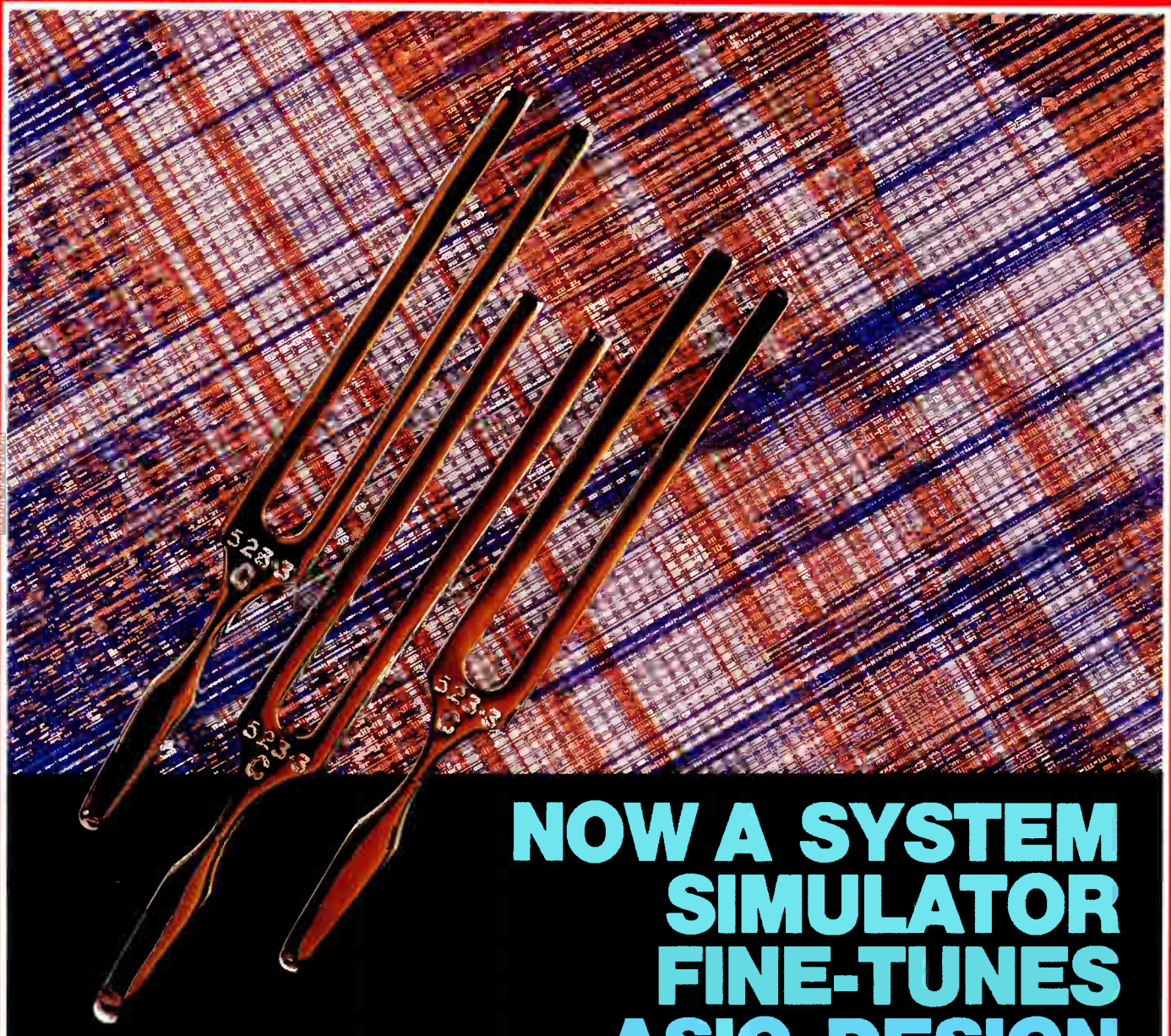
WHAT'S DRIVING THE SEMICONDUCTOR UPTURN?/55

MERGERS: HERE COME TWO BIGGER, TOUGHER IC MAKERS/56

A McGRAW-HILL PUBLICATION SIX DOLLARS MAY 14, 1987

Electronics



NOW A SYSTEM SIMULATOR FINE-TUNES ASIC DESIGN

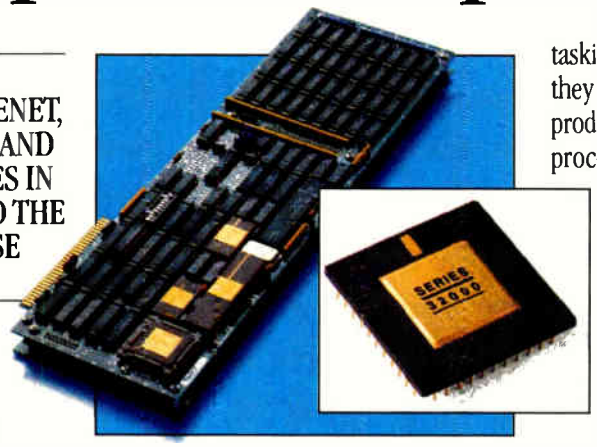
LSI LOGIC'S CAD TOOLS RUN APPLICATIONS SOFTWARE ON SIMULATED SYSTEMS

PAGE 67

National Semiconductor

Series 32000 makes VAX power more personal.

NOW YOU CAN JOIN HEWLETT-PACKARD, FUTURENET, EATON, COMPUTERVISION, AND OVER 50 OTHER COMPANIES IN BRINGING 32-BIT POWER TO THE LARGEST INSTALLED BASE IN THE WORLD



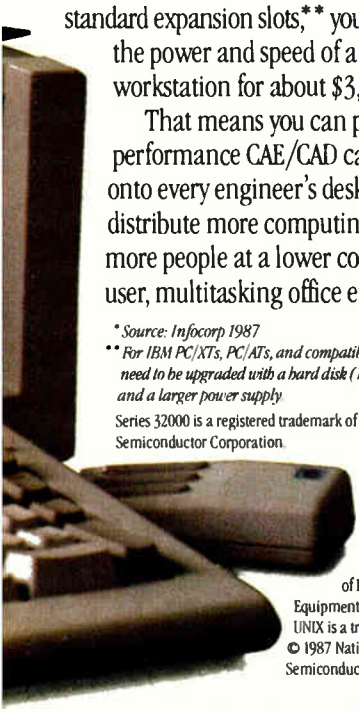
There are over 10.7 million* IBM® personal computers and compatibles in use today. That's the largest "installed base" in the world — an enormous pre-existing market that represents an enormous marketing opportunity. And National Semiconductor is leading the way for OEMs, systems integrators, VARs and VADs to take full advantage of it.

Because it's now possible to put the power of a VAX™ 11/780 into the PC environment. At a mere fraction of the cost.

PC add-in boards, based on National's Series 32000® family, allow you to immediately upgrade almost any personal computer to true 32-bit performance.

Simply by plugging a Series 32000-based board into one of the computer's standard expansion slots,** you can deliver the power and speed of a $30,000 workstation for about $3,000.

That means you can put high-performance CAE/CAD capabilities onto every engineer's desktop. You can distribute more computing power to more people at a lower cost in a multiuser, multitasking office environment.



Source: Infocorp 1987

***For IBM PC/XTs, PC/ATs, and compatibles. Standard PCs need to be upgraded with a hard disk (10 Mbyte, minimum) and a larger power supply.*

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You can capitalize on the hot new market in desktop publishing. The opportunities are endless.

DELIVER TRUE 32-BIT POWER

Already more than 50 key systems integrators, VARs and VADs have realized the potential of this market by using PC add-in boards.

And more PC add-in board manufacturers are using the Series 32000 than all other 32-bit microprocessors combined.

That's because no other 32-bit microprocessor offers a more complete, integrated family of solutions, including coprocessors, peripherals, software, and development tools.

And, because the entire family was designed with the same highly symmetrical, orthogonal 32-bit architecture, the Series 32000 is fully software-compatible across all its CPU offerings. So your customers' software investment is completely protected even as they migrate to higher performance.

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A Series 32000-based add-in board gives your customers the best of both worlds in operating systems. Since the Series 32000 was the first 32-bit microprocessor to support full demand-paged virtual UNIX,™ your customers can run high-performance engineering and business applications in the most cost-efficient multiuser, multitasking environment in the industry. Yet they can still run important personal-productivity tools like spreadsheets, word processing, and project managers under DOS.

PLUG INTO THE MARKET *NOW*

Obviously, the potential of the PC add-in market is enormous. And it's already being tapped with Series 32000-based boards being manufactured by a number of OEMs. If you're a systems integrator, VAR or VAD, contact one of these companies about their products.

Or if you're a board-level OEM yourself, follow their lead by contacting National Semiconductor about how you can design the Series 32000 into your own product.

PC ADD-IN COMPANIES USING SERIES 32000

Selected OEMs

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Cybertool Systems USA, San Jose, CA (408) 263-1700
Definicon Systems, CA (818) 889-1646
DFE Electronic Data Systems, CA (415) 829-3925
Hightec EDV Systems, Saarbrücken, Germany
Matrox Electronic Systems, Quebec, (514) 685-2630
Opus Systems, Cupertino, CA (408) 446-2110
Sritek, Cleveland, OH (216) 526-9433
Zaiaz, Huntsville, AL (205) 881-2200

Selected VARs

Analog Design Tools	Lattice Logic USA
Auto-Trol Technology	Matrox Elec. Sys.
Cambridge Graphics	National Semiconductor
Computervision	Oasys
Cybertool Systems USA	Olivetti
Hightec EDV Systems	Siemens AG

Either way, the PC add-in market represents one of the most significant business opportunities in years. With over 10,000,000 prospective customers. And the Series 32000 can help you reach every one of them.

Personally.

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National Semiconductor

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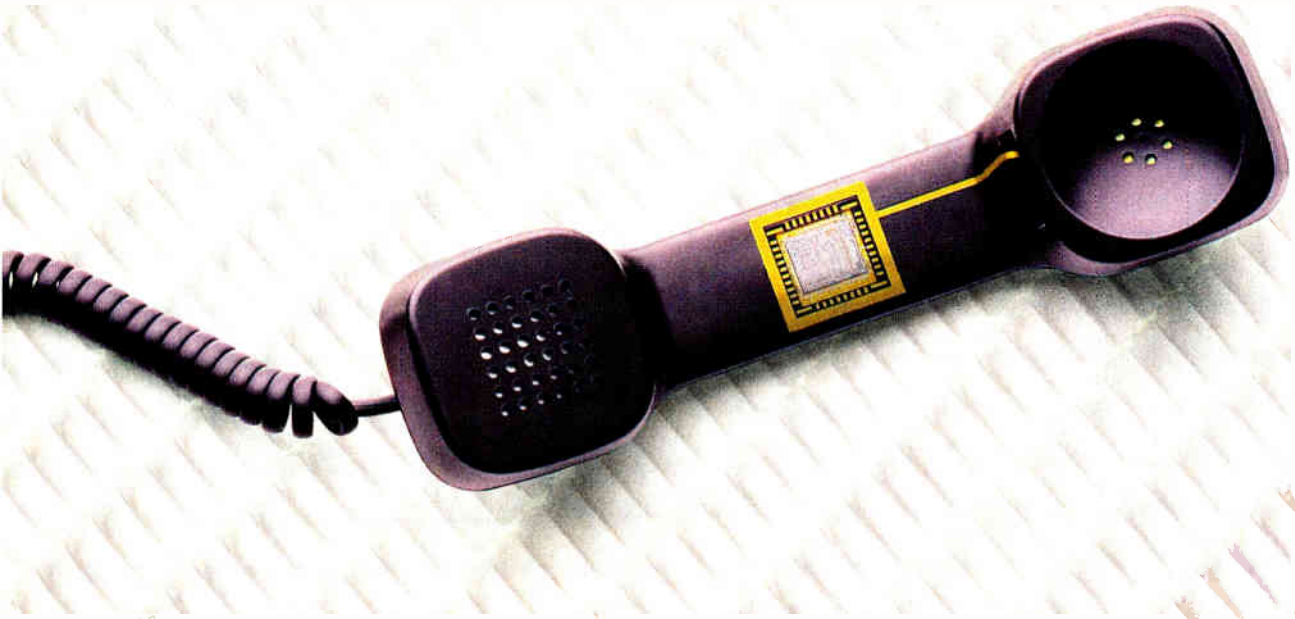
THE $17* DIGITAL TELEPHONE



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Except for *Electronics*, magazines covering the electronics industry traditionally work with long lead times. In fact, some of our competitors write their news stories so long before the readers see them that they wind up working on two or three issues at a time.

Electronics has always been known as the magazine that can turn around faster on a major story than any of the others. And as far back as the 1960s we were getting late-breaking news into the magazine literally minutes before pages went to press. Our pages close only one to three days before press time. Waiting until the last possible hour enables us to give our readers added value—perspective, interpretation, and a measure of the significance—at the same time they would get the raw news from the industry's newspapers.

WALLER: Turning around fast on the turnaround story.

In this issue is a package of stories that are prime examples of how much we can do in very little time. They make up the entire Probing the News section beginning on p. 55, they concern the semiconductor industry—and they required us to change plans and rewrite schedules.

Leading off the section is "What's Driving the Semiconductor Upturn?" It's followed by stories of two mergers—between Advanced Memory Devices and Monolithic Memories, and Thomson and SGS—and an alliance between National Semiconductor and Cypress Semiconductor. Finally, we explain how ITT Semiconductors turned in the best margins in the industry last year.

The pages of the upturn piece were locked on press just a week after we decided to do the story. The go-ahead came from Phoenix, where editor-in-chief Bob Henkel and Los Angeles bureau manager Larry Waller were at In-Stat's Semiconductor Forum. Associate managing editor Ben Mason added two pages to the magazine, Waller sent an assignment to our news bureaus around the world, and the production staff prepared to handle the added story.

For Waller, the deadline pressure was like the call to the post for an old thoroughbred. "I'm a semiconductor junkie," he confesses, "and I go back in this industry to the early 1960s—before there was a Silicon Valley. But the industry is showing a new face in 1987: humility. Chip executives ordinarily are the most optimistic in America, but they have been bloodied so badly in the last few years that even though orders are turning up, they remain skeptical."

Digging into the AMD-MMI merger was another longtime industry watcher, San Mateo bureau chief Cliff Barney, with the aid of semiconductors editor Bernie Cole. Cliff says, "I wasn't too surprised by the deal, because in my talks with company officials back in February I was able to detect hints that something was in the works."

Steve Rogerson's fast-turnaround report from London on Thomson-SGS points up the big difference in the scene there. Says Steve, "The U.S. companies have to contend with the Japanese, but for European companies there are the Japanese *and* the Americans."

In total, that's a lot of deadline bending. But we have a lot of experience.

Laurence Altman

May 14, 1987 Volume 60, Number 10
129,988 copies of this issue printed

Electronics (ISSN 0883-4989). Published biweekly by McGraw-Hill Inc. Publication office: 1221 Avenue of the Americas, N.Y., N.Y. 10020; second class postage paid at New York, New York and additional mailing offices. Postage paid at Montreal, P.Q. Registration Number 9034.

Executive, editorial, circulation, and advertising addresses: Electronics, McGraw-Hill Building, 1221 Avenue of the Americas, New York, N.Y. 10020. Telephone (212) 512-2000. Teletype 12-7960 TWX 710-581-4879. Cable address: M C G R A W H I L L N E W Y O R K.

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MAY 14, 1987

Electronics

NEWS

INSIDE TECHNOLOGY

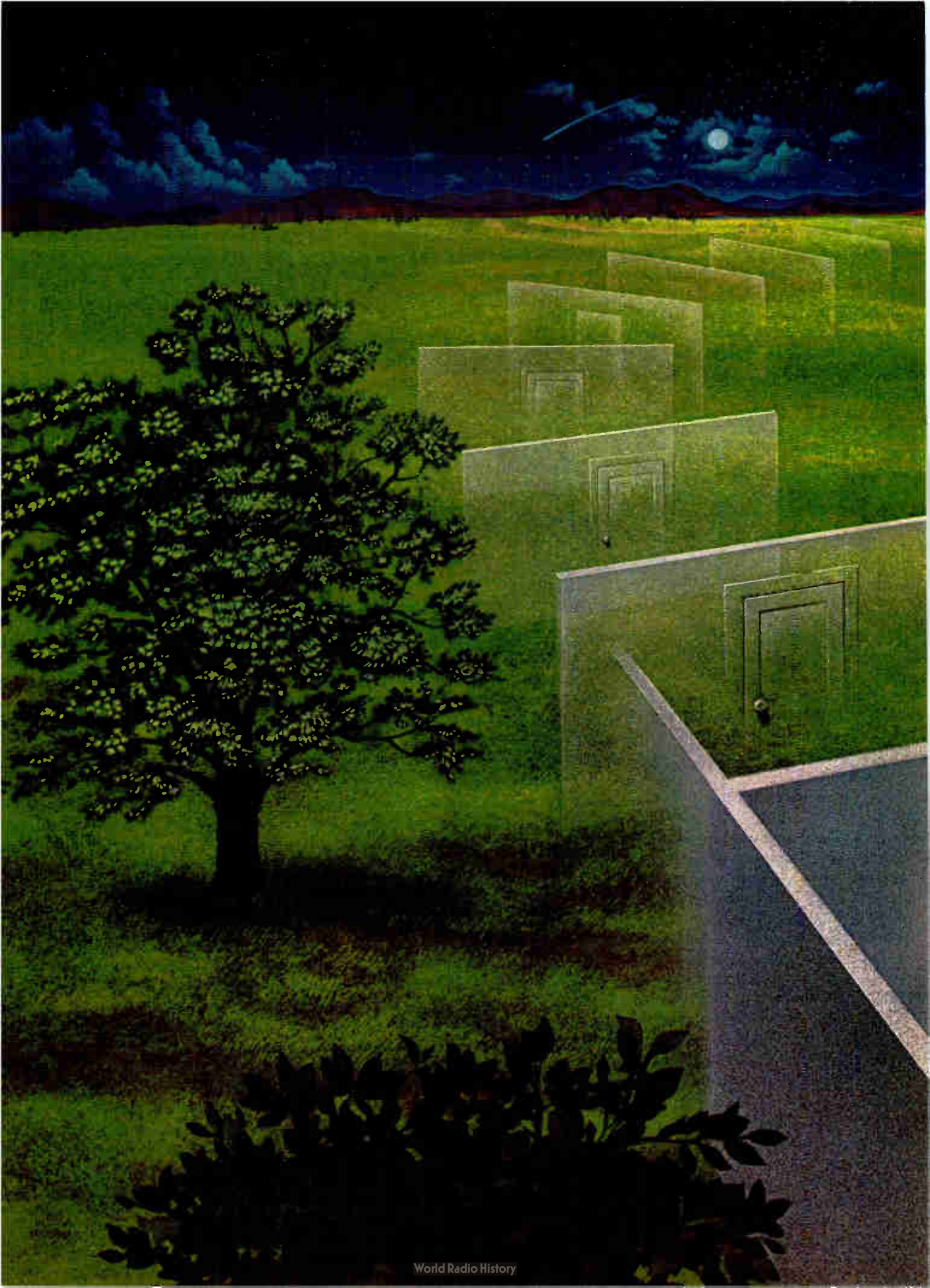
PROBING THE NEWS

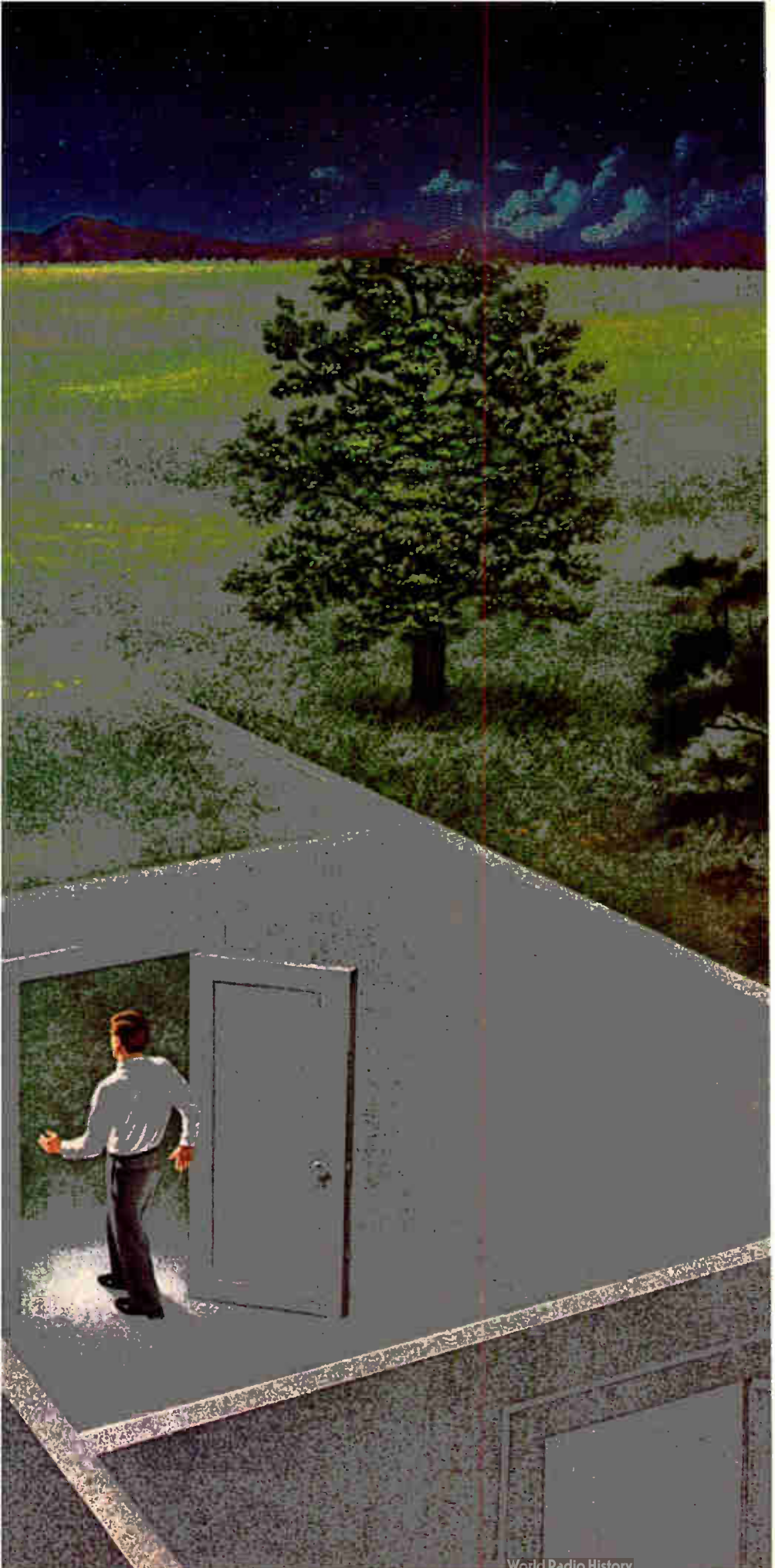
COVER: NAVA BENJAMINI

PAGE 67

NEW PRODUCTS

DEPARTMENTS





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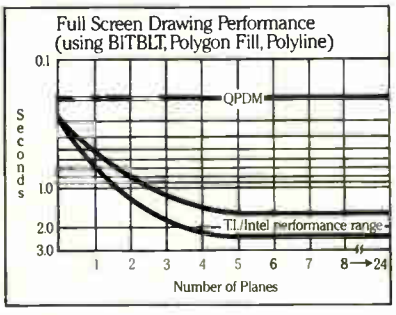

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IMS1620 (x4)	35, 45, 55ns
IMS1624 (OE, x4)	35, 45, 55ns
IMS1630 (x8)	45, 55, 70ns

LOW POWER DATA RETENTION CMOS SRAMs		
Device	Access Times	Idr*
IMS1403L (x1)	25, 35, 45ns	0.5µA
IMS1601L (x1)	45, 55, 70ns	10µA
IMS1620L (x4)	45, 55, 70ns	10µA
IMS1624L (OE, x4)	45, 55, 70ns	10µA

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LETTERS

Lend a helping hand

To the editor: In response to your editorial [*Electronics*, March 5, 1987, p. 8], your column accurately summarizes the lack of direct government funding for research into automation. The failure of the Administration to enact the Manufacturing Sciences and Robotics Research and Development Act, and the poor funding provided by the National Science Foundation, do point up the lack of direction of the federal government vis-à-vis automating manufacturing.

Of course, the administration is elected, and unions tend to do two things: vote and resist change. Therefore, it is not likely that any agency of our federal government will ever commit to officially promoting factory automation.

However, there are several agencies that already are promoting automation, namely, the U. S. Postal Service and the Internal Revenue Service. Both departments are using computers to increase productivity, and both have historically moved toward new technologies.

Recall that the post office did much to fund the intercontinental railway in the previous century and also paved the way for air transport.

My point is that factory automation developers would be well advised to direct much of their work toward fulfillment of the needs of these two agencies. By effectively creating equipment for the Post Office and the IRS, automation developers can work out human-machine interfaces, debug communications protocols, develop documentation techniques, and build a track record of successful automation.

If the manufacturers of factory automation equipment can use the above-mentioned areas to "simulate" factory automation conditions, then a large amount of government funding will be made available in an indirect manner, through purchasing of automation equipment for the post office and the IRS.

Instead of complaining about the lack of direct funding, manufacturers ought to be supplying those agencies who can help.

Gerry Kaufhold
Project Engineer
Security Sciences Corp. of America
Scottsdale, Ariz.

It's a custom chip

To the editor: We recognized some erroneous descriptions about the functional features and availability in the marketplace for the NEC μPD9002 [*Electronics*, March 19, 1987, "NEC won't be offering its spiced-up V30 CPU to U.S. systems houses," p. 54] that we would like to correct.

First of all, the article stated "the μPD9002 will not be available in the U. S., at least for now. Despite the V30's popularity . . . ongoing copyright battle over the chip's microcode with Intel Corp . . . ." This is not correct. Since the μPD9002 chip has been developed as a custom chip, we have no plan to sell the chip into the open market as a general commodity in any country, including Japan. The current wording, including the article title, is grossly misleading.

Second, the article also stated that it "provides higher-speed and enhanced graphics." This, too, is wrong. The operation clock of the μPD9002 is 8 MHz, while it is 10 MHz in the V30. Accordingly, the μPD9002 is not a higher-speed chip than the V30. Besides, there is *no* enhanced graphics capability on the μPD9002. This is done by another chip and in the computer.

Hajime Sasaki
Vice President, Electron Device Group
NEC Corp.
Kawasaki, Japan

Just keep in mind . . .

To the editor: Clifford Barney states: "National Semiconductor Corp. built its reputation as a sometimes-abrasive low-cost maker of jellybean integrated circuits with no time for hand-holding with buyers" [*Electronics*, April 2, 1987, p. 63]. I must take issue with this broad-brush generalization.

Apparently, Barney forgot about National's historic (and continuing) position of leadership in state-of-the-art linear integrated circuits. If you look at the linear circuits in our catalog, over half of the part numbers have been new proprietary designs. The next time you use a BiFET, or a Superbeta op amp, or a three-terminal adjustable regulator, remember where these concepts started out. Also, our applications handbooks and linear data books have been industry standards for over a dozen years. Barney talks about "jellybeans," but perhaps he does not realize that today's inexpensive LF357N was originally a technology pioneer selling for $5 and up 10 years ago. So, tomorrow's "jellybean" may be the natural evolution of today's leadership, after we have learned how to get the yield up and the manufacturing costs down.

Most of the customers we talk to are highly appreciative of our extensive "user-friendly" Applications Engineering staff and would refuse to comprehend the allegation of "no time for hand-holding."

Martin Giles
Applications Manager
National Semiconductor Corp.
Santa Clara, Calif.

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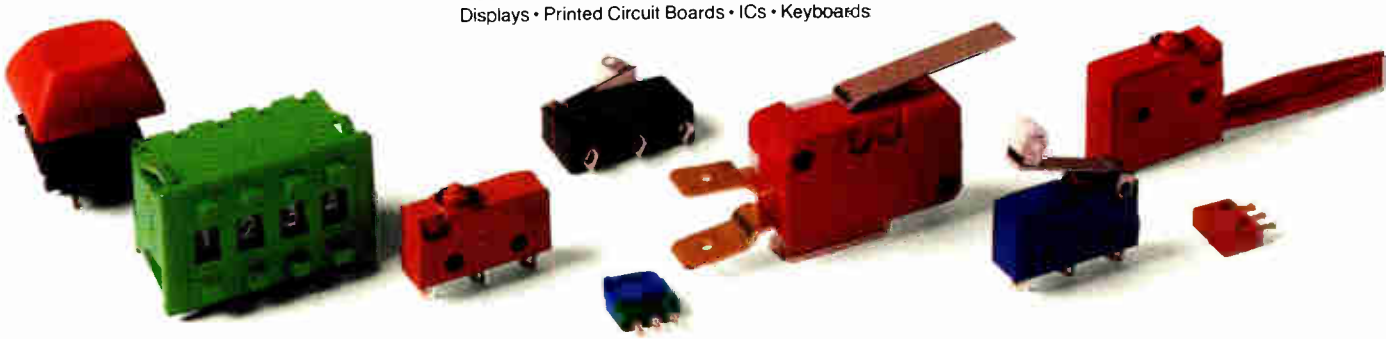

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Introducing the si
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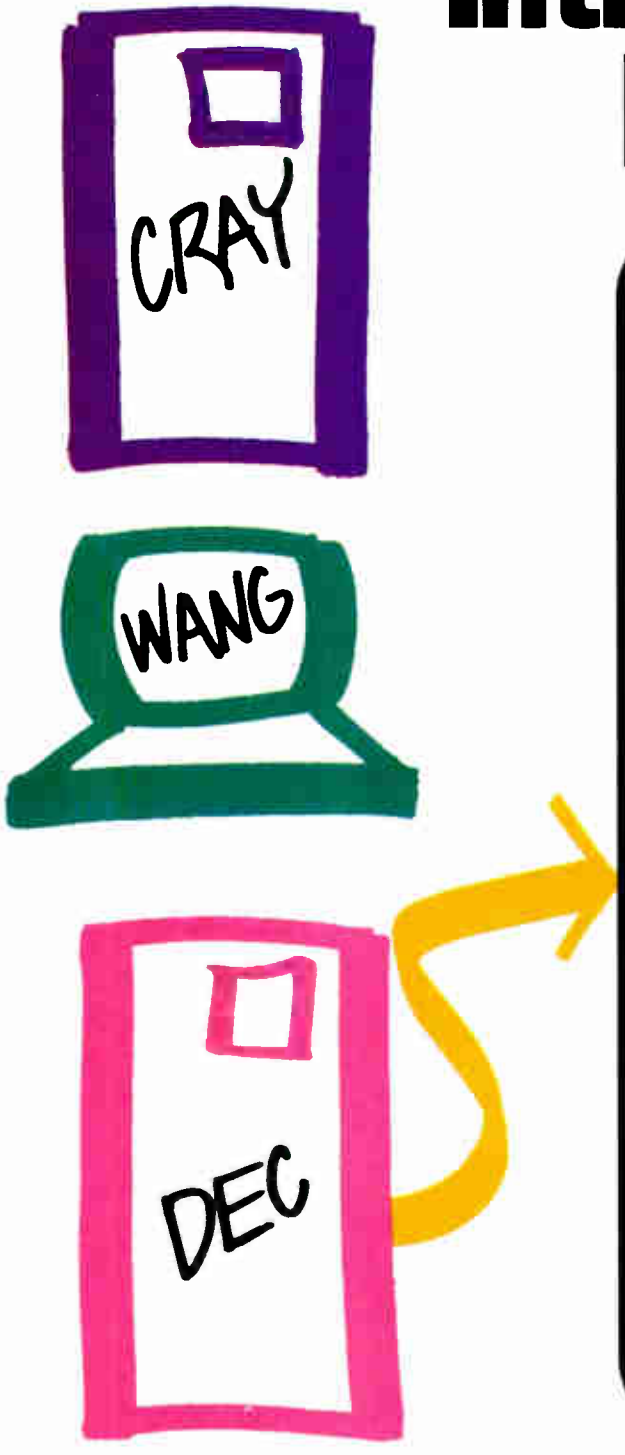

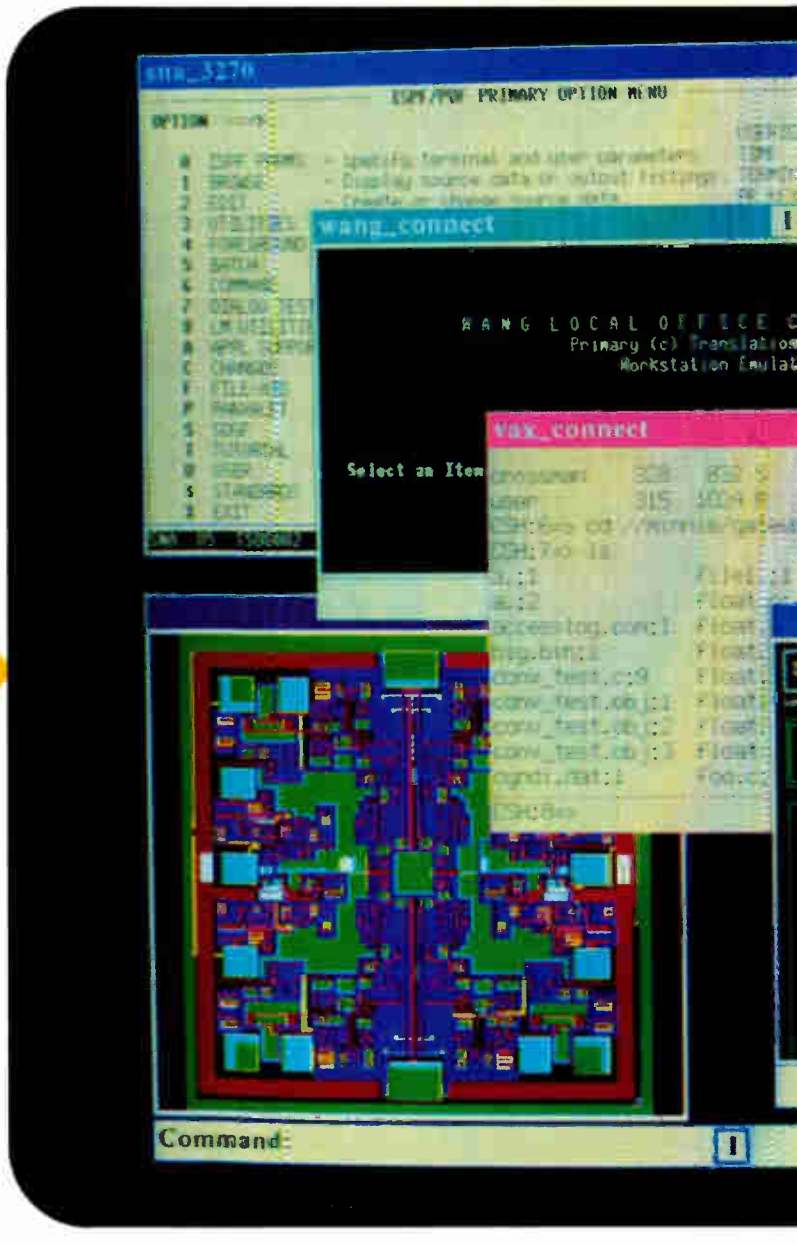

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But now an Apollo workstation presents you with the files on your VAX® system. The corporate data stored in your IBM® mainframe. Even the information generated by personal computer users.

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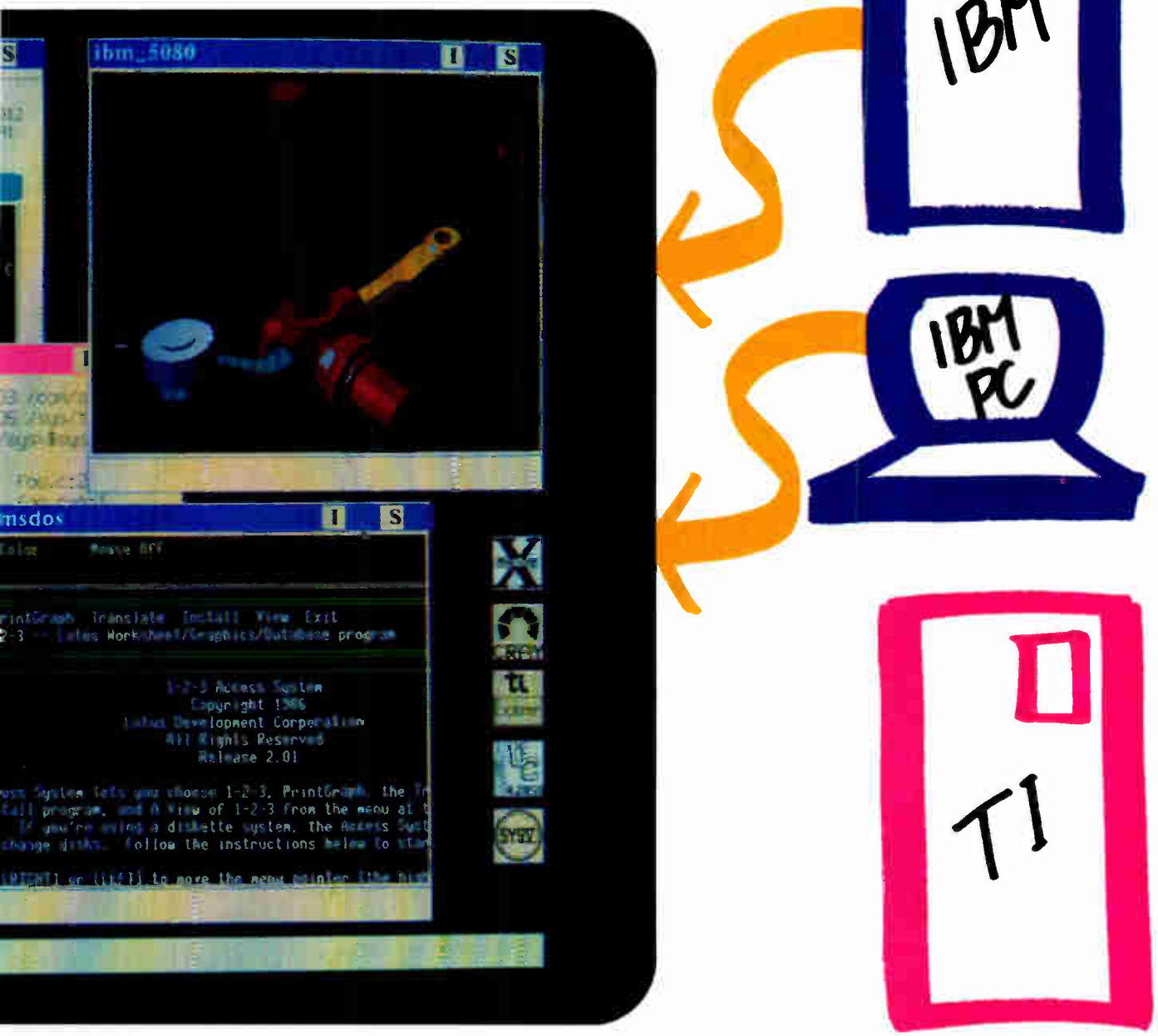

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FOR SIR CLIVE, THERE'S ALWAYS A TOMORROW

LONDON

They can stop writing those obituaries bemoaning the end of an era in the British computer business. Sir Clive Sinclair is still around, as feisty as ever.

When the iconoclastic entrepreneur sold his ailing computer business to rival Amstrad Consumer Electronics plc to concentrate on new markets and challenges [*Electronics*, April 14, 1986, p. 64], it appeared that he might just fade away. But Uncle Clive, as he is affectionately known in the industry, is not the fadeaway type. He has bounced back with a new company called Cambridge Computer Ltd., a $300 laptop computer, and plans for a wafer-scale-integration-based version—as well as a new type of telephone system.

To understand why Sinclair made the Amstrad deal, it is necessary to know that he is a man who lives for the future. "I sold the old computer range and the use of my name on computers because we were short of cash," he says. "It was a long-term outlook. The important parts of our business were wafer-scale and other computers. We are not aiming at the home market. We are aiming at the serious user. The new computer is cheap because we don't want to give people an excuse not to buy it."

It is perhaps not the new Z88 but the one after that that looks most exciting. Sinclair says that the research into wafer-scale integration has as its goal a small computer. He expects the first wafer-scale products to materialize early next year and the computer to be out by year's end.

Next year will also be exciting for Sinclair, because that is when he intends to take on the cellular telephone market with a portable phone featuring a radio link to any of three other phones: the telephone at home, the telephone at work, and the cellular telephone in the car. The phone will automatically select which is the nearest and cheapest of the three and make the call on that.

