgoing dial-pulsing on the phone line.

To reduce possible interference from nearby citizens' band equipment, Tel-Tech uses a crystal notch-filter in the base station. Otherwise, high-powered CB signals could show up, like crosstalk on a regular phone line, and cause the relay in the base station to chatter.

Answers get new twist

Answerers and other devices that interconnect to the telephone can also extend its power and convenience, but the market for them only opened up in 1968 with the Carterfone decision. Currently, all such devices must have a Bell-specified interface inserted between them and the telephone line, to protect the network, though next year that rule will change (see "Birth of the interconnect industry," p. 95).

As of now, though, it's convenient that a Bell-approved authorized protective connecting module (APCM) is incorporated into a new line of phone-answering devices from Phone-Mate Inc., Torrance, Calif., a pioneer in this area. The machines make what may well be the first practical use of the möbius loop (made from a long rectangular strip that is given one 180° twist along its length before its two short ends are joined). This loop, in the course of two complete revolutions, delivers a recorded message in response to a call, then switches the machine to an incoming mode to allow the caller to leave his message.

When the ring voltage is present, a solid-state switch closes for about 5 seconds. That's ample time for the möbius tape to start turning and move a microswitch out of a slot near one tape edge to provide the call holding. During the first 25-second revolution the message prerecorded on the möbius tape instructs the caller to speak when he hears a tone signal. After one revolution, because of the möbius twist, the slot is now near the other edge of the tape and actuates another microswitch, turning on a recorder for the tape's second 25-second revolution. After that the slot returns to its original starting position, the phone goes back on-hook, the motors stop running, and the machine is ready to accept the next call.

Privacy—protected and invaded

Growing preoccupation with security against theft, vandalism, and invasion of privacy is behind the development of new electronic devices that turn the ordinary telephone into a monitoring device. About 13% of the telephones installed nationwide and as many as 26% in some major cities are unlisted.

An electronic signaling device, recently offered by American Dial-Matic Corp. of New York City, N.Y., may prove more foolproof. It lets a telephone subscriber know if the caller is someone he knows. Called Privacy-Phone, it identifies "wanted" calls through tones generated electronically by the caller. Using either a Touch-Tone telephone or an inexpensive tone-generating code device no bigger than an AA battery, he or she simply punches in a tone code or sounds the tone key into the transmitter of the telephone. The tone then is sounded along with the normal telephone ring at the number dialed. At $1 per key it's not costly to give them to friends, family or business contacts.

To check out a home or place of business, American Dial-Matic also has what it calls Monitor-Phone. This electronic device makes it possible to monitor an area using the telephone's transmitter, even though the handset remains on-hook. The user simply places a call and, before dialing the last digit, allows the device to transmit a code signal over the telephone mouthpiece. This signal activates the monitor circuitry that disconnects the ring circuit before the completion of the dialing. The phone at the remote location then acts as if it were lifted off-hook and can monitor the area for anomalous noises. The company claims the system can detect sound within a 60-foot radius of the handset.

Unfortunately, this device can also be used to "bug" other phones as well. In fact, it can monitor any area with access to a phone line, although that is illegal.

Touch-Tone telephones play key part in low-cost data terminals

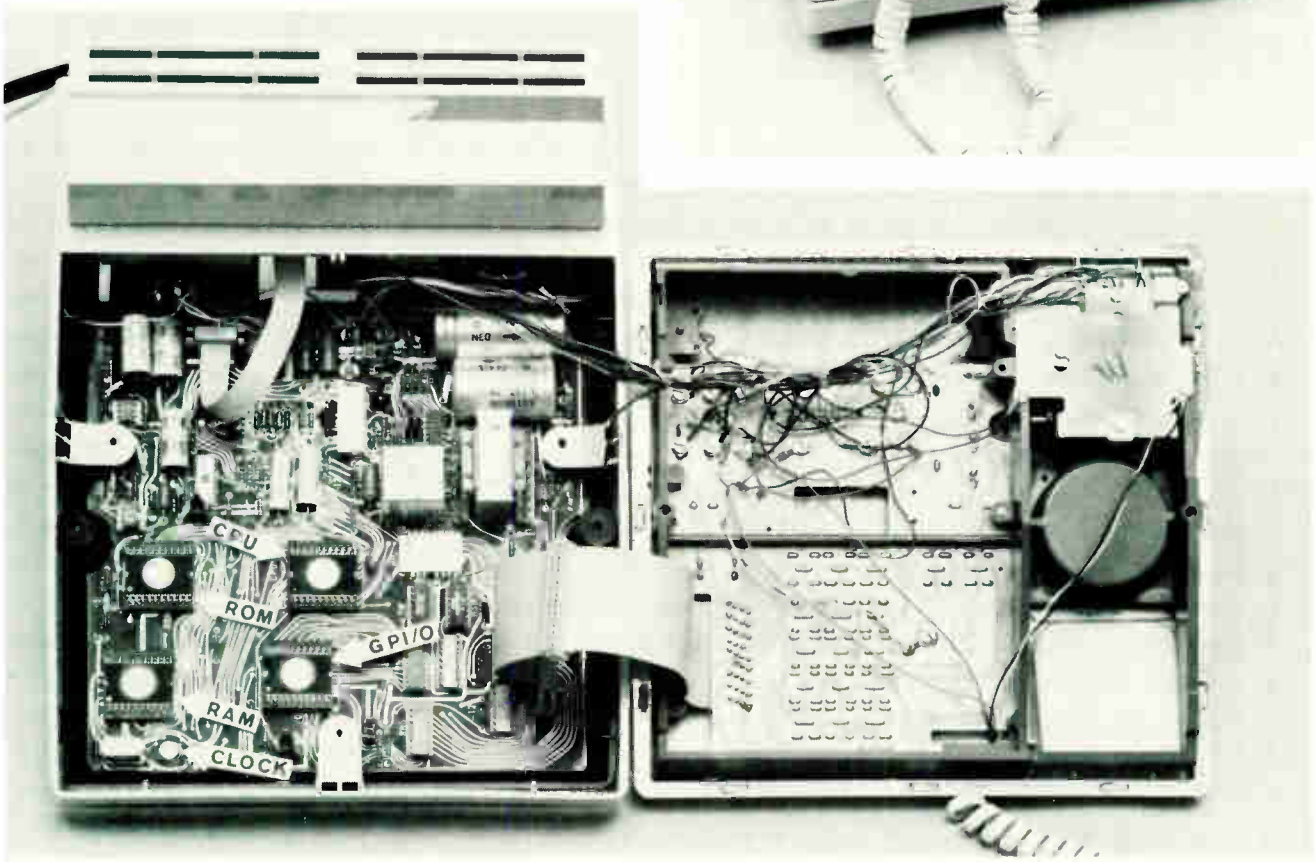
Touch-Tone signaling is the key to sending data as well as voice signals down the phones, suggesting a future in which every push-button tone telephone could double as a low-cost data terminal. (The dialing pulses of rotary-dial telephones cannot provide the tones needed for the end-to-end signaling necessary to operate terminals.)

Much existing equipment and services make use of the push-button pad either on the telephone itself or as the heart of an expanded full-blown terminal. Applications include: a computer system that responds verbally to Touch-Tone instructions and so speeds the transfer of patient information between doctor and laboratory; paying bills and doing accounting by phone, and acting as a stand-alone point-of-sale terminal.

Typical of services based on Touch-Tone signaling is one offered by Pay Fone Systems Inc., Sherman Oaks, Calif. It uses its own push-button keyboard and numeric display to enable small and medium-sized companies to transmit bookkeeping data to a computer.

A pay-by-phone system from Telephone Computing Service Inc., Seattle, Wash., allows a subscriber with a Touch-Tone telephone to transfer funds electronically. The system uses a computer with voice answerback to request the subscriber's account number and secret code, whom he wishes to pay, and the amount. The subscriber responds via the push buttons.

Bell's newest interactive point-of-sale terminal, called



5. Smart terminal. Several LSI circuits, including a microprocessor, RAM, ROM, a general-purpose input/output chip, turn this telephone (Bell System's Transaction) into a point-of-sale terminal. It dials up the central computer automatically, acts as a straightforward interface that lets the operator input data regarding the particulars of a transaction and receive verification from the computer.

Transaction II, provides hands-free operation and can serve as a business telephone as well. Without taking the device off-hook, the operator pushes a dial card through the terminal's magnetic-card reader to dial the central computer, then pushes the customer's credit card through, and finally enters the amount of the purchase using the keys on the tone pad. The computer responds with an authorization code that is displayed on an LED readout, adding the letter C if it has dumped additional information into the telephone terminal and is waiting for the operator to display it.

The heart of the set is a five-chip microprocessor set, including 32,000 bits of ROM, made by Rockwell International (Fig. 4). As the dial cards are pulled through the magnetic-card reader, the resultant pulses are reshaped and stored in the 1,024-bit scratchpad buffer memory until the telephone line connection is established and the computer is ready to accept data.

Information entered through the push-button pad specifying the amount of sale, etc., goes into the microprocessor, and the output is a series of tone pulses made up of combinations of the frequencies used for dialing. A ROM holds the instructions for doing this.

If only a rotary-dial line is available, the microprocessor instructs the circuitry to drive the appropriate relay to generate rotary-dial pulses. But when the telephone connection is made, the microprocessor switches over to the tone oscillator to signal the computer. The microprocessor also converts the computer's frequency-shift-keyed signals into signals that will drive the seven-segment LED display.

Pictures by phone

The best-known type of video telephone is AT&T's trademarked Picturephone, which consists of a small TV viewing screen, a solid-state video camera, and "hands free" audio equipment. The 1-MHz bandwidth used does limit picture resolution, though, and even so it can only handle animated video data through special transmission channels, since a phone line's bandwidth is a mere 3 kilohertz.

Maybe a million video telephones may be around by the year 2000, says Edward M. Dickson of Stanford Research Institute, Calif. But as of now, there are probably fewer than 1,000 in use—for instance, there is still some Picturephone service in Chicago. But Bell is taking an-

Coin phones get smart

Operating and maintaining the myriad coin telephones of the U.S. is different from, and often more complicated than, keeping track of the ordinary home or business telephone. The coin station deals with a transient trade amid dirty, noisy rough surroundings and must permit a business transaction—the exchange of cash—to take place accurately and securely.

To provide maintenance-free, secure operations, the coin telephone is being converted from an electromechanical operation to more and more of an electronic one. What's more, the change provides the basis for taking the operator out of the loop.

In the U.S., Bell committed long ago to using central control and operator-intervention for all coin stations. But now the aim is automation of toll service in all pay telephones in production today. In addition, the coin-totalization function is implemented electronically, a radical departure from the traditional electromechanical unit.

For local calls the complete coin-totalizer circuit senses the denomination of the coin or coins deposited and totals the amount to verify its correctness before allowing the caller to proceed. (In Bell System operating companies this call varies from 5¢ in Louisiana to 20¢ in Washington, D.C.) For toll calls the totalizer circuit generates tone signals corresponding to the coins deposited, so that the operator may recognize them or machines in suitably equipped switching centers may detect them.

The totalizer circuit contains an RC oscillator to generate the appropriate frequencies, plus logic circuitry to turn on the RC oscillator and turn off the speech network (handset) at the appropriate times. The trial version used p-channel metal-oxide-semiconductor chips for the logic circuits. But the production models have already moved onto integrated-injection-logic circuits that need only about half a milliampere at 3.2 volts.

The totalizing logic chip, the interface chip, and an array of thin-film tantalum resistors come in a dual in-line package. The RC tone oscillator circuit is also in a DIP. These sets will go into service in coin telephones that are in dial-tone-first areas (these have loop power applied when the handset is taken off-hook).

In West Germany, ITT's Standard Electrik Lorenz AG and Siemens AG have designed a new generation of push-button pay phones that are loaded with electronic devices [*Electronics*, June 21, 1975, p. 78]. NT2000 is the world's first coin-operated telephone that allows users to dial international and even intercontinental calls directly without any assistance from the operator. It uses no fewer than eight MOS large-scale integrated circuits and an array of other electronic components, such as photodiodes and LEDs not found in coin phones before.

Truly a smart terminal, it offers the caller conversation time to match the amount of money he inserts. During conversation the "credit" is continually reduced by coin-adapted "debiting" pulses derived from metering pulses sent down the line from the switching center, and a display shows the exact amount of credit remaining at any particular moment. Upon completion of the call, only the amount to cover the charges (to the nearest-value coin) is collected.

Unlike conventional pay phones, in which a mechanical coin-detection unit senses a coin's weight and dimensions, the model NT2000 uses a contactless detection system. The coin drops through a coil-generated magnetic field, developing eddy currents that vary with its metallic composition and its size (the larger the coin, the longer it stays exposed to the field). The coin's unique ohmic and inductive resistance detunes a bridge circuit.

other look at the market in visual communications to discover what people are willing to pay for. One possibility is to use video to link criminal justice organizations like lawyers or police. Recently, for example, three judges in Washington were linked by video to two lawyers in New York in the course of actual court proceedings [*Electronics*, Nov. 13, p. 8].

Given another 10 years, according to Dickson's projections, video phones will be offering a choice between low-resolution animated pictures and slow-scan high-resolution pictures, with optional facsimile paper output, video storage, and a fully alphanumeric keyboard. But right now, few users seem ready for more than the slow scanning of graphics and printed matter and transmission of the data over the telephone lines for display on a television set or cathode-ray tube.

For instance, the British Post Office plans to begin a two-year trial of Viewdata, an interactive information-retrieval system that enables a resident to telephone the BPO requesting information, which is then displayed on his television screen. A viewer sends a simple code through a handheld keypad to request information stored in computers [*Electronics*, Oct. 2, p. 65].

In a similar setup, a modular communications system, called Modacom by its developers at Siemens AG, Germany, can use a TV set to display the telephone-to-computer dialog. The set (Fig. 6) shows the data fed in as well as the information coming from the computer. The transmission speed is 20 characters per second. Up to 256 alphanumerics from a supply of 64 are represented simultaneously in eight lines, each 32 characters long.

With hardware from ELMI A/S, a small Danish company, even printed communications can be sent over any conventional phone line. "Teledialog" is aimed mainly at bringing phone service to deaf persons but should find its way also into low-traffic uses. It consists mainly of a 200-baud modem, a keyboard, a five-by-seven matrix printer that uses 60-mm-wide metalized paper, and a microcomputer.

Video conferencing

One of the coming revolutions in telecommunications will allow several users at different locations to interact simultaneously in a common visual electronic space. Bell Northern Research is designing for Bell Canada what may be the first of a new generation of integrated audio, alphanumeric and graphic terminals. All inputs are interactive, linking participants at different geographic locations over the existing telephone network. Visual information is carried over one voice channel, conversation on a second channel. The final result is the combined effort of several people all of whom may have been thousands of miles apart.

The terminal will consist of a video screen, either a CRT or a 6-foot-square projection screen, showing straight video, graphics, or data from a computer file. The participants, instead of writing memoranda or preparing charts for a meeting, will simply store that information in their computer files. Then, if any of it comes up in discussion during the meeting, they will call it up from the file and display it on the screen. Any changes being discussed can be entered directly into the files, cutting down on the amount of follow-up and paperwork needed later on.

Those attending the "meeting" will use a light pen to interact. By directing it to the different areas of the CRT screen dedicated to different callup instructions, they will enter input commands. They will also use the pen to draw freehand or to do digitized drafting.

Bell Laboratories in Murray Hill, N.J., is working on something similar—an experimental flat-screen video system to transmit graphics and handwriting over telephone lines. The terminal can also communicate directly with a computer.

Bell uses a modified, commercially available plasma panel display and a special light pen. The panels are vertical and horizontal arrays of thousands of neon-gas cells, which glow when energized by an electric current. Instructions transmitted over ordinary phone lines selectively energize these dots to produce an image.

To look farther ahead, the telephone may become entirely digital to allow for facsimile and other data-re-

6. Telephone-TV-computer dialog. With the Siemens "Modacom" system a commercially available television set can be used to display information sent to and received from a computer over the telephone lines. The caller can enter his data either with the push-button keyboard of the telephone or over a complete alphanumeric keyboard module if he needs a more extended exchange of information.

7. Programed push buttons. Pye TMC, England, has introduced its "SpheriCall" autodialer that adds push-button dialing to a standard rotary dial telephone and also stores 10 telephone numbers.

lated services to be brought directly into the home. This won't happen, however, until the local telephone lines are upgraded to handle the high bit rates required.

But putting more intelligence into the subscriber's location would also have to go hand in hand either with servicing and repair at the customer's premises, or with making the receiver cheap enough to throw away. Robert C. Scrivener, Bell Canada's chairman, indicates that a $5 phone that could be thrown away might be in the cards, but he is quick to point out that such a scheme is probably 10 to 20 years away.

In the future, more people will own their own telephones. All the telephone companies would then supply would be a box full of electronics plus a four-wire line (two wires for transmitting and two for receiving) to go around the business or residence location. Inside the "black box" would be wideband electronics capable of looking after many inexpensive telephone-like devices. In this way the subscriber could plug just about anything into the lines, which would already be protected and would be short enough to handle video signals as well as voice.

Although all that lies in the future, the next level of sophistication to come is voice-answering computer technology. John Tyson, Bell Northern Research's head of interpretive design, thinks that voice interaction with computer will eventually be joined to word-processing facsimile. He also expects that competition for the telephone company in the future will not come from so-called interconnect companies, but from Xerox and IBM in man-machine-man-interface techniques. □

What the push-button telephone signifies

The push-button phone has become very popular—customers are even willing to pay extra for it. By now over 40% of the installed terminals are Touch-Tone types, as Bell calls them, up from 10% in 1971.

Originally introduced in 1962 to shorten the time it takes a dial a number, Touch-Tone dialing is today making the telephone into a low-cost data terminal. Because the tones lie in the voice-frequency spectrum, the keyboard can also be used for signaling—an impossibility with the rotary dial. The keys of the Touch-Tone telephone (the 10 digits plus a star and number key) can be assigned various functions, and the extra keys then used to select the function desired.

In the push-button tone, the use of two nonharmonically related frequencies protects the message against false keying by stray signals and voice-generated tones. Some of the combinations can also be used to provide security or a reduced error-rate, but at the cost of reducing the number of combinations available to transmit the data itself.

The three-by-four Touch-Tone system uses seven frequencies in the audio range: three in the high-frequency group (1,209, 1,336, and 1,477 hertz) and four in the low-frequency group (697, 770, 852, and 941 Hz). Each digit consists of a burst of two superimposed frequencies, one from the high and one from the low group—for instance, the digit 2 combines 1,336 and 697 Hz. The plan includes two pairs of unassigned frequencies (1,209 and 941 Hz, and 1,477 and 941 Hz).

When a key is depressed, it sends its pair of distinct nonharmonically related audio tones down the telephone line. A sequence of double tones conveys a telephone number to a central office equipped to handle tone signaling. Commercial push-button tone phones use only 12 of the combinations, but the military has used a 16-button set to provide security codes and priority interrupt.

Unfortunately, true push-button-tone service can be offered only in areas with central offices that use electronic switching systems or systems modified to accept tone signals. There are, however, telephones on the market that provide the user with the push-button convenience in rotary-dial areas. What they use is a push-button array decoder, a pulsing circuit, and memory. When the buttons are depressed, coded signals are converted by the decoder into string of pulses equivalent to those produced by a rotary dial. But because it's much faster to punch seven or nine push buttons than to dial a number, these pulses are stored in a buffer memory (64 bits will handle all U.S. dialing codes) and then read out at the standard rotary-dial rate.

Insight into RAM costs aids memory-system design

Several empirical and statistically based theoretical equations have been developed to help show system designers how the cost of a RAM chip is related to the number of bits it can store

by Jim Cunningham and Jim Jaffe, *Advanced Memory Systems Inc., Sunnyvale, Calif.*

☐ Designers of semiconductor-memory systems should not only know their own manufacturing costs, but they should also know the cost factors involved in production of semiconductor chips. With such knowledge, they can evaluate semiconductor manufacturers' claims for new devices and even gauge the time such new devices are likely to become available.

System designers are probably entitled to some skepticism about the promises being made for 16-kilobit memory chips. The 4-kilobit chip received much of the same early promotion, but system designers had to wait until this year before reliable devices were actually being shipped in volume. With such a history, will the 16-kilobit story be any different?

It probably will. An analysis of the cost factors indicates that the 16-kilobit random-access-memory chip is close to having the minimum cost per bit today—second only to the 8-kilobit RAM. In fact, the semiconductor industry need not invent a thing to make a viable 16-kilobit device. All that's necessary is to scale up the 4-kilobit RAM, which, as the calculations show, is surprisingly far from the minimum cost per bit. On the other hand, the 32-kilobit RAM will require new developments to become economically feasible, since the calculations indicate that the 32-kilobit size is riding on a steep up-slope of the cost curve.

Estimating production costs

In estimating production costs of the various chip types and capacities, the important considerations are:

- Determining device yields as a function of mask quality and process complexity.
- Prorating mask costs for individual die costs according to the number of devices that can be produced during the lifetime of the particular masks used.
- Costs of packaging, assembly, and testing.

The relation of device yield to the photo-masking operation depends on the die area and the density of photomask defects. In determining the density of defects, calculation results are not significantly affected by the way these defects are assumed to be distributed. Of the several possible ways of quantifying defect densities, equations based on Bose-Einstein statistics are probably the simplest, yet they have been found to closely approximate actual experience. Thus, that method will be used in this article. The yield can be determined for a single processing step from

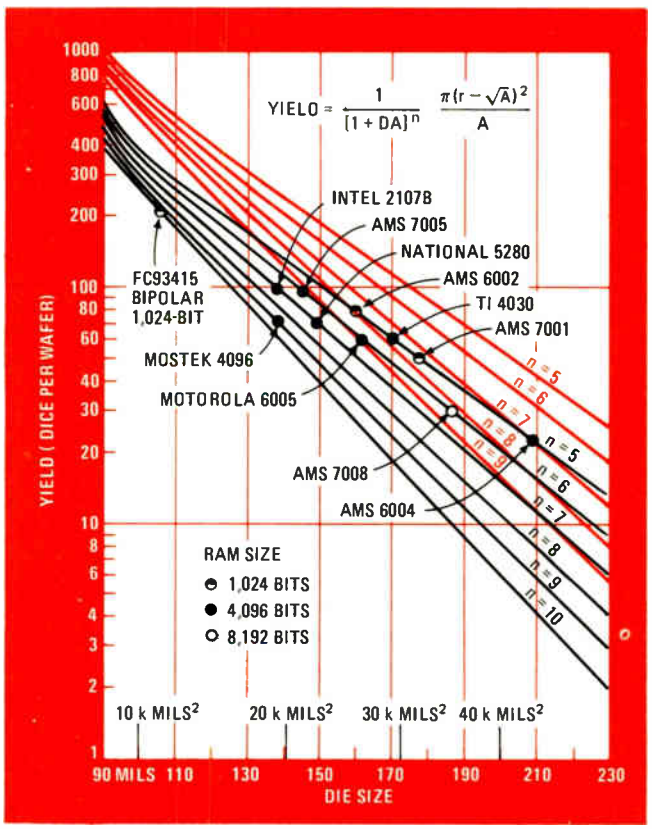
$$Y = \frac{1}{1 + DA}$$

where Y = yield, D = density of mask defects, and A = die area.

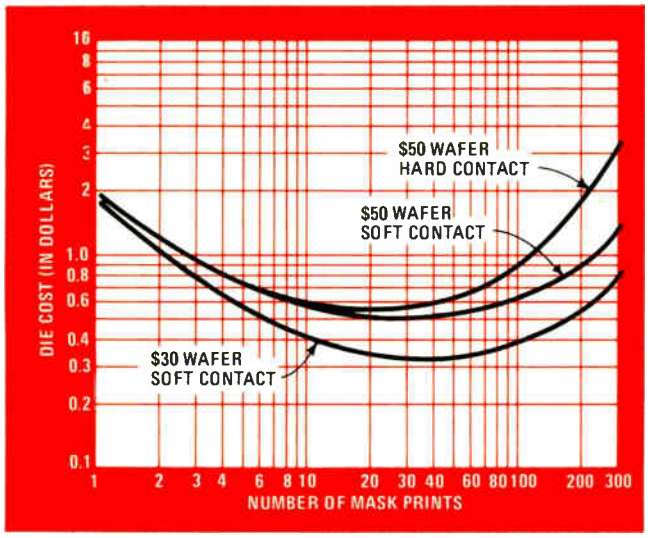
However, since five to 10 such masking steps are required, the yield from the entire photo-masking process with n steps would be

$$Y = \frac{1}{(1 + DA)^n}$$

The number of good dice per wafer can be found by



1. Photomasking yield. The number of good dice per wafer depends on the die size, density of mask defects, and number of masking steps, n. For common three-inch wafers, several commercial devices are plotted. Curves for four-inch wafers are in color.

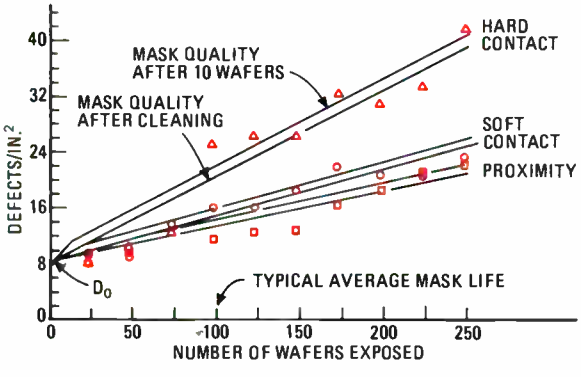


2. Die costs. Lowest die costs result when about 20 to 40 prints are made from each photo-mask. The curves show results for alignment machines that use hard contact (about 18 kilograms between mask and wafer) and soft contact (only a few hundred grams).

Comparing masking equipment

In determining empirical expressions for the effective life of various types of masks for fabricating integrated circuits, Advanced Memory Systems has found that although proximity masks can be used much longer than hard-contact masks, they can stand only a few more exposures than soft-contact masks. In several experiments supervised by Sal Spano, senior process engineer, 18 kilograms of force was used in the hard-contact equipment, only a few grams of force with the soft-contact aligners, and a gap of 10 to 20 micrometers between the mask and wafer with the proximity machine.

Test masks with an incoming defect density, D_o, of eight defects per square inch were printed 25 times on a mix of wafers and then 100% inspected. This process was repeated through 250 exposures, and the wafers and masks were cleaned after every 25-exposure run. The results below clearly show that, although the proximity machine is designed to prevent wafer-mask contact, some contact does occur. The resulting defects are probably related to the curvature of the mask and/or the wafers, as well as the presence of particles that are nearly the same dimensions as the proximity gap.



multiplying the yield by the maximum number of potential dice per wafer. This number could be found by simply dividing the area of the wafer, πr^2, by the area of a die, A. However, some bad dice are always produced around the edge of the wafer, and, to account for these, the radius of the wafer should be reduced by, say, an amount equal to one side of a die, $A^{1/2}$. Thus, the number of good dice per wafer is

$$Y_{D/W} = \frac{1}{(1 + DA)^n} \frac{\pi(r - A^{1/2})^2}{A}$$

A good-quality new chrome photomask has an average defect density of about five defects per square inch. After about 100 exposures, this density typically becomes two to three times its original value, depending on the type of alignment equipment used in the factory. The mask is then discarded. The average density of defects is about nine per square inch. This value is used to plot, in Fig. 1, dice-per-wafer yield for devices made from 3-inch and 4-inch wafers.

Increasing process complexity

Several commercial RAMs are spotted on the curves (dimensions and number of masking steps for each device are general knowledge and do not reveal any proprietary information). The penalty in yield for increased complexity of a process is clear. For example, the remarkably small 1,024-bit bipolar RAM indicated on the chart is made by a complex 10-mask local-oxidation process. Assuming that this device would have to be at least doubled in area to have 4,096 bits, it would then yield only about 40 dice per wafer, which is about half the yield of a typical MOS 4-kilobit RAM.

Generally, to maintain high yields, the manufacturer must use fewer photo-masking steps for large dice than for smaller ones. The two 4-kilobit RAMs, which yield nearly 100 dice per wafer, require six and seven steps, respectively, and are nearly the same size.

Since these curves do not include other factors that affect yield, they should be interpreted as representing only the highest yield theoretically possible. In fact, it normally takes a manufacturer several years of fine-tuning the process before he even comes close to the yields shown.

If LSI chips have considerable area devoted to nonactive purposes, such as metalization runs, the photomask defects may not affect the yield so significantly. Thus, for such products—the ROM is an example—the actual yields may be higher than those shown on the curves. Also, certain masking steps used in producing RAMs are not as critical as others. The masks for ion-implantation and protective oxides, for example, do not affect yield significantly, and such steps therefore should not be weighted as heavily as the more critical steps. As a practical matter, such steps can be accounted for by simply decreasing the number of masking steps on the curves by one or two.

Determining processing yields

The other yield factor that is sensitive to the complexity of the manufacturing process is the wafer-fabrication yield, which relates to diffusion and other processing

steps that determine device parameters. Although only empirical, this equation can be used to estimate wafer-fabrication yield:

$$Y_{Mfg} \approx (Y_{PP})(0.96)^n(0.99)^M$$

where M = the number of other major process steps and Y_{PP} = parameter-probe yield.

Typical values for a metal-gate MOS device would be

$$Y_{Mfg} \approx (0.95)(0.96)^5(0.99)^{10} = 0.70$$

Typical values for a silicon-gate MOS device would be

$$Y_{Mfg} \approx (0.95)(0.96)^6(0.99)^{14} = 0.64$$

The effect of the mask-alignment equipment on the density of mask defects depends on the type of equipment used. The results of an experiment comparing hard-contact mask aligners (those that apply about 18 kilograms of force between the mask and the wafer during exposure) and soft-contact aligners (which use only a few hundred grams of force) show that there is approximately a straight-line relationship between the defect density, D, and the number of mask prints, m.

