HOW THE ANALOG WORLD IS CHANGING / 73

OPTICAL STORAGE PUSHES INTO THE PICTURE / 82

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SEPTEMBER 1989

Electronics®

CAN U.S. MEMORIES TILT THE BALANCE IN DRAMs?

SANDY KANE TAKES ON A $1 BILLION PUZZLE

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TECHNOLOGY IS THE WILD CARD

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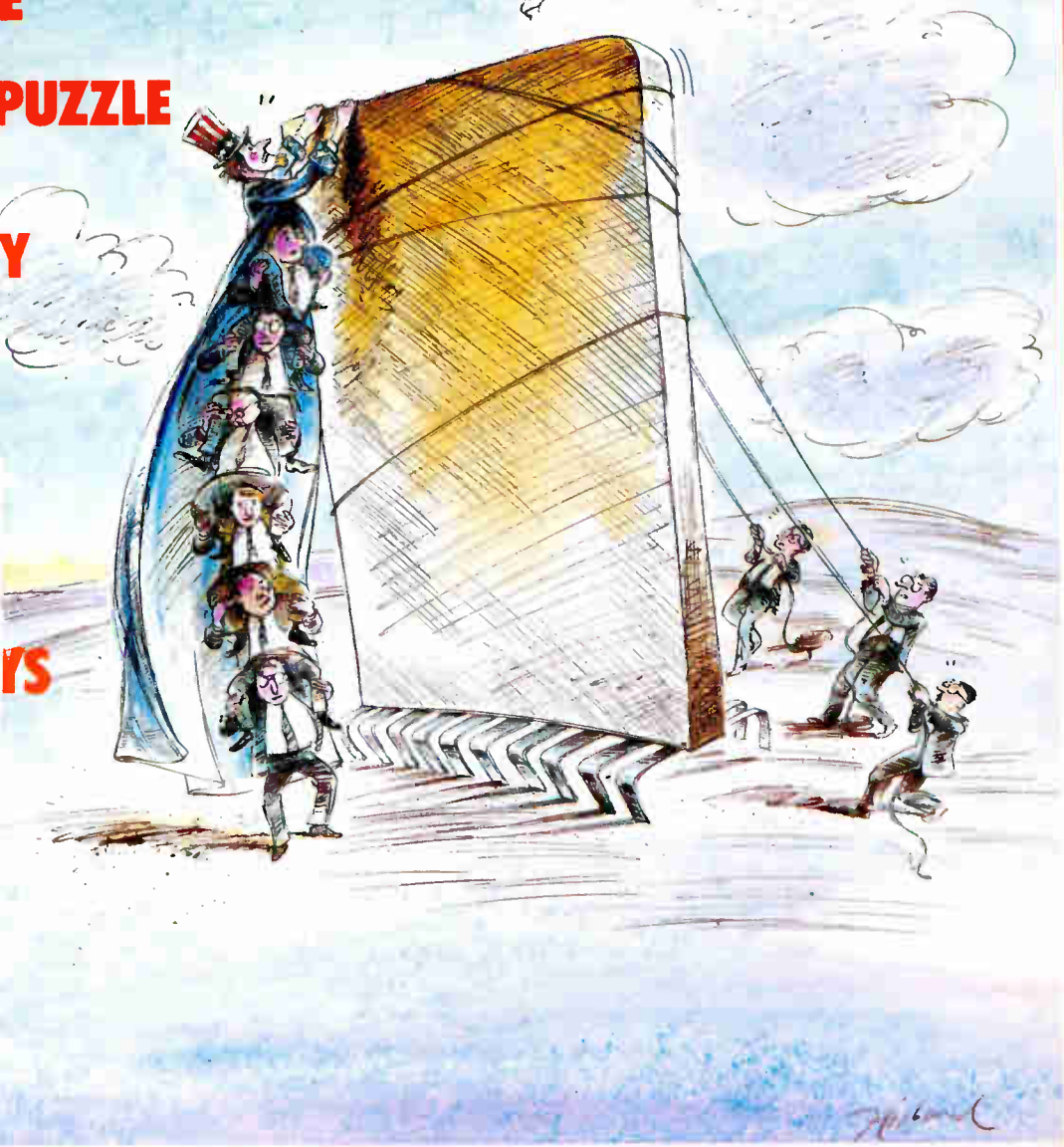
PAGE



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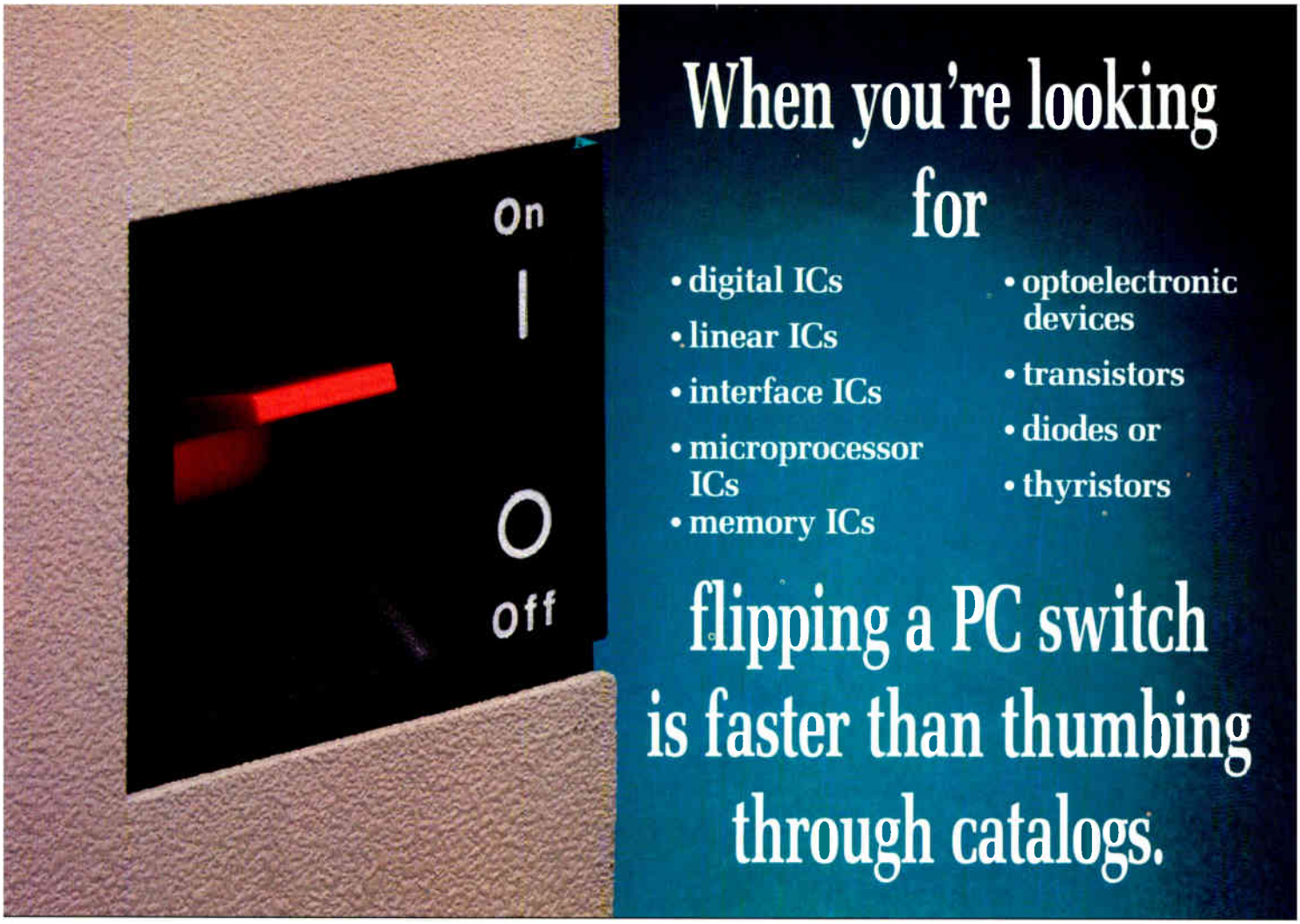
Circle 28



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Circle 96

HOW NOT TO SELL STATIONERY

The man who turned down U. S. Memories' business exemplifies the what-have-you-done-lately syndrome that infects American executives

Sandy Kane, a man who certainly doesn't need any lessons in how to run a business, got one anyway a little while ago when he attempted to buy office supplies. His experience might serve as food for thought for his fellow semiconductor-industry executives.

But first let's introduce Kane. He resigned in late spring as vice president in charge of IBM Corp.'s General Technology Division to become the president and chief executive officer of U. S. Memories Inc., the consortium formed to produce made-in-the-USA parts that will compete in the Japanese-dominated market for dynamic random-access memories (see p. 44). Kane, who clearly has his work cut out for him, has been spending the traditional vacation months preparing to do battle with giant, well-established, well-financed corporations that have a head start of many years. And he's doing it from a standing start, with a staff of one (himself—even an ex-IBM vice president needs more than that) and with only some seed money in the bank from the seven companies that are backing U. S. Memories. For Kane, the summer has been anything but the lazy, restful time that it is believed to be.

So Kane didn't need another reminder of that stark reality. However, that's just what he got when he tried to establish an account for his new company at a stationery store near his temporary office in New City, N. Y. "I told the guy that I wanted to open an account," recalls Kane. "He said that was fine, but could I provide him with my credit history. I explained to him that we were a new company, but asked if IBM or Digital Equipment Corp. sounded familiar. He wasn't impressed; he said that without a credit history, I couldn't open an account. So I went somewhere else."

Consider what that store official has turned down. To do that, imagine the advantages of a business relationship with a company that is expected to become a billion-dollar corporation. Weigh the strength of its backers—in addition to IBM and DEC they are Advanced Micro Devices, Hewlett-Packard, Intel, LSI Logic, and National Semiconductor—against the risk of providing supplies to a startup and the chance that it might go belly up. What would you do?

Therein lies the lesson. The man in the stationery store could serve as a metaphor for the U. S. chip industry—in fact, for U. S. industry as a whole. His concern for tomorrow's balance sheet blinded him to the opportunities that exist over the long run. As a Massachusetts Institute of Technology study [*Electronics*, August 1989, p. 55] points out, this quarter-to-quarter mentality is one of the top reasons for the current debilitated state of American industry in general and the memory business in this country in particular. Today's executives have got to plan for more than the day after tomorrow, because if they don't, more and more of their smart counterparts in Asia and Europe are going to be more than happy to do it for them.

HOWARD WOLFF

September 1989 Volume 62, Number 9

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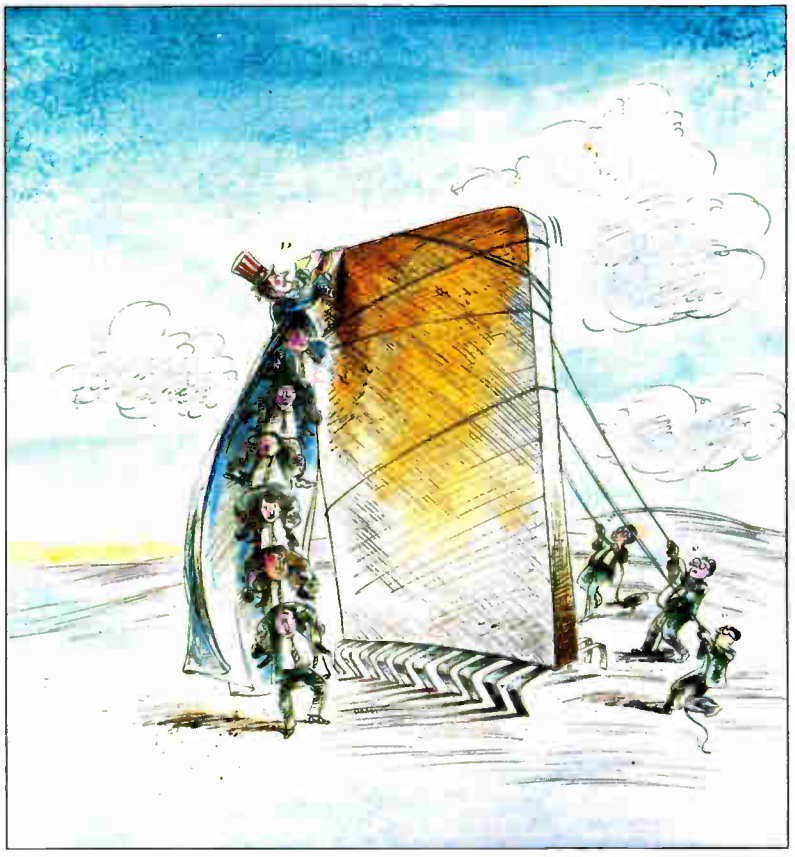
SEPTEMBER 1989

Electronics

NEWSLETTERS

FEATURES

COVER ILLUSTRATION: GARY HOVLAND



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WORLDWIDE NEWS ANALYSIS

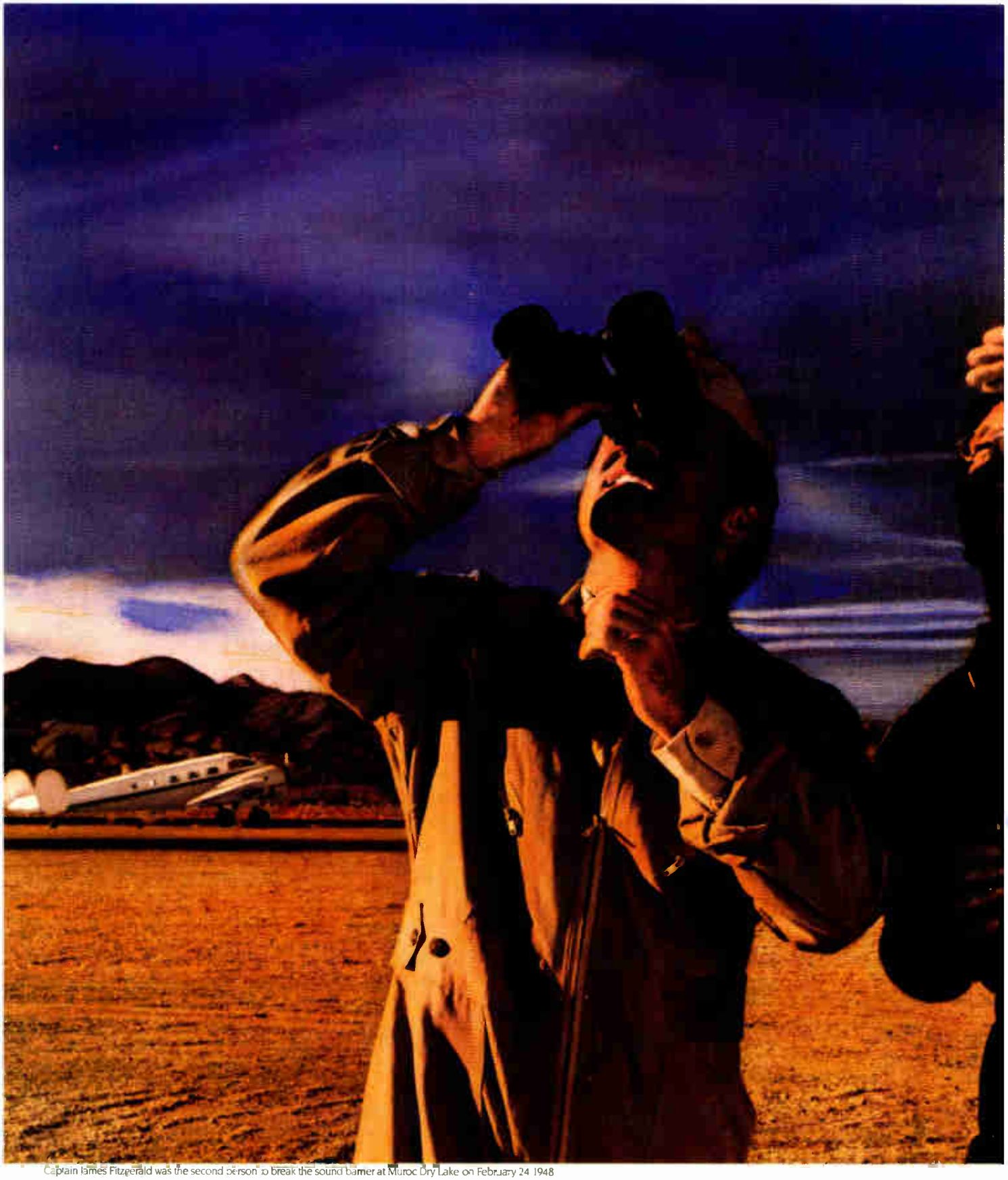
Probing the News

COMPANIES TO WATCH

PEOPLE TO WATCH

DEPARTMENTS

Who was the second person



Captain James Fitzgerald was the second person to break the sound barrier at Muroc Dry Lake on February 24 1948

to break the sound barrier?

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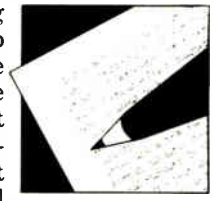
Circle 24

THE 'FIRST STATE' GETS LEFT OFF THE LIST

WILMINGTON, DEL.



Companies looking for a good spot to build a plant may be missing a bet: the state rated most hospitable to manufacturing in a recent study has been all but ignored by the electronics industry.

The state is Delaware, carved out of the eastern half of the Delmarva Peninsula on the Atlantic Ocean, facing New Jersey across the Delaware Bay, with Maryland and Pennsylvania at its back. First to ratify the Constitution in 1787, Delaware is the second-smallest state in area and home to chemical giant E. I. Du Pont de Nemours & Co. and to 49 banks.

On the face of things, Delaware seems to have the right stuff for manufacturing. A study by the Grant Thornton accounting and management consultants of Chicago singles out its many state-sponsored business incentives, which include corporate income tax credits and property tax reductions. Delaware also boasts a large skilled work force; as manufacturing becomes increasingly technical, a state's ability to provide the necessary workers becomes more important in luring new business. Delaware also rates well in terms of cost of living, with lower housing costs than those in the West and the Northeast.

Despite these favorable conditions, "manufacturing is definitely not on the rise here," says Mark Carlson, sales manager for the Arlon Corp. in Bear, a small town near Wilmington, the state's capital and its largest city. Arlon, which employs 118 people, manufactures printed-circuit boards and heat-sink products.

SHADOW DWELLER. For one thing, Delaware falls in the shadow of the 40-mile corridor that joins Washington and Baltimore, where more than 1,800 technology-related companies are flourishing [*Electronics*, June 1989, p. 8]. For another, in the northern part of Delaware, the land available to build and expand manufacturing facilities seems to be in short supply. It isn't that all the real estate has been used. Rather, "New Castle County hasn't zoned any more land for manufacturing," Carlson says.

"As in many other areas, it's getting more difficult to rezone," concurs Donna Murray, business development specialist at the Delaware Development Office. But Murray points out that Delaware has targeted 30 tracts that are well distributed throughout the state; companies that build on one of them qualify for various credits and other incentives.

If electronics companies haven't taken advantage of Delaware's business incentives, banks have. "Delaware seems more interested in trying to persuade service industries, like banks, to move to the state," Carlson says. What cleared the way for the influx of banks was Delaware's 1981 Financial Center Development Act, which allowed out-of-state banks to locate holding companies in Delaware and removed interest-rate ceilings on credit cards. Banking continues to show strong growth, with a gain of 2,700 jobs since June 1988, according to the Delaware Development Office. In comparison, 70,000 people are employed in manufacturing, about the same number employed in 1984.

An exception to the dearth of new manufacturing is an upcoming move to Delaware by Hewlett-Packard Co.'s Avondale (Pa.) Division, which employs 700 in making gas chromatography instruments and process-control equipment. The division recently signed a let-

Moving a division to Delaware brings HP a lower corporate tax rate

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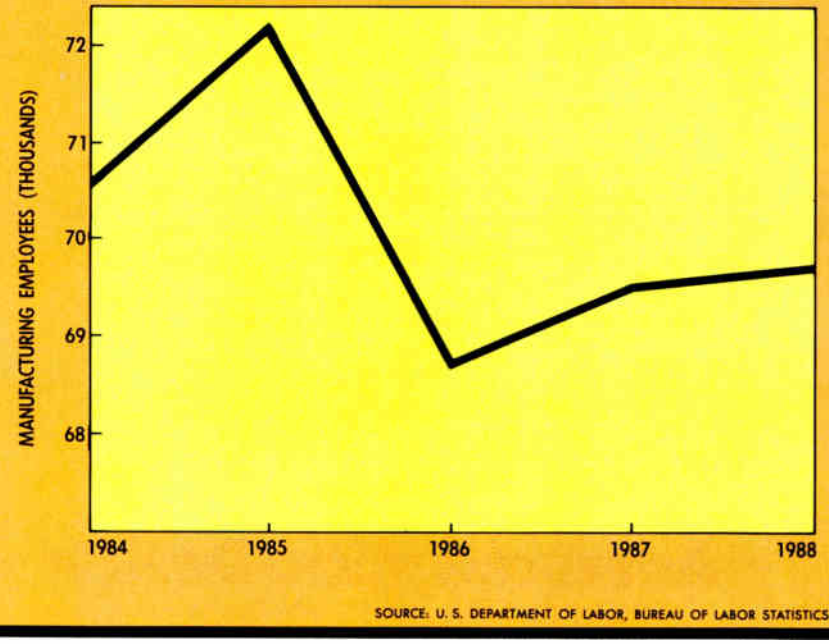
- The exemption of certain investment and holding companies from corporate income taxation

SOURCE: DELAWARE DEVELOPMENT OFFICE

...TO REV UP MANUFACTURING



SOURCE: U. S. DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS

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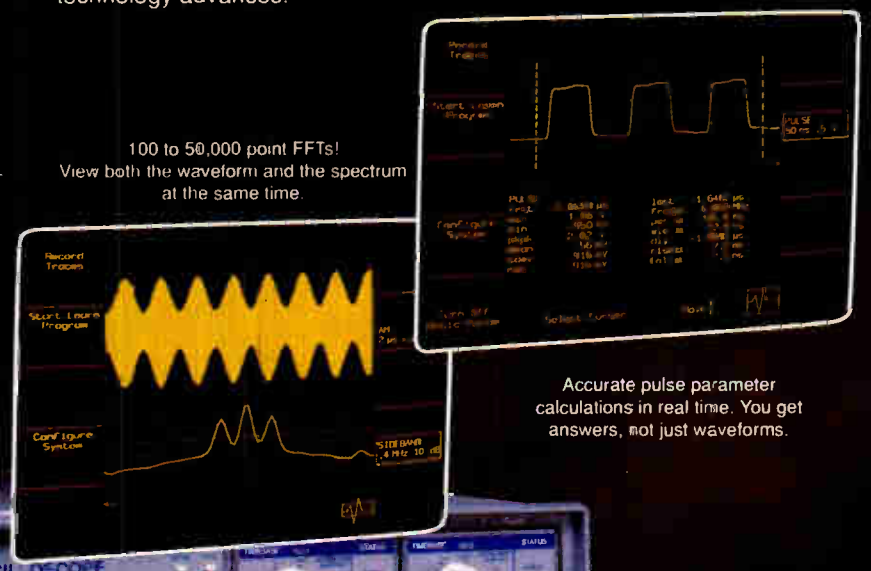

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ter of intent to buy a 100-acre site west of Wilmington, half from chemical maker Hercules Inc. of Wilmington, the rest from the state. By 1992, the division will move its operations from its present site in Avondale, seven miles across the Pennsylvania border.

"We needed a bigger site," says Dan Herman, the division's community affairs manager. "We have 54 acres [in Avondale], and we would be cramped for space in 5 to 10 years." When the decision about whether to move or stay was being made, he says, HP compared various Pennsylvania and Delaware business incentives; the result was "just about a wash." Still, "as a byproduct of the move, we will have a lower corporate income tax," he adds.

The employees are divided among research and development, marketing, and production. Citing competitive reasons, Herman declines to specify how many division employees work in R&D.

Executives at companies in Delaware are quick to point out one of the major advantages of manufacturing in the state: the ease of attracting and keeping good employees. They report little trouble filling either executive suites or blue-collar jobs, despite an unemployment rate that hovers between 3% and 4%, still below the national average.

With the University of Delaware in Newark nearby, software company BLS Inc. in Wilmington, for example, has had no trouble hiring programmers versed in C, says Brad Siegfried, director of systems development.

William Bewley, corporate economist for Hercules, says another reason for the abundance of talent is that a pool of highly educated people is drawn by the research laboratories of Du Pont, Hercules, and ICI Americas, the U. S. subsidiary of British chemical giant Imperial Chemical Industries plc. Another plus for employers is a historical lack of labor disputes, says Bewley. Hercules employs about 100 workers in a plant in Middletown that manufactures photoresist materials for fabricating pc boards. "We could have built the plant anywhere," he says. But the state's proximity to transportation hubs like Interstate 95 and the Philadelphia International Airport is an advantage for companies that ship most of their products.

> There's little trouble filling jobs, either in executive suites or blue-collar ranks

If there's any exception to the skilled-worker availability, it's in clerical jobs. "It seems as if the banks came in and snapped up all the clerical people," says Barbara Hines, president of Software Services of Delaware, a Greenville software company that builds custom applications for Novell-based local-area networks. Indeed, says Bewley, "for the first time in 75 years, we had to advertise for secretarial positions."

To those who work there, Delaware earns high marks in terms of quality of life. Besides offering affordable housing, the state is one of a handful without a sales tax, property taxes remain low, and Delaware recently reduced its personal income tax rates.

"We're 45 minutes from Philadelphia and not far by train from New York, with none of the big-city headaches," says Hines. "Basically, Delaware is a good place to be—it's growing. And there is a wide range of businesses, which suits what we do." But the rave reviews from those who live and work in Delaware apparently would still be news to the electronics business. *–Sherrie Van Tyle*

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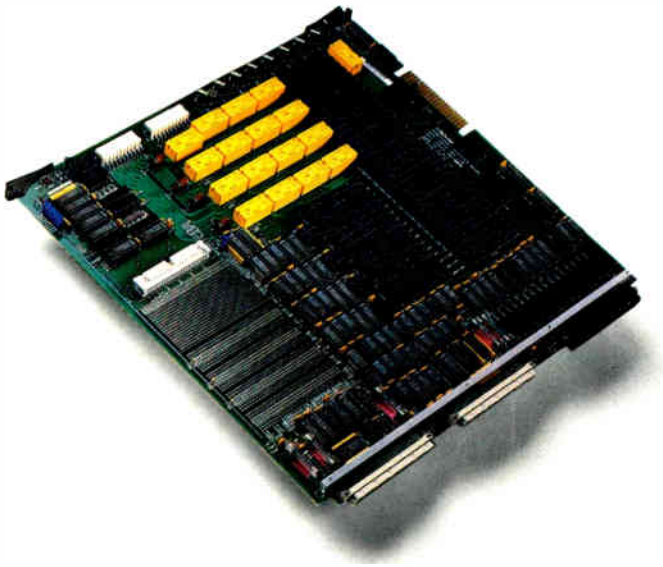
Circle 40

A GENTLE REMINDER ON THE IMPORTANCE OF LOOKING AROUND.



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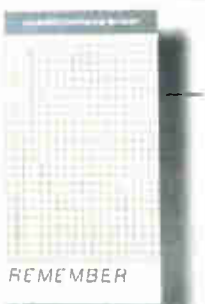

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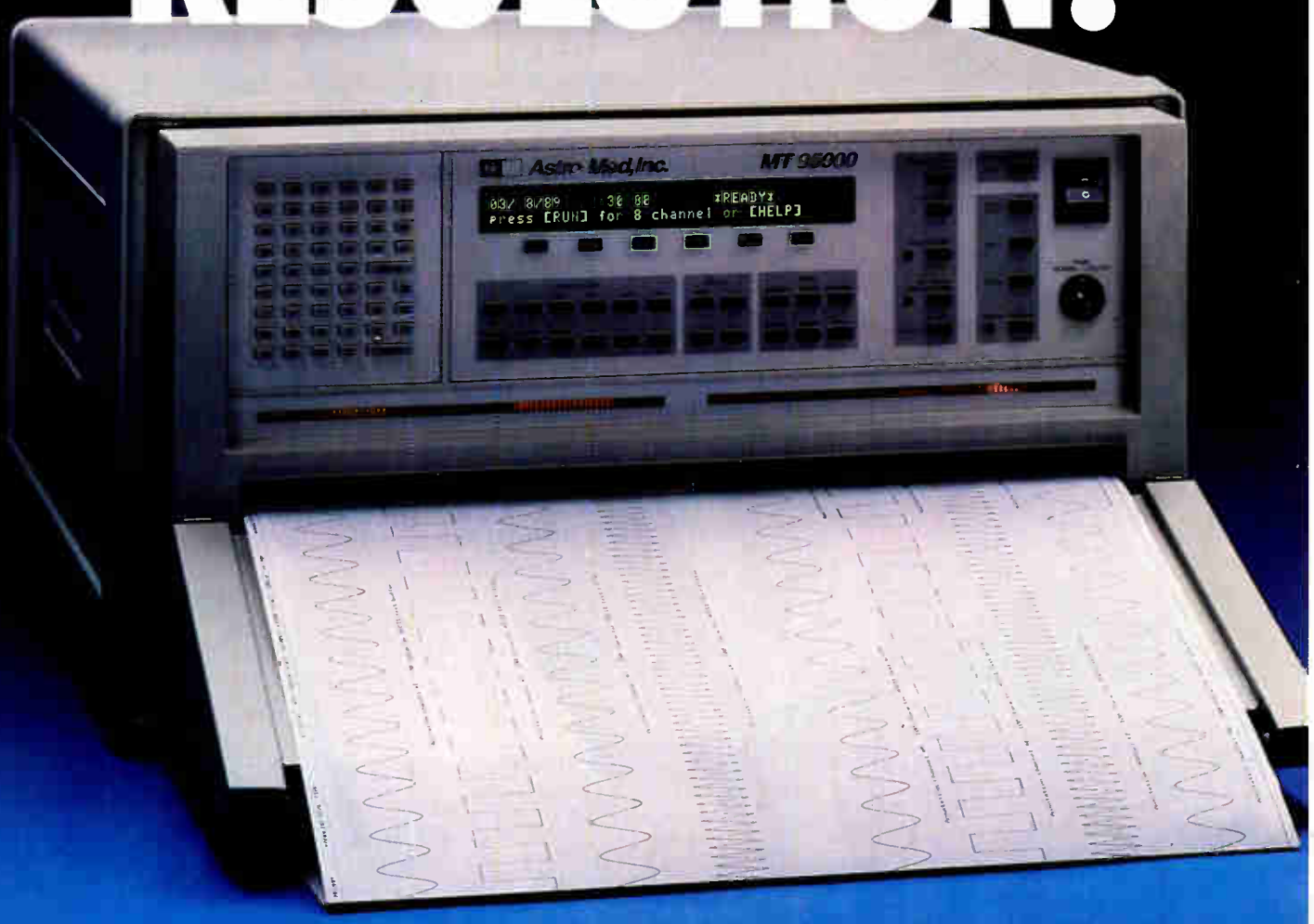

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Circle 34

ELECTRONICS NEWSLETTER

AT&T MICROELECTRONICS BUYS ITS WAY INTO THE FAST SRAM MARKET

AT&T Microelectronics has forged still another strategic alliance to bolster its market position—this time, with San Jose, Calif., memory wizard Paradigm Technology Corp. The five-year deal focuses on producing 20-ns 256-Kbit and 25-ns 1-Mbit static random-access-memory chips. AT&T will provide Paradigm with equity and codevelopment funding, as well as access to AT&T's 0.9-μm CMOS production facilities. In return, the Berkeley Heights, N. J., chip maker will gain an edge in the fast-growing market for high-speed SRAMs that support advanced processors such as reduced-instruction-set-computer chips and digital signal processors. Samples of Paradigm's 256-Kbit SRAMs will be available in the fourth quarter. □

A PC STARTUP TAKES THE MULTINATIONAL ROUTE OUT OF THE GATE

Look for a multinational financing announcement soon for ATU Corp., an ambitious Milpitas, Calif., startup that needs $30 million to design and manufacture a lightweight portable computer with advanced features. The brainchild of Kamram Elahian, cofounder of Cirrus Logic Inc., ATU expects $5 million from U.S. venture capitalists, $10 million from Taiwan, and $15 million from Japan and Europe. In Japan, support will probably be through a corporate partner. The ATU PC, which will boast such features as handwriting recognition, is slated for arrival by mid-1990. ATU's operations will be as international as its financing. Manufacturing will be done in Taiwan, components will come from Japan, and design will take place in the U. S. □

CRAY COMPUTER GETS GaAs LOGIC CHIPS FROM THREE SOURCES . . .

Seymour Cray's new company, Cray Computer Corp., is busily bringing on alternate sources to supply gallium arsenide logic chips for the forthcoming Cray-3 supercomputer. "We've got parts in house now from Gigabit Logic [Cray's original GaAs supplier], Rockwell, and sample parts have just arrived that look promising from Fujitsu," says Neil Davenport, chief operating officer for the Colorado Springs-based company. Each of the Cray-3's 16 processors will require 4,096 digital logic chips—each equivalent to about 500 gates and built in diode-transistor-logic GaAs technology. The company has been receiving chips regularly from Rockwell for the past six months, and process debugging with Rockwell looks promising, Davenport says, and the first Fujitsu chips also look good. "The availability of GaAs doesn't look to be an issue," he says. Davenport adds that the GaAs-based Cray-3 will start shipping in 1991. The peak rate for a full-blown Cray-3 is projected to be 16 billion floating-point operations per second. □

. . . BUT ROCKWELL REMAINS CAUTIOUS ABOUT GaAs COMMERCIAL PROSPECTS

Despite its new link as a gallium arsenide chip supplier to Cray Computer Corp., Rockwell International Corp. is still taking a wait-and-see attitude when it comes to commercial digital GaAs integrated circuits. "The GaAs market is still fairly problematic in terms of standard products," says Fred Cherrick, director of marketing and sales at Rockwell's Microelectronics Technology Center in Newport Beach, Calif. He acknowledges that there are opportunities in meeting the custom digital GaAs needs of big computer, communications, and military suppliers—the Cray Computer link is an example—but adds that Rockwell isn't taking anything for granted. Winning GaAs sockets in the Cray-3 will be "a very competitive situation," Cherrick says. "I think a lot of people would like to supply them." He notes that although Rockwell is known primarily as a military supplier of GaAs ICs, it also has a commercial digital circuit development effort under way with IBM Corp. □

ELECTRONICS NEWSLETTER

INTEL'S RISC-LIKE CHIP FOR EMBEDDED APPLICATIONS HITS 66 MIPS...

Intel Corp. this month introduced its second-generation 32-bit embedded processor, the i960CA. The chip is built around what the Santa Clara, Calif., company calls a 32-bit "RISC-like" core that executes up to three instructions per clock cycle to perform up to 66 million instructions per second. It derives its speed from a highly pipelined architecture in which the CPU execution unit operates in parallel with a number of on-chip coprocessors, including a 64-bit-wide floating-point unit, a multiply-divide unit, and an input/output coprocessor with a 128-bit-wide bus. □

...AND HEURIKON'S VME BOARD IS ONE OF THE FIRST TO USE IT

A single-board computer for VMEbus systems that builds around Intel Corp.'s new i960CA embedded processor may be a showstopper at Buscon East, to be held Sept. 12–14 in Marlboro, Mass. The HK80/960E from Heurikon Corp., Madison, Wis., takes aim at real-time applications, including intelligent input/output operations, communications, embedded control, and image processing. Besides the ample memory addressing inherent in the i960CA, the board also uses Intel's 32-bit 82596 Ethernet LAN processor and supports the TCP/IP protocol and Sun Microsystems Inc.'s Network File System. Heurikon says the board will sell for less than $2,800, giving it the best price/performance ratio of any single-board CISC or RISC CPU. □

GSS, NEC TEAM UP TO ACCELERATE WINDOWING APPLICATIONS

Two display controllers developed by Graphic Software Systems Inc., Beaverton, Ore., and NEC Home Electronics Inc., Wood Dale, Ill., rev up graphics applications using Microsoft Windows, Presentation Manager, and X Windows. The GSS AT1000 is designed for the IBM Personal Computer AT and the MC1000 for the Micro Channel architecture; both controllers offer a resolution of up to 1,024 by 768 pixels and improved performance for AutoCad, Ventura Publisher, and more than 1,000 other PC application programs. GSS-designed custom hardware called PFM, for pixel-fill multiplier circuitry, assists the graphics processor to speed such functions as text writing, line drawing, and area fills, running them more than three times faster than on an unassisted Texas Instruments TMS34010 graphics processor. The controllers drive NEC MultiSync monitors; they'll be sold as the NEC MultiSync Graphics Engine. GSS is licensing the hardware designs, firmware, and software to PC vendors for private-label manufacturing. □

OBJECT MANAGEMENT GROUP EXPANDS ITS MEMBERSHIP ROLLS

The Object Management Group Inc., formed in April to create and promote standards for object-oriented programming, has added 11 members, expanding its roster to 29 companies. Object-oriented programming promises rapid software development and a means for making computer systems and software from different manufacturers work together. OMG also is forming a technology committee "first to establish a process for working together on distributed object-management standards," says Christopher M. Stone, OMG's executive director. "We are on track to produce specifications within 12 months for an operating environment that is an independent layer that all software developers can write to." The committee, led by Phil Sakakihara, research and development manager of Hewlett-Packard Co.'s Santa Clara (Calif.) Information Systems Division, has a mandate to propose extensions to the core technology base, foster the adoption of standard tools and applications, provide a way to certify compliance with standards, and represent OMG in other standards-making organizations and consortia. □

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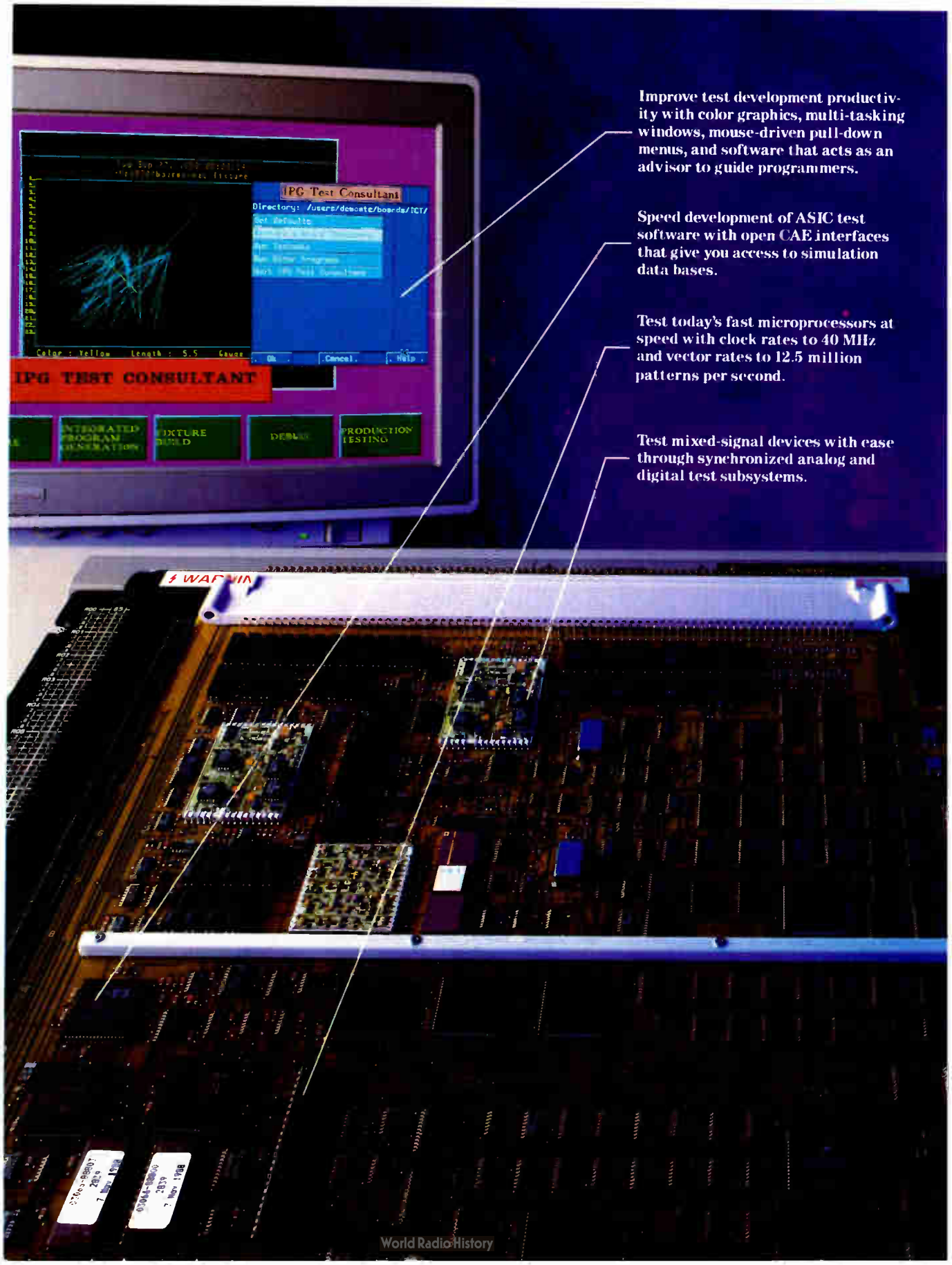

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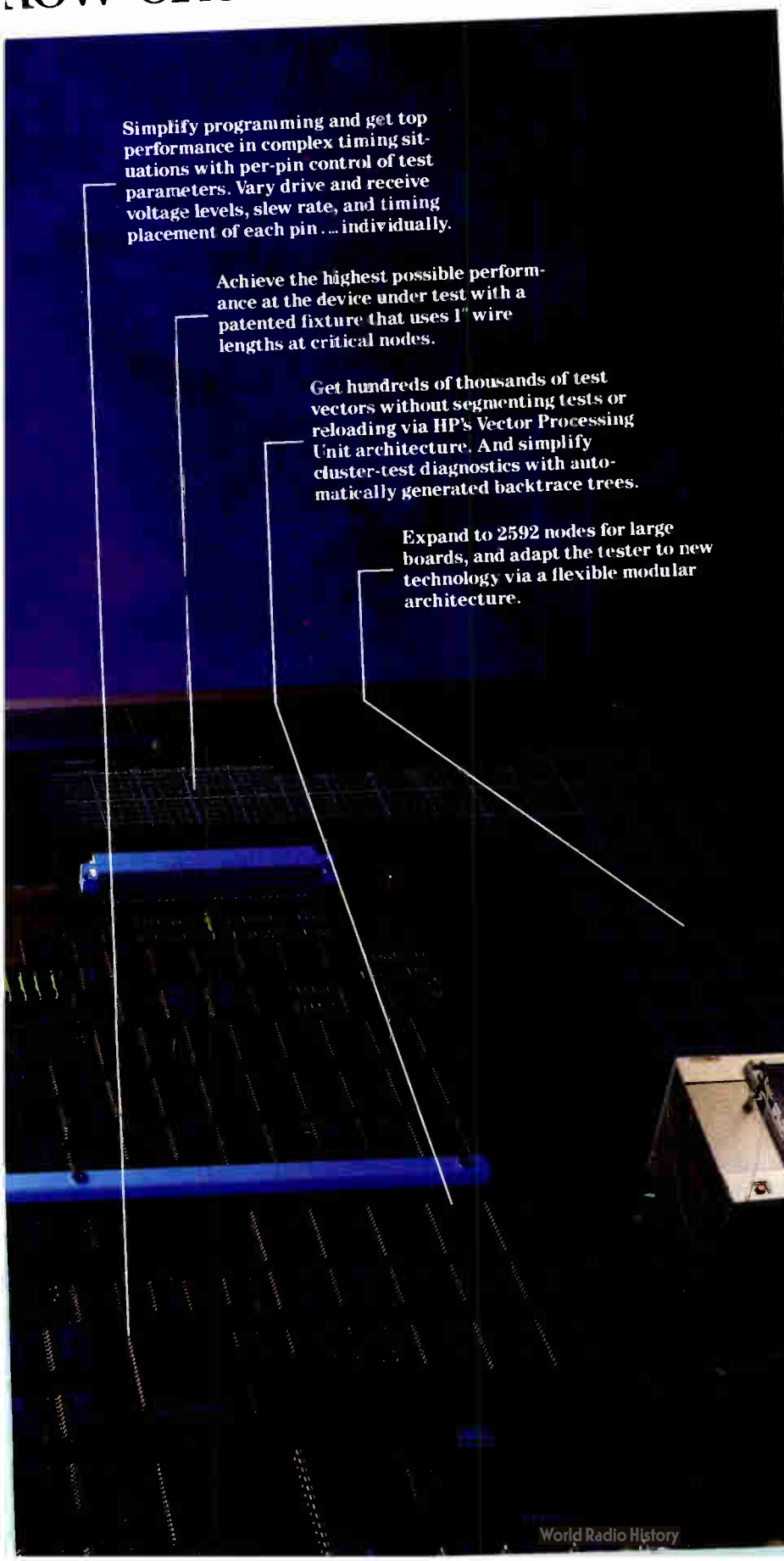

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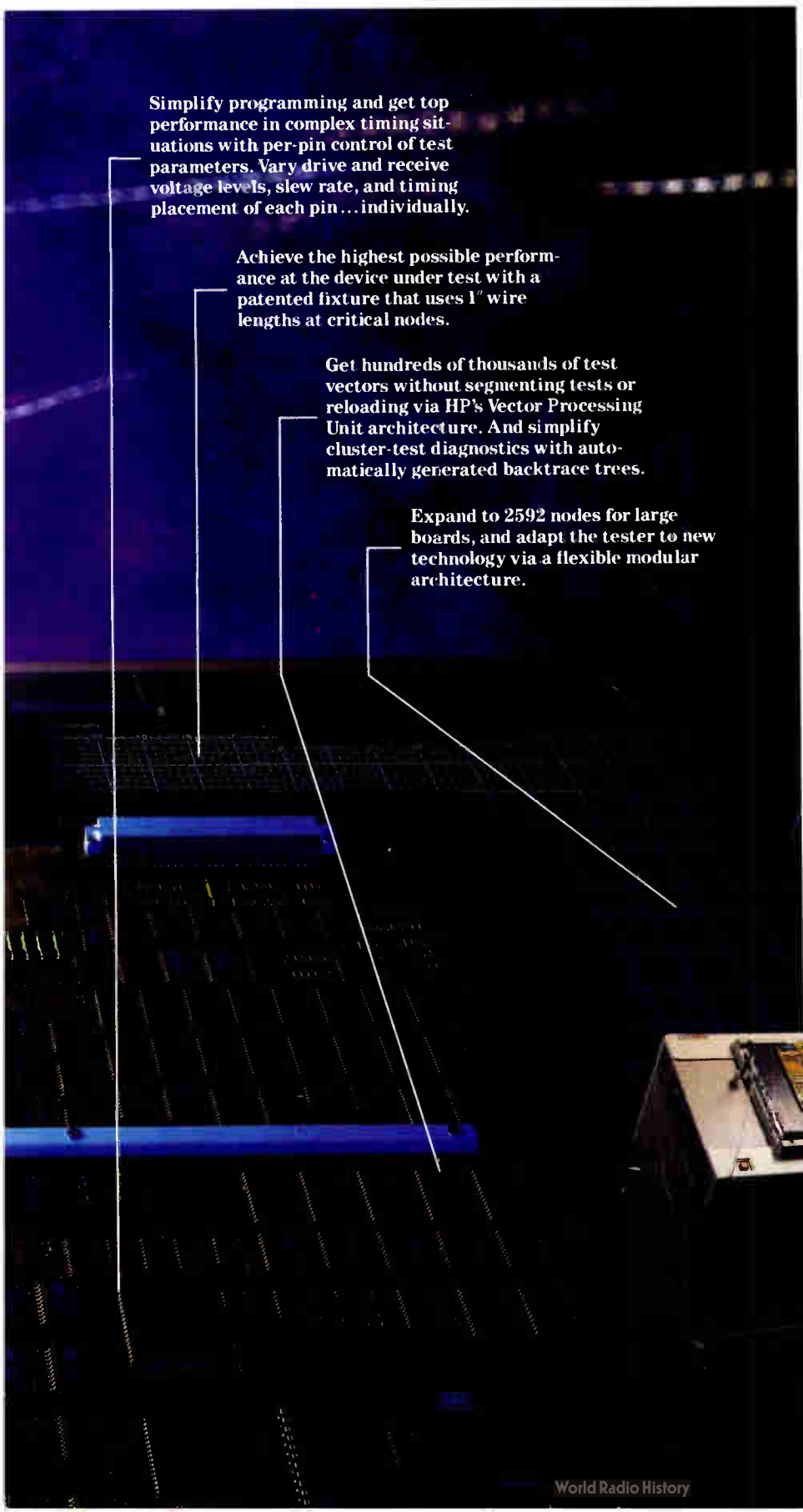

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PRODUCTS TO WATCH

VMEBUS BOARD DELIVERS ARRAY-PROCESSING POWER AT LESS THAN HALF THE PRICE

VMEbus platforms such as Sun Microsystems Inc. work stations will be able to deliver up to 100 million floating-point operations per second thanks to a new series of add-on boards from Transformation Systems Inc. The New York company's Racer series, based on AT&T Co.'s 32-bit DSP32C digital signal processor running at 50 MHz, is targeted at military and commercial applications in image processing, graphics, robotics, process control, and voice recognition. A 100-megaflops system, including work station, costs about $40,000—some $60,000 less than a comparable array-processing system. Transformation Systems also offers an applications library and a complete set of development tools, including C language support, an assembler, a linker, and a simulator and linker. The firm's single-processor, 25-megaflops board costs $6,885; the four-processor, 100-megaflops version costs $8,500. The software suite for a Sun work station costs $3,800. □

HEWLETT-PACKARD LAUNCHES A SLEW OF VMEBUS PRODUCTS

Hewlett-Packard Co. continues to add to its line of VMEbus Extended Interface products. Its latest offerings include B-size and C-size VXIbus mainframes, switches, instrumentation, and embedded computers. With its HP75000 family, the Palo Alto, Calif., company is responding to the growing popularity of VXI modular instruments, which are based on the VMEbus standard. HP is introducing 29 products, ranging from digital multimeters and synthesized function sweep generators to counters and multiplexers. All but three are available now, and the rest are expected by year's end. The system's firmware is HP's test-and-measurement-systems language, and the software is HP's Interactive Test Generator. □