All this suggests that if the industry was surprised by his quick return, it shouldn't have been. Sinclair's history has been full of such ups and downs since 1962, when he formed Sinclair Radionics to make and sell radio and amplifier kits. The kits were inexpensive and were sold by mail order—two features that have marked every Sinclair product since, except for his electric tricycle, which was too big to mail.

MOVING ON. Sinclair's first move forced the prices of hi-fi systems down to a level that people could afford. In 1972, he started making pocket calculators, using the profits from the successful hi-fi business. They were also low-cost, they sold like hotcakes, and they forced the market price of calculators down. Then the Japanese flooded the market with even cheaper calculators that were far more reliable than the Sinclair models. Sinclair tried to balance his losses with a new idea—one of the first digital watches. It was a great idea with a large market. But reliability problems caused the company heavy losses in 1976.

During that year the British government poured close to $4 million into the business. And despite another innovative product—a pocket TV with a 2-in. screen—the company suffered heavier losses. By 1979, the company looked dead, and Sir Clive was out.

In 1980 he bounced back with a new company, Sinclair Research, and the ZX80 home computer. The success of that and later computers in the range earned him knighthood in 1983. But by 1985 the home computer market was disappearing. His QL computer was a flop. And his latest quirk, the electric tricycle, was a nonstarter.

But, he adds, "the computers are my principal interest." Although the deal with Amstrad specifies that the machines will not bear the Sinclair name, Sir Clive is not worried: "It doesn't matter; everybody knows where the computers come from."

–Steve Rogerson

SINCLAIR: "I sold the old computer line because we were short of cash."

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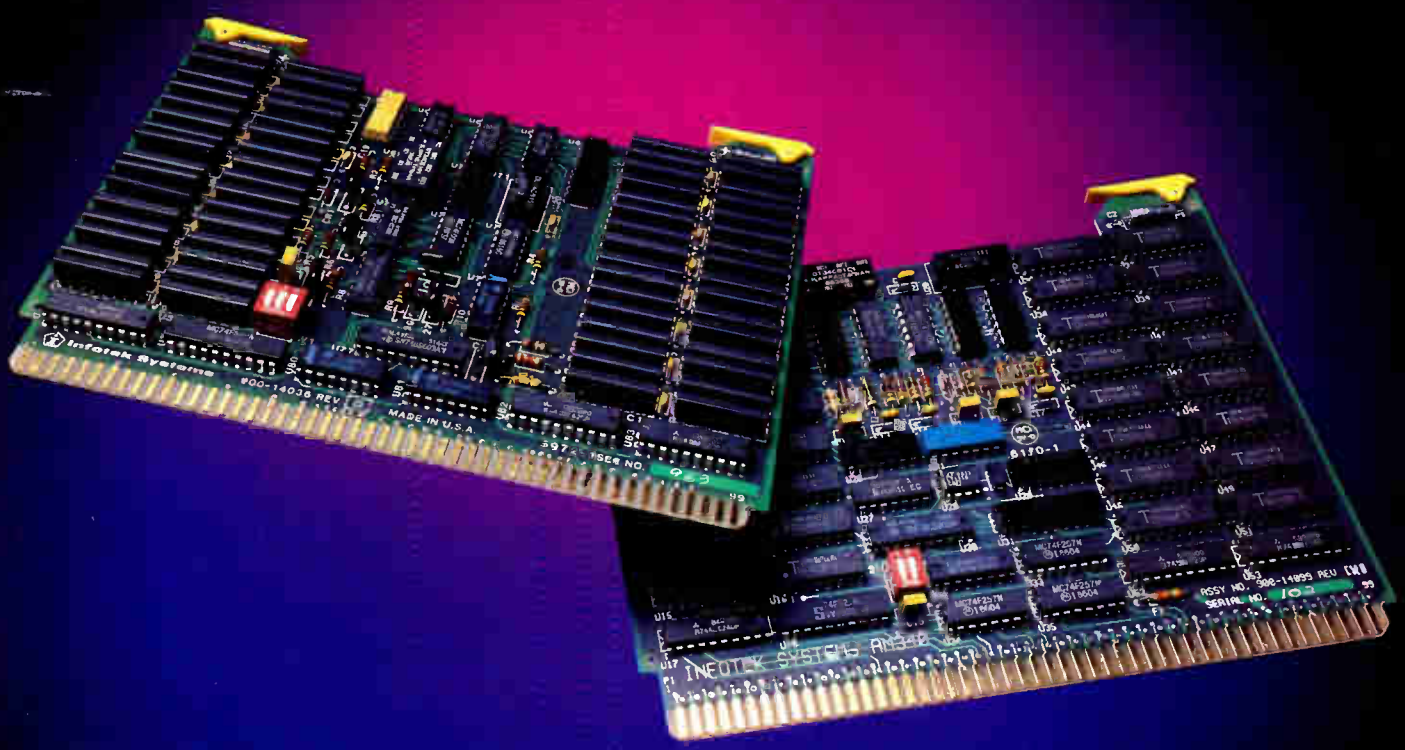
New Infotek 8 and 4 MByte Memory Cards Give Lowest Cost per Byte for HP 200/300.



Now, get all the memory you need for the most complex programs—CAD, CAE—all on a single, compact card. And, at the same time, get the lowest cost per megabyte of memory on the market.

Infotek's new AM380 is the first 8 megabyte single-card memory available for HP 200/300 computers. It allows you to take advantage of the full storage capacity of your HP workstation without wasting valuable backplane space. ZIP packaging of 1 MByte monolithic DRAMs makes the low cost per byte possible.

For the many applications requiring 4 MBytes of memory, Infotek again uses 1 MByte DRAMs in single in-line packages to reduce costs. That means you can now have Infotek quality in the lowest-cost 4 MByte board available! Of course, Infotek's popular 1 MByte and 2 MByte memories are also available.

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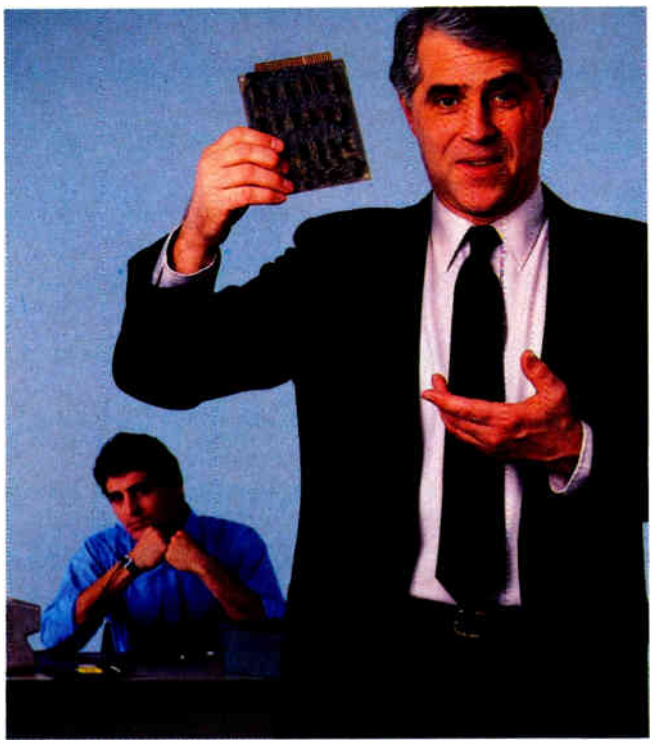

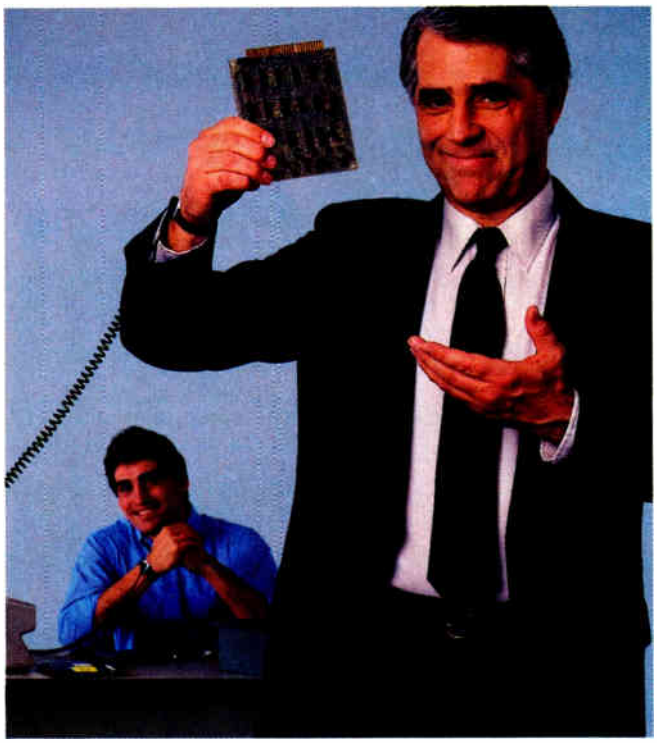

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ELECTRONICS NEWSLETTER

MOTOROLA AIMS TO HALVE DSP PRICE FOR ADAPTIVE PCM APPLICATIONS

Motorola Inc. is shooting to halve the price of digital signal processors used for adaptive pulse-code modulation in telecommunications applications. By using barrel shifters rather than multipliers in their adaptive PCM transcoder chip, engineers at Motorola's Austin, Texas, telecom unit expect to be able to produce a chip that will sell for $5. ADPCM transcoders can double the number of telephone channels on PCM lines, transforming what would be 64-kbit/s transmissions into 32-kbit/s transmissions. In most digital signal processing, multipliers usually account for a large area of a die, but in ADPCM transcoding, multiplication accounts for a small percentage of clock cycles. So Motorola's 16-pin C145432 will employ a split-control storage architecture enabling the chip to operate as two parallel microcode machines—and specially encoded registers on the CMOS chip recode incoming signals into a modified form. As a result, barrel shifters can adequately perform functions usually handled by dedicated multipliers. The application-specific DSP will run at 20 MHz and will have 100-ns instruction cycle times. Motorola hopes to see working silicon this fall. □

CHERRY WILL SHOW OFF A PRACTICAL THICK-FILM EL DISPLAY

Developers have long known that thick-film technology could build lower-cost electroluminescent flat-panel screens than current thin-film techniques. But several problems have plagued thick-film EL displays. For one thing, they needed a programmable chip to cut the cost of the driver circuitry. They also have shown softening—a loss of sharpness—and load-line flattening—a loss of brightness. Now Cherry Display Products Corp., of El Paso, Texas, and Siliconix Inc. say they've solved these problems. They showed the result at the Society for Information Display meeting in New Orleans in mid-May, a new 640-by-200-pixel thick-film flat panel. The two companies designed the high-voltage, high-current driver chip, and the Santa Clara, Calif., chip maker built it. By adding silver to the copper-coated back layer of the panel, Cherry reduced the electrical resistance and heat that degrade sharpness and brightness. Product prototypes, which should be available from Cherry in August, are rated at 25 foot-lamberts and no more than 30% degradation after 10,000 hours. Cherry projects a 1989 price of $250 in very high volume; that could be about half the cost of thin-film EL displays. □

SEQUENT WILL SOON LAUNCH ITS MOST POWERFUL SYSTEM YET

Sequent Computer Systems Inc., the Beaverton, Ore., maker of multiprocessor computers, is about to introduce its most powerful system to date. The new computer line uses the same basic architecture as its popular Balance series and will incorporate up to 30 central processing units based on Intel 80386 and 80387 microprocessors—enough power to handle 80 million instructions per second. Sequent's current top-rated model, the Balance 21, has 30 National 32032 microprocessors but manages just 21-mips performance. The new machine could help Sequent broaden its market to traditional data processing, such as interactive transaction processing. □

A STRONGER YEN MAY SINK RICOH'S BOARD DEAL WITH CONVERGENT

The strong yen may be chasing some manufacturing jobs out of Japan. Ricoh Co., of Tokyo, which has been producing central processing boards for Convergent Technology Inc. at its Hatano, Japan, plant, says it is being forced out of the deal because of skyrocketing costs directly attributable to the imbalance in the yen-dollar equation. Ricoh expects Convergent, a San Jose, Calif., computer maker, to transfer the job to its home plant by the end of the year. □

ELECTRONICS NEWSLETTER

WILL VACUUM-COMPATIBLE ROBOTS CUT DOWN ON WAFER CONTAMINATION?

The best way to stop wafer contamination in chip processing may well be to keep production in a vacuum and let robots—not people—do all the work. The Center for Robotics Systems in Microelectronics at the University of California, Santa Barbara, is working with a Japanese company to do just that: develop manufacturing techniques based on robots that can work in a vacuum. Yaskawa Electric Manufacturing Co. of Kitakyushu City, Japan, will loan the center a prototype robot developed to operate in a high-vacuum environment. Santa Barbara researchers will use it to develop systems in which entire clean rooms are enclosed in a vacuum, with robots handling the wafers, thereby removing people from the work area. The center is already developing a multichamber vacuum enclosure as part of a research contract with Delco Electronics, but it has been hampered by a lack of suitable robots, motors, and mechanisms. The Yaskawa robot uses new axial pulse-gap motors that can withstand temperatures of 300° C in a 10^{-11} Torr vacuum. □

GI'S CHIP DIVISION IS FOR SALE AND—SURPRISE!—IT MAY BE MAKING MONEY

General Instrument Inc. may be trying to cast it aside, but there are those who think General Instrument Microelectronics has a rosy future. Chief among them is Don Sorchych, the division's president, who says GI Microelectronics is seeing strong sales growth and could actually turn a profit for the current quarter. Sorchych isn't entirely delighted, though. Turmoil in the chip business, and events such as Fujitsu Ltd.'s failed attempt to buy Fairchild Semiconductor Corp. do not bode well for a quick sale. Still, a surge in programmable read-only memories has caused an order upsurge that topped $10 million in April, more than double the orders for December 1986. GI said in April that it was writing off both GI Microelectronics and the Optoelectronics Division in Palo Alto, Calif., at a cost of $89.6 million. □

CERAMIC CUTS SOLAR CELL COSTS TO 16 CENTS PER WATT

A new scheme for building solar-energy cells being developed at the University of Delaware holds the promise of solar cells that will cost just 16¢ per cell. With each cell rated at about 1 W, that's far less than the $1.27 to $2 per watt that many of today's cells cost. Allen Barnett, an electrical engineering professor at the university, in Newark, Del., says the secret behind his new cells is the low-cost ceramic substrate on which they are built. The ceramic material is less costly than commonly used semiconductor-grade silicon. A reflecting layer of silicon carbide is built onto the ceramic and then coated epitaxially with a thin film of polycrystalline silicon that traps light optically and improves the cell's efficiency. The cells so far have an efficiency rating of better than 10%; Barnett is shooting for 17% efficiency. □

INTERNATIONAL RECTIFIER'S NEW CHIP PLANT SHOWS ITS STUFF

Increasingly, the power-chip business has regarded a giant new power MOSFET plant being built by International Rectifier Corp. as a potential white elephant. Indeed, the $86 million factory in Rancho California was an expensive undertaking for a niche semiconductor maker whose sales were only about $150 million annually. But the El Segundo, Calif., chip maker may be getting the last laugh. Surprisingly, first silicon is showing device yields above 90%, it says. If the company can keep it up in volume production, such yields would be a big step toward its goal of making the facility the efficiency leader in producing power devices. Turnaround time will initially be 10 working days, IR says, compared to nine weeks at present. It is aiming at an ultimate turnaround of just four days. Capacity is 50,000 5-in. wafers a month. □

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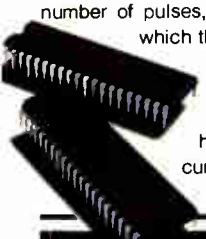

Automatic test equipment designed to simulate the electrostatic discharge which may occur between a charged body and a semiconductor. Presetting the voltage to be applied, the number of pulses, and the pins to which the voltage will be applied allows testing to be carried out with a high degree of accuracy.

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Test equipment designed to simulate lightning surges which may damage low voltage control circuitry. This equipment facilitates surge testing (such as FCC Part 68, paragraph 68-310) by superimposing a transient signal directly onto the power supply line.

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NOISE CANCELER

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Test equipment designed to determine electronic equipment tolerance to transient signals which may superimpose on the power supply lines.

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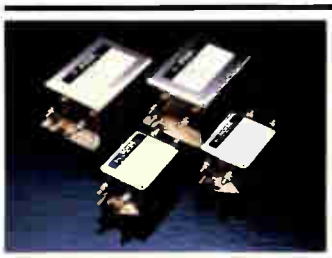
Test equipment designed to simulate a momentary voltage drop or the momentary power failure which may occur on a commercial power supply line and adversely affect sensitive electronic equipment.



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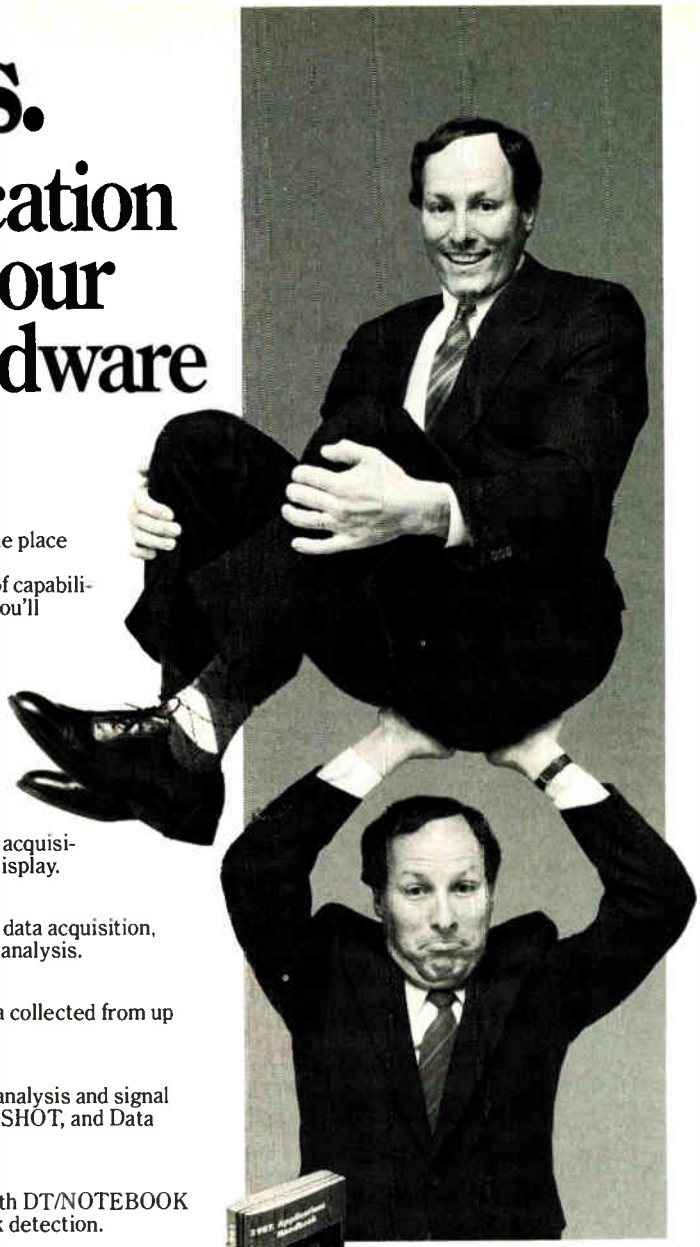

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Circle 24 on reader service card

PRODUCTS NEWSLETTER

MOTOROLA CONTROLLER CHIP TAILORS ISDN BANDWIDTH TO NEED

Motorola Inc. is staking its claim in the Integrated Services Digital Network market with a protocol controller chip that allocates bandwidth up to ISDN's maximum 2.048-Mbit/s primary-rate service on an as-needed basis. Unlike other ISDN-chip players, Motorola is betting that bandwidth-hungry applications such as high-resolution graphics will overwhelm the basic ISDN network rate of just two 64-Kbit/s channels. That means high-end users will demand primary-rate service (up to 24 channels of 64-Kbits/s in North America and 31 channels in Europe) at their desktops. The 84-pin 68606 LAP D protocol chip handles bandwidth allocation with a statistical multiplexing technique. Each ISDN-attached station gets its needed bandwidth on the fly—up to the full 1.544 Mbits/s in the U. S. and 2.048 Mbits/s in Europe. Samples of the CMOS controller will be available in August for $100. Additional interface logic is being added to the 68606, enabling it to attach the buses of Intel Corp. iAPX86 microprocessors or Motorola's own 68000 family. The 68606 will control up to 8,192 logical links using a memory-based architecture, in which the 68606 intelligent peripheral and host processor communicate through shared memory. □

NOW A ¼-IN. TAPE CARTRIDGE FROM CARTREX BACKS UP WINCHESTER DRIVE

With its new drive technology for ¼-in. streaming-tape cartridges, Cartrex Corp. has pushed storage capacity 20% to 33% beyond the former 60 Mbytes that until now has been tops in the industry. Just one 72-Mbyte Cartrex 72 can back up a typical Winchester disk drive, and a single 80-Mbyte Cartrex 80 can handle the newest high-capacity Winchesters. The key, say Cartrex engineers, is using two tension belts instead of the conventional one. This results in a flattened tension curve and allows the San Diego, Calif., company to run longer tapes without fear of failure. Available now, the Cartrex 72 retails for $39.90 and the Cartrex 80 for $42.90. □

IBIS DISK DRIVE TRANSFERS DATA 4 TO 20 TIMES FASTER

A parallel-transfer 14-in. disk-drive system from Ibis Systems Inc. boasts a data-transfer rate of 12 Mbytes/s—4 to 20 times faster than conventional serial channel drives. The 2812 uses 6-Mbyte/s recording-channel technology and two channels to achieve this speed. Moreover, the system's 2.8-gigabyte capacity doubles that of its predecessor, the 1400. Together these features make it more than a match for the needs of supercomputers and other high-performance systems, says the Westlake Village, Calif., company. The 2812 costs $77,200; deliveries begin in the fourth quarter. □

TRIQUINT'S GaAs DAC CONVERTS 1,000 MEGASAMPLES/S

Monolithic gallium-arsenide technology makes ultra-high-speed digital-to-analog applications such as waveform synthesis and megapixel displays a snap for TriQuint Semiconductor's Giga-DAC family of converters. They boast a conversion speed of up to 1,000 megasamples/s—more than twice as fast as the speediest converters now on the market. The Beaverton, Ore., division of Tektronix Inc. guarantees 600-megasample/s operation for its TQ6111 series and 1,000 megasamples/s on its TQ6112 series. Sample converters are available now in die, packaged part, and daughterboard modules, the latter being suitable for the video or instrumentation applications. In 100-unit purchases the 6111 costs $159 each for the die version, $199 for the surface-mount, and $695 for the daughterboard module. The 6112 costs $259 each for die, $299 for surface-mount, and $895 (in purchases of up to nine) for the daughterboard. Production quantities are set for the third quarter. □

PRODUCTS NEWSLETTER

APOLLO'S 3-D WORK STATION UNDERCUTS COMPETITION BY $30,000

The level of performance in solids-modeling applications formerly available only in $100,000-plus work stations can now be had for just $69,900 on Apollo Computer Corp.'s first three-dimensional graphics work station. The DN590 Turbo boasts software-implemented, multiple-color light sources; 24 color planes; shading and highlighting capability; and the simultaneous display of 16.7 million colors, say engineers at the Chelmsford, Mass., company. Specialized graphics processors and an advanced lighting model are key to the performance. The machine is configured around a Motorola Corp. 68020/68881-based work-station processor. It has Apollo's 3DGA graphics accelerator, 24 bit-planes, a 16-bit Z buffer, and 154 Mbytes of formatted disk storage. The DN590, which runs the Unix System V.2 and BSD 4.2 operating systems, will be available 90 to 120 days after confirmed order. □

SIERRA'S MODEM CHIPS FIT BOTH PARALLEL AND SERIES INTERFACES

Sierra Semiconductor Corp.'s 2,400-baud modem chip set gives designers flexibility that helps them cut costs. Competitive chip sets use either an analog or a digital signal processing solution that requires the use—and expense—of an additional microcontroller. Sierra has divided modem functions differently among the chips, allowing designers to couple an analog front-end SC11006 part with either of two microcontrollers—the SC11009 for parallel-bus interfaces or the SC11010 for RS-232-C serial transmission. Both controllers use a bit-slice core processor architecture for digital signal processing and an instruction set that is similar to Intel Corp.'s 8096 but up to 2.3 times faster. The chips are fabricated in the San Jose, Calif., company's process combining 3-μm analog and 2-μm digital CMOS. They are available now in sample quantities in ROM-less versions that allow designers to construct their own firmware. The SC11006 costs $49 each; the SC11009 and SC11010, $40 each in 100-unit quantities. □

HITACHI'S 24-K GATE ARRAY RUNS AT BLISTERING SPEEDS

Hitachi Ltd.'s fast gate array with 24,020 gates uses 1-μm design rules to achieve state-of-the-art performance. A 2-input NAND gate, for example, has a 0.7-ns delay, but it consumes just 400 μW per gate at 10 MHz. The array handles either TTL or CMOS input and output levels and is one of seven in the HG62E series ranging from 24K to 4K gates. In lots of 1,000, unit prices range from $20.71 for a 4,309-gate part in a 40-pin dual in-line package to $707.14 for a 24,020-gate part in a 240-pin pin grid array. Design costs start at $21,000 and depend on design complexity. Tokyo-based Hitachi is accepting orders from Japanese companies now, with delivery in from 8 to 14 weeks. Overseas customers will have to wait until July 1 to place an order. □

HERE'S A TEMPEST CAD TERMINAL FOR IBM MAINFRAME USERS

Government contractors and original-equipment manufacturers pressed to deliver graphics terminals that are compatible with IBM Corp. mainframes and comply with federal Tempest security requirements now have a simple solution. Spectragraphics Corp.'s DS 1082GTX work station runs IBM 5080-based computer-aided design and engineering software without modification and is the first plug-compatible Tempest unit. It supports 1,024-by-1,024-pixel resolution in 256 colors with local 3-d transforms and area fill. A system consisting of a single-board graphics controller, 19-in. color monitor, 512 Kbytes of display list memory, digitizing tablet with four-button puck, and programmable function keys costs $35,350. The work station will be available in the fourth quarter, says the San Diego, Calif., company. □

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Electronics

A NEW TYPE OF MAGNETIC HEAD MAY BE JUST AROUND THE CORNER

MAGNETORESISTIVE HEAD'S BIG CLAIM: IT DOUBLES DISK-DRIVE DENSITIES

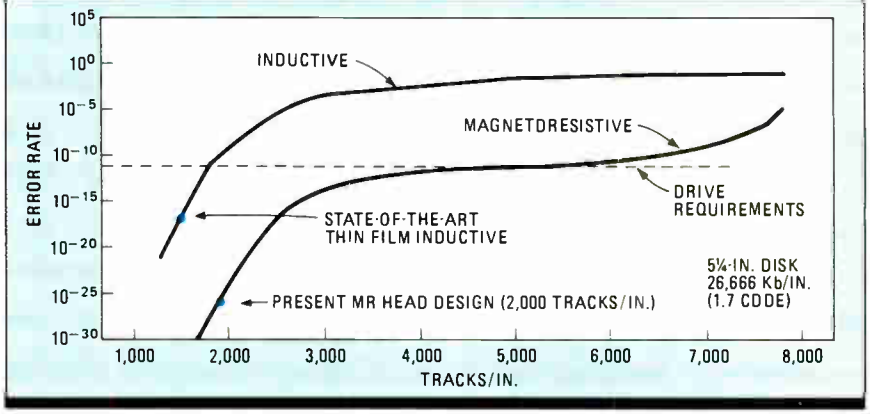
MINNEAPOLIS

After a wrenching transition from ferrite to thin-film magnetic disk heads that cost the industry plenty of time, trouble, and money, another major change in head technology may be just around the corner. Not everyone agrees, but Control Data Corp., for one, thinks the time is right for the new head, which relies on a magnetoresistive technique to read data from a disk. The driving force behind the new head technology is that with its potential for reducing errors it may be able to double the densities of magnetic disk drives.

Come September, the Minneapolis company's supplier of merchant drive components—Peripheral Components International—hopes to be the first to ship evaluation units of a new breed of thin-film head. "This opens up a whole new set of conditions for placing high capacities on small-diameter disks," says Anthony F. Maggio, vice president of small-disk engineering for Magnetic Peripherals Inc., Control Data's captive disk-drive supplier in Oklahoma City.

"We're very excited about this. If anything is going to keep optical recording at bay for any length of time, it's going to be this technology," says Carl Wirtanen, manager of product development for Control Data's Data Storage Products Group. Wirtanen heads a new-product development team, formed last month, for magnetoresistive heads. But the optical recording industry is moving ahead strongly with new systems (see p. 38).

MAGNETORESISTIVE HEADS REDUCE ERRORS



The new heads will write data inductively in the same manner as today's generation of ferrite and thin-film heads. But by using a second element integrated into the head to read magnetoresistively, they will produce signal outputs two to five times greater than current heads. What's more, the new heads will not be dependent on disk velocity for read-signal strength, as are conventional inductive read heads.

Another advantage comes in the ability to "write wide and read narrow," since the new heads will use a separate element for each function. This will lessen sensitivity to servo errors and thermally induced media perturbations that can cause problems for very high-density inductive read/write heads.

The Minneapolis firm expects the heads to be used first in 3½- and 5¼-in. drive products, where inductive head-read methods are threatening to peter out as disk areal densities get tighter (see story, below). The heads will easily handle media at 1,600 to 2,400 tracks/in., with bit densities from 30,000 to 40,000 bits/in., says Gregory S. Mowry, manager of advanced head design. That compares with the 1,000 to 1,400 tracks/in. of today's

A BUNCH OF HEAVY HITTERS ARE WORKING ON THE NEW HEADS

Disk-drive heads that rely on a magnetoresistive read technique are being developed by head component manufacturers and large captive disk-drive makers. For example, at the April 14-17 Intermag conference in Tokyo, Kodak, Matsushita, NEC, Sharp, and Control Data presented papers on magnetoresistive heads for rigid disk drives.

IBM Corp., too, is known to be working on the technology. Officials at the Armonk, N. Y., computer giant decline to comment on any plans to apply the new head technology in disk-drive products. But IBM is already using the heads in its 3480 tape drive, introduced in 1984.

The potential advantages of the new heads relate to the physics of the head's read mechanism. With conventional inductive read technology, a magnetic flux change passing under the head induces a voltage in the coil that is proportional in strength to the rate of flux change, in line with Faraday's Law. As media track and bit densities increase, this means that signals get weaker, necessitating more turns on the coil or a lower head-flying height to bring signal-to-noise ratios to acceptable levels. The problem is most acute on 3½-in. and 5¼-in. disks, where small inner-track diameters translate to a slower track speed, and thus weaker and weaker inductive read signals, while ambient noise levels remain the same.

A magnetoresistive head, by contrast, is a direct flux sensor. When a constant current is applied to its sensor element, changes in resistivity caused by flux on the media are read as voltage changes, in accordance with Ohm's Law. Signal levels are not related to track velocity. "The real beauty is that the signal-level output is entirely independent of the linear velocity of the flux transition," says Donald Collier, director of market analysis for Applied Magnetics Corp. of Goleta, Calif.

–Wesley R. Iversen

switching measurements promises to be a technical minefield, sprinkled with potentially explosive issues that could be seen as favoring one product line over another as the panel digs deeper into the matter.

TI's competitors are still insisting that logic pinouts stay as they have been for nearly two decades, but they agree that standard measuring techniques are now necessary because of the hubbub. Some contend it's all a TI-conspired controversy aimed at stalling fast CMOS logic markets until the Dallas company launches its own parts. The first wave of TI 1-μm CMOS logic, featuring TI-style ground and power pins in the center instead of at the corners, is in fact now hitting the market (see p. 126).

The next official steps will be taken when the 40.2 panel discusses the TI proposal at its July meeting in Minneapolis. Committee chairman Dick Funk, who is manager of IC applications at the GE/RCA Solid State Division in Somerville, N.J., hopes to have a published specification by year's end. Funk notes that all manufacturers have their own testing techniques, and the difficult task will be to agree on the details. Solid State has been using a method similar to TI's to characterize the voltage noise on its new ACL chips—which, Funk points out, use new output structures instead of center ground and power pins to reduce potential spikes.

TI's foes agree standard measuring is now needed

Some of TI's foes say it will be virtually impossible to standardize techniques that show meaningful voltage measurements for every system design. Some favor a differential-mode measurement technique that eliminates conditions of the test-fixture boards, which can vary at each manufacturer and customer site. TI product managers counter that isolated chip measurements mean little, since the voltage spike will often be increased along the path between chips on boards.

SENSITIVE ISSUE. "We are now to the point where this is something that typically was done back in an applications lab or at the system house," says Dan Reynolds, department manager for TI's advanced CMOS and bipolar Schottky logic components in Sherman, Texas. "We are saying that this is a sensitive enough issue on this class of product that we need to be communicating to the customer what to expect—just like they can pick up a data sheet and compare propagation delays, with measurement techniques and conditions understood, and all products done under the same conditions. The measurements are moving from just the parametrics arena to measurements that indicate application performance."

Jedec members fighting the pinout change agreed to tackle the voltage-spike measurement issue as a preamble to any action on pinout schemes. "A standard test methodology—the proposal I know of—is not going to put this [pinout change] issue to rest," promises Charles Pace, applications manager at Fairchild Semiconductor Corp. in South Portland, Maine. Fairchild, which now has a growing FACT product line of 60 parts, is using the conventional logic pinout for its speedy CMOS logic.

Some believe Jedec might set two standards: a differential mode for isolated chip measurements, and a second for single-ended tests that factor in board noise. Panel member John Mick, who is vice president for product definition and application engineering at Integrated Device Technology Inc., agrees. "It's kind of a touchy subject, one of those things where everyone seems to have a lot of opinions and no one has a lot of answers." His company is combating voltage spikes with an edge-rate control structure. *–J. Robert Lineback*

SOFTWARE

ALLIANCE WITH IBM BROADENS LOTUS BASE

CAMBRIDGE, MASS.

One of the reservations that industry analysts have had about Lotus Development Corp. is that the software leader's revenues are too narrowly based on spreadsheet products that run on single-user personal computers. But they'll have to change that tune now that the Cambridge, Mass., company has formed a strategic alliance with IBM Corp. The deal could lead to additional affiliations that will significantly broaden the Lotus product, customer, and revenue bases.

The alliance with IBM includes an initial agreement for the two companies to offer a mainframe-based version of Lotus's mainstay spreadsheet, to be called 1-2-3M. And it opens the door for additional joint offerings that could include Lotus products for other IBM hardware platforms, including minicomputers and superminis.

Equally important, Lotus isn't barred from similar strategic alliances with other hardware manufacturers. Michael Kolowich, vice president for marketing and business development at Lotus, emphasizes that although the IBM deal is very important, "we have not painted ourselves totally blue. Nothing we've done with IBM precludes us from developing other products or other alliances with other companies."

The new mainframe spreadsheet, plus an announced intention to market a multiuser database-management system, launch Lotus well beyond the restrictions imposed by the company's mainstay products—personal computer spreadsheets. Bruce Watts, an analyst with Morgan Keegan & Co. in Boston, says, "These are very logical moves for Lotus. The trick for them has been to identify substantial new business opportunities that are related to their existing business. Both the IBM and DBMS moves offer that potential."

MORE MOVES. The other Lotus moves include Lotus/DBMS, the code name for the DBMS product line; a new graphical interface spreadsheet code-named 1-2-3G; and release 3 of the 1-2-3 personal computer spreadsheet.

The new mainframe spreadsheet is for use on IBM System/370 computers using the VM or MVS operating systems. It will be marketed by both companies and carry the logos of both, but will be distributed—beginning early next year—only by IBM. Both IBM 3270-compatible terminals and personal computers will be able to access the spreadsheet.

KOLOWICH: "We have not painted ourselves totally blue."

However, at least one Lotus competitor isn't ready to concede automatic success to 1-2-3M. Allen Kluchman, president of Access Technology Inc., South Natick, Mass., points out that a significant development effort is required to tune a personal computer spreadsheet for mainframe use. The Access spreadsheet, which is called 20/20, is widely used on both minis and mainframes, as well as on personal computers.

Kluchman estimates that 1-2-3M could be a

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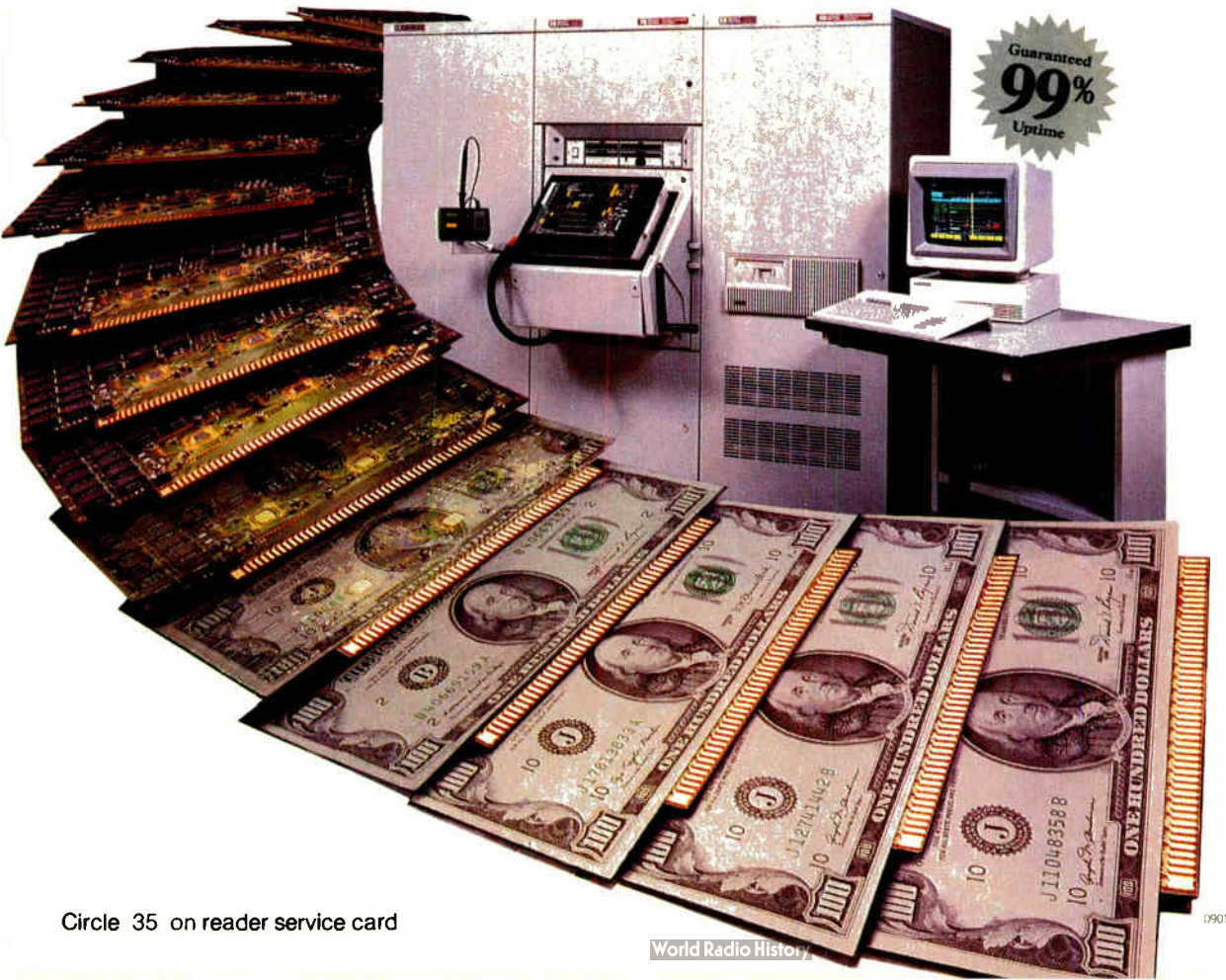

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Which is the

brighter power?

ket potential could bring new players into the game. AT&T Co., which integrated an optical storage system for the Navy, is now building one for itself that will make engineering drawings and other documentation available almost instantly anywhere on the company's internal nationwide network.

The sheer size of the AT&T effort is indication enough that the company is committed to optical storage and retrieval systems. The Document Development Organization in Indianapolis has a billion documents on file, spends more than $250 million a year on document handling, and prints more than 100,000 pages a day. All of these tasks—plus work stations, terminals, and other peripherals at locations spread from coast to coast—will be consolidated into a single network.