For hard-contact aligners (using the data from the experiment described in "Comparing mask-alignment equipment," p.102), the relationship is

$$D = D_o(1 + 0.0147m)$$

For soft-contact machines, the relationship is

$$D = D_o(1 + 0.0076m)$$

Each of these equations can be combined with previous equations to indicate the relationship between the cost per die and the other factors:

$$C/D = \frac{WC - MMC + (MC)(n/m)}{Y_{D/W}}$$

where C/D is cost per die, WC = wafer cost, MMC = mask-material cost, and MC = mask cost. This equation is plotted in Fig. 2, which shows the results of using m prints from a given mask. The curves are based on the following practical assumptions:

- Number of photomasking steps, n = 6
- Mask cost = $35
- Initial defect density, D_o = 5 defects/in.^{2}
- Die size, A = 150 mils square

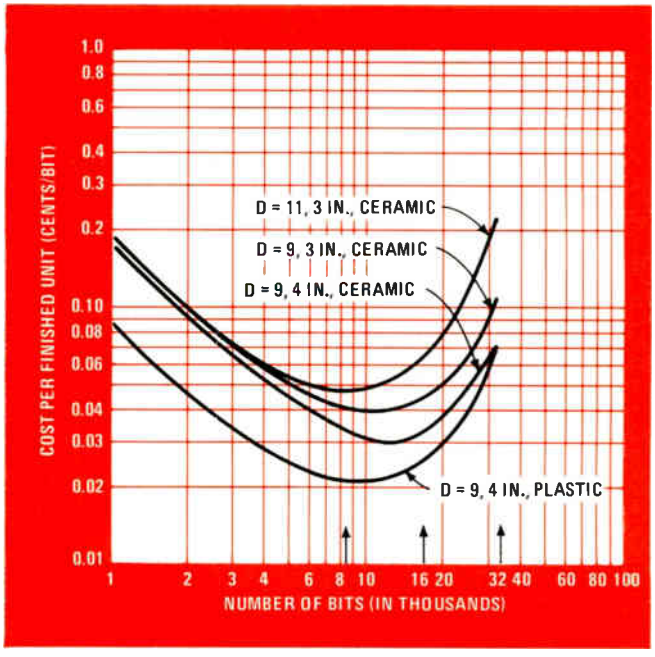
The curves show that the maximum economical mask life ranges from 20 to 50 prints. The soft-contact equipment, of course, allows more mask exposure than hard-contact aligners, thereby reducing device costs.

Estimating over-all costs

The final cost of a device is basically the manufactured cost of the packaged device plus the testing cost. A reasonable prediction for the total cost of the packaged device can be obtained from

$$UC = \frac{(DC/OY) + AC + PC + TC}{FTY}$$

where UC = unit cost, DC = die cost, OY = dice optical yields (from microscopic inspections), AC = assembly cost, PC = packaging cost, FTY = final test yield, and TC = test cost.



3. Cost per bit. When empirical and theoretical equations are combined, cost per bit can be related to chip capacity. Curves show that 8-kilobit chips have lowest cost per bit, and 16-kilobit chips are not far behind. However, 32-kilobit chips are far from the minimum.

Now, if an expression relating the area of a RAM chip to the number of bits that it can be built to hold were written, the total cost of the device could be related to its number of bits. Such a relationship would allow a designer to estimate the potential final cost. The area of the chip and the bit capacity, N, can be related by the following empirical expression:

$$A = 1.7 \times 10^{-6}(N + 69N^{1/2} + 2{,}400)\ \text{in.}^2$$

This equation assumes n-channel silicon-gate technology with standard 6-micrometer design rules and a typical one-transistor cell. In the summation term in parentheses, the first term, N relates to the total storage-cell area. The second term, $69N^{1/2}$, essentially relates to the area required by decoders and sense amplifiers and other areas that depend on column or row length. The third term, 2,400, is a constant because it accounts for unused periphery and circuits, such as buffers, that do not depend on cell area.

After some algebraic manipulation, the equations can be combined to develop one complex equation for relating cost per bit to the number of bits, N. Although the equation is not shown (it would require about three lines of coefficients and constants), the results are plotted in Fig. 3. These assumptions were used:

- Final test yield = 80%
- Ceramic package cost = 82 cents
- Plastic package cost = 15 cents
- Optical yield = 90%
- Test cost = 30 cents

These curves have several messages. They show how near the 16-kilobit RAM is to reality and how much invention will be necessary before the 32-kilobit RAM becomes cost-effective. They also indicate that the 8-kilobit RAM costs the least per bit today. □

Feedback in phase-locked loop linearizes phase demodulator

by Ron Rippy
RI Technology Branch, Goddard Space Flight Center, Greenbelt, Md.

The phase of a carrier wave is easy to change, and therefore phase modulation (PM) is convenient in many applications. However, most phase detectors have at least two shortcomings: restriction of the linear operating region to about ±60° and an inability to lock to PM signals that have no carrier power. The circuit in Fig. 1 uses phase-compressive negative feedback to avoid these limitations. The linear operating region is set mainly by a phase modulator, rather than by the usual product detector, and extends to at least ±160°.

As shown in the circuit diagram, the data output from an ordinary phase-locked loop (PLL) is amplified, reversed in phase, and fed back to a linear phase modulator that is connected ahead of the product detector. Because the data fed back to the modulator is out of phase with the incoming data, it reduces the phase swing of the signal and restores some sideband power to the carrier. This carrier power allows the loop to lock to signals that had no carrier power before reaching the phase modulator.

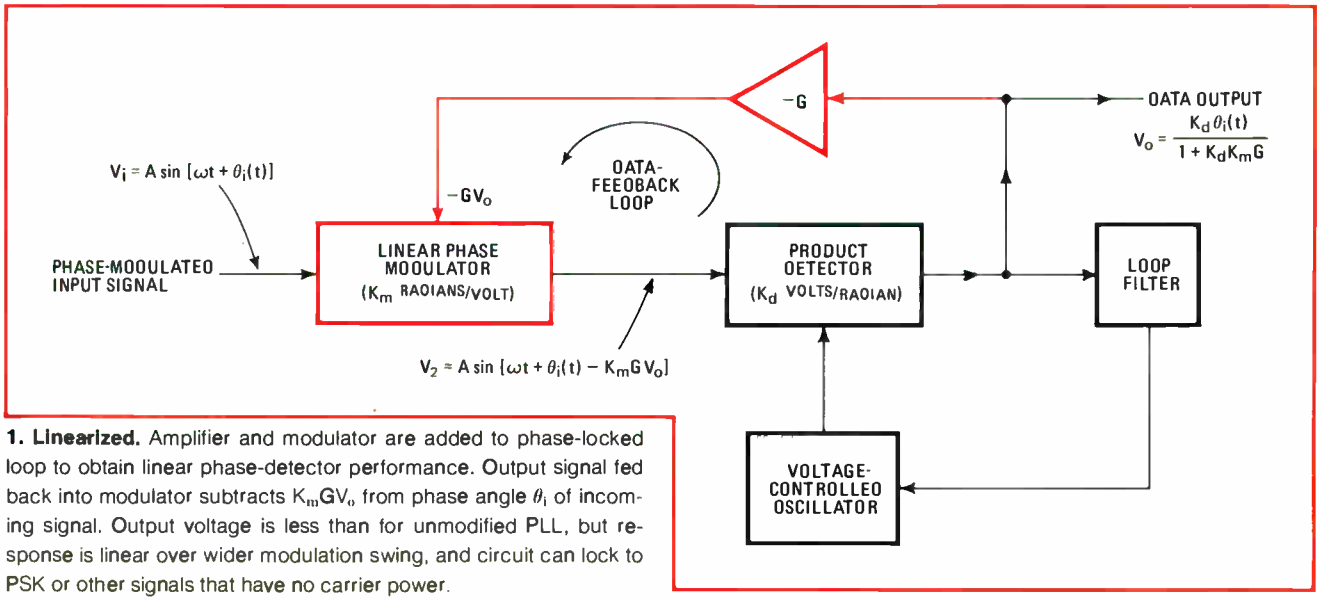
If an rf carrier is phase-modulated ±90° by a square wave, the carrier itself disappears, leaving only the modulation sidebands. This modulation technique is called phase-shift-keying. A conventional phase detector does not lock to such a signal because it has no carrier, but the circuit in Fig. 1 does lock. The amount of restored carrier power can be controlled by adjusting the gain of the feedback amplifier. This circuit can also be used to detect biphase modulation.

The compressive negative-feedback arrangement also tends to keep the product detector operating in its linear region at high modulation angles, where severe distortion would otherwise occur. The improvement in linearity is illustrated in Fig. 2, which shows the output of the phase detector when the input signal is a 2.2-gigahertz carrier modulated 160° by a triangular voltage. Without feedback, the detector distorts both the positive-going and negative-going ramps by turning them into segments of a sine wave.

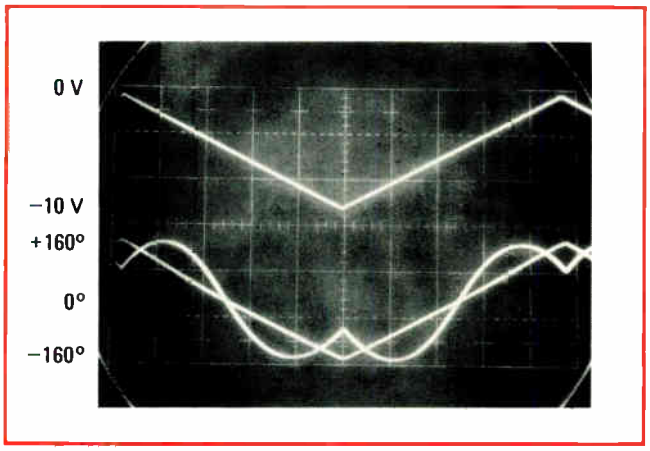
When the feedback loop is connected, however, the modulation swing is reduced, and operation in the linear region of the product detector is restored.

Another advantage of using feedback is that it increases the pull-in range of the phase-locked loop. When the loop is out of lock, the input signal is multiplied by the voltage-controlled-oscillator signal to produce a beat frequency that is fed back to the phase modulator. The beat note produces a modulation spectrum having one PM sideband that is always synchronous with the VCO frequency. This synchronous sideband results in a dc component at the output of the phase detector, which passes through the loop filter and pulls the VCO into lock. From experimental observation, the pull-in range appears to be of the same order of magnitude as the i-f bandwidth preceding the phase detector.

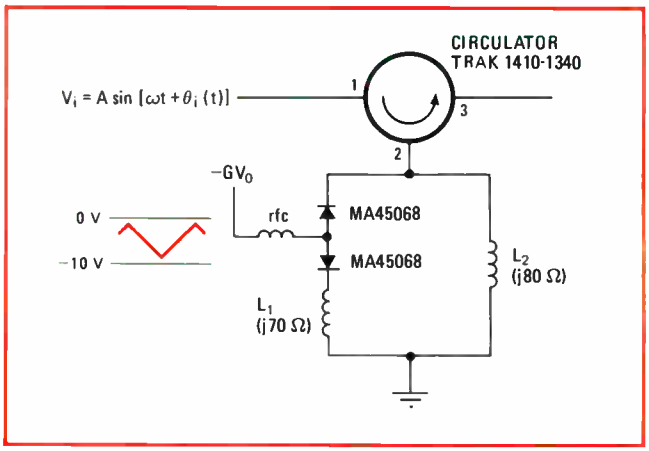
To prevent the data-feedback loop from oscillating, the open-loop gain must fall to 0 decibel before the open-loop phase shift climbs to 180°. This effect can be accomplished by using components in the loop that have wider bandwidth than needed and adding a single-pole or double-pole filter between the phase modulator and product detector to establish the over-all



1. Linearized. Amplifier and modulator are added to phase-locked loop to obtain linear phase-detector performance. Output signal fed back into modulator subtracts $K_m GV_o$ from phase angle θ_i of incoming signal. Output voltage is less than for unmodified PLL, but response is linear over wider modulation swing, and circuit can lock to PSK or other signals that have no carrier power.



2. What you see is what you get. Effect of data-feedback loop on linearity is shown in scope photo. Top trace shows triangular voltage that modulates incoming 2.2-GHz carrier. Lower traces show detected angle without feedback (curved) and with feedback (linear).



3. Modulator. The linear phase modulator that is part of Fig. 1 can be realized at vhf and higher frequencies by use of a circulator and a variable reactance. Reflected signal in port 2 changes phase as voltage on back-to-back varactors changes.

data-loop bandwidth. If any sharp filtering is needed, it should be done ahead of the phase modulator. Then the data-loop bandwidth can be left rather wide to ensure a flat frequency response without degrading the phase-detection performance in the presence of noise.

Figure 3 shows the linear phase modulator that was used to implement the circuit for the test in Fig. 2. This modulator is useful at vhf and higher frequencies. (A similar modulator with a 3-dB hybrid in place of the circulator has been used a frequencies as low as 500 kilohertz.) The carrier enters port 1 of the circulator and travels to port 2, which is terminated in an LC combination that is voltage-tuned by two varactor diodes. Because this termination is purely reactive, all of the energy at port 2 is reflected to the rf-output port.

The angle of the reflected carrier varies with the modulating signal applied to the diodes. One modulator section of this type will produce about ±90° of linear modulation. Two sections were cascaded to produce the ±160° phase shift in Fig. 2. □

PROM converts binary code to drive 1½-digit display

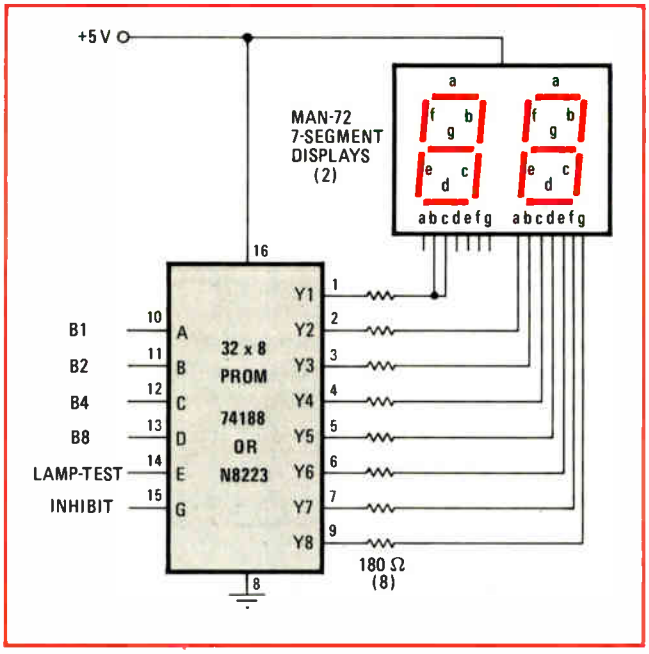
by V.R. Godbole
North Electric Co., Galion, Ohio

In providing visual readouts for test circuits, inspection equipment, error indicators, and the like, it is often necessary to go from a machine-generated 4-bit binary code to a 1½-digit display of the numbers 0 to 15. This process is usually performed in two steps, but a programable read-only memory can handle it in one.

In the usual approach, the first step is to convert the binary code into a BCD code by any one of the several available techniques. The second step is to use standard BCD seven-segment decoder/driver integrated circuits to drive the popular seven-segment visual readouts. The PROM, however, can be programed to accept the binary input signals and generate the proper outputs to drive the display directly.

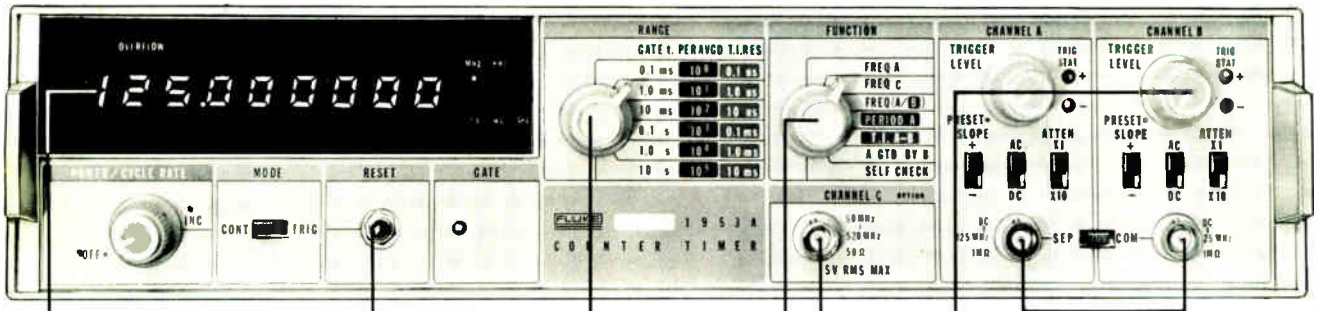
This use of a PROM has several advantages. Conversion and driving are done in one step, thus providing direct interface to the visual display. Blanking and lamp-test can be included at no extra cost. Space is conserved, and cost is competitive with other approaches.

Binary coding of the numbers from 0 to 15 requires



Here's how. PROM drives seven-segment display to show decimal value of 4-bit input signal. This compact interface is convenient in microprocessor circuits, which often have spare PROM capacity. A 32-by-8-bit PROM can provide the drive signals for numbers 0 through 15 and also accommodate lamp-test and inhibit commands. Applications include test-number indication in small test instruments and display of settings on binary-output touch switches.

If your counter looks this good...



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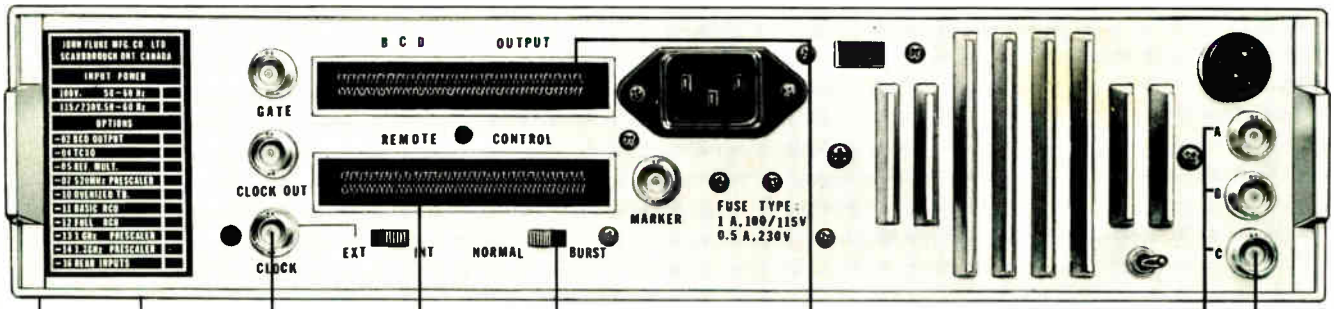

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only four binary bits. The most-significant-digit position of the visual decimal display requires only a 1 or else no indication at all; therefore, this digit can be driven by generating only a single output signal that can turn on the segments to show a 1 when required. To drive the seven segments of the least significant digit, seven outputs are needed. Thus the converter/driver must accept four binary inputs and produce eight outputs to drive display segments.

A 32-by-8-bit PROM, type 74188 or N8223, can serve this purpose. The PROM has open-collector outputs with sink capability of 16 milliamperes per output at output voltage of 0.5 volt, enabling it to interface directly with the display segments through suitable resistors. Also, besides performing the necessary conversion, the PROM has additional word capacity that can be used for desirable features such as blanking and lamp-testing at no additional expense. The figure shows the complete circuit diagram for the converter; it requires only the display devices and eight resistors in addition to the memory IC. The truth table lists the instructions required to program the PROM.

Locations 0 through 15 contain the bit patterns that generate segment drives to produce numbers from 0 to 15. Locations 16 through 31 are left unprogramed; therefore when the lamp-test input is taken to a logic 1, one of locations 16 through 31 is addressed. This circuit state causes all outputs to be set at logic 0, turns all segments on, and produces the number 18. When the inhibit input is taken to a logic 1, the PROM outputs are turned off and cause the display to be blanked. □

TRUTH TABLE AND PROGRAM FOR DRIVING 1½-DIGIT DISPLAY

Inhibit	Lamp test	B8	B4	B2	B1	Display	Program in memory Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
0	0	0	0	0	1	1	1	1	0	0	1	1	1	1
0	0	0	0	1	0	2	1	0	0	1	0	0	1	0
0	0	0	0	1	1	3	1	0	0	0	0	1	1	0
0	0	0	1	0	0	4	1	1	0	0	1	1	0	0
0	0	0	1	0	1	5	1	0	1	0	0	1	0	0
0	0	0	1	1	0	6	1	1	1	0	0	0	0	0
0	0	0	1	1	1	7	1	0	0	0	1	1	1	1
0	0	1	0	0	0	8	1	0	0	0	0	0	0	0
0	0	1	0	0	1	9	1	0	0	0	1	1	0	0
0	0	1	0	1	0	10	0	0	0	0	0	0	0	1
0	0	1	0	1	1	11	0	1	0	0	1	1	1	1
0	0	1	1	0	0	12	0	0	0	1	0	0	1	0
0	0	1	1	0	1	13	0	0	0	0	0	1	1	0
0	0	1	1	1	0	14	0	1	0	0	1	1	0	0
0	0	1	1	1	1	15	0	0	1	0	0	1	0	0
1	X	X	X	X	X	(OFF)	1	1	1	1	1	1	1	1
0	1	X	X	X	X	18	0	0	0	0	0	0	0	0

1 = HIGH 0 = LOW X = DON'T CARE

Sensing resistor limits power-supply current

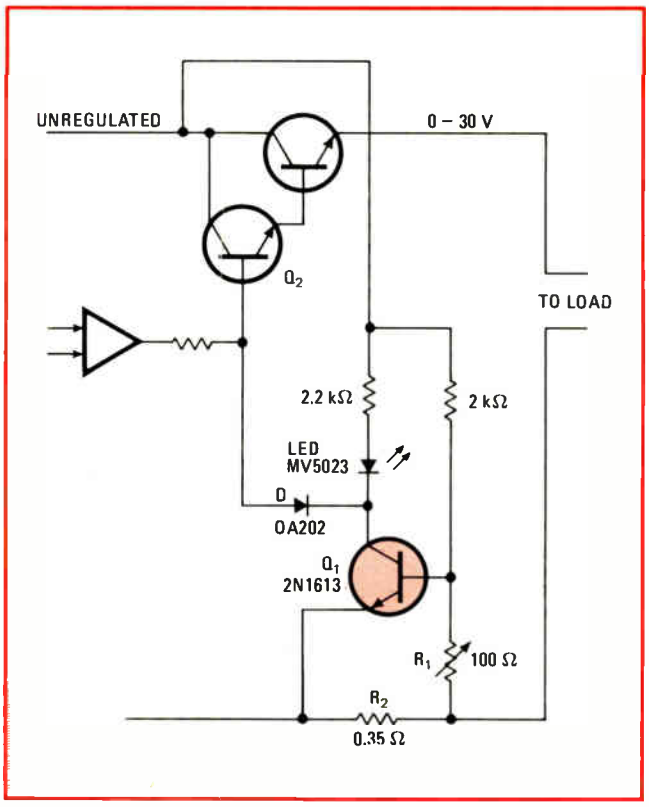
by Theo W. Smit
Euratom, Ispro, Italy

To protect a power supply against the excessive currents that would flow if the load were short-circuited, a simple drive-shunting transistor controlled by a sensing resistor is all that is necessary. As described here, the protection circuit is adjustable and includes an indicator light to warn of the current-limited condition.

The schematic diagram shows the current limiter connected in a 30-volt/2-ampere power supply. If adjustable resistor R_1 is set at zero, then the load current is limited to 2 A. If the current exceeds this level, the voltage drop across R_2 turns on transistor Q_1, which sinks the input current to driver transistor Q_2. Thus the load current is limited to the 2-A level.

If R_1 is set greater than zero, Q_1 turns on at a current less than 2 A, limiting the load to this reduced level.

The light-emitting diode lights up when Q_1 conducts, indicating that the current limiter is in operation. Diode D prevents the LED from lighting if Q_1 is off. □



Protective limiter. To limit current in power-supply circuit, voltage drop across resistor R_2 turns on transistor Q_1 when load current exceeds 2 amperes (current value will be lower if R_1 is greater than 0 ohm). Q_1 then shunts drive current away from Q_2, reducing current to the load. LED turns on to indicate conduction in Q_1.

Have you used a microprocessor to replace either hard-wired or mechanical logic in a circuit or made some other use of these versatile devices? Engineers who are just starting to design with microprocessors would be interested in learning about your experiences. We'll pay $50 for each microprocessor item published, as we do for all published Designer's Casebook ideas. Please send them to our Circuit Design Editor, summarizing the problem and how a microprocessor provides a novel solution.

Parametric tests meet the challenge of high-density ICs

George F. Nelson, *Naval Research Laboratory, Washington, D.C.*,
and William F. Boggs, *E-H Research Laboratories Inc., Oakland, Calif.*

In tandem with more common methods, they can push minimum IC acceptability standards close to the 99.99% level

☐ Higher densities in integrated circuits and printed-circuit boards have been placing increasing demands on IC testing—to the point where the minimum level of acceptable quality is generally climbing. Fortunately, recent evidence shows that ac parametric testing, combined with the more-common dc and functional tests, is an effective way to meet the more stringent criteria and to increase the yield of high-density pc boards. Indeed, if the so-called "four-nines" level of acceptability—IC shipments in which 99.99% of the devices are good—can be reached, it will have to be through the use of ac parametric testing.

The common, established methods of dc and functional testing, adequate for producing acceptability standards of 95%, will become less so as the scale of circuit integration and breadboarding continues on an upward spiral. Dc and functional tests can determine whether a device has proper logic voltage and current levels and conforms with a truth table, but they cannot discover the subtle weaknesses that can knock out an IC at the worst time—when it is implanted in an operational system.

Present-day requirements show up clearly in that, aside from solder splashes and similar assembly snags, the yield Y′ of good pc boards containing N ICs with an IC device yield Y is $Y' = Y^N$. The first-order approximation of this, where Y is not too far from 100%, is $Y' = 100\% - NX$, where $X = 100\% - Y$.

With 50 devices on a board, the IC user is in trouble if the IC yield is below 99%, since board yield would then be $(0.99)^{50}$, or about 60%. The problem isn't completely under control until the IC yield is around 99.99%, where board yield is $(0.9999)^{50}$, or about 99%. With MSI the accepted norm, with the accelerating use of LSI, and with the 200-device pc board becoming common, the realities of large-volume IC use are sobering.

Verifying the concept

Fortunately, parametric tests have anticipated these problems. Some of the alternatives for testing one class of circuits—microprocessors—are listed in Table 1, and it has been found that propagation delay, time- and noise-margin tests—ac parametric measurements in general—provide the qualitative information necessary to uncover not only devices that are dead on arrival, but short-life devices as well. When used in conjunction with the standard dc tests or with real-time functional tests, it has also been found that the direct measurement of ac parameters can boost IC yields to the 99.99% necessary for 200-device pc boards.

Verification of this hypothesis has been underscored by tests conducted at the Naval Research Laboratory. These tests detected "hard" logic failures, such as erroneous states at device outputs, and also so-called "soft" failures, like an incorrect voltage level or an excessive propagation-delay time (Table 2). In the fault analysis of complex ICs, soft failures are expected to

TABLE 1: MICROPROCESSOR TEST TECHNIQUES

Test technique	General type	Comments
Self-Test	Functional only	Microprocessor executes own test program and determines pass/fail
Comparison	Functional	Microprocessor compared against a known good unit
Emulation	Functional	Microprocessor compared against emulator
Learn	Functional	Microprocessor compared against previously "learned" test pattern
Parametric	Functional and propagation delay	Available propagation delays are directly measured
Extended Parametric	Functional and all propagations	Device timing signals adjusted to verify all internal propagation paths.

TABLE 2: HARD AND SOFT FAILURES IN TTL INTEGRATED CIRCUITS

Device type	Number of devices tested	Rejects			
		DC failures (e.g. wrong input voltage or current)	Functional (truth-table) failures	Parametric (dynamic) failures	Total failed devices*
SSI	8328	489 (5.87%)	55 (0.66%)	378 (4.54%)	908 (10.9%)
MSI	905	72 (7.96%)	7 (0.77%)	195 (21.55%)	248 (27.4%)

* Some devices failed more than one test

TABLE 3: TECHNOLOGIES AND "SOFT" FAILURES

Technology	Susceptibility to soft failures	Prevalent soft modes	Techniques to detect soft failures
EFL (emitter-follower logic)	Very low	Improper resistor values	Check minimum and maximum propagation times
TTL	Low	High junction leakage currents Low transistor Beta	Check maximum device propagation time
Single-channel MOS	Low to moderate	Threshold voltage variations Excessive leakage currents	Check propagation times with a worst-case clock Check input noise immunities Check quiescent current consumption
C-MOS (bulk)	Moderate	Excessive leakage currents Threshold voltage variations	Check quiescent current consumption Check input noise immunities Check propagation times with a worst-case clock
C-MOS (SOS)	Very high	Excessive leakage currents Threshold voltage variations	Check quiescent current consumption Check input noise immunities Check propagation times with a worst-case clock
CCD	Probably high to very high	Unknown	Undetermined
I^2L	Probably moderate	Unknown	Undetermined

predominate. The ability to observe directly a device's ac parametric behavior gives the test-system engineer a potent weapon against such failures.

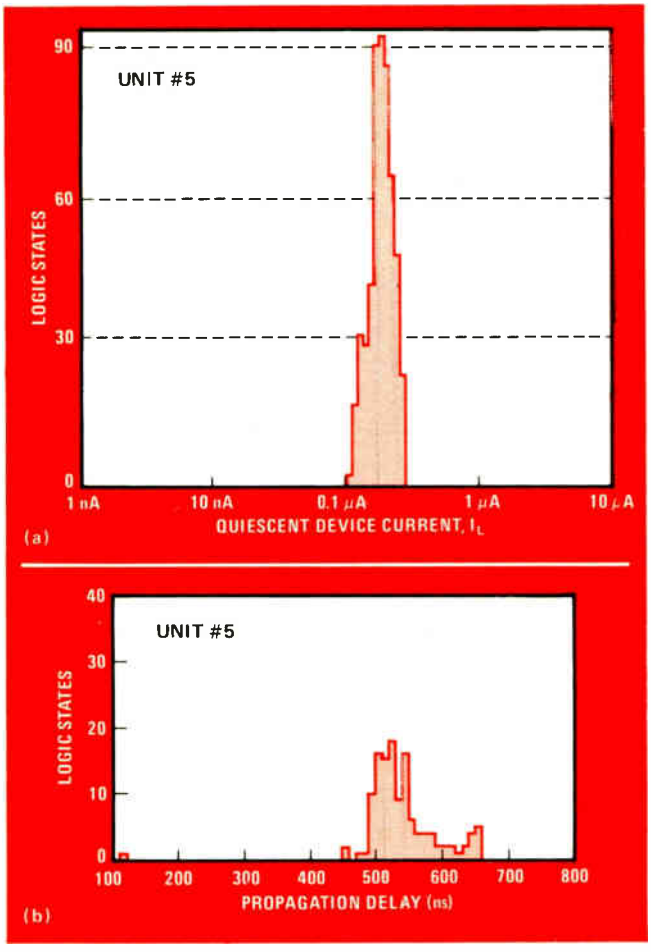
Direct ac parametric testing is not a cure-all, however. Various technologies are used to create ICs, and the optimum combination of tests for a device changes accordingly (Table 3).