TI CHIP SET SUPPORTS MODEM SPEEDS FROM 300 TO 9,600 BITS/S

An operation started by Texas Instruments Inc. in Japan to supply complete systems solutions has yielded its first dividend. The System Business Division of TI Japan Ltd. in Tokyo has introduced a three-chip modem system that outguns existing modem chip sets, the company claims. The set comprises a semicustom version of TI's TMS320C25 digital signal processor, a standard TLC32040 analog interface, and a TMS3498 8-bit microcontroller. While competing sets support only one or two modes at 2,400 through 9,600 bits/s, the new TI chip set supports all modes from 300 to 9,600 b/s for two-wire standard telephone lines and four-wire leased-line data communications. TI Japan developed the chip set jointly with NTT Data Communications System Corp., also of Tokyo, which will market the set. □

MICROPROCESSOR BOARD FAMILY PACKS UP TO 340 MIPS IN A VME BACKPLANE

A family of microprocessor boards offers processing speeds of 34 million instructions per second in pairs and up to 340 mips when the maximum 10 pairs are plugged into a VME backplane. The 32-bit CPU-8X series from Force Computers Inc., Campbell, Calif., is based on the 20-MHz Motorola 88000 reduced-instruction-set-computer chip. It is aimed at high-level real-time computing and transaction-processing systems, which are usually served with much larger and more expensive boxed systems. Priced at $9,900 in single quantities, the CPU-80 has one 88100 CPU, two 88200 cache-memory-management units (CMMUs), 4 Mbytes of dynamic random-access memory, and a VMEbus and Small Computer System Interface. The $9,990 CPU-81 includes a VME Subsystem Bus interface instead of SCSI. The $8,900 CPU-82, designed to work with either of the other boards, has one CPU, two or three CMMUs, and 8 Mbytes of DRAM. □

PRODUCTS TO WATCH

WINDOWS-BASED PACKAGE BUILDS CONTROL-SYSTEM OPERATOR INTERFACES

Developers should have an easier time creating and running control-system operator interfaces with a new offering from Wonderware Software Development Corp. The Irvine, Calif., startup's package, called Intouch, runs under Microsoft Windows and uses all of Windows' multiprocessing functions. Intouch includes two components: Windowmaker, which offers an easy graphical approach to developing user interfaces, and Windowviewer, a graphics-oriented system for operators running control systems. Because it uses the Windows technology on IBM Corp. and compatible PCs, Intouch is device independent. It accepts input from a mouse or touch screen and accommodates displays at any available resolution. Intouch is aimed at big control systems, including those built with programmable logic controllers, distributed-process control systems, microprocessor-based single-loop controllers, and special-purpose controllers. Early users of the system include semiconductor companies in their fab-line control systems. Intouch's development system is priced at $6,995; the run-time system costs $1,495 to $2,995. □

VORTEX AUTOMATES LAN BACKUPS WITH A FAIL-SAFE SYSTEM

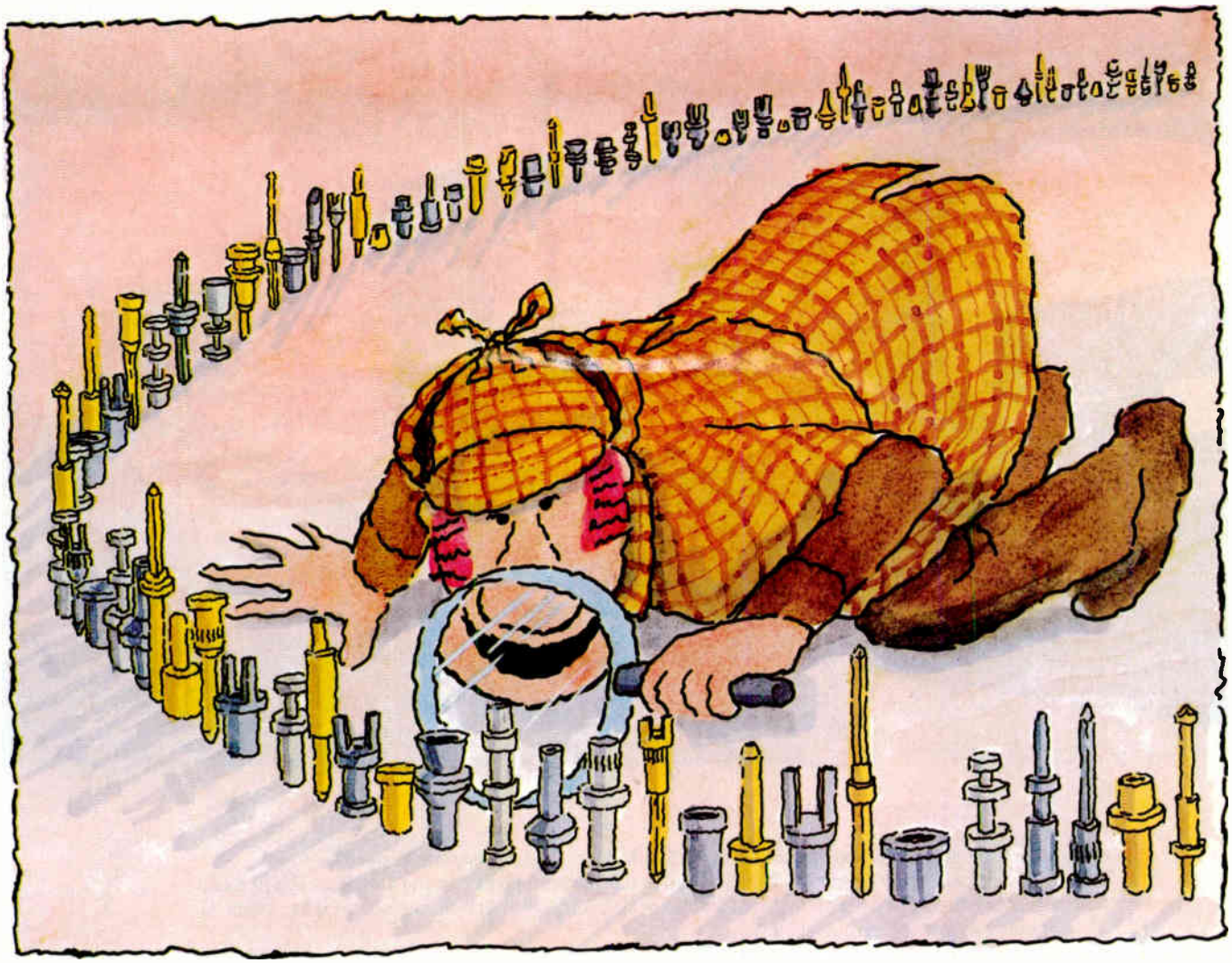
A new local-area-network backup system from Vortex Systems Inc. promises rapid and seamless data recovery for LAN users. The Pittsburgh-based company's Retrochron system employs a virtual disk drive for continuous backup rather than backing up periodically with schemes such as disk mirroring. The system continuously inscribes data on an optical disk; meanwhile, it generates tables that consolidate these transactions into a reference map. When a data loss occurs, the system operator can create a virtual drive by accessing the map and recreating the data exactly as it existed at the time of failure. Since the Retrochron system records only the changes made to a data base, it does not degrade network operation. Retrochron, which is packaged as a standard IBM Corp. PC AT card, supports a data transfer rate of 2.5 Mbits/s. The board contains a 10-MHz Intel 80186 processor and features 1 Mbyte of local memory. Peripherals are interfaced through three Small Computer System Interface controllers. □

BURR-BROWN UNVEILS AN INDUSTRIAL-STRENGTH PERSONAL COMPUTER

Burr-Brown Corp. says its new industrial-grade personal computer provides a variety of embedded applications. The VIPc from the Tucson, Ariz., company is fully compatible with the IBM Corp. PC AT and features shock-mounted disk drives, EGA graphics, and communications ports. Mounting options allow installation in a variety of locations, including on a standard 19-in. rack, on a desktop, under a factory conveyor, or on a wall. The VIPc comes in four basic model configurations ranging in price from $3,995 to $7,435. The top-of-the-line models come with 2 Mbytes of memory, a 40-Mbyte hard disk, and a monitor. The lowest-priced system has no monitor, no hard-disk drive, and 512 Kbytes of memory. All models are slated to ship this month. □

FALL COMDEX TO FEATURE $800 GRAPHICS BOARDS

Watch for the Fall Comdex show, to be held Nov. 13–17 in Las Vegas, to serve as a springboard for graphics boards in the $800 price range. That's the word from Texas Instruments Inc.'s Semiconductor Group, which produces the popular TMS34010 graphics microprocessor. That chip will form the heart of the boards, which will deliver a resolution of 1,024 by 768 pixels. The keys to lowering the current $1,200-to-$2,500 price are TI's conversion of some glue logic to application-specific integrated circuits and the use of TI's low-cost 1-Mbit dynamic random-access memories. □



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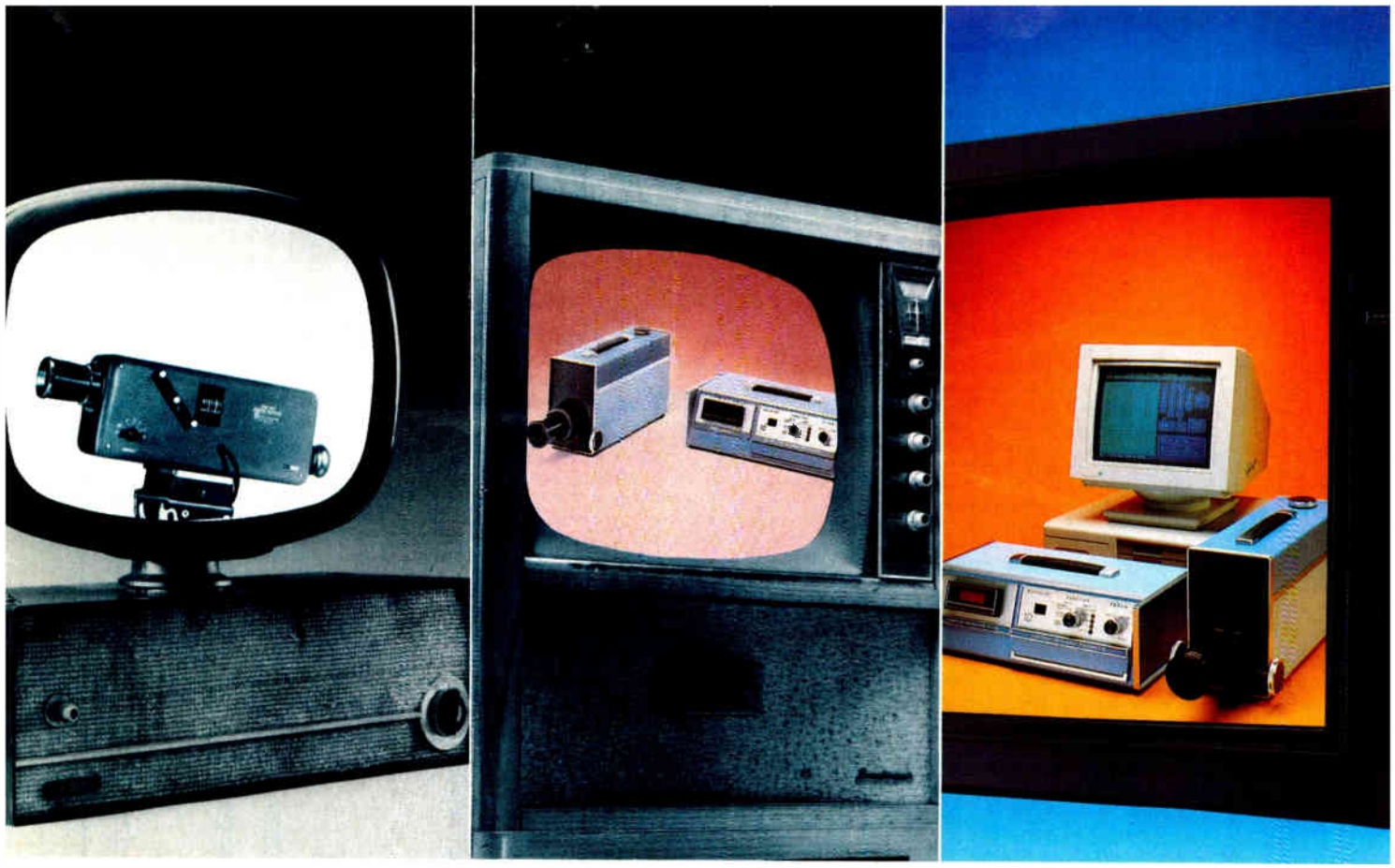

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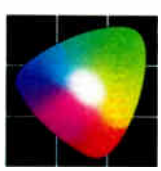

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Electronics

A FIRM FDDI STANDARD HAS VENDORS SCRAMBLING FOR A PIECE OF THE ACTION

Systems integrators are finally getting what they need for this complex fiber-optic network

BOULDER, COLO.

After two years of hype and hoopla, systems integrators are finally starting to get what they need from the Fiber Distributed Data Interface: a full complement of products from a growing crowd of network equipment vendors.

By early next year, the complete 100-Mbit/s FDDI network standard may well be in place, buttressed by interoperable network bridges and routers, VMEbus interface boards to systems on the network, and function-rich network-management protocols. Original-equipment manufacturers can even look forward to FDDI chip sets that will compete with Advanced Micro Devices Inc.'s SuperNet set, which kicked off the hype when it was introduced in 1987.

The American National Standards Institute firmed up FDDI's network-management protocols at its X3T9.5 committee meeting in Boulder last month. Just as important, the Advanced Networking Group, a trade organization spearheaded by AMD, simultaneously held its first meeting, also in Boulder. The 35 member companies brought with them expertise in the broad range of technologies needed to transform FDDI from a chip set looking for a system to join to a multivendor nuts, bolts, and fiber system.

NOT JUST ANOTHER LAN. The FDDI standard is based on the use of fiber-optic cable as a transmission medium. An FDDI network is configured as two active, counter-rotating rings; each ring can be up to 100 km in circumference, and stations can be up to 2 km apart. The cost of an FDDI-to-Ethernet connection, which only a year ago was $25,000, plummeted to about $12,000 last month when Fibronics International Corp. of Hyannis, Mass., introduced a router product that offers dual local-area-network interfaces. "FDDI is a systems product," says John Mazzaferro, director of marketing for In-Net Corp. in San Diego. "It's too big, too fast, and too expensive to be considered just another LAN."

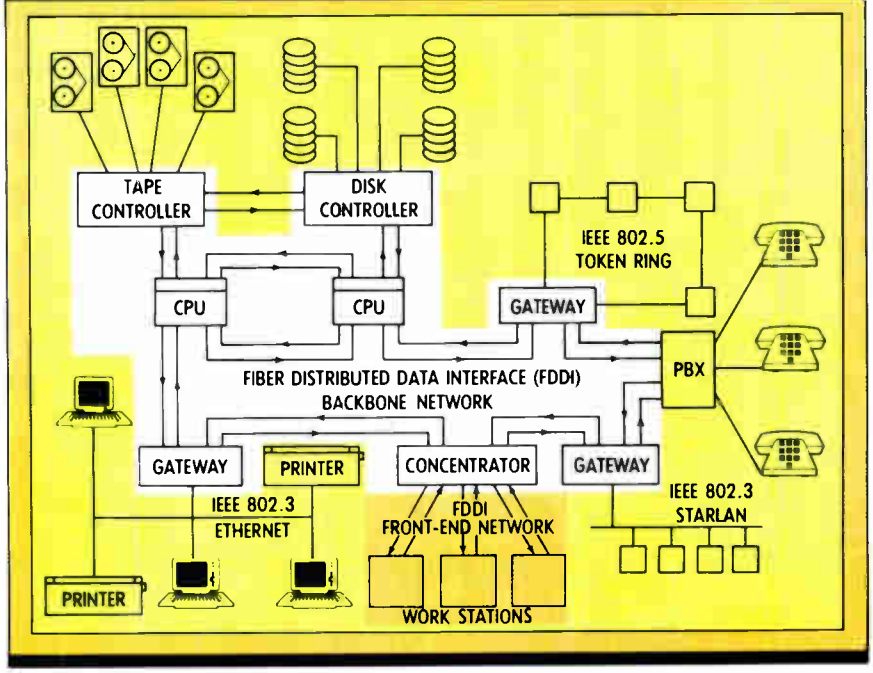
Two vendors—In-Net and Fibronics International—already boast wide FDDI product portfolios, but the competition is closing in fast. In the internetworking arena, Proteon Inc. of Westborough, Mass., is developing an FDDI interface for its p4200 router. The company will demonstrate the interface and router later this year, says Diane Rahe, product manager for high-speed networks. Using the router, systems integrators can connect an FDDI backbone with IEEE 802.3 Ethernet and 802.5 token-ring LANs, as well as with T1 telecommunications lines.

But Rahe sees a bumpy road ahead for FDDI in the short term. Interoperability testing for FDDI products is not yet in place, she says, and neither is testing of large networks of 100 or more nodes. "Interoperability is not going to come rolling out of the pipe," she says, referring to the inevitable incompatibilities that crop up when different vendors implement any standard. The Advanced Networking Group will eventually address the interoperability problem with its testing center, Rahe says.

Testing large networks is a more difficult knot for the Advanced Networking Group to unravel, mostly because there are not many large FDDI networks in operation. Proteon sees a market opportunity in that area, says Rahe. Its proprietary fiber-optic 80-Mbit/s ProNet 80 network has more than 2,000 nodes installed and lots of operating experience. Proteon will provide a clear migration path to FDDI for customers choosing ProNet 80, she says, plus a partial rebate of their initial ProNet 80 costs.

Internetworking includes the thorny issue of network management. Here, FDDI starts off with a big advantage—its ANSI standard will incorporate a rich set of management functions. The Station Management (SMT) protocol will allow the network to be managed apart from any system on the network, says Bruce McClure, president of Synernetics Inc., a North Billerica, Mass., startup. Synernetics will field an FDDI network-management product that McClure hopes will play a role similar to that of Phoenix

THE PIECES FALL TOGETHER



By early 1990, systems integrators will be able to put together total FDDI systems that include VME interface boards, bridges, routers, and concentrators.

Technologies' BIOS in IBM Personal Computer compatibility. Other companies with that aspiration include In-Net and San Diego-based Cumulus Corp.

In the FDDI scheme, management functions are divided into four basic types. "Get" functions let the network retrieve network data, such as statistics from each attached device concerning the number of packets it is processing and its error rate. "Set" functions allow network managers to handle such operations as setting FDDI's parameters and configuring machines on the network. "Action" functions direct a computer or other system on the network to run diagnostics on itself. "Event" functions can tell systems on the network to trigger some action on a particular event. "If a machine sees its data exceeding a certain error rate threshold," explains McClure, "it can report to the network manager. You don't want to poll for that kind of information all the time."

FDDI is also blazing new trails with its Express Transport Protocol, or XTP. The network's raw speed means that software implementation of protocols that isolate user applications from the LAN—such as the Transmission Control Protocol/Internet Protocol—may slow the network down. To sidestep this problem, XTP is being designed to be implemented in silicon. The developer, Protocol Engines Inc. of Santa Barbara, Calif., is being funded by a group of companies with FDDI products.

At the board level, more than a half dozen VMEbus manufacturers—including Rockwell International's CMC Division, Ferranti, Interphase, Martin Marietta, and Xylogics—are hoping to gain the upper hand. "Don't expect FDDI to take off until the end user can take full advantage of its data bandwidth, and you're not going to do that with the cards out there today," says Bruce Sacks, director of system engineering at Burlington, Mass.-based Xylogics.

FDDI starts off with a big advantage: a rich set of management functions

Achieving FDDI's 100-Mbit/s speed will require full utilization of VMEbus's 32 Mbytes/s; that utilization is only being offered by VMEbus specialists, Sacks says. Xylogics attains its power with a proprietary custom chip set.

In the realm of chips, by the mid-1990s AMD's SuperNet chip set will be in a fierce scrap for market share, predicts Jack Freeman, senior analyst for data communications at the Yankee Group, a market researcher in Boston. Plessey Semiconductors of Scotts Valley, Calif., and Digital Equipment Corp. of Maynard, Mass., already have teamed up on a chip set. AT&T Microelectronics, Motorola, and Texas Instruments are other likely competitors. Freeman is particularly high on TI, whose communications design group just finished its IBM-compatible 16-Mbit/s token-ring chips.

The chip sets will probably use Plessey's bipolar chips as the front end to implement the physical layer of the FDDI protocol and concentrate on CMOS implementations for the data-manipulation functions. Plessey's chips are not compatible with AMD's SuperNet chip set.

For its part, AMD seems finally to have exterminated the bugs in its 16-bit SuperNet chip set. The last revision—slated to be ready in early 1990—will correct a problem in the 79C81A random-access-memory controller integrated circuit that forced users into a software workaround, says Tom Medrek, product marketing manager for the Sunnyvale, Calif., chip maker.

AMD is turning its attention now to reducing the cost of the $645-per-set ICs. One plan is to move the three CMOS chips from expensive pin-grid-array ceramic packaging of 144 pins to plastic. A plastic version of the 79C83 media-access-controller IC, which should be ready early next year, will serve as a prototype for the other chips, AMD says.

INTERNATIONAL ACCORD. Optical components are just as critical as chips to FDDI. To solve compatibility problems, three electronics giants—AT&T, Hewlett-Packard, and Siemens—announced last month an international multisourcing agreement. The companies have agreed to define a common package and pinout for FDDI transceiver components. Another major player in the FDDI optical component market is British Telecom & Du Pont Technologies Inc. of Wilmington, Del. BT&D has just announced a tranceiver that is fully FDDI-compliant. It will be available in early 1990.

Analyst Freeman predicts the FDDI market will blossom quickly, but adds that accurate estimates of FDDI's growth are not possible now because of the current high cost and lack of systems-integration products. "It will take about 12 months before we can get a good fix on the market," he says.

Freeman also contends that the FDDI standard will eventually be eclipsed by the gigabit-per-second Synchronous Optical Network. "Sonet was conceived by long-distance carriers to manage their bandwidth requirements," he says, "but hardware makers are already beginning to design for those bandwidths right to the desktop." *–Jack Shandle*

SUN'S SPARC COUP: THE PHILIPS CONNECTION

EINDHOVEN, THE NETHERLANDS

The RISC wars took another turn last month when Dutch electronics giant Philips International NV became a Sparc licensee and joined Sparc International, the industry group set up to promote the Sparc (Scalable Processor Architecture) reduced-instruction-set computing architecture. The move worked a public relations coup for Sun Microsystems Inc. of Mountain View, Calif., creator of Sparc, and gives Europe's No. 1 semiconductor producer a RISC architecture for its embedded systems business.

Philips is the last of the big three European semiconductor makers to join the 32-bit RISC systems battle. The Italian-French combine SGS-Thomson Microelectronics, Europe's No. 2 player, has put its weight behind the Transputer, developed by its recently acquired affiliate Inmos Ltd. of Bristol, England (see p. 134). And Siemens AG of West Germany, the third-ranked vendor, stirred waves earlier this year when it announced that it would manufacture the MIPS chip from MIPS Computer Systems Inc. of Sunnyvale, Calif., Sparc's main competitor [*Electronics*, May 1989, p. 70].

In light of the Siemens-MIPS link, Sun needed a European ally in its efforts to promote Sparc for competitive advantage in the European market, says Dean McCarron, vice president of technology at market research firm In-Stat Inc. in Scottsdale, Ariz. Indeed, at the press conference announcing the pact early last month, Scott McNealy, president of Sun, summed up the PR victory by stating that there is now major Sparc development in Europe as well as in the U. S. and the Pacific Rim. Through its licensees and Sparc International, Sun has been working vigorously to establish Sparc as a standard.

MORE HEAT. If the agreement gives Sun more presence in Europe, it also means increased competition for the semiconductor makers that are already building the Sparc chip, says Michael Slater, editor and publisher of the *Microprocessor Report* newsletter in Palo Alto, Calif. Besides Philips, these vendors include Fujitsu Microelectronics of Japan along with U. S. manufacturers Bipolar Integrated Technology, Cypress Semiconductor, LSI Logic, and Texas Instruments.

Demand for RISC devices is small considering the number of companies vying for market share. The work-station market is currently consuming tens of thousands of RISC chips per month, says McCarron. By contrast, hundreds of thousands or even millions of 80386 and 68030 complex-instruction-set chips from Intel Corp. and Motorola Inc., respectively, are gobbled up monthly, he notes.

But the RISC numbers are rising rapidly, according to analysts at Munich-based Siemens. The 32-bit processor market should reach about $500 million worldwide this year and keep growing at 33% annually into the early 1990s, Siemens says. Within that market, the 32-bit RISC segment should register a much steeper climb; the current growth rate is about 100% a year, according to Siemens. By the early 1990s, the RISC devices should account for roughly half of all 32-bit processor sales, the Siemens marketers believe, compared with about 5% now.

"This important product area represents by far the largest growth potential of all microprocessors," says Peter Draheim, director of the integrated circuits business unit at Philips's Components Division in Eindhoven. The Dutch company settled on Sparc because of its high performance, open architecture, and scalability, Draheim says. "We feel that Sparc is becoming a standard for RISC technology," he declares.

The division, which achieved $5.2 billion in sales last year, will develop Sparc processors for use in application-specific embedded controllers for industrial, communications, consumer, and military applications. Philips will also supply Sparc chips to other divisions within the $28 billion company, and it may develop Sparc processors and components for a range of data-processing equipment, including general-purpose Sparc computers.

Despite these hints that Sparc may become the microprocessor of choice for the Philips Data Systems Division, some U. S. observers believe that that business is still up for grabs. Among them is Jeff Nutt, microprocessor marketing manager for Motorola Inc. in Austin, Texas, which has its own 32-bit RISC entry, the 88000. Nutt, who declines to say whether Motorola is pursuing a Philips connection, notes that the Sun deal is an agreement with the Components Division only. But a Philips spokesman indicates the Sparc commitment is company-wide. "Theoretically, the Data Systems Division can buy RISC chips from companies other than Philips, but that would be unwise," he says.

Philips's licensing agreement with Sun

coincides with its alliance with Sparc International, the worldwide consortium committed to establishing Sparc as a RISC standard. The Dutch company is now represented on the board of Sparc International, an independent, nonprofit organization founded last February and based in Sunnyvale. The group's aim is to work with AT&T Co. on development of an application binary interface for the Sparc architecture and AT&T's Unix System V, release 4.

The Sparc chip will become Philips's 32-bit CMOS microcontroller series, joining its existing 8-bit 84CXXX and 16-bit 90CXXX families. Around the Sparc core processor will be a library of cells used to build microcontrollers aimed at specific vertical markets. Draheim says it will be two years from now before the Sparc core finds its way into final products.

In developing the Sparc devices, Philips will use its CMOS and advanced biCMOS processes. Most of the development work will be in Europe, with manufacturing and sales to be handled at facilities around the world. In the U. S., that includes the Philips affiliate Signetics Corp., based in Sunnyvale.

With Siemens backing MIPS, Sun needed a European ally for Sparc development

Sparc has "a clear advantage over other RISC architectures in the availability of design tools," Draheim says. Also convincing Philips that Sparc will remain the leading RISC solution is its powerful system software, including the SunOS and Unix System V release 4 operating systems and Open Look graphical user interface, along with a large selection of application software. The widespread acceptance of the Sparc standard has resulted in the development of more than 750 software applications, more than for all other RISC platforms combined, Philips says.

With Philips soon to offer Sparc components, non-European companies manufacturing in Europe can commit themselves to Sparc and thereby comply with the "European contents" requirement that will be in force in 1992, when Europe's Single Market is established. At that time, products sold by non-European firms within the European Community must contain components made in an EC member country.

The MIPS alliance brings the same benefits to Siemens. Also lined up behind the MIPS implementation are International Device Technology, LSI Logic, and Performance Semiconductor in the U. S. along with NEC in Japan. *–John Gosch, with additional reporting by Jonah McLeod*

ASICs

SGS-THOMSON WEIGHS IN WITH MIXED-MODE ASICs

AGRATE BRIANZA, ITALY

For several years, systems engineers have enjoyed the convenience of having mixed analog and digital functions on the same chip. Now they are about to get their hands on application-specific integrated circuits incorporating both mixed-mode functions and mixed technologies—specifically, bipolar and CMOS.

A series of biCMOS standard cells from SGS-Thomson Microelectronics, Europe's No. 2 semiconductor maker, will make such ASICs possible. The Italian-French chip maker is now designing the first circuits using cells from the new family and will make them available before year's end.

SGS-Thomson says the new STKM2000 cell family grew out of the company's efforts to meet user needs for greater latitude in ASIC design. The family's mixed-technology feature "allows designers to pick cells using a technology that best suits the application," says Daniel Aufaure, manager of the business unit for analog cells and arrays at SGS-Thomson's development facility in Grenoble, France.

In the new approach, a CMOS cell provides the low power consumption and high density desirable in filters, amplifiers, and digital signal processors, while a bipolar cell provides the high speed needed for converters and video amplifiers and the high drive currents needed for output amplifiers. A single chip can, for example, contain all the circuitry—such as input and output amplifiers, filters, converters, and DSPs—between an external sensor and actuator in any application requiring analog signal processing.

ASIC FOCUS. The STKM2000 family underscores SGS-Thomson's focus on dedicated ASICs. Dedicated ASICs are the company's biggest market, making up 36% of its sales last year. SGS-Thomson's strong presence in ASICs "goes with our mission of establishing close customer relationships with exclusive products," says Carlo Ottaviani, vice president of communications at the company's facilities in Agrate Brianza, near Milan.

The biCMOS technology featured in the STKM2000 series is applicable at 10 V, an unusually high voltage that makes for improved noise immunity. The series also offers a comprehensive library of analog and digital functions. Computer-aided-design support includes what the company believes is the first compiler for analog functions, allowing designs to be done at the system rather than the transistor level. With the compiler, a designer can work with an infinite number of functions rather than a finite number of library cells. Using a set of attributes at schematic capture, designers have access to such electrical parameters as gain-bandwidth product, phase margins, bias currents, supply voltages, and threshold level.

The cells are made with SGS-Thomson's HF2CMOS process, a 2-μm, double-metal, double-polysilicon process. The company started developing the process two years ago; it is being used for the first time in production this year. The two metal layers make for high density on the digital side, and the double-polysilicon step provides accurate capacitors for analog functions.

For CMOS circuitry, the HF2CMOS process behaves like a high-performance n-well technology, enabling high-speed isolated n-MOS transistors to be made. The process allows the design of bipolar npn transistors with a transition frequency up to 6 GHz and vertical pnp transistors working at 2.5 GHz.

SGS-Thomson's library will initially encompass 60 CMOS digital cells and 80 analog cells, which use either CMOS, bipolar, or biCMOS circuitry. All cells can operate in a power-down mode to minimize power consumption. The company plans to expand the library regularly, Aufaure says.

FULL LIBRARY. The analog library includes cells performing as op amps with gain-bandwidth products as high as 50 MHz, transconductance amplifiers for up to 25 MHz, and comparators with propagation delays as low as 100 ns. It also incorporates cells for such advanced functions as voltage generators, oscillators, switched-capacitor filters up to 15th order, and analog-to-digital and digital-to-analog converters with a resolution of 15 bits, a precision of $\pm\frac{1}{2}$ least significant bit, and operation at up to 500 KHz.

The digital library permits the design of complex circuits with up to 10,000 gates. Designs may incorporate not only basic flip-flops, counters, and registers but also memory blocks such as static random-access memories, read-only memories and, in the near future, electrically erasable programmable ROMs.

The high performance of the CAD tools provides several advantages, Aufaure says. From the basic library of functions, users can derive a practically unlimited number of new cells by specifying the requirements as a parameter. The "soft macro" facility automatically generates virtually any type of digital function. The analog compiler offers such design features as a filter compiler, automatic biasing, programmable cells, and multiple power supplies. *–John Gosch*

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CAN A DEBT-SADDLED WANG CLIMB OUT OF ITS HOLE?

LOWELL, MASS.

Visitors approaching Lowell on Interstate 495 see the Wang towers—the headquarters of computer manufacturer Wang Laboratories Inc.—long before any of the area's old red brick factories come into view. Wang's rise to the Fortune 500 has paralleled the rebirth of Lowell, a once-thriving textile city, as a technology center. Now, however, the outlook for Wang is fraught with uncertainty. The $3 billion company's very survival is at stake in the wake of its latest fiscal woes.

Last month, the roof fell in at Wang. The company reported a loss of $424 million in the year ended June 30—almost $375 million of it coming in the fourth quarter of Wang's fiscal 1989—and announced a sweeping restructuring plan calling for yet more layoffs.

Then, a week after Wang announced its losses, president and chief operating officer Frederick Wang resigned. He has been replaced by Richard W. Miller, formerly head of the consumer-electronics operations at General Electric Co. and RCA Corp., and the man who consolidated the consumer operations of GE and RCA after GE purchased RCA. He left GE after the company made a deal with France's Thomson SA in which Thomson got the consumer business.

The hiring of Miller is an important step that receives high marks from Wang watchers, as much for the speed with which it was taken as for the person who was named. Also earning approval was a major debt-restructuring move accomplished just two days before the appointment of Miller. After scrambling for weeks to come up with a plan to repay $962 million in short- and long-term debt, Wang's board of directors announced that it had negotiated an agreement with its banks that would permit the company to borrow $575 million.

WHAT NEXT? But before the bank-loan agreement and the appointment of a new president were announced by Wang, all that bad news had Wang watchers buzzing and speculating on the future of the beleaguered company. Tom Willmott, vice president and the main Wang analyst at the Aberdeen Group, a Boston-based market researcher, foresees Wang eventually withdrawing from head-to-head direct sales competition with Digital Equipment Corp. and IBM Corp. in favor of heavy emphasis on sales to systems integrators and value-added resellers.

Adopting that strategy would be only one of numerous changes that have been forced by sagging sales and profits. Fiscal 1989 revenue was $3.02 billion, down from the $3.06 billion Wang recorded the previous year. The $424 million loss follows a turnaround year in which Wang made $92.7 million. In 1987, the minicomputer maker lost $70.7 million. Even before reporting the shocking 1989 results, Wang had laid off more than 2,000 workers in recent months to cut costs, a move that was far too little and too late.

At the same time Wang released its 1989 numbers, Fred Wang announced a restructuring plan intended to cut expenses further. The plan includes layoffs of several hundred employees, the shutdown of a manufacturing facility in Stirling, Scotland, the sale of portions of Wang's business not related to its core computer lines, and the possibility of a badly needed cash infusion by selling a minority interest in the company.

That Fred Wang won't be around to oversee the restructuring after his abrupt resignation is attributed by a number of analysts to a decision by his father, An Wang, the company's founder, chairman, and chief executive officer. However, some observers contend that the company's bankers demanded the move.

How did Wang get so deeply in debt? The reasons are varied, but some of the company's problems are paralleled in the current malaise of its Boston-area neighbors—veteran minicomputer companies including Data General Corp. of Westboro and Prime Computer Inc. of Natick [*Electronics*, June 1989, p. 36]. Wang has relied too long on its proprietary VS minicomputer and operating system. The company was late getting into personal computers and hot technologies—such as the Unix operating system and reduced-instruction-set computing. Further, Wang failed to trim its sails soon enough in response to shifting market winds, while its neighbors have made tough moves to cut expenses.

IGNORED CHANGES. "For some time, Dr. [An] Wang, Fred, and Wang management were unwilling to accept that the market had changed," offers Willmott. Although the company made a successful transition from heavy reliance on word-processing systems to the minicomputer business, Wang failed to move into the PC business soon enough to snare any significant market share, he adds.

"Wang felt the dramatic growth rates of the early 1980s would return," Willmott maintains. "It chose to borrow from equity instead of biting the bullet by downsizing the company."

"Wang didn't believe what was going on in the market," observes David Steadman, president of Atlantic Management Associates, a Boston-based company that specializes in managing efforts to turn around embattled firms. "It didn't get into Unix systems soon enough. And its closed strategy has hurt."

Paul Henning, director of investor relations at Wang, acknowledges that expenses "were much higher the last couple of years than the revenue base warranted" after the company's growth rate slowed suddenly in the minicomputer slump. Henning argues, however, that

The Wang towers dominate the approach to Lowell from Interstate 495. The troubled computer maker's woes are a hot topic in the computer business.

NEWS UPDATE

Entry Price Redefined for Hardware Accelerators

The industry's lowest prices for logic and fault simulation accelerators have been announced by Zycad Corporation. Bundled as a complete system, the Magnum™ Series of simulation accelerators delivers 16,000 gate modeling capacity, serial fault simulation, and ZILOS™ software interface for $55,000.

One Million Gate Barrier Broken

Large system designs of up to four million gates can now benefit from the performance of hardware acceleration. Zycad's System Evaluator™ combines 128 custom, parallel processors to produce 320 million event per second simulation speeds. Over 6,000 times faster than simulations running on 10 MIP workstations, the SE makes virtual prototyping of entire computer systems a reality.

Behavioral Simulation Speed Triples for Accelerator

Behavioral simulation speed has been increased for Zycad's MACH™ Series hardware accelerators. The MACH 1500™, with its new UNIX™ front-end processor, performs logic and fault simulation two to three times faster than previous models. Integration of the processor with the simulation acceleration hardware ensures that added processing performance translate directly into faster simulations. Total simulation throughput, including netlist compilation and output processing, also benefits from increased processing performance. MACH accelerators are available from only $60,000.

Fault Simulator Sets Speed and Capacity Record

One million gate designs can now be fault simulated on Zycad's MACH 2000™ hardware accelerator. A new parallel-concurrent fault simulation algorithm increases the accelerator performance by processing up to 64,000 faults in a single simulation pass. A new front end processor delivers 10 MIPS of behavioral-level simulation, netlist compilation and output processing performance.

VHDL Simulator Solves Complex Problems

Zycad's System VHDL™ simulator, a full implementation of the IEEE 1076 standard, is now in use for the verification of complex designs. From analyzing the design of military computers to verifying the correctness of synthesized logic, this new simulator has demonstrated the speed, power and capabilities of the Zycad VHDL product. The industry's first VHDL source-level debugger comes standard with the Zycad System VHDL. The state of simulation variables is displayed as each line of VHDL code is executed, thus simplifying the development and verification process. Zycad System VHDL is available now and runs on Apollo™ and Sun™ workstations, and VAX™ computers.

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the VS minicomputer line remains one of Wang's strengths. "You can't underestimate the strength of an installed base," he says. "With more than 50,000 [VS machines] in place out there, customers will find that they need to upgrade. And while the minicomputer market has slowed down, the VS can be a server in a PC-based local-area network or in a multivendor network environment."

Henning adds that Wang's push into VS-based integrated imaging systems [*Electronics*, April 30, 1987, p. 83], which integrate images with text in a desktop work station, is beginning to pay off in sales. Wang derived $112 million from its imaging systems in fiscal 1989 and will double that performance in 1990, Henning projects. Other promising developments, he says, are a 25% boost in PC sales in 1989 as well as the company's move into PC LAN products—an industry growth segment.

Henning points out that Wang's well-received Freestyle product also runs on all major PC LANs. Freestyle is a PC-based system intended for people who don't want to use keyboards [*Electronics*, December 1988, p. 132]. It allows PCs to accept handwritten notes and voice input, combine this information with representations of pages on the PC display, and then ship the combined information package to similarly equipped computers in a network.

MORE LIGHTNING BOLTS. In addition to a new president, Wang also needs a fresh product strategy, says Aberdeen's Willmott. "Wang has had a couple of lightning bolts in its imaging systems and in Freestyle," he says, "but Freestyle isn't going to drive a $3 billion company. Its imaging systems are dandy products, too, but if they account for $112 million in revenue, they're not going to save 26,000 jobs." That's Wang's approximate head count goal after completing its current round of layoffs.

Willmott suggests that Wang's established beachhead in imaging systems could be part of a strategy for the company to move much more strongly into indirect sales through systems integrators and value-added resellers, rather than slugging it out with IBM and DEC in direct sales. "My sense is that Wang is still a viable business but is likely to become a systems-integrator kind of company," Willmott says.

Atlantic Management's Steadman isn't so sanguine. "Once a product line has gone awry, computer companies are tough to turn around because it's difficult to get products up to date," he observes. "The banks may force a turnaround specialist on Wang. That person may look for a company that has good products but weak marketing and marry it with Wang, which has good marketing, sales, and service." *–Lawrence Curran*

TEST EQUIPMENT

A SLOW YEAR TRANSLATES TO A SLUGGISH SHOW

WASHINGTON

The kindest thing to be said about the automatic test equipment business is that it's flat. The 30% rise that the ATE market enjoyed last year has leveled off (see p. 150); the sluggishness is reflected in the shortage of new product announcements at the International Test Conference, held last month in Washington.

Still, a number of ITC exhibitors did generate excitement with new systems for testing scan designs, while chip makers showed integrated circuits for implementing boundary scan on printed-circuit boards. And manufacturers of logic test systems displayed devices that add analog test functionality to digital schemes. Such mixed-signal testers will not be affected by the market slump, according to market watcher VLSI Research Inc. in San Jose, Calif.

Makers of board and chip testers are building systems to accommodate the emerging Joint Test Action Group scan test standard for testing digital ICs and pc boards. JTAG, one of many scan testing models, has been adopted by the Institute of Electrical and Electronics Engineers P-1149.1 Test Standards Committee. Boundary scan techniques such as those embodied in JTAG relieve the problem of testing surface-mount, double-sided pc boards with fine pitch traces. Such boards cannot be easily tested with bed-of-nails, in-circuit testers.

JTAG specifies the adding of scan cells on every input/output pin of an IC. During operation, a scan controller on the pc board serially shifts a test pattern, scanning cells on the input pins of each chip to set an initial state. Applying a clock to the chips latches the results of the stimulus in the output pins' scan cells. These results are then shifted out of the chips and evaluated. JTAG specifies the test bus that links all chips on a pc board so that test patterns can be serially shifted in and results shifted out at I/O pins on the card edge connector.

Texas Instruments Inc. in Dallas, a leading proponent of JTAG, rolled out three IC devices for building JTAG control circuits onto pc boards. TI's ACT8990 test-bus controller IC accepts commands from an external computer or test system; it creates the serial bit stream shifted to the input scan cells and reads the response from the output scan cells. The ACT8997 and ACT8999, which sit on a primary scan ring of a pc board, select one or more of the multiple scan paths on the board.

Driving the scan rings on a pc board will likely be new board testers such as the L300 combinational in-circuit functional board test family introduced in June by Teradyne Inc. of Boston. The tester comes with two subsystems for delivering long serial test patterns at high speed to the pc board.

At ITC, Integrated Measurement Systems Inc. of Beaverton, Ore, rolled out a fully integrated scan test module for its Logic Master XL series of application-specific IC verification systems. The module supports scan test implementations including JTAG, scan path, scan set, random-access scan, boundary scan, and level-sensitive scan designs.

While boundary scan increases the testability of boards, scan techniques like level-sensitive scan design increase the testability of ICs. Adding scan circuits to an IC gives the engineer test points to probe inside the chip, areas that cannot be reached with test vectors from the chip's I/O pins.

HEAVY ALLIANCE. Gillytron Inc. of San Jose has added to its ScanMaster DV-8005 test system capability to support the P-1149.1 standard. In late May, Motorola Inc. of Phoenix, Ariz., announced an alliance with Schlumberger Technologies Inc. ATE Division of San Jose to develop a new type of test system to reduce the cost of testing ICs with high pin counts. The system will be based on a Motorola-derived overall test strategy incorporating conventional scan design to access internal nodes of a chip. The machine, which will be able to test devices with up to 1,024 pins, will be priced at $1.3 million to $1.5 million, says Fred Berneche, ASIC test development manager at Motorola. That's a bargain considering a 512-pin tester now costs $3 million to $5 million.

The continued development of mixed-signal testers also made news at ITC. Integrated Measurement Systems introduced its Logic Master XL Mixed-Signal Verification System. With a price tag of $120,000, the system has 176 digital and 16 analog I/O channels, which can be configured with a variety of analog instruments complying with the IEEE 488 standard.

Other test makers unveiled systems that included some degree of analog testing capability. For example, the Trillium Division of LTX Corp. of San Jose announced it was adding an analog pin card to its line of logic testers. The card has a 16-bit digital-to-analog converter on-board to allow testing 12-bit DACs and analog-to digital converters, says Dennis Petrich, director of marketing. Trillium also announced a DAC testing option for chips with an on-board DAC, such as video RAMs. *–Jonah McLeod*

TV CIRCUITRY IS PICTURE PERFECT IN BERLIN

WEST BERLIN

Unlike the American TV market, which U. S. manufacturers have all but abandoned to the Japanese, the market in Europe is still in the hands of native companies. In fact, with their allies in the chip business, European set makers have turned their market into a go-go world where innovations abound and one-upmanship in receiver design and performance is the order of the day. For proof, just look at the International Audio and Video Fair, Aug. 25 to Sept. 3, in West Berlin.

Among the latest advances in TV circuitry being demonstrated are a picture-insertion processor from Siemens AG and a two-chip set from Intermetall GmbH that enables a receiver with today's 4 : 3 horizontal-to-vertical picture format to display the new 16 : 9 format—or vice versa.

The Siemens circuitry, developed at the company's Semiconductor Division in Munich, represents a low-cost way to blend a small picture into the display's normal picture, not only with digital sets but also on conventional analog receivers. The inset lets viewers check what's on another channel without switching off the program to which the set is tuned.

TV PIONEER. With the Intermetall chip set, the number of lines in the TV picture remains the same whether the receiver is old style or the new 16 : 9 format—625 horizontal lines for the European transmission standard and 525 lines for that used in the U. S. and elsewhere. The Freiburg, West Germany, company—which pioneered the circuits for digital TV in the early 1980s—has built its chips into a color receiver and is putting them through their paces in a hotel presentation at the fair.

Picture tubes with a 16 : 9 ratio are getting a close look as part of the Eureka EU95 project, a pan-European endeavor to establish high-definition TV standards for the 1990s. This format is also favored by the Japanese in their HDTV efforts and will probably be adopted in the U. S., making it the likeliest candidate as a worldwide standard.

One reason TV experts are favoring a 16 : 9 display is that it adapts well to human vision. A person's field of view is much wider across—nearly 180°—than it is up and down. What's more, a 16 : 9 display conforms to today's wide-screen movie format.

Intermetall came up with its format-processing scheme in response to industry demands, says Ulrich Sieben, manager of the company's Concept Engineering Department. "Producers were clamoring for a new sales argument for their sets. So with the industry's cooperation we developed the chip set."

The time seems ripe for the new concept. Picture tubes with the 16 : 9 format are already appearing on the market, albeit in expensive receivers. But with the advent of HDTV, sales of wide-screen TV display tubes should take off fast. At the same time, conventional 4 : 3 tubes will be around for some time, especially in countries where the swing to HDTV is slow.

The Intermetall chip set is designed for receivers using digital signal processing, as is implemented with the company's Digit 2000 circuitry. The set consists of the DMA2285 descrambling integrated circuit and the DTI2250 digital transient improvement processor.

The 2285, a DSP that packs some 300,000 transistors on a 61-mm^2 chip, is a real-time descrambling circuit for signals of the D-MAC and D2-MAC as well as the upcoming HD-MAC standards. Installed in the receiver's video channel, the circuit descrambles the MAC TV signals and interpolates the 16 : 9 MAC pictures to the conventional 4 : 3 format. In effect, the circuit cuts out a 4 : 3 picture from the 16 : 9 format and puts it on the screen.

The DTI2250, an IC with 80,000 transistor functions on a 14-mm^2 chip, presents a picture in the standard 4 : 3 format without distortion on new TV tubes with the 16 : 9-format screen. The leftover screen space can be used to display videotext or receiver settings.

As for the new Siemens picture-in-a-picture concept, the company implemented it with its picture-insertion processor, the SDA9088, the only IC needed to obtain the blend-in feature on a digital receiver. With a conventional analog receiver, all that's required in addition is the company's triple analog-to-digital converter, the SDA9087.

In either case, the savings in components are enormous, says Rolf Deubert, who heads Siemens's activities in semiconductors for entertainment electronic applications. That's because the 9088 combines the picture memory, control circuits, digital signal-processing stages, and digital-to-analog converters all on one chip, thereby replacing as many as eight ICs. Also, both the 9088 and 9087 can be installed on a board that's up to four times smaller than would normally be required. As a result of the small component count, set makers can realize the picture-in-a-picture function in TV sets and video recorders at low cost and with excellent reliability.

FINE-LINE. The picture-in-a-picture function is not new. But previous implementations did not find wide acceptance in consumer electronics because costs were kept steep by the high price of the picture memory and the peripherals needed for the ADCs. Siemens managed to push costs down to acceptable levels by using the fine-line semiconductor technology and expertise acquired as part of its Mega high-density-memory project.

With the 9088, the sources for both the smaller, blended-in picture and the larger, or normal, picture may be entirely different regarding transmission standards and synchronization. The chip's prime task is to miniaturize the picture from the second source and synchronize it with the larger picture.

Two formats for the blended-in image are available: 1/9 and 1/16 the area of the larger picture. The image can be positioned in any of the screen's four corners. Fine-positioning in 16 horizontal and 16 vertical steps is possible. *–John Gosch*

TRAFFIC CONTROL

EASING LONDON'S TRAFFIC, WITH THE HELP OF AUTOGUIDE

LONDON

People have been talking for decades about vehicle-navigation systems based on technology ranging from buried cables to radar to on-board displays of road maps. Now it appears that England is going to get such a system—Autoguide, set to start up in London in the early 1990s.

To be run by a consortium headed by the UK's General Electric Co. plc, the system will rely on a real-time on-line data base continuously supplied with information on traffic conditions throughout the metropolis. The GEC group has just bagged a government license to operate the system commercially.

With Autoguide, a motorist will drive into the zip code of his intended destination with the help of the system, which will point out the most efficient route by feeding turn directions and recommendations for speed and which lane to use on multilane highways. Directions may be given by a synthesized voice unit or displayed on a small liquid-crystal display. As traffic conditions change because of weather, road work, accidents, or volume, the system will modify the route it has preselected for a particular journey to

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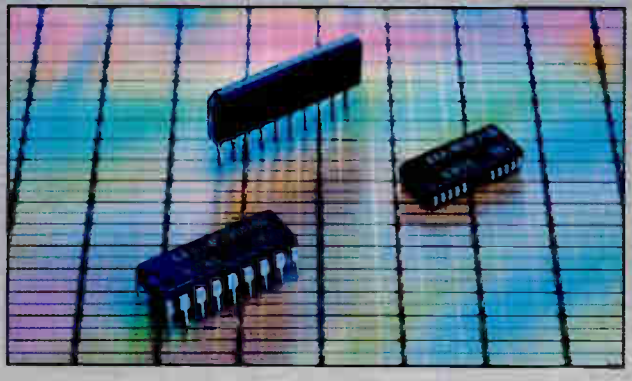

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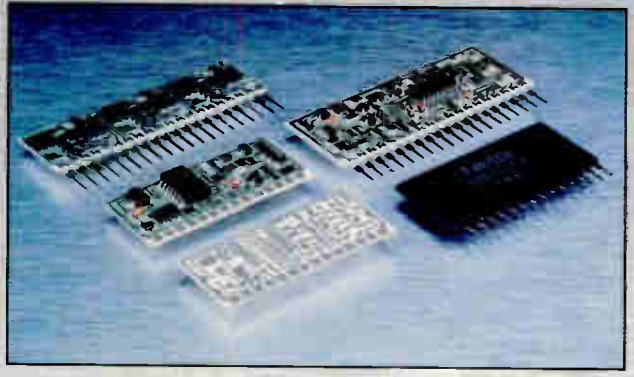

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Hy-Pack thick film hybrid ICs feature double-sided component mounting, chip-on-board capability and high density circuitry. They exemplify the latest in automated production techniques.