What will really make this market fly? Try IBM Corp. When Big Blue unveiled its Personal System/2 line of computers recently, buried in the announcement was an optional 5¼-in. optical disk drive, IBM's first step into commercializing the optical technology. "Whenever IBM blesses a technology, that's going to have enormous impact," says Cygnet's Binder. "But they're in no hurry, because that could impact some of their own magnetic-based storage products." *–Tobias Naegele*

PRODUCTION

NATIONAL SLASHES PROGRAMMING TIME

SANTA CLARA, CALIF.

National Semiconductor was looking for a way to program patterns of read-only memories for video games in less than the typical 12 weeks. What the company found is much more: a production process that yields custom-programmed microcontrollers in just two weeks.

The new technology, called Post Metal Programming, employs a high-energy ion-implantation process that programs a microcontroller's on-chip ROM after the wafer has been metallized. The new process is being used initially to program National's COP 413L—a best-selling 4-bit microcontroller that costs 49¢ in quantities of a million units.

"Our COP 400 family of single-chip 4-bit microcontrollers is a very important product line for National—it is still growing 10 years after its introduction," says Stanley Katz, director of strategic planning for National's microcontroller products group. In fact, recent information from market researcher Dataquest Inc. shows that the worldwide 4-bit microcontroller market is still growing

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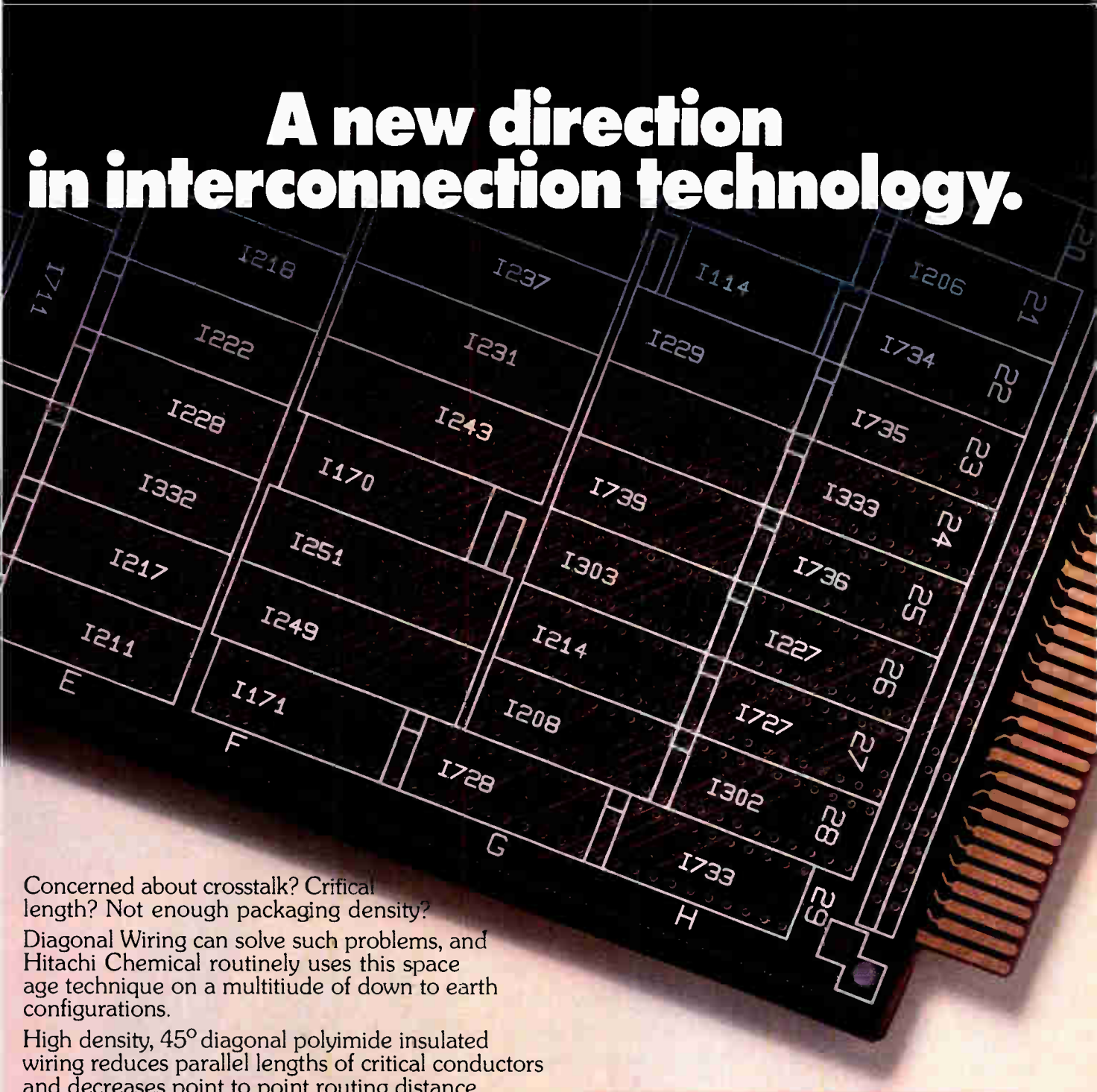

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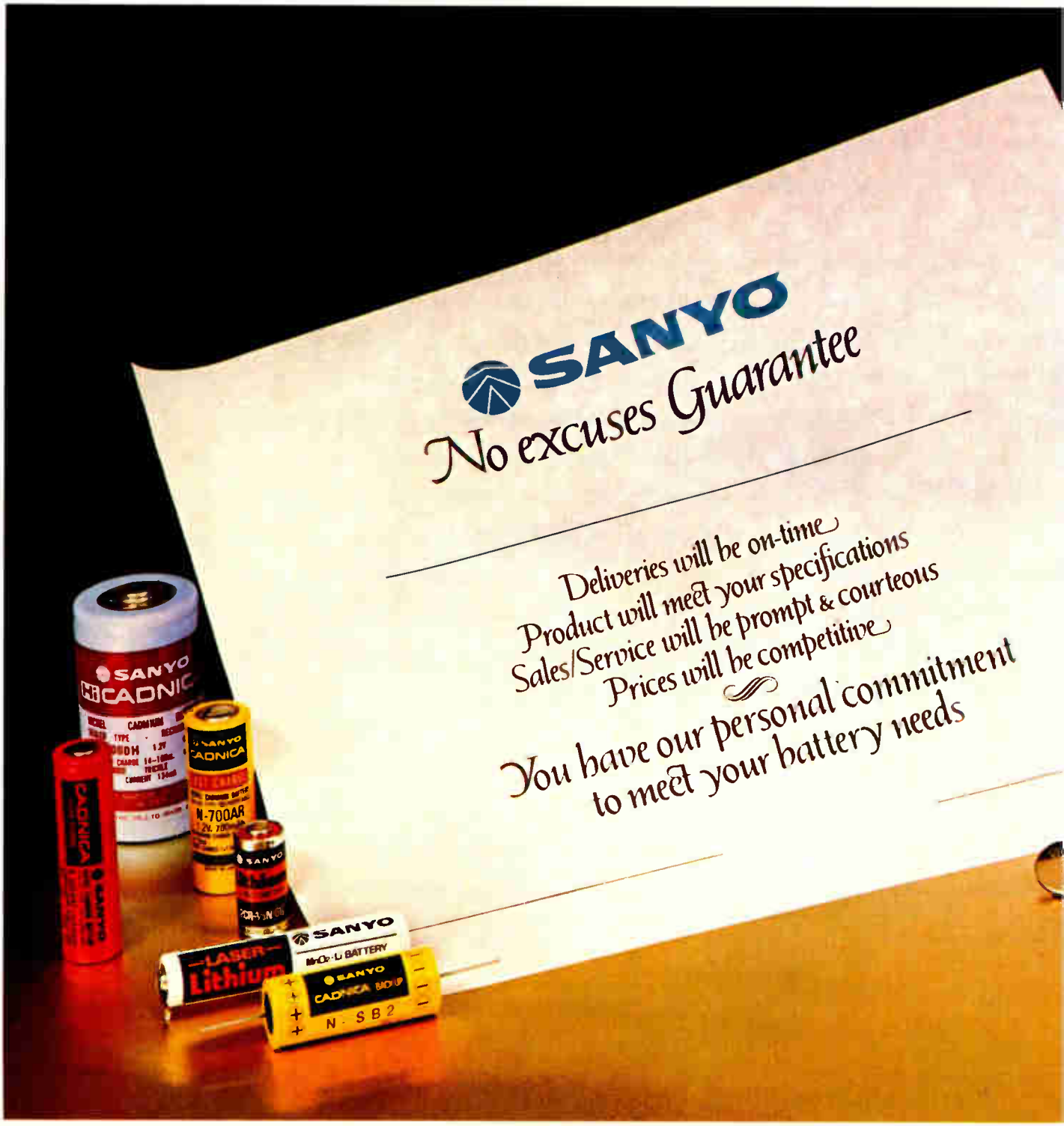

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INTERNATIONAL NEWSLETTER

SEIKO EPSON AVOIDS NEC'S LAWSUIT AND UNVEILS CLONE OF NEC COMPUTER

In a neat maneuver that sidestepped legal actions by NEC Corp., Seiko Epson released its clone of NEC's popular PC-9801 computer on April 30 with an alternate BIOS that is not covered in NEC's suit [*Electronics*, April 16, 1987, p. 54]. Seiko also omitted ROM Basic from the new machine and is selling its PC-286 Model 0 as strictly a business computer. Seiko claims that it always has two groups develop new products, and that the BIOS it originally planned to offer happened to be completed first. The company says both its BIOS programs are superior to NEC's because they enable the PC-286's Intel 80286 microprocessor to run more than 95% of the MS-DOS programs written for both NEC's V30 microprocessor and the 80286. NEC's machine is equipped with both processors, and users must toggle between them to match a given program. □

CONTINUOUS SPEECH RECOGNIZER FROM THE UK WILL SELL FOR $300

A potentially low-cost continuous-speech-recognition system developed in the UK is slowly working its way to market after three years of preparation. The speaker-dependent system was created by PA Technology of Royston, Hertfordshire, with funding from the British Technology Group, a government-owned venture-capital organization in London. The system has a 64-word vocabulary, but it can toggle back and forth between multiple vocabularies. It also has its own processing engine and therefore doesn't steal processing power from the host computer. PA Technology is now selling a $10,000 development kit of the speaker-dependent speech recognizer. A two-board version will be available by summer for about $300 in volume quantities. The company has bigger plans for 1988: a single-board version, a speaker-independent system, and a 20-chip implementation of the original system that will sell for about $180. □

IT'S BACK TO THE FUTURE FOR THIS 3-D COLOR CAD DISPLAY

What do you get when you cross 1950s technology with today's leading edge? Researchers at Leeds University in England have done just that to develop a three-dimensional color computer-aided-design terminal. The system is called the Leeds Liquid Crystal 3D Viewer, and it is being built and marketed by Millenium Professional & Technical Services Ltd., of Stevenage, England. Based on the viewing goggles once used for 3-d movies, the system consists of an interface unit, including a photo pickup module, and up to four pairs of 3-d goggles. The system generates two video images and an optical synchronization signal and displays them on the graphics screen. The signal is detected by the optical sensor, which causes the lenses of the goggles to flash rapidly between opacity and transparency. The display, which alternates from left to right eye views at a 50-Hz rate, generates the stereoptic image by rotating the image about its y-axis by $+2°$ and $-2°$, respectively. □

BRITAIN'S EEA WARNS THAT R&D SHORTFALL COULD SEND JOBS OFFSHORE

The UK is risking precious manufacturing jobs by not investing enough in electronics research and development, says Tony Thatcher, the outgoing president of the UK's Electronic Engineering Association and chief executive of the Dowty Group plc. He attacked the British government for its lack of support, saying the government shot down an EEA proposal that would have turned a $1 billion government investment into 250,000 manufacturing jobs. "We are going down in R&D and we should be growing," adds his successor at the EEA, Alan Carnell, who is commercial director of Racal-Decca Ltd. "If you take R&D out of this country, you take away jobs." □

INTERNATIONAL NEWSLETTER

SIEMENS DEVELOPS A CONTACT-FREE WAY TO TEST SILICON BOULES

Engineers at Siemens AG have developed a contactless device that can measure the charge-carrier lifetime of silicon boules, providing detailed analysis of their defects and impurities. The system replaces a method that sometimes produced misleading results. The boule is placed in the device and becomes the core of a coil that forms a high-frequency resonant circuit. Infrared light pulses impinging on the boule produce charge carriers, thereby increasing the boule's conductivity. The carrier lifetime, which may be between 10 μs and a few milliseconds, is determined from the time it takes for the conductivity to decay after the light pulses are removed. □

NOW A LASER CAN CLEAR CLOGGED ARTERIES WITHOUT RISK

A team of doctors at the University of Nüremberg's Medical Clinic are experimenting with a neodymium-YAG laser made by MBB Medizintechnik GmbH, of Munich, to open blocked arteries in patients' legs. Unlike a similar technique that employs an argon laser, the neodymium laser can be applied with blood flowing through the artery. With argon lasers, the artery must be blood-free, because blood can absorb the laser's green light, causing clotting within the artery. MBB Medizintechnik, a subsidiary of the West German aerospace firm Messerschmitt-Bölkow-Blohm, says the laser has a maximum power of 40 W and that its light can be coupled into optical fibers with core diameters as small as 0.2 mm. The laser's high power density can also burn away calcified deposits without risk of thermal damage to arterial walls. The Nüremberg doctors caution that the method is not ready for routine clinical use, but they hold out the hope that the system can eventually be used to cure blocked coronary vessels. □

ASIC ACTION IS HEATING UP DOWN UNDER

Australians may be better known for their beer than for their technical prowess, but a fledgling chip industry may just change that perception. Local chip makers are rapidly gaining strength down under. The latest development is the construction by Amalgamated Wireless Australasia Ltd. of a $42 million wafer fabrication facility near Sydney to produce application-specific integrated circuits for the Pacific and Southeast Asian markets. Amalgamated, Australia's largest electronics company; British Aerospace (Australia) Ltd., and the state government of New South Wales will be partners in the plant, which will be geared for a 1.5-μm to 2-μm double-metal CMOS process when it opens in mid-1988. Not to be outdone, the Victoria state government is also considering construction of an ASIC plant and has approached Plessey Semiconductors, of the UK, for advice. □

COFFEE, TEA, OR DATA: JAPAN'S AIRLINES TO OFFER COMMUNICATIONS SERVICES

Passengers flying on Japanese international flights should be able to send and receive both data and voice transmissions in the not-too-distant future. The Société Internationale de Télécommunications Aéronautiques, of Geneva, Switzerland, is planning to establish stations at Narita and Osaka airports for its international aeronautic data-communications operations, and Japan Air Lines Co. and All Nippon Airways Co., both of Tokyo, say they will each introduce airborne data-communication operations by 1990. The airlines will utilize communications satellites that are to be launched by Inmarsat and Absat, a subsidiary of Aeronautical Radio Inc., of Annapolis, Maryland. In the meantime, Japan's Ministry of Posts and Telecommunications and the Ministry of Transport plan an experimental program later this year using JAL planes and an MPT satellite scheduled to be launched this summer. □

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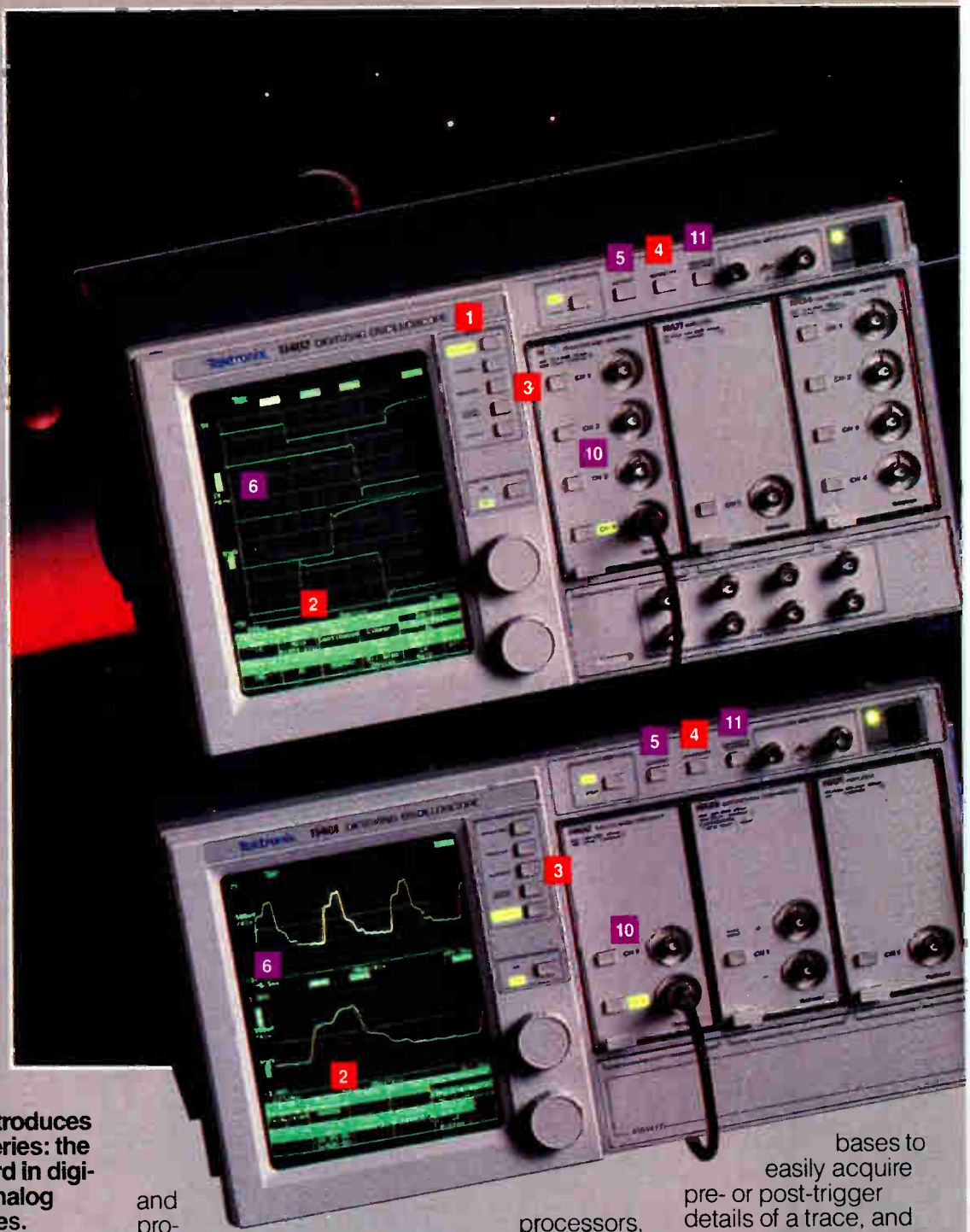

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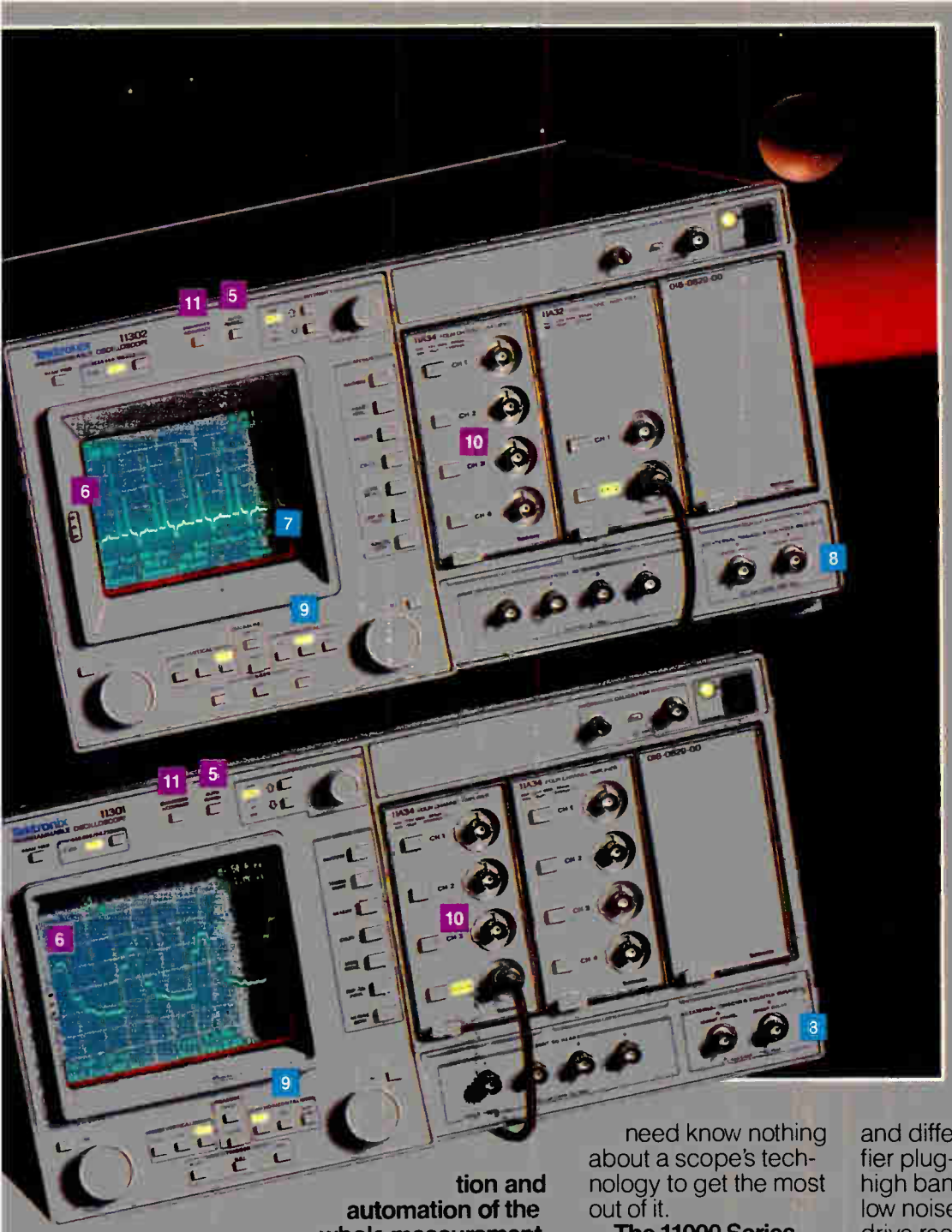

ANALOG

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PROBING THE NEWS

SOMETHING BIG IS HAPPENING IN THE SEMICONDUCTOR INDUSTRY

A REAL LIVE UPTURN, MAJOR CONSOLIDATIONS, AND EVEN HIGH PROFITS

In the annals of the semiconductor industry, the spring of 1987 will stand out as a season of high hopes and an increasing tempo of consolidation. After three years of recession, chip makers see an upturn in sales; some of them see the surge in orders from personal-computer makers spilling over into the minicomputer and work-station sectors and fueling a full-fledged upturn (story below).

If that wasn't enough to get the juices flowing in the industry, then two other major developments were. In late April, Advanced Micro Devices Inc. and Monolithic Memories Inc. startled the industry by announcing that they would merge, resulting in a much stronger company (p. 56). Days after that deal was inked came word that the French and Italian governments had given a go-ahead for a plan to meld the Thomson Group's semiconductor division and SGS-Microelettronica into an equally owned venture (p. 60). In the midst of the urge to merge, there are still prime examples of companies prospering on their own. ITT-Intermetall stays profitable—even during industry slides—by skillfully exploiting its niches (p. 62).

WHAT'S DRIVING THE CHIP UPTURN?

LOS ANGELES

The mood among U.S. chip makers right now is downright upbeat. A painful month-in, month-out stretch of dwindling bookings ended in December with a strong upturn in orders. And business continues to roll in at a good 1.21 book-to-bill clip for April. But after the earlier disappointing "false springs" that marked nearly three years of recession, the chip makers are wary. They're still trying to figure out just how strong the current recovery is, with critical decisions for production, technology, and finances hanging in the balance.

So far, the main engine behind the surge in chip orders has been the producers of new families of personal computers. A growing number of semiconductor executives see this narrow upturn as a precursor to broader expansion. In fact, some industry watchers expect it to widen to include the manufacturers of minicomputers and work stations. But there's an undercurrent of concern among some industry figures, who fear the upturn might be only an inventory-filling bubble that will burst fairly soon. Many chip users, however, say they're buying for production, not inventory.

In fact, other market watchers play down any downside effects from inventory problems. Among them are William J. McClean of Scottsdale's Integrated Circuit Engineering Corp., and Mel Thomsen of Dataquest Inc., San Jose, Calif., both of whom see solid chip gains that will continue well into 1988. One big producer agrees. Texas Instruments Inc. is holding to its earlier bullish forecast of a 15% increase in U.S. sales this year—although executives at the Dallas firm do worry about inventory buildup.

Even the bears are smiling more these days. Surging orders through the first half will help U.S. semiconductor firms post 15.5% growth for the year, now predicts Jack Beedle, president of In-Stat Inc. The Scottsdale, Ariz., chip consultant's predictions have leaned toward the bearish side during the downturn, but have been generally on the mark. Previously, Beedle had projected 5% growth, but he recently raised his sights along with most other market researchers (see chart below).

McClean, a vice president at ICE, concedes that "everything hinges on the computer industry." But he points out that this pivotal sector's sales of hardware already are running at well above ICE's earlier prediction of 5% for 1987. ICE has compiled the financial reports of the top 15 U.S. computer firms for the first quarter, and they show an average 10% gain. "No matter what, the first half is excellent," he says, and as a result, ICE has jumped its prediction for 1987 semiconductor industry growth from 4% to 14%. McClean says the semiconductor expansion ICE initially predicted for next year is starting to occur this year. Nevertheless, ICE is still forecasting 18% growth for 1988.

CHIP-MARKET FORECASTERS WARM UP ON 1987

(U.S. semiconductor market growth)

Forecaster	Original estimate	Revised estimate
Electronics	12%	12%
Dataquest Inc.	12%	15%
Integrated Circuit Engineering	4%	14%
In-Stat Inc.	5%	15%

The semiconductor upturn is anything but narrowly based, declares Dataquest's Thomsen, associate director of its semiconductor industry service. "Basically, all segments of the industry are experiencing growth, which is reflected by an across-the-board improvement in semiconductor orders," he says. He downplays concerns about inventory ballooning, in large part because users are installing sophisticated management systems. Such service improvements as just-in-time and ship-to-stock deliveries came on stream during the past few years. These can more closely track stocks of components than previous, less precise schemes. They "pushed inventory levels below what most companies felt comfortable with," Thomsen notes.

The upshot is an intensified surge in chip sales, as demand grows and stocks remain lean. As this unprecedented condition continues, the Dataquest analyst believes that more tremendous increases could lie ahead, "as much as a 100% swing in semiconductor consumption."

At the computer manufacturers, officials largely confirm that buying

IN-STAT UPS 1987 ANTE EXCEPT FOR TELECOM		
Sector	Original estimate	Revised estimate
	(Percentage growth)	
Computers	2,400 (5.8%)	2,925 (27.7%)
Telecommunications	1,930 (10.1%)	1,927 (8.9%)
Industrial	1,721 (5.7%)	1,898 (15.4%)
Consumer/automotive	1,440 (−1.3%)	1,565 (6.2%)
Military	1,360 (3.7%)	1,508 (13.5%)
Total	8,851 (5.1%)	9,823 (15.5%)

U.S. semiconductor market in millions of dollars

plans have been cranked up. And the devices are going into computers, not onto shelves, they say. Compaq Computer Corp., the office PC maker based in Houston, has seen its U.S. sales exceeding the 15% growth it had planned on, reaching 20% to 25%, according to Michael Swavely, vice president of marketing. Compaq's first-quarter revenues shot up 47%. With the expansion, Compaq is taking a more aggressive posture in ordering ICs, but Swavely vows the company is not "hoarding away chips or changing its basic purchasing policies."

ORDERS UP. In Dayton, NCR Corp. has stepped up its chip orders across the board, especially for central processing units and memory devices. Procurements are up nearly 10% from the level anticipated at the start of the year. Data General Corp., Westborough, Mass., is buying more chips, too, partly to use in new products and partly because lead times are stretching. They were 60 days last year and they're four to six months now. "With lead times as short as they were, we bottomed out on our inventory," says John Kavazanjian, director of purchasing. At Prime Computer Inc., Natick, Mass., executives note that longer lead times are a factor, and logic chips are in shortest supply. Although Prime is "demand-driven," it is stockpiling some of the hottest items "as a hedge in areas where lead times may lengthen," says William I. Calhoun, director of corporate procurement.

The most outspoken worrier about this upturn turning into another inventory blip is In-Stat's Beedle. He still believes the PC buying is likely to fade at the end of spring. And he figures that total U.S. sales of computers and office equipment, whose manufacturers buy nearly 30% of U.S. chips, are forecast at only a 5% growth rate for 1987, still too low to support a robust upward cycle in the chip business.

Beedle also disagrees with other industry forecasters about next year; there's a good chance, he says, of a general recession hitting, something that could pull U.S. chip growth once again into the minus column. Beedle made his prediction in April to more than 175 industry executives gathered in Phoenix for his annual forum on semiconductors. "The next two months will tell us whether we are in a true recovery or are just going through another false start," Beedle notes.

Also treading warily on the inventory issue are TI executives. James Watson, vice president of marketing for the firm's Semiconductor Group, poses "the $64 question. Is it [the upturn] sustainable?" The picture is not yet clear, he says, and "August and the dog days of summer" could arrive before it is. His own opinion tilts "on the side of the inventory buildup," he says. Watson is echoing concerns expressed by TI President Jerry R. Junkins in mid-April. TI customers' inventories are down to six weeks' worth of chips in the first quarter, from 11 weeks in late 1986, and the firm is starting to worry that the orders coming in now are not a direct reflection of end equipment sales.

One worry that both chip suppliers and users share is a flareup of double ordering, the bane of any semiconductor recovery. Double ordering distorts buying and selling patterns and always leads to troubles. No evidence of it is yet in sight, says James H. Currier, NCR's director of corporate purchasing, but he warns of some telltale signs. A sure tipoff is when suppliers who have been competing fiercely on such services as short lead times, smaller lot sizes and more precise deliveries begin to back off. If that happens, the frenetic phase of the cycle could be near, "and that's going to start the double ordering like we've seen in the past," he says.

One commodity chip that could repeat its roller-coaster history of shortage, rising prices, double ordering, overproduction, and plummeting prices is the workhorse 256-Kbit random-access memory.

Japan's Ministry of International Trade and Industry has orchestrated stringent cutbacks in 256-Kbit RAM production—some 40% below late-1986 levels. The move is intended to dry up an oversupply of parts that was being dumped in markets outside Japan and the U.S.

The fallout already is starting to hit U.S. computer makers. In-Stat's Beedle estimates that U.S. computer makers need 20 million 256-Kbit parts a month, but domestic producers currently can only come up with half that. U.S. leader TI is now building upwards of 5 million 256-Kbit RAMs a month, but is not pushing to expand its 20% market share, company officials say.

A shortfall exists in the supply pipeline now that could mean price hikes by early summer, but users believe the problem won't last. Other U.S. producers, including Motorola Inc. and Micron Technology Corp., could fill the gap, along with Korean firms battling for a U.S. toehold. *-Larry Waller*

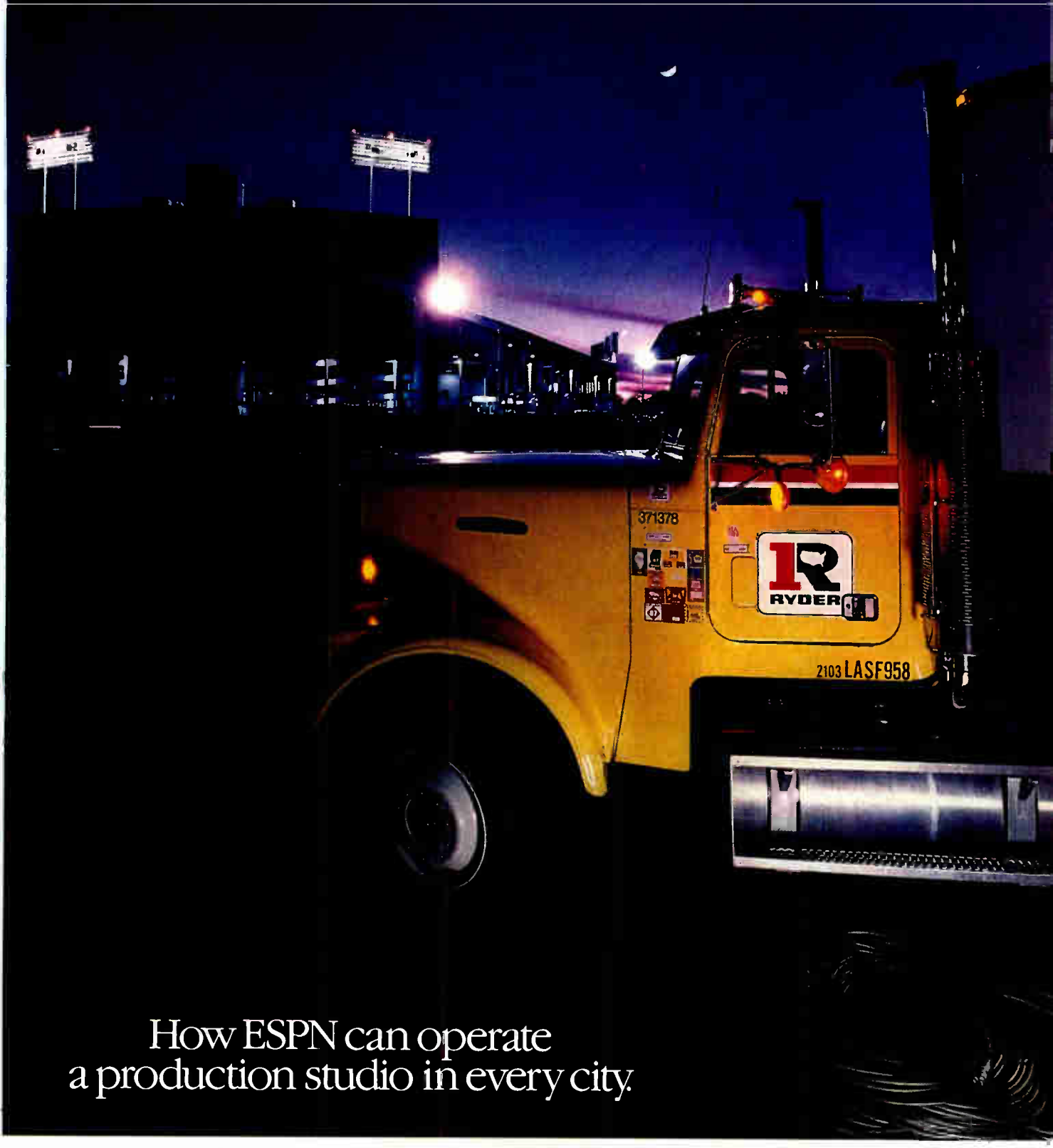
HERE COME BIGGER, TOUGHER CHIP MAKERS

SAN MATEO, CALIF. Here come a bunch of stronger, bigger U.S. semiconductor makers, as the industry heads down the road toward more and more corporate consolidations. But it still came as a big surprise to industry watchers on April 30 when Advanced Micro Devices Inc. made the boldest consolidation move by proposing to swallow its Silicon Valley neighbor and the industry's dominant supplier in programmable logic, Monolithic Memories Inc. Following only days later was an agreement by National Semiconductor Corp. to form an alliance with tiny, struggling Lattice Semiconductor Corp., the Beaverton, Ore., specialist in programmable logic.

The move, which would boost AMD to the No. 5 U.S. semiconductor supplier, really enables the struggling chip maker to grab a commanding lead in one of the industry's fastest-growing niche businesses. National, too, is in a position to gain a major foothold in this same market, since Lattice has a strong position in reprogrammable CMOS, the fastest-growing product segment of this market niche. National will license Lattice's Generic Array Logic technology, participate in product development and marketing, and acquire what it delicately calls a "small minority interest" in Lattice.

Clearly, AMD has taken the quick road to PLD supremacy; MMI's $150 million in 1986 PLD sales were fully half the market. The two firms together had about 60% of the market for programmable logic devices, or 1986 sales of about $177 million. AMD wants to swap seven eighths of a share of its stock for each share of MMI's in a merger that will begin with MMI as a wholly owned subsidiary of AMD and probably will end with its complete assimilation.

With total revenues of only $15 million and its credit impaired because of a legal challenge from MMI, Lattice is a less formidable ally. But Lattice has de-



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veloped an electrically erasable CMOS technology that is in the forefront of new applications for PLDs. National is betting that it will pay off when the market takes its predicted jump. Integrated Circuit Engineering Corp., a Scottsdale, Ariz., research firm, expects sales of PLDs to more than triple, going from $300 million in 1986 to more than $1 billion in 1991. The expansion will be fueled largely by reprogrammable CMOS products. They will make possible new applications, such as in-circuit emulation and general logic replacement, and new levels of performance and testability. ICE predicts that CMOS, which accounted for only 5% of the market in 1986, will amount to 33% in 1991.

WHERE AMD AND MMI PRODUCTS OVERLAP

	AMD	MMI
Bipolar		
Emitter-coupled-logic gate array	■	
Programmable read-only-memory	■	■
Random-access memory	■	
TTL logic and interface	■	■
Bipolar and CMOS		
Bit-slice microprocessors	■	
Field-programmable array logic	■	■
Microcontrollers	■	
Peripheral circuits	■	
CMOS		
Erasable programmable read-only-memory	■	■
Fixed-instruction-set microprocessors	■	
Static random-access-memory	■	
Telecom circuits	■	

MMI has access to reprogrammable CMOS through an agreement with Xilinx Inc. of San Jose, Calif., which has developed a very fast device called a logic cell array, based on static-random-access-memory technology. MMI also owns 16% of Seeq Technology Inc. of San Jose, Calif., which is developing a PLD based on an electrically erasable programmable read-only memory. However, both MMI and AMD have fallen behind in developing CMOS.

National's deal with Lattice boosts GAL as a standard

"If AMD could have waited a few days, they might have saved some money," says Michael Gumport, a Drexel Burnham Lambert analyst. "The announcement that National will back the Lattice chip might have dropped MMI a dollar or two and saved AMD a significant amount of money."

Gumport was skeptical on the value of the AMD/MMI deal. "I liked AMD both before and after," he says, "but slightly less after than before." Gumport says that the merger has many pluses, in that it links the market leader, MMI, with the design leader, AMD, in bipolar PLDs and immediately gives AMD 30% more revenue. On the other hand, Gumport says, AMD will have 30% more shares outstanding, diluting its value. "I don't think AMD is a better company because of the acquisition of MMI," Gumport concludes. "However, it's still top-notch."

However, many analysts feel that the deal was beneficial to both firms, if only because of the sheer muscle it added. "It's a good deal for both of them, and makes a powerhouse in bipolar," says William Groves, vice president for technology of market researcher In-Stat Inc. in Scottsdale. "There are also cost savings and expense savings," comments Mel Phelps of Hambrecht and Quist, the San Francisco investment firm. "I think this is a hell of a deal." The merger also gives MMI access to badly needed capacity in both bipolar and CMOS manufacturing; AMD has nearly idle lines for both in Austin. "We are up against it in bipolar capacity," says MMI marketing vice president Timothy Propeck. "The mainstream PAL [programmable array logic] business is bipolar, and demand is exploding, particularly in high-performance circuits. We are flat out of capacity, and the market is in the beginning of the cycle.

"It's clear that we need a larger critical mass to be a long-term success," Propeck adds. "We compete with people who have a lot of resources. And it costs us as much to develop the next generation of bipolar as it does Texas Instruments."

AMD, too, was looking for a sizable partner to help in the pursuit of chairman Jerry Sanders's goal of $1 billion in sales. Combined, AMD and MMI would have sold about $825 million last year, three quarters of it accounted for by AMD. The discussions with MMI are reported to have begun as long as three years ago, when Sanders and MMI president Irwin Federman hitched a ride together on an Intel Corp. private plane after an industry meeting.

PROPECK: The mainstream is bipolar, and MMI is 'up against it' in bipolar capacity.

Federman will become vice chairman of the merged company, but the exact nature of his relationship to Sanders and the tightly knit AMD executive team was left unanswered. Phelps suggested, and other analysts concurred, that Federman might stay on only long enough to merge MMI gracefully into the larger AMD operations.

The alliances came as no surprise to Stan Bruederle of Dataquest Inc., the San Jose research firm, who says that broader-based suppliers, like AMD, are filling in their product lines by making links to smaller firms. "Clearly the National-Lattice deal fits that situation," Bruederle says.

At Lattice, the relief in finding support for its technology from an industry leader was almost palpable. Lattice had been in the position of a gambler with a good hand who doesn't have the chips to match a bet. The company has had cash problems since last fall and has put off paying creditors and employees for a while. A patent-infringement suit by MMI had frightened off potential financial support.