For example, although the same electrical function may be performed by a transistor-transistor-logic device and a metal-oxide-semiconductor device, failures of the same function on both devices would likely result from different mechanisms. The important characteristics in TTL devices are high internal currents and a static nature. These characteristics combine to reduce adjacent cell interaction. In a comparable MOS device, operation often requires the storage of electrical charge on each cell. If there is any leakage between cells, errors can result because only a small charge transfer is required for a cell to change state. Variations in adjacent cell interactions between the two device technoligies requires different test techniques.

Combination needed

A soft failure in a TTL device can be found by using functional tests coupled with propagation-delay measurements. On an MOS device, no single test technique—including extremely long functional tests—is by itself sufficient to fully test the device. Rather, a combination of dc, ac parametric and real-time functional tests are required.

At the Naval Research Laboratory (NRL), the quiescent current-consumption test—basically a dc test performed under ac conditions—is added to functional testing for MOS and C-MOS devices. This is done because



1. Connection. In a multi-state device, the number of states for which the quiescent current (a) and the propagation delay (b) have given values are related. Here, both graphs cluster in a small area.

there is evidence of a strong correlation between the distribution of quiescent current levels and the distribution of propagation delay time as a function of the logic states in a given IC (Figs. 1 and 2). The spread in propagation-delay distributions is, in turn, a prime suspect in IC failures in the field. The rationale for this suspicion is that some portions of the IC do not turn off completely, the other transistors do not saturate as quickly, and propagation times are slowed. This effect is related to the pattern sensitivity of access times in MOS devices.

At NRL it is believed that a close examination of quiescent current distributions, coupled with direct measurements of propagation-delay distributions, will help detect soft failures in devices using MOS and C-MOS technology.

This dependence on the distribution of propagation delays has been present all along in MOS devices but has become significant only with the increasingly critical timing parameters and shorter on-chip delay times of newer devices. It was also obscured in the past because very few people had the ac-parametric-test capability necessary to observe these effects. Work on pattern sensitivity using functional patterns to screen out bad devices has gone part of the way toward dealing with these spurious intra-device interactions. But even the best of this work is limited in that, no matter what patterns are tried, the comparators will still detect only a hard failure at the device output, not a soft failure. It is also limited in that, no matter how many devices fail when tested with a given pattern, there is no guarantee that it is a "worst-case" pattern. In other words, a different method of stimulation may fail a device which passes when tested with the first pattern.

If, however, real-time functional testing can be combined with direct single-shot time measurements, then some sophisticated "soft" failure analyses can be made. This kind of analysis uses the best of both techniques—the pattern depth of functional testing and the sensitivity and accuracy of ac parametric measurements—to detect otherwise invisible faults. These faults are the most insidious because they relate to future failures rather than operational failures that occur while an IC is in the test socket. That is why that, 99% of the time, the functional modules in the NRL test system are used only for the dynamic conditioning of a device for ac parametric tests.

Obtaining the best mix of dc, real-time functional, and ac parametric measurements requires a clear understanding of both the technology of an IC and of what the various kinds of tests will reveal. The present generation of ICs has from 14 to 40 pins, and 10-to-1 timing margins (the ratio of IC logic speed to system speed). The next generation of ICs—some of which are already functioning in laboratories—will have 100 or more pins, subnanosecond timing parameters and some systems applications with less than 2:1 timing margins. The one common element these devices share is the increased importance of timing. And the need for direct, accurate ac time measurements grows dramatically as timing margins decrease.

The standard dc tests will still be valuable because they sort out gross failures like shorts. The burden of testing, however, is and will remain with the ac tests.

A good deal of debate is currently going on over the ability of either functional-only or ac-parametric-only testing to predict various IC phenomena loosely classified as "input pattern sensitivity." It is a problem usually resolved by equipping for both test capabilities. To understand the debate and why the largest computer manufacturers have turned in the last few years to test systems that include ac parametric test capability, it is necessary to look more closely at functional testing.

Finding shortcuts

The basic philosophy of functional testing is simple: if you put a known set of ones and zeros into a device and get the right set of ones and zeros at the output, the device works. This technique goes a long way toward verifying the truth table compliance of a device, but it runs into two major problems when applied to complex ICs. It requires an enormous number of input patterns to completely test a device, and it can only give a very coarse idea of device timing.

The enormous number of input patterns comes from the well-known combinatorial logic problem that if a device has N active input pins then there are 2^N possible input states. If the device contains sequential logic, then the figure is 2^{MN}, where M is the sequential depth of the

IC. For MSI, the number of input patterns required to test all possible states quickly becomes unwieldy, and for LSI it becomes unachievable.

Test-system vendors have been working on reducing test-pattern length and testing time without losing the gross fault-catching value of functional testing. Two basic approaches have evolved from these efforts: the so-called "black box" pattern approaches and the Boolean-compacting schematic approaches.

The black-box approach—primarily used for testing memories—essentially divorces the schematics of the IC under test from the initial test pattern generation. The test program feeds in a fixed pattern such as "walking ones and zeros," a "ping pong" pattern, or a similar pattern without regard to the schematic of the particular device. The patterns are then traced through the schematic to obtain for comparison the expected output patterns.

This technique is convenient and simple if one is testing highly repetitive arrays such as random-access memories. But when sequential or complex combinatorial logic such as a microprocessor is considered, or when an IC's manufacturing process is not well-known and stable, the faults that can go undetected by these pre-formed patterns become unacceptably numerous. There is no way that a number short of 2^{MN} patterns can detect all the device's failure modes, or that, without recourse to tracing signals through all parts of the schematic, they can guarantee that every portion of the device will be tested.

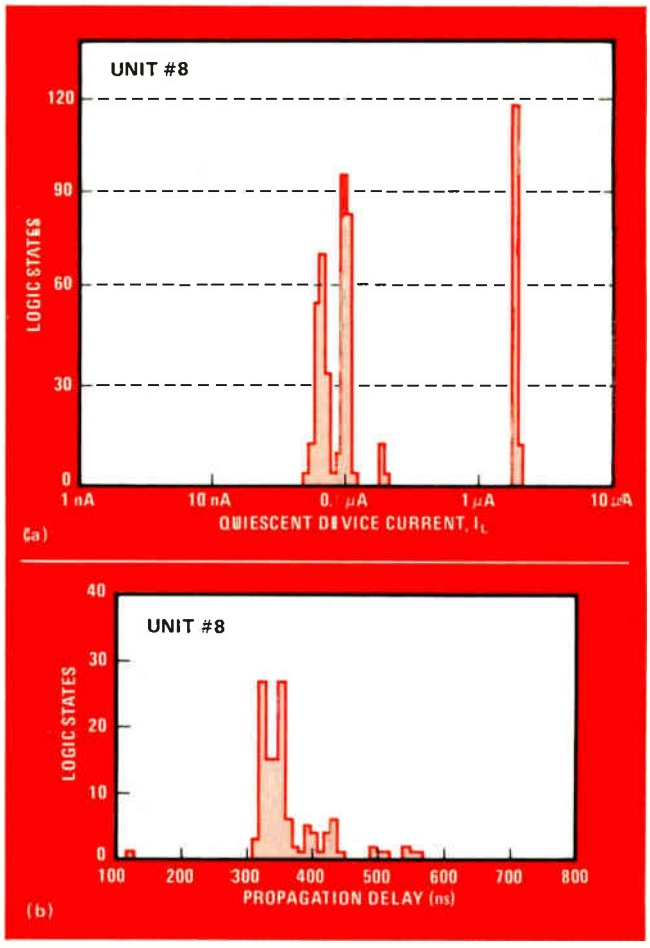
An alternative is some sort of Boolean-compacting scheme where the number of input patterns is reduced from 2^{MN} to the order of N by eliminating patterns that toggle the same circuit node or path twice. Finding these patterns requires tracing all possible output states backwards through the schematic to determine the necessary input patterns. Two alternatives are possible: either toggle all the nodes or toggle all the paths.

Toggling all the nodes in an IC generally requires 30% fewer patterns than toggling all the paths, but offers less assurance that the entire circuit will be tested. The reason is that each node may switch slightly faster or slower than it should, and the minimizing set of patterns that toggles all the nodes may not toggle a path that contains all fast nodes or all slow nodes. The incorrect propagation times resulting from these deviant paths could cause a soft failure that is untested by the node method. Toggling all the paths at least insures that these worst-case paths will be uncovered.

Delaying propagation

The classic way around propagation-delay problems is to use synchronous logic, positioning clock pulses at times when voltage levels are stable. This clocking will become increasingly necessary as the ICs become faster, but without a clear measurement of the propagation delays it will become very difficult to know exactly where to position the clock pulse. This problem is intensified by the pressure to build faster systems.

One method to obtain a propagation-delay measurement using computer-controlled real-time functional equipment is to vary the strobing of the test system's comparators until a "fault" or transition occurs in the device's measured output from the zero level to the one level or vice-versa. This point can be thought of as the leading edge of the output pulse. By comparing this edge time to the time of the input pulse one obtains a kind of propagation-delay measurement.



2. Likely failures. When the quiescent device current (a) and the propagation delay curves (b) show wide distributions, the IC is a likely candidate for failure in the field.

Unfortunately, this technique is limited in its ability to determine the placement of the propagation edge with good-enough accuracy. One problem is induced by the time skew between the pulsers driving each device-input pin; this is at least 5 ns. The other problem is the error induced by the uncertainty of the timing of the comparator strobe itself, and by the width of the strobe. The technique of varying the strobe on the comparators is adequate, however, when measuring propagation delay times in excess of 50 ns.

With direct ac parametric measurement added to dc and functional tests, on the other hand, the whole world of soft failures is open for inspection. Effects such as insufficient fan-out, low noise immunity, excessive power consumption, timing gradations and other deviations from the manufacturer's specifications can be put in the proper perspective. Experience gained at NRL and elsewhere suggests that it is these subtle deviations that explain how an IC that operates functionally in a test system can fail in the field not much later. □

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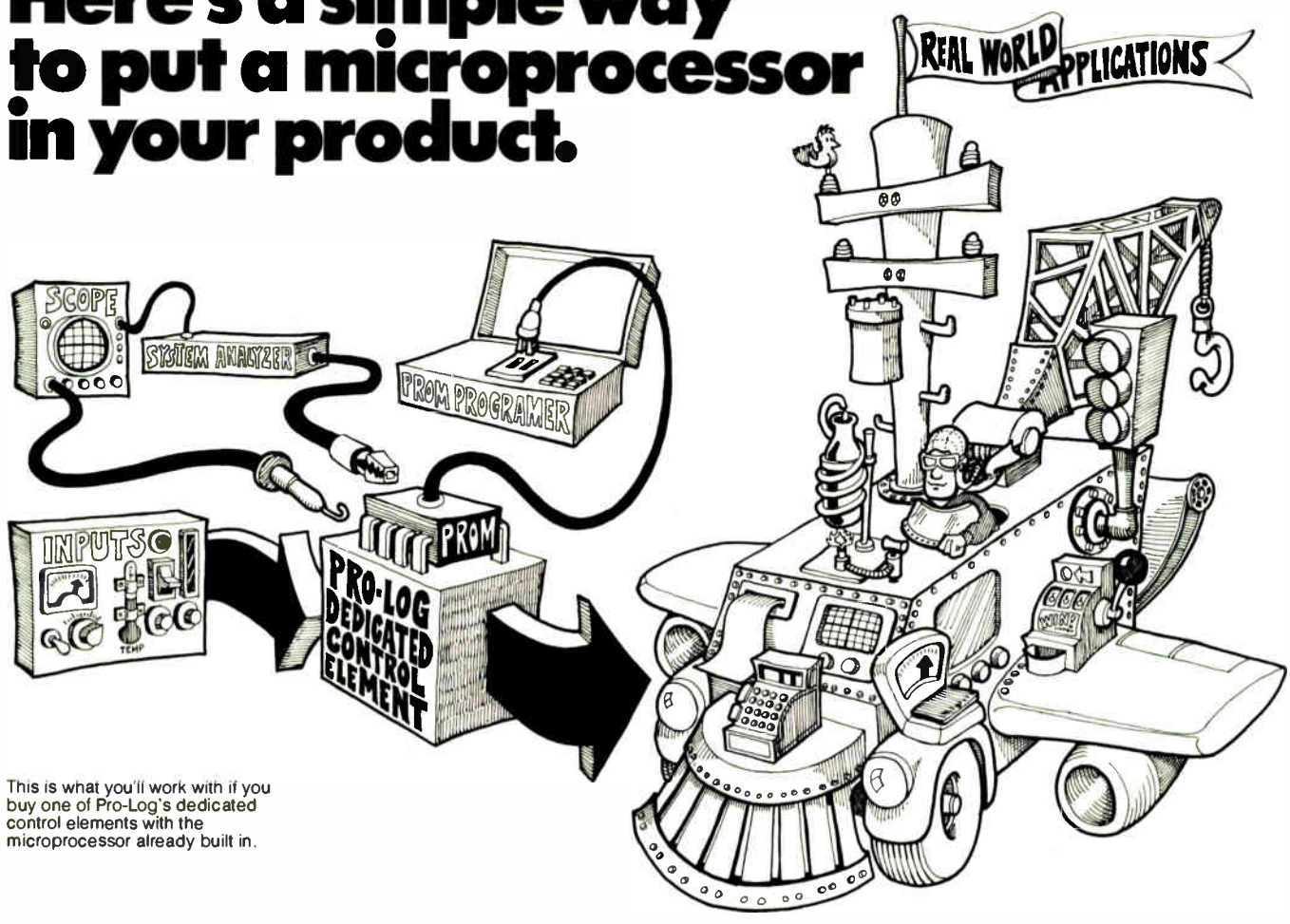

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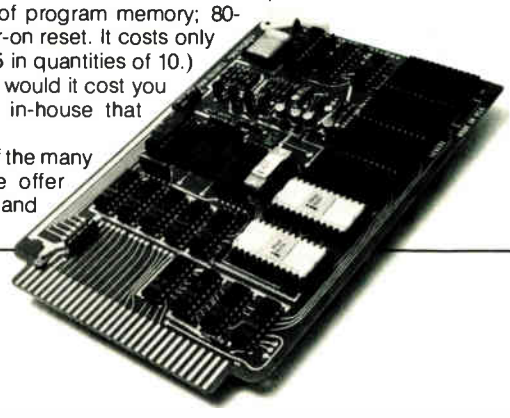

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Storing fast transients calls for transfer scope

Target optimized for writing speed captures spikes, transfers them to storage mesh

by Ron Roberts and Ken Arthur, *Tektronix Inc., Beaverton, Ore.*

☐ Fast-transfer storage oscilloscopes will make life much easier for the circuit designer or troubleshooter—the instruments can capture some of the fastest transients that can plague a circuit's operation. Only digital sampling systems have higher-speed capability, but they are harder to operate than storage-tube oscilloscopes and are also much more expensive and bulky.

Other storage oscilloscopes suffer from speed limitations. Signals with the highest input frequencies and shortest rise times either fail to register or produce traces that are too dim for proper examination. Such waveforms are beyond the capabilities of a scope with a low maximum stored writing speed—the measure of how fast a storage cathode-ray tube's electron beam can move while still producing a visible stored trace on the phosphor.

In calculating the necessary stored writing speed for a known signal, only the vertical component of the display need generally be considered, since this is usually one or more orders of magnitude faster than the horizontal component. The magnitude of the vertical component, V_y, for a sine wave of frequency f is approximately equal to πfA, where A is a peak-to-peak amplitude of the displayed signal in centimeters.

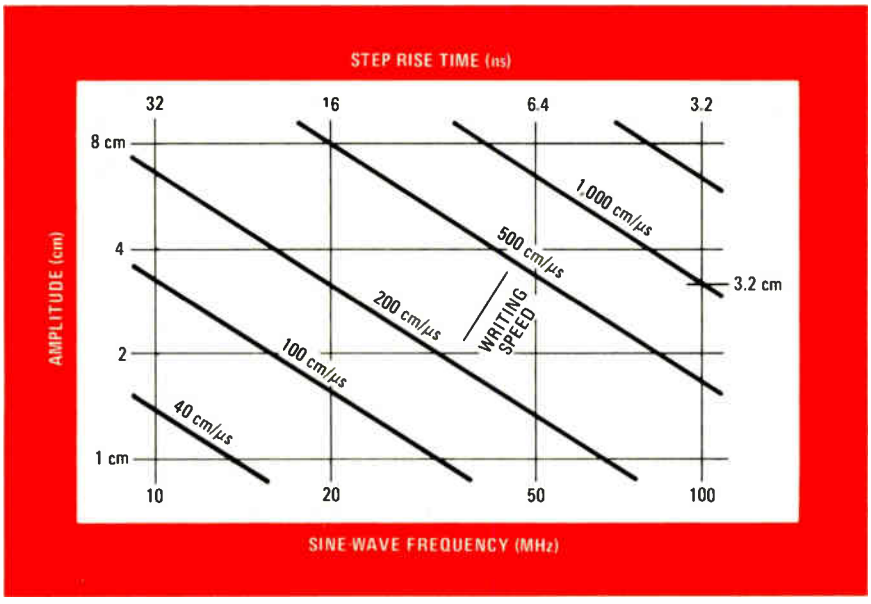
Thus, to display a 100-megahertz sine wave that has a peak-to-peak amplitude of 3.2 cm would require a stored writing speed, W_s, greater than or equal to $V_y = 3.14 \times 10^8 \times 3.2$, or about 1,000 cm per microsecond. For a step input, the required writing speed can be calculated from $W_s = kA/t_r$, where k is a factor that depends on waveshape and t_r is the risetime of the signal. A value of 1.0 can be assigned to k for an oscilloscope that has a step response characterized by only a few poles.

The nomograph of Fig. 1 shows the relationship between stored writing speed and the input signal's amplitude and either sine-wave frequency or step rise time.

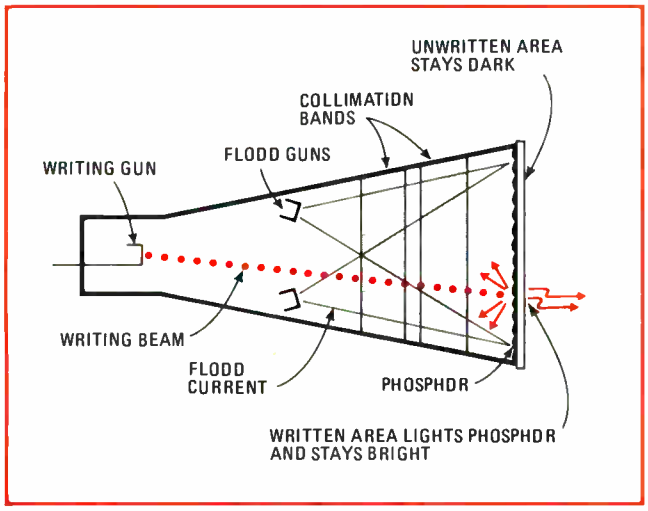
Factors underlying speed

The maximum stored writing speed of a storage oscilloscope is determined largely by the technique used to store the waveform within the cathode-ray tube. The first storage scopes used the bistable technique, and later units employed the variable-persistence approach.

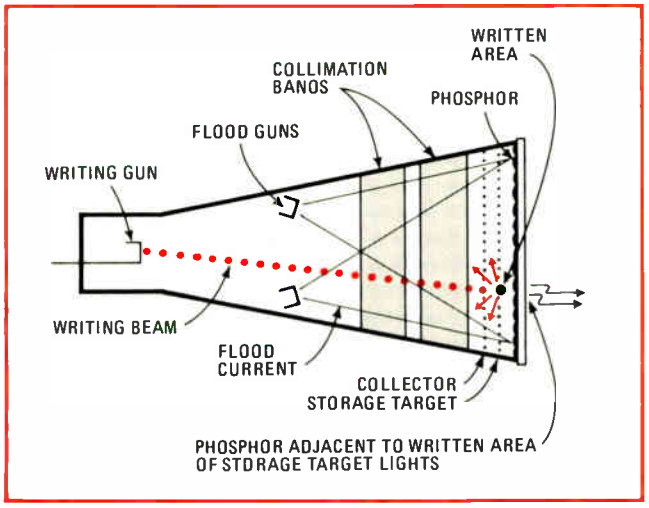
In bistable storage, the cathode-ray tube houses one or more flood guns to spray a target with low-energy electrons (Fig. 2). When the writing beam traces an image on the target, the low-energy electrons are reinforced on the written portion of the target, and the image is bright. The unwritten portions of the target repel



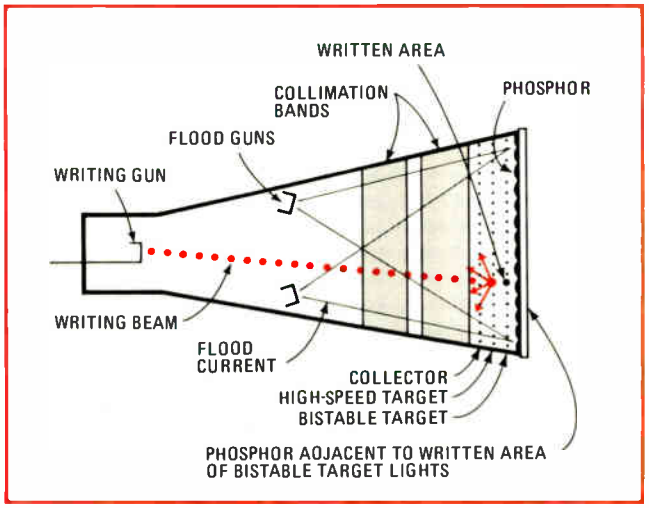
1. Relationship. The amplitude and sine-wave frequency or step rise time of a signal determine the writing speed required of a storage scope. For example, a 100-megahertz sine-wave signal of a peak-to-peak amplitude corresponding to a scope-screen deflection of 3.2 centimeters requires a stored writing speed of 1,000 cm/μs.



2. Bistable storage. Flood guns in a bistable storage CRT spray the phosphor or a fine-wire-mesh target with low-energy electrons that reinforce the written portion of the target to keep the image bright.



3. Variable-persistence storage. Variable voltage on a fine-wire mesh controls the energy required from the writing beam. The stored writing speed is increased, but image retention time drops.



4. Fast-transfer storage. Capturing the image on a high-speed mesh, then transferring it to a long-retention target combines the advantages of bistable and variable-persistence storage.

the low-energy electrons and remain relatively dark.

The target may be the phosphor itself or a coated mesh of fine wire suspended between the electron guns and the phosphor. Maximum stored writing speeds are about 10 cm/μs for the bistable phosphor type and 25 cm/μs for the bistable mesh type. The image will remain on the CRT for hours or even days after storage without degrading appreciably.

Variable-persistence CRTs increase the maximum stored speed to more than 400 cm/μs but at the expense of image retention time. Images are retained only for seconds or at most minutes. The image is stored on a dielectric-coated mesh of fine wire, and this target is charged from a power supply with anything from zero to full voltage (Fig. 3). Floodgun electrons pass through the target to the phosphor, their energy proportional to the charge on the mesh at a given point. Since the writing-beam electrons previously knocked other electrons off the mesh and left a positive charge there, the floodgun electrons form a corresponding trace on the phosphor. Electron leakage and ion currents begin to degrade the image as soon as it is formed, and this degradation is worst at the brightness levels required to display very fast signals.

The fast-transfer storage CRT—the latest tube storage device—combines the advantages of variable-persistence and bistable storage at only a slight increase in cost. It captures the image on a dielectric-coated fine-wire mesh that is optimized for writing speed rather than retention time (Fig. 4). Then it transfers the image to a second mesh designed for longer image retention. This second target may operate in either the variable-persistence or bistable mode, and front-panel controls can be adjusted to give the best tradeoff between writing speed and image retention.

Fast-transfer storage scopes can achieve stored writing speeds as high as 1,350 cm/μs. Only digital storage techniques can achieve higher equivalent writing rates—up to 8,000 cm/μs—but the increase in cost is considerable.

High writing rates are required in various of applications. Perhaps the worst headache for the circuit designer or troubleshooter is the unpredictable transient, and only slightly less vexing are turn-on and turn-off spikes. Both types of waveforms may sometimes require not just the memory capability of a storage scope, but also the high speed of fast-transfer storage.

Some applications

In one case, intermittent arcing in the high-voltage section of an oscilloscope caused extensive damage to components in the Z-axis circuit (Fig. 5). Monitoring the collector of transistor Q_1 with a fast-transfer storage scope showed a -70-V transient that reverse-biased the base-collector junction of Q_1 and imposed severe stress on operational amplifier A_1. This transient was caused by the slow forward recovery time of diode D_1, and changing this component from a rectifying type to a faster signal-and-switching unit corrected the problem by limiting the transient to a mere -3 V in amplitude.

However, this was not enough. Although the Z-axis circuit became more reliable, Q_1 continued to show

unacceptable failure rates in induced arcing tests. Use of a current probe to obtain a single-sweep photo of the reverse-recovery spike showed a forward current of 4 amperes flowing through D_2 and charging capacitor C_2. After a delay of 150 nanoseconds, Q_1 turned on, pulling a surprising 28 A from C_2 through D_2. This reverse current was caused by the slow reverse recovery time of D_2, which also had to be replaced by a faster switching-type diode. Reverse current was then limited to 3 A.

Another problem commonly occurs whenever a transistor is directly connected to a power-supply bus (Fig. 6). Often, the transistor shows a high failure rate, with a collector-to-emitter short that indicates avalanche or secondary breakdown.

In this situation, a storage scope can record most transients by itself, without intervention from an operator, if it is connected to the transistor's collector and the trigger controls set to positive slope, single sweep, and at a level too high for triggering by a normal signal. However, two types of transients—those coupled through the power-supply transformer and those generated in other circuits supplied by the same bus—are too fast and random to be captured by a real-time or storage scope other than a fast-transfer model.

Storing digital waveforms

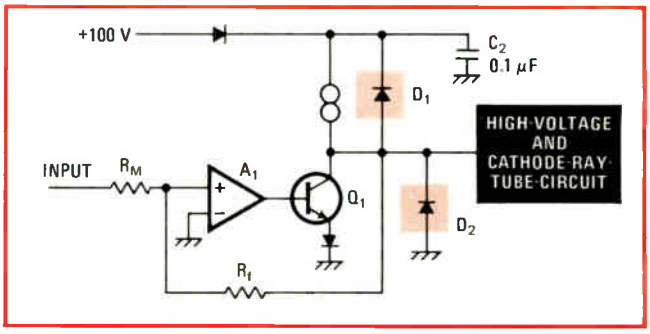
Fast-transfer storage can also help in tracking down problems in digital circuits, where clock and logic phasing, parity, and similar timing relationships require accurate measurement of periods as short as a few nanoseconds. Real-time oscilloscopes cannot display logic events that are noncyclical or occur at very low repetition rates, and slower storage scopes cannot reproduce the fast rise and fall times of the pulses typical in modern digital circuits.

For example, a random-access memory in association with other circuitry may sometimes produce incorrect data at its output (Fig. 7). The cause is often improper mode switching or power-supply transients.

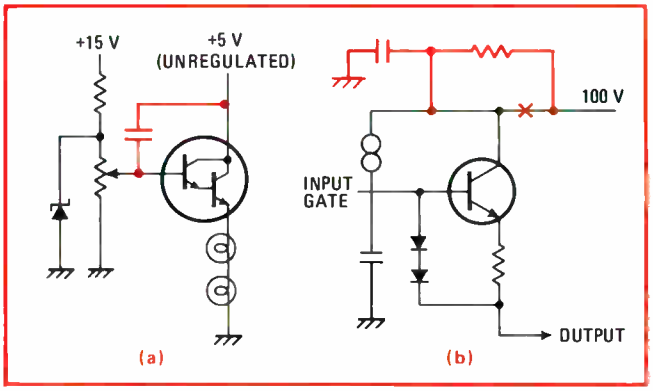
To get a close look at the mode-switching waveforms, a virtually time-coincident display of the signals on lines ME and WE was obtained by setting the storage scope in the alternate sweep mode and displaying the signals on each of two traces. The trigger controls were set for channel 1, and the view time was set to maximum. The channel 1 display of the ME waveform was stored as the mode-switching circuit was activated. Then the trigger circuits were rearmed by pushing the single-sweep reset button. The second channel was stored by reactivating the mode-switching circuit.

A time-comparison measurement showed that, during the switch from the data-transfer mode to the read-from-storage mode, a 10-ns interval occurred in which the circuits were placed in the write-into-storage mode. As a result, improper data was stored in the memory at random locations. The solution was to introduce a delay in the ME line to assure that the WE line completed its switch to high before the ME line went low.

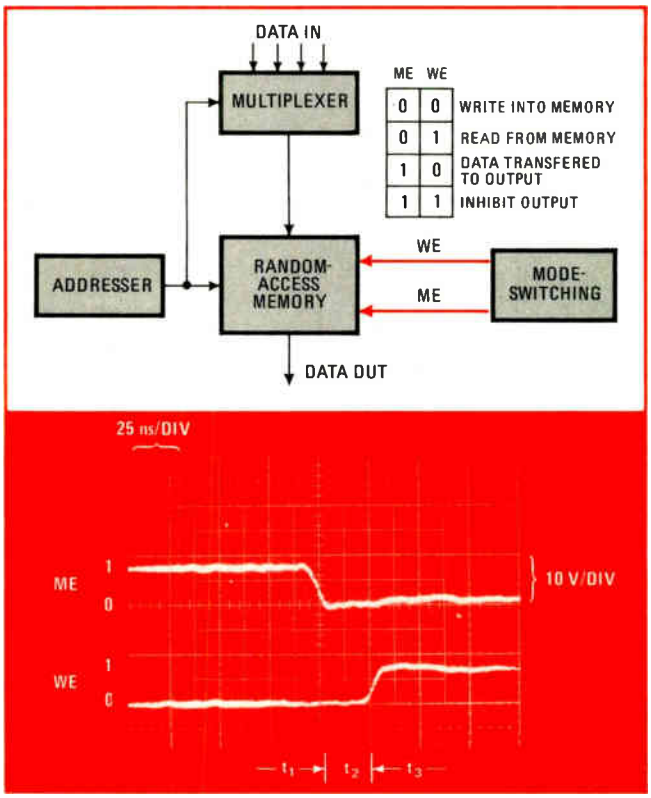
Cut-and-try methods could be employed to solve these problems if fast-transfer storage scopes were not available. But fast-transfer storage makes trouble-shooting such high-speed transients easier and faster. □



5. Catching transients. Fast-transfer storage captured high-speed transients in this oscilloscope circuit. The recovery times of diodes D_1 and D_2 were too slow for proper operation of the circuit.