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Circle 39

steer the driver around congestion.

The system's sponsor, the UK Department of Transport, expects Autoguide to help speed traffic throughout the city. Currently, traffic creeps along at peak times in parts of London at an average speed of barely 6 miles per hour. Besides being frustrating, the slow crawl can be expensive to businesses. For example, the British Post Office says that traffic congestion costs it more than $18 million a year, while one company that operates a large fleet of cars in London figures that an increase in average traffic speed of just 1.4 mph would save it $13 million in a year.

Two years ago, the Department of Transport asked industry to come up with proposals and bid for a license to operate a vehicle-navigation system. The GEC consortium that won out includes the Royal Automobile Club, Logica Communications and Electronic Systems Ltd., and traffic-flow consultant W. S. Atkins Consultants Ltd. Only one other group bid for the business—a team made up of Plessey Co. plc and Siemens AG of West Germany. The Plessey-Siemens proposal, Aguide, is based on a similar system that Siemens is running in Berlin.

ROADSIDE BEACONS. With Autoguide, drivers will equip their vehicles with $400 in-car units consisting of an LCD screen and a two-way infrared transmitter-receiver. These units will gather information from a series of roadside beacons, which in turn will be interconnected by land lines to a central computer control network. Beacons will interrogate the vehicle transponders as they pass to determine their current intended destination, and will update the dashboard display as necessary. An icon display will make recommendations indicating the direction a driver should take at junctions, the distance to an intersection, the best speed at which to drive, and, on major roads, which lane to use. Synthesized voice messages will back up the potentially distracting visual displays.

Autoguide will monitor the progress of a vehicle as it passes from beacon to beacon, providing data on the average speed of traffic section by section. When consolidated with data collected from static traffic systems already in place in London, along with preloaded information on road-repair projects, traffic accidents, weather conditions, and the like, it will offer on-line recalculation of a driver's most efficient route.

The dual effect, the Department of Transport hopes, will be to speed a driver on his way while diverting traffic flow from the most congested spots, thereby evening out road usage.

GEC says that it could have a pilot scheme running in London early in 1992, complete with with 300 beacons and their supporting infrastructure. This initial implementation will serve about 1,000 vehicles. A full commercial service will follow shortly after. Costs to users would be minimal, the company says, with an annual fee for individual drivers of around $100 on top of the hardware cost. Later versions will incorporate speech-recognition units, developed by Marconi Secure Communications Ltd. at Portsmouth, so that drivers can ask for additional information if they need it.

A GEC spokesman says that the company also plans to sell data-base space to gasoline companies, banks, restaurants, and the like. When linked with mobile communications systems, the Autoguide unit could be programmed to respond to verbal inquiries such as "Direct me to the nearest cash dispenser" or gas station or parking lot, he says.

Now the company has to wait for the passage of the new Road Traffic Bill, which is awaiting Royal Assent on its progress through Parliament. That provides for the introduction of the Autoguide service and empowers the Secretary of State for Transport to license and regulate commercial operators. Significantly, the measure prohibits the gathering of information from the in-car units that would identify an individual vehicle and prevents the identity of a vehicle from being retained within the system.

The Department of Transport says it is willing to consider similar licenses elsewhere in the country. *–Peter Fletcher*

NETWORKS

ENGLISH CHANNEL TUNNEL WILL SPORT TELECOM LINKS

LONDON

History will be made when trains start rolling in 1993 between England and France through a 26-mile tunnel beneath the English Channel. At the same time, what is probably the first private telecommunications network linking the public networks of two nations will start handling the total communications infrastructure of the tunnel.

Six months before opening day, Racal-Milgo Ltd. of Hook in Hampshire, UK, expects to have the $30 million integrated voice and data network operational. It will take care of all switched voice and data traffic for the tunnel's administration, emergency services, environmental monitoring and control, signaling, public-address systems, and track-to-train communications.

The system will be based on eight Northern Telecom Meridian digital private-branch-exchange switches, two of which will be dedicated to emergency services. The switches feature transparent integrated voice and data services. Since they will be required to work to French and UK standards for the integrated services digital network, they will be made ISDN-ready by means of a signaling system based on the draft Q.931 international standard.

FIBER-OPTIC LINKS. Transmission links will be almost totally fiber optic for maximum immunity to electrical noise and to provide for future expansion. The system's backbone will comprise triplicated 140-Mbit/s "through-tunnel" transmission links and 37-Mbit/s drop-and-insert fiber links to 400 multiplexers.

More than 300 of the multiplexers will be installed in a series of signaling and communications control rooms located in spur galleries connecting the central-services tunnel with the two main rail tubes at 2,500-ft intervals along the tunnel. Additional fiber links, working at 2 Mbits/s, will interface with the PBXs and connect to other networks, including French and UK public telecommunications networks. Radio communications in the tunnel will be served by coaxial cable systems. Installation will start next March. Although the network is complex and sophisticated, it will be assembled from tried and tested equipment and systems.

50 BIDDERS. The competition for the contract was stiff. It was awarded by Transmanche Ltd., main contractor for the tunnel, and there were more than 50 bidders, says Tim Holley, deputy chairman of Racal Data Communications Group. "Racal-Milgo was selected from a short list of four," he says, beating Siemens AG of West Germany, Alcatel SA of France, and a consortium comprising the UK's GEC Plessey Telecommunications Ltd. and France's Jeumont Schneider SA.

Racal will act as prime contractor, taking overall responsibility for system design, project planning, and program management. Hardware and installation services will be provided by a team of subcontractors put together by Racal so that the work is evenly shared by British and French companies.

The team includes major subcontractors Costain Telecommunications and Systems Ltd. of the UK, Compagnie Générale de Travaux et d'Installations Electriques of France, and Northern Telecom Meridian, the Paris-based subsidiary of the Canadian telecommunications giant. They will be backed by Eurotel Ltd., which will supply 2-Mbit/s multiplexers, Société Anonyme de Telecommunications, to supply multiplexers working at higher speed, and Whitely Electronics Ltd., which will be responsible

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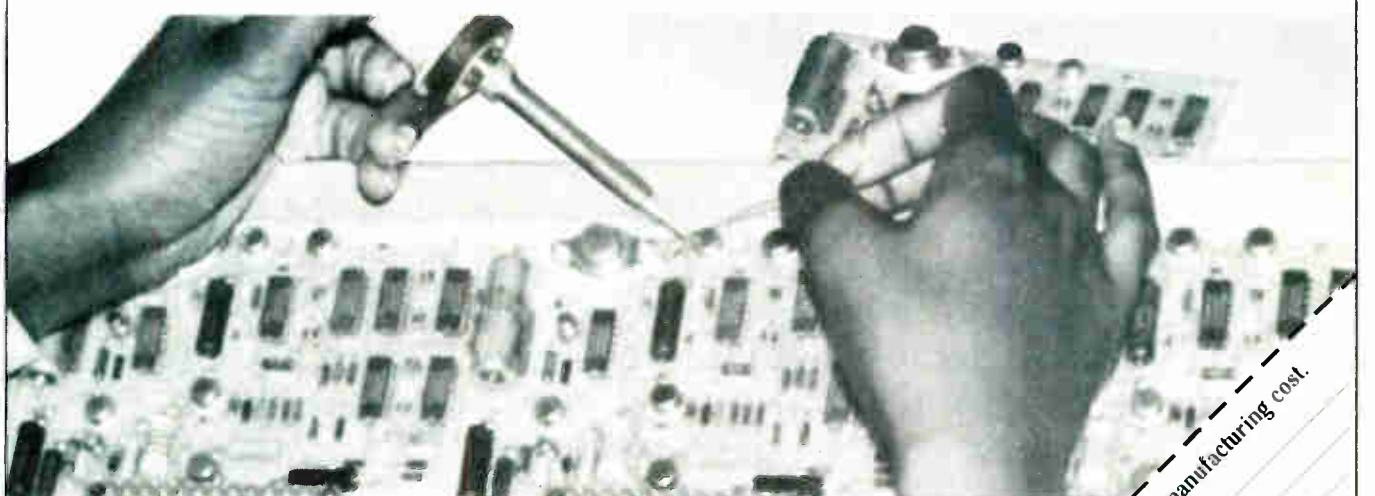

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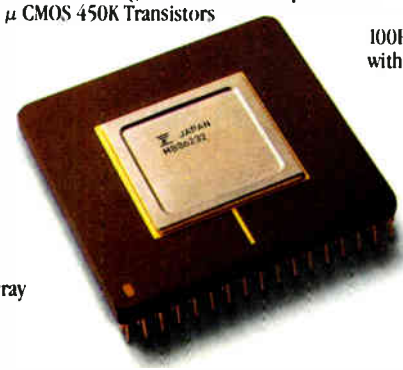

100PS 10K Gate ECL Gate Array
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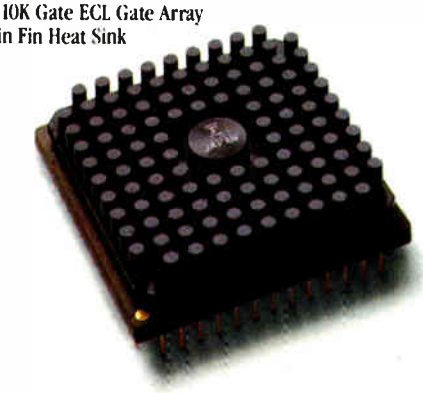

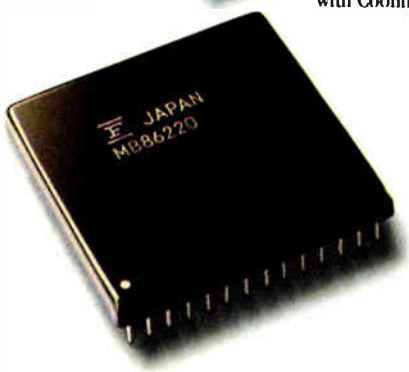

24-bit Floating-Point General Purpose DSP
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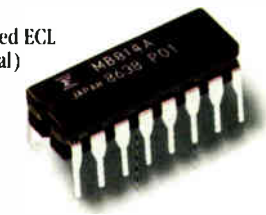

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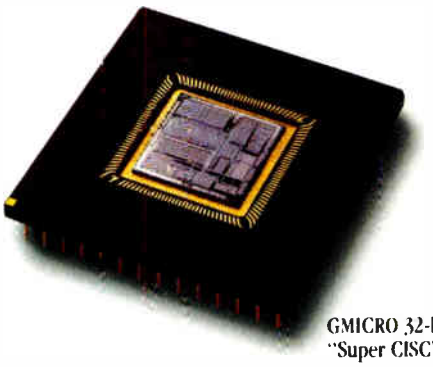

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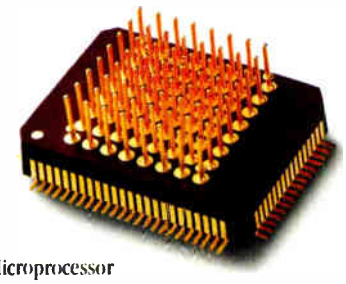
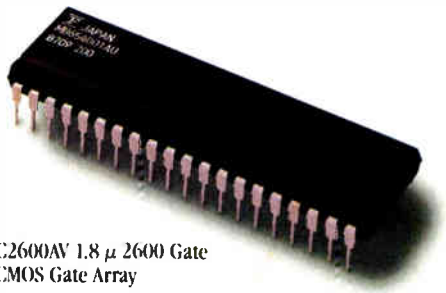
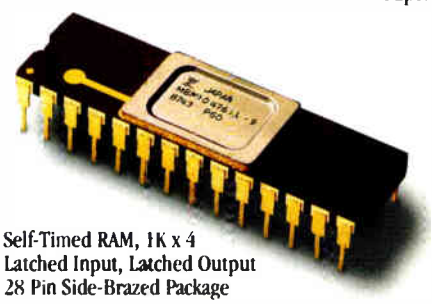




C2600AV 1.8 μ 2600 Gate
CMOS Gate Array



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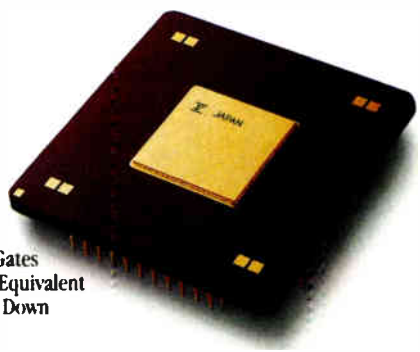

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As technically complex as the network will be, that's nothing compared with the regulatory issues it will raise. The net will be unique in being a private network that interfaces—and thus interconnects—two national public networks. In addition, there has to be provision for interworking the network on either side of the Channel with third parties.

VERY CONFUSED. Among them: customs and excise and immigration, the power-generating companies, railway operators, and emergency services. Add to that the need to access data bases and provide value-added services originating on either side of the Channel and the situation could get very confused. "Fortunately, those problems will be for the network's owners to sort out," Holley says.

However, Racal has not totally escaped the administrative complexities of building a network that straddles national boundaries. The company's accountants have yet to come to grips with the differing rates of value-added tax in force—15% in the UK, 18% in France. The problem is defining at what point along the tunnel the VAT rate changes. For example, officials must wrestle with problems like this one: Does equipment hauled in from the UK but installed beyond the halfway mark get taxed under British or French rates? *–Peter Fletcher*

TAKEOVERS

GEC-SIEMENS BID FOR PLESSEY MAY BE REALIZED AT LAST

LONDON

The seemingly interminable battle over Plessey Co. plc may finally be drawing to a close. GEC Siemens plc, the joint venture set up by the UK's General Electric Co. plc and Siemens AG of West Germany, plans to make a fresh bid to take over Britain's second-largest electronics company—a bid that most analysts expect to succeed. The new offer will be set at about $4.25 per share, bringing Plessey's total value to about $3.15 billion. Lord Arnold Weinstock, chairman of GEC, asserts that the new offer "is final and will not be increased under any circumstances."

If the bid is indeed approved, GEC and Siemens will carve up Plessey's businesses between themselves. Plessey's naval systems and avionics holdings outside North America will become wholly owned by GEC. In addition, GEC will take over Sippican Corp. of Marion, Mass., and Leigh Instruments Ltd. of Ottawa, Ontario. Meanwhile, Siemens will gain Plessey's radar and defense-systems operations, including military communications and Plessey's Australian defense plants.

Several Plessey divisions will be owned jointly. GEC will own 75% of Plessey Electronic Systems Corp. of Wayne, N. J., formerly the Electronic Systems Division of Singer Corp., with Siemens controlling the remaining 25%. Other divisions to be jointly owned include Plessey Semiconductors, Plessey's aerospace and engineering division, and its research centers. In semiconductors, says Weinstock, "it is intended that the existing management should remain in place," but under the control of Siemens.

HOPES DASHED. GEC Siemens, formed specifically to acquire Plessey, made its first bid for the company last November. At that time, the two partners expected to spend $2.75 billion on the deal. Plessey's management, however, engaged in a series of maneuvers in an attempt to foil the bid. Its biggest tactical victory was getting the proposed bid referred to the UK's Monopolies and Mergers Commission. With the UK Ministry of Defence on its side, Plessey's management expected the takeover bid to be quashed. But those hopes were dashed in April, when the MMC recommended that the bid be allowed to proceed.

Since then, GEC Siemens has been locked in negotiations with the Ministry of Defence to hammer out an agreement to end the stalemate. The ministry wants to make sure that British military electronics secrets don't fall under the influence of a foreign-owned company; at the same time, it needs to maintain a vestige of competition for the supply of major defense electronics equipment.

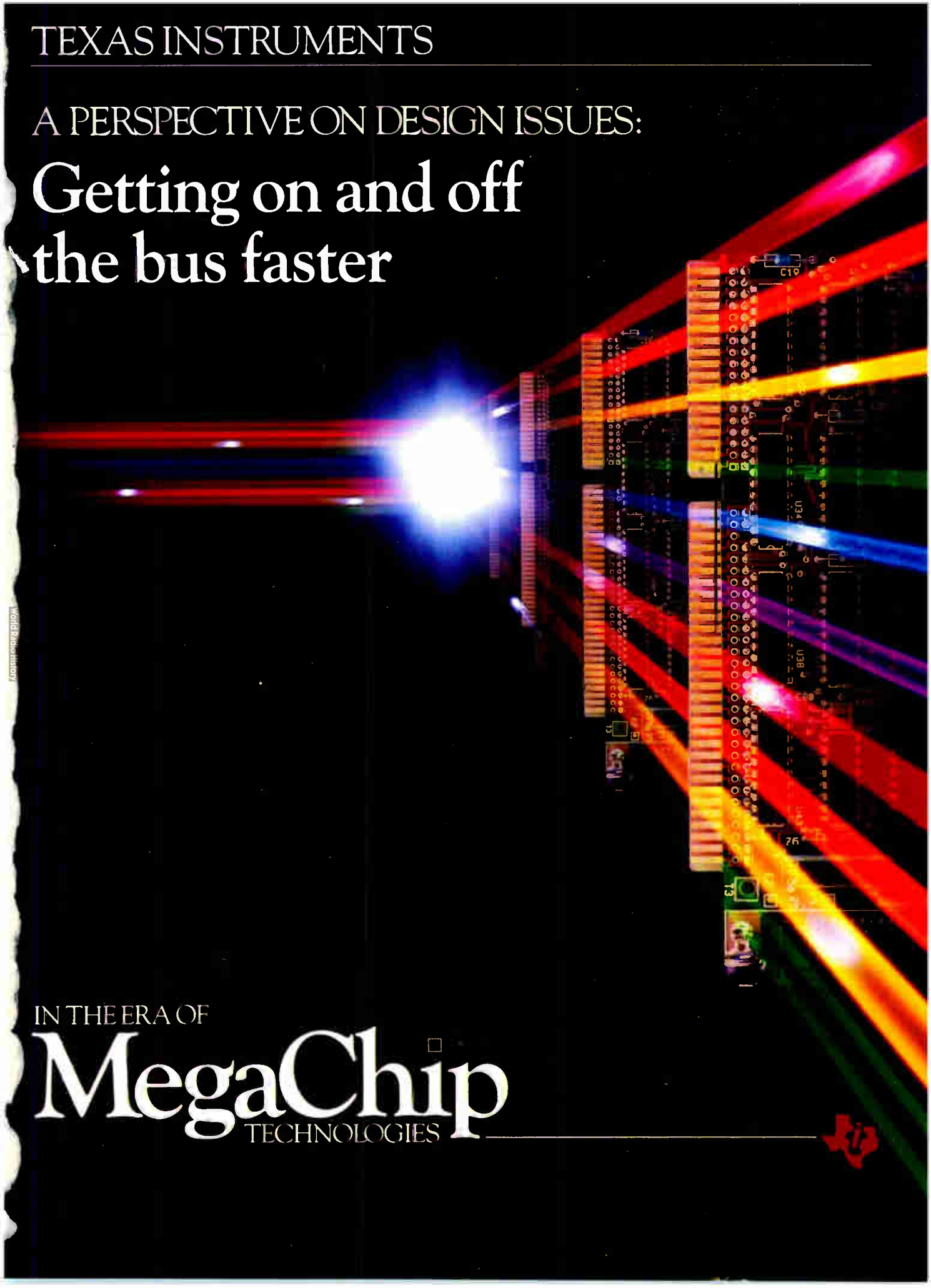
For a while, it looked as though these talks, which dragged on for more than three months, would fail to yield a solution. Just a week before the new bid was announced, Plessey executives were confident the company would stay independent. Reports from Siemens indicated that the Munich company would not get involved in another bid before September 30, the end of its financial year. And it didn't seem likely that the two government departments involved—the Ministry of Defence and the Department of Trade and Industry—would reach a decision before the government's annual summer shutdown in the first week of August.

But changes of ministers in both government departments involved brought negotiations to a rapid conclusion. Although they will not admit to it, it seems likely that the incoming politicians wanted to embark on their summer recess without the messy Plessey deal hanging over their heads. *–Peter Fletcher*

TEXAS INSTRUMENTS

A PERSPECTIVE ON DESIGN ISSUES:

Getting on and off the bus faster



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New bus interface ICs from TI can keep your total system up to speed.

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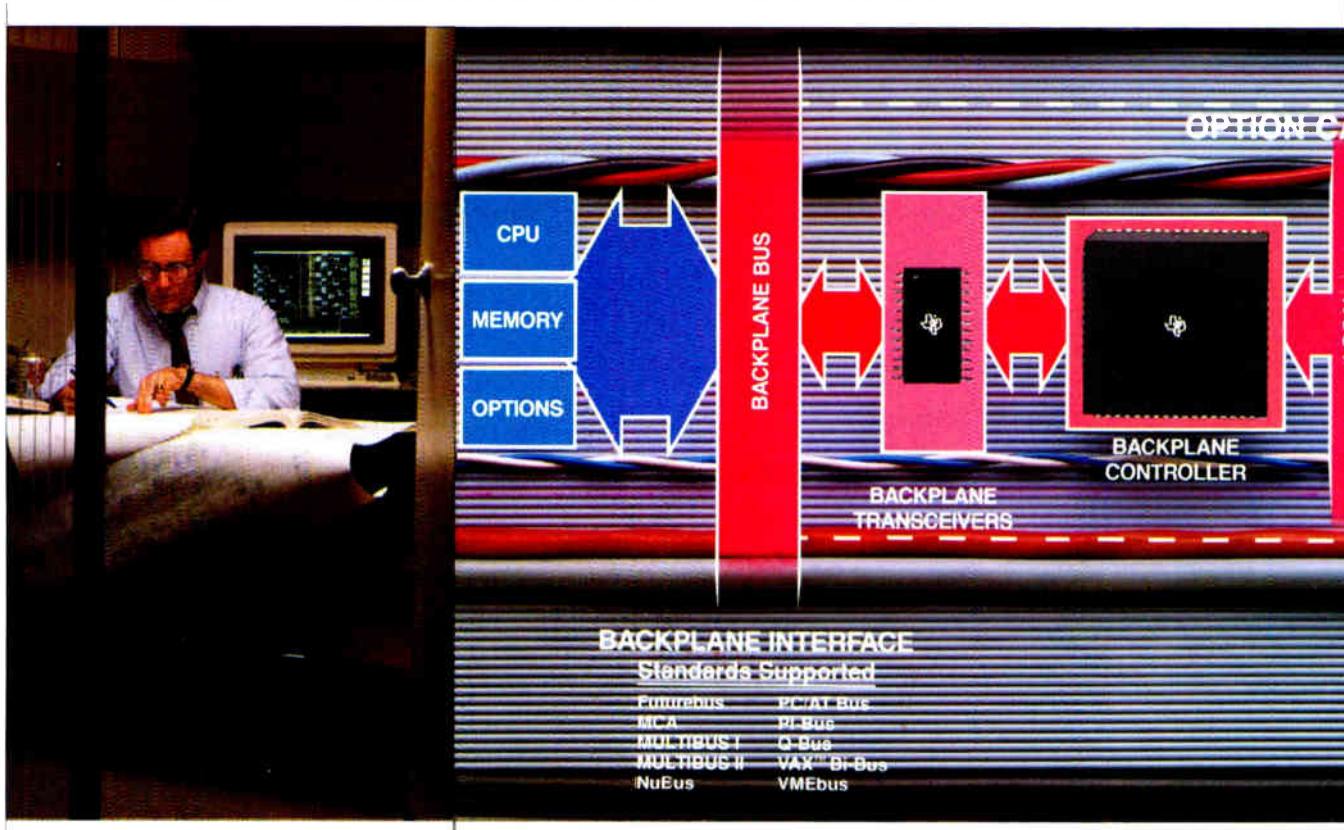

High-speed, low-power implementation of backplane and peripheral interfaces for most popular standards is made possible by TI's comprehensive family of both digital and analog physical-layer

What use is a high-performance CPU if its processing power can't be delivered to the backplane and outward to the peripherals?

Typically, some system throughput is lost at the local bus interface, some at the backplane interface, and some at the peripheral bus interface.

To help you minimize such losses and maximize system throughput, Texas Instruments offers a series of innovative chips for (1) backplane interface and (2) peripheral bus interface, as well as (3) controllers to regulate data flow.

These devices support the major industry standards listed above so that you can achieve system compatibility regardless of the bus you are implementing.

Superior backplane interface performance

To maximize system throughput, data must be able to get on and off the bus quickly. Therefore, the backplane bus transceivers must be capable of high speed and high drive.

Our high-speed/low-power BiCMOS logic (SN54/74BCTXXX) is specifically designed for bus interface applications.

As the name implies, TI BiCMOS merges low-power CMOS with high-speed bipolar, delivering switching speeds comparable to advanced bipolar devices. You also get the 48/64-mA

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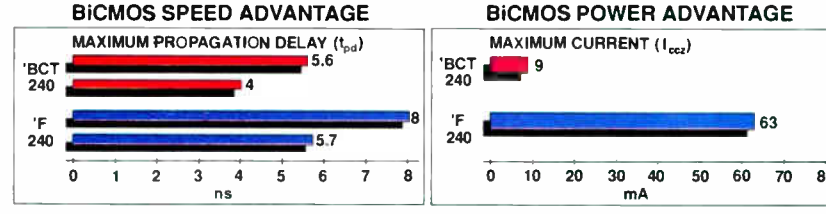
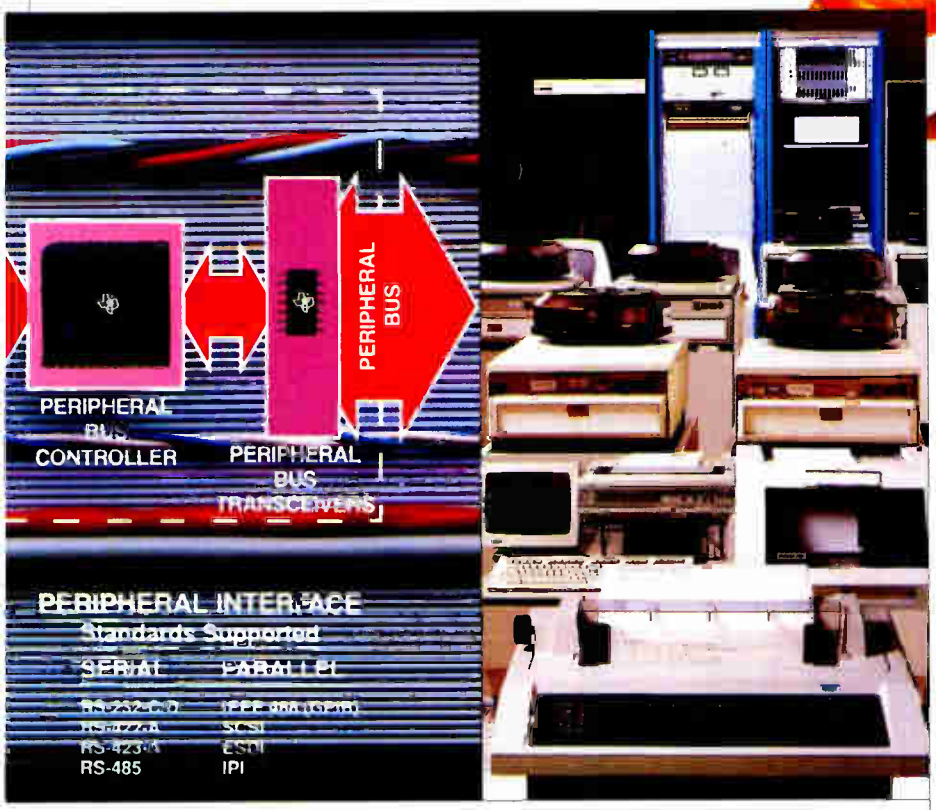


The BiCMOS lead over bipolar is proven by this comparison between TI's '74BCT240 and a comparable advanced bipolar standard device. Typical propagation delay of TI's BiCMOS part is faster *(left)* while power dissipation is less *(right)*.

TI's MegaChip™ Technologies are the means by which we can help you and your company get to market faster with better, more competitive products. Our emphasis on volume manufacturing of high-density circuits is the catalyst for ongoing advances in how we design, process, and manufacture semiconductors and in how we serve our customers.



ICs. To complete the implementation, TI offers a series of innovative standard and ASIC control devices. Use of TI's leadership bus interface devices can help shorten system design cycles.

drive current you need, and total system power savings can be as high as 25% (*see charts*).

There are more than 60 members in our BiCMOS family, including 8-, 9-, and 10-bit latches, buffers, drivers, and transceivers. The family is also available in military versions.

Our family of octal ECL translators (SN10KHT/100KTXXXX) delivers a low-power, high-speed translator solution with 48 mA of drive capability on the TTL side.

Our high-speed Futurebus transceiver family (SN55/75ALS-05X) includes quad and octal devices compatible with Futurebus implementations of the IEEE 896.1 standard. With a drive capability of 100 mA, a 5-ns (typ) propagation delay, and a supply current of 65 mA (max), our SN75ALS053 has the best speed/power ratio of any Futurebus transceiver on the market today. ■

High-performance peripheral interfaces

Peripheral bus interface design decisions revolve around trade-offs between line length, data rate, and noise immunity.

Where data rates are low and line lengths are short, as with the popular RS-232-C/D standard, the major concern is power savings. However, relatively high voltages (30 V) prevent the use of standard CMOS devices. Your answer lies with TI's Linear BiCMOS family.

Included are low-power versions of industry-standard quad drivers and receivers (SN75C188/89). Driver/receiver combinations, ranging from single to quad combinations (SN75C1154), substantially cut package count.

This BiCMOS technology will also allow us to provide charge pump circuitry for single 5-V operation.

Where data rates are high and line lengths are long, as the newer peripherals demand, noise can become a major problem. It is overcome by the use of differential drive. Typically, the major application requirement is higher speeds at, ideally, lower power.

For example, disk drives using ESDI, IPI, or SCSI interfaces will benefit from TI's SN75ALS17X devices conforming to RS-422-A and/or RS-485 standards. These chips are fabricated using our unique IMPACT™ processing that delivers up to 50% greater speed compared to competing products with as much as a 30% power reduction.

IMPACT processing is also behind the unmatched speed of our SN75AS030 RS-422 dual driver/receiver. Typical propagation delays are only 6 ns. ■

No matter which of TI's innovative devices you choose to improve speed, cut power, and reduce real estate at the media interface, the complete bus interface requires another element — controllers. *For details on how TI is addressing your needs in this area, turn the page.*

High-performance controllers make system design easier.

While the majority of physical-layer devices—those used to implement backplane and peripheral interfaces—transmit data, your system design also requires a device to regulate the flow of that data through the bus interface. To do the job, TI offers a series of controllers that simplify and shorten your task while cutting chip count and improving overall system throughput.

Simplified NuBus design

TI has taken much of the work out of NuBus™ design by introducing the industry's first standard NuBus interface devices. They are the SN74ACT2440 NuBus Controller and the SN74BCT2420 NuBus Registered Transceiver.

A typical implementation, using two 16-bit transceivers and one 32-bit controller (*see below*), replaces as many as 45 discrete devices. Compared to a discrete approach, this solution uses 60% less board space and 90% less power.

Because the necessary logic is embedded within the controller, design cycle time is reduced significantly.

A low-power UART

There is now more need than ever for low-power RS-232 interfaces. Our TL16C450 Universal Asynchronous Receiver/Transceiver (UART), made with CMOS process technology, is an excellent choice for desktop applications and is especially suited for use in laptop/battery-powered units.

A flexible SCSI controller

Available soon, our SCSI controller (designed to conform to ANSI X3.131-1986 specifications) will deliver data rates of 3 Mbytes/s (asynchronous) and 5 Mbytes/s (synchronous).

Unique byte-stacking control logic will allow interface to 16-, 24-, and 32-bit buses. The TI controller will also provide powerful multiphase SCSI commands, including automatic handling of save-data pointer to minimize interrupts to the host processor. Dual 32-byte FIFOs will provide smooth, efficient buffering between processor and DMA ports.

Customized controllers, too

The NuBus and UART controllers are available as part of our ASIC standard-cell library.

In addition, TI offers TGC100 Gate Arrays and TSC500 Standard Cells as part of our ASIC family which allows you to build the precise chip functions you need. ■

System complexity and the future

As systems become more and more complex, the need will emerge for combining the functionality of controllers and physical-layer devices on a single chip. To that end, TI is applying its acknowledged expertise in physical-layer devices to the design and development of such advanced control-level ICs.

System complexity also brings with it the need for simulation models to make design easier and faster. As a result, we already have simulation models available for more than 1,300 TI devices, including BiCMOS bus interface and ACL logic devices.

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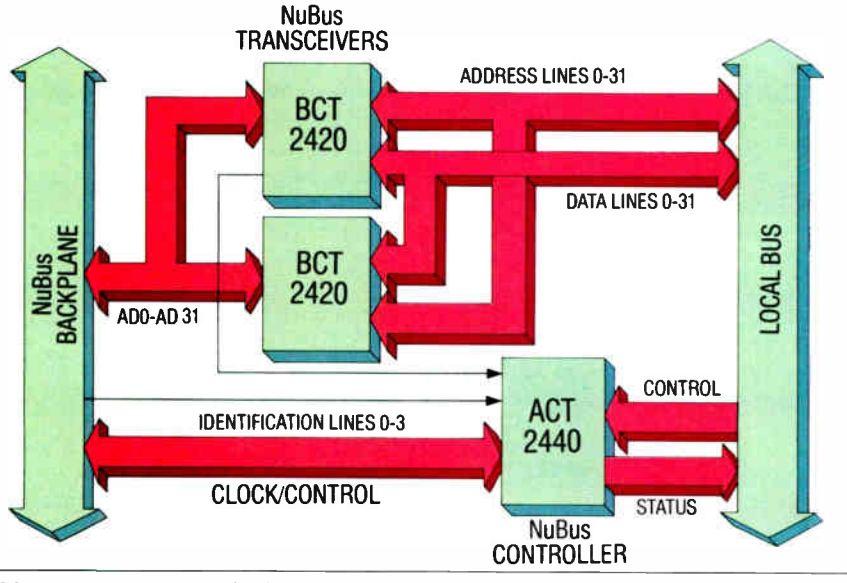

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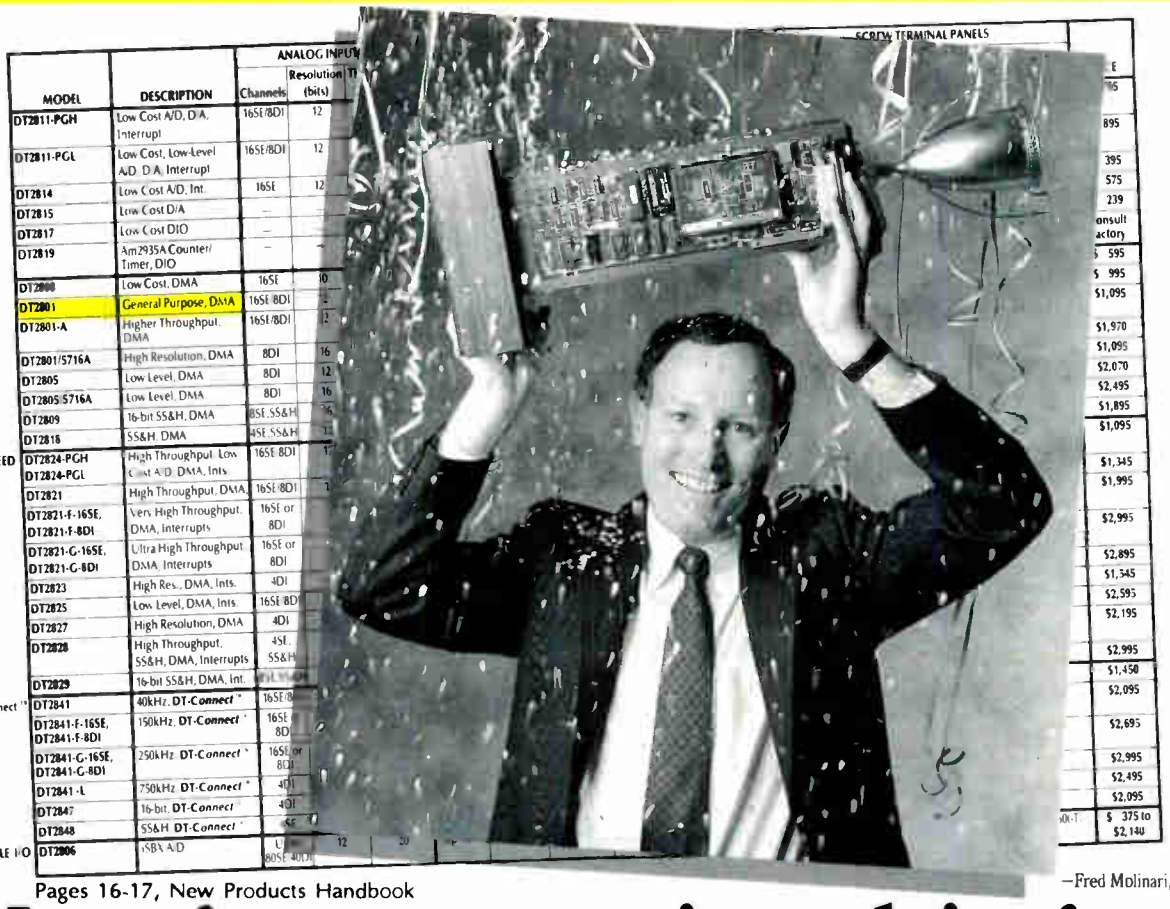

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Circle 17

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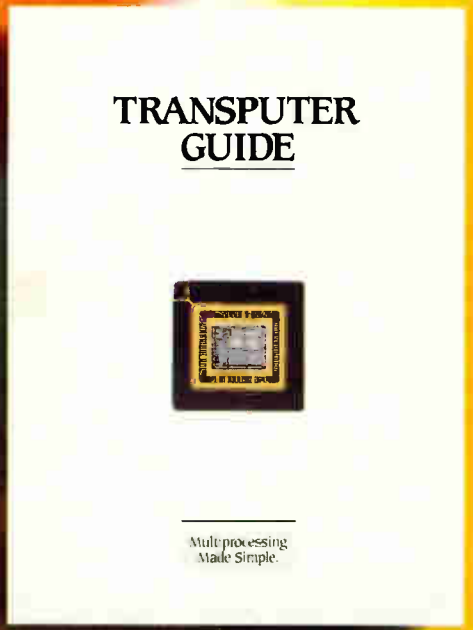

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Circle 44

Software Engineering Update

A REPORT FROM THE NETHERLANDS FOREIGN INVESTMENT AGENCY

Today, Holland has more than 12,000 trained software engineers. More than 20 universities and technical institutes are adding annually some 1,000 graduates to this work force, making these men and women available to an ever-growing number of Dutch and foreign companies.

Here's a closer look at Dutch software engineers' capabilities and some of their leading-edge activities:

A Decision and Simulation System (DSS) controls the unmanned, computerized storm-surge barrier at the mouth of the Eastern Scheldt. Developed and implemented by the 11-year-old BSO, DSS also can alert a crisis team should forecasts of weather and sea conditions require on-site monitoring. With more than 850 people in 25 cities throughout Holland, Utrecht-based BSO consults for more than 200 European and American firms in such areas as language science, AI, medical systems, transportation and communications.

An advanced, real-time, distributed multi-tasking operating system, ARTOS®, developed by five-year-old, Enschede-based LOCAMATION, is being used in software for "smart building" management, process control, machine controls, factory automation and robots. ARTOS is a modular, expandable package suited for 16/32-bit microcomputer systems and runs both on ROM- and DOS-based systems using UNIX/OS9. These systems can be coupled transparently using various networks. Application of the UNIX development environment and combination with 4GL relational database package (ACCELL/UNIFY) results in a large reduction in programming costs.

Cross-compiler products used to develop software for embedded microcontrollers and digital signal processors, written in Portable C or Pascal, are being marketed worldwide by Tasking B.V. of Amersfoort. All compilers are hosted on a range of products including IBM PCs, Philips PMDS, Digital's VAX/VMS and VAX/UNIX, Sun and HP workstations. Tasking is the world's first software company to develop a C-compiler for digital signal processors with built-in pipeline optimization.

A database constructed around 60-plus language elements has been compiled by Van Dale Lexicografie, B.V. to automate the assembly of bilingual dictionaries. Based in Utrecht, Van Dale's unique database is also being used to create hybrid products—dictionaries of "common sayings" in various languages and basic material for bilingual dictionaries in which Dutch is neither the target language nor source language, as well as a CD product that combines encyclopaedic information and the Dutch-language database. Van Dale is recognized as the publisher of the world's "standard" bilingual dictionaries for Dutch with English, French and German, with Spanish now in production.

A "workbench" system, called BLUES, was used initially for drawing flow charts. Its developer—the Amsterdam-based software company Interprogram, a part of the Volmac organization—has now expanded BLUES to supply full documentation for the system being designed. BLUES is being used by Dutch, American and other international companies.

The Software Engineering Research Center—established in late 1987 jointly by the Dutch government and 13 companies, including three major U.S.-based information technology firms—was created to undertake industry-relevant software research in cooperation with Dutch universities.

All of these Dutch organizations along with dozens of others stand ready to develop further a world-class software industry to solve problems facing businesses all over the world.

Netherlands Foreign Investment Agency

Circle 20

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EUROPEAN OBSERVER

PHILIPS ACHIEVES BREAKTHROUGH IN GaAs CIRCUITS

Researchers at the Paris-based Laboratoires d'Electronique Philips have hit upon a discovery that could open the way for a new generation of gallium arsenide integrated circuits. The lab, which is part of Philips NV's international research organization, has demonstrated that metal-insulator-semiconductor FETs, or MIS FETs, using GaAs heterojunctions exhibit a negative differential resistance at room temperatures over a wide operating range. This discovery, the Dutch company says, paves the way for GaAs ICs with considerably simpler structures than are possible with conventional metal-semiconductor FETs. For example, an exclusive NOR port using MIS FET technology consists of just two resistors, a transistor, and a load resistor. A similar port built with MES FET technology requires eight transistors and five load transistors. □

INTERMETALL DEMONSTRATES A TV PICTURE-ENHANCING CIRCUIT . . .

TV circuit design has taken a big step forward now that engineers at Intermetall GmbH have readied a device that gives digital TV receivers a picture quality equal to that of Super-VHS video cassette recorders. The Freiburg, West Germany, company achieves this feat with an adaptive comb-filter video processor, the ACVP2205. This highly complex digital chip processes signals of both the PAL and NTSC transmission standards, largely eliminating their inherent cross-color and cross-luminance disturbances. To accomplish this, the device looks at each of the TV pixels according to different criteria and then selects those that best match neighboring pixels. The resulting picture quality matches even that obtained with expensive improved-definition TV sets, Intermetall says, without generating those "hanging dots" at the picture's edges. The ACVP2205 is being shown at the International Audio and Video Fair in West Berlin this month. □

. . . AND IS READY FOR VOLUME PRODUCTION OF D-MAC CHIPS

With development work on a two-chip D-MAC TV signal decoder for British Satellite Broadcasting just completed, Intermetall is getting set to produce the chips in volume. BSB has ordered 4 million chip sets for four vendors making D-MAC TV receivers for the UK market—the UK's Ferguson, Finland's Nokia, Holland's Philips, and Taiwan's Tatung. The first devices should be available well before the start of BSB's satellite TV transmission next spring. The chip set consists of the DMA2280 decoder, with 175,000 transistor functions on-chip, and the DMA2285 descrambler, with more than 270,000 on-chip transistor functions. Both chips will be made in 1.2-μm CMOS technology. □

HUGHES TO SECOND-SOURCE MARCONI'S RAD-HARD TECHNOLOGY

Hughes Aircraft Co.'s Technology Center at Carlsbad, Calif., is to second-source silicon-on-sapphire radiation-hard products made by Marconi Electronic Devices Ltd. at Marconi's Lincoln, UK, plant. The two companies are "negotiating a memorandum of agreement" on the technology, says a Marconi spokesman. Marconi wants to use the Carlsbad facility to supplement capacity at Lincoln. Its rad-hard products include 1-to-64-Kbit RAMs, a MIL-STD-1750A microprocessor and peripherals, standard logic devices, and 2900 bit-slice ICs and arrays with up to 10,000 usable gates. Under development are a 3-to-4-mips, single-chip 1750 microprocessor, high-capacity static RAMs, and high-speed logic and linear circuits. Marconi claims that its process is the only one commercially available that can produce 16-Kbit SRAMs that can work with radiation doses up to 300 Krads. □

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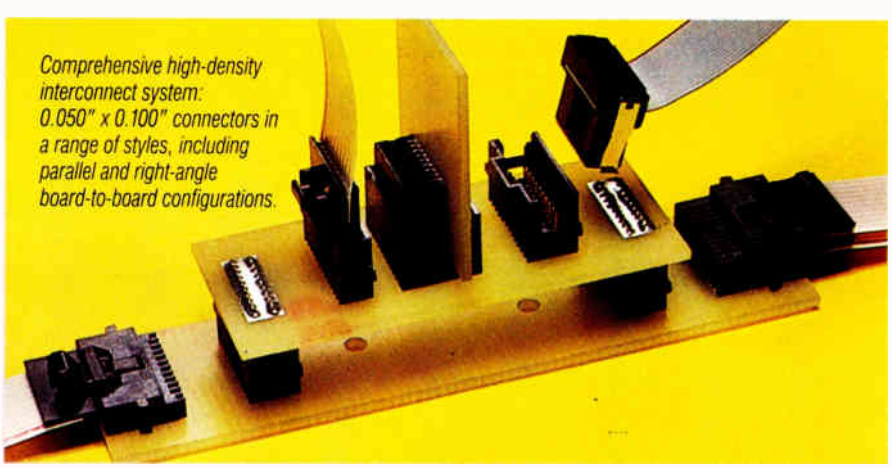
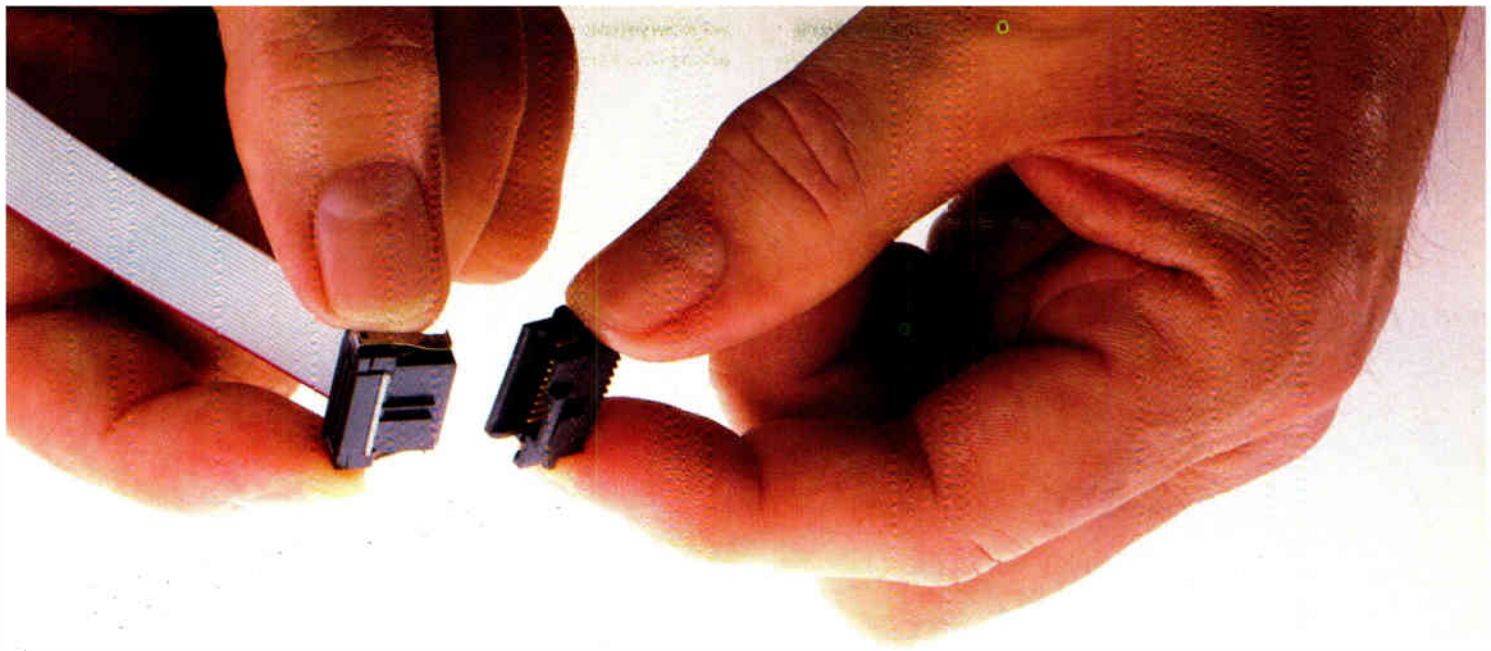


Comprehensive high-density interconnect system: 0.050″ x 0.100″ connectors in a range of styles, including parallel and right-angle board-to-board configurations.



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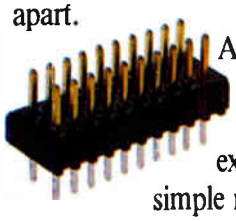

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AMP Interconnecting ideas

Circle 94

BY JACK SHANDLE

SANDY KANE'S $1 BILLION U.S. Memories PUZZLE

PHOTO BY WILLIAM COSTELLO

On June 30, Sanford L. Kane resigned as vice president of IBM Corp.'s General Technology Division to crawl out on a limb called U. S. Memories Inc., a radical departure from the way America has been doing business since the Sherman Antitrust Act became law in 1890. By the mid-1990s, U. S. Memories is modestly projected to hit the $1 billion plateau in annual revenues by manufacturing and selling cutting-edge dynamic random-access memories. But right now, president Sandy Kane occupies that corporate limb all by himself in temporary office space in New City, N. Y. He signs the checks and initials contracts for copy and facsimile machines. His secretary is a temp.

Can he turn back the clock to the 1970s, when U. S. vendors dominated DRAMs?

The world has not seen the likes of U. S. Memories before. The seven founding members—Advanced Micro Devices, Digital Equipment, Hewlett-Packard, IBM, Intel, LSI

Logic, and National Semiconductor—represent an enormous concentration of economic power. But Kane's task is daunting. His "short list" for U. S. Memories' board of directors must include raising $500 million in equity capital; finding a $500 million source of debt capital at rates competitive with those enjoyed by Japan's chip makers (perhaps government-guaranteed low-interest loans); locating a manufacturing site by November (in all likelihood, one of the five Sematech finalists); signing 4- and 16-Mbit DRAM-technology agreements with IBM; nailing down a technology path to 64-Mbit DRAMs within a year; and guiding antitrust exemptions and foreign-trade policy through a sympathetic but independent and regulation-minded Congress.