The question: how long will MMI's Federman stay after the merger?

Lattice got some help in February when it signed a technology agreement with SGS Semiconductor Corp. That alliance has suddenly begun to look even better, now that SGS merged with Thomson CSF (see story, p. 60). "We were pleasantly surprised to find that we have an even stronger partner in Europe," chairman C. Norman Winningstad says. "SGS was No. 5 in Europe; now it is No. 2."

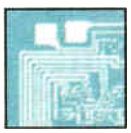
The National agreement, says Winningstad, means that Lattice's GAL technology has become a world standard. He adds that alliances with SGS, National, and VLSI Technology Inc. will provide the manufacturing required by large customers. (Lattice has no fabrication capability of its own.)

Winningstad says he's unworried about MMI's suit, although MMI has forced Altera Corp. of Santa Clara, Calif., to acknowledge its claims. Lattice, too, is ready to settle, he indicates.

National is a significant player in PLDs, drawing about 3% of its total fiscal 1986 revenue of $1.478 billion from bipolar PALs made with MMI technology. Single

Lattice CMOS chips can do the work of many of these ICs, according to Jerry Brandeberry, National's vice president for programmable logic and ECL products. In addition, National was attracted by the testability of reprogrammable parts. Fuse-programmable PLDs, and even ultraviolet EPROM-based devices, cannot be tested as completely as a circuit that can be electrically cycled. "We feel that a number of people will get into the CMOS PLD area," Brandeberry said. "We want to establish standard product types in high-performance CMOS and grow with the market." *–Clifford Barney, J. Robert Lineback, and Larry Waller*

A COMBINED SGS-THOMSON WANTS TO HIT THE TOP 10



LONDON

Europe will have a new billion-dollar semiconductor company by the end of the decade if the merger between Thomson Semiconducteurs SA of France and SGS-Microelettronica SpA of Italy pans out. The two state-owned chip firms got the final okay from their governments for the deal in late April. They still don't have a clear idea of how they'll work together under Pasquale Pistorio, SGS's chief executive officer, who will lead the new company. But their goals are clear: to join the ranks of the top 10 chip makers worldwide and to become a major force in the international chip market.

That goal looks attainable. Even though the military semiconductor parts of Thomson are not included in the deal, the combination is still enough to make the new company, which has yet to be named, the 12th largest in the world market at the outset. It will rank as No. 2 in Europe—ahead of Siemens AG of Munich, but still behind Philips of the Netherlands.

Counting the sales of its Carrollton, Texas, subsidiary, Thomson Components-Mostek Corp., Thomson has 1.8% of the world commercial semiconductor market and employs 10,000 people. SGS is slightly smaller, with a 1.4% share and 8,500 employees. Together they form a company having sales of $800 million, with just over $400 million coming from Thomson.

Along with the initial strength, what also bodes well for the success of the new venture is the fact that the two companies' product lines overlap very little. "Thomson, especially in the Mostek subsidiary, has strengths in MOS technology but a relatively weak presence in bipolar," says Mostek president James R. Fiebiger. "SGS is the reverse, with about 50% of its worldwide sales in bipolar."

Adds Michel Motro, vice president, international, for Thomson, "We will take advantage of very different product lines; less than 35% is common. We will also take advantage of the very large sales force. There are more than 500 salesmen, about 50% coming from each company."

Outsiders see it much the same way. "It is almost uncanny how complementary they are," says Malcolm Penn, director of Dataquest UK Ltd., a London-based market research firm.

To get the new company on track, Pistorio intends to start at home. "We are in a phase of seeing how to fit the companies together, and Pasquale is looking first at Europe, where the bulk of our resources are," says Daniel Queyssac, president of the Italian firm's U.S. subsidiary, SGS Semiconductor Corp. of Phoenix.

Pistorio: He intends to make the Thomson-SGS combine a new force in the chip industry.

Motro adds, "All the operational decisions have yet to come, but it will not be an overnight change. The management team has not even been sorted out. First, Pistorio has to meet everybody.

"The plan is to rationalize the manufacturing first, then the design side, and then the marketing. We want to be a billion-dollar team and in the world's top 10." At that level of revenue, officials of the two companies feel that they will have the resources to compete head-to-head with Japanese and U.S. chip makers.

Once European operations have been squared away, the key issue will be to meld the U.S. operations of both companies. Mostek at Carrollton has a MOS plant that can handle chips with technology down to 1-μm line widths. SGS at Phoenix has a brand-new plant—built but not yet fully fitted out—designed to turn out submicron chips.

Fiebiger, who is a strong candidate for the top job at the U.S. operation, expects the new company will operate from both Carrollton and Phoenix. "I don't think it [Phoenix] is in competition with the facilities we have here," he says. "I can see the need for both."

At the European headquarters of each of the partners, executives are tight-lipped about the plans for the U.S. Says Thomson's Motro, "There has been no decision on the American operation." Fabio Dornelles, a spokesman for SGS, adds: "I have nothing to say about the plant in Phoenix yet. What is to be done will be decided when the operating plan is decided."

Dataquest's Penn terms the merger

The French and Italian firms look like a near-perfect match

"incredibly significant." And, he adds, "it is incredibly visionary and very brave. It is a move that guarantees the future of both companies. Now there is a second major European company. Before, we only had Philips. They will not be as big as Philips, but they're in that league.

"They also have a very strong international presence," Penn adds. "Together they can be incredibly powerful. Both of them have been very aggressive over the last five years. SGS has been better at internationalizing the company, but both have been successful. SGS has a large amount of revenues outside Europe, and Thomson has Mostek. Together, they have more than a 3% market share, which makes them very strong."

Penn warns that the French-Italian team still has some managerial problems to sort out. But if it can solve them, the new company will be able to attack the European, U.S., and Far East markets. "They can position themselves against the major Japanese and U.S. companies," he says. "Also, the parent firms are large electronics companies in their own right, which gives the new company a good vertical integration base."

Penn also believes that this will be the first of many mergers announced in

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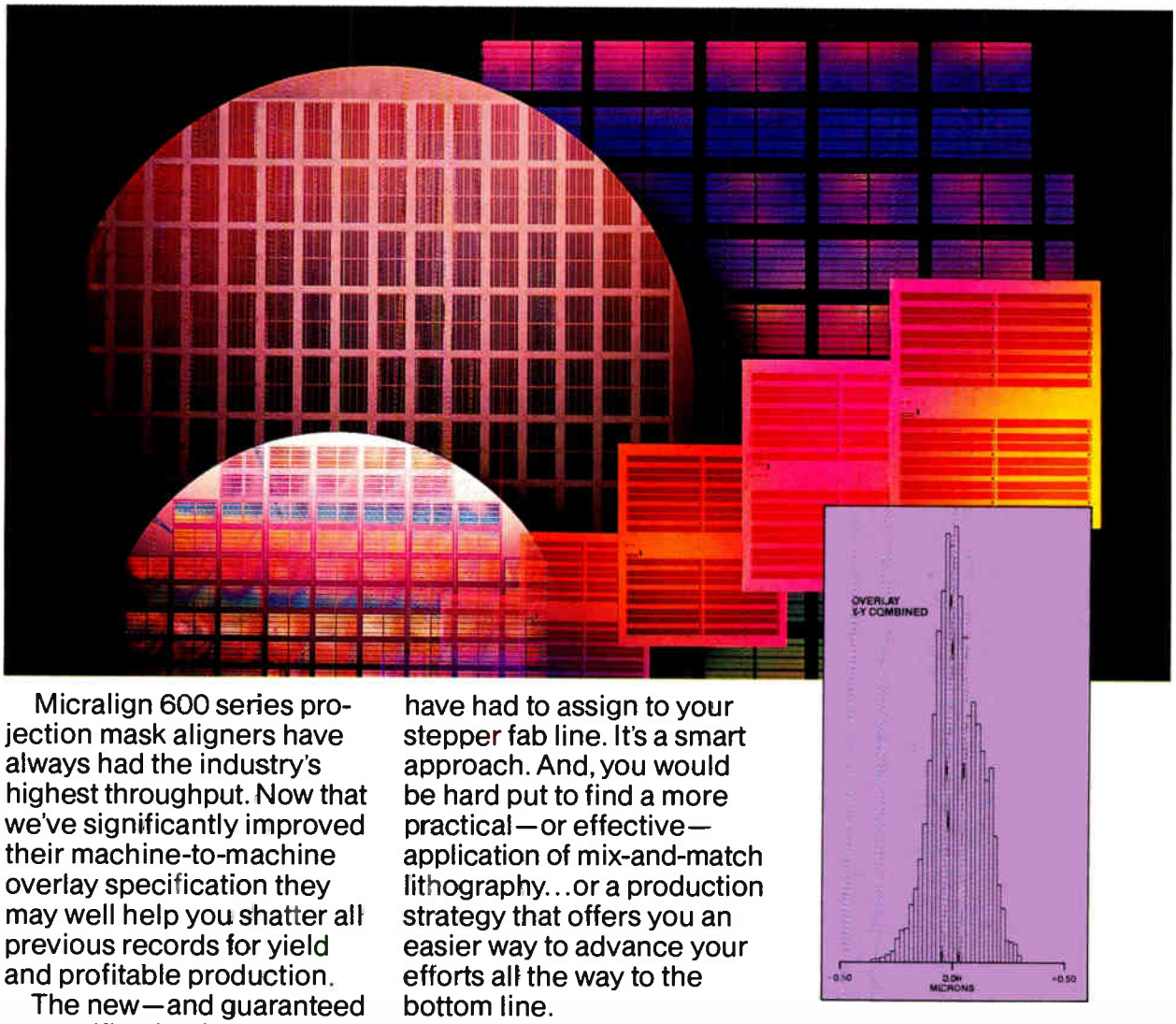

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Europe and worldwide: "This is the way that companies will have to go in the future," he says. The industry is split between the very large firms of the U. S and Japan, and the small companies in niche markets. "The ones in the middle get squeezed," he says. "They will find it very difficult to survive unless they do this type of merger."

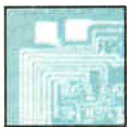
Penn maintains that the electronics industry is now "in a maturing process." When the industry was growing quickly, he says, it could support a number of medium-sized companies. But now he feels that semiconductors are no longer an industry driven by technology: "The OEMs [original-equipment manufacturers] are getting indigestion from so much new technology."

At one point it looked like the SGS-Thomson deal might not be approved by the French and Italian governments, because of arguments over which company would have the lion's share. This was settled in an unusually logical compromise for the electronics industry; the partners decided that each of them would own 50%.

Says Penn, "You would have laughed a year ago at the thought of a French and an Italian company merging. The old rules don't apply anymore. It's exciting." If Penn is right, and he probably is, the only question remaining is: who will be next?

–Steve Rogerson

HOW ONE CHIP MAKER KEPT PROFITS HIGH



FREIBURG, WEST GERMANY

Most semiconductor manufacturers would rather forget the past two years. Chip makers went through the worst recession in the industry's 25-year history. Choked with excess capacity, they were forced to cut back operations and lay off people, and now they're starting what some analysts expect to be a wave of mergers. Nearly all manufacturers were hit with slumping sales and dwindling profits—but not the ITT Semiconductors group.

Based in West Germany, the group in 1985-86 chalked up its best two years ever in revenues and profits. It turned the trick by following a product-niche philosophy that emphasizes high-end devices, such as signal processors and system-specific chips for selected markets, while not letting its low-tech diode business slide. Also, because two thirds of its output goes abroad—its lead house, Intermetall GmbH in Freiburg, is West Germany's biggest semiconductor exporter—the company is less affected by business downturns on the home market. This lends it stability. Those factors should leave it relatively unaffected by the new companies formed by Advanced Micro Devices and Monolithic Memories in the U. S., and SGS and Thomson Semiconducteurs in Europe.

ITT Semiconductors' figures are impressive. Sales last year shot up 32%, to $330 million from $250 million the previous year, ranking it 15th in the world. Increased productivity was the main reason. The workforce was unchanged at 2,800 people—1,500 at Intermetall and the rest elsewhere in West Germany, as well as in France, Italy, and the U. S.

Significantly, profit margins also went up—for both 1985 and 1986 they reached 15% to 20% before taxes. "As far as we know, in [pretax] profit margins we were No. 1 among the world's chip makers last year," says Lubo Micic, managing director worldwide for ITT Semiconductors. By comparison, the fifth-ranked Motorola Semiconductor Products Sector, one of the few chip makers to remain profitable last year, earned 4.63%, or $87 million pretax, on sales of $1.88 billion.

"[ITT Semiconductors] has always been highly profit-oriented," says Malcolm Penn, director of London-based Dataquest UK Ltd., a market research firm. Also, says Penn, its niche strategy "has served the company well." Though not the biggest, "it has attained a leadership position in performance, becoming the 'BMW' in the industry."

ITT's biggest advantage is that it had not expanded as much as other chip makers in the years prior to the slump and so was not caught in the capacity glut, says Andrew J. Kessler, an analyst at PaineWebber Inc. in New York. "It remained a niche company and has done well as one," he says.

ITT's MICIC: In the early part of the decade, he zeroed in on three niche markets: auto, consumer, and communications.

Doing well entails selecting the right niches. Micic says that in ITT's case, that meant laying the groundwork in the early 1980s by picking the three markets with the best potential and developing devices for them: automobile electronics, consumer electronics, and communications. The forecasts were pretty accurate, as those three areas have performed well in Europe. They account now for more than 85% of the group's integrated circuits output and remain fertile ground.

The auto sector has expanded strongly, and the output of big-ticket consumer products such as color TV sets has hovered at high levels. West Germany, for example, produced 3.7 million sets last year, nearly half of them for export. The communications business hasn't grown as strongly, but West Germany's Standard Elektrik Lorenz AG, builder of the System 12 digital switch, is a big outlet for Intermetall chips.

For autos, ITT sells system-specific chips, or what Micic calls strategic components, such as engine-revolution, service-interval, and mileage-counter circuits. In development are chips for dashboard displays. For TV, there are the Digit 2000 chips, which have ushered in the digital era in television [*Electronics*, April 5, 1984, p. 89]. These circuits are high-speed, real-time digital signal processors that digitize all video and audio functions between a receiver's input and output stages. On the market for several years, they are being used by TV set makers in Europe, Japan, and the U. S. For communications systems, ITT makes telecom processors and other circuits.

To keep the momentum gained with its Digit 2000 chips, Intermetall is developing digital audio and video signal processors for car radios and video cassette recorders. And it is the first company in Europe to produce a one-chip system for decoding D2-MAC signals, a European transmission standard for satellite TV [*Electronics*, March 19, 1987, p. 54].

On the other side of the technology scale is the unglamorous but lucrative diode business. Though most other semiconductor producers have quit that field, the ITT group has stuck with it. Indeed, Intermetall ranks itself as the world's biggest diode producer, satisfying a third of global needs. Production at Colmar, France; Latina, Italy; and

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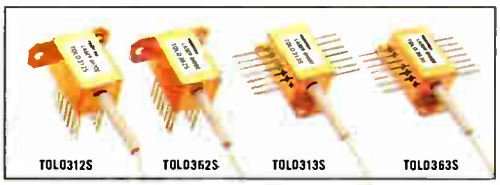


PACKAGE	1.3μm DFB	1.55μm DFB
CHIPCARRIER	TOLD300S	TOLD350S
DIL	TOLD312S	TOLD362S
BUTTERFLY	TOLD313S	TOLD363S

TOSHIBA

TOSHIBA CORPORATION TOKYO, JAPAN

Lawrence, Mass., came to more than 2.5 billion units last year. Production is so highly automated that even these low-end devices are profitable.

Still, the main action is in the three high-end markets, which have one thing in common: relatively few customers with big components needs. Only 50 customers worldwide account for more than 80% of the group's sales; each feels it is getting close personal treatment.

In fact, aware that loss of a customer when the base is narrow can spell problems, ITT has made individual customer service a top priority. "Our aim is to react quickly to customers' demands regarding device development, delivery, and help in solving their systems design problems," Micic declares. "The stress on service fosters loyalty," he adds.

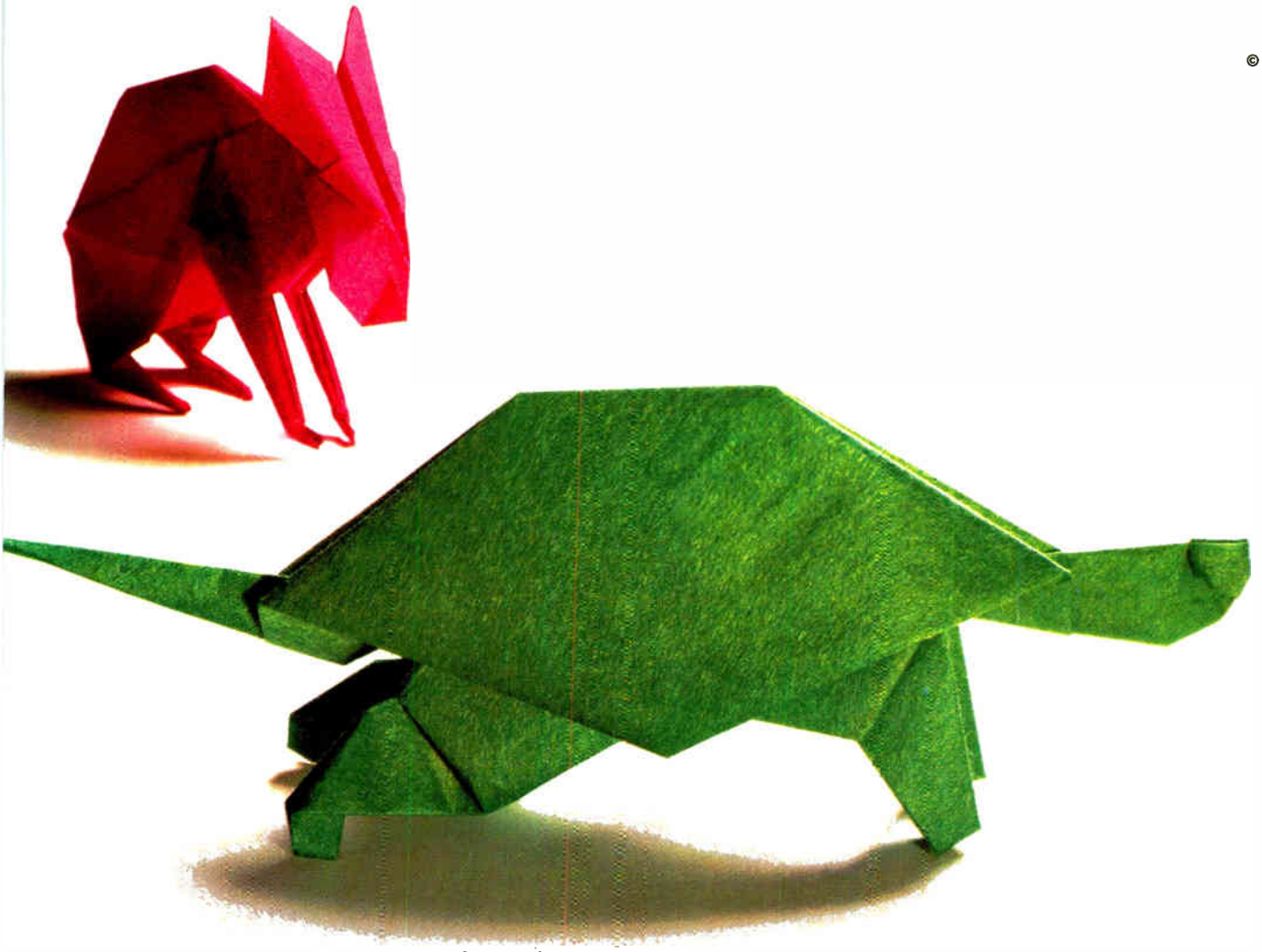
For a company of its size, some of the ITT group's production figures are impressive. It fabricated around 130 million ICs and 5.4 billion discrete components last year, putting it among the top five device producers in the world, based on number of units made, company executives claim.

A profit-oriented ITT stuck to three niches and didn't overexpand

Almost as clear a view of the ITT group's thinking can be gained from what it doesn't make as from what it does. For example, a few years ago it eliminated power devices, light-emitting diodes, and high-frequency discrete components. "We felt that in the face of heavy competition in these fields, we would not be profitable," Micic says.

And it is staying out of the memory business. With memories accounting for a big chunk of the world's semiconductor needs, it is an enormous business, Micic acknowledges. "But we don't think we could make money in it." ITT is unmoved by the Mega project, the Philips-Siemens drive for 1- and 4-Mbit static and dynamic random-access memories. Conceding that the initiative is a vehicle for developing future submicron logic devices, Micic argues that "we will be able to develop and turn out such devices as fast as our competitors" without taking the high-density memory route.

Instead, it is by exploiting its expertise in production automation and in signal processors and other systems-specific components that Micic thinks his company will continue to make its mark. This expertise also will help ITT Semiconductors push revenues to $500 million by the end of this decade. "But we are not so much in pursuit of high sales figures," he says. "What we are after is primarily profits." *–John Gosch*



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INSIDE TECHNOLOGY

NOW A SYSTEM SIMULATOR FINE-TUNES ASIC DESIGN

LSI Logic's new design tools are able to run applications software in a complete simulated systems environment, cutting down on both bugs and development time

by Jonah McLeod

When a designer builds an application-specific chip for his system, he hopes to take it from the foundry, plug it into his printed-circuit board, and have it work without a hitch. But chips often fail to perform up to expectations because the designer can't simulate the chip's running of the applications software in the total system environment. Until now, there has been no way to adapt the applications software code to a simulation of the system hardware being designed.

LSI Logic Inc. of San Jose, Calif., aware of the systems designer's problem, has begun to develop such a capability. Because the designer can now run the software on his system before the chip is fabricated, he can determine how to fine-tune the silicon architecture to best support the applications programs the system will execute.

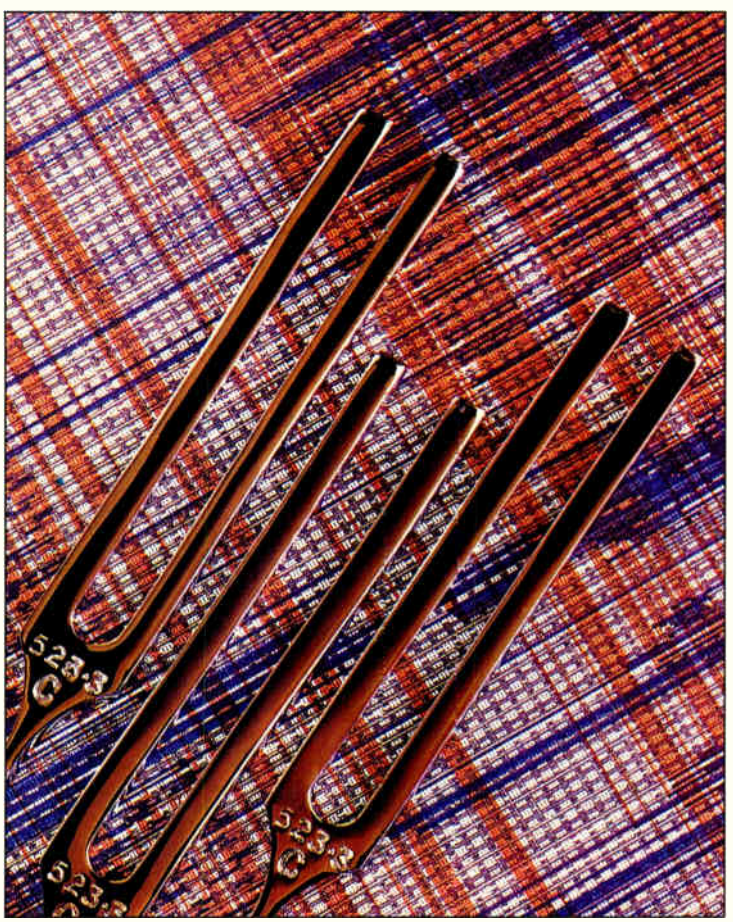
"This can provide designers with the ability to take a software environment, use it as the seed for designing a computer whose instruction set is optimized for the final application, have it successfully implemented in silicon, and do it all in one software environment," says Keith Lobo, vice president of marketing for advanced silicon and software products. LSI Logic's new Integrated Design System will be available at the company's design centers in July. Software licenses will cost $500,000 to $1 million, depending on hardware configuration.

An example of the benefit of running software on a simulation of a final system design can be seen in the way LSI Logic reduced a three-board implementation of the Department of Defense's MIL1750A computer system to just two integrated circuits. The final system—a central processing unit and a memory-management block-protect unit, or MBU, had to provide the same performance as the original while consuming less power and costing less.

To solve the problem, LSI Logic developed the conversion software needed to transform applications-program code into stimulus patterns for its LSIM logic simulator [*Electronics*, Feb. 5, 1987, p. 59], which could then be used to simulate the operation of the CPU. LSIM would also simulate the operation of the MBU chip.

Finally, the company's multichip simulator, MSIM, performs the gate-level simulation of both the CPU and the MBU. When required for other system designs, the MSIM software works with the company's behavioral simulator, BSIM, to simulate the behavior of off-the-shelf chips that will be used in a final system design.

The power of being able to simulate a chip's



small-scale-integration line drivers to drive the backplane of the bus into which the board is plugged, as the output current of the pins on the chips is not sufficient to drive the backplane.

The ability of MSIM to handle mixed-mode simulation makes it possible to model chips other than those that are part of the gate-level design. For example, a designer building a computer compatible with the IBM Personal Computer may want to design several peripheral chips and simulate their operation with an 80286 microprocessor and an associated off-the-shelf memory-management unit (see fig. 3). He could simulate the ASIC chips at the gate level while simultaneously simulating the 80286 and memory-management unit behaviorally.

To simulate the operation of the system, the multichip simulator would interact with the behavioral simulator. First, the multichip simulator would create an output signal from a chip simulated at the gate level, connected to a chip for which there was only a behavioral model. Then BSIM would run the behavioral model and return the result to the multichip simulator, which would then continue the gate-level simulation.

"In designing the 1750A, we were developing microcode at the same time we were developing multichip simulation," says Schwarz. "We adjusted the microcode as we modified the chip at the system level. We made changes to the microcode to improve timing between the two ASIC chips." Most affected in this optimization was the microcode for the load and store instructions. The multichip simulation gave an accurate picture of how much time was required for a memory transfer operation initiated by the CPU and routed through the MBU.

This is the real strength of mixing the software and hardware design environments—being able to alter the microcode on the chip while also being able to alter the chip's physical layout. In the design of the 1750A, for example, the company substantially changed the microcode to improve system performance. "Probably 80% of the improvement in the final design came from making changes to the microcode of the CPU chip, while the remaining 20% improvement came from changing the hardware design of the CPU and MBU chips," says Schwarz. □

For more information, circle 480 on the reader service card.

TECHNOLOGY TO WATCH *is a regular feature of* Electronics *that provides readers with exclusive, in-depth reports on important technical innovations from companies around the world. It covers significant technology, processes, and developments incorporated in major new products.*

HOW A DESIGN PROBLEM BECAME A BUSINESS OPPORTUNITY

Some design projects pay off a bonus by opening up unanticipated new market opportunities. Such was the case with a chip design undertaken by LSI Logic Corp. of San Jose, Calif., for Elisra Electronics Systems Ltd. in Bene Beraq, Israel. Elisra, which was recently acquired by Tadiran Ltd. of Tel Aviv, wanted to convert a design for a MIL1750A computer occupying three printed-circuit boards into a couple of CMOS gate-array chips. In the course of designing the chips, Elisra wanted to demonstrate that the final chips would run the 1750A verification software test suite before implementing them in silicon.

James Koford, 49, LSI Logic's vice president of design automation, and his group got involved in the project in April 1986. They had the simulation tools that could accept the compiled code of the 1750 test suite: LSI Logic's multichip simulator (MSIM) and Zycad simulation (ZSIM) accelerator, part of the company's Modular Design Environment. The team had designed LSI Logic's design tools, including the new MDE tools.

The problem was that the MDE runs on an IBM Corp. mainframe, whereas the 1750A verification software is a Fortran program developed on a Digital Equipment Corp. Microvax. Koford's group hooked up the Microvax to an IBM PC AT and used the PC to link the Microvax with the IBM mainframe. On the Microvax they cross-compiled the Fortran test programs into binary code that the MSIM program on the mainframe could use, and downloaded the file via the PC to the mainframe.

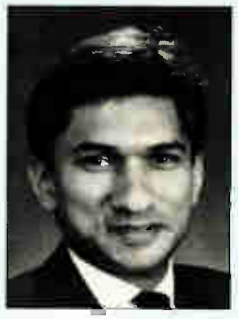
In June, 29-year-old Hans Schwarz, manager of advanced project development at LSI Logic, joined the effort. Schwarz, who had previously headed up North American marketing for the company, wanted to become involved with more technical projects.

Elisra had done the front-end part of the chip design, including the extensive system-level simulation that Koford and his team had made possible. Schwarz had to ensure that the chip got laid out in the company's 1.2-μm CMOS process. He reported to Keith Lobo, 36, LSI Logic's vice president of marketing for advanced silicon and software products.

The group soon realized that the technique of taking compiled programs and using them to simulate a system's operation before implementing chips in silicon has applications far beyond the 1750 project. Lobo, who has been with LSI Logic since its founding in 1981, began looking for ways to turn the capability into products. He was approached by Advanced Computer Technology Corp., New York, which had an idea for combining its software compilers with ASIC tools to improve silicon designs. On April 22, the two companies announced their intention to form a joint venture to design, develop, and market integrated hardware/software design systems.

KOFORD

SCHWARZ



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FLUKE'S BOARD TESTER CAN COVER ALL THE BASES

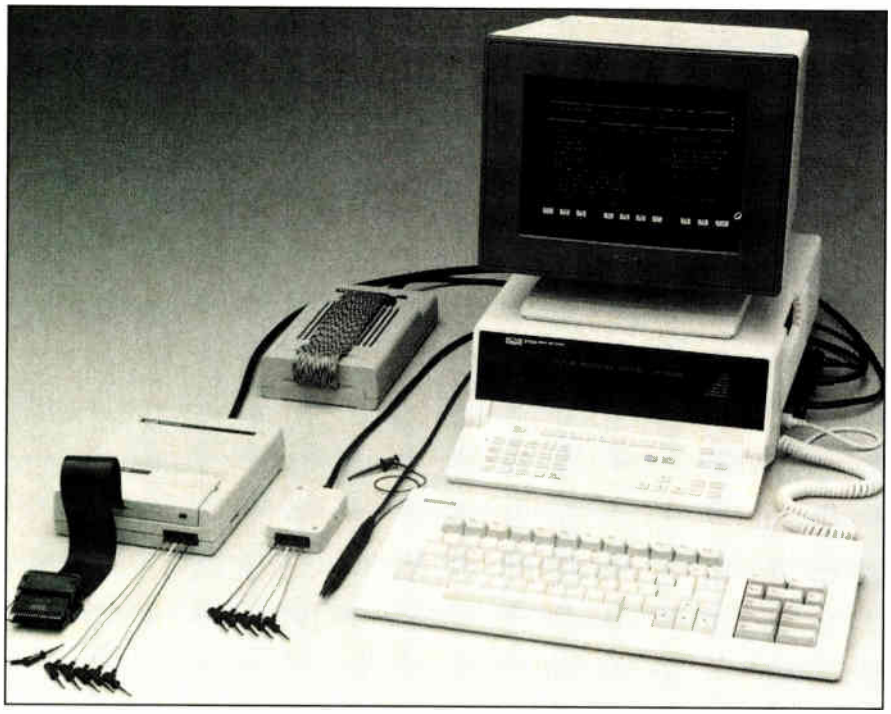
The compact instrument works in the lab, on the production line, or troubleshooting in the field, and its system software makes it easy to design new tests

by George Sideris

Some digital testers star in the development lab, others shine in production testing, and a few are best at troubleshooting in the field. But the 9100 series of microprocessor board testers from the John Fluke Manufacturing Co. aims to do a job in all three test roles. The Everett, Wash., company is grooming the compact emulative testers for design debugging in the lab, as well as for functional testing and fault isolation in the factory and field.

One of Fluke's goals for the 9100 series is ease of use; for example, the input/output modules can serve for both functional testing and for automated debugging and fault isolation. Another is versatility—there are different test modes for designers and experienced technicians and for low-skill production-line workers. Moreover, Fluke is making test design easy—the system software can construct factory and field test programs from the debugging programs and other design information. In addition, the software simplifies and speeds other test-writing chores so that the typical troubleshooting program can be developed in only 20% of the time it usually takes, says Fluke. And programs that use the pass-along design information can save even more time.

The inspiration from the triple-threat design to serve in board development, production testing, and troubleshooting came from an earlier, less powerful compact emulative tester, the 9010. Fluke developed it for production testing and troubleshooting—but discovered that its engineers were also using the system to develop microprocessor board designs. "We learned a lot in the last few years from the 9010 about how engineers want to use compact testers," says Hugo Draye, marketing group manager for the manufacturing and R&D group. For one thing, board designers like the versatility of the emulative approach, because one tester could be used for both debugging and design verification. Also, with an emulative tester, they don't have to wait for the software to begin developing the hardware. "Microprocessor software is never ready on time, but with these testers, hardware development can start on day one. You still need a logic analyzer for software debugging, but these systems are better for most kinds of hardware work," he says.

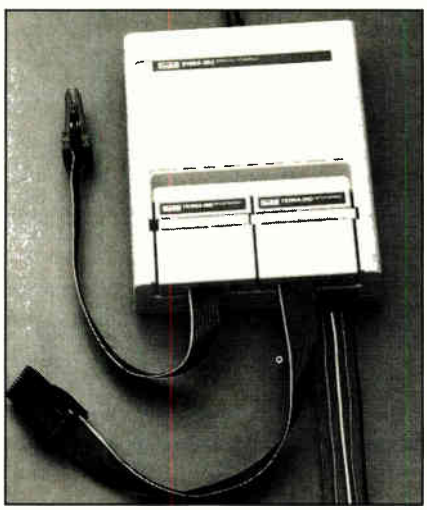


1. SYSTEM. The 9100A digital test system with its accessories: programmer's keyboard and monitor, probe, clock module, interface pod, and with the DIP clip, I/O module.

"Manufacturability issues get resolved sooner, too. For one thing, designers soon find out where extra test points are needed. Boards with missing test points have always caused redesign problems, especially multilayer boards," he notes. He expects the production applications to be small-lot testing and troubleshooting and repairing boards rejected by high-volume test systems and manufacturing-defects analyzers. For maintenance, the new systems will be used mostly for screening and repairing boards that were swapped during on-site maintenance, he says.

The series is an example of the direction Fluke's product development is taking: away from traditional test and measurement tools and into the new world of computerized test and measurement (see p. 77).

The members of the 9100 series are built around the Motorola 68010 microprocessor. The 9100A digital test system heads the new series. It performs functional tests and isolates faults in manual, unguided, and guided modes. The 9100A comes with a 55-key keyboard and a 3-line-by-42-character vacuum fluorescent display. With the addition of a standard keyboard and video monitor, it becomes a program development system (see fig. 1). A low-cost version, the 9105A digital test station, performs the same tests as the 9100A but cannot be used for programming. Fluke offers the development system with a 40-pin parallel I/O module as a startup package for $21,500 and the 9105A test station for $9,000.



2. PROBES. I/O modules with DIP clips do the work of probes at test rates to 10 MHz.

During tests, the system controls and exercises a board at the board's clock rate through an emulation pod connected to a board's microprocessor socket. Fluke has emulators for more than 50 microprocessors. The system automatically tests the board's kernel—the microprocessor bus, random-access memory, and read-only memory—then runs the board for other functional tests and fault-isolation tests.

Fluke set out to simplify testing by designing the 9100's I/O modules to be used for both functional testing and fault isolation. The I/O lines may be equipped with either board connectors or other test fixtures for functional testing, or with clips for dual in-line packages (fig. 2).

During fault isolation, DIP clips totaling up to 160 pins can be attached to components on the board. Each of the lines does the work of a conventional single-point probe—driving nodes high or low, stimulating the nodes, and gathering response data at rates to 10 MHz. As a result, an operator need use the tester's 40-MHz probe only for precise analysis of very fast signals and for those nodes that can't be reached through the DIP clips.

Consisting mostly of some 200,000 lines of code written in C, the system software took some 25 man-years to develop. But with it, test and troubleshooting programs that usually take 20 to 30 man-weeks for development can be churned out in only four to six man-weeks, Fluke says. The system software is designed so that a hardware-design engineer can build debugging and verification programs from scratch, update them as a prototype evolves, and hand them to a test engineer on a diskette for the writing of a fault-isolation program.

For programming, there's a new high-level language that is tailored for the test methods and a syntax-checking editor that immediately points out programming errors to users. To help ensure that guided fault isolation proceeds along the shortest route to the fault, the system software provides a built-in decision tree. Other utilities check and cross-check files to make sure the programs will be correct and consistent. These functions prevent errors from percolating through programs and bogging down users in software problems, says David Bezold, chief software engineer.

Storage capacity is the main difference between the 9100A system and the 9105A test station. The 9100A has 2 Mbytes of RAM (half for the system software and half for working memory), a 20-Mbyte hard-disk drive for program files and data bases, and a 3.25-in. microfloppy disk drive. The 9105A test station has only 1 Mbyte of RAM and a microfloppy drive.

Each station also has two RS-232-C interfaces with rates to 19,600 baud. One is isolated for communications with the board being tested; the other can be used to print out test results or send them to a computer, such as the IBM Corp. Personal Computer, for production-line accounting. Both the 9100A and the 9105 can log test results and faults detected on boards that have been tested. A typical setup of a line of test, troubleshooting, and repair stations is shown in fig. 3.

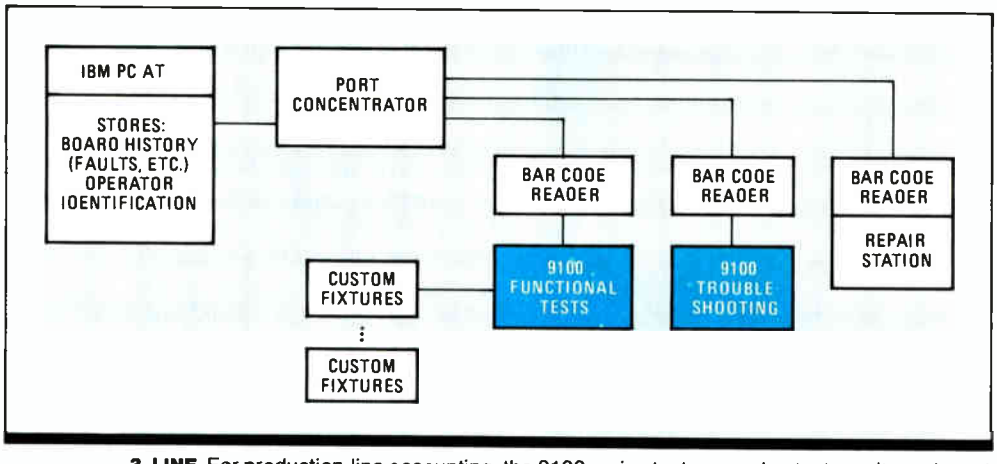
For fault isolation, both the 40-MHz probe and the I/O modules can monitor synchronous and asynchronous signals and stimulate nodes. For the probe, minimum pulse width is 12.5 ns, and other timing can be as short as 5 ns.

The I/O modules can monitor pulses down to 50 ns. They have a resolution of 2 Hz at 10 MHz. Besides allowing simultaneous signature collection at up to 160 locations, the I/O modules can

store a sequence of 400 stimulus patterns and can run it at rates to 40 kHz.

The system's keyboard and display may be used in immediate, unguided, and guided fault-isolation modes. The immediate mode is an interactive mode with tests set up, addressed to particular test points, and controlled manually while the operator observes responses on the display. The unguided mode is programmed, but a skilled operator controls the probing sequence. The guided mode is aimed primarily at low-skill operators and makes heavy use of programmed graphics on the bit-addressable vacuum fluorescent display. An operator may, for instance, work from a diagram showing him where to probe.

An operator working in the immediate mode can use built-in stimulus routines and mode-control keys to loop, repeat, stop, and continue routines. Also, he can use the keyboard to execute initialization and diagnostic programs stored in a board's memory.



3. LINE. For production-line accounting, the 9100 series testers can log test results and send data to personal computers via the built-in RS-232-C testers.

A design engineer can use the immediate mode to start up a library of stimulus/response tests and node signatures (signal patterns analyzed by the tester). Such tests can generally be used with little modification in production and maintenance testing but should be updated with fresh signatures when a known-good board is available, Draye says.

Like the immediate mode, unguided fault isolation is aimed at skilled operators and designers and can be much faster than guided fault isolation. Once a node is selected, the system executes the corresponding stimulus routine and displays the results along with a suggestion on the next node to probe. But it's only a suggestion—an experienced operator can take shortcuts.

