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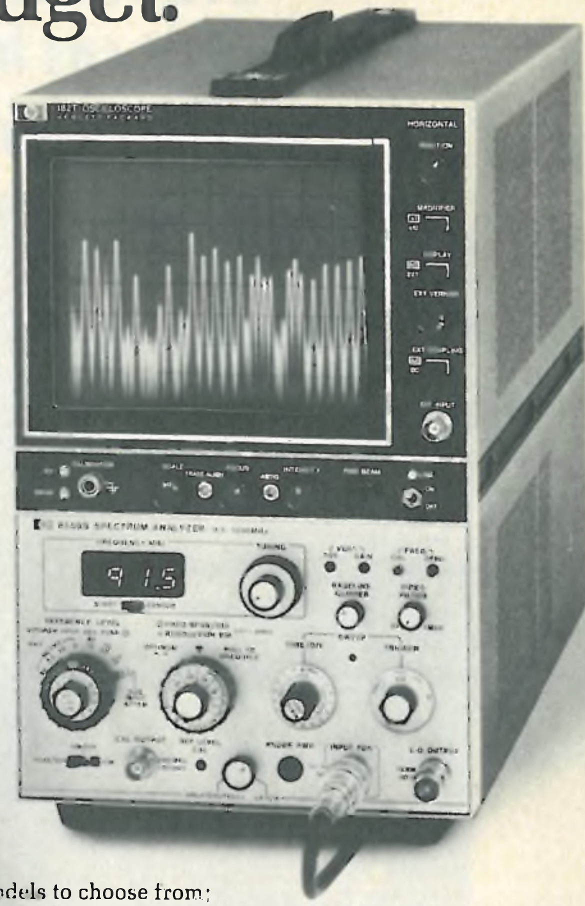

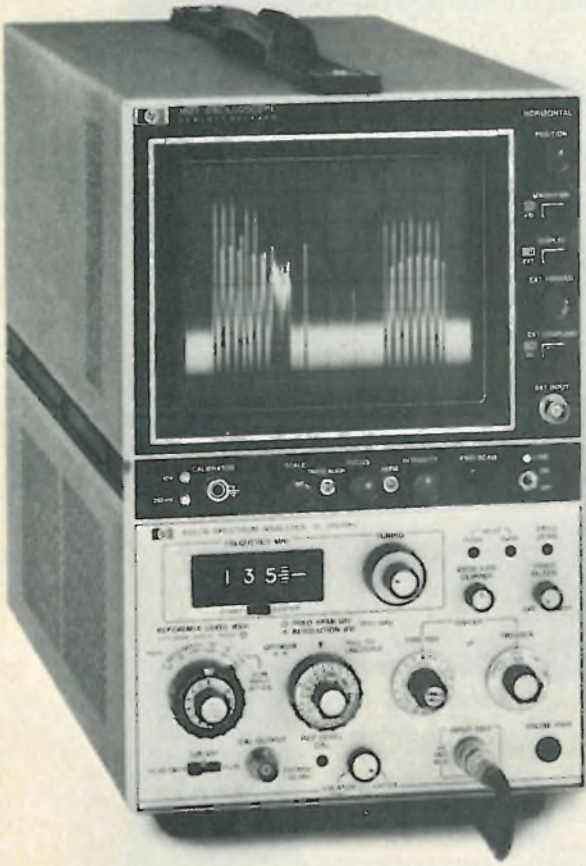

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Electronics

The International Magazine of Electronics Technology

Vol. 48, No. 14 • July 10, 1975

Highlights

Cover: Bipolar large-scale integration excels, 81
Fast bipolar LSI chips are being produced in such quantities that, gate for gate, they cost as little as hardwired circuitry. In this special report, the first part analyzes price trends, the second hails the performance of integrated injection logic, and the third describes available chip families. Cover is by Walter Einsel.

TI, Motorola set out to outdo themselves, 78
By manufacturing almost every kind of MOS or bipolar microprocessor there is, two leading semiconductor firms intend to prevent their hardwired logic families from being upstaged by anyone else's LSI products.

The Wiegand effect's magnetic attractions, 100
The direction and degree of magnetization of a wire's core and surface can be made to differ and may be switched quickly by an external magnetic field. These properties can be exploited in such applications as noncontact switching, bidirectional flowmetering, and fast pulse generation.

Optimizing timing in an MOS main memory, 107
If the memory designer who uses MOS chips tries to build too fast a system, bit errors will occur. But he can easily keep the timing straight if he follows four basic rules.

And in the next issue . . .
Special report on electronic funds transfer . . . electronics and industry, part 3: petroleum . . . a new class of instruments based on probability.

Electronics

Publisher's letter

The recent chapters in the story of large-scale integration using the bipolar approach to circuit fabrication make fascinating reading. The trouble is, technological developments often come in ones and twos. Then, it's hard to put together news stories that both detail those developments and give the big picture of how they interact with other recent developments.

And so much has been happening lately in bipolar devices that we decided the time was ripe to sit back and take a long, hard look at just where the technology stands. On page 81, you'll find our 12-page report, which was written by Solid State Editor Larry Altman.

"Wielding a variety of new weapons," he says, "from circuit forms like integrated injection logic to processing enhancements like ion implantation, semiconductor manufacturers have fought their way to high-volume production of highly complex bipolar chips. Not only do these chips each contain thousands of logic gates or tens of thousands of memory bits—they also far outperform their predecessors. And this formidable array of bipolar LSI circuitry is arming today's designer of high-performance computers, computer controls, and other digital systems with the revolutionary power of buying the hardware he needs at a price he can easily afford."

Indeed, the new vitality in bipolar technology is going to change the shape of the entire semiconductor market. As we point out on our editorial page (see p. 10), the potential of the circuit form called integrated injection logic is great. It holds the promise of combining the performance of bipolar designs with the low costs of MOS approaches.

Its potential is there, but the ways in which semiconductor houses may harness it are still up in the air. Some observers predict that MOS will hold its ground, with price cuts and technological advances of its own. In fact, there's a round of complementary-MOS price cutting going on right now (see p. 65).

Speaking of semiconductor technology, you'll be interested in another article in this issue—Poland's recent strides in industrialization. Recognizing the importance of electronics in any attempts to raise the level of a country's industrial sophistication, Poland is pushing forward in several electronics areas, from consumer wares to components. But no sector shows as impressive a set of growth statistics as do semiconductors.

John Gosch, our man in Frankfurt, just finished a swing through Poland and toured its Silicon Valley, near Warsaw. "Production of semiconductors will jump 60% this year and reach the $90 million level," he says. "For 1976, the estimate is for a 50% rise above this year's figure. Discrete semiconductor components predominate, but ICs are shooting up much higher: from last year's 1 million devices to this year's 13 million, about equally divided between linears and digital TTL types."

July 10, 1975 Volume 48, Number 14
94,679 copies of this issue printed

Published every other Thursday by McGraw-Hill, Inc. Founder: James H. McGraw 1860-1948. Publication office 1221 Avenue of the Americas, N.Y., N.Y. 10020; second class postage paid at New York, N.Y. and additional mailing offices.

Executive, editorial, circulation and advertising addresses: Electronics, McGraw-Hill Building, 1221 Avenue of the Americas, New York, N.Y. 10020. Telephone (212) 997-1221. Teletype TWX N.Y. 710-581-5234. Cable address: M C G R A W H I L L N. Y.

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Readers comment

The quest for status

To the Editor: Irwin Feerst's letter in *Electronics* [May 1, p. 6] refers to "loud cries from IEEE members that the organization should limit entry into the profession . . . done successfully by other organizations."

Engineers often talk longingly of wanting the status, respect, compensation, etc., accorded doctors and lawyers. I think this desire is presumptuous. Let me just note that—in general—doctors and lawyers: (1) have passed an examination and obtained a license to practice, without which they cannot even use their titles; (2) subscribe to a "Code of Ethics"; (3) pay significant amounts in annual dues to their associations; (4) have gone into business for themselves, dealing with the public on problems considered serious enough to justify payment for services rendered; (5) subject themselves to possible malpractice suits or loss of their licenses for incompetence, negligence, etc.

When engineers are willing to do likewise, they will deserve and receive comparable respect and compensation. I would like to see our status as engineers enhanced, but I think it will come from greater emphasis on post-BS training, more widespread registration for engineers, and more individual responsibility. In short, it will be the result of exertion, not pleading.

T. M. Stout
Northridge, Calif.

Fluxmeter doubted

To the Editor: Readers who try to use a direct-reading fluxmeter such as that described in your Engineer's notebook section of May 15 [p. 112], might end up with serious measurement errors. The problem is that any amplifier that precedes the integrator has to cope with a voltage that is a function of *both* the magnetic field and the speed with which a search coil is inserted into or removed from that field. Using [Lawrence F.] Marinaccio's own example (after figuring out that he must have used a 60-turn search coil), it follows that his gain-of-320 amplifier will *saturate* whenever the coil is ex-

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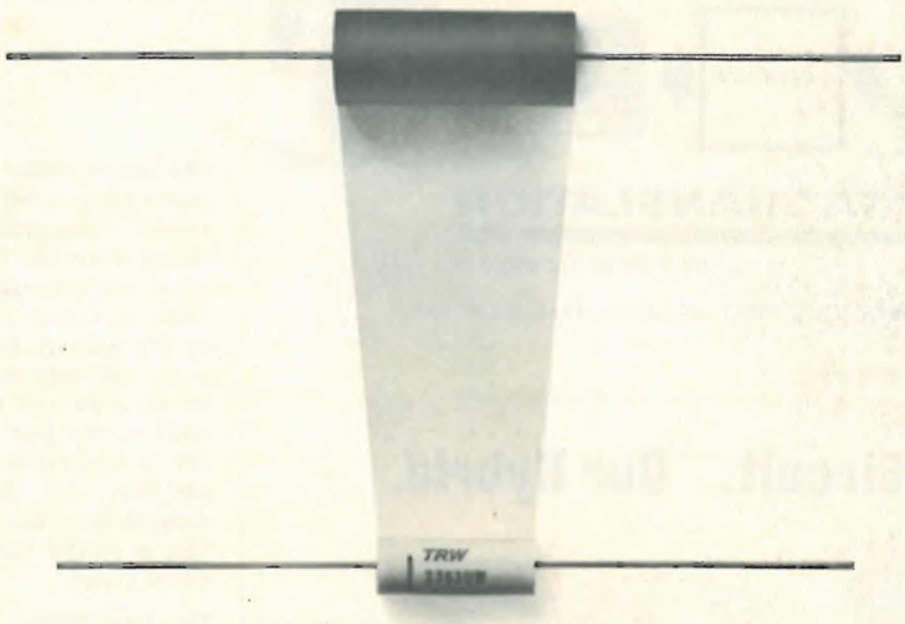

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Readers comment

tracted from a 1,000-gauss field in a time faster than 1/6 second.

What this means is that signal information will be lost, very probably without the user being aware of it. The integrator can do nothing about this state of affairs at its location in the circuit, which is one good reason why integrators are so seldom preceded by amplifiers. Another good reason is that there are many modern operational amplifiers with sufficiently good offset and drift specs that they make excellent integrators without the need for voltage boost.

Lawrence G. Rubin
Massachusetts Institute of Technology
Cambridge, Mass.

***The author replies*:** The circuit constants given in my article were chosen for a magnetic flowmeter application where the flux density is 800 gauss and coil-extraction times *to a field-free region* cannot be as short as 1/6 second. For other applications, an overload indicator may be required and this was an oversight on my part. However, as you say, a better solution is to use an amplifier with specs that make a preamplifier unnecessary. I was not able to do this with the 536 op amp which I used.

On productivity

To the Editor: I was interested in the editorial in your April 17th issue, which criticized the government's efforts to deal with the problems of productivity. I agree with your assessment, and I would point out that Senator Charles H. Percy and I have introduced legislation that would reorganize and strengthen the National Commission on Productivity and Quality of Work. This legislation should be considered by the Senate Committee on Government Operations in the very near future.

(U.S. Sen.) Sam Nunn
Washington, D.C.

■ *Sen. Nunn is chairman of the Subcommittee on Oversight Procedures of the Committee on Government Operations.*

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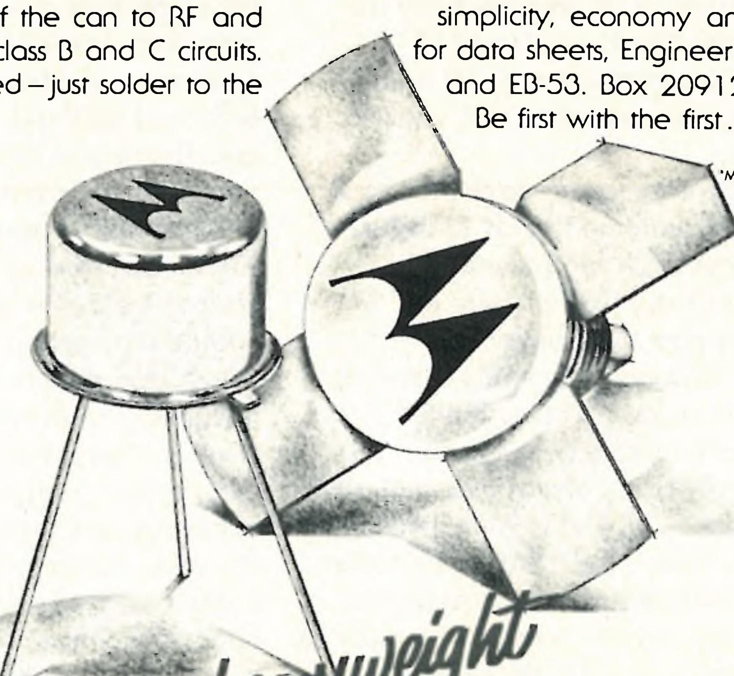

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Editorial

Resurgence in bipolar technology

From the scope of activity cited by Solid State Editor Larry Altman in his special report this issue, one might conclude that the recently developed bipolar circuit form called integrated injection logic will make significant dents in the flourishing MOS market. There's certainly no question that I^2L is an inexpensive bipolar alternative to MOS that can meet high-performance requirements with only a slight premium in fabrication cost. So versatile is this circuit form that it is attractive for cheap, modest-performance applications like watches and calculators, yet it also spans the performance spectrum to meet the more stringent requirements for microprocessors, memories, and high-speed counters.

Will I^2L take over the world? It depends on how semiconductor manufacturers respond to this new technology.

For those firms that are already heavily committed to MOS, it's not too late to start developing an I^2L capability—and some are already doing this. Others might choose to fight back by continuing to refine and improve n-channel and complementary-MOS capability. After all, as Intel's Gordon Moore says (see p. 116), there's still plenty of untapped performance left in MOS.

In any case, this new upsurge in bipolar technology after a lull of five years is a very healthy state of affairs in the semiconductor industry. The equipment designer can only benefit from the new vigor that this competition brings to the IC business.

Can technology live with regulation?

After several fatal airplane crashes, many in the Congress stepped up their criticism that the Federal Aviation Administration has delegated too much of its responsibility for safety to industry. The Department of Transportation's response was to set up a special task force to study the FAA's structure and operations.

In the event, not too surprisingly, the task force, which was made up largely of industry veterans, gave the FAA high marks in overseeing an industry that is based on increasingly complex technology.

Significantly, however, the study served to shine a spotlight on that "increasingly complex" aspect of aircraft equipment—just look at the sharply rising electronics content in the world's commercial and private aircraft. Thus, one of the task force's proposals is that the FAA beef up its inspection procedures, while allowing industry to continue to enjoy its present high degree of self-regulation.

The FAA, says the task force, "must continue to place increasing reliance on the role of industry in the safety compliance inspection process" if it is to keep up with increasing aircraft certification demands and the inspection of air carriers and manufacturers of aircraft and avionics. At the same time, the FAA "must strengthen its technical staff and its ability to monitor the effectiveness of delegated functions, and must assure strict monitoring."

The FAA's approach to delegated responsibility has worked in the past to give the United States the world's best safety record in commercial aviation. However, the FAA has often been slow to open the way to new technological developments that can improve even on that record. If the system of inspection and product-sampling techniques can be expanded and improved by industry under the direction of the FAA, then a technology-rich industry can avoid the stifling of creativity and enterprise that so often accompanies Government regulation. Yet the system must move faster in utilizing the technology spawned by that creativity.

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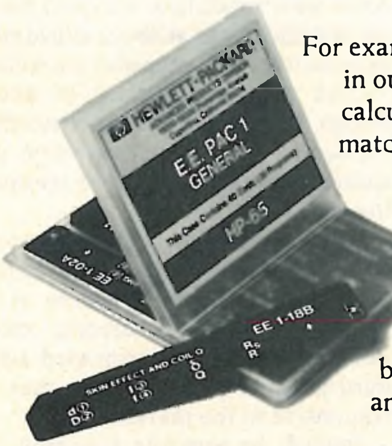

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People

Motorola marketing gets 'two-heads-are-better' look

In a bid to solve its long-standing problems of declining sales and delays in bringing high-technology products to market, Motorola Semiconductor Products Inc. has appointed a two-man team to direct its marketing organization.

Charles E. Thompson, 45, until recently an inside operations man, will head day-to-day world sales operations as director of marketing. Assistant director Colin Crook, the 33-year-old marketing whiz who got Motorola into the metal-oxide-semiconductor memory and microprocessor business, will handle the strategic market planning for products that might be as much as five years in the future. Both will report to general manager John Welty [*Electronics*, May 15, p. 38].

Imposing. Thompson sees no conflict in this setup. "Add up our credentials, and we're a pretty imposing person," he quips. "We have noncompetitive experience and, besides, there is enough to keep us both busy without stumbling over each other."

Thompson, a mathematician-turned-computer expert from General Electric, joined Motorola in 1969 and has been involved with internal data processing, productivity improvement, cost analysis, and customer service.

Crook has a solid background in semiconductor technology. Although he's been with the company's semiconductor operation in Phoenix for just two years, he's a veteran at Motorola.

Remembering his days in the computer business at General Electric when GE was fruitlessly chasing IBM, Thompson vows that Motorola will not be a hanger-on in the microprocessor business but will be going after an "important" share. He will strengthen its sales operation, for microprocessors as well as its other products, which has traditionally aimed at geographic penetration. Thompson plans to add a greater industry orientation by supplementing the geographic sales force with specialists who will focus on specific areas such as consumer, automotive and computer markets.

The new marketing director brings a strong belief in customer service to the job, a conviction acquired during his years of competing with IBM.

The longevity of Motorola's technology is where Colin Crook enters the picture. His big concern is to harness Motorola's diverse technologies behind a coordinated standard-product development that is responsive to the market.

Indeed, he sees the planning aspect of his job as the most crucial if long-lasting products having wide marketing impact are to result. He can certainly call on his MOS experi-

Tandem. Charles E. Thompson, left, takes over as director of marketing, handling day-to-day operations for Motorola Semiconductor, while Colin Crook looks at future planning.

ence to serve him here. It was Crook who at age 31 put Motorola's MOS technology right on the money, getting the company's floundering MOS program into solid standard-product areas, such as memory and microprocessors. And it was he who took Motorola out of marginal watch and calculator chip activities.

"It was already too late for that stuff," notes Crook, who, when joining Motorola Semiconductor division in 1972, felt that market conditions had bypassed these custom areas in favor of high-run standard data-processing products. He also realized that Motorola had the high-performance MOS process required to build these products. The result was high-run factory output in all the glamorous MOS product high rollers—the M6800 microprocessor family, and the 1- and 4-kilobit random-access memories.

Review. Now Crook will review Motorola's expertise in bipolar technology with an eye to finding the best approach to develop large-scale-integrated products. He'll examine the full range of bipolar LSI process technology at Motorola's central research laboratory to see which technique fits into which product. "In this activity our market inputs will be strong and formal, coupling market research and customer contacts with technology capability. If the market demands more powerful microprocessors and memories—and we are convinced that it does—then we'll put our technology to work right there."

Such market guidance had been lacking in past Motorola programs, which were often changed midstream or, just as abruptly, dropped in favor of others. "This zig-zag approach to market development is a thing of the past," says Crook.

Crook's background qualifies him to run this type of marketing program—sort of the manager of a group strategic planning effort. Schooled in MOS and bipolar IC technology, Crook spent his early years heading Motorola's technical marketing efforts in England, where he was responsible for defining C-MOS efforts in Europe.

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Scot Pot's total performance is better than or equal to any other 10-turn wire-wound miniature precision pot you can buy. One look at the Scot Pot spec sheet tells the story. (Be sure to ask for a copy.) Scot Pot has improved electrical, mechanical, and environmental characteristics. Its performance meets even the most demanding design requirements. All at that surprisingly low price.

Save up to 25%.
And the Scot Pot price-tag is a surprise. A very pleasant one. Because Scot Pot can replace what you're using now—in form, fit, and function—and save you as much as one fourth the cost.

Scot Pots are available—now.
You can get immediate, off-the-shelf delivery on Scot Pots from your Amphenol Industrial Distributor. He's located close to you—so call him. Or for more information (and a copy of the Scot Pot spec sheet) contact: George Boyd, Amphenol Connector Division, Controls Operation, 2801 South 25th Avenue, Broadview, Ill. 60153. Phone: (312) 261-2000.

When you can connect it and forget it...that's quality.

BUNKER RAMO **AMPHENOL**

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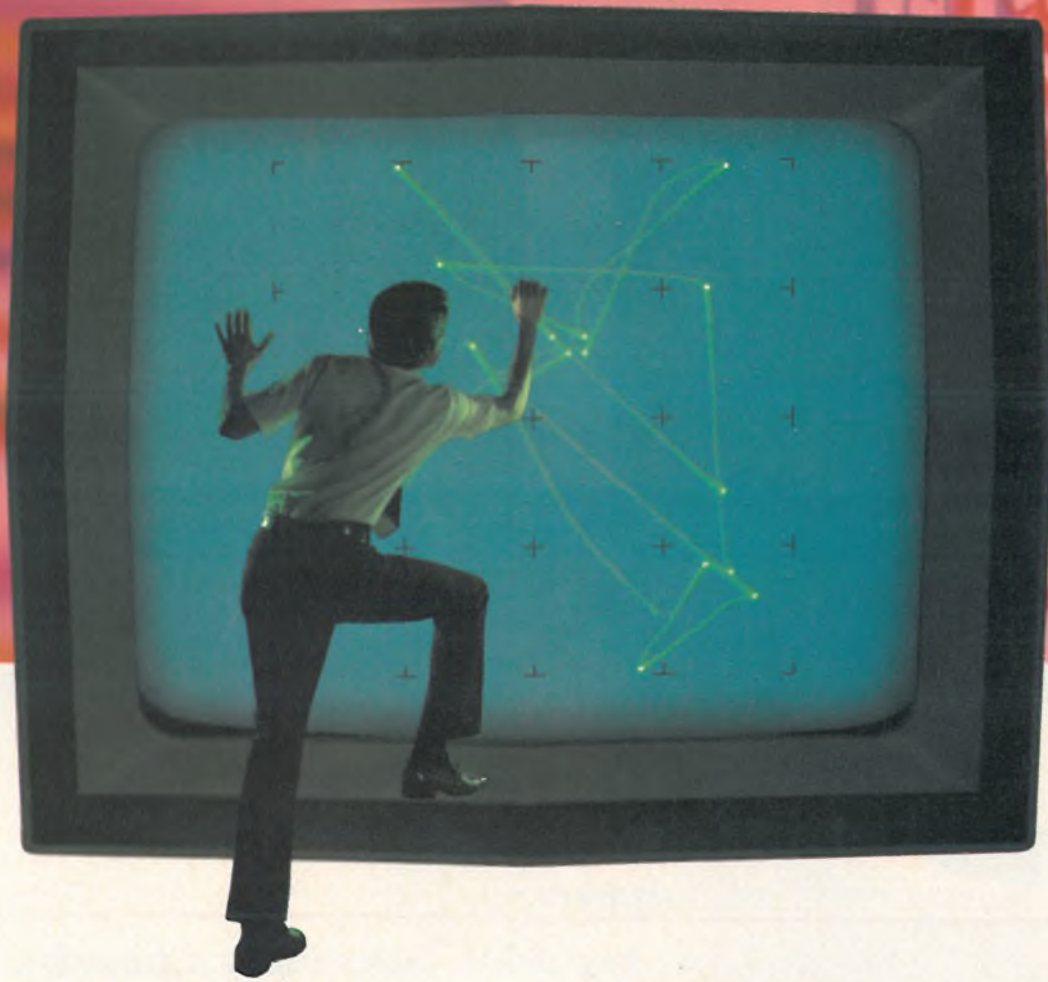
Another data domain

Breakt

With two new ways to get inside your



HP invites you to step inside your 16-bit parallel circuits for an overall view—and a detailed view—of logic-circuit operation. How? Just connect our new 1600A Logic State Analyzer to an operating circuit, and view actual logic states on the CRT—at clock rates to 20 MHz. Select the data you want to observe with pinpoint accuracy. And choose from two display methods for viewing the data words.

What does this mean to you? It means a better way to see hardware and software in action... a faster way to spot problems and find solutions. For example:

In the mapping mode, the 1600A can display all possible combinations of its 16 data-channel inputs—over 65,000 in all. Each input combination or "word" appears as a discrete point whose location on screen identifies its address. Spot intensity shows relative frequency of occurrence, and the vectors show the sequential state locations.

This mode converts parallel data into a pattern that your eye can easily scan to quickly spot changing conditions or unusual events. You can even expand the view to zoom in on data of interest. And, with a curser, locate the address of any spot. You can then use the address as a trigger point for a detailed look with the tabular display, or to trigger your scope for electrical analysis.

In store and compare mode, the 1600A triggers on any preset word up to 16 bits wide. The analyzer then displays the trigger word and 15 sequential words before, after, or surrounding the trigger word, so you can easily analyze logic states in detail. You can store one table of data and compare it with an active data display... have the analyzer compare the two tables and give you a display of logic differences on a bit-by-bit basis for easy comparison ...or you can set the instrument to automatically halt when all the data in one table isn't identical to data in the second—freeing you from the tedious task of waiting and watching for infrequent sequences.

And that's just the beginning. The 1600A gives you qualifier inputs to help locate the specific data you want on a busy bus. It gives you a sequential trigger by providing a trigger arm that inhibits the word trigger until an arming signal is received. You can

hrough

logic designs: Mapping...... Store and compare.

delay the display up to 99,999 clock pulses from the trigger point, which lets you look virtually anywhere in your program flow.

The 1600A, priced at $4,000*, gives you new insight to operating logic circuits. With 16-bit word size, parallel operation, and 20 MHz speed, it's the ideal instrument for designers of minicomputers, peripherals, microcomputers, and microprocessor-based systems.

If 16-bit words aren't enough, our new 1600S, priced at $6,800*, displays words up to 32 bits wide. This powerful system includes both the 1600A and our new 1607A Logic State Analyzers. Hook it up to your 16-bit machine, and in single clock you can look at both the data and address simultaneously. In dual clock, you can view two independent active tables of 16 bits each—synchronized together through the bus triggering capabilities.

When you have all the details, you'll see how these new logic-state analyzers put you inside your logic programs for a better overall picture . . . and for a clear detailed look. And you'll see how they can save you hours in design, debugging and troubleshooting. For the complete story, just contact your local HP field engineer. Or, write for our new 8-page data sheet on Logic State Analyzers.

For low-cost logic state analysis and electrical measurements too, add HP's new 1607A to your present scope and have a complete digital system . . . see the next page for details.

*Domestic USA price only.

085/7

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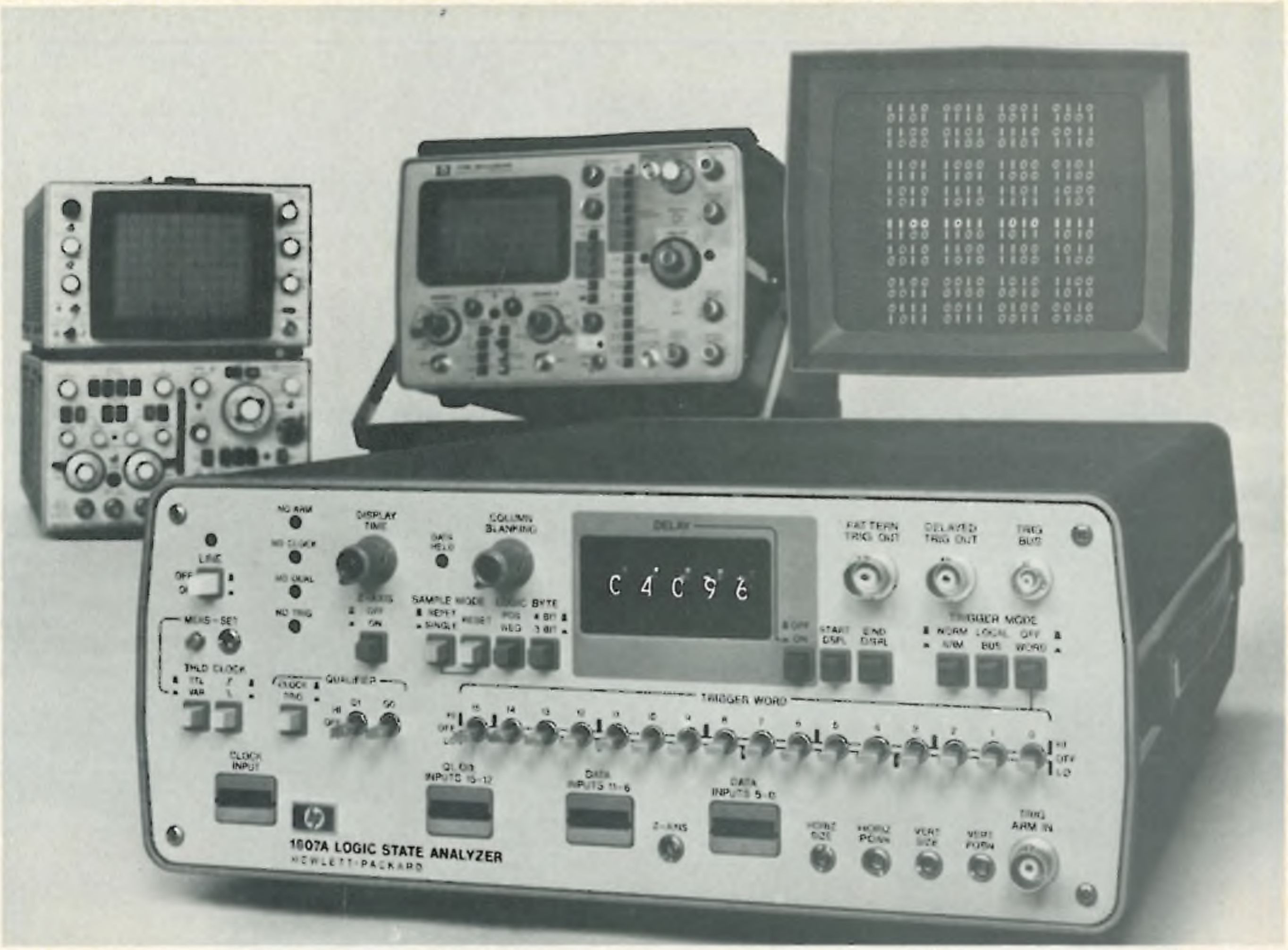

Introducing a powerful new team to speed logic analysis - HP's 1607A and your present scope.

You already have half of a complete digital-analysis system ...the scope you've been using for level and timing measurements. The other half is HP's new 1607A Logic State Analyzer. Simply make four BNC connections, and you have a combination logic analyzer and oscilloscope—a complete analysis system for the digital designer.

Data domain or time domain. In the data domain, the system shows you a display of logic states in operational circuits so you can pinpoint a program problem. Then, in the time domain, the 1607A triggers your scope at the point where the problem occurs so you can analyze the electrical characteristics of the waveform using the conventional scope input. Now you can really pin down those hardware/ software compatibility problems.

Parallel words to 16 bits. The 1607A triggers on any preset word up to 16 bits wide...and at clock speeds to 20 MHz. In the data domain, it displays—on your scope's CRT—15 sequential words before, after, or surrounding the trigger word. You see the bits as 0's or 1's for easy analysis of your circuits or programs—while they're operating full speed.

Qualifier inputs help locate data. If you're looking for specific data on a busy bus, the 1607A's qualifier inputs let you selectively extract data of interest. In addition, a trigger arm gives you a sequential trigger by inhibiting the word trigger until an arming signal is received. You can delay the display up to 99,999 clock pulses from the trigger point, which lets you look virtually anywhere in your program flow.

With the 1607A, and your scope, you can select the data you want to observe with pinpoint accuracy...then observe either logic states or electrical parameters.

Drives a scope or display. The 1607A, priced at just $2,750*, drives nearly all modern scopes. You can even combine the logic state analyzer with a large-screen CRT display for easy viewing at a distance, such as a classroom situation.

Put this team to work in program analysis of microprocessor based systems...for microprogram analysis in minicomputers...or in situations where flow diagrams are the best way to describe your design. You'll find that its detailed view will result in faster design and debugging. And easier troubleshooting.

There's more to learn about this new logic-state analyzer ...and how it gives you a better way to see hardware and software in action for faster solutions to your digital-design problems. Get all the details by contacting your local HP field sales engineer. Or by writing for the 8-page data sheet on HP's new Logic State Analyzers.

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085/5

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Meetings

Nuclear and Space Radiation Effects Conference, IEEE, Humboldt State, Arcata, Calif., July 14–17.

Summer Computer Simulation Conference, ISA et al, St. Francis Hotel, San Francisco, Calif., July 21–23.

Dielectric Materials, Measurements, and Applications, IEEE, Churchill College, Cambridge, England, July 21–25.

1975 Gordon Research Conference on Solid State Studies in Ceramics, Brewster Academy, Wolfeboro, N.H., Aug. 4–8.

Associated Public-Safety Communications Officers National Conference, APCO, Washington Hilton Hotel, Washington, D.C., Aug. 11–14.

Symposium on the Simulation of Computer Systems, NBS and ACM, Boulder, Colo., Aug. 12–14.

10th Intersociety Energy Conversion Engineering Conference, IEEE, University of Delaware, Newark, Del., Aug. 17–22.

19th Annual SPIE Technical Symposium: Developments in Optical and Electro-Optical Engineering, Past and Future, Society of Photo-Optical Instrumentation Engineers, Town & Country Hotel, San Diego, Calif., Aug. 18–22.

Active Semiconductor Devices for Microwave and Integrated Optics, IEEE and Cornell University, Ithaca, N.Y., Aug. 19–21.

IFAC/75: International Federation of Automatic Control's Sixth Triennial World Congress, IFAC, Massachusetts Institute of Technology, Cambridge, Mass., Aug. 24–30.

17th Conference on Electronic Materials: Preparation and Properties of Electronic Materials, AIME, Princeton University, Princeton, N.J., Aug. 25–27.

NBS Seminar on Frequency Standards and Clocks: Characterization, Usage, and Problem Areas, NBS, Boulder, Colo., Aug. 25–27.

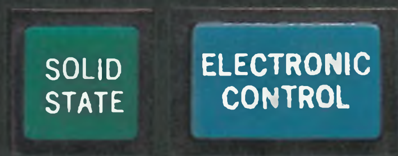
Developing this new pushbutton was a little like coming up with a Ferrari that gets 32 mpg, holds 12 people and costs less than a Pinto.

Until now, there have been some good-looking lighted pushbuttons and indicators.

And there have been others with varied electrical capabilities. But there's never been a line that gave you harmonious panel design, electrical flexibility, and low cost. All at the same time. Until now.

Introducing the MICRO SWITCH Advanced Manual Line—AML.

The most sophisticated line of pushbuttons and indicators ever designed. And you can see a few of



the reasons why right here. The AML button height, bezel size and visual compatability of the square and rectangular sizes "harmonizes" your panel. To give you a panel with a clean, good-looking geometric face. And a panel with increased efficiency, because it doesn't distract. The low-profile square and

rectangular buttons are available in five colors: white, red, yellow, green, and blue. Display capabilities include split screen, hidden color, and a unique three segment lens cap indicator. Illumination can be transmitted or projected. But what you can't see here is what

helps to make these the most advanced line of lighted pushbuttons and indicators available: their extreme electrical flexibility.

Solid state operates at 5V or 6-16V with a built-in regulator, sink (TTL) and source (CMOS).

Electronic control is capable of handling low energy circuits and has a maximum rating of 3 amps, 120 VAC, with single or double pole double throw.

And power control, DPST, with a rating of 10 amps at 120 VAC.

The AML has snap-in mounting from the front of panel and can also be subpanel mounted. There's a choice of individual or strip mounting.

All devices are the same shallow depth behind the panel to provide a unique single level termination system. The result is ease of wiring and neat appearance.

There are 5 types of terminals available: solder, quick-connect, wire-wrap, push-on or p.c. board mount.

Relamping is accomplished from the front of the panel. And it's done without a tool. With a choice of lamps including a T-1¾ wedge base lamp, neon and LED. To provide international acceptance, every AML device has been designed to comply with essential IEC, CEE24, UL and CSA standards.

For more information on the AML, call your nearest MICRO SWITCH Branch Office. Or write for our literature.

What you'll see is a line of lighted pushbuttons and indicators that give you a completely harmonious panel design in the front.

And the utmost in electrical flexibility behind the panel.

All products shown on this page are actual size.

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Now! Automatic wiring at twice the speed and half the cost.

1,100 to 1,200 wires per hour

That's the cycle-time performance built into this new Vertical Gardner-Denver Automatic Wire-Wrap* Machine. The wrapping area is 56 cm x 56 cm. It is designed for 26 and 30 A.W.G. wire.

For increased production of solderless wrapped connections, for lower production cost and improved efficiency contact your local Gardner-Denver Representative. Or, write: Gardner-Denver Company, International Division, 8585 Stemmons Freeway, Dallas, Texas 75247, U.S.A.

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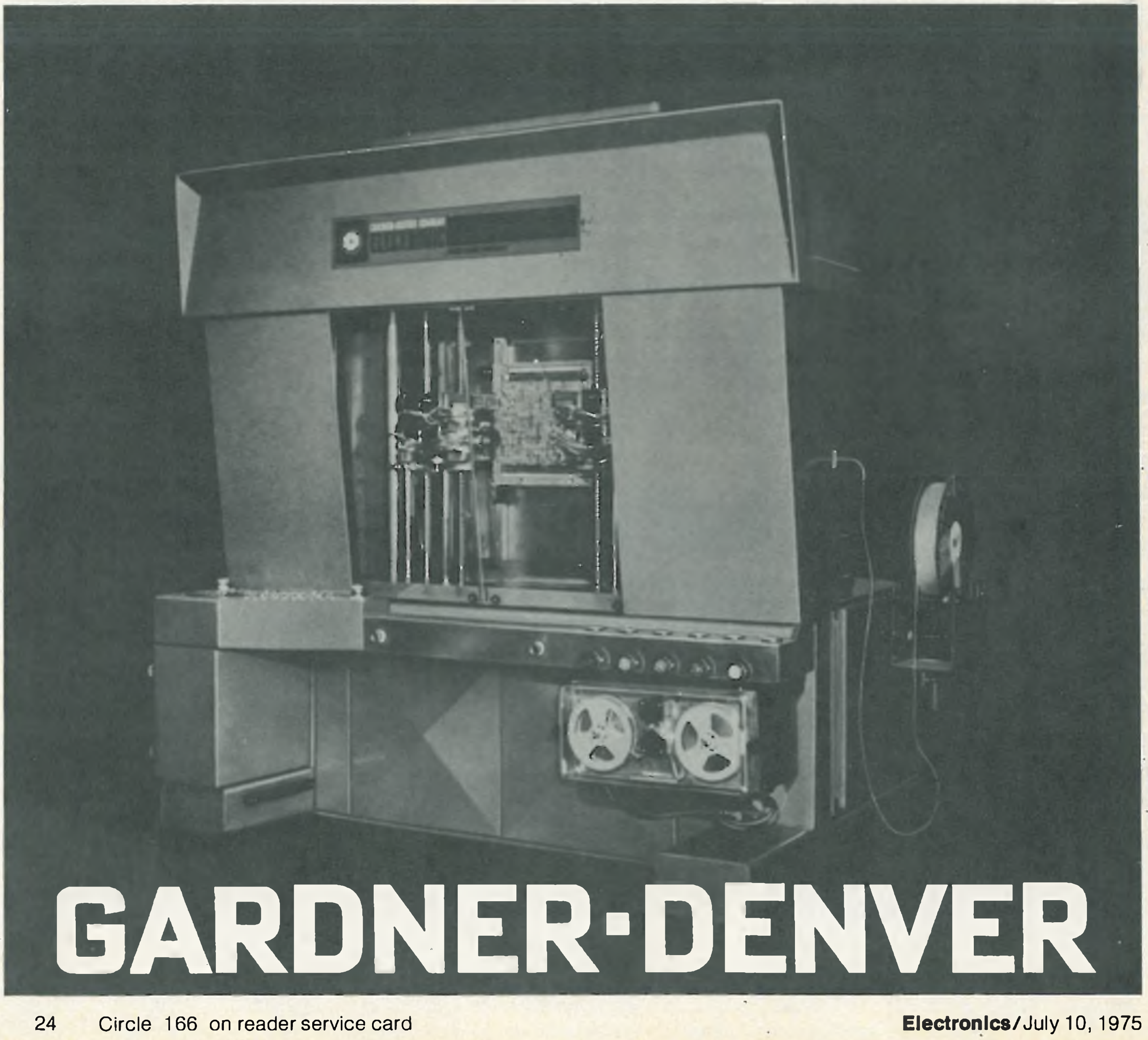

RCA mounts SOS drive with 1-kilobit RAM

Vowing to start pushing silicon-on-sapphire circuitry, RCA's Solid State division is **sampling 1,024-bit SOS random-access memories as it begins production of the devices at its Somerville, N.J., headquarters,** Philip R. Thomas, division vice president for MOS products, says that RCA is already negotiating several "sizable" orders for SOS timing circuits, and that **the division plans to announce 4000-series complementary-MOS devices on sapphire next month.**

Also, the division is developing a 256-by-4 SOS RAM for high-speed microprocessor applications, especially for the peripheral-equipment market, says Thomas, who plans to have the division's facility in Palm Beach Gardens, Fla., for n-channel and SOS devices, as well as microprocessors up and operating by the end of this year.

ITT fiber loses less than 8 dB per kilometer

ITT's Electro-Optics division in Roanoke, Va., has developed a high-silica, low-loss fiber with an **attenuation of "under 8 decibels per kilometer" at a wavelength of 0.85 micrometer,** according to James Goell, director of the Fiber Optics Laboratory there. This compares with a maximum loss of 8 dB/km for Corning Glass Works' Corguide [*Electronics,* May 15, p. 121].

Working under an "experimental" contract from the Naval Electronics Laboratories Center, San Diego, Goell's group has made 400-meter-long cables with six individual fibers placed around a central supporting core. The 210-mil-diameter cable has withstood tensile loads of 500 pounds.

Goell's laboratory has also been working with a less expensive but higher-loss plastic-clad silica fiber under a U.S. Army contract. Loss is in the range of 25 to 30 dB/km. Goell expects the Roanoke operation **will bring "some kind of cable to market within six months,"** although just what kind is still to be decided.

Meanwhile, Germany's Siemens AG has reported on a laboratory material with attenuation of only 1.35 decibels per kilometer at a wavelength of 0.06 micrometer (see p. 55).

Life of cw-laser diode set at more than 500 hours

"The first commercially available continuous-wave laser diodes with a reasonable lifetime" were launched by Robert Gill, president of Laser Diode Laboratories Inc. of Metuchen, N.J., at the Laser '75 exhibition June 24 to 27 in Munich. **Gill says that an operating life of 500 to 1,000 hours can be expected from the new devices.** The gallium-aluminum-arsenide diodes are of a multihetero structure, use monolithic-stripe geometry, and come in two versions—the LCW-5 and LCW-10. The LCW-5 has maximum continuous power output of 10 milliwatts and the LCW-10, 20 mW. In quantities of more than 10, Gill says the LCW-5 will sell for $100 to $200 and the LCW-10 for $200 to $300.

Intel bases memory system on CCD chip

Look for Intel Corp.'s Memory Systems division in Sunnyvale, Calif., to soon begin supplying prototype quantities of a memory system using Intel's 2416 CCD memory chip to several original-equipment manufacturers in the computer industry. Expandable from 1,179,648 to

18,432,000 bits, **the system, designated the IN-65, consists of three types of boards.** They are the memory unit, a 14.6-by-12-inch card with a basic memory capacity of 1,179,648 bits; the control unit, which provides all interface, timing, and control logic for up to eight memory unit cards; and the buffer unit, acting as a slave to the control unit, which provides for word length expansion from 9 to 18 bits and handles an additional eight memory unit cards. A 1,024-word, 18-bit system would, therefore, contain one control-unit board, one buffer-unit board, and 16 memory-unit boards. Shift rate is 750 nanoseconds when seeking a new random address and 9 microseconds when in standby for data retention. Data-transfer rates per 8- or 9-bit word range from 9 to 550 nanoseconds.

Cramer to have processor product

Distributors agree that microprocessors could be the biggest item they've handled since transistors [*Electronics,* June 26, p. 78], but at least one distributor, Cramer Electronics Inc., seems to be going a step further. **It apparently will be coming out in early fall with a microprocessor-based product.** "This involves a whole new thing for a distributor; it will involve service and everything," a spokesman says. But so far the company is keeping details under wraps."

$11 billion by 1995 for laser-fusion work, says ERDA

At current and projected expenditure rates, approximately $11 billion will have been spent by 1995 to prove the economic feasibility of laser-pumped nuclear-fusion power plants, according to the Energy Research and Development Administration.

About $75 million will be spent in the current 1976 fiscal year. And, to keep the program on schedule, ERDA says, this will grow to $80 million in fiscal 1977, $99 million in 1978, $114 million in 1979, $130 million in 1980, and $144 million in 1981. An ERDA official says that about 25% of the $11 billion will have been spent on high-powered short-pulse duration lasers. **Early models will use oil-filled capacitors pumping flash lamps, which are controlled by minicomputers for accurate aim of beams for exploding deuterium pellets.** The first such laser, under construction at the Lawrence Livermore Laboratory in California, is rated at 10 kilojoules and will have cost about $16.8 million when completed in 1977, ERDA says.

Addenda

IBM Corp. has introduced a new data entry terminal, the IBM 3760 dual-key entry station, to enhance the 3790 communications system by automatically checking data for accuracy and **alerting operators to errors before data is transferred to a computer.** . . . IBM also cut purchase prices 15% on its System/370 Model 115 and 125 processing units, and for terminal and communications products, and 10% for magnetic-tape and disk storage units, printers, and optical recognition units. . . . The FAA will pay $30.2 million for 16 air-route surveillance radars from Westinghouse Electric Co. now that the General Accounting Office has turned down Bendix Corp.'s protest of the award. Of the solid-state ARSR-3 models, 14 will be fixed and two mobile. The FAA also has options on eight more fixed and two more mobile systems that operate at L-band using 5 megawatts.

Only 1½ watts for 4½ digits

The AN2545 logic powered DPI provides the best combination of low power and optimum (DIN/NEMA) case size for the most reliable performance in its class.

None Like It Hot
In the heat of specsmanship, important factors affecting a Digital Panel Instrument's true performance can often be overlooked. Temperature, for instance. The hotter a DPI runs the less reliable it becomes. With every 10°C rise (above 40°C), the MTBF of a digital panel instrument decreases by a factor of 2, thus the lower the power consumption, the lower the temperature, and the higher the reliability.

Analogic's AN2545 DPI was specifically designed to stay cool. With only 1.5 watts to dissipate in a standard DIN/NEMA case, the AN2545 has only a fraction of the power density of the nearest competitive unit resulting in much greater long term stability and reliability. And the AN2545 displays its rated accuracy immediately upon turn-on instead of the 15 to 30 minutes required by competitive units to drift into spec.

Engineering Where It Counts
Again, unlike most competitive units, the AN2545 was designed from the ground up specifically as a true 4½ digit 20,000 count device. Accuracy has been designed beyond the last displayed digit to insure the integrity of the displayed value resulting in jitter (uncertainty) of only 0.2 of a bit (a fraction of the LSD).

More Optional Versatility
Two systems oriented BCD output options are available—serial by digit or fully latched and buffered parallel—and if desired, both can be used at the same time. Provision for an external reference can also be provided for true 4-wire ratiometric measurements, thereby increasing the stability of system calibrations.

Other important features include—true high impedance differential inputs, autozeroing, a true, dual-slope, integrating A/D converter, 0.55" gas plasma display, absolute accuracy of 0.01 percent of reading ±1 count guaranteed, temp. coef. of 15 ppm of reading /°C, common mode rejection greater than 70 dB, input impedance of 500 megohms, programmable decimal point position and automatic polarity indication.

Testing and More Testing
Reliable performance to specs is assured by 100% testing of subassemblies and a minimum of 100 hours burn-in of all units at 55°C and vibration test of 5Gs at 50 cycles. In addition, all units are subjected to rigid QC confirmation of specs and are shipped with printout of final test results.

The price for this ultra reliable 4½ digit DPI is about what you would expect to pay for a sophisticated 3½ digit unit. And like all Analogic products, the AN2545 is guaranteed for 12 months.

To get full details, contact your nearest Analogic sales office. For our new 40-page Catalog/Handbook, write on your letterhead to Analogic Corporation, Audubon Road, Wakefield, Massachusetts 01880 U.S.A.

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Pro-Log microprocessor modules reduce parts count and design time, and drop assembly costs.

Design engineers using this new approach can cut system costs up to 80%.

Choose the wrong approach to microprocessor system design and you could wind up quadrupling your total cost.

The computer-oriented approach costs big money, gives you more capability than you may need.

Semiconductor manufacturers regard microprocessor-guided systems as a form of computer typified by data processing techniques.

They promote features like interrupt, built-in control panels, program loaders, direct memory access, memory capacity and throughput. But their approach is only applicable to situations where large volumes of data must be manipulated in a job that may change from hour to hour. This kind of versatility tremendously increases system costs—you wind up buying RAM memory, canned software, and such peripheral devices as tape, card, disk, keyboard and display controllers. And you need a computer programer to design your system for you.

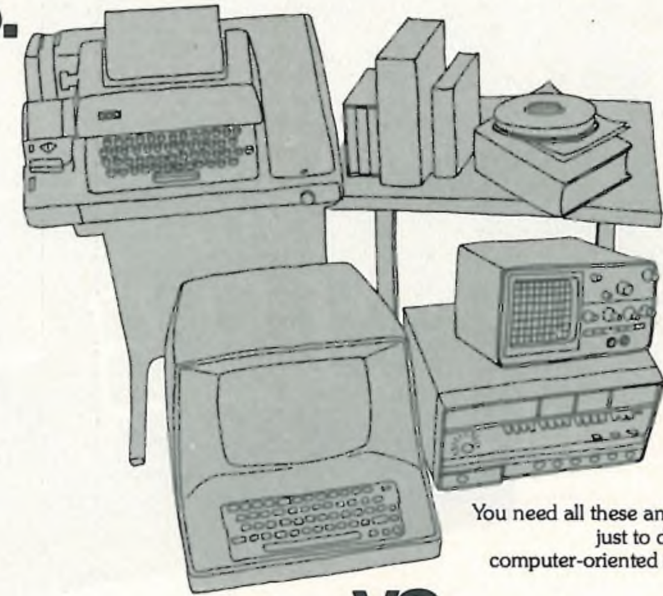
If you really need that kind of versatility, maybe you need a computer, not a microprocessor.

The Pro-Log Logic Processor approach does the job at minimum cost.

Pro-Log treats the microprocessor module as a logic processor especially suitable for dedicated control.

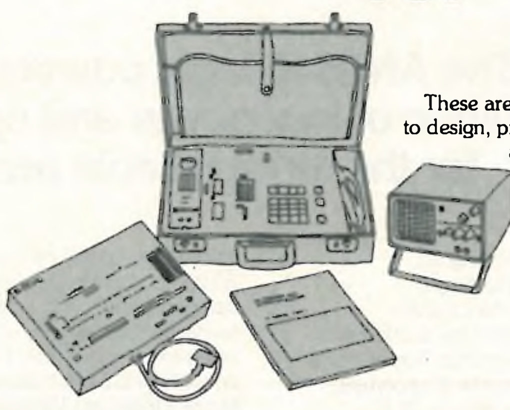
This avoids the computer-oriented requirements for software, complex peripherals and unnecessary performance. Pro-Log's microprocessor modules are normally hardwired to relay contacts, switches, push buttons, displays, or other devices instead of communicating with them through expensive controllers. Simple-to-program PROMs rather than software-directed RAMs configure Pro-Log's modules in their specific activity. Using Pro-Log's approach, system design stays with the design engineer, not the computer programer. And our approach not only enables you to design hardware but to produce it easily and maintain it in the field.

A microprocessor module, correctly applied, can replace large numbers of logic gates and timing elements as well as the sockets, power supplies, packaging, connections and wiring that go with it. By decreasing parts and interconnections, you lower assembly and rework costs, improve reliability, and cut inventory. The simplicity of microprocessor modules lets you get into high volume production quicker.



You need all these and more just to design a computer-oriented system.

VS.



These are the only tools you need to design, produce, and field-service a logic processor system: M821 system analyzer, Series 90 PROM Programer, coding form, oscilloscope.

If that describes your product application, maybe you should be using a Pro-Log logic processor.

Only Pro-Log has the tools you need to apply the logic processor approach.

We've got the most complete line of microprocessor modules anywhere, including off-the-shelf delivery on modules using 4004, 8008, 4040, and 8080 CPU chips. We'll be delivering modules using the 6800 chip in the near future. We've got designer manuals, applications notes, instruments and test equipment, too.

Money-back guaranteed education.

Pro-Log offers two microprocessor courses nationwide.

Our one-day applications course costs $100. If we don't convince you we've got the best approach to the use of microprocessor modules, just tell us so and we'll give you your money back, no questions asked.

We've also got a three day hands-on course we've given to more than 1,000 design engineers in the past two years. The only two requirements are that you know what a flip-flop and a gate are. If you do, we guarantee you'll come out of our course knowing how to design, program and use microprocessor modules because you'll have done it.

Contact Pro-Log for a complete list of course schedules and locations. Also send for our free paper "Microprocessors for Dedicated Control."

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Low-cost watch to keep time with RC oscillator

Exar Integrated Systems also uses integrated injection logic to develop single-chip watch; goal is under $30 price tag

Working with a major watch manufacturer, Exar Integrated Systems Inc., Sunnyvale, Calif., is planning to manufacture a watch circuit made with integrated injection logic. Several versions should be in production by year-end.

What's more, the small (70-employee), privately held company, best known for bipolar monolithic linear integrated circuits, expects to have at least one circuit using a resistance-capacitance, rather than a crystal, oscillator.

According to Exar's vice president of engineering, Alan B. Grebene, the combination of these two factors, plus the lead he believes his company has built up investigating the commercial potential of integrated injection logic, gives Exar a clean shot at a large share in the market for a high-volume, under-$30 electronic watch.

The development of the RC oscillator to replace the quartz crystal unit was crucial to bringing watch costs down. "At current market value, 32.72-kilohertz quartz crystals suitable for watch applications cost as much as the rest of the circuit put together, another $3 or so," observes Grebene.

RC oscillator. Grebene's goal is an RC oscillator costing 80 cents to $1. "Of course, the big advantage of crystal oscillators is that they have a natural frequency and are extremely accurate to within minutes or seconds a year," he says. "But for many portions of the consumer watch market this may be overkill. Even though it has no natural frequency and must be set externally, an RC oscillator accurate to within 90 to 100 parts per million, or about 3 or 4 minutes a month, would be acceptable."

The impact of temperature and power-supply variations on stability must be no more than 50 ppm, he says; component aging, no more than 25 ppm. Both are within range of Exar's RC oscillator design, Grebene says.

On-chip MOS. One possible way to achieve the stability, he explains, would be to include a metal-oxide-semiconductor capacitor on the chip connected to a series resistor as well as to an external trimmer capacitor. "What you would start with would be an RC product accurate to within 5% or 10%," Grebene says. "Laser trimming during final assembly would bring this down to about 0.05%. A final setting by means of an external trimmer capacitor would bring the accuracy down to 0.0025% or 25 ppm."

Such an RC oscillator configuration would require about 7 to 10 microamperes beyond what is required for the rest of the watch chip. This would still be within the one-year lifetime of standard silver-oxide batteries, he says.

The attraction of I^2L technology is a high-current output which allows a light-emitting-diode display to be driven directly from the watch-circuit chip. In fact, Exar began thinking about I^2L "shortly after the first papers were published," Grebene says. "By the middle of last year we had already begun design work, by January we were running test wafers and circuits. We are now at the point where we think we know what is achievable."