6. Power-supply spikes. Fast-transfer storage oscilloscopes can also be triggered to monitor power lines for large transients that could destroy any semiconducfors directly connected to the bus.



7. Time check. Noncyclic events that last less than a few nanoseconds occur in the operation of many circuits. Fast-transfer storage can cope with them, but real-time and slower storage cannot.

Multiplexed detectors isolate water leaks

by F.E. Hinkle
Applied Research Laboratories, University of Texas, Austin

The need to detect water leaks at any number of sites is common to public utilities, communications links, warehouses, chemical plants, and many other industries. Warning systems are required to indicate not only the existence of the leaks, but also their location, and the warning arrangement should be as simple as possible for reliability, efficiency, and economy.

This warning arrangement is built of several water-detectors and one master indicator that monitors all of the detectors simultaneously. Each detector indicates the presence of water by sounding a unique tone signal on a loudspeaker at the master-indicator location. The system uses only two wires for supplying power to all of the detectors and carrying signals from all of the detectors to the monitor.

Each detector is composed of one complementary-MOS quad NOR-gate integrated circuit and a few components. One of the NOR gates is used as the water sensor, the second as an inverter, and the other two as an astable multivibrator. If the input terminals of the sensing gate are dry, the resistance between them is greater than 500 kilohms, and the output logic level is low. Therefore the output from the inverter is high, and the multivibrator is disabled. But if water connects the input terminals of the sensor, the resistance between them is below 100 kilohms, the input to the inverter is high, and the multivibrator oscillates at a frequency determined by its RC time constant. Each detector has its own characteristic frequency, given by

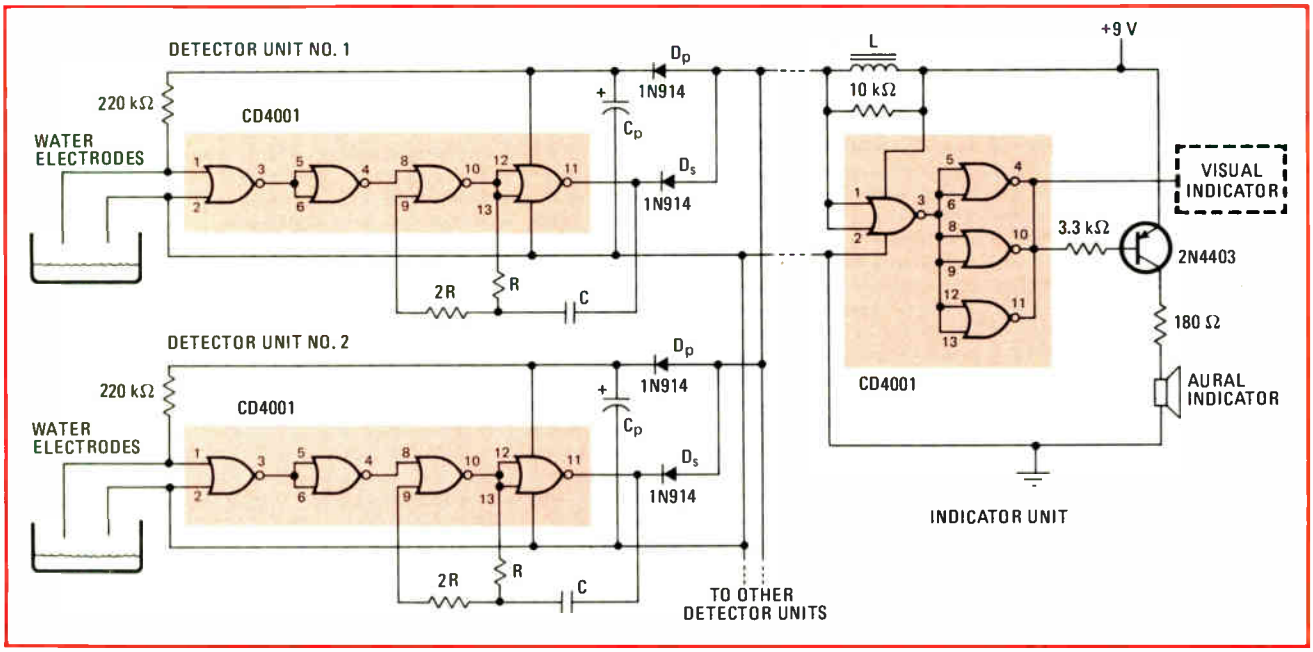
$$f_n = 1/1.4\,R_nC_n$$

where the resistance R_n is in ohms and the capacitance C_n is in farads.

The oscillator signal is carried back to the indicator unit over the two wires that supply dc power to the detector. Since the signal oscillates between 0 and +9 volts with a 50% duty cycle, the average value of the supply voltage is reduced considerably. Therefore, diode D_P and capacitor C_P are used to detect the peak supply voltage and store it. The value of C_P in farads is chosen to be $1/1000f_L$, where f_L is the lowest frequency (in hertz) used by any of the detectors. This amount of capacitance allows less than 0.5-volt ripple on the C-MOS chips.

To isolate all of the detector oscillators from one another, a diode, D_S, is used at the output of each multivibrator. Collectively, these diodes in the detectors form a multi-input OR gate.

The indicator unit contains a C-MOS gate that detects voltage fluctuations on the two-wire interconnect line and feeds a transistor amplifier to drive the loudspeaker. Inductor L isolates the detector signals from the dc-power source. The inductance value is deter-



Handles water music. A variety of tones from a loudspeaker signals water leaks and their locations. Visual display can also be provided, if necessary or desirable. Each one of a large number of detectors is identified by its unique frequency. Only two wires are needed to connect all detectors to the monitoring location; the wires supply power to the detectors, and carry the warning signals back to the indicator.

mined by the lowest signal frequency and the maximum current permitted during the oscillations. If this current is taken to be 1 milliampere for C-MOS devices used, the value of L in henries is about $1600/f_L$. This value of inductance seems large if f_L is a few hundred hertz, but the low currents permit use of miniature types of coils. A resistor shunts the coil so that no signal will see an impedance greater than 10 kilohms.

In operation, the detectors normally are quiescent. If a leak is detected, the frequency corresponding to the particular location is generated and transmitted via the two-wire interconnect cable to the indicator unit. The indicator emits the tone that identifies the location of the leak.

In a large system with many detectors, the oscillating frequencies may be too close together to distinguish between them, but a visual display, such as an oscilloscope or frequency counter, can be used to measure the precise frequency of oscillation.

Because C-MOS integrated circuits are used, the standby power demand is extremely low. A 9-V battery can power the complete system.

This system can be adapted to many other applications besides water-leak detection. Various types of sensors can be connected to produce logic-level changes at the input gate of the detector; only two interconnect wires would still be required to tie all the detectors to the indicator unit. □

Current tests ensure IC-package orientation

by Sylvan E. Shulman
Hughes Aircraft Co., Fullerton, Calif.

The symmetry of integrated-circuit packages makes it all too easy to orient them incorrectly in fixtures of automated testing systems or on circuit boards. Even though dual in-line packages may accidentally be rotated 180° from their correct mounting positions and flat-packs may be rotated or flipped over, they may fit into a jig or board. Such misalignments cost time and money to trouble-shoot and rework, but faulty orientation of most transistor-transistor-logic circuits can be detected routinely by a nondestructive automated measurement.

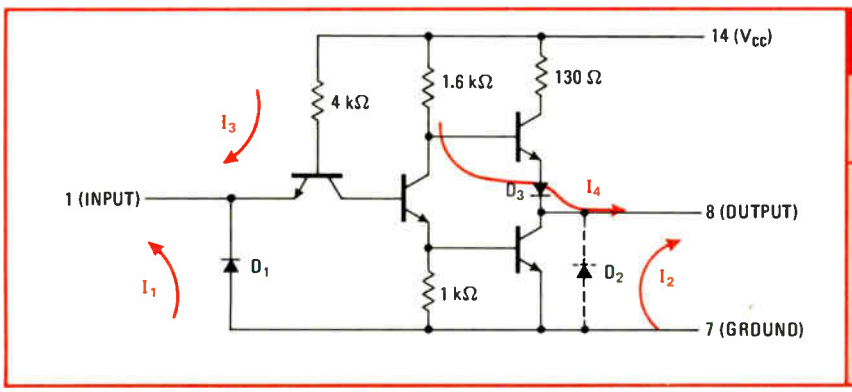
These measurements are important because, at incoming inspection, the IC packages are loaded into a chute that feeds them to an automatic tester. If the package emerges in the wrong position, voltages applied to the wrong terminals cause wrong results and may damage the IC.

To realize the importance of testing a stuffed board, it's only necessary to remember that the possibility of an insertion error on a board rises exponentially with the number of ICs. If a board contains 40 ICs and the insertion error per IC is 1%, then the yield of good boards is $(99\%)^{40}$, or 66.8%. Therefore 33.2% of the boards contain an incorrectly inserted IC.

The technique for measuring IC orientation is based on the current paths furnished by the input clamp diode in more than 95% of all TTL circuits or the substrate diode between every transistor collector and ground. These diodes are shown as D_1 and D_2 in the typical TTL gate of Fig. 1. They can carry currents of not more than 100 milliamperes.

In Fig. 1, the integrated-circuit gate is not connected to any power supplies except a constant-current source. If the current source drives a 1-milliampere current through the IC from the ground terminal to an input terminal such as terminal 1, the voltage drop across those terminals is about 0.7 volt. This ground-to-input current flows through clamp diode D_1 and is shown as I_1 in Fig. 1. Similarly, if 1 milliampere is driven through the IC from the ground terminal to an output port, the voltage across the terminals is about the same. This current flows through the substrate diode D_2 and is I_2 in Fig. 1.

By contrast, if the constant-current source is connected to drive 1 milliampere from the V_{CC} terminal to the input, that current, I_3, flows through a silicon-diffused re-



TERMINAL VOLTAGES FOR ORIENTATION-TEST CURRENTS

Current	Terminals	Level (mA)	Terminal voltage (V)
I_1	Ground to input	1	0.7 ± 30%
I_2	Ground to output	1	0.7 ± 30%
I_3	V_{CC} to input	1	1.4 ± 20%
I_4	V_{CC} to output	1	1.4 ± 20%

1. Current situation. Current flow from supply terminal to input or output terminal of a typical TTL gate produces a voltage that is different from the voltage that is produced when current flows from ground to input or output, and this difference can be used to check IC orientation. The forward voltage drop across a base-to-emitter junction is about 0.7 volt; across a diode, it is about 0.55 V; and across a diffused resistor, it depends on current. One milliampere through the 4-kΩ resistor produces 0.7 V, but through the 1.6-kΩ resistor, 1 mA produces only 0.1 V.

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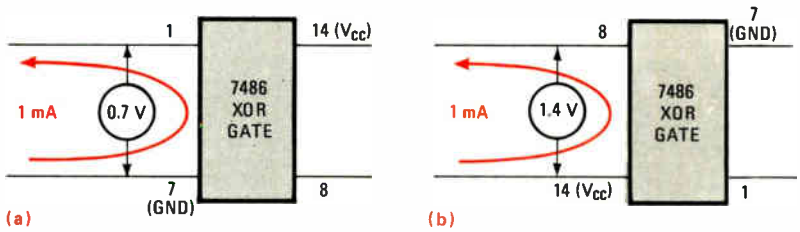
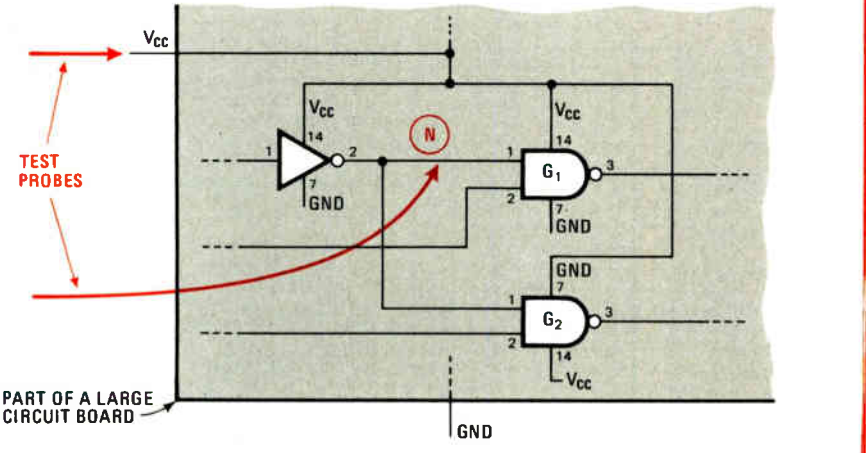


2. Single IC. Test set sends 1-mA current through left-corner terminals and monitors resulting voltage. If IC is positioned correctly, as at (a), terminal voltage is in range 0.49–0.91 V. If IC is incorrectly positioned, as at (b), the range is 1.12–1.68 V, so test station ejects unit without applying possibly damaging test voltages.



CURRENT LEVELS FOR STUFFED-BOARD TESTS

IC inputs at node	IC outputs at node	Probe current (mA)	Expected voltage (V)
1	0	1	1.4
2	0	1	1.4
3	0	2	1.4
4, 5	0	3	1.4
0	1	1	1.4
1	1	1	1.4
2	1	1	1.4
3	1	2	1.4
4, 5	1	3	1.4

3. Stuffed board. To check orientation of IC mounted on circuit board, probes connect current source to V_{CC} terminal of board and to any node on the board. Voltage across probes is 1.4 V (±20%) if all packages are mounted properly. A lower voltage indicates that some IC is turned around or upside down—here, gate G_2 has its ground pin where its V_{CC} pin should be, so voltage at probes is only 0.7 V. Table shows current-source levels that should be used in testing orientation of standard TTL integrated circuits; high-power TTL requires more current.

sistor, as well as a base-to-emitter junction. Although the diffused resistor is labeled as 4 kilohms in the circuit diagram, its resistance is strongly dependent on the current level. At 1 mA, the drop across the resistor is about 0.7 V; this value is added to the 0.7-V drop through the base-emitter junction to make the voltage between the V_{CC} and input terminals about 1.4 V.

Likewise, if the current I_4 from the V_{CC} terminal to an output terminal is 1 mA, the voltage across the terminals is again about 1.4 V. In this case, the drop across the diffused resistor is on the order of 0.1 V. The base-emitter drop and diode drop add up to 1.3 V. (All of these voltage values are experimental results.)

For incoming inspection of ICs, when a unit slides out of the loading chute into an automated test fixture, the orientation of the package can be checked as shown in Fig. 2. The 1-mA current source is connected between the lower left terminal and the upper left terminal of the package, and the voltage across these terminals is measured. If the package is positioned properly, the current flow is from ground to input, and the voltage is 0.7 V. The test station can then power up the chip and measure performance characteristics.

If the IC has been loaded 180° out of position, the current flows from the power-supply terminal to an output, and the voltage is 1.4 V. When this too-high voltage is sensed, the tester ejects the IC into a bin for reloading.

A similar sort of test can ensure correct orientation of all the ICs mounted on a circuit board. The test fixture for this stuffed-board test must be a bed-of-nails arrangement that makes contact with every circuit node on the board. No power is applied to the board except a current source that drives current from the common V_{CC} terminal to one or another node. The amount of current that the source must supply depends on how many inputs and/or outputs are connected to that node, as listed in the table of Fig. 3. The tabulated values are for conventional TTL ICs; high-power TTL requires larger currents. Correct orientations produce 1.4 V across the current-source terminals; if a package is misoriented so that current flows into its ground pin, the voltage is only 0.7 V.

Figure 3 shows a portion of a circuit board that contains a number of ICs, with the current source connected between V_{CC} and node N. This node connects one output and two inputs, so the test current is 1 mA in accordance with the table, and the voltage drop from the V_{CC} terminal to node N should be 1.4 V. However, gate 2 has been mounted incorrectly, with its ground pin and supply pins reversed. In this position, current flows from ground to the node, the voltage is only 0.7 V, and the go/no-go tester rejects the board.

Although the discussion here has been limited to TTL devices, the testing technique is also applicable to metal-oxide-semiconductor devices. □

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

Engineer's newsletter

IEEE brightens retirement prospects of self-employed EE

If you're a member of IEEE and you or your spouse are self-employed or get some part of your income from free-lancing, you can now sign up for a new retirement investment program. Managed by the Continental Illinois National Bank and Trust Co. of Chicago, the plan offers **a special low initial fee and five different investment plans,** over and above the income tax benefits possible with Keogh retirement plans.

Other IEEE members, please note—the IEEE and Continental are also trying to set up the broader Individual Retirement Account plan now open to salaried employees who lack pension programs. But this second plan may be slower in coming—it requires approval from the Securities and Exchange Commission and may not be granted without considerable legal maneuvering to meet the regulations.

A hot tip on cooling tips of soldering irons

Installing a simple half-wave rectifier in the line cord of a small soldering iron makes a soldering tip last much longer, claims Hugh Macdonald of the Hypnosis Research unit of Stanford University's Psychology department. For example, an iron-clad or gold-clad miniature tip has such a small thermal mass that the heater cartridge must supply up to about 35 watts for fast soldering. This is enough wattage to oxidize and corrode the tip while the iron is idle.

But **if you mount a diode with a simple switch across it in the line cord, you can lower the tip temperature during idle times.** With the switch in the open position, the diode passes half-wave rectified current. But five seconds after the switch is closed, short-circuiting the diode, the temperature is again high enough for rapid soldering. Both parts fit easily into a standard in-line power switch case and cost only about 50¢ (if they're not already in your junk box). Yet they do the same job as expensive heat controllers, Macdonald says.

When you *want* ICs to come unstuck . . .

Normally, you "glue" ICs to flexible printed-circuit material before using automated soldering to fasten the connections—that way, the devices stay precisely in place. Trouble is, you cannot unglue them, since the adhesive has to be permanent to resist the heat of soldering (about 550°F) as well as various degreasing solvents. So the whole printed circuit has to be thrown away if there's a single IC malfunction.

Now you can do better, by using Kapton dielectric film plus a different kind of adhesive from Rexham Corp., Matthews, N.C. **This adhesive bonds only with pressure and releases easily once solder connections are reheated and softened.** It's also not heat-reactive and is inert to solvents.

Booklet solves pc processing problems

Have any problems you want to cure in processing single-sided, double-sided, and multilayer rigid printed-circuit boards? A new document from the Institute of Printed Circuits lists the probable causes and suggests various forms of corrective action. The IPC booklet covers **problems in design, raw-material usage, mechanical fabrication, imaging, plated-through-hole sensitizing, plating,** and much more. Get your copy from IPC National Headquarters at 1717 Howard St., Evanston, Ill. 60202 for $5.00. **—Stephen E. Scrupski**

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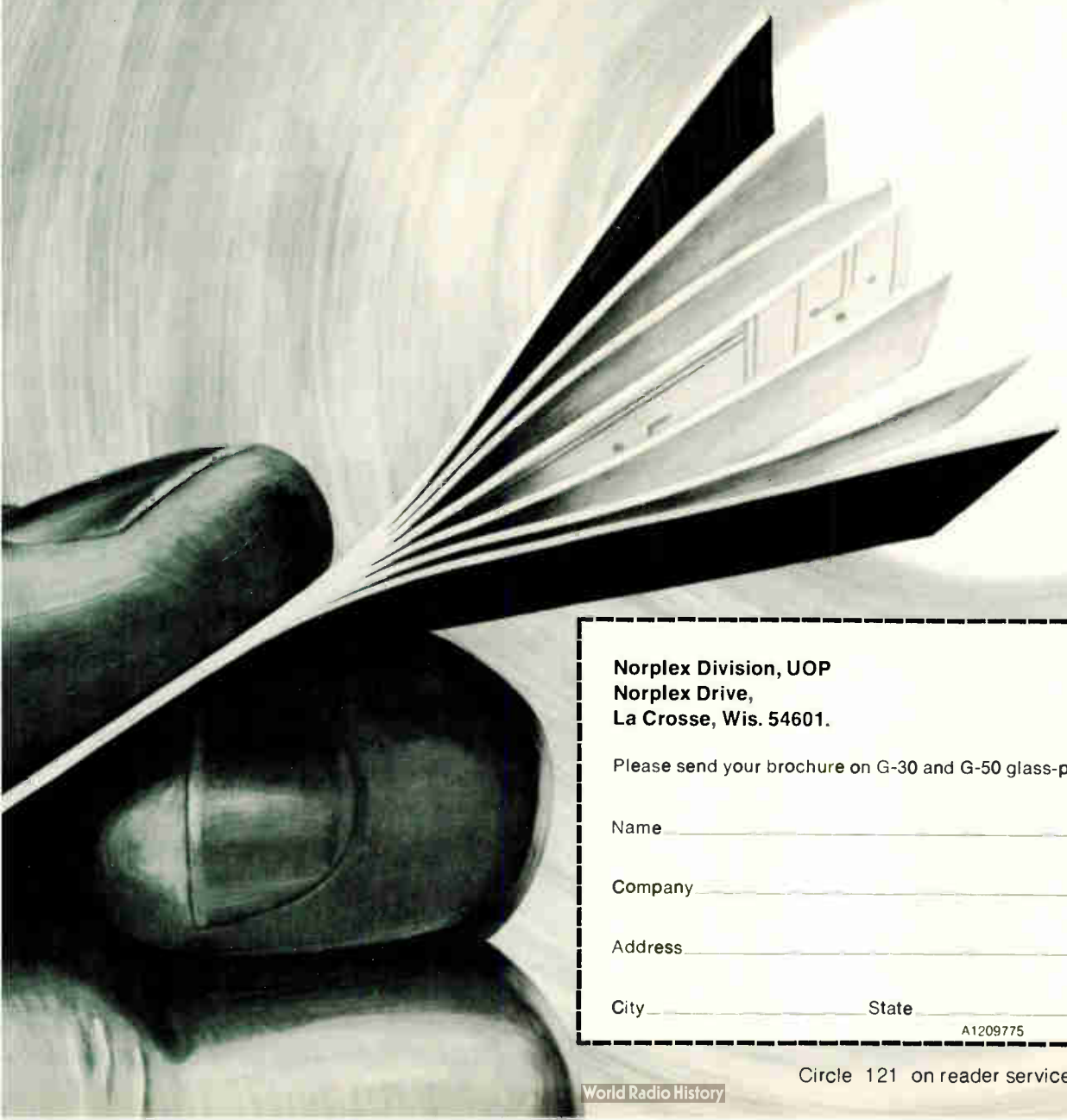

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Synthesizer on a card spans 1-32 MHz

Low-priced instrument can be plugged into communications, test systems; using a single phased-lock loop, it provides a resolution of 500 Hz

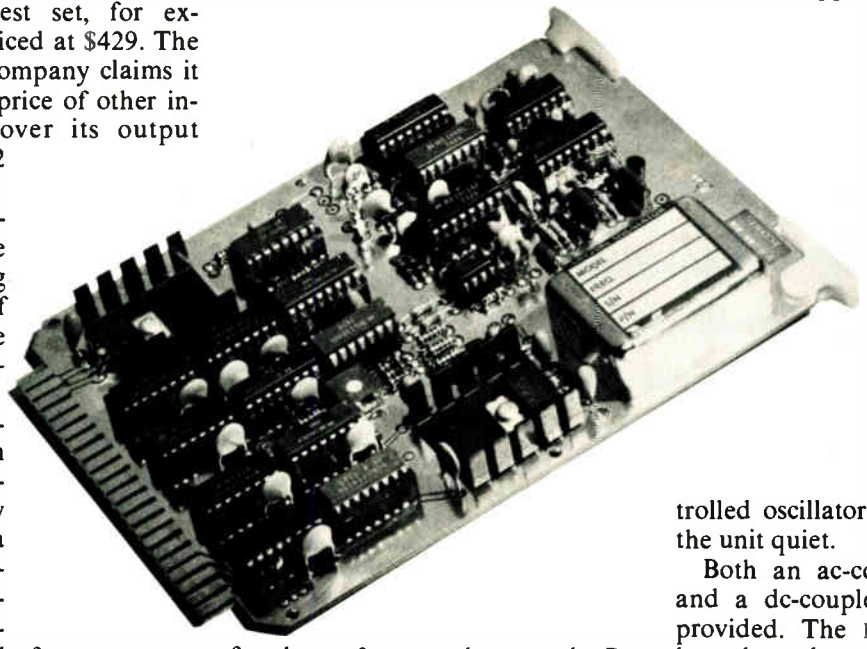
by Gail Farrell, Boston bureau manager

Usually stand-alone instruments, frequency synthesizers can cost in the thousands of dollars in the high-frequency range. But now the Syntest Corp. has developed a modular frequency synthesizer on a board. It can be plugged into an automatic communications test set, for example, and it is priced at $429. The Marlboro, Mass. company claims it is about 1/10 the price of other instruments that cover its output range of 1-32 megahertz.

Syntest sees applications for the SM-105 in plotting and alignment of active and passive filters, as a variable-frequency generator in automatic test sets, in inspection and testing of large-array comb filters, as a calibration standard for analog oscillators, as a precision variable clock for IC system testing, and as a transceiver local oscillator.

The 4¾-digit synthesizer provides 1-32-MHz TTL signals with 500-hertz resolution into a 50-ohm load by using a single phase-locked loop. The company says that, although a phase-locked loop can be quite noisy, it was able to keep noise down by using the latest versions of phase-locked-loop chips and by linearizing the voltage-controlled oscillator over the whole range. This makes the loop stable with its fixed set constants, which determine the performance of the loop and therefore the unit's noise level.

In designing for low cost and modularity, some performance was sacrificed. For instance, the frequency stability of a single phase-locked loop can be a problem on a short-term basis—there is jitter of a few hertz from peak to peak. But Syntest emphasizes that these variations are well below the audio-frequency range, and the company is, after all, aiming the SM-105 squarely at high-frequency audio communications. For longer times—more than a second—the stability is just as good as the crystal standard, the company says.



There was also some compromise in the frequency resolution. Syntest chose a 500-Hz step, which is not as difficult or expensive to reach as steps with 100-Hz resolution but is well below the 1,000-Hz steps common in communications applications, according to Syntest.

The unit also employs a crystal oscillator with a temperature compensation of ±10 ppm as a frequency standard. As an option, a crystal with a temperature coefficient of ± 1 ppm is available, or the unit can operate from an external oscillator.

The SM-105 uses C-MOS and low-power TTL as well as ECL for higher speeds. On-board voltage regulators take an 8–10-volt dc supply at 700 milliamperes down to 5 V to power the logic, plus a 22–30-V dc supply at 20 mA down to 20 V for the voltage-controlled oscillator, which helps keep the unit quiet.

Both an ac-coupled ECL output and a dc-coupled TTL output are provided. The ECL output, which has the advantage of a cleaner square wave, has rise and fall times of 2 nanoseconds, while the TTL output has rise and fall times of 8 ns. But ECL and TTL outputs level into a 50-ohm load.

Frequency accuracy and stability of the entire unit is ±10 ppm over the operating range of 0–50°C. Frequency is selectable by binary-coded-decimal TTL lines or can be set with thumbwheel switches. Settling time to within 10% of the step is 50 milliseconds.

Price of the SM-105 is $429.

Syntest Corp., 169 Millham St., Marlboro, Mass. 01752 [338]

National invades active-filter market

Semiconductor company introduces first two in a family of 20 to 25 laser-trimmed hybrid parts; low prices aimed at in-house fabricators

by Bernard Cole, San Francisco bureau manager

Setting its sights on dominating what has been a relatively modest market for active filters, National Semiconductor is introducing the first two parts in a series of 20 to 25 units. Pricing on most of the laser-trimmed hybrid parts, according to product manager Dean Coleman, will be 50 to 75% lower than what is now being offered on the active-filter market.

"We believe there is a substantial market for a family of standard active-filter parts," he says. "The key to opening up this market is in attracting those users who now fabricate most of their filters in-house, using discretes."

Two parts will be available this month: the AF100 universal active filter, which in its commercial versions will range in price from $4.95 to $8.95 in 100 to 999 quantities; and the AF120 generalized impedance converter, a ladder-network building block, which will range in price from $3.50 to $6.50 in quantities of 100 to 999. Militarized versions of the AF100 will also be available, and they will be priced in the $14 to $18 range.

Also scheduled for introduction over the next six to nine months, says Coleman, are a set of about 10 filters designed for use in dual-tone multi-frequency telephone receivers; two D-3 channel bank filters for use in pulse-code-modulation systems; seven or eight models that are intended for use in multifrequency tone receivers; and several rejection filters for use in stereo audio amplifiers.

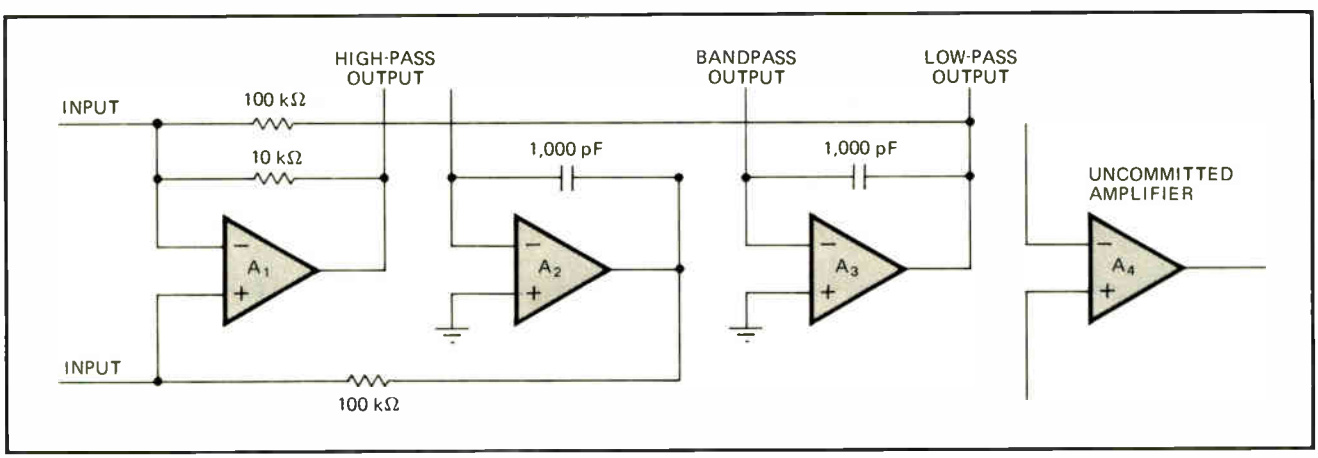
Four op amps. The AF100, essentially just four internally produced operational amplifiers hooked onto an RC network, is providing a general second-order lumped RC network, says Coleman.