In contrast, the guided method requires no decisions or data entry by the operator, who simply follows instructions and diagrams that are displayed by the program.

The 9100A's system software comprises a programmer's interface, an applications interface, and a run-type system used by both. It is packed with features, some familiar, some new to software engineers, that speed program development. Some of the familiar features, says Bezold, are "things we've been doing to prevent errors and make life easier but have never applied to test programming. The main idea with this system was to help the test engineer focus on the tests and not on the software."

Among the features being introduced to test programming are a syntax-checking editor and a source debugger that examine programs for errors. The editor checks inputs line by line as they are entered and points to errors and then continues checking block by block for structure. The debugger interacts with an I/O software module to verify that tests are workable.

One new feature is a tailored test language, TL/1. Its command list incorporates all of the 9100 functions, program control constructs, and allowed variables. Most commands have default entries to prevent problems for the unwary programmers. For instance, every variable is local: it cannot propagate into other routines unless the programmer defines it as a global variable. Built-in error handlers operate unless the programmer overrides them. "We went to this approach because the earlier you catch an error, the easier it is to correct it," Bezold says. "If you let an error propagate through a system, it's very difficult to find. There have been systems that assumed every variable was global unless specified as local." In such setups, variables from one programmer's file can soon contaminate another programmer's file.

To build guided-fault-isolation software, the programmer can call on a data base that contains stimulus routines, known-good responses, a reference list relating board part numbers to component types, a parts library with descriptions of the component types, and interconnectivity data. The latter can be a network listing downloaded into the system from a computer-aided-design system. The user can specify the relative importance of nodes—those prone to be faulty, for instance. Part descriptions are tailored on the video display for a particular board—such as pins tied together, I/O directions. Custom part descriptions are prepared with the same editor.

To help structure guided-fault-isolation programs, a specially designed back-tracking algorithm acts as a decision tree to determine the best route to a fault from a point at which a malfunction is detected. This algorithm uses a dynamic linking method, similar to a Unix path but hard-wired, to call programs from different files. □

For more information, circle 481 on the reader service card.

FLUKE'S OVERHAUL STARTS PAYING OFF

The new 9100 series of microprocessor board testers is a far cry from the traditional meters and calibration instruments with which the John Fluke Manufacturing Co. made its reputation. The 9100 system (see p. 74) is a highly automated digital tool that can be used in lab, factory, and field applications—and establishing an organization to develop such gear that cuts a swath through traditional product-line boundaries is a key reason that Fluke has completely transformed itself.

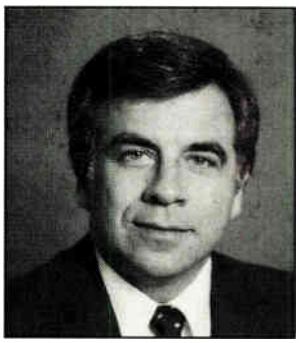
Along with the massive reorganization, the Everett, Wash., instrument maker has gone all out to adapt to global competition. It's looking for ways to work with other companies—the recently announced tie-up with the Dutch giant, Philips, being one example. And it has invested more than $4 million in equipment for manufacturing automation and adopted just-in-time manufacturing practices to fine-tune assembly lines and keep inventories down. It is so focused on long-range planning that its chairman and chief executive officer, John M. Fluke Jr., makes that his chief responsibility.

Fluke's goal in the reorganization was to get a better handle on its customer needs, so it went from nine business units organized along narrow product lines to three application-oriented product groups. And to react with greater flexibility, each group can call on the other groups' product-development and production units.

The company's sweeping reorganization was inevitable, given the increasing importance of digital technology and software in the test and measurement process, says George M. Winn, president and chief operating officer. "When you have a product group responsible for voltmeters, you get a broad product line of very good voltmeters," he notes. "But as the business changes, and you have more and more functions and more and more intelligence in a box, you need to worry about the customer applications."

Fluke began planning the reorganization three years ago and put it into effect last fall. Throughout this period, Fluke has remained profitable despite the industry downturn recession. Sales were $103.6 million in the first six months of fiscal 1987, a hair under the $104.5 million in the comparable 1986 period. Profits were $5.2 million versus $6.4 million last year.

JOHN FLUKE, JR.



GEORGE M. WINN

One of the spurs for the way Fluke reorganized was an analysis by consultant Yorum Wind, a faculty member at the Wharton School of Business. He told Fluke that it had, in effect, diversified too far. There were nine business units, selling many products into many countries through many sales forces. Moreover, the business units had become a collection of baronies that sometimes competed for R&D funds.

Nine business units became three applications groups

In the reorganization, Fluke collapsed all of the product lines into three main applications areas: the small bench and hand-held service instruments on which founder John Fluke Sr. had built the company, were assigned to the Service Equipment Group; the precision instruments used for calibration were folded into the Calibration and Government Group; and new systems products, like the 9100 board tester, were assigned to the Manufacturing/R&D Group.

Central to the whole restructuring is the notion that each group can become more prosperous by working with the other groups. Each group has a strategic marketing unit, a product development unit, and an operations unit to build products. The development and operations units are loosely coupled to their groups; they can serve the other two and can even bid for their work.

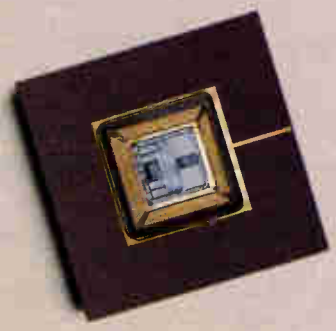
"There is still a tendency for a group's units to think of themselves as a team," say Frederick R. Hume, vice president and general manager of the Manufacturing/R&D Group. "We are just getting to the point where marketing people have their eyes wide open and realize that they can draw on virtually the entire organization to satisfy their needs."

If Fluke does not have the development capability for a particular product in house, the strategic marketing group can go to outside suppliers via cross-licensing or acquisitions. Also, when the Philips alliance is cemented, presumably by the fall of this year, the entire test and measurement line of the Dutch firm will be available to the Fluke application groups. Philips will buy a stake, pegged at under 10%, in Fluke and take a seat on its board.

Another crucial step for Fluke has been the automation effort, which grew out of its vigorous defense of its leadership in hand-held instruments against an invasion of low-cost Japanese suppliers in the 1970s. Fluke investigated setting up manufacturing plants in the Far East and then decided to spend the money on automation instead. "It really paid off," says Winn. "Once we swallowed the costs of major capital investments, our costs of manufacturing have enabled us to innovate in the marketplace."

–Cliff Barney and George Sideris

IT'S A JUNGLE IN THERE.



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SPECIAL REPORT
GRAPHICS SOFTWARE IS ON THE MOVE

By far the most important tool is artificial intelligence, being used for goal-directed behavior, dynamic analysis, and even complete animation from a written description

by Alexander Wolfe

Graphics software is breaking new ground. A wide range of research and development, particularly in the field of animation, is on the verge of producing a dazzling display of new graphics for a wealth of applications. By far the most important new development is the use of artificial intelligence techniques to create and control animated graphics. AI is making it far easier to use animation for far more complex graphics.

The increasing availability of applications programs for high-performance graphics hardware such as the Pixar Image Computer from Pixar, San Rafael, Calif., is giving greater graphics capability to engineers, video artists, and businessmen (see fig. 1). And software for personal computers is putting relatively sophisticated graphics in the hands of those on a tight budget.

The drive is being spearheaded by the entertainment industry, where fascinating work is being done to develop sophisticated animation techniques. The release in 1982 of "Tron," the first feature film to rely heavily on supercomputer-generated imagery, marked the beginning of a new era in graphics software technology. Since then, research has been intensifying, and now its promise is about to be realized, propelled by recent developments from companies such as NEC, Pixar, and West End Film.

Markets for the new software are only beginning to emerge, but its potential is enormous. The graphics being explored for today's movies and videos will become valuable resources tomorrow for applications as diverse as medicine, energy, and data processing and will enrich the garden-variety business graphics used in the corporate boardroom.

Many of those applications will draw on new AI software showcased in April at the Human Factors in Computing Systems and Graphics Interface conference in Toronto. Several intriguing projects unveiled there were based on AI techniques, which are being used to provide such capabilities as goal-directed behavior, dynamic analysis, and even the generation from scratch of a complete animation from a user-entered written description.

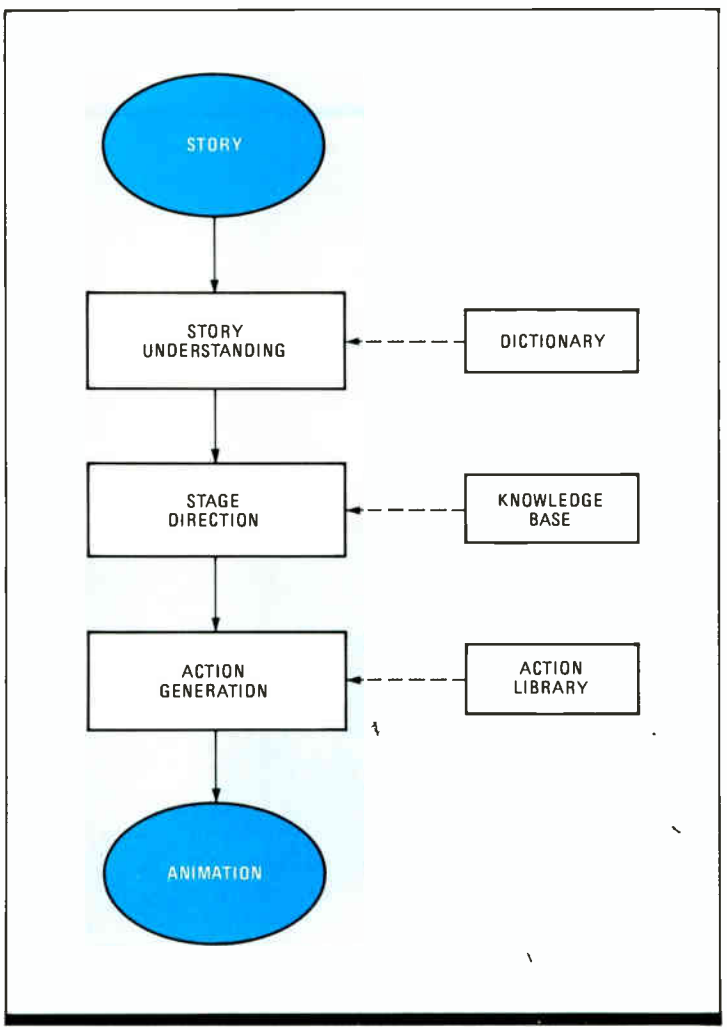
Goal-directed behavior means that the animation package automatically generates action in response to a high-level command. For example, the user could tell a character in an animation sequence to run, without having to program all the low-level motion equations required to move its arms, legs, and torso. Similarly, dynamic analysis automatically animates characters so that they respond to the forces of nature. For

1. BIG PICTURE. Wide-ranging research is propelling computer-graphics technology to new levels of sophistication.

example, if a system were equipped with equations on climbing a staircase, graphics for any character climbing those stairs, and thereby reacting to gravity and inertia, could be generated.

"We want to free the human user from the burden of having to specify what's going on in the animation," says David Zeltzer, a researcher at Massachusetts Institute of Technology's Computer Graphics and Animation Group. Currently, Zeltzer is developing algorithms to animate complex three-dimensional objects. So far, he has come up with a number of initial models of motor behavior. Such work focused on the development of equations for inverse kinematics—equations with which users can implement the features of goal-directed behavior and dynamic analysis.

Even more ambitious is the animation software developed at NEC Corp. by researchers Yosuke Takashima, Hideo Shimazu, and Masahiro Tomono. Story-driven animation, as their technology is called, means the software enables animated computer graphics to be generated from stories written in natural language. Such AI-based software is becoming increasingly important in graphics software. "To encourage widespread use of computer animation, easier-to-use systems must be developed," says Takashima. The use of a natural-language structure (Japanese, in this case) is the key to a user-friendly system interface. Such an interface is important because most users of graphics systems will not be programmers.



2. FREEHAND. NEC Corp.'s story-driven animation software automatically generates pictures from a natural-language description.

The NEC package (see fig. 2) consists of three modules: a story-understanding module, a stage-directing module, and an action-generation module. Working from the user-entered story, the story-understanding module, written in the AI language Prolog, extracts actions and events and generates a scenario, or plot, of the story flow. To this scenario, the stage-directing module (also written in Prolog) adds information on the position of the characters relative to one another.

The characters themselves are defined as 3-D articulated figures. For each character, primitive motion equations are written; complicated actions are formulated by combining primitive motions. The action-generation module produces animated sequences by assigning complex actions to the characters in accordance with the information contained in the scenario. The action-generation module is written in Flavors, an object-oriented language derived from Lisp. Because the module functions like a program generator, a Lisp-like ability to create new functions and evaluate them dynamically is important.

Associated with all three modules is a knowledge base containing basic information on story understanding, motion, and direction. Proof of the system's possibilities was demonstrated at the Human Factors conference in the form of a three-minute videotaped version of the Aesop's Fable "The Tortoise and the Hare" that was generated from a description written in Japanese.

Zeltzer's work at MIT and the NEC developments, like most of those discussed at the Human Factors conference, are still confined to laboratory use. But elsewhere, a number of companies are producing software that is headed for commercial application. Much of that software is intended for use with the Pixar Image Computer, a powerful system optimized for graphics.

ChapReyes, a software package developed by Pixar, was introduced at the recent National Computer Graphics Association conference in Philadelphia. ChapReyes, running on the Pixar system, can achieve rendering speeds of between 50,000 and 100,000 polygons per minute (the standard industry performance yardstick for image processing and computer graphics).

Along with its high speed, ChapReyes boasts features that allow users to render images more realistically. Among them is the ability to simulate the illumination of an object by multiple light sources. Another is the capability for depicting a variety of textures, allowing the accu-

rate rendering of grooved, matte, or wood-grained surfaces. Also provided is support for what are called bicubic patches, which allow curved and sculpted surfaces to be displayed more accurately than can be done with traditional flat-faced polygonal rendering methods.

Another sophisticated imaging software package running on the Pixar system has been designed by Wavefront Technologies, Santa Barbara, Calif. Just released is version 2.5 of its 3-Dimensional Dynamic Imaging Software. New features include programmable ray tracing and shadows and improved texture mapping and shading. A module to perform plotting with hidden-line removal is available as an option.

All this sophisticated off-the-shelf applications software shows just how far the field has advanced during the past five years. Using the best laboratory-grade equipment available at the time, the graphics used in 1982 in "Tron" contained roughly 50,000 polygons per frame. By 1984, the technology had advanced to the point where the graphics sequences in the movie "The Last Starfighter" contained about 800,000 polygons/frame. Last year, Pixar made "Luxo Jr." (see fig. 3), an animated short that was nominated for an Academy Award in the short animated film category. It contains upwards of 3 million polygons/frame.

Although such complexity far outstrips what is available today for noncustomized applications, the challenges of efforts such as "Luxo Jr." lead to solutions for tough graphics problems. "The hidden-surface problem is a real tough one in computer synthesis," explains Alvy Ray Smith, vice president and cofounder of Pixar. "In 'Luxo Jr.,' the computer has a 3-D representation of a Luxo lamp. When you look at the lamp from any given angle and compute what it looks like, you have to figure out which surfaces are in front of the others, and not show the ones behind. Handling motion blur adds a fourth dimension to that problem—that means you have to solve the hidden surfaces during time. That makes it a four-dimensional hidden-surface problem, which requires another order-of-magnitude increase in computing time. We couldn't have done these things a few years ago—we just didn't have the compute power."

Yet today, even systems that do not wield heavy-duty computing power can provide sophisticated image-rendering techniques. West End Film Inc., Washington, D. C., recently added enhancements to Artwork and Videowork, two computer graphics packages. Artwork (see fig. 4) is a 3-D graphics program running on IBM Corp. PC AT and compatible computers. Videowork, an animation package, allows images generated by Artwork to be sequenced so that they appear to move. The images can be copied directly onto videotape, one of the trickiest problems in animation. The difficulty lies in controlling the video recorder so that it records one frame at a time. That problem has been solved by including special software and hardware to interface the animation system with professional editing video recorders such as the Sony BVW40 Betacam recorder.

West End Film's Animate Series II package, under control of the Videowork software, connects a separate controller box to the IBM PC AT and uses it to run the video recorder. Within the PC, add-on circuit cards include a high-resolution video frame buffer capable of supporting 256 colors from a palette of more than 16 million and a video frame-capture card to route images from the system to the controller.

An AI-based software package from NEC generated an animated film of 'The Tortoise and the Hare,' working only from a description written in Japanese

Animation control in another form comes from Computer Graphics Laboratories Inc. The New York company offers Animate!, an automatic single-frame video-recorder software package working in conjunction with the company's Images II hardware. Animate! is a keyframe-based program. A key is a set of parameters used to define a graphics effect. Animated effects are defined by interpolating parameters from one key to the next.

As a result, it is possible to blend different graphics effects together within the same motion sequence. A frame to be generated may consist of any combination of keys and interpolations. For added flexibility, color and brightness levels within the frames can be adjusted independently.

For managing the sequencing of frames that will make up the videotape, Animate! uses a menu-based system constructed like a spreadsheet. Within the spreadsheet, vertical rows cor-

3. LAMPLIGHT. "Luxo Jr.," a computer-animated short produced by Pixar, was nominated for an Academy Award.

respond to individual frames. Up to 65,000 frames, or about 30 minutes of video, can be controlled.

Packages such as West End Film's prove that advanced image processing need no longer depend on the availability of high-priced, high-powered hardware. Relatively inexpensive PCs can be used to run software packages such as Image-Pro 1000 from Media Cybernetics Inc., Silver Spring, Md. Consisting of a mouse-driven image-processing package, icon-driven graphics editor, and a library of image processing subroutines, Image-Pro 1000 manipulates video information from documents, photographs, and X-rays.

To get that information into a PC, a complete turnkey imaging system is generally used. Besides the PC, such a system typically includes a digitizing video camera for capturing images, a high-resolution monitor, graphics controller cards, and, as options, a slide camera and color-graphics printer for producing hard copies of the images reworked by the PC.

With those aids in place, programs such as Image-Pro 1000 can be put to work. For example, Image-Pro 1000 can perform color shifting, contrast enhancement, and spatial filtering. It can also resize, rotate, or change the contours of an image. And the image editor included with Image-Pro 1000 allows users to add grids, ellipses, boxes, or text in more than 20 fonts to existing images. Cut and paste functions, useful in generating overlays or combining multiple pictures, are also available.

For those who want to develop their own graphics applications from scratch, one package for developing image-processing software is P-Cubed from the Advanced Technology Center, Culver City, Calif. P-Cubed includes both a subroutine library of common image-processing functions and a full-blown command-driven interactive development system. P-Cubed is based on the idea that image-processing software will be developed in independent software modules, separate blocks of code just like the library subroutines. When P-Cubed is run, an interpreter accepts user commands and initiates execution of the requested module. When the module has finished, control returns to the interpreter.

The interpreter approach allows new functions to be developed and run independently, without being linked with existing applications code. Facilities available in P-Cubed include parameter prompting, multiframe images, virtual image addressing, and on-line help. The package runs on any system supporting Fortran 77; in addition, versions tailored for the Microvax II, work stations from Sun, Apollo, and Masscomp, and the IBM PC AT are available.

A development system in a more experimental form comes by way of the Midnight Movie Group, a group of engineers at Apollo Computer Inc. who worked in their spare time to build Movit (short for movie editor). Running on Apollo work stations, Movit features a Macintosh-like mouse-driven user interface through which up to 25 separate images can be combined, by editing, to create an animation sequence. The original images themselves are synthetically generated by Movit under control of programs written and entered by the user in ADL, the Animation Description Language.

Movit can be used to highlight different parts of individual frames or even to add new figures to those frames. Though Movit is not marketed as a product by Apollo, its developers have demonstrated its potential by making several short films. "When Movit was designed, none of us had written computer animation software, so we started from scratch," says one of the Apollo engineers, Michael Sciulli. "One reason engineers spend their spare time on animation is that's where the glamour is."

That's good news for users of other kinds of graphics software. Talented people are being lured by the challenges and rewards of animation. Their work promises to evolve into important new graphics applications. In medicine, for example, ordinary CAT-scan data can be turned into stunning moving representations of the insides of human bodies. In energy, sonic recordings of the earth can be converted into images that will aid the search for oil. Visual presentation of the output of supercomputer applications programs promises to be another important application. Even the slides used every day in business will benefit from the ongoing improvements in computer graphics technology.

"[Image] synthesis, by its glamorous nature, has attracted a lot of the best brains in the business. The problems are so hard that, by solving them, we stay ahead of the field in the understanding of algorithms and in the production of hardware to implement them. That's the driving force for our business," says Pixar's Smith.□

4. BUDGET ART. The Artwork graphics software can generate images such as this one on IBM Corp. PCs and compatibles.

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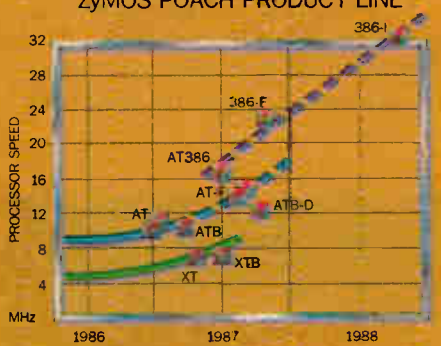

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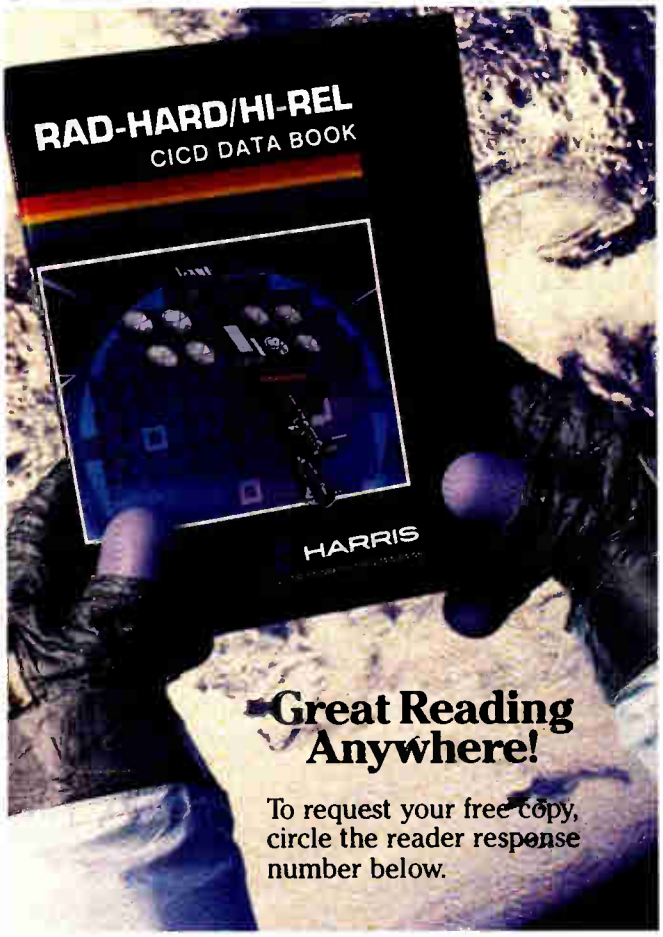

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UPDATE: BIT'S PROCESS BREEDS A HEALTHY FAMILY

Bipolar Integrated Technology Inc. introduced a process for producing high-performance data-path elements a year ago, promising to bring out a family of parts based on that process. Today, six members of the family are being produced in volume and a seventh and eighth are scheduled for introduction soon, says Les Soltesz, vice president of marketing at the Portland, Ore., company.

BIT fabricates the devices with a proprietary first-generation bipolar process [*Electronics*, April 7, 1986, p. 35]. Called BIT1, the process uses 2-μm design rules and MOS-like self-aligning polysilicon techniques to shrink transistors to about 14 μm^2 and cut gate delays to as low as 300 picoseconds. More important, per-gate power dissipation is about 300 μW, which is roughly a tenth the dissipation of conventional emitter-coupled logic at comparable gate propagation delays.

The newest members of the family, due in July, are ECL and TTL versions of a 32-bit floating-point chip set: a multiplier and an arithmetic logic unit. Designated the B3110/B3120 and B2110/B2120, respectively, they feature 32-bit fixed-point operations as well as 32- and 64-bit floating-point functions.


SURPRISE! ECL RUNS ON ONLY MICROWATTS

The existing members of the family are the B3210 and B2210, introduced in December. They are ECL- and TTL-compatible, SRAM-based register files with a unique five-port architecture. Preceding them were the B3011 and B2011, introduced in September. The former is an ECL 16-by-16-bit fixed-point multiplier-accumulator chip; the latter is a TTL version. The first parts to be announced were fixed-point, 16-by-16-bit multipliers brought out in June—an ECL version, the B3018, and a TTL version, the B2018.

The parts are aimed primarily at the high end of the digital-signal-processing market. However, Soltesz says, they also are finding wide acceptance in the general-purpose processing market as well.

–Bernard C. Cole

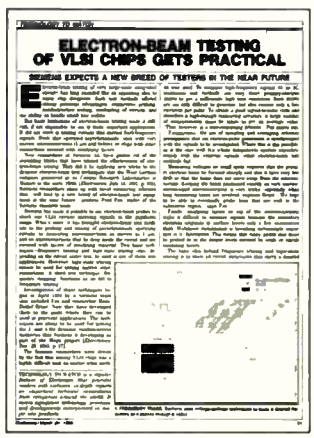
UPDATE: SIEMENS' E-BEAM TESTER GETS ON TRACK

A second-generation electron-beam test system under development at West Germany's Siemens AG is more than a year overdue, but Siemens researchers say there's no problem with the tester itself—an experimental version works fine. The delay was caused by a supplier who failed to deliver a crucial component. Another supplier has been found, and Siemens now expects to produce a practical version of the tester in the second half of this year.

Researchers at the Siemens Central Research Laboratories thought in March 1986 that they were close to a practical version of the system, which is designed to probe VLSI circuits carrying high-frequency signals and operating asynchronously. Their laboratory test setup had already proved that the various test methods under development—frequency tracing, logic-state tracing, and frequency mapping—could be applied to live VLSI circuits for testing signal parameters [*Electronics*, March 24, 1986, p. 51].

But to build a working system, the researchers needed a scanning-electron-beam microscope. One was ordered from a European optical company, but the firm failed to deliver it on time, says Hans-Detlef Brust, a member of the research team. Another microscope has been ordered from a different company, but it must be specially configured for use in the system.

While they wait for the microscope, the Siemens people are honing their test methods. The logic-state tracing method has been refined so that now circuits carrying 100-MHz signals can be checked, up from 5-MHz signals a year ago. The increase, Brust says, was achieved by using the E-beam itself for signal correlation. He expects eventually to probe 250-MHz signals.

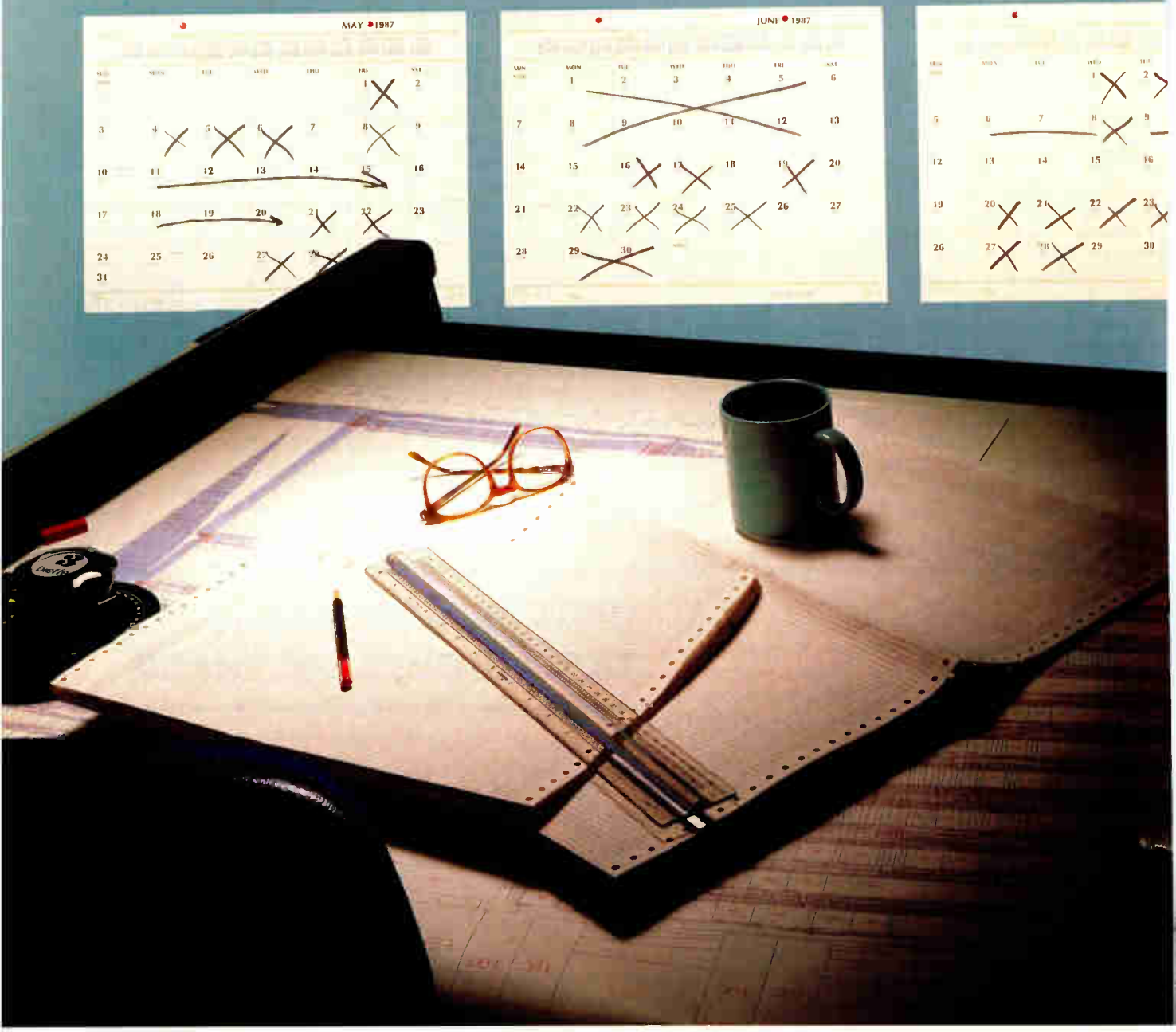

ELECTRON-BEAM TESTING OF VLSI CHIPS GETS PRACTICAL

The researchers also have cut the time it takes to trace a signal in a VLSI circuit up to five times, by modulating the E-beam scan speed so the beam scans slowly over circuit areas where a signal is expected and rapidly over those where no signal is likely to be present.

The lab version of the tester is also being used for high-density-memory and complex-logic development work for Siemens. Once a perfected system is working, the company may license the rights to build and market the machine to an outside company.

–John Gosch

Three months



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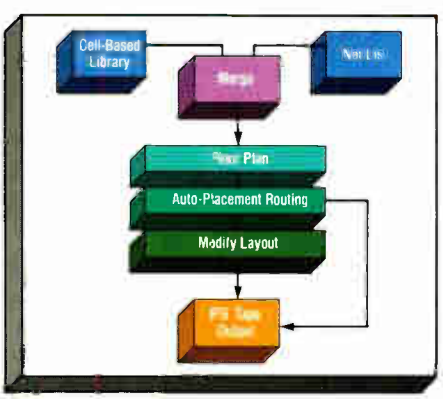

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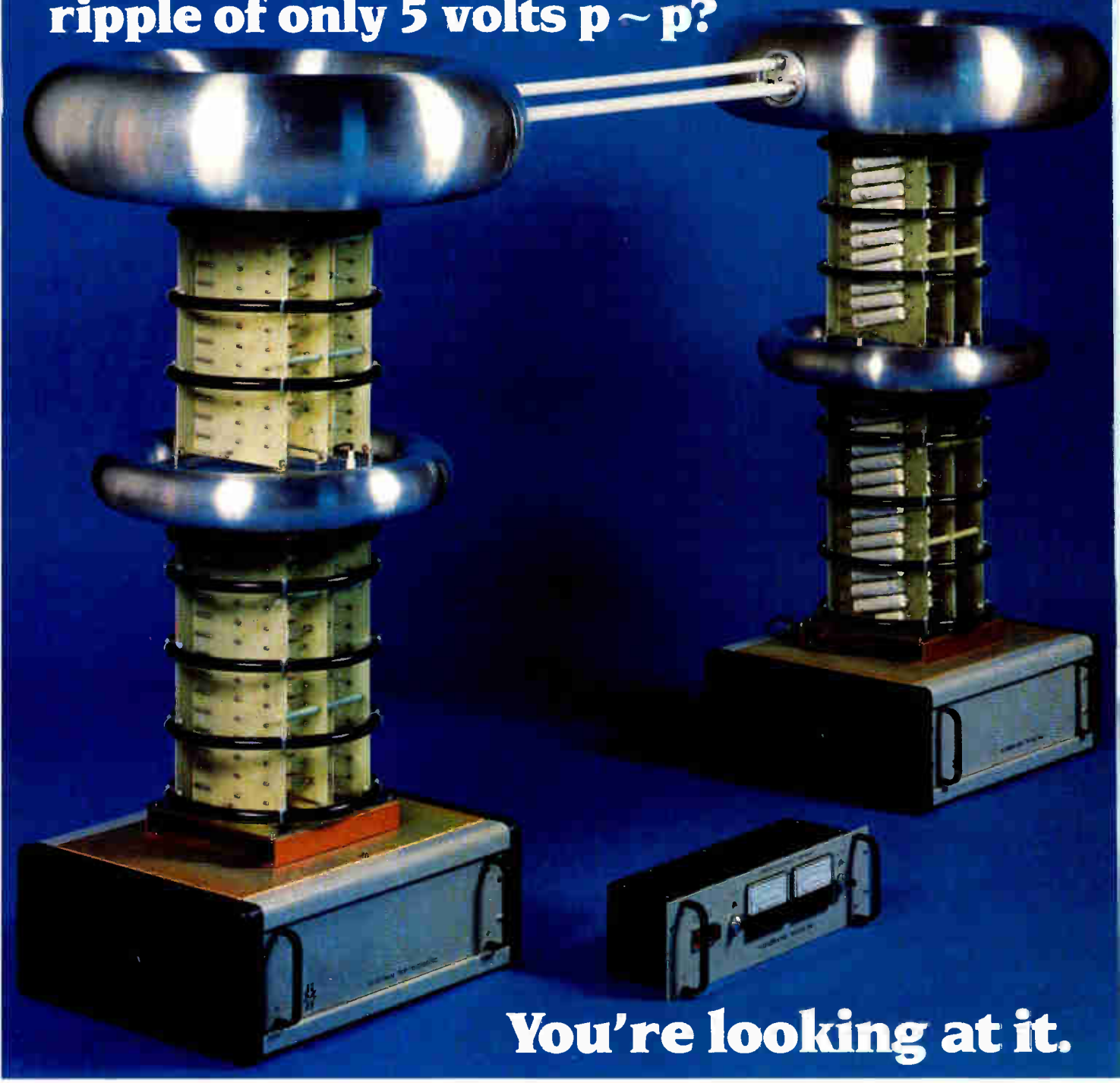

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WHAT'S NEW IN POWER SUPPLIES?

WHY MAKERS ARE STEPPING UP THE PACE IN TECHNOLOGY

Merchant makers are developing more compact and more efficient power supplies to increase their 30% share of a market that runs more than $6 billion annually

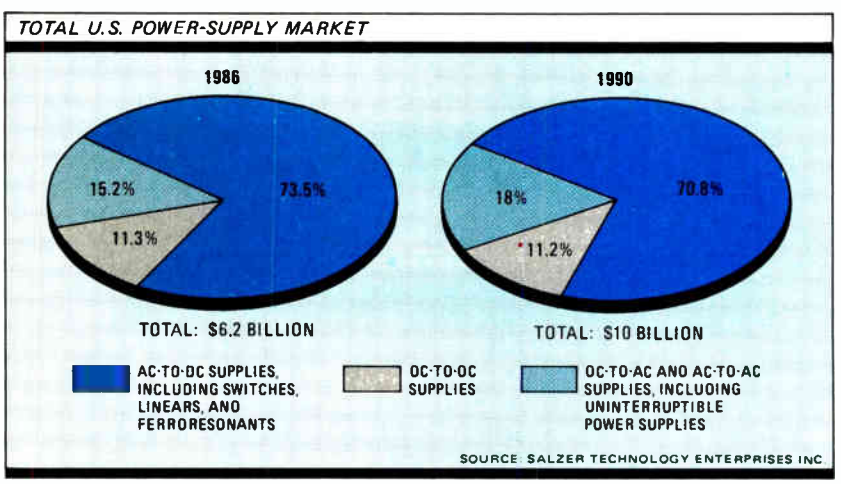
by Jerry Lyman

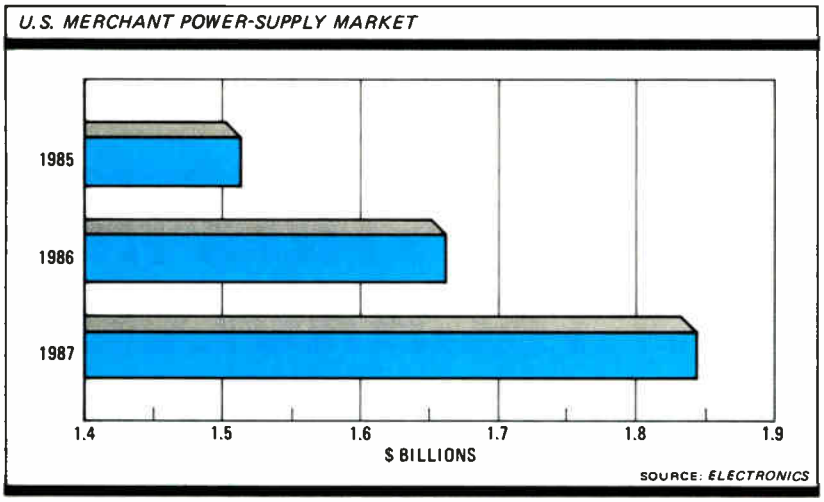
Major merchant power supply makers are trying hard to expand their one-third share of the U.S. power supply business by breaking out into new markets. They're targeting military, computer, data communications, and telecommunications equipment, where power supplies typically are produced by small specialty companies or by the equipment makers themselves. Their principal weapon in this campaign is to bring new technology to market faster, and they're doing this by shrinking their products and making them more efficient.

The merchant power supply industry is mounting its campaign by making acquisitions in the military field, by direct assault on specialty firms who have been making uninterruptible power supplies, and by negotiation—trying to persuade manufacturers of data communications and telecommunications equipment to buy rather than build. As they have tried to enlarge their market share, power supply makers have worked at making their products smaller and more efficient, with great success. Higher frequencies are bolstering the advantages of compactness and efficiency already held by switching power supplies and have speeded their displacement of linear types. And the belated arrival of packaging technology from other parts of the electronics industry has dramatically shrunk control circuitry.

The total U.S. power supply market for 1986 was some $6.2 billion (see chart, right). About 70% of this figure is captive, leaving a sizable merchant market of about $1.7 billion, which should grow to almost $2 billion in 1987, according to *Electronics'* 1987 U.S. Market Report (see top chart, p. 94). Ac-to-dc supplies, which include switchers, linears, and ferroresonants, account for almost three quarters of the U.S. market.

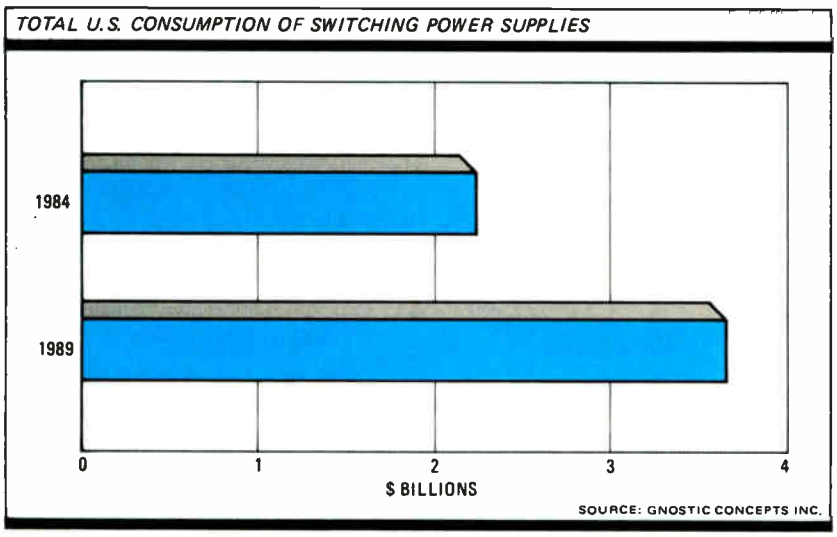
The remainder of the market is split between dc-to-dc converters, with 11.3% market share, and dc-to-ac and ac-to-ac types (including uninterruptible power supplies, or UPSs), with a 15.2% market share. Market research firm Gnostic Concepts Inc., San Mateo, Calif., projects an average growth rate of over 10% a year in switching power supplies from 1984 to 1989 (see bottom chart,





p. 94). Another market researcher, Salzer Technology Enterprises, of Santa Monica, Calif., expects even higher growth for three power supply types: well over 17% in switchers and UPSs, and a healthy 12.3% in dc-to-dc converters spurred by growth in the telecommunications industry. But it sees linears and ferroresonant regulators steadily losing market share at the rate of about 1% a year.