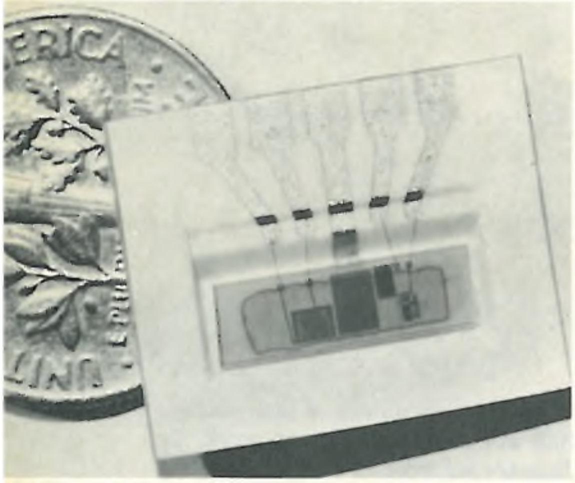
Universal circuit. What is achievable, Grebene calls a "universal watch circuit" of about 15,000 to 20,000 square mils, which can use either a crystal or an RC oscillator and which contains six functions—seconds, minutes, hours, day, date, month and a.m./p.m.—as well as both the segment and digit drivers for a light-emitting-diode display. While all six functions will be on chip, the watch circuits will be manufactured with two, four, five or six functions, depending on market and price.

From experimental data and test runs, Grebene says the I^2L portion of the watch chip—the segment counters and digital and timing circuitry—should require no more than 3 to 5 microamperes of current. It should cost no more to fabricate than a three-chip complementary-MOS watch circuit of comparable performance—about $2 to $3. □

Consumer

Zenith adding surface-wave i-f

Zenith Radio Corp. has started substituting surface-wave filters for tuned circuits in the intermediate-frequency strip of its color-television sets. The move promises better channel selectivity and the virtual elimination of drifting caused by ag-



Less tuning. Transmitter transducer (left) on Zenith's surface-wave i-f filter is acoustically coupled to receiver transducer (right) through a multistrip coupler.

ing components in the receiver.

Zenith has gone into pilot production of the new filter at its Elk Grove Village, Ill., microcircuit facility. While the firm is unwilling to reveal the production volume or the models they're used in, "tens of thousands" will be built into sets this year, says Robert B. Hansen, executive director of color TV engineering for the Chicago-based company. Though Zenith characterizes its current production as a field test, "within five years, we'll be in a position where we'll be able to afford to use it across the board," he adds.

Costly. There is still a hitch, however—it's a relatively costly technology. Although Zenith first demonstrated a surface-wave i-f filter, called SWIF, 10 years ago, high costs of the lithium niobate substrate and technical problems of edge and bulk reflection have stopped the device from being used by any TV manufacturer to date. "When we compute material and labor costs, there's still a cost premium with SWIF," he says. "So we're paying the initiation fee."

Since a large part of the selectivity and adjacent channel trapping is carried out at the front end of the i-f, that's where SWIF is going. Zenith retains a tuned circuit for maximum gain adjustment, plus two more to separate sound and video after conventional third-stage amplification. Electrical characteristics of the SWIF-equipped i-f closely parallel the discrete design, with deep adjacent sound and picture traps and an out-of-band rejection that's 10 decibels better.

"Performance now equals or exceeds the best we can do with discretes," he says. Adds Roy F. Baker, manager of color-TV video i-f and sound systems: "And as we learn, better selectivity can be had than with [conventional] coils, and the only cost will be a mask change."

Component count at the front end is down only slightly, 29 versus the earlier 38, because the firm chose to add enough components to make the SWIF strip interchangeable with earlier ones, Baker explains. But the components it eliminates include five tuned circuits—inductance coils and their associated capacitors—that must be adjusted individually and interactively in the factory. In all, SWIF eliminates seven adjustments that have to be made twice before the set is shipped, according to Baker.

And SWIF will require no adjustments in the field as the set ages. "It appears to be noncritical once it's made," Baker says. "It either works forever, or it doesn't work at all." In contrast, capacitors and printed-circuit boards are the most significant cause of long-term drift of conventional i-f strips.

Piezoelectric. Surface-wave filters rely on the piezoelectric conversion of electrical signals to mechanical waves and then back again, with the wave moving from a transmitter transducer to a receiver transducer screened on a substrate. Zenith uses a lithium niobate substrate about ½ by 3/16 inches in area and 20 mils thick. The two transducers are formed of interdigitated aluminum fingers 0.5 micrometer wide printed on the dielectric.

The receiver transducer has uniformly spaced fingers of equal length. However, the configuration of the transmitter transducer determines frequency and bandwidth characteristics. For example, center-to-center spacing of the fingers is proportional to the filter's middle frequency; the number of fingers is inversely proportional to bandwidth. Coupling the two transducers is a multistrip coupler of 100 metal lines that also helps reduce unwanted reflections of the waves.

The chip is mounted with epoxy on a conducting plane printed on the base of a ceramic package. After wirebonding to four printed terminals, the device is hermetically sealed to a ceramic lid with epoxy. □

Avionics

Grumman to test aircraft navaids

Should the Federal Aviation Administration upgrade its ground-based navigation-aids stations that dot the U.S. landscape from coast to coast? Or should it look for more advanced navigation systems to meet future air-traffic-control requirements? To help answer this question, the FAA has given Grumman Aerospace Corp. in Bethpage, N.Y., a $1.3 million contract—its first from the FAA—to investigate the accuracy of existing systems, particularly the very-high-frequency omnidirectional-radio range (VOR) navaids.

"Grumman's job," says Richard Townes, who heads the program for the company's Flight Acceptance department, "will be to provide a flying laboratory to research error factors in a cross section of the country's 900 navaids stations." These stations, using tactical air navigation (Tacan), distance measuring equipment (DME), very-low-frequency, long-range navigation (Loran), and VOR systems, provide air-navigation information throughout the U.S.

Grumman, which will assemble the system with off-the-shelf equipment, will install and operate it aboard an FAA DC-6. The Grumman system, called the Navigation Flight Test System (NFTS), includes a Grumman-developed multi-DME aircraft positioner (MAP), which consists of an airborne DME sensor, real-time operator-interactive minicomputer, and a control/display unit containing a cassette tape drive.

Data. Essentially, MAP indicates in real time latitude and longitude, as well as north and east velocities. It also provides data for post-flight trajectory computations. The system receives signals from as many as 10 ground-based navaid stations at a time, sequencing from one station to another at approximately 1-second intervals, thereby minimizing possible signal errors from any one station. Each station has a three-letter-code designator, available from aeronautical charts. The operator simply enters the letter codes for the 10 nearest stations, and the computer does the rest. The computer uses a polynomial filter algorithm to combine the range data with altitude, determined by barometric pressure, to estimate the significant ground-station errors and the aircraft's position and velocity.

Townes says applicable software programs exist from first-generation NFTS hardware, flown on Grumman's E-2C and A-6 flight test projects to evaluate navigation and weapon systems. Before Grumman developed the positioner system, airborne-position-reference tests were conducted with mechanical tuners. However, these tuners could not be sequenced fast enough between navaid stations to produce accurate and reliable data, says Townes.

Accuracy. He says the FAA will be able to keep the circular-error probability of an aircraft's position within 300 feet. This means that half the possible errors will occur within a circle with a radius of 300 feet. This accuracy is far better, says Townes, than commercial airborne navaids now on the market can provide. Nevertheless, a large part of the contract effort is devoted to the validation and initial testing of the system before it goes into service, probably by next spring.

The FAA plans to use the MAP-position determinations as a standard for comparison with position readings from each of the navaid stations being tested. "There are other navigation systems the FAA is looking at," says Townes, "such as Doppler VOR, which seems to be very effective in areas where there are tall buildings, for example. Our work with MAP will help evaluate these systems." He also says that a recent survey by Grumman Aerospace indicates some interest in its navigation flight-test system and a proposed third-generation positioner system by European FAA-equivalent agencies. □

Collins adapts flight system

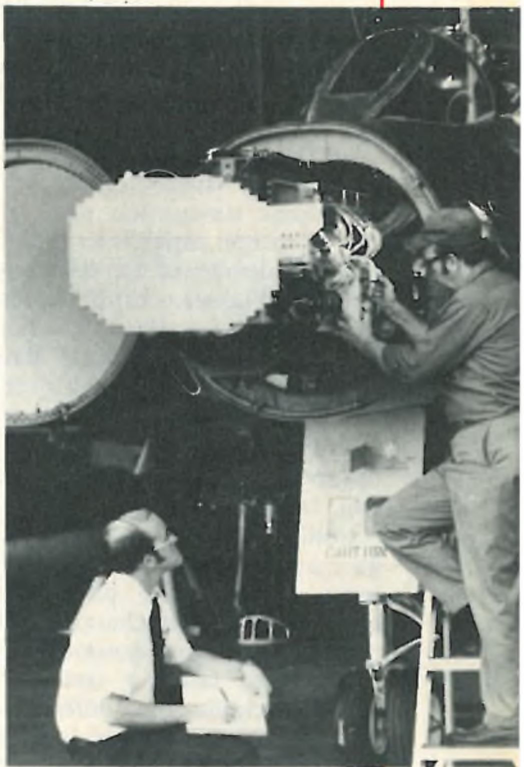
Reversing the usual order of things, Collins Radio Group of Rockwell International Corp. wants to spin off some military avionics gear from commercial equipment. The group has reconfigured and upgraded its ANS-70 automatic navigation system, which now flies in DC-10s, as a digital flight management system for tactical fighters.

Because the system makes wide use of time-shared controls and displays, which do not lend themselves to retrofit, Collins admits that a production version is at least 10 years off. But the first version was recently "flown" in a simulator by McDonnell Douglas Corp., and Collins hopes for a flight test in the next two or three years, says Ray A. Krippner, project manager at Collins' Avionics Engineering division, Cedar Rapids, Iowa.

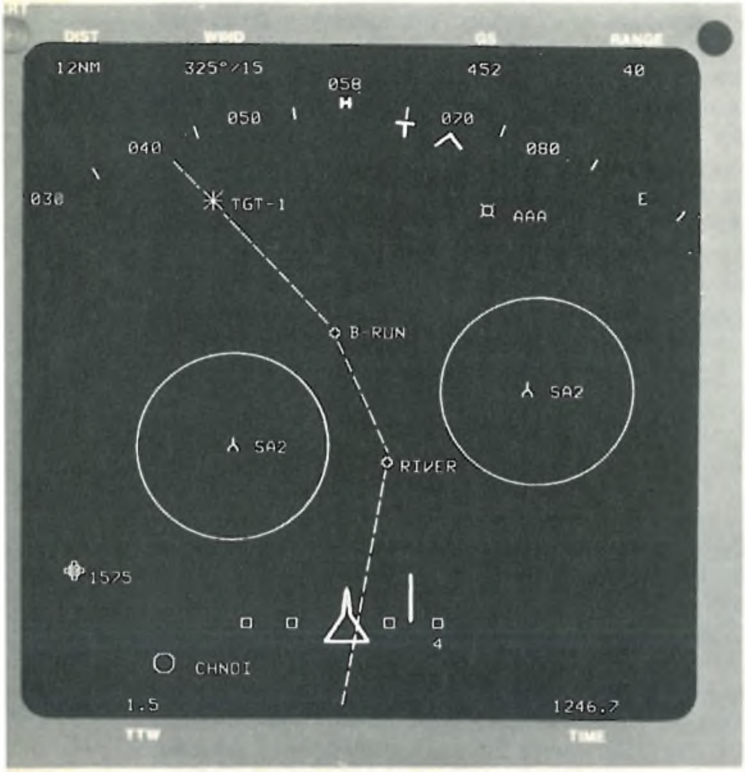
Although the system relies on concepts similar to the Air Force's digital avionics information system (DAIS) [*Electronics*, Feb. 6, p. 76], it's less ambitious. Collins integrates only the communications and navigation functions.

Workload. McDonnell Douglas originally went to Collins for mode selection gear for the 16 flight-control modes in a project to replace the hydraulics in an F-4B Phantom with an analog fly-by-wire system. Early next year, it expects a four-year follow-on program, jointly

Phantom tries F-16 radar contender



Radar competitor. Engineers from Westinghouse Electric Co. mount the first F-16 development-model phased-array search-and-track radar in the nose of an Air Force F-4D Phantom preparatory to flight tests. The check-out flights will be followed in October by a competitive flyoff with a radar system from Hughes Aircraft Co. Derived from the WX-200 digital radar that was previously designed by Westinghouse and which was a losing contender in the earlier McDonnell Douglas F-15 fighter competition, the new design-to-cost model eliminates flight-line test equipment, substituting computer-controlled built-in test hardware that can isolate faults in the radar system down to a replaceable unit. The production design features six first-line replaceable units—antenna, transmitter, low-power rf units, digital signal processor, control computer, and a radar-control panel. Air-to-air operating modes of the radar include uplook and downlook for search-and-track above and below the horizon, plus air-to-ground ranging for measurement of slant range from the aircraft.



Digital data. Computer-generated symbology shown on 6.5-inch-square CRT display in Collins' flight management system includes the aircraft's position (lower center), the flight plan (dashed line), along which are landmarks such as a river and the target, and the location of surface-to-air missiles and their lethal range (big circles) at the aircraft's altitude.

funded by the Air Force and Navy, to design, build, and flight-test a digital version.

McDonnell Douglas granted Collins a study contract to apply the automatic navigation and time-shared cockpit capabilities that Collins had developed for commercial aircraft. "Fighter cockpits represent the severest case of pilot workload and panel area constraints," Krippner points out, "and we felt strongly that we could do more than just implementing in a different kind of hardware everything the pilot's done before."

Collins' concept puts traditional navigation functions under computer control. "The pilot doesn't have to tune Tacan channels, select courses, create the transition to ILS (instrument landing system), or make selections from different on-board navigation systems," he says. Instead, that's all canned as part of the flight plan before takeoff. "Comparing aircraft position with the desired position in the flight plan, we derive both lateral and vertical steering signals."

A computer combines and filters the output of individual sensors "to come up with a better estimate of aircraft position than is available from any single sensor," according to Krippner. The sensors that can be used involve or derive from inertial, Tacan, Loran and ILS systems, the air data computer, and attitude and heading references. But since the system is under software control, future sensors could easily be added, he says.

For flight-testing, Collins will provide three multifunction cathode-ray-tube displays, plus a pair of control/display controllers, and a Collins CAPS-4 computer. The computer drives the controllers and displays and also handles flight plan management and automatic navigation functions. McDonnell Douglas will integrate the system.

Criticism. Air Force critics point out that the Collins system is not designed for much beyond communications and navigation and, unlike DAIS, does not integrate more memory-intensive functions, such as weapons or energy management or electronic warfare. Collins also relies on computer-generated map symbology on the CRTs, instead of the projected maps used today.

"To be truly usable," a DAIS-program official says, "Collins must either prove we don't need all the tactical map information we get today, or it must upgrade the capacity of its commercial map symbology by a quantum step." □

Government

GSA wants more EDP competition

More pressure to compete will soon be felt in the Federal market for nonmilitary data-processing and telecommunications equipment and services, and so will more direct control of such procurements by the General Services Administration, the Government's purchasing agent. This is the message of GSA's Theodore Puckorius, the new commissioner of the Automated Data and Telecommunications Service, who has the job of overseeing an annual $1 billion shopping list of hardware and services.

Competition. "What we are really trying to do is develop competition," declares the 45-year-old management consultant who joined the Government two months ago following 10 years with the Chicago-based consulting firm of Lester B. Knight & Associates. Within the next four months, Puckorius' organization will request bids for annual computer system purchases worth $100 million. This contract was held by IBM for 10 years, but ended when IBM neglected to renew its option to continue the deal. Now Puckorius will be able to issue new requests for proposals to take the place of the IBM award.

He will also issue five RFPs for competitive bids to replace outmoded communications equipment in five Federal office buildings. Each RFP represents at least $1 million in potential sales of telephones, switchboards, circuits and interconnection switches.

Until now, the three-year-old ATDS has not been involved with bidding for Federal telecommunications hardware. Its one other attempt to obtain competitive equipment proposals came in December, 1973, for a new building in Syracuse, N.Y., and that attempt failed because non-AT&T companies did not bid, Government sources say. However, the reason why other

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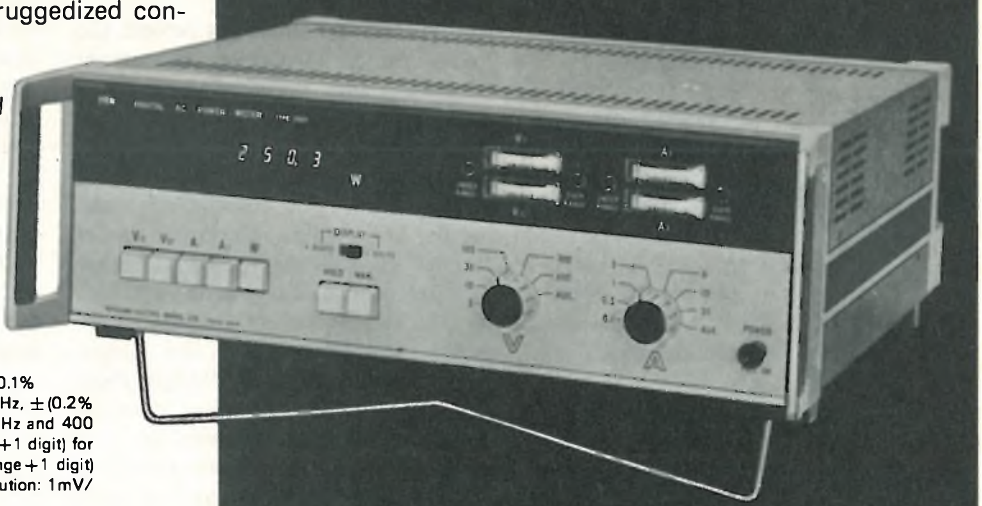

Main Specifications

• Measurement Ranges: Voltage; 3/10/30/100/300/600V. Current; 0.1/0.3/1/3/6/10/30A. Power; 600mW to .36kW. • Frequency Ranges: Voltage; DC and 25Hz to 2 kHz. Current; 25Hz to 2kHz. Power; 40Hz to 1.2kHz. • Accuracy: V; ±(0.1% of rdg + 0.02 % of range + 1 digit) for 50Hz to 400Hz, ±(0.2% of rdg + 0.03% of range + 1 digit) for dc, 25Hz to 50Hz and 400Hz to 2kHz, A; ±(0.1% of rdg + 0.02% of range + 1 digit) for 50Hz to 400Hz, ±(0.2% of rdg + 0.03% of range + 1 digit) for 25Hz to 50Hz and 400 Hz to 2kHz, W; ±(0.1% of rdg + 0.02% of range + 1 digit) for 50Hz to 400Hz, ±(0.2% of rdg + 0.03% of range + 1 digit) for 40Hz to 50Hz and 400Hz to 1.2kHz. • Resolution: 1mV/digit, 10μA/digit, 0.1mW/digit.

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companies like the specialized common carriers did not bid was their inability to obtain either the necessary interconnection rights from AT&T's New York Telephone Co. or intra-state permits from the state, says an official of MCI Inc., a Washington, D.C.-based specialized common carrier.

Enthusiasm. But such difficulties may now be overcome. MCI president William McGowan is so impressed with Puckorius' activism that MCI will shortly propose to ADTS an unsolicited $8 million package for communications services. It would replace AT&T services that MCI says now cost the Government $12 million annually.

MCI has already received from ADTS this past June a $500,000 contract for 166 circuits between New York and Washington, D.C. This was the first data services contract awarded by ADTS after competitive bidding. "The Government had to learn how to deal with a competitive communications environment. But now they are doing something. Things are happening," McGowan declares.

Puckorius also says he will resuscitate his service's obligation to oversee the telecommunications plans of individual Federal agencies. Reacting in part to demands made by Congress, Puckorius wants to regain the power to approve both telecommunications and computer purchases that had been delegated to the agencies through what he calls "inaction" by "inactive" commissioners who had headed his department.

"I will look at any award over $1 million," he says, to make sure agency requests are necessary and well documented.

Of approximately $300 million in annual communication systems purchases reviewed by GSA, about $200 million had been delegated to the agencies for direct negotiation with contractors. "In communications, we had been delegating virtually everything, but now we will severely limit delegation of authority," he says. Even the leasing of data links will be reviewed, he vows. □

Fiber optics

ITT invades Europe with fiber optics

Claiming to be the first in Europe with a wide range of components for fiber-optic systems, the ITT Components group of the United Kingdom displayed three new products at the Laser '75 exhibition in Munich in late June: an optical fiber for video transmission, a prototype solid-state gallium-aluminum-arsenide continuous-wave laser, and a prototype portable tester for measuring the attenuation and continuity of optical fibers [*Electronics*, June 26, p. 55].

On tap are such products as electronic-terminal modules, including circuitry to drive the lasers, condition the electrical inputs, and reconstruct the signal levels on the far end, ITT executives say. They add that integrated optical components are also on the way. ITT is aiming to sell components, rather than systems. "We're not getting involved in complex networks," declares James Jewell, marketing manager for the Fiber Optics and Modules division, Leeds, which is spearheading the thrust.

Applications. But, says Jewell, the group hopes to follow its current contracts and negotiations with a host of classified military and industrial-control applications in which fiber optics transmit data from analog sensors in hostile environments and where electrical interference forbids conventional transmission media. Targets are systems as long as 500 meters, but use of repeaters might increase the range. The company regards Philips, Plessey, and some emerging systems houses as potential competitors.

The GaAlAs solid-state cw laser, of double-heterodyne structure, fires in the 850-nanometer (near-infrared) spectrum and puts out about 10 milliwatts.

The optical fiber, designed to be compatible with the PAL-television 5.5-megahertz bandwidth, attenuates at 50 to 100 decibels per kilometer. ITT distinguishes between bundles of fibers and cables of eight separate insulated fibers or individual information channels that the company will market.

Testing. The analog test instrument, due for production before year's end, can be used by field or production personnel to ensure that lengths of optical fibers have no breaks before they're installed. The developers have found it can also measure attenuation. To do so, a technician puts a short length of the same kind of optical fiber to be measured into the two outputs of the tester to establish a reference. Then he can measure attenuation in other lengths. Results are displayed on a dial calibrated in five ranges of 10-dB increments down to -50 dB. The tester consists of two parts, each with its allied circuitry, the laser source, and the photodetector. The unit, which weighs 10 pounds and is 4 by 5 by 8 inches, can be battery-powered because of the laser's power requirements.

ITT is quoting prices to prospective customers but won't reveal them or any market projections. Another ITT organization, Standard Telecommunications Laboratories, is helping produce the optical fibers and lasers. STL has tested the cw laser for more than 6,000 hours and is producing optical fibers as part of its development effort, which includes applications for the British Post Office. The effort is being coordinated in the U.S. by ITT's Electro-Optics division in Roanoke, Va., which will market the wares in North America. Connectors are being made in the UK in conjunction with ITT-Cannon. ITT is also buying optical fibers from outside sources. □

Medical

Scanner X-rays body organs

A half-million-dollar minicomputer-based X-ray machine that produces pictures of cross sections of the human body is stirring keen interest

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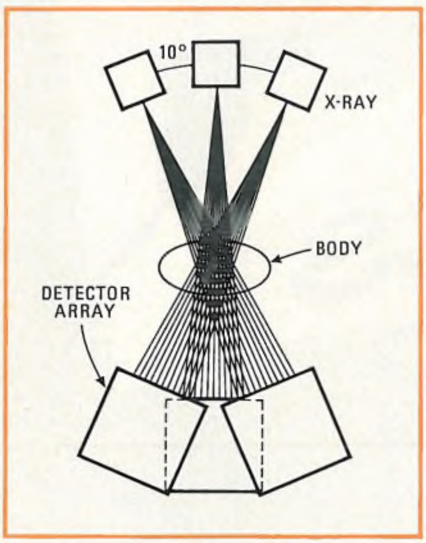
In operation. Adjustable couch of EMI's CT 5000 body scanner can be moved through the circular aperture until the section of the body to be examined is directly in line with the X-ray source. The couch of the $550,000 machine can also be tilted for various angles away from the vertical.

Slice of life. A sectional X-ray picture of the body at a level of the kidneys, looking downward, shows the kidneys on either side of the spinal column, as well as other clearly defined abdominal tissues. A total of 324,000 digitized X-ray absorption values is processed by a Data General Eclipse computer to piece the complete picture together.



Scanning. The X-ray source and the detector array move in an arc around the body, producing 80,000 X-ray absorption values at 10° intervals for each scan of a 13-millimeter-thick cross section. The unit can produce up to eight sections automatically.

among radiologists around the world. Three of 20 preproduction models have already been ordered from the X-Ray Systems division of EMI Ltd., Middlesex, England, the company that three years ago introduced a similarly conceived brain scanner.

The earlier brain scanner and the new EMI-Scanner CT 5000 owe the impetus for their development to the shortcomings of conventional X-ray devices which usually cannot render well-defined pictures of soft body tissue. Hailed by EMI as a "major advance in body-tissue examination," the body scanner was described at last month's conference of the European Association of Radiology, which met in Edinburgh, Scotland. One prototype is undergoing clinical trials at the Northwich Park Hospital in Harrow, England, and two are slated for installation in the U.S., one at the Mayo Clinic in Rochester, Minn., and one at the Edward Mallinckrodt Institute of Radiology, Washington University, St. Louis.

Basically the EMI body scanner consists of a scanning unit housing an X-ray source and an array of 30 detectors, a computer cabinet with disk store, and a TV-display console and control panel. The patient reclines (top left) on a couch that extends through an aperture in a framework that contains the X-ray source and detectors.

324,000 values. For each complete sectional picture (top right), the minicomputer processes 324,000 X-ray-absorption values that are fed into it by the detectors. The technique is called computerized axial tomography, and the result of each 20-second scanning sequence is a detailed representation of all types of body tissue contained within a 13-millimeter-thick slice of the body, viewed from a downward-looking perspective, as if one were looking along a line extending from the patient's head to feet.

Eight successive, contiguous slices may be represented without moving the patient on the examining couch; the couch can be actuated to move through the aperture at 13-mm increments. Around the scanning aperture, the X-ray source moves in an 180° arc, stopping at 10° intervals to project an established amount of radiation (see diagram). The 324,000 absorption values—80,000 at each 10° interval—recorded during each 20-second scanning sequence are digitized and shown in the form of a matrix contained within a circle having a diameter of 320 picture elements. The first stage of calculating the results is completed by an Eclipse computer from Data General Corp., Southboro, Mass., in about 90 seconds, during which time the operator can position the patient for the next scan. The processed information is stored on the system's disk, while a stan-

dard magnetic tape reel can store 240 sectional pictures.

E. J. Gowler, general manager of the X-Ray Systems division, says, "We didn't set out to take the brain machine and make it a body scanner." The approach to the brain scanner had to be modified considerably, he says, noting, for instance, that the number of detectors was increased from two to 30, with scanning every 10° instead of every 1°.

Coupled with sales of the $390,000 brain scanner, EMI expects to gross some $240 million yearly for about 400 of the two machines by 1980, Gowler estimates. Currently, the company has 232 orders for the brain scanner, 90% from North America, and they're being delivered at an annual rate of 150. □

Packaging & production

Elastomers aim at leadless carriers

Start with something that's rubbery and conducts electricity, give it to some engineers to play with, and what do you get? A lot of imaginative electronic devices, apparently, and one of the latest is a way to connect leadless integrated-circuit packages to printed-circuit boards.

The connecting system is being developed by Tecknit Inc., Cranford, N.J., one of the major suppliers of the material—a silicone conductive elastomer. This elastomer is already seeing lots of use as contact points in digital-watch displays and calculator keyboards [*Electronics*, Sept. 19, 1974, p. 122] and has been proposed as an aid to the fabrication of pc boards [*Electronics*, Oct. 31, 1974, p. 26].

"Use of the space-saving leadless IC carriers is actually being held back because of the lack of an effective solderless connector," maintains Tecknit's vice president of marketing, Steve Cifani. These small, square ceramic packages presently must be reflow-soldered to printed-circuit boards. This requires special production equipment, and the heat required for the removal of a defective carrier may damage the IC chip, pc board or adjacent circuitry.

To remedy this, Tecknit has developed a new solderless connector that it calls the Zebra frame. Based on the company's earlier Zebra-strip connecting device, it consists of alternate 5-to 10-mil-wide layers of non-conductive silicone rubber. The conductive portions of the strip are made of either a low-resistance silver- or high-resistance carbon-mix elastomer, depending on the circuitry in the IC chip, and four of the strips outline a square of non-con-

News briefs

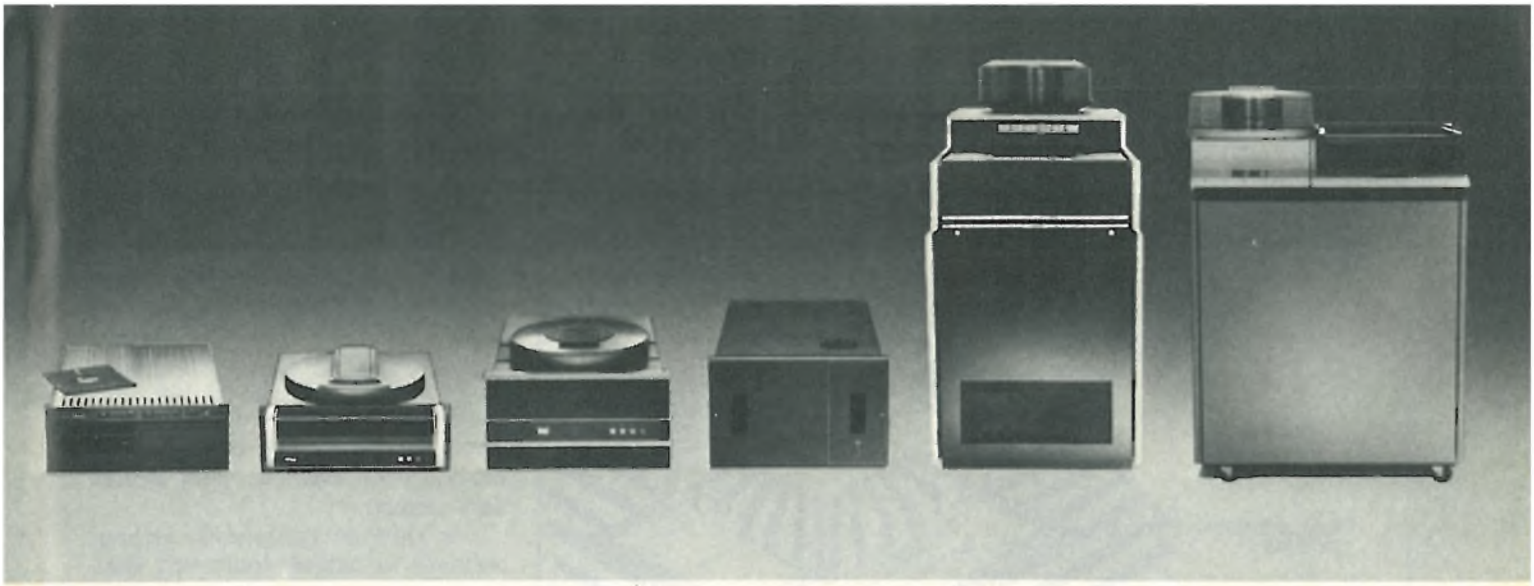
CCD camera reaches broadcast resolution
Bell Telephone Laboratories in Murray Hill, N.J., has built what it says is the first solid-state television camera that meets the resolution requirements of commercial TV broadcasting. The camera is built around a new charge-coupled device with a quarter million sensing elements. The CCD has 496 vertical interlaced scan lines and 475 horizontal picture elements.

IEEE names 1976 slate of officers
Joseph K. Dillard, manager of advanced systems technology at Westinghouse Electric Corp. in East Pittsburgh, Pa., has been nominated by the Nominations and Appointments Committee for the presidency of the Institute of Electrical and Electronics Engineers for 1976. Now the institute's executive vice president, Dillard has also served as treasurer and as vice-president for technical activities. Nominated for executive vice president was Robert F. Cotellessa, chairman, Department of Electrical and Computer Engineering, Clarkson College of Technology, Potsdam, N. Y.

IBM, SMC reach cross-licensing agreement
Standard Microsystems Corp., a small semiconductor manufacturer in Hauppauge, N.Y., has agreed with IBM Corp. to worldwide cross-licensing for the next five years of each other's patents and patent applications relating to semiconductor technology. In addition, IBM will have an option to a non-exclusive license for Standard Microsystems' Coplamos technology for manufacturing n-channel metal-oxide-semiconductors. Thus, IBM and Standard Microsystems, which could gross $3 million in its current fiscal year, appear to have settled their patent differences regarding selective-oxidation techniques for bipolar integrated circuits. In 1973, the U.S. Patent Office declared four-way patent interference centered around these techniques between SMC, IBM, Philips N.V., and Fairchild Semiconductor.

HP opts for miniature data cartridge
Hewlett-Packard Co.'s Computer Systems Group in Cupertino, Calif., is replacing tape cassettes now used for data entry and program storage in minicomputers and terminals with a new miniature data cartridge produced by the Minnesota Mining and Manufacturing Co. By the fourth quarter of this year, 3M says it will be ready to supply the mini cartridge to customers other than HP. The cartridge measures 3 by 2½ by ½ inch, or about a third the size of a cassette. With a simpler drive mechanism, the minicartridge offers better tape control than a cassette and therefore can be used for more reliable recording and playback of high bit densities, say HP engineers. The cartridge, which contains 140 feet of 0.15-in.-wide tape, records at 800 bits per inch for a total of more than 100 kilobytes on one track. The transfer rate is 8,000 bits per second at a tape speed of 10 in./s.

No charges pressed in Keronix arson complaint
Federal authorities in Los Angeles have ended the investigation prompted by a complaint from Keronix Inc., Santa Monica, Calif., that Data General Corp., Southboro, Mass., had burned down a Keronix plant. No criminal indictments are being returned. Data General, however, has not dropped its separate civil suit against Keronix, which alleges theft of trade secrets, defamation of its name, and fabrication of evidence.



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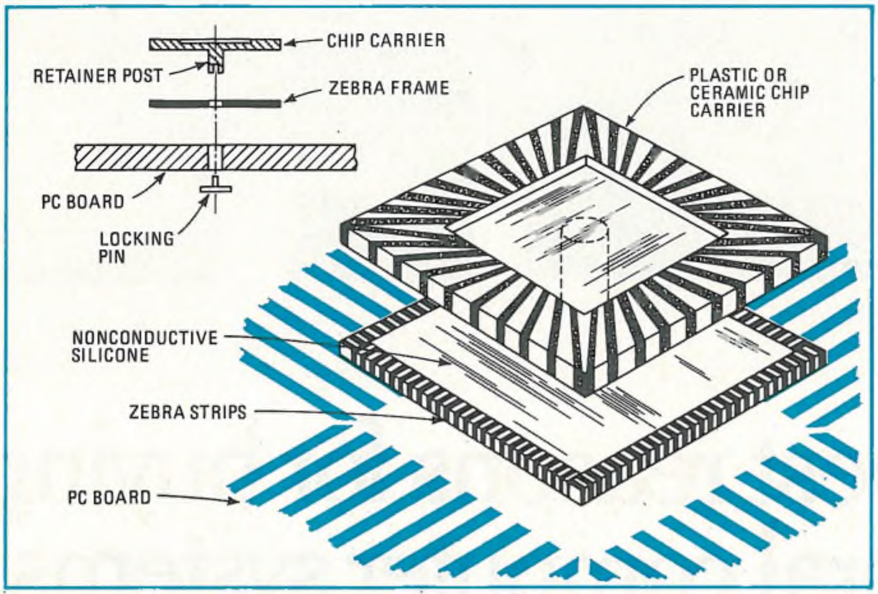

No solder. Leadless chip carrier is mounted by Tecknit on a printed-circuit board by pressing its contacts against conductive elastomer Zebra strips. Firm contact to the board is made with the help of a special post and locking pin.

ductive silicone.

Tecknit's Zebra frame fits between the leadless carrier and the surface of a pc board (above). The combination resembles a sandwich that must be pressed firmly together so that contacts on the IC carrier are electrically connected through the Zebra-frame conductive elements to the pc board. One Tecknit approach has been to pass a plastic pin through a hole in the pc board so that it engages a post that's been added to the bottom face of the IC carrier. But to simplify matters, Tecknit's designers are also working with a plastic piece that snaps onto the leadless carrier and provides the engagement post.

Elastomer dots. According to Cifani, still another version of the elastomeric frame is currently being considered by a major aerospace firm. In this device, conductive elastomer dots are molded onto the perimeter of a 2-mil-thick nylon or Kapton frame. And the dots are precisely positioned to mate with the IC carrier's conductive fingers, unlike the more random connection used in the Zebra frame.

Tecknit's designers are also applying conductive elastomers to the "bed of nails" fixtures used for automated testing of pc boards. Boards tested in these fixtures are placed on a bed of metal pins through which test signals are sent. By molding a button of conductive silicone onto the spring-loaded beryllium-copper pins, Tecknit thinks it can avoid problems caused by misaligned, bent or dirty pins. □

Solid state

I-R laser shows crystal defects

To discover when defects are present in polished crystal wafers, researchers at Siemens AG have devised a quick, simple, and nondestructive method that combines both optical techniques and infrared technology. The method is aiding development of high-grade crystals.

Most semiconductor materials, such as silicon and gallium arsenide, are opaque to visible light but not to infrared light. In Siemens' method, developed at the Munich laboratories by Heinrich Grienauer and his associates, the ir light penetrates the crystal and shows up defects, usually characterized by stress fields in the lattice structure. Visibility results from the optical principle whereby linearly polarized light changes its direction of polarization when it passes through a zone with a defective lattice structure.

Such flaws as atomic dislocations, precipitates, and slip-line formations can seriously impair the electrical characteristics of semiconductor crystals. It is therefore necessary to find out what causes these defects.

For such investigations, etching methods or radiographic and electron-microscopic techniques are commonly used. But these, Grienauer says, are either slow or destructive. What's more, he adds, they require a large array of equipment and much preparation. In contrast, the Siemens method can be implemented with relatively simple equipment and gives an instantaneous representation of the defects.

Developing technology. Grienauer admits that his is not the first method based on infrared techniques. In the late 1950s, he says, Soviet scientists used infrared film for the purpose. But since this film is slow, researchers in the U.S. and elsewhere later turned to X-ray and electron-microscopic methods. But now the availability of light-intensive infrared lasers and highly sensitive ir vidicons makes it possible to test crystals effectively.

The key item in the Siemens setup is a laser that emits linearly polarized infrared light at a wave length of 1.1 micrometers. A microscope enlarges the view of a crystal section for examination. An analyzer absorbs the light that has not had its plane of polarization rotated. An infrared TV camera converts the infrared picture into video signals for display on a monitor.

In examining a crystal wafer, the analyzer is adjusted so that it absorbs the portion of the light that passes through the crystal without deviation of its plane of polarization so that flawless crystal areas show up dark on the monitor. But zones with defects in the lattice structure cause the polarization plane to rotate and show up as bright spots against a dark background. □

TRW/Cinch low profile D.I.P. sockets

Don't let the small size and low cost fool you. These low profile DIP sockets are first string all the way. The unique TRW/Cinch design incorporates many features previously available only in larger more expensive sockets, resulting in improved performance and reduced assembly costs. With a height of only 0.150", these low-profile sockets are high scorers with a high tensile strength contact material that provides 4.0 ounce contact force, pointed terminal tips for easy PC insertion, generous lead-in dimensions and tapered socket entry to align bent DIP leads during automatic insertion.

Center slots with cross bars permit air flow under the DIP for more efficient cooling, and the glass-fiber filled SE-0, U.L. rated insulator allows operating termperatures from −65° C to +125° C. The sockets also feature recessed ends for ample removal tool clearance and stand-off bosses for rapid flushing of flux residue.

TRW/Cinch low profile DIP sockets are available in 8, 14, 16 and 24 contact sizes. And a full bench of other sizes will be developed when the need arises. For fast team action, contact your local TRW/Cinch distributor, or TRW/Cinch Connectors, An Electronic Components Division of TRW Inc., 1501 Morse Avenue, Elk Grove Village, Illinois 60007; Phone: (312) 439-8800. CC 7509

TRW CINCH CONNECTORS

Circle 41 on reader service card

News update

■ There was a growing demand for high-speed optical isolators, Hewlett-Packard determined a year or so ago, so it developed the industry's first dual optical isolator with gated outputs [April 18, 1974, p. 25]. The device, TTL-compatible and operating from a 5-volt supply, showed off good grades for common-mode rejection (20 V at 1 megahertz) and featured typical delay times of 40 nanoseconds. And HP promised the same high speed and high isolation, in the same size package, as was attained by the ubiquitous single-channel version.

Now, HP reports its model 5082-4364 plastic dual isolator is selling 20% to 30% better than its sales targets. The device has found its way to customers building equipment for data-communications terminals and peripherals and banking systems. Three models have also been added to the family: a hermetic device (model 4365) for military and high-reliability applications; a slower transistor version (model 4354); and a second transistor version (model 4355) with a different current gain. The plastic isolator's delay time is now specified at 75 ns, while the delay time of the high-reliability version is 95 ns.

■ While an emerging consensus about C-MOS on sapphire seems to be that it has a limited future (see p. 65), Hewlett-Packard disagrees. Even though a company spokesman admits that HP "hasn't got anything to show for it" yet, he emphasizes that the Palo Alto, Calif., company is going ahead with its own sapphire circuit development program [April 18, 1974, p. 25].

HP is working on C-MOS-on-sapphire circuits for minicomputers and said when announcing the program that the technology offered the most attractive speed-power-cost tradeoffs for minicomputer applications. HP hopes its project will come up with circuits for input/output, central processor, and memory portions of the mini.

—Howard Wolff

A new champion– the clean-punching laminate from Norplex.

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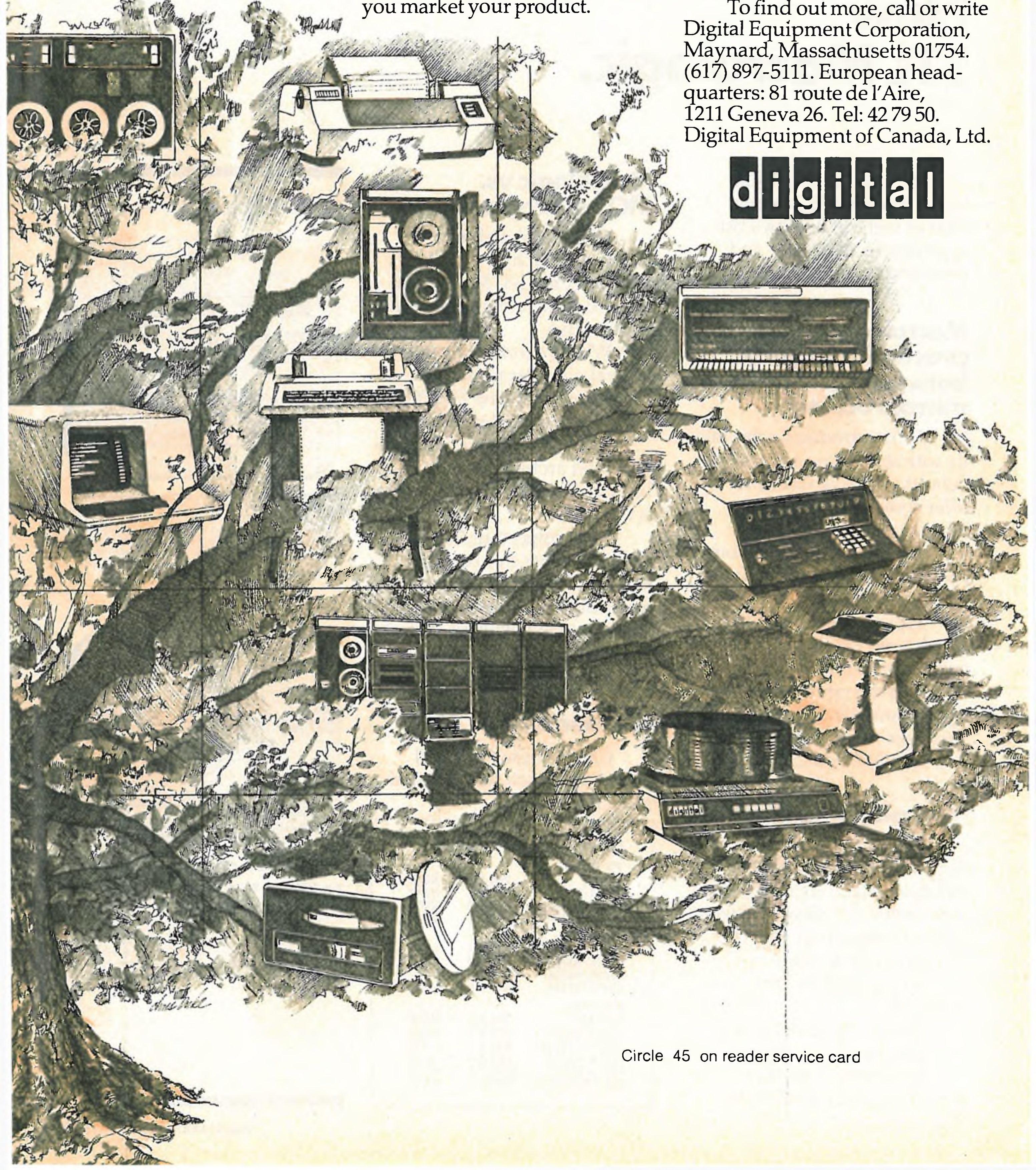

Circle 45 on reader service card

How to go faster than MOS microprocessors and easier than SSI/MSI. New TTL Macrologic.™

Fairchild's latest 9400 Series Macrologic is a new kind of high-speed, low-cost approach to computer and peripheral system design.

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We're introducing this family with seven new advanced Schottky TTL devices that offer some very distinct advantages.

Typical Macrologic complexity ranges from 150 to 250 gates per device.

Typical gate delays are just 4ns per on-chip gate, and 6ns per output buffer.

And the circuits are packaged in standard 14 and 18-pin packages—as well as in a slim new standardized 24-pin unit.

Macrologic vs. SSI/MSI.

Compared with conventional SSI/MSI design, for example, Macrologic devices represent a significantly higher level of integration—up to 250 gates per device..

So fewer parts are required.

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Design is simpler.

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And the system cost is less.

Macrologic vs. MOS microprocessors.

Compared with microprocessors such as Fairchild's own two-chip F8, Macrologic is more complementary than competitive.

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TTL Memory

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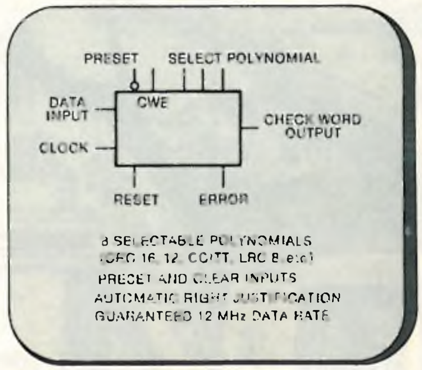
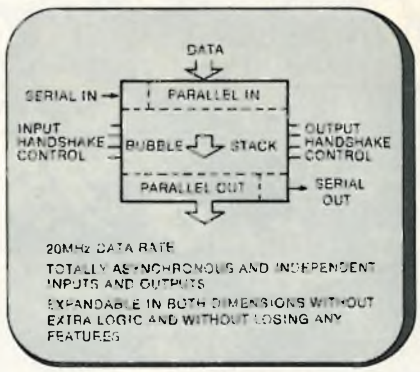
93432/93442	512 X 8	NOW
93454/93464	1024 X 8	3rd Q
TTL PROMs		
94316/93426	256 X 4	NOW
93417/93427	256 X 4	3rd Q
93436/93446	512 X 4	NOW
93438/93448	512 X 8	NOW
TTL RAMs		
93410/A	256 X 1	NOW
93411/93421	256 X 1	NOW
93L420/93L421	256 X 1	NOW
93412/93422	256 X 4	3rd Q
93415/93425	1024 X 1	NOW
93L415/93L425	1024 X 1	NOW

DEDICATED SUBSYSTEMS

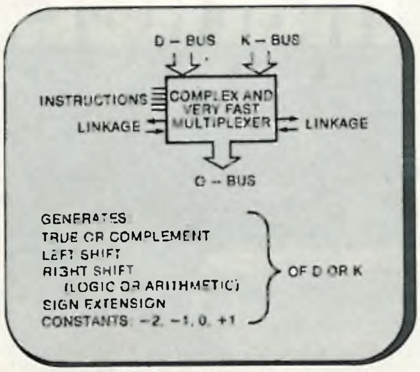


The 9401 Cyclic Redundancy Check Generator/Checker is an advanced tool for implementing the most widely used error-detection scheme in serial digital data handling systems. A 3-bit control input selects eight different generator polynomials, including CRC-16 and CRC-CCITT, as well as their reciprocals (reverse polynomials). Separate Clear and Preset inputs are provided.

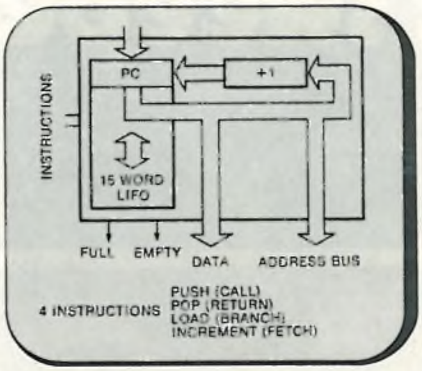


The 9403 FIFO Buffer Memory is a high-speed expandable fall-through type with totally independent and asynchronous inputs and outputs. Organized as a 4-bit wide by 16-word deep "bubble stack," it has four bits parallel and bit-serial data inputs and outputs. Complete "handshake" control signals are provided for unambiguous operation in asynchronous systems. It is intended for disk and high-speed communications applications with data rates of up to 20 MHz.

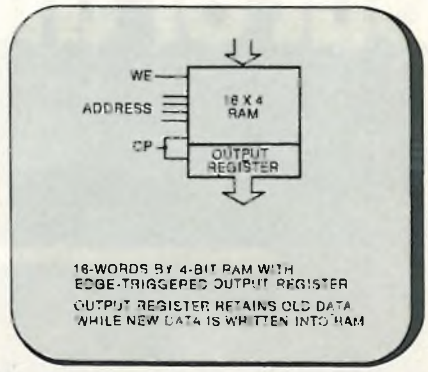
FUNCTIONAL BUILDING BLOCKS



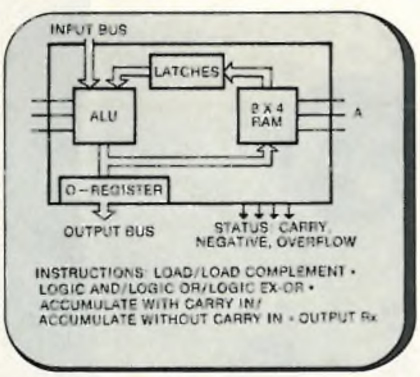
The 9404 Data Path Switch (DPS) is a very fast combinatorial array for closing data path loops around arithmetic logic networks (like the 9405 ALRS). A 5-bit instruction word selects one of the 32 instructions operating on two sets of 4-bit data inputs. Four linkage lines are available for expansion in 4-bit increments. The delay is less than 30ns over 16 bits. Samples available August.



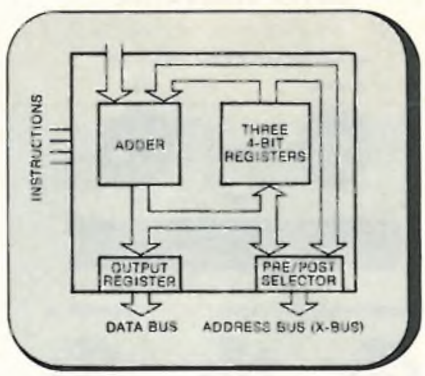
The 9406 16-word by 4-bit "Push Down-Pop Up" Program Stack stores program counter and return addresses for nested subroutines in programmable digital systems. It executes four instructions — Return, Branch, Call, and Fetch as specified by a 2-bit instruction. The 9406 may be expanded to any word length without additional logic and operates at a 10 MHz Microinstruction rate over 16 bits.



The 9410 64-bit Read/Write Memory is a register-oriented high-speed device organized as 16 words by four bits. An edge-triggered 4-bit output register allows new input data to be written while previous data is held. Three-state outputs are provided for maximum versatility. The 9410 operates at a 10 MHz Microinstruction rate.



The 9405 Arithmetic Logic Register Stack contains a 4-bit arithmetic logic unit (ALU), an 8-word by 4-bit RAM, an edge-triggered output register, and associated control logic. The ALU implements eight different arithmetic or logic functions where one of the two 4-bit operands is supplied from the input data bus and the other is supplied from one of the eight registers selected by the Address inputs. The result of the operation is loaded back into the same register and is also loaded into the edge-triggered output register and becomes available on the 3-state output data bus. The 9405 operates at a 10 MHz microinstruction rate over 16 bits.



The 9407 Data Access Register (DAR) performs memory address arithmetic for RAM resident stack applications. It contains three 4-bit registers — program counter, stack pointer and operand address — a 4-bit adder, a 3-state address output buffer and a separate output register with 3-state buffers. The DAR performs 16 instructions, and operates at a 10 MHz Microinstruction rate. Samples available August.

Information here.

Most devices are available for sampling immediately.

For more detailed information on Macrologic devices, write or call your Fairchild Sales Office, Distributor or Representative today.

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FAIRCHILD

No.1 for logic and memory.

Washington newsletter

Navstar speed-up next year urged; resistance felt . . .

Will success hurt Navstar? Some proponents of the new tri-service satellite navigation system say it will if Pentagon leaders go ahead with plans to accelerate the program next year. At its present pace, the program, for which Rockwell International is prime, is expected to generate at least $200 million for space and user hardware between now and 1980. But that schedule is looming as a battleground for a policy dispute shaping up within the Pentagon as the drafting of the fiscal 1977 budget gets under way. **Advocates of a speed-up foresee savings of up to $10 million a year if Navstar were to become operational earlier to replace such interim navigational hardware as Omega.** In addition, they say it could reduce production buys for Loran receivers, which are now estimated to be costing up to $35 million a year for airborne and manpack units. Opposition to a Navstar speed-up includes some leading Navstar program officials. They argue that acceleration would invite problems in both costs and hardware performance.

. . . while TI wins two contracts on first phase

As the Navstar policy dispute evolves, two contracts for development of navigation-receivers for the program's first phase have both been won by Texas Instruments Inc.'s Equipment Group in Dallas. TI thus becomes an alternate source for the receiver to the Magnavox Advance Products division, Torrance, Calif., which is also developing receivers to be evaluated during phase one. The TI awards, let by the Air Force Space and Missile Systems Organization, have a "very large potential," says one senior USAF official. **Most significant potentially is the $2.9 million contract to develop two "hi-dynamic" airborne navigation receivers for tactical aircraft.** As replacements for existing tactical air-navigation units in the 1980s, it is estimated that the U.S. military will require 9,796 Navstar-oriented systems with a price range of from $17,600 to $25,600 each in current dollars. Finalists against TI for that award included Rockwell's Autonetics division, Hazeltine Corp., and TRW Inc.

The second TI-Navstar contract is for just under $3.2 million to develop two manpack receivers. The USAF estimates that the U.S. military will need 5,860 such units during the 1980s, at a unit price of $16,300 to $18,200. Losing finalists for that award were Collins Radio, Litton's Amecom division, Cincinnati Electronics, Teledyne, and TRW.

Aerosat delayed until the fall by power specs

The request for proposals to build satellites to relay navigation and communication signals between trans-Atlantic aircraft and airports will be delayed until this fall, according to the Federal Aviation Administration, which will be a heavy user of the $150 million system. An international management group, headquartered in Holland, **will delay the planned July release of specifications for the "aerosats" because contractors warn that the required 1,000 watts of operating power exceed their designs.** "They want us to cut it down to about 600 or 700 watts," says an FAA official, which would lower costs and enable industry teams to modify existing spacecraft designs. Expected to bid on the project are three industry groups, led by TRW Systems Group, General Electric, and RCA.

Washington commentary

Offshore operations that worry DOD

Are U.S. companies that export manufacturing processes, rather than products, contributing to the erosion of the nation's leadership in technology? George H. Heilmeier believes they are. As director of the Defense Advanced Research Projects Agency, Heilmeier advocates more and better U.S. R&D and tougher controls on its export—including the threat of recovery of R&D tax credits. Significant excerpts from Heilmeier's recent comments to the National Aerospace and Electronics Conference follow. **—Ray Connolly**

Today we possess technological superiority over the rest of the world but, as we look to the future, I believe that there are some causes for concern. We shall have to renew our national commitment if this nation is to maintain its traditional [technological] preeminence. But we face challenges and dangerous trends.

Let's examine some quantitative trends: the U.S. accounted for 75% of the free-world R&D in 1961, but less than 60% in 1969, and the downward trend persists. U.S. total R&D is about equal to the USSR, but 60% of theirs is devoted to military, space, and atomic energy versus 45% in the U.S.