Only four external resistors are needed to program the AF100 for specific second-order functions, he says, and any of the classical filter characteristics—such as Butterworth, Bessel, Cauer, and Chebychev—can be obtained from this universal active filter. Low-pass, high-pass, and bandpass functions are available simultaneously at separate outputs. Notch and all-pass functions are available by summing the outputs with the device's uncommitted amplifier.

Features include: Q, frequency and gain adjustments that are independent of each other; low sensitivity to external component variation; inputs that may be differential, inverting or noninverting; an operating range of up to 10 kilohertz; a Q range of up to 500; a power-supply range from ±5 volts to ±18 V; an unadjusted frequency accuracy that is within ±1%; and a Q frequency product less than or equal to 50,000. The parts are available in either a 16-pin dual in-line or a 12-pin metal can package.

Despite the fact that several companies offer universal active filters as a standard product, their recep-

Four in one. Low-pass, high-pass, and bandpass functions are available simultaneously at separate outputs of the AF100 universal active filter. A notch function can be realized by summing two outputs in the uncommitted amplifier. The filter operates to 10 kHz.



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tion has been mixed, since tuning them to the desired specifications is not easy, often taking hours or days of an engineer's time.

"What we have done to ease this problem is develop a set of proprietary computer programs," says Coleman.

"We work with the user to develop the set of filter specifications he needs. This information is fed into a computer and minutes later we get an answer, telling us which value of resistors to attach to which pins in order to provide us with a particular function."

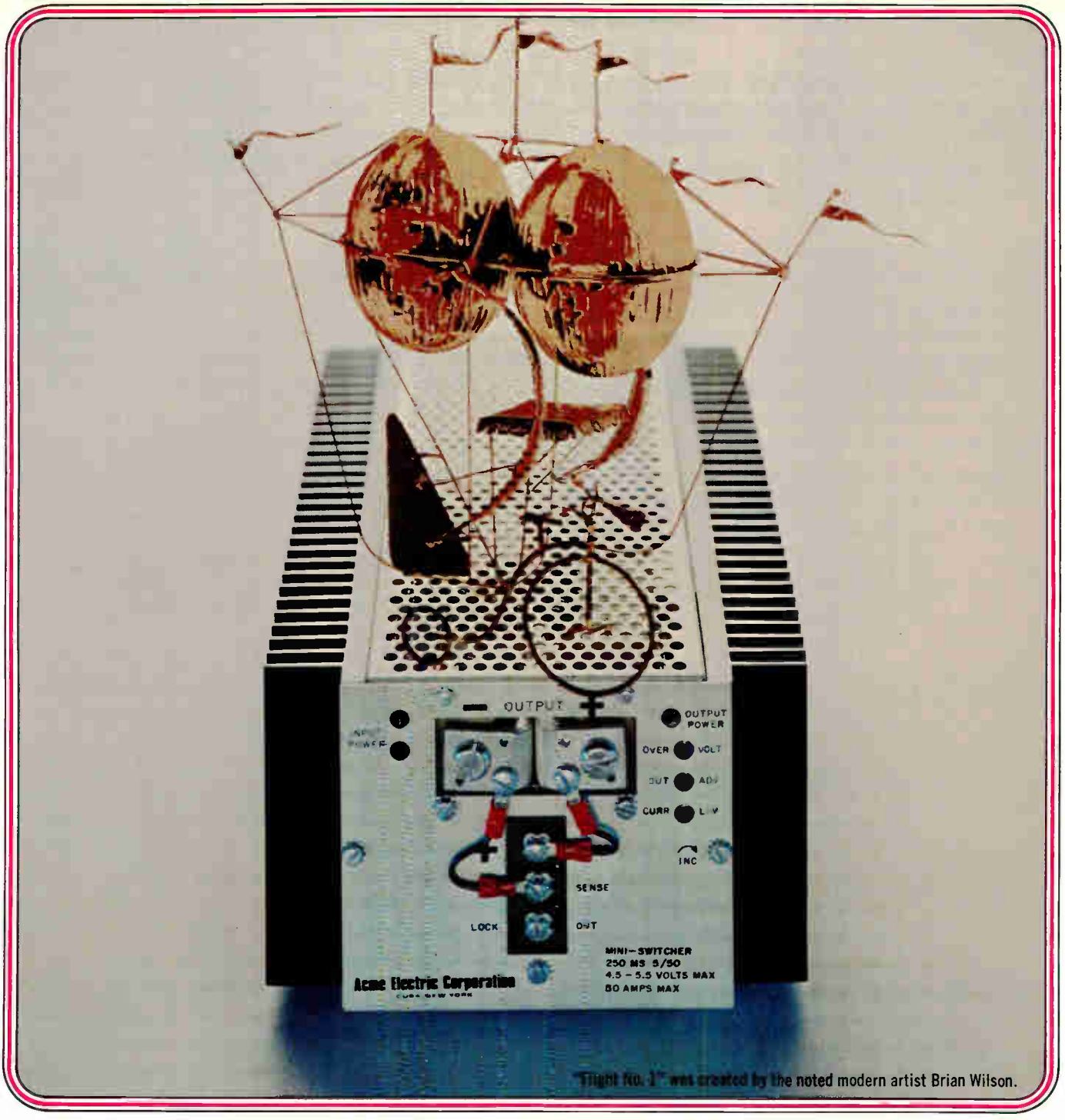
Also available this month, says Coleman, will be the AF120, a generalized impedance converter that can be used in low-frequency active ladder-filter networks; as a "gyrator," a substitute for bulky impedance filters; or it can be used as a frequency-dependent negative resistance. Containing a pair of operational amplifiers and four precision thin film resistors in a 10-pin metal can package, the AF120 can be used as a gyrator by adding one external capacitor. A frequency-dependent negative resistance can be formed by adding two external capacitors to the op amps and resistors.

"Thus, with the appropriate transformations, the generalized impedance converter makes possible an active realization of any low-frequency ladder filter network," says Coleman.

"The advantage of ladder filters, of course, is that they exhibit lower sensitivity to component variations than any other type of filter realization. Temperature coefficients of the internal resistors are equal and opposite in sign to that of polystyrene capacitors, thus the RC product exhibits almost zero temperature coefficients."

Other features include matched internal resistors (7,500 ohms, ±0.1%); a resistor temperature coefficient of 110 ±3 ppm per °C; a 7,500-ohm input impedance, and a ±5-to ±18-volt supply range.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051 [339]



"Flight No. 1" was created by the noted modern artist Brian Wilson.

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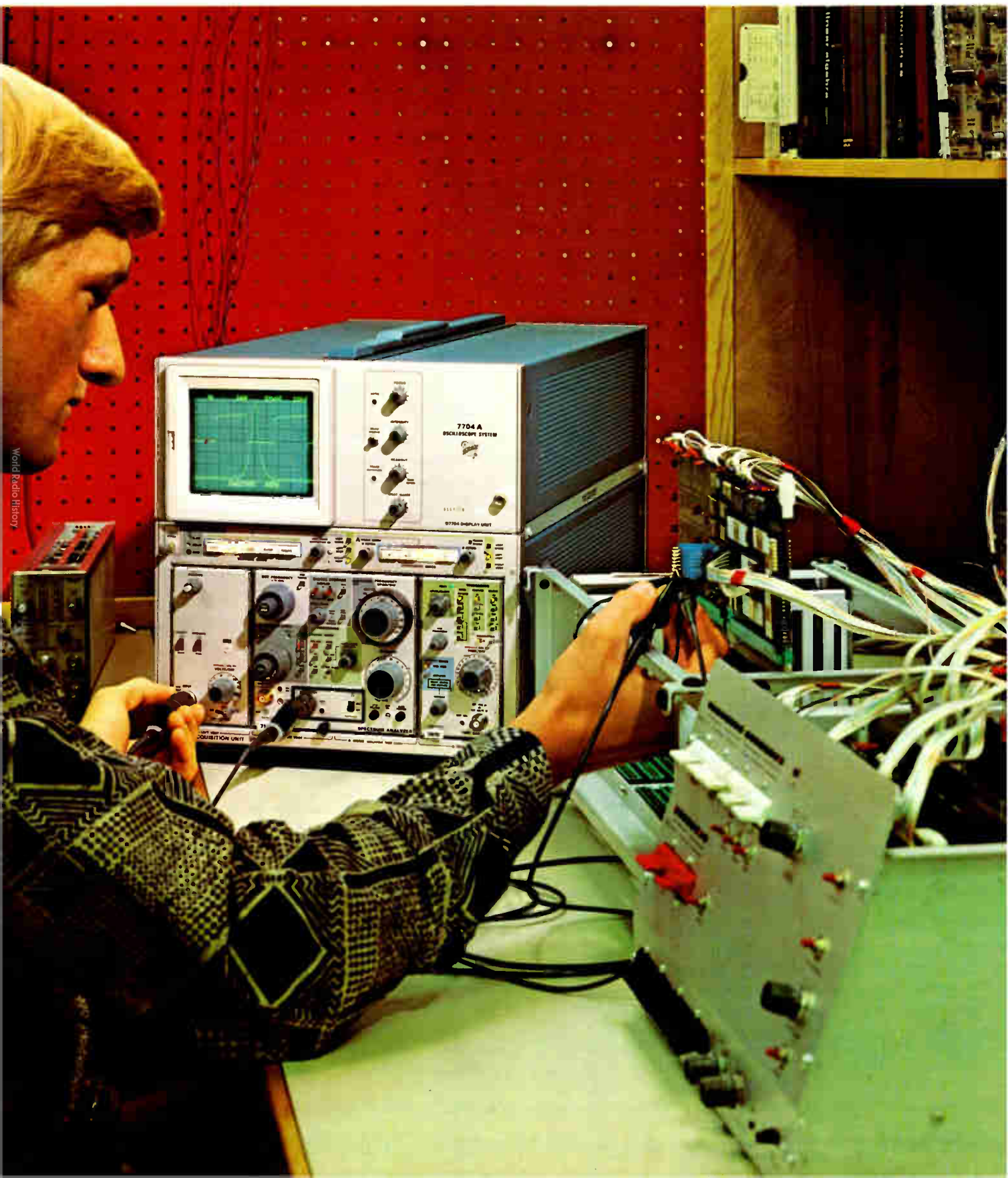


Measurement Flexibility

In today's research and development laboratory your work calls for measurements of many different types. For example, in integrated circuit development you most likely need a real time oscilloscope, a sampling oscilloscope, a digital multimeter and digital counters/timers. Or in communications R & D you probably use a spectrum analyzer in addition to all of or most of the instruments mentioned for the IC lab.

However, your space limitations, budget considerations and operator's convenience all demand that you get the maximum measurement flexibility from each instrument package.

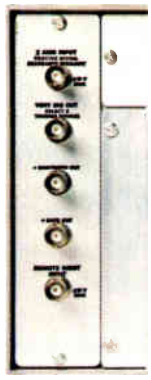
The TEKTRONIX 7000 Series offers just such flexibility in a system of laboratory instruments. Its flexibility allows you to tailor the oscilloscope-based measurement system that most closely fits your needs. You select the measurement parameters—and the measurement techniques—you need, and combine them into interchangeable mainframe and plug-in packages.

Here are a few examples of 7000-Series flexibility:

BANDWIDTH RANGE—Whether your maximum bandwidth requirement is less than 100 MHz or up to 500 MHz (or even up to 1 GHz in some circumstances), there is a mainframe to match your needs. Eleven amplifier plug-ins and five time-base plug-ins (with sweep speeds to 0.5 ns per division) further help you tailor your system.

INPUT CHANNELS—Whether you need only one trace or up to four inputs, you can select just as many amplifier channels as you need.

SIGNAL ACCESS—For special signal access or processing such as Z-axis input, sweep gate and sawtooth, remote reset input, or vertical amplifier output, the interconnection scheme of the plug-in scope gives you convenient access points.



DELAYED SWEEPS—For complex measurements requiring delayed sweep, the 7000 Series offers both analog and digital techniques for delaying and expanding sweeps.

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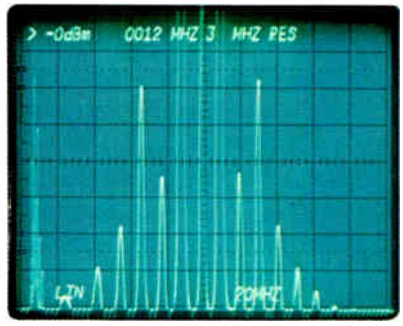
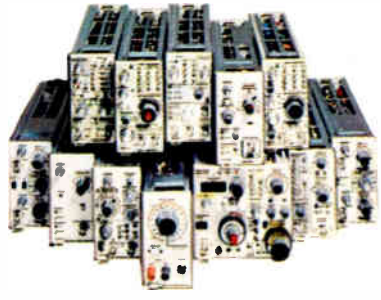
What about your measurement needs that are outside the realm of a conventional oscilloscope, such as spectrum analysis, curve tracing and rapid scan spectrometry? Three spectrum analyzer plug-ins handle up to 1.8 GHz with 30 Hz resolution. A curve tracer plug-in displays dynamic parameters of devices up to one-half watt. And the RSS plug-in scans 400 nm in just 4 ms. (RSS available in U. S. only.)



One more thing about 7000-Series flexibility: with a choice of more than 30 plug-ins and 17 mainframes in a continually evolving family, you can be assured of a long-lived oscilloscope system that will continue to accommodate your needs.

For a catalog describing all the 7000-Series instrument mainframes and their plug-ins, call your local Tektronix Field Engineer, or write Tektronix, Inc., P.O. Box 500, Beaverton, OR. 97077. In Europe, write Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey. Channel Islands.

The 7000 Series . . . more than an oscilloscope



Microprocessor designer uses time domain plug-ins (7A16A/7B70) and spectrum analyzer plug-in (7L5) to give a combined display on 7704A mainframe. While the oscilloscope displays pulse characteristics, the spectrum analyzer identifies clock jitter down to 10 Hz and measures system noise directly in dB.

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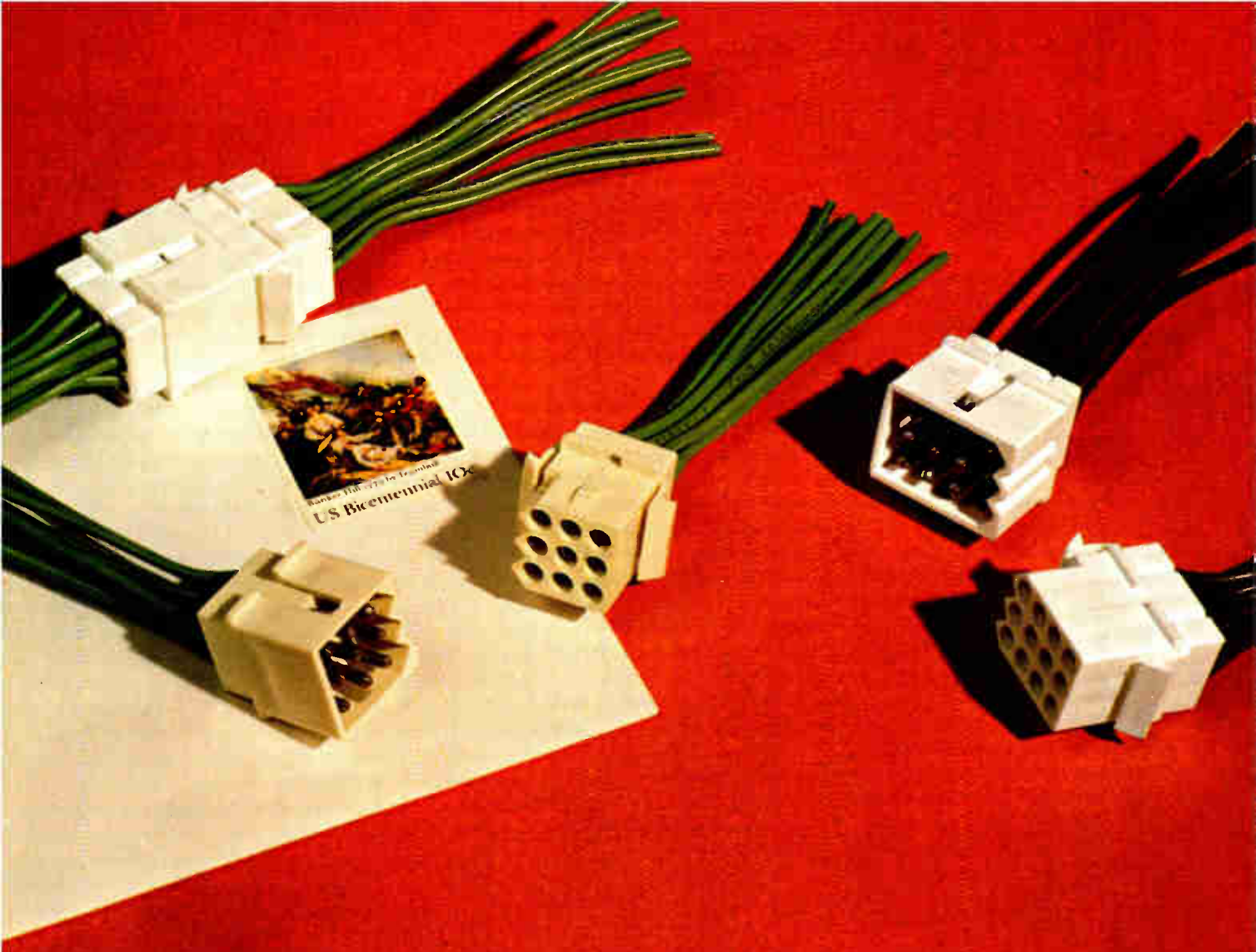

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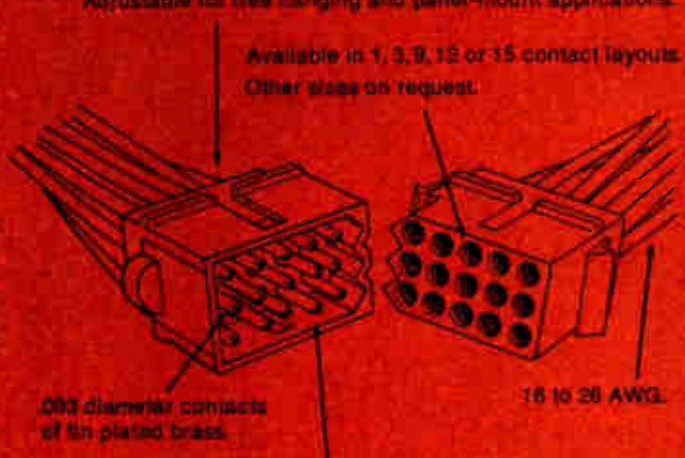

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Instruments

Recorder spans dc to 500 kHz

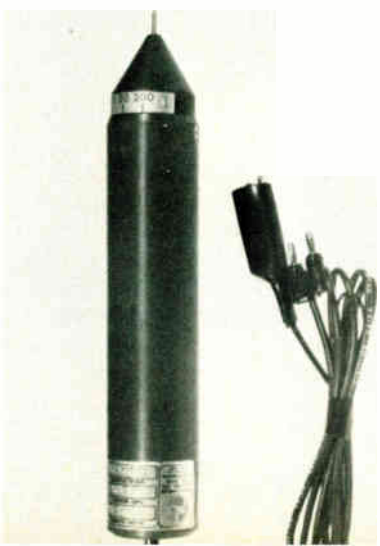
Automatic unit permits unattended gathering of transient data

Designed to provided unattended automatic recording of limits (levels, peaks, or valleys), single events, and transients, the model 526A high-speed transient recorder accepts signals from dc to 500 kilohertz in 12 switch-selectable ranges from 100 millivolts maximum to 500 v maximum. The unit comes with an analog chart recorder; two digital (event) input channels being optional. A 500-point semiconductor memory, which can can store up to 1 million points per second, together with post-event triggering capability, allow the recorder to capture and analyze data from one-time and random events. The 526A starts at $4,250. Delivery time is 60 days.

QuantaLog Inc., 42 Enterprise Dr., P.O. Box 1523, Ann Arbor, Mich. 48106. John Duté (313) 769-4936 [351]

Battery-powered probe responds to rms values

A portable, battery-operated probe called the model RMS-10 can convert any dc voltmeter into a true-rms meter. The probe accepts complex input signals—pure ac, pure dc, or combinations of both—and produces a dc output voltage proportional to the rms value of the input. The unit has three input ranges: 2, 20, and 200 volts full scale, and always produces an output between 0 and +2 v dc. The probe has an input impedance of 1 megohm, a 3-decibel bandwidth of 10 kilohertz, and a conversion accuracy within 1%. Measuring 7 inches long by 1.4 in. in diameter, it has a small-quantity price of $149. The nickel-cadmium batteries and a charger for them are included. Delivery of the RMS-10 is from stock.



Non-Linear Systems, Inc., P.O. Box N, Del Mar, Calif. 92014. Phone (714) 755-1134 [353]

3½-digit panel meter sells for $49 in singles

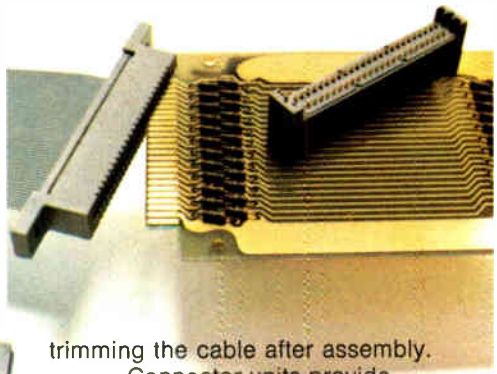
Offered with an optional dummy zero at the least-significant-digit position, the series 500 digital panel meter is a 3½-digit instrument with a maximum error of ±(0.05% of reading + 1 count). The unipolar meter uses 0.4-inch LED readouts and sells for only $49 in unit quantities. Zero and full-scale adjustments are accessible from the front panel.

International Microtronics Corp., 4016 E. Tennessee St., Tucson, Ariz. 85714. Phone (602) 748-7900 [356]

Portable meter measures rms values

Designed to measure the rms value of voltages and currents from 15 Hz to 20 kilohertz and dc, the Multavi eff., as it's called, is a portable analog multimeter with a full-scale crest factor of 4.5. The dc-coupled meter, which is electronically protected against overload damage, has an input impedance of 10 kilohms per volt. There are 11 current-measuring ranges from 300 microamperes full scale to 30 amperes

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.

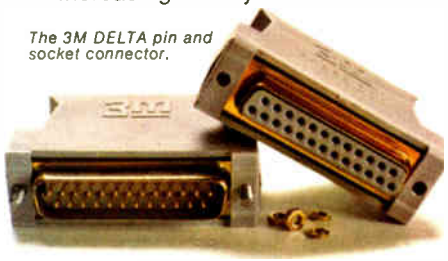
Assembly-cost savings are built in when you design a package with "Scotchflex" flat cable and connectors. But more important, 3M Company offers you the full reliability of a one-source system: cable *plus* connectors *plus* the inexpensive assembly aids that crimp the connections quickly and securely (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.

New products

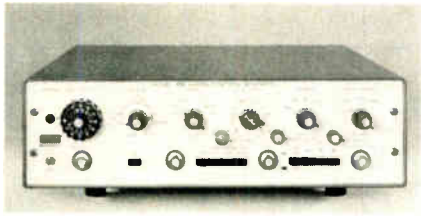
and nine voltage ranges from 100 millivolts fullscale to 1,000 V. The scales are in a one-three sequence.
Epic Inc., 150 Nassau St., New York, N. Y. 10038. Peter Letica (212) 349-2470 [354]

Dual-threshold logic probe responds in 5 nanoseconds

The LP-313 hand-held logic probe is a digital-circuit troubleshooting tool that can indicate the presence of pulses as narrow as 5 nanoseconds. The dual-mode instrument has two thresholds: one for DTL and TTL, the other for C-MOS. Its input impedance is 2 megohms shunted by 12.5 picofarads and remains essentially constant to 200 megahertz. The probe has three indicating LEDs: a red one glows to show the presence of a logic 1; a green one indicates the presence of a logic 0; and a yellow LED lights whenever there is a change of state. All the LEDs are blanked to show either an open circuit or a voltage that falls between legitimate threshold levels. A memory switch for the yellow LED allows it either to flash on for about 0.1 second every time a transition occurs or to latch on after a transition. This latter mode can be useful when one is looking for a rare event. The LP-313 sells for $94 in unit quantities; delivery time for the logic probe is two to four weeks.
Logical Technical Services Corp., 71 W. 23 St., New York, N. Y. 10010. Phone (212) 741-8340 [355]

11-MHz function generator includes modulation source

Combining a conventional 1-millihertz-to-11-megahertz function generator with a 1-Hz-to-1-MHz modulation generator, the model 519 is a function generator that can sweep its main generator over three decades and can amplitude- or frequency-modulate it from 0 through 100%. The carrier may be a sine, square, triangle, ramp, or pulse waveform, and the modulating signal may be any of the same. Hence, the unit offers a great deal of flexibility in a single package. Trigger and burst capabilities are included as is a capability for external modulation. Push-button controls allow the output level to be adjusted in 10-dB steps, and a continuously variable control can add 20 dB. The 519 also has a sync output, dc offset, and variable time symmetry. It sells for $795.



Exact Electronics Inc., 455 S.E. 2nd Ave., Hillsboro, Ore. 97123. Joe Foster (503) 648-6661 [357]

Portable frequency counter measures up to 1.25 GHz

The model 1920A-14 frequency counter is a portable instrument with a nine-digit display, an upper frequency limit of 1.25 gigahertz, a burst mode of operation, and a price tag of $1,155. The counter has a sensitivity of 15 millivolts and automatic gain control. In its burst

New products

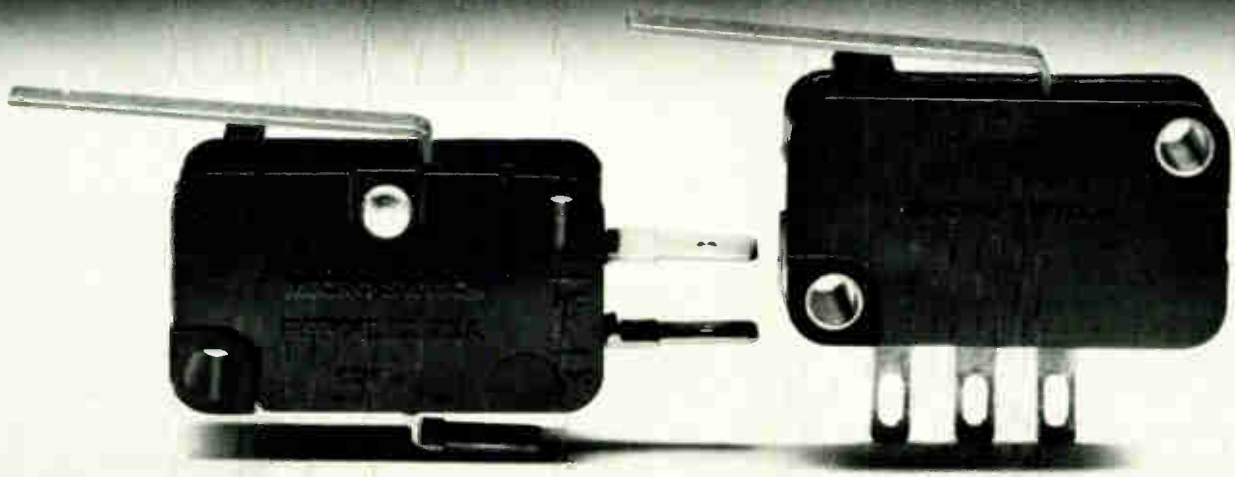
mode, it can measure the frequencies of rf bursts with durations of at least 2 milliseconds; if the bursts are less than the selected gate times, the display is automatically blanked to prevent erroneous readings. Two other members of the 1920A family are the 1920A-13, which goes up to 1 GHz and sells for $1,055, and the 1920A, which has a 520-megahertz rating and an $860 price. All three units can be fitted with rechargeable battery packs at an extra charge of $150. An optional resolution multiplier, which is used to multiply audio frequencies by a factor of 1,000, yields a resolution of 0.001 Hz in 1 second. It adds $100. Delivery time for all units is 30 days.

John Fluke Mfg. Co. Inc., P.O. Box 43210, Mountlake Terrace, Wash. 98043. Morgan Howells (800) 426-0361 [358]

TOPICS

Instruments

Hewlett-Packard's familiar 8620A sweeper mainframe has been superseded by its new model 8620C. The new unit allows easy changeover from wideband sweeps to narrowband analysis, and it includes three markers instead of just one. All plug-ins for the old mainframe will fit the new one. . . . A 4.5-inch round analog panel meter from **LFE Corp., Waltham, Mass.,** has a polycarbonate front window which is so tough that a one-pound steel ball dropped from a height of five feet bounces off it without leaving a trace. Suggested applications are in automotive shops, pollution control, and portable instrumentation.