One market on which merchant power supply firms are casting covetous eyes is the military field. Until recently, they had avoided it because military customers are much more demanding than civilian customers. Specs are tighter, EMI standards are stricter, and equipment must operate over a wider temperature range and use expensive derated MIL STD parts. On the other hand, manufacturing supplies to military specs can be a very profitable business. Rather than make a frontal attack, power supply makers are acquiring companies that specialize in military supplies. For example, Computer Products Inc., Pompano Beach, Fla., has bought Tecnetics Inc., Boulder Colo.; and Lambda Electronics, a division of Veeco Instruments Inc., Melville, N. Y., has purchased Magnepower Inc., Ronkonkoma, N. Y.



In another specialized market, the fast-growing UPS sector, merchant power supply makers have elected to go head to head with the specialists, rather than buy their know-how. Computer Products and Lambda already have UPS units available from stock, and most of the other merchant makers are looking into this field.

With almost 85% of all switchers going into computers and computer-related applications, makers of these supplies are trying to expand into other markets. Two segments receiving a lot of attention are data communications and telecommunications.

For data communications, power supplies compatible with the VMEbus and Multibus have begun appearing in catalogs. For telecommunications, practically everyone in the power supply business now makes off-the-shelf units powered by 115 V ac and putting out 48 V dc. Also available are devices with 160 to 500 W ac inputs and several dc output voltages: for example, 5 V for memory and logic and ±12 V for line drivers, network interfaces, and RS-232-C serial outputs. These units must meet tighter noise specs than the typical computer power supplies. A third type of supply aimed at the telecommunications field is a unit that converts the standard 48-V dc telecom supply to well-filtered 5 V dc.

SWITCHERS vs. LINEARS

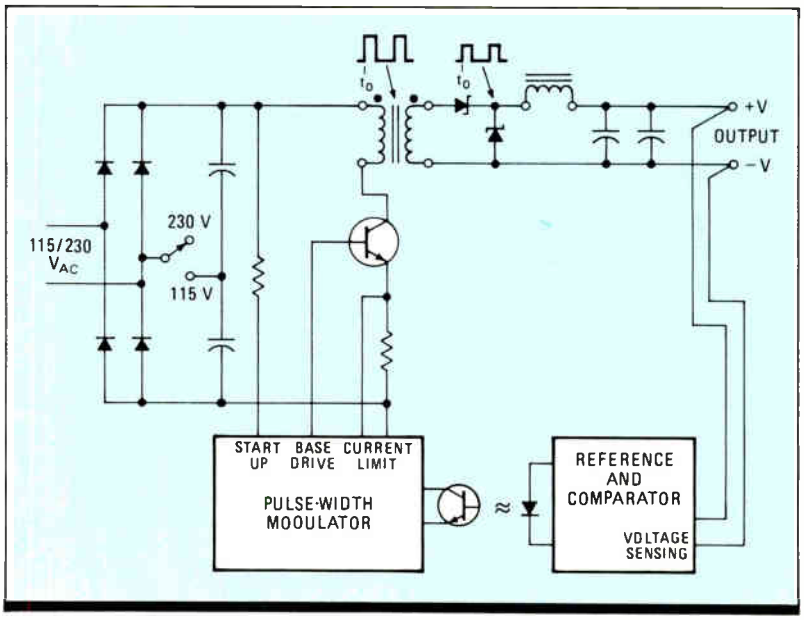
To put more firepower into their assault, merchant power supply makers are improving the technology of their products. Much of their attention goes to ac-to-dc units, the biggest slice of the overall market. This billion-dollar business is split 60% for switchers and 40% for linear types, and switchers are projected to gobble up 73% by 1989, predicts Salzer Technology Enterprises.

The reason for this trend is the electrical performance and cost-per-watt advantages the switcher has over the linear type. The linear supply typically is simply a solid-state analog of the old series-pass tube regulator, in which a transistor acts as a variable resistor to control voltage. The newer switching supply, in contrast, is basically a dc-to-dc converter in which a transistor switches on and off at a set frequency and controls voltage by pulse-width modulation. Unlike the linear regulator, which has a standard design, a switching supply can take several forms. Today, the forward converter is probably the most popular type of switcher (see fig. 1). This circuit minimizes the number of magnetic components needed, thereby cutting costs and increasing reliability.

Compared with linear supplies, switchers are smaller (see the table, p. 95) and maintain voltage longer when power sags, which is important for

computers, says Eugene Zuch, director of corporate marketing for Computer Products. In addition, he points out, the switching supply accepts a wider range of input voltages. Linear supplies can handle a ±10% variation but consume extra power in direct proportion to the departure from the design point. Switchers take in stride swings in input voltage of ±20% with no loss of efficiency. Linear supplies, on the other hand, have the redeeming qualities of simplicity, a more constant output voltage, faster recovery from outages, and less EMI, since switching is inherently noisy.

Probably the most telling difference is that the worst switcher is more efficient than the best linear power supply. Along with compactness, this has proved a particular advantage for switchers in displacing linear power supplies from the high end of the power spectrum, where heat dissipation becomes a problem. At the same time, switchers have been more gradually pushing out linear supplies at the lower end of the power spectrum.



1. FORWARD CONVERTER. The single-ended forward converter eliminates many magnetic components, thereby increasing reliability.

Switching power supplies are now available off the shelf from 0.5 W to 300 W—and at least two firms, Lambda Electronics and CEAG Electric Corp, Hauppauge, N. Y., will deliver units delivering kilowatts. Lambda offers a stand-alone fan-cooled LT860 bench supply for test and burn-in that can supply 4 kW at 500 A in a 5.2-by-19-by-17.5-in. package, no bigger than half a microwave oven. The cost is $3,200, or about 75¢ a watt.

CEAG's unit is a 3-kW, single-output switcher for OEM use producing 5 V at 600 A and stuffed into a 7.73-by-17.8-by-5.48-in. envelope on a cold plate. It was originally designed for a supercomputer, then commercialized to get its price down to $3,500. But it still retains semiconductors that meet the full MIL STD temperature-range specs, and most of its components are conservatively derated in accordance with U.S. Navy Navmat P4855-1 guidelines.

One of the biggest reasons for the rising efficiencies and shrinking sizes of switching power supplies has been a steady increase in switching frequency. The original switchers had a pulse repetition rate of around 25 kHz. Today, many operate anywhere from 50 to 300 kHz, and several versions of a new type of supply called the harmonic or resonant converter run at 1 to 2 MHz. In this advanced converter, the output transformer is part of a circuit tuned to resonate at the desired frequency. To control voltage, pulse width is held constant and is frequency-modulated.

A case in point is Kepco/TDK's ERD series of single-output dc-to-dc converters, available in 30-, 60-, and 150-W models. This series grew out of a 1976 design that switched at 25 kHz. Boosting frequency to 300 kHz has cut the parts count in half, reduced weight 70%, and split the cost per watt in half. It also raised efficiency up to 10%, almost tripled the power density, and nearly quintupled the mean time before failure.

Among other companies going to higher switching rates are Vicor Inc., Andover, Mass., Lambda, and Sierra Power Systems, a division of Sierracin Corp. of Chatsworth, Calif. Vicor has squeezed a dc-to-dc converter that would usually have a power density of 3 W/in.^{3} into a package with a power density of 37 W/in.^{3} Aiming at the telecommunications market, Lambda has designed a line of dc-to-dc converters in a 1-by-4-by-6-in. module delivering up to 250 W from a 48-V dc input.

By using harmonic resonant circuitry, on which it has applied for a patent, Sierra has chipped away at some of the switcher's disadvantages. "This technology gives almost the performance of a linear supply—10-to-15-mV ripple and low conducted EMI, " says applications engineer Mukesh Mehta about the company's 9S400 single-output supply.

In all of these advanced converters, the tuning of the output transformer that the resonant approach makes possible extends the potential frequency limit to the megahertz range—where the

LINEAR VS. SWITCHING SUPPLIES

Specification	Linear	Switcher
Line regulation	0.02 – 0.05%	0.05 – 0.1%
Load regulation	0.02 – 0.1%	0.1 – 1.0%
Output ripple	0.5 – 2 mV rms	25 – 100 mV p-p
Input voltage range	±10%	±20%
Efficiency	40 – 55%	60 – 80%
Power density	0.5 W/in.^{3}	2.3 W/in.^{3}
Transient recovery	50 μs	300 μs
Hold-up time	2 ms	32 ms

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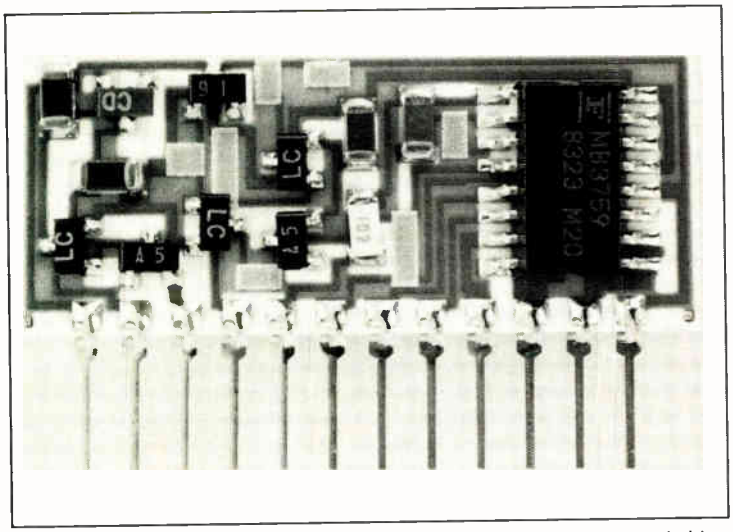
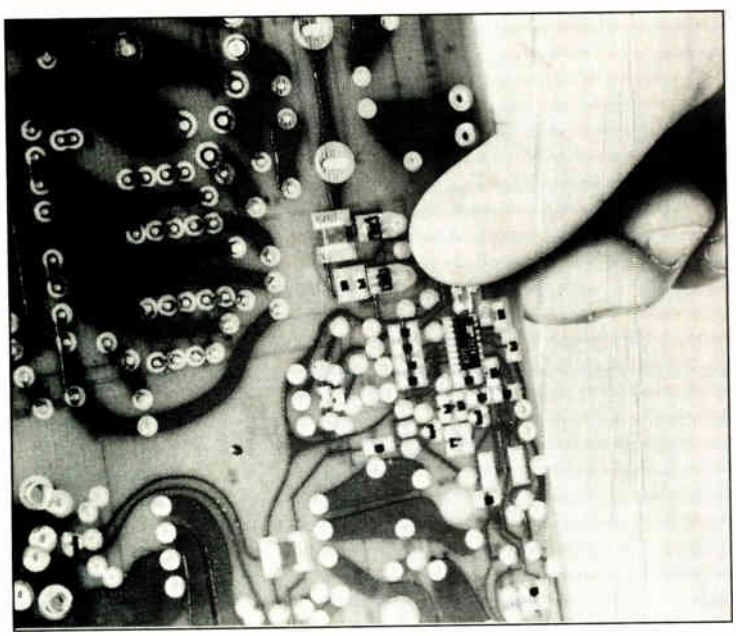


2. HYBRIDIZED. The pwm circuitry of a Kepco/TDK switching supply is squeezed onto this small thick-film SIP.

commonly used pwm approach is limited to a maximum of 300 kHz. Rather than use pulse-width modulation to control the average dc level of the output of the supply, these resonant supplies hold the pulse width constant and vary the frequency in a form of frequency modulation.

Future resonant-mode switching supplies will make greater use of integrated circuits in order to shrink their size even more. For example, Linear Technology Inc., Burlington, Ont., Canada, is introducing just such an IC, with the control circuitry for a resonant-mode supply. The chip has such features as soft starting and overvoltage/undervoltage protection and is housed in a 16-pin DIP.

Even more than high frequencies, a belated adoption of modern packaging techniques has dramatically shrunk power supplies. Until fairly recently, most power supply circuitry was being packaged by the methods of the late 1960s. That is, DIP pins were inserted through holes in printed-circuit boards and wave-soldered. Lately, the power supply industry has begun joining the rest of the electronics manufacturers in using thick-film hybrid substrates and surface-mounted assembly to pc boards for circuitry dissipating low and medium power, such as for control of pulse width and over- and undervoltage limits.



3. UNDER THE BOARD. To compress control circuitry, Todd surface-mounts semiconductors and passives on the bottom of a pc board.

Most of the major power supply manufacturers, such as Computer Circuits, Kepco, Lambda, Power One, and Sierra, have been using hybrids, particularly for control circuitry. ICs in tiny surface-mountable packages and resistive and capacitive chips are reflow-soldered to a small ceramic substrate having screened-on thick-film conductors and a single in-line lead frame. This module in turn is usually potted and then inserted into the supply's pc board (see fig. 2).

Such hybrid boards radically reduce size and cut EMI because of their short leads. They can be tested before final board assembly, and they often can be used in several different power supplies. Companies like Computer Products and Lambda are using enough hybrids to justify setting up their own facilities for producing them.

HYBRIDS vs. SURFACE MOUNTING

Surface mounting directly to pc boards has been introduced more recently in the power supply industry. Firms such as Power One and Sierra Power Systems stick to hybrids, asserting that they are more cost-effective and that surface mounting can't handle enough power. The ceramic substrate of hybrids offers better thermal characteristics than standard pc laminates such as epoxy-glass, and so hybrids can be used in medium-power applications, such as a low-current post regulator on a multioutput switching supply.

Other companies, such as Todd Products Corp., Brentwood, N. Y., Computer Products, Kepco, and Lambda are starting to use surface-mount technology in their latest supplies. "Originally we worked with surface mounting to make units smaller and simpler," says Frank Sposato, vice president of Todd. "Next we are going to work on full implementation of this technique, where we will take advantage of the electrical characteristics" that result primarily from the short leads and pay off in higher efficiency.

Todd was one of the first to use surface mounting, adopting it to reduce sizes in its MDT series of open-frame switching supplies. Now it is being applied to a second design, the MAX series.

Todd mounts small-outline ICs, SO-23 transistors, and chip components to the undersides of its main pc board (see fig. 3), allowing it to wave-solder all surface-mounted and conventional components in a single operation. Todd is committed enough to surface mounting to have recently bought its second Dynapert 500 pick-and-place machine, which can handle 6,000 components per hour. □

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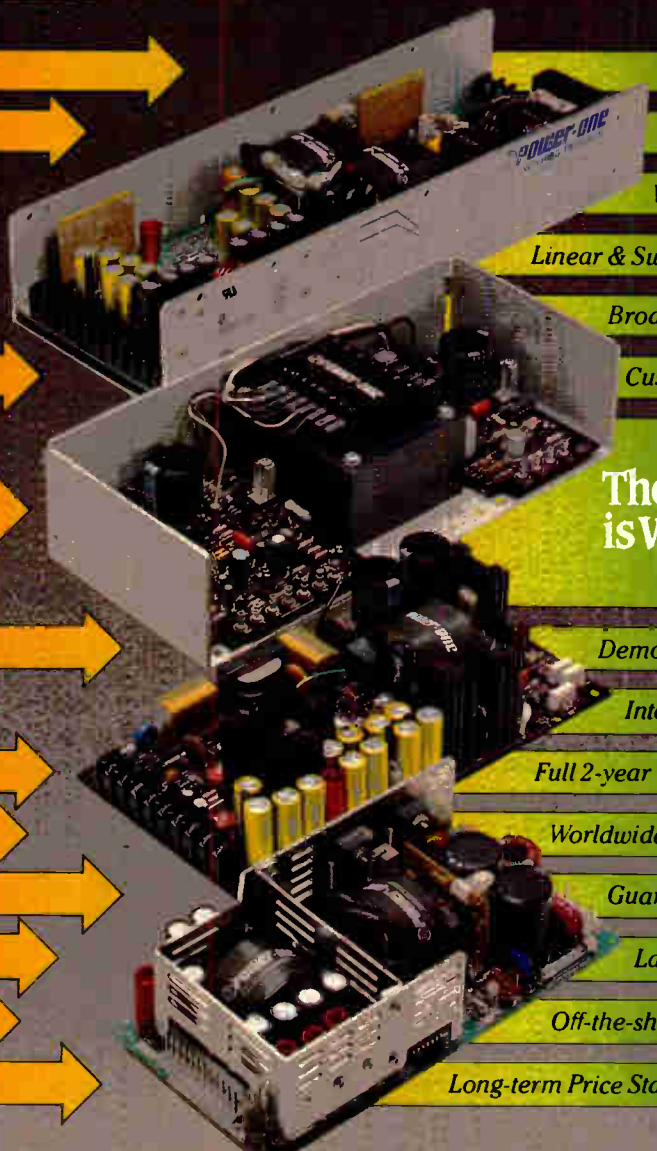

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ONE TESTER HANDLES ASIC AND COMMODITY VLSI CHIPS

Application-specific integrated circuits have created a dichotomy in the requirements of component testing. Commodity VLSI merchant manufacturers need to test large numbers of the same IC quickly, but ASIC makers have to test a wide variety of chips, most in relatively small runs.

For the ASIC manufacturer, this means being able to switch rapidly from testing one variety of chip to another. And to give the fast turnaround his customers demand, he must generate test programs quickly—preferably taking no longer than a few hours, certainly no more than a few days.

Megatest Corp. says it solves both problems with its MegaOne/AP test system (see fig. 1). The AP, or advanced productivity, is an update of the San Jose, Calif., company's MegaOne system [*Electronics*, Aug. 5, 1985, p. 46]. The AP comes with a high-performance system controller and up to three test stations. The faster 32-bit 16.67-MHz 68020 processors, which replace the 16-bit 8-MHz 68000s in the controller and test stations, cut test times by a factor of two and program load times by a factor of 2.5. Typical test time is 100 ms for a VLSI chip. The AP costs $300,000 to $1 million, depending on the number of pins.

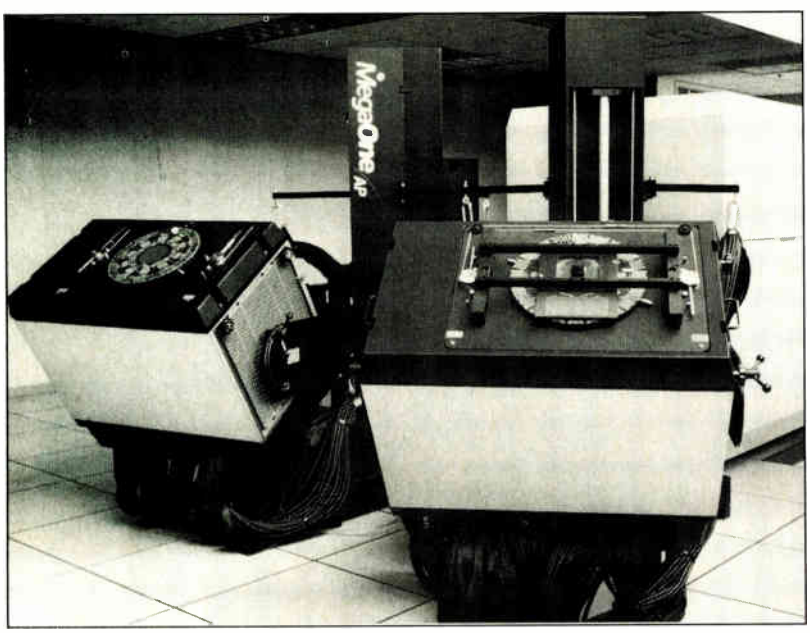
To reduce the time required to generate new test programs, the updated system includes some new features. A Sun 3/180 test-development work station from Sun Microsystems Inc., of Mountain View, Calif., is tied to the test system by a private Ethernet network. Via a public Ethernet, the development system can access test vectors generated during the development of an ASIC chip by the computer-aided-engineering Sun work station in the engineering lab. The link eliminates the need to develop test vectors for the AP. A fast Pascal computer speeds test-program development.

Before testing begins, the system controller loads into the program memory of the individual test stations the test programs that will direct the application of the test vectors to the chip under test. Each station has 16 Mbytes of memory for its program. The 68020 in each test station executes the test program directly from the memory, without drawing on the system-controller 68020.

Decoupling the system-controller 68020 and test-station 68020 helps cut test time in half. The faster microprocessors cut program loading time by two and a half times, by starting a sequence of tests and checking their status afterward. "Having three test heads gives the tester the capability to perform different types of testing as well," says Craig Foster, vice president of marketing at MegaTest. "For example, there can be a prober set up to test wafers on test head 1, packaged parts can be tested on test head 2, and an engineer can be performing device characterization on test head 3."

Decoupling also helps solve the problem of switching tests quickly from one ASIC chip to another. It frees the processors from the burden of running the Unix operating system, as the slower 68000s had to do in the original Megatest. In addition, each test station comes with its own dc-testing resources so the system controller multiplexes only the output of the more expensive timing generator between the three test stations. Also, the test stations share a 1-Mbit-deep test-vector memory. The vector memory can be as wide as the number of pins on a system.

In operation, the test vectors and expected response for a given ASIC chip are loaded into the vector memory. Unless the device is extremely complex, the test vectors for one ASIC device will not fill the memory. The remaining space can be used to store the test vectors for the other two test stations. Conceivably, all the test vectors for each device under test can reside in the memory at the same time. In that case, no overhead time is required to unload the test vectors for one device and load them for another. During testing, the system controller multiplexes the vector timing generator shared by the three test stations. The timing generator clocks the test patterns applied to the device under test.



1. POWERFUL UPGRADE. A typical MegaOne/AP system comes with a system controller and these two test stations, each with a 68020 microprocessor.

Up to three types of ASICs can be tested concurrently, one at each of the test stations. For example, the test-system controller can allocate use of the timing generator to test head 1, which can be running a functional test program. At the same time, test head 2 can be performing a dc test, drawing on its own dedicated dc test resources. When the task on test head 1 is finished, the controller switches allocation of the timing generator to test station 2, which can then execute the dynamic functional test on test head 2. At the same time, dc testing or test setup can be in progress on test head 3, while test head 1 is setting up a new device. The process of multiplexing the main timing resources and sharing vector memory continues for every subsequent test on each test head.

SPEEDING DEBUGGING

To speed program debugging, the system uses the test vectors generated when the chip is being designed. The system ties into the design work station in the engineering lab over a public Ethernet network. Once connected, the system transports test vectors from the CAE system's simulator into the engineering development system on the AP (see fig. 2).

On the engineering development system, the test engineer develops and debugs test programs comprising instructions on what tests to run and in what order to run them. For example, the test engineer might specify that the test sequence include a search for shorts and opens and a simple functional test to see if the part is operational. These could be followed by a dc parametric test and then a full functional test.

The test program would specify the waveforms and voltages to be applied to each pin and the expected response. Programming with Pascal, the test engineer writes terse procedural calls followed by a list of variables such as pin names and associated signals.

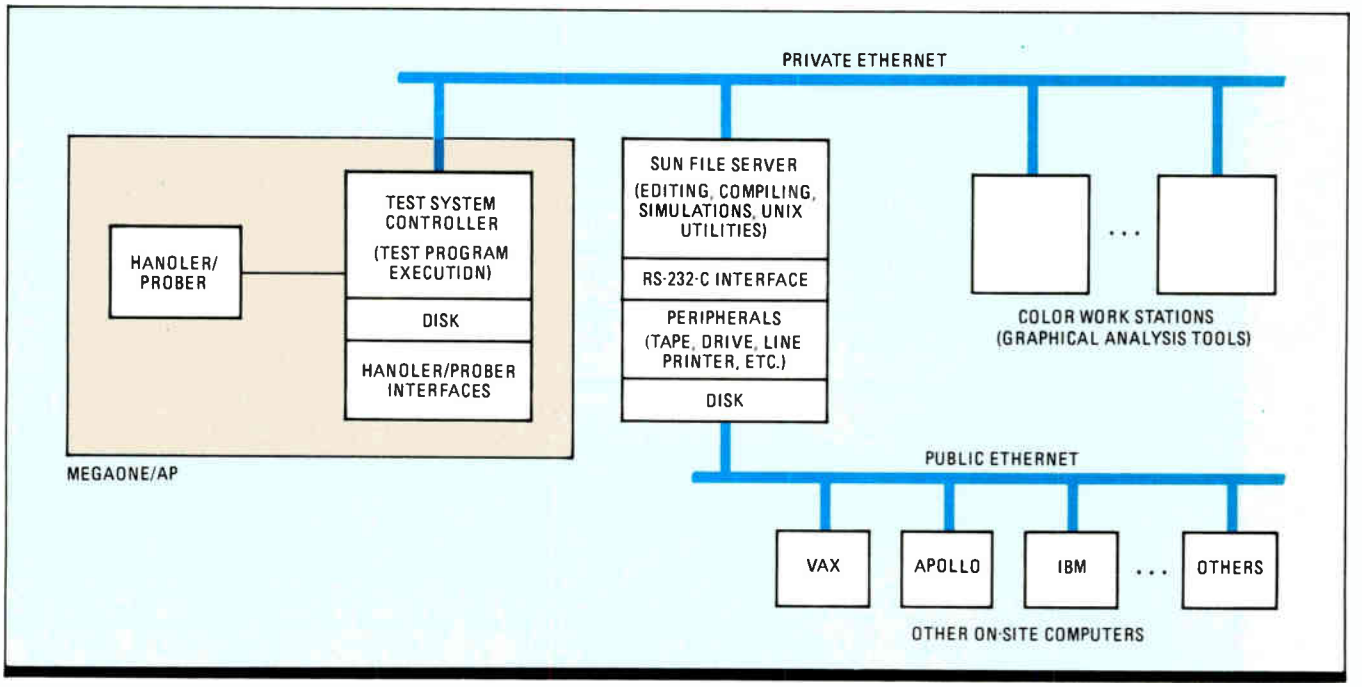
For fast program development, the work station contains interactive Pascal. "Normally, the test engineer produces source code that is then compiled and executed," says Foster. "If the designer finds a bug, he fixes it, then recompiles and repeats the process until all bugs are found." With interactive Pascal, the test engineer can fix his bugs in the executing code, eliminating recompilation. Furthermore, the AP's improved compiler runs 2.5 times faster than the previous version.

Besides Pascal, the system contains VPL, a proprietary vector programming language that runs five times faster than the version on the original. VPL is used when the test engineer wants to generate test vectors or to add test vectors to an existing set.

For test-program debugging, the development system contains a test-system simulator, which is a software package on the original MegaOne tester but now has been adapted to Sun work stations. It allows the test engineer to simulate the operation of the tester on the work station so that he can debug his test program without tying up the test system.

The company's goal is to make test development available on any Unix-based work station. "Besides the Sun work station, we have plans to support work stations from Apollo Computer Inc. and the MicroVAX work station from Digital Equipment Corp.," says Foster. *–Jonah McLeod*

For more information, circle 482 on the reader service card.



2. TRANSPORTED. The MegaOne/AP transports test vectors from the computer-aided-engineering system simulator tool into its engineering development system to reduce test-generation time.

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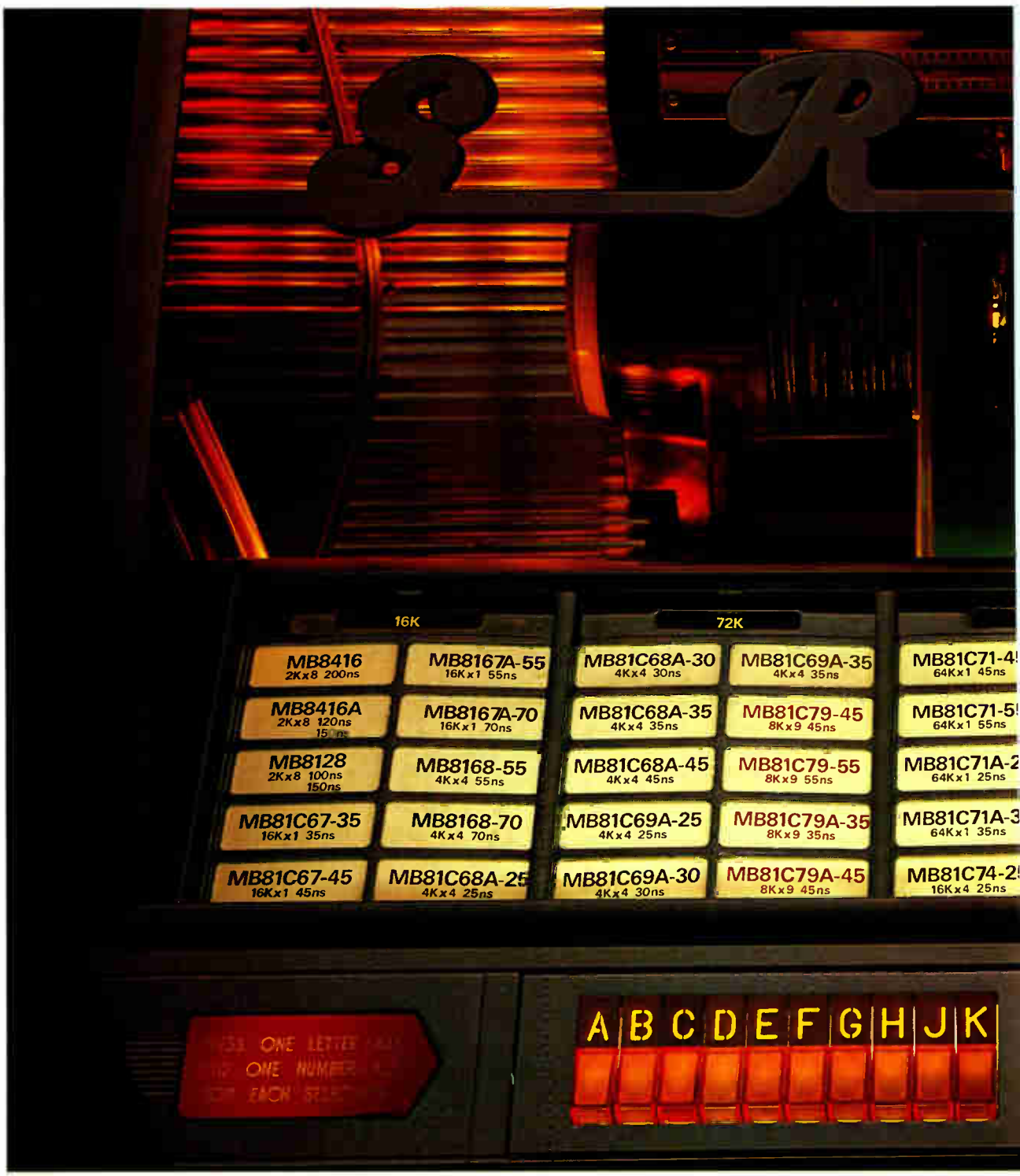

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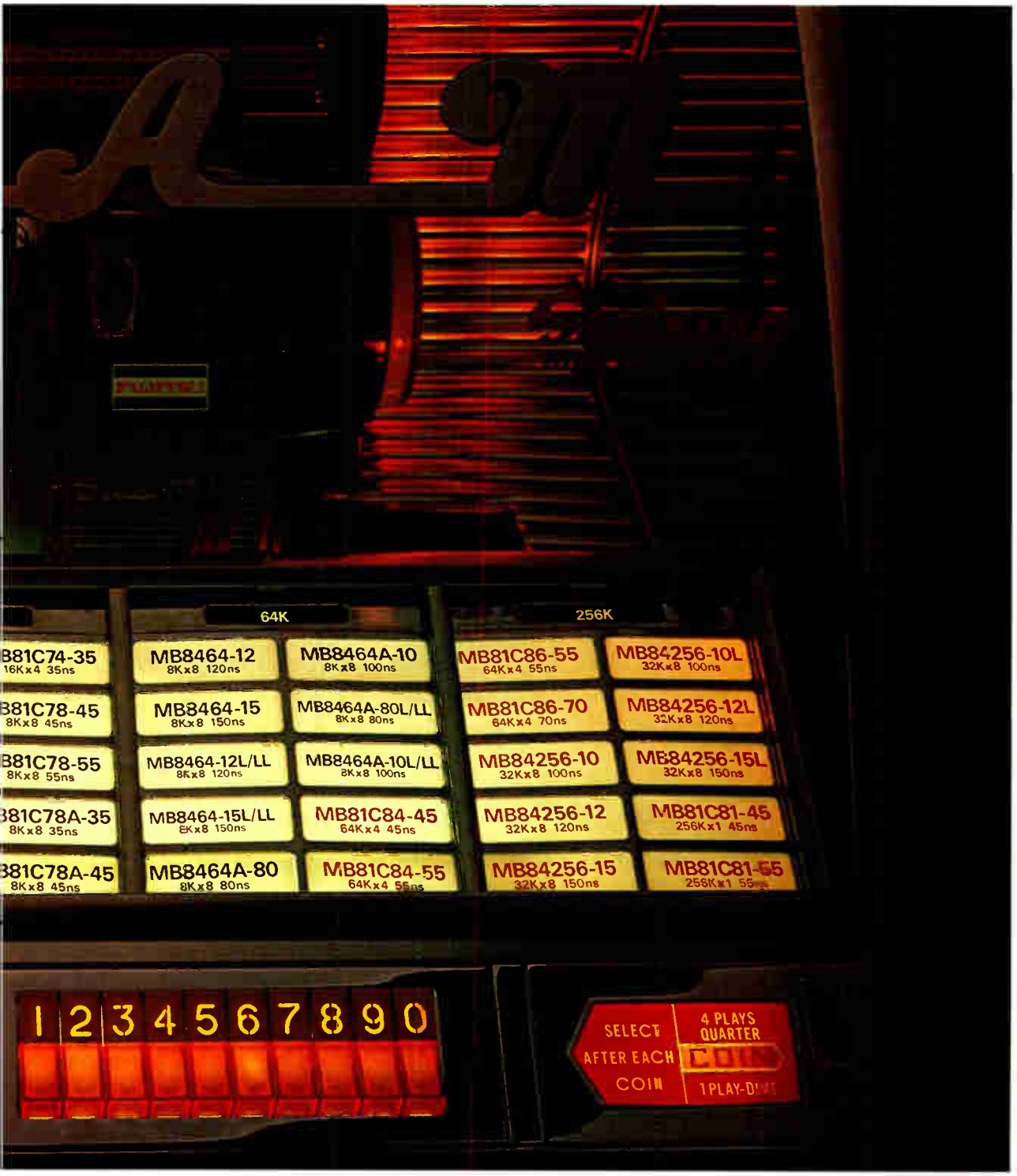

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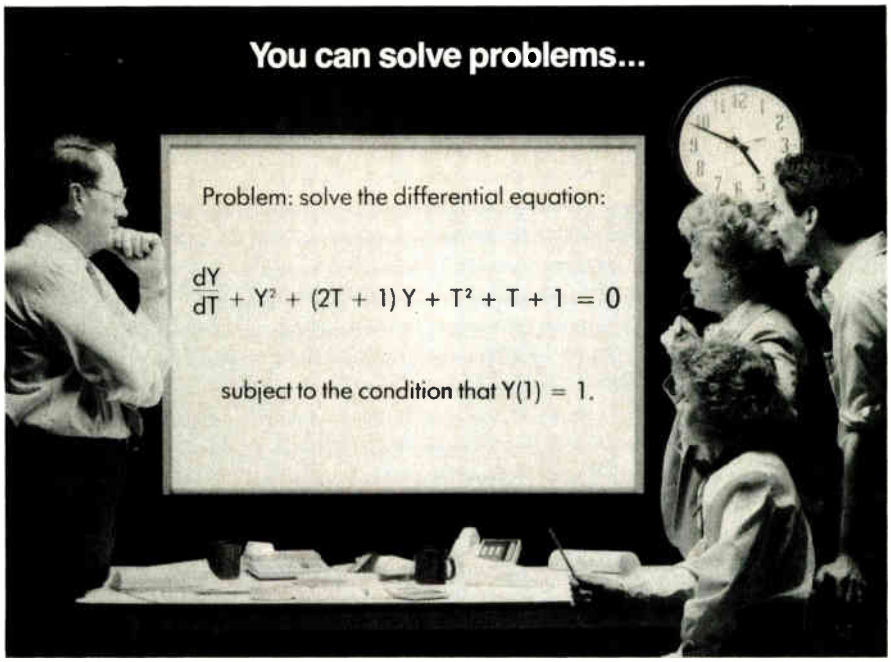

Symbolically...

```
(C1) DEPENDS(Y,T)$
(C2) DIFF(Y,T)+Y^2+(2*T+1)*Y+T^2+T+1;
(D2)  dY/dT + Y^2 + (2 T + 1) Y + T^2 + T + 1
(C3) SOLN:ODE(D2,Y,T);
                              %C T %E^T - T - 1
(D3)                  Y = - ------------------
                              %C %E^T - 1
(C4) SOLVE(SUBST([Y=1,T=1],D3),%C),NUMER;
(D4)                  [%C = 0.5518192]
(C5) SPECIFIC.SOLN:SUBST(D4,SOLN);
                              0.5518192 T %E^T - T - 1
(D5)                  Y = - ------------------------
                              0.5518192 %E^T - 1
```

and Numerically.

```
(C6) FORTRAN(D5)$
      Y = -(0.5518192*T*EXP(T)-T-1)
     1      /(0.5518192*EXP(T)-1)
```

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Circle 102 on reader service card

A LOW-COST WAY TO GET VMEBUS IMAGE PROCESSING

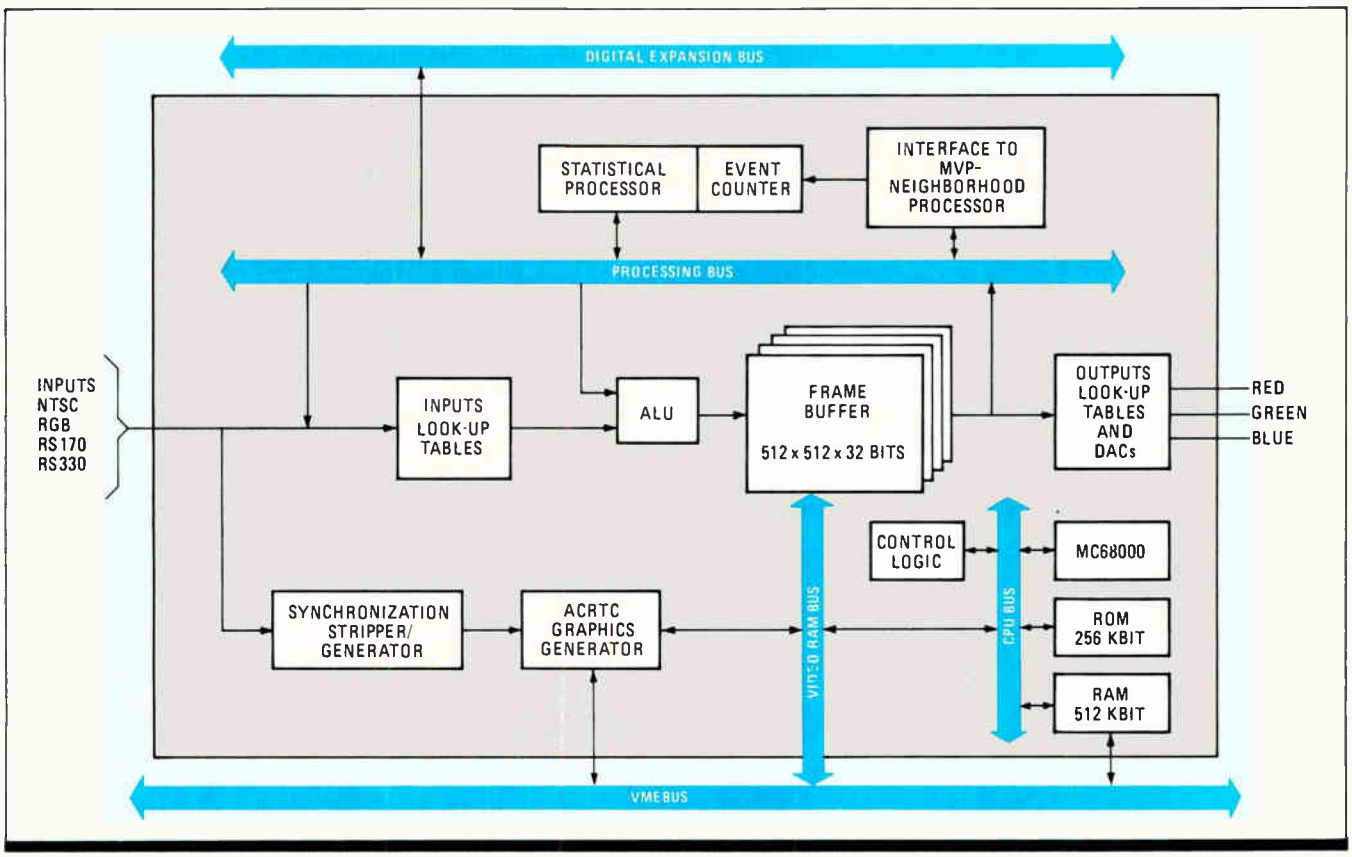
A Canadian company has beefed up its graphics board set without adding much fat to its price, by combining real-time image processing with hardware-generated graphics. The MVP-VME from Matrox Electronic Systems Ltd. provides an easy way for VMEbus systems designers to include both image processing and high-end graphics capabilities in their designs. The two-board set, however, costs $6,000, just one half to one quarter of the price of competing systems.