In technical manpower between 1965 and 1970, France and the USSR expanded by 9.5% per year, Japan by 4.5%, the U.S. by 3.9%. The USSR is graduating twice as many scientists and engineers as the U.S. and now has more than the U.S. In contrast, U.S. freshman enrollment is 35% below the 1967 level. The defense industry's inability to attract and retain young engineers is particularly serious. Average age of technical personnel in 17 aerospace companies surveyed last year was 43.

The picture in electronics is particularly disturbing since modern electronics is based on 16 innovations developed since World War II. It started with Bell Labs' discovery of the transistor in 1947 and progressed through . . . LSI.

Of these, 12 were accomplished exclusively in the U.S. Yet U.S. trade, production and domestic consumption of nondefense electronics and communications equipment had a favorable balance of $200 million in 1965 but a $953 million deficit in 1972.

More R&D for sale

I am also disturbed by the fact that the export of U.S. technology seems to be accelerating. This trend is difficult to measure, but U.S. receipts from foreign countries for royalties and licenses exceeded U.S. payments for such items by a ratio of 8:7 (1972)—a 16% increase since 1965. I believe that this mostly one-sided transfer of U.S. technology is a prime factor in our decreasing technological advantage.

If these trends continue unabated, it seems plain that the U.S. will fall behind in innovation, in trade, and in economic growth.

There are those who try to make the case that the shifting technological balance is due to over investment in defense R&D at the expense of R&D in the civil/industrial sector. The data do not support this claim. The U.S. invests 1.35% of its gross national product in industrial and civilian R&D. This is more than that for military R&D. Only Japan and the Netherlands (with 1.4% and 1.7% respectively) exceed the U.S. in this respect.

A fair price for technology

If we are to maintain our leadership, we clearly must maintain our technology base. Thus, in general, when we sell, we should sell our products—not our productivity. If we do sell our technology, we must demand a fair price, and that includes the cost of developing the several options which lead to the technology in question, as well as the cost of developing maintenance and repair organizations and the cost of developing the market.

We must also consider recovery of tax credits for development investment from licenses, royalties, and outright sales of technologies when such exports could ultimately contribute to a negative balance of trade.

To retain our technological leadership in the future will take more than bigger R&D budgets and enlightened export control policies. We must pick the right technologies to work on.

Let me close with two questions and a suggestion: do we have the will to regain our momentum? How do we pay for expanded R&D?

Clearly, our commitment and the resources we are willing to devote will depend on the perceived value of the end objective. We will always need research on targets of opportunity—the good, the new, the little ideas—but major funding commitments require real markets or the promise of increased productivity. R&D for its own sake no longer captures the public imagination. The "markets" include those foreign markets in which we are not yet active. We can develop these markets through the application of technology which, as I have pointed out, is not the evil some would make it. Our challenge as technologists is to contribute not only our scientific skills to this development, but to contribute to the public debate.

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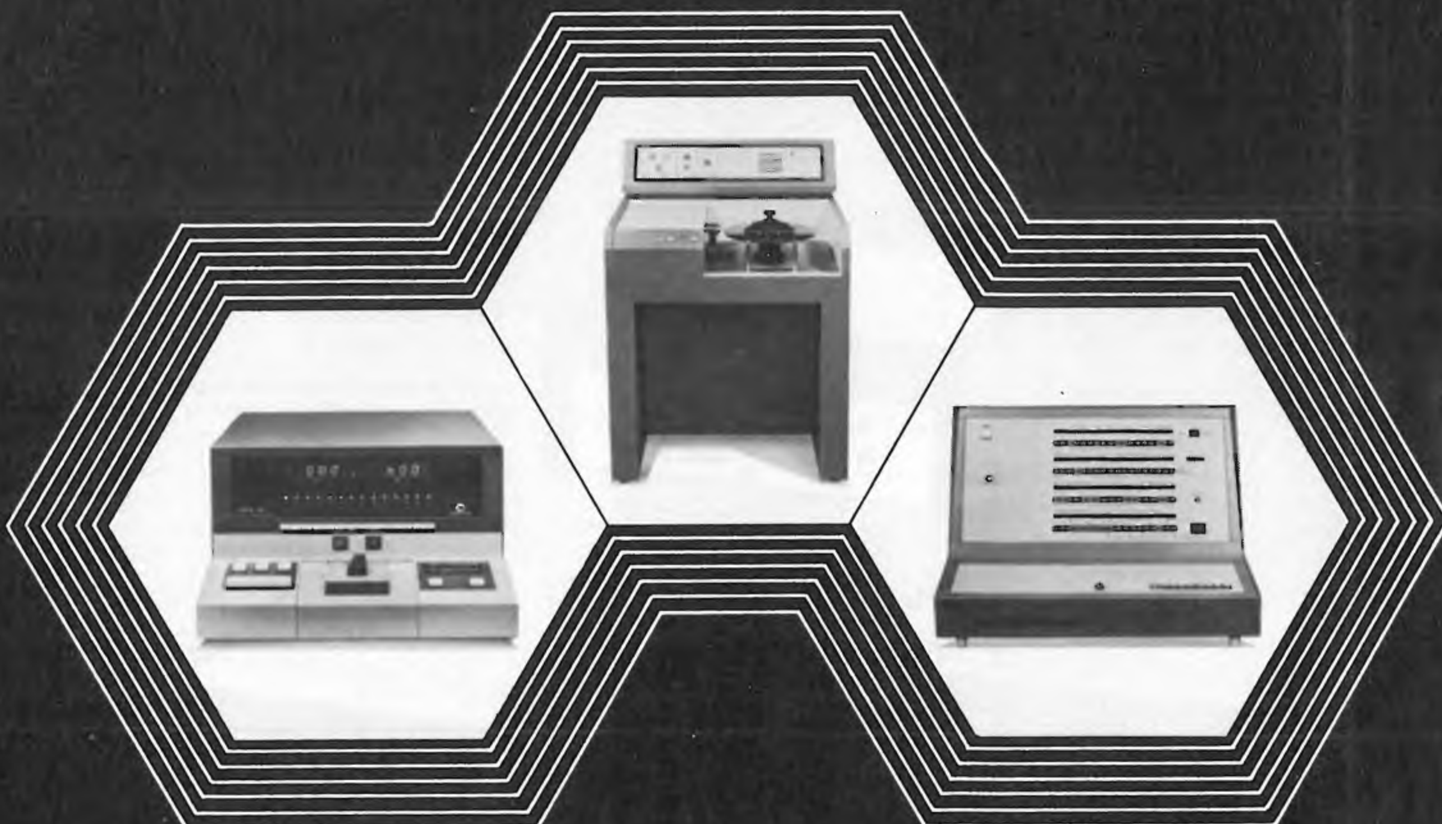

July 10, 1975

Electronics International

Electronics stars at world machine tool show: page 1E

Poland is industrializing rapidly, with electronics growing twice as fast as other industries: page 68

Want to simplify control system design?

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3 linear-IC makers divide production in Japan pact

Three Japanese semiconductor manufacturers have agreed to divide the production of industrial linear circuits among themselves and sell from the same joint catalog. Initially, they will offer a total of 62 different devices. **Of that number, 32 will be produced by Fujitsu Ltd., 19 by Sharp Corp., and 11 by Kyodo Electronics Laboratories Inc.,** a subsidiary of Toko Inc., a manufacturer of magnetic-wire memories. Products are divided so that Fujitsu concentrates on high-power and high-frequency devices, Sharp on optoelectronic-conversion devices, and Kyodo on sense amplifiers and control devices.

The industrial linear-IC market requires many devices, but total demand in Japan is small enough to make the business unprofitable for three manufacturers competing in all the lines. The three companies hope that by dividing the varieties to be produced, they will all be able to make a profit. Although total sales through the end of this fiscal year are only estimated to be between $6 million and $7 million, **the companies expect that in fiscal 1977, sales will total more than $40 million.**

Barclays automates banking functions in United Kingdom

Barclays, the UK's largest bank, is going on line with a network of NCR Corp. 770 automatic tellers that dispense and receive cash deposits. This automation has beaten out rival Lloyds Bank Ltd., which had announced first that it would offer the self-service convenience with its Cashpoint system [*Electronics*, Oct. 3, 1974, p. 69]. **Barclays' $5 million system will enable customers to deposit cash, notes, and checks, as well as withdraw packets of cash worth up to $120 a day, at about 100 locations** in stores, factories, and banks. Two prototypes are in service, and 40 auto-tellers are on order. Lloyds' plans for a larger network of IBM 3614 terminals also will include the self-service feature, a spokesman says.

Siemens cuts loss in glass fibers . . .

Researchers at the Siemens AG laboratories in Munich, West Germany, have developed optical fibers having an attenuation of only 1.35 decibels per kilometer at a wavelength of 1.06 micrometers.

Those values, the firm says, are near theoretical minimum, which Siemens puts at 1.2 dB per kilometer at the 1.06-μm wavelength. In the U.S., fiber cables with individual fibers having attenuation of less than 8 dB/km have been developed by ITT's Electro-Optics division in Roanoke, Va., and Corning Glass Works (see p. 25).

The Siemens fibers are made inside a quartz tube containing deposits of synthetic quartz and a two-component glass. After the tube is collapsed under high temperatures, the fiber can be drawn from the material. The fiber has a diameter of roughly 140 μm and a core 50 μm in diameter. The coating around the core is about 7 μm thick.

. . . as Japanese begin on glass cable for use in 1980s

Glass-fiber cable for communications will go into production early in 1977 and begin operation in the 1980s if a new research project by Nippon Telegraph & Telephone Public Corp. succeeds. NTT has contracted with its three traditional cable suppliers for a two-year joint research project to develop cables suitable for manufacture by the end of fiscal 1976. The budget for the current fiscal year is about $2 million. NTT hopes to start installing the cables between 1981 and 1985. The three manufacturers are the Furukawa Electric Co., Sumitomo Electric Industries Ltd., and the Fujikura Cable Works Ltd.

Glass-fiber cables are attractive because they can be installed in existing ducts designed for coaxial cables. **And even though they are slimmer than coaxial cables, the glass-fiber ones have much higher information capacity and need only about one tenth as many repeaters for a given transmission distance.**

UK firm cuts lens weight and bulk for ir detectors

Britain's Mullard Research Laboratories has developed a process that reduces the weight and bulk of high-resolution germanium lenses for portable military infrared detectors. **The process produces lenses as large as 150 millimeters in diameter that have more than twice the resolution for the same amount of material and half the weight of conventional lenses,** the company claims. Most lenses are multielement and spherical. They can be expensive, partly because the exotic crystal costs almost $500 a kilogram. But Mullard's single-element nonspherical lens is produced by a proprietary process in which the lens is profiled to first-order accuracy on one machine, to second-order accuracy on a second, and then finished by cut-and-try polishing techniques.

Panafacom cuts speed of mini, but adds functions

By using two 8-bit-slice register/arithmetic units and slowing the operating speed, Japan's Panafacom Ltd. has reduced to a moderate level the cost of its new reasonably powerful U-100 minicomputer. **The architecture is identical to that of the company's present U-200 model, and the U-100 even includes standard capabilities that are options in the U-200.** These capabilities include hardware multiplication, divide, double-precision operation, and debugging routines.

However, the price of the U-100 has been held to about half that of the U-200. In one tradeoff, this register-to-register program-execution time is increased from 1.58 microseconds in the U-200 to 2.8 μs in the U-100, and all other operations are correspondingly slower. **Execution speed for the U-100 is two thirds that of the U-200.** The processor is on two boards, one piggybacked on the other.

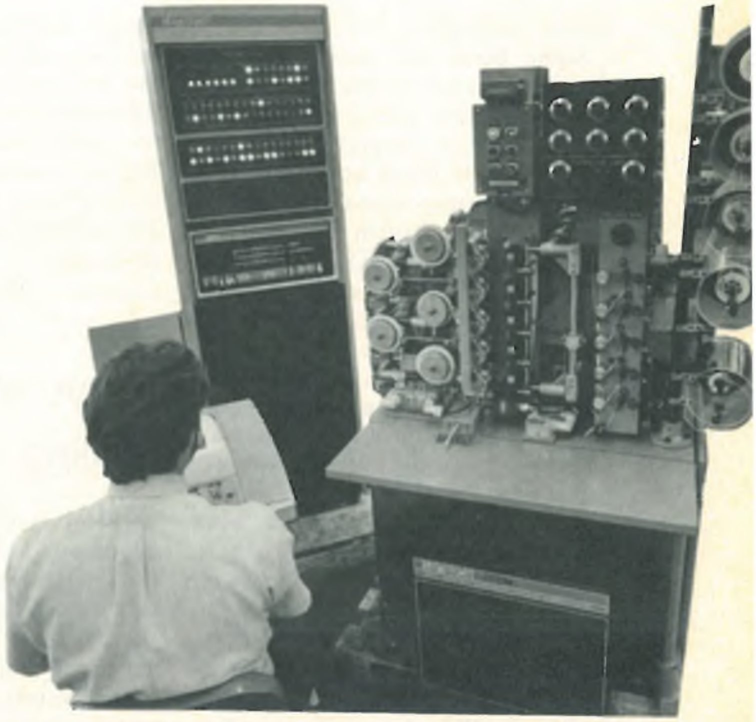
The register/arithmetic units, made by Fujitsu Ltd., are standard depletion-load, n-channel silicon-gate MOS devices. Microprograming is provided by 12 1-kilobit bipolar programable ROMs, which give 500 24-bit words of instructions at a higher speed than MOS could.

Ferranti prototype gas pump begins tests in Scotland

Add Britain's Ferranti Ltd. to the list of companies active in gasoline-pump automation. The company has developed an electronic pump, typically priced at about $3,600, that calculates and displays the price and volume of fuel dispensed and then relays the stored information to the station's office on demand. The system can be retrofitted to hydraulic pumps. Now undergoing prototype evaluation at an Edinburgh, Scotland, gasoline station, **the modular system easily allows conversion from imperial gallons to liters and has a self-service option keyed to a typewriter-size central control unit.** The pump uses RCA and Motorola components, plus a Ferranti optical encoder that has a gallium-arsenide light source and photovoltaic-cell detector.

Electronics stars at tool show, but few are buying

Automation costs too much, and lack of expertise will delay automation, visitors say at European exposition



Electronics must wait a little longer to break through to one of the largest of all potential industrial markets—machine tools. However, at the first world machine tool show, 1-EMO, last month in Paris, anyone would have thought that electronics already is dominating the world's machine shops. The 90,000 square meters of floor space bristled with computers, hard-wired logic, and displays, but the surprising reality is that electronic numerical-control systems account for less than 10% of all machine-tool shipments in Europe.

Although electronics has swept other industries off their feet, the conservative machine-tool makers are still balking at a wholesale switch to electronic N/C systems. And despite the barrage of sales talk from both electronics companies and machine-tool builders at the Paris show, it looks as if it will be several years before many European workshops and factories that could profit from electronics will be ready to make the change.

Two tough obstacles block fast market penetration—high cost and the barrier that divides the mechanical-engineering knowhow of most machine shops and the hardware/software expertise that electronic control systems demand. "Everybody wants to go into numerical control," explains an engineer at West Germany's VDF-Boehringer, "but the smaller companies cannot afford to do so, or they are afraid of having to hire a software specialist."

Reduce. Both buyers and sellers at 1-EMO agreed that the emphasis has now got to shift to development of simpler, low-cost electronic N/C systems for smaller machines and smaller workshops. "In the last few years," notes Henry de Landevoisin, president of H.E.S. Machine Tool Inc., N/C has gone into high-production shops that are the front runners in the manufacturing industry. Their engineers are getting the most sophisticated machines, and they don't care if it is out of line with the size of the investment. There's no way you can do that in a small shop." H.E.S.'s parent company is the big French machine-tool company, H. Ernault-Somua S.A.

Until now, most N/C systems have been fitted to machines costing $100,000 and more. What's more, the recent surge in computer usage has been concentrated even higher up the price scale. "It's a very limited market you're talking to," concedes Werner Rieben, manager of General Electric's Numerical Control Application Engineering department in Frankfurt, Germany.

But this year's slump in the European market is putting new urgency into efforts to diversify into the lowest-cost market. "The major problem for all machine-tool makers now is that it is becoming more and more difficult to sell at all," admits a salesman from Italy's Graziano & C. SpA. "But, to survive, we have got to sell smaller machines."

Routes. Microprocessors, and to a lesser extent minicomputers, are both regarded as routes to lower-cost controls better suited to the small workshop. The microprocessor packages are expected to replace many hard-wired logic systems at much lower cost, and minicomputers offer flexibility in standalone systems that older computer-controlled systems could only offer at a much higher price. But right now, the thrust into the lower-cost market is being led by simplified versions of hard-wired-logic N/C systems like those offered by West Germany's AEG-Telefunken.

For simple operations requiring only three access channels for a tool such as a lathe, AEG-Telefunken is selling a combined hard-wired logic and memory package for about $10,000. For more sophisticated jobs, demanding a two-axis lathe, for example, the German firm's Swedish subsidiary is readying a minicomputer-controlled system that will sell for about $15,000. Replacing the hard-wired logic with the minicomputer will achieve a significant cost saving.

Some basic N/C machines were already on view at the Paris show. Italy's Graziano had a simple twin-turret lathe on display selling for about $56,000 when equipped with General Electric controls, or $49,600 when using a British Plessey N/C system. France's H.E.S., which has been something of a pioneer in small N/C machines, is offering a range costing from $45,000 upwards. Indeed, H.E.S. has been scoring well in the U.S. market for some time. "My best customers have always been small job shops," explains de Landevoisin. "Piece-by-piece in the last few years, we have sold more N/C lathes in the U.S. market than Cincinnati Milacron, and the machine we sell is half the cost of theirs."

CNC ahead. Whatever their potential, computer-driven machine tools (CNC) are still in their infancy in Europe, and there is some fierce controversy over how far and how fast CNC will penetrate the industry. Some Europeans are enthusiastic. "If well handled," predicts de Landevoisin, "CNC should in the near future be less costly than hard-wired control and, on top of that, will offer fantastic versatility to the user." Others take a more cautious view. "A lot of the CNC systems on show in Paris were just playthings," grumbles one German engineer. "But, providing we develop it enough, we feel CNC will be the future."

Privately, many machine-tool makers and even the computer companies are worried. One sales engineer from a leading U.S. minicomputer builder concedes, "it is extremely hard to open a dialog with a company with no knowledge of computer techniques, and so we find ourselves limited to big companies with their own data-processing capability." Companies such as Digital Equipment Corp. and General Automation thus tend to focus largely on OEM customers that build complete systems.

One senior German specialist goes further still. "CNC will not catch on," he forecasts. "A lot of people have sunk a lot of money into it, so they have to go ahead. But the real emphasis is going to be on developing cheaper N/C machines for smaller businesses." And as GE's Rieben comments, "You have to remember that companies with under 200 employees buy 60% of all machine tools." □

Japan

Tokyo automates mailing routine

A set of machines based on microprocessors and universal controllers has begun operation in the Tokyo post office. These machines enable patrons to perform most of the steps needed to mail first-class letters, registered letters, and parcel post. Customers are instructed how to perform these operations by the numbers to speed up service.

To start operation of the first-class-mail machine, the patron places his letter in a weighing box. He then pushes buttons to indicate whether his letter is standard letter size or larger, for which there is a surcharge. He pushes another button to indicate how his letter is to be sent—regular mail, special delivery, registered, or some combination of these options. He then notes the postage fee, inserts coins totaling that value in the slots, and pushes a button to instruct the machine to print a meter stamp that he sticks on letter. Insertion of the letter in a slot in the machine is the final step.

Intelligence is needed for several functions. For one thing, the weight is not displayed until the letter is weighed three times to ensure the correct reading. The logic runs a sums check on a fee table to ensure that the memory contents have been read correctly. When the system is not in use, a standby check with fixed date indicates that it is functioning. A read/write memory is needed to take care of rate increases, to store such data as sales figures, and print these figures.

Registered letters. A second machine for registered letters was designed, like the first-class letter machine, by the Production Engineering Laboratories of the Matsushita Electric Industrial Co., but by a different group. It uses special-purpose circuits, rather than a universal controller. The machine handles standard-size registered letters that have a value of less than 5,000 yen. To begin operation, these letters must have already been stamped by either conventional stamps or stamps from the metering machine.

Depressing a button causes the machine to dispense a registered-let-

Automated. Machines are (from left) for first-class letters, registered letters, computing parcel post fees, dispensing stamps, and changing money.

ter sticker, which the patron affixes to his letter. Then he inserts the letter in the slot and pushes a button. The letter drops into a built-in safe, and the machine issues a receipt, which includes a copy made by a built-in copying machine of front and back of envelope. A similar copy is retained by the machine for its records.

Parcel post. A third machine computes postage for parcel post. To operate that machine, the patron places his package on large scale and indicates the delivery zone by means of buttons keyed to a map of Japan. After choosing from regular, special-delivery, or registered service, the machine indicates the required postage. The patron must purchase a meter stamp from another machine and take the stamped package to a conventional parcel post window.

The fourth machine dispenses stamps in response to keyboard input. A microprocessor keeps track of sales and handles printouts. The fifth machine, which changes 1,000-yen notes into 10 100-yen coins was built by Omron Tateisi Electronics Inc. It was not designed specifically for this installation, but it is in use in other places, such as subways, where patrons might desire change for operation of vending units.

Availability of universal controllers with 8-bit microprocessors enabled the Matsushita laboratory to compress into a mere four months the development of three of the self-service machines. Even though the controller capabilities are in excess of those needed, the only development required was the software. However, the capability of the controller should also simplify modifications if any are required during the trial period. And 4-bit microprocessors may well be used to decrease costs when a large production order is received.

Design. The universal processor is a special microcomputer built at the Matsushita laboratory around the Intel 8080 microprocessor from the U.S. The microprocessor contains a programable read-only memory, but 1 kilobyte of nonvolatile core memory is included to keep track of sales figures and print them out for official records.

Use of the universal controller requires considerably less development time than special-purpose circuits, especially for only one machine. Even when a large number of machines is needed, the universal controller speeds up development of a prototype. Special-purpose circuits then can be designed for serially produced machines if that appears to be more economical.

A subtotal can be printed at any time. A source says a printout keeps machine attendants from pocketing part of the income and that Motorola has started selling a chip set designed especially for this job in vending machines. □

Diode may lead to satellite-TV sets

A new stable super-high-frequency gallium-arsenide Impatt-diode local oscillator should help bring down the cost of television sets intended for direct reception from satellites. The temperature coefficient approaches zero, and the diode has a low noise level. The Impatt was developed at the technical research laboratories of NHK, Japan's public-service broadcast system, as part of its project for adapting existing technology to all types of satellite broadcasting.

The experimental system, which is matched to a satellite's repeater amplifier, uses frequency modulation rather than the usual amplitude modulation for the video signal. The width of the signal in the 12-gigahertz band is 25 megahertz. In an actual TV receiver, the local oscillator would be displaced from the carrier frequency to obtain the first intermediate-frequency signal at about 1 GHz.

Most system experiments so far have been carried out with a local oscillator consisting of a crystal oscillator, followed by a multiplication circuit using a step-recovery diode. But the Impatt-diode oscillator should cost less to build because the parts count is much lower—one diode and one cavity are all that are needed.

Specifications. This diode oscillator has an output of 10 milliwatts, or more than enough for a local oscillator. Input power is about 17 milliamperes at 50 volts. The design of the package, which is much simpler than the usual "pill"-type package for microwave devices, ensures that device temperature and cavity temperature are tightly coupled to decrease frequency drift. The length of the device from end to end is about 15 millimeters. Width of the slender legs carrying the pellet and gold ribbon is about 1.2 mm.

Similar diodes of the same area and doping, but with a slightly thinner active region, have been fabricated for high-power operation. Because gallium arsenide does not conduct heat as well as silicon, the diode is mounted upside down on its Schottky-junction side with gold-to-gold thermal-compression bonding. Units with one to four chips have been fabricated. Output of 2.5 watts is obtained from four chips operating at a total current of 300 milliamperes at 63.5 V. Efficiency is high—about 13%.

Perhaps the most important reason for not using Impatt diodes so far has been the fear that frequency stability would not be good enough, but this problem can be overcome. Experimental oscillators have a frequency-drift-temperature coefficient of only about -20 kilohertz per degree celsius, and even this amount can be reduced by fine adjustment. Although this temperature coefficient seems extremely large to those designers accustomed to working with signals having a narrower bandwidth, it is small enough to permit an ambient-temperature range of about 60°C without degrading system performance for this wideband fm signal.

Design. The copper cavity in which the Impatt diode is mounted has a temperature coefficient of about -500 kHz/°C. Fortunately, the Impatt diode has a large positive temperature coefficient. Proper design of the cavity and adjustment of the coupling between the cavity and the diode makes it possible to obtain a temperature coefficient approaching zero.

Another property of the gallium-arsenide Impatt that makes it suitable for use in a local oscillator is its low noise. Unlike the noisy silicon Impatts, gallium-arsenide Impatts are almost as quiet as Gunn diodes. But Gunn diodes, although quiet, are not suitable because their inherent temperature coefficient of frequency has the same sign as that of the cavity.

Starting material for the diode is an n^+ GaAs substrate about 50 micrometers thick. It has an n-type epitaxial layer 3 μm to 4 μm thick with a doping density of about 1 to 1.5×10^{16} atoms per cubic centimeter. Platinum deposited on the epitaxial layer forms a Schottky junction to make the device a diode. Platinum deposited on the substrate does not form a true ohmic junction, but it provides a reliable contact, and departure from true ohmic characteristics hardly degrades the diode's desirable characteristics at all. Gold deposited over the platinum aids in making thermal-compression bonds.

The active side of the diode is mounted on a gold-plated lead frame, while contact to the substrate side is made with a gold ribbon by thermal-compression bonding. After mounting, pellets are etched to an area of 1×10^{-4} square centimeters. A small circular glob of silicone resin both protects the diode and supports the two ends of the lead frame to form a packaged diode with two terminals. □

West Germany

Giving crystals a whirl grows thin, smooth layers

A team at West Germany's Max Planck Institute for Solid State Research has used centrifugal force to produce perfectly smooth crystal layers about 0.5 micrometer thick. This sharp departure from conventional crystal-growing methods could pave the way to mass-producing much thinner multiple layers in a one-step fabrication process.

The still-experimental technique being investigated by Elisabeth Bauser and her co-workers at the institute in Stuttgart is aimed at refining the apparatus so that such various multilayer components as semiconductor lasers and microwave diodes can be made.

In conventional methods of growing thin crystal layers by liquid-phase epitaxy, the residue solution is either wiped off the surface or flows from it by gravity. However these practices have some serious drawbacks. For one thing, surfaces are easily scratched while the solution is removed. For another, complete removal of the solution after the epitaxial layer is grown is difficult. Usually, tiny droplets cling to the layer, and this residue makes for rather rough layer surfaces and nonuniform coating thicknesses.

Centrifuge. The crystal-growth apparatus the Bauser team has developed consists essentially of a quartz tube surrounded by a furnace. A graphite crucible is fixed at the top of a shaft running through the tube and extending into the center of the furnace. The shaft's lower end is connected to a rotor, and a stator outside the quartz tube drives the rotor at speeds as high as 3,000 revolutions per minute.

The crucible, which is symmetrical with respect to the shaft's rotational axis, has small stock bins inside to hold the solution. These bins, which are adjacent to the center of rotation, have slotted openings ending in a narrow gap that points away from the axis. Substrates can be fixed on one or both sides of the gap. The crucible's outer shell constitutes a container that collects the residue solution.

In growing an epitaxial layer—for example, a gallium-arsenide layer on a substrate of the same material—the liquid gallium and the gallium arsenide are put into the stock bins and then heated either in a vacuum or in hydrogen. High surface tension of the liquid prevents the solution from escaping.

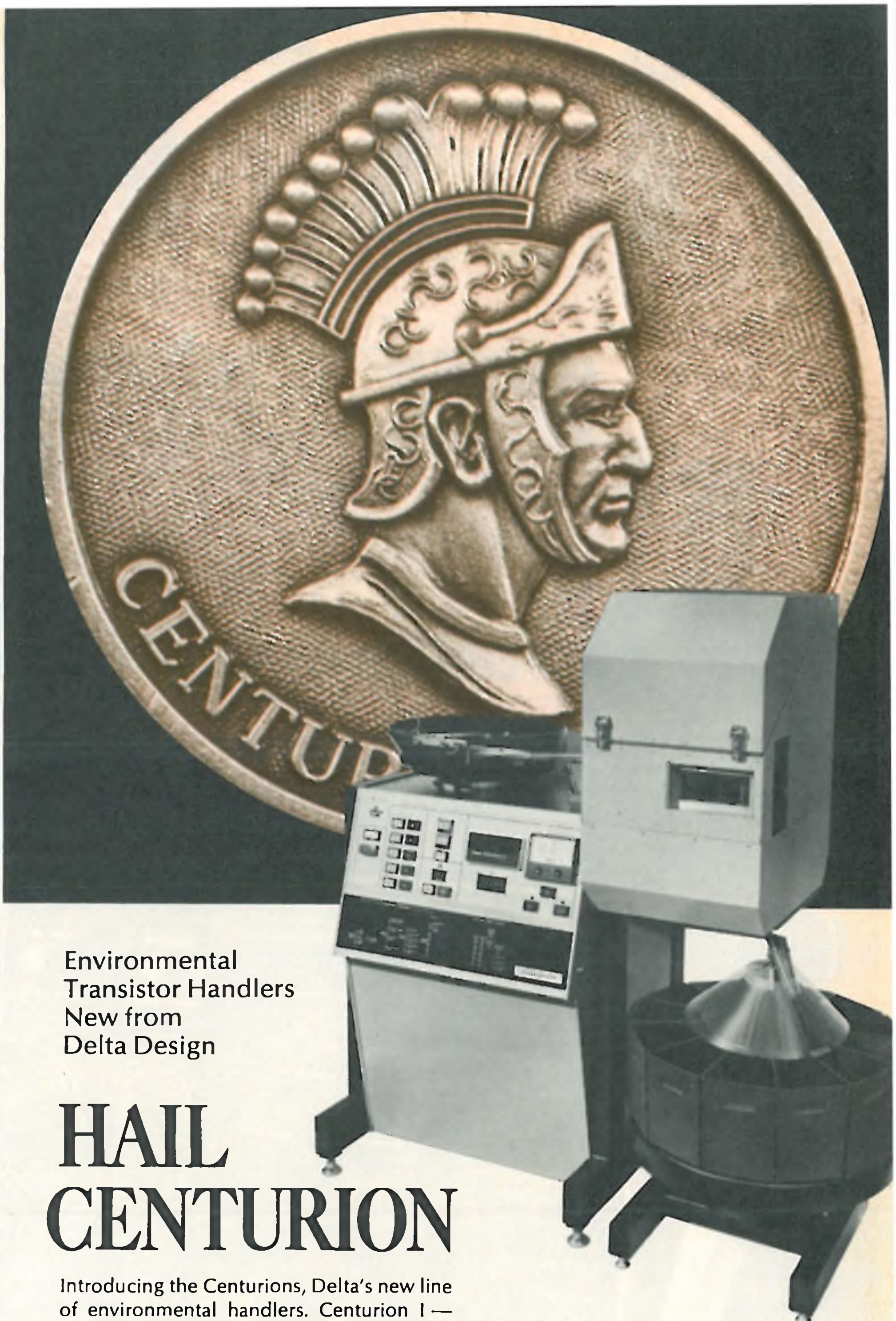
Deposition. When substrates are in place, the crucible is heated to the desired growth temperature. When the crucible assembly has reached thermal equilibrium, the system is rotated fast enough for the centrifugal forces to exceed the forces of the surface and interfacial-tension components. The solution then enters the gap and passes over the substrate's surface to deposit the epitaxial layers.

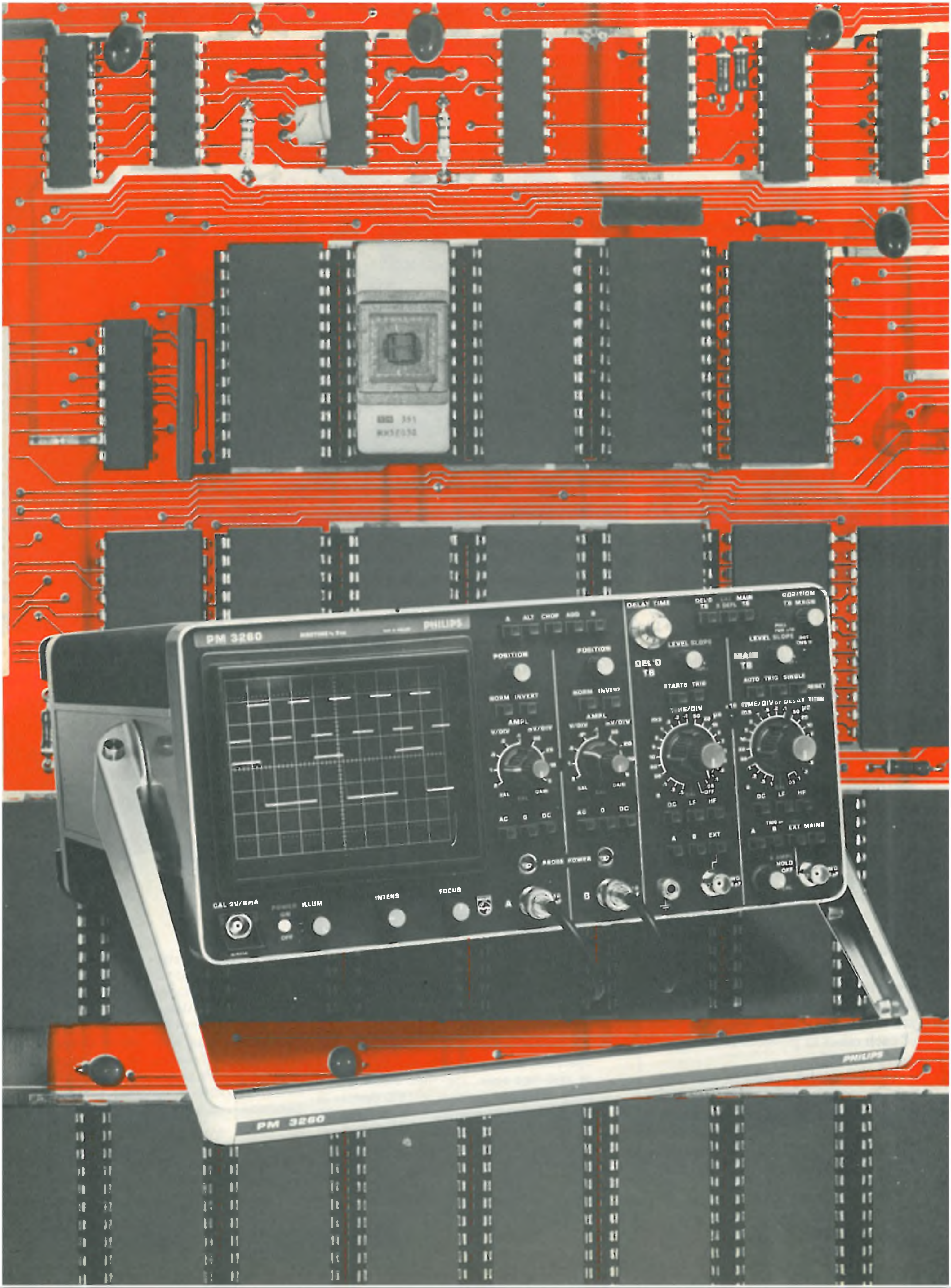
The crystalization process apparently takes place within fractions of a second. "This has come as a surprise to us, for at first we weren't sure whether such short time would be sufficient for crystalization.

A prime advantage of the method is the easy removal of the residue solution. When the growth process has been completed, the unused solution is removed from the crystal surface by raising the crucible's rotational speed to throw the solution off the edge. From there, the solution is transported, again by centrifugal force, back to the stock bins and reused in subsequent crystal-growing processes.

Multilayer. The researchers are now readying their equipment for experiments aimed at producing multilayer crystals. For that, they'll use a drum-type magazine with several containers, each for a different solution. Bauser says, "We want to grow as many crystal layers on top of each other as possible in a single-step process."

The team also wants to find out how to make semiconductor layers much thinner. Whirling the materials by means of a contactless-bearing mechanism much faster than the present maximum of 3,000 rpm will be the first step. □

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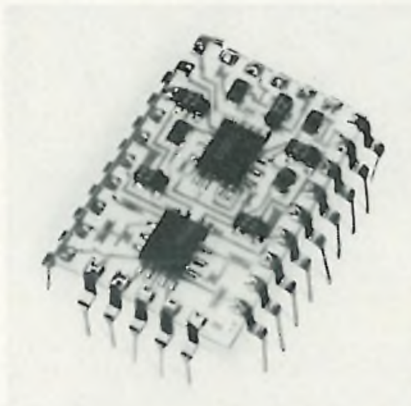

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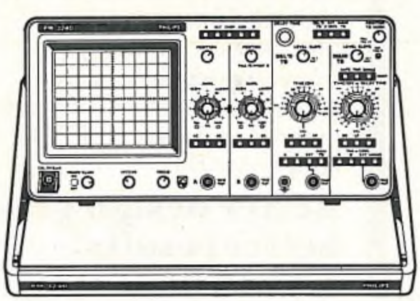
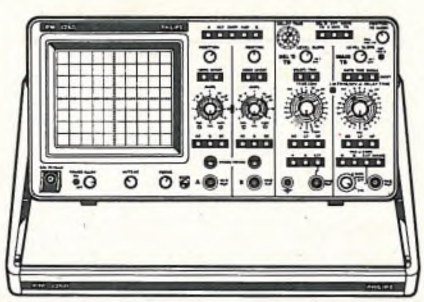
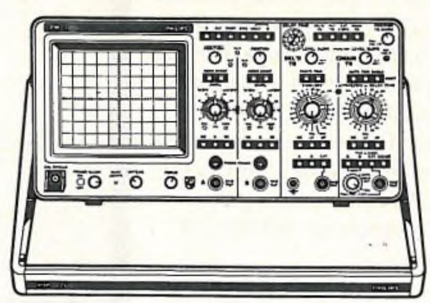


PM 3240 : 50 MHz/5 mV; 8.4 kg; bright 8 x 10 cm display.



PM 3260 : 120 MHz/5 mV; 9.0 kg; ergonomic layout; wide choice of line supplies*.*



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Fast-switching thyristors handle high power

by William F. Arnold, London bureau manager

British firm develops line of power semiconductors for industrial control, motor and rf heating systems

Designing power devices that offer both high power and fast switching can be difficult—to achieve one goal you may have to lower your sights on the other. Capitalizing on its long experience, however, AEI Semiconductors Ltd. is introducing high-power thyristors that promise high voltages, high current and fast switching.

One of these devices, the DCR880, is designed for switching speeds up to 6.6 kilohertz at a reverse blocking voltage of 2.2 kilovolts. The amplifying-gate device, mounted on a 1½-inch silicon wafer, offers a turnoff time of 40 microseconds. It has a forward and reverse blocking voltage of 1.2 kilovolts and a voltage-rise rate of 300 volts per μs.

Following soon will be the DCR1377, an amplified-gate thyristor mounted on a 2½-in. silicon wafer and targeted to have reverse voltages greater than 2 kilovolts and surge currents in excess of 25,000 amperes. Larger silicon slices mean that devices can handle higher surges, AEI executives point out. These devices follow two recently introduced fast-switching high-power thyristors in the 1.2-kilovolt reverse-blocking range, the DCR857 and 860.

AEI officials say the significance of these devices is in achieving the voltage, current and switching-speed levels in individual units. Credit is given to the company's refinements in design and in the use of silicon. One result is that switching losses have been cut to a minimum, which means that the devices can handle more power at higher frequencies.

Although already widely used in radar, communications, television and even automotive electronics, thyristors have not been extensively adopted by designers of heavy industrial equipment. With the combination of high power and fast switching, however, smaller and lighter rotating machinery looms as a potential application because machinery size decreases as operating frequency increases. Another avenue that may be opening up is inverter power supply technology, where high switching speeds can save money by allowing the use of smaller transformers.

"The 2-kV region is a particular need" for several applications, says Roger J. Bassett, unit manager in the high-power products group, commenting on the DCR880 and the upcoming DCR1377. AEI hopes these products will allow designers to cut down on the number of commutating components, ultimately yielding lines of cheaper power circuits. General applications of the DCR range include traction motor systems for rapid transit, rf heating, smooth motor control for industrial control and, in the case of the DCR 1377, uses in high voltage dc transmission as well as ac applications.

The dc case is the more difficult of the two, of course, since the means of turning the thyristors off cyclically is not automatically present in supply reversals. The new thyristor can simplify the external circuitry needed to provide timing.

On watch. A crucial factor in measuring the performance of high-power thyristors, Bassett cautions, is watching the repetitive rates of current rise time, important for switching applications. He notes that the DCR880, 857 and 860 have rates of 200 to 400 amperes per microsecond. Moreover, they're intended to do that over a lifetime greater than 10 years, he says.

Specifically, the DCR880 has a rate of rise of current of 200 A/μs repetitively and 800A/s non-repetitively. Other specifications include a high rate of rise of voltage up to 700V/μs, a high overload capability of 800 A peak, and low switching losses at high frequency.

The earlier 857 and 860 DCRs use distributed amplifying-gate techniques that cause certain limitations to voltage performance. However, they can switch power up to 10-kilohertz frequencies and have very short maximum turnoff times of 15 and 25 μs and they have a high repetitive rate-of-current-rise of 400 A/μs. Other specifications include a high current-overload-withstand capability, the company says, up to 8,500 A.

The 857 and 860 units are mounted in rigid ceramic hermetic housings with a 1-in. minimum creepage path—the distance between the anode and the cathode. AEI effectively lengthens that distance by using a ridged surface.

The DCR 880 will cost about $350 each. No price has been set for the upcoming DCR 1377.

AEI Semiconductors Ltd., Carholme Rd., Lincoln, LN1 1SG, England [441]

Plessey adds four low-power dividers for portable applications

Several years ago Plessey Semiconductors got a jump on the competition with a series of high-speed dividers—so successfully, Plessey claims, that 95% of the major instrument makers are using the devices for their counter/timers. Now in an attempt to broaden its market in instruments and communications, Plessey is adding low-power-consumption, high-speed dividers for battery-powered applications.

The SP8695 and SP8690 can be logically programed in the popular divide-by-10 or -11 mode at frequencies up to 200 megahertz. Typical power consumption is 75 milliwatts at 5 volts. The new models also include the SP8790, a low-power divide-by-four control counter, and the SP8660, a 150-megahertz prescaler.

Popular. The devices fit into the 150-to-200-MHz spectrum because "there's a lot of interest in that range," says Paul A. Davis, product-marketing engineer. The 10/11 divide function was chosen because "certain breeds of synthesizers tend to be tuned that way." But alternative ratios are on the way, such as 5/6, 6/7 and 8/9, he says.

All the devices are made with Plessey's Process 3 bipolar planar technology. Process 3 features thin epitaxy and shallow junctions to provide high packaging densities. The devices come in either TO-5 cans or dual in-line packages. Plessey is confident that its Process 3 technology gives it an edge over slower processing technologies.

High-speed dividers generally are used in synthesizers for television and military applications. Communications is becoming a big market, too, Davis notes.

The SP8690 and SP8695, together with the SP8790, are designed for the "low-power manpack synthesizer market which is starting to take off," Davis says. The SP8660 150-MHz decade prescaler is designed for portable battery-operated frequency counters and timers in laboratory uses. Prices in lots of 100 in the UK are about $16.25 each for the first two, $6.96 for the control counter, and $15.60 for the decade prescaler.

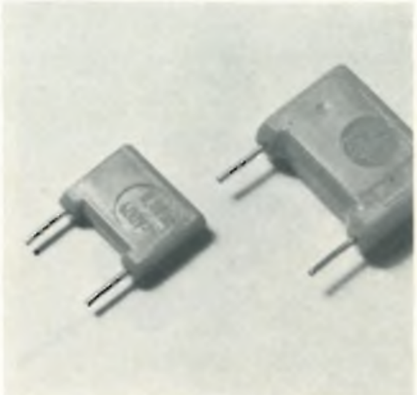
The SP8695 is compatible with emitter-coupled logic for all inputs, including the clock. Plessey guarantees that it will work down to dc as long as the input slew rate is better than 3 V per microsecond. The ac version, the SP8690, designed for easier operation, doesn't quite match the 8695's frequency performance in that it isn't meant to work as slowly [*Electronics*, June 12, p. 138] but the 8690 operates down to dc, he says, if the minimum slew rate is 40 V/μs.

Both devices have true and inverse outputs in ECL-compatible levels plus a free collector-saturating output stage for interfacing transistor-transistor logic and complementary MOS. All control inputs are directly ECL/10K-compatible and can be made compatible with TTL and C-MOS by using two external resistors. The electrically programable products bring the benefits of the popular 10/11 divide functions to lower-power applications, Davis notes. Faster and better noise performance often result when these programable divide functions can be designed to operate higher in the frequency range, he says.

Low power. An advantage of the divide-by-four control counter is that when used with the first two devices, or other SP-series dividers, it provides a programable divide-by-40 or -44 function, important for some synthesizers. Typical power consumption is 35 milliwatts. The prescaler, which peaks at 108 MHz, complements Plessey's present range of binary prescalers used in instruments and communications gear. Their typical power consumption is 45 milliwatts.

Plessey Semiconductors, Cheney Manor, Swindon, Wilts SN2 2WQ, England [442]

The 200 series of resin-encapsulated high-voltage power-supply modules provide high voltages for CRT displays. Designed for severe environments, the units have outputs of 4 to 20 kilovolts. Brandenburg Ltd., 939 London Rd., Thornton Heath, Surrey CR4 6JE, England [467]

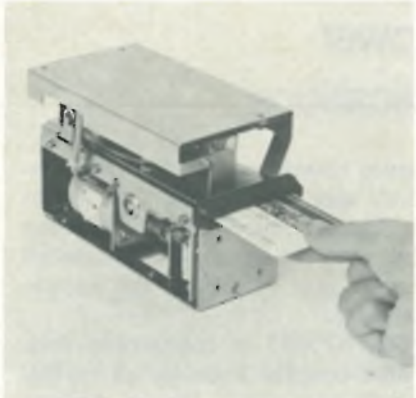


A radial-lead configuration makes the PM series of molded metalized polyester capacitors suitable for pc-board applications, particularly where space is limited. Capacitances range from 0.01 to 1.0 microfarads. Advance Film Cap Ltd., Wrexham, Denbighshire, England [468]

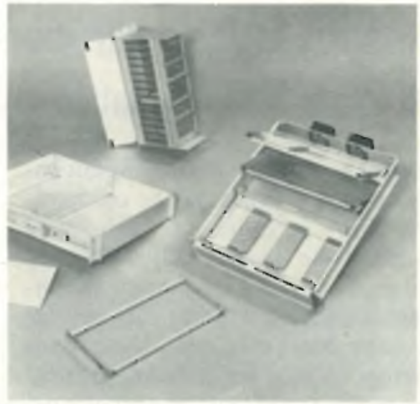
A high-speed opto-isolator, designated the IL-100, transmits data at 5 megabits per second with a common-mode rejection of 50 dB. The IL-100 uses a LED light source and an IC receiver that incorporates a photodiode. Litronix, Hitchin, Herts. SG5 1LW, England [469]

New products international

Digital panel meter, model MP-1000, has 0.59-inch-high light-emitting-diode display that can be read at 20 feet. Accuracy is within (0.1% of reading ±1 digit). LSI circuits are used extensively. Asahi Keiki Co. Ltd., 1-15-13 Shimomaruko, Ota-ku, Tokyo 144, Japan [443]



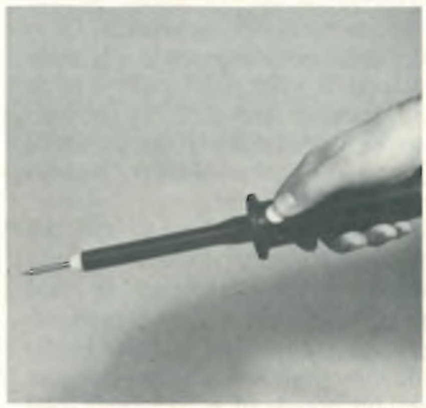
Originally developed for gasoline stations, a magnetic-card reader that can handle even distorted and stained cards has a bit-error ratio of less than 10^{-6}. Maximum recording density is 72 characters. Matsushita Electric Industrial Co. Ltd., 3-1-1 Inazu-cho, Osaka 561, Japan [446]



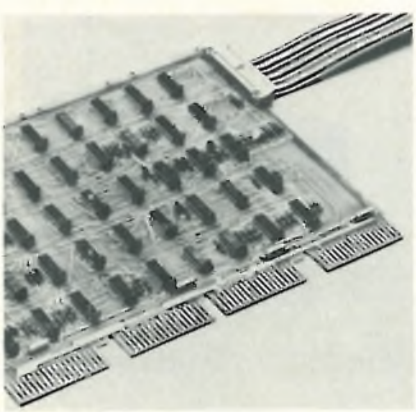
Versatile socket boards for wire-wrapping provide engineers with maximum design flexibility and are aimed at cutting costs and long lead times in both prototype and production equipment. Vero Electronics Ltd., Chandlers Ford Industrial Estate, Eastleigh, Hampshire, England [449]

Long-life electrolytic capacitors, type PEG 124, have compact axial-lead construction. Rated capacitances range from 10 to 2,200 microfarads and dc voltage from 12 to 100 volts. They are designed for high-reliability applications. Aktiebolaget Rifa, Fack S-161, 11 Bromma, Sweden [444]

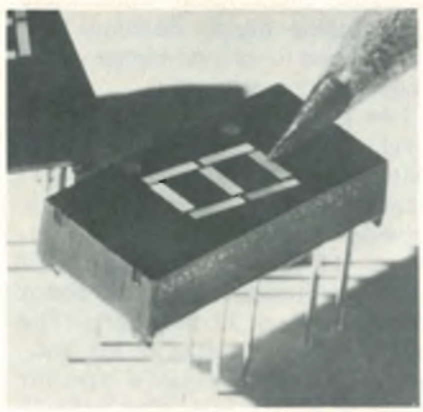
A family of rf miniature coaxial terminations includes laboratory types 12 mm long for dc to 18 GHz, and 9-mm industrial versions for dc to 12.4 GHz. Both types have a maximum VSWR of 1.25 and can handle 1 watt. Radiall, 101 rue Philibert Hoffmann, 93116 Rosny, s/Bois, France [447]



A high-voltage test probe with detachable tips is rated at a maximum working voltage of 30 kilovolts. It is said to be completely safe, since the design ensures thorough earthing and screening of the probe head. Wallis Electronics Ltd., Worthing, Sussex, England [450]

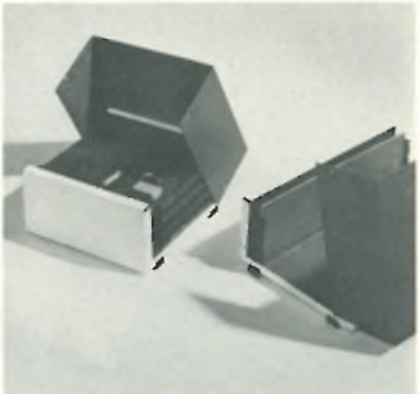


A wire-wrappable module, the MDB-11, is designed for interface applications for the PDP-11 and PDP-8 computers. It will accommodate up to 70 14- to 40-pin dual in-line ICs or sockets. Sintrom Electronics Ltd., 2 Arkwright Rd., Reading, Berkshire RG2 OLS, England [445]



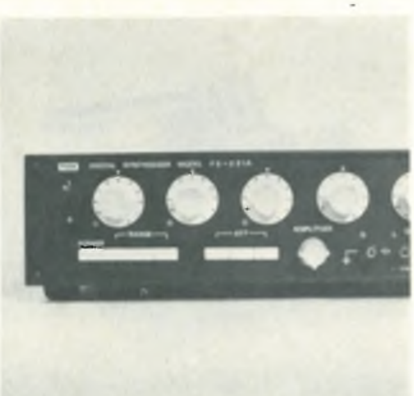
An orange LED display has been added to Monsanto's series of green, red, and yellow displays. The series of readouts, designated MAN 3600, is available in a variety of configurations and is compatible with most circuit requirements. Monsanto Europe S.A., Place Madou 1, B-1030 Brussels, Belgium [448]

A series of transmitters and receivers, developed for use with optical waveguide, can be used for data-transmission links and for actuating stepping motors, relays, and other components in process-control systems. Triskelion AG, CH-6317 Oberwill, Switzerland [451]

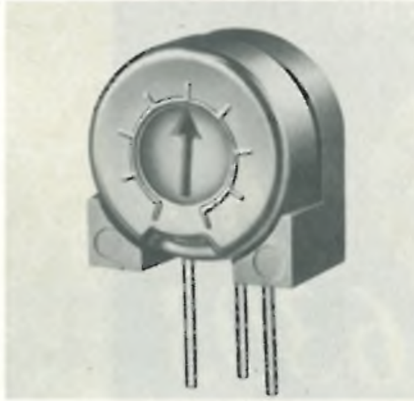


The Samos series of cases houses low-cost instruments. The cases, which come in seven sizes, have simple hinged openings for inspection. Supports permit circuit boards to be inserted vertically or horizontally. West Hyde Developments Ltd., Northwood, Middlesex, England [452]

Dc servomotors with ironless rotors and permanent magnets are 23 millimeters in diameter and 48 mm long. Units of the Escap-23D series have a low moment of inertia for their power (4 watts). Portescap, 165, rue Numa-Droz, La Chaux-de-Fonds, Switzerland [453]

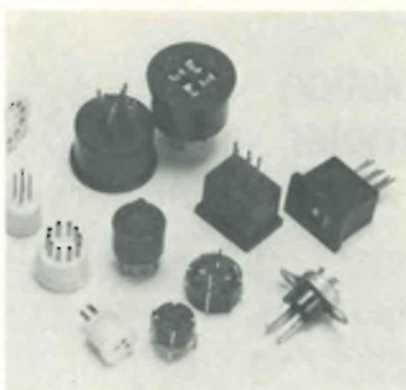


Using a direct-synthesizing system without a phased-lock loop, the model FS-221A generates signals ranging from 0.01 Hz to 200 kHz. Frequency of the signals can be controlled remotely. TOA Electronics Ltd., 307 Suwa-cho, Shinjuku, ku, Tokyo 160, Japan [454]



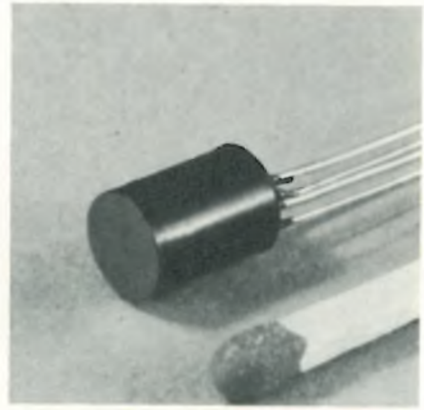
Thin-film trimmer module, the NX-13, has two fixed-resistor branches built in. The device is used primarily for adjustment of operational amplifiers and voltage-regulator integrated circuits. Copal Electronics Co. Ltd., Shiba-nishikubo, Minato-ku, Tokyo 105, Japan [455]

Full-scale controllers, called Getrosist 96, can be panel-mounted and used for indicators, limit-signalers, and two- or three-point controllers. The units have a 270° red motor-driven display band. Indicators may be reset during operation. Pye Ether Ltd., Stevenage, Herts., England [456]

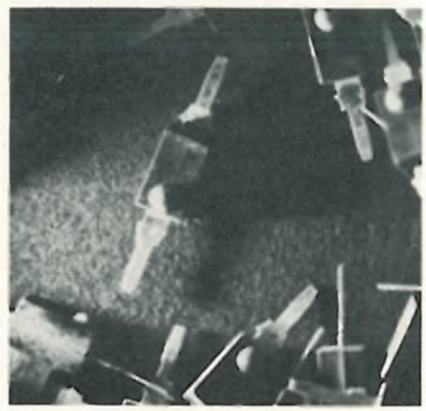


A wide range of sockets is designed for use with transistors and ICs in various metal cans. The number of contacts ranges from three to 10, and the configurations vary to match the packages. Dieter Assman Electronics Ltd., Victoria Works, Watford, Herts., England [457]