It's enough to make one's head spin. But Kane seems up to the task; 27 years of laboring in the Big Blue vineyards has done little to dampen his candor, squelch his entrepreneurial enthusiasm, or gray his wardrobe.

"To me, this is a tremendous opportunity," Kane says. "It gives me the chance to put my stamp on something I believe is terribly important." That "something" is nothing less than turning back the global challenge in manufacturing and marketing DRAMs—turning back the clock to the early 1970s, when U. S. chip makers dominated the industry.

LOTS OF CASH. First and foremost, Kane has to scoop up lots and lots of cash—to the tune of $1 billion. Not everyone believes raising it will be a slam dunk. Pierre R. Lamond, a veteran Silicon Valley venture capitalist, has the bruises to prove that point. Lamond, a partner in Sequoia Capital of Menlo Park, Calif., tried and failed last year to stitch together a DRAM company. When the point of no return arrived, he says, users would not support it (see p. 56).

Kane counters that U. S. Memories "has a formula for success that has never existed before." Three ingredients are well known: not having to spend money developing 4- and 16-Mbit designs and process technologies; a rock-solid market for 50% of its output guaranteed by consortium members as soon as they sign on; and the support of three major computer makers—DEC, IBM, and HP.

And there are corollary advantages as well. With its guaranteed market, U. S. Memories does not need much of a sales and support staff. Then too, IBM's technology starts the consortium off with 8-in. wafers, not the 6-in. wafers of the competition. "For a little bit more processing cost, I'll be getting almost twice as much yielded product," Kane says.

In 1-Mbit technology, IBM is getting the same yields on 8-in. as on the smaller wafers, Kane says, and the path to 4 Mbits is a smooth one. In terms of keeping costs competitive, guaranteed markets will let his fab run "flat out," without the peaks and valleys that scuttle profitability.

U. S. Memories will not be subsidized. "Investors will put their money on the table not just to have access to DRAMs, but because they want to get a return on investment," he says. Just what the return will be, however, has been left up in the air. One reason American chip makers dropped out of the DRAM business was that even when they were making money, they could get a better return on their fab investments by manufacturing something other than "jellybeans."

'I am confident we can get the financing, and I could build a good case for loan guarantees'

"It's far too early to tell if [the investors] would be satisfied with a lower ROI than they might otherwise get," says Kane. "I'm not looking for them to think of this as some second-class operation."

Then there is the other half of the 50-50 equity-debt equation. The key seems to be loans that carry lower interest rates because they are backed by federal guarantees. "In our case, I am absolutely confident we can get the financing we want [without loan guarantees]," Kane says. "I could build a very good case on why there should be loan guarantees. The most obvious is the difference between U. S. and Japanese companies for cost of capital. But that [argument] works well for everybody else who wants a loan. I can't come up with any reason why the government could do it for U. S. Memories and not for any other company."

Kane says that while he would "love to have" the guarantees, "I'm just not going to spend the next six to eight months in Washington lobbying to make that happen." On the other hand, he says, "there are a number of people talking about the notion of a government fund for companies that compete against the Japanese. It's a great idea; I would be glad to support it enthusiastically."

The idea does not, however, count California Rep. Tom Campbell as an immediate convert. Campbell, a Republican, is sponsoring key legislation that will provide an antitrust exemption not just to U. S. Memories, but to any similar consortium. "There's nothing about loan guarantees in my bills or any of the others [allowing manufacturing and marketing consortia]," he says. "Loan guarantees for New York City, Chrysler, Lockheed, or anyone else should be decided on individual merit, not as a class."

Campbell will be of considerably more aid in the antitrust arena. "It is a very live problem for U. S. Memories," says Campbell. In testimony before Congress last month, T. J. Rodgers, president of Cypress Semiconductor Corp., repeated his threat to sue U. S. Memories should it enter the static RAM business. Just as important, Intel Corp.'s president, Gordon Moore, testified that his company would be very antsy about proceeding with its part of the consortium unless there's clear sailing on the antitrust waters.

Throwing the biggest scare into Moore and other backers is the treble-damages stick some semiconductor maker—or small systems house—might use against U. S. Memories once it enters production. The damages can be measured as losses incurred by the plaintiff or on a profit-per-unit basis, says Campbell. His bill reduces punitive action to injunctive relief. Other legislative solutions simply scale down the damage awards (see p. 67).

Some legal experts see the consortium as an all-out attack on the principle of preserving competition within the nation-

al boundaries. Others find the idea palatable, given the realities of the global marketplace. Larry Boes, an antitrust attorney for the New York firm of Fulbright, Jaworski & Reavis McGrath, calls an antitrust exemption reasonable, considering the trading practices of Japan—but only if it's the right legislation.

"The big boys are going to have to accept the fact that they are going to be regulated," Boes says. Congress or some regulatory arm of government must assure fairness on price, access to the DRAM product, the priority in which DRAMs are distributed, and membership in the consortium.

A COMPLIMENT? But Kane calls regulation "an absurd notion." With U. S. manufacturers now supplying at most 10% of the global DRAM market, he argues, "even with a very aggressive plan, adding U. S. Memories to the equation is not going to make us the dominant player. At least not right away. To go from worrying about getting U. S. Memories off the ground to having to worry about regulating price and availability—I guess I should view that as a compliment, but I don't see it happening." Kane is not as clear on U. S. Memories becoming a safety net for small systems houses that depend on access to DRAMs. "If it does anything," he says, "it ought to help stabilize prices and assure supply in the U. S."

When pressed on the priorities given consortium members, Kane responds with a promise. "Let's put it this way: enough of the production will be available to third parties so that if there is a company that is concerned about somebody getting an unfair advantage and they are—by definition—small enough that they did not choose to invest, then I will have more than enough memory left beyond the investors' needs to supply all of their needs and a number over them as well."

Although a sweeping antitrust exemption is "important to us," Kane says, U. S. Memories can afford to go ahead on a favorable opinion from its legal counsel, which should be ready before October. Congress will not move as quickly. Although several bills are pending in the House, he notes, "the Senate hasn't done squat. If they could pass a bill in less than a year, I would view it as a major achievement. If we were put in a position where we had to wait on that, you could kiss the whole idea goodbye."

Issues that coalesce around the U. S.-Japan Semiconductor Trade Agreement, which will expire just as U. S. Memories starts ramping up its 4-Mbit production, raise Kane's hackles higher than antitrust talk does. "If [the Japanese] price their product below cost, it is going to make it difficult to compete," he says. "I'm counting on the U. S. government to see that that doesn't happen." Kane believes existing legislation can do the job.

Kane has already discussed trade with Secretary of Commerce Robert Mosbacher. "We need to get the procedures in place so that when someone files an action, we don't have to wait for [the bureaucrats] to figure out what Congress meant when it passed the law," Kane says. "We want to have action now when we make a complaint. We don't want to have to wait six months."

On another front, Kane is moving fast to find a site for his state-of-the-art fab. "My gut feeling is that we will start in a green field," he says. U. S. Memories will also start with a pile of incentives—local tax abatement, an outright grant of land, and low-interest loans are all in the equation. The proposals will come through state or local agencies—no real estate developers need apply.

Kane expects that the site chosen will be one of the five finalists in the site search for Sematech, a search that Kane directed.

Although U. S. Memories will not shun offers of existing facilities, Kane says, they "shouldn't just offer us a building. They have to tell us why it will have a dramatic impact on our schedule." □

TWO CHEERS FROM THE DRAM MAKERS

Reaction of the three remaining U. S.-based makers of dynamic random-access memories to the formation of U. S. Memories ranges from lukewarm to cool. Although Micron, Motorola, and Texas Instruments say they are "supportive" of the concept, all three have declined to participate in the consortium.

"I'd rather invest my money in my own activity, where I can manage it more efficiently than in a consortium," says Pat Weber, president of Texas Instruments Inc.'s Semiconductor Group in Dallas.

The trio has paid dearly to stay in the DRAM business—or, in the case of Motorola Inc., to reenter it. TI admits losing "hundreds of millions" of dollars during the dumping crisis of 1985–1986, and Micron Technology Inc. was reportedly close to going under until the government moved in with antidumping regulations. For its part, Motorola exited the business in 1985; the price for reentering less than a year later was trading its microprocessor technology for Toshiba Corp.'s DRAM and static RAM know-how.

TI, Motorola, and Micron are 'supportive,' but none have joined U. S. Memories

Motorola produces devices in Sendai, Japan, as part of a joint venture with Toshiba and in plants in Arizona and Scotland. TI too has a Japanese connection: TI Japan has been a major factor in DRAM production for the company for many years, and last December TI forged an alliance with Japanese competitor Hitachi Ltd. to jointly develop 16-Mbit DRAM technology. As of last year, says consultant In-Stat Inc., TI had 6% of the world market share in 1-Mbit devices, Micron 1%, and Motorola 0.4%.

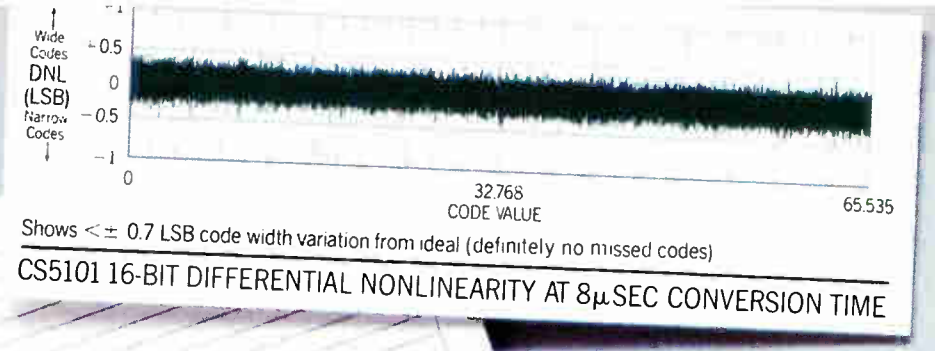
Given the magnitude of their private investments to stay in the business, none of the three U. S. suppliers might be expected to look kindly on government backing for U. S. Memories in the form of low-interest loans. Micron declines to comment on the issue, but TI's Weber and Motorola's Jim George say such a move would set a dangerous precedent. "I don't think there is a role for the government in this," says George, who is general manager of Motorola's MOS Memory Products Division in Austin, Texas. Although Motorola has taken no public stance on the issue, George says he believes funding should come from venture capital and private investment.

Still, the DRAM market is so huge and U. S. share so small that the entry of U. S. Memories will not pose a competitive threat to the threesome. From that stance, the companies welcome the new initiative.

"If we ever lose our technology base in semiconductors," says TI's Weber, "we lose the hardware, the software—all those things we pride ourselves on in terms of leadership." Similarly, George proclaims himself encouraged "in principle" by U. S. Memories' arrival. "Anything that moves to increase the supply base of U. S. sources is in the right direction," he says.

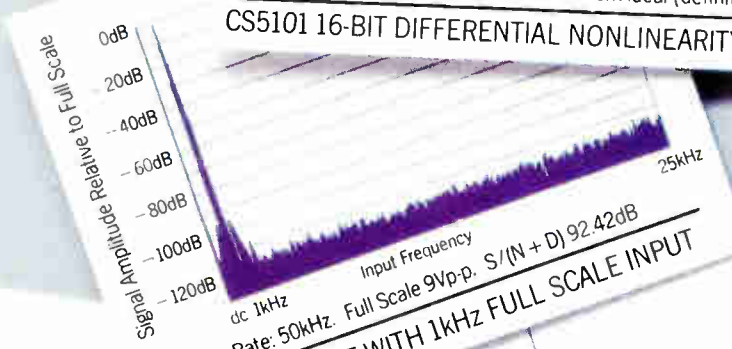
He even opens the door for possible participation somewhere down the line. "It's not impossible that we would end up participating in some way," he says, "but I don't think it's likely at this time."

Micron, which led the fight in Congress and the courts against Japanese dumping, is keeping a lower profile than TI and Motorola. "Although we are very supportive [of U. S. Memories], like TI and Motorola we opted out of it," says Joe Parkinson, chief executive officer of the Boise, Idaho, company. He refuses other comment except to say, "we already have DRAMs." *–Jon Campbell, with additional reporting by Sam Weber*



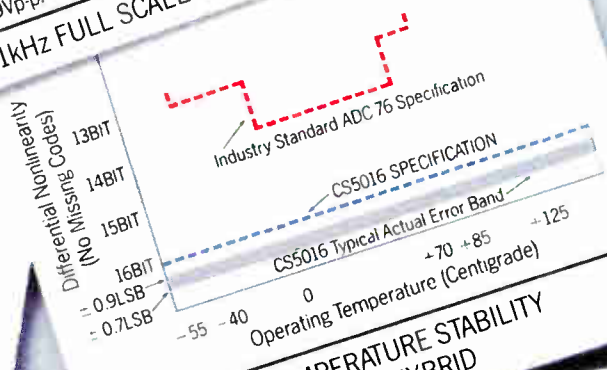
Shows < ± 0.7 LSB code width variation from ideal (definitely no missed codes)

CS5101 16-BIT DIFFERENTIAL NONLINEARITY AT 8μSEC CONVERSION TIME

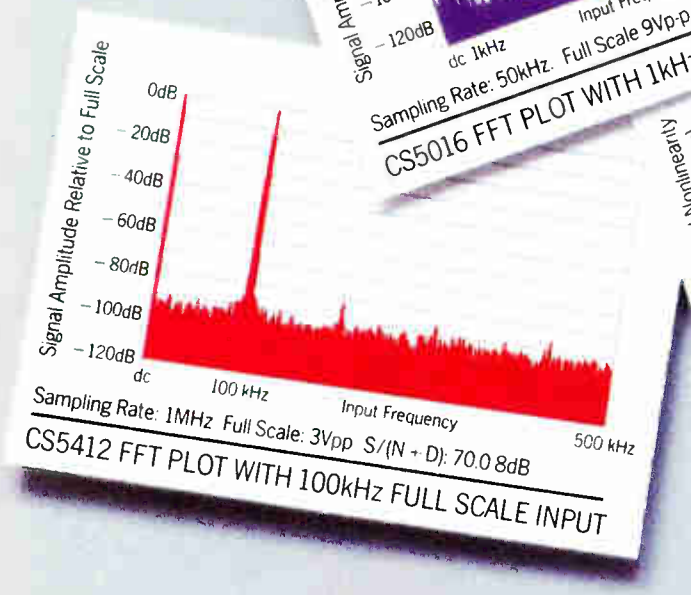


Sampling Rate: 50kHz. Full Scale 9Vp-p. S/(N + D) 92.42dB

CS5016 FFT PLOT WITH 1kHz FULL SCALE INPUT

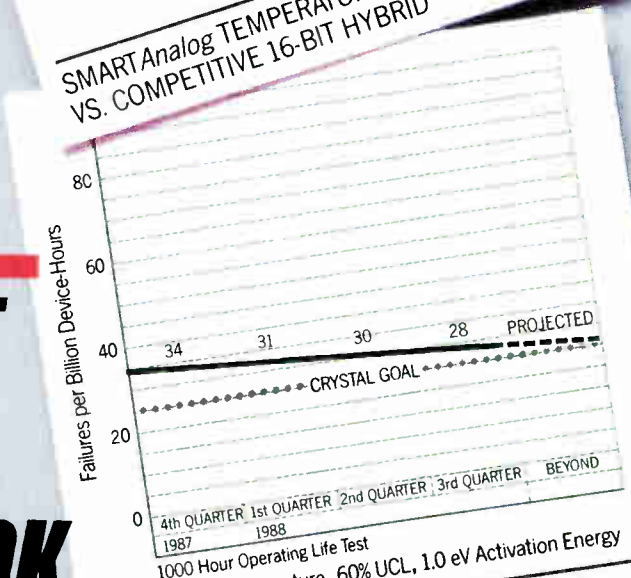


SMART*Analog* TEMPERATURE STABILITY VS. COMPETITIVE 16-BIT HYBRID



Sampling Rate: 1MHz Full Scale: 3Vpp S/(N + D): 70.0 8dB

CS5412 FFT PLOT WITH 100kHz FULL SCALE INPUT



SMART*Analog* RELIABILITY

OUR 12-TO 20-BIT CMOS A/D CONVERTERS LOOK GREAT ON PAPER.

AND ARE THE WORLD'S BEST IN ACTION.

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Differential Non-Linearity of 16 bits with no missing codes is so outstanding we've published a DNL plot no one else dares to.

Stability over temperature is dramatically better than the competition across the entire military range.

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What the plots don't show, you already know: monolithic A/D converters using CMOS technology mean lower design and assembly costs, higher reliability, lower power consumption, easier manufacturing and faster deliveries than hybrid or discrete designs can manage.

And our SMART*Analog* devices are the first with self-calibration at any time/temperature. Which ensures accuracy throughout their operating lives, correcting for gain, offset and even linearity errors. Automatically.

If that weren't enough, Crystal's SMART*Analog* line is the first line of 12- to 20-bit A/D converters with the converter, track/hold, digital interface, calibration circuitry and timing all on a single chip. So you can forget designing, building and characterizing discrete devices while trying to correlate component specifications with system requirements.

Prove to yourself how our revolutionary SMART*Analog* technology makes hybrids a very expensive proposition, indeed. Call 512-445-7222 today for your very own pre-tested evaluation board. Or ask for a demonstration at your facility.

Either way, you'll know why seeing a SMART*Analog* converter in action makes our promises on the opposite page seem flat by comparison.

DEVICE	CS5012	CS5014	CS5016	CS5101	CS5102	CS5317	CS5324	CS5326	CS5328	CS5412	CS5501	CS5503
Resolution (Bits)	12	14	16	16	16	16	>20	16	18	12	16	20
Conversion Time (µs)	7	14	16	8	80	-	-	-	-	1.25	-	-
Throughput Speed (kHz)	100	56	50	100	10	20	>1kHz	48	48	1MHz	4	4
Input Bandwidth (kHz)	-	-	-	-	-	10	500Hz	22	22	4MHz	10Hz	10Hz
Linearity Error (±% F.S.)	.006	.002	.001	.0015	.0015	-	-	-	-	.01	.0007	.0003
No Missing Codes (Bits)	12	14	16	16	16	16	20	16	18	12	16	20
THD (%)	.008	.003	.001	.001	.001	.007	.0003	.0015	.0015	.02	-	-
Dynamic Range (dB)	73	83	92	92	92	84	120	95	98.5	70	-	-
Power Dissipation (mW)	120	120	120	280	40	220	150	450	450	750	25	25
On - Chip S. & H.	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
On-Chip Filtering	-	-	-	-	-	YES	YES	YES	YES	-	YES	YES

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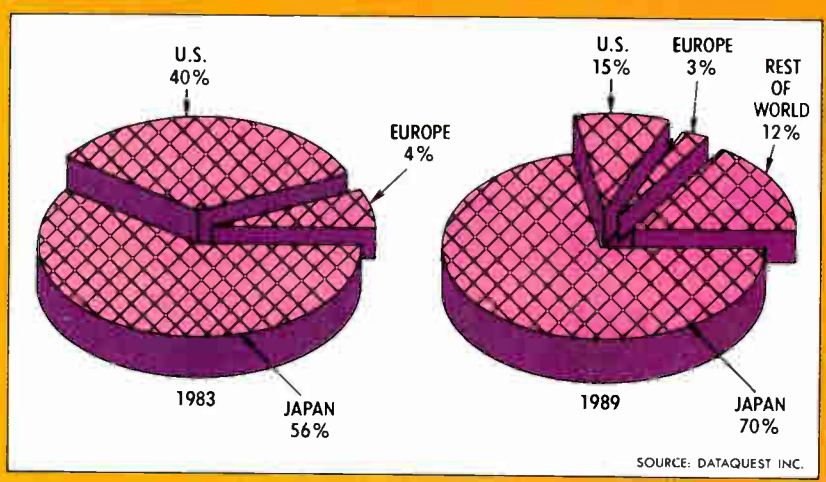
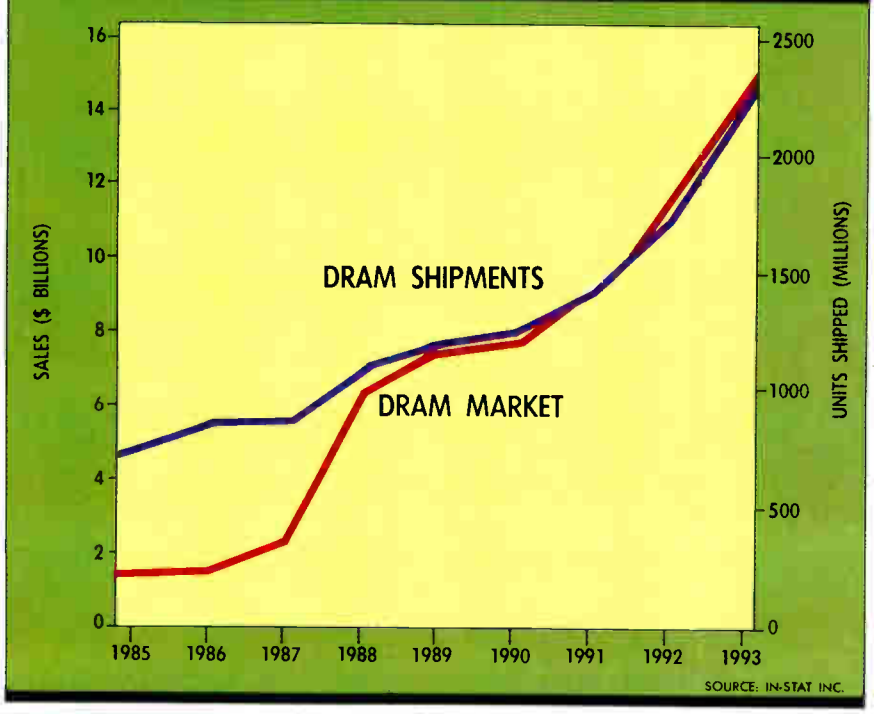
U.S. Memories: A MARKET IN FLUX

A SHRINKING U.S. SHARE



HOW THE MARKET IS GROWING



The formation of U. S. Memories comes at a time when the DRAM market—always a volatile one—is becoming less predictable and more lucrative. As the price per bit nosedives, DRAMs of higher density are going into all types of electronic equipment, from facsimile machines to color copiers. And the DRAM scenario is yet another example of how U. S. industry—here, U. S. semiconductor makers—is losing market share to overseas suppliers, chiefly the Japanese. The stakes are high.

Makers of electronic equipment are packing more memory into their products. Examples on the commercial side include laser printers, which need sizable memory to store different type fonts. "No longer is half a megabyte or even a megabyte enough," says Fred Jones, semiconductor analyst at Dataquest Inc. in San Jose, Calif.

On the consumer side, high-definition TV leads the way in applications that will play a big part in driving the DRAM market. "I think consumer equipment like HDTV and compact-disk players will need storage and buffering memories, generating numbers that will dwarf the needs of the computer industry," says Don Lewine, engineering director at Data General Corp., Westboro, Mass.

This burgeoning demand in consumer products stands in contrast to the computer-based beginnings of the DRAM market. Fueled by IBM Corp.'s introduction of the PC in 1981, the DRAM market began to take off in 1983. Integrated Circuit Engineering Corp. of Scottsdale, Ariz., estimates that 700 million 256-Kbit DRAMs and 500 million 1-Mbit DRAMs will ship this year. Next year the numbers will reverse: 700 million 1-Mbit DRAMs will ship, against 500 million of the older 256-Kbit DRAMs, ICE predicts.

In-Stat, the Scottsdale-based market watcher, estimates the DRAM market will be worth $15 billion by 1993. Dataquest offers a much more ambitious projection: it estimates that the world DRAM market will more than double by 1993, soaring from $10.97 billion this year to $22.3 billion in four years.

The fierce competition that has characterized the DRAM market since its inception will continue, with Japanese, Taiwanese, and other Pacific Rim competitors carving out bigger pieces of the pie. Today, according to the Semiconductor Industry Association, Japanese companies control more than 90% of the 1-Mbit DRAM market. In the next generation, expected to peak in the mid-1990s, U. S. Memories aims to capture a 5% to 10% share of that market, which In-Stat pegs at $9.7 billion. But it remains to be seen whether U. S. Memories can buck the trend of an eroding U. S. share in the world market. *–Sherrie Van Tyle*

DRAMs: A VOLATILE HISTORY

U.S./JAPAN MARKET SHARE

?

U.S. MEMORIES

1994 Meet challenge of 16-Mbit DRAMs' arrival on world market.

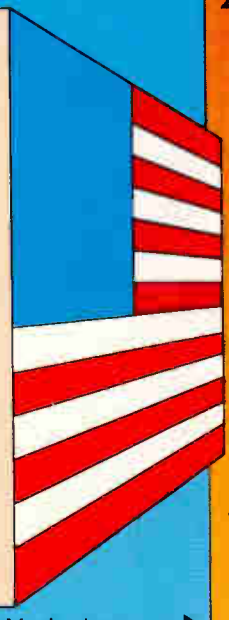
1993 Turn a profit.

1992–1995 Garner 5% to 10% of world market for 4-Mbit DRAMs.

1991 Release first product, 4-Mbit DRAM, by midyear.

1990 January-February. Join Sematech. Secure $500 million in equity and $500 million in loans. Break ground on site. Hire personnel. By midyear, choose technology for 64-Mbit memory, secure antitrust exemption.

1989 November: Have business plan in place. Select site for fab facility.



2000

1995

1990

1985

1980

1975

1970

1996-1997 64-Mbit DRAM arrives in volume on world market.

1995-6 Jessi builds 64-Mbit DRAMs with 0.3-to-0.4-μm design rules.

1993 Approximately 50 million 16-Mbit DRAMs ship.

1992 Approximately 450 million 4-Mbit DRAMs ship.

1990 1-Mbit DRAMs sell for $9 or less.

1989 Japan controls 80% of DRAM market, 90% of 1-Mbit market. Motorola reenters DRAM market. Joint European Submicron Silicon (Jessi) project begins.

1985-6 Japanese DRAM producers slash memory prices. U.S. firms accuse them of dumping. All U.S. memory makers but Micron and TI abandon DRAMs.

1981 Japan announces fifth-generation computer program. NTT has 256-Kbit DRAM.

1980 64-Kbit DRAM arrives.

1978 Japan introduces 16-Kbit DRAMs and captures 40% of world market share.

1976 Japan announces a national VLSI program.

1974 4-Kbit DRAM makes its appearance.

1973 Approximately 8 million 1-Kbit DRAMs ship.

1987–8 DRAM shortage occurs. Using Toshiba's technology, Siemens starts volume production of 1-Mbit DRAMs.

1987 Sematech founded.

1986 U.S.-Japan Semiconductor Trade Agreement is signed.

1984 Siemens/Philips Mega project begins. Goal: develop 4-Mbit DRAM by 1989.

1981 Eleven U.S. companies produce DRAMs: AMD, AMI, Fairchild, Intel, ITT, Micron, Mostek, Motorola, National, TI, and Zilog.

1979 U.S. Very High-Speed Integrated Circuits (VHSIC) program launched.

1977 Semiconductor Industry Association founded.

1970 Intel introduces 1-Kbit DRAM, the 1103, which sells for about $35.

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BY LARRY WALLER

U.S. Memories Financing: The Big Uneasy

Because even so public-spirited an undertaking as U. S. Memories Inc. cannot flout economic laws, the issue of financing—both for raising the initial ante and supporting the operation—is critical. In fact, much of the skepticism about the consortium's chances stems from seasoned industry observers who over the past decade have watched U. S. chip companies make short-term decisions that would earn flunking grades in Economics 101. Dropping out of dynamic random-access memories a few years before the product soared, for whatever reason that seemed sensible at the time, was one of their worst.

SEVERAL UNKNOWNS, ESPECIALLY PRICING, COULD DERAIL THE CONSORTIUM'S FINANCE PLAN

The basic financing proposition is a simple one. Historically, in the chip business, it takes an investment of about $1.25 to generate and support $1 in annual sales. By that reckoning, U. S. Memories will need $1.25 billion in capital to become a $1 billion player by the mid-1990s. According to the game plan, U. S. investors among the top tier of the semiconductor industry merely need to plunk down their stakes, let the experts run a company based on IBM Corp. technology and serving locked-in buyers, and the good times will roll. U. S. Memories representatives now out there in the industry are selling what looks to be a sweet deal.

But as with most simple theories that look unshakable on paper, there are several practical problems that could upset the applecart. First is pricing, which for DRAMs has been a roller-coaster ride during the 1980s. For U. S. Memories to become a solid business venture, paying its bills and paying back its investors, the price of DRAMs must stay at levels that return a profit. Given the experience of the middle of this decade, when falling demand colliding with overproduction caused prices to drop below break-even, there is always the chance of a fall. If the projected price for 4-Mbit devices—consultant In-Stat Inc. pegs it at $11—drops steeply far in advance of 1993, the red ink would surely begin to flow.

That undoubtedly would lead to another problem that would test any consortium. Will U. S. Memories' management be flexible enough to react in the same way that a private enterprise

would? As semiconductor companies found during the last down cycle, tough measures are needed to adjust production and pricing to market conditions.

"There is a perilous nature to the DRAM business," says Fred Jones, semiconductor-industry analyst at Dataquest Inc., a market researcher in San Jose, Calif. "A company must make a tremendous investment in capital equipment and intellectual resources to enter the market. Then, once it gets in, it requires enormous continued investment in research and development to continue the rapid advance in technology to keep pace with worldwide competition. Then, when the market gets glutted with supply, it is extremely difficult for a company to simply cash out and quit the industry."

All these issues must be taken into account by prospective investors, says Matt Crugnale, a Palo Alto, Calif., market consultant. Pricing by itself represents a big stumbling block, especially if the deal guarantees investor-buyers a tab competitive with market levels. Crugnale doubts that the startup can achieve this mark, because it is four years or so behind world-class competitors. The alternative is that investors be made aware of this possibility and agree up front to buy their DRAMs from U. S. Memories, no matter what the price. "U. S. Memories can't make it if it doesn't charge a premium price," Crugnale says.

Still, he doesn't rule out the consortium's chances, even if it needs to charge higher prices than the competition, pointing to the oil business as a role model. U. S. companies buy domestic oil for strategic reasons and would do the same with DRAMs, in Crugnale's view. In short, U. S. Memories "has got to be subsidized, because the investment is not really an investment but the price to play the game," he says.

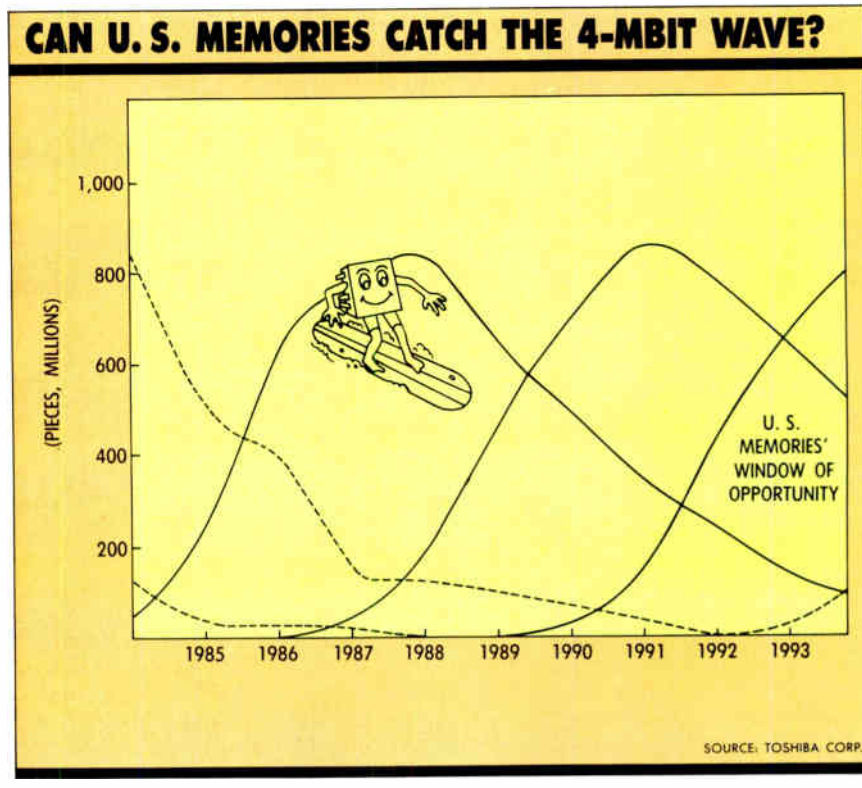
But Sanford L. Kane, U. S. Memories' president, puts the kibosh on any such scenario. The new company will "absolutely not" be subsidized by its backers, he says.

"We talked about that in the committee and somebody came up with the notion of a floor price," he says. "My response was, 'that's nonsense.' I'm convinced that if there are legitimate prices in the marketplace, based on cost of production and market values, we can compete with the best of them." Customers will pay a fair price and investors will make a fair return, he says.

Kane sees two big variables in the pricing equation for U. S. Memories: DRAM dumping by the Japanese, a problem over which the new consortium will have little control, and production costs. "With regard to costs, the model we have gives me a firm conviction that we can be competitive with the best in the world," Kane says. "I'm starting out with a good technology, and I'm going to be producing with a better capability of productivity."

At the same time, says Kane, "I am not going to set artificially low prices to gain market share. If I'm competitive, you're going to buy from me because you're getting a good product at a competitive price—and, by the way, it's made in the U. S. I expect to take advantage of that, but it's not a way to run a whole company. You can take patriotism just so far."

As for who the heaviest backers will be, analyst G. Dan Hutcheson of VLSI Research Inc. in San Jose notes that the lineup of the original seven companies is significant. Except for relative newcomer LSI Logic Corp. of Milpitas, Calif., which was founded in the early 1980s, they are long-established firms with a history of industry support. "They all understand the value of infrastructure," says Hutcheson. By infrastructure he means the institutions and companies that generate component technology and the information that supports the industry as a whole. In fact, "the Hewlett-Packards, IBMs, and Digital Equipments"—all consortium members—



"helped build [the infrastructure] over the past 25 years or so," Hutcheson says.

By contrast, he says, the fast-growing newer concerns—the Apples, Compaqs, and Suns—don't recognize the value of infrastructure as represented by U. S. Memories. Companies from this rank must be recruited to the U. S. Memories team if the consortium is to succeed, says Hutcheson, "but it's a hard sell."

A more negative view is taken by Cindy Thames, a vice president at Boston's Technology Research Group, who calls U. S. Memories' chances for success very slim. "The dynamics involved in a bunch of companies getting together aren't conducive to success," Thames says. A consortium, in her view, takes the pressure off individual companies' efforts to be competitive themselves.

Although it's too early for investors to sign up officially, the word among insiders is that the financial commitments are there and the $500 million or so needed in capital from industry will be forthcoming more or less on schedule. (The other half is expected to come from some form of government loan guarantees.) Present terms call for a single firm taking no more than 10% or less than 1% of the total. The final roster may include up to several dozen companies.

Consultant Crugnale thinks the $1 billion or so that U. S. Memories says it needs might not be enough, given the magnitude of investments that Japanese companies alone are making. One example is Fujitsu Ltd., which is plowing some $680 million immediately into a DRAM plant in the UK as part of a $1.4 billion expenditure there over the next three years. The need for capital on this scale makes it even more imperative that many U. S. companies cooperate on their own DRAM venture, Hutcheson says.

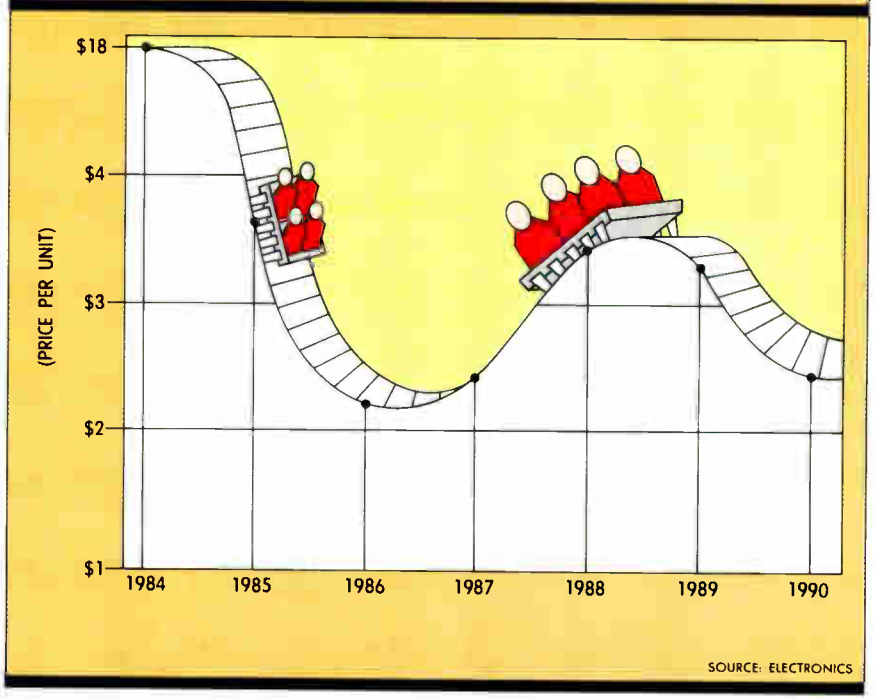
"We have to recognize that every time we buy something from Japan, it also finances their research and development for them to get ahead of us," says Robert Noyce, chief executive officer of Sematech, the semiconductor-industry research consortium in Austin, Texas. He gives U. S. Memories a "better than 50-50" chance of success. "Denying the Japanese part of that market by supplying it ourselves enhances our R&D and the total availability of funds for America to get ahead of them," he says.

In this regard, Noyce says, the guaranteed-buyers setup works very much to U. S. Memories' advantage. "It ought to be able to manufacture with less ups and downs and, therefore, more efficiently than an individual company subject to the whims of the marketplace," he says.

"The biggest firms—IBM, Texas Instruments, and Motorola, along with the Japanese—can go it alone," says Hutcheson. "But the others cannot."

Additional reporting by Jon Campbell, Jonah McLeod, Jack Shandle, and Sherrie Van Tyle

256K DRAM PRICES RIDE A ROLLER COASTER



ONE THAT GOT AWAY: POSTMORTEM ON ANOTHER DRAM EFFORT

WHEN PUSH CAME TO SHOVE, THE COMPUTER MAKERS NIXED A VENTURE-BASED INITIATIVE

For some industry players, watching U. S. Memories look around for financing brings a sense of déjà vu. "They will have a very tough time raising that much money," says Pierre R. Lamond, a partner at Sequoia Capital of Menlo Park, Calif., one of Silicon Valley's most successful venture-capital firms. Lamond should know.

Last year he spent a good chunk of time and his firm's resources trying to put together a venture-backed deal aimed at producing 1-Mbit DRAMs for its backers, a number of major U. S. systems firms. Started in March 1988, the time when the DRAM shortage was hitting systems makers the hardest, the project was much less ambitious than U. S. Memories. It was trying to raise just $125 million in the form of loan guarantees from buyers. Working capital of some $30 million was expected to come from venture sources.

Armed with samples based on a design from Alliance Semiconductor Corp., Lamond canvassed potential buyers and set himself an October deadline for deciding whether to proceed. But when October rolled around, he says, it was apparent that users would not support the initiative. Lamond says there was just too much risk involved for the target computer firms, some of which were big customers of Japanese suppliers and wary of souring those relationships.

A U. S. Memories insider plays down the possibility of encountering the same problem. In his view, the Sequoia deal failed because it did not have enough weight behind it. Still, says Lamond, U. S. Memories has its work cut out for it. *–L. W.*

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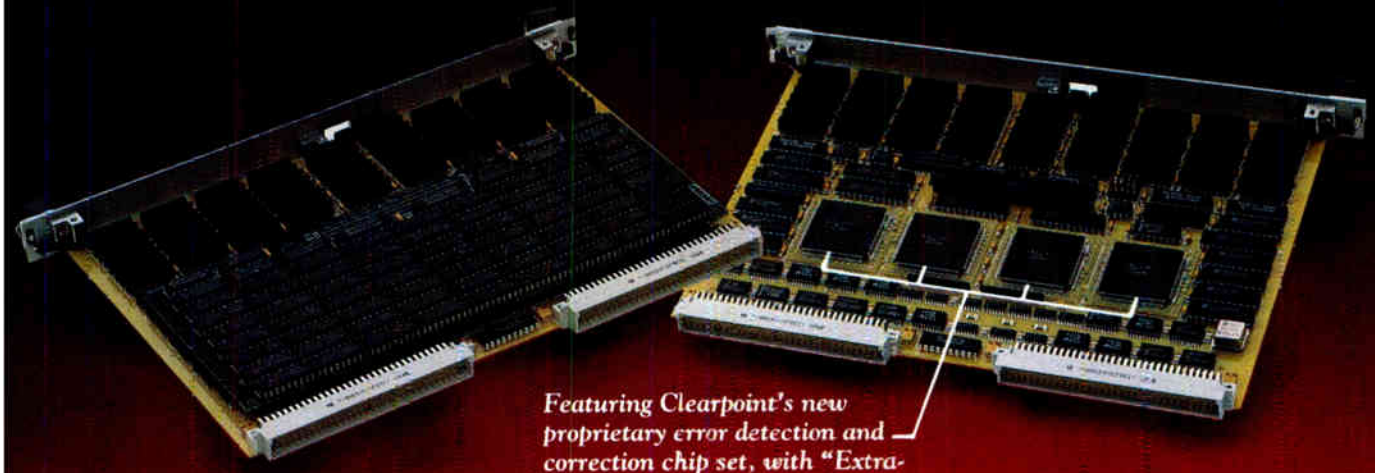

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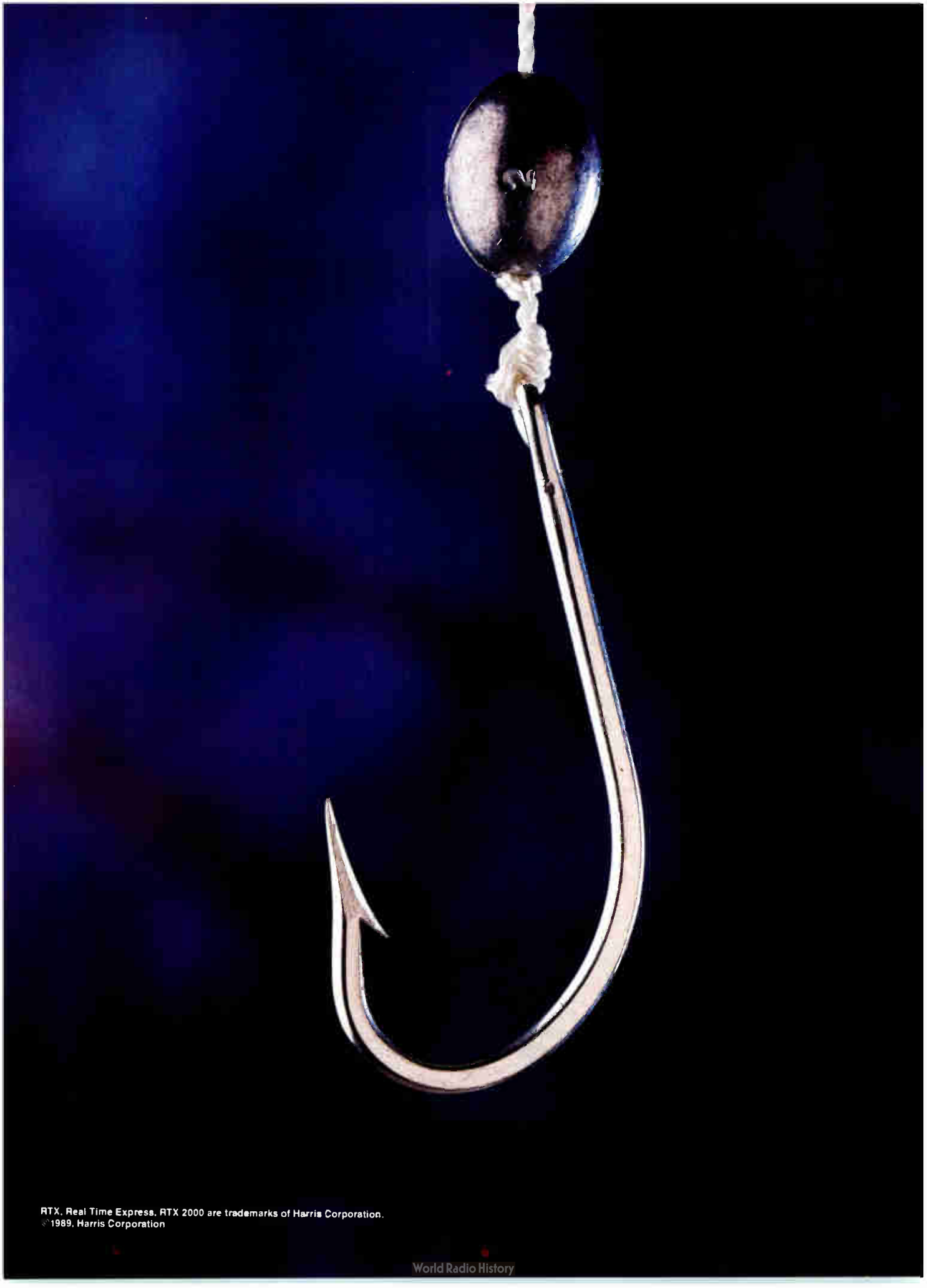

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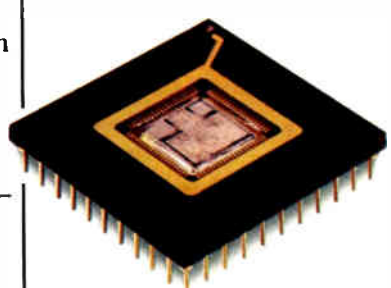

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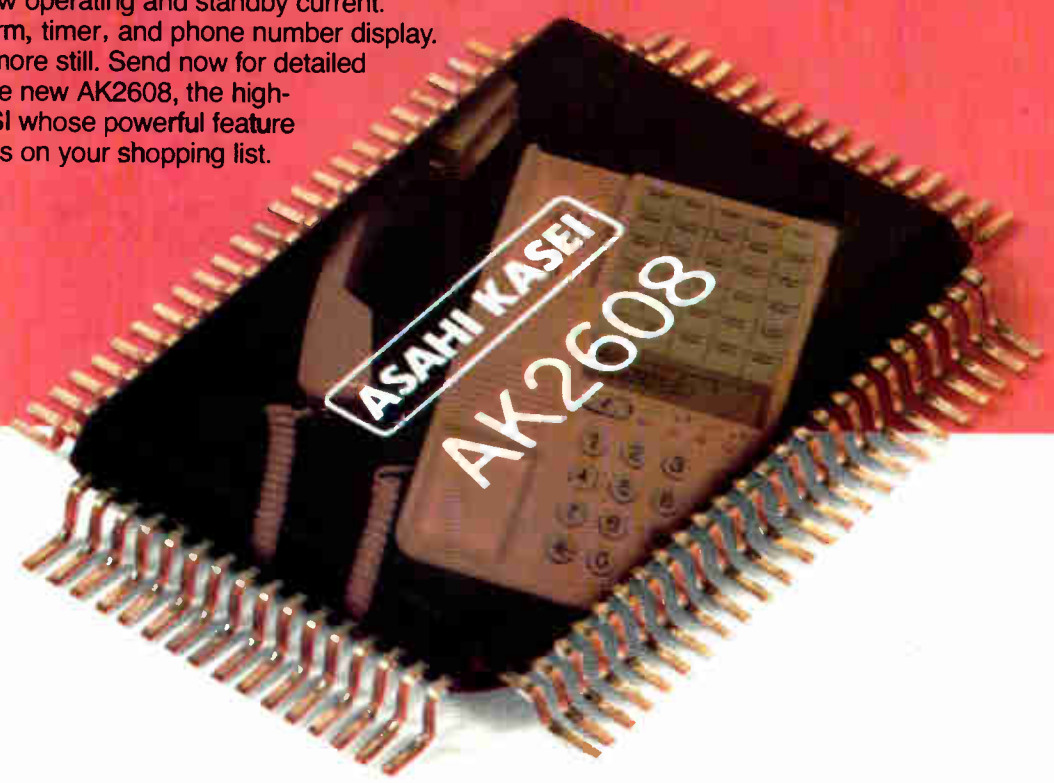

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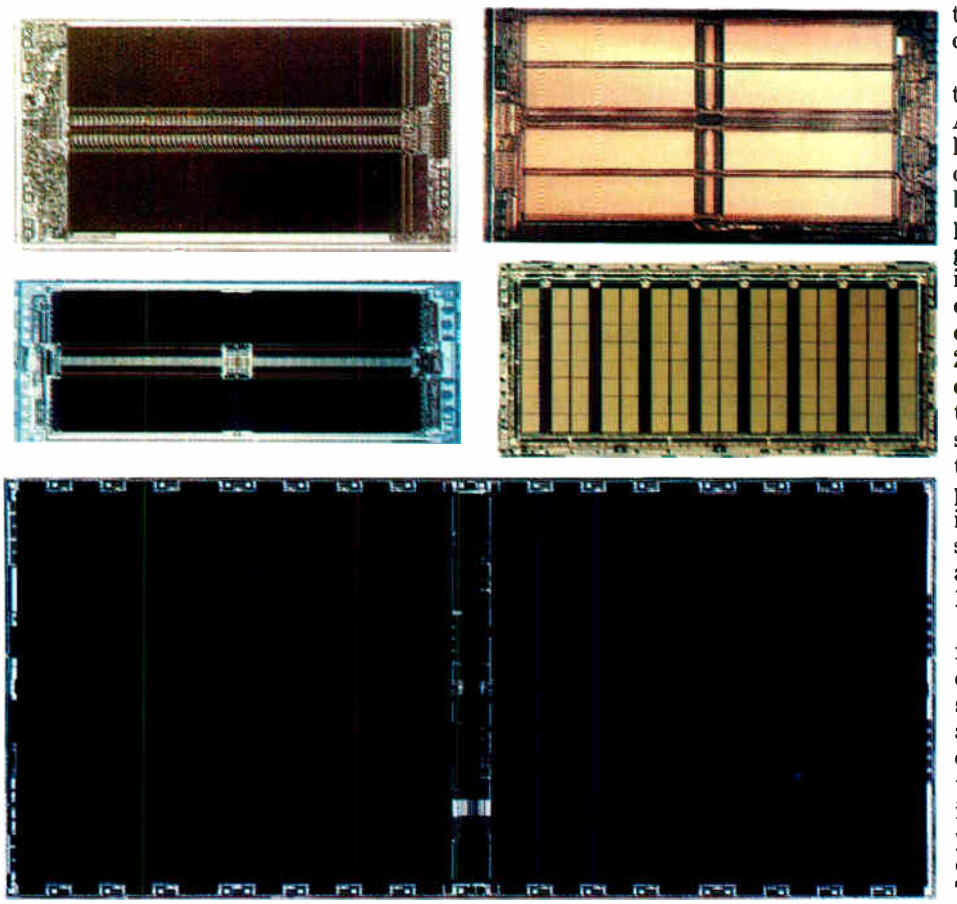
TECHNOLOGY
The Wild Card

BY BERNARD C. COLE

Memory makers may be rewriting the rule book as they start building DRAMs at 4 Mbits and beyond; the sheer complexity of the task could be a boon to U. S. Memories



Five generations: clockwise from top left, 64-Kbit, 256-Kbit, 4-, 16-, and 1-Mbit DRAMs. U. S. Memories will produce 4- and 16-Mbit versions with technology from IBM but will explore other approaches if it moves on to 64-Mbit devices.