The MVP-VME is the Dorval, Quebec, firm's second image-processing and graphics-combination board product. The first, the MVP-AT, brought real-time image processing and graphics display to IBM Corp. PC AT users for less than $5,000. The new product offers the same functions to the VMEbus system designer.

By combining basic functions in different arrangements, the board set provides a wide variety of real-time image-processing functions. Onboard processing elements such as the arithmetic logic unit and the statistical processor can be used to perform complex imaging tasks—including area-of-interest processing, where selected rectangular areas of the image are singled out for processing. An optional neighborhood processor increases image-processing speed and adds functions, and state-of-the-art high-performance graphics hardware effectively and efficiently delivers the image to a color monitor.

The MVP-VME (see fig. 1) incorporates true-color digitization, real-time area-of-interest processing, a high-performance Hitachi ACRTC graphics generator, non-interlaced display drivers, four 512-by-512-pixel-by-8-bit frame buffers, and an on-board Motorola MC68000 microprocessor, all on two boards. Options include up to four frame buffers and a neighborhood processing accelerator, the MVP-NP. Neither requires additional slot space. The MVP-VME, which costs $5,995, is designed as a single integrated imaging system. The integrated approach packs more functions and power into less space, because interboard communications protocols are not needed.

The complex real-time image-processing functions performed by the MVP-VME are achieved with software programs that assemble sophisticated operators out of the simple primitive operations performed by the hardware—a primary reason for the low cost of the MVP-VME. The alternative is a separate board for each image-processing function.



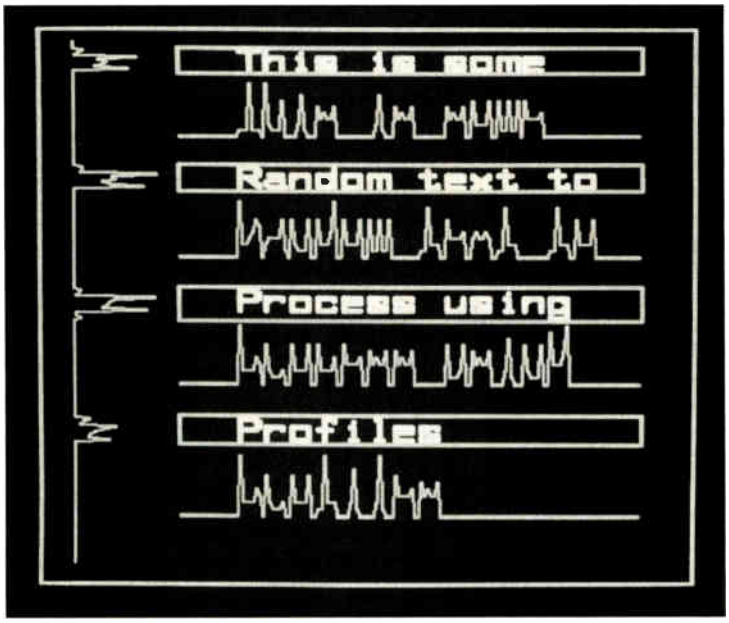
1. INSIDE THE BOARD. The MVP-VME incorporates true-color digitization, real-time area-of-interest processing, a high-performance graphics generator, non-interlaced display drivers, four frame buffers, and a microprocessor.

Among the image-processing primitives, image transforms are key operations. The ALU performs two classes of point-to-point transforms: single- and dual-image operators. Other operators supported are add, subtract, multiply, or divide by a constant; add or subtract two images; calculate the minimum or maximum of two images; negate absolute value; and mix two images on a pixel-by-pixel basis. Athough important by themselves, these primitives are even more useful as building blocks for more sophisticated operations. For example, a convolution is expressed as $K_1P_1 + K_2P_2 + \ldots + K_nP_n$ where the K's represent a series of constants and the P's are the neighbors of the pixel to be convolved. The convolution is performed by combining multiplication and addition operators. Because a multiply/accumulate operation can be performed in one step with the MVP-VME, an entire 512-by-512-pixel image may be convolved using a 3-by-3-pixel kernel in nine passes over the frame buffer, taking one third of a second.

THE STATISTICAL PROCESSOR

The statistical processor obtains global information about an image. It supports three main processing techniques: histograms, profiles, and the minimum and maximum operators. Histograms represent the number of pixels at each intensity in an image and provide information about the distribution of intensities, allowing the implementation of algorithms that enhance the contrast of designated images.

Profiles take a sum of the pixel values along each line or column in the image and are used to obtain information about the shape and location of objects. For example, in a character-recognition system (see fig. 2), a Y-profile, which sums pixels along the y axis, will extract the location of each line of text in the image. X-profiles, which sum pixels along the x axis, are then performed on each text line to find the characters. That information will help determine the shape of a character. Minimum and maximum operations simply retrieve the minimum or maximum pixel value in a region of interest.



2. CHARACTER RECOGNITION. In a character-recognition system, a Y-profile will extract the location of each line of text in the image.

Three area-of-interest algorithms—a scan-out rectangle, a write-back rectangle, and an object-of-interest bit plane—increase processing speed and precision. Like most image-processing hardware, the MVP-VME supports a rectangular area of interest, which takes the pixels that are to be scanned out of the frame buffer and sent to the processors. Processing an area of interest increases the speed of operation; scanning is restricted to a fraction of the buffer.

The optional plug-on neighborhood-processor daughter board serves two purposes: it speeds up the MVP-VME and it adds functions. Convolutions, erosions, dilations, and other neighborhood operations are speeded up fivefold, making the system practical in real-time assembly-line applications.

In addition, a new class of operators will become possible with the neighborhood processor, which establishes the new value of a pixel from changes in the pixels surrounding it—the neighborhood. Among them are color processing, feature extraction, and pattern matching.

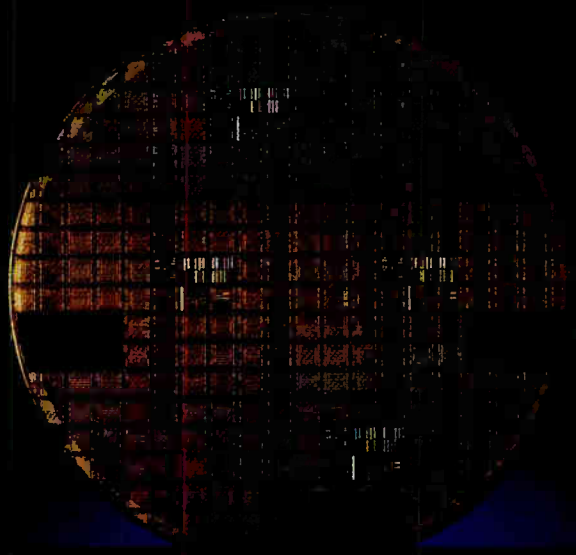
Color operators are used to extract information about the color content of an image. In many industries, such as cosmetics and food processing, color is essential.

To find special types of features in an image, the feature-extraction process takes the result of any neighborhood operation, passes it through two comparators, and generates the x-y coordinate of any pixel that meets one of four possible test conditions: below the minimum, above the maximum, between the two, or outside the two. Because the operation is pipelined, feature extraction does not take additional time.

The third operator class, pattern matching, passes a binary mask over the image and matches it against each point in the image. A value is generated to indicate the number of pixels in the mask that have corresponding pixels in the image. An 8-by-12-pixel mask is passed over the image in two frame times, resulting in a peak processing rate of over 500 million pixels/s.

An important objective in the development of the MVP series was to improve the user interface for image processing. Using a high-performance graphics engine, the Hitachi ACRTC, the designers increased drawing speeds by an order of magnitude or more. Character and cursor updates are fast and responsive. With four overlay bit planes, information can be superimposed on an image without destroying it. The user also can have up to 12 bit planes of image data in pseudo-color mode or 24 bit planes in true color mode. *–Tom Manuel*

For more information, circle 483 on the reader service card.



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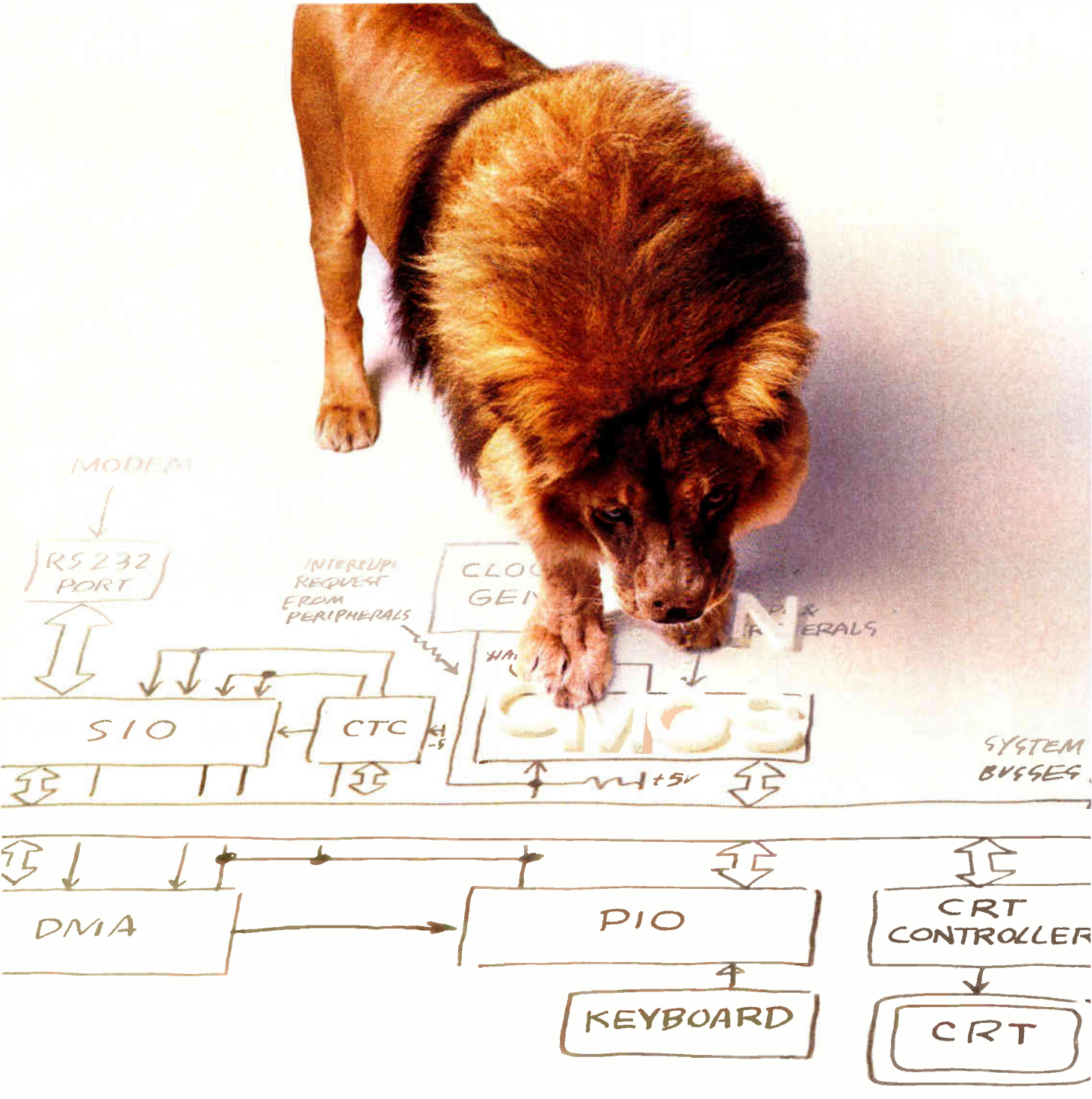

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TMPZ84C30	CTC: Counter/Timer Circuit	CMOS	3mA	< 10μA
TMPZ84C20	PIO: Parallel Input/Output Controller	CMOS	2mA	< 10μA
T6497	Clock Generator/Controller	CMOS	2mA	< 10μA
TMPZ84C40	SIO: Serial Input/Output Controller	CMOS	25mA	< 10μA
TMPZ84C10	DMA: Direct Memory Access Controller	CMOS	25mA	< 10μA

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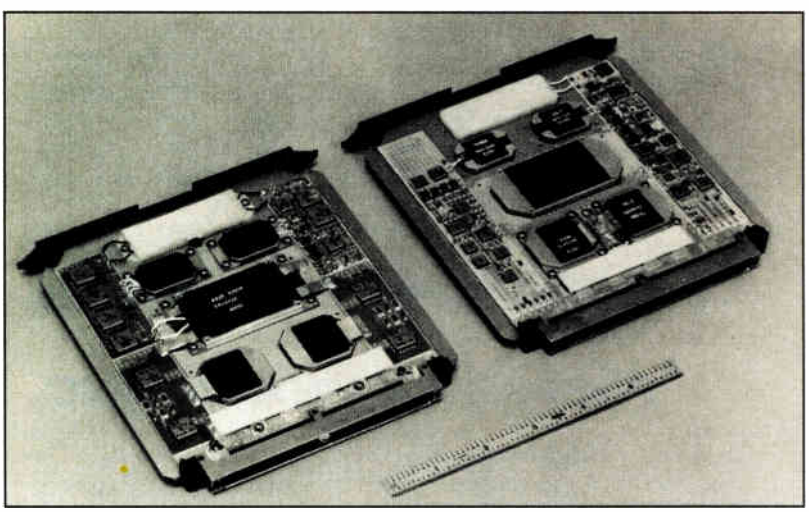
Circle 107 on reader service card

MILITARY: TI CUTS THE SIZE OF POWER SUPPLIES BY 90%

By applying new packaging and circuitry concepts to the design of military power supplies, engineers at Texas Instruments Inc., Dallas, have produced a family of modular power supplies that offers a 90% reduction in size and therefore a tenfold increase in power density over discrete power supplies of equivalent performance.

Power supplies are a standard element of every military electronics system, but their design and packaging have not kept pace with the advances in circuitry and high-density packaging techniques seen elsewhere in these systems. As a result, power supplies in today's military electronics systems often occupy as much space as the rest of the components combined. With the introduction of surface-mount technology, thick-film hybrid techniques, and high-density integrated circuits derived from the Pentagon's Very High Speed Integrated Circuits program, system electronics are getting even smaller, pressing the need to reduce the size and weight of power supplies while retaining power density, efficiency, and high reliability.

By combining efficient switching regulator design with low-profile magnetics, thick-film hybrid techniques, and surface-mount technology, TI's engineers have achieved this goal. The units in the company's new modular family measure just 6.5 by 5.8 by 0.5 in. and weigh as little as 1.3 pounds. A typical unit, the HVS200-5 (see fig. 1), delivers 200 W at 5 V from a 270-V dc source with an efficiency of up to 80%. It achieves a 10 : 1 reduction in volume over commercial power supplies of equivalent performance.



1. COMPRESSED POWER. The compact size of TI's MIL-qualified power supplies results from the use of small surface-mounted hybrids and miniaturized magnetics.

The modular packaging approach was chosen to permit easy removal and replacement of power supply modules, thus lowering system maintenance costs and reducing downtime. What's more, up to five modules can be used in parallel in a distributed configuration to increase current output capability or to provide redundancy.

A key factor for the modular packaging concept is that the power supplies have the same form factor as the other replaceable system modules, providing identical thermal and mechanical interfaces and yielding additional benefits in reliability and supportability.

The circuit design combines a switched-mode regulator with fixed-frequency pulse-width-modulated feedback control, with internal overload protection and protection against over- or undervoltage, phase loss, phase reversal, and overcurrent.

One of the first of TI's new modular supplies, the HVS-200-5 is currently in a pilot-line type of production and is undergoing test verification. This unit converts 270-V dc power to a regulated 5-V dc output and can be operated in parallel with other similar supplies to provide increased current. This is not a master/slave arrangement, but one in which each supply acts independently—a factor that aids in redundant operation.

This supply is synchronizable to a system clock and features built-in test provisions to isolate fault conditions, including overcurrent and overvoltage conditions. The overtemperature status can be connected directly to an automatic thermal-shutdown input, and remote-sense lines allow compensation for external voltage drops.

The HVS-200-5 conforms to TI's high-density standard-module specifications with dimensions of 6.58 by 5.88 by 0.5 in. and is designed to fit in a 3/4ATR (Air Transport Rack) line-replaceable unit (LRU). Squeezing the 150-kHz switching supply and all its control and logic circuitry (see fig. 2) into the small volume available required a combination of smaller low-profile magnetic and capacitive components. This was made possible by the high switching frequency and the application of thick-film hybrid circuitry with surface-mounted components for the entire power supply's small signal and high-power dissipating elements, such as the power switches and the output rectifiers. In contrast, typical commercial supplies are just now incorporating thick-film hybrids or surface mounting—and only for the low-power portions of the circuitry.

In accordance with military specifications, no electrolytic capacitors are used. Instead, the module uses either ceramic or tantalum microchip capacitors tied together in low-profile modules. TI declines to disclose how it produced the extremely low-profile magnetic components other

than to say it took many hours of design and optimization.

Along with the low-profile magnetic components, the key to this low-volume module is its high-density packaging. The switching supply module is composed of two printed circuit boards on either side of a central metal core. The top board interconnects four thick-film hybrids on small ceramic substrates, plus six low-profile reactive components. These extend through the core and through the bottom board. The bottoms of the four hybrids contact the top of the metal core through cutouts in the top board. This permits efficient heat removal to the card's edge connector. The top board carries the circuitry for such high-level circuits as the rectifiers, power switch, and pulse-width modulation.

The board on the bottom of the module interconnects two hybrids containing the control, built-in test, and bias-supply circuitry, along with the large reactive components. The bottoms of these hybrids contact the bottom of the metal core.

All of the hybrids have their semiconductors mounted in leadless ceramic chip carriers, and all passive components are surface-mountable chips. All components are reflow-soldered to copper thick-film conductors on each hybrid.

TI went to surface mounting of components rather than the customary wire-bonding of chip components normally used in military hybrids for two reasons. First, placing all semiconductors in leadless carriers allowed these devices to be tested, burned in, and even stressed before their assembly to a hybrid substrate—raising system yield and improving reliability.

A second reason was that a surface-mounted board can be modified much more easily than a wire-bonded board with bare chips. This allows TI to create a whole family of power-supply modules by making only minor modifications. Cooling is done by conducting the generated heat from the metal core through the power-supply-card edges to an LRU, where either air or liquid can be used to cool a chill plate. The thermal design is such that when the core is at 70° C, no junction in the supply is higher than 110 °C when the module is plugged into an LRU. The HVS-200-5 delivers 200 W when air-cooled and has the potential for 300 W in liquid-cooled applications, yielding power densities of 10 and 15 W/in.^{3}, respectively. Comparable commercial power supplies have power densities of about 3 W/in.^{3}

TI supports module development with a complete design assurance program consisting of design analysis, design verification test, component and module environmental screening, and manufacturing control.

Design verification testing includes module burn-in, failure reporting and corrective-action systems, and environmental qualification and reliability testing. Components are screened and burned in to appropriate military specifications.

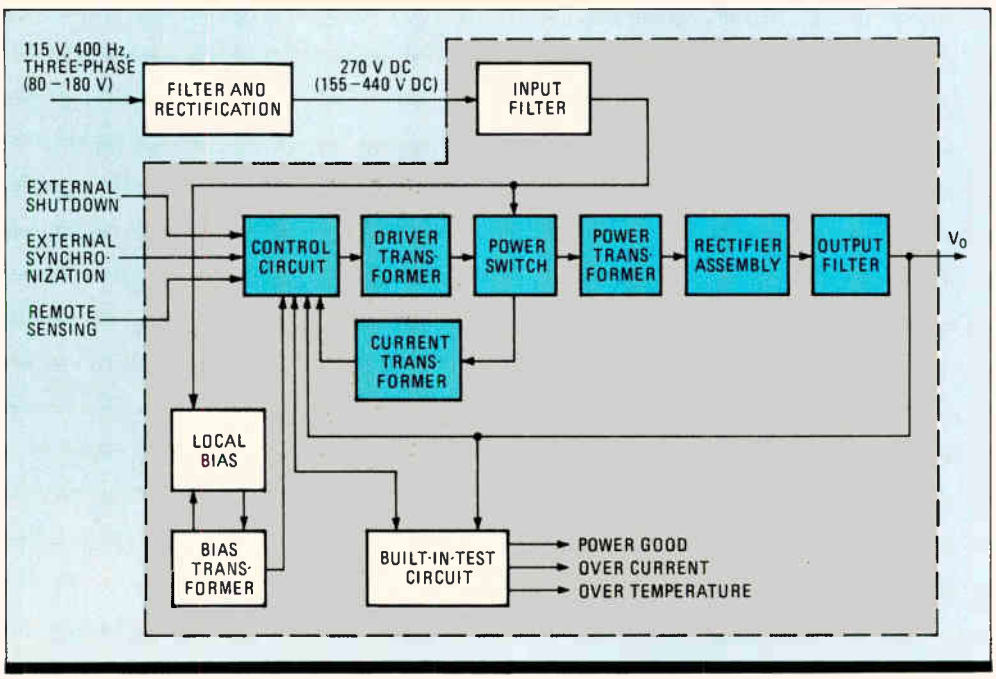
In a typical application, 115-V, 400-Hz, three-phase power would be fed into a combination EMI filter/rectifier producing 270 V dc, as per MIL-STD-704D. This voltage in turn feeds the modular supply, where it is filtered and sent through a pulse-width-modulated MOS switch. The transformer-isolated output of the switch is then rectified and filtered. A sample of the output is fed back and used to control the pulse width of the power switch to regulate the output voltage. The same output-voltage sample is fed into a built-in test circuit whose output is logic-level-type signals indicating the state of several parameters.

The modules have a completely independent bias supply, whose only purpose is to maintain the built-in test circuitry. This makes the built-in test circuits independent of the main supply and allows diagnostic analysis of a possible failure in the primary supply.

The built-in test circuitry continually monitors current, voltage, and core temperature. The circuitry can be configured to put out either differential signal voltages for noise immunity, or open output-collector levels for digital interfacing.

–Jerry Lyman

For more information, circle 484 on the reader service card.



2. AIRBORNE. The modular switching supplies are based on pulse-width-modulation circuitry. The units are fed by 270 V dc and feature a built-in test function for monitoring of power status and module temperature.

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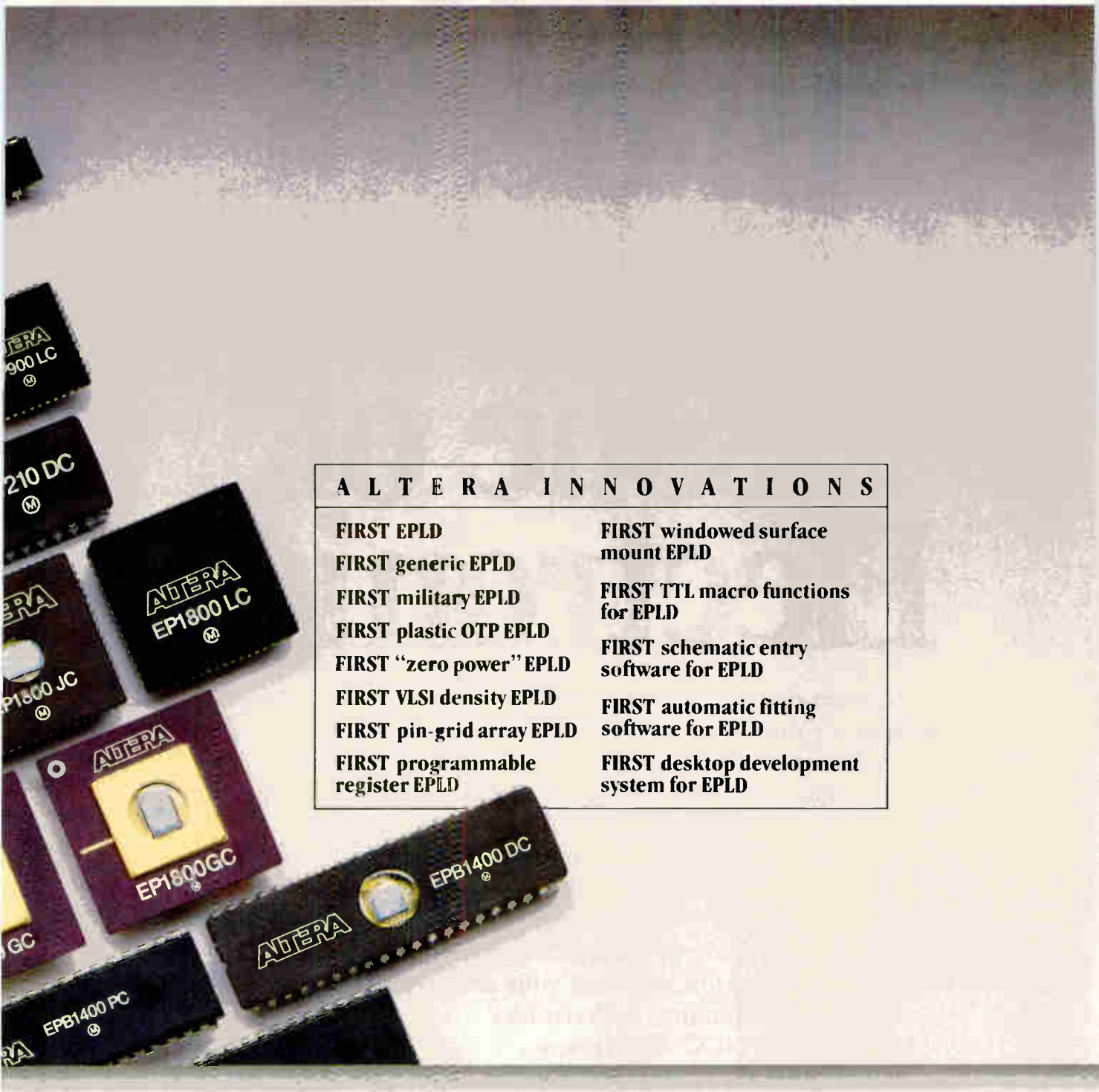

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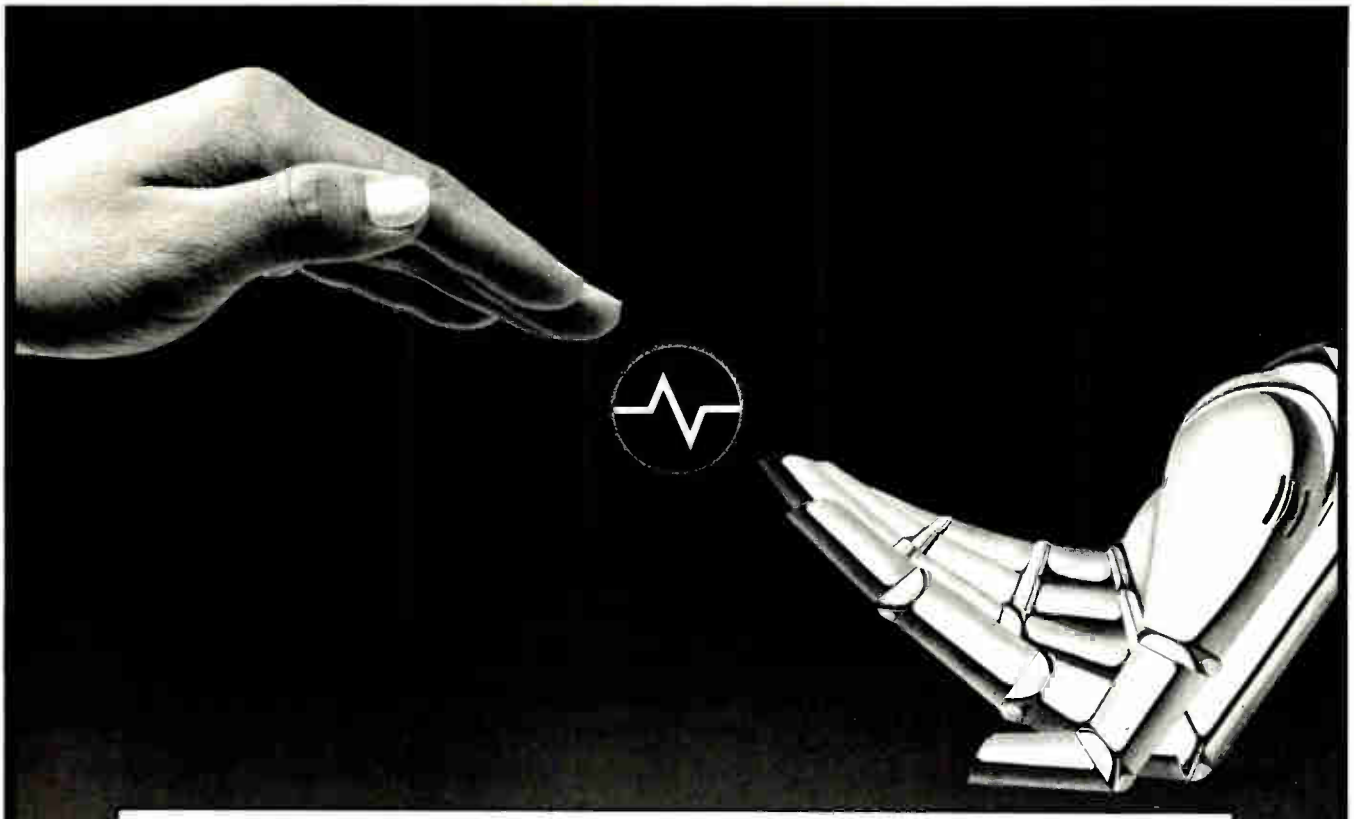

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6–12 October, 1987
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More than 900 exporting companies from Taiwan and other major manufacturing countries will be displaying their wares.
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MILITARY/AEROSPACE NEWSLETTER

SEMATECH SHOULD GET FEDERAL FUNDING; THE QUESTION IS, HOW MUCH?

Backers of the Semiconductor Manufacturing Technology Institute still don't know what level of funding they will get from the government. The Senate Armed Services Committee has proposed an annual budget of $100 million for both 1988 and 1989 for Sematech. However, the committee's request is 10 times higher than the funding proposed by the House Armed Services Committee, which approved a budget of only $10 million for Sematech for 1988. An aide to the Senate Armed Services Committee's new Subcommittee on Defense Industry and Technology indicates that because the Senate and House budget proposals are so far apart, committee conferences will be necessary. Besides the Sematech funding, the Senate committee proposed adding $50 million to the Defense Advanced Research Projects Agency's budget in 1988 for manufacturing technology development, and giving another $50 million to the Defense Department for improving the manufacturing technologies of the three branches of the military. □

PENTAGON MOVES AHEAD ON VHSIC TECHNOLOGY EXPORT POLICY...

The Pentagon is reviewing procedures for sharing Very High Speed Integrated Circuit technology with U. S. allies and may publish them by late June. In addition to design and processing data, there is a plethora of hardware information related to various weapon systems or military applications. As a result, VHSIC devices have been placed on the U. S. Munitions list and are subject to International Traffic in Arms Regulations, or ITAR. The VHSIC export policy will assign a release category to each element of the VHSIC program. The Pentagon has already issued two documents that deal with the security aspects of VHSIC technology: the VHSIC Program Security Classification Guide and the VHSIC Technology Security Program. Technical data, even if unclassified, will require a validated license under ITAR for release to another country. □

... BUT DELAYS VHSIC LANGUAGE DOCUMENTATION REQUIREMENT

The Pentagon is postponing at least until October its mandate that all components it procures must have Very High Speed Integrated Circuits Hardware-Description Language (VHDL) documentation. The delay from the original July deadline came about when the IEEE's subcommittee on VHDL analysis and standards had to make administrative changes in its procedures to meet the Institute's balloting requirements. As a result, balloting won't be completed until late June, and the subcommittee won't be meeting again until the middle of September. IEEE acceptance of a VHDL Reference Manual will establish an industry standard. Meanwhile, the VHSIC Program Office at Wright-Patterson Air Force Base, Dayton, Ohio, is working with Bell Northern Research in Canada to produce a subset of the proposed IEEE VHDL standard for computer-aided design and manufacturing. The CAD/CAM standards will be available in August. They are being developed under a U. S.-Canadian government contract. □

NATIONAL SEMICONDUCTOR OFFERS ON-LINE MILITARY-TEST-SPEC CATALOG

National Semiconductor Corp. has developed an on-line electronic catalog of military test specifications for integrated circuits. The directory includes a detailed listing of essential electrical tests performed on all military devices qualified by National, as well as test-program revision information. National's sales personnel will be able to access the system by the end of the year, and computer-printed copies of test specifications can be supplied at no charge to customers from National's sales offices. □

MILITARY/AEROSPACE NEWSLETTER

ARMY SCALES DOWN ITS DEVELOPMENT PLANS FOR THE LHX HELICOPTER

The Army has revised its development plans for the LHX helicopter and now seeks a less costly 57-month demonstration/validation program. Current plans call for the construction of four avionics-laden scout and attack versions of the LHX with two seats, but operated by a single pilot. Predesign work is also anticipated during the demonstration/validation phase on a second LHX for observation and utility missions. The LHX will eventually replace the OH-58 Scout, AH-1 Attack, and UH-1 Utility helicopters. If the Army's proposal is approved, requests for proposals will be issued in early June and fixed-price contracts will be awarded in January 1988. Competition to build the new helicopter has already begun, with a team led by McDonnell Douglas and Bell Helicopter bidding against a team led by Boeing and Sikorsky. Under the proposed schedule, 24 aircraft are to be delivered in 1994. A total of 4,168 LHX helicopters would be acquired—2,004 scout and attack versions and 2,164 assault aircraft. The Army originally requested $408 million in funding for LHX research and engineering for 1988 and another $616 million for LHX development work in 1989. Some observers believe, however, the Army may still have to sacrifice other weapons programs to get the LHX off the ground. □

PROPOSED JAPANESE FIGHTER LOOKS LIKE A MAJOR AVIONICS OPPORTUNITY

Despite declarations by Japanese government officials that national pride and anticipated technological benefits make it vital for Japan to build its own fighter aircraft, Forecast Associates, a market research and consulting group that closely follows international aviation markets, is predicting that Japan will either buy an American fighter as part of a military buildup, or opt for coproduction with U. S. aircraft makers. In either case, U. S. avionics manufacturers would benefit. The Newtown, Conn., organization cites two reasons for its prediction: pressure from the U. S. aimed at improving its balance of trade with Japan, and the improbability of Japan's designing and building from scratch a combat-ready fighter before the mid-1990s. Forecast's best-case near-term scenario is that Japan will go along with a Pentagon request to take a more active self-defense role, including extending its maritime coverage from a few hundred miles to 1,000 miles off its coastline—a task that would add greatly to Japan's avionics needs. There's one possible hitch, however: the Pentagon believes that Japan's military security measures are lax, and it has stopped shipment of a Loral Corp.-built ALR-56C radar warning receiver for the Japanese Air Force's F-15s. □

NAVY'S CAD2 PROGRAM COULD END UP WORTH $2 BILLION IN CONTRACTS

Final request-for-proposal documents for the Navy's CAD2 Phase 2 computer-aided design and computer-aided manufacturing program won't be issued for several weeks, but industry observers are already anticipating contracts worth more than $1 billion. In time, the Navy's CAD/CAM program could be worth $2 billion. More than 40,000 Navy engineers and designers will acquire work stations during the five-year contract from mid-1988 to mid-1993. Work-station software is expected to represent 41% of the total award, with another 28% allocated to hardware, 13% to peripherals, and 18% to service. Contracts will call for systems delivery to more than 380 separate Navy installations. The CAD2 program and related business will represent 10% of the overall North American market in technical work stations during the first year of the contract, and this could grow to 20% or 25% by 1990, according to Dataquest Inc., a San Jose, Calif., market research firm. Dataquest also expects 10 or more prime vendors to be in the final running for contracts from five Navy systems commands. □

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NORTHWEST

NEW PRODUCTS

LEITZ SAYS MASK-MEASURING UNIT IS FOUR TIMES MORE ACCURATE

ITS LMS 2000 OUTDOES COMPETITORS BY MEASURING WITHIN 30 NANOMETERS

A West German mask-measuring system boasts an accuracy to within 30 nm in production operation—four times the accuracy of competing systems, according to its maker, Ernst Leitz Wetzlar GmbH. The LMS 2000 can make up to 100 measurements automatically in each of the x and y directions in 15 min and can handle masks up to 9 by 9 in. in size.

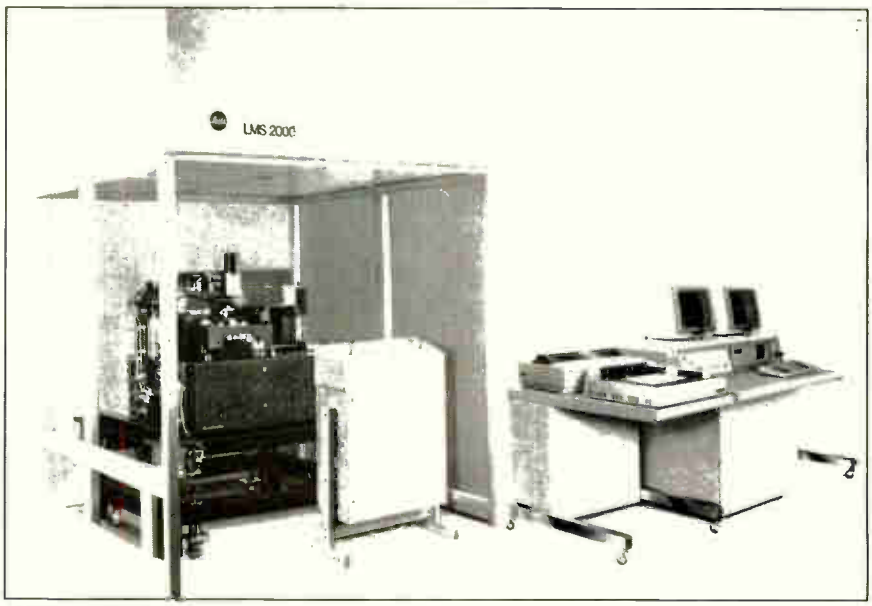
The LMS 2000 achieves its ±30-nm accuracy with high repeatability. Over a measuring distance of 200 mm, 95% of the measured results do not deviate by more than 20 nm from the actual value, the company says.

WELL AHEAD. The LMS 2000 is four times more accurate than competitive systems, claims the West German firm. To illustrate its accuracy, Ewald Bentz, head of Leitz's Semiconductor Equipment Division in Wetzlar, points out that 30 nm is just 1/50 the side length of a bit cell in a typical 256-Kbit dynamic random-access memory. The LMS 2000 "will cover the industry's submicron mask-measuring and inspection needs well into the 1990s," says Bentz.

The system owes its high accuracy to interferometric alignment techniques. All parts that can conceivably drift—such as mirrors, the x-y table, and the lenses—are interferometrically monitored and drift-compensated, using a Hewlett-Packard helium-neon laser with a resolution of 5 nm relative to the mask-carrying x-y table, says product manager Holger Feindt.

An absolute necessity for precise measurements is an environment chamber with a highly constant temperature, says Feindt. If temperatures vary, he says, so do the mechanical and optical characteristics of the measuring head and the laser, adversely affecting accuracy. So the whole measuring setup is contained in a chamber in which the temperature is kept constant to within ±0.05° C.