New products international

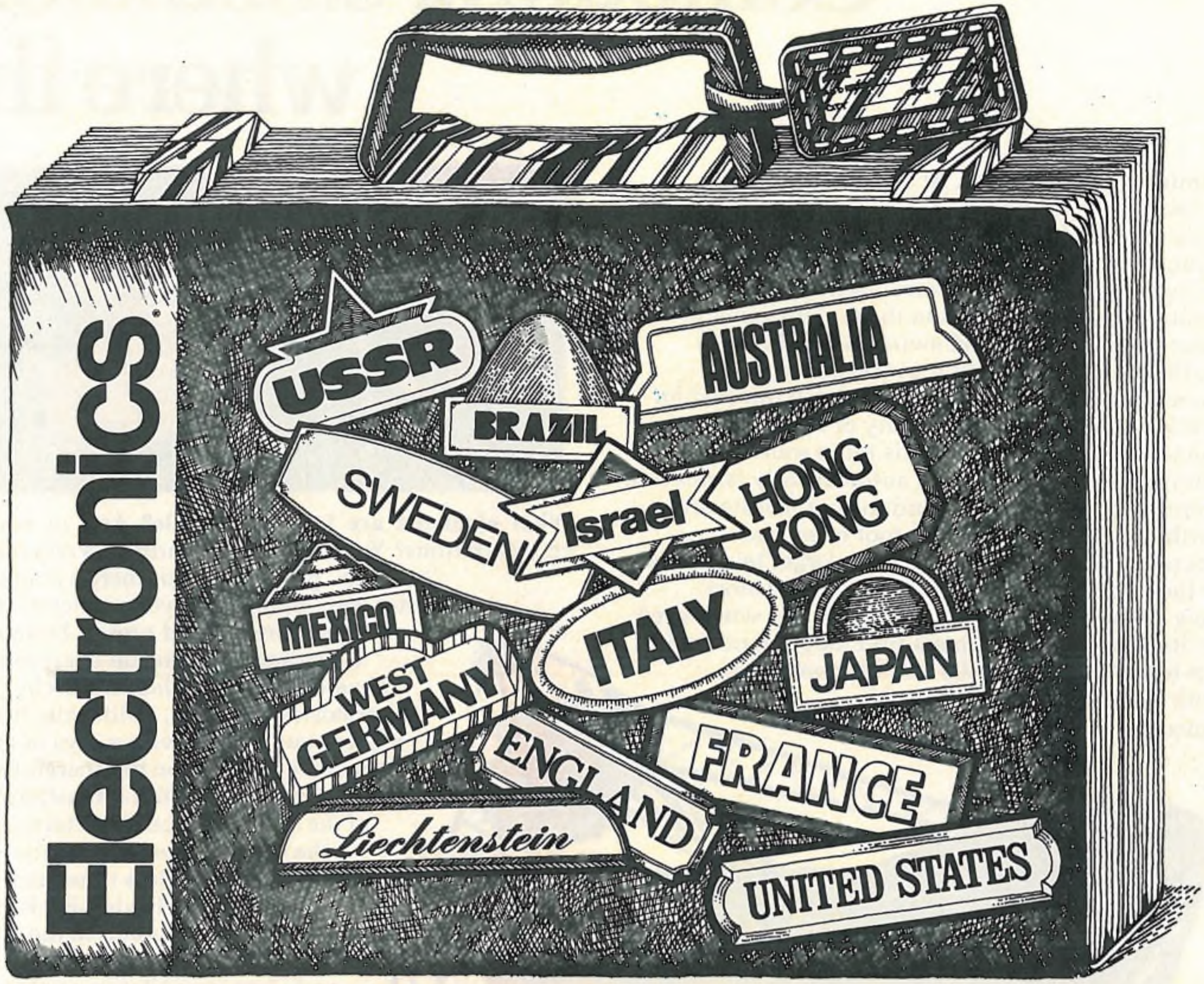


Miniature photocoupler built with a LED and a photoresistor has isolation of 250 V between input and output. An input signal of 10 mW suffices, and the response time is 1 ms. The output circuit can handle up to 80 mW. Segor/Silec, 69 rue de Monceau, 75008 Paris, France [458]



Developed for TV- and CATV-channel selectors, a line of diodes with ratings to 1 GHz can also be used in industrial equipment. The line includes varactors (BB 209), pin diodes (BA 379), and Schottky diodes (ESM 247). Sescosem, 50 rue J.P.-Timbaud, 92403 Courbevoie, France [459]

Circuit blocks handle currents to 2 A and test voltages to 2,000 V. The base blocks have 30 connections with wire-wrap terminals. The plug-ins are available with 10, 20, or 30 connections for crimped wires up to 1.5 mm² in cross section. Entrelec, rue Leon Blum, 69611 Villeurbanne, France [460]



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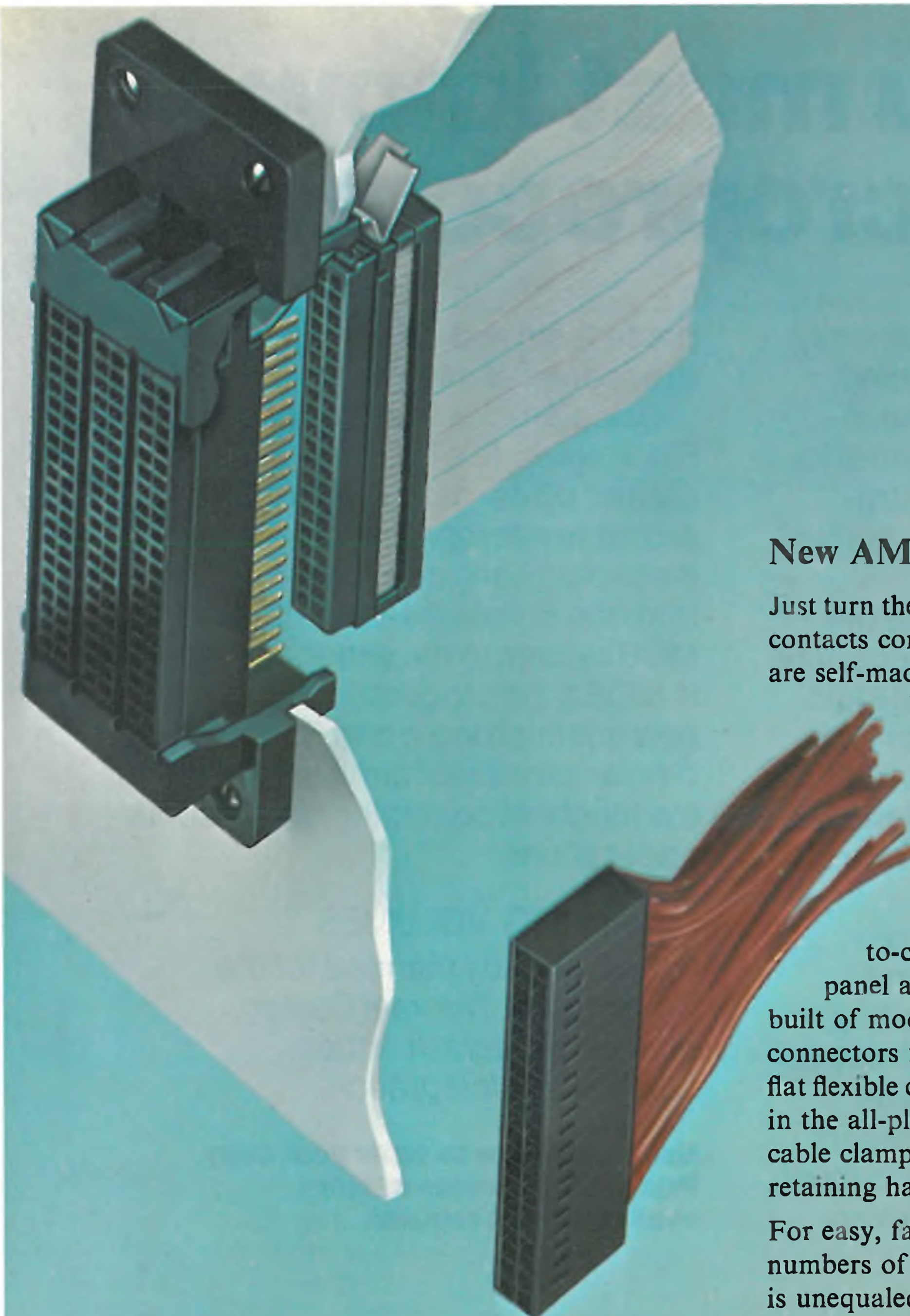

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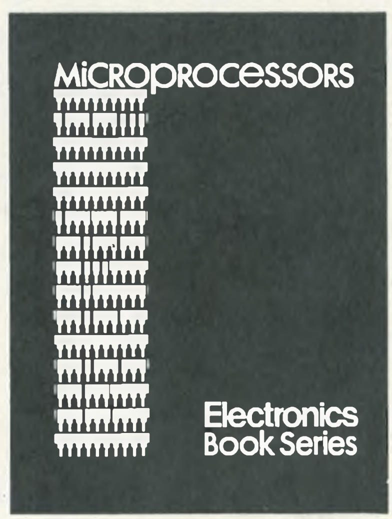

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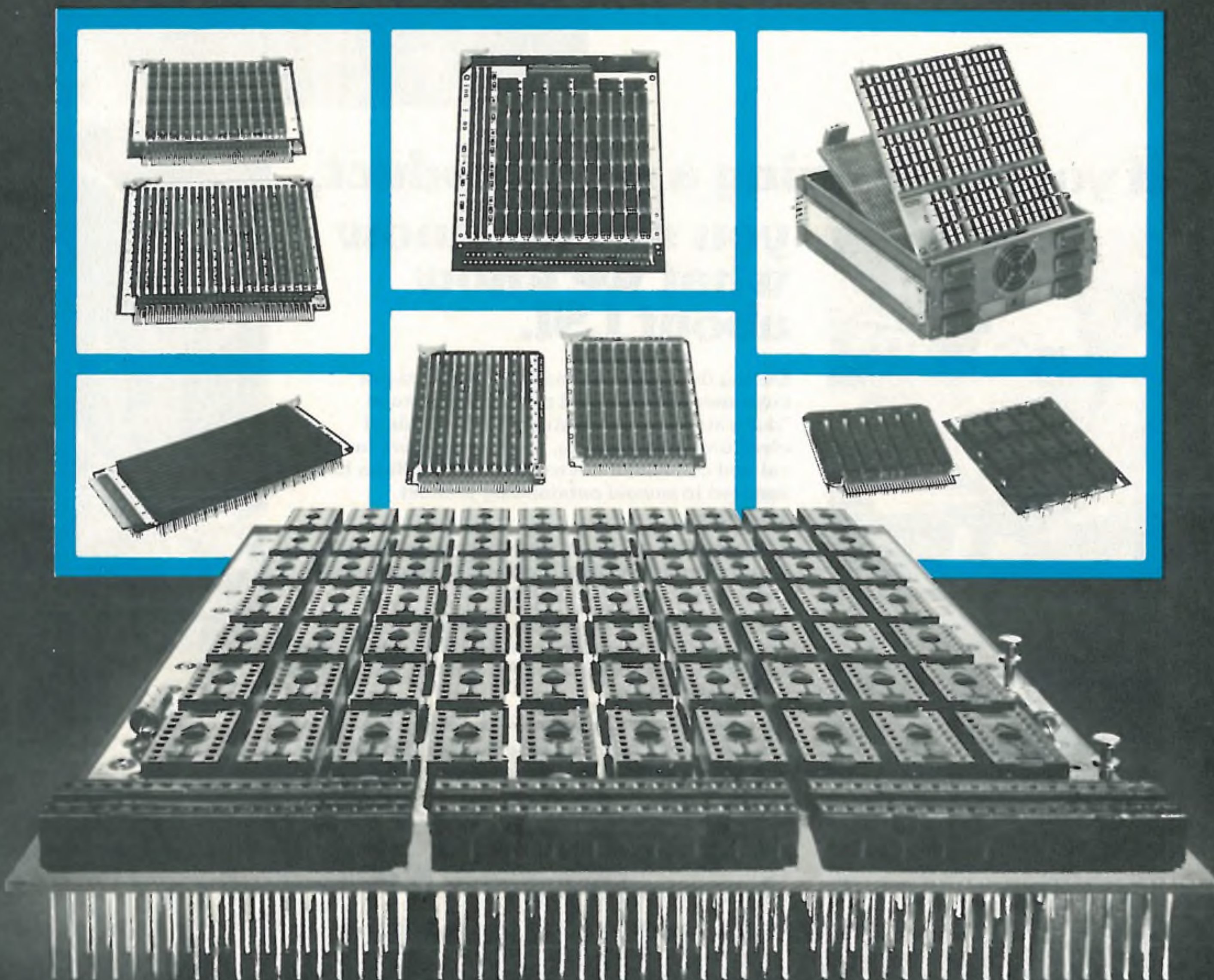

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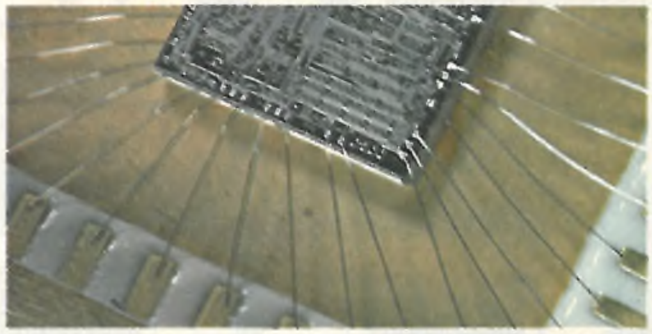

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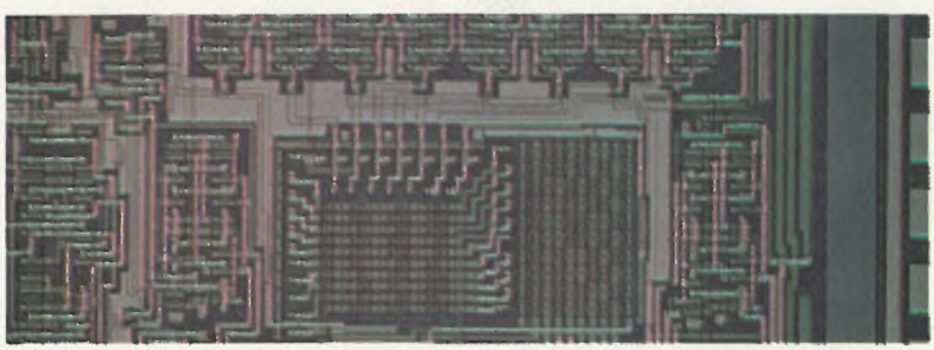


Probing the news

Analysis of technology and business developments

C-MOS prices slide in all-out market battle

RCA, leader in the field, takes aim at TTL sockets, while competitors match slashes, gate for gate

by Ron Schneiderman, New York bureau manager

Pricing of complementary MOS is entering the twilight zone. Prices continue to fall, and no one knows what impact this drop will have on the total C-MOS dollar market. Competition for market share is so intense that prices are dropping faster—recently, by a factor of three—than they did in the bloody old days of the TTL price wars.

Although most C-MOS makers are less formal about announcing their cuts, the market leader, RCA Solid State division in Somerville, N. J., along with Harris Semiconductor in Melbourne, Fla., last week published new price lists, with reductions of 50% or more on many standard devices in distributor and small OEM quantities. And more cuts are planned.

Not surprisingly, most of RCA's and Harris' new numbers are about the same. Although Texas Instruments slashed prices on its plastic-packaged C-MOS lines in early May, William Brennan, Harris' C-MOS product marketing manager, frankly admits: "We ignored the TI move and responded to the RCA cuts. In fact, I don't think anyone responded to the TI move. They're just not a factor in this market."

'Experience.' But RCA, with 40% of the market, is a factor. And RCA slashed its prices, effective June 30, an average of 31% for its 4000A series and 15% in the 4000B series in quantities of 100 to 999. Philip R. Thomas, division vice president for C-MOS products, says that the division planned to upgrade its C-MOS program last February with tighter specifications and lower across-the-board prices, but decided to hold off for what he called "inventory corrections. We think we're in super shape for the third quarter and beyond." Thomas adds that RCA's pricing is based on its "experience curves, and we think we are on the right experience curve, based on our market share."

In the works, adds Thomas, is a heavy campaign aimed at promoting C-MOS at the expense of TTL, a market he projects at $600 million to $800 million in 1976. "For some time, C-MOS suppliers have considered their devices to be cost competitive with TTL devices on a system-cost-effectiveness basis. Our new prices should eliminate any questions on the matter." He says that some C-MOS devices will be priced lower than comparable standard-TTL circuits. But adds Thomas, "the market potential for C-MOS is much greater than is the industry's ability to quickly meet it and the users' ability to redesign for it."

Meanwhile, Solid State Scientific Inc. in Montgomeryville, Pa., claims it is not only underpricing RCA products, but that it has been doing so since February. Walter F. Kalin, C-MOS marketing manager, cites the example of his firm's BCD-rate multiplier, which it has been selling at $1.10 since February. Last week, RCA reduced the price of its CD4527A multiplier to $1.54.

Similarly, RCA reduced its CD4041 quad true-complement buffer last week from $1.56 to 75 cents, but Kalin says his company has been selling that device at 57 cents for at least the past four months. "So they're [RCA] still not there yet," says Kalin. RCA's Thomas, however, discounts the "who's-lower" argument. He insists that RCA is "not taking a price leadership position in the industry; we're taking an orderly approach to the market." At any rate, Kalin says, "We're in the game," and no matter what prices the industry leaders come up with, Solid State Scientific will be price-competitive.

Last May, TI cut prices on about 55 parts, including about 35 that are alternate sources for RCA's 4000 series. In distributor quantities, the 4001, which TI had priced at 48 cents, was cut to 27 cents, although most sources agree that TI's C-MOS prices had been too high. Also, TI's cuts were made only in the U. S., and levels were maintained in Europe.

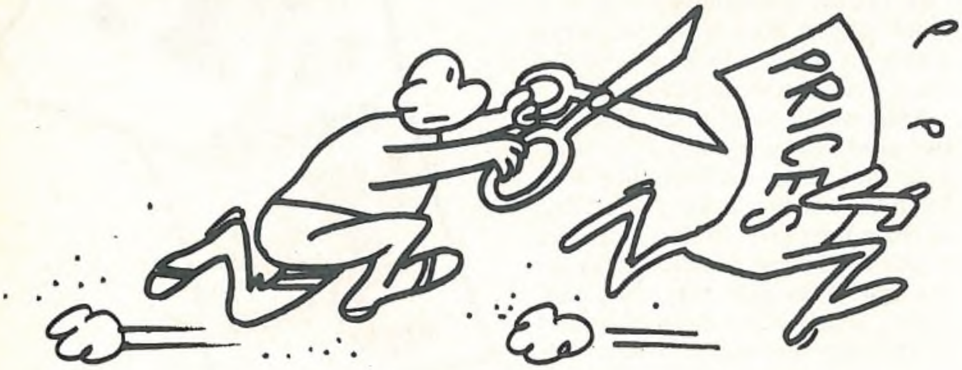
Bill Kean, TI's C-MOS marketing manager in Dallas, points out that C-MOS gates that had been going for more than 50 cents each a year ago had dropped to 15 cents by year-end, and they are selling today for about 13 cents. Coupling the few C-MOS medium-scale-integration standard functions with that—and the C-MOS standard-product mix is about 85% gates—TI estimates that C-MOS prices dropped 64% in the second half of last year.

Demand drops. But low prices are only part of the dilemma. "Customer-demand for C-MOS is at the lowest point since the market started to turn sour," Kean says. He doesn't expect much more erosion in prices, at least for a little while. "It's one thing to see price stabilization with a lot of quote activity, it's another thing to see it when no one is quoting on anything."

Strategy. The Motorola Semiconductor Products division in Scottsdale, Ariz., generally ranked second in the C-MOS market, plans a "pricing-strategy move relatively shortly." Colin Crook, assistant director of marketing for the division, says, "Actually, we began making our pricing moves in mid-'74, based on our pricing strategy, which has been successful to date." Analyzing his competitors' price cuts, Crook says, "they're trying to preempt our next move."

At National Semiconductor Corp., Robert Bennett, C-MOS marketing manager, says that prices for large-quantity orders have been firming up for the past three weeks, but he did not comment on other prices. National officials are taking a wait-and-see attitude before making any pricing moves. Like their counterparts at the Fairchild MOS Products division in Mountain View, Calif., they are considering price cuts, but have not decided on their timing.

Barry Cox, marketing manager of digital ICs at Fairchild, agrees that C-MOS prices have "eroded significantly," adding that further price erosion is likely in the newer, more complex circuits that are second-sourced while prices of established members of the 4000 family will bottom out. "Continued price erosion," he says, "indicates that supply is far over the subscribed industry demand." Whether or not that low demand will drive some manufacturers from the market depends on that company's financial stability, he says.



Harris Semiconductor has its own answer to the pricing competition. Harris, which has been supplying ceramic-packaged C-MOS products at epoxy-packaged prices, last week issued a price list for 32 new 4000-series devices in epoxy. The Harris 4001 ceramic device at 33 cents, for instance, will sell for 27 cents in epoxy. "Our commitment is to compete," says Brennan, "but we hope to compete with people who know what their costs are."

Siltek International Ltd. in Bromont, Ont., near Montreal, is actually boosting its gate prices an average of 3 cents, says marketing director Ralph Bennett, from the 13-to-16-cent range. But most of these products are going to customers who are "favorably disposed" to long-term contracts and are willing to pay for guaranteed delivery.

Imponderable. The size of the market is another story,—one that Motorola's Crook calls "one of the big imponderables created by so much price erosion." RCA places the total worldwide C-MOS market for calender 1976 at slightly more than $200 million, although one of its competitors says that "RCA has been overstating the total available C-MOS market for the past two or three years." Harris' Brennan says he would be "hard-pressed to give a figure for what's going to happen in 1975, and we're already into July."

One question RCA has already asked itself is what will happen to its market share as random-access memories and microprocessors—product lines in which RCA has been weak—come on strong. Thomas admits that RCA already has lost several market-share percentage points, "and we expect to lose more."

TI isn't in the C-MOS-memory or microprocessor business—it covers microprocessors with its I²L logic family. And like Fairchild, National Semiconductor is not looking at sapphire. "We don't see it as the way industry is going," says National's Bennett. "It's too expensive, and you don't get much more for your money" using silicon on sapphire than by using TTL, he says. □

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MK2600	512 × 8 or 1024 × 4	700 ns	325 mW	Fairchild 3514
MK28000	2K × 8 or 4K × 4	600 ns	320 mW	EA 4900, TMS 4900

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Semiconductors. If consumer electronics is growing fast, production of components is increasing even faster. Away out front are semiconductors. Unitra's Bilip forecasts that production will jump 60% this year and reach the $90 million level. For 1976, his forecast is for a 50% rise above this year's figure. Discrete semiconductor components predominate, but ICs are shooting up much higher: from last year's 1 million devices to this year's 13 million, about equally divided between linears and digital transistor-transistor logic.

Meeting domestic demand for electronic components and equipment is Unitra's prime goal, and for many of its product groups exports are secondary. "We have orders from abroad equaling about one fifth of our output this year," says director Nasalski of Unima, which will have a 1975 volume of about $15 million. "But we are limiting our exports to one tenth of our production this year because of the big demand from our own industry," Nasalski says.

Unitra managers are candid about their need for knowhow from the West. "We're not the strongest in technology," admits Bilip. And Kujalnik adds that "we are not deluding ourselves about our R&D capacity. We just aren't big enough to develop everything on our own."

Independence. Dependence on Western technologies does not mean that Poland cannot come up with innovations of its own. In many such product groups as relays, transformers, resistors, and crystals, Unitra is self-sufficient and says it even scores significant sales with such devices on Western markets. With particular pride, Unitra officials point to a contract to ship International Business Machines Corp. $2.5 million worth of custom-designed piezo crystals during the next five years [*Electronics,* June 26, p. 55].

In even sophisticated devices like light-emitting diodes and liquid crystals, the Poles are also going it alone. One Unitra engineer hints that complementary-MOS devices, now in development, will be available next year. And another says a

Inspection. Polish-designed OS-150 oscilloscope gets final checkout at Unitra. Scope is for use in 0-to-60-MHz range.

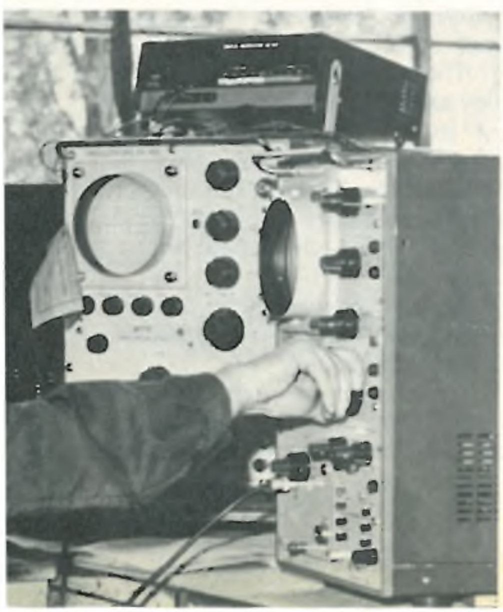
 Circle 70 on reader service card

1-kilobit random-access memory will appear on the scene next year.

Of note, too, is Unitra's expertise in marine-navigation equipment, "in which we believe we can stand up to Decca and other top firms in West Europe," Bilip says. Polish design expertise also comes to the fore in TV sets. Last year, Unitra's 16-, 20-, and 24-inch models were redesigned to mount on a single components-board both ICs and varactor tuners for the uhf/vhf bands. Portable receivers are in the making, and Unitra plans this year to introduce a solid-state version with a 12-inch, 110° tube.

Spending. Much of the Unitra group's past growth of better than 20% a year is attributable to higher consumer spending. And no letup in the Poles' craving for more and more home-electronic products seems to be in sight. Tape-recorder production at the 6,500-man Kasprzak Radio Works in Warsaw will climb from 750,000 units in 1974 to more than 1 million this year; at Unitra's 2,500-employee Tonsil factory in Wrzesnia, output of speakers, microphones, and other electroacoustic devices will rise by another 30% this year.

Also attesting to the Poles' demand for more home-electronics gear is the fast increase in sales of television receivers—both black-and-white and color. The Unitra group's Bilip says production, which is increasing by about 15% each year, is now more than 80,000 sets per month—mostly black and white. As for color sets, 100,000 have been sold since colorcasting was started in 1972. □



Data General president says minicomputer makers must integrate vertically

To **Edson D. de Castro,** president of Data General Corp., Southboro, Mass., the key to survival in the minicomputer business is vertical integration. He says it is vital to keep costs down and meet head-on competition from mainframe houses and microcomputer makers.

Growth in the industry has been rapid. Data General, founded in 1968, is a good example. In fiscal 1974, it had sales of $83,196,000—a 56% increase over the previous year's figure. The company is in excellent financial shape and "well positioned" at both the high and low ends of its product line, says John McManus, an analyst for the Wall Street brokerage firm of William D. Witter Inc.

"We're very enthusiastic about their prospects," adds McManus. "The company will have $40 million in cash by the end of September—that's $4.20 a share, just in cash. He also points out that earnings for the quarter just ended rose 4 cents a share from the similar year-ago period.

But to continue growing will be a big challenge. For one thing, minicomputer firms have moved up in competition: they are producing more powerful computers and software packages, and are taking on the manufacturers of large computers in a competition for commercial installations. Among the systems trying to chew away at the bottom end of the mainframe lines are Digital Equipment Corp.'s PDP 11/70, Varian Associates' V-70 line, Interdata Corp.'s Megamini, and, of course, Data General's own Eclipse 200. And just to make life interesting, microprocessors made by semiconductor companies are chipping away at the lower ends of the minicomputer lines.

In the face of all this, de Castro, a soft-spoken yet articulate executive, is moving his company aggressively to integrate vertically—its moves into the semiconductor field have been successful, and it is pursuing peripherals markets. To get de Castro's views on the outlook for his company, he was questioned by the editors of *Electronics*.

Q. In the last few years, you have added your own core-memory capability and a semiconductor operation. Do you think that minicomputer companies are going to have to have this kind of vertical capability to stay in competition?

A. We feel very strongly that it is important for us to be vertically integrated to be able to keep our costs in an area that will allow us to compete effectively in the marketplace. I feel there's a lot of similarity between the computer industry right now and the auto industry back in the '30s. There were a lot of companies around that made radiators, axles, etc. They've all virtually vanished, and there are several large integrated companies. It's really essential that a company aggressively go after vertical integration.

Q. Is there room for those that aren't?

A. I think that there's room for them in terms of the specialized applications in computers. I doubt there will be in manufacturing of hardware. An enormous number of applications in small computers are fairly specialized. I think that market is best served by the small pseudo-consultant-type companies that take on the job of tailoring hardware to specific needs of an individual industry.

Q. In the minicomputer industry, you seem to have two new major areas of competition—the large mainframe firms are moving downward, and the microprocessor houses are moving upward. How do you compete with the big-computer firms?

A. We're attempting to take advantage of educational developments in computation. Computers have been around long enough that people know now just what they are and how to use them. They don't need as much help or hand-holding as they used to. In addition to that, people are also doing their applications themselves. This class of user is beginning to turn to companies like ourselves to provide tools to solve their problems. In this way, they can save some money, as well as get more optimum solutions to their problems.

Q. What's the biggest drawback for mainframe makers in this competition?

A. They have a problem in that they are all selling things at a different level of service. The performance of their hardware isn't that dramatically different, but they provide the customer with a greater degree of service and charge prices to cover that.

Q. What is happening on the lower end, as far as the microprocessor firms are concerned?

A. I think that the major impact of the microprocessor is going to be in creating new marketplaces. Whether or not we want to compete in that area is still an open question.

Q. What about the single-board computer market? Does it make sense for you to get into the market the way DEC has with the LSI 11—by buying semiconductor parts?

A. I don't know whether we will be in the market at all. But if we are going to be in there, we have to be vertically integrated and produce our own circuits. We wouldn't follow the DEC strategy.

Q. What kind of impact will the semiconductor firms that are making microprocessors have on you?

A. I think that some of the semiconductor firms have indicated they intend to integrate into the minicomputer business one way or the other. I expect that it is possible if they want to and make the appropriate investments and do the right thing at the right point. The semiconductor firms don't have an unusual number of advantages. The fact that they produce semiconductor parts is probably useful at the very low end, but as you move beyond that, it becomes a very minor part of the system.

Q. If semiconductor firms don't have unusual advantages, what advantage do you get from making your own semiconductor parts?

A. I didn't say there was no advantage. I said there were a whole lot of things you have to do. Making semiconductor parts is interesting to us, but so is making peripherals, and so is developing software.

Q. What kind of new-product trends do you expect in the next year?

A. I think that the market will continue to grow in a multitude of directions. Obviously, there's a move into more sophisticated equipment. There's a clear move into lower-cost equipment and more sophisticated system software. A lot of attention is being given to developing peripherals.

Q. Finally, how is your development effort coming along on a point-of-sale system for supermarkets? How good will that market be for Data General?

A. We're ready to go, so far as marketing is concerned. We don't expect it to be a large part of the company's business, but it certainly is an interesting area. □

Will standard cure pacemakers' ills?

by Larry Marion, Washington bureau

Manufacturers of cardiac pacemakers, working at the Federal Government's request, are close to agreement on a set of performance standards for their devices. Action on the standards, which have gone through three versions since work started on them a year ago, has been spurred by a flurry of pacemaker recalls, and some deaths and injuries laid to malfunctioning units. The action also comes in anticipation of Congressional passage of a law regulating pacemakers.

How far will any standards go toward altering pacemaker design? Not very far, say industry officials. They estimate that there will be no change in 90% of the designs. Rather, standards will set out general test methods and require more information to be inscribed on the units. In any event, the standards now being reviewed by manufacturers wouldn't be issued until the first of next year at the earliest, says Robert Cangelosi, director of the Federal Drug Administration's Medical Device Standards office.

What could have a greater effect on pacemakers—if not on design, then certainly on manufacturing—are upcoming Federal rules called Good Manufacturing Practice codes. These codes, based on company-supplied proposals, will dictate for the first time detailed quality-control procedures for components and completed pacemakers. And it is in that area—quality control and testing, rather than design—where most troubles lie.

Victims? David Link, director of the FDA's bureau of medical devices and diagnostic devices, says that manufacturers of pacemakers were "victims of bad parts."

Pacemaker manufacturers apparently don't have too much experience testing high-reliability electronic components. In fact, the FDA has asked the National Bureau of Standards for help because of the bureau's experience with such tests. In response the NBS will hold a workshop for manufacturers on July 28 and 29 to teach techniques used elsewhere, such as the Air Force, to test hi-rel parts. Harry Schafft, NBS program coordinator, who toured the pacemaker manufacturing facilities, says that reliability testing is the top problem at those plants.

Most pacemaker manufacturers are reluctant to discuss publicly problems that have caused them to warn doctors of possible malfunction of more than 20,000 units since 1972, according to FDA statistics, but FDA reports show that possible failure of electronic components caused at least 75% of the recalls. FDA commissioner Alexander Schmidt counts 26 deaths and hundreds of injuries from faulty units since 1972, including two recent fatalities [*Electronics*, May 29, p. 60]. A 1969 study by the FDA, the first review of medical-device failures, attributed 89 deaths and 186 injuries from 1960 through 1969 to faulty pacers.

Parts. Cordis Corp. of Miami, the second largest manufacturer in a $100 million annual market, has warned physicians about possible failures in 17,500 units, although "less than 3% actually failed," says an FDA official. Suspected moisture in transistors supplied by Fairchild Camera and Instrument Corp.'s Semiconductor Components group and moisture-vulnerable resistors supplied by C.T.S. Berne Inc., Berne, Ind., were cited by FDA officials as examples of component failures [*Electronics*, April 3, p. 41]. David Link, FDA's director of medical-device regulation, says that Cordis and other manufacturers "were victims of bad parts."

Don Stone, vice president for product assurance and regulation at

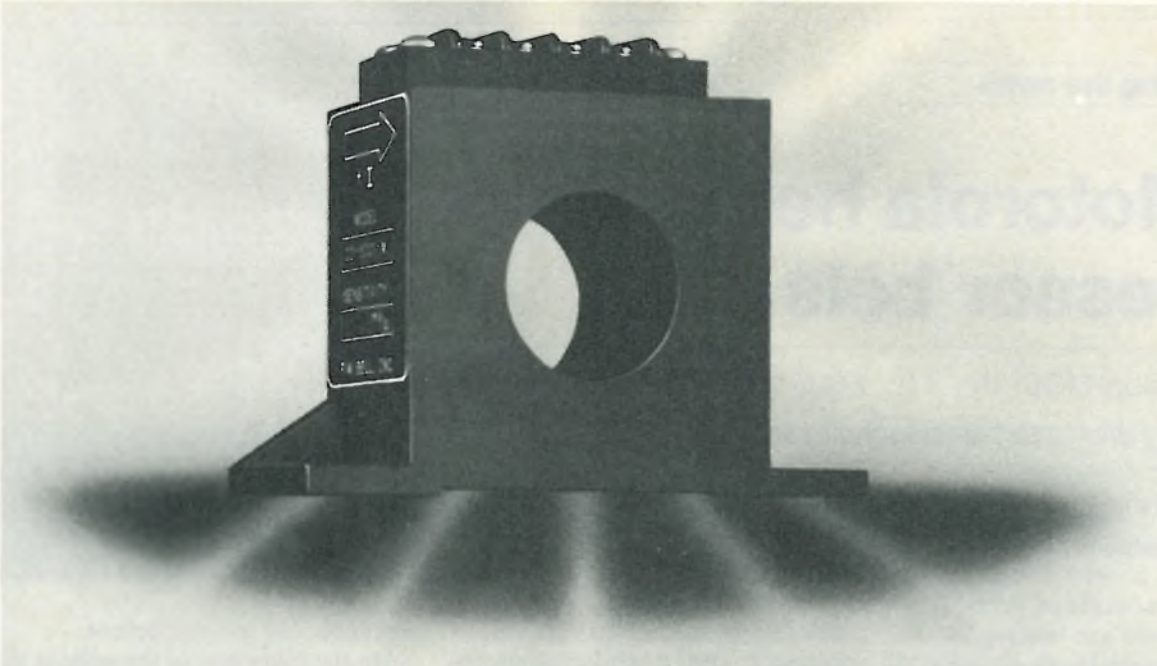
Medtronic Inc., Minneapolis, says that all circuits are tested before being inserted in his company's devices. Medtronic, which has about half the annual sales, is considered the leading U.S. manufacturer. "It is exceedingly important to have good control over how a pacer is put together."

Pacemaker manufacturers, who cite the lessons learned in the past as evidence of their vigilance, say that the current crop of units is exceptionally safe and reliable. "Pacemakers are better than ever," notes FDA's Schmidt, while Saul Aronow, chief electrical engineer at Massachusetts General Hospital and member of the industry-standards panel, says, "pacemakers are almost foolproof. Improvements are now hard to come by because units are so good." But significant problems, such as lead breakage, poor battery life, and electromagnetic interference cropped up in the early 1970s, he says.

Authority. Explicit authority for the FDA to require good manufacturing practice codes, premarketing clearance, and enforce performance standards are contained in legislation passed by the Senate in April but waiting for House action. The Senate version would require premarket clearance for all implantable devices, plus others which "support or sustain" human life.

Still, there probably always will be human error of the sort that occurred in June, when Medtronic was alerted that three faulty pacers, rejected from its assembly line, had been shipped to physicians and implanted. A doctor discovered a failed unit while the patient was still in the hospital, removed it and sent it back to Medtronic.

Medtronic discovered two other rejected units had been shipped to doctors and notified them to remove the units. No injuries or deaths resulted, a Medtronic spokesman says, but the incident shows how extensive quality control and production precautions can be defeated. Yet manufacturers, trade association officials, and U.S. regulators agree that the level of risk is "acceptable." □



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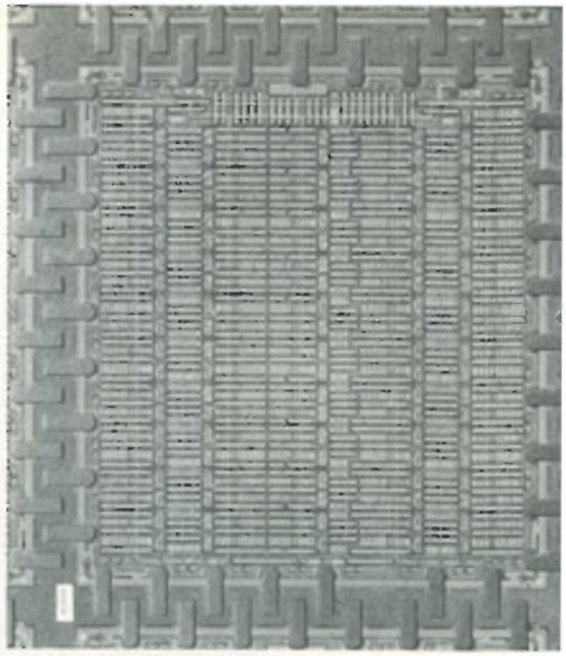
TI, Motorola hedge processor bets



Giants develop MOS, I²L, TTL, ECL, transistor-coupled logic as they aim to supersede their own hard-wired logic

by Larry Armstrong, Midwest bureau manager

Most semiconductor makers have paraded out a microprocessor or two in the past couple of years. Now two of the giants are beating all the technology drums in an attempt to make their own hard-wired logic families obsolete—before someone else does.

Both Motorola and Texas Instruments have introduced MOS devices—apparently to fill an immediate need in memories and their peripheral circuits. But, since neither firm wields a particularly strong MOS weapon, their efforts are concentrated on newer and higher-technology products that they regard at least as partial replacements for the hard-wired bipolar families they dominate—transistor-transistor and emitter-coupled logic. And while TI has retooled what it has, Motorola has chosen to develop new families.

TI is playing the microprocessor game unusually close to the vest. But it plainly sees the devices as the next wave of digital design and has produced devices to handle all jobs. "We have three products which have unique characteristics that justify their existence from a marketing point of view," flatly states James Huffhines, manager of computer-market development for the Dallas firm. Two of them, the TMS-1000 and TMS-8080, are MOS products that don't push the state of the art, either in technology or support.

Dramatic. But TI's dramatic entry into the microprocessor race is the SBP0400, a 4-bit slice through the arithmetic/logic unit and register of a microcomputer, implemented in integrated injection logic. The full-temperature, low-power chip can operate in parallel and it is microprogramable, so the user can emulate machines with existing software bases. The SBP0400 is aimed at the minicomputer and peripheral-equipment manufacturers.

Instruction execution times are now about a microsecond, and Huffhines admits there's a need for a higher-performance device from TI. Such a device is forthcoming, he asays. A Schottky T²L-microprocessor slice is in the works.

The TMS-1000 is a programable p-MOS 4-bit microcomputer spun off the firm's calculator-chip activity [*Electronics*, Nov. 28, 1974, p. 48]. "It's angled at the high-volume application where low cost is the prime concern," Huffhines points out.

Controller. For controller applications, TI has opted to leave market development and software support of its bigger, faster microprocessor to Intel Corp. of Santa Clara, Calif., and is second-sourcing the Intel 8080. TI does, however, plan peripheral support.

"It's clear that the road to higher performance is I²L, and it may be the lowest-cost solution to the highest performance—better than Schottky," notes Edwin S. Huber, the firm's marketing manager for MOS—not a wholly disinterested party. "But the road to higher complexity is not clear; it may be MOS."

Software. On the other hand, Motorola's approach to the MOS end of the microprocessor business requires a good deal of software support, implying a solid commitment to the product. Its M6800, a proprietary 8-bit device with a fixed instruction set, is aimed at such low-speed applications as point-of-sale terminals and test equipment.

On the other end of the scale is its extremely fast M10800 4-bit slice and accompanying chip set, built from ECL. Motorola is touting that processor, to become available early next year, as an enhancement to its MECL 10K family. "We realize that it will start replacing some of the MSI in some systems," concedes William Blood, manager of system-logic development at Motorola Inc.'s Semiconductor Products division. He points out, however, that the microprocessor will require many standard ECL parts, such as memories and register files, and 10K MSI can also be used to tailor systems around the LSI-chip set for such tasks as hard-wired fast multiplication.

"But there's definitely a gap between the M10800 and the M6800, and a very large gap, as far as we can see," says Jim Loro, the firm's bipolar-LSI planner. Gate delays for the ECL part are 2 to 5 ns, and they're about 50 ns for the n-channel 6800. "The solution is to evolve some bipolar microprocessor that would fit into the Megalogic family."

Mixed bag. Megalogic is the new name for a mixed bag of TTL-compatible technologies at Motorola. Implemented now only in hard-wired form, "it's primarily directed at the low-cost I²L market, for people that don't need the performance of I²L but need something faster than MOS," he says. The principal technology to date has been transistor-coupled logic. □

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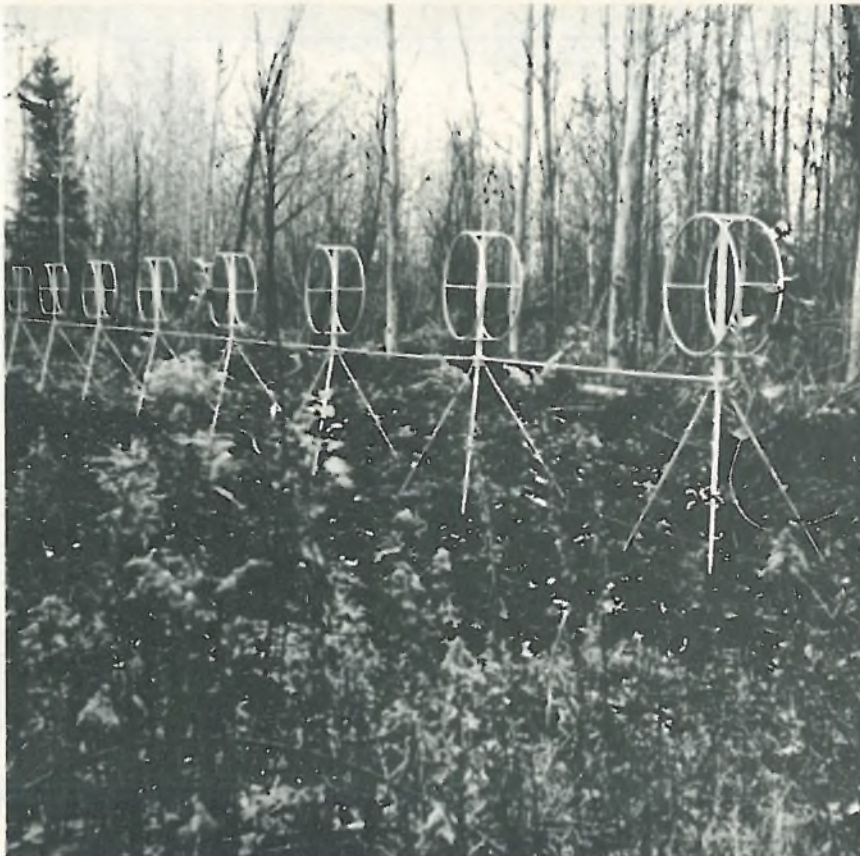

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THE NEW LSI

Bipolar chips are best buy for designers of fast systems

by Laurence Altman, Solid State Editor

☐ Wielding a variety of new weapons—from circuit forms like integrated injection logic to processing enhancements like ion implantation—semiconductor manufacturers have fought their way to high-volume production of highly complex bipolar chips. Not only do these chips each contain thousands of logic gates or tens of thousands of memory bits—they also far outperform their predecessors. And this formidable array of bipolar LSI circuitry is arming today's designer of high-performance computers, computer controls, and other digital systems with the power of buying the hardware he needs at a price he can easily afford.

In performance, bipolar large-scale integration takes up where the metal-oxide-semiconductor techniques leave off. It achieves propagation delays of 50 nanoseconds per gate and better, at power dissipations of 1 milliwatt per gate and below. Consequently, the bulk of today's real-time transistor-transistor-logic applications can be realized with microprogramable LSI circuits that per system function now cost 10 to 100 times less than the standard TTL-package approach.

How cheap?

Figure 1, which compares bipolar and MOS prices over the years, defines just what the new bipolar LSI means in terms of price. The most important point it makes is this: in their new LSI format, regardless of the particular bipolar technique used, bipolar circuits are beginning to track MOS prices. This is a wholly new phenomenon. Till now, prices of small- and medium-scale integrated bipolar chips have simply leveled off at each stage in their maturation, the SSI gates bottoming out at about 20 cents each and the MSI ones at 15 cents.

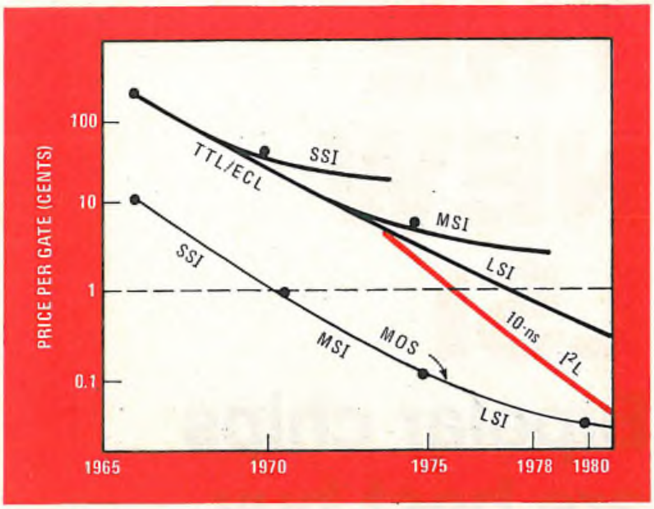
The reason gate prices are dropping so swiftly is, of course, not just the attainment of LSI but the attainment of LSI at high yields. When thousands of circuit functions can be laid down on one chip, and when that chip can be manufactured in quantity, the cost of the individual function plummets.

MOS has a parallel history. Once it achieved LSI status in 1971, prices plunged, and by now a 3,000-gate calculator chip sells for less than $2, or less than 0.1 cent per gate, while a 4,096-bit memory will shortly sell for less than $4, or 0.1 cent per bit.

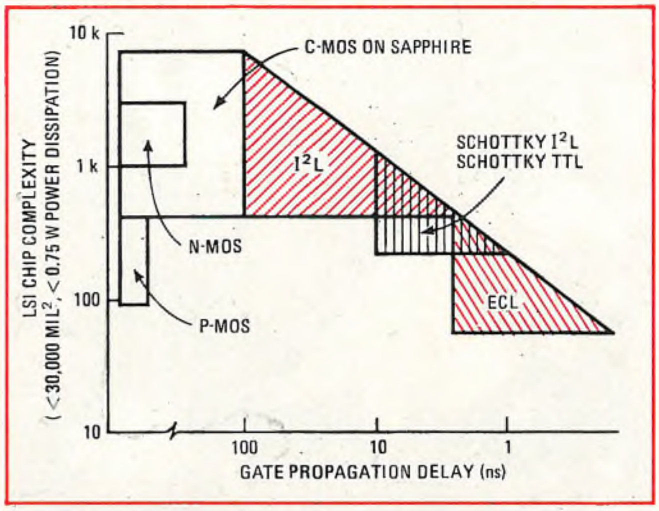
Now, suppose that even the new LSI TTL and emitter-coupled-logic gates remain 10 times more expensive to build than equivalent MOS gates. (And this is definitely a worst-case assumption, since even conventional bipolar structures are not 10 times more complex to build than MOS gates.) Then the indications are, simply tracking the MOS experience, that the industry will attain penny-a-gate costs over the next two years. And, as a widening range of manufacturers becomes experienced in producing the new TTL and ECL LSI designs, the trend can only accelerate.

What penny-a-gate LSI logic with TTL performance means to the logic system designer is almost awesome to contemplate. Consider this: a full-performance 16-bit parallel-processing minicomputer carrying, say, 32 kilowords of memory and equipped with all the features (flag interrupts, direct memory access, carry look-ahead capability) now costs anywhere from $10,000 to $25,000 in medium volume, depending on its add-on capability and how much software it needs to handle. It's expensive because it's almost handmade—it needs about 500 circuit packages for the processing logic alone—and it remains expensive because its hardware and assembly costs are too high for it to be sold in high volume.

Now an equivalent TTL design with penny-per-gate prices will knock the hardware costs down by more than



1. Economical. Injection logic is the cheapest way of achieving high performance across the board. Using standard bipolar technology, I²L gates should break the crucial 1-cent-per-gate level this year and reach the 0.1-cent-per-gate level of MOS in 1980.



2. The best for the most. Of the three approaches to bipolar LSI, I²L handles the greatest range of applications—from 100-ns to 1-ns gate propagation-delay times. Schottky TTL and ECL overlap at the fast end, and n-MOS technology takes up the slow jobs.

an order of magnitude. Extrapolating from loose MSI and SSI designs, a 16-bit LSI processor function should require about 6,000 gates to realize. If so, at a penny a gate this single chip will cost no more than $60—that's for the entire processing block of logic. Add to this some input and output capability (say another 1,000 gates) at about $10, and 32 kilowords of memory (256,000 bits) at $256, and the hardware costs total less than $350.

Assuming the manufacturing process multiplies the hardware costs by an extravagant 10, this TTL/LSI design will cost less than $5,000 to the user. Yet it is a full-performance computer capable of controlling, say, a 32-channel real-time on-line chemical processing system, or handling the multicode levels of a secure military communication system, or processing the entire payroll of a 5,000-member organization.

There's no doubt that this type of device at these prices will cause an explosion of the medium- and high-performance computer and data-processing markets. A $2,500 16-bit mini, or a $5,000 32-bit midi—these prices will really push digital and computer control technology into every corner of industry. Again, the key is not just low cost, but high circuit performance at low LSI costs. Remember, most computer applications are still in the traditional TTL range of 100-ns instruction times, and it's this performance level the new LSI is challenging.

To put it another way, the new LSI will make computer manufacturing a mass-production industry. The fact is, excluding microprocessors, only 45,000 computers have been installed in this country since 1960 and that's not even one day's wafer run for a modern semiconductor facility. LSI means mass production, and bipolar LSI means low-cost computer and computer controls.

Enter I²L

Exciting as is the prospect of a penny-per-gate computer logic, some observers see even this goal as modest in the light of the capability of certain new LSI techniques. What they are stirred by is integrated injection logic. Indeed, when an optimized injection logic circuit form is successfully applied to processor- and memory-type devices, according to the recent experience of some bipolar integrated-circuit manufacturers, I²L becomes both a truly high-performing 10-ns technology and a manufacturing process that costs as little as (or less than) MOS. This is because of 10-ns I²L gate can be built with a straightforward four- to seven-mask process (MOS, fully loaded, also takes seven), dissipates less than 0.1 mW of power (as against twice as much for MOS), and occupies a third the area of today's typical MOS gate. Contrary to popular belief, no complicating Schottky clamps are required to get this performance. In short, the use of two or three implant steps, and only four masks, will make a 10-ns LSI logic form available that could cost 1/100 of today's bipolar gates.

The colored line in Fig. 1 projects I²L gate costs to 1980. Penny gates can be expected by the end of 1976 and half-penny gates by 1977–8. Whether I²L will ever catch the moving MOS target of course is conjecture, but if the I²L experience pans out the way some think, the end of the year may see 4-k I²L random-access-memory chips with less than 80-ns access times, as well as 16-bit I²L microcomputer chips—that is, the central processing unit, read-only memory, and input/output circuitry all on one chip.

The performance range

This bipolar activity has a wide spectrum. It breaks down into three performance categories (Table I):

- 100–25-ns gate propagation delays. This performance characterizes today's bit-slice I²L processing circuits and collector-diffusion-isolated circuits where, say, a 4-bit parallel-processing chip dissipating less than 0.5 watt can execute a microinstruction cycle in 0.5 to 1 microsecond (or a simple add in less than 1 μs). It's the speed of today's stand-alone control and data-processing equipment for non-real-time operation. Such performance is also useful for monitoring jobs, such as automobile engine and instrument data management, as well as telephone controls, analog-to-digital conversion, and data switching systems.

- 25–10-ns propagation delays. These suit the high-speed controls and general-purpose data-processing equipment that need to execute an instruction in 50 to 100 ns. Here, ion-implanted versions of I^{2}L are being developed, as well as Schottky I^{2}L and TTL, complementary constant-current logic (C^{3}L), and ECL built with a triple-diffused process. This is also the performance range of mainframe memory controllers and many real-time military signal processing applications that are considered beyond the range of MOS techniques.
- Finally, 10–1ns propagation delays, the highest LSI performance range, where ECL and fully implanted low-power Schottky are taking hold. At these speeds, processor circuits can handle real-time signal processing and control the fastest mainframe memories.

The technologies compared

These performance regions are principally being addressed with three bipolar techniques: some form of non-Schottky injection logic; Schottky TTL and Schottky I^{2}L, and emitter-coupled logic. The interrelationship of these techniques is shown in Fig. 2, where they are also contrasted with today's MOS.

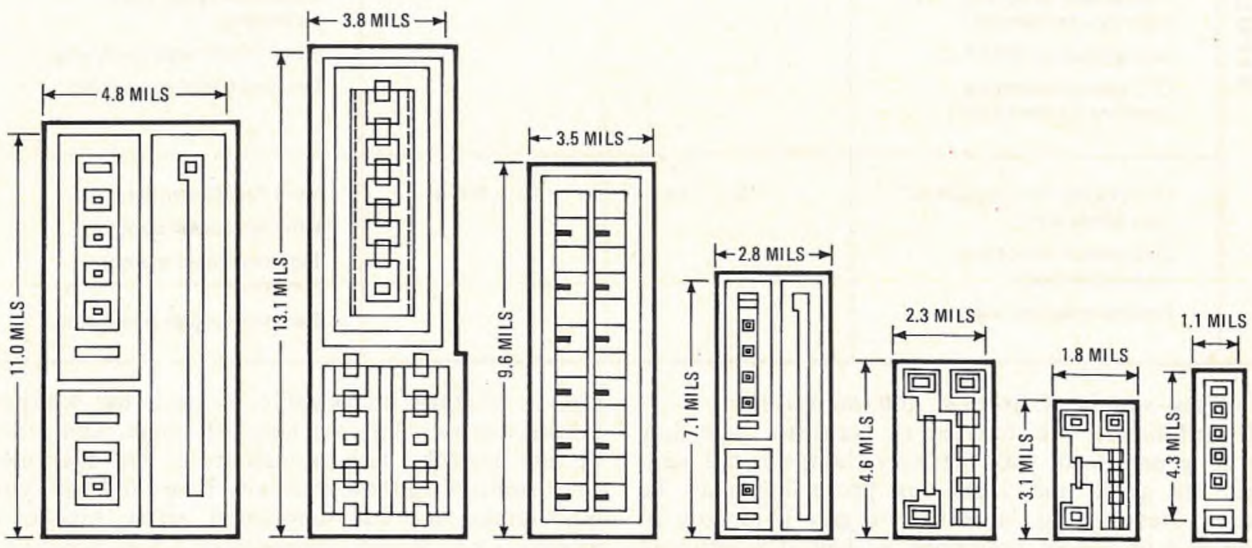
Clearly the broadest range of applications belongs to injection logic, since it can achieve speeds of 100 to 10 ns on chips containing 1,000 gates or more. Being roughly the application area of today's TTL circuits, these figures indicate that today's hardwired TTL designs will soon be replaced with microprogramable I^{2}L designs costing much less.