In some respects, U. S. Memories Inc. is entering the dynamic-random-access-memory fray at exactly the right moment and with exactly the right product. Unlike any previous generation, 4-Mbit and higher-density DRAMs may present technological hurdles that could change the rules of the business.

U. S. Memories has an advantage over many Japanese and American competitors in that it is hitting the ground with a well-characterized, proven process based on the 4-Mbit trenched-capacitor design that IBM Corp. is beginning to produce in volume for internal use. Also, because of their complexity, 4-Mbit DRAMs are coming on line more slowly than 256-Kbit and 1-Mbit parts. By the end of 1988, about a year after introduction, the 4-Mbit volumes scarcely registered, with no more than 20,000 units shipped. By comparison, four quarters after their introduction in 1982 and 1985, respectively, 256-Kbit volumes were approaching 500,000 units, and 1-Mbit DRAMs about 1 million units.

U. S. Memories president Sanford L. Kane considers the technical difficulty in moving up the scale from 4-Mbit DRAMs a tactical advantage, because it will probably extend the generation's life beyond the average four years—and with it, U. S. Memories' window of opportunity. This year, only two noncaptive suppliers, Hitachi Ltd. and Toshiba Corp., are expected to begin ramping up for production in the millions-of-units volumes associated with DRAMs. Still, produc-

tion of 4-Mbit DRAMs isn't expected to exceed 1.5 million units this year.

By the third quarter of 1990, worldwide volume of 4-Mbit DRAMs should approach 20 million units and the number of players beginning to ship in real volumes will increase to about 10 companies, including Fujitsu, Matsushita, Mitsubishi, Motorola, NEC, and Oki Semiconductor in Japan, along with Micron Technology and Texas Instruments in the U. S.

Balanced against its inherent advantages going in, U. S. Memories must deal with a number of technological wild cards if it is to become a successful player in the DRAM business. Wasting no time, Kane has already made his views known on several technology issues. U. S. Memories will start with 8-in. wafers and will build a facility to produce 4-, 16-, and possibly 64-Mbit DRAMs.

MOVING TO SUBMICRON. The first possible hurdle U. S. Memories and other manufacturers face is the sheer complexity of fabricating DRAMs at 4 Mbits and beyond. Unlike 1-Mbit and less complex DRAMs, the future versions will demand submicron lithography—between 0.7 and 0.9 μm for 4-Mbit, near 0.5 μm for 16-Mbit, and 0.5 μm and below for 64-Mbit.

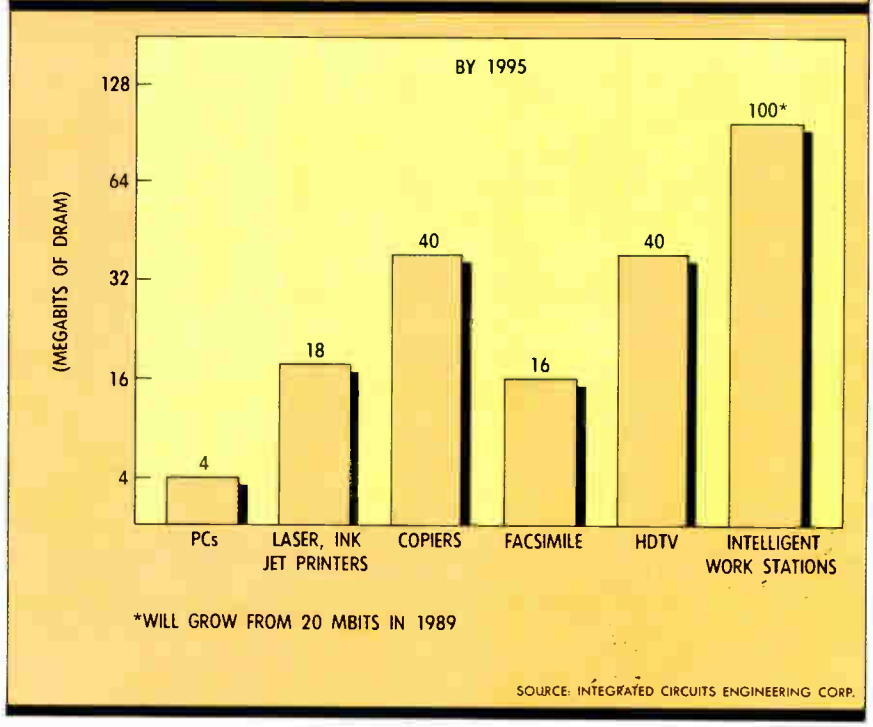
Just as innovation is needed to pare design rules, the increasing DRAM density gives U. S. Memories another opportunity to innovate by speeding up access times, says Rich McAndrew, vice president of hardware product development at Alliant Computer Systems Corp. of Littleton, Mass. While RAM access times have improved from 125 to 60 ns in recent years, he says, computer systems have experienced hundredfold improvements in nonmemory performance.

"If they can come up with some architectural innovation that gets bits in and out faster, they can make a real contribution," he says. "Perhaps at the 16-Mbit DRAM level they can figure out a way to eliminate multiplexing on the output and pipeline it."

The technology front also needs a shift from the current planar approach, in which devices are fabricated by placing cell elements side by side on the surface of the silicon, to a three-dimensional design. Offering the easiest transition is the stacked-capacitor cell, which places the DRAM cell capacitor atop the planar-cell transistor. Although the design offers slightly lower soft-error rates, its capacitance is limited, and it cannot be used beyond 4 Mbits.

Another alternative is the trenched-capacitor approach IBM uses, in which a hole is etched in the substrate with the capacitor built on its walls. Although this scheme offers the increased density necessary for 16 Mbits, smaller dice, and ultimately higher yields, these pluses are offset by more complex processing requirements and leakage problems that are still to be solved. Ultimately, achieving densities beyond 16 Mbits requires an "ulti-

APPLICATIONS SHOW A GROWING APPETITE



WILL THE INDUSTRY SEE COLLABORATING CONSORTIA?

In the technological puzzle that U. S. Memories must solve to move to higher-density devices, what part will Sematech play? The heads of both semiconductor-industry consortia indicate that U. S. Memories may be in a prime position to make use of Sematech's advances in manufacturing know-how.

"U. S. Memories is starting from scratch and very likely will be able to take better advantage of what Sematech is doing" than companies with fab lines already running, says Robert Noyce, chief executive officer of Sematech, the Austin, Texas, research combine.

Indeed, says Sanford L. Kane, president of U. S. Memories, the new consortium may be wed to IBM Corp. technology only through the 16-Mbit level. After that the door is wide open for competing design and process technologies. Those are not in Sematech's ken, but the door is open just as wide for the production-equipment prototypes Sematech does create. Since U. S. Memories is not committed to any continuing relationships, "we will be more ready to pick up the value you can get from Sematech than some other company might be," Kane says.

Both men expect U. S. Memories to join Sematech's ranks by the start of next year, once its financing is in place. As the 15th member, it will "interact with Sematech in the same way that Texas Instruments or Motorola or Intel does," says Noyce. There will be no special priviliges based on its status as a cooperative venture.

How much manufacturing technology U. S. Memories gets from Sematech depends on a crucial choice the board must make soon, says Kane—namely, whether to continue the IBM way or to look to other approaches when the move is made to denser parts, in terms of both process technology and manufacturing equipment. "That's a major decision that will have to be made," he says. "Do you want to maintain dependence on IBM, or do you want to go to the other extreme and be independent and start your own lab and your own R&D capability?"

IBM technology will take U. S. Memories through the 16-Mbit stage, he says; "it's simply too late" to do otherwise. "But as far as the 64-Mbit is concerned, it isn't too late." *–Jon Campbell, with additional reporting by Jack Shandle*

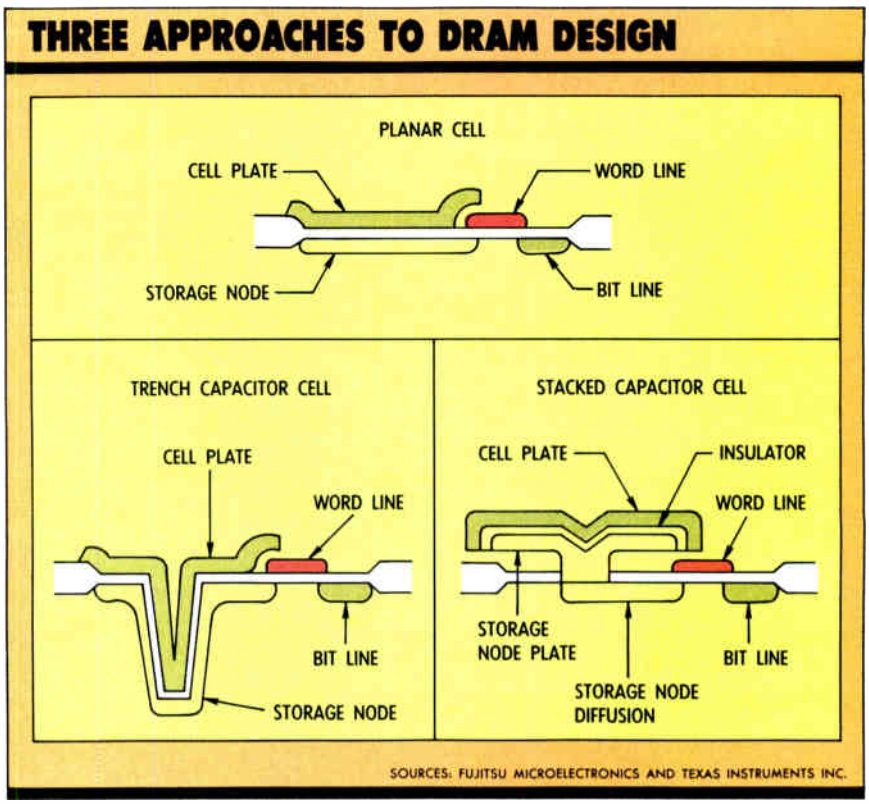
mate cell" structure, which will combine the two approaches.

Another technological consideration is equipment. Should manufacturers take the conservative route, working with upgrades of existing systems, or must they invest in new equipment to reach 16 and 64 Mbits, using the lower-density 4-Mbit parts as a testing ground? Kane says he will not enforce a "buy America" policy that puts his company at a competitive disadvantage. On the other hand, he promises more than mere encouragement to U. S. equipment manufacturers that stay competitive globally. Although he expects to adopt IBM's tool kits for the 4- and 16-Mbit DRAMs, he leaves the door open to other design and process technologies for the future. He is interested in picking up as much of Sematech's technology as possible (see p. 62).

TRADING OFF. In terms of lithographic equipment, some complex trade-offs must be weighed. For example, at the 0.8- to-1.0-μm level necessary for 1- and 4-Mbit DRAMs, existing g-line systems are adequate. To move beyond requires more advanced optical systems, either i-line, with shorter wavelengths that will allow fabrication at 16 Mbits, or the excimer laser stepper, which pushes optical lithography to its limits, handling the 0.5-μm design rules needed for 64 Mbits. As for other alternatives, electron-beam systems can't be used for high-volume production, and X-ray lithography is still largely experimental. Similar trade-offs must also be made on a wide range of fabrication equipment, including etchers, ion implanters, sputterers, and chemical-vapor-deposition equipment.

Another wild card is Kane's choice of 8-in. wafers rather than 5- and 6-in. wafers with their well-understood and debugged fab lines. Among many considerations is the question of yield. Although Kane maintains that IBM's 1-Mbit technology gets high yields and that the 4-Mbit variety will too, yields on the present generation of 4 Mbits are barely at the 30%-to-35% level. That compares with at least 50% for initial runs on previous generations. Going to 8-in. wafers means U. S. Memories will go to market with a much more conservative larger die, but apparently with sufficient yield to be competitive.

Currently, only IBM is producing DRAMs on an 8-in. fab line at its facility in Japan. However, much of Sematech's efforts are focused on developing equipment for fabrication of memory circuits based on 8-in. wafers. For U. S. Memories, the trade-off again is between getting to market faster or coming to market later with a higher-density, smaller, lower-cost device. Toshiba, the first into high volume with the 4-Mbit DRAM, is working with a 6-in. line for its first generation and will go to 8 in. for its second-generation 4-Mbit design. NEC Corp. is also going into production on a 6-in. line, sidestepping the agony of debugging an 8-in. line.



Most DRAMs are built with the planar-cell approach (top). For higher-density parts, trench-capacitor and stacked-capacitor designs are being tried, but moving beyond 16 Mbits will require an "ultimate cell" combination of the two.

Yields on the present generation of 4-Mbit DRAMs are barely 35%; Kane sees 8-in. wafers as the key to improvement

Such considerations by U. S. Memories and most other DRAM manufacturers could be moot if two long-shot gambles by Texas Instruments Inc. of Dallas and NMB Technologies Inc. of Chatsworth, Calif., pay off.

Early on, TI took the leap into advanced DRAMs. Instead of coming to market with a planar design, TI chose to use its 1-Mbit generation to gain experience in building trenched capacitors. In its 4-Mbit design, it builds a cell in which the transistor is also fabricated on the walls of the trench. This allows TI to build its 4-Mbit DRAMs with the 1.0-μm process it used for 256-Kbit DRAMs and then move to a submicron design on a much more relaxed schedule.

This bid pales against the strategy taken by DRAM newcomer NMB, a subsidiary of Japan's Minebea Co. Ltd. Just entering the 1-Mbit DRAM arena with an ultrahigh-speed part based on a design developed by Alliance Semiconductor Corp. of San Jose, Calif., NMB is pursuing a planar rather than a 3-d design for its 4-, 16-, and 64-Mbit offerings.

The company is using features of ferroelectric-materials processing acquired in an alliance with Ramtron Corp. of Colorado Springs [*Electronics*, August 1989, p. 88]. NMB hopes to take advantage of the fact that the dielectric constant of ferroelectric-modified silicon is at least 100 times higher than that of pure silicon. As a result, it could build high-density memories without the trenching, stacking, and other complex processing techniques that are now being considered.

The only other large chip maker evaluating this technology is National Semiconductor Corp. of Santa Clara, Calif., a member of U. S. Memories. National is working with Krysalis Corp., also of Santa Clara, on a competitive ferroelectric technology.

Additional reporting by Lawrence Curran and Jack Shandle

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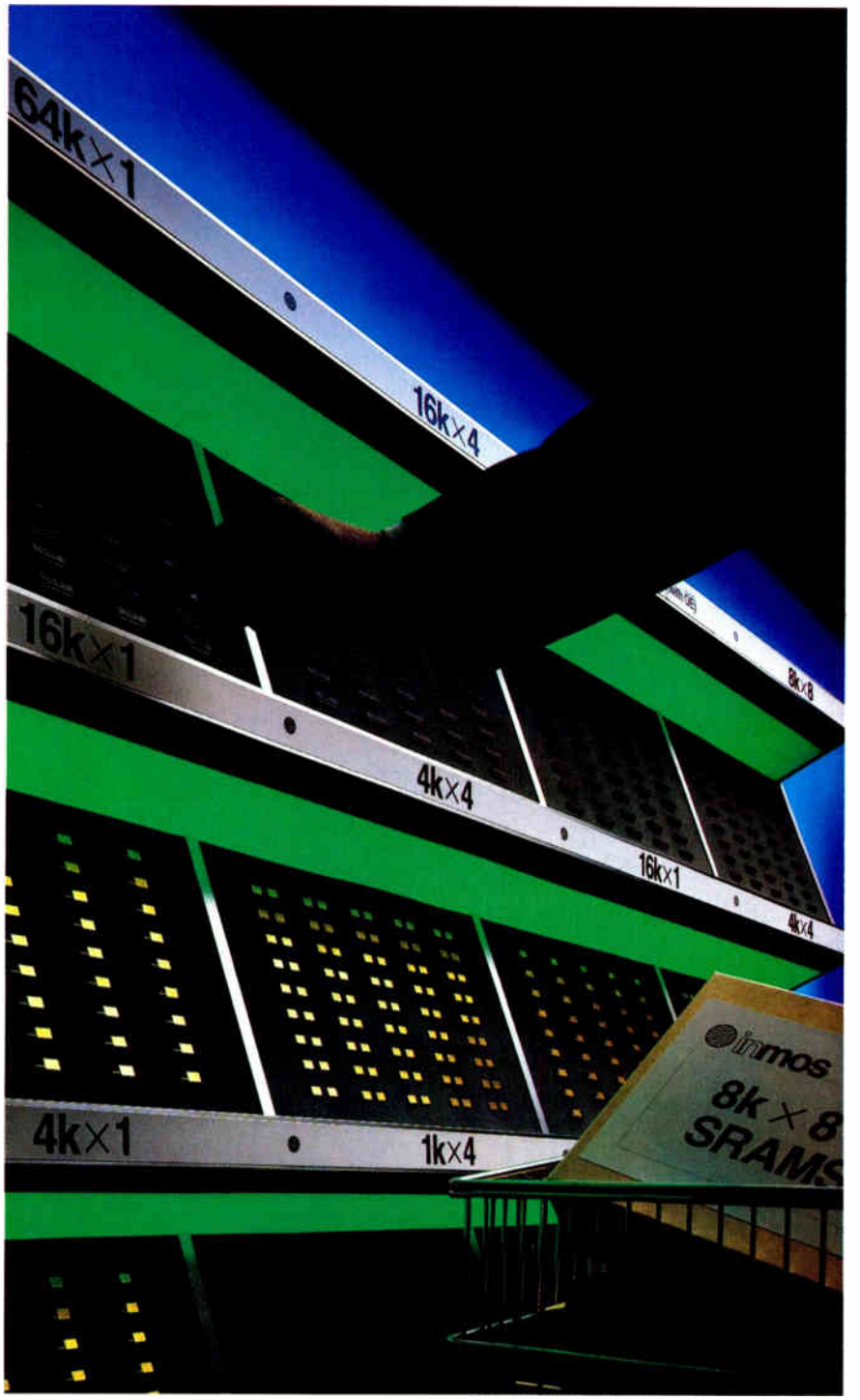

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	IMS 1205M	25,35,45
1K×4	IMS 1225	20,25,35,45
	IMS 1225M	25,35,45
16K×1	IMS 1405	25,35,45,55
	IMS 1405M	35,45,55
	IMS 1405LM	35,45,55
	IMS 1400M	45,55,70
	MK41H67	20,25,35
4K×4	IMS 1425	25,35,45,55
	IMS 1425M	35,45,55
	IMS 1420M	55,70
	MK41H68	20,25,35
	MK41H69	20,25,35
	MK41H79	25,35
2K×8	MK6116	150,200

Organisation	Part No	Access Time (ns)
2K×8	MK6116L	150,200
	MKJ6116	150,200
	MKJ6116L	150,200
64K×1	IMS 1600	20,30,35,45,55
	IMS 1601L	45,55
	IMS 1600M	45,55,70
	IMS1601LM	45,55,70
16K×4	IMS 1620	25,30,35,45,55
	IMS 1620M	45,55,70
	IMS 1620LM	45,55,70
	IMS 1624	25,30,35,45,55
	IMS 1624M	45,55,70
	IMS 1624LM	45,55,70
8K×8	IMS 1630M	55,70
	IMS 1630L	45,55,70,100,120
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To industry analysts, U. S. Memories Inc. may seem just a new kind of dynamic random-access memory supplier, but the legal community has a different perspective. It sees the consortium as the culmination of a 30-year trend against enforcing antitrust laws. Many legal experts—but not all—consider this right and proper, given the decline in U. S. global competitiveness.

But lawyers and law professors don't make laws: Congress does, and it will be up to Congress to strike the balance that protects all parties. That task may be relatively easy in the context of Japan's DRAM dominance.

COURTING CONGRESS

The next wave for corporate America?

The collateral question of federally guaranteed loans is a much thornier problem: it raises the specter of fiscal liabilities that drag down hopes for a balanced budget.

Perhaps in consideration of these economic realities, U. S. Memories president Sanford L. Kane calls an antitrust exemption critical to the consortium's success but characterizes guaranteed loans only as something the company would "love to have." Kane says the consortium can make it without them and adds that loans should be available to other companies that can prove similar circumstances in international trade (see p. 44). The loan problem stems from the vast difference in the cost of capital between Japan and the U. S., a difference of 5% or more, depending on prevailing interest rates. In its 1990 authorization bill

BY JACK SHANDLE AND TOBIAS NAEGELE

for the Commerce Department budget, the Senate's Commerce, Science, and Transportation Committee is directing Commerce Secretary Robert Mosbacher to develop a strategy—including loan guarantees or other financial instruments—to deal with the problem.

The Commerce proposal is likely to have tough going. "I don't see the case for government support," says Claude Barfield, an analyst with the Brookings Institution, a conservative Washington think tank. "Direct support is out of the question. [But even] if it's a loan guarantee, it's a measure of favoritism. It puts the full faith and credit of the U. S. government behind the deal."

Federal loan guarantees are not now counted as liabilities against the federal budget. So strictly speaking, a loan guarantee does not figure into the budget picture unless the borrower defaults. But Senate Budget Committee aides say there is growing pressure from the academic and financial communities to force the government to change its accounting procedures so that loan guarantees are considered potential liabilities, just as banks must figure that a certain percentage of their loans will result in default.

"It's probably too late this year to get anything done anyway," says Ed McGaffigan, a technology adviser to Sen. Jeff Bingaman (D., N. M.). "[U. S. Memories is] starting too late to get loan guarantees" for fiscal 1990, which starts Oct. 1, because the budget process is already too far along, he adds. "They might be able to try next year, but it's going to be very tight. Next year is going to be a crunch year—right now we're still getting by with smoke and mirrors. Getting a new thing started will be very tough."

An antitrust exemption is nearer to U. S. Memories' heart, because manufacturing consortia have a bumpy legal row to hoe under present laws—which the Reagan and Bush administrations have interpreted laxly. "If a new administration comes in that disagrees with the Reagan and Bush administrations' rather loose antitrust enforcement policies," it could enforce such laws more vigorously, says Pamela Samuelson, law professor at Emory University in Atlanta. "Except, of course, if there is a specific legislative exemption" in place protecting a consortium, she adds.

The most effective club is treble damages—three times the amount of money the company made on its product. Each of a consortium's members is 100% liable for the treble damages until they are paid in full. "The notion of being able to conduct business without the threat of treble damages, or having a test that looks at the world market instead of the U. S. market, are rational changes that bring antitrust law into the 20th century—and are critical to our success," says Kane.

Riding out of the West with legislation to do just that is Rep. Tom Campbell (R., Calif.). His bill eliminates monetary damages. Under it, any manufacturing consortium engaged in high-risk, capital-intensive ventures—not just DRAMs, but high-definition TV and superconductivity, for example—may petition the Justice Department for a certificate of complete immunity to monetary damages. "In return," says Campbell, "they must make a showing that they are not anticompetitive, and that boils down to how big you are. In U. S. Memories' case, that would amount to from 5% to 10% of the world market." Campbell's bill also lets small companies that could merge without danger of antitrust violations form consortia.

Other bills remove the treble-damages provision but leave in place financial liability for single damages. No certificates of exemption are required from the Justice Department, but a consortium has to inform the department of its plans, under these proposals.

THIRD-PARTY SUITS. However, "there's a fly in the ointment," says Larry Boes, antitrust specialist at the New York law firm of Fulbright, Jaworski & Reavis McGrath. "While a consortium may be able to persuade the Justice Department in the first place, there's nothing to stop a third party from filing a suit. Somebody can drag it out in the courts for years." Since a consortium will naturally serve up product to its own members first, Boes contends, either the Justice Department or a regulatory agency should ensure fair treatment by monitoring access to the product, the priority in which it is distributed, its price, and membership in the consortium.

Not all antitrust lawyers believe the exemption is reasonable. One is Malcolm Hoffmann, a New York attorney who made his mark on antitrust law 30 years ago as an assistant attorney general by prosecuting General Electric Co. executives for price-fixing. Hoffmann fears for the small systems house that now has to stand in line for DRAMs. "I think they [the large computer companies] want freedom from competition," says Hoffmann. "And the victims will be the smaller computer manufacturers who are not given access to the consortium's production."

Although Samuelson agrees that allowing manufacturing consortia is "a change in historic attitude" from U. S. economic policy, she believes smaller companies have a recourse. "They should go to Congress and explain the possible anticompetitive effects of U. S. Memories," she says. "In other words, build a record for future litigation. Smaller companies can also use the Justice Department in an informal way to negotiate with the consortium." □

ANTITRUST IN EVOLUTION

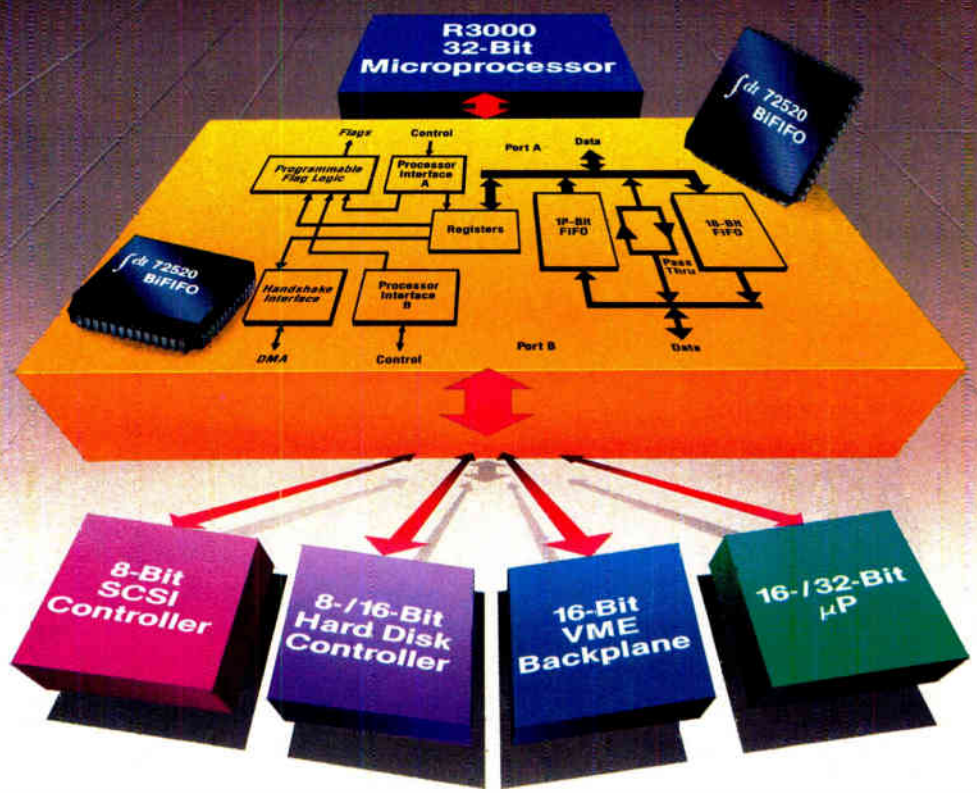
Existing Legislation:

Export Trading Act of 1982	• Allows consortia to manufacture and market products for export only under government oversight • Provides complete immunity from antitrust damages for export-only consortia
National Cooperative Research Act of 1984	• Allows consortia to engage in research and development activities • Reduces antitrust liability from treble to actual damages for research-only consortia • (Sematech formed under this legislation)

Pending Legislation:

HR 1024 (Sponsored by Tom Campbell, R., Calif., and Rick Boucher, D., Va.)	• Allows consortia to manufacture and market domestically under government oversight • Provides complete immunity from antitrust damages • Allows small companies that could merge under antitrust regulations to form consortia
HR 1025 (Don Edwards, D., Calif.) HR 2264 (Hamilton Fish, R., N. Y.)	• Allows consortia to manufacture and market domestically under government oversight • Reduces antitrust liability from treble damages to actual damages

The μP-to-Peripheral Connection



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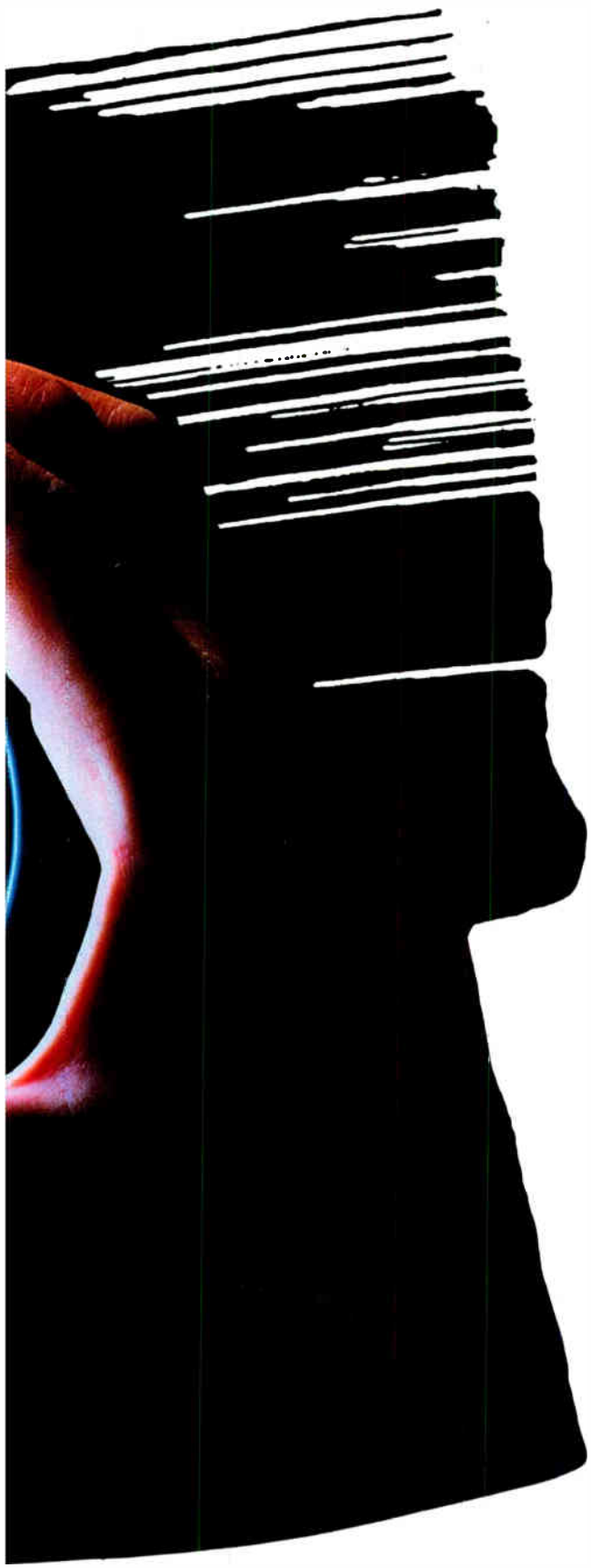

Sizing Up the Earth in 200 B.C.

Eratosthenes believed the earth was round. As director of the great library at Alexandria in Egypt, he decided to go beyond abstract argument and actually measure it to back up the argument.


Eratosthenes

Knowing that the midsummer noon sun shone straight down a vertical well in Syene far to the south, he measured the slight angle of the sun's shadow in Alexandria on the same day. He figured the distance between the two cities by how long it took a camel to walk there. Then, with a little simple geometry, Eratosthenes came up with fairly accurate figures for the earth's circumference and radius. His pioneering measurement made a significant impact on history.

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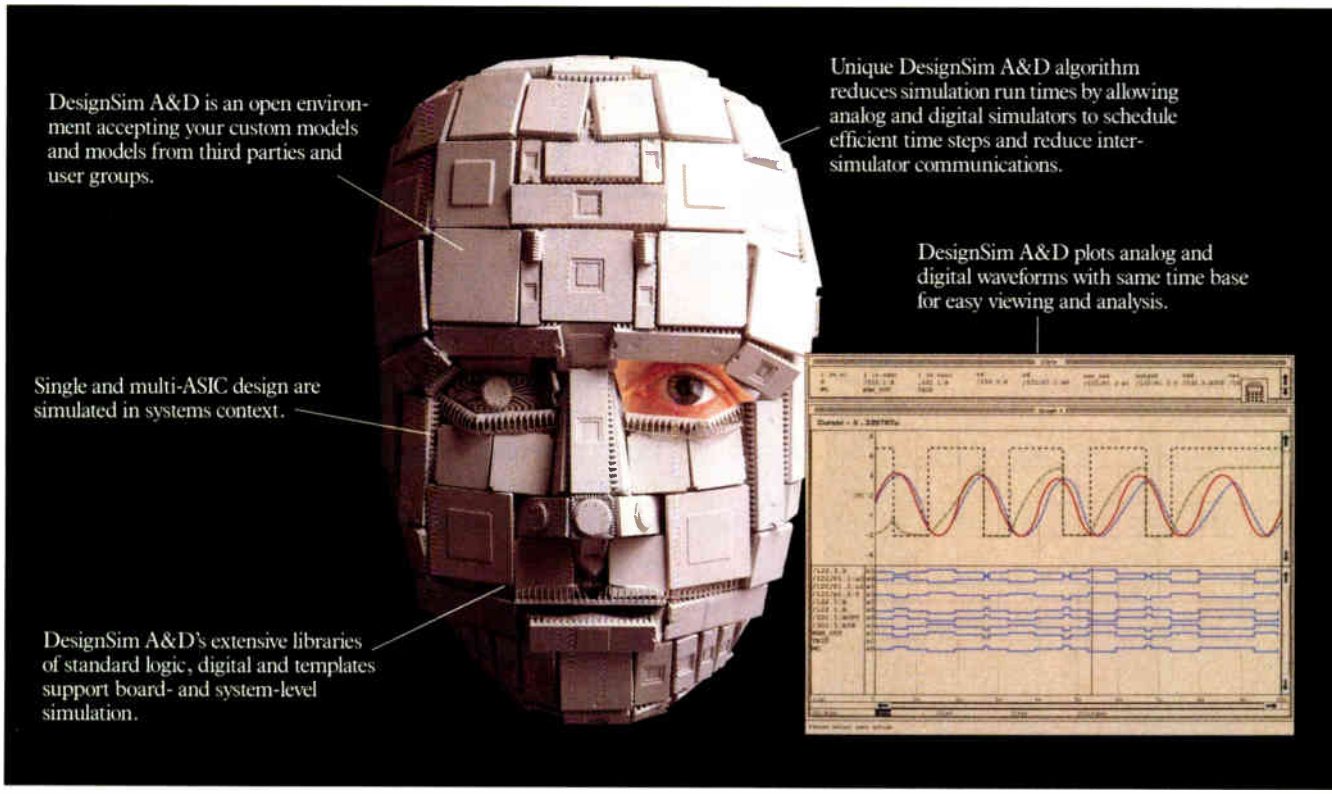

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Creating value

The CHANGING ANALOG WORLD

Analog's big guns are adopting new product strategies in their tussle with challengers over an $8 billion market

BY BERNARD C. COLE

The semiconductor industry's old-line analog integrated circuit manufacturers are under siege, buffeted by challenges on all sides. The biggest players—most, if not all, based in the U. S.—are facing some of the same problems as their digital counterparts, including increased competition from foreign companies and domestic startups and a need to retool their commodity-based strategies. And companies such as Analog Devices, Burr-Brown, Harris, Motorola, National Semiconductor, Philips Signetics, Precision Monolithics, SGS-Thomson, and Texas Instruments are facing a few difficulties that are unique to the analog business.

At stake is a market for analog ICs that since the mid-1970s has consistently hovered between 20% and 25% of total monolithic circuit sales. In absolute terms, the analog segment has grown apace with sales of digital circuits, from about $2 billion in 1982 to about $8 billion this year to a projected $10 billion in 1991.

Threatening the dominance of the large-scale U. S. suppliers are a host of competitors nibbling away market share. Chief among them are Japanese vendors that are pinpointing particular analog market segments, notably consumer, along with U. S. startups that are claiming the fast-growing high-performance arena. Also making inroads are companies parlaying their CMOS technology, in-house analog expertise, or a mixed-mode or application-specific approach into analog market share.

But the big analog houses are mounting counteroffensives of their own. Most of the market leaders—including National Semiconductor Corp. and Texas Instruments Inc., No. 1 and No. 2, respectively—are backing away from a commodity stance. National, for example, is focusing on mixed-mode ASICs, application-specific standard products, and high-performance building blocks, while TI is turning toward cell-based designs, mixed-mode ASICs, and intelligent-power functions.

The Japanese have discovered that nailing down portions of the analog market can work to their advantage as high-volume IC suppliers—primarily specialized consumer analog circuits for their in-house production of such items as TVs, video cassette recorders, radios, printers, and facsimile machines. Constituting no more than 40% of the analog market in 1982, or about $1 billion, the consumer segment is expected to grow to perhaps $3.5 billion by 1991. Such companies as Fujitsu, Hitachi, Matsushita, Mitsubishi, NEC, Rohm, Sanyo, Sony, and Toshiba have moved into the ranks of the top 25 suppliers of monolithic analog circuits worldwide.

Of even more immediate concern to the mainstream U. S. suppliers is the emergence of new players targeting the high-performance segment of the application spectrum. Founded early this decade, often by top linear designers from the big IC houses, these startups include companies such as Advanced Linear Devices, Brooktree, Crystal, Elantec, Exar, Linear Integrated Systems, Linear Technology, Maxim, Microlinear, and UltraAnalog.

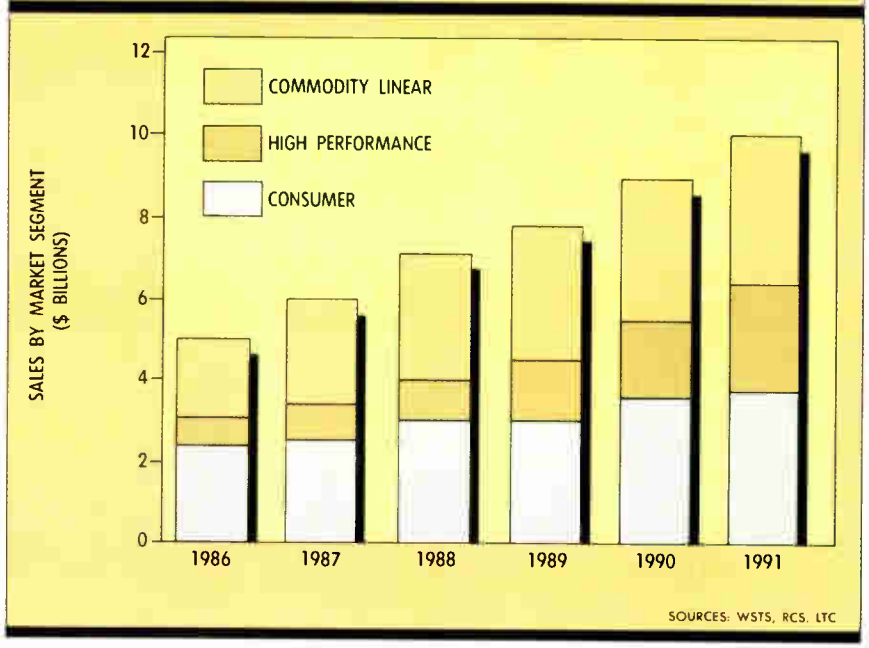
Ranging in size from a few million dollars to $50 million in annual sales, these startups have targeted a variety of high-performance niches where products command high selling prices—up to $100 a pop, against 20 cents to $1 at most for commodity analog circuits. This segment is emerging as the fastest-growing portion of the market. Where in 1982 high-performance circuits represented no more than 5% to 10% of total worldwide sales, by 1991 they will account for nearly a third, according to Linear Technology Corp. of Milpitas, Calif.

This means big growth for the high-performance vendors. Where mainstream houses such as Motorola, National Semiconductor, and TI are netting growth rates of 10% to 15% in the analog portion of their business, companies in the high-performance segment typically report growth rates of 25% to 40% per year. Leading the pack in this new generation of niche-oriented ICs are two California companies: Linear Technology and Maxim Integrated Products Inc. of Sunnyvale.

Started by a group of analog designers who left industry pioneer Intersil Inc. after its acquisition by RCA Corp. (which itself was later acquired by General Electric Co. and then by Harris Corp.), Maxim made its debut as basically an analog CMOS house offering improved second-source products. But it quickly began to expand its offerings, moving into linear bipolar products and proprietary building-block circuits. Maxim has almost 300 products in its portfolio; 40% of them are proprietary, including a unique digitally compensated CMOS operational amplifier offering precision previously found only in bipolar op amps (see p. 76). On the process side, the company has just entered into a strategic alliance with VTC Inc. of Minneapolis to develop a family of circuits using VTC's advanced 4-GHz ±5-V complementary bipolar process.

Linear Technology, founded by a group of analog designers from Nation-

WHERE THE LINEAR MARKET IS HEADING



al Semiconductor, also began its life offering improved second sources of industry-standard bipolar building blocks, but it has moved gradually into CMOS. It now boasts about 1,600 line items, about 500 of which are proprietary. About 50% of Linear Technology's sales are derived from proprietary devices, including its recently introduced family of 12-bit analog-to-digital subsystems (see p. 78). On the process side, the company moved to improve its capability in both bipolar and CMOS by entering into a strategic alliance with TI last year in exchange for linear-circuit expertise.

Maxim and Linear Technology were the first of the new analog startups to go public last year, and both boast robust growth rates. From sales of $28.3 million in 1988, Maxim expects to garner $42 million this year and $55 million in 1990. Linear Technology achieved about $28 million in sales in 1988, almost double its 1987 total, and expects to hit about $42 million this year and $56 million in 1990.

As if the arena were not crowded enough, there are also nonanalog IC houses forcing their way into the analog market. Among them are telecommunications giant AT&T Co. and instrument maker Tektronix Inc., both of which have transformed in-house expertise into commercial products. Also in this category are companies such as Atmel and Catalyst Semiconductor Inc., which are parlaying their high-voltage CMOS processes for electrically erasable programmable read-only memories and EPROMs into analog CMOS designs (see below).

At the same time, analog arrays from companies such as Exar, Microlinear, Plessey-Interdesign, and Silicon Systems are also making life difficult for the mainstream analog houses by eating up sockets that would normally go to commodity analog building blocks. Then, too, a new breed of cell-based vendors is responding to market need by developing mixed analog and digital capabilities. The roster here includes International Microelectronic Products, NCR Microelectronics, Sierra Semiconductor, VTC, and, more recently, such digital ASIC stalwarts as LSI Logic and VLSI Technology.

According to a study of the analog ASIC marketplace compiled by Electronic Trends Publications of Saratoga, Calif., continued and robust growth can be expected for both analog and mixed-mode ASICs through the early 1990s. Just as digital ASICs gnawed at the market for high-volume commodity logic, so analog and mixed-mode ASICs will grow at the

FINALLY, HERE'S EEPROM TECHNOLOGY TO RECALIBRATE ADCs

Analog designers have long envied the fact that their digital counterparts could reprogram and recalibrate their memory and logic devices using electrically erasable programmable read-only memories and programmable logic devices. Now, however, EEPROM technology is finally available in the analog design world—to recalibrate analog-to-digital converters.

SECOND SOURCE. Surprisingly, the first company to offer this technology is not an analog device vendor but a manufacturer of nonvolatile EPROMs, EEPROMs, and memory-based microcontrollers: Catalyst Semiconductor Inc. In terms of pinout and functionality, the Santa Clara, Calif., startup's 12-bit CAT5412 is an improved second-source version of Austin, Texas-based Crystal Semiconductor Corp.'s 1-MHz CSZ5412, the fastest and most accurate 12-bit monolithic CMOS ADC now available.

But the addition of an on-board EEPROM correction scheme enables Catalyst's monolithic device to achieve absolute accuracies of $\pm\frac{1}{2}$ least significant bit over the full temperature range—a necessity at 10 bits and higher—by calibrating the device after it is assembled.

"Once you have an EEPROM process, you have by definition a high-voltage CMOS process, which is precisely what you need to do good analog [design]," says B. K. Marya, president of Catalyst. The company has also developed a 2.0-μm biCMOS process that allows the incorporation of high-performance npn junction transistors with switching frequencies as high as 3 to 4 GHz. Marya expects the EEPROM and biCMOS parlay to make Catalyst a player in the high-performance segment of the analog design market.

Most monolithic ADCs now available are implemented with laser-trimmed resistors to achieve proper matching. As accuracies and resolution of monolithic circuits move to 12 bits and beyond, Marya says, a different process is needed. The problem is that while inherent device matching works with devices up to 10 bits, to guarantee 12 bits at $\pm\frac{1}{2}$ LSB, the initial accuracy must be trimmed to $\pm\frac{1}{4}$ LSB at the factory. "Even with the best trimming technology available, this is almost physically impossible," Marya says. And even if a device is trimmed to the necessary accuracy, packaging introduces inaccuracies. Another problem surfaces with switched-capacitor-based CMOS ADCs: laser trimming is less effective for capacitors than for resistors.

In the last few years, a technique called self-calibration has been employed by several companies, including Crystal Semiconductor, Microlinear, National Semiconductor, and Texas Instruments. In the self-calibration approach, on-board circuitry is used to correct capacitor matching errors introduced in the manufacturing and packaging processes. In most cases, the calibration occurs when power is first applied to the devices; in some cases, it occurs when the device is in the system, under the control of a microprocessor or on-board controller.

The problem with self-calibration as the technique is currently implemented,

expense of commodity analog ICs.

From worldwide sales of about $145 million in 1988, analog ASIC sales will rise almost threefold, to $335 million, by 1993, the study says. The growth rate for mixed analog and digital ASICs is even more impressive: they should nearly quadruple in sales, from about $1.22 billion this year to $4.55 billion by 1993.

To counter these market-share contenders, the traditional mainstream suppliers have evolved a variety of strategies, including "if you can't beat 'em, join 'em." Virtually all are forgoing the classic jellybean approach in favor of more customized solutions.

Front-runner National Semiconductor has mounted perhaps the most all-encompassing effort, sinking what company executives say is a substantial investment into process and circuit development. The Santa Clara, Calif., company scored $524 million in analog sales last year, according to estimates from market watcher Dataquest Inc. of San Jose, Calif.

National's R&D supports efforts in virtually every market sector with a variety of new state-of-the-art bipolar, CMOS, biCMOS, and bipolar-FET processes, says Thomas Odell, vice president of National's Analog Division. The company has also made major investments in both bipolar and CMOS-based standard-cell mixed-mode libraries, he says. National continues to support its existing line of mature commodity-type analog building blocks, such as digital-to-analog and analog-to-digital converters, voltage references, multiplexers, filters, sample and hold amplifiers, and regulators, pushing for higher yields and lower prices.

National's thrust is to build a presence in the ASIC market as a mixed-mode vendor and to bring to market quickly a range of application-specific standard products and high-performance proprietary building blocks. In the last two to three months, Odell says, the company has unleashed a broadside of products, including the first in a series of analog subsystems, part of its new "Super-Block" family combining multiple analog functions on a single chip.

Also new from National is a series of high-speed analog products built using its vertically integrated pnp bipolar process, a 12-bit self-calibrating ADC (the ADC1241), and a new generation of switching regulators.

STRATEGIC SHIFT. Rated No. 2 by Dataquest with $426 million in 1988 analog sales, TI is shifting its strategy from commodity ICs to cell-based designs, mixed-mode ASICs, and intelligent-power functions, building on its traditional strengths in process technology.

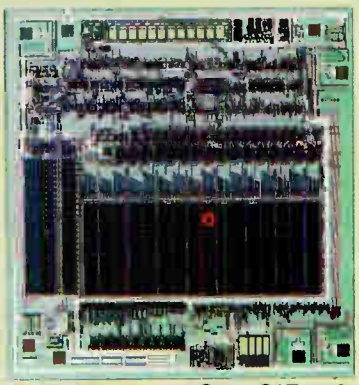
One reason for the shift is a slowdown in sales of standard products, says Tom Engibous, the Dallas company's semiconductor group vice president for linear products. Total available market for TI's classic op amp, voltage regulator, and standard ADC have been growing at slower rates over the last three or four years and will continue to do so, he says. "If you're a startup, you can carve out a small $40 million to $50 million business somewhere." But for large companies to grow, he adds, they must penetrate many markets, from commodity to niches.

Besides participating in the traditional analog and linear markets, TI has two major prongs in its strategy: penetrating the smart-power segment, particularly automotive, and developing linear ASICs. Seven years ago, "a very, very high percentage" of TI's linear business was in standard, general-purpose components, Engibous says. Today, customer-specific circuits, many of them cell-based, are the largest segment. Many of TI's catalog products, although sold to many customers, are designed for particular applications, such as modems, disk-drive servo controls, or analog-to-digital and digital-to-analog functions that interface with digital signal processors, he says.

Hand in hand with the move to application-specific analog parts, says Engibous, the company has seen a "huge change" in process technology over the last few years. Five to seven years ago, TI was designing almost solely with standard bipolar technology. Today, the company is not developing a single product that uses what could be called a standard bipolar process. "The proliferation of technologies has been tremendous," says Engibous. And those technologies have transformed analog design.

In the past, the linear designer was

says Marya, is that an extra die is required to implement the extra control logic. As a result, fewer dice per wafer are produced, resulting in a much higher price. "If price is no object," he says, "self-calibration is one way to go."



Catalyst's 12-bit ADC, the CAT5412, has on-board EEPROM correction.

In the CAT5412, Catalyst combines its 2.0-μm biCMOS process with a modified two-step flash-conversion technique that incorporates a digital correction scheme based on the use of EEPROM. The first step in the flash conversion determines the seven most significant bits, while the second determines the five LSBs plus the bit used for error correction.

This initial digital error correction reduces the accuracy requirement from 12 to 7 bits, Marya says, which means a smaller, lower-power comparator can be used. The circuit incorporates a correcting digital-to-analog converter that is based on a polysilicon resistor string to achieve the optimal combination of initial accuracy, immunity to substrate noise, voltage coefficient, temperature coefficient, and stability, Marya adds.