Measurements are performed with a technique whereby a 0.25-μm-wide slit scans the mask over a 100-μm range. This range is divided into 10,000 steps, which means that the evaluation electronics registers up to 10,000 light-intensity readings for one scan. The measuring head above the mask contains a lens and the zoom optics for a charge-coupled-device camera. The camera presents a 200-by-200-μm area of the mask on a monitor.



AUTOMATED. Measurements, mask alignment, and focusing on the LMS 2000 are fully automatic, controlled by an IBM Corp. PC AT with a 20-Mbyte hard disk.

The electronics controlling the temperature, the operation of the measuring head, and the power supply come from Leitz's American affiliate, Leitz-IMS Co., of Billerica, Mass. So does the menu-controlled software.

The system is controlled by an IBM Corp. Personal Computer AT with a 20- to 40-Mbyte hard-disk drive. Measurements, mask alignment, and focusing are fully automatic. All the operator need do is load the masks into a 10-mask magazine.

For stability, a granite block polished to a flatness of 0.5 μm supports the x-y table. Air bearings allow the table to be moved freely in both directions. A differential-laser interferometer determines the table's position with a 5-nm resolution. A theta drive rotates the mask on the x-y table.

Deliveries are scheduled to start during the second half of 1987 and will take from six to eight months. Prices range from $1 million to $1.2 million, depending on the type of loading system and peripherals. The system also will be built by Leitz-IMS.

—John Gosch

Leitz-IMS Co., 900 Middlesex Tpk., Building 8, Billerica, Mass. 01821.
Phone (617) 663-7070 [Circle 420]

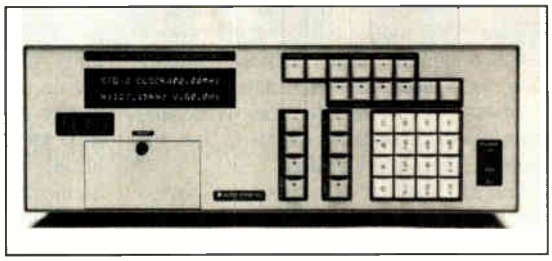
The new era of submicron fabrication technologies will be on display to the more than 10,000 exhibitors and 45,000 visitors expected to attend the Semicon/West annual show in San Mateo, Calif., May 18-21. A wide variety of ground-breaking production equipment, including the mask-measuring system and wafer steppers featured here, will help Semicon/West reaffirm its reputation as the premier showcase for semiconductor production equipment and materials in the U. S.

S E M I

SIGNAL GENERATOR HAS 400-MHz PIXEL FREQUENCY

ASTRO DESIGN'S VG-850 PACKS ENOUGH SPEED TO DEVELOP, TEST HIGH-RESOLUTION DISPLAYS

Astro Design Inc.'s newest video signal generator provides all the performance needed to develop and test 2-K-by-2-K-pixel displays, the type of raster-scan display now being designed for engineering work stations, command-and-control systems, and other very high-resolution color-graphics applications.



AUTOMATIC. The VG-850 offers electrically erasable read-only memory storage of setups for easy testing.

Astro's VG-850 runs at pixel frequencies to 400 MHz, twice the rate of the company's previous video signal generators. It easily surpasses the 360-MHz dot-clock frequency and 125-KHz scan rate typically needed to refresh a full-screen test pattern filled at 2-K-by-2-K resolution. The analog dot-clock limit is 400 MHz, the digital limit is 480 MHz, scan rates go to 200 KHz, and frame formats range to 4,080 lines.

This performance was achieved with a 480-MHz voltage-controlled oscillator, phase-locked frequency synthesizers, and gallium arsenide circuits from Gigabit Logic Corp., Newbury Park, Calif.

All colors and grey-scale levels are available at the 400-MHz pixel rate, along with 2.5-ns pulses. For example, color test patterns can have as many as 16 differently colored blocks, with the red, blue, and green components varied in 1% steps. Also, 16 out of 100 grey-scale levels can be randomly selected. Distortion-checking patterns can be programmed in single-dot and single-line increments.

The VG-850 also offers single-pixel control, push-button selection of standard test patterns and character fonts, superimposed patterns, programming of custom patterns and characters, and electrically erasable read-only memory storage of test setups. Like previous Astro video generators, it is based on an 8086 microprocessor system and can be operated through the front panel, an IEEE-488 bus, or an RS-232-C port.

Last year, the Tokyo-based firm introduced a 200-MHz model for designers moving up to 1.6-K-by-1.3-K displays. But as display technology has accelerated, design companies have experienced testability bottlenecks, says George Stoeppel, president of Test & Measurement Systems Inc., which markets and supports the Astro line in North America.

REFRESHING. Display designers are now using Astro's 200-MHz VG-809 generator to trigger sets of high-speed pulse generators for testing of 2-K-by-2-K displays one pixel at a time, says Stoeppel. Without refreshable test patterns, military equipment designers, for instance, can't tell if radar blips will be properly spaced. That will end when the VG-850 ships in July, Stoeppel says.

The VG-850 costs about $7,000 more than the 200-MHz VG-809, at its North American list price of $23,300, but it will enable designers to see and correct such problems as frequency-response distortion, color infidelity, and mislocated pixels at the higher resolution.

–George Sideris

Astro Design Inc., 4-17, Denen-Chofu 2-Chome, Ohta-Ku, Tokyo 145, Japan.
Phone 81-3-722-0911 [Circle 381]
Test & Measurement Systems Inc., 2934 Corvin Dr., Santa Clara, Calif. 95051.
Phone (408) 720-8777 [Circle 382]

CAD LINE COVERS PC-BOARD WATERFRONT

Calay Systems Inc. has based its new line of printed-circuit-board design work stations on a bedrock tenet: pc boards vary so widely in complexity that no single package of hardware and software for computer-automated design can handle them all cost-efficiently.

Calay's Design Automation family consists of three machines. The top-of-the-line DA5000 targets the most complex multilayer boards. The slower DA3000 has automated routing features. The DA1000 is an entry-level computer-aided-design work station.

HIGH TO LOW. It is difficult to compare the throughput of pc-board design work stations, the company says, but for identical boards, the DA5000 is five times as fast and the DA3000 twice as fast as the DA1000.

All three work stations are open-architecture, turnkey units that let users integrate them with other design and manufacturing equipment. Each has a similar central-processing unit, but main memory and Winchester-disk systems differ in size, depending on the model. Common software features include packages for interactive graphics design and multilayer circuit routing, among others.

The DA5000 couples high-performing hardware and software features, among them automatic component placement and 100% multilayer, variable-grid autorouting that uses a reduced-instruction-set-computer accelerator. This feature enables the work station to optimize the routing of pc board layout, after all connections are done, by adjusting line lengths and critical spacing.

The variable grid allows resolution down to 0.001 in. This is useful for pc-board designs using newer components, such as pin-grid arrays, and for surface-mount packages, which have odd spacings, the company says. The machines can handle large, complex board designs, which often have a mix of surface-mount and through-hole-mounted components implemented in many chip technologies. The hardware supplied with the $120,000 DA5000 includes an 85-Mbyte hard disk, a color monitor, a printer, and work-station furniture.

The mid-range DA3000 has better graphics performance and autorouting options than the DA1000 and costs $90,000. It addresses the center of the pc-board design market and is expected to lead the new family in sales.

ALL THE TOOLS. The DA1000, at $65,000, comes with capabilities for interactive graphics, component placement, multilayer autorouting in hardware, and post-processing software. Also standard with the DA1000 is software for handling surface-mounted devices. The machine has a 25-Mbyte disk drive.

The new family replaces the Calay VO3 and V04 stations, whose early versions in 1982 are credited with introducing fully automatic routing in pc-board design. Delivery on the new models is 30 days. *–Larry Waller*

Calay Systems Inc., 2698 White Rd., Irvine, Calif. 92714.
Phone (714) 863-1700 [Circle 383]

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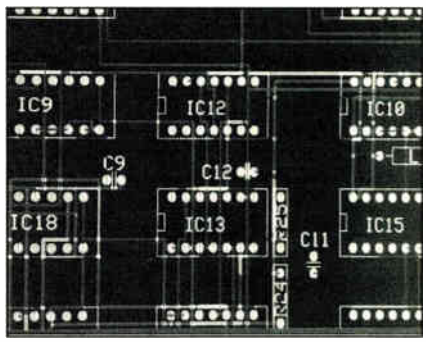
PCB DESIGN TOOL COSTS JUST $695

Visionics Corp.'s EE Designer layout tool set for printed-circuit-board designers handles board sizes of up to 24 by 24 in. with as many as 26 design layers and 16,000 components, but it costs only $695.

The package, which offers features typical of much more expensive computer-aided-design tool sets, targets designers who already have design-entry software packages that perform schematic capture and simulation but need a back-end pc-board layout system, the Sunnyvale, Calif., firm says.

The tool also allows design engineers to define up to eight different board trace widths and 10 different pad sizes. Other features include rubber-banding of connections, rat's-nest function, automatic design-rule checking, automatic



parts placement, component and gate swapping, and interactive trace manipulation at any angle.

The software automatically inserts vias while routing traces, generates silkscreen and solder masks, and produces component reference text.

UTILITIES. Optional utilities include Gerber-format file output for photoplotting, and automatic routing for two-sided boards, including vias/no-vias modes and trace-repeat function.

The software is intended to work with schematic-entry software from Orcad Systems Corp., Hillsboro, Ore., and Omation Inc. (Schema), Richardson, Texas, and converts standard library symbols of the Orcad or Schema schematic-capture systems into Visionics library symbols.

The software requires an IBM Corp. Personal Computer XT, AT, or compatible with 640 Kbytes of random-access memory, a hard-disk drive, and a bidirectional parallel communications port. The system also needs an IBM Enhanced Graphics Adapter equivalent display option. The software is available 30 days after order. *–Jonah McLeod*

Visionics Corp., 343 Gibraltar Dr., Sunnyvale, Calif. 94089.
Phone (408) 734-9012 [Circle 380]

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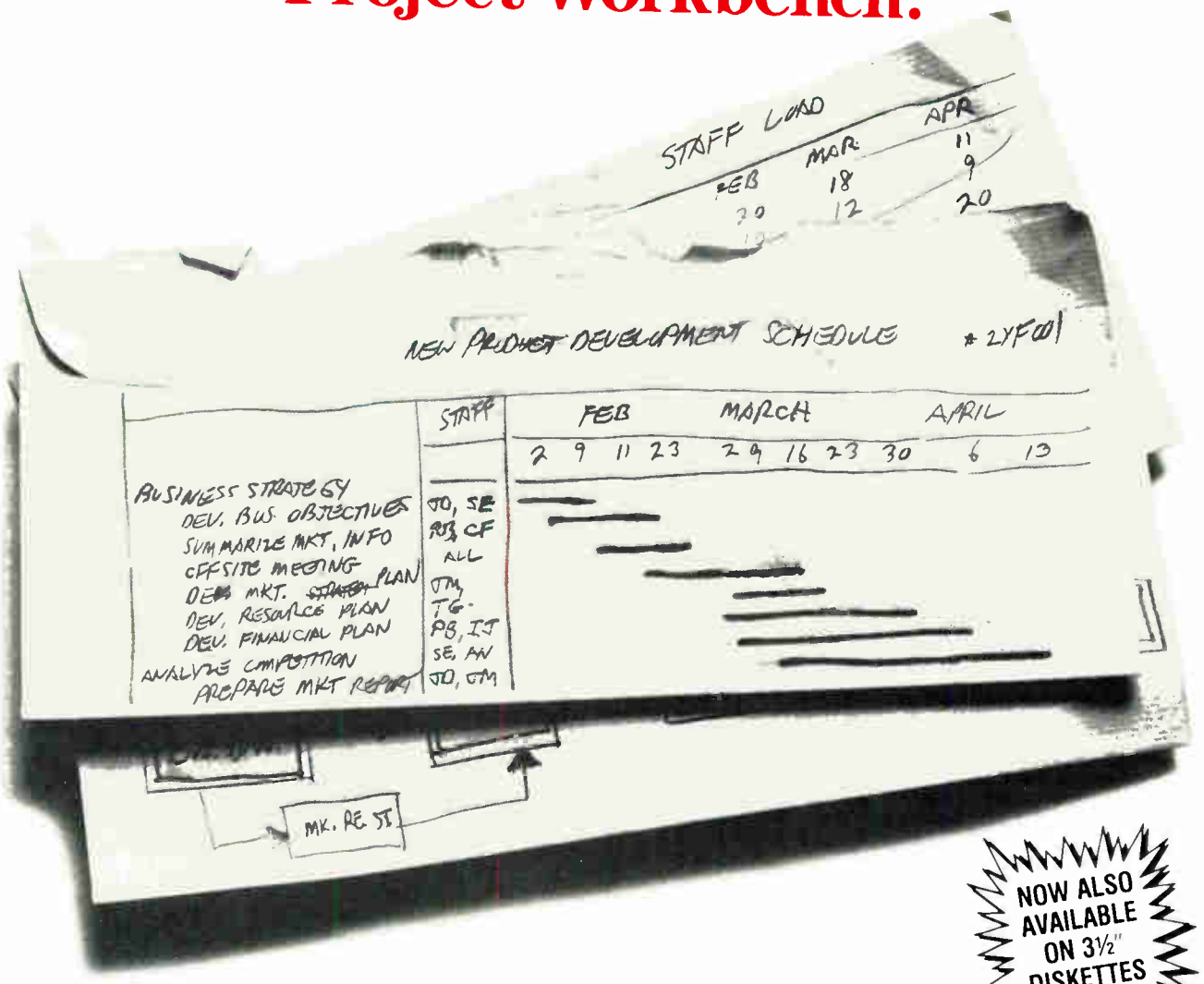

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TI'S LOGIC FAMILY PUTS POWER PINS IN CENTER

SIX DEVICES WITH 8-ns SPEEDS CHALLENGE INDUSTRY AND PUSH FAIRCHILD'S FAST FAMILY ON PERFORMANCE

The advanced 1-μm CMOS logic family that touched off an industry feud over package pinouts last year is being launched by Texas Instruments Inc. with a dozen devices that boast 8-ns clock-to-cue speeds.

TI's new ACL product line breaks with the standard pinouts of previous commodity glue logic by moving ground and power pins away from the corners to the center of dual in-line packages and surface-mountable, small-outline integrated-circuit packages. TI maintains that inductance in long leads can cause voltage spikes on unswitched pins during simultaneous output switching in the fast CMOS logic.

The only solution—save slowing down the parts—is to shorten the power and ground pins, says Bill Thompson, strategic marketing manager of TI's bipolar and CMOS logic. The pinout scheme adds a ground pin for every pair of data output pins. Up to two power pins will be used on 24- and 28-pin ACL functions, many of which are octal buffers, latches, and flip-flops. TI also is using a new flow-through architecture that places most input pins on the right side of the packages and output pins on the left [*Electronics*, Aug. 7, 1986, p. 29].

Thompson says the initial ACL parts are showing 50% improvements in quelling system voltage spikes, compared with advanced CMOS logic devices housed in DIPs with ground and power pins at the corners.

SAMPLES. "We now have products released to the market and have been sampling quite a few other functions as well," says Thompson, referring to the target of shipping 35 functions by the end of June. "We are achieving our goal of being very compatible to speeds of the 74F series [the bipolar logic benchmark set by Fairchild Semiconductor Corp.'s FAST family]. Our goal was to come as close to the 74F parts as possible. Some of our devices are faster. Some are a nanosecond slower. We are within 1 to 1.5 ns, either way."

Clock-to-cue maximum speeds are 8.2 ns low to high and 7.5 ns high to low for the CMOS-input ACL parts. That is comparable to the 74F series, which has 7.8 ns low to high and 9.2 ns high to low. Internal propagation gate delays are about 0.5 ns, giving the parts three times the speed of standard high-speed CMOS logic.

GROWING. TI's 1-μm logic family has 103 standard functions in more than 200 devices.

The ACL family is fabricated in 1-μm double-level CMOS, named Epic technology by TI. Power dissipation for the 11074 dual D-type flip-flop function is about 40 mA with input of 5.5 V across a temperature range of −45 to +85°C. If the ACL parts were actively operating 100% of the time in equipment, power dissipation would remain under the levels of 74F bipolar parts under 30-MHz speeds. The devices are designed to have 24 mA of output drive current.

The first wave of 1-μm CMOS gates and flip-flop parts is part of a planned family of 103 standard logic functions. Each part will be available with either TTL- or CMOS-level inputs, making a total of more than 200 component types. About 65% to 70% of the entire logic series is expected to be available for volume shipments by the end of 1987.

Four TTL parts—designated ACT—are available. The 74ACT11030 (8-input positive NAND gate), ACT11074 (dual D-type flip-flop), ACT11109 (dual J-K flip-flop) and ACT11240 (octal buffer line driver with 3-states).

CMOS PARTS. Eight CMOS parts—designated AC—are available: AC11020 (dual 4-input positive NAND gate), AC11074 (dual D-type flip-flop), AC11109 (dual J-K flip-flop), AC11000 (quad 2-input NAND gate); AC11010 (triple 3-input NAND gate); AC11240 (octal buffer line driver with 3 states); AC11244 (octal buffer line driver with 3 states); and AC11373 (octal D-type latch with 3-states).

The four octal chips come in 24-pin packages with two power and four ground pins. They cost $1.41.

The AC11020 and ACT11030N parts sell for 33c each housed in either a 14-pin plastic DIP or surface-mountable small-outline integrated circuit package. The AC11074 and ACT11074 are housed in 14-pin packages, and the AC11109 and ACT11109 chips have 16 pins. They cost 44c each.

The AC11000 and AC11010 are packaged in 16-pin DIPs with a pair of grounds and power pins each and cost 33c each. All prices are for 100-unit quantites. *–J. Robert Lineback*

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By predesigning more than 100 linear, digital, and memory functions into its 6-GHz bipolar VL3000 cell library, VTC Inc. has made it possible for designers to mix linear and digital functions on the same chip without having to design at the transistor level.

The dual-metal library also boasts high-performance cells such as 1.2-ns emitter-coupled comparators, 2,50-V/μs buffers, and 500-MHz operational amplifiers and transconductance amplifiers. It is the fastest mixed linear/digital offering available, says VTC vice president John Hodgson.

Designed for use with ±5-V or +5-V power supplies, the performance of the linear cells exceeds that of typical ±15-V circuits, says Hodgson. For example, the operational amplifiers in the library have slew rates ranging from 30 to 150 V/μs. Unity-gain buffers have slew rates to 2,500 V/μs, he says.

The key to the high performance and high density of the linear cells is the use of a proprietary complementary bipolar process that incorporates not only vertical 6-GHz unity-gain npn transistors but vertical 1.5-GHz pnp transistors as well.

The problem with complementary bipolar circuits has been the lack of vertical pnp devices equivalent in quality and performance to vertical npn structures. Compared with those of vertical npn structures, pnp parameters are less reliable and harder to control. "The addition of a vertical pnp allows engineers to use monolithic silicon to design cir-

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cuits that must source 100 mA of current into a 50-Ω transmission line," says Hodgson. "Plus, more efficient class AP amplifiers can replace power-hungry class A types."

The digital cells include small-scale-integration functions with 350-ps propagation delays and a variety of LSI functions, such as 2901 4-bit arithmetic-logic-unit core cells, dual-port static random-access memories, look-ahead carry generators, and priority-interrupt encoders.

As with the linear cells, the digital cells are capable of flexible power supply configurations with −5.2- and 5.2-V options available.

SERIES GATING. The digital cells in the VL3000 cell library use current-mode logic for fast propagation delays and three levels of series gating, which allows complex macro functions to be implemented with fewer gates while maintaining maximum performance. In series gating, or cascading, one source of current is used to drive two or more sets of transistors that are configured so that the collectors of one set are connected to the emitters of the next higher set.

Included as a subset to the VL3000 cell library is a component library for custom cell design, which allows design of unique or proprietary circuits from predefined transistors, resistors, and capacitors.

The library is designed for use in commercial and military applications requiring maximum linear performance or high digital speeds, or both. Such applications include peripherals, local-area-network transceivers, transmitters and switching elements in telecommunications, pin-driver circuits in automatic test systems, analog signal processing, and high-speed video and RF/UHF systems.

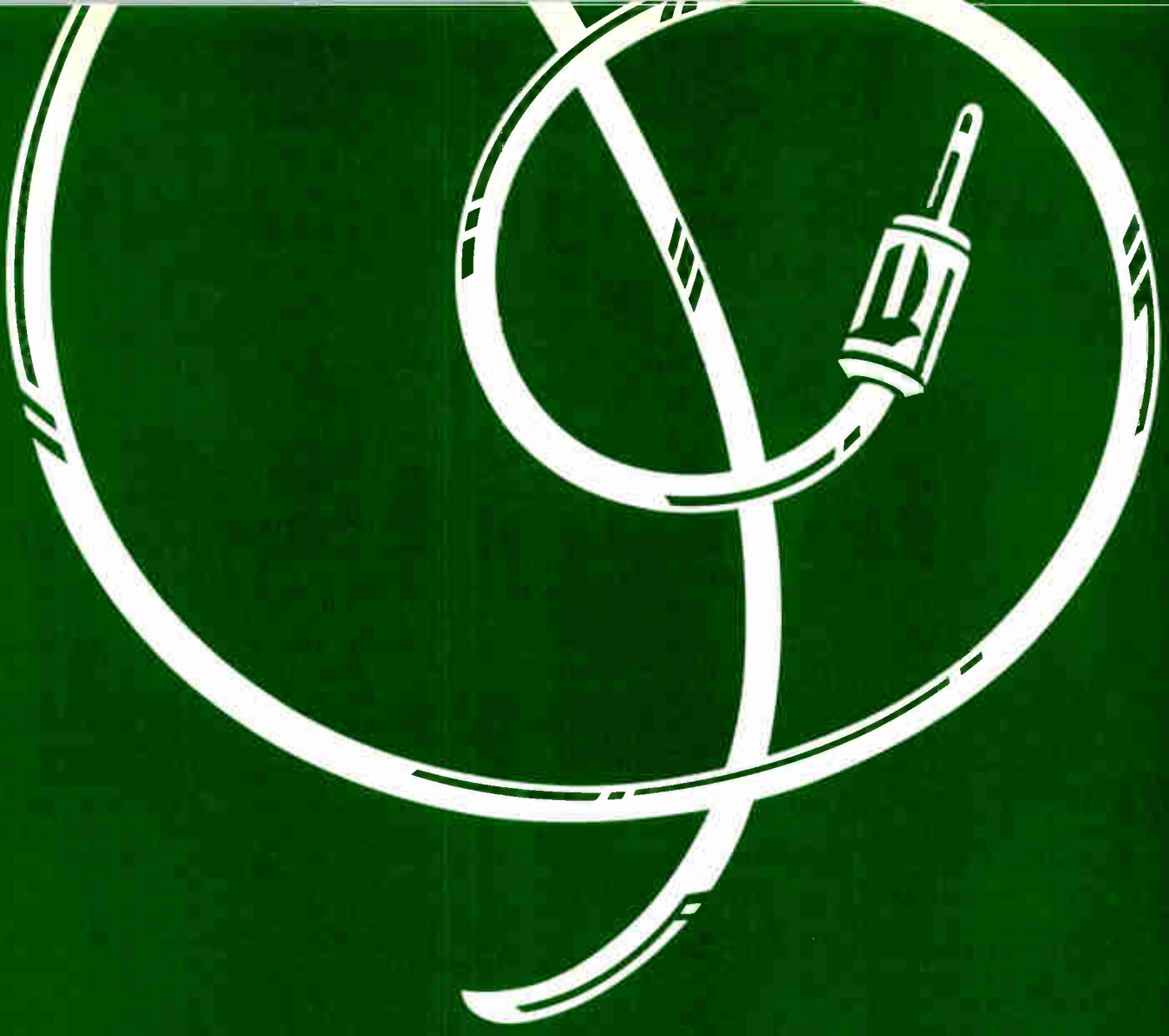
TURNKEY SYSTEM. Available now, the VL3000 cell library is being offered by VTC as a turnkey system, in which company engineers will take a schematic or block diagram and complete design, simulation, circuit layout, design verification, mask construction, wafer fabrication, and circuit testing. However, users have the option of doing the front-end design work using the VL3000 design tools.

The VL3000 cell library runs on a Mentor Graphics Corp. work station. Nonrecurring engineering costs start at $35,000 and include 15 prototypes. VTC estimates that turnaround time will be no more than eight weeks from netlist to prototype.

A design kit that includes floppy disks containing the design tools and comprehensive documentation in text form is available now and costs $400.

–Bernard C. Cole

VTC Inc. 2401 E. 86th St., Bloomington, Minn. 55420.
Phone (612) 851-5222 [Circle 361]



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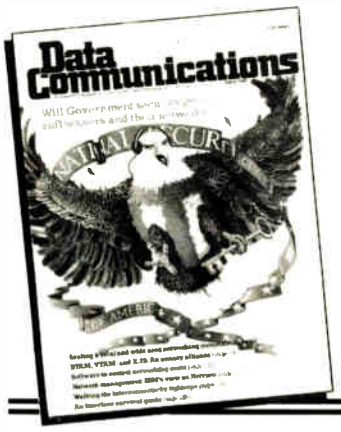

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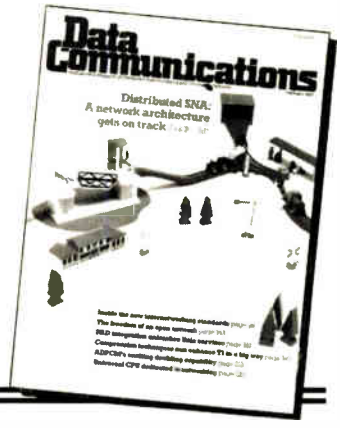

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Product development in a production environment is one of Micron's unique and valuable attributes. Our Research and Development Department employs circuit designers, layout engineers, product engineers and technicians who mutually participate in product development.

The work climate at Micron is characterized by hands-on participation at all levels of the organization. Micron's reputation for innovation in circuit design, quality manufacturing and product reliability is due to the contribution and ideas of our people. And we consider our people to be our most valuable asset.

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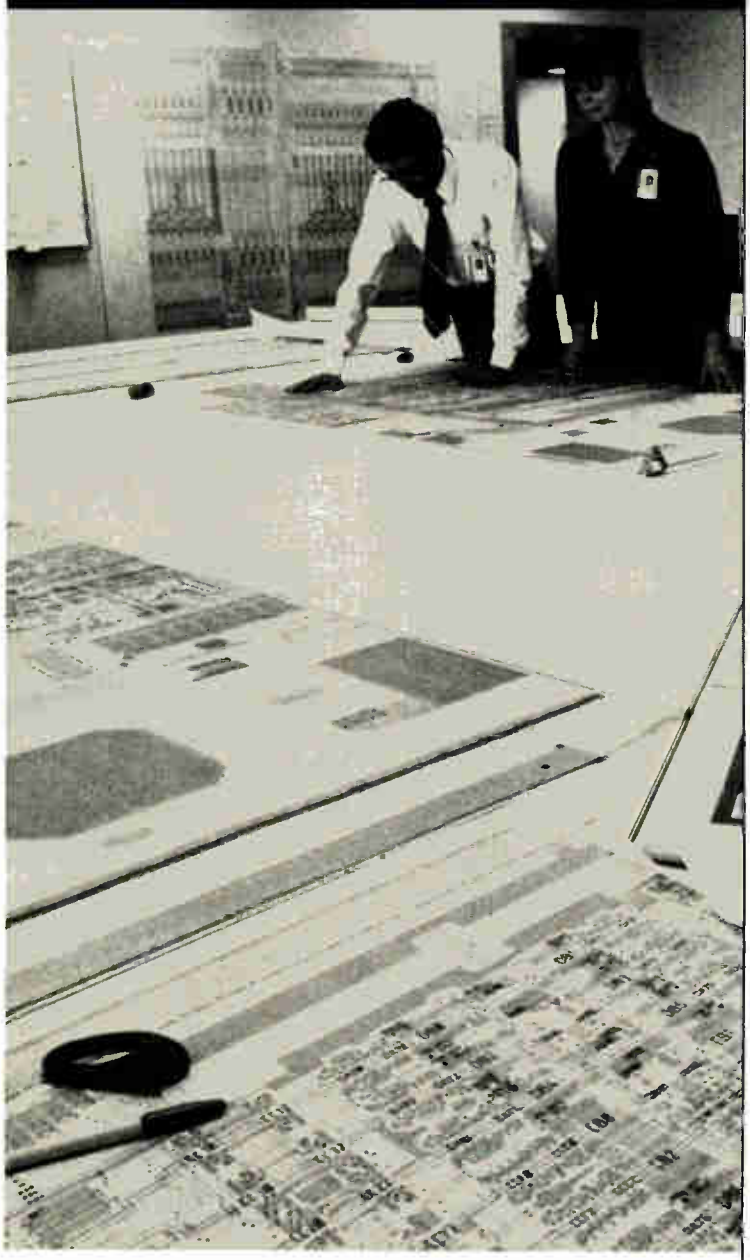
Micron's strategy for the future is to diversify its product line and expand its customer base. Our first steps toward product diversification include 2- and 4-MB memory expansion cards for IBM-compatible PCs. Our next steps will further enhance Micron's reputation for product innovation.



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Rounding out the activities will be the traditional SEMMY Awards Banquet on Wednesday, May 20, at the San Francisco Airport Marriott Hotel. In addition to honoring those selected for SEMMY Awards, attendees will also enjoy guest speaker J. Peter Grace, chairman and CEO of W.R. Grace and Company.

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ELXSI ADDS VECTOR PROCESSING POWER

Elxsi Ltd., San Jose, Calif., is now offering Sky Computers Inc.'s high-performance Vortex integrated vector processors [*Electronics*, March 5, 1987, p. 69] in its System 6400 minisupercomputers. Each of the vector processors from the Lowell, Mass., company can perform as many as 20 million floating-point operations per second in 32-bit mode, or 10 megaflops in 64-bit mode. As many as seven processors, and perhaps more, will be available in the System 6400 when demo units begin to ship in the fourth quarter of this year. Volume shipments are set for 1988. Although prices have not been set, they are expected to correspond with the $140,000 to $200,000 price of Elxsi's current scalar-processor 6400.

InP SOLAR CELLS GAIN EFFICIENCY

An indium phosphide photovoltaic cell produced by Spire Corp., Bedford, Mass., has achieved 17.9% efficiency—a record for InP cells—under simulated deep-space conditions at the National Aeronautics and Space Administration's Lewis Research Center, Cleveland. The cell was developed under a program begun in 1985 at NASA Lewis. It surpasses peak efficiencies of 16% observed in earlier InP cells built by Spire, Arizona State University, and Japan's Nippon Telephone and Telegraph Laboratories. NASA hopes to employ InP solar-cell technology in future spacecraft because of its superior radiation resistance compared with silicon and gallium-arsenide photovoltaics.

PROCESSOR HITS A DIZZYING 2.5 BIPS

Thinking Machines Inc. has bested the speed of its Connection Machine CM-1 processor, which ran at 1 billion instructions per second [*Electronics*, May 5, 1986, p. 16]. Its new CM-2 scorches along at 2.5 bips in data-parallel scientific computing. The Cambridge, Mass., company's new processor reaches 2.5 bips in a double-precision or 3.5 bips in a single-precision floating-point multiplication of two 4,096-by-4,096 matrices. The blazing speeds are achieved by using as many as 64,000 processors to operate in parallel on single data elements of the same program simultaneously. Prices for CM-2 configurations range from $1 million to $5 million; deliveries will begin in the third quarter of this year.

ALLIANT SYSTEM GOES TO BOEING

Boeing Commercial Airplane Co., Seattle, will use an FX/8 minisupercomputer from Alliant Computer Systems Corp., Littleton, Mass., for real-time simulation of various aspects of Boeing's next-generation aircraft, the 7J7. The FX/8 will perform flight simulations that include the autopilot, flight-management, and propulsion systems. Alliant president David Micciche says the application will be the first use of a minisupercomputer in real-time simulation.

STORAGE TEK SETTLES TAX SUIT

The last steps out of bankruptcy proceedings are being taken by Storage Technology Corp. of Louisville, Colo., following a crucial settlement of income tax liabilities with the U.S. government. Storage Tek, once a $1 billion firm and the largest computer-equipment maker to ever file for Chapter 11 protection, has agreed to claims of $37.1 million for interest and income taxes for 1984 and prior years. The company and the Internal Revenue Service had been battling for months over tax liabilities, which were as much as $267 million by IRS accounts and no more than $3 million by Storage Tek's. The settlement is the final major impediment for Storage Tek to emerge from Chapter 11 proceedings after more than two years of protection, says chairman Ryal R. Poppa.

DG UNVEILS HIGH-END LAPTOP . . .

Data General Corp., Westboro, Mass., is launching an IBM PC/XT-compatible laptop computer into a 1987 market in high-end laptops that could exceed 250,000 units. Based on Intel's 80C88 chip, the new Model 2T can be configured with 2.5 Mbytes of random-access memory, a 10-Mbyte hard disk, a full-size backlit LCD screen, a dual-speed CPU, and other user-installable options. An entry-level system with 512 Kbytes of RAM and a 3½-in. diskette drive costs $1,695.

. . . AND MAKES A BEDSIDE TERMINAL

Data General also signed a three-year, $11 million contract with Health Data Sciences Corp. of San Bernardino, Calif., to provide 10,000 hospital bedside terminals. Each terminal is customized with an implosion-proof screen, a board for transmitting data and voice over a single line, an enlarged display on a 14-in. screen, and other features designed for easy interaction.

COMPAQ CHIEF BLASTS IBM PS/2

Highly critical of IBM Corp.'s changes in its personal computer line, Compaq Computer Corp. has declared itself king of the PC clones, vowing not to abandon the original system standards set by Big Blue. "IBM, the company that had the most to do with creating this powerful standard, now has taken some dramatic steps to leave the standard behind," warned Compaq president Rod Canion during a recent news conference in New York. Canion believes the new IBM Personal System/2 introduces too many major incompatibilities with the existing PC standard, including the move to 3½-in. diskettes from the 5¼-in. floppies and the new 32/16-bit Micro Channel expansion bus. Compaq plans to provide as much power as the new IBM units, but without major departures from the existing PC standard. Still, Compaq marketing officials in Houston won't rule out moves to follow IBM if customers begin to demand similar products.

SENTRY NAMES U.S. MANAGER

Schlumberger Ltd.'s Sentry subsidiary has consolidated its North American management under Irwin H. Pfister, who previously headed Sentry Schlumberger's San Jose, Calif., operations, which produces most of the firm's digital-circuit test systems. As vice president and general manager for North America, a new position, Pfister is also responsible for the analog, memory, and digital testers made in Simi Valley, Calif. He reports to Daniel Pujol, Sentry's vice president and general manager.

EDS FORMS ASIAN JOINT VENTURES

Electronic Data Systems Corp., the computer-services arm of General Motors Corp., continues its aggressive push into global markets, with a decidedly Far Eastern tilt. Dallas-based EDS has formed a joint venture in Japan with Nippon Information Industry Corp. to focus on large-scale computer services and telecommunications networks. The birth of Nippon EDS comes only two weeks after EDS announced a joint venture with China for a large computer and data processing center to be built near Beijing. Earlier this year EDS formed joint ventures in South Korea and Italy [*Electronics*, Feb. 19., 1987, p. 18].

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5	20	35	50	65	80	95	110	125	140	155	170	185	200	215	230	245	260	275	352	367	382	397	412	427	442	457	472	487	502	707	901
6	21	36	51	66	81	96	111	126	141	156	171	186	201	216	231	246	261	338	353	368	383	398	413	428	443	458	473	488	503	708	902
7	22	37	52	67	82	97	112	127	142	157	172	187	202	217	232	247	262	339	354	369	384	399	414	429	444	459	474	489	504	709	951
8	23	38	53	68	83	98	113	128	143	158	173	188	203	218	233	248	263	340	355	370	385	400	415	430	445	460	475	490	505	710	952
9	24	39	54	69	84	99	114	129	144	159	174	189	204	219	234	249	264	341	356	371	386	401	416	431	446	461	476	491	506	711	953
10	25	40	55	70	85	100	115	130	145	160	175	190	205	220	235	250	265	342	357	372	387	402	417	432	447	462	477	492	507	712	954
11	26	41	56	71	86	101	116	131	146	161	176	191	206	221	236	251	266	343	358	373	388	403	418	433	448	463	478	493	508	713	956
12	27	42	57	72	87	102	117	132	147	162	177	192	207	222	237	252	267	344	359	374	389	404	419	434	449	464	479	494	509	714	957
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14	29	44	59	74	89	104	119	134	149	164	179	194	209	224	239	254	269	346	361	376	391	406	421	436	451	466	481	496	701	716	959
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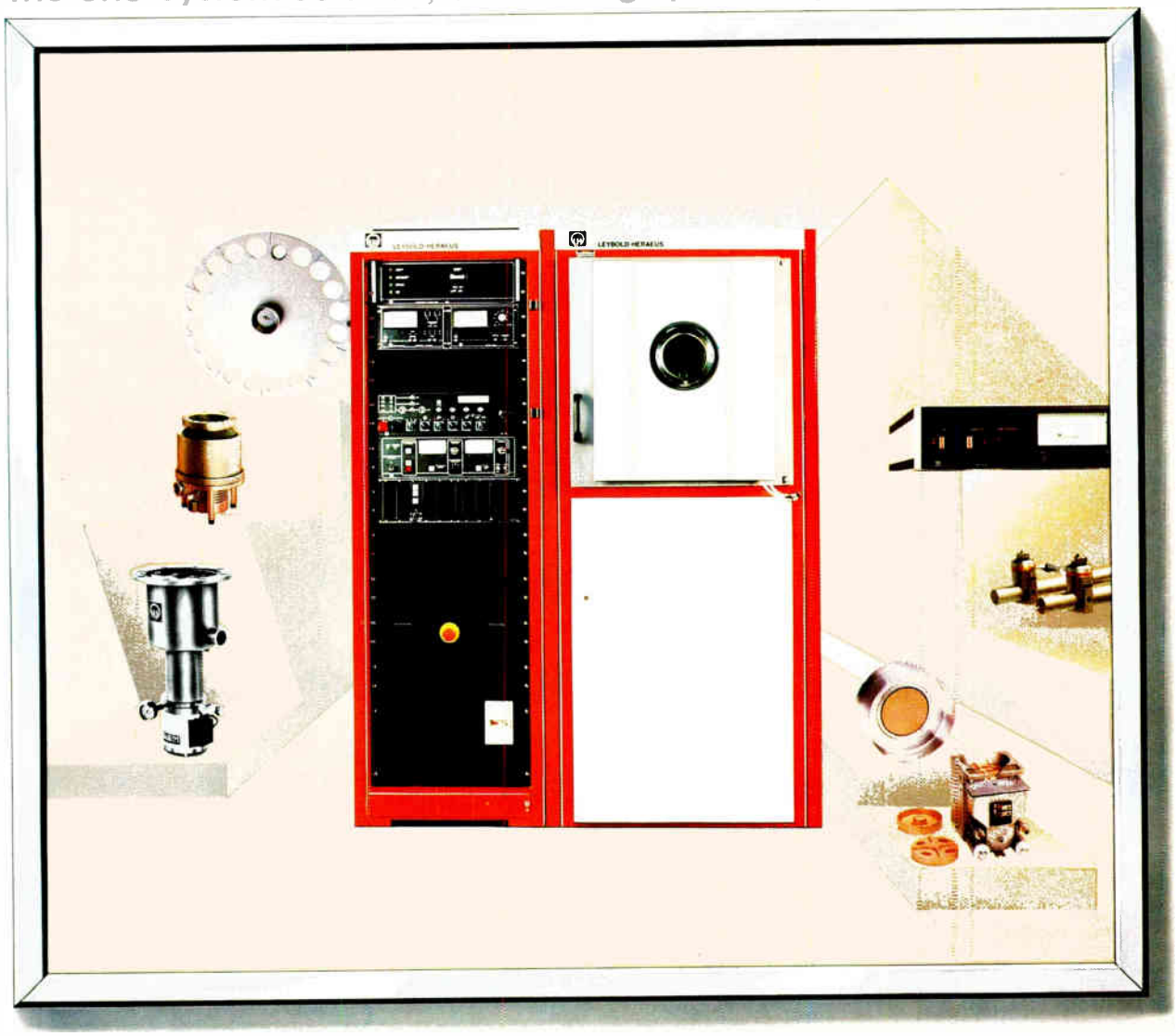

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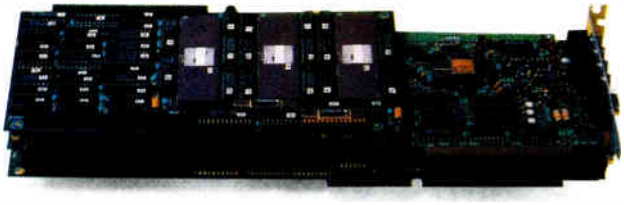

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