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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FREEPORT, ILLINOIS 61032
A DIVISION OF HONEYWELL

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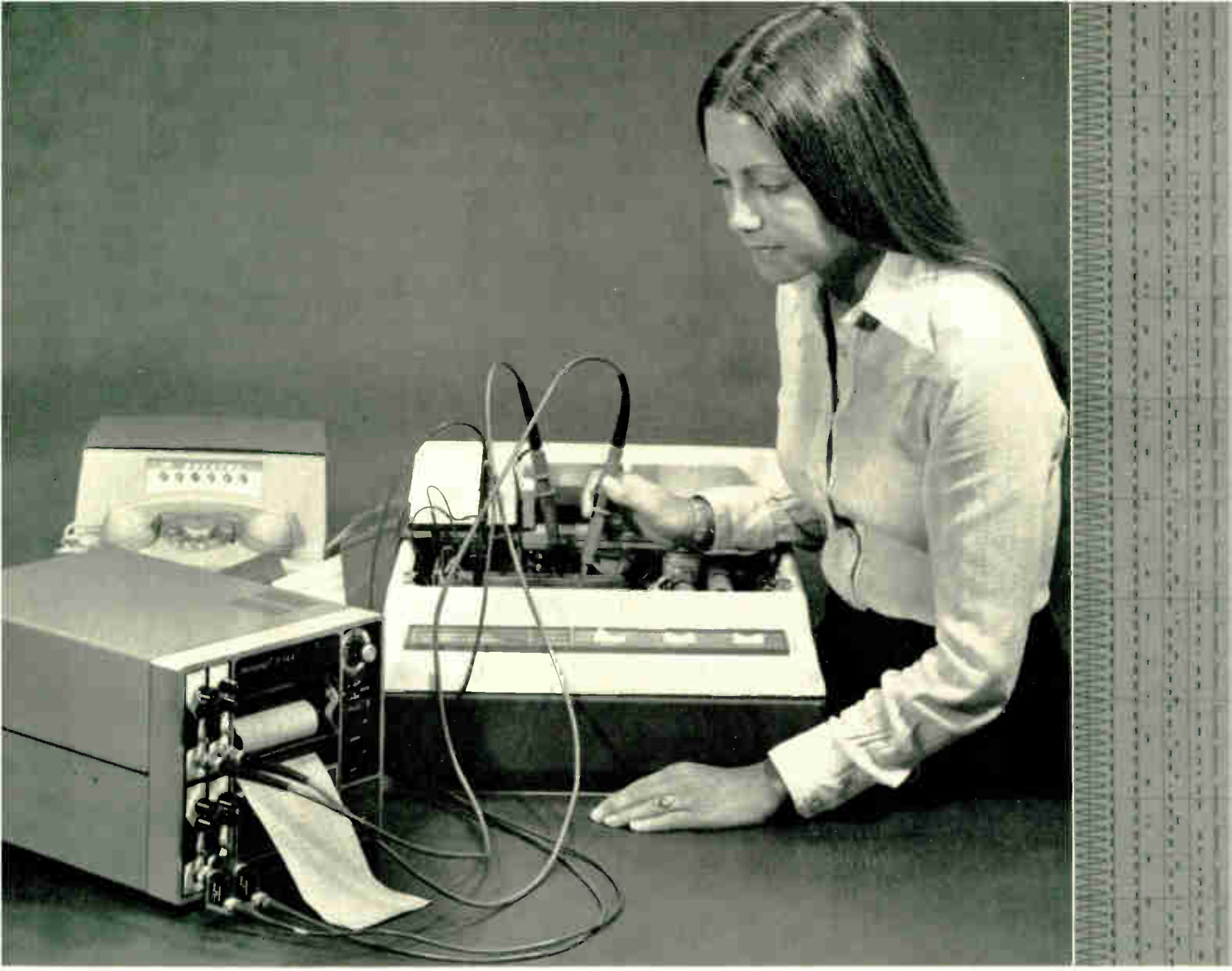
Circle 109 for Data, 135 for Salesman Call



Have a Closer Look

Bell & Howell's Datagraph® Model 5-144 recording oscillograph. Probably the most convenient test instrument you'll ever use.

In addition to the on-off switch, only five controls are needed to operate the Datagraph® 5-144.

Human engineered for efficiency, the 5-144 is as easy-to-use as an oscilloscope, and provides a permanent record up to 200 feet long for later study.

The Model 5-144 contains all of its own necessary electronics. Plug-in amplifiers eliminate the need for special cables or calculating complicated damping networks. Just plug in your scope probes and record your data.

Its four channels permit simultaneous examination of several data signals, and with a frequency response greater than 10,000 Hz, the 5-144 is capable of recording both analog and digital data with equal ease. Complete systems from $2570.00.

Bell & Howell's Datagraph® Model 5-144 recording oscillograph — backed by more than 35 years of experience in the development of quality, precision instrumentation.

CEC DIVISION

360 Sierra Madre Villa, Pasadena, Calif. 91109 (213) 796-9381

BELL & HOWELL

(In Canada: 125 Norfinch Drive, Downsview, Ontario M3M 3B5)

Data handling

Minicomputer fits on 2 cards

Semiconductor memory brings price down to $1,364 for 16-bit system

The low cost of microprocessors may be opening new markets for programable systems, but the declining prices of conventional minicomputers are keeping original equipment manufacturers loyal to them, too. Interdata Inc. has the latest entry in low-cost minicomputers with its model 6/16, a 16-bit unit with a single-board processor (based on medium-scale-integrated TTL circuits) and a single-board memory as large as 64 kilobytes (either core or MOS). The unit is upward-compatible in software with the company's earlier 16-bit and 32-bit minis, but is 30% faster than its predecessor, the 7/16.

Price is a key feature. In fact, the two prices indicate just how much semiconductor memories can help keep cost low. In quantities of 100, a processor with 8 kilobytes of core memory costs $1,736 while the same processor with a semiconductor memory costs $372 less, or $1,364. (The core-based unit is available immediately, while the semiconductor-equipped processor will be available in the spring of 1976.)

The 6/16 has 16 general-purpose registers, four high-speed direct-memory-access channels, and vectored hardware interrupts that handle up to 225 input/output devices. Instruction execution times range from 900 nanoseconds for register-to-register operation to 10 microseconds for a fixed-point multiply (using an optional multiply/divide feature.) Cycle time of the core memory is 1 μs, while the semiconductor memory cycle is half that—500 ns.

Interdata is offering the unit in eight-slot and 16-slot chassis. Also, those OEMs who reach high-volume production may purchase only the board sets.

The unit has a task-oriented set of 104 instructions that avoids unusual codes for such basic functions as exclusive-OR, multiple shifts, or byte-processing. Instruction formats are similar to that of the IBM 360 and 370 series, but the company also has added other instructions that enhance memory utilization. The set provides both 16-bit and 32-bit formats and permits operation between any two general registers, a general register and any memory location, a general register and a 16-bit data constant carried in the primary instruction word, or a general register and four-bit data constant.

Several options are available: memory parity, power fail/auto restart, binary display panel, 6/16 hexadecimal display panel, display interface, automatic loader, turnkey console, signed multiply/divide, selector channel, and other features that allow a user to upgrade the processor to become software and I/O-compatible with a 7/32 processor. The 6/16's software includes a new real-time multi-task operating system (OS/16 MT2) and is for sale, so that users need not enter into restrictive, costly licensing arrangements.

Interdata Inc., Oceanport, N.J. 07757 [361]

Head-per-track disk system is priced under $4,000

Head-per-track disk memories are among the most expensive peripherals, so General Instrument Corp. decided to tackle this problem in developing a new line. Its small, lightweight Series 700 is, at $3,895 for quantities of 100, the lowest-priced of its kind, the company claims, bringing head-per-track memories within a few hundred dollars of less expensive but slower, moving-head disk units.

One place where costs were shaved is in the interchanageable-head-assembly design; the head can be replaced in the field without op-

ALL 8080As DON'T COME FROM THE SAME PLACE.

Meet the μPD8080A. From NEC Microcomputers, Inc. The microprocessor that's both fully software and pin compatible with Intel's new 8080A. And it's backed by all the chips, support systems, software, and service you need to make it into a complete microcomputer system — the μCOM-8.

THE CHIPS.

We start with not one, but four 8080-type microprocessors.

At the top of the line is the μPD8080A. It gives you everything their 8080A does, plus extras like full BCD capability for both addition and subtraction. For low-cost applications, we also have a 1.25 MHz option — the 8080A-E. Plus there are two other models, featuring improved I/O.

In addition, we can give you the best in RAMs, ROMs, and PROMs, including the only Electrically Alterable PROM with the speed to match the processor.

THE SUPPORT SYSTEMS.

We offer both a full-scale microcomputer — the PDA-80 — for software development and hardware emulation; *and* a microcomputer-on-a-board — the EVAKIT — for evaluation purposes.

THE SOFTWARE.

For the PDA-80 we have a full line of resident software. Or, we can give you a full line of cross software, available on national timesharing services or installed on your own computer system. This includes our unique Macro Maintenance Program (MMP) for storing common macros and sub-routines for use with our Macro Assembler.

AND THE SERVICE.

The μCOM-8 package also includes complete documentation, an ever-expanding library of Applications Notes, and a responsive, in-depth applications engineering service, available nationwide.

SO...

Whatever your application or your needs — first source or second source, large volume or small, chips or complete systems — take a look at everything *our* 8080A gives you.

You really can't afford not to.

NEC Microcomputers, Inc., Five Militia Drive, Lexington, Mass. 02173, 617-862-6410.

NEC microcomputers, inc.

tical alignment. Dowel pins on the base fit into the head assembly and align it, so it can be mounted with a minimum of technical expertise. The 17-track heads are mounted in pairs, one on each side of the disk for recording on both surfaces, with a maximum of 64 tracks on each side and 128 tracks in all. For every 32 tracks, one spare is provided; the extra track can be activated inexpensively by simply cutting in a jumper.

A modular design is employed in the unit's electronics. Digital circuits such as read amplifiers and basic input/output, analog circuits such as preamplifiers, head-select and write amplifiers, and power supply are on three separate circuit boards which can be tested independently. An intercoupled board at the rear of the drive can take almost any interface. Up to four drives can be daisy-chained together, and field test units can be plugged into the I/O connector for on-site troubleshooting and repair.

The series 700 has a capacity of up to 19.2 megabits and a data rate of up to 4.5 megahertz. Average access time is 8.5 microseconds and there are two nominal rotation speeds: 3,600 rpm and 1,800 rpm. Optional features include a doubling of capacity up to 256 tracks and 38 million bits, 150,000 bits per track, rotation speeds of 1,800 rpm or 2,400 rpm, and 2-, 4-, or 8-bit parallel operation. Power requirements are 115/230 V ac, 50–60 Hz.

General Instrument Corp., Rotating Memory Products, 13040 South Cerise Ave., Hawthorne, Calif. 90250 [362]

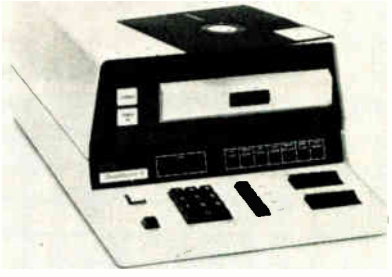
Add-on memory developed for IBM S/370 model 168

An add-on memory for the IBM System/370 model 168 is offered in 1-megabyte increments up to a total of 8 megabytes. Called the Itel 168 MMM (for monolithic main memory), the system uses a 4-kilobit n-MOS random-access memory as a building block. The Itel 168 is attached in the back of the CPU in a swinging-gate design for easy accessibility and space-saving. The manufacturer claims that its price is between 10% and 30% less than the price of comparable IBM memory. The first shipment of the 168 MMM is scheduled for January 1976.

Itel Corp., 1 Embarcadero Center, San Francisco, Calif. 94111. Phone (415) 983-0404 [363]

Diskette storage system offers fast access

DataMaster II is a flexible-disk input/output data-recording and -editing system for use between existing ASCII printer/display terminals and their RS-232 modems. The system effectively adds 311,000 characters to the working storage of the terminal. Performance highlights include: random access to any of 2,431,128 character records in an average of 300 milliseconds, each line or block automatically numbered, operation at any speed from 110 to 1,200 baud, and no need of modification to terminal or modem.



Western Telematic Inc., 3001 Red Hill—Bldg. 5-107, Costa Mesa, Calif. 92626. Phone (714) 979-0363 [365]

Microcomputer is designed for use in appliances

A one-chip microcomputer, the SX 200, is a low-end device intended principally for applications in the home-appliance industry. The 4-bit p-MOS device includes 256 bits of random-access memory while its

New products

mask-programable ROM provides 1,024 words of program storage. The microcomputer is compatible with touch-plate controls and can be synchronized with the ac power line for direct control of such power devices as SCRs. The SX 200 also has 16 settable, resettable, and testable flag bits for enhanced program control. A second microcomputer, called Bitsy, is similar to the SX 200 but lacks its touch-plate compatibility and power-line synchronization. It is intended for very simple tasks such as the making of sequential timing decisions.

Essex International, Semiconductor Group, 564 Alpha Drive, Pittsburgh, Pa. 15238. Phone (412) 782-0200 [364]

Unit converts Selectric typewriter into I/O printer

Based on the standard IBM Selectric typewriter, the Tycom 735 input/output printer system is constructed by adding a standard Holmes Tycom baseplate to any Selectric I or Selectric II. The system is similar to the discontinued IBM 735. In attaching the Tycom baseplate to the Selectric, no modification is made to the typewriter, hence the user can still obtain IBM service. The Tycom 735 sells for $835 in OEM quantities; delivery is from stock to 60 days after receipt of order.

Tycom Systems Corp., 26 Just Rd., Fairfield, N. J. 07006. Phone (201) 227-4141 [367]

Interactive display system works with any PDP-11

Designed as an add-on for any PDP-11 computer, from the small PDP-11/04 minicomputer to the medium-size 11/70, the VS60 interactive graphics display subsystem is a high-speed analog stroke system with a 21-inch CRT, a light pen, and hardware vector and character generators. It offers four types of lines, eight intensity levels, subscripts, superscripts, hardware blink, windowing, and subroutining with auto-

There's a little tiger in every Cherry switch

...but we're pussycats to do business with

Our products are tough, but our people aren't... and that's the beauty of dealing with Cherry.

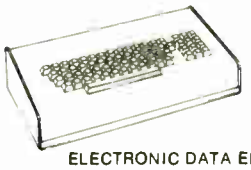
You see, we can control the quality of our switches because we fabricate most of our own parts (moldings, stampings, springs, printed circuits, etc.) And we can keep the price down because we're loaded with automatic equipment to handle high volume.

But the real difference is in the *people* you work with at Cherry... from your first contact with a technically trained sales representative... through careful analysis and recommendations by engineers who are really concerned about *your* problem... to production scheduling and customer service men who follow-up and expedite to make sure we keep our delivery promise to you.

Of course we're proud of our modern facilities and equipment... but what we're proudest of is our reputation for customer service. Try some.

Test a free sample "tiger" from the pussycats at Cherry. Ask for our latest catalog which contains complete information on all our switches and keyboards, and we'll include a free sample switch. Just TWX 910-235-1572... or PHONE 312-689-7700... or circle the reader service number below.

Circle 141 on reader service card



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PLASMA-LUX GAS DISCHARGE DIGITAL DISPLAYS

New products

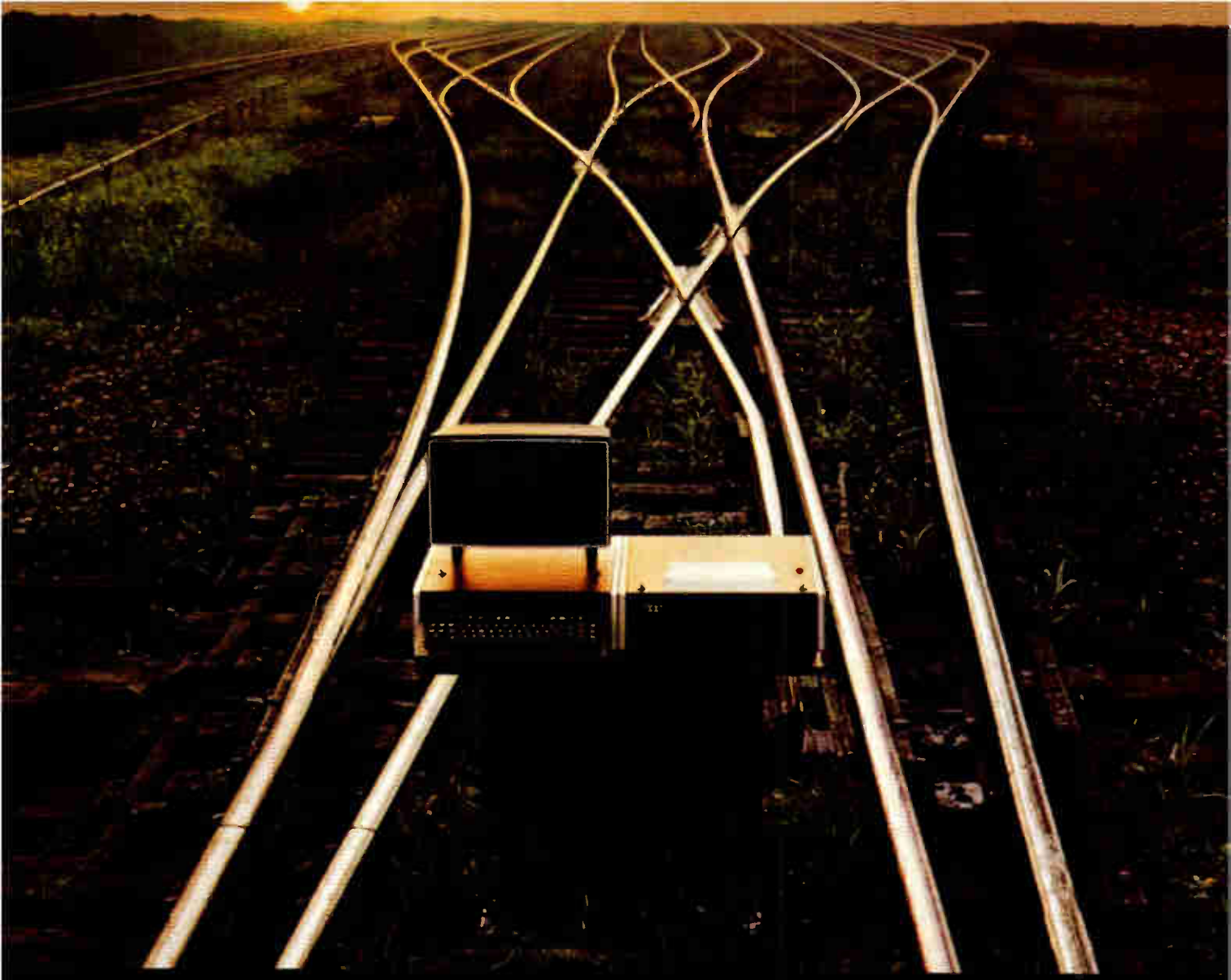
matic stacking. The VS60 is priced at $38,800. A complete graphics terminal consisting of a VS60 display system, a PDP-11/10 minicomputer, an ASCII keyboard, and provision for communications links sells for $47,500. Housed in a short-bay cabinet, the terminal is designated the GT62.

Digital Equipment Corp., Maynard, Mass. 01754. Phone (617) 481-9511 [366]

TOPICS

Data Handling

The K2480D terminal from **Ann Arbor Terminals Inc., Ann Arbor, Mich.** is now offered with a batch-transmit option. The option equips the KSR unit with a screen-transmit capability that enables the operator to write to the screen off-line, at typing speed, and transmit the displayed data to the computer at high speed. . . . **Mohawk Data Sciences Inc., Parsippany, N. J.** has announced major additions to its line of key-to-disk equipment. The additions include two new large systems with capacities of 90,000 and 150,000 125-character records; concurrent processing on all systems; operator prompting on all systems; tripartitioning on the 2409 system; user programability on the 1204, 2409-0, -1, -2, and -3 systems; and up to 64 subformats per job on all systems. . . . A telecommunications option which allows Wang computers to communicate with IBM System/370 and other host CPUs as a 2780 remote batch terminal has been announced by **Wang Laboratories Inc., Tewksbury, Mass.**



When it comes to flexibility, the model 40 gives you a lot of ways to go.

When we designed the model 40 system, we included a long list of features and options to give it the flexibility for practically any data transmission requirement. Whatever your industry or application.

First, there's a variety of speeds ranging from 110 to 4800 bps, along with a choice of interfaces, half/full duplex operation and character and batch mode transmission. The model 40 system also has a number of on-line controls, even/odd parity generation and a destructive scrolling feature that permits continuous bottom line reception with no loss of data until memory overflow.

Flexibility features don't stop there, either. There's an expandable memory with line and page scrolling, protected format with variable field transmission, plus many other features and options to select from. And since the entire system is modular, it can be custom-tailored to fit your needs.

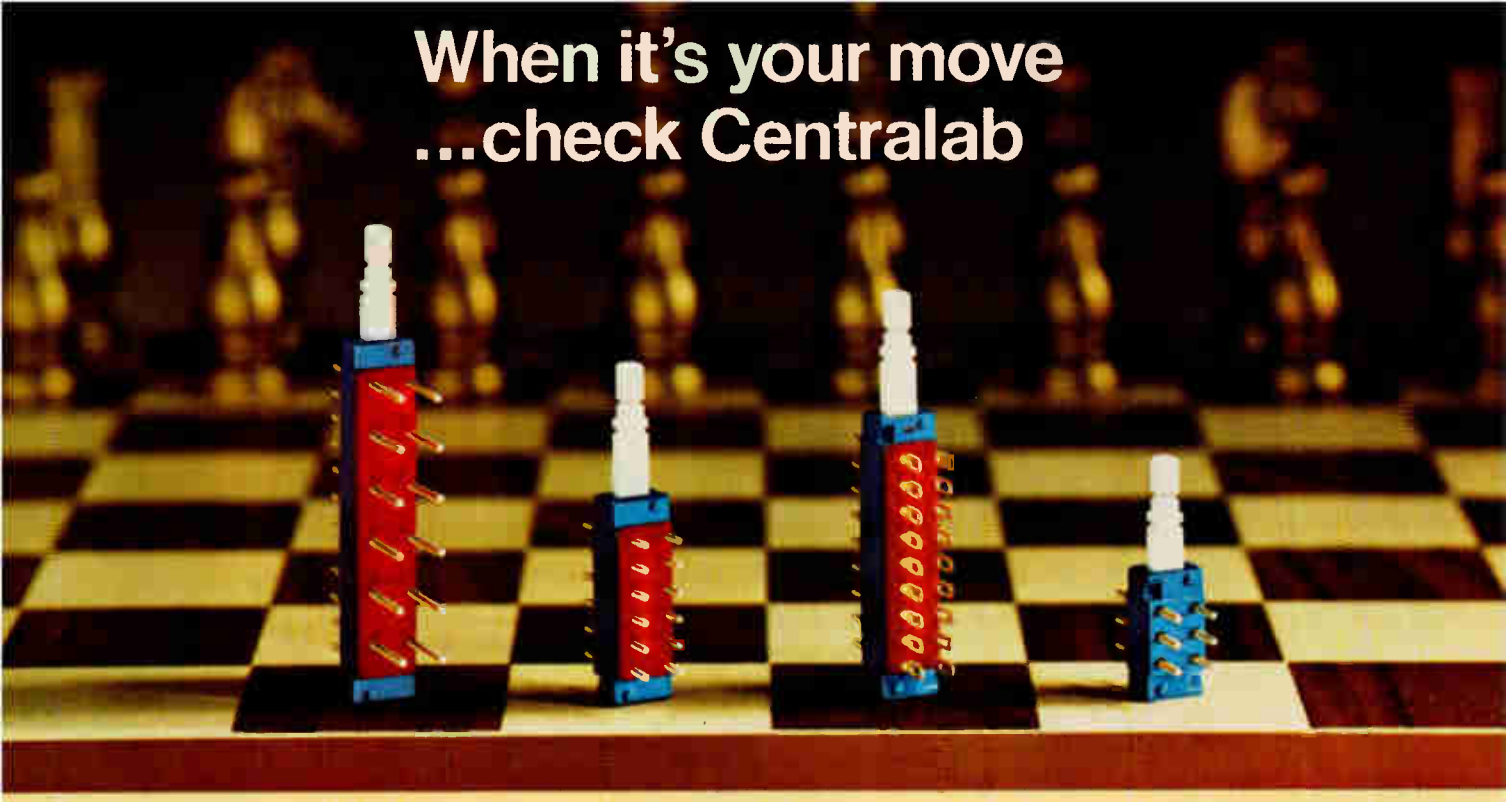
These are just some of the many reasons why the model 40 has the flexibility to fit just about any system. But the model 40's strongest suit is economy. Because on a cost/performance basis, nothing even comes close. And delivery is a lot sooner than expected.

For complete information, please contact our Sales Headquarters at: 5555 Touhy Ave., Skokie, Ill. 60076. Or call Terminal Central at: (312) 982-2000.

TELETYPE

The Teletype model 40 system. Nothing even comes close.

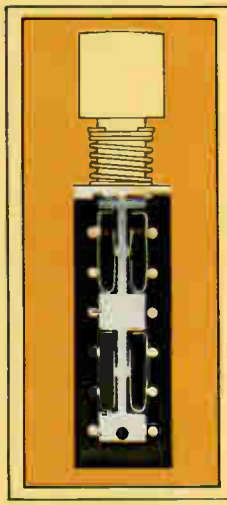
Circle 143 on reader service card



Best pushbutton switch for your board

Don't be checkmated. Only Centralab offers you the best low-cost switch module, plus so many extra-quality options.

THE BEST SWITCH — The basic Centralab pushbutton switch module is unique because of its inherently simple and rugged construction. High speed machinery produces the parts and performs assembly operations simultaneously, ensuring that the parts always fit the assembly perfectly. Stationary and movable contacts are enclosed in a high-dielectric thermoset housing to protect the smooth, positive wiping action of the slider bar and contacts. And Centralab switches are 100% tested.



Unretouched cutaway view of Centralab 4 PDT module showing positive spring force for superior contact wiping action.

Centralab pushbutton switches meet these demanding specifications:

Insulation Resistance: Up to 10^{12} ohms.

Dielectric strength: 1,500 volts.

Contact resistance: .004 ohms.

Life and reliability: Up to 250,000 MTBF in ganged assemblies. Over 500,000 operations on contact systems.

Shock and Vibration: 100g's and 10g's low frequency.

Electrical rating: Covers range from dry circuits to 1 ampere, and low millivolts to 120 volts.

If your requirements go beyond the basic Centralab module, consider these optional moves:

HIGHEST INSULATION RESISTANCE — Centralab offers diallyl phthalate housing material, in addition to phenolic.

BEST CONTACT RESISTANCE — Gold contacts and terminals are standard options. Best for dry circuit applications and contaminating environments.

NO INTERNAL CONTAMINATION — Epoxy sealed terminals prevent failure from solder flux and other contaminants.

Proven in use by more quality-conscious users, Centralab 2, 4, 6 and 8 pole pushbutton switches are available in four types of lockout for momentary, push-push or interlocking action. Both PC and solder lug terminals are available. PC terminals can be selectively cut to your desired lengths.

PLUS THESE NEWEST ADDITIONS — A new 5 amp line switch, a new low-cost lighted switch and a new visual display for non-lighted switches.

Get all the technical help you need from our 19 assembly distributors or network of experienced sales engineers. They'll help you select the best pushbutton switch for your board. Now it's your move!

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GLOBE-UNION INC.
P.O. BOX 858
FORT DODGE, IOWA 50501

144 Circle 144 on reader service card

Packaging & production

Mask tests check to 0.5 microinch

Laser-based system uses diffraction analysis and 16-k computer

If manufacturers of semiconductors get headaches from trying to check the dimensions of today's microminiaturized production photomasks with conventional microscopes, they'll be getting migraine

headaches tomorrow because integrated circuits are getting smaller all the time. Basically, the problem is a human limitation, semiconductor companies say. With a microscope, even the best operator can't measure a line or gap smaller than 100 microinches with any degree of accuracy or repeatability.

But help is on the way. A small Van Nuys, Calif. company, Recognition Systems Inc., has developed a virtually automated system that eliminates manual measurements. In prototype tests, the system has detected variations as small as 0.5 microinch in a photomask line or gap that is 60 microinches wide. The important repeatability factor varies less than 1%. Called the Microinch-Accuracy Measured Electroptically (MAME) system, it employs electro-optical techniques based on diffraction analysis and uses a low-power laser, photodetector arrays, Fourier-transform optics and a Computer Automation 16,000-word LSI-2 minicomputer.

The Recognition Systems unit operates by passing coherent light from a 1-milliwatt laser through special optics, an isolation aperture, and through the target area of the photomask. A second optical package focuses the resulting diffraction pattern on a linear photosensor array that scans it and feeds the signal into an analog-to-digital converter. From the a-d output, a minicomputer determines the exact dimension of the photomask line or gap, displaying it in microinches or micrometers.

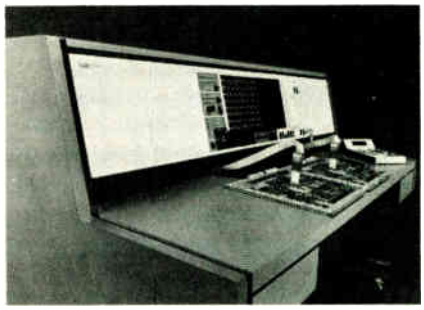
In using the system, an operator inserts a photomask plate into the unit and positions it by rotation and by X and Y motion. A built-in television-display screen monitors the mask movement, and a superimposed reticle delineates the area to be measured. The operator may use a front panel control to black out unwanted adjacent lines. Providing up to 800× magnification of the mask under inspection, the system accepts either positive or negative masks up to 5 inches square, a size range that covers wafers measuring from ¾ to 4 in.

After a mask line or aperture is positioned, the unit provides the dimension within 15 seconds or less. Initial production models available early in 1976 will be capable of inspecting iron and chrome-oxide photomasks in addition to chromium and emulsion types. Single-quantity price is about $40,000.

Recognition Systems Inc., 11531 Cabrito Rd., Van Nuys, Calif. 91406. Phone (213) 785-4264 [391]

Large-board tester needs little programing

For a tester of logic boards containing upwards of 240 ICs, the 3020A logic tester is unusually simple to program, requiring no assemblers, compilers, or tapes. In fact, it takes only a few hours to complete a pro-

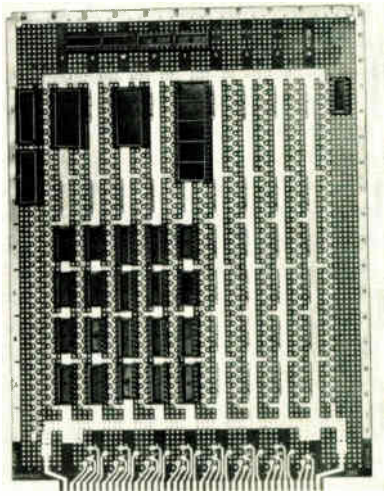


gram, which is then stored on a small plastic card much like a commercial credit card. A comparison type device, the 3020A includes 12 aids to speed the diagnosis of faulty boards. Among them are programmable probes and IC clips, 128° override controls that permit partitioned testing and the opening of logic loops, and speed margin testing where propagation delays are compared to reference performance. The Logictester is priced at $26,500; delivery time is 45 to 60 days.