It's also evident from Fig. 2 that I^{2}L circuits can be much denser than the other mainline bipolar technologies, like ECL or Schottky TTL. The basic cell structure both is smaller and dissipates much less power—a matter of microwatts per gate for 100-ns operation. Figure 3 presents the layouts of elements, four gates wide, built with the various technologies.

Indeed, compared to a standard TTL gate, an I^{2}L gate is less than 1/10 the size and dissipates 1/100 the power. It's also even smaller than the smallest silicon-gate n-MOS structure and, more importantly, can be built with only four masks and two diffusions, as against seven and three respectively for n-MOS. In short, I^{2}L appears to yield the smallest circuit form known today—and it may also prove to be the cheapest.

The regions where I^{2}L performance intersects with that of other techniques are, of course, at the low end and the high end. At the low end, at propagation delays slower than 100 ns, MOS will continue to dominate because it's so well established. At the high end, faster than 10 ns, 4-bit-processor chips are now being built in low-power Schottky LSI designs. To achieve an equally good performance range, I^{2}L circuit designers will probably also have to resort to using Schottky clamps, as well as double levels of metalization. The problem is, will this additional process rob the basic I^{2}L process of

COMPARISON OF 4-GATE-WIDE ELEMENTS



	STD TTL	C-MOS	ECL LSI	SCHOTTKY LSI	P-MOS	SG-NMOS	I^{2}L
COMPONENTS	3	3	3	3	2	2	1
GATE AREA (IN SQUARE MILS)	52.8	49.8	31	19.9	10.6	5.6	4.8
MASK STEPS	7	6	7	7	4	7	4
DIFFUSIONS	4	3	4	4	1	3	2

3. Minimum. The I^{2}L gate is the smallest that can be built with any of today's circuit techniques, including MOS. It also is the simplest to fabricate, needing only four masks and two diffusions. For highest performance, another diffusion is needed for Schottky structure.

TABLE 1: PERFORMANCE COMPARISON OF BIPOLAR AND MOS LSI PROCESSORS

	LSI Technology	Gate Propagation Delay	Microinstruction Time	Applications
	Bulk standard p-MOS	< 1 μs	100 μs	Calculators micro controls.
MOS	n-MOS (1974) C-MOS (1974)	< 100 ns	1 – 10 μs 2 – 10 μs	Medium-speed and non-real-time data processing. Analog-to-digital conversion. Consumer controls (white and brown goods, household). Low-speed monitor (auto, etc.) High-speed calculator.
	n-MOS (1975) C-MOS-on-sapphire I^2L (non-ion-implanted) CDI (collector diffusion isolation) RTL (resistor-transistor logic) 3D EFL (triple-diffused emitter-follower logic)	100 – 25 ns	0.5 – 1 μs	Stand-alone control. Slow real-time processing. Fast a-d conversion. Fast monitor (auto engine, etc.) Telephone terminal processing. Switching controls. Instrument management.
BIPOLAR	I^2L (ion-implanted) Low-power Schottky TTL (non-ion-implanted) Ion-implanted 3D EFL C^3L (complementary constant-current logic)	25 – 10 ns	50 – 100 ns	High-speed controller. General-purpose data processing. Small mainframe controller. Delayed signal processing.
	I^2L (1976) (ion-implanted plus Schottky) Low-power Schottky (ion-implanted) Emitter-coupled logic	10 – 1 ns	10 – 50 ns	Very fast controller. On-line process control. Big mainframe memory control. Real-time signal processing.

its virtues—simplicity, low cost, and small size?

Unfortunately, the inverted I^2L transistor type may not be as easy to fit with Schottky clamps as the standard TTL gate, and ingenious processing may be needed. Nevertheless, since the I^2L gate is already so small and its power dissipation so low, it might well prove capable of absorbing the added structures and extra processing steps and still end up smaller than a low-power Schottky TTL gate.

The tradeoffs between the two approaches are of course being pursued at the large bipolar design centers. These include TI, Motorola, National, Fairchild, AMD, MMI, IBM, Bell Labs, Siemens, and Philips, all very experienced in building all types of bipolar logic.

Another overlap in performance occurs at the 1-ns interface between Schottky TTL and ECL. Here the question is whether it's possible to push the low-power Schottky process into the 1-ns ECL range. And it might be just possible, with enough tricks like micrometer-deep emitters and low-resistivity bases and with circuit innovations like fully-implanted active bipolar elements. TI has already demonstrated 1-ns Schottky SSI devices [*Electronics*, Dec. 12, 1974, p. 29] but at some cost in gate power. Still, ECL's LSI limitation also is high power consumption: a 4-bit ECL slice consumes more than 1 W and requires a special package.

In any case, 3- to 5-ns Schottky LSI chips are certainly within range of today's techniques and most probably will appear in 4-bit-slice formats by the end of the year. These will surely compete with the ECL processor slices that are just not becoming available. Below 1 ns, of course, unsaturated ECL has no rival.

Who's doing what in bipolar LSI

Hardly surprising, the old-line bipolar-integrated-circuit manufacturers are the ones on the leading edge of bipolar large-scale integration. Although much of their work is still hidden in laboratories, enough is known to indicate the types of technology being developed and the kinds of products each will yield. So here's a roundup of what's pretty certainly happening at the four largest bipolar houses and a selection of smaller ones:

Texas Instruments: The activity here is intense, both in integrated injection logic and fast forms of Schottky transistor-transistor logic, the aim being to leapfrog MOS circuit capability. TI was the first to announce an I^2L microprocessor and has already developed second- and third-generation I^2L circuit designs that perform more than twice as well as the original 4-bit processor slice.

TI's newest version of the I^2L process uses a fully implanted I^2L structure that has no need of Schottky devices. It results in gate delays of 10 to 20 ns at injection currents of less than 100 μA—figures that translate into 4-bit processor slices capable of executing instructions in 100 ns while dissipating well below 0.75 W per chip. Also, a 16-bit microcomputer chip containing everything but the storage memory—that is, the central-processing unit, control memory, and input/output interface circuitry—could be realized with this new I^2L form.

Also possible with advanced I^2L are high-performing bipolar memories, a project to which the company is also deeply committed. In fact, a 4,096-bit I^2L random-access memory may well emerge before next year.

On the Schottky TTL front, TI has made rapid progress on an ion-implanted minimum-geometry process (Schottky II) that extends TTL capability into the 1-ns range. TI, which as a company is committed to Schottky TTL in preference to ECL, has already made available the first dozen or so parts of a 30-part family and should introduce the central element, a 4-bit Schottky slice, in a few months. Processor performance here will be well within full minicomputer capability and may actually be high enough to achieve the next level of system performance—in the IBM 370 class. Cycle times of less than 50 ns are expected.

Motorola Semiconductor. Another champion of the bipolar market, Motorola, like TI, has moved quickly into LSI. While developing several forms of injection logic, Motorola also has programs in proprietary logic designs.

Motorola already has exploited its strong ECL capability with the industry's first ECL 4-bit processor slice. All the details are not yet disclosed, but it's known that the 750-gate chip dissipates about 1.3 W and therefore requires a new high-power package. Nevertheless, the big 80-pin package occupies no more board space than the standard 40-pin DIP because its pins are in pairs of offset rows. The part will be available in about 12 months and, together with a variety of ECL companion processor parts, will form a new ECL LSI logic family.

Motorola also has developed an injection-type logic it calls complementary constant-current logic, or C^3L, for the TTL (10-to-50-ns) application range. This logic form is complicated by five Schottky devices in each gate, but it pays off in compact LSI processor circuits. Although no marketing plans have been made, it's possible that a C^3L processor slice could be built by the end of the year.

Another Motorola circuit form is a triple-diffused (3D) emitter-follower logic that the company licenses from TRW Corp. Motorola views the 3D technology as suitable primarily for military computers and intends to build a set of fast signal-processing chips for airborne equipment.

Motorola has also developed a set of LSI circuits it calls Megalogic. This bag of mixed-technology computer elements includes low-performing RTL 400-gate arrays, injection logic, and various memory circuits. Designed to operate at 50–100-ns, the family could grow to as many as 50 circuit elements over the next few years.

Fairchild Semiconductor. Its move into bipolar LSI centers around a new family of Schottky TTL processor and memory circuits called Macrologic. This family, which could number about 20 circuit types, could include oxide-isolated memories to gain a performance edge over similar Schottky TTL circuit types. The company has already introduced a half-dozen Macrologic circuits and plans to fill out the rest of the family over the next 18 months. The performance range (100-ns instruction cycle times) easily satisfies today's minicomputer requirements.

it also appears that Fairchild will develop a Macrologic ECL line, but details are lacking at this time. Once again, since ECL uses high power, a new LSI format may have to be found before high-density ECL chips can be implemented.

An aggressive program at Fairchild involves injection logic. Already plans have been made to market an I^2L watch circuit, and I^2L microprocessors and memories are well advanced. Here again the company is exploiting its strength in oxide isolation and ion implantation. A 4-k oxide-isolated I^2L RAM is expected at any time (access time under 100 ns). What's more, an I^2L microprocessor is within reach, probably a 16-bit chip, so as not to compete too strongly with Fairchild's own 8-bit n-channel MOS microprocessor system.

National Semiconductor. Although possessing formidable bipolar capability, National Semiconductor's LSI plans are not at present visible. However, the company has indicated its intention of rebuilding its 16-bit p-MOS IMP microprocessor in LSI form using Schottky TTL, and as an intermediate step it will introduce the product in standard small- and medium-scale integrated packages. Undoubtedly, National also has a strong program in I^2L, both for memory and logic, but again it has not indicated at what stage those developments are.

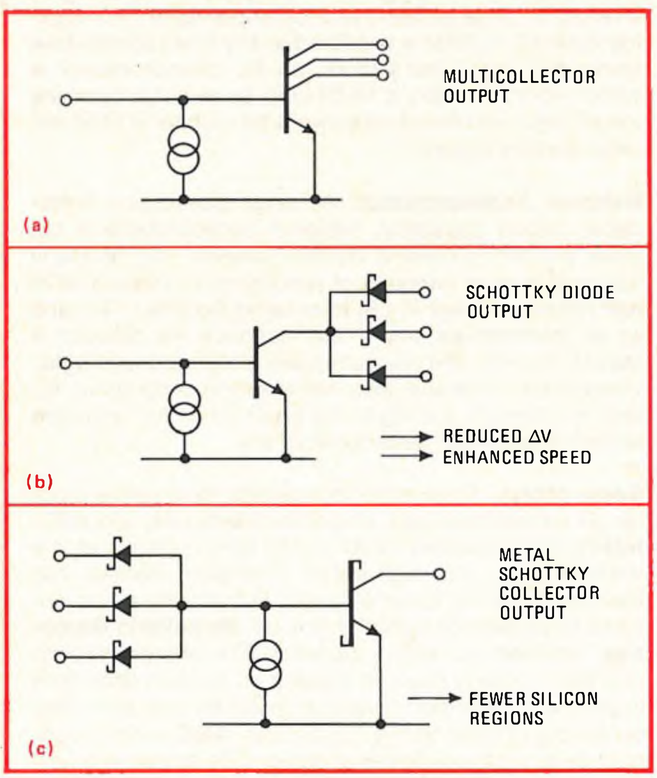
Some others. Three other companies have visible bipolar LSI capabilities: Intel, Monolithic Memories, and AMD. **Intel's** 2-bit Schottky slice 3,000 family, aimed at the minicomputer and high-speed controller market, has been available for about a year. It is built with a conventional low-power Schottky technique. **Monolithic Memories** was first out with a Schottky TTL microcontroller, and the company plans to expand its product lines both in programable logic arrays and matched emulation sets consisting of three to five LSI circuits. **AMD** will soon announce its 4-bit low-power Schottky slice as part of a new family of bipolar LSI circuits. This family is aimed at the high-speed stand-alone controller market and at minicomputer emulation designs.

THE NEW LSI: PART 2

Injection logic's range of applications is widest

Integrated injection logic is easily the most versatile and potentially the most explosive of all the different bipolar LSI processes now in use. Unlike TTL, ECL, C^3L, current-hogging logic, T^3L (an extra buffer stage), EFL, triple-diffused logic or current-mode logic, I^2L combines two very desirable properties: it is very simple to build and, if the designer knows what he's doing, it can be very fast. No wonder it attracted the attention of the most creative minds in the semiconductor industry when it first became known in 1972.

Even so, the speed with which I^2L circuits were brought into production was astonishing. It took less than two years after their introduction at the International Solid State Circuits Conference for a full 4-bit I^2L microprocessor to come on the market [*Electronics*, March 6, p. 100]. Since then, improvements in fabrication techniques (minimum-circuit geometry and ion-implanted active elements) have upgraded performance till the I^2L circuit form is the equal of any other saturated bipolar technique.



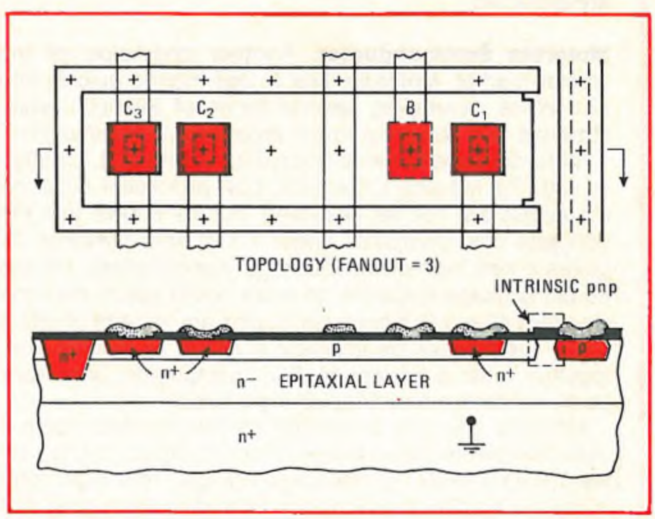
4. The forms of I^2L. Injection logic can be built in three forms: the standard-multicollector I^2L gate (a), the Schottky-diode output device (b) and its ultimate configuration, a pure metal Schottky collector (c). The last is fastest and smallest and comes from IBM.

The simplicity of the I^2L inverse-transistor gate had many designers fooled at first. Granted the device was small and dissipated very little power, but still, how could such a simple circuit be fast? Many said its performance would be limited to 50 nanoseconds at best, which made it only marginally better than existing n-channel MOS technologies and 10 times slower than existing TTL circuits.

These fears have now proven groundless. Even without Schottky clamps on the I^2L gate structures, propagation delays down to 10 ns at injection currents of 100 microamperes are now being routinely obtained, and this gate performance is comparable to that of standard TTL gates. By using Schottky clamps, the I^2L structure, although now more complicated, can be pushed down to 5-ns speeds, and possibly to as low as 1 ns, making the structure as fast as today's low-power Schottky TTL gates. Yet it still remains 10 times smaller and consumes 100 times less power than Schottky TTL.

The gate analyzed

The simplicity of the basic I^2L gate is evident from Fig. 4, which presents schematics of a conventional I^2L gate (a), a Schottky I^2L gate (b), and—most elegant of all—an advanced pure-metal-Schottky design proposed by IBM (c). In all three cases, the basic logic unit is simply an inverter, implemented as a multicollector transistor or, in other words, a conventional multi-emitter transistor operated inversely. Base drive to the npn ele-



5. Easy to make. Schottky I^2L logic unit from Bell Laboratories is for a fanout of 3. It is fabricated with the aid of a minimum of selective diffusions—p-type for pnp emitters and collectors, n-type for collector contact, and an n^+ emitter diffusion for npn outputs.

ment is supplied from the collector of a lateral pnp transistor operating in a current-source mode. The emitter of this lateral pnp serves as the gate injector. There are no resistive loads to waste chip space.

The I²L gate is small because it reduces to the size of a single transistor when laid out on silicon. All transistors are fabricated in a single n-type region into which are diffused a standard p-type (conventional npn base) region and an n+-type (conventional npn emitter) region. But to capitalize on these advantages, inverse transistors had to be built that were as good as the ones operating in the forward mode.

The basic structure derives much of its appeal from the fact that a multiplicity of npn inverters may be powered from a single npn emitter or injector, which then distributes current to all the units that form its multicollectors. Consequently, it's possible to guarantee that current is evenly distributed simply by ensuring uniform injection at the pnp and npn emitter connections—a condition easily satisfied by today's fabricating techniques. Together with high npn inverse gains (which in a conventionally operated npn transistor means forward gains), this even distribution of current prevents one output from hogging electricity that should go to adjacent saturated outputs. (Current hogging plagued the generically related direct-coupled transistor logic and helped it lose favor in the 1960s.)

Once the I²L gate was optimized, with or without Schottky clamps, all the elements required for conventional logic functions followed. NAND logic implementation was achieved by simply wire-ANDing the outputs from various I²L gates at the input mode of an adjacent gate. This unit then performs the inversion and makes the NAND function available at its multiple outputs to be similarly wire-ANDed at the next inverter. Therefore, not only is the gate structure itself no larger than a single minimum-geometry transistor, but precious chip area is saved during each NANDing step: the strings of I²L gates multiply the area saving as they are cascaded, resulting in truly compact logic chains.

Again, I²L can be built using all the technology advances that have been made in bipolar circuit fabrication over the last five years—Schottky clamps, standard buried collectors, minimum-resistor bases, shallow emitters, and so on. The point here is that this powerful and impressive set of technology advances, when united with the simplicity of the I²L circuit, produces truly exciting performance.

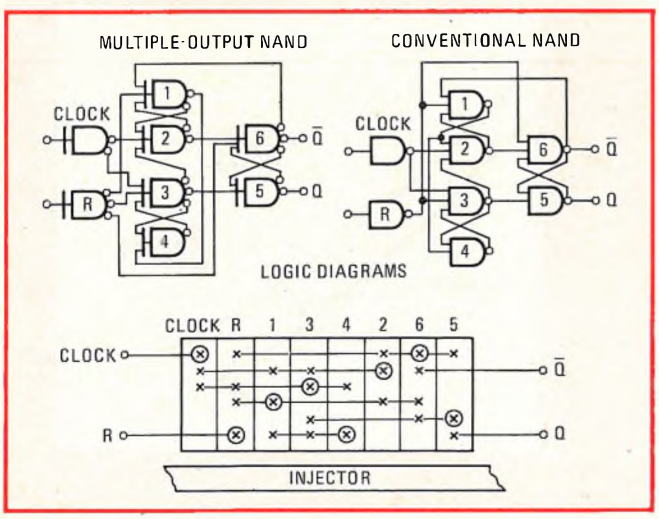
Rivalling TTL

For example, the simplified I²L process, which includes neither the n-type buried-collector-plug diffusion required for Schottky clamps nor the p-type isolation diffusion required for oxide-walled devices, still yields devices capable of the 10-ns performance typical of the bulk of today's bipolar applications. This makes the basic I²L structure the simplest means yet of obtaining such a speed.

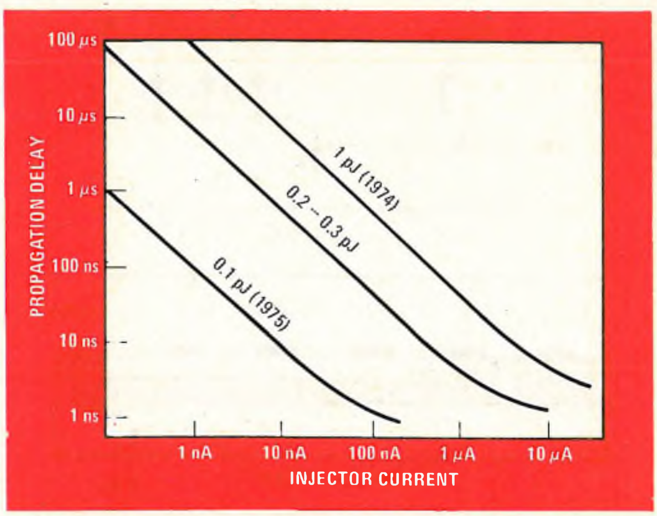
The topological simplicity of a logic unit with fanout of 3 is evident from the Bell Labs structure shown in cross section in Fig. 5. The logic unit is formed in an n-type epitaxial layer over an n+ substrate or buried layer. Three selective diffusions are then used in the formation of the unit. A p-type base diffusion forms the emitter and collector of the lateral pnp transistors as well as the npn bases. An n+-type collector-contacting diffusion compensates the base diffusion where they intersect, separating the logic units electrically and forming the multicollectors of the lateral npn transistor. An n+ emitter diffusion forms the outputs of the vertical npn transistor. Standard contact window and metalization operations complete the process.

Note that because of the merging of the transistors in the unit no wiring is required within the cell, and all wiring is of the between-cell variety, passing directly over the unit. Also, only M + 1 contacts are required to form a unit with a fanout of M. These factors, along with the absence of resistors, contribute to the high packing density which can be achieved with I²L.

The D-type flip-flop in Fig. 6 (again from Bell Labs)



6. Less wiring. D-type flip-flop from Bell Labs requires no contacting between cells. This is because logic units in the configuration abut one another adjacent to the injector rail and can therefore be placed automatically in the six available wiring channels.



7. Looking better and better. In just two years the basic I²L process has been improved to the point where 10-ns gates are possible at 100-ns injection current. This is better than TTL performance and signals a new level of programable processor circuit speed.

is a good instance of the layout technique. The multiple-output and conventional NAND logic diagrams are shown for clarity, although in practice no logic diagram conversion is required. The logic units abut one another adjacent to the injector. The x and (x) indicate an output or input, respectively, either of which may be placed in the six available wiring channels.

The advantages summarized

As for flexibility of operation, since I²L structures are totally—and uniquely—independent of resistors, all units are powered through lateral npn transistors, and the current that reaches each unit is simply the total injection current multiplied by the inverse gain (alpha) of the lateral npn and divided by the number of units associated with the injection. This means that a single circuit can be operated over a wide speed range simply by varying the total current into the injector. Indeed, a practical range of operation for a single I²L design can easily extend for three or four orders of magnitude (10^{-8} amperes to 10^{-4} A) or more, depending on the details of the process. Thus, the same I²L structures can operate in a watch application at slow speed, dissipating microwatts, or in microprocessor applications at high speed, dissipating milliwatts.

In any case, the speed-power product associated with the operating power level (Fig. 7) is typically on the order of 1 picojoule (five to 10 times better than other bipolar technologies), while minimum delay is in the 10-to-30-ns range for the non-Schottky I²L process. Theoretically, optimized structures and device profiles could achieve a speed-power product of better than 0.1 pJ and minimum delays close to 1 ns—but these figures would of course depend on the use of full-blown Schottky clamp technology.

Finally, the simple non-Schottky devices are the basis for the densest circuit layouts yet seen. Even with relaxed lines and spaces of 10 micrometers, densities of 85 gates per square millimeter can be routinely achieved. When standard optimization techniques are used with 5-micrometer lines and spacings, density exceeds 250 gates per square millimeter. This outdoes the densest MOS devices in existence today.

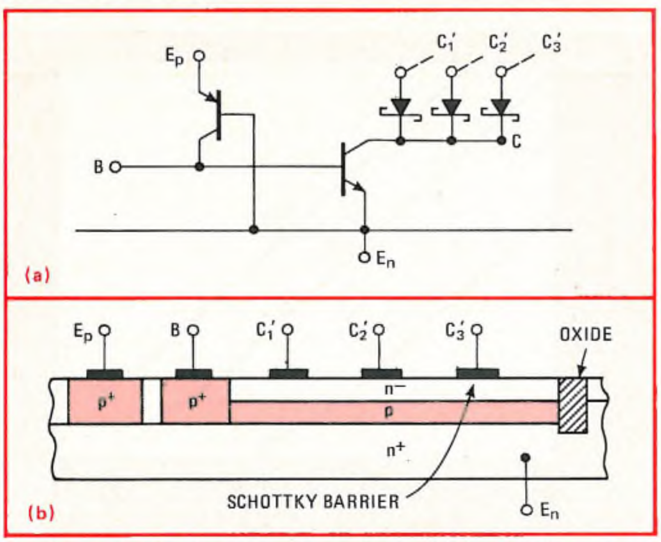
Although Schottky diodes are not required for 10-ns I²L operation, they probably will be needed if gate speeds are to be pushed below this level, into the 1-to-5-ns range. True, Schottky clamps complicate the simple I²L structure, but that drawback is more than compensated for by the improvement in performance—up to five times the speed of non-Schottky I²L gates.

The Schottky road is even faster

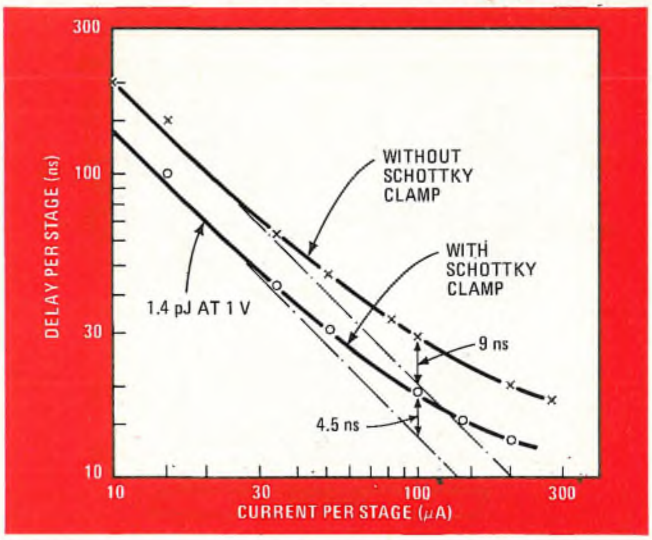
For example, Horst Berger and Siegfried Wiedmann of IBM Laboratories, Boeblingen, West Germany, used Schottky clamps in the outputs of their I²L structures (Fig. 8a) to reduce logic swings from 700 mV to 150–350 mV and increase the speed proportionately. To judge from IBM data comparing the speed-current relationships of Schottky and non-Schottky versions, I²L gates operating with the desired 2–5-ns propagation delay are apparently just around the corner. Figure 9 certainly shows that even with unoptimized Schottky techniques Wiedmann and Berger could obtain speeds of 4.5 ns (as against 9 ns for non-Schottky devices) at injection currents of 100 nanoamperes.

Not only that, but the IBM scheme wastes little space on the Schottky clamps: the n^- collector of the npn transistor is used to integrate them into the structure (Fig. 8b). Adding an ohmic contact to this collector region also makes it possible to interface I²L gates directly with conventional TTL gates, increasing the structure's versatility for circuit design.

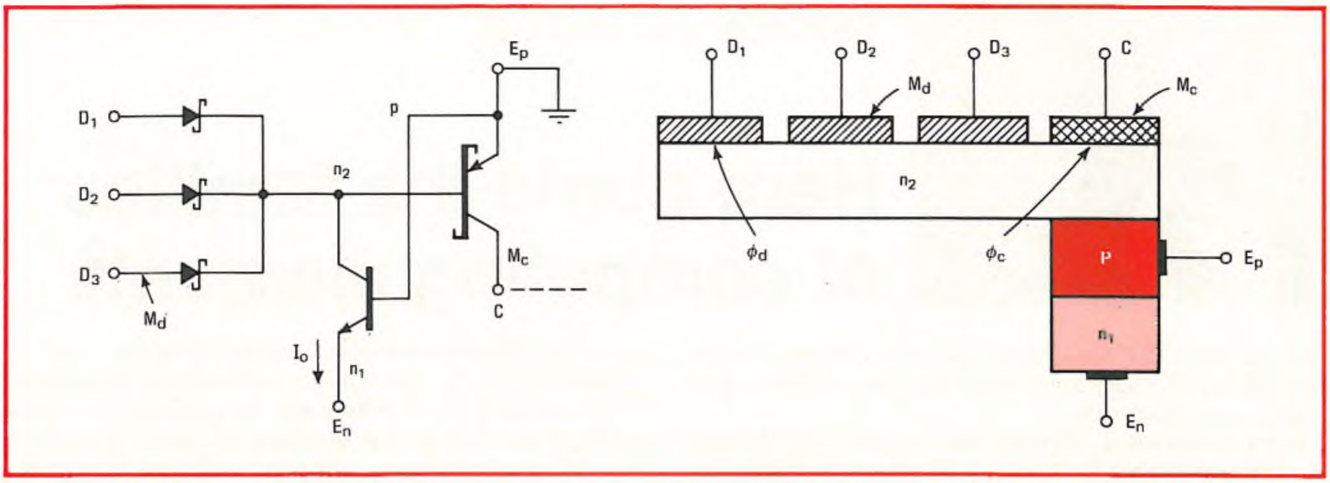
Looking ahead, Berger and Wiedmann have suggested using a genuine Schottky collector and substituting metal for one of the active semiconductor regions. This novel type of metal-base transistor (designated pnm, with the m standing for metal) would result in a very elegant, very small gate design (Fig. 10). The struc-



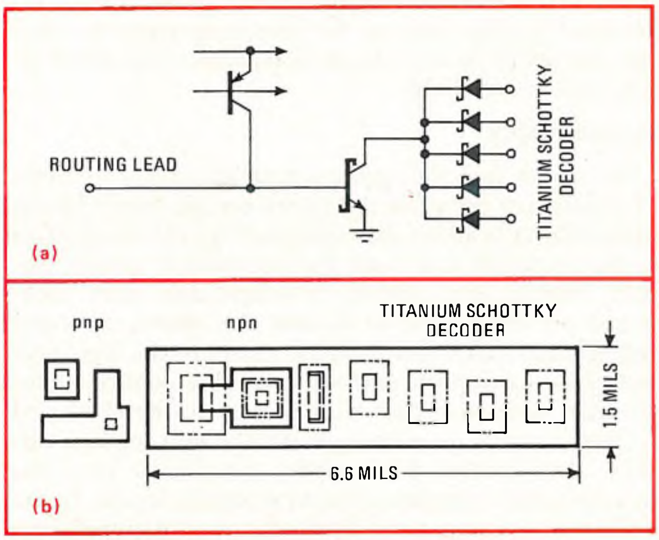
8. Clamped. The Schottky clamp in an I²L gate reduces logic swings, which in turn reduce gate delays. The clamps can be built in just one additional mask step directly into the p-diffusion wells (b), so that as a result very little space is wasted.



9. Proof. When equipped with Schottky clamps, I²L gates operate at the 5-nanosecond gate propagation-delay needed for high-performance applications. This speed is to be contrasted with non-Schottky gates' 9-ns operation. (Data courtesy of IBM, Boeblingen.)



10. Down the road. IBM's Wiedmann and Berger have proposed an elegant solution to the Schottky problem—pure metal Schottky collectors—which they say result in minimum-geometry gates much faster than conventional ones. But new processing techniques will be needed.



11. Getting Schottky both ways. This injection-like logic structure from Motorola uses Schottky diodes to maximum advantage. Routing to the gate is achieved through low forward Schottky diodes, while gate outputs also are Schottky-clamped for extra performance.

I²L honors list

Oddly enough, only a handful of people were responsible for bringing integrated injection logic to the present level of development.

Foremost, of course, came the German and Dutch inventors of I²L. At IBM in Boeblingen, Germany, researchers Siegfried Wiedmann and Horst Berger formulated the I²L concepts, and at Philips in the Netherlands, N. C. de Troy headed the research effort.

In this country credit for exploiting the I²L technique for digital applications goes to Dean Toombs, technology manager at Texas Instruments, who, relying on formidable bipolar experience, immediately saw how to optimize the performance of inverted transistors. The result was the industry's first I²L microprocessor.

Equally deserving is Thomas Longo, vice president and general manager of Fairchild's IC group, who committed a sizable effort to applying the company's proprietary Isoplanar process to the I²L configuration. That project resulted in the industry's first 4,096-bit I²L random-access memory.

Finally, special mention must be made of a small Bell Labs circuit design group in Allentown, Pa. By applying the Schottky process to the I²L configurations, they raised LSI to new levels of performance.

ture would need only three active semiconductor regions, packed into no more space than a single bipolar transistor, yet it would perform as well as a Schottky TTL gate occupying 100 times the area. But the pnm device would, of course, have to be the electrical equivalent of the conventional pnp transistor if replaced, and it will require some new processing techniques if it's not to leak.

Another Schottky approach is Motorola's C³L circuit arrays. They are built with an I²L-like complementary constant-current logic that also resembles I²L in being a modification of the old direct-coupled logic. The gate structure is fairly complex (Fig. 11a), having a form of current routing on the input and a series of Schottky clamps on the output. But even so, all the circuitry for a single NAND gate fits in the area of a single transistor, again just as with I²L.

Figure 11b, which shows a five-output C³L NAND gate, illustrates how the pnp current source transistor and the complementary npn switching transistor are fabricated in the same small isolation region. The use of passive polysilicon isolation around active circuit elements allows nearly 1,000 C³L gates to fit on a 130-square-mil die. Speeds of 3 ns at 1 millivolt per gate and of 100 ns at 0.01 mV/gate can be attained.

In the Motorola scheme, which was designed by a team led by Arthur W. Peltier, the Schottky diodes are formed right in the collector region of the driving gate's npn, so that they occupy very little chip space. The base lead of the driven gate is then routed across the collectors of the gates that perform the input function. To operate, the Schottky diodes need forward voltage levels between the 750-mV level of the base-to-emitter voltage and the 300-mV collector-to-emitter voltage on the Schottky-clamped npn. This requirement is satisfied by the use of a titanium, tungsten, and titanium-tungsten alloy metal system.

THE NEW LSI: PART 3

Here come the families of computing elements

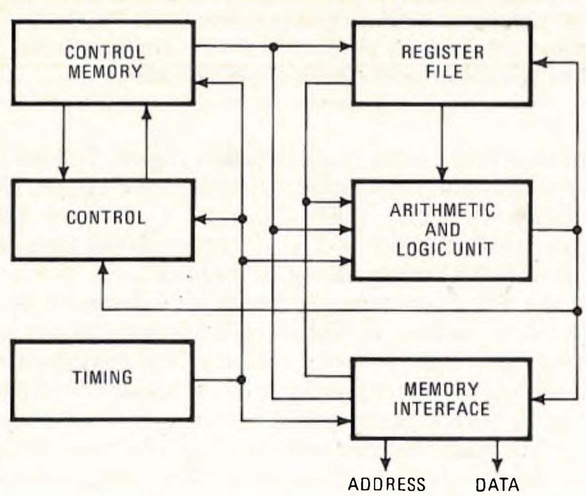
The success of the new bipolar processes needs no other proof than the many LSI circuits by now available for a variety of applications.

For the market in stand-alone controls and low-end minicomputers there's TI's I²L 4-bit processor slice. This chip, with 1,500 gates operating at delays of 25 nanoseconds, is designed to work with TI's existing family of TTL LSI processor parts. In addition, a 4-bit Schottky TTL slice is to be introduced shortly, increasing speeds into the 1–10-ns range.

For high-speed processors and fast minicomputers there are the 2-bit and 4-bit Schottky TTL slices produced by a growing number of bipolar circuit manufacturers (Fairchild, TI, AMD, MMI, Intel). These families are intended primarily for emulating existing minicomputer designs.

Finally, there are the highest-performing ECL processor slices for the control of big mainframe memories. Motorola has already announced a 4-bit ECL processor slice using its ECL 10K technology.

The chief asset of these new bipolar LSI processor families is their processing power, which is far greater than that presently available from MOS microprocessors. Indeed, the MOS systems are used only where limited processor capability, which can be accommodated on a single chip, is required. In these applications low cost is wanted and is worth the tradeoff of a limited word length (usually 8 bits), a fixed set of instructions (seldom more than 80), and slow speed (normally below 1 ns).



12. It's standard. This basic building block configuration characterizes most of today's bit-slice chip configurations. From Motorola, this block of circuits is incorporated into a new ECL slice. Key elements are, of course, the ALU and control memory.

The new bipolar LSI families afford quite a contrast. They overcome these limitations by packing their processing power on several matched LSI chips. These are the 2-bit and 4-bit processor slices that extend system design capability well beyond the range of the self-contained MOS microprocessor systems. For example, the bipolar slices are easily expandable to 16-bit or even 32-bit word lengths, and can be microprogramed to tailor the circuits to handle the most powerful high-level instruction sets available.

Commonality

No matter how different a manufacturer's new family of bipolar LSI circuits may appear, certain circuit blocks are common to all bit-slice systems (Fig. 12). In addition to the processor slice itself, the functions of control register, timing, slice-memory interface, and carry look-ahead are all needed to expand the system. In every configuration the control register contains the logic necessary to accomplish microprogramable control. It includes a 4-bit-wide data path, which can be expanded to larger words, plus enough storage and logic to address and control the memory circuits. It can also handle status, branching, and interrupt functions. In the arithmetic-and-logic-unit block, the computational logic sits side by side with data routing paths and the input/output ports that handle the control register inputs and memory outputs. The timing function ties the other functions together by providing the various clock phases needed to drive all parts of the system.

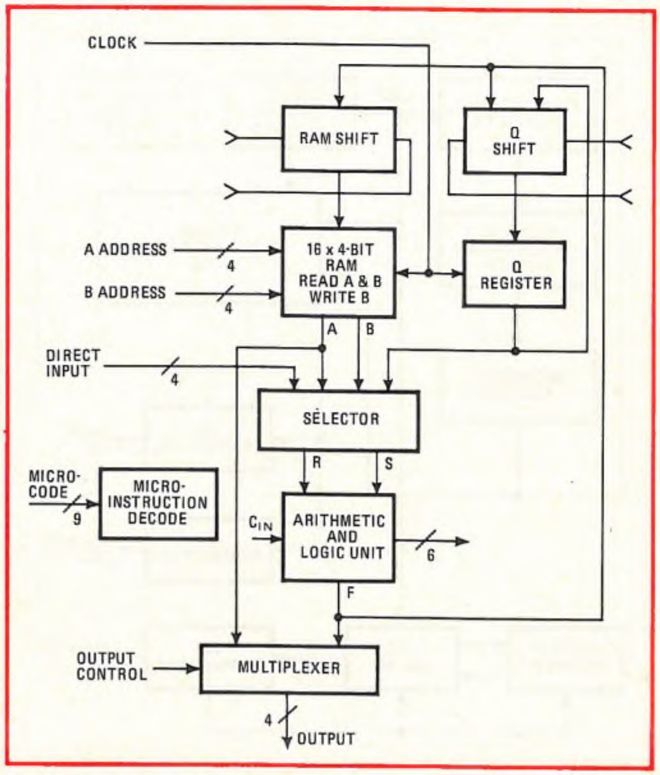
Where the systems generally differ is in what they offer in system capability and speed (Table 2). For example, TI's 4-bit I²L slice has no greater bit-handling capacity than other 4-bit slices, but it offers twice as many ALU functions. This feat is possible both because the chip has been designed for parallel instead of serial operations and because the I²L process allows TI to put more components (1,500) on the single-chip slice. Also it offers low power dissipation.

On the other hand, the TI device can manage only one address operation at a time, whereas the others can handle two address operations simultaneously. This means that TI's system, while processing data faster on the chip, slows the system down during data address.

The Intel system, by virtue of its 2-bit format, is probably the most flexible. But this versatility is achieved at the expense of the number of chips needed for a complete CPU system—usually twice as many as the others need for a system of given complexity. Nevertheless, since six functions are supplied per 2-bit slice, com-

TABLE 2: BIPOLAR MICROPROCESSORS COMPARED

Parameter	AMD Am2900	MMI MM6701	Intel 3002	TI SBP0400
Slice width	4 bits	4 bits	2 bits	4 bits
Arithmetic and logic unit functions	8	8	about 6	16
Number of microcode control inputs	9	8	7	9
Working registers	17	17	11	9
Two-address operation	Yes	Yes	No	No
Independent shift and arithmetic	Yes	Yes	No	Yes
Cycle time (register to register, read, modify, write)	100 ns	200 ns	150 ns	1,000 ns
Technology	Low-power Schottky	Schottky	Schottky	I^2L
Power dissipation (4 bits)	0.92 W	1.12 W	1.45 W	0.13 W
Pin connections (4 bits)	40	40	56	40



13. Double dealing. AMD's new low-power Schottky TTL processor-slice can handle information 4 bits wide. Entered simultaneously via two input ports and processed simultaneously by the twin RAM ports, this data is handled in sequence on chip by the speedy ALU.

pared to eight for the 4-bit Schottky TTL designs, the system designer may actually end up with more system capability than is apparent from the number of bits he processes. Yet the Intel system has only a few working registers and, like the TI design, has only one address input and no independent shift mechanism. Also, because it requires more pin connections per bit, it takes up more board space. In speed and power dissipation, though, the Intel chip is in the same range as the other Schottky TTL designs.

Almost in dead heat are the AMD 2900 and MMI 6700 designs. More points go to the AMD system, which can operate twice as fast off less power. It must be said, however, that AMD designers may have profited from MMI's experience, since their family appeared on the market two years after the MMI system. (Considerable credit goes to MMI, which as early as 1972 saw the potential of a large family of programable bipolar LSI computing elements.) Nevertheless, with 17 working ALU registers, two address operations, and a powerful Schottky process, both systems offer the digital designer a large measure of high-quality design capability at very reasonable costs.

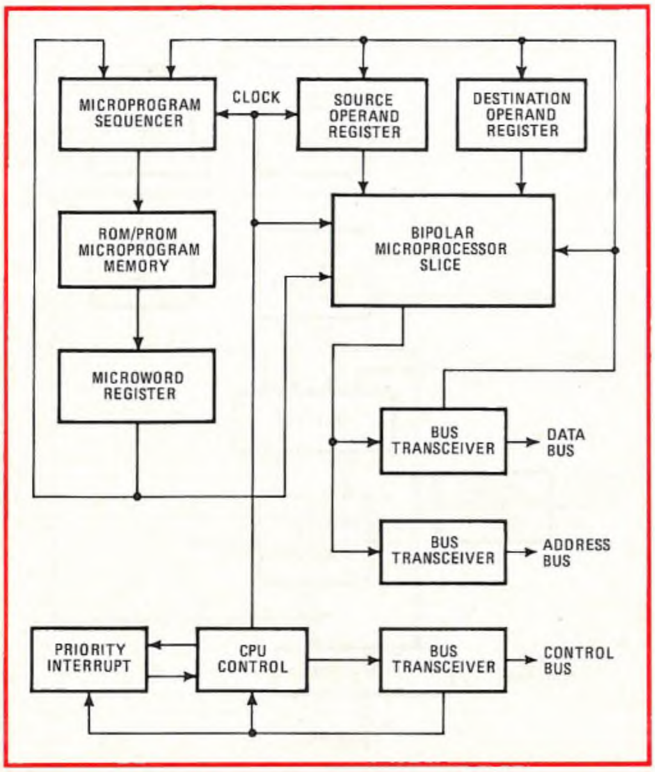
AMD's 4-bit slice (Fig. 13) is typical of processor-slice architecture, since it includes a high-speed ALU, a 16-word-by-4-bit two-port RAM (to handle the two-port address configuration), and all the associated circuit blocks for shifting, decoding and multiplexing. Crucial to the layout is the 9-bit microinstruction word-decode block, which selects the ALU source operands, the required ALU function, and the ALU destination registers. Thus configured, the microcontroller can be cascaded either with full look-ahead logic capability or with ripple carry, it has three-stage outputs, and it can provide various status flag outputs directly from the ALU.

Double address operation is made possible on the CPU chip by the two-port RAM and very fast ALU—it can handle each input sequence in turn without slowing up the system. Essentially, data in any of the 16 words of the RAM can be read from, say, port A of the RAM, under control of the address field input selector. Likewise, B-port data can simultaneously be read using the same code that selects A data, so that both data groups will appear simultaneously at the RAM port output for ALU processing.

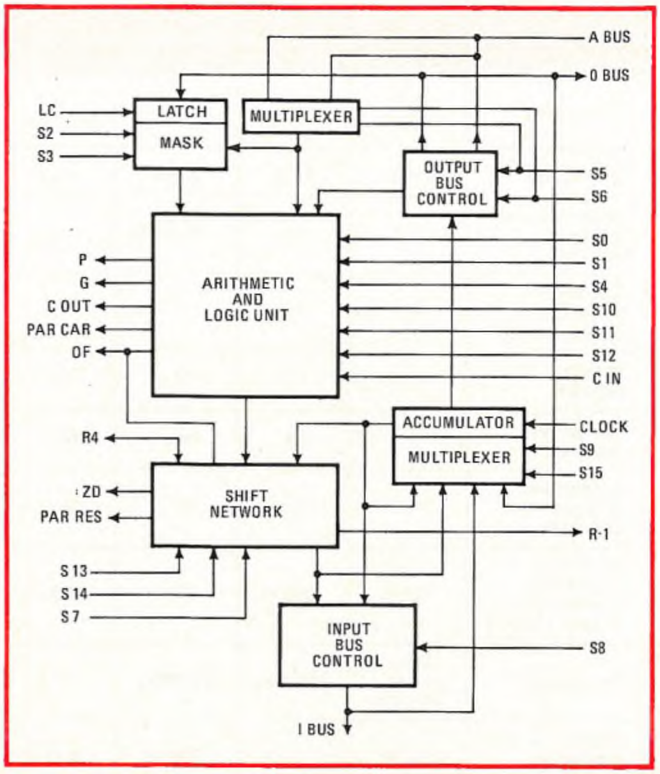
The 11 AMD chips required to implement a typical central processing unit are shown in Fig. 14. Four distinct data processing functions are discernible—the microprocessor data slice, the I/O bus interface transceivers, the microprogram control, and the CPU control, including priority interrupt—all of which are in addition to whatever main memory is needed. Nevertheless, these 11 chips replace about 200 standard TTL packages.

Motorola's ECL 4-bit-wide CPU chip design (Fig. 15) is sliced parallel to the data flow so that it too is fully expandable. That means the system can be laterally extended to any bit length in increments of 4 bits and can be vertically extended in ECL pipe-line designs for very high data throughput rates (under 50 ns).

Configured somewhat differently from the Schottky TTL units, the slice contains a latch/mask block, the ALU, an accumulator, the shift network, input and out-



14. The system. Beating high system costs is this minimum-package CPU built from 11 of AMD's 2900 family of LSI computing elements. It's expandable to handle 16- or 32-bit-wide words typically required in today's minicomputers and data-processing equipment.



15. Emulation. Motorola's 4-bit processor slice is configured like the typical ECL controller. The ALU is driven by a multiplexed latch which loads an accumulator for fast iterative computer operations. It's designed for very fast programable data-processing duty.

put bus controls, and associated interconnections. This configuration copies most mainframe controller designs built with hardwired ECL packages.

For example, when the ALU is combined with a latch/mask network it can perform logic operations, binary arithmetic, and BCD arithmetic on combinations of one, two, or three variables—more than enough capability to control mainframe memories. Also included in the ALU section of the 4-bit slice is the logic for overflow and carry-out functions.

Following the ALU, the shift network performs data shift operations within the 4-bit slice. Select lines to the shift network control the operations of shift left, shift right, and ripple through.

Next, the master-slave accumulator provides for fast, iterative computer operations needed in high-performing systems. These may include repeated add with accumulated sum, multiply, divide, and multiple-shift operations. A multiplexer circuit feeds the accumulator from one of three possible sources—the results of the shift network, the input bus, or the output bus. A fourth condition inhibits the accumulator clock so that stored data is retained. The accumulator is the only section of the 4-bit slice that requires clock operation. This is done to eliminate possible race conditions when the circuit is connected within a system.

Another set of LSI circuits following the architecture generally found in today's data processing systems is Fairchild's Schottky TTL Macrologic family. Here a five-chip set makes up a 4-bit slice. In the set are a stack of arithmetic and logic registers, a P-stack (program memory), a data path switch, a data-access register, and an R-stack (or 64-bit RAM). The family is so designed that any number of matched circuits may be selected to realize a particular design.

For example, the arithmetic-and-logic-register stack can implement general registers in high-performance programable digital systems. It consists of a 4-bit ALU, an 8-word-by-4-bit RAM with latched outputs, instruction decode networks, control logic, and an output register. Where one 4-bit operand is supplied from an external source, the ALU implements eight arithmetic and logic functions.

The P-stack is a push-down, pop-up program memory that complements the program count and return address storage facilities in a programable digital system. Alternatively, it can be used as a 16-level general-purpose register. It consists of an input multiplexer, a 16-by-4-bit RAM with latched output, an incrementer, control logic, pointer, stack limit monitors, and output buffers.

For the other three parts, the data path is a two-port multiplexer with two 4-bit ports and a 4-bit output port. With its 5-bit instruction bus, the switch consists of a data-routing network, a control block section and output buffers. The data-access register, on the other hand, can actually implement 16 instructions suitable for memory address arithmetic and manipulation. Finally the R-stack is a fast 64-bit RAM, organized as 16 4-bit words and capable of handling local data storage. □

New series of generic PROMs–a family affair.

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In addition, these PROMs have fast programming speeds. Equivalent I/O characteristics for easy upgrading. Faster access time, guaranteed over temperature and voltage. Improved testability.

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Device #	No. of Bits	Organization	No. of Pins	Max. Access Time* comm./mil.	Availability
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HM-7610 (open coll.) HM-7611 (three-state)	1024	256 x 4	16	60/75ns	in stock
HM-7620 (open coll.) HM-7621 (three-state)	2048	512 x 4	16	70/85ns	in stock
HM-7640 (open coll.) HM-7641 (three-state)	4096	512 x 8	24	70/85ns	August
HM-7642 (open coll.) HM-7643 (three-state)	4096	1024 x 4	18	70/85ns	January '76
HM-7644 (active pullup)	4096	1024 x 4	16	70/85ns	January '76

*Access time guaranteed over full temperature and voltage range.
Industrial (T_A = 0° C to 70° C, V_{CC} ± 5%)
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Designer's casebook

Digital word sets gain of amplifier

by Craig J. Hartley
Baylor College of Medicine, Houston, Texas

Digital control of gain or attenuation is often desirable in programable systems or when the gains of many circuits have to be varied simultaneously. In the circuit shown, the gain or attenuation of an analog signal is controlled by means of a binary input. The circuit, which is similar to a multiplying digital-to-analog converter, uses a single 741 operational amplifier for gain or attenuation, plus two transistors for each control bit.

The circuit has two parts. The first is a noninverting operational amplifier; the second is a set of resistors that can be connected in parallel to produce various values for an equivalent single resistor R_C between switch S and ground.

The value of R_C is determined by the digital inputs. When the input labeled 1 is low, transistors Q_1 and Q_2 are saturated, so that the 100-kilohm resistor R is connected from switch S to ground. When input 1 is high, Q_1 and Q_2 are off, so the bottom of R is open-circuited.

Similarly, if inputs 2, 4, and 8 are low, they connect R/2, R/4, and R/8 to ground. Therefore the control inputs can be considered as a binary number with negative logic (high voltage = 0, low voltage = 1) so that the total resistance connecting the switch to ground is

$$R_C = R/N$$

where N is the value of the binary input number. For example, if N equals 5, the binary number is 0101, which means that inputs 1 and 4 are low; therefore R and R/4 are connected in parallel to provide a resistance of R/5 from S to ground.

When switch S is in position A, the gain of the op amp is

$$G_A = E_o/E_i = 1 + R_F/R_C = 1 + NR_F/R$$

The values of R_F and R are equal, so

$$G_A = 1 + N = 1, 2, 3, 4, \ldots$$

For a 4-bit control word, the maximum G_A value is 16.

When the switch is in position B, the op amp is connected as a voltage follower fed by a voltage divider, so the gain is

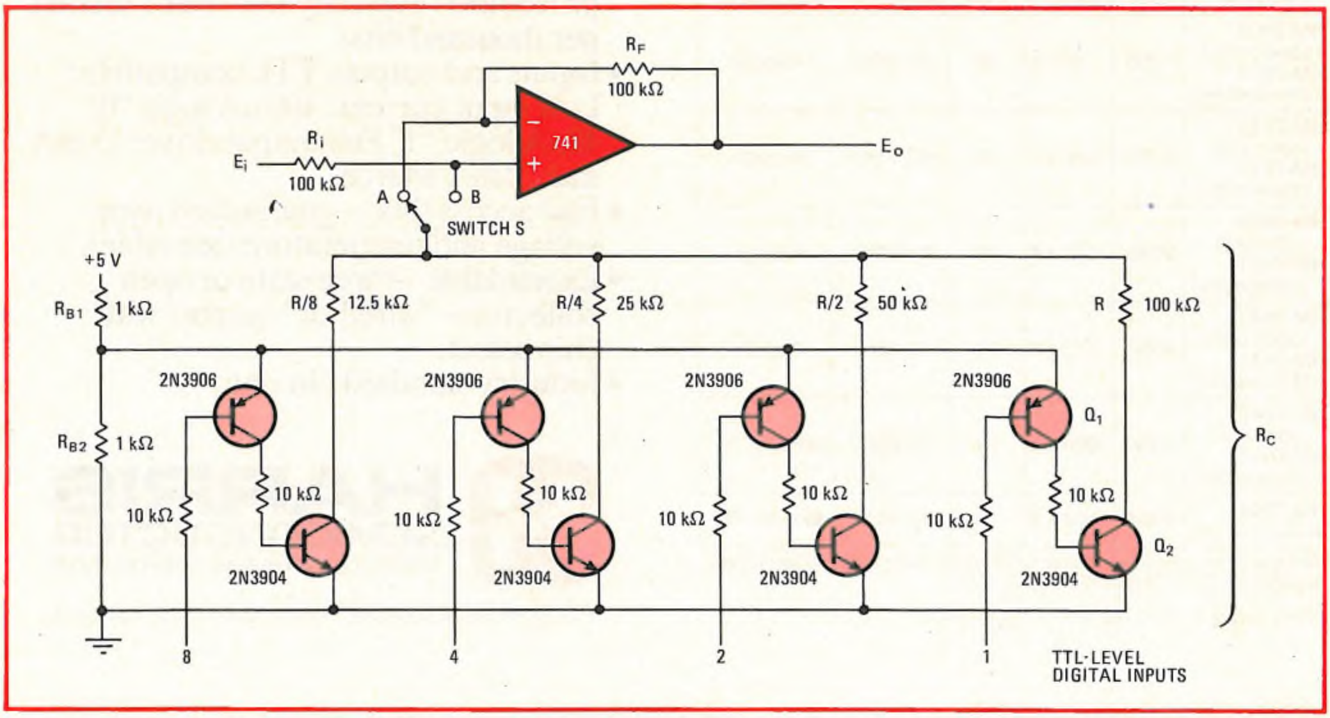
$$G_B = R_C/(R_i + R_C) = (R/N)/(R_i + R/N)$$

Because R_i is equal to R,

$$G_B = 1/(N+1) = 1, \tfrac{1}{2}, \tfrac{1}{3}, \tfrac{1}{4}, \ldots$$

Thus the circuit can amplify (switch position A) or attenuate (switch position B).

The circuit as shown will handle analog input levels



Programable gain or attenuation. The operational-amplifier circuit has a gain of $G_A = N + 1$ or $G_B = 1/(N+1)$, depending on whether switch S is set to position A or position B. The number N is the value of the negative-logic binary number applied to the digital inputs. If programable sign-reversal is required, a digitally controlled inverter [*Electronics*, March 6, p. 85] can be used in tandem with the amplifier.

of ±7 volts, and the digital inputs will accept TTL logic levels. The bias resistors and supply voltage can be varied as needed for use with other logic forms. The offset is about 0.02 V maximum in the B mode and 0.25 V maximum in the A mode and is a function of gain. Additional digits can be added for finer control. □

Bootstrap circuit generates high-voltage pulse train

by Lawrence H. Bannister
Center for Space Research, MIT, Cambridge, Mass.

A circuit can easily be built to generate a high-voltage pulse train from a low-voltage power supply. Such a circuit is used in a recently developed spacecraft instrument to generate a 400-hertz square wave with an amplitude of 4 kilovolts from 20 identical 200-volt stages connected in series. A high-voltage supply is not needed because each stage includes a capacitor that functions as a floating power supply for the next stage. These capacitors are charged in parallel and then connected in series so that the pulse generator does its own dc-to-dc conversion.

The schematic of Fig. 1 is drawn to emphasize the modularity of the circuit. To simplify the explanation, it is assumed that all transistors and diodes are perfect switches, having infinite impedance when turned off and zero voltage-drop when turned on.