The Catalyst device employs self-calibration to correct the offset of the input, the gain and offset of the residue amplifier, and the DAC's nonlinearity. During a normal conversion, each tap of the DAC's resistor ladder tap is measured by an on-board integrating ADC; the results are compared with the ideal result, and the difference is stored in a small amount of on-board static random-access memory. The SRAM data then drives the correcting DAC for the linearity correction. As a final step, the EEPROM correction circuitry trims out the nonlinearities introduced over temperature due to the use of the simpler and more silicon-efficient two-step flash scheme—usually on the order of 25 to 75 parts per million per degree Celsius.

Marya says the EEPROM trimming offers two improvements not possible in other approaches. First, it circumvents initial shift due to packaging stress. Second, it minimizes long-term drift, because stabilization schemes—which in themselves introduce further nonlinearities—aren't needed to improve overall long-term performance. This third-order correction, made possible by the use of EEPROM, enables the CAT5412 to achieve a typical specification of 1 ppm/°C, which is comparable to hybrids and devices using externally heated substrate references.

The CAT5412, which is available now in sample quantities, costs $190 each in 100-unit quantities. *–B. C. C.*

considered something of an artist, he says. Give him the design rules and he would create the next generation of components through clever design techniques. But today, just as in the digital world, process technology is more important than clever design. For example, Engibous says, an inexperienced digital designer working with a 1.0-μm process can come up with a better component than an experienced designer saddled with a clunky 3.0- or 5.0-μm process.

Similarly, an analog designer with a 1-GHz npn has a major advantage over one with a 200-MHz pnp. "Sometimes, you can come up with a much, much better performance just by having that process technology than by having clever design techniques," Engibous says. "We have now moved from a point where the design engineer was 100% the king to right now, where maybe he's 50% the king and the process engineer is the other 50%."

Because of the breadth of its semiconductor line, TI has had an advantage in developing new linear processes. Like many analog houses, TI is able to use the linear techniques that yield precision analog performance, high voltage, and high power. Among them are the Excalibur process for high-performance op amps, the 1.0-μm LinEPIC process for such products as flash ADCs, Advanced LinCMOS for analog interface chips, LinBiCMOS for linear ASICs, and Power BIDFET and Multi-EPI for intelligent power. Because TI has a very large digital business, it has been able to adapt many of its state-of-the-art digital lithography advances to linear processes.

Processes available to TI's linear designers, in addition to 1.0-μm CMOS, include high-speed bipolar processes, high-voltage processes (up to 400 V), high-power processes (up to 10 A), and a process for linear ASICs that's compatible with digital ASICs. According to Engibous, all of them make for big performance gains and better integration levels, allowing TI to design chips for specific functions, such as servo controls for disk drives and facsimile chips.

TI's proprietary processes were all developed because existing processes could not offer what the customer wanted, Engibous says. For example, market research indicated that the No. 1 concern of users of op amps was input offset stability. TI responded with the Excalibur process, which yields the most stable input offset capability in the industry. The No. 2 concern was speed, so the second-generation Excalibur process, being used in the company's latest op amps, provides high-speed capability, he says.

Ranked sixth by Dataquest in monolithic analog sales, with 1988 revenues of $353 million, Motorola Inc. has two analog IC operations: a Bipolar Analog IC Division in Phoenix, Ariz., and a MOS Digital-Analog Division in Austin, Texas. The Phoenix operation mainly produces traditional analog building-block functions using bipolar technology, while the Austin operation concentrates on application-dedicated circuits built with CMOS technology for markets such as telecommunications and automotive.

Like its mainstream competitors, Motorola has turned away from commodity parts to concentrate on particular market segments, says Tom Lantzsch, director of marketing at the Phoenix facility. Its energies are in four main areas, he says:

MAXIM'S SPEEDY OP AMP BORROWS DIGITAL TECHNOLOGY

It's getting tougher to pinpoint what is digital and what is analog. Digital logic and memory designers are borrowing analog techniques to solve signal-conditioning problems, and developers of mixed analog and digital data-acquisition subsystems are using digital techniques for compensation and calibration chores. It should come as no surprise, then, that designers of mainstay analog building blocks such as operational amplifiers would succumb to the digital lure.

The first company to do so in monolithic form is Maxim Integrated Products Inc. of Sunnyvale, Calif. Maxim has developed a proprietary digitally compensated CMOS op amp—the MAX425—that compares well with both chopper-stabilized CMOS precision op amps and bipolar implementations. Where previous generations of precision op amps offered speed or precision but not both, the MAX425 sacrifices neither.

The device offers an unprecedented minimum open-loop gain of 160 dB, says David Fullagar, vice president of research and development, and it combines that gain with an offset voltage of under 1 μV. Also, the MAX425 is unity-gain stable. Input voltage noise runs a maximum of 0.5 μV peak to peak, from 0.1 to 10 Hz. Typical open-loop gain is about 180 dB, and maximum offset drift is 0.02 μV/°C, with changeover time less than 0.5 μV over five years.

Many other improvments have also been made: the amplifier recovers immediately from overload and its output has a very symmetric drive. When combined with its 180-dB open-loop gain, this means that its dc gain error is negligible in virtually all applications. It also has a high-speed mode that gives it a 15-MHz gain bandwidth. Finally, its output swings rail to rail and the input will work down to the negative supply rail.

THE MAX425 MATCHES CMOS AND BIPOLAR PRECISION OP AMPS IN PERFORMANCE

Key to this remarkable performance is a set of innovative circuit techniques. Built with relatively conservative 5.0-μm design rules, the op amp combines three gain stages with a digital autozeroing circuit. The differential input stage is optimized for low noise and low offset voltage and is further reduced from 1 mV to less than 100 μV by laser trimming. The second stage of the amplifier is a single-ended, supercascoded stage with a gain of 130 dB, more than that of most op amps. However, this advantage is offset by a limited voltage swing. So a third stage is added to provide the extra gain to drive the output. This output stage is a low-gain, high-speed op amp with internal feedback that sets its closed-loop gain to about 10 dB.

Unlike most autozeroing implementations, which store an amp's offset voltage on a capacitor and require frequent autozeroing to stay in calibration, the MAX425 digitally autozeros the input and second stage of the amplifier during calibration, storing the results digitally. As a result, the offset voltage is unaffected by leakage currents. An on-board 16-bit digital-to-analog converter in the input stage supplies the actual error-correction voltage that cancels the amplifier's low offset voltage. An 8-bit DAC calibrates the second stage.

Because of its flexibility, says Fullagar, the MAX425 can fill a much wider range of applications than either bipolar or chopper-stabilized CMOS precision op amps. It can be used in weight scales with signal bandwidths runnning as low as fractions of a hertz to several hertz, in ultralinear integrators, and in low-frequency active RC filters. Available now, the MAX425 is priced at $7.50 in quantities of 100. It comes in plastic eight-pin mini dual in-line packages. *–B. C. C.*

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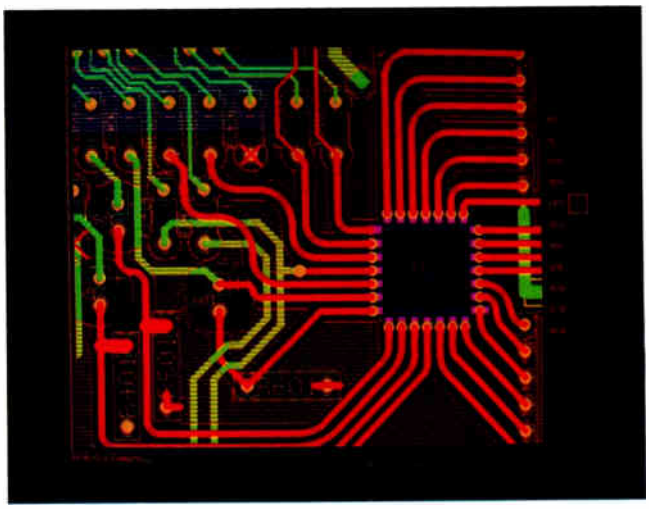

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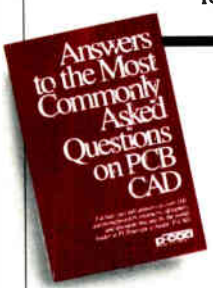

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consumer, automotive, mass-storage (including circuits for both floppy-disk and Winchester drives), and communications, with parts mainly for use by other Motorola operations in such products as pagers and cellular telephones.

The consumer, mass-storage, and communications areas all require high-frequency analog devices. Motorola produces most of these circuits with its high-speed bipolar Mosaic process, which was derived from an emitter-coupled logic scheme. However, the next generation of these products will probably be biCMOS, the company says. Although some automotive circuits are produced by Mosaic, most of them utilize Motorola's smart-power process, SmartMOS.

Motorola too is harking to the call for custom and semicustom designs, Lantzsch says. "We are seeing more and more requests from our customers to do semicustom or custom design as they become more economically feasible," he says. "This means that analog IC suppliers will be challenged to find ways to profitably handle smaller volume requirements with shorter product life cycles."

SOFTWARE COMING. Motorola is currently doing designs internally using the standard-cell approach, says Lantzsch. It expects to provide software to customers for analog standard-cell designs using the Mosaic process in 1990, he says. The software is now being beta-tested.

To counter the Japanese penetration of the analog market, Motorola has established relationships with several major manufacturers in Japan and is designing products both for consumer and mass-storage applications. "In 1988, our market share grew at a considerable rate in Japan, and we expect that to continue," Lantzsch says.

One reason for Motorola's optimistic view of the Japanese market is the company's link with Toshiba Corp. The alliance swapping Motorola's microprocessor technology for Toshiba's dynamic random-access-memory technology (see p. 47) also involves analog ICs. "They have access to our analog products and we have access to theirs," says Lantzsch.

Another big analog player is Analog Devices Inc. Ranked 11th in total worldwide sales with 1988 revenue of $272 million, the Norwood, Mass., company has been a leading supplier of high-performance analog products since it was founded in 1965. The company started with modular data-converter and data-acquisition modules but has moved in recent years into new applications in computer, communications, and consumer markets that fall within this high-performance segment.

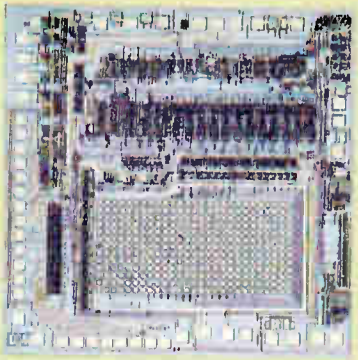
Analog Devices' strategy from the time it got into the monolithic linear IC business has been to serve the high-performance segment, with its higher prices and potentially higher profit margins; that strategy hasn't changed substantially except to broaden into new application areas. Its linear and mixed-signal ICs are produced in much lower volume than are digital ICs, such as RAMs. As a result, the company hasn't assigned a very high priority to economical high-volume production until recently. Now it is going after sockets in consumer audio and video equipment as well as in disk drives, all of which must be produced in high volume at competitive prices.

"We plan to selectively but aggressively penetrate these new opportunities for two reasons," says Ray Stata, Analog Devices' cofounder, president, and chairman. "First, we want to expand our available markets to maintain high [company] growth over the long term. Second, if we don't compete in these markets, we could allow our competitors to establish strong positions in large, high-growth markets for products and technologies that also apply in our traditional markets." Stata

LTC GETS MORE ANALOG FUNCTIONS ON-CHIP

A growing number of semiconductor companies are capitalizing on their expertise in designing analog integrated circuits by developing so-called analog subsystems. These devices combine on a single chip a number of important analog functions along with an interface that makes them look like just another microprocessor peripheral.

One of the most ambitious efforts in this vein comes from Linear Technology Corp., which recently introduced the LTC-1290. This analog-to-digital monolithic subsystem is targeted at instrumentation, robotics, automotive, and industrial-control applications. The LTC-1290 is fabricated in a 3.0-μm silicon-gate CMOS process; it combines a 12-bit, 12-ms analog-to-digital converter with an eight-channel multiplexer, sample-and-hold circuitry, a serial input/output channel, and a wide range of other programmable functions—all on one chip.



LTC's new LTC1290 is an analog-to-digital monolithic subsystem.

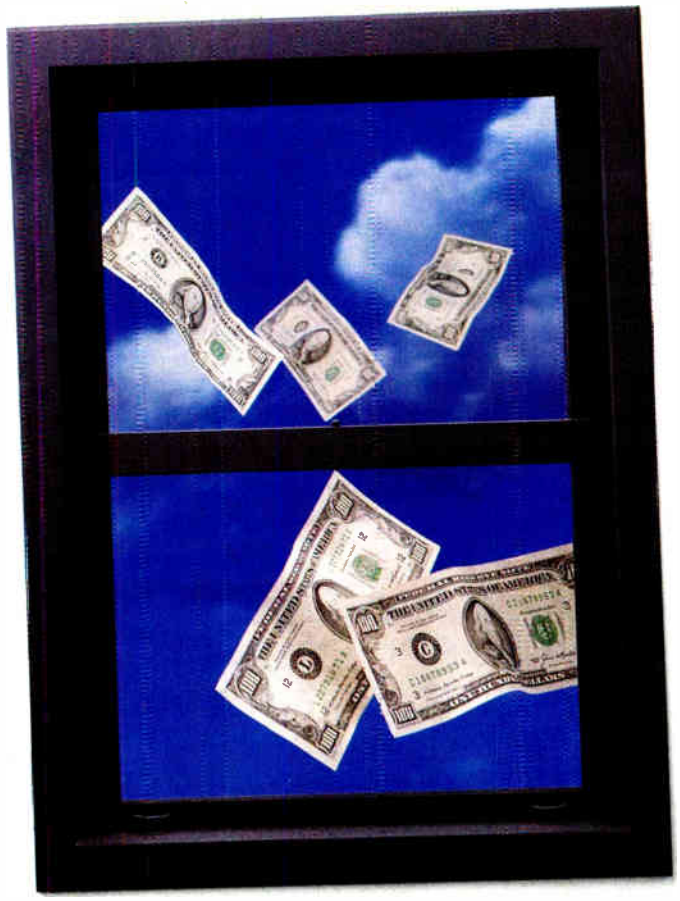
Since any system using an ADC almost always has more than one analog signal to convert, Linear Technology's engineers have incorporated a multiplexer that is software-configurable for many applications, says Robert Dobkin, vice president of research at the Milpitas, Calif., chip maker. The multiplexer can be organized as eight single-ended inputs, four differential inputs, or any combination of the two, such as one differential input and six single-ended channels.

To address the need to communicate with any of a number of microprocessors, microcontrollers, or single-chip digital signal processors, the LTC1290 incorporates a synchronous full-duplex, four-wire serial interface. The interface can be programmed to conform to a number of serial protocols, including Motorola's serial peripheral interface, National Semiconductor's Microwire, and Hitachi's serial communications interface. Other processors without standard serial protocols can be accommodated with little or no external hardware. A shift clock synchronizes the data transfer, with each bit transmitted on the falling edge and captured on the rising edge. To conform to the various serial protocols, the output word can be programmed for 8, 12, or 16 bits.

The LTC1290 can shut power completely off under processor control, a feature that's useful in battery-powered or remote applications, says Dobkin. The shutdown is accomplished by choosing the 10-bit word-length option on the serial interface. The next time the ADC is accessed, power is turned on. Because the internal circuitry requires no warm up, there is no power-cycling delay.

Also, for the first time, many of the analog features of a 12-bit ADC can be digitally programmed. For example, when operating from $\pm$5-V supplies, an input can be dynamically programmed as unipolar (0 to +5 V) or bipolar (–5 to +5 V).

The LTC1290 costs $15.95 each in 100-unit quantities. It is available now in sample quantities in a 20-pin plastic or ceramic dual in-line package. Linear Technology plans to introduce a number of variations on this design by year's end, using a metal-mask programming technique developed for other analog products. Among its planned offerings: the LTC1291, with a two-channel and a single-input multiplexer, both in an eight-pin DIP; the LTC1293, with a six-channel multiplexer in a 16-pin DIP; and the LTC1294, with an eight-channel multiplexer and a half-duplex serial interface in a 20-pin DIP. *–B. C. C.*



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Circle 52

believes that these newer applications can boost the growth rate of Analog Devices' high-performance market segment from 14% to 18% by 1992. Along the way, the company's own goal is to be a $900 million corporation by that time.

The product breadth hasn't changed substantially at Analog Devices over the past 10 years, says Lewis Counts, engineering manager for amplifier products at Analog Devices Semiconductor, the semiconductor division in Wilmington, Mass. "Our customers still need to acquire, condition, and send a signal back out," he says. "So we still make converters, op amps, references, multipliers, and root-mean-square converters. Those were our main revenue producers 10 years ago and they are today. But we address different market segments today, such as the DSP market." In fact, he says, DSP has become a very significant market, one that "didn't exist 10 years ago."

Counts says Analog Devices is very active in semicustom linear and mixed-mode analog and digital arrays and in standard cells. The impact of those technologies on the company has been positive, he says. Arrays, especially, have broadened the markets Analog Devices can serve, "providing some opportunities in midrange mixed-signal ASICs. We're more than a generation behind the digital side, but I can't imagine not using arrays now," says Counts.

Analog Devices has a Japanese connection: its Tokyo-based affiliate, set up in 1970, which does assembly but not wafer fab. Some 20% of the company's revenue has come from Japan over the last few years, a proportion that's on the rise. The business is spread across Analog Devices' entire product line. More recently, however, Japan has beckoned with opportunities not found elsewhere, especially for consumer audio and video DACs.

SEEKING SUCCESS. Harris Corp., too, is hoping to find success in the high-performance end of the analog market. The 16th-ranked supplier, with $146 million in analog sales last year, Harris has sought in recent years to redirect its efforts to this segment rather than the commodity-oriented lower end, says Jeff Peters, vice president and general manager of the Commercial Products Division at Harris's Semiconductor Sector in Melbourne, Fla. Once a stalwart in the military market, the company has also tried to increase its commercial sales by focusing on application-oriented products, such as high-performance video for the broadcast market, automotive applications (a sizable part of the former RCA/GE Solid State Division's business), and even some consumer and industrial applications.

"Our approach in the past was primarily military and custom-analog," Peters says. "We're not de-emphasizing the military, only trying to grow the other parts of the business faster. The acquisition of RCA/GE Solid State makes that easier, but we had already been moving in this direction for a while. The strategy is to look at application-oriented commercial products, such as high-end video-broadcast equipment." Also important, he says, are automotive, process control, and "various applications that can use a new high-voltage process we have."

The Harris strategy is embodied in a number of new products, Peters says.

MAINSTREAM SUPPLIERS ARE REJECTING JELLYBEANS IN FAVOR OF CUSTOMIZED SOLUTIONS

These include a video switch, video analog multiplier, video op amp, and current-feedback amplifiers, all optimized for video performance. Another direction Harris is pursuing is high-power analog parts, such as a new power IC that "replaces a transformer, a rectifier, and a regulator with one chip, and runs off 120-V ac wall current." The part, which provides a 5-to-24-V, 50 mA dc output, is aimed at a variety of applications, including small robotics systems and even consumer applications, such as a portable electric drill.

"We're focused on complementary bipolar processes, with both high-performance pnps and npns on the same chip," Peters says. Dielectric-isolated, not junction-isolated, processes are at the heart of the Harris strategy. "We concluded that dielectric-isolated processing offers better performance at no expense in complexity," he says. "There is a perception that it's more expensive than junction-isolated, but that's not the case any more. Dielectric isolation is more cost-competitive [than it used to be]."

Harris has been in Japan for 15 years, says Peters, selling proprietary products the Japanese don't make, such as high-performance op amps, multiplexers, and switches. "Traditionally, our Japanese penetration has been higher in analog than in digital," he explains. "The U. S. companies' share of the Japanese market is growing, but not as fast as the Japanese appetite for analog chips. U. S. share is growing in the open market, but the captive market is growing faster. So the captives are growing faster than U. S. companies can grow."

The primary reason: commodity parts for commodity products, such as faxes, VCRs, and copiers. Peters says, however, that this is not part of a Japan Inc. conspiracy. "Their captives already make the parts they need. So they buy them."

NO SALE. Although initially there was some thought of selling its Santa Clara subsidiary Intersil, acquired when Harris purchased RCA, the company has nixed that possibility, says Peters. Intersil, which has been a major player in data-conversion products since the mid-1970s, will be a factor in Harris's long-term strategy, he says.

"One of the things that happened is that we were undergoing our annual operating planning process in parallel with talking to various groups about the possibility of divestiture [of Intersil]," says Peters. "And it was during the course of that strategic-planning process that it became more and more obvious that we could enhance our overall position in data acquisition [by keeping Intersil], which is a very important input into any strategy of signal processing and control as a main thrust. It turned out that Intersil was more complementary than we had orginally realized."

Peters points out a couple of areas where he says Intersil is a nice fit. Data conversion, particularly integrated ADCs, is one: "The old Harris made some converters, but it wasn't nearly as full a line [as Intersil's]." Next is op amps, where Intersil's products "fill a nice area between the general-purpose and commodity-like parts that were the old RCA line and the predominantly bipolar, very high-performance Harris parts," he says.

And even though there is an overlap between Intersil and Harris in such areas as analog switches and multiplexers, Peters even paints a bright face on that. He says that it will actually enhance Harris's overall position in the analog switch and multiplexer marketplace. Since the bulk of Intersil's designs are junction-isolated and bulk of Harris's parts are dielectric-isolated, there are some performance differences, even though both lines perform the same basic functions, Peters says. "I think there may be some positioning possibilities for these two families that will make them complementary rather than competitive. That's certainly the approach we're going to take." Peters contends that Harris does not intend to cut any parts from either product line.

Additional reporting by Jon Campbell, Lawrence Curran, Wesley R. Iversen, Tobias Naegele, and Larry Waller

Erasable optical disks finally take off, and write-once disks gear up for document management. But low-cost digital tape drives may compete for storage tasks

Make Room For OPTICAL

BY JONAH McLEOD

The going has been rough for optical-disk drives. From 1983 on, a host of large corporations and small startups have poured millions of dollars into commercializing write-once and erasable optical-disk technologies, with precious little return on investment. Now that erasable optical drives are finally poised to take their place alongside such mass-storage mainstays as Winchester disks, they face competition from cheaper digital-audio-tape recorders that rely on technology borrowed from the consumer ranks. Meanwhile, write-once optical drives are the stars of a new business altogether—document management.

"The optical [disk] market is taking off as a result of erasable optical drives becoming gener-

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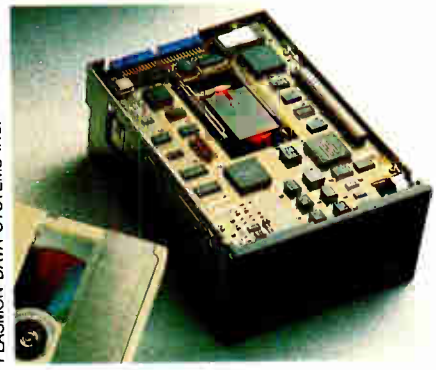


Write-once optical media from Plasmon Data Systems is designed for archiving (far left). Hitachi's OD112-1 erasable optical drive (top) has a 75-ms access time and a 690-Kbyte/s transfer rate; Maxoptix's Tahiti 1 has a 43-ms access time and a 540-Kbyte/s transfer rate.

STORAGE

ally available," says James N. Porter, president of Disk/Trend Inc., a market researcher in Mountain View, Calif. At hand are reliable 5.25-in. erasable drives from Hitachi, Maxtor, Ricoh, Sony, and others. These removable optical drives can back up or even replace fixed Winchesters in computer systems. What's more, the multiple-drive jukebox is fostering a new class of mass-storage product, the optical server, which spools information between the optical disk and a computer's hard disk in much the same way as virtual memory spools between random-access memory and a hard disk in a computer.

Write-once optical storage has sparked a new market category—complex document management. Though in their infancy, these systems in turn are fostering a thriving business in products to build them—for example, document scanners and coprocessors that compress and decompress scanned images for storage and retrieval.

But just as optical storage solutions are coming into their own, they may be facing yet another challenge—a tape-drive market revitalized by helical scan tape technology developed for 8-mm video and DAT consumer products. Compared with optical-disk drives, DAT recorders cost 40 times less per Mbyte (see p. 87).

Despite increasing competition, the optical-drive market is showing signs of finally catching fire. Optical drives are expected to enjoy a compound annual growth rate of more than 100% between now and 1992, according to Disk/

Trend. Between 1989 and 1992, shipments of erasable disks will grow nearly 300%, and write-once drives will realize a 37% annual increase. Last year, of the 42,600 drives shipped, 83% were write-once; the rest were erasable. This year, Disk/Trend predicts, 118,300 optical drives will ship worldwide. Of the total, 64,500 will be erasable drives; the remaining 53,800 will be 12-in. and 5.25-in. write-once drives. By 1992, erasable drives will make up 86% of the 884,700 optical units shipped, the market researcher predicts.

First to market with an erasable optical drive was New York-based Sony Corp. of America, with the model SMO-D501. Canon U.S.A. Inc. of Lake Success, N. Y., is shipping the OM-500D drive in its Canon File 250 document-storage and retrieval systems. The drive also works as the primary disk storage in the Next computer from Next Inc. of Palo Alto, Calif.

Since January, Ricoh Corp. has shipped nearly 6,000 of its RO-5030E drives worldwide, half in the U. S., says Kim Rice, assistant sales manager for the San Jose, Calif., company. Spun out of San Jose-based Maxtor Corp., Maxoptix Corp., also of San Jose, is shipping its Tahiti drives from preproduction. Maxtor Subsidiary Storage Dimensions, a Maxtor company in Los Gatos, Calif., has integrated the drive into its LaserStor erasable optical subsystem. Others expected to offer an erasable optical drive are Optotech of Colorado Springs, Panasonic Industrial of Secaucus, N. J., Sharp Electronics of Mahwah, N. J., and Toshiba America of Irvine, Calif.

As with most mass-storage drives, most optical-drive units are going to systems integrators that build add-on equipment for computer systems. Alphatronix Inc. of Research Triangle Park, N. C., is one of the first systems integrators to use Sony's SMO-D501 drive. Three versions of Alphatronix's Inspire subsystem, introduced last year, plug and play with work stations and computers from Digital Equipment Corp. and Sun Microsystems Inc., along with IBM Corp. PCs and compatible computers.

REAL-TIME TASKS. Compared with the 300-to-600-Kbyte/s throughput of write-once units, erasable optical drives, at 680 Kbytes/s, can accept data in real time for data logging. Moreover, optical drives, including the Sony unit, write a continuous spiral from the outside to inside diameter of the disk with individual tracks delimited by a full revolution of the disk. During data logging, the optical drive can write continuously without having to reposition its head each time it fills a track, as in a magnetic-disk drive that writes separate concentric tracks.

Erasable optical drives gained quick acceptance because of their easy integration into a computer system's storage hierarchy. If mass-storage devices were to be arranged in an order of decreasing cost per Mbyte and speed, RAM, fast and expensive, would be on top. Below RAM would be slower, less expensive, rotating magnetic-disk storage. Next lower in the hierarchy, slower, higher-capacity optical storage would find its place, with magnetic tape resting at the bottom.

Distributed network computing is a good example of how this hierarchy works. In a typical system, six or seven work stations connect to a file server holding 2 to 5 Gbytes of magnetic-disk storage. The work-group network in turn connects to a backbone network containing department-wide resources such as compute servers, printer servers, communications servers, and so on.

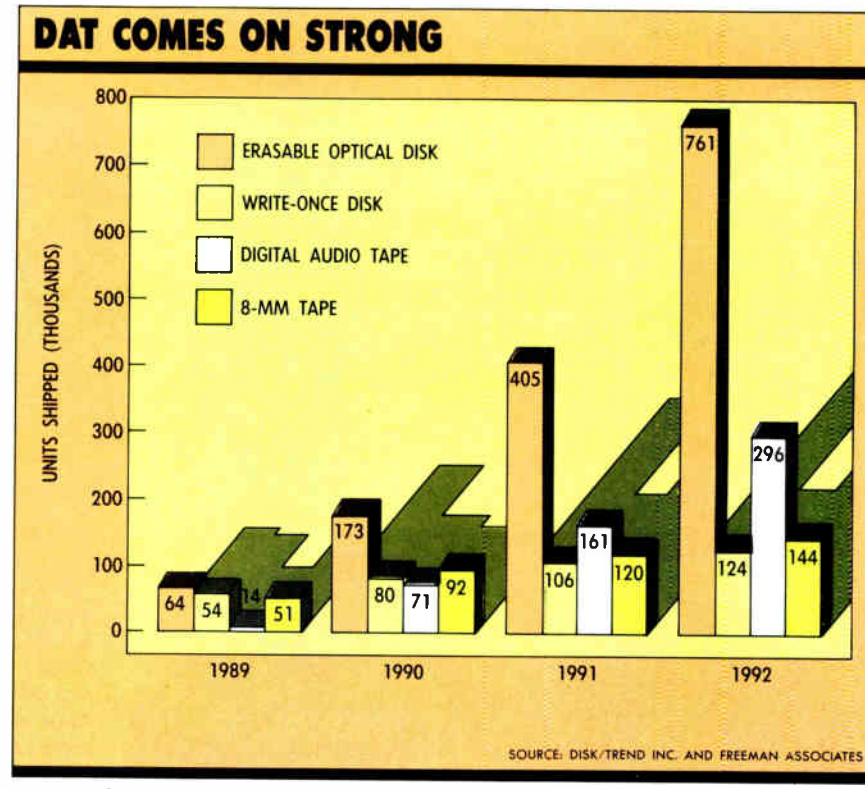
Each work station has its own 70-to-150-Mbyte magnetic disk that holds the Unix operating system and the user's application programs. The user's data, however, is contained on the work-group file server, which performs periodic backup. But to back up the file server, the operator must take the server off line and dump the magnetic disks to multiple tape reels or cartridges.

One solution is a storage server, which resides on the backbone with other departmental server resources and not in the work group, says Don Byrne, vice president of field operations at Epoch Systems Inc., Marlborough, Mass. The Epoch-1 Infinite Storage server with 28.8 Gbytes of optical storage automates the backup operations, performing the task on-line. It costs $150,000, the price of a high-end file server.

"With our system, the file server magnetic disk in each work group is made to appear as a virtual disk," Byrne says. Unused data is spooled off the file servers to the optical disk, and new data is spooled off optical and onto the file servers. An optical-disk jukebox with its rack of disks and two or more erasable optical-disk drives makes the storage server concept possible. The Epoch-1 uses the 24-cartridge OL101, a 5.25-in. jukebox equipped with OD101-1 erasable optical drives—both announced in April—from Hitachi America Ltd. in Brisbane, Calif. Hitachi and Nippon Telegraph and Telephone Corp., both in Tokyo, developed the jukebox and drive.

OPTICAL JUKEBOXES. The first major computer system company to offer its own jukebox for its computer product line is the Greeley Storage Division of Hewlett-Packard Co. in Greeley, Colo. Introduced this month, the HP Series 6300 Model 20GB/A, a jukebox with 20 Gbytes of storage and up to two erasable SMO-D501 optical drives from Sony, is a networked peripheral for the HP 9000 work-station line. HP announced its jukebox, the HP C1710A Optical Disk Library System, as an OEM product in April. "We built hooks into the HPUX [HP's implementation of Unix] kernel to handle removable erasable optical-disk drives," says William Boles, HP's product marketing manager. "The operating system views the optical jukebox as a disk farm of 64 logical drives."

Each side of a disk is viewed as a sepa-



rate disk because only one side of the disk is read at a time. The software includes other functions, such as mount and dismount. Two jukebox characteristics critical for operation in networked systems are average access time and mean time between failures. HP's unit boasts an average media-exchange time—the time to find a cartridge and exchange it with one already mounted on a disk—of 7 seconds. Its MTBF is 20,000 hours or 1 million cartridge exchanges.

Jukeboxes put new requirements on optical-disk drives. Drives require an electrical eject instead of a manual eject so that the jukebox can remove a disk automatically, says Gordon Knight, vice president of engineering and technology at Maxoptix. More important, the drive must be built to withstand hundreds of thousands of cartridge exchanges, something not required for a stand-alone drive.

Cygnet Systems Inc. announced its Model 5250 5.25-in. optical-disk jukebox in April 1988, but it was intended to handle write-once drives and up to 25 cartridges. The system is currently being modified to handle erasable drives. The Sunnyvale, Calif., company claims a worst-case cartridge exchange time of 4 seconds and an MTBF of 10,000 hours and 300,000 cartridge exchanges.

Others with jukeboxes initially designed to accommodate write-once drives include Filenet, Mitsubishi Electronics America, and Ricoh. Torrance, Calif.-based Mitsubishi offers the MG-5G1 5.25-in. optical-disk jukebox, which can hold up to 132 cartridges. Meanwhile, Filenet Corp. of Costa Mesa, Calif., has introduced the Series 1000, a 48-cartridge jukebox, while Ricoh has rolled out the RJ-5160, a 20-cartridge jukebox.

REPLACING PAPER. Write-once drives, though about equal to erasable optical disks in capacity, serve a different purpose. Having captured data and images once, write-once drives archive them for a long time. Now the drives compete with the traditional means of archiving data

OPTICAL JUKEBOXES FOSTER NETWORK OPTICAL SERVERS

and images—paper and microfilm—forming the heart of what are called computer document-management systems, which handle compound electronic documents consisting of images plus text, data, graphics, or voice [*Electronics*, July 1989, p. 61]. Sales of such systems by U. S. vendors will top $2 billion in 1992, growing at a compound annual rate of 80%, according to estimates by International Data Corp., a market research company in Framingham, Mass.

Manufacturers of these systems include Filenet, Wang Laboratories Inc. of Lowell, Mass., and Advanced Graphics Applications Inc. of New York. AGA's Discus, for example, is a networked storage system using write-once, erasable, and compact-disk read-only-memory storage, as well as magnetic disk and tape.

The problem with large systems, however, is that they don't create a mass market for optical drives. "Filenet, one of the more successful systems integration companies in the document-storage business, has 250 installed systems," says Richard Zech, president of Zech Tech International, San Mateo, Calif. "That accounts for 1,000 drives shipped over an eight-year period. Companies building disk subsystems are the ones making money in the optical-disk market."

Write-once optical drives need lower-cost systems that can sell into applications requiring many drives and media. One potentially high-volume application that uses write-once optical storage to archive data is the Recall system from Dataworks Inc., a startup systems integrator based in San Antonio, Texas. The system is sold to banks to store the text reports generated by their host computers. A typical system comprises a PC AT or compatible with a large display to view a 132-column report and a magnetic disk as a buffer between the mainframe and write-once optical drive and software.

BANK ON IT. During operation, weekly, monthly, or yearly reports downloaded from host computers are indexed, compressed by 60%, and stored on the write-once drive. "System cost is not an issue," says Richard Cobb, Dataworks' president. Banks, legally bound to archive data for seven years, have relied in the past on microfilm, microfiche, and paper. "A small bank with $100 million in assets spent $1,000 a month on microfilm. Our optical system costs $12,000, including the software, so the system can be paid off in a year or two," Cobb says, adding that the same system can serve insurance and medical applications as well.

The Dataworks system uses write-once media supplied by Plasmon Data Systems Inc. of San Jose, which was chosen for its low cost, Cobb says. Plasmon's media is made by sputtering a highly stable layer of platinum, which affords long archival life; unlike other media, it won't oxidize if the plastic enclosure sealing the media from the environment is broken.

Write-once drives are also serving in stand-alone and networked PC-based document storage and retrieval systems. Starting in 1988, a number of companies received venture funding to address this market. Among them are Courtland Marketing of Columbia, Md., Document Technologies of Palo Alto, and Entire of East Rochester, N. Y.

George Trigilio, president of Courtland, says the company's Alexsys system contains a PC with 640 Kbytes of RAM, VGA graphics, and document scanner,

HOW ERASABLE OPTICAL DRIVES STACK UP

Company	Model	List Price	Average Access (ms)	Transfer Rate Read Operations (Kbytes/s)	RPM	Capacity Per Side (Mbytes)
Canon*	OM-500D	$6,000	102	825	3,000	256
Hitachi	OD112-1	$5,000	75	690	2,400	322
Maxoptix	Tahiti 1	$5,995	43	403/540	1,800/2,200	325/500
Ricoh	RO-5030E	$3,800	71	300	1,800	325
Sharp	NA	—	97	635	2,400	325
Sony	SMO-D501	$4,650	95	680	2,400	325

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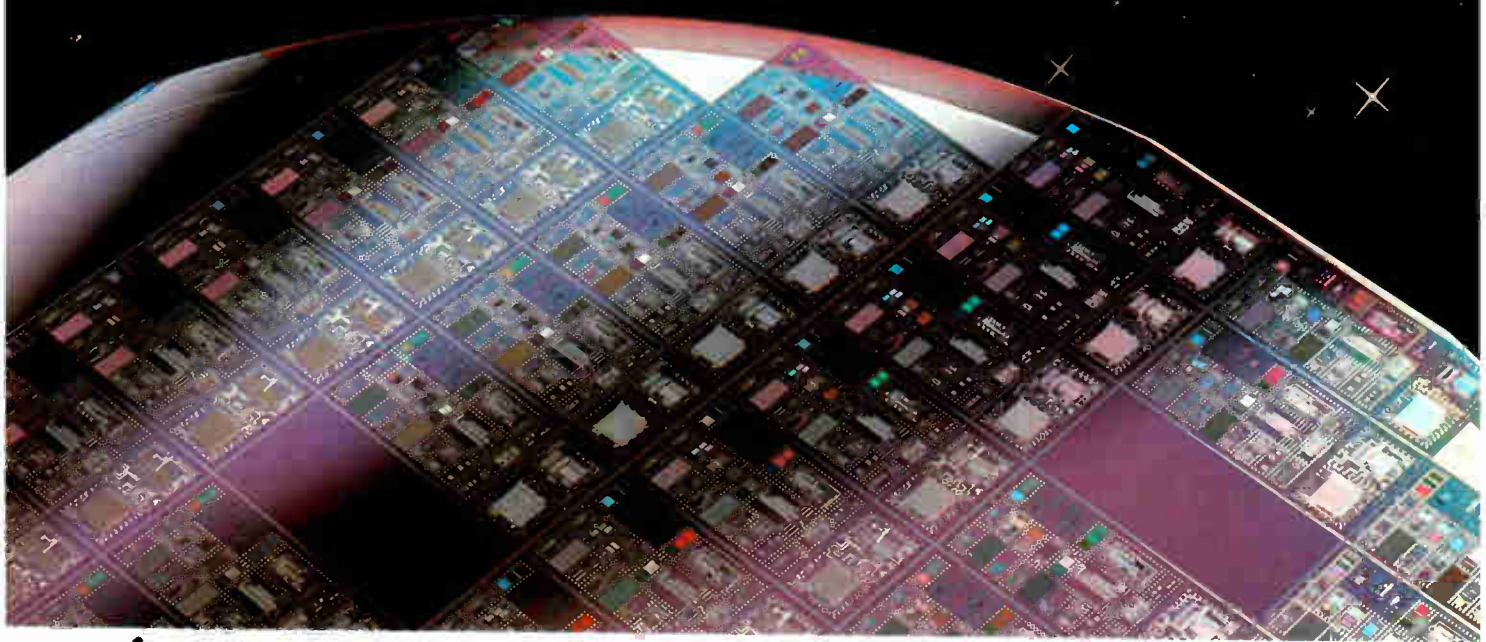

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printer, hard-disk drive, and write-once optical drive. Courtland software configures itself to determine system resources. The software controls all the storage, scanning, retrieval, and printing tasks. When a document is scanned, the user enters key words to the image file, which can be read by the computer to find the image in a large data base. Trigilio says the company may provide OCR packages, which can perform this capability. The image is then sent to the optical-storage device. A document can be a single page or a file of up to 400 pages.

Within the last two years, complementary products, including PCs, laser printers, and graphics cards and displays, have become available to support this business. Companies also have sprung up to offer products tailored to the document market. For example, Kofax Image Products Inc. of Irvine offers several of the components needed to build a complete system, including the KF-8100 image compressor/decompressor, which Courtland offers in its Alexsys system.

The KF-8100 PC add-in board compresses and decompresses scanned bit-mapped images. Because an uncompressed scanned image consumes a great deal of storage, makers of document systems have resorted to the CCITT Group III facsimile compression technique. As a result, storage space needed for an image is reduced tenfold.

The document-management market is fueling the growth of other products. Document scanners, for example, are offered by such companies as Calera Recognition Systems of Santa Clara, Calif. (formerly Palantir), Complete PC of Milpitas, Calif., and Datacopy of Mountain View. The competitive battle among scanner suppliers is to reduce the cost of a high-quality scanner from over $2,000 to under $1,000. Complete PC Inc.'s 300-dot/in. scanner, introduced in April, sells for just $899.

ITALIAN ENTRY. Startup companies aren't the only ones in the PC-based document storage and retrieval business. From Ing. C. Olivetti & Co. SpA, Ivrea, Italy, the optical document-image system ODIS-3 uses its own PC, scanner, laser printer, and the model 810 write-once optical-disk subsystem from its subsidiary, Laserdrive Ltd. of Santa Clara.

Still, the high media cost of most write-once drives is curbing their growth. The market is elastic in terms of price. When Maxoptix's RXT-800S, manufactured by Ricoh, was introduced in 1986, the drive sold on an OEM basis for $1,300 and its 800-Mbyte write-once cartridge for $75. Competitive drives sold for twice as much and offered less capacity. The RXT-800S "has gotten to be standard in its own right," says Rice of Ricoh. "In December, the drives accounted for a 38% market share. Now they have around a 50% market share. And we're seeing an increase in demand for the write-once drive through Maxoptix."

Larry Holstrum, director of business development at Iomega Corp. in Roy, Utah, agrees that cost is constraining development of write-once disks. To solve this problem, Iomega and ICI Americas Inc. of Wilmington, Del., have launched a joint venture—Bernoulli Optical Systems Corp. in Boulder, Colo. Iomega is contributing its Bernoulli floppy-disk-drive technology and ICI Americas a flexible optical medium called digital paper, which can be produced in large quantity for very low cost.

Holstrum believes it will be possible to build a floppy write-once optical-disk drive with a digital paper-based cartridge with 1.2 Gbytes of capacity and sell the cartridge for $50. A prototype of the product could appear next year. The company also plans to license other manufacturers to make the drive.

Such price-cutting innovation will be required if write-once and erasable optical storage options are to continue on their upward market path without losing applications to less expensive digital-audio-tape technology. □

DIGITAL AUDIO TAPE'S LOW-COST CHALLENGE

Digital audio tape's big advantage in storage tasks is that it costs less than optical-disk drives. "A 2.3-Gbyte 8-mm drive costs $1,600 in large quantities," says Robert Abraham, vice president at market researcher Freeman Associates, Santa Barbara, Calif. "The projection for DAT is that it will hit $1,360 next year." Erasable optical drives sell for at least twice that. DAT holds a massive advantage over optical disks in cost per Mbyte—40 cents for optical compared with 1 cent for tape.

The first drive to find its way into digital storage applications was 8-mm tape, which showed up in 1987 in Exabyte Corp.'s EXB-8200 cartridge-tape subsystem. The Boulder, Colo., company's tape drive uses the 8-mm tape cartridge found in the Camcorder from Sony Corp. of Tokyo. Juan Rodriguez, founder and chairman of Exabyte, says a new version, expected before the year's end, doubles the current unit's 246-Kbyte/s transfer rate and its 2.3-Gbyte capacity.

"The biggest advantage of the Exabyte product is its head start in the market," says Abraham. "Exabyte's 8-mm drive is well entrenched as an add-on product in the work-station market." Rodriguez says the product has also gained wide acceptance among leading computer system manufacturers.

But DAT's incursion into the U. S. market has been slow, because of the head-banging between record companies and DAT-recorder manufacturers. Because DAT units can record music at the same high quality level as compact disks, record companies, fearing widespread piracy of prerecorded compact disks, have fought to ban the players from the U. S. market. Nonetheless, DAT recorders are sold widely in Japan. Manufacturers of DAT recorders have agreed to build their products so that they can make only one copy of a prerecorded CD or DAT, thereby limiting the number of copies that a DAT machine can record.

With the piracy hurdle overcome, Abraham believes the market for audio DAT players will enjoy the same meteoric growth as the one for CD players. Makers of DAT recorders for digital applications will benefit from leveraging the research and development and manufacturing scales of the consumer audio production. "The market has 13 announced products, and 12 more will be announced in 18 months," says Abraham. "They are all going after same customer base—PC aftermarket and system OEMs."

Two recording formats are contending for market acceptance. One group, led by Sony and Hewlett-Packard Co., is offering the DDS format, which has been forwarded to the ANSI X3B5 committee for adoption as the American National Standards Institute standard for 4-mm tape. The other, promoted by Hitachi Ltd. of Tokyo, is DATA/DAT, based on Hitachi's proprietray DAT format. An ad hoc group has been formed to make DATA/DAT a standard.

DDS units are expected from Sony with its STD-1000, Hewlett-Packard with its HP 35450A—Sony builds the drive mechanism for both drives—and Wangtek Inc. with its 6130FS drive. Victor Co. of Japan (JVC), a subsidiary of Victor Data Systems Co. Ltd. in Kahagawa, builds the mechanism for the Simi Valley, Calif.-based Wangtek.

Freeman Associates predicts that shipments of DAT units will grow 228%, increasing from 14,000 this year to 623,000 in 1994. The market researcher expects shipments of 51,000 8-mm tape units this year, with that number reaching 144,000 in 1992. *–J. McL.*

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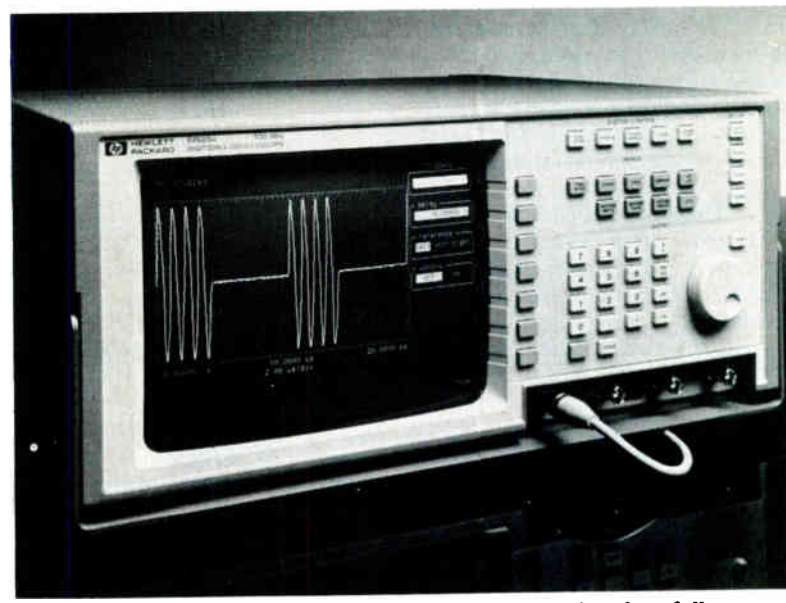
Circle 60

The market is heating up as vendors unleash a flurry of products to fill the demand for digital oscilloscopes

GOODBYE ANALOG, HELLO DIGITAL

BY JONAH McLEOD

They say you can't teach an old dog new tricks, but one of the oldest instruments in the engineer's arsenal has been undergoing a transformation over the past few years. Fast-paced digital technology is doing to the oscilloscope what it has already done to computers: accelerating the pace of product development. As a result, 1989 marked the first time more dollars were spent on digital scopes than on their analog counterparts—a total of $610 million, against $570 million for analog. Last year, $598 million was spent on analog scopes and $524 million on digital.



Hewlett-Packard's 54503A digitizing oscilloscope has four full-range channels and a 500-MHz bandwidth.

In light of the demand, vendors are unleashing a host of new offerings in a rousing battle for market share. In the midrange arena, Hewlett-Packard Co. and Fluke & Philips have each launched fierce attacks on market leader Tektronix Inc., with products offering superior performance at a lower price than Tektronix's popular 2400 series. The 2400 was the first digital scope to look, act, and feel like an analog scope, says Marc Brenner, product marketing manager for the 2400 line. Meanwhile, Tektronix has returned HP's fire with a hot new product that threatens HP's dominance in the high end of the market.

The thirst for digital oscilloscopes shows no sign of abating, says Galen Wampeler,

president of Prime Data, a San Jose, Calif., market research firm. The digital scope market has grown at an annual rate of 30% over the past five years, he says, and sales should increase at about 18% per year through 1993 while sales of analog scopes slide about 4% per year in that period. By 1993, he says, digital scopes should be a $1.2 billion market. What is surprising, Wampeler says, is that up to now the digital scope market has soared even though buyers have had to pay a premium for the digital units.

That premium no longer exists, thanks to the June introduction of the HP54502 and HP54503 scopes from Hewlett-Packard's Colorado Springs Division. Each of the new models is priced at $6,450, which is 20% lower than comparable analog scopes. "Building products that play off technology investment in fast digital logic provides us high research-and-development leverage," says Tom Saponis, HP's general manager in Colorado Springs.

The new scopes represent HP's second attempt at unseating midrange market leader Tektronix of Beaverton, Ore. Tektronix's leading midrange digital offering, the 2440, was introduced in mid-1988 and costs $11,960. "Last year, HP attempted to take market share from Tektronix in midrange oscilloscopes, where Tektronix has traditionally been strong, with the HP54501," says Dan Nelson, vice president of research at Regan & McKenzie, an investment firm in Seattle. "But that product did not quite live up to the market's expectations." The scope simply did not offer the price/performance advantage needed to convince users to make the switch; HP believes that the new scopes do.

The HP54503 pushes the performance envelope in the midrange. "The 54503 is the true box for every engineer," Saponis says. "It has four channels, each with 500 MHz of bandwidth." The 54503 features custom hybrids that give all four channels full dynamic range from 1 mV to 5 V per division. With conventional four-channel scopes, two channels offer full range and two have a limited input range.