Fluke Trendar Corp., 500 Clyde Ave., Mountain View, Calif. 94043. Noel Lyons (415) 965-0350 [393]

Microprocessor board has multilevel busing

A new Plugbord accommodates various combinations of 24- and 40-pin microprocessors along with standard 14- and 16-pin DIPs. Power distribution of two independent voltages is facilitated by means of interwoven zig-zag lines, to allow



ALSIMAG 805.

AS FIRED IT'S ONE MICROINCH SMOOTH!

Need a supersmooth substrate for thin film circuitry? Need it, what's more, at a reasonable cost? Here's AlSiMag 805, with a one-microinch surface finish that makes it the smoothest as-fired polycrystalline substrate your money can buy.

Without polishing, AlSiMag 805 holds precise resolutions of intricate thin film circuitry. And it is possible to hold ±2½% resistors without trimming. All this at a price that would warm an accountant's heart.

This remarkable, 99.9% alumina substrate is a genuine technological breakthrough from 3M. But more importantly, it's an excellent example of how 3M ceramics engineers can put their special expertise to work to help solve your problems.

AlSiMag 805 is available only from 3M. For information and specifications, call or write: 3M Technical Ceramic Products Division, Sales Dept., Laurens, South Carolina 29360, (803) 682-3215.

3M COMPANY

AlSiMag is a registered trademark of 3M Co.

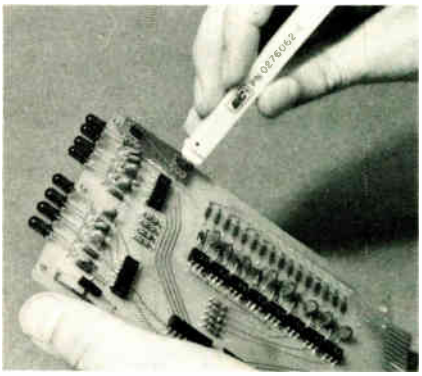
Circle 147 on reader service card

use of both MOS and TTL devices. The 7- by 9.6-inch board can hold 63 14- or 16-pin DIPs and also has room for bypass capacitors at each DIP position and at the incoming-power position. Priced at $14.95 each, the model 4350 Plugbords were originally designed to interface with Texas Instruments' 980 Series computers. Delivery is from stock.

Vector Electronic Co. Inc., 12460 Gladstone Ave., Sylmar, Calif. 91342. Phone (213) 365-9661 [395]

IC probe tests flatpacks

Able to probe all of the leads on an IC flatpack simultaneously, regardless of solder configuration, a probe from Everett/Charles performs such basic tests as leakage detection, continuity checking, and the detection of opens and shorts. Individual probes can be easily removed for the testing of flatpacks in which some leads are absent.



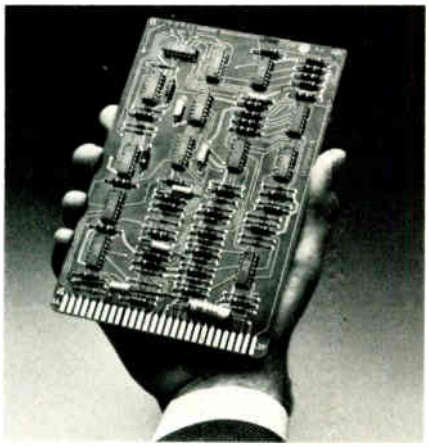
Everett/Charles Inc., 2806 Metropolitan Place, Pomona, Calif. 91767. Phone (714) 593-2541 [394]

Height of DIP socket can be adjusted

A 14-pin elevator socket is adjustable from 0.25 to 1.0 inch in height. This allows the convenient mounting of LED displays, DIP switches, and similar components at various heights above a printed-circuit

THE FEDERAL EXPRESS PARTSBANK. IT WILL CHANGE THE WAY YOU THINK ABOUT DISTRIBUTION FOREVER.

This little part can shut down an entire plant.



But so far, it's had to go through a complex series of separate operations and companies to get it where it's needed: regional warehouses, air freight forwarders, commercial airlines, and trucking firms. And nobody's been very happy with the results.

Now Federal Express has come up with a solution. And like all great ideas, this one is simple.

A WAREHOUSE WITH ITS OWN AIRLINE.

Air Freight Supplement called it "the coup of the year in respect to air freight and physical distribution."

We call it The Federal Express PartsBank.

What it is, is a warehouse and an airline combined.

It's located in the "air center" of the United States, Memphis.

The Federal Express PartsBank. An average of 6 hours from anywhere.

And once you put your parts in The Federal Express PartsBank, they're only 100 feet from the Federal Express jets.

And on the average they're only 6 hours from any place in the country.

FEWER MOVING PARTS.

The advantages of The Federal Express PartsBank seem to put every other system of distribution at a disadvantage.

First, you don't need as much inventory.

With one central warehouse that can serve the entire country in a matter of hours, you don't need a lot of regional warehouses full of expensive inventory.

And that money can be used to work for you in other areas.

Aside from money, we can save you a lot of aggravation.

A broken machine is an unhappy customer.

And there's no faster, more efficient way for machines scattered all across the country to get the parts they need than from The Federal Express PartsBank.

It also offers more control.

Because it's easier to keep track of everything if it's all in one place.

We receive, store, take orders for, select, pack and fly your parts for you.

And we do it 24 hours a day, 7 days a week, to virtually every city in the country.

Say one of your customers' computers breaks down in Seattle at midnight. Just call us by 2:00 a.m. and the part will be in Seattle hours later, where either you can pick it up or we'll deliver it to you with one of our trucks.

Only Federal Express can perform this feat because we're the only airline that flies mainly overnight.

And if a Federal plane isn't the next one leaving, we'll have it in the air on one of the hundreds of commercial airline flights that serve Memphis.

That's the theory. Now for the results.

IT'S WORKING.

At this point, 25 companies are using The Federal Express PartsBank.

It's costing them the same or less than the way they were doing things before.

And instead of getting complaints for their service, they're starting to get some compliments.

We think The Federal Express PartsBank is the ultimate in fourth generation field support.

If you're interested, call Wylie Tate, Vice President, at 800-238-5345.

He'll arrange for you to talk to some of our customers to get their opinions.

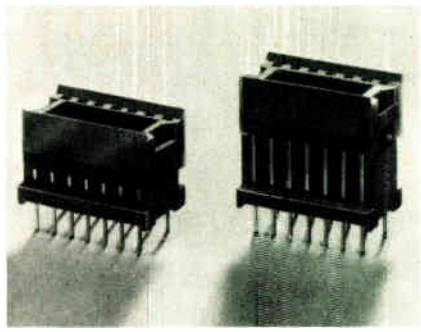
Or he'll do a systems and cost analysis of the way you're distributing now versus the way we would do it.

And if you like, he can arrange for you to try us on a 4-week trial basis.

We know if we can change your thinking about distribution for 4 weeks, we can change it forever.

FEDERAL EXPRESS
PartsBank

New products

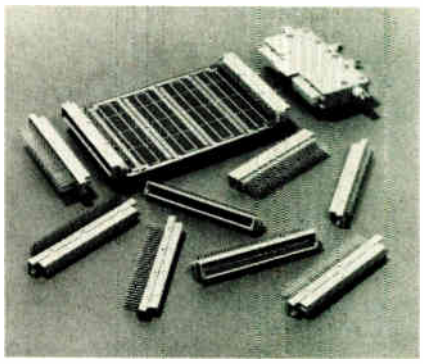


board. Incorporating gold-plated bifurcated contacts and a glass-filled nylon body, the socket sells for from 29 to 99 cents depending upon quantity.

Aries Electronics Inc., P O. Box 231, Frenchtown, N J. 08825. Phone (201) 996-4096 [396]

Two-piece connectors mount on pc boards

Available with a choice of 16, 32, 48, 64, 72, or 96 contacts in a variety of configurations suitable for mounting to multilayer, single- or double-sided boards, Elco's series 8257 connectors are two-piece devices that snap together for easy contact replacement. A wide range of contact terminations is offered, including



0.025-inch-square solderless wrap, 90° formed contacts, and solder posts. Series 8257 connectors have a contact grid of 0.1 in. Contact material is phosphor bronze with gold over nickel plating. Rated at 3 amperes, the contacts have a maximum resistance of 12 milliohms.

Elco Corp., 2250 Park Place, El Segundo, Calif. 90245. Phone (213) 675-3311 [397]

If you haven't had a Model 3500 demo yet here are 7 reasons why you should.

Data Precision's Model 3500 5½ digit multimeter gives you more at reduced costs.

1. BCD Output and Digital Control

Parallel BCD output and digital control signal capability at *no extra cost.*

2. Ratio Measurements

DC/DC and AC/DC ratio measurement capability at *no extra cost.*

3. High Normal Mode and Common Mode Rejection

Model 3500 performance is significantly more effective in rejecting normal mode and common mode signals up to 80dB NMRR and up to 160dB CMRR.

4. Hi-Frequency Measurements

The Model 3500 AC voltage measuring capability is specified up to 100KHz.

5. High and Low Range ACV Measurement Capability

Provides a measurement capability of AC voltages on 5 range scales, including the low scale with 1μV resolution and a high scale to 700 volts RMS.

6. Zero Stability

Model 3500 incorporates Tri-Phasic ™ autozeroing performance eliminating the need for zero adjustment between measurements on any range and any function.

7. Price

High quality performance and accuracy for $995 complete.

The Model 3500 has a 6 months basic DC accuracy of ±0.007% of reading ±1 LSD, full autoranging from 1 microvolt to 1000V (DC or AC peak) and 1 milliohm through 12 Megohms resistance, 20% overranging and an easy-to-read ½ inch planar display.

The Model 3500 also features our Tri-Phasic ™ conversion cycle, Ratiohmic ™ resistance mode, and Isopolar ™ referencing, circuit techniques that increase performance and decrease price.

To arrange an immediate demonstration or for technical data and a comparative analysis of the Model 3500 contact: Data Precision, Audubon Road, Wakefield, MA. 01880 (617) 246-1600.

DATA PRECISION

...years ahead

Don't get stuck with a microwave counter tailor-made for somebody else.

With our extensive range of options, EIP can give you a microwave counter built to do exactly what you want it to do.

Automatic input level control for wider dynamic range and multiple signal discrimination.

YIG preset for frequency selectivity and fast acquisition time.

IF offset for direct receiver frequency readout.

Remote programing for use with automatic test equipment.

Band elimination so you can delete frequency ranges you don't need.

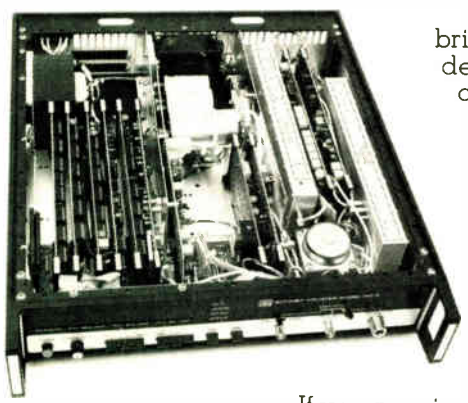
Increased sensitivity available from 1.1 to 6.5 GHz.

Rear inputs.

20 GHz frequency extensions.

The EIP 351D, 20 Hz to 18 GHz. The EIP line also includes the 350D, 20 Hz to 12.4 GHz; the 331, 825 MHz to 18 GHz, and the E01-350D or -351D designed to MIL-T-21200 environmental specifications.

All EIP counters are constructed using printed circuit boards mounted vertically for easy test point access and servicing. The entire microwave section can be taken out and replaced in a few minutes by unplugging 4 cables and removing 6 screws.



EIP microwave counters give you a lot more than you pay for.

Across the board, EIP counters cost less than comparable counters, yet they're simple and better.

EIP counters are all fully automatic. EIP displays use bright, non-flickering LEDs, sectionalized to eliminate decimal positioning, frequency range annunciators, and confusing overflow. And EIP counters all have leading zero suppression.

EIP's Autohet™ technology allows measurement of signals with FM deviation to 200 MHz at FM rates to 10 MHz. Using an EIP counter you can easily test high density communications links without removing them from service, and test EW/ECM circuits, too.

If you're measuring signals only in the microwave range, EIP makes the Model 331 so you don't have to pay for more capability than you need.

If you require a ruggedized/environmental counter, EIP has the E01, the only such field proven counter in the industry.

PC board and module exchange program means quick, reliable service.

EIP offers an assembly exchange program to minimize down time. If your system should ever fail anywhere in the United States, give us a call. We'll help you track down the problem by phone, and ship you a replacement plug-in board or an entire pre-aligned microwave converter section the same day. For systems in Europe, we have a complete service facility in Brussels.

What you need is what you get.

Call us and tell us what you want your microwave counter to do. We'll show you the perfect EIP counter to do it.

DANA EIP

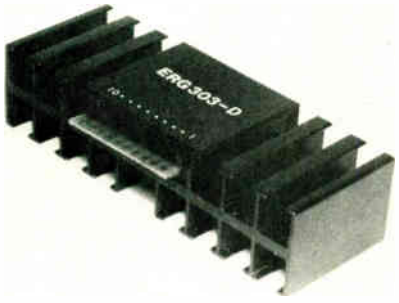
EIP, Inc.
3230 Scott Boulevard
Santa Clara, CA 95051
Telephone (408) 244-7975

Subassemblies

20-W op amp is easily boosted

Two added transistors allow voltages to ±50 V and powers beyond 300 W

Many potential users of high-power operational amplifiers shy away from these useful devices for fear that the output transistors may be accidentally destroyed, taking with them the entire power module. To



overcome this problem, Electronics Research Group has developed what it calls its model ERG 303D transconductance power driver—actually a power amplifier with two outputs.

The two outputs may be connected to form a 20-watt power op amp, or else used to drive the bases of a pair of complementary power transistors. In the latter case, supply voltages may run as high as ±50 volts dc, and the power rating is determined by the output devices. Rms levels in excess of 300 W are easily obtained. Furthermore, since the power transistors are separate from the rest of the driver, if they are destroyed they can be replaced easily and cheaply—they cost only a couple of dollars apiece. The model 303D itself is quite inexpensive, selling for $33.50 in quantities of one to nine and $29.95 for 10 to 99.

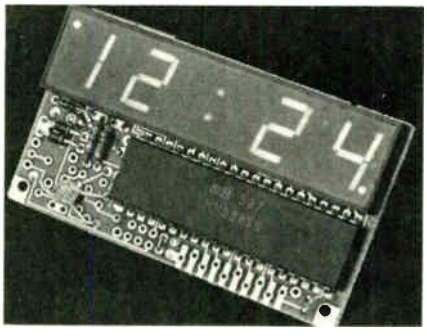
Essentially a very high-power version of the Signetics SE540 and the Motorola MC1438, the 303D is an epoxy-cast device affixed to its own heat sink. It has a small-signal open-loop gain of 80 decibels, a small-signal bandwidth of 200 kilohertz, and a maximum power dissipation of 20 W in still air at 25°C. When used alone, the maximum permissible supply voltages and output power are determined by the load impedance. A typical closed-loop configuration with an 8-ohm load would have a gain of 25 dB, a full-power bandwidth of 80 kHz, and maximum supply voltages of ±24 V dc. Maximum harmonic distortion at 15 W output is 0.05% for an input frequency of 1 kHz; typically, the THD is only 0.01%.

When used to drive a complementary pair, the driver can accept any supply voltage from ±12 V dc to ±50 V dc. Actual output power is determined by the output transistors used; if the transistors are an MJ802 and an MJ4502, minimum power into 2 ohms is 320 W, and minimum power into 8 ohms is 100 W.

Electronics Research Group Inc., 22 Mill St., Arlington, Mass. 02174. Robert B. Straus (617) 661-9383 [381]

Versatile OEM clock module sells for only $20

Electronic "clockwork" made in-house for clock radios, TV-stereo timers, instrument-panel clocks and so on, now has competition in a module from National Semiconductor Corp. Called the MA1001, the 1-by-3-inch circuit-board module contains a LED display and a digital alarm clock and costs about $20—a figure that, according to Jerry Zis, module products market-



ing manager, makes it less expensive than in-house modules.

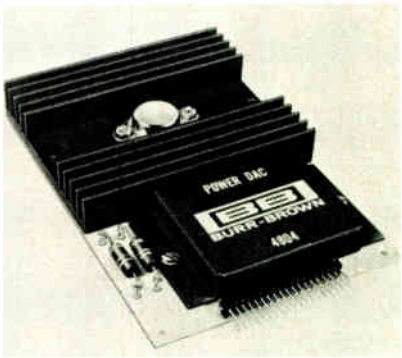
The MA1001 combines a 140-by-140-mil p-channel MOS chip, a four-digit 0.5-inch light-emitting-diode display, a power supply, and associated discrete components to form a complete electronic clock movement. The user needs to add only a transformer and switches to construct a pretested digital clock. Timekeeping may be from 50- or 60-hertz inputs, and 12-and 24-hour display formats may be chosen. A direct, nonmultiplexed LED drive on the MOS chip eliminates radio-frequency interference, so that fewer components are needed to protect the radio circuits in a clock/radio configuration.

Time-setting is made easy, says Zis, through use of "fast" and "slow" scanning controls. Features include alarm, "on," and "p.m." indicators, blinking colon, "sleep" and "snooze" timers and variable brightness control capability. Alarm-clock options include a transistor oscillator circuit for use with low-cost earphone audio transducers. Power failure is indicated by flashing the display. The clock/radio modules, with various combinations of line frequency and display formats, are $20 each for 100 to 999 quantities. The alarm-clock modules sell for $21.50 each.

National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, Calif. 95051. Phone (408) 732-5000 [382]

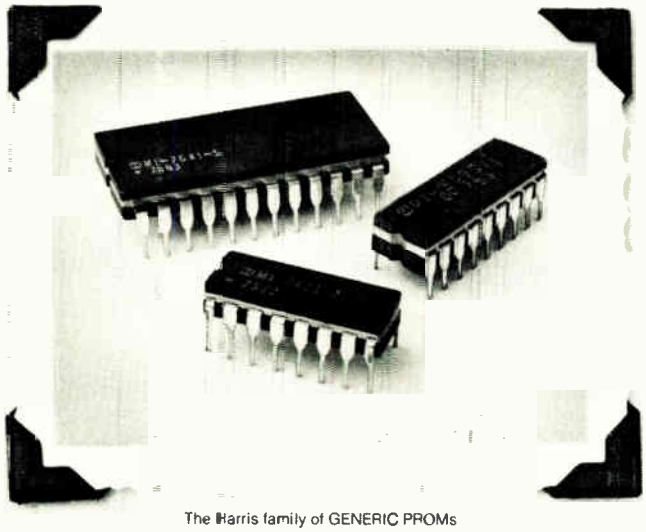
D-to-a converter puts out up to 30 watts

Apply a 12-bit TTL-level word to the input of the model 4804 power digital-to-analog converter and out comes a dc voltage in the range of ±30 volts at a maximum current of 1 ampere. For finer adjustment, the 60-volt range can be reduced, by adding one external resistor, while maintaining the full 12 bits of resolution. The 4804 settles to within



0.01% of final value, for any input change, in a maximum of 100 microseconds. Priced at $209 for 1 to 24 units, and $188 for 25 to 99, the converter is constructed on a 4.01-by-6.038-by-0.875-inch card that includes an extruded heat sink for the

Memories are made of this.



The Harris family of GENERIC PROMs

Once you know about the Harris family of GENERIC PROMs, stand-alone PROM designs are easy to forget. That's because the diverse requirements for density, modularity and performance within a system can be completely satisfied by our one GENERIC family.

As a result, there are many advantages of the Harris GENERIC PROM to keep in mind. Like the identical DC electrical specifications and common programming requirements featured in each device within a series.

Plus fast programming speeds. Equivalent I/O characteristics for easy upgrading. Faster access time, guaranteed over temperature and voltage. And improved testability.

Right now, our entire family of GENERIC PROMs is in volume production (see table). With 100 and up pricing at less than ½ cent per bit on the popular 1K, 2K and 4K configurations.

So remember, if you want PROMs with common programming requirements, low system costs, and the highest performance, get the Harris family of GENERIC PROMs.

It'll give you plenty of great memories.

Device #	No. of Bits	Organization	No. of Pins	Max. Access Time* Com.	Max. Access Time* Mil.	Price 100 up Com.	Price 100 up Mil.
HM-7602 (open coll)	256	32x8	16	40ns	50ns	$2.95	$5.95
HM-7603 (three state)	256	32x8	16	40ns	50ns	$2.95	$5.95
HM-7610 (open coll)	1024	256x4	16	60ns	75ns	$4.95	$9.95
HM-7611 (three state)	1024	256x4	16	60ns	75ns	$4.95	$9.95
HM-7620 (open coll)	2048	512x4	16	70ns	85ns	$9.95	$19.95
HM-7621 (three-state)	2048	512x4	16	70ns	85ns	$9.95	$19.95
HM-7640 (open coll)	4096	512x8	24	70	85ns	$19.95	$39.95
HM-7641 (three-state)	4096	512x8	24	70	85ns	$19.95	$39.95
HM-7642 (open coll)	4096	1024x4	18	70	85ns	Available January '76	
HM-7643 (three-state)	4096	1024x4	18	70	85ns		
HM-7644 (active pullup)	4096	1024x4	16	70	85ns		

* Access time guaranteed over full temperature and voltage range.
Industrial (T_A = 0°C to 70° C, V_{CC} ± 5%)
Military (T_A = 55° C to 125° C, V_{CC} ± 10%)

HARRIS SEMICONDUCTOR
A DIVISION OF HARRIS CORPORATION

P.O. Box 883, Melbourne, Florida 32901 (305) 724-7412

WHERE TO BUY THEM: OEM SALES OFFICES: CALIFORNIA: Long Beach, (213) 426-7687, Palo Alto, (415) 964-6443 **FLORIDA:** Melbourne, (305) 724-7430 **ILLINOIS:** Hinsdale, (312) 325-4242 **MASSACHUSETTS:** Wellesley Hills, (617) 237-5430 **MINNESOTA:** Minneapolis, (612) 835-2505 **NEW YORK:** Endwell, (607) 754-5464, Melville, L.I., (516) 249-4500 **OHIO:** Dayton, (513) 226-0636 **PENNSYLVANIA:** Wayne, (215) 687 6680 **TEXAS:** Richardson (214) 9041

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NATIONAL DISTRIBUTORS: Hamilton/Avnet, The Harvey Group, Inc., Schweber Electronics, R.V. Weatherford Company

New products

power output stage, plus a 12-bit storage register with strobed inputs and a d-a converter.

Burr-Brown, Box 11400, Tucson, Ariz. 85734. Joe Santen (602) 294-1431 [383]

Low-cost amplifiers span 5 to 400 MHz

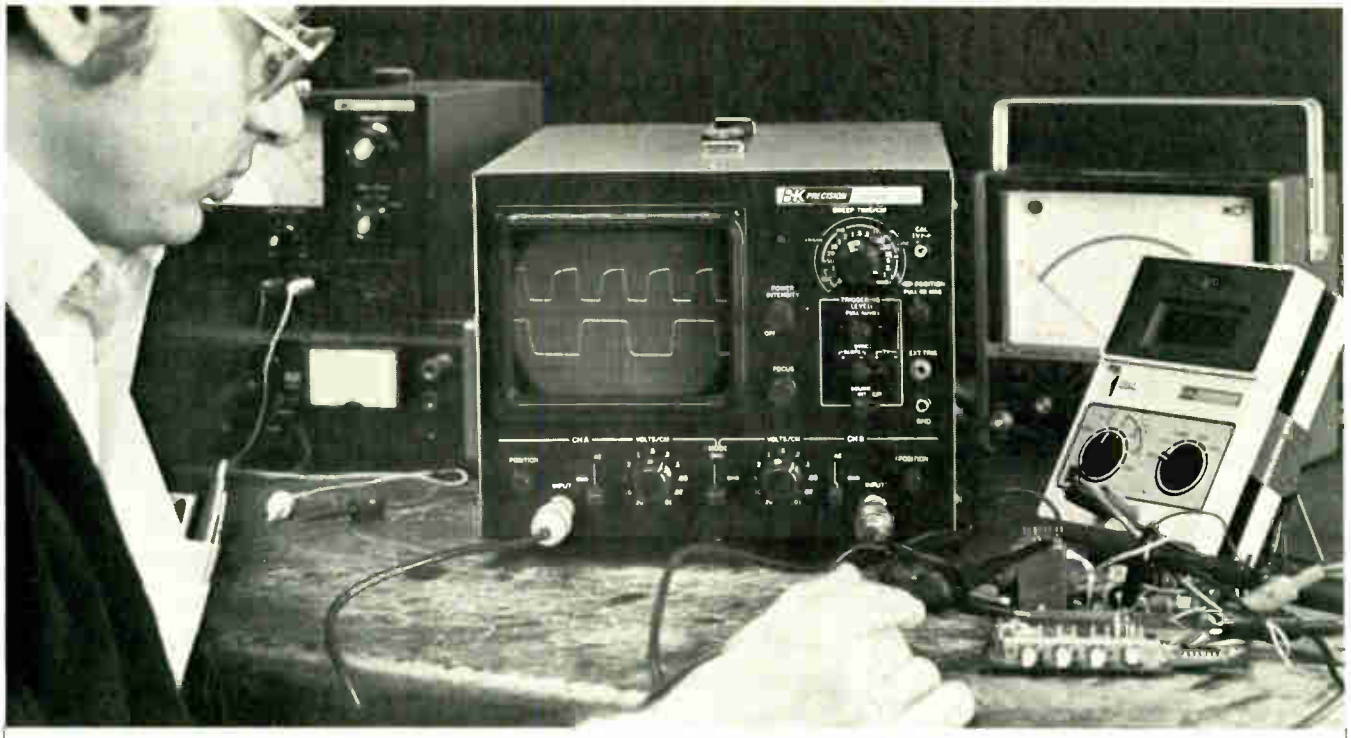
Selling for less than $30 each, and housed in miniature TO-12 packages, a pair of broadband amplifiers provide 13 decibels of gain from 5 to 400 megahertz. Both units are flat within 1 dB and have maximum input and output VSWRs of 2. The model GA1 has a 4.5 dB noise figure and consumes 10 milliamperes at 15 volts dc. The GA2 has a noise figure

of 6 dB and consumes 24 mA at the same voltage. Both units are insensitive to supply-voltage variations from 10 to 15 V dc. They each weigh one gram, measure 0.355 inch in diameter and 0.175 in. high, and can operate from −55°C to 100°C. All specifications are guaranteed, not typical.

Aydin Vector, P.O. Box 328, Newton, Pa. 08940. Phone (215) 968-4271 [384]

Photodiode/amplifier has 10-nanosecond rise time

Optimized for the central wavelength of GaAs and YAG lasers, a series of integrated photodiode/amplifiers has an electro-optical bandwidth of 35 megahertz and a rise time (from 10% to 90%) of less than 10 nanoseconds. The MHZ series has a responsivity of more than 2.5×10^4 volts per watt, a full-bandwidth noise voltage of no more



Remember when a good dual trace scope cost less than $500? It does again.

Model 1471 Dual Trace Oscilloscope
$495

As the B&K-Precision Model 1471 rolls back the economic calendar, it significantly advances performance capabilities of 10MHz oscilloscopes. Model 1471 shares many of the performance and convenience features of our higher priced scopes, benefiting from Dynascan's position as a leading supplier of medium bandpass scopes.

Deflection factor is 0.01V/cm to 20V/cm in 11 ranges. Model 1471 has 18 calibrated sweeps—1μSEC/cm to .5SEC/cm and sweep to 200nSEC/cm with 5x magnification. Regulation maintains calibration accuracy from 105 to 130VAC. Rise time is 35nSEC. Automatic triggering is obtained on waveforms with as little as 1cm deflection. Dual trace display mode automatically shifts between CHOP and ALTERNATE as sweep time is changed, speeding set-up.

Front panel X-Y operation uses matched vertical amplifiers, preserving full calibration accuracy for both amplitude and phase. The intensity modulation input (Z axis) is compatible with TTL, permitting use in character display systems, and for time or frequency markers. Bright blue P31 phosphor makes any waveform easy to see. Circuit board with plug connectors permit easy user maintenance. BNC connectors. Operates on 117/230-VAC 50/60Hz.

- 10 MHz Bandwidth—useable to 15 MHz
- Mode automatically shifts between CHOP and ALTERNATE as you change sweep time
- Bright blue P31 phosphor
- 18 calibrated sweeps—1μSEC/cm to .5SEC/cm
- Sweep to 200nSEC/cm with 5X magnification
- Maintains calibration accuracy over 105-130VAC range
- Front panel X-Y operation using matched vertical amps
- Input grounding switches
- TV sync separators
- Check most digital logic circuitry including CMOS
- Character display applications using TTL Z-axis intensity modulation
- BNC connectors

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New products

than 2.5 millivolts rms, and an output impedance of 50 ohms. The MHZ units are offered with light-sensing areas of either 5 square millimeters or 13 mm².

EG&G Inc., Electro-Optics Division, 35 Congress St., Salem, Mass. 01970. Phone (617) 745-3200 [386]

TOPICS

Subassemblies

Electronic Devices Inc., Yonkers, N. Y., is offering free samples of its new 10-ampere PK rectifier bridge to anyone who specifies an OEM application. Available in voltage ratings from 50 to 800 volts, the bridge sells for about $1.10. . . . The accuracy of the true-rms to dc converter module (model 440) made by **Analog Devices Inc., Norwood, Mass.** has been improved by a factor of more than 10 with no accompanying increase in price. Conversion uncertainty used to be 2.5%, it is now 0.15%. . . . An accessory module that makes time-delay relays of all but a few of P & B's 5, 6, 12 and 24-volt dc relays has been announced by **Potter & Brumfield, Princeton, Ind.** . . . A pair of inexpensive, passive low-pass filters from **ESC Electronics Corp., Palisades Park, N. J.,** is particularly well suited for compressed-speech applications. The miniature devices are offered in TO-8 cans or flat-packs. Rolloff is at least 140 dB per octave. . . . Special semiconductor overvoltage protectors intended for applications in which the allowable peak voltage is very close to the continuous operating voltage are available from **Power Functions Engineering, Garland, Texas.**

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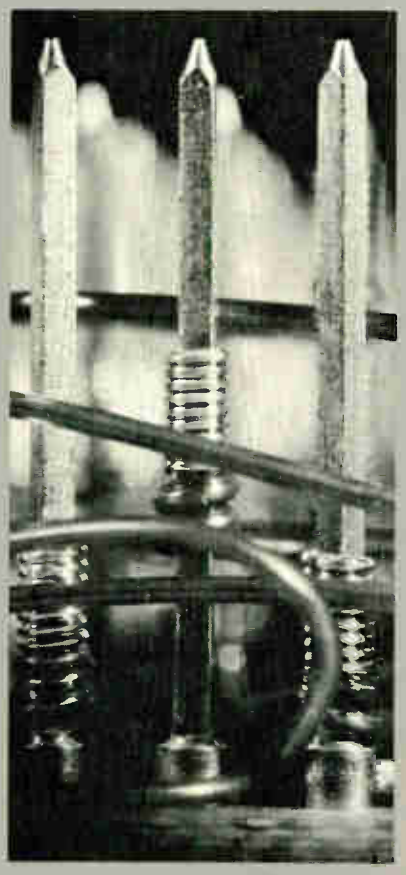

dataCon's equipment is the most advanced, too. Its computer-controlled semi-automatics and fully automatic machines can produce over 100,000,000 wires annually.