Suppose, first, that transistors $Q_{1\text{-}1}$, $Q_{1\text{-}2}$, . . . $Q_{1\text{-}N}$ are all turned off. Then diodes $D_{1\text{-}1}$, $D_{1\text{-}2}$, . . . $D_{1\text{-}N}$ are forward-biased and transistors $Q_{2\text{-}1}$, $Q_{2\text{-}2}$, . . . $Q_{2\text{-}N}$ are driven to saturation. Capacitor $C_{1\text{-}1}$ charges through the path $D_{3\text{-}1}$, $C_{1\text{-}1}$, $D_{2\text{-}1}$, and $Q_{2\text{-}1}$. Concurrently, $C_{1\text{-}2}$ charges through the path $D_{3\text{-}2}$, $C_{1\text{-}2}$, $D_{2\text{-}2}$, and $Q_{2\text{-}2}$. So, in this circuit condition, all of the capacitors charge in parallel, and the potential difference across each capacitor is equal to the supply line voltage of 200 volts:

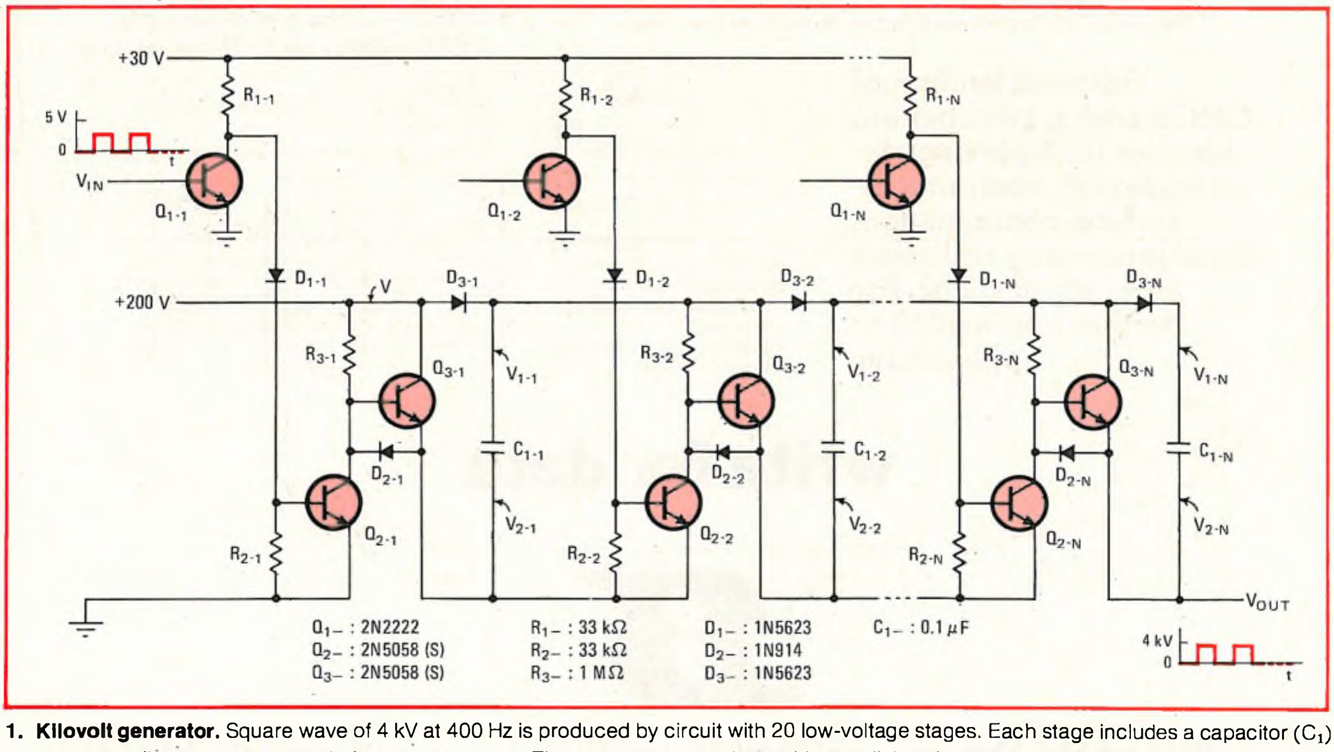
$$V_{1\text{-}N} = V_{1\text{-}2} = V_{1\text{-}1} = V = +200 \text{ V}$$
$$V_{out} = V_{2\text{-}N} = V_{2\text{-}2} = V_{2\text{-}1} = 0$$

If, now, $Q_{1\text{-}1}$ is turned on, diode $D_{1\text{-}1}$ no longer conducts, so $Q_{2\text{-}1}$ turns off. Current through resistor $R_{3\text{-}1}$ then causes $Q_{3\text{-}1}$ to turn on, and the emitter potential of $Q_{3\text{-}1}$ approaches its collector potential so that $V_{2\text{-}1} = V = +200$ V. And, because $C_{1\text{-}1}$ was previously charged to the supply voltage, $V_{1\text{-}1} = V_{2\text{-}1} + V = 2V = +400$ V.

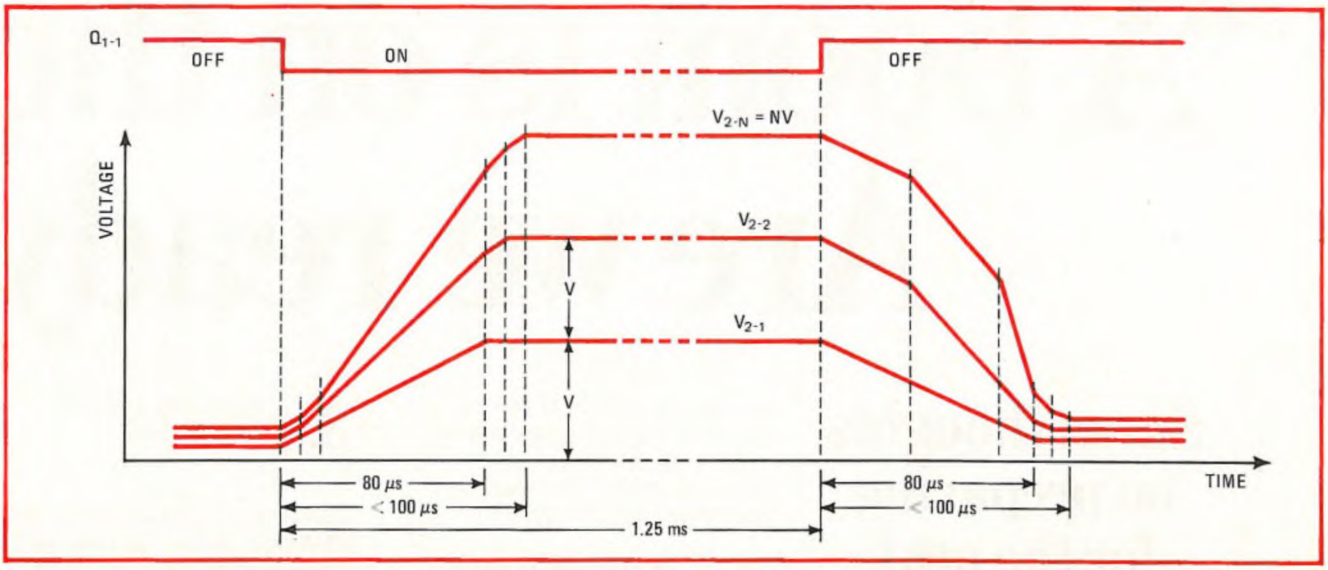
Now, regardless of the state of $Q_{1\text{-}2}$, when $V_{2\text{-}1}$ becomes positive, $D_{1\text{-}2}$ becomes reverse-biased, and therefore $Q_{2\text{-}2}$ turns off. Current through $R_{3\text{-}2}$ then causes $Q_{3\text{-}2}$ to turn on, and the emitter potential of this transistor approaches its collector potential so that:

$$V_{2\text{-}2} = V_{1\text{-}1} = 2V = +400 \text{ V}$$
$$V_{1\text{-}2} = V_{2\text{-}2} + V = 3V = +600 \text{ V}$$

As illustrated by Fig. 2, this sequence continues along the series of stages, each stage increasing the positive level of the pulse by V volts. The final output voltage is NV volts, where N is the number of stages and V is the



1. Kilovolt generator. Square wave of 4 kV at 400 Hz is produced by circuit with 20 low-voltage stages. Each stage includes a capacitor (C_1) that acts as a floating power supply for the next stage. The capacitors are charged in parallel and then connected in series. If lower output voltage is desired, input can be applied to $Q_{1\text{-}2}$ or $Q_{1\text{-}3}$ or . . . instead of $Q_{1\text{-}1}$. (Actual circuit also includes elements shown in Fig. 3.)



2. Timing. The stages start switching sequentially, as diodes D_{1-1}, D_{1-2}, . . . successively become back-biased, but after all stages are switched, they change voltage levels concurrently. Therefore the rise time is essentially that of a single stage. Similarly, the fall time is essentially independent of the number of stages. The output amplitude is the product of the power-supply voltage and the number of stages.

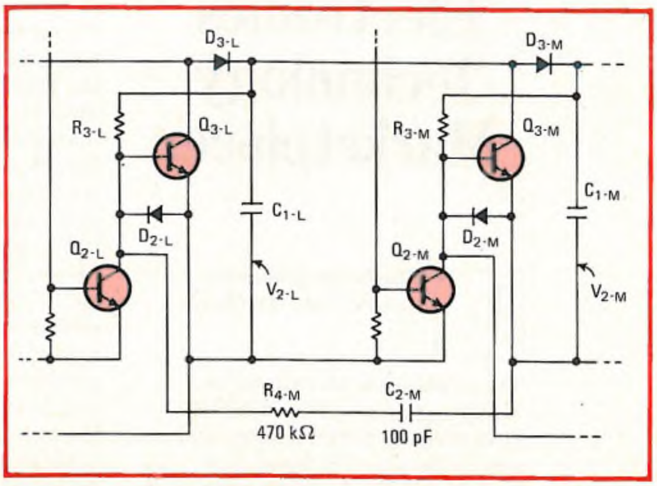
supply voltage. Because the stages switch concurrently, the total pulse rise time is only slightly longer than the rise time of one stage.

Smaller-amplitude pulses can be generated by switching only the last few stages to the "high" state. For example, if Q_{1-1} remains off, but Q_{1-2} is turned on, the first stage will remain in the "low" state with V_{1-1} = V = +200 V but all subsequent stages will switch to the "high" state so that $V_{out} = (N - 1)V$. If only Q_{1-N} is turned on, the preceding stages will remain in the "low" state and the output pulse amplitude will just be V volts. Generally, then, the output-pulse amplitude can be selected in increments of V up to a maximum of NV.

The positive-going edge of the pulse generated by the circuit of Fig. 1 is quite slow because, in each stage, when Q_2 is turned off, the potential at the base of Q_3 increases exponentially toward a limiting value. Further, the output impedance of the circuit is quite large because the current in R_3 approaches zero in the "high" state and Q_3 never really saturates.

The circuit modification shown in Fig. 3 prevents these problems by the use of positive feedback in and between the stages. R_3 is connected to provide positive feedback within the stage; when Q_2 is turned off and Q_3 starts to conduct, the potential at the top end of R_3 remains V volts above the potential at the emitter of Q_3. Thus, the potential difference across R_3 is sensibly constant, and Q_3 is driven by a constant current supply so that its base potential increases linearly until the base-collector junction is forward-biased. Q_3 then behaves like an inverted switch transistor with a very low offset voltage that is just the difference between the voltage drops of the base-emitter and base-collector diodes.

R_4 and C_2 provide positive feedback from one stage to the immediately preceding stage to speed the switching action. For example, when the stages switch to the "high" state, V_{2-L} increases toward LV while V_{2-M} increases toward MV. The difference between these voltages, $MV - LV = (L+1)V - LV = V$, causes a tran-



3. Feedback. To achieve 400-Hz operation, the circuit in Fig. 1 is modified as shown here. R_3s provide positive feedback within each stage, and R_4s and C_2s provide positive feedback from each stage to the preceding stages. Without the feedback, rise time is about 1 ms; with feedback, rise and fall times are both less than 0.1 ms.

sient current through R_{4-M} that drives the base of Q_{3-L} positive more rapidly.

With these feedback connections, the operating circuit produces a 400-Hz square wave with rise and fall times of about 100 microseconds that are essentially independent of the number of stages switched. The number of stages switched changes only the amplitude of the square wave; this amplitude can be selected in increments of 200 V, up to a maximum of 4,000 V for a 20-stage circuit. The only high-voltage components are the diodes labelled D_1 in Fig. 1. In the spacecraft instrument, series strings of diodes are used as D_1 to provide the necessary isolation for the higher-voltage stages of the pulse generator. □

"A boom is on the
Are we ready

Seven thoughts on preparing for the next boom in the Electronics Technology Marketplace.

1. *The boom is coming sooner than we think.*

The evidence is all around us. Many segments of the market have already found bottom and are on the way up. Inventory liquidation has been the most rapid in the history of our economy, and the pipelines are almost empty. Federal monetary policy has become extremely stimulative. Interest rates are down, and industry can afford to invest in the instrumentation and modernization it needs. Productivity is increasing. And our most reliable lead indicator —the market—has been booming for six months. No matter what data you look at, it now seems definite that we are in for a *very sharp* economic upturn, and that short of another Arab oil embargo or a drastic tightening of the money supply by the Fed, nothing can stop it. If you are not planning for an electronics economy that is booming by year-end, you will be 'way too late to take advantage of it.

2. *Be glad you're in the electronics business.*

In terms of *real product demand*, the recession has been slight or non-existent in many sectors of the Electronics Technology Market. For example, a major instrumentation manufacturer just reported on its most recent six months: Incoming orders up 11%, sales up 14%, profits up 21%—compared with the "boom" market of late 1973 and early 1974. Even in the hard-hit semiconductor industry, there is a good deal of evidence that *real product usage* will be essentially flat from 1974 to 1975, and that the apparent boom-bust in bookings and shipments is entirely due to inventory.

Considering that the economy as a whole has experienced its sharpest recession since the '30's, the electronics market has performed extremely well. It will far outperform the economy during the recovery—especially if *we are ready* for the boom.

3. *Start now to build inventories.*

Sound crazy? Consider this: an important part of the boom and subsequent bust was based on product shortages, which led to panic buying, which in turn led to panic production, and thus to inflated inventories. *Let's not do this again.*

It shouldn't take any genius to figure out what products the market would need for a sharp year-end recovery, and it wouldn't be a super-gutsy decision to start now to build toward that level. But let's also be sensible. Ideally, each company should build only toward the market share it can legitimately expect to get. Otherwise, we'll have everybody building to get 50% market share, and it will be August, 1974 all over again.

4. *Get your marketing house in order.*

In the last boom, marketing and sales people spent a major part of their time *killing snakes*—expediting their factories, and hand-holding their customers. Let's not do that again either.

Now is the time to organize and mechanize your marketing and distribution operations, your communications, and your

way. for prosperity?"

service functions so your sales staff can be free to do what it does best—*close orders*. A quick review—painful as it may be—of the problems you had during the last boom should tell you what changes to make.

5. *Unload some old ideas.*

One of the reasons we keep making the same mistakes each time the economic cycle repeats itself is that we keep clinging to our old ideas, articles of faith, corporate dogma, and former solutions. I wish I had a dollar for every knee-jerk statement I've heard about share of market ("we know all our customers"), market coverage ("80% of our business comes from 20% of our customers"), forecasting ("the resistor market will grow 7% per year through 1983"), market development ("we have a planning department for that"), target audiences ("we want to reach the design engineer"), ad budgets ("we spend 2.3% of sales"), etc., etc.

Consider spending some time in a cool, quiet, dark place—rethinking all the things you "know," and tossing out those that are beginning to look a little tired. And you'd better do it *now*—because the business cycles are coming faster and sharper, and the old ideas just aren't good enough anymore. And because in a few months you're going to be too busy to do it at all.

6. *Start now to broaden your markets for 1976.*

One of the important lessons of the 1974-75 downturn is that companies which had broadened their markets during the boom outperformed their competitors in the bust—by *very* wide margins. It doesn't much matter whether the broadening was in customer base, product/service mix, or geography.

One of the best ways to get ready for the next boom is to turn on your marketing operation *now*, and turn it on with the main objective of finding new customers. One way you could do this is to hire more salesmen. Now is the time, because it will take months of training before they can be productive, and also because in six months *everybody* will have decided to hire, and good people will be hard to find.

The other thing you can do is turn on your advertising. Think about that for a moment. Advertising is the cheapest, most efficient way to help new customers *find you*, and you can turn it on in a couple of weeks without any training at all. Besides, you can turn it on now before the market gets cluttered with messages—in six months, *everybody* will be advertising again.

7. *Be glad you're not in my business.*

Do electronics companies cut advertising in a recession? Do they ever. In the first 5 months of 1975, the advertising page pool for which Electronics competes is down a whopping 26% from last year. Our market share is substantially up, but that's small comfort.

Yet when all the smoke clears away, and the 1974-75 recession is studied, we will learn again what every recession of the past has taught us: Companies which maintain or increase their advertising investments in recessions make more profit *during* the recessions, and come out of the recession with improved market share—compared with companies that cut.

In other words, companies which take a long, consistent view of their markets and their marketing objectives do well in good times *and* bad.

And now, a word from the sponsor—

When you decide to broaden your markets by turning on your advertising, the most effective place you can put that advertising is in Electronics.

Daniel A. McMillan III
Publisher

Electronics
THE SOURCE.

This is the Seventh of a series of editorials on advertising, marketing, and planning in the Electronics Technology Marketplace. Your comments are welcome.

Wiegand wire: new material for magnetic-based devices

Switching properties of specially-treated magnetic wires can generate pulses of up to 500 millivolts, with amplitudes unaffected by speed of operation, and no electrical power needed for most applications

by Philip E. Wigen, *Ohio State University*

□ About 10 years ago, John Wiegand discovered that by properly work-hardening a magnetic wire, it is possible, along the exterior "shell" of the wire, to produce a coercive force significantly greater than the coercive force in the wire's core. By virtue of this magnetic differential, and depending on certain external conditions, the direction of magnetization in the core of the wire can be the same or opposite to that in the shell. And switching from one state to the other is easily and repeatably induced at well-defined magnetic-field levels.

Short lengths of wire exhibiting the Wiegand effect can serve as the heart of magnetic pulse generators that have distinct advantages over similar devices, including non-contact operation and a facility for being "read" by detection devices having virtually no input power. Other important advantages are that pulse signals are not rate sensitive, meaning the amplitude of the pulse signal remains the same regardless of speed of operation; they offer any combination of pulse-generation direction and polarity, that is, uni-directional or bi-directional, unipolar or bipolar. Thus any combination of direction and polarity are available for pulse generation. And such devices are capable of withstanding severe environments, including temperatures from -95°F to +300°F.

Over the years, Wiegand has developed material composition and work-hardening procedures to a point where brief pulses (10^{-4} duration) at levels of 2 milliwatts can be produced. With properly-designed detectors, peak voltages of 500 millivolts in the 50-ohm load have been observed.

Domains are oriented

While switching is not a new application for magnetic devices, the Wiegand effect introduces new capabilities in a variety of applications. There is now, for example, a credit-card reading device that needs no electrical power input into the read head. Also possible are a Wiegand-encoded key, a non-contact switch, a flowmeter that's bidirectional and impervious to severe environmental conditions, and a rotary pulse generator that causes no wear on the read head—to name a few. These are being developed under the registered trademark SNMW, for self-nucleating magnetic wire.

Before considering the operation of the Weigand effect, it would be well to review a few properties of magnetic materials. In a "demagnetized" material, illustrated in Fig. 1(a), different regions or "domains" in the material have their magnetizations oriented in different directions, with domain walls separating them. The aggregate magnetization, M, in this state, is zero. By applying a magnetic field, H, to a magnetic material a net magnetization process occurs in three phases. Initially the domain walls move but are reversible, that is, if the magnetic field is removed, the domain walls will return to their original positions. In the next phase, the domain walls move irreversibly. Eventually the domain walls in effect disappear, as in Fig. 1(b), and the direction of the magnetization is uniformly in the direction of the field (c); this third phase is called magnetization rotation. The magnetization process is shown in Fig. 2.

If the magnetization process is reversed, the material will not return to its original magnetic condition. Instead, as the magnetic field is reversed, the magnetization passes through zero at a value called the coercive force field. The resulting plot of $\bar{M}$ versis $\bar{H}$ is called the hysteresis loop, as shown in Fig. 3.

Geometry considered

In a sufficiently large magnetic field, the magnetization, $\bar{M}$, of the material is oriented into the direction of the magnetic field and the material is said to be saturated. Magnetic "poles" are formed on the surfaces of the material in a familiar pattern (Fig. 4). The pole distribution will establish a magnetic field that is opposite to the direction of the material's magnetization. If the external applied magnetic field, $\bar{H}$, is removed, the magnetic field produced by the pole distribution will tend to demagnetize the material. In a permanent magnet, the magnetization maintains its polarization because the internal coercive force field of the material is larger than the demagnetization field.

Closing the loop

Readers interested in discussing the Wiegand-effect technology and its applications may call Milton Velinsky, who heads product development for Wiegand Electronics. Days: July 16 and 17, 9 a.m. to 5 p.m. Number: (201) 291-3818.

Who's John Wiegand?

The man who has devoted much of his life to magnetics and who discovered and exploited the effect bearing his name, is neither an engineer nor a physicist. He's a musician by training, but instead of music, he chose to devote himself to the application of magnetics.

Born in Germany in 1912, John Wiegand came to the United States in the 1930s and studied piano and choral conducting at the Juilliard School of Music in New York. While attending Juilliard he became interested in audio amplifiers and later became an engineering assistant for magnetic amplifiers at the Bell Telephone Laboratory.

These moves set Wiegand on a different course than music. In 1944 he began working for Sperry Gyroscope Co., Lake Success, N.Y., and later for a Government contractor as a product developer of tape recorders. In 1965 he began to pursue the magnetic research that led to the development and patenting of the Wiegand effect. He has been issued 13 U.S. patents and has several more U.S. and foreign patents pending, all dealing with magnetics.

When Wiegand began his independent research he was joined by Milton Velinsky. Together they organized Wiegand Electronics to develop product applications for the Wiegand effect. Velinsky's primary responsibility has been in arranging licensing agreements with manufacturers.

The strength of the demagnetization field will depend on the geometry of the sample. A thin flat disk has a strong, uniform demagnetization field. As the ratio of the width to the length of the magnetic material decreases, the demagnetization field at the center of the sample gets weaker although it is still quite strong near the end faces (Fig. 4).

In an ellipsoidally shaped piece of material, the demagnetization field is uniform throughout, and for a sample magnetized along the ellipsoidal axis the magnitude of the demagnetization field is given by

$$H_D = 4\pi NM \qquad (1)$$

where N is the demagnetization factor of the ellipsoid.

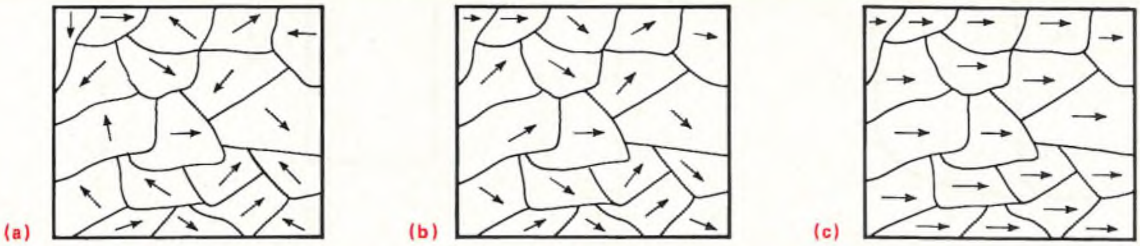
For non-ellipsoidal geometries, the demagnetization field is not uniform and can only be approximated. For wires, the demagnetization field at the center of a sample will depend on the solid angle subtended by the face of the bar from the central point of the wire. For the wire shown in Fig. 5, the solid angle will be proportional to the ratio d/L and the demagnetization field can be approximated by the expression

$$\overline{H}_D = -c(d/L)\,\overline{M} \qquad (2)$$

where c is a proportionality constant somewhat less than 4π. This relationship is accurate to within 5% when L/d is greater than 10. In the wires used for the Wiegand effect, $\overline{M}$ is 1,000 gauss and L/d is about 100 for a wire one centimeter long. The resulting demagnetization field at the center of the wire is about 10 oersteds.

As noted earlier, this field is responsible for the demagnetization of a saturated material when the external field is removed. However, in a long wire, L/d = 1,000, the demagnetization field at the center of the wire is negligible.

If the wire is placed under tension, an internal coercive force field provides a stable state of magnetization when the magnetization lies parallel to the axis of the



1. Three states. Domain arrangements for a polycrystalline material, such as Permalloy, are drawn for simplicity as if each crystalline contains a single domain. In the demagnetized state (a), domains are oriented randomly. As a magnetic field is applied, the domains begin to orient in the direction of the applied field, as in (b). In (c) a saturated state is achieved wherein the domains are uniformly in one direction. In a Wiegand wire, the core magnetization remains in the phase represented by (b), but the net magnetization can be switched back and forth.

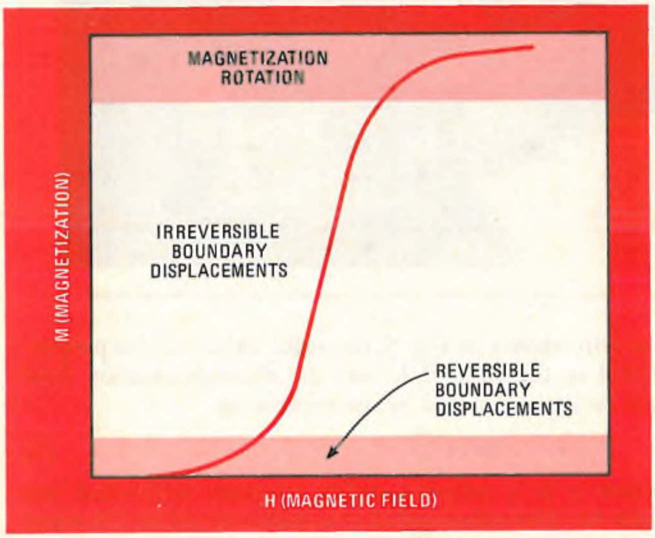
wire. On the other hand, if a magnetic field is applied in the direction opposite to that of the magnetization, the reversal process occurs by domain-wall propagation. Traveling at velocities near 10^5 cm/s, these complex domain walls take on the characteristics shown in Fig. 6. At this velocity the switching time is very short and the peak power is high.

In the Wiegand effect, this magnetization-reversal process is coupled with some unusual physical properties imparted to the wire. The wire first is treated to work-harden the outside. As a result, a relatively large coercive force field, on the order of 20 to 30 Oe, is produced in this layer. Once the magnetization of the wire shell is set in one direction, an applied magnetic field of more than 30 Oe in the opposite direction will be required to reverse its magnetization. On the other hand, the inner core has relatively low coercive force and can be reversed in a magnetic field of less than 10 Oe. During the magnetization process, the core switches by domain-wall propagation as discussed above, but now the shell region of the wire remains unchanged. When the shell and core are magnetized in the same direction, the wire is magnetized. When they are in opposite directions, a permanent cylindrical domain wall exists and the wire is in a demagnetized state.

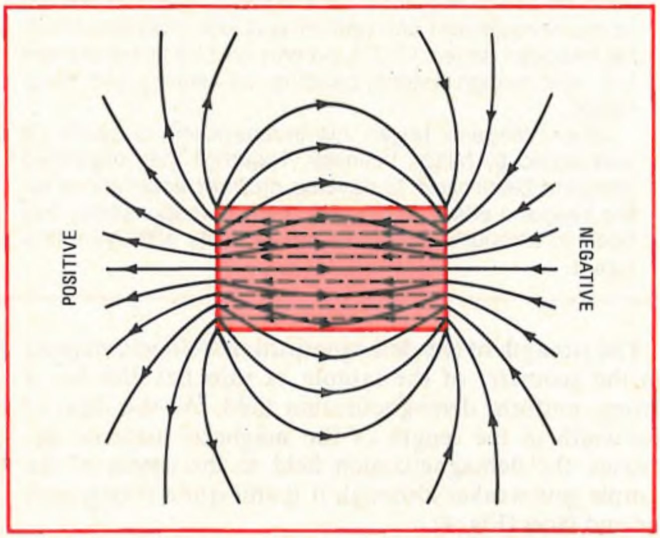
Set and reset

In a short wire of 1 centimeter the demagnetization field is on the order of 10 Oe and will shift the magnetization loop or Wiegand loop to either side of zero, depending on the state of the magnetization in the shell.

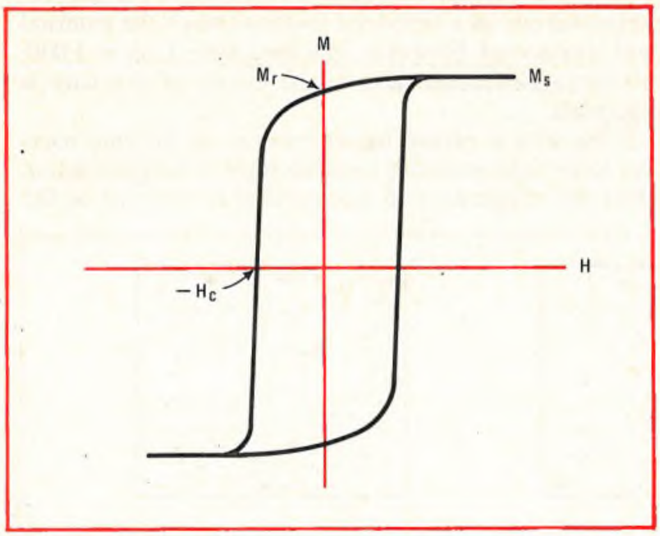
As the magnetic field is increased the magnetization



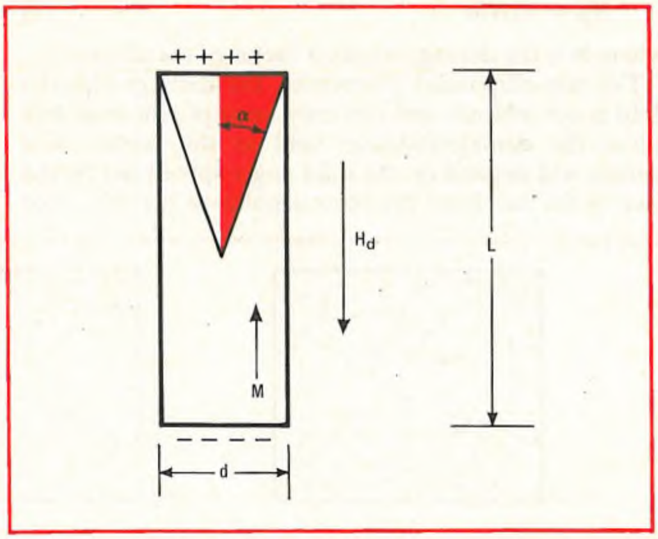
2. Magnetic boundaries. A typical magnetization process occurs in three phases: first, a reversible phase in which the domain boundaries move, next an irreversible phase, and finally the domain walls in effect disappear with all the magnetization in one direction.



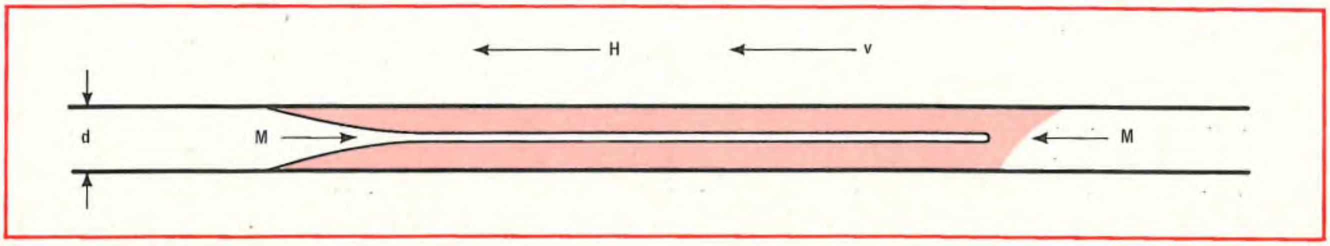
4. Poles apart. Magnetic poles, formed on the uniformly magnetized surfaces of a cylinder, establish a magnetic field opposite to the direction of the magnetization. If the external field is removed, the field established by the poles tends to demagnetize the sample.



3. Magnetic switch. In this plot of a typical hysteresis curve, the coercive field H_c is the reverse field necessary to bring the magnetization M to zero; the remanence M_r is the value of M at H = O; and the saturation magnetization M_s is the limiting value of M.



5. In reverse. The demagnetization field of a long cylinder (wire) will be proportional to d/L. This demagnetization field operates in a saturated material when the external magnetization field is removed, which is a key factor in the Wiegand effect.



6. Wire domain. The approximate shape of the domain formed during the switching process in an inelastically stretched nickel-iron wire travels down the wire at a rate of about 2×10^5 centimeters per second. At this velocity, switching times are on the order of 100 μs.

enters a "set" or magnetized condition when the cylindrical domain wall between the shell and the core in effect disappears. On reduction of the magnetic field, the core reverses direction again, producing a cylindrical domain wall at the "reset" value of the field. The treated short wire, therefore, produces the magnetic loop (Fig. 7) that can be applied to various product designs.

In the Wiegand-effect devices, the wire is made of a variety of magnetic alloys. Two readily-available materials include Permalloy (50 Ni, 50 Fe) and Vicalloy (10 V, 52 Co, 38 Fe). By a twisting action, the shell of a 10-mil wire is work-hardened to produce a coercive field of 20 to 40 Oe. The core meanwhile maintains a relatively low coercive field, in the neighborhood of 5 Oe. Thus, in a long wire saturated to the right, the core switches in an applied field of about ±5 Oe to either the left or the right with the magnetization of the shell remaining unchanged.

If the ratio of length to diameter is chosen properly, the demagnetization field of the wire will be large enough for the set and the reset processes to occur for magnetic fields over the range of 0 to 20 oersteds.

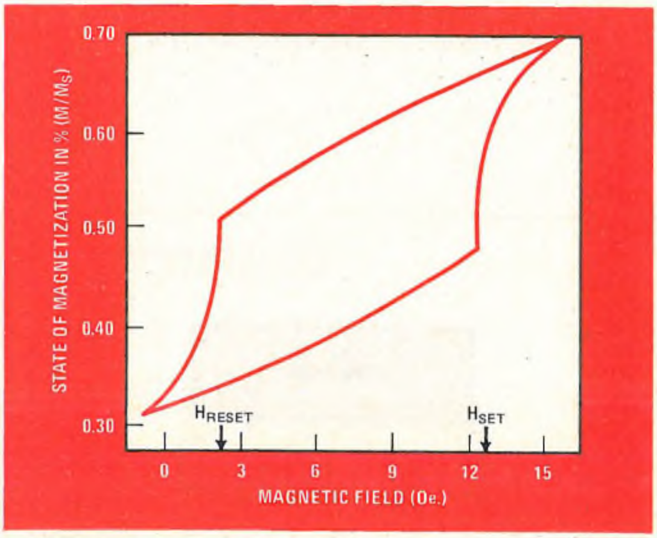
As for the short-wire configuration, the demagnetization will be given by $H_D = -c(d/L)\overline{M}$. The value of c will depend on the degree of magnetic saturation, and will probably be less than 4 π. Using the midpoint between H_{set} and H_{reset} as the value of the demagnetization field, the magnitude of c can be determined by computing H_D/M versus d/L for a number of wires, and turns out to be approximately 2 for this case. From the Wiegand loop in Fig. 7, domain wall switching apparently occurs when M/M_s is about 0.5 or when the material is only half saturated. In equation (2), this accounts for the significant deviation of the constant, c, from the expected value of 4 π.

By reversing the applied magnetic field sufficiently to switch the magnetization in the shell, the Wiegand loop will occur in the negative M and H directions, indicating the bipolar nature of the switching process.

Experiments have shown that the velocity of the domain wall in a wire will be given by

$$v = A(H - H_o) \qquad (3)$$

where A = 40,000 cm/s Oe for Permalloy and $H - H_o$ is the field acting on the domain wall. In the short wire, H_o is the demagnetization field and H is the applied magnetic field at which the magnetization is reversed. The result is a domain-wall velocity of 2×10^5 cm/s. A 1-cm wire should produce a pulse width of 5 microseconds. However, the domain wall observed in Fig. 6 is



7. Wire switch. A key factor in the Wiegand effect is the magnetic loop that provides "set" and "reset" points that are repeatable and depend upon the relative magnetization of shell and core of the wire.

stretched out to a length of nearly 100 cm. The resulting switching is the creation of a domain wall that propagates from one end to the other in 5 to 10 μs. The domain wall then expands radially at a much lower velocity resulting in a switching time in the neighborhood of 100 μs. The very rapid axial velocity assures one pulse per switch.

In the switching process, the magnetic system is changing from a higher energy state to a lower energy state. The difference in the energy, Δε, between these states is given by

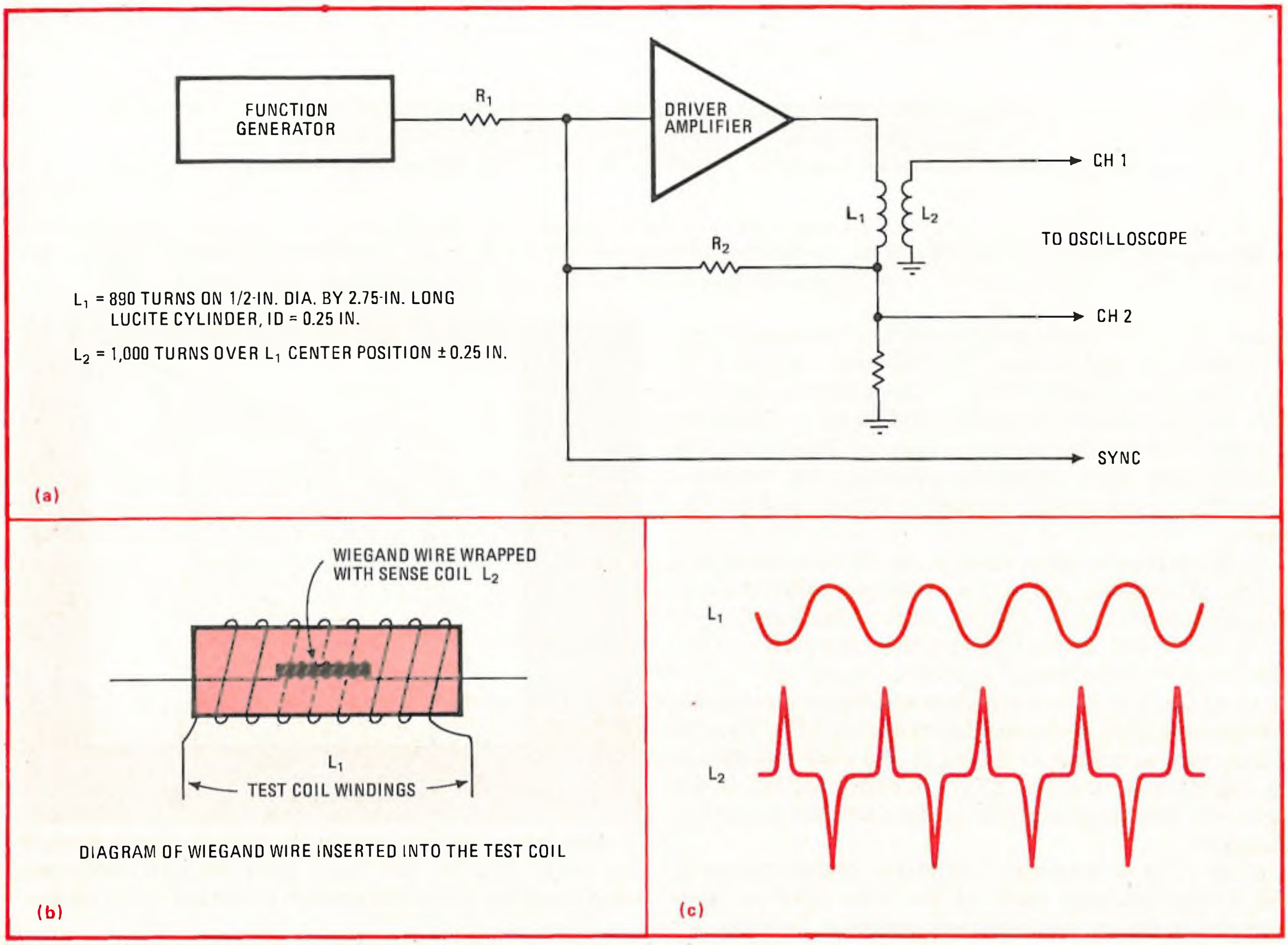
$$\Delta\varepsilon = H_{int}\,\Delta M V \qquad (4)$$

where H_{int} is the internal magnetic field, ΔM is the difference in the magnetization in the two states, and V is the volume of the material involved in the switching process.

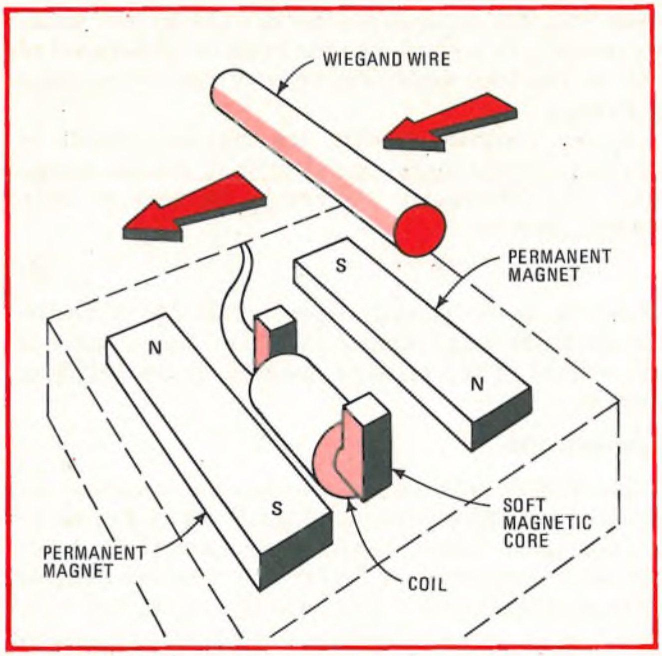
Applications

The energy radiated into surrounding space can be detected by appropriately designed detectors. For an internal magnetic field (H_{int}) on the order of 10 Oe, a difference in magnetization before and after switching of 100 gauss (ΔM) and a d/L ratio of 0.01, a 1-cm wire switching in 10^{-4} sec. radiates a power of 2 milliwatts. Experimentally, detector signals up to 500 millivolts have been recorded in 50 ohm loads.

Practical applications of the Wiegand effect are relatively simple to implement. For instance, a magnetic



8. Sensing. Typical Wiegand-wire test apparatus (a) has a coil arrangement as in (b). Output signal (c) shows oscilloscope trace of waveforms in drive coil L_1 and sense coil L_2. The means of detecting the signal pulse depends on the particular application, however.



9. Moving on. Schematic of a transformer-style read head shows the "switching" magnets used to control the position of the switching signal for maximum sensitivity of the read head as Wiegand-treated wire passes in direction of the arrow.

field of 10 oersteds can be applied by a small magnet moving relative to the wire, or by applying a direct current to a coil wrapped around the wire. In either configuration the switching process occurs when the magnetic field achieves a certain magnitude that depends on the length of the wire and the state of the magnetization. The important point is that the switching is independent of the rate at which the magnetic field is applied. The signal in the detector is not rate sensitive, giving the same output for operation at a low or high velocity.

The means of detecting the signal pulse depends on the particular application. If the wire is at rest and the magnetic field in the surrounding space is changing, the detector may be a coil wrapped around the Wiegand wire.

Details of the coil arrangement in a typical test apparatus are down in Fig. 8, where the drive coil is L_1 and the detector or sense coil is L_2. Waveforms of the magnetic field drive in L_1 and the switching signals induced in L_2 are also shown.

In other applications it is desirable to mount the magnetic wire, or series of wires, on a device moving through a changing magnetic field. A transformer-type read head (Fig. 9) is particularly useful in such an arrangement. A typical system may have up to 150 wires mounted on a 5-cm-diameter wheel. As the wheel ro-

10. Turning point. Rotary pulser with Wiegand wires embedded in the rotor could be used for electronic auto ignition since the pulse generated is independent of the velocity of the distributor shaft. As each wire passes the read head a pulse is generated, which could be used to produce, among other things, an ignition spark.

11. Easy reading. As a card reader, a Wiegand-effect system could provide binary-coded signals without need of power line or batteries. Wires in the card slide past the magnetic read head, producing the coded output signal without any other moving parts.

tates, small magnets on the read head cause the switching action (Fig. 10). Such a device requires no electrical input power to the read head, has a signal-to-noise ratio of better than 40 dB, and a uniform signal amplitude at rotation speeds that can vary from near zero to 720 rpm. At a constant angular rotation velocity of the wheel, the reproducibility of the pulse is $\pm 10^{-4}$ seconds or about the width of the pulse. The Wiegand effect is useful in this application because it is a non-contact, solid-state device composed of low-cost stable materials, and has a long lifetime. The output signal varies by less than 2 dB in the temperature range of $-50°C$ to $+100°C$. It will operate in aqueous, gaseous, organic solvent, or vacuum environment, and if properly encapsulated, it will operate in a corrosive medium.

Because the polarity of the output signal is determined by the form of the external magnetic field, the device can be any combination of direction and polarity to distinguish forward or backward motion. A typical bipolar application of this feature is a plastic card reader using binary coded output signals (Fig. 11). Instead of using the C core shown in Fig. 9, an E core with the coil wrapped on the center leg is used. By properly cancelling the SNMW properties of one half or the other of a Wiegand wire the induced pulse will have either positive or negative polarity.

This type of card reader offers several advantages. The wires cannot be altered or "erased" except by destroying the entire card. The detection system requires no electrical power input to the read head and the detection signal is independent of the velocity of the card as it passes the read head.

The Wiegand-effect device will operate in single-wire or multiple-wire configuration. It also can be used in a wire bundle. In this configuration, the wires switch in a mutually exclusive manner making distinct pulses from each wire detectable. Signals from bundles of four to six wires are readily discriminated, and as many as 20-wire bundles have consistently produced individually-detectable pulses.

By alternating the way wires are arranged, other products have been designed using the same Wiegand-effect technology. A plastic-key cylinder having two or three embedded wires, when pushed into a reader-lock, provides the signal to open a door. Window-mounted Wiegand-effect wires sliding past a simple reader will set off a burglar alarm. The pulse generator described earlier can be designed as an automobile ignition system that will perform at any speed, and in harsh environments. In short, the list of potential products cover many applications that may require a pulse generator or a magnetic-field sensor. □

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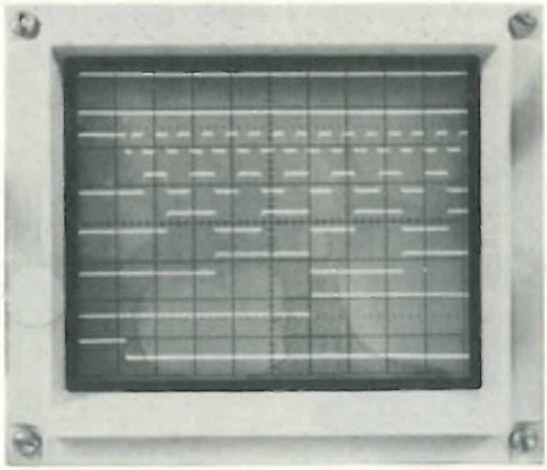

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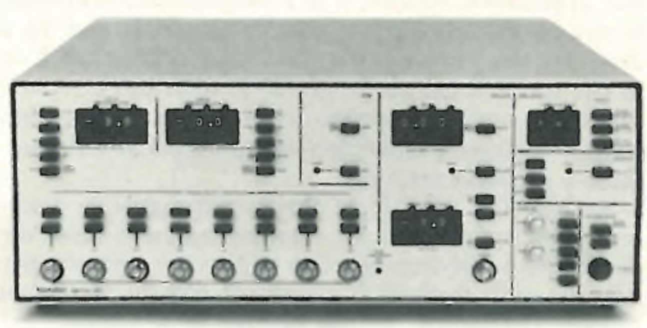


biomation

Timing: a crucial factor in LSI-MOS main-memory design

Extremely tight constraints are manageable, but not without definite ground rules under which to proceed; herewith some ground rules to make the most of the cost/speed advantages of semiconductors

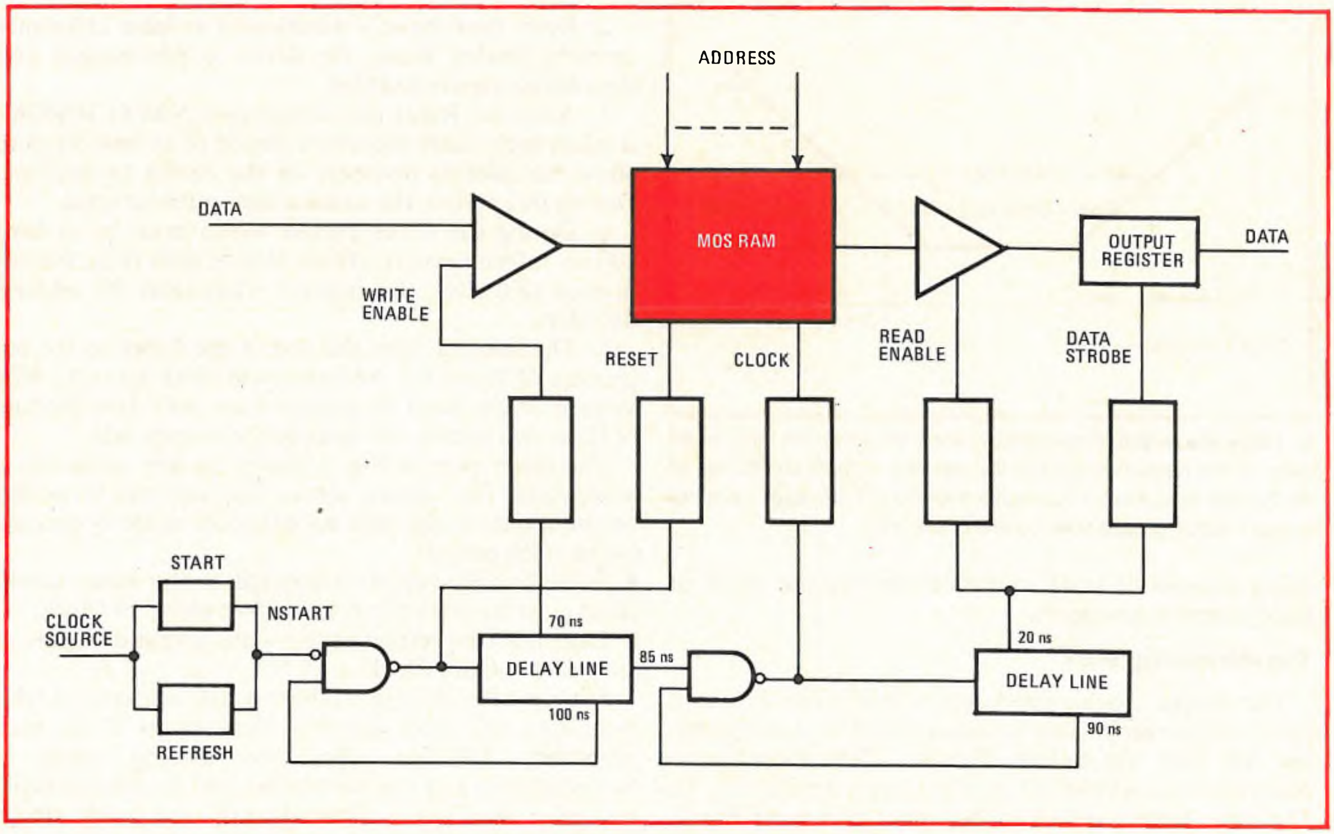
by Len Levine and Ware Myers, *Xerox Corp., El Segundo, Calif.*

☐ Semiconductor main memories based on MOS random-access-memory devices offer important advantages to the designer. Cost per bit is substantially less than core, and read and write access times are faster. But in using many types of MOS RAMs, the memory designer faces opposing constraints that are difficult to reconcile. He must assure that the memory operates slowly enough—that is, the reset and clock periods are long enough—to avoid bit errors. On the other hand, the longer the reset and clock periods, the slower the basic computer speed.

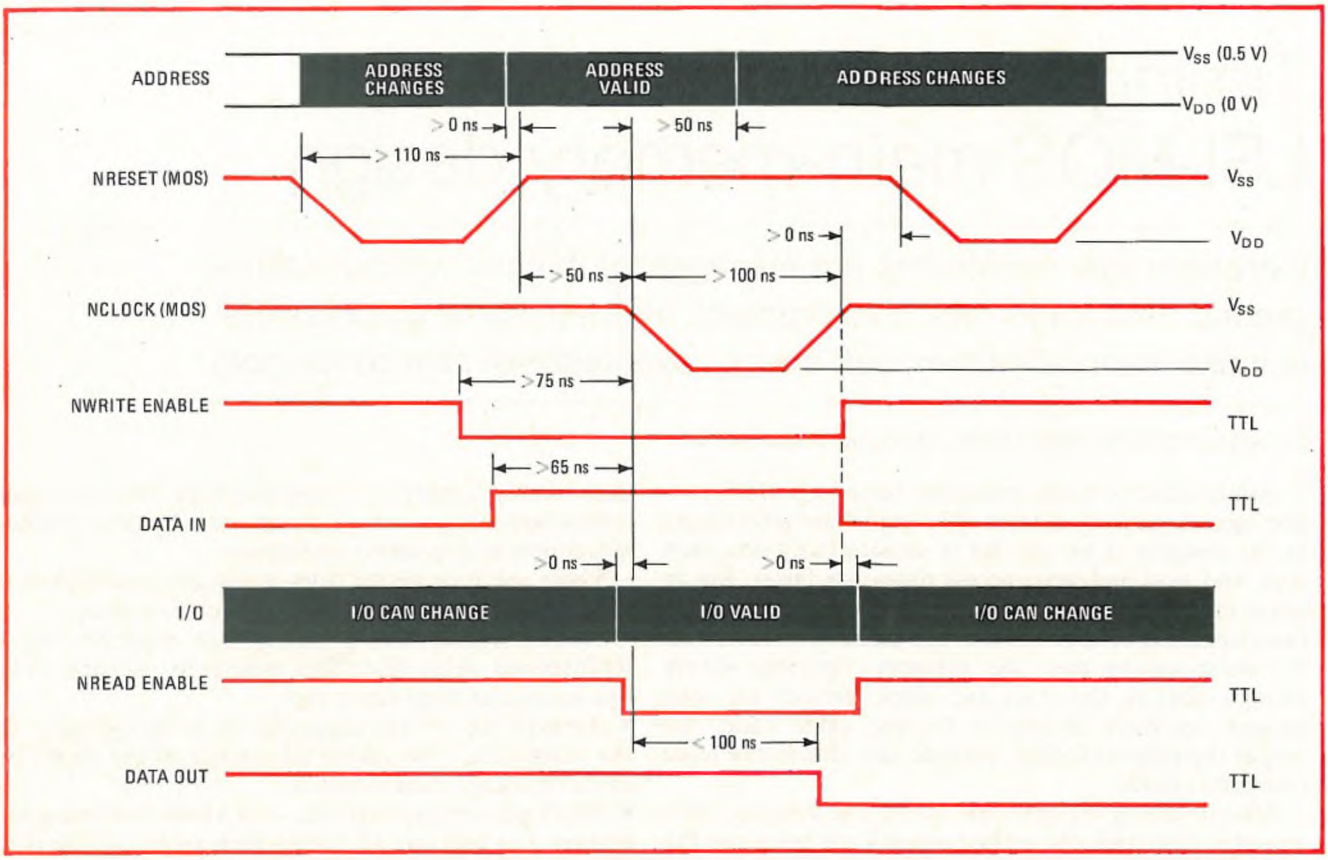
Also, in setting the optimum speed, the designer must consider that critically related signals are found at the ends of long logic chains, whose delays can vary from unit to unit. He must maintain critical timing relationships across hundreds of manufactured units in which component delays can lie anywhere between specified minimums and specified maximums.

There are four major rules a designer can follow to assure proper timing in a semiconductor memory:

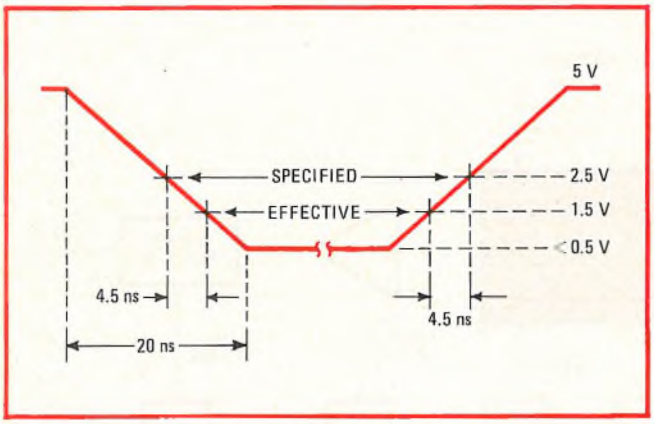
- Where several timing signals are required, use a multitapped delay line. This maintains excellent relative accuracies from tap to tap.
- Arrange the critical sequences so as to use gates on the same chip, thus taking advantage of the chip's inherent tracking characteristics.
- When possible, use relative—not absolute—timing tolerances and measure all timing with respect to the closest common reference point.
- Do not overlook the small timing shifts that can de-



1. Memory. A system built around an MOS random-access-memory device can use delay lines to distribute timing signals having close timing accuracies. In the logic chains leading to the memory, gates on the same chips can help equalize time delays.