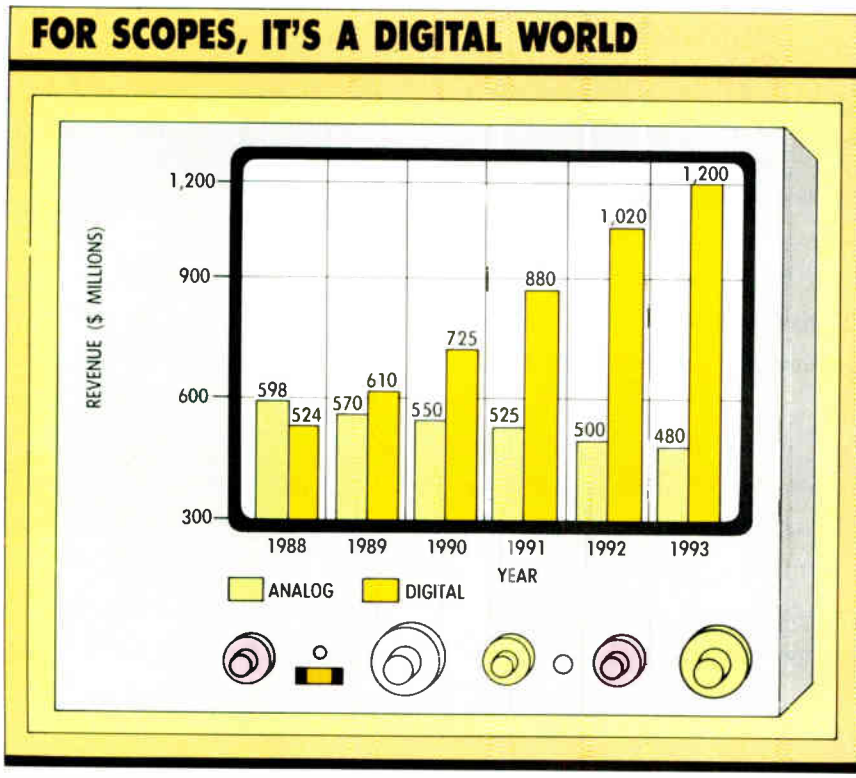
The 54503 is the first digital scope to offer 500 MHz of bandwidth with input impedance switchable between 1 MΩ and 50 Ω. Above 400 MHz, other scopes provide only 50-Ω inputs. "With faster emitter-coupled logic and CMOS digital logic becoming available, engineers are going to need 500-MHz performance and 1-MΩ input impedance," Saponis says.

The Fluke & Philips PM3323 offers a critical performance advantage: 10 bits of vertical resolution in each of its two channels. Bandwidth is 300 MHz.

MORE RESOLUTION. Fluke & Philips, a joint venture of John Fluke Manufacturing Co. Inc. of Everett, Wash., and Philips Test and Measurement of Eindhoven, the Netherlands, also wants a piece of the midrange market. At the same time HP rolled out its new digital scopes, Fluke & Philips unveiled its new offering, the PM3323. The $7,750 scope offers a critical performance advantage the competition doesn't have, says Hans Toorens, oscilloscope product marketing manager at Philips: "in its performance range, the PM3323 is the only scope with 10 bits of vertical resolution." Competitive units offer 6 or 8 bits of vertical resolution; the Tektronix 2440, for instance, offers 8 bits of vertical resolution with a 500 Msample/s digitization speed, and the new HP scope has 6 bits.

The PM3323 features an optional fast Fourier transform facility, which performs a 4,000-point FFT in 13 seconds. FFT capability is just becoming available in higher-end products like the new Tektronix DSA600 series. The Fluke & Philips scope also comes with an integral digital signal-processing capability. In addition, it comes with post-processing and analysis capabili-

FOR SCOPES, IT'S A DIGITAL WORLD



ty such as signal averaging, integration, differentiation, and stop- or save-on-difference—it compares an incoming signal with one stored in memory.

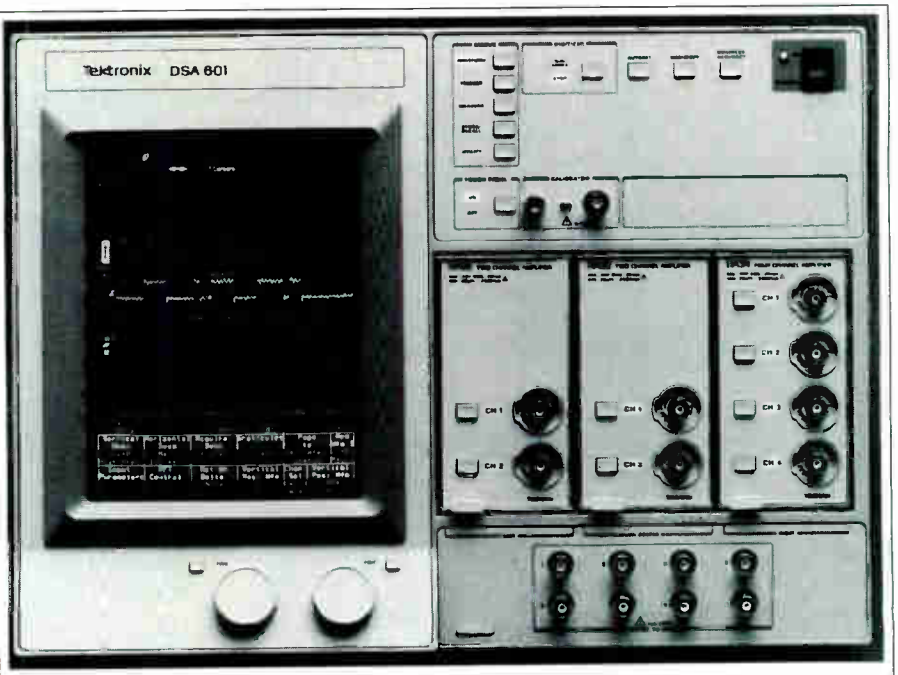
While Tektronix was being assaulted in the midrange arena, it launched a counterattack at the high end, where it has been trading fire with HP for years. Its vehicle: the DSA600 series, unveiled in June. The introduction is a late but still potent attempt to enter the market for units with a very high digitizing rate. The first product in this category was HP's HP5411D, released in 1986.

"Tektronix has been a year and a half late in responding to HP in the high end," says Regan & McKenzie's Nelson. Still, he believes that with this new announcement Tektronix may have regained the initiative. The DSA601 and DSA602 match the HP scope's 1-GHz bandwidth and 2-Gsample/s digitizing rate using 8-bit analog-to-digital converters. And they provide something the HP instrument lacks: on-board digital signal processing, which eliminates the need for external computers for many measurements.

The three criteria for judging a digital oscilloscope are sample rate, bandwidth, and record length or waveform storage, explains Ron Henricksen, software project leader at Tektronix. The HP54114A offers a digitizing rate of 2 Gsamples/s, but at a lower bandwidth than Tektronix's new scopes (500 MHz) and with only a 6-bit vertical resolution.

TWO BITS. "The extra two bits mean a lot to a class of users like the nuclear community," says Nellie Brock, product marketing manager for Tektronix's DSA600 series. "Tektronix is the first to market 8-bit ADCs at a 2-Gsample rate."

Record length determines the amount of waveform that an instrument can capture. The longer the record length, the more signal the engineer can view to locate an event of interest. LeCroy Corp. of Chestnut Ridge, N. Y., with its 9450, holds the lead in record length with 50,000 points, although this scope has a modest sample rate of 400 Msamples/s (see below).



At the high end, Tektronix's DSA600 combines DSP technology with a digitizing oscilloscope architecture for real-time measurement of ultrafast signals.

Tektronix uses a method called time-qualified triggering (also called glitch capture) that deploys a smaller amount of memory to locate the event of interest. With this approach, the DSA600 series can trigger on events as small as 2 ns in duration. The new PM3323 from Fluke & Philips comes close to this performance with its 3-ns glitch capability.

But Tektronix is banking the success of the DSA600 series on its powerful DSP capability, which comes from two on-board dedicated signal-processing chips, called Tristar. The real strength of the DSP is its ability to perform FFTs. Though it isn't intended to replace a spectrum analyzer, the DSP can perform spectral analysis on a discrete event, a capability that spectrum analyzers don't offer. "The user can analyze the harmonic content of a noise spike or laser pulse as a single-shot event," says Henricksen.

The DSP also performs functions found on other scopes, such as single average, much faster. "For example, with 1,000-point records, the DSA600 series can average 180 waveforms/s, a sixfold increase over the Tektronix 11400 series," a digitizing scope that doesn't have the potent signal-processing capability of the DSA600, Henricksen says.

The marketplace move to digital is happening because the price/performance advantage of digital scopes is improving much faster than that of the analog versions. Technology developments in the computer industry—including lower-cost memory, higher-speed application-specific chips, and higher-speed general-purpose processors—can be directly applied to the digital oscilloscope; the same cannot be said for analog scopes. As a result, the long-term outlook is for digital oscilloscopes that get progressively smarter, that offer more features—and that cost less, as well. □

LECROY PURSUES TEKTRONIX AND HP AT THE HIGH END

The first company with a 1.3 Gsample/s digital scope in 1984, LeCroy Corp. of Chestnut Ridge, N. Y., is out to get some respect from the larger players in the oscilloscope business. The company is rolling out a new line, the 7200 System, aimed squarely at the high-end market segment occupied by Tektronix Inc.'s DSA600 series and Hewlett-Packard Co.'s HP54100 family. To be introduced this month, the scopes are priced at $32,900, including a two-channel plug-in unit.

These offerings—the first LeCroy scopes with plug-in units—bring two special features to the game: large sample memory (50,000 samples per channel) and extensive digital signal-processing capability. To achieve its high storage capacity, the 7242 plug-in unit contains two full channels; equipping a scope with two units gives it four input channels, each with its own sample memory, 8-bit analog-to-digital converter, and input amplifier. The ADC and sample memory on other scopes are typically shared among the input channels.

But simply adding more memory per channel is not what makes the 7200 unique. The trick is being able to process all the data captured in that memory and display the results on the screen in real time, says Henry J. Bickel, vice president of business development. LeCroy has developed a unique algorithm that makes this possible.

Powerful DSP capability allows real-time analysis of the waveform, Bickel says. Because of the large memory capacity, the scope can perform a 50,000-point fast Fourier transform at a higher resolution than a scope doing an FFT with a smaller sample memory. *–J. McL.*

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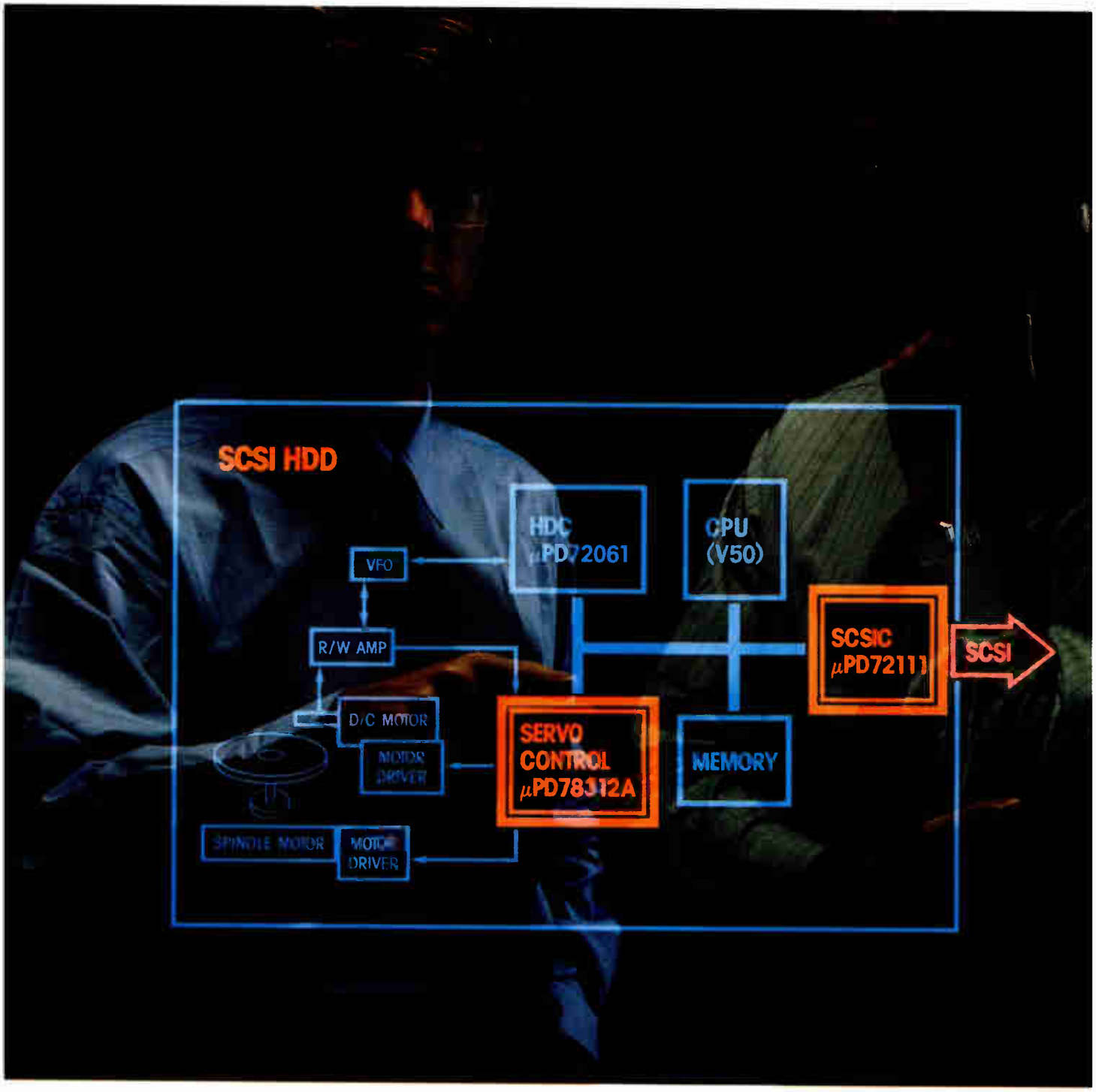

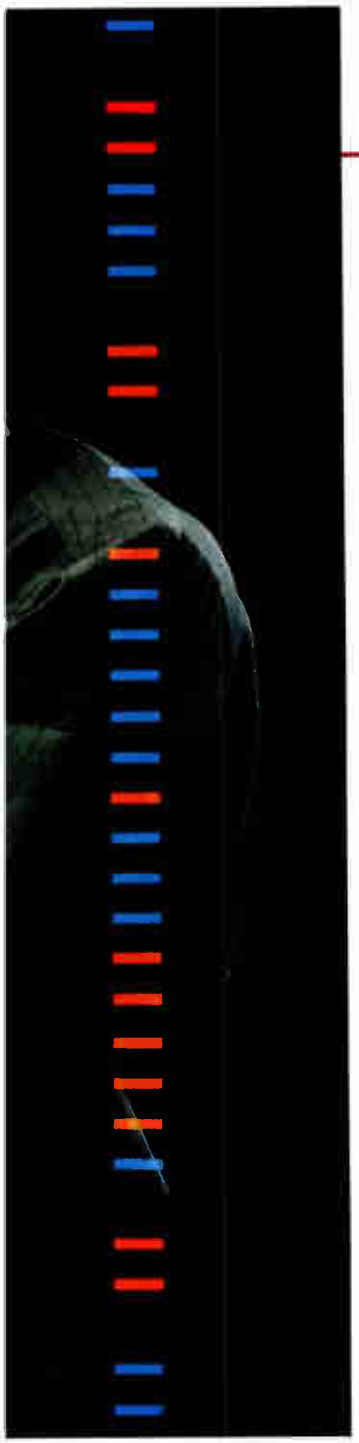

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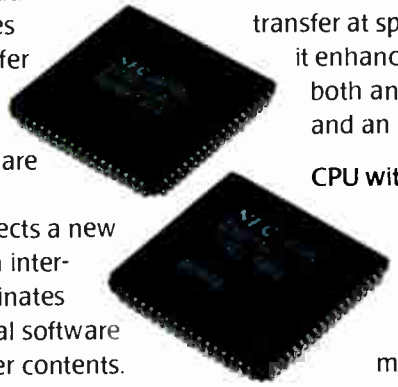

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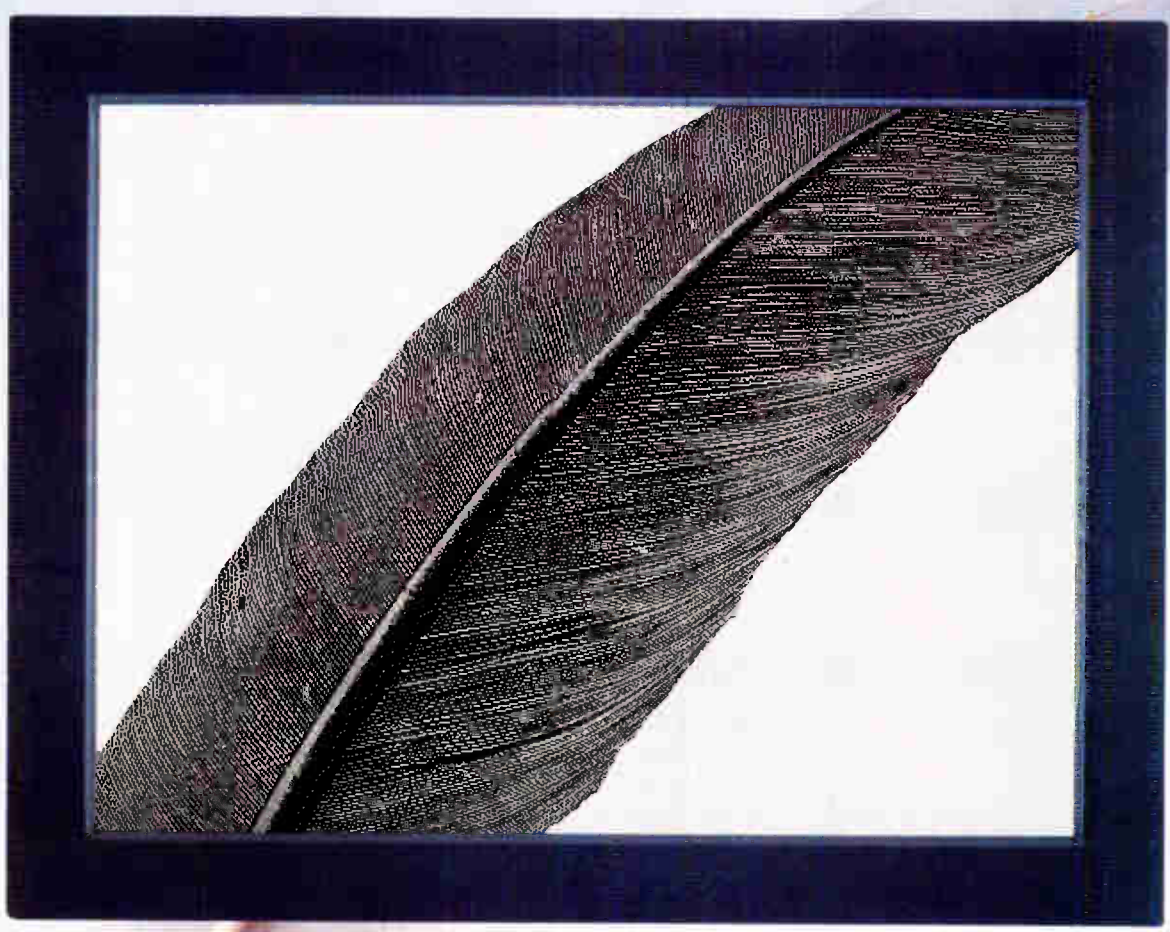

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Circle 66

Supercomputers are on the fast track

Fujitsu aims for first place with new operating system and data base

The following is an account of major trends in product development in Japan in the sectors of mainframes, supercomputing systems, engineering work stations (EWS), personal computers (PC), and peripheral equipment.

Japan's mainframe market contains four major entrants: IBM Japan, PC manufacturers Fujitsu and Hitachi, and NEC, that is marketing a non-compatible model. No great change is expected in the balance of power among these entrants for the next three or four years. This is because all are equipped with sufficient developmental capability.

The major development in this stable market was the news, released in June of 1989, that Fujitsu had finally created an Operating System (OS) to counter ESA, some time after the AAA ruling paved the way for a full-scale project. The OS in question is known as MSP-EX, and has a virtual storage space of 2 gigabytes, far smaller than the ESA's 16 terabytes. To compensate, it is equipped with a system storage (SS) function that can boost this space to 128 terabytes. In effect, its functions are on a par with those of ESA.

At the same time, Fujitsu announced its data base management systems (DBMS) that is more sophisticated than IBM's DB2 ver.2 relational data base management systems (RDBMS).

Although Hitachi has not yet announced an OS counter to ESA, it is reportedly testing one at its Kanagawa plant, and anticipates shipments before the end of fiscal year 1989.

As this suggests, all of the entrants are leaning toward data-oriented (or DB-oriented) architecture. Japan's market for RDBMS has rapidly grown over the last few years. Some manufacturers are even bundling DBMS with OS, particularly for small, general-purpose models. In the process, the mainframe is gradually coming to be viewed as a DB machine.

Japan's supercomputing market is rapidly expanding. As of the end of fiscal year 1987, there were about 130 supercomputers, including IBM's 3090VF, in operation in Japan. By the end of fiscal year 1988, the number had grown to about 180. At 13 for Cray and about 50 for IBM, U.S.-made models account for over 60 systems. Fujitsu holds about half of this market.

Shipments of Cray models have increased sharply in 1989. The surge represents acceptance of Cray's application software resources and its scalar processing capabilities, as well as the maturation of Cray Japan's operation. Japan too is gaining a greater awareness of the importance of packaged software resources, albeit five years later than the U.S.

The supercomputing market is expected to grow at an average annual rate exceeding 30 percent over the next five years. Financial institutions are recent customer additions.

The market for mini-supercomputers is expanding too. The number of such models in operation had reached the 130 mark as of the end of fiscal year 1988. The 1989 shipments are expected to be up over 50 percent. This market consists entirely of U.S.-made products; there are no Japanese entrants. The leading share belongs to Convex, which is the subject of agency sales by Tokyo Elec-

COMPUTERS & PERIPHERALS

TABLE 1. SPECIFICATIONS OF MAJOR PORTABLE COMPUTERS

Manufacturer	Seiko Epson	Toshiba
Model	PC 286 Note executive	J 3100 SS Dyna Book
CPU	V30 (10 MHz)	80C86 (8MHz)
RAM	1.1MB (max. 1.6MB) Main memory: 640KB EMS/hard RAM	1.5MB (max. 3.5MB) Main memory: 640KB I/O bank RAM
Storage unit	128/640KB-IC Card × 2	2DD/2HD - 3.5" FDD
Weight	2.2 Kg	2.7 Kg
Size	315 × 235 × 35 mm	310 × 254 × 44 mm
Battery life	3 hours	2.5 hours
Price	$3,225	$1,394

tron and value-added reselling (VAR) by NKK. Convex is followed by Alliant (sales through Alliant Japan and VAR sales by NTT Data Communications), FPS, and Supertech. However, Tokyo Electron is embarking on the production of models that are similar to computers at the bottom of Convex's line.

Other U.S. vendors of minisupercomputers besides Convex are making significant sales in Japan as well.

A tone of rapid expansion also colors the market for the high-performance EWS known as "super EWS." The leader here is Kubota Computer, which markets the Titan model of the U.S.-made Ardent Computer. It is folowed by Stellar Computer, which is sold by three firms, and Nippon Computer's Super 3. The super EWS market was virtually nonexistent in 1987, but shipments topped 200 units during fiscal year 1988. This remarkable turnabout is a good indication of the fast-paced expansion of Japan's supercomputing system market.

In short, this market is undergoing dramatic growth. More and more, vendors are being evaluated by the quality of their software as the circle of users enlarges. All entrants offer an open architecture and have adopted Unix as the standard OS. A major priority is the formation of groups encompassing major customers and software houses.

Growing Dominance Of Sun Microsystems In The EWS Market

The number of EWSs, shipped within the Japanese market topped 40,000 during fiscal year 1988 and is projected to increase by over 50 percent during 1989. The leading vendors are Sun Microsystems in Japan, YHP, Sony, Apollo Japan, and DEC Japan. Among the indigenous Japanese entrants, Sony is making the best showing, followed by NEC, Sumitomo Electric Industries, and Omron Tateishi.

As might be expected, applications center around CAD/CAM/CAE and CASE, but office use now accounts for about 15 percent of the total. A problem in this connection is Japan's dearth of Unix-based OA (open architecture) software. This is behind the widespread use of EWS as terminals in financial institutions.

Sun Microsystems is expanding its domination of this market in Japan. Sun Microsystems of Japan supplies OEM-based systems to Fujitsu, Toshiba, Nippon Steel, Fuji Xerox, Oki Electric, Tokyo Electron, Seiko Electronic, Sofia Systems, and others. SPARC-based EWS manufacturers are Matsushita Electric Industrial (Solbone) and Toshiba.

As noted, various companies are supplied with SMJ's machines on an OEM basis, and the Solbone EWS is being marketed by Matsushita Electric Industrial. Since the list contains such big-name computer manufacturers as Fujitsu, Toshiba, and Oki, SMJ's EWS is expected to capture the largest share of Japan's EWS market. In addition, MIPS-based EWSs are being marketed by Sony, Sumitomo Electric Industries, and Kubota Computer.

PC Market Enters A New Phase

In fiscal year 1988, Japan's PC market registered steep growth for the first time in three years, with domestic shipments on the order of 1.5 million units. Major developments were expanded sales of lap-top computers and the emergence of additional new-concept PC models. The share of the total PC market occupied by lap-top models has reached about 17% and is expected to rise further. This is because companies such as Toshiba, NEC, Seiko Epson, IBM Japan, Fujitsu, and the AX Group (Japanese-language PC/AT-compatible PC makers) are all developing lap-top models.

AX's fiscal year 1988 results were disappointing. Despite membership of over ten companies, shipments for the Group as a whole were only on the order of 20,000, and were centered around Mitsubishi Electric. However, the picture could begin to change this year; Sony's announce-

TABLE 2. PC COLOR LCDs SHOWN AT THE TOKYO BUSINESS SHOW

PC Type	PC9801 & compatibles				AX			AT compatible	Fujitsu	Hitachi	
Manufacturer	NEC		Epson		Mitsubishi	Sharp	Oki	Toshiba	Fujitsu	Hitachi	Ricoh
Technology	TFT	2-layer STN	MIM	2-layer STN	TFT	2-layer STN	2-layer STN	2-layer STN	2-layer STN	2-layer STN	2-layer STN
Size	12"	12"	10"	10"	10"	14"	10"	11"	10"	10"	9"
Pixel	640x400	640x400	640x400	640x400	640x400	640x400	640x400	640x410	640x400	640x400	640x400
Colors	8	8	16	8	8	16	16	16	8	8	8

SOURCE: NRI BASED ON VARIOUS MATERIALS

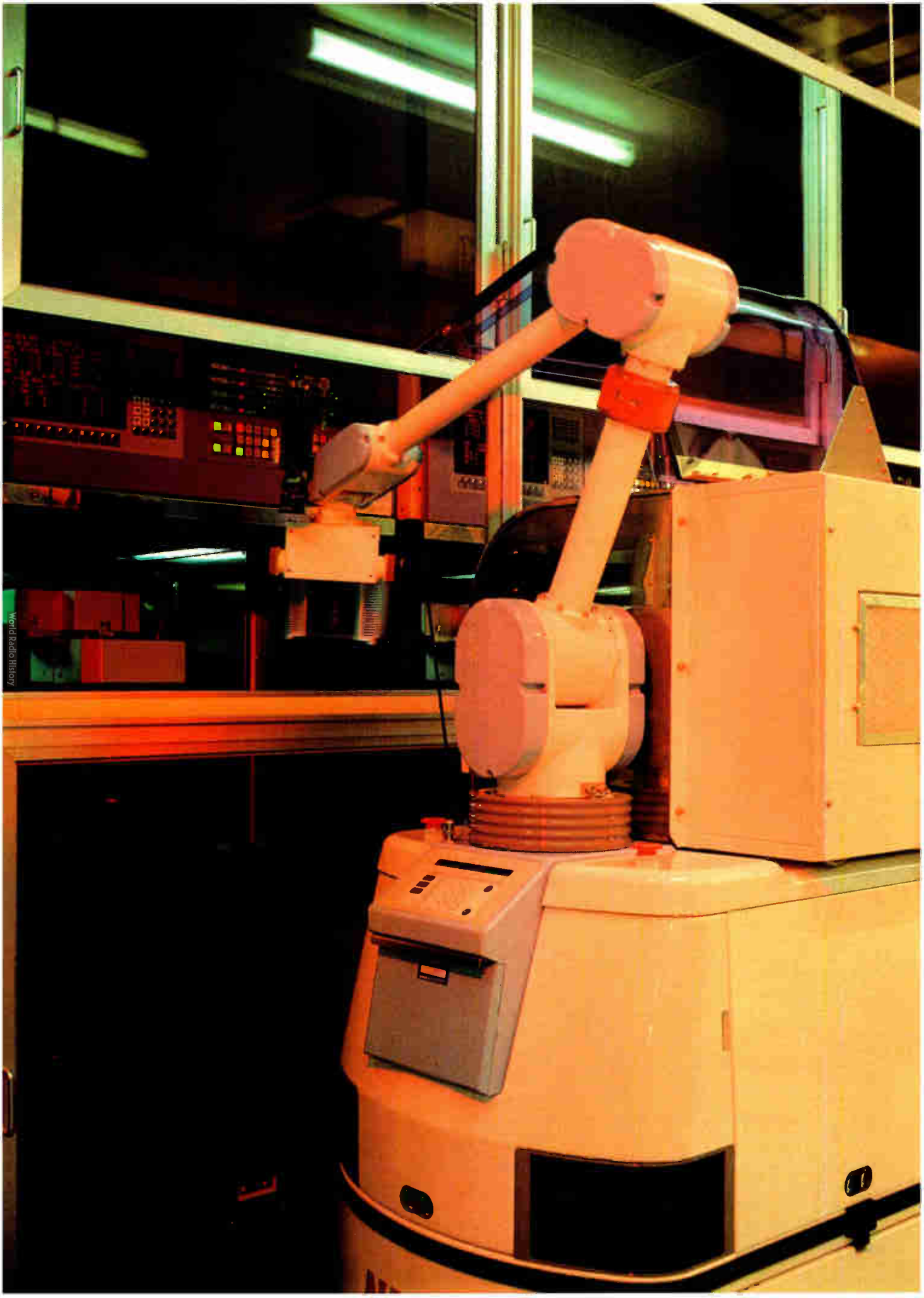
ment of a low-priced 32-bit PC model had stimulated expanded shipments by Oki, Canon, and other suppliers.

However, there was no major new activity surrounding TRON (Real-time On-line Nucleus) developments. In March, 1989, the Matsushita Group held a comprehensive exhibition of TRON technology, at which it unveiled multimedia-oriented applications that combined analog-digital images and PCM audio. Nevertheless, development of commercial TRON products is lagging.

A dedicated Japanese-language word processor with a TRON user interface is scheduled to be marketed toward the end of this year, but a date for the marketing of actual TRON machines has not yet been set. And in the United States, TRON has been placed on the list of possible subjects for the application of the "Super 301" Article of the Omnibus Trade Act. This has made uncertain adoption of BTRON (Business-TRON) as the standard classroom-use PCs in Japan.

One of the notable new-concept PCs is Fujitsu's FM TOWNS. The machine uses an 80386, original OS, and a CD-ROM drive. It is configured as a home-use PC with hypermedia orientation. Shipments were initially expected to center around use as a game machine, but FM TOWNS is equipped for a variety of applications and can run conventional MS-DOS software. Shipments have been brisk, and are projected to hit 100,000 for fiscal year 1989.

Hitachi has also brought out a new PC model, "PROSET," that combines an MS-DOS ma-



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The photo shows the fully automatic diffusion process by advanced vertical furnance.

NMB Semiconductor's Ultra-speed DRAM Series.

[RAS Access time 60ns~]

256K×1	: AAA 2800 Series
256K×4	: AAA 1M 304 Series
1M×1	: AAA 1M 200 Series
(1M×4	: AAA 4M 304 Series)*
(4M×1	: AAA 4M 100 Series)*

*Products in parenthesis are currently under development.

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Circle 87

chine with a telephone and printer. In addition, its standard software is "Ichitaro," the most popular Japanese-language word processor software, and "Hanako," the most popular design software (both products of Justsystem). The concept is basically the same as that of Canon's "NAVI," which first appeared on the market in 1987. Since numerous manufacturers have similar concepts, PROSET could even be viewed as indicative of the future direction of Japan's PC product development.

Development of portable computer models is making great strides. One case in point is "PC 286 Note Executive," a V30-based MS-DOS machine announced by Seiko Epson. It is mounted with an IC card instead of a floppy disk drive. Also notable is "DynaBook," an 80C86-based MS-DOS machine announced by Toshiba. The distinctive feature of this model is its 3.5-inch floppy disk drive (see Table 1).

The foundation for these portable PC models is a dedicated Japanese-language word processor (termed a "notebook word processor"). Advances in controller chips and batteries are anticipated to further reduce the size and boost the performance of these PCs.

Concepts behind PC advertising have changed along with the products. Having stressed the sophistication of performance and functions thus far, ads are now beginning to feature popular young female entertainers in a bid to capture the interest of more viewers. In other words, PCs are being advertised in the same way as electrical appliances and soft drinks, evidencing the extent of their utilization among the Japanese public.

Growing LAN Market

As compared with the United States, LANs have been very slow to spread in Japan, partly because major manufacturers of computers and communications equipment and the information industry have grown up without compatibility among their products.

However, LANs finally appear to have entered into full-fledged penetration. The share of PCs in operation with LAN links is now approaching the double-digit level. The main LAN type at present is Ethernet. LAN shipments of Ungermann-Bass and 3Com are rapidly picking up. The market for file servers is also expanding. Novell and 3Com are the leaders, but ASCII's PC-NFS is moving well. File servers are likely to make inroads into the market now occupied by "office computers," a category distinctive to Japan.

Peripheral Equipment: Disk Drives

A description of trends in optical disk drives can be found in another section; the comments here will be limited to the types built into systems.

Sony's EWS, "NEWS,"is coming to the fore as a system applying optical disk drives. Sony belongs to both the UII and OSF Unix standardization groups. NEWS' use of optical disks enables it to accommodate both of these OSs in a single system. The OS of the user's choice is recorded on the optical disk media, with the application software, and either OS can be booted up.

This would enable system development independent of an OS if application interfaces and device-level protocol for the various OSs are standardized in the future.

Certain PCs also house built-in CD-ROM drives. Examples are Fujitsu's FM TOWNS, noted above, and Sony's AX model "QuarterL." Shipments of the former during fiscal year 1989 are projected to hit the 100,000 mark, suggesting the arrival of the "hypermedia age" in Japan.

Displays

Improved performance of lap-top PCs is stimulating development of flat panel display (FPD) products. A major focus of such efforts is liquid crystal displays, which are the most promising as far as multicolor displays are concerned. Table 2 presents specifications of major PC liquid crystal displays exhibited by various manufacturers at an industry show held in May, 1989. This activity could lead to marketing a stream of portable computers with color liquid crystal displays in the early 1990s.

Printers

The spread of printers accommodating page description language (PDL; mainly Postscript) has been lagging in Japan for several reasons. Besides the lagging development of Japanese-language Postscript, the major ones are the vast memory space required to mount a Japanese-language outline font (which must contain several tens of thousands of words) and the great amount of time required for the creation of an outline font for the complicated system of Japanese ideographs. These and other factors have slowed development of practical printers at affordable prices.

Going for about $3,170, Japanese laser printers are hardly bargains compared to their U.S. counterparts, but are still experiencing rapid growth. In addition, sales of printers capable of handling PDL are expected to grow rapidly in 1990. This is because advances in semiconductor fabrication technology and design technology have resulted in a portable Japanese-language word processor mounted with an outline font in 1989.

The arrival of the optical disk age

Major problems of speed and compatibility among makers slow market acceptance

Writable optical disks were first commercialized in Japan in 1983. This initial commercialization took the form of write-once optical disk drives, incapable of erasing data once it had been written. They were designed as document file systems to replace microfilm. Hard disks were still high-priced at the time, and were only mounted in minicomputers or computers in the 100 MB class and below. Personal computers had just begun to find widespread use, and models containing hard disks were virtually non-existent. For this reason, optical disks were heralded as new technological "seeds" that could dramatically increase recording capacities. However, during 1988, some five years later, shipments of optical disk drives (excluding the read-only type) numbered less than 30,000, far below the corresponding figure of over 10 million for hard disk drives.

Use of optical disk drives as external storage devices for computers failed to meet anticipations. Presumably, this is because almost all optical disk drives shipped by manufacturers were of the write-once variety, which are incapable of rewriting. Many suppliers thought that, given the huge capacity of optical disks, non-erasability would not pose a serious barrier to penetration, and that the write-once type would have good prospects for computer use.

Nevertheless, wide acceptance of computer recording systems depends on an erasable medium. For this reason, use of a non-erasable medium would compel major system modifications. Numerous firms developed subsystems that bore a superficial resemblance to hard disks, but were much harder to use.

TABLE 1. SUPPLIER TRENDS RELATED TO REWRITABLE OPTICAL DISKS

Supplier	Size (mm)	Status
Sony	130	Sales launched 10/88
Sharp	130	New model announced 5/89
Canon	130	OEM shipments to NeXT
Nikon	300	Sample shipments
Olympus	130	OEM supply to Ricoh
Matsushita Comm	130	Sample shipments
Matsushita Elec	130	Announced prototype
	86	Announced prototype (phase change type)
Maxtor	130	Sample shipments
Verbatim	89	Under development
Ricoh	130	Sales launched 12/88
Pioneer	86	Under development
NEC	200	Commercialization as CM bank
	86	Under development
Fujitsu	130	Under development
	200	Development of solid-state drive
Hitachi	130	Sample shipments
Mitsubishi Elec	130	Announced product 5/88
Toshiba		Under development
IBM		Under development

SOURCE: NRI

OPTICAL DISKS

Erasable optical disks became commercially available in 1988. The first supplier to offer a commercial version of a small diameter disk capable of use with computers was Sharp. Sharp was soon followed by Matsushita Communication Industrial, Maxtor, Sony, Canon, Ricoh, and others. By the end of 1988, shipments of rewritable optical disks totaled about 5,000. Sony and Canon accounted for the overwhelming bulk of this total. Production continued to expand in 1989, leading to projections that shipments for the year would reach about 50,000. This is substantially greater than that for 1988 shipments of 5.25-inch hard disks in the 760 MB class. It is estimated that rewritable disks will account for more than half of the total number of optical disks shipped during 1989. Table 1 presents the status of business related to optical disks among major suppliers.

Rewritable optical disk

TABLE 2. PRICES OF NEWS AND NeXT RECORDING EQUIPMENT

	NEWS	NeXT
MT	$ 5,300 (60MB)	
HDD	$ 8,800 (156MB)	$2,000 (330MB)
	$10,900 (286MB)	$4,000 (660MB)
MO	$ 3,200	$1,500 (approx)

Note: NeXT prices indicate discount prices to universities.
NeXT MO price indicates price for system enlargement (building in) and is an estimate.

SOURCE: NEWS: Sony catalogue NeXT: CSN

drives are used for minicomputers, work stations, and file servers. Production has been unable to keep up with demand in 1989, spawning an enormous backlog. A particularly urgent priority is to increase production of media.

While they have gotten off to a good start, rewritable optical disk drives harbor several problems which remain to be solved. The major ones are an inability for direct overwrite, which results in a write speed that is slower than that of hard disks, and a lack of data compatibility between models from different suppliers. In addition, there are some new technologies that could undermine attempts to solidify their position in the market. A hard disk with a glass substrate, for example, is now under development, and could offer a capacity per side comparable to that of magneto-optical disks. Removable hard disks and large-capacity floppy disks (with capacities on the order of 50 MB) have already been developed in preparation for competition with optical disks. In short, optical disks must be equipped with a value sufficient to meet the challenge posed by these competitors.

One of the major applications envisioned for optical disks is use as a backup for hard disks. Thus far, magnetic tape has been used for this purpose, but does not permit free data access. By contrast, optical disks are still not fully equipped to function as a backup medium; their on-line capacity (recording capacity accessible without changing disks) is only about 320 MB, as compared to over 1 GB for a maximum capacity of 5.25-inch hard disks. For 3.5-inch hard drives, hard disks with a capacity in excess of 200 MB are already available, but the ceiling for optical disks is likely to be around 120 MB. The view of optical disks as offering a virtually boundless capacity is now outdated; optical disk suppliers are pinning their hopes on second generation, large-capacity models.

Optical disks are a removable medium that, in principle, enable management of unlimited recording capacity. These properties stimulated expectations that optical disks would be priced somewhat higher than hard disks of equivalent

capacity. However, these expectations proved to be wide of the mark. Rewritable optical disks now commercially offered carry prices that are fully competitive with those of hard disks, at least in terms of the market price. Table 2 presents list prices for peripheral equipment for Sony's engineering work station ("NEWS") and for NeXT's computer ("NeXT"). It can be seen that optical disks are even cheaper than hard disks, and much cheaper than magnetic tape. If this pattern of pricing takes root, there is a strong possibility that users able to sacrifice a degree of access speed will prefer optical over hard disks.

Since they started out with a price per unit of on-line capacity that was equivalent or inferior to that of hard disks, it might be said that optical disks are compelled to undergo as sharp a price reduction as hard disks have undergone. At any rate, competition among optical disk manufacturers is certain to intensify.

In application, optical disks are anticipated to occupy a position intermediate to magnetic tape and hard disks. Optical disks enable information backup as is, without restoring on hard disks as is necessary for magnetic tape. This could constitute a significant advantage. However, full-fledged replacement of hard disks will take considerable time.

The biggest influences on tomorrow's storage devices are expected to be increased semiconductor integration and the spread of networking. A further rise in the scale of integration exhibited by semiconductors would erode the position of hard disks as storage devices able to keep pace with semiconductors, and create a need for larger on-line capacities. The spread of networking would probably add impetus to this trend. It is estimated that the current gap between optical disks and hard disks in recording speed will gradually be closed through the increased use of semiconductor caches. If the environment of recording equipment begins to change in this fashion, it is conceivable that optical disks would replace hard disks as the main storage device for personal systems.

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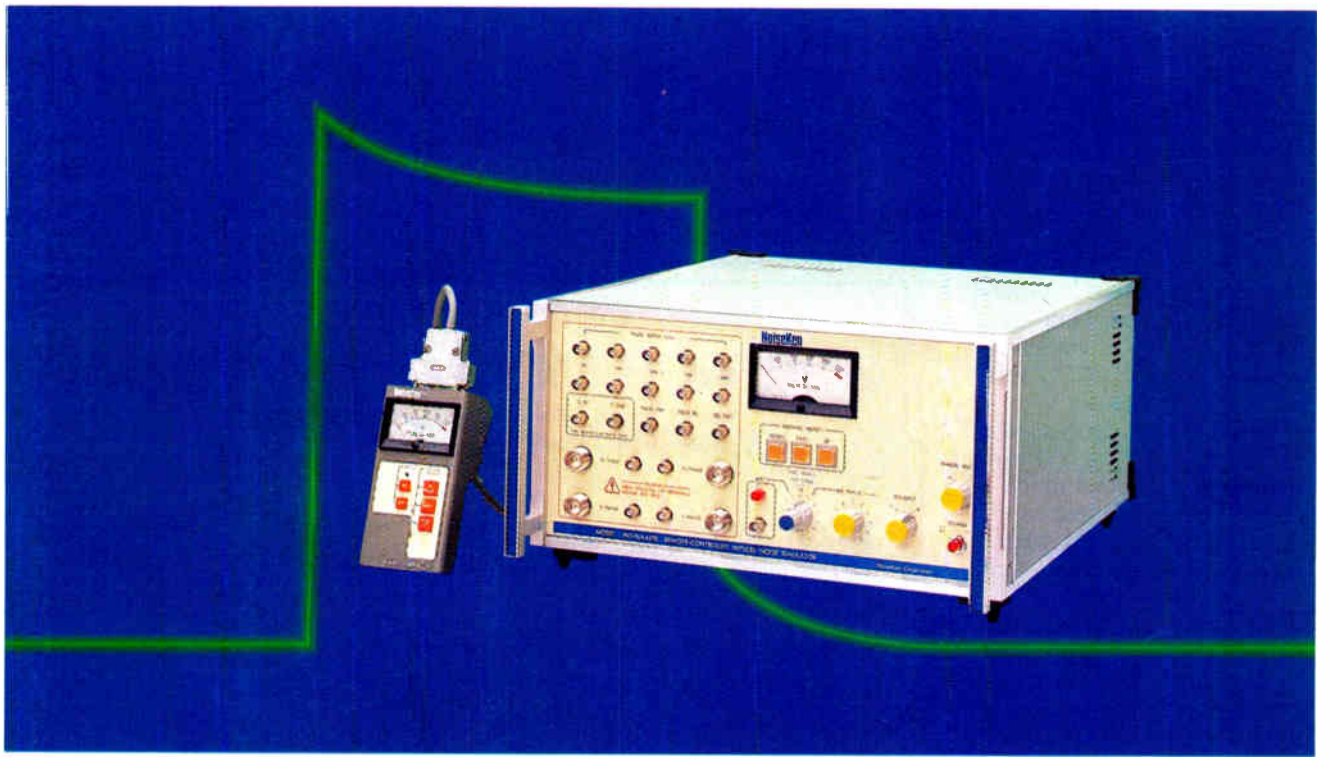

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Circle 22

Fujitsu goes to FM TOWNS

Fujitsu's computer business began with the first Japanese commercial computer in 1951. Since then we have strengthened our product lines, and now lead the market. As a manufacturer of computers, we offer a wide range of products, such as super computers, mainframes, office processors, workstations and personal computers.

Today's computer market is influenced by a highly competitive economic environment in which companies regard efficient use of information as a "fourth management resource." At the forefront of this trend is the everwidening use of personal computers within corporations.

In order to respond to the increasing demands of PC users we developed the "FMR series" general purpose personal computers. Based on an open architecture, the FMR Series of personal computers interface with a host computer and have a wide range of software. In addition, they have word processors for the Japanese language.

Customers want a home PC that can handle new educational and entertainment applications as well as personal business. We believe that the number of users will grow with the expansion of ISDN and computer education in schools. Ultimately, the worlds of sound and color that characterize personal computers and business processing will become integrated on a higher level.

Such a new generation of personal computer is Fujitsu's FM TOWNS, a hypermedia PC offering an unprecedented range of features for both pleasure and business. FM TOWNS, marketed since February, meets the new computing needs of hobby and business users. Advanced features include a 540MB CD drive that combines sound and images. To achieve a rich sensory appeal, FM TOWNS supports high quality sound and video, such as simultaneous display of 32,000 colors and audio from 14 sources. The CPU uses an Intel 80386 chip.

FM TOWNS opens a totally new world of personal computing that has not been possible. For example, it can be used for games with impressive stereo sound background effects, electronic picture albums of near-photograph quality, and new language learning tools utilizing voice and picture.

Many business uses of FM TOWNS include computerized information retrieval systems with hugh databases such as automobile parts, inventory, various types of design consultation service systems (such as hair styling and house designs) and monitoring systems (Viking Surveillance System). Moreover, FMR Series business software, such as "Lotus 1-2-3" or "Multiplan," can be run with MS-DOS V.3. FM TOWNS users enter the new computing world opened up by CD-ROM in addition to retaining familiar MS-DOS applications—all in one machine!

To provide our customers with first-hand experience, Fujitsu held an FM TOWNS exhibition in March of this year at the Tokyo Dome baseball stadium. The 3-day exhibition attracted 180,000 people, a record-setting crowd for the Tokyo Dome.

FM TOWNS was also exhibited (in March) at the CD-ROM Conference held in Anaheim, California. American software companies, which are noted for their high-tech capabilities, gave rave reviews to FM TOWNS and the outstanding quality of CD-ROM software. For example, Ms. Laura Buddine, president of Tiger Media and an authority on CDI, said: FM TOWNS combines the New Media system of tomorrow with the state of the art in both productivity and entertainment computers, and delivers it all without sacrificing performance or compatibility." Mr. Brad Fregger, president of Byte Size Note, praised the FM TOWNS's comfortable interface, which he said "provides ease of use that is reminiscent of the Macintosh (potentially even more friendly) while providing all the power and flexibility of MD-DOS." And Mr. Thomas M. Lopez, who is chairman of Mamnmoth MicroProductions and regarded as the father of CD-ROM, called FM TOWNS a truly revolutionary personal computer that will "delight children and adults in learning, at play, and at work." Moreover, Mr. Lopez said that "the implications for a machine of this type in the U.S. market are staggering."

In order to expand the world of FM TOWNS still further, we plan to expand both the product line and distributed software. It is our goal to promote the availability of 100 CD-ROM software products exclusively for FM TOWNS as well as 500 MS-DOS distributed software products by the end of this year. And we have been receiving excellent responses from software makers. In order to give full cooperation to American software companies to develop FM TOWNS products, we have established a support base in San Francisco.

We believe that FM TOWNS will not only pioneer a new generation of products, but will also be a strong commercial success, thanks to the enthusiasm of our customers and the support of software makers. FM TOWNS exemplifies Fujitsu's commitment to develop products that contribute to the creation of a new computer culture and improve service and customer satisfaction.

Fujitsu declares, "THE WORLD IS FLAT!"

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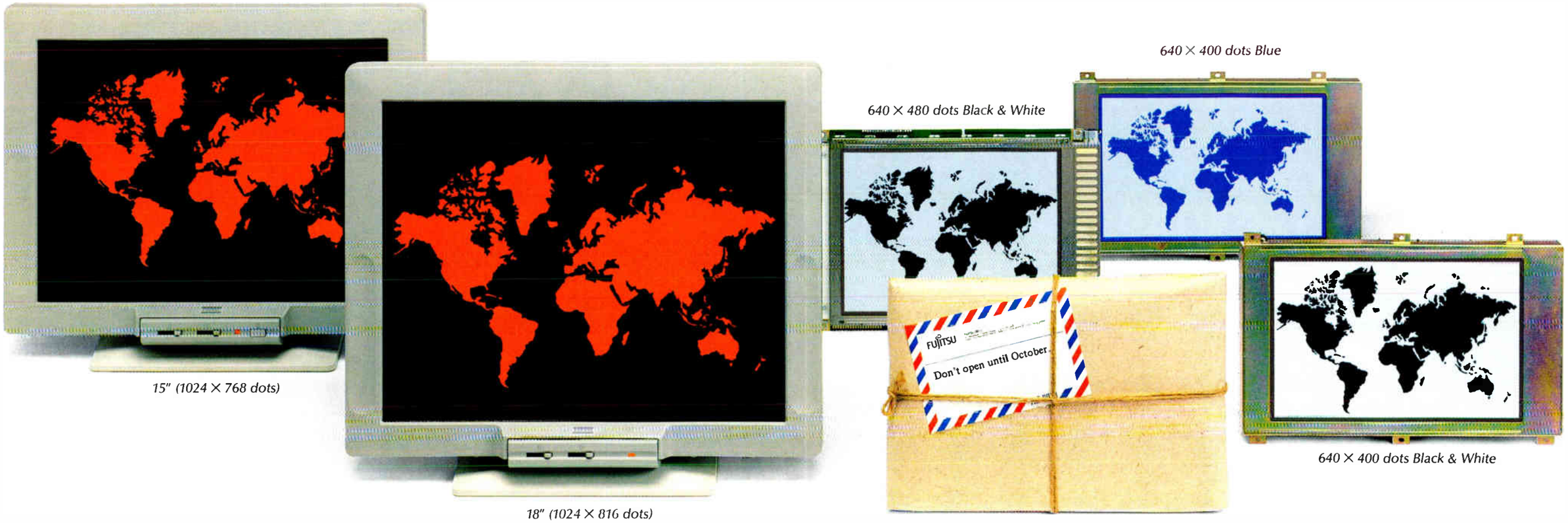

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We even have some flat-panel displays we'd like to show you, but we can't. Not yet. But we will very soon.