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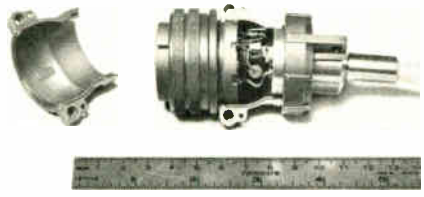
Communications

Fiber optics links data

One system has transmitter and receiver built into a standard connector

Improvements in fiber optics have been spurring developments of an increasing number of transmitters, receivers, connectors, and associated components, to form fiber-optic communications systems. And now



Valtec Corp., a manufacturer of fiber-optic cables in West Boylston, Mass., is joining in with two fiber-optic links for data communications, one of which combines a transmitter and receiver in one connector.

The links were originally designed for applications in power stations: a duplex link for high-voltage switching where electrical interference was a problem in getting information from the high-voltage area to a computer console, and a half-duplex link for transmitting information gathered from monitoring nuclear reactions, which involve high-voltage plasma conditions. Due to the high optical isolation of fiber-optics, both links can operate continuously when exposed to 5,000 volts along a 120-foot-long cable, or for one minute when exposed to 20,000 V. Valtec President James Godbey sees major applications for these links in the computer industry for communications between the mainframe and peripherals and terminals, as well as under hazardous conditions where there may be arcing or fire potential.

In the duplex link, a specially designed printed-circuit board with a light-emitting diode and photodetector circuitry for two-way transmission, modulating and demodulating circuitry, and TTL load drives, is environmentally sealed into a standard Amphenol connector. While the standard model has only one transmitter and receiver per connector, the company says that more could be added in custom orders.

The standard link is intended for short-range communications; the two transceivers are connected by a high-loss (attenuation of 400 decibels per kilometer) cable up to 120 feet long; the link can also be used with medium- and low-loss cables. Since the link is duplex, the cable has two individually sheathed light guides enclosed in a silicone outer sheathing.

The link has a bandwidth of dc to 250 kilohertz; Godbey claims it can handle almost any data rate since "that is a function of the equipment used with it, not of our link." It will be offered with LEDs of varying speeds as well as with laser diodes. The standard link takes an input signal of 1.7 V dc, 100 milliamperes; power requirement is only 30 mA at 5 V dc, and the output will drive 10 TTL loads.

The half-duplex data link has a faster LED and offers a bandwidth of 1 megahertz in the standard model. A modified BNC connector contains a pc board with LED, op amp, and modulating circuitry for the transmitter, and a p-i-n photodiode and demodulating circuitry for the receiver. Input and output are C-MOS compatible; it draws 10 mA from 10 V, and will drive C-MOS or TTL loads. Again, Valtec can tailor the link to the application, using different light sources.

This link uses a recently introduced medium-loss cable, with attenuation of 30 dB per kilometer, that can be up to 2 kilometers long. The cable has a high numerical aperture, with an index of 0.30, so it can accept light coming in at a wider angle than most medium-loss fibers can accept. This allows the fiber to carry

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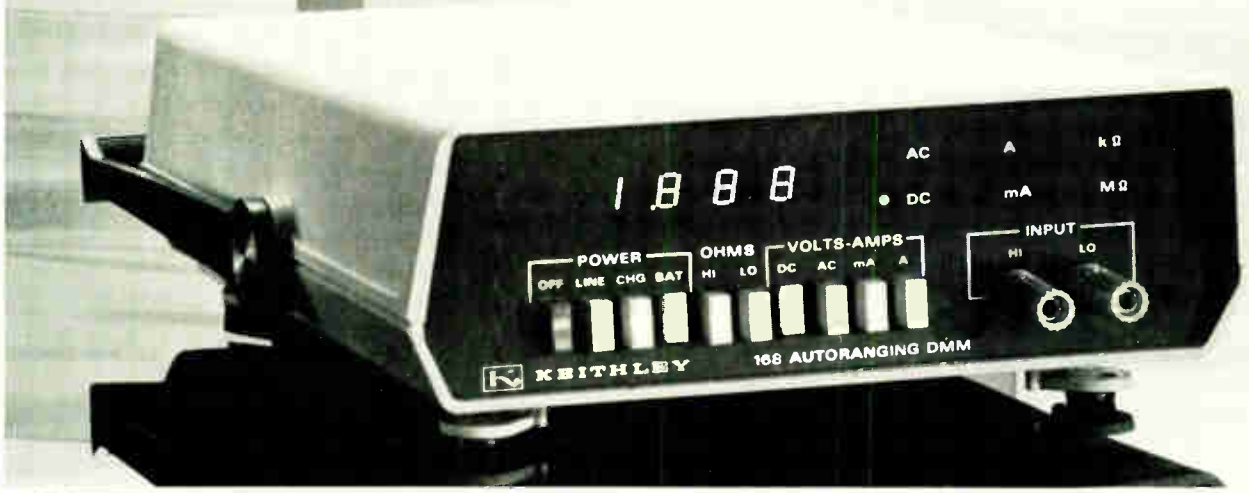

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more of the LED's power and makes connections easier. This high aperture is due to the difference in the index between the quartz fiber and the plastic cladding; usually a doped quartz cladding is used but its index is close to that of the fiber. Valtec uses a proprietary, high-temperature plastic cladding with an index much lower than that of quartz. And sometime next year, as part of its plan to offer a full range of cables and communications systems, the company plans to introduce a low-loss fiber with attenuation of under 5 dB per kilometer.

Price for the half-duplex link starts at $200; the duplex, at $300.

Valtec Corporation, Electro Fiberoptics Division, West Boylston, Mass. 01583. Phone (617) 835-6082 [401]

Modems use LSI for greater reliability

A third generation of high-speed data modems, as Codex Corp. describes its new series, is designed around large-scale integrated circuitry. By using LSI for such functions as equalization, transmit, receive, carrier-recovery, automatic gain control, and timing, the modem designers were able to significantly reduce power consumption to below 10 watts on average and to lower the operating temperature, giving greater reliability. Mean time between failures is said to be in excess of 20,000 hours.

The line includes three point-to-point modems, three multipoint fast-poll types, the CCITT V-27 modem that is compatible with European standards, and a dial-network unit for the direct-distance dial network. Since the units are almost entirely digital, variations caused by component age and mating characteristics that are usually found in analog systems are eliminated. Each modem measures only 5.25 by 8.5 by 18 inches, weighs less than 15 pounds and has an average power requirement of less than 10 watts.

In the point-to-point group are

the LSI 9600, the LSI 7200, and the LSI 4800, which operate at 9600, 7,200, and 4,800 bits per second, respectively, and are designed for use in point-to-point full-duplex configurations over four-wire voice-grade lines. All units include fall-back speeds of 2,400 bits per second, to permit operation over degraded lines.

The multipoint fast-poll models, the LSI 96 FP, LSI 72 FP, and LSI 48 FP, are automatic, adaptively equalized modems. Codex notes that many large multipoint systems such as those for airline reservations, operate at low speeds and could be upgraded to faster operation. Typically, multipoint systems take 50 milliseconds to equalize the signal from the modem in the receiver. To bypass this delay, Codex has the modem respond at 2,400 b/s, so that the receiver takes only 9 ms to recognize the timing and accept the signal. Data is transmitted at 2,400 b/s for 27 ms after that, then shifts in synchronization to 4,800 b/s. On the outbound side the units can have data rates of 4,800, 7,200, or 9,600 b/s.

The CCITT-V-27-compatible modem, designated the LSI 481, operates at 4,800 b/s and uses the eight-phase signal structure adopted in Europe. Its equalization time is 47.5 ms for multipoint applications and it also has a point-to-point mode.

The LSI 48D provides 4,800 b/s in the half-duplex mode on the direct-distance-dial network. Initial equalization time is 180 ms, and line turnaround time is 50 ms. Lower fallback speeds and line-turnarounds are provided for poor line conditions.

All of the modems include the eye-pattern generation (EPG) as an option that gives a qualitative analysis of line disturbances like noise and phase jitter. A circuit-quality display includes the EPG and in addition shows the digital-equalizer X and Y error signals indicating line distortions and signal perturbations. It provides input to the EPG or the optional stand-alone circuit quality monitoring system (CQMS) which in-

New products

cludes a modem test set, a digital decibel meter, an audio monitor, a digital monitor, and a phase and amplitude hit counter.

Other options include a multipoint network control system (MNCS) for remote test, control, and reconfiguration of multipoint modems, and remote loopback.

Prices for the LSI series start at $4,325 for the LSI 4,800, $6,400 for the 7200, and $8,500 for the 9600.

Codex Corp., 15 Riverside Ave., Newton, Mass. 02195. Phone (617) 969-0600 [402]

Scan converter/receiver sends frame in 34 seconds

Pictures of any object can be transmitted anywhere in the world by telephone, using the model 300 scan converter/transceiver. The closed-circuit-quality pictures have 256-

line resolution, and an entire image can be transmitted in full frame in 34 seconds, or half-frame in 17 seconds. The converter/transceiver is used in conjunction with any black-and-white monitor (or a commercial TV set) and a closed-circuit TV camera. Price is $995.

Robot Research Inc., 7591 Convoy Ct., San Diego, Calif. [403]

Synchronous data set runs at 19.2 kilobits per second

A limited-distance synchronous data set, designated the model DS548, can operate at speeds up to 19.2 kilobits per second and is suitable for the interconnection of most high-speed terminals and processors

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across distances up to 35 miles. Typically, the unit will operate over a distance of 11 miles at 4,800 bits/s using 26-gauge cable. The DS548 complies with EIA RS 232-C interface requirements and AT&T's private-line metallic circuit specifications. Price is $595 each, and OEM discounts are available.

Develcon Electronics Ltd., 108-103d St. East, Saskatoon, Saskatchewan, Canada S7N 1Y7 [404]

Translator lets one person set up transmission link

Designed for back-to-back testing and level-setting of microwave terminals operating from 790 MHz to 2.5 GHz, the type 8953 loop-back translator allows one person to set up a terminal without an assistant at the other end of the link. A crystal oscillator beats with the carrier signal to produce a receiver test signal. The translator can be equipped with up to four switch-selectable crystals for different transmitter/receiver frequency separations in the range of 3.6 to 80 MHz.

Cardion Electronics, Communications Dept., Woodbury, N.Y. Phone (516) 921-7300 [406]

Mastergroup equipment boosts multiplex channels

Built for long-haul microwave radio and coaxial cable networks of common-carrier, industrial and government communications systems, new mastergroup equipment built by GTE Lenkurt increases the number

of voice and/or voice-grade data channels in multiplex systems. Designated Mastergroup 4, the equipment increases from 600 to 2,400 the number of channels that can be handled by the type 46A3 multiplex system. Mastergroup equipment is end-to-end compatible with Western Electric MMX-2R/C and the equivalent. It is furnished in standard rack arrangements. Also available is a Mastergroup 3 assembly that permits the expansion of the voice and/or voice-grade data service provided by 46A2 and similar 1,200-channel systems.

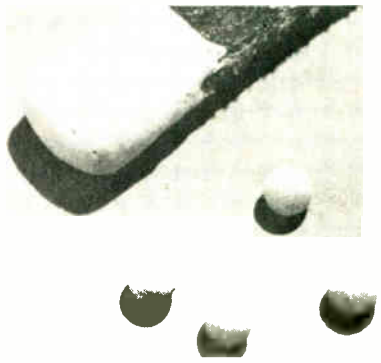
GTE Lenkurt Inc., Dept. C720, 1105 County Rd., San Carlos, Calif. 94070 [405]

TOPICS

Communications

A revised system practice that has been issued on voice couplers ERC-195522-21 and -22 (USOC-RDL/RDM) lists three optional time delays for disconnect from the telephone line on receipt of the disconnect signal. Additional information can be obtained from **Elgin Electronics Inc., Waterford, Pa.** . . . New plug-in thin-film code cartridges for the recently introduced model 2141 pulse-group encoder and model 2151 pulse-group decoder have been announced by **TMX Inc., New York City.** . . . A tone generator that can be purchased as a stand-alone unit or as a plug-in for the communications monitors made by **Cushman Electronics Inc., Sunnyvale, Calif.,** uses direct digital synthesis for frequency accuracy of four significant digits. . . . The model FS-20 field strength meter from **Infinite Inc., Cape Canaveral, Fla.,** is a six-digit device with an rf bandwidth that extends from 2 megahertz to 1.1 GHz. The battery-operated unit weighs only six ounces. . . . **RCA Closed Circuit Video Equipment, Lancaster, Pa.,** has announced its very low light level CCTV camera, model TC1030, which can operate in light levels from bright sunlight to quarter-moon darkness (0.0001 foot-candle).

New products/materials



Conductive elastomeric spheres measuring 0.05 inch in diameter are offered with two resistances: 0.5 ohm for the silver-filled type and 500 ohms for the nonmetallic version. The spheres are intended to provide electrical interconnections in three main applications: in through-holes in printed-circuit boards, in probe tips, and in the tubular connection of two hard wires. In quantities of 2,500, the silver-filled spheres sell for 19 cents each, the nonmetallic ones for 14 cents.

Technical Wire Products Inc., 129 Dermody St., Cranford, N. J. 07016. Phone (201) 272-5500 [476]

Pc-board laminate PG-450 tolerates temperatures up to 400°C because it blends epoxy and polyimide resins. Prices of PG-450 begin at $9.23 per square foot—more than epoxy-glass which can only stand 125°C), but less than polyimide-glass (which survives up to 500°C). The material is available in thicknesses of 0.031 inch and above, in sheet sizes of 18 by 24 or 36 in.

The Mica Corp., 10900 Washington Blvd., Culver City, Calif. 90230. Phone (213) 559-4223 [477]

A broadband microwave absorber in the form of a lightweight, flexible, foam sheet, Eccosorb AN can be cemented to or draped over objects that produce undesired reflections. Available for use over several frequency bands from 0.6 to 50 gigahertz, the material reflects less than 1% of normally incident energy. Applications include radar antenna nacelles, target test mounts in radar ranges, antenna pattern

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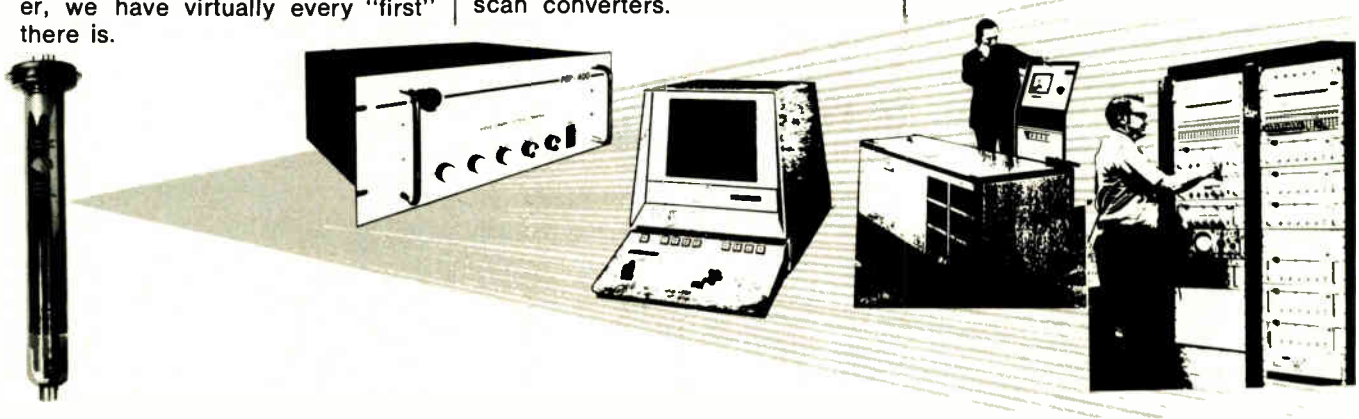

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Emerson & Cuming Inc., Canton, Mass. 02021. Phone (617) 828-3300 [478]

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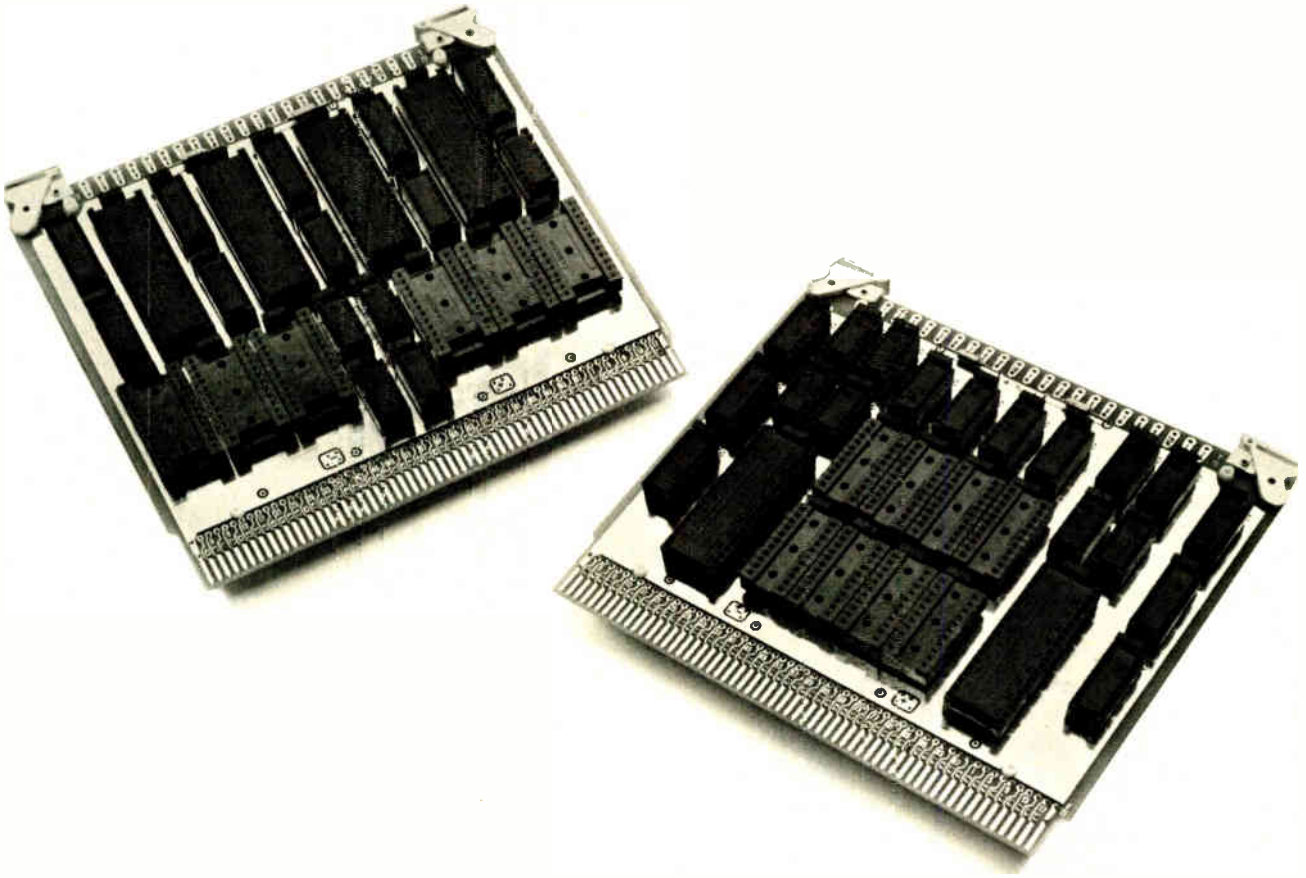
Semiconductor Specialties Corp., Pollitt Dr., Fair Lawn, N. J. 07410 Phone (201) 797-1500 [479]

The RTP line of reinforced molding compounds uses carbon-graphite fibers, Du Pont Kevlar fibers, or glass fibers to strengthen such thermoplastic polymers as olefinics, styrenics, nylon, acetals, PPS, polyesters, and polyurethanes.
Fiberite Corp., 501 West Third St., Winona, Minn. 55987 [480]

Shielding tape consisting of 4 mils of aluminum foil totally encapsulated by 6 mils of copolymer plastic was developed for the telephone and communications cables, particularly in pulse-code-modulation applications. The shielding provides complete conductor isolation plus complete isolation of the shield. It is corrosion-resistant.
Sun Chemical Corp., Facile Division, 185 Sixth Ave., Paterson, N.J. 07524 [341]

Low-glare plastic sheet materials are designed to be used as filters with LED, liquid-crystal, plasma-discharge, and incandescent displays and readouts. Called Homalite-LR sheets, they match the readability characteristics of whatever display is used, and they come in clear or colored types.
SGL Homalite, 11 Brookside Dr., Wilmington, Del. 19804 [342]

New socket cards for microprocessors.

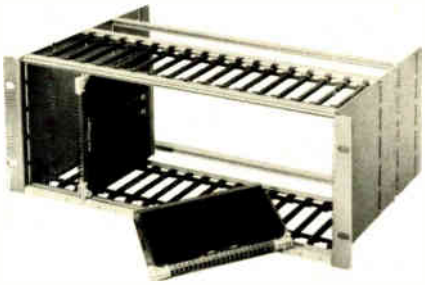


Instantly available, these two new cards are your answer to second-source problems. They enable you to change ICs and wiring for new pin patterns with great ease.

They are designed specifically for microprocessor applications, including controllers, random access memories, and erasable programmable memories. As such they are the newest in our line of 3D socket cards:

3D2017 Four 40-pin sockets, six 24-pin sockets, five 18-pin sockets, five 16-pin sockets, and four 14-pin sockets. $124.70.

3D2018 Two 40-pin sockets, eight 22-pin sockets, four 18-pin sockets, six 16-pin sockets, and eight 14-pin sockets. $140.70.



In addition, both cards provide a good ground plane for high-speed operation. They include a ceramic monolithic bypass capacitor at every socket, and provision for bypassing other voltages that may be required for chips. Power can be connected to various pins on LSI chips by means of solder tabs. And each card includes 22 built-in test points.

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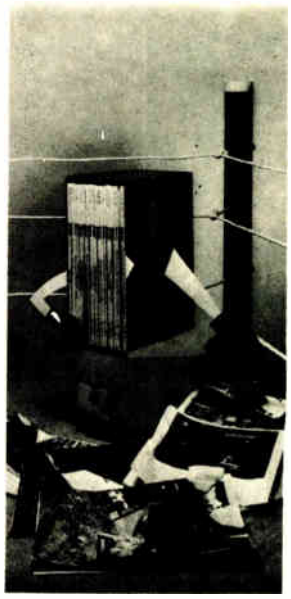

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Power transistors. A line of high-power, 400-volt transistors intended for use in switching regulators, deflection circuits, ignition circuits, and similar applications is described in data sheet No. PD-9.002, put out by International Rectifier Corp., Semiconductor Division, 233 Kansas St., El Segundo, Calif. 90245. Circle reader service number 421.

Antenna reflectors. A selection guide to more than 30 reflectors from 12 to 60 feet in diameter gives basic data on focal lengths, construction materials, centers of gravity, and shipping weights. Design criteria for wind survival, resonace ratings, and surface tolerances are also provided. The guide is offered by RF Systems Inc., 155 King St., Cohasset, Mass. 02025 [422]

Thyristors and rectifiers. A 40-page catalog from RCA lists more than 500 thyristors and rectifiers. The product guide, THC-500E, is completely revised and includes RCA's full line of triacs, SCRs, ITRs (integrated thyristor/rectifiers), diacs, and rectifiers. Copies can be obtained from RCA Solid State Division, Box 3200, Somerville, N.J. 08876 [423]

Statistics programs. A series of summaries describes new software packages for four statistical applications on the Hewlett-Packard 9830A programable desktop calculator. The software handles probability distributions, cross tabulation, one-sample analysis, paired-sample analysis, two-sample nonparametric statistics, regression analysis, and analysis of variance. The brochures are numbered 5952-8945 for statistical distributions, 5952-8962 for cross tabulation, 5952-8977 for paired-sample and two-sample analysis, and 5952-8960 for regression analysis. They can be obtained separately or as a group from Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [424]

White-noise generators. A family of

New literature

white-noise generators with outputs up to 1.0 volt rms over a 3-kilohertz bandwidth is the subject of a four-page data sheet from CODI Corp., Pollitt Dr., Fair Lawn, N. J. 07410. Both noise diodes and noise modules are covered by the data sheet. [425]

Plastic labware. A line of more than 240 items of Nalgene thermoplastic labware is pictured, specified, and priced in a 48-page catalog offered by Markson Science Inc., P.O. Box 767, Del Mar, Calif. 92014, Attention: Liz Spira. Items in the catalog include magnetic stir bars, bigmouth wash bottles, beakers, flasks, funnels, tubing, and centrifuge ware. [426]

Miniature switches. Short-form catalog 3001 describes and illustrates the Airpax line of miniature toggle, rocker, and level handle switches. Specifications and ordering information are also part of the catalog, which can be obtained from Airpax Electronics, Woods Rd., Cambridge, Md. 21613 [427]

Oscillators. A wide variety of oscillators spanning the frequency range from 0.01 hertz to 600 megahertz is listed in a 38-page catalog put out by Greenray Industries Inc., 840 West Church Rd., Mechanicsburg, Pa. 17055. The publication supplies data on crystal-controlled, hybrid, voltage-controlled, and temperature-stabilized oscillators. Rather less space is devoted to LC and RC oscillators, multifrequency oscillators, multiplier/amplifiers, and a synthesizer. [428]

Brushless motors. A six-page bulletin from the Power Engineering Division, Siemens Corp., 186 Wood Ave. South, Iselin, N.J. 08830, discusses the company's line of brushless dc motors. The motors range from 0.40 to 48.0 ounce-inches of running torque at 25°C. Their direction of rotation can be reversed by changing the sequence of the winding commutation—a task easily accomplished with a low-power control signal. [429]

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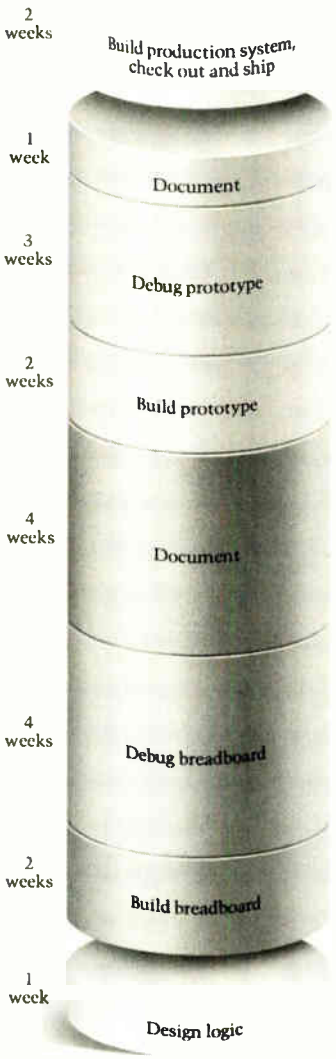

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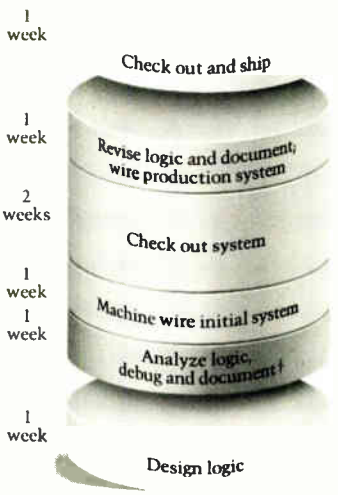

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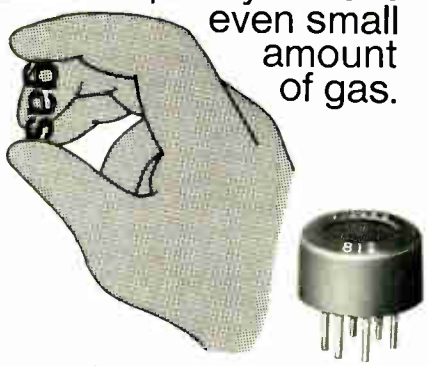

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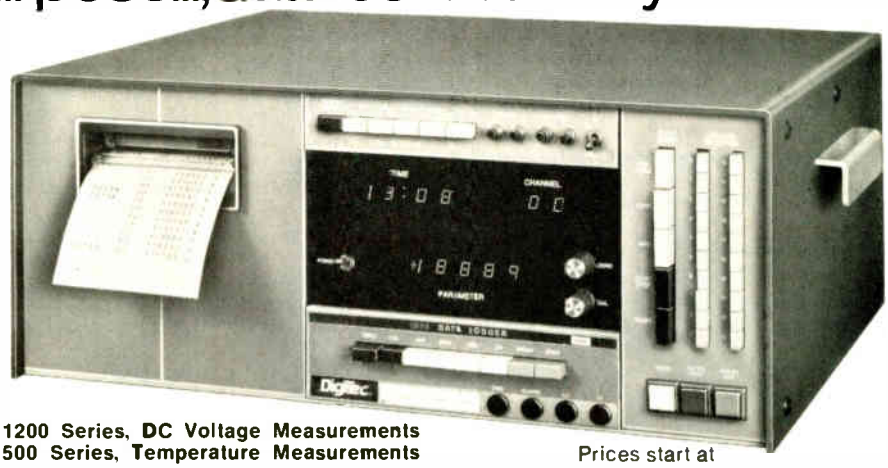

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