2. Timing is everything. For each of the signals to a semiconductor memory, there are basic restrictions on when transitions for address changes, input-output, write and read signals can occur. (Voltage levels are for MOS and TTL devices.)



3. Delay line output. Rise and fall times at the delay-line outputs depend on the relative position of the tap, and outputs are defined at the 2.5-volt level. Since TTL circuits respond at 1.5-V level, extra delays can occur for taps near the end of the line.

velop because of small variations among the levels of logic-element thresholds.

The measuring stick

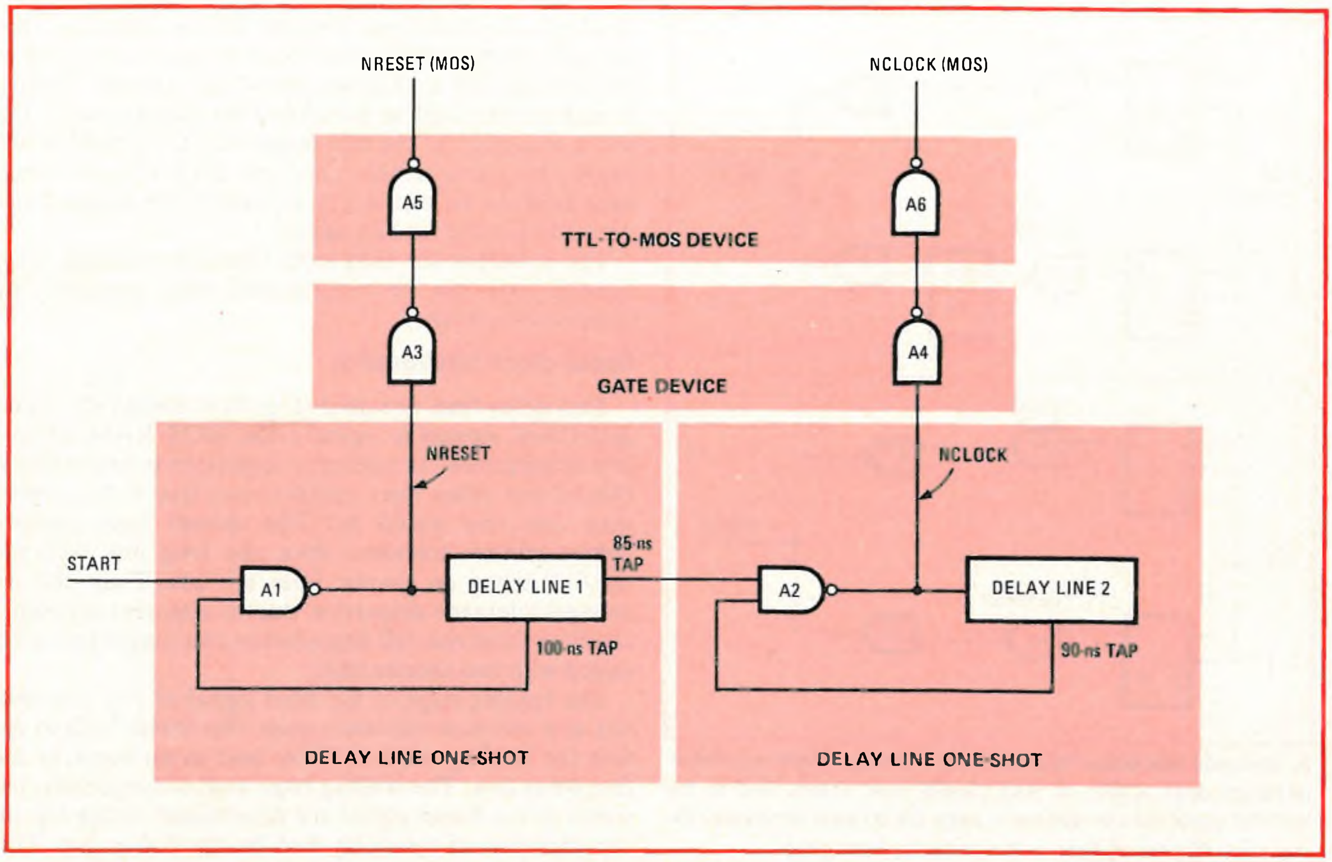
The proper design approach is best studied with a particular example. This article is based on a design using the 7635 TTL-to-MOS Driver, 75370 Read/Write Amplifier, and AMS 6002 × 1 MOS RAM device (Fig. 1). The basic timing, shown in the upper portion of Fig. 2, is the same for the write cycle and the read cycle:

1. The address lines change prior to or during Reset.
2. Reset must have a duration of at least 110 nanoseconds. During Reset, the device is pre-charged and the address inputs disabled.
3. After the Reset line, designated NRESET(MOS), is taken high, there must be a period of at least 50 ns to allow the address decoders on the device to function. During this period, the address lines must be valid.
4. During the Clock period, which must be at least 100 ns, information is written into or read from the addressed cell. Also, this input is what gates the address decoders.
5. The spacing from the end of the Clock to the beginning of Reset for the next cycle, both taken at MOS voltage levels, must be greater than zero. Overlapping of these two signals can damage the storage cells.

The lower part of Fig. 2 shows the key signals in a write cycle. Two criteria assure that data will be settled on the inputs to the MOS RAM devices at the beginning of the clock period:

- Write Enable (which is applied to the write amplifiers) must be available at least 75 ns ahead of Clock.
- Data must be settled at the write-amplifier inputs at least 65 ns before Clock.

For a read cycle (Fig. 2) there is only one critical relation: data will have settled at the outputs of the read amplifiers 100 ns after the leading edge of NCLOCK(MOS) and can be latched into the output register after that point. Consequently the latch strobe should be timed to the settled data as closely as accumulated tolerances will permit.



4. Reset and clock. Use of two delay lines permits shorter lines, with closer relative timing accuracies. Circuits in the gates and TTL-to-MOS devices which lead to the memory are arranged on the same chips so that their performance tracks closely.

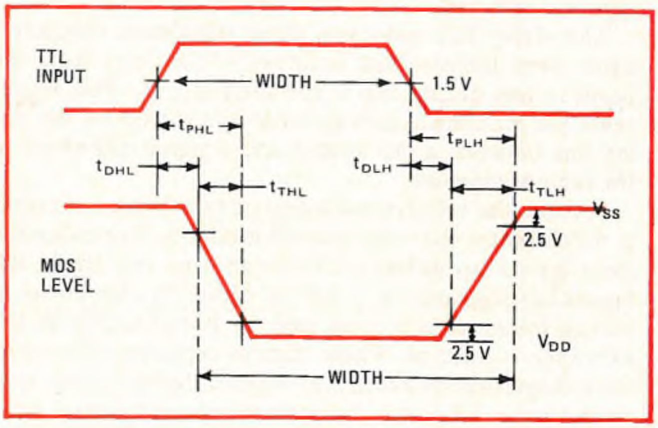
At the memory-system level, a memory access must be completed within the 700-ns computer-microinstruction period. This period covers not only the actual memory-access time, which is 330 ns worst-case, but also the time the computer needs to command an access, make address and data available (for a write cycle), or further process data read-out (in a read cycle).

Because the MOS RAM device is dynamic, the storage cells must be refreshed periodically, at least once every 2 milliseconds. This imposes the additional constraint of having to accommodate refresh cycles within the timing limits.

Fundamentally, two approaches to refresh can be taken. The first causes the computer to delay a memory access when refresh is due. The second "hides" the refresh cycle in the overall time allowed for one memory access. The latter method was used in this application. With a 330-ns memory access maximum, there are 370 ns left in the overall time for refresh.

However, with this method of refreshing the memory, there is another timing limitation. In theory a memory-access cycle of 330 ns can be followed by a refresh cycle of 330 ns, and both cycles can be carried out well within the 700-ns computer-clock period. In practice, the logic chain leading to a memory access port must be approximately equal in length to the logic chain leading to a refresh cycle. The beginning of one chain is offset from the beginning of the other by 350 ns—half the computer period.

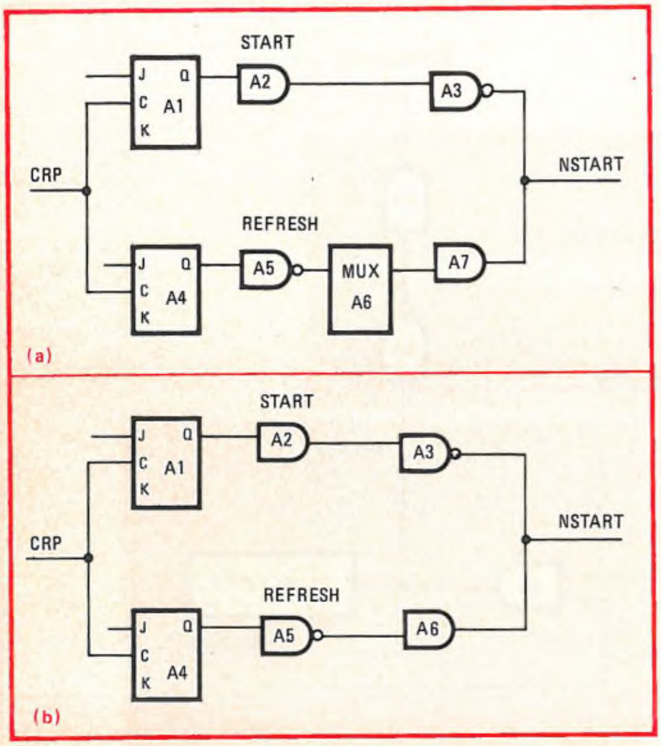
Determining when to do a memory access and when



5. Driving time. The TTL-to-MOS driver tends to stretch out the trailing edge and the MOS pulse widths are larger than the TTL widths. This fact must be taken into account when calculating the pulse widths of the TTL signals.

to do a refresh takes quite a bit of what may be thought of as parallel logic. Each chain is initiated basically from the computer clock, but the length of one chain must be within ±20 ns of the length of the other chain, after allowing for the worst-case tolerance accumulation—minimum for one chain and maximum for the other. The absolute length of the chains is critical to the criterion of completing an overall memory cycle within 700 ns.

For error-free memory operation, precise distribution of timing signals is essential. To meet this requirement a



6. Common reference. Relative timing is measured from a common reference point (CRP). In 6(a), parallel logic chains lead to the NSTART signal but the multiplexer stage (MUX) adds extra delay tolerance. In 6(b) the multiplexer is replaced by logic gates.

highly accurate delay line of the powdered-iron-toroid type was selected.

This delay line possesses three significant characteristics. First, the absolute accuracy of the delay from the input to any output tap is specified at ±3%. This represents the maximum timing error introduced by the delay line between a tap output and a signal elsewhere in the memory system.

Second, the relative accuracy, or tap-to-tap tolerance, is much better than the overall accuracy. For example, for a tap-to-tap difference between 5 ns and 50 ns, the tap-to-tap tolerance is ± 0.5 ns. Similarly, for 50 ns to 100 ns, tolerance is ±1.0 ns, and for 100 ns to 250 ns, the tolerance is ±2.0 ns. These figures represent the tolerance dispersion between key signals derived from taps on the same delay line. In other words, outputs of a delay line may be said to "track" each other within a dispersion range less than the normal tolerance.

Third, the delay time at each line tap shifts from nominal as a result of rise-and-fall-time degradation, and the amount of this shift is a function of the tap position on the line (see Fig. 3).

Adding it up

This delay results from a combination of factors. The delay-line taps are specified at the +2.5-volt level, while the TTL threshold at which the signals become effective is 1.5 V. Furthermore, the rise or fall time is directly related to the number of inductor-capacitor sections between the input and the output tap. For example, if the rise/fall time is 20 ns, the 1-V difference between 2.5 V and 1.5 V delays the threshold 4.5 ns beyond the nominal time. On one 200-ns delay line, the fall time at the first tap was observed to be 10 ns and at the last tap, 20 ns. Consequently, the amount of shift from nominal must be calculated for each tap used. On the tailing edge of the tap output, the threshhold is advanced by a comparable time, but this is of less interest here because all of the key signals in the memory are derived from the leading edges.

The apparent tap shift from nominal, resulting from rise-fall time, can be compensated when necessary by using adjacent taps.

Reset-clock relationship

Two delay lines are used (Fig. 4) to obtain the Reset and Clock signals to operate the MOS RAM devices and to minimize the tolerance dispersion between them. Use of two delay lines permits each line to be shorter than one line would be. The shorter lines provide tighter relative tolerance than one long line, and the rise/fall times on shorter lines are less. Thus, the increased tolerance dispersion due to apparent tap shifts resulting from rise-fall degradation of a longer line is reduced with two shorter lines.

The leading edge of the Start signal of Fig. 4 is chosen as a common reference point that serves both to define the leading edge of Reset and as an input to the first delay line. The trailing edge and, consequently, the width of the Reset signal are determined to the tap-to-tap precision of the delay line by the 100-ns tap. This combination of the Start gate, delay line, and feedback to the start gate may be thought of as a high-precision one-shot.

The minimum, nominal, and maximum widths of the Reset signal at the TTL level are calculated as follows:

Tap (100 ±1.0 ns)	99	100	101
Gate A1 delay	2	4	6
NRESET(TTL) Width	101 ns	104 ns	107 ns

The tap-to-tap tolerance is employed here because the main point of concern is the width of NRESET relative to the address-decode period between Reset and Clock. Absolute width is important, too. The width of Reset at the TTL level is set short of the 100-ns minimum required at the MOS level. How the TTL level gets stretched by the TTL-to-MOS driver by the time it reaches the MOS level is discussed later.

The 85-ns tap sets the leading edge of Clock and determines the duration of the device-decode period relative to the trailing edge of NRESET:

Tap (85 ±1.0 ns)	84	85	86
Gate A2	2	4	6
Device-Decode time	86 ns	89 ns	92 ns

The 90-ns tap on the second delay line fixes the width of Clock, relative to its leading edge:

Tap (90 ±1.0 ns)	89	90	91
Gate A2	2	4	6
NCLOCK (TTL) Width	91 ns	94 ns	97 ns

To reduce the relative dispersion of Reset and Clock at the MOS level, the principle of tracking components can be used (Fig. 4). Elements located on the same chip track each other in their performance much more closely than elements on different chips. Consequently, tolerance dispersion for tracking Schottky gates (A3 and A4) can be reduced to ±0.5 ns compared to ±2 ns between devices. Tests are necessary to establish the tracking tolerance, since vendors do not normally specify this value. The TTL-to-MOS drivers have a specified tolerance of ±4 ns, but this can be reduced to ±1 ns between drivers on the same device. Note that it must be kept in mind that the reduced tolerance is relative, not absolute. Relative to each other, the signals being compared may vary by the small tracking tolerance. But relative to other signals, full tolerance dispersion applies.

In the Reset-Clock design, use of the tracking principle improves the dispersion through the two parallel elements from ±6 ns to ±1.5 ns.

TTL-to-MOS stretching

The TTL-to-MOS drivers stretch out the trailing edge of pulses applied to them (Fig. 5). The MOS level becomes effective at the MOS RAM device 2.5 V below V_{SS} (+20.5 V) and remains effective until the trailing edge of the negative pulse returns to this level.

In terms of the width of the TTL pulse, (PW_{TTL}) the width of the MOS pulse (PW_{MOS}) may be expressed as follows (see Fig. 5):

$$PW_{MOS} = PW_{TTL} - t_{DHL} + t_{DLH} + t_{TLH}$$

If $t_{DHL} = t_{DLH}$, as is approximately the case, then $PW_{MOS} = PW_{TTL} + t_{TLH}$.

For the driver used, t_{TLH} is 14 ±6 ns. In consequence, the NRSET and NCLOCK widths at the TTL level, previously calculated, are increased by this amount at the MOS level.

The identification of the closest common reference point for related signals permits the designer to ignore tolerance buildup prior to the common point. Tolerance dispersion can then be calculated from the common reference point for the two (or more) signals whose times must satisfy a specification with respect to each other. For example, the inputs to the delay lines in Fig. 4 are common reference points for signals derived from the delay line.

To take another example, as in Fig. 6, the signal labeled CRP is the common reference point for the two chains of components leading to NSTART. This latter signal is itself another common reference point, constituting the starting point for a MOS memory access. The signal at CRP clocks two flip-flops and is the product of a combinational logic network (not shown), which removes it by several stages from the basic computer clock governing overall timing. Each flip-flop has a set input, itself the product of a combinational network, which determines when the flip-flop can be clocked. The upper (start) path is triggered for a memory access, read or write, while the lower path initiates a refresh cycle. The J inputs are not shown in detail because they are not critical to the timing.

Some of the successive gates in Fig. 6(a) may appear unnecessary, but in the detailed design, additional enabling or disabling signals were added at each gate level to implement various logic requirements.

Recall that the maximum memory cycle is 330 ns and an access cycle and a refresh cycle must both be completed within 700 ns. Under these circumstances, the Start chain and the Refresh chain must be equal in delay length within a tolerance of ±20 ns. The original design (Fig. 6a), had the following tolerance dispersions from CRP:

	Minimum	Typical	Maximum
Start	9 ns	21 ns	52 ns
Refresh	13 ns	28 ns	63 ns

The worst-case path difference thus was 63 minus 9, or 54 ns, well in excess of the 20-ns requirement.

The excessive dispersion resulted from two factors. First, a multiplexer device with a rather wide stage-delay tolerance was included in the Refresh path. Second, relatively slow flip-flops, with a different device on each path, were employed. Also, the paths were divided between two modules whose designs happened to be the responsibility of different groups.

Once the need to equalize path length and minimize tolerance dispersion became apparent, two changes were made. First, the multiplexer device was removed from the Refresh path entirely, as in Fig. 6(b), and the logic functions it was performing were reassigned to the gates. This change tended to equalize path length as well as eliminate one source of dispersion. Second, the relatively slow flip-flops were replaced by Schottky flip-flops—not so much to gain speed, but because the Schottky devices have low dispersion. To further reduce disperson, the two flip-flops were obtained in a single package. The result is that the current design has the following dispersion:

	Minimum	Typical	Maximum
Start	9 ns	17 ns	26 ns
Refresh	8 ns	15 ns	23 ns

Maximum dispersion from the common reference point is now ±9 ns, well within the required figure of ±20 ns.

Thus, when a new memory design involves critical time relationships the designer should take advantage of the concepts developed in this article: precise timing sources (such as delay lines), common reference points for critically related signals, and tracking components on parallel chains. Following a synthesis stage, the tentative design should be analyzed to find out which time relationships are critical and which are not. The critical times then can be worst-case analyzed.

In parallel with analysis, breadboards or prototypes should be built and tested to verify the design and to measure the actual delays, providing further insight into the timing relationships. Sample-device tests to establish the dispersion of certain component types will prove necessary when vendor-supplied data is incomplete.

Both analytical and experimental stages will normally lead to various design changes. Because of the use of delay lines, retiming can often be accomplished merely by changing a signal from one tap to an adjacent tap. But in designs where timing is a critical factor, delay lines provide much-to-be-desired flexibility for meeting the inevitably changing circumstances. □

Op-amp circuit measures diode-junction capacitance

by D. Monticelli and T. Frederiksen
National Semiconductor Corp., Santa Clara, Calif.

For measuring the small-signal junction capacitance of a semiconductor diode, this simple circuit has two advantages over conventional capacitance bridges or meters. The ac test voltage is low enough to avoid excessive modulation of the diode's depletion layer. (Many conventional capacitance meters use such high ac voltages that their readings do not accurately represent the small-signal characteristics of the diode.) And a variable dc bias voltage can be applied to the diode, making the circuit more flexible.

As shown in Fig. 1, the diode is connected to the inverting input terminal of an LM324 operational amplifier, and ac and dc voltages are applied to the noninverting input terminal. The values of the input and output voltages, v_i and v_o, are read on high-impedance voltmeters. The diode junction capacitance, C_J, is then

$$C_J = C_F (v_o - v_i)/v_i$$

where C_F is the known value of the capacitance in the op-amp feedback loop. In the circuit shown here C_F and v_i have been made numerically equal (10 picofarads and 10 millivolts, respectively), so

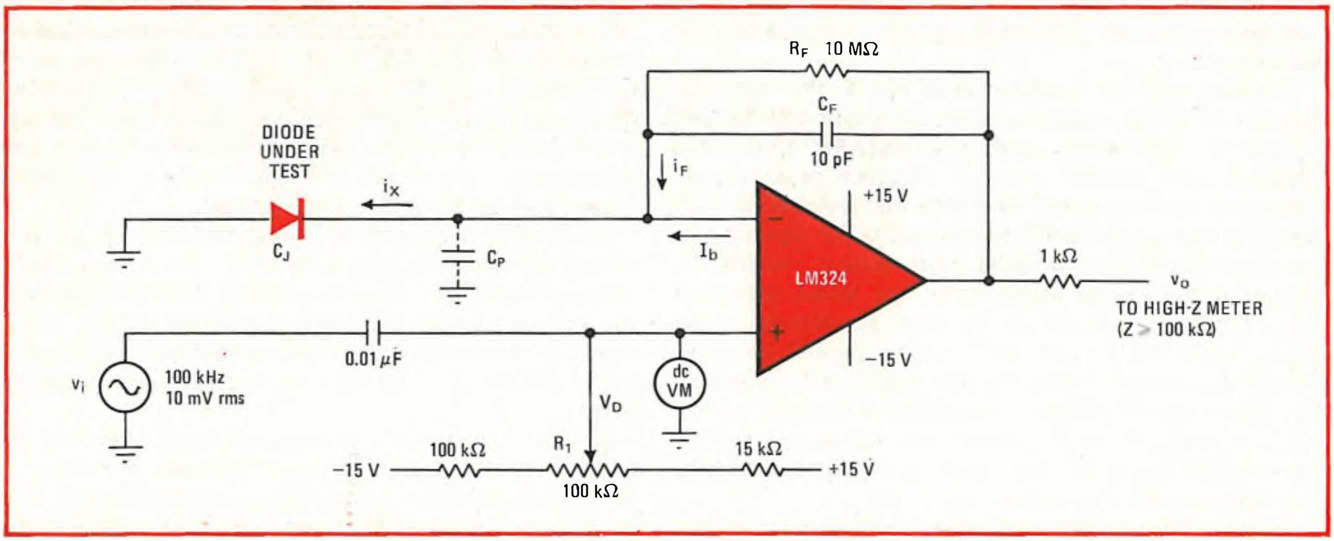
$$C_J = (v_o - v_i)\, pF/mV$$

The dc voltage, V_D, that is applied to the noninverting terminal can be varied through the range from 13 volts to −1 V by means of potentiometer R_1. As a result of the feedback, this voltage appears at the inverting input and is impressed across the diode to provide any value of reverse bias from −13 V to the verge of conduction. The ac input voltage, v_i, is made small to avoid excessive modulation of the junction's depletion layer; 10 millivolts rms is a good value. Voltage v_i is also impressed across the diode through the action of the op amp. C_F and C_J then make up a simple ac voltage divider so that $C_J = C_F (v_o - v_i)/v_i$.

Feedback resistor R_F provides a path for the input-bias current of the LM324 (typically 45 nanoamperes), which allows the amplifier to impress V_D across the diode. In doing so, it offsets the dc-output voltage slightly, but does not affect operation. The actual dc-output voltage is given by $V_O = V_D - I_b R_F$. R_F must be chosen carefully; too large a value offsets V_O excessively, and too small a value (relative to the reactance of C_F at the operating frequency) introduces phase shift.

When i_F is out of phase with i_X, the simple capacitive divider relation does not hold, and phasor relationships must be considered. A value of 10 megohms for R_F is practical if the frequency is about 100 kilohertz because the reactance of even a 10-picofarad C_F is only 160 kilohms and gives a phase error of only 1°. Furthermore, the real part of the 324's input impedance shunts C_J slightly and phase-shifts the diode current i_X in the direction of i_F, thereby minimizing the phase difference between the two currents.

To achieve good results in measuring small values of capacitance, the parasitic capacitance C_P that shunts C_J must be accurately known. The parasitic capacitance consists of stray capacitance C_{STRAY} and the input capacitance of the LM324 op amp C_{IN}. The C_{STRAY}, lead and socket capacitance, is independent of V_D. The input



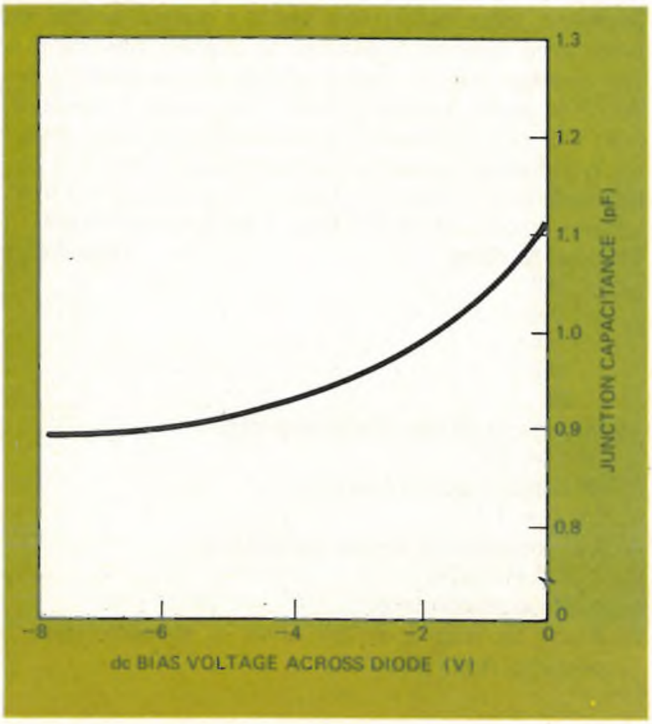
1. Measuring capacitance. Junction capacitance of a semiconductor diode is measured as a function of dc-bias voltage in this circuit. Diode is connected to inverting input terminal of LM324 operational amplifier, and dc-bias and ac-test voltages are applied to noninverting input terminal. Low ac test voltage avoids excessive modulation of depletion layer, for accurate measure of small-signal junction capacitance.

capacitance of the 324 is dependent on V_D (C_{IN} typically is 0.85 to 0.75 pF for common-mode voltages of 5 to 20 V). Fortunately C_{STRAY} usually dominates. Operating the 324 with positive and negative supplies while simultaneously restricting the input voltage to −1 V on the low end of the V_D range reduces the voltage dependence of C_{IN}. In the authors' circuit, C_P measured 3.55 pF with $V_D = -1$ V and 3.45 pF with $V_D = 13$ V. A differential measuring technique, first measuring C_P with the diode out of the circuit and then measuring ($C_P + C_J$) with the diode in, gives the best results. C_F should be a low-tolerance capacitor (a good silver-mica was used by the authors). The pin-to-pin parasitic capacitance of the LM324 that shunts CF is negligible if the board layout minimizes adjacent lead length between the inverting and output pins.

Figure 2 shows a plot of junction capacitance in relation to reverse bias for a 1N914 diode as measured by the circuit in Fig. 1.

Those who want a self-contained unit can use the remaining three op amps in the quad LM324 package plus two additional amps from the dual LM358; both will operate from +9-V and -9-V batteries because of their small current drain. One amplifier can be wired as a Wien-bridge oscillator to supply v_i, while two others can peak-detect voltages v_i and v_o. These peak-detected voltages can then be differenced by a fourth amplifier, and a fifth amplifier can be used to drive a 1-mA meter for a direct reading of capacitance in picofarads. A pot in the noninverting leg of the difference amplifier can be used to offset-null the C_{STRAY} of the circuit. □

2. Result. Junction capacitance of 1N914 diode as a function of reverse bias is measured with circuit shown in Fig. 1. Data sheets do not provide all the information on C_J that is sometimes needed. Conventional capacitance meters use ac voltages that are too high for small-signal measurements and do not provide adjustable dc bias.



Fast method converts numbers from base 10 to any other

by Hans Treichel
Siemens Corp., Cherry Hill, N.J.

Engineers, programers, and others who have undergone the drudgery of converting numbers from the decimal system to systems with other bases will welcome this quick and simple conversion method. If a pocket calculator is available, no manual calculation or recording is needed other than jotting down the answer.

A chart is provided as reference for conversion to hexadecimal, octal, and binary numbering systems. The first column provides equal fractional parts of the numbering system to be used; e.g., hexadecimal notation the column is divided into 16 fractional parts 0/16, 1/16, 2/16, 3/16, . . . 15/16. In the other columns, each fractional part is assigned a digit; the digits are assigned consecutively, starting with the smallest fractional part of the numbering system.

The first step in conversion is to divide the decimal number by the base of the numbering system to which you are converting. If the number following the decimal point is greater than or equal to a fractional number in the chart, record the equivalent number as the least significant digit (LSD) in the new numbering system. Next divide the base number into the result of the first step. Look at the chart again and record the equivalent number as the second LSD. Repeat this process until the division produces a number smaller than 1.

As an example, let's convert the decimal number 321 to its hexadecimal equivalent:

1. Divide 321_{10} by 16 to get 20.0625.
2. From the chart, 0.0625 corresponds to 1, so record 1 as LSD.
3. Divide 20.0625 by 16, getting 1.2539.
4. From the chart, 0.2539 is greater than 0.25 but less than 0.3125, so record 4 as the second LSD.
5. Divide 1.2539 by 16, getting 0.0784.
6. From the chart, 0.0784 is greater than 0.0625 but less than 0.125, so jot down 1 as third LSD.
7. Since the result in step 5 is less than 1, conversion is complete. Answer is 141_{16}.

As you can see, the answer 141_{16} was reached in only seven steps, and nothing had to be written down except the answer itself.

As another example, using the larger digits in hexadecimal notation, convert 687_{10} to base 16:

1. 687/16 = 42.9375.
2. From chart, 0.9375 corresponds to F as the LSD.
3. 42.9375/16 = 2.6836.
4. From chart, 0.6836 corresponds to A as second LSD.

5. 2.6836/16 = 0.1677.
6. From chart, 0.1677 corresponds to 2.
7. The result in step 5 is less than 1, so conversion is complete. Answer is $2AF_{16}$.

The chart provided shows equivalent numbers in the hexadecimal, octal, and binary numbering systems. However, what makes this method unique is that the table need only be expanded to enable conversion to any number system; simply divide the numbering system into equal fractional parts; (e.g., base 5 would be 0/5, 1/5, 2/5, 3/5, and 4/5) and assign the digits within the numbering system to each fractional part: 0/5 corresponds to 0; 1/5 to 1; 2/5 to 2; 3/5 to 3; and 4/5 to 4.

Thus, to convert 28_{10} to base 5, jot down this table:

Decimal fraction	**Base-5 digit**
0.8	4
0.6	3
0.4	2
0.2	1
0	0

Then go through the conversion steps:
1. 28/5 = 5.6.
2. 0.6 corresponds to 3 as LSD.
3. 5.6/5 = 1.12.
4. 0.12 corresponds to 0 as second LSD.
5. 1.12/5 = 0.224.
6. 0.224 corresponds to 1.
7. Result in step 5 is less than 1, so conversion is complete. Answer is 103_5. □

CHART FOR CONVERTING DECIMAL NUMBERS TO HEXADECIMAL, OCTAL, OR BINARY NOTATIONS

Numbering System Fractional Parts	Equivalent Digits		
	Hexadecimal	Octal	Binary
0.9375 to 0.9999	F	7	1
0.8750	E		
0.8125	D	6	
0.75	C		
0.6875	B	5	
0.6250	A		
0.5625	9	4	
0.5	8		
0.4375	7	3	0
0.375	6		
0.3125	5	2	
0.25	4		
0.1875	3	1	
0.125	2		
0.0625	1	0	
0.0	0		

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.

Three measurement points give coax loss equation

by L.S. Gay
Standard Telephones and Cables Ltd., Basildon, Essex, England

The design of amplitude equalizers for both analog and digital coaxial-line systems requires a knowledge of the insertion loss (L) of the line in decibels, expressed as a function of the length (l) of the line, frequency (f) of the test signal, and perhaps temperature (T). Once this information is available in equation form, the insertion loss can be determined for any length of a given cable at any frequency and any temperature. A loss equation of the form

$$L = l(a + bf^{1/2} + cf)$$

usually provides a satisfactory fit over a wide range of frequencies.

The constants a, b, and c can be derived from three linear equations that are based on measurements of insertion losses in a length of cable at three different known frequencies. Carrying through this procedure, if the loss equation is rewritten as

$$\alpha = L/l = a + bf^{1/2} + cf$$

and α has measured values α_1, α_{10}, and α_{100} at frequencies of 1, 10, and 100, respectively, then

$$\alpha_1 = a + b + c$$
$$\alpha_{10} = a + 10^{1/2}b + 10c$$
$$\alpha_{100} = a + 10b + 100c$$

Solving for a, b, and c yields

$$b = (-10\alpha_1 + 11\alpha_{10} - \alpha_{100})/[11(10)^{1/2} - 20]$$
$$c = [\alpha_{10} - \alpha_1 - b(10^{1/2} - 1)]/9$$
$$a = \alpha_1 - b - c$$

For example, the loss in 1.85 kilometers of type 174 coaxial cable was measured at 20°C, yielding the values α_1 = 5.281 dB/km, α_{10} = 16.584 dB/km, and α_{100} = 52.61 dB/km. Therefore, cable loss in dB at 20°C is

$$L = l(0.068 + 5.21f^{1/2} + 0.0045f)$$

where l is in kilometers and f is in megahertz.

The effect of different temperatures on the insertion loss can be included in the equation as follows:

$$L_T = l_0(1 + \gamma\Delta T)(a + bf^{1/2} + cf)$$

where l_0 is the length of the cable at the reference temperature T_0, and ΔT is $(T - T_0)$. Using a test signal with a fixed frequency, the value of the constant γ can be determined by measuring the insertion loss of a given cable at temperatures T_1 and T_2. Then

$$\gamma = (L_2 - L_1)/[L_1(\Delta T)_2 - L_2(\Delta T)_1]$$

where L_1 denotes the insertion loss at T_1, $(\Delta T)_1 = (T_1 - T_0)$, and so forth. □

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3M COMPANY

Circle 115 on reader service card

Engineer's newsletter

How to make light of LED work

Ever wonder how much of the LED drive current is turned into usable photon energy and how this affects LED life? Both are crucial questions for LED users who often have trouble relating the efficiency of light production to the maximum quantity of available drive current. According to Franc Noel, an associate engineer with IBM's optical development group in Poughkeepsie, N.Y., the conversion efficiency of radiated light (photon energy) is highest at highest drive currents—up to 100 milliamperes. But at lower current values, say, 10 mA, the conversion efficiency drops to about 65%, and at 1 mA it's only about 20%. For the user, the tradeoff, however, is LED lifetime, which degrades as drive current is increased. The rule of thumb is that **life failure rates jump an order of magnitude for each doubling of drive current.**

Career package from IEEE: $30 worth of help?

IEEE's Education Services has put together a package of its three most important reports published during the last few years on the electrical engineering career. If you're a member, you can get "The EEs at Mid-Career: Prospects and Problems," "Your Job in EE," and "Career Outlook in Engineering," for $30 for the set or $15 each bought separately. (Nonmembers' prices are $60 for the package or $25 each.) **Certain to be the best seller for engineers of all ages, "The EE at Mid-Career,"** which has just been released, can be gotten by writing to IEEE Service Center, 445 Hoes Lane, Piscataway, N.J. 08854.

MOS makers think of boosting performance . . .

Most MOS circuit makers who've been worriedly looking over their shoulders at the threat of the oncoming I^2L steamroller may take comfort from the words of Gordon Moore, president of Intel Corp. Says Moore, donning his Mr. MOS hardhat, "Hang in there, fellas, MOS ain't dead yet." Moore sees **"considerable mileage" left in the MOS technology, especially for the tough memory applications,** where cost must be traded off against performance. "That's a job MOS does best," claims Moore. As proof of MOS longevity, he points to the recent advances made in 4-k and 16-k MOS memory, observing happily that these advances can just as well be applied to logic with the equally dramatic results. What's more, he backs up his faith in MOS: "We have no I^2L circuits in development at Intel."

. . . but how to do it is another story

Instead, the more Moore looks at MOS, the more performance he sees, but it may mean **applying new fabricating technology to the basic MOS structure—ion—implanted gates, double levels of interconnections, and very small low-capacitance scaling techniques.** (Silicon gates, remember, gave MOS a similar performance boost years ago.) Moore points to MOS memory performance, where 1- to 2-mil^2 memory cells operate at less than 100-ns switching speeds. This performance, when applied to logic, renders gate operation in the 10-ns TTL range, achievable even without fancy systems such as sapphire substrates or oxide notches.

The big problem with MOS remains, however: limited drive capability. Still, this condition is not so bad for LSI applications where most of the action remains on the chip. Again Moore has an answer: "Use I^2L on the periphery for off-chip driving." **—Laurence Altman**

A Subsidiary of THOMSON-CSF

Introducing four important features in cockpit display CRTs:

RED YELLOW GREEN ORANGE

DuMont is now offering a complete line of cockpit displays in four colors. These CRTs can present two or three times the information capacity of monochrome screens, and yet they make the data far more coherent and more quickly comprehensible than can a monochrome display or a mechanical gauge.

Take energy management, for instance. One DuMont color CRT can display the total fuel remaining, the normal energy consumption according to the flight plan, the fuel reserves for loitering and the fuel reserves for extraordinary fuel demand situations. The pilot can read any or all of these functions at a glance: each is displayed in its own color, and all can be continuously updated. Thus the considerable time and attention required of a pilot by the conventional collection of mechanical gauges is greatly reduced by the use of even one color CRT.

DuMont's color CRTs provide the exceptionally high performance and high resolution that are demanded by cockpit displays in Digital Avionics Integrated Systems. Display precision is completely unaffected by airframe vibration. Line widths as fine as 4 mils are available on most standard designs.

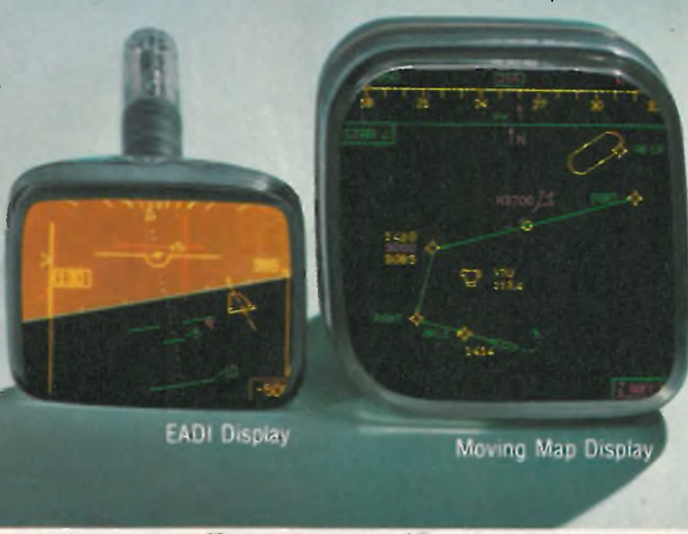
DuMont's proprietary multicolor penetration screen permits the display of data in up to four colors by varying the voltage of a single electron beam. It eliminates the complicated convergence circuitry required by conventional multi-gun color CRTs.

Two typical display formats that are enhanced by multicolor penetration screens are shown below. The EADI mode clearly presents information needed for take off, cruise, approach and final flight control bearings. A simplified moving map display showing distance to stations, course, relative station position, station identification and selcted course outbound is at the bottom, right.

All DuMont color CRTs will withstand vibrations exceeding 60Gs and up to 90Gs with state-of-the-art vibration isolation.

DuMont head down displays also provide superior brilliance and contrast, and perform beautifully in raster-scan and dot-matrix applications, as well as in random-address, stroke-writing systems. There is a wide choice of available CRT models with dimensions ranging from 1.9 x 3.4 to 7.6 x 7.6 inches.

DuMont
Electron Tubes & Devices Corp.



EADI Display

Moving Map Display

For complete specs and information on the most advanced color cockpit CRTs in the world, contact us at: 750 Bloomfield Avenue, Clifton, N.J. 07016 (201) 773-2000.


PROFIT

Mixer is low in distortion—and cost

Small single-balanced device uses novel Schottky diode technique, beam-lead bonding, printed transformers, and cold-epoxy encapsulation

by Bernard Cole, San Francisco bureau manager

To the engineer designing a system that needs frequency conversion, the ideal component would be a tiny mixer that combines the low cost and conversion loss of a single-balanced system with the low distortion and high isolation of a double-balanced mixer. There'd be immediate high-volume applications for a device like this in such widely diverse areas as fm stereo and television receivers, cable-TV converters, communications systems, high-level receiver front ends, up and down converters, and phase detectors.

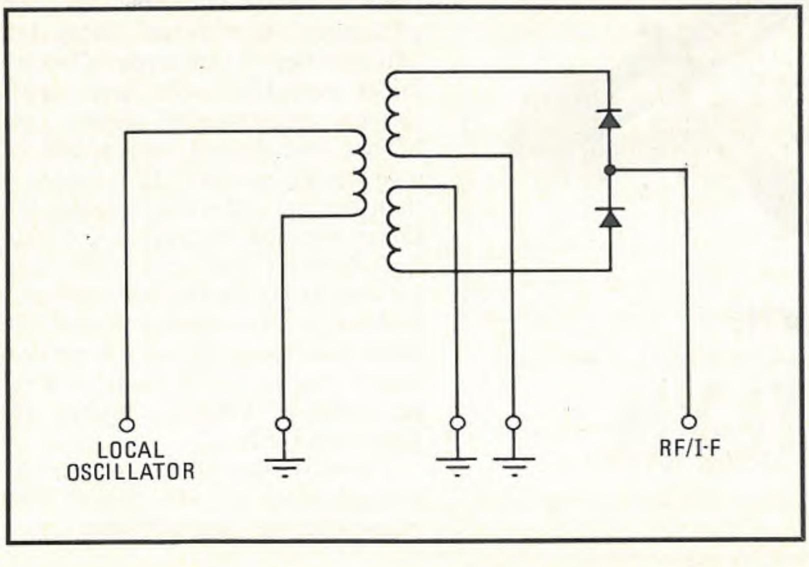
Engineers at Hewlett-Packard Co. may have developed just such an ideal circuit: a single-balanced mixer with conversion loss, isolation, and distortion characteristics that equal or exceed those of the more popular and expensive ($25 to $30) double-balanced mixers now on the market. Furthermore, the HP printed-circuit balanced mixer, the 5082-9200, comes in a 0.56-by-0.53-by-0.12-inch package that is 100 to 1,000 times smaller than the discrete circuits now used and less expensive, says project leader Patrick Fosco.

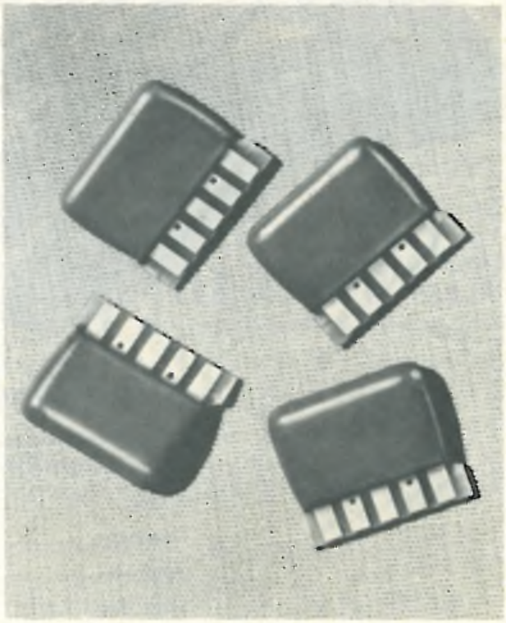
Using a monolithic Schottky barrier-diode technology developed in-house, beam-lead bonding, printed transformers, and epoxy cold-powder encapsulation, HP's device will be priced at $1.50 each in quantities of 100,000; $6.50 for 500 to 999; $8 for 100 to 499; and $11 for 1 to 99.

Intermediate frequency. In a mixer, the output of a tunable local oscillator is modulated with an incoming radio-frequency signal to produce a specific intermediate frequency. This i-f, which carries the information that had been on the rf carrier, is amplified and then detected. But because of nonlinearities and imbalances within the circuitry itself—such as mismatching of diodes, capacitances, and inductances, as well as nonsymmetrical transformers—other unwanted frequencies are produced as dissonant noise or distortion.

By careful circuit-balancing, the various mismatches are played off one against the other, canceling each other to a large degree. In the past, if low cost has been more important than a high quality i-f signal, single-balanced mixers containing a single transformer with a center tap, two diodes, and a common rf/i-f port have been used. In such high-quality systems as fm stereo receivers, double-balanced mixers achieved balance by physically separating the rf and i-f por-

Low-key. Shown in schematic and in packaged form, printed-circuit single-balanced mixer is low-cost, low-distortion device for frequency conversion.





tions of the mixer, using two transformers, four diodes and, separate rf and i-f ports.

At a local oscillator frequency range of 200 to 900 megahertz, conversion loss of the HP device is about 6.5 to 7.5 decibels, a 0.5-to-1-dB improvement over the performance of double-balanced circuits. Moreover, isolation is 15 to 20 dB higher, being 55 dB at 200 MHz and 25 dB at 900 MHz. In terms of distortion, at a local oscillator level of 10 dBm, second-order output intercepts are typically 38 dBm, about a 10-dBm improvement. The one disadvantage of the mixer is that a filter must be added at some later stage to separate the rf and i-f signals. But, Fosco points out, to the large-volume user it's cheaper to add the filter than use the more expensive double-balanced mixer.

To achieve such significant improvements, Fosco explains, HP engineers simply improved on the concepts of matching, balance, and symmetry by using techniques that remove the manufacturing process from human hands. One example is avoiding use of hand-wound ferrite-core transformers. Instead, the transformer is etched onto a printed-circuit board, where the spacing between windings is controlled down to dimensions of less than 1 mil.

"Not only is the geometry tightly controlled and symmetrical," says Fosco, "but the parasitic capacitances between the windings are also balanced. When you hand-wind, these elements vary widely and so does the balance of the circuit." Because diode matching is so important in balancing a mixer, discretes were not used. Instead, the HP engineers went to their own Schottky process because of its inherent high yield in terms of matched-diode pairs. "In processing, the diodes are spaced only mils apart," Fosco says, "so that everything that one 'sees' the other sees also. The result is a 1% matching in forward voltages and 0.1-picofarad capacitance match."

A significant factor in getting the price of the mixers down was the packaging. HP uses an automated "fluidized-bed" technique in which mixer assemblies, with their transformers and bonded diodes, are heated and dipped into a bed of cold epoxy powder. The epoxy is then heated and melted, fixing the mixer components into a compact heat-resistant package. "Each step by itself is not particularly unique," Fosco says. "But when you combine them you come up with a process that is precise, tightly controlled, repeatable in volume, highly reliable—and cheap."

The mixer is available from stock.

Hewlett-Packard Co., HPA Division, 6290 Page Mill Rd., Palo Alto, Calif. 94340 [338]

New type of thyristor challenges triac

Symmetrical bidirectional gated switch with monolithic seven-layer structure offers fast commutation rates and low gating currents

by Lucinda Mattera, Components Editor

A new type of thyristor device—a symmetrical bidirectional gated switch—may not only replace the triac, but it may well be ushering in a new era of power technology. Called Gemini by its developer, Jerry Hutson, president of Hutson Industries in Dallas, the unit is a monolithic seven-layer structure (see cross-section and device symbol below) that functions as though it were two discrete silicon-controlled rectifiers connected to provide a triac function.

Unlike conventional triacs, which are five-layer structures that are often prone to commutation failure, the new Gemini switch "can be commutated like crazy," says Hutson. As a matter of fact, the seven-layer construction permits commutation rates that are five to 10 times faster than those of a standard triac, he adds.

A Gemini thyristor is also easy to gate in all four quadrants of operation. Futhermore, the new structure permits carrier lifetimes to be altered by means of gold-doping without harming other performance characteristics. And, most important, the seven-layer construction makes it feasible to fabricate a signal device and a thyristor device on the same chip.

Hutson Industries is using 4-inch wafers to fabricate the devices, which measure 100 by 125 mils individually. What's more, each chip is fully glass-passivated, the company points out.

Initially, Hutson Industries will offer two series of Gemini thyristors—sensitive-gate units that can operate directly from logic signals and insensitive-gate units intended for light dimming, heat control, and similar applications.

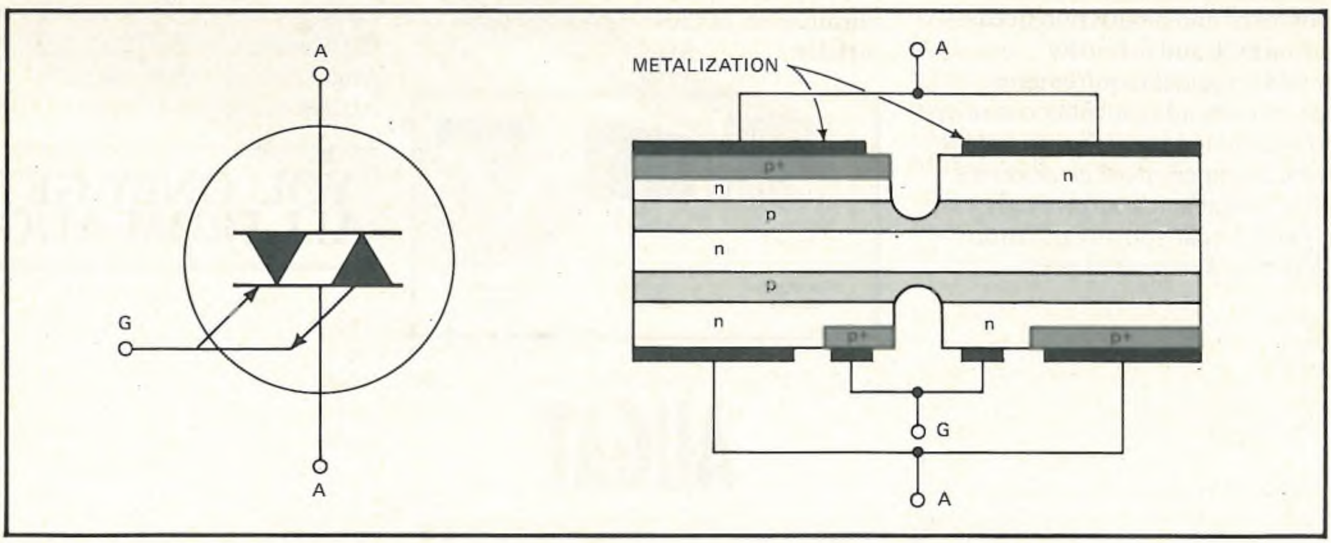
The sensitive-gate units are expected to be used in calculators, computers, and solid-state relays, as well as interface devices. All the Gemini thyristors are packaged in T-202 plastic housings.

The sensitive-gate versions are available in ratings of 50 to 400 volts at 3 amperes root mean square. They provide four-quadrant operation at a gate current of 3, 5, 10, or 25 milliamperes. Futhermore, the critical rate of rise of the off-state voltage (static dv/dt) is at least 25 V/microsecond for a device having a 3-mA gate current.

Ratings for the insensitive-gate series are 200, 400, 600, or 800 V at 3 A rms. The units provide first- and third-quadrant operation and have a gate current of 50 mA. Their commutation rate is 25 V/μs minimum, while static dv/dt is between 150 and 200 V/μs.

Sample quantities are currently available from stock; production quantities will be available by September. Typically, a 200-V sensitive-gate device having a 25-mA gate current is priced at 45 cents each in quantities of 1,000.

Hutson Industries, 2019 West Valley View Lane, Dallas, Texas 75234 [339]



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New products

Instruments

4½-digit DMM priced at $425

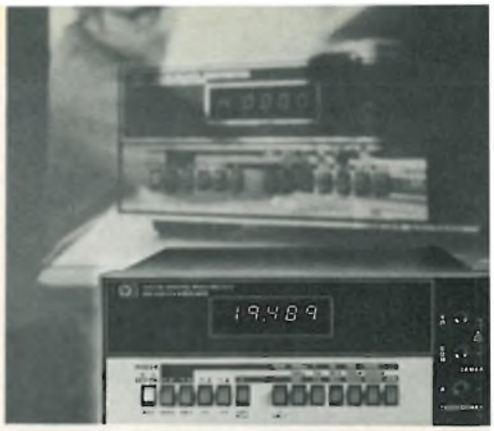
Battery- or line-powered, five-function unit has dc sensitivity of 1 μV

Applying efficient production techniques and distilling circuit designs to minimize parts counts can lower the cost of building electronic products. Hewlett-Packard Co., for example, combines computer-aided testing, laser-trimmed thin-film resistors on a sapphire substrate, and a simple circuit for developing voltage references in the model 3465A 4½-digit, five-function digital multimeter. These techniques keep the price down to $500 or less.

The model 3465A has full-scale ranges from 10 millivolts to 1000 V dc, 100 mV to 1000 V ac, 100 microamperes to 1 A ac or dc, and 100 ohms to 10 megohms. The standard DMM, priced at $500, operates from 86 to 127 V or 175 to 254 V, with 44- to 66-hertz power lines, or from internal nickel-cadmium batteries. Power consumption is 2 or 3 watts. Option 001 eliminates the batteries and cuts the price to $480. Option 002 versions, priced at $425, operate from four D cells and have rear-panel connectors to accept the dc voltage from battery chargers for most HP hand-held calculators if ac-line operation is desired. Power consumption of this version is about 650 mW.

Mid-range accuracies are within ±0.02% of reading ±0.01% of range on dc voltage, ±0.15% of reading ±0.05% of range on ac voltage, ±0.1% of reading ±0.01% of range on direct current, ±0.25% of reading ±0.25% of range on alternating current, and ±0.02% of reading ±0.01% of range on resistance.

The model 3465A's input attenuator has a custom tantalum-nitrate thin-film-resistor network on a sapphire substrate. The resistors



are laser-trimmed in production to an accuracy within 50 parts per million. Only four potentiometers and two capacitors require adjustment for calibration. In most applications, calibration should be required no more frequently than at 90-day intervals.

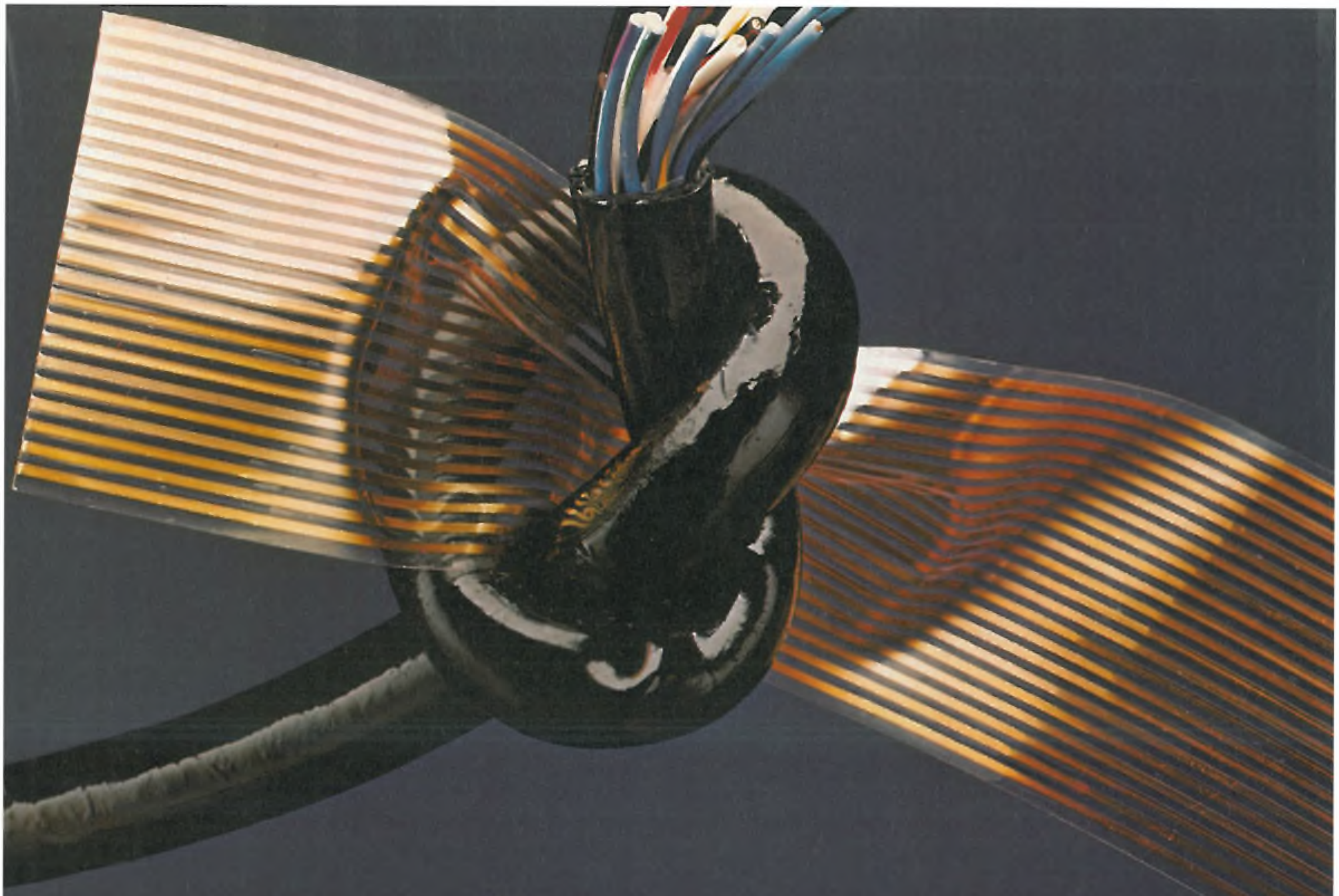
Instead of using two circuits to obtain the positive and negative voltage references required by its dual-slope design, the 3465A derives one of the references from the other, using a few components and existing auto-zero circuitry.

Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [351]

Instrumentation printer has variable speed control

Featuring the most complete set of engineering symbols among printers of its type, the model 750 has a built-in print-interval control that allows its printing rate to be adjusted without an external timer. The 18-column unit is intended for use with digital multimeters, count-

ers, and similar electronic instruments. It can print at a maximum rate of two-and-a-half lines per second and can be connected to practically any instrument by means of a general-purpose printer input interface. The model 750 printer is priced at $1,075 and has a delivery time of stock to 30 days. Accessories



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Solving switching problems is what we're all about.

Circle 126 on reader service card

include a clock and a sequence counter.

Keithley Instruments Inc., 28775 Aurora Rd., Cleveland, Ohio 44139 [354]

Digital multimeter includes analog indicator

A new version of the Fluke 8000A digital multimeter includes a small analog panel meter for ease in making peaking and nulling adjustments. The 8000A/MTR has all of the features of the standard 3½-digit instrument plus the analog meter. When the 8000A/MTR is fitted with its optional rechargeable battery pack, the analog meter serves

the additional function of battery status indicator. Measurement capabilities of the instrument include ac and dc voltages from 200 millivolts full scale to 1,200 volts full scale, ac and dc currents from 200 microamperes full scale to 2 amperes full scale, and resistance from 200 ohms full scale to 20 megohms full scale. The 8000A/MTR sells for $385; delivery time is 60 to 90 days.

John Fluke Manufacturing Co., P. O. Box 43210, Mountlake Terrace, Wash. 98043 [355]

Shaft-angle indicator is accurate to within 0.01°

Capable of tracking the shaft angle of a synchro or resolver with an accuracy and resolution of 0.01°, the C-500 digital angle indicator is an autoranging device that can accept input voltages from 10 to 135 volts. It maintains its accuracy at slewing

speeds up to 1,000° per second. The unit is priced at $2,600; delivery is from stock.

Astrosystems Inc., 6 Nevada Dr., Lake Success, N. Y. 11040 [356]

11-MHz sweep/function generator sells for $495

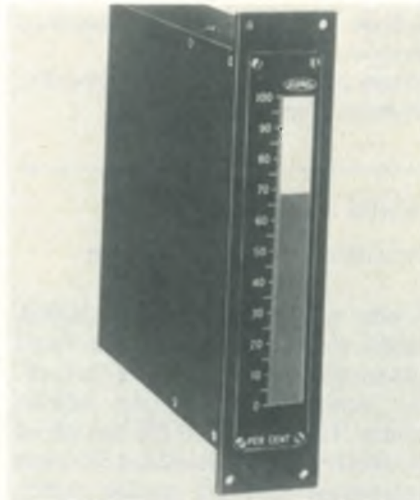
Spanning the frequency range from 0.01 hertz to 11 megahertz, the model 405 sweep/function generator can be swept by an external source over a frequency range of 1,000:1. The $495 instrument puts out sine, square, and triangular waves with maximum peak-to-peak amplitudes in excess of 20 V. A TTL-compatible sync-pulse output is also

provided. The unit is available from stock.

Instrument Division, Systron-Donner Corp., 10 Systron Drive, Concord, Calif. 94518 [357]

Vertical scale indicators have military ruggedness

A line of vertical-scale indicators is built to military specifications for applications in aircraft, test con-



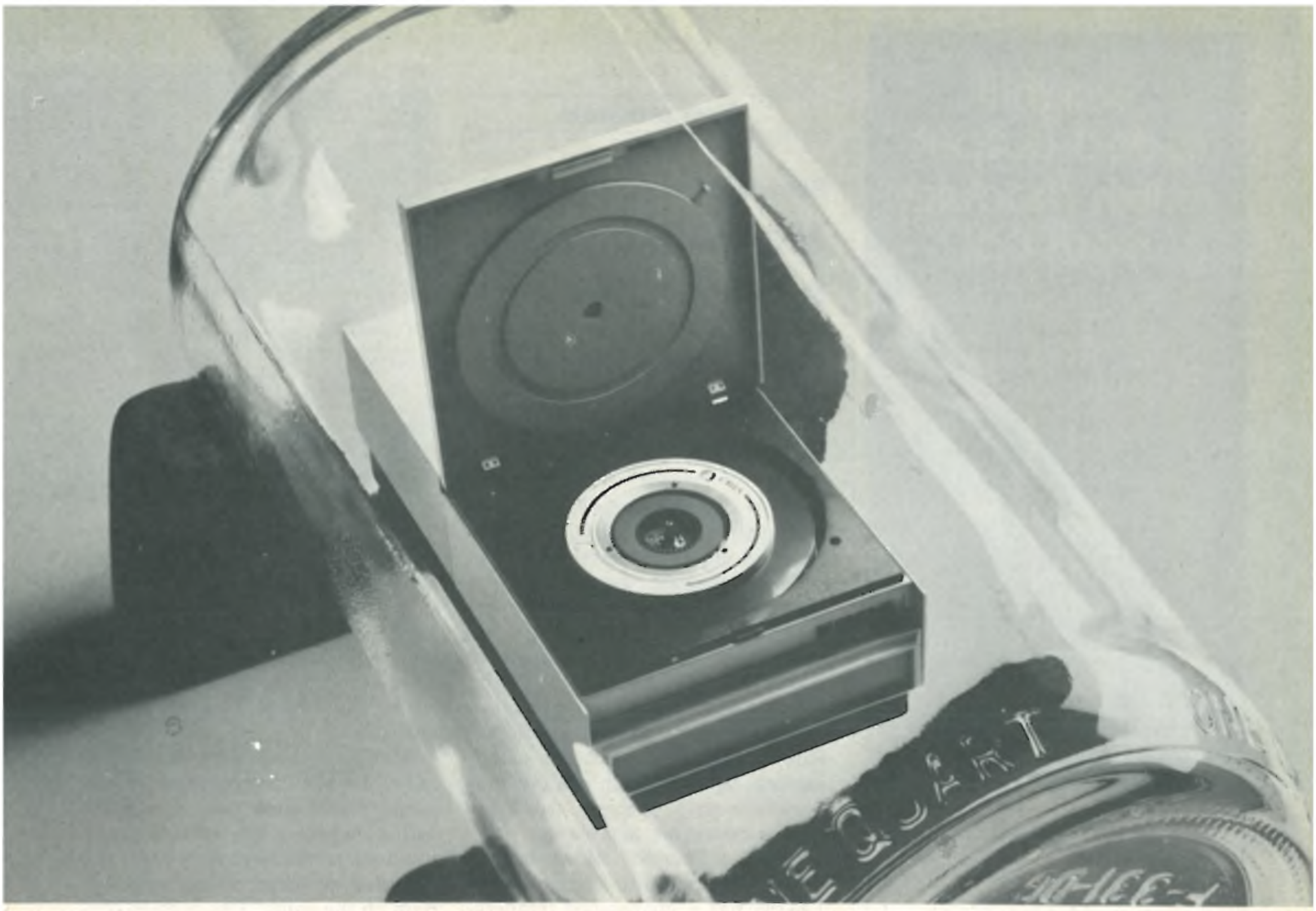
soles, and engine instruments. The units accept analog or synchro-type inputs and display them on endless tape by means of servomotors that drive sprocket assemblies. Accuracies are within 0.25% of full scale, and the units are said to be easy to operate and service.

Northern Precision Laboratories Inc., 202 Fairfield Rd., Fairfield, N. J. 07006 [358]

Logic trigger helps ordinary scopes show digital signals

A problem in the use of ordinary oscilloscopes for the examination of digital waveforms is getting the scope to trigger reliably on long digital sequences. It is even more difficult to create a stable display hundreds or thousands of bits downstream from the trigger event. The HP 1230A logic analyzer solves these problems by delivering a trigger pulse when it recognizes a preset parallel 8-bit word in a stream of data. Furthermore, the 15-megahertz unit can delay its trigger output by any number of clock pulses, from one to 9,998. In addition to working with clocked systems, the instrument can operate asynchronously by using a ninth-bit qualifier input. The complete 1230A sells for $495, with a cable set, power cable, and carrying case.

Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [353]



Semiconductors

Monolithic zener has low drift

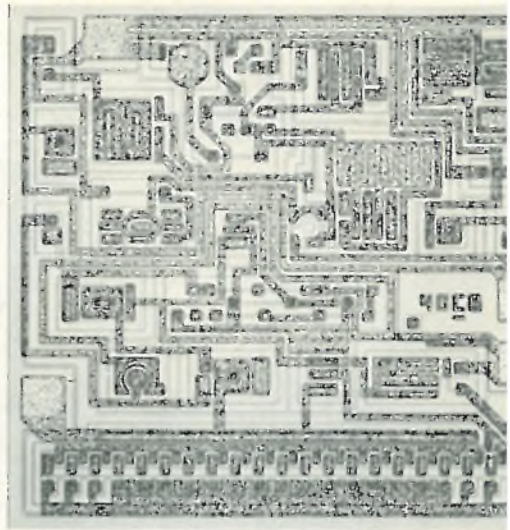
Three diffusions and on-chip stabilizer yield advantages in noise and impedance, too

For low dynamic impedance, noise and drift characteristics, low-temperature coefficients and long-term stability, discrete voltage-reference zener diodes have usually performed better than monolithic zeners. Now, however, engineers at National Semiconductor Corp., Santa Clara, Calif., have built a monolithic zener that, its developer, Robert C. Dobkin, director of advanced linear design, claims outperforms many discrete zeners, as well as most other monolithics.

Using a "buried" zener and an on-chip temperature regulator, the LM199 has a guaranteed temperature coefficient of 0.0001%/°C. Drift is guaranteed at a maximum of one part per million/°C, and long-term stability is within 0.002%. Low-frequency noise is less than 10 microvolts. Active circuitry and an on-chip resistor lower the zener impedance to 0.5 ohm, which, says Dobkin, allows the 6.9-volt reference to operate over a 0.5-to-10 milliampere current range with virtually no change in temperature coefficient.

The usual method of fabricating zeners is to diffuse p-type material into an n-type base, leaving the boundary between the p and n regions exposed. But because the high field strengths across the exposed junctions ionize surface contaminants and sweep them into the junction area, performance is often erratic.

Dobkin and his engineers have eliminated many of the contamination problems by adding a third diffusion step. "In our 'buried' zeners, the first step is to lay down a deep p^+ diffusion well into the n-type base material," he says. "Atop this is



diffused a shallow p-type layer. Over both is placed a thick n^+ diffusion. As in the surface-pn device, zener breakdown occurs in the area of highest pn concentration. But in this case, it is beneath the n^+ layer, where the n^+, p, and p^+ regions meet."

If this technique were used alone, says Dobkin, temperature coefficients would still vary too much with changes in the ambient environment, so the engineers have also designed a temperature stabilizer right on the chip. "This portion consists basically of two npn transistors, one acting as the sensor and one as the heater," explains Dobkin. "The temperature of the chip is kept at a constant 90°C by the amount of power it allows another npn transistor to dissipate."

The device comes in a four-lead TO-46 hermetic can. In lots of 100, the LM199, specified from -55°C to +125°C is priced at $35 each; -25°C to +88°C, $10; and 0 to 70°C, $3.25. Sample quantities are now available.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051 [411]

AMD prepares debut of seven bipolar microprocessor parts

After a year of development work, the first seven parts in Advanced Micro Devices' Am2900 bipolar microprocessor family are scheduled for introduction during the next two months in sample quantities. John

Springer, bipolar-microprocessor marketing manager, says the first part available will be the Am2901, a 4-bit bipolar microprocessor slice, to be followed in short order by the Am2902, a look-ahead carry generator; the Am2918, a 4-bit 1-by-2-port register; the Am2950/51, a 256-by-1 random-access memory; the Am2952, a 1,024-by-1 RAM; the Am2960/61, a 1,024-by-8 read-only memory; and the Am2970/71, a 256-by-4 programable PROM.

In development and scheduled for introduction by November are the Am2905, 2906 and 2907, 4-bit bus transceivers; and the Am2909, a microprogram sequencer. In quantities of 100, the price of the 2901 4-bit slice will be less than $40 each, says Springer. Prices of the other devices have not been set.

The 2900 family has been designed for use in high-speed digital equipment.

The 40-pin Am2901 4-bit microprocessor slice with its 16 working registers performs arithmetic and logic operations on the data. Some internal registers may be assigned as program counters, stack pointers, or other operating/control registers. The Am2905/6/7 transceivers interface with high-speed bus systems. The 28-pin Am2901 is designed to perform microprogram control. The 16-pin 2902 generates carries for four 2901s.

The 2901 4-bit slice, says Springer, has a cycle time of 100 nanoseconds, a power dissipation of 0.92 watt, nine microcode inputs, and 203 possible source-operand combinations to the arithmetic/logic unit.

Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086 [412]

High-voltage MOS clock chip drives large LCDs directly

Energized by a single 50-volt dc power supply, the C1200 ion-implanted MOS clock circuit produces peak-to-peak output voltages of 80 V ac—sufficient for driving seven-segment liquid-crystal displays from

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12.0	2.8	4.2	8.0	10.5	15.0	23.0	36.0	58.0
15.0	2.4	3.1	7.5	9.5	14.0	20.5	27.0	47.6
18.0	2.1	3.3	6.0	8.0	13.0	18.0	26.0	40.0
24.0	1.5	2.8	4.2	7.0	11.0	15.0	21.0	33.0
28.0	1.4	2.4	4.0	6.3	9.0	14.0	20.0	29.0
36.0	1.2	2.2	3.1	5.6	8.0	11.0	14.0	23.0
48.0	95	1.8	2.6	4.2	6.0	8.0	10.0	16.0

MODEL	10000
VDC	AMPS
0–7.5	2.10
0–16	1.25
0–25	0.85
0–32	0.68

DUAL OUTPUT SUPPLIES	
MODEL	N03[illegible]
VDC	AMPS
±15 12	400MA
MODEL	N60052
VDC	AMPS
±15 12	1.04

Listed here are the more popular models–many other voltages are available.

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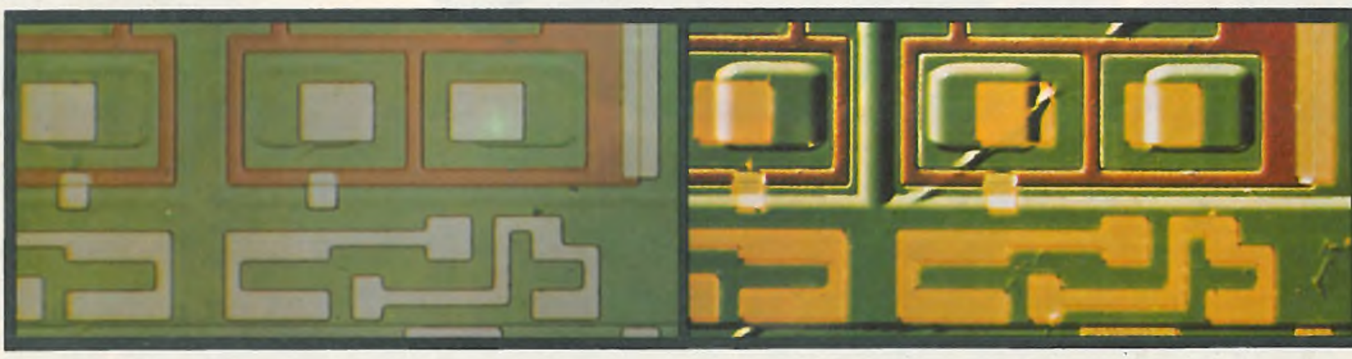
SP-16

Circle 134 on reader service card



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The AO DICV Series 10 Differential Interference Contrast Microscope can make a big difference. A standard brightfield microscope reveals only what is shown in the specimen on the left.

Now look at the specimen on the right. With this ability to reveal significant detail in outstanding relief in black and white or color, the AO DICV Series 10 can help you spot surface irregularities, inclusions and faults.

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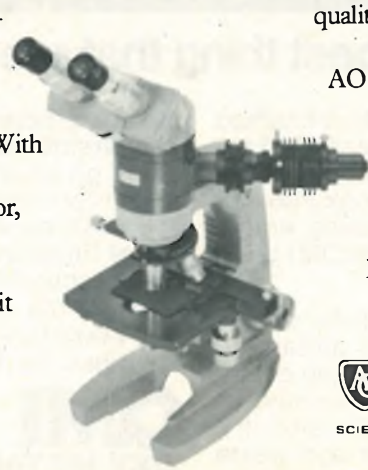

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New products

2 to 12 inches high. The clock circuit, which uses the 60-hertz line frequency as its time base, can operate as an ordinary 12-hour clock or as an elapsed-time indicator. Built-in circuitry eliminates contact-bounce effects so that it's both quick and easy to set hours and minutes. The monolithic chip needs only 15 external components to make a complete clock; they are the LCD, nine resistors, four diodes, and a capacitor. Housed in a 28-pin dual in-line package, the C1200 sells for $10.80 in lots of 100 pieces. Delivery time is stock to eight weeks.

LSI Computer Systems Inc., 22 Cain Drive, Plainview, N. Y. 11803 [413]

8-megahertz dual op amp consumes only 75 milliwatts

Boasting a unity-gain bandwidth of 8 megahertz, a full-power bandwidth of 30 kilohertz (80 kHz, typical), and a slew rate of 2 V/microsecond, the HA-2650 dual operational amplifier is noteworthy for its 100-nanoampere bias current, 8 μV/°C input drift, and 75-milli-

watt power consumption. The internally compensated monolithic device is especially suited for high-frequency video circuits such as tone generators, active filters, integrators, and high-impedance buffers. Available in both commercial and military temperature ranges, and in both TO-116 dual in-line packages and TO-99 metal cans, the HA-2650/2655 has a 100-piece price that ranges from $3.40 to $9.40.
Harris Semiconductor, P. O. Box 883, Melbourne, Fla. 32901 [414]

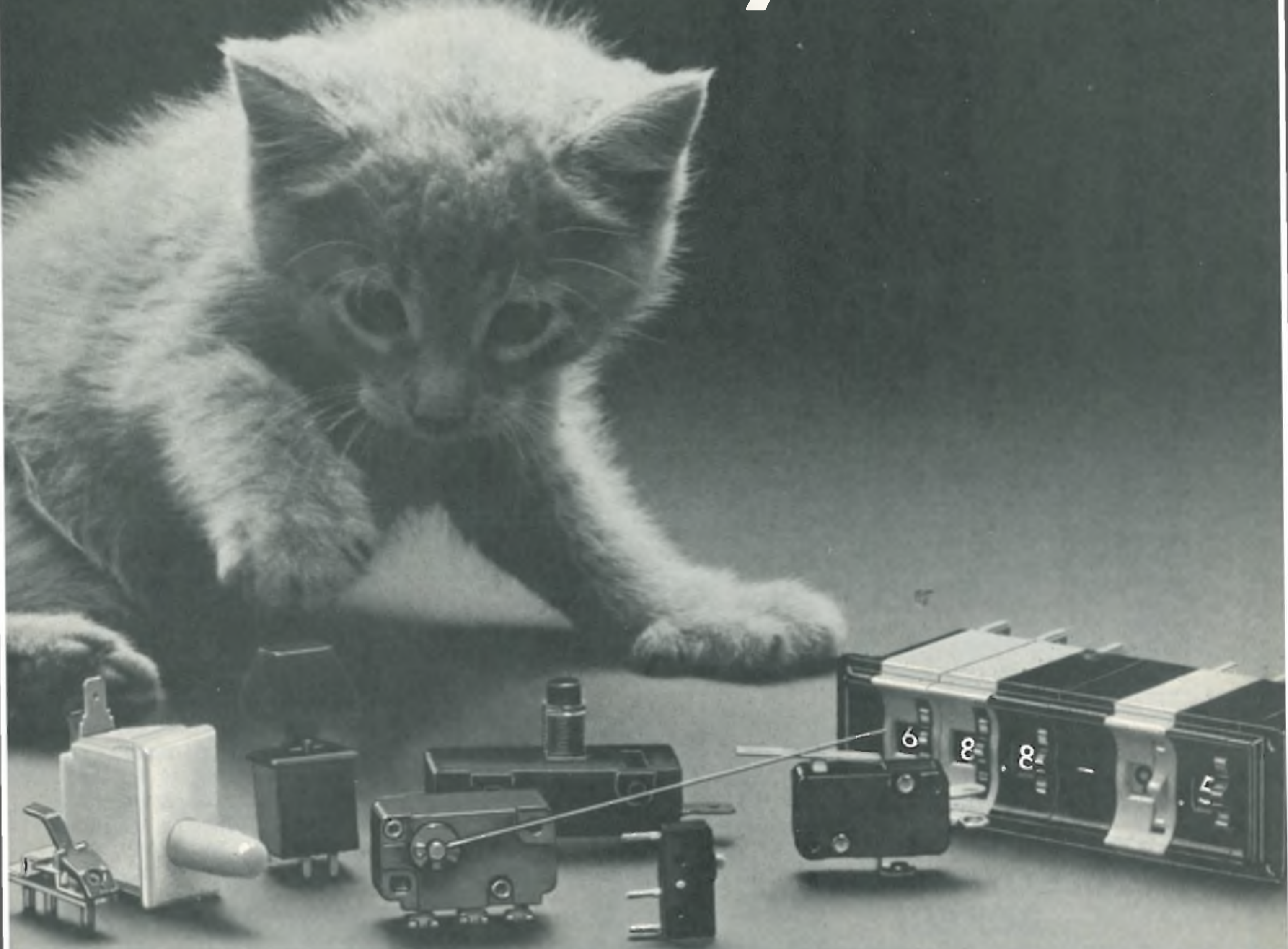
National enters 4-bit microprocessor market

Designed to be a pin-for-pin replacement for the Intel MCS-4 microprocessor system, the FIPS (for four-bit integrated processor system) by National Semiconductor marks that company's entry into the low-cost microprocessor area. Built around a central processing unit, a 2,048-bit read-only memory, and a 320-bit random-access memory each of which sell for $9.95 in hundreds, the FIPS dissipates approximately 20% less power than the MCS-4. Other chips in the set include a 10-bit serial-in/serial-out shift register, an eight-bit address latch interface, and an eight-bit instruction and input/output transfer port. The shift register sells for $3.95 in hundreds, the others are priced at $7.50.
National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, Calif. 95051 [415]

Chopper-stabilized op amp has offset drift of 0.2 μV/s

The series 1012 chopper-stabilized monolithic operational amplifiers are self-contained except for external capacitors and have offset drifts of only 0.2 microvolt per second. The units are particularly well suited for use in dc instrumentation, precision integrators, and high-performance data-acquisition systems. The amplifiers have an open-loop

There's a little tiger in every Cherry switch



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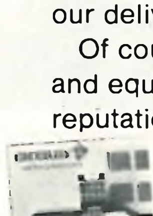

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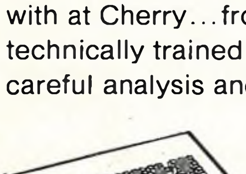

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Circle 137 on reader service card

New products

gain of 170 dB, a gain-bandwidth product of 3 megahertz, and an input current drift of only 1 picoampere/°C. Unit-quantity pricing is $34.10 for the commercial temperature range 1012 CT, and $68.20 for the military range 1012 MT. Delivery is from stock.

ILC Data Device Corp., Airport International Plaza, Bohemia, N. Y. 11716 [416]

16-k n-channel ROM has 450-ns typical access time

Organized as 2,048 words of eight bits each, n-channel static read-only memories in the NCM6590 series have maximum access times of 800 nanoseconds with 450 ns claimed to be typical. The mask-programable NCM6590 is a direct replacement for the Motorola MCM6590, while the preprogramed NCM6591 is

equivalent to the MCM6591. The latter units are programed with six character-conversion codes. Pricing on the units is $23.95 in hundreds. Delivery on the preprogramed unit is from stock, while the custom unit requires five weeks from verification of code.

Nitron, 10420 Bubb Road, Cupertino, Calif. 95014 [417]

Packaging & production

Card cages are standardized

For component insertion and wiring, user can choose predesigned cards in 4 sizes

There isn't much standardization of size in wire-wrap back-panel card cage systems, so Teradyne Components Inc., a subsidiary of Teradyne Inc., is tackling the problem with its standard-module library. The library offers four cage sizes with card spacings of 1.2 inches for wire-wrapped cards or 0.6 in. for etched cards, and there are four different card sizes for each spacing. In each card size, the customer may choose from 24 predesigned cards ready for component insertion and wiring interconnection. In prototype development, they eliminate the need for laying out pc cards, designing back-panel assemblies, and designing card cages. The user can move directly from breadboard prototypes to hardwired production with a minimum of documentation changes.

Depending on size, cards used in cages with 1.2-inch spacing can hold from 24 to 126 16-pin IC devices, while cards with 0.6-in. spacing can hold from 16 to 81 devices. Single-row cards have 12 test points, and double-row cards have 24 test points. The 24 different IC-layout configurations in each card size allow use of logic, analog, or MSI devices.

Because card size is standard, Teradyne has been able to develop geometry programs for wire-wrapping; all the customer has to do is send his tool list or a deck of cards with the wiring pattern to Teradyne. With standard sizes, it is also possible to develop a test fixture for the cards to verify wiring and automatically check out the system.

There are 13 connectors for 1.2-in. spacing and 26 connectors for 0.6-in. spacing for a single-row cage, and 26 and 52 connectors respectively for a double-row cage. The 76-pin card edge connectors have a 100-by-200-mil grid, and every socket and pin is identified. The four voltage buses are placed on the inside of the back plane so they are not in the way of wire-wrapping. An input/output cutout on the end of the back plane allows different types of adapter panels to be used.

Prices range from $60 for 10 4-by-4.25-in. cards to $240 for 10 9.25-by-8.35-in. cards. A single-row standard module library costs $135 for 10 units, while a double-row cage costs $270 for 10 units. Delivery time is one to two weeks for components, and Teradyne also offers completely wrapped panels within two weeks of receiving the wire list. The system is designed to be automatically wrapped by a Gardner-Denver system.

Teradyne Components Inc., 900 Lawrence St., Lowell, Mass. 01852 [391]

Electronic vacuum pump offers high throughput

Combining extremely high throughput and compact design with a virtual absence of stray magnetic fields, Varian Associates has developed an electronic vacuum pump (shown in photo with control unit) for use with such analytical instruments as mass spectrometers and in production of vacuum tubes and other devices.

The Hi-Q VacIon model 911-5039 pump is an extension of the concept used in the development of the first sputter-ion pump at Varian in the late 1950s. However, the stray magnetic fields produced in sputter-ion pumps prevented their use in research and development and in analytical instruments that are sensitive to such fields. And, according to John McLaughlin, product manager at Varian, because such pumps had lower throughput than turbomolecular and diffusion pumps, they could not be used in processing such tube types as microwave, grid power, X-ray, and light-amplification or in the manufacture of breakers, interrupters, capacitors, switches, and other devices.

The Varian Hi-Q pump, says McLaughlin, will, however, do many of these jobs because it has a useful speed below .00001 torr. In gas-vacuum pumping, for a given throughput (Q), pressure is indirectly related to speed. The more speed available, the lower the pressure. "Speed at high pressure is desirable," says McLaughlin, "this is the essence of high Q."

The Hi-Q VacIon pump, which compares well with its mechanical and diffusion counterparts, maintains a throughput of 70 microliters per second for hydrogen and 20 microliters for nitrogen. Speed is 45 liters per second at .003 torr and 19 liters per second at .0002 torr.

Though weighing only 22 pounds, the new electronic vacuum pump's heat-transfer design makes possible the gas-handling throughput of a 300-pound, sputter-ion pump. Rather than separating the cathodes, walls, and heat-transfer mechanism from one another as in earlier ion pumps, Varian engineers have made the walls of the pump into cathodes and buried a water-cooling system in the walls on each side. The stray-field effect is eliminated by the use of a ferrite alloy to complete the magnetic circuit.

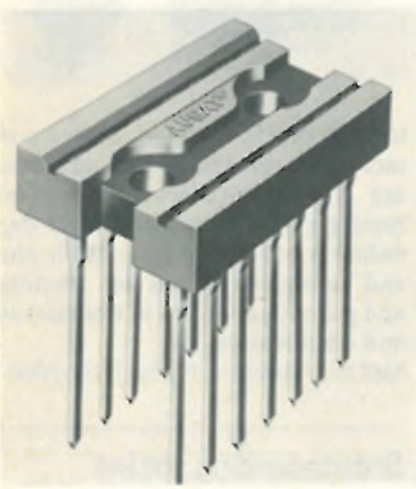
When the diffusion and mechanical-pump systems require constant power input regardless of the gas load, the Hi-Q ion pump consumes only the power necessary to handle the pressure or gas load. Input to the power supply is 208/240 volts ac, 50/60 hertz, single-phase. Open-circuit voltage required is +7,500 volts dc. The unit is 7.75 inches in diameter and 4.875 in. thick. Price

for the pump and the magnet, complete with water-cooling fittings, is $940. With control/power supply unit and cable, the price is about $2,000.

Varian Vacuum Division, 611 Hansen Way, Palo Alto, Calif. 94303 [392]

Selective plating cuts cost of wrapped-wire IC sockets

A new, economical and low-profile wrapped-wire integrated-circuit socket uses selective gold plating to keep prices down to the range of 25 cents to 50 cents each, depending upon size and quantity. The 14- and 16-pin sockets, which are also offered with tin plating, feature a closed, tapered-entry insulator design with large contact openings for

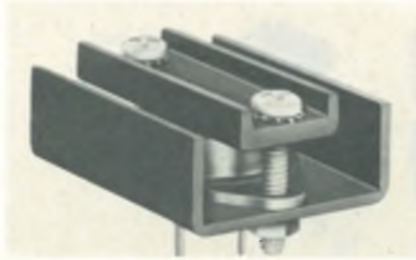


fast and easy insertion of the IC. They also contain self-locking tapered terminals which improve retention and positioning in printed-circuit boards. Delivery time is from stock to six weeks.

Augat Inc., 33 Perry Ave., Attleboro, Mass. 02703 [393]

Two-piece heat sinks fit in tight places

Designed to provide component cooling where board space is limited, a series of two-piece heat sinks are used in a sandwich configura-



tion with one part mounted above the component and the other below. For maximum convenience and versatility, the top and bottom segments may be ordered and used separately, although the thermal resistance will, of course, be lowest when both are used together. Made of 1100-H14 aluminum alloy, the bottoms are available in two styles for TO-3 cans. Model 323 is for standard hole patterns, and model 325 is for stud mounting. The thermal resistance of the combined unit is 11.6°C per watt for natural convection cooling.

Tor Corp., 14715 Arminta St., Van Nuys, Calif. 91402 [394]

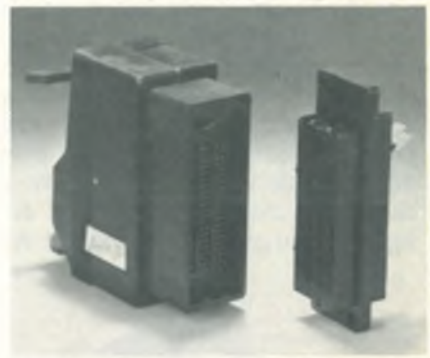
Cambi-Cards with 140 I/O connections now available

Like its predecessor, the 715 series, the new 714 series of General Purpose 3 boards has been designed primarily so that large numbers of 22-pin devices can be installed along with any required mixture of 14-, 16-, 24-, and other sizes of dual in-line packages. Basically a double-width version of the 715 series, the new series provides a substantially larger capacity with 140 input/output connections. The board-drilling pattern permits efficient intermixing of different size devices whether the number of 22-pin devices is 5% or 95% of the total. Designed to complement 22-pin DIP devices, which usually require reference voltages or common clock lines, the 714 series has two extra bus paths (in addition to the normal voltage and ground distribution planes). One of them is near the top of the board and the other close to the edge fingers. The 714-series

boards are normally supplied with gold-plated three-wrap-length pins.
Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. 02138 [395]

Cable-to-panel connectors require zero insertion force

The CR series of cable-to-panel connectors are zero-insertion-force devices that incorporate a mechanical advantage device for easily mat-



ing 120 or 156 contacts. Mated contact forces of 150 grams minimum are typical, with several thousand mating cycles possible without degradation of performance. Both plug and receptacle halves are modular and permit variations in termination and conductor styles.
AMP Inc., Harrisburg, Penna. 17105 [396]

Breadboarding socket needs no soldering

A reusable breadboarding socket for dual in-line packages allows convenient interconnection without soldering. The model 570G-1 consists of two nylon-based termination blocks with contacts spaced to accommodate any standard 14- or 16-pin DIP. Four tie points per contact allow solderless interconnections with ordinary 22-gauge hook-up wire. Priced at $2.63, the sockets have beryllium-copper contacts with current ratings of 5 amperes and contact resistances of 1 milliohm.
Vector Electronic Co. Inc., 12460 Gladstone Ave., Sylmar, Calif. 91342 [397]

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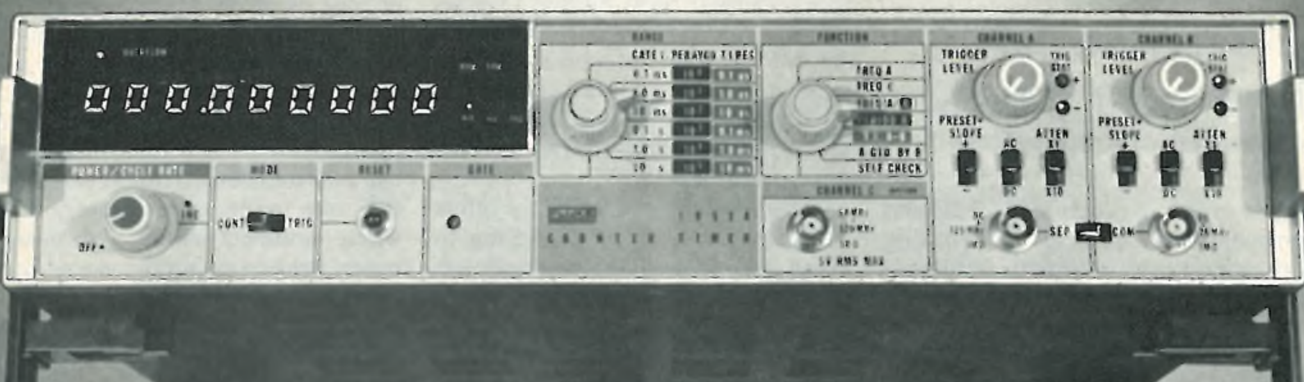

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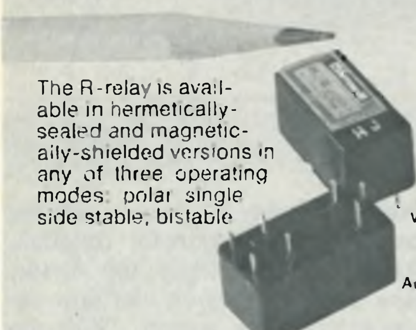

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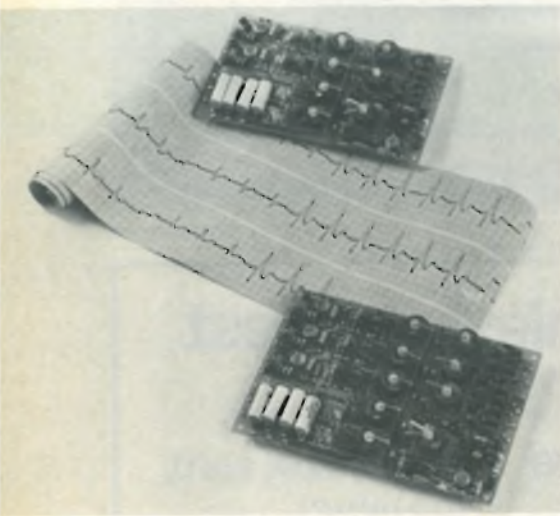
Subassemblies

Isolators handle several channels

Amplifiers provide high common-mode rejection at low per-channel prices

Since many applications of isolation amplifiers—biomedical recording, off-ground measurements, industrial process control, and data-acquisition systems—need more than one isolation amplifier per installation,



Analog Devices decided that the per-channel cost of these units could be significantly reduced by putting more than one channel into each amplifier package. Since the channels all share a common oscillator, this approach not only saves money but has the added advantage of eliminating beat-frequency noise caused by oscillator mixing.

Both the model 282J two-channel amplifier and the model 283J three-channel isolator include dual ±3-V dc and ±6-V dc regulated outputs that are isolated from the amplifier's power terminals. These outputs can be used to excite external bridges, signal conditioners, and other transducers such as thermistors. Because the floating power is supplied at the amplifier inputs, the user can enclose all of the input circuitry, including the power supplies, in a single electrostatic shield, thus improving the common-mode rejection ratio by about 40 decibels. For users who don't need a custom shield of their own, Analog Devices offers a standard socket and shield for $15. The manufacturer emphasizes that the full performance of the amplifier will not be realized unless a shield—either custom or standard—is employed.

With a shield, the amplifier offers a CMRR of 160 dB at dc, falling to about 130 dB at 100 hertz and 105 dB at 1 kilohertz. All of these figures are for a 5-kilohm source imbalance. Input noise of the device is a low 1.5 microvolts rms in a 1-kHz bandwidth, and maximum ground leakage current is 2.4 microamperes rms at 115 V at 60 Hz.

The gain of each channel can be set from 1 to 100 V/V by changing the gain resistors mounted on standoff terminals on the amplifier board.

Each amplifier channel has a 100-megohm differential input resistance, a 220-V rms continuous differential input voltage rating, and ±350-V dc or peak ac input/output isolation. Operating temperature range is 0° to 70°C.

The two-channel 282J sells for $149 each in small quantities, while the three-channel 283J is priced at $189. Both units are available from stock.

Analog Devices Inc., P. O. Box 280, Route 1 Industrial Park, Norwood, Mass. 02062 [381]

12-bit a-d converter has 250-kHz throughput

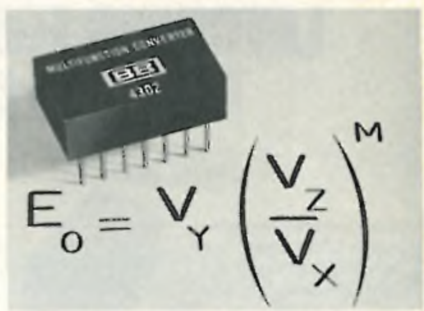
Priced at only $229 in unit quantities, the MP2712 is a true 12-bit analog-to-digital converter with a

conversion time of less than 4 microseconds for a throughput of 250 kilohertz. The MP2712, which has a temperature coefficient of gain of only 12 ppm/°C, drifts only 1 least significant bit for a temperature change of 20°C. The converter has four pin-selectable full-scale ranges: 0 to 5 volts, 0 to 10 V, −5 to +5 V, and −10 to +10 V. It is housed in a compact, 2-by-4-by-0.44-inch Modupac that shields it from both electric and magnetic fields. This allows the unit to operate properly even when mounted within a minicomputer, printer, or similar noisy environment.

Analogic Corp., Audubon Rd., Wakefield, Mass. 01880 [383]

Multifunction analog module sells for $32

Called a multifunction converter, the model 4302 is an analog element whose transfer function is given by $E_o = V_y(V_z/V_x)^m$ where V_x, V_y, and V_z are input voltages, and m is a resistor-programable constant be-



tween 0.2 and 5. Because of the flexibility of its transfer function, the 4302 can multiply and divide, take roots and powers, and raise ratios to arbitrary powers. With the addition of some active and passive components, it can also compute true-rms values, find vector sums, and calculate trigonometric functions. Typical accuracies, for multiplying and dividing, are within 0.25% of full scale. Housed in a 14-pin dual in-line package, the 4302 accepts input voltages in the range from 0 to +10 V and puts out from 0 to 10 V at up to 5 milliamperes. It

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Circle 147 on reader service card

is priced at $32 in single quantities.
Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85734 [385]

Pincushion correctors settle within 1 microsecond

Available in two versions—a current-output device and a voltage-output unit—the C201/202 is a solid-state module that corrects for pin-cushion distortion in flat-face cathode-ray-tube displays. Slewing at 30 V/microsecond and settling to within 1% of final value in 1 μs, the units have typical errors of 0.5% for

tubes with a 60° deflection angle. The C201, the current-output version, has an output impedance of 10^7 ohms and is priced at $130 in single quantities. The voltage-output C202 has an output impedance of 0.1 ohm and a price of $160. Delivery time on all units is four weeks.
Intronics Inc., 57 Chapel St., Newton, Mass. 02158 [384]

10-MHz a-d converters can resolve up to 13 bits

Available in versions with 11-, 12-, and 13-bit resolutions, the 9000 series of analog-to-digital converters has models with maximum conversion rates of 5 and 10 megahertz. To provide this level of performance, all units in the series have internal track-and-hold circuits with an aperture time of 10 picoseconds. Intended for very high-speed applications, such as the digitization of radar signals, the 9000 series units

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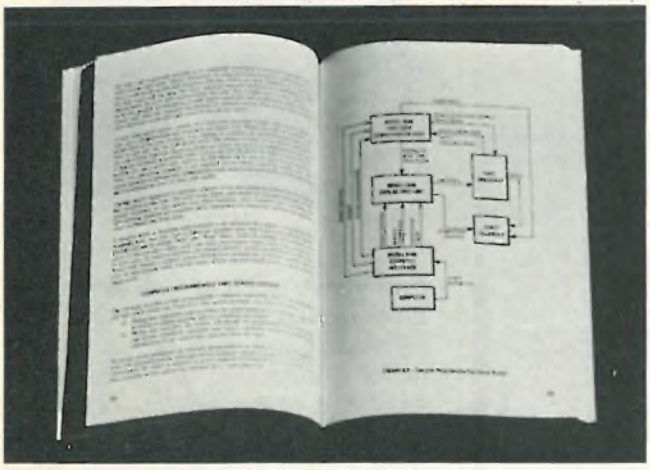

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Circle 149 on reader service card

New products

are offered with input impedances of 50, 75, or 93 ohms. Prices vary from $8,200 for the 5-MHz, 11-bit unit to $13,980 for the 10-MHz, 13-bit machine. Delivery time is 12 to 14 weeks.

Computer Labs, 1109 So. Chapman St., Greenboro, N. C.27403 [386]

Militarized line-to-dc power supplies operate up to 85°C

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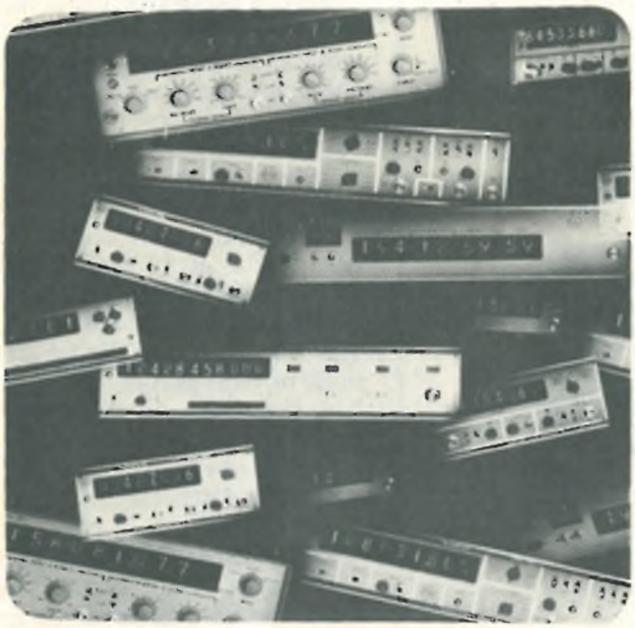
Semiconductor Circuits Inc., 306 River St., Haverhill, Mass. 01830 [387]



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New products/materials

Beryllia substrates with a thermal conductivity 14 times that of alumina and 15% greater than that of aluminum are made by a tape process for hybrid and microwave-circuit applications. Berlox-Strates have surface finishes of 15 microinches rms on one side and 20 μin. on the other. Their dielectric constant is 6.5 at 10 GHz and 25°C, while their dissipation factor is 0.0001 under the same conditions. The substrates are available from stock in 1-in.-by-1-in. and 2-in.-by-2-in. sizes, both of which are 0.025 in. thick.

National Beryllia Corp., Greenwood Ave., Haskell, N. J. 07420 [476]

Glass microsheet with a nominal thickness of only 0.2 millimeter (8 mils) has been adapted as a substrate material for iron-oxide photomask blanks used in the production of integrated circuits. The microsheet is sufficiently thin and flexible to conform during contact printing to minute variations in the surface of a silicon wafer. The Dur-Cor blanks carry a sputtered iron-oxide film with a standard thickness of 1,400 angstroms, although 950 Å is available for special applications. The microsheet blanks are available with coatings of either positive or negative photoresist.

Corning Glass Works, Electronic Materials Department, Corning, N. Y. 14830 [477]

Epoxy resin system PR-2200 is an all-purpose casting, potting, and encapsulating formulation with an operating temperature range from −55 to 200°C. The resin has a very low viscosity, which means that it can normally yield bubble-free castings

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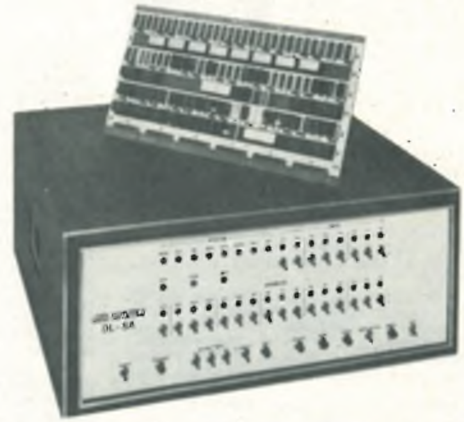

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Our DL-8A Microcomputer is designed with wire-wrapped socket board assemblies that will accept any component having 14 to 40 pins. Virtually guarantees unlimited life; as computer density increases and pin configurations change, the DL-8A will be ready to use them.

Furthermore, problems inherent in printed circuit card and card file construction are eliminated. Since extender cards aren't used, servicing is easy. And there's no volatile solid state RAM memory erasure that occurs when power is interrupted to install or remove extender cards. Avoids time-consuming memory reloading from an external device.

The DL-8A is available in several forms. The complete unit consists of a wire wrapped socket system with 4K RAM, 2K PROM (expandable to 64K), four input and four output ports, a communications channel, interrupt system and DMA. Also comes with control panel, power supply, I/O interfaces, selected peripheral device and enclosure.

Or you can purchase the wire wrapped system by itself, with or without components. And with or without a control panel or I/O interface cards.

The full DL-8A board with Control Panel gives an open, easily accessible layout for debugging other devices that may be added.

The DL-8A software is systems oriented and includes Cross Assemblers for DEC PDP-8 and PDP-11, PROM and Paper Tape Loaders, Hardware Diagnostics, and Debug Routines.

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without the use of vacuum de-aeration equipment. PR-2200 sells for $1.60 per pound in 1-quart cans and 85 cents per lb in 55-gal drums.
Formulated Resins Inc., P. O. Box 508, Greenville, R. I. 02828 [478]

Temperature-indicating crayons covering the range from 65°C to 670°C change color at specific temperatures. Each of the 18 crayons offered changes its color within one or two seconds if the surface on which it is applied exceeds the crayon's rated value. Kits contain six, 12, or 18 crayons. The 18-crayon kit is priced at $35.
Telatemp Corp., P. O. Box 5160, Fullerton, Calif. 92635 [479]

A silicone encapsulant that meets the requirements of MIL-S-23586 is noteworthy for its uniform curing even in deep sections. The room-temperature-vulcanizing silicone-rubber material has a low initial viscosity of 80 centipoises, temperature stability from −54 to 250°C, and bondability to most substrates.
Dow Corning Corp., Midland, Mich. [480]

Platinum-silver conductor paste No. 1150 is a thick-film product that can be fired at temperatures as low as 750°C. It is priced at $19.95 per ounce in 1,000-ounce quantities.
Electro Oxide Corp., 3896 Burns Rd., Palm Beach Gardens, Fla. 33410 [401]

Microwave dielectric material Di-Clad 527 is a laminated composition of PTFE-coated glass fabric with copper cladding on one or two surfaces. Noteworthy for its low dissipation factor of 0.0019 at X band (8.2 to 12.4 gigahertz), the material has a dielectric constant of 2.5.
Keene Corp., Chase-Foster Laminates Division, 199 Amaral St., P. O. Box 4305, East Providence, R. I. 02914 [402]

Fusible shielding tape Lamiglas 1112, is intended for cable television and similar applications. Made of 1-mil aluminum foil with an adhesive copolymer coating, the tape is available in split widths from ⅜ to 20 in.
Sun Chemical Corp., Facile Division, 185 Sixth Ave., Paterson, N. J. 07524 [403]

New literature

Thick-film resistors. A one-page bulletin, No. R-850-5, describes the effects of various screen-printable conductor pastes on the resistivity of thick-film resistors. Results are shown for platinum-gold, palladium-gold, palladium-silver, and silver conductors. The bulletin can be obtained from Thick Film Systems Inc., 324 Palm Ave., Santa Barbara, Calif. 93101. Circle 421 on reader service card.

Communications testing. Called "The White Noise Book," a publication put out by Marconi Instruments, 100 Stonehurst Court, Northvale, N. J. 07647, deals with the subject of multichannel communications testing—both cable and radio. The 104-page book has a postage-paid price of $6. [422]

SEM packaging. A so-called erector-set packaging system for the Navy's Standard Electronic Module (SEM) Program is detailed in a 17-page booklet available from International Electronic Research Corp., 135 W. Magnolia Blvd., Burbank, Calif. 91502. The booklet illustrates the six standard components of the IERC system, along with some nonstandard parts. [423]

Uninterruptible power systems. An eight-page brochure from Static Power Inc. covers the need for uninterruptible power systems and important features to look for. The brochure includes specifications, dimensions, and application notes on a 313-kVA UPS made by Static Power Inc., 3800 Campus Dr., Newport Beach, Calif. 92660 [424]

Beryllium-nickel. Berylco-nickel alloy 440 is a nickel-beryllium-titanium formulation that combines high strength with easy formability because it can be formed before it is hardened. Bulletin 306 2-PD1 presents detailed data on this alloy plus information on temper selection, heat treatment, cleaning, forming, and joining. The brochure is offered by Kawecki Berylco Industries Inc., Box 1462, Reading, Pa. 19603 [425]

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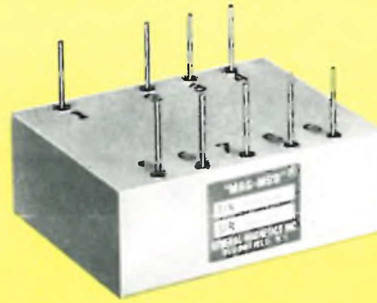
SOLID STATE SINE-COSINE SYNCHRO CONVERTER



This new encapsulated circuit converts a 3-wire synchro input to a pair of d-c outputs proportional to the sine and cosine of the synchro angle.

- Complete solid state construction.
- Operates over a wide temperature range.

UNIT	DMD 1436-1	DMD 1430-1	DMD 1403-2	DMD 1361-6	DMD 1361-4	DMD 1193-4	DMD 1361-8	DMD 1446-1	DMD 1193-5	DMD 1193-6	DMD 1361-10	DMD 1472-2
L - L SYNCHRO INPUT (VRMS)	11.8	90	95	90	11.8	11.8	11.8	11.8	11.8	11.8	11.8	90
FREQUENCY (Hz)	400	400	60	400	400	400	400	400	400	400	400	60
FULL SCALE OUTPUT (VDC)	± 10	± 10	± 3	± 3	± 3	± 10	± 10	± 10	± 10	± 10	± 10	± 10
OUTPUT IMPEDANCE	$<1\Omega$	$<1\Omega$	$<1\Omega$	$<1\Omega$	$<1\Omega$	$<1\Omega$	$<1\Omega$	$<10\Omega$	$<1\Omega$	$<1\Omega$	$<1\Omega$	$<1\Omega$
L - L INPUT IMPEDANCE	>10K	>30K	>5K	>30K	>5K	>5K	>5K	>5K	>5K	>5K	>5K	>5K
REFERENCE VOLTAGE (VRMS)	26	115	115	115	26	115	26	115	115	115	26	115
ACCURACY SIN/COS (+25°C)	± 6MIN	± 6MIN	± 6MIN	± 6MIN	± 6MIN	± 6MIN	± 6MIN	± 0.5%	± 6MIN	± 6MIN	± 6MIN	± 6MIN
FULL TEMPERATURE RANGE ACCURACY SIN/COS	± 15MIN	± 15MIN	± 15MIN	± 15MIN	± 15MIN	± 15MIN	± 15MIN	± 0.5%	± 15MIN	± 15MIN	± 15MIN	± 15MIN
D.C. SUPPLY (VDC)	± 15	± 15	± 15	± 15	± 15	± 15	± 15	± 15	± 15	± 15	± 15	± 15
D.C. SUPPLY CURRENT	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA	<30MA
BANDWIDTH	>10Hz	>10Hz	external set	>20Hz	>5Hz	>10Hz	>10Hz	>10Hz	>2Hz	>40Hz	>5Hz	external set
SIZE	1.1x3.0 x1.1	2.0x2.25 x1.4	1.1x3.0 x1.1	1.5x1.5 x0.6	1.85x0.85 x0.5	2.01x2.25 x1.4	0.85x1.85 x0.5	2x2.25 x1.4	2x2.25 x1.4	2x2.25 x1.4	2.15x1.25 x0.5	1.1x3.0 x1.1
NOTES	–	dual channel unit	–	–	–	dual channel unit	–	dual sine output	dual channel unit	dual channel unit	–	–
TEMPERATURE RANGE	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C

4 QUADRANT ANALOG MULTIPLIER

Model MCM 1478-1

DC x DC = DC OUTPUT

Product Accuracy is ± ½% of all theoretical product output readings over Full Temperature Range of −55°C to +125°C.

Maximum Output Error for Either
X = 0, Y = 10V
Y = 0, X = 10V
X = 0, Y = 0
would be ±2 MV over Entire Temperature Range.

Specifications: Model MCM 1478-1
Transfer Equation: E = XY/10
X & Y Input Signal Ranges: 0 to ± 10V peak
Maximum Static and Dynamic Product Error: ½% of point or 2MV, whichever is greater, over entire temperature range
Input Impedance: X = 10K, Y = 10K
Full Scale Output: ± 10V peak
Minimum Load for Full Scale Output: 2000 ohms
Output Impedance: Less than 10 ohms
Bandwidth: 1000Hz
DC Power: ± 15V, unless otherwise required, at 20ma
Size: 1.3" x 1.8" x 0.5"
Output is short circuit protected

4 QUADRANT SINE FUNCTION GENERATOR

Model MSFG 1489-1
Model MSFG 1489-2
Model MSFG 1489-3
Model MSFG 1489-4

FEATURES:

- Provides a sine function with ½% accruacy over a − 180° to + 180° range
- Excellent temperature stability
- Full scale output of ± 10V DC
- Scale factor adjusted by a DC signal
- Hermetically sealed package

Specifications:
DC accuracy: ± 30 min of ARC or 0.5% whichever is greater
DC accuracy over operating temperature range: ± 30 min of ARC or 0.75% whichever is greater
Transfer equation: $E_o = -E \sin\theta$
E represents an external DC voltage in the range of + 2V to + 10V
Input resistance: θ input (pin 6) - 100K ± 10%
Input resistance: E input (pin 4) −47K ± 10%
Rated output voltage: ± 10V max at 5ma
Output impedance: $<1\Omega$
Frequency response:* 400HZ
Power requirements: ±15V DC ±1% at ± 40ma
Operating temperature range:

MSFG 1489-1	− 40°C to + 100°C
MSFG 1489-2	− 25°C to + 85°C
MSFG 1489-3	0°C to + 70°C
MSFG 1489-4	25°C ± 10°C

*Frequency response is specified for a ± 5V triangular input waveform.

There is No Substitute for Reliability

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