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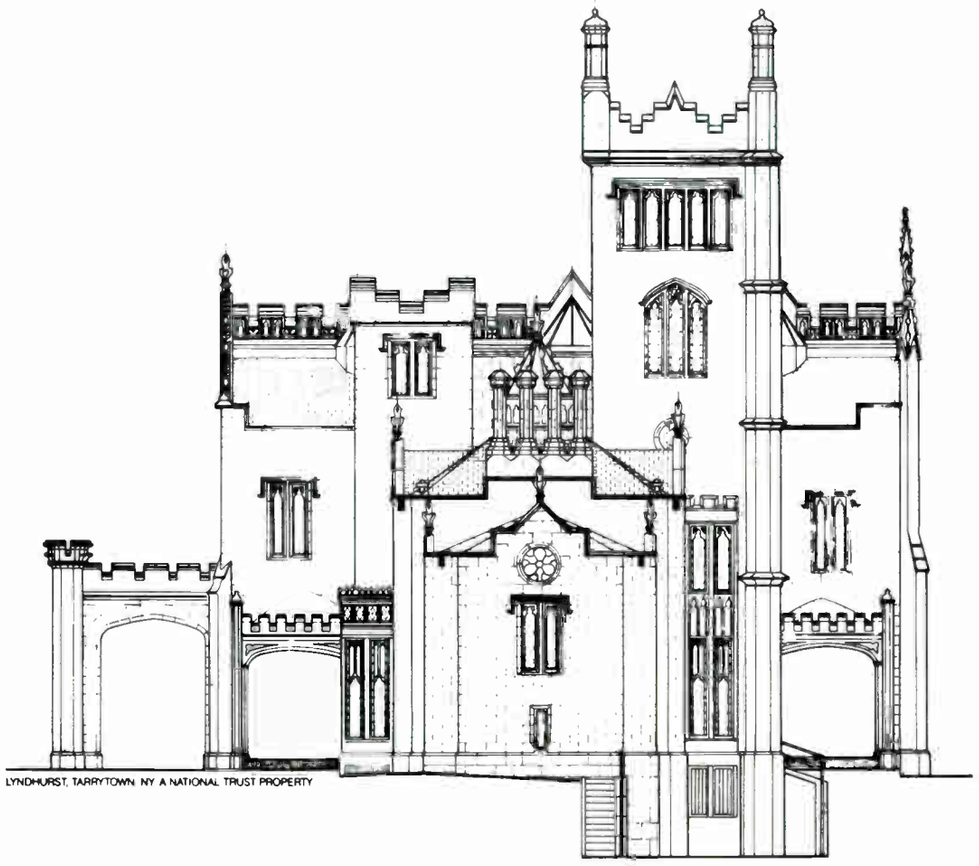

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Circle 89

Trends in Japan's chip industry

DSPs, 32-bit MPUs, RISC processors, and image processors follow DRAM demands

SEMICONDUCTORS

It was estimated that the demand for semiconductors would expand during the end of 1988, and level off at the beginning of 1989. But the demand for DRAM and MPU/MCU chips is still on the rise. It was influenced by expanding domestic demands and the growing market of computers and office equipment inside and outside Japan. It was also driven by a shift toward higher functional equipment. At the present rate, 1989 chip production will equal or exceed 1988 output.

However, production expansion in general-purpose 1-Mbit DRAMs, a principal product for larger chip makers, is now being reconsidered. Toshiba, one of the largest makers, will maintain a production level of roughly 10 million units a month, and NEC intends to produce 6 million until the end of the year. Also, other leaders, such as Hitachi, Mitsubishi, and Fujitsu, set up a production ceiling of 5 to 6 million units monthly.

Such production adjustments focus on full-scale production of 4-Mbit DRAM chips. To meet expected demands for the product next year, leading makers have shifted capital investment from vigorous expansion of mass production lines for 1-Mbit DRAMs to beefing up submicron lines, including 4-Mbit DRAMs. Another noteworthy trend in 1-Mbit DRAM production is its diversification. Toshiba is focusing on its application products, including video RAM. NEC intends to increase monthly production of high-speed 1-Mbit DRAMs to nearly 2 million.

The technological shift toward general-purpose products can be attributed to the idea that "systems on a chip" have been widely accepted by the industry. It is also because development of precise processing technology has made possible new chips that meet more stringent requirements for electronics equipment. Because of such environmental changes, chip suppliers will have to depend on "design-in"

Kodenshi eyes U. S. market

Kodenshi Corp. is one of the largest photoelectronic semiconductor specialists in Japan. With over $7 million invested in capital equipment and space, the 17-year-old company has recorded sales in excess of $48 million for the fiscal year ended March 31, 1989.

Kodenshi's presence is still largely based in Asia and the Pacific Rim, but now the company is looking to North America for optical sensor and other unique manufacturing markets.

Kodenshi boasts that its production facilities in Kyoto, Japan, are so versatile it can respond to orders as small as a single custom unit or as large as a full-scale production run. Kodenshi employs 2,000 workers in Kyoto and various subsidiaries. Quality is emphasized at every stage, from wafer production to final shipping. "Flexible manufacturing is our forte," says Hirokazu Nakajima, Kodenshi's president. "We are able to supply products in many different forms." Package variety is especially important for photodiodes, phototransistors, and LEDs. Kodenshi supplies these as discrete components and as preassembled functional blocks.

HIROKAZU NAKAJIMA
President

"We have made remarkable advances in products for TV and VCRs," Nakajima says, "in particular, light transmitter/detector units for infrared remote controllers." These contain light transmission and detection elements, plus ancillary components, in a single package. Kodenshi also makes tape

TABLE 1. PRODUCTION BY SEMICONDUCTOR MANUFACTURERS

(unit: billions of dollars)

Manufacturer	'87	'88	'89 (Planned)	CGR % '87 – '88	CGR % '88 – '89
NEC	3.6	4.4	4.8	23.5	9.5
Toshiba	3.3	4.2	4.7	27.7	11.7
Hitachi	2.9	3.4	3.8	17.6	12.0
Mitsubishi	1.5	2.3	2.6	50.0	10.6
Fujitsu	1.7	2.2	2.5	25.5	12.9
Matsushita	1.5	1.7	2.0	11.6	16.7

TABLE 2. CAPITAL INVESTMENT BY SEMICONDUCTOR MANUFACTURERS

(unit: billions of dollars)

Manufacturer	'87	'88	'89 (Planned)	CGR % '87 – '88	CGR % '88 – '89
NEC	282	493	563	75.0	14.3
Toshiba	493	634	634	28.6	0.0
Hitachi	282	493	598	75.0	21.4
Mitsubishi	113	317	331	181.3	4.4
Fujitsu	282	458	613	63.7	33.8
Matsushita	155	366	528	135.4	46.2

from the initial stages of design to finished electronics equipment.

For Design-In

Design-in appeals to chip makers in the sense that they can achieve "pioneer gains" in the future. But this must be done carefully. If a maker enters into an existing chip market, where product development has already been terminated, it can merely find a limited niche as a second or third supplier and enjoy little gain.

Moreover, in the Japanese market, where present demands are focusing more on memory chips and consumer custom-made products, foreign makers should not go with design-in hastily. Within the next five years, however, there will be many areas they can design-in with technological advantages.

In any case, chip makers need to develop new markets to inspire chip demand.

Market Evaluation

An overall understanding of the electronics industry is indispensable to evaluate potential markets for design-in. Two important factors that bring about new opportunites for business expansion in the electronics equipment industry are technological innovation and social change.

Technological innovation is promoted mainly by software and man-machine interface technologies. Artificial-intelligence devices, pattern recognition equipment, and display devices apply this technology and can expect further business expansion.

Meanwhile, social change will advance in accordance with communications and new media. Demand for information communication equipment will bring a need for new services.

We can illustrate four directions for the development of new electronics equipment that will stimulate chip demands: improvements in man-machine interfaces, response to network systems, orientation toward knowledge processing, and development of complex digital equipment.

First, new electronic equipment focusing on improving man-machine interfaces includes pattern recognition, image and speech processing, and display technologies. Recently, these core technologies have reached an unprecedented level of development owing primarily to advances in support chips and software technology.

New equipment includes high-definition TV and OCR, OLCR for office automation, and robot vision in factory automation. Moreover, they will help formulate future product concepts based on today's PCs and workstations, facsimiles, copiers, and automotive electronics.

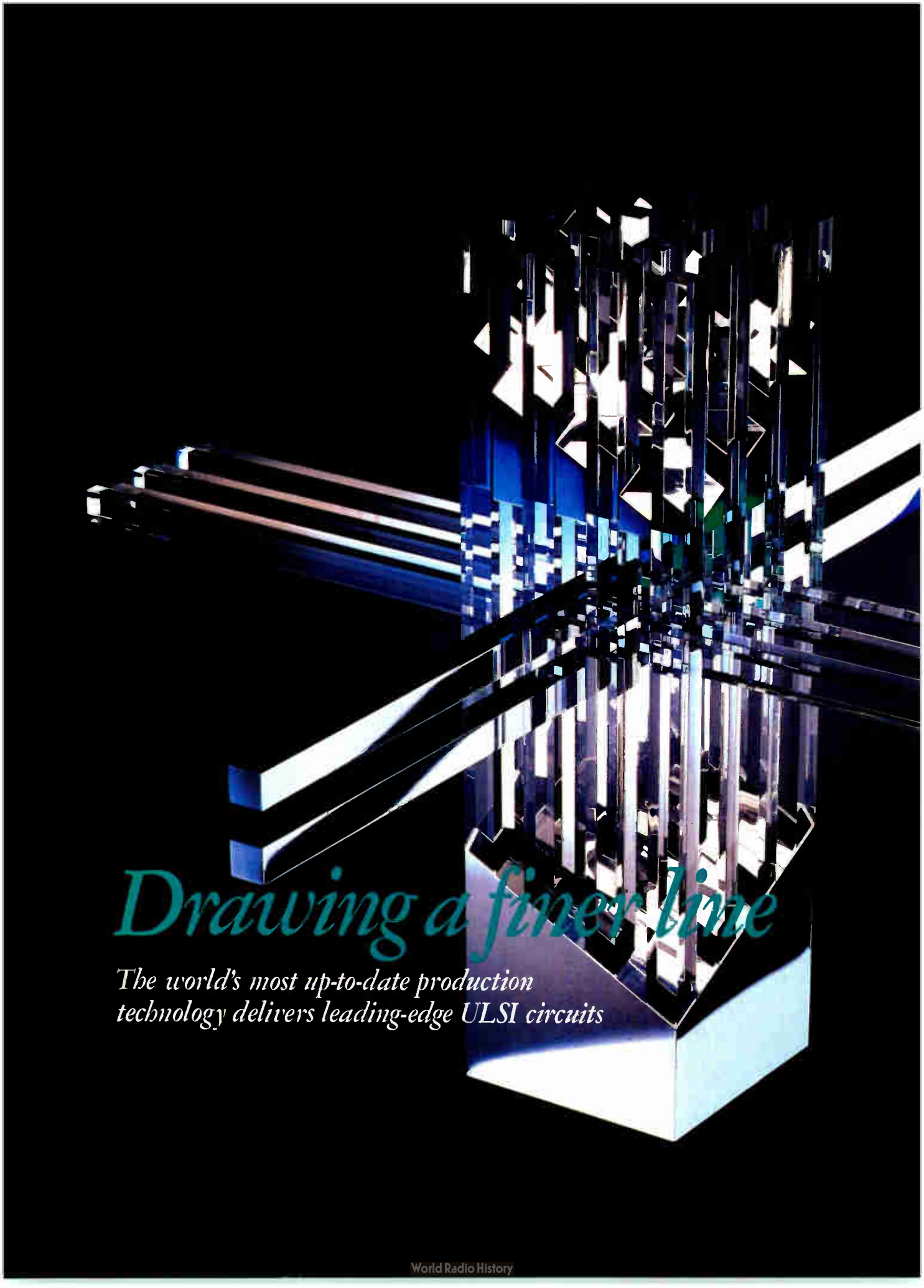
Secondly, expansion of new electronics equipment for networks is very promising in new industrial environments.

end sensors and laser detectors for compact and laser disks.

In office automation, Kodenshi provides index detectors and rotary encoders for disk drives for personal computers. In factory automation, it offers high-precision photointerrupters, photo reflective devices, and photocouplers.

Kodenshi is also active in optical communications, supplying highly efficient light transmission/reception elements to communications equipment.

Kodenshi is looking to the future with advanced integrated photosensors, subminiature photonic switches, and other technologies. Heading into the 1990s, Kodenshi will use its strong research prowess to stay on the cutting edge.



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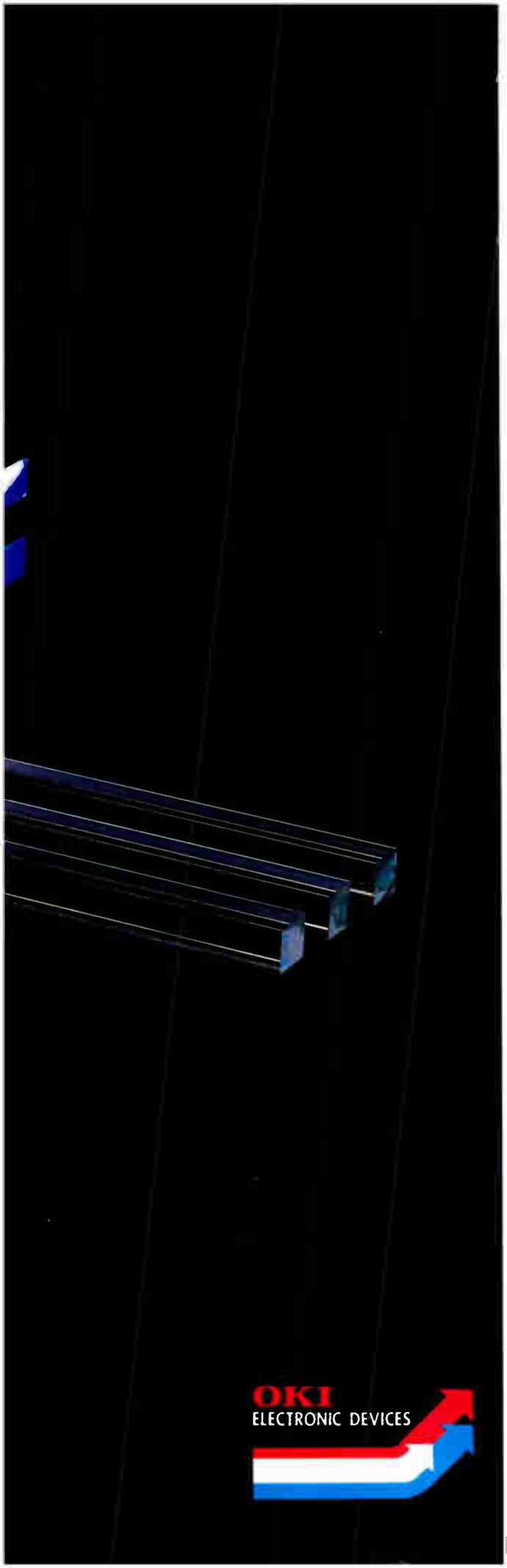

OKI SYSTEM TECHNOLOGIES.

Sub-micron production in full swing, bringing the new age of 4M DRAMs

Oki's Miyagi Plant, benefitting from the latest advances in the company's system technology, has already reached mass production and shipment of 1M-bit memories and has recently begun quantity production of 4M DRAMs. At the Miyagi Plant, broad utilization of ultra-fine process technology and state-of-the-art automation combine to assure the high quality of these products. Oki is already well underway with technological innovation enabling production of 16M-bit memories.

High-level automation with ultra-fine process production

Oki's 0.8μ process technology used in its second-generation 1M-and 4M-bit memories has been integrated into one of the world's most advanced production lines for reliable mass production of over 20,000 6-inch wafers per month.

In 1988 Oki led the world with the first facility dedicated for production of sub-micron devices. Today that lead is being extended with the latest advances in automated manufacturing, such as sophisticated wafer tracking systems for improved quality and production control monitoring.

From the transportation system, driven by linear motors, to individual production equipment in each process machine group, all are computer controlled. To assure products of extremely stable quality, automation and every detail of the production environment are maintained at the world's highest levels.

High performance and packaging flexibility support customers in a wide range of applications

Oki's Advanced System Technologies are dedicated to total customer satisfaction. A comprehensive service system provides flexibility, quality, cost savings and quick turn-around times.

Oki's Miyagi Plant, featuring world-standard process technology and automation.

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OKI

Oki Electric Industry Co., Ltd.
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Circle 88

Common use of databases resulted from development of digital information memory, a shift from integrated information processing to dispersed information processing, an improvement in digital communication technology, and standardization of communication protocol.

New communication functions will be used in various OA equipment including workstations, NC machines, MAP interface systems for CIM, industrial robots, and programmable controllers.

In the public environment, electronics equipment for large capacity communication systems is being installed. Optical communication technology, mobile communications, and ISDN will play a major role in this area.

Thirdly, as we have already witnessed, application of knowledge processing technology based on artificial intelligence and post-binary elec-

At Oki, the customer is the key to success

What makes a company a leader in its markets today? What makes the difference between success and failure? Is it an extra nanosecond, gate, pin, package or product? I do not think so. Those things are important, of course, but I believe the most significant differentiator an organization can have is the attitude its employees have toward the customers they serve. If you wish to distance yourself from a competitor you simply satisfy your customer.

It is therefore part of the strategic direction of Oki to constantly renew and strengthen our commitment to the customer.

Let me illustrate how we have taken this abstract concept of customer satisfaction and woven it into the fabric of Oki's plan. It simply starts with strategic planning. Strategic customers and their resultant alliances are elements of our plan. Our aim is to provide customer satisfaction through the delivery of superior products and services in a way that the customer has not likely experienced before.

The success of strategic alliances is based on total customer satisfaction, so in essence, Oki's success is tied to that. I would have it no other way. If you neglect the needs of the customer I doubt that your stay in the market will last long. So, the success of the business plan is based on strategic customer alliances, that success is based on customer service and that success, in turn, is based on creating a culture in the company.

You see it is a far greater issue than the term "customer service" might limit it to. In the cultural sense we strive to carry the importance of the customer to every level in the organization. If you do not serve the customer directly then you serve someone who is. When the commitment to the concept of customer satisfaction exists at all levels of Oki then it touches at all levels of the customer's site.

It was only last month that I was in the United States at a press conference announcing our latest manufacturing plant in Portland, Oregon. My comments included, "the new facility and its output is a vital link in the overall Oki strategy. The ability to provide a local source of semiconductors to meet the needs of Oki's U.S. customers and increase our service to those customers is key to our company's business plan. Our decision to be here is critical to the needs of our customers and represents our commitment to superior customer service and is, by necessity, critical to the needs of Oki overall. We are committed to this direction."

MASAO NOGAMI
Senior Managing Director

Certainly your product and its performance is important but your performance in the process of delivery is the test of staying power. As another example, our wide range of capabilities, and ASICs through advanced board level products provide customers with one-stop shopping. While these capabilities are formidable indeed, they become the ingredients of market leadership when mixed with a concern for improving the customer's product.

So, in conclusion, in today's business environment it is not enough to have the best technology, manufacturing automation and robotics, or excellent quality. These are givens for companies who simply stay in business. To expand beyond mediocrity, the delivery of all these ingredients to the customer's total satisfaction is the key to success.

tronics (such as fuzzy and neural technologies) has reached the stage of initial commericialization.

in the meantime, expert systems now are fully introduced into various products, and speech recognition devices, which apply fuzzy technology, have been commercialized.

R&D of neural technology is vigorously conducted in the U.S. Also in Japan, this technology, though at a trial stage, is being applied to letter recognition devices and its availability is acknowledged. Like pattern recognition technology, knowledge processing technology will significantly change electronics equipment in the future.

Finally, the issue of developing complex digital products is more current than the other three points illustrated above. Development of the system-on-a-chip concept in tandem with improving chip device technology has contributed to creating favorable conditions for product technology, such as facsimiles, TVs, and VCRs.

Consumer Sales

In the consumer area, sales of new digital audio-video (AV) equipment, including enhanced definition TV (EDTV) and digital audio tape (DAT), plus microcomputer processing devices used for the white goods industry are expected to increase.

In other product areas featuring new chips, image processing devices, 32-bit MPUs, RISC processors, DSPs, high speed ADCs/DACs, and 4-Mbit DRAMs also show promising growth. Similarly, demand is being driven by the automotive industry for a variety of new semiconductor devices such as high speed MPUs, EPROMs, and CMOS gate arrays.

Next generation DRAMs drive T&M sales

LSI testers, oscilloscopes, and spectrum analyers account for market growth

Market growth of test and measurement equipment for the whole semiconductor area tends to lag half a year behind silicon cycles. For instance, deflated demands in the 1985 chip market caused a negative growth of test and measurement equipment from 1985 to 1986. A growth rate of 20% in 1988 for chip manufacturing equipment is expected to cause the test and measurement equipment market to grow by 20% for 1989. Total sales could be as much as 110 billion yen.

Owing to capital investment in setting up new production lines for 4-Mbit DRAMs, the test and measurement equipment market will continue to be favorable until the second half of this year when facility investment reaches its peak.

In the chip area, markets for optical linewidth measurement, SEM linewidth measurement, and wafer particle detection equipment are continuing to grow both in scale and rate. This growth is due to strong demands for equipment in the wafer treatment process. Non-contact and highly precise measurement is realized by using lasers.

Markets for image processing and testing devices to measure two and three dimensional information, including vision inspection testers, image testers, and location sensors, topped 20 billion yen in 1988. These devices have registered a growth rate of 30 to 40% in these few years. Demands for image processing for automated and electronics assembly and processing lines will expand further.

The market size of three-dimensional measuring devices, including contact measurements, reached roughly 20 billion yen in 1988. This favorable growth is still going on at an annual growth rate of roughly 20 to 30%. Optical devices are emerging and are considered to be in the mainstream of this area.

TEST & MEASUREMENT

Electric Measurement Equipment

The 1988 market of electronic measurement equipment is estimated at 300 billion yen (14.8% growth). In particular, LSI testers, which are installed as electronic tubes, ICs, and LSI analyzers, have recorded a sizable 50% growth. Other major equipment, such as oscilloscopes and spectrum analyzers, have grown more than 10%.

Increased production of ICs has contributed to the sharp

growth of LSI testers. The demand for oscilloscopes originates in expanded applications of digital equipment. Spectrum analyzers are used increasingly for satellite broadcasting, satellite communications, and measurement of electromagnetic wave noise.

Semiconductor Fabrication

Major applications for size measurement devices are in line width measurement and lithography pattern matching measurement. Devices for optical linewidth measurement and SEM linewidth measurement are considered indispensable for further development of precise semiconductor processing.

More than ten major suppliers of optical linewidth measurement devices, such as Nikon, Hitachi Electronics Engineering, Ryokosha, Toho Electronic Indistry, Nanometrics Japan, OSI, and ITP, have entered into sharp competition for market share. Low price competition together with product specialization by function is adding fuel to the fire.

SEM linewidth measurement devices are designed to precisely measure linewidth of wafer patterns that are unmeasurable by optical methods. Leading equipment suppliers, such as Akashi Beam Technology, JEDL, and Hitachi dominate nearly 90% of the market. While these big three have formulated a monopolistic situation in the SEM market, Akashi Beam Technology is conducting joint development of new products with Toshiba.

Wafer particle detectors are designed to detect dust, scratches, and other foreign substances on wafer surfaces. Hopes are that such detectors will help eliminate production line stagnation. Market participants include Hitachi Electronics Engineering, Tokyo Optical Co. and Tencor Instruments.

PRODUCTION OF TEST & MEASUREMENT EQUIPMENT

(unit: in millions $)

	1986	1987	1988
Semiconductor fabrication			
Optical linewidth measurement	1.4	1.8	3
SEM linewidth measurement	2.7	3.4	3.8
Thickness measurement	1.1	1.3	2.2
Wafer particle detection	2.2	3	5.6
Wafer pattern defect detection	4.9	0.6	1.4
Mask/reticle defect detection	3.2	2.6	5.2
Flatness measurement	1.6	1.8	1.9
Assembly and manufacturing			
Vision inspection testers	N/A	14.1	18.5
Location sensors	N/A	0.8	1.1
Image testers	N/A	1	1.2
Printed character readers	N/A	1	2.4
Three dimensional	N/A	N/A	2
Electrical testing			
Digital multimeters	7.6	8.4	8.5
Oscilloscopes	18.8	17.1	19.5
Spectrum analyzers	8.4	8.2	9.1
Distortion testers	4.5	6.5	6.2
Logic analyzers	4	2.5	3
MPU development support system	9.4	8.2	8.7
Measuring system for audio-visual equipment etc.	10.5	12	13.4
IC/LSI testers etc.	48.5	58.9	80

SOURCE: NRI/ITG FROM VARIOUS STATISTICS

However, this segment is characterized as monopolistic by Hitachi E.E. that has 60% of the market share.

Image processing devices are increasingly being accepted by vision inspectors. Over 100 manufacturers have joined the market. But no one is dominating the market. Omrom Tateishi Electronics, Fuji Electric Co., Hitachi, Nippon Avionics Co., and Toshiba are running ahead with market shares by 5% or more.

Mitautoyo and Tokyo Seimitsu are enjoying a 70 to 80% share in all segments of the three-dimensional measuring device market. Since around 1986, Hitachi and Nikon have been supplying products for non-contact three-dimensional measurement. Many manufacturers consider this segment as a promising future market and are targeting market entrees. But no winning product has been introduced.

Electric Measurement

Iwasaki Electric Co., Sony/Tektronix, and Hitachi E.E. are the major suppliers of oscilloscopes. The industry is expecting oscilloscopes to improve functionality by adding MPUs, memory storage for measured data, color display, and portability, as well as 1 GHZ digital sampling.

Spectrum analyzers are mainly supplied by Advantest Corp., Anritsu Corp., Sony/Tektronix, YHP, and Ando Electric Co. With outstandingly high performance, spectrum analyzers can respond to needs for measurement in satellite communications. High frequency measurement of up to 20 GHZ has been achieved with internal mixers. External mixers have made available products up to 325 GHZ. Also, in order to respond to weak signals, a high performance spectrum analyzer guarantees a dynamic range of 110 dB.

Image processing moves into third generation

Banks use character recognition to process remote transactions

Presently, many applications for neural network technology in pattern recognition are being actively pursued. Today, neural network technology is being actively applied in pattern recognition. In Japan, basic research in neural networks has been conducted since the 1960s. Amari's neural network analysis, Nakano's Associatron, and Fukushima's Cognitron represent major achievements in this field. The study of neural network technology has progressed even after Minsky-Papert's demonstration of the limit in Perceptron.

Recent research and development activities in the application of neural networks for pattern recognition are shown in Table 1.

Optical character recognition (OCR) is one of the most widely used techniques for pattern recognition technology today. Recent OCR applications are found in financial sectors such as banks, insurance companies, and credit card companies. And these businesses are presently involved in the development of third generation online systems.

TABLE 1. THE APPLICATION OF NEURAL NETWORKS FOR PATTERN RECOGNITION

Company	Research Theme
NEC	• Character recognition of printer fonts • Character recognition of handwritten numbers • Voice recognition of words of unspecified speakers by use of dynamic programming neural network models and neural prediction models
Hitachi	• Voice recognition by combining neural networks and fuzzy technologies
Toshiba	• Character recognition of handwritten numbers by combining neural networks and statistical character recognition technologies
Matsushita	• Character recognition of handwritten alphabet and numbers • Voice recognition
Canon	• Visual image recognition
NHK,ATR	• Character recognition of numbers by use of Neo Cognitron
NTT	• Voice recognition by collective implementation of existing knowledge in neural networks to achieve high speed learning
Sokisul Chemical, NTT Technology Transfer	• Speaker matching by use of 3-layer neural networks

OCR Applications

Input of data in vouchers for transfer payments, public utility charges , payment of various tax payments, and domestic exchange are major applications of OCRs in banks. Both life insurance and nonlife insurance companies as well as credit card companies are also introducing OCRs for data input.

The characteristics of new OCRs used in financial sectors are as follows:

- Small desktop type OCRs priced under $70,000
- Distributed processing with OCRs introduced in branch offices instead of central locations
- Introduction of OCRs in bulk (several hundred units per company) to be located in branch offices nationwide
- Optical function to recognize hand-written Kanji characters.

The vendors in this field are Toshiba, Hitachi, Fujitsu, NEC, Mitsubishi, Oki and NTT.

Another development in OCR technology is the introduction of a low-end peripher-

TABLE 2. DEVELOPMENTS IN VOICE RECOGNITION TECHNOLOGY

Company	Products/applications
NEC, Sharp	• Japanese language word processors with voice recognition interface for input
Toshiba	• Telephone equipment with voice recognition interface for dialing • Elevators with voice recognition interface for specifying destination floor (Prototype)
Matsushita	• Machine translation system (Japanese to English) with voice recognition interface for input (Prototype)
Kinki Nippon Railway	• Train ticket vending machines with voice recognition interface for specifying destination station (Pilot test)

al unit to personal computers. The products in this field use OCR software based on PC scanners to read printed characters. The vendors are software houses such as BIRDS and System Quality. BIRDS's recent products accommodate printed Kanji characters.

Human machine interfaces are becoming increasing becoming important in the design of various electronics products.

Voice recognition technology is utilized to provide user-friendly human machine interfaces. Recent developments are shown in Table 2.

In the commercialization of the products listed, the miniaturization of voice recognition products is most important. Accordingly, development programs for specialized voice recognition ICs and boards are being vigorously conducted.

Machine Translation Telephone

One of the important targets for long-term research and development in pattern recognition technology is the machine translation telephone. This device will make use of both realtime machine translation and voice recognition technology.

Although there are many difficulties involved in development, machine translation telephones are one of the key features in universal intelligent communication networks conceived by the Ministry of Post and Telecommunications. These telephones are to be constructed in the early 21st century, after broadband ISDN is completed. In addition, NTT, KDD, and ATR are involved in the basic research.

Facsimile-phone seen as new home appliance

Banking services move into homes with improved telecommunications

TELECOMMUNICATIONS

Development of a telecommunications infrastructure is greatly changing the business environment in Japan. Table 1 illustrates the characteristics of several telecommunications applications and their impact on various sectors of the economy.

In the financial sector, such as banks and security houses, improvements in operational efficiency and service quality are expected through implementation of online transaction systems. The network simplifies and accelerates the cumbersome tasks of fund transfer, inquiry and interest calculation. Moreover, customers can enjoy improved service quality in terms of expanded service points and reduced waiting time.

In addition, home transaction services are available by simply attaching a communication interface to a game machine's "Famicon" port. Users can participate in stock dealing like playing a computer game. Home services take full advantage of the utility that the Famicon has provided in more than twelve million Japanese households in the past several years.

Meanwhile, facsimile has been introduced as home information equipment. Its applications include responses to TV programs and the collection of catalogue information. Accordingly, telecommunications now influence home life

SMD & SMT
EMC MICROWAVE

Crossing the technical barrier with Murata's human technology. Vol. 1.

A technician — in pursuit of causes behind tombstoning phenomenon — inspects results after passing mounted chip components through the reflow oven under variable conditions.

IN THE PURSUIT OF ZERO SOLDERING DEFECTS.

Continuous technological inovations for ever changing Market needs. — Murata.

Murata - a leading chip manufacturer and a strong advocate of component miniaturization - is also deeply engrossed in the improvement of chip mounting technology.
Recently reporters interviewed Murata engineers about the latest mounting techniques.

Q: What is the importance of mounting technology?

A: No matter how good a chip component is, it would be useless if it couldn't be mounted properly. For any chip product to exhibit its fullest characteristics, a compatible mounting system must be available.

Q: Could you be more specific?

A: Of course. Practical packaging, placing, and soldering techniques are necessary for error-free chip mounting. One example of our work is our research on appropriate measures to prevent tombstoning - a frequent problem during the soldering process.
Tombstoning occurs when chips break free from the solder and stand on end, resembling tombstones.

Q: How extensively have you studied tombstoning?

A: We've been doing research for several years.
Lengthy experiments had to be repeated in various types of reflow ovens to determine the origin and formation of the tombstone effect. Tests included minute analysis by high-speed photography, influence of land shape and size, and influence of application amount of solder cream. Tests were also performed to determine the most suitable pre-heating conditions.

Q: What were the results?

A: These tests proved that the defective ratio could be reduced to a mere fraction of one percent by adjusting both the land dimensions and the preheating temperature to optimum conditions.
Furthermore, by feeding back this know-how to product development, we are now in a very good position to manufacture chip components that are less susceptible to tombstoning.

Chip tombstoning in reflow soldering process.

Q: Are there other soldering problems?

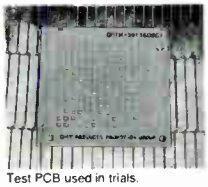
A: Yes. Solder bridging, solder balls, and solder migration are three others.
These types of soldering defects are liable to cause short circuits in the finished product; so one of the major requirements is for high quality in the solder itself. Just as important, special attention must be directed towards precision during the printing of solder cream.

Q: How do you intend to solve these problems?

A: We are working to solve all these outstanding problems through concerted coordination between material manufacturers, set manufacturers, and placer manufacturers.

Q: What are Murata's future plans with regard to chip mounting?

A: We intend to continue developing and applying new technology relating to the mounting process.
As one of the leading manufacturers of chip products in Japan, it is the firm policy of Murata to contribute our technology to society and to meet the requirements of our customers.



Test PCB used in trials.
Soldering defects: No two were ever alike.

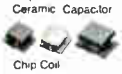
Tombstoning.
A phenomenon attributable to surface tension of solder, causing the mounted chip component to break free from the solder and stand on end.

Chip Monolithic Ceramic Capacitor

Chip Ceramic Trimmer Capacitor

Chip Trimmer Potentiometer

Chip Potentiometer



Chip Coil

Chip Solid Inductor

Chip EMI Filter (EMIFIL®)

Chip Ceramic Filter

Chip Ceramic Discriminator

Chip Ceramic Resonator (Ceralock®)

Chip type Hall Element

Chip PTC Thermistor (Posistor®)

MURATA'S CHIP PRODUCTS

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CIRCLE NO. 8

TABLE 1. CHANGES IN TELECOMMUNICATION ENVIRONMENTS

Sector	Features of telecommunication use	Impacts
Manufacture	– Production automation (CAD/CAM) – Establishment of networks (communication between factories, research institutes, and offices)	– Rapid improvement in productivity – Geographical decentralization (satellite offices, job at home) by making most of features of each activity (research, manufacturing, and sales activities)
Finance	– Establishment of in-house networks (letter transmissions between the main office and its branches) – Establishment of a global network – Exchange of financial information by conjunctive networks of different industries	– Development of immediate and organizational activites of business services – Promotion of a 24-hour business system – Business synergy with other industries (tele-shopping and sending/receiving orders)
Distribution	– Diffusion of POS and EOS systems in retail selling – Exchange of users' information by conjunctive networks of different industries – Sales through telecommunication networks	– Automation of clearance and sending/receiving orders – Business synergy with other industries (telemarketing, etc.) – Augment sales without stores
Home	– Use in home trading service through a Famicon	– Development of new entertainment area using communications
	– Use in multifunctional terminals with a telephone and facsimile in combination	– Development of communications taking advantage of non-telephone calling media

SOURCE: NRI/ITG

TABLE 2. MARKET SHARE OF THE FIRST COMMON CARRIERS

	(unit: billions of dollars (%)) 1987/4 - 1988/3	1988/4 - 1988/9
Telephone network service	32.2 (100.0)	16.2 (100.0)
NTT	32.0 (99.7)	16.1 (99.9)
NCCs	.091 (0.3)	.183 (1.1)
Proprietary network service	2.1 (100.0)	1.2 (100.0)
NTT	2.0 (98.0)	1.1 (97.0)
NCCs	.042 (2.0)	.035 (3.0)
Paging service	.661 (100.0)	.373 (100.0)
NTT	.655 (98.0)	.345 (97.0)
NCCs	.007 (1.1)	.035 (8.4)

SOURCE: MINISTRY OF POSTS AND TELECOMMUNICATIONS

in addition to the business environment.

Current Conditions

Nippon Telegraph & Telephone (NTT), Japan's largest common carrier, is now providing various services through networks (see the figure, p. 128).

Besides telephone networks, its communication network includes facsimile, data communication and videotex. NTT is constructing ISDN as an integrated and intensified form of these networks.

The number of NTT subscribers reached 49 million as of December, 1988. More than 70 million telephones, 2.2 million facsimile terminals, and 1 million data terminals, such as personal computers, are connected. Through the telephone networks, NTT provides not only telephone service but other services including message handling, toll-free dialing and call screening.

Home transaction services are available by simply attaching a communication interface to a game machine's "Famicon" port. Users can participate in stock dealing like playing a computer game.

Facsimile networks make available further services, such as transmission of image, simultaneous transmission to multiple facsimile terminals, and output of computer text information through terminals. The daily use of facsimile comunications services amounts to approximately 400,000

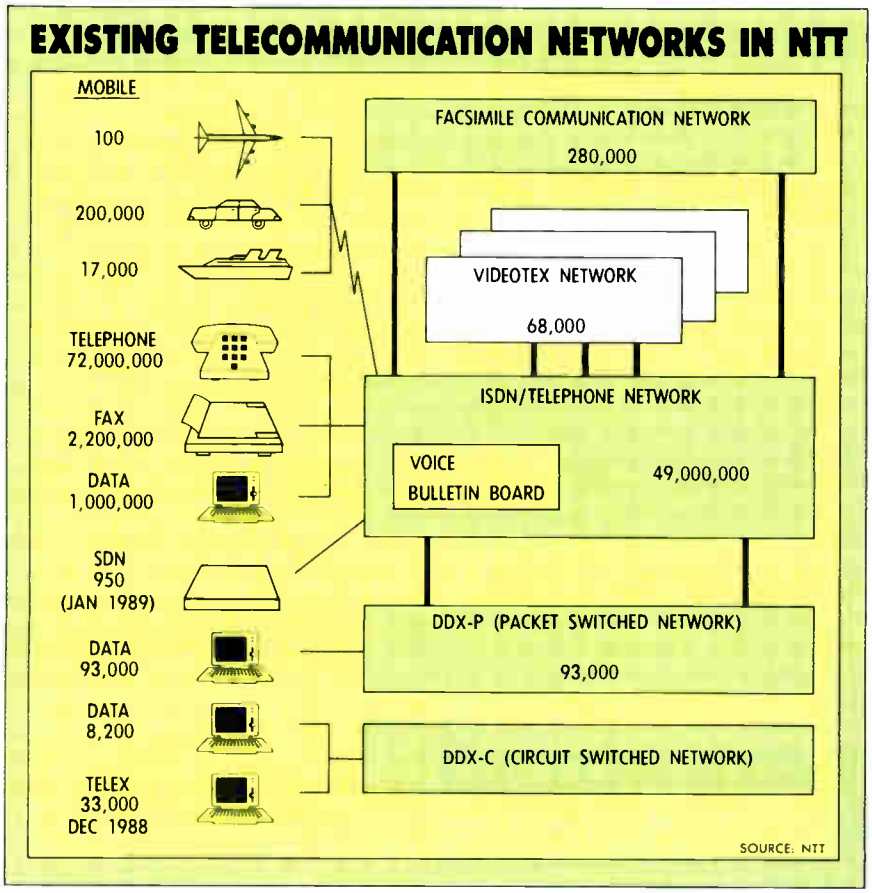
TABLE 3. SHIPMENT OF TELECOMMUNICATION EQUIPMENT

(unit: millions of dollars)

	1985	1986	1987	1988
Telephone	706.3	719.7	783.8	1,087
Standard	359.8	269.0	223.9	189.4
Multi-funtion	166.2	204.2	278.1	364.8
Wireless	N/A	N/A	N/A	242.9
Others	180.3	246.5	281.7	289.4
Telephone related units	1,871	1,753	1,405	1,187
Key telephone	1,442	1,283	973.2	867.6
Telephone recorder	147.9	225.3	192.9	109.8
Others	281.0	244.4	238.7	209.8
Image transmission terminals	2,308	1,534	2,673	3,380
Facsimile	2,205	2,135	2,569	3,280
Very high speed	N/A	N/A	N/A	19.7
High speed	N/A	N/A	N/A	3,030
Medium speed	N/A	N/A	N/A	229.6
Others	102.8	102.8	104.2	100.0

	1985	1986	1987	1988
Telephone and dota switching	2,091	2,300	2,764	3,237
Public	1,231	1,272	1,694	2,017
Private	579.6	719.0	729.6	847.2
Others	281.0	308.4	340.8	372.5
Transmission equipment	2,363	2,419	3,350	3,585
Coded data	826.0	750.0	1,559	1,606
Broodband terminal	433.8	471.1	442.2	486.6
Modem	307.7	302.8	484.5	581.0
Others	795.1	895.1	864.1	911.2
Broadcast equipment	519.7	470.4	42.7	491.5
Wireless communicotion equipment	2,641	2,722	3,132	3,522
Fixed station	1,413	1,465	1,539	1,547
Mobile station	1,063	1,101	1,351	1,663
Automobile	581.7	597.9	711.3	945.1
Portable	267.6	281.7	407.0	479.6
Others	213.4	220.4	232.4	238.0
Personol stations	165.5	157.7	241.5	312.7
Wireless related units	1,337	1,481	1,644	1,806

SOURCE: MINISTRY OF INTERNATIONAL TRADE INDUSTRY



pages.

Data networks are divided by packet-switched and circuit-switched data networks. The number of subscribers are 93,000 and 41,000, respectively. The latter is mostly used for telex services.

Mobil communication services are one of the most promising services in Japan's telecommunications. NTT's users of cellular telephones (including portable types) amount to more than 200,000. Telephone services in trains, ships, and airplanes are also provided through cellular networks.

Videotex service is also provided through telephone networks. The number of subscribers is about 68,000.

Since its liberaliza-

tion in April, 1985, the telecommunication market is welcoming new common carriers (NCCs). As of the end of 1988, the NCCs consist of three long-distance telephone companies (Daini Den Den, Japan Telecom, and Teleway Japan Corp.), four local companies (Tokyo Tsushin Network, Chubu Telecommunications, Osaka Media Port, and Lake City Cable Vision), Tokyo Bay Marinet Telecommunication, and 24 paging companies.

Table 2 shows a comparison between NTT and NCCs regarding service income of the first common carriers. The telecommunication market has experienced new diversified participants and has implemented price reductions several times.

In terms of telephone service, which is the current major communications service, NTT is enjoying an overwhelming market share of 99.7%. In proprietary circuits or paging services, however, NCCs have gained shares of 3.0% for proprietary circuits and 8.4% for paging services. And NCCs are offering inexpensive services to their customers.

Expansion Of ISDN

NTT has been providing a circuit switching service called "INS Net 64" with basic-rate interface, since May, 1988. As of April, 1989, the number of subscribers and circuits stood at 300 and 1,500, respectively. NTT's service area covers 28 cities including Tokyo, Osaka, and Nagoya. Additional services available at present are identification of a calling number, notification of service charges, sub-addresses, and dial-in services.

Furthermore, NTT has implemented a circuit switching service with the primary-rate interface, which is called "INS Net 1500." Since the end of

June, 1989, ten companies have subscribed to this service for 21 circuits.

While the main targets of the basic-rate interface are small offices, office branches, or homes, the primary-rate interface is focusing on organizational use by large offices and manufacturing lines. The implementation of the primary-rate interface will introduce a new era for ISDN.

As can be seen in Table 3, total production of telecommunication equipment in Japan in 1988 amounted to 18.3 billion dollars. The average growth rate in the past three years (1985-88) was 9.8%, owing much to a favorable growth in local switches, PABX, and facsimile equipment.

The switches are considered necessary in new equipment used for NTT digital telecommunication networks and in-house communication networks. NEC, Fujitsu, Hitachi, and Oki are the major equipment suppliers. Given that the range of equipment is expanding due to ISDN, the design of PABX is predicted to change in order to satisfy new needs for data transmission.

Japanese manufacturers of facsimile machines, such as Ricoh, Matsushita Graphic Communication Systems, NEC, Toshiba, and Canon, occupy the greater part of the world market. Their production scale on an installed base amounted to 4.3 million units in 1988.

Because more than three million facsimiles have been sold in Japan, we can conclude that facsimiles are a very promising segment of telecommunication equipment second only to telephones. A new type of facsimile combined with a telephone has already been introduced as home information equipment. Further development of this new facsimile market is very feasible.

NDK leads quartz crystal industry

NDK (Nihon Dempa Kogyo Co., Ltd.) is currently ranked as the top manufacturer in the world of quartz crystal units and related products. Our quartz crystal units and related products are currently being used in a wide range of computer and audio-visual products including communications equipment such as car telephones and other similar applications.

This year marks the 40th anniversary of the founding of NDK. Over the course of those forty years, we have been successful in substantiating both our sales and production bases. With the establishment of NDK Europe Ltd. last year in London, we have been able to set up a network of directly-controlled sales bases outside of Japan in the U.S., Singapore and Europe. In the U.S. in particular, we have gained a considerable level of trust and confidence from major computer and automotive manufacturers in the ten years that have passed since the establishment of our subsidiary there.

With respect to our production base, we currently have 5 plants in Japan and 2 additional plants in Malaysia. In particular, we established Hakodate NDK, located in Hakodate, Hokkaido, in April of this year in an effort to respond to the current demand for products related to mobile communications.

Based on our slogan of "Crystallizing Confidence,"

TOSHIAKI TAKEUCHI
Vice President

NDK is currently undertaking various challenges. The complete discontinuation of the use of freon gas is one of the tasks we have undertaken. The use of freon gas has become a serious concern throughout the world as a problem which threatens the destruction of the environment.

At NDK also, we are using freon in the cleaning of our quartz crystal units. However, as early as July of last year, as a result of experiments on curtailing the amount of freon used and establishment of effective countermeasures to deal with such reduced amounts, we were successful in the spring of this year in reducing the amount of freon used to half of its former level. Moreover, NDK had firmly decided to completely eliminate the use of freon by 1992.

At NDK, we take pride in not only the reliability of our products and our high level of technical expertise, but also that we are able to maintain a trusting relationship with local communities as a result of our contributions to society.

Modest profit for components and materials

Foreign component makers are serious competitors for Japan's industry

The Japanese electronics component industry, boasting a production scale of 21.1 billion dollars, has been experiencing a growth rate of 16% a year, overcoming a stagnant period from 1985 to 1987. Japan is supplying more than 40% of the world's demand for electronics components. Above all, it occupies more than a 50% share among numerous segments of the consumer equipment market. On the other hand, its share in the U.S. market for industrial equipment, the largest in the world, is at a low level.

World depreciation of the U.S. dollar has shifted up local currency rates in newly industrialized economies (NIEs), such as the Korean won and New Taiwanese dollar. Consequently, Japanese manufacturers, particularly consumer equipment manufacturers, have shifted their off-shore production to ASEAN counterparts, such as Thailand and Malaysia.

Production in the U.S. and Europe is being substantially increased in order to meet local content laws. Being affected by these factors, domestic growth of consumer equipment is estimated to be no more than 1.1% a year. On the other hand, a production growth of industrial equipment is expected to approach 8.1% and stimulate growth of components to this area.

Hybrid-ICs

Use of hybrid ICs is expandng because of the need to minimize product size and build complex functions into today's electronic products. In the hybrid area, thick-film hybrids account for 95% of total production. The total market is 1.27 billion dollars. Major firms in the industry are Taiyo Yuden, Sanyo Electric, Sanken Electric, and Matsushita Electronics Components.

Shipments of CRTs consist of 65% TVs and 35% computer displays, accounting for roughly 1.13 billion dollars and 563 million dollars, respectively. The CRT industry is expected to grow, driven by large CRTs for TVs and HDTV in the future. Major firms in this business are Hitachi, Matsushita Electronics, Mitsubishi, Toshiba, and Sony.

Liquid crystal displays (LCDs) are used as displays for laptop PCs, word processors, and as screens for small TVs. A number of display manufacturers have introduced colored liquid displays in the STN format. In terms of an active matrix format, the MIM format is adopted by Seiko Epson and the TFT format by NEC and Mitsubishi.

Other multi-color display devices such as plasma display panels (PDRs) and light emitting diodes (LED) are currently supplied by several Japanese manufacturers.

Fluorescent indicator panels (VFDs), based on a new thin-film display technology using the tunnel effect, produces displays with contrast and resolution as high as CRTs. A fluorescent display can be illuminated by as little as 10 volts. NEC, Futaba Electric, and Canon are the main makers of VFDs.

Passive Components

Because of well-established production overseas, resistors

CHANGES IN PRODUCTION COMPOSITION OF ELECTRONICS COMPONENTS

(unit: billions of dollars)

	1984	1985	1986	1987
General	19.2	20.1	20.4	20.9
Passive components	7.9	7.9	7.6	7.8
Functional components	1.9	2.6	3.0	2.9
Mechanical components	5.0	5.3	5.3	6.0
Tubes	4.1	3.9	4.2	4.2
Semiconductors	4.3	4.0	3.9	3.9
ICs	13.9	12.9	12.5	13.5
Total	56.3	56.7	56.9	59.3

SOURCE: MITI STATISTICS

experienced zero growth, but accounted for 1.83 billion dollars. Chip resistors for high density mounting and network resistors are promising products for the future. Matsushita Electronics has already implemented mass production of cylindrical metal film chip resistors with a size of 1.6 mm x 1.0 mm and a weight of 4.5 mg. Besides Matsushita, Rohm and KOA are enjoying dominant market shares.

Transformers and inductors for consumer equipment are increasingly produced in offshore locales, and domestic production is decaying. With a rapid growth of switching power supplies and inverters for industrial components, however, demands for high frequency transformers and inductors are expected to burgeon. While ferrite cores are largely being used for all high-frequency transformers, amorphous core is being used for high-frequency chalk coils or transformers for mag-amps. The major suppliers are TDK, Toshiba, and Tohoku Metalse.

Led by the demand for fixed capacitors, the capacitor industry is expected to reach a production level of 3.38 billion dollars or more. Meanwhile, chip capacitors are another promising type for the future. For example, in terms of both tantalum and ceramic capacitors, chip-type capacitors have gained a 50% share. Also, aluminum electrolytic capacitors are being used as chip capacitors for vertical chips, parallel chips, and cubic chips. Matsushita Electronics, Nippon Chemi-con, ELNA, Murata Manufacturing, and TDK are the market leaders.

Shipments of quartz crystal oscillators, represented by oscillators and filters, are going to expand to 915 million dollars. Particularly, mobile radio applications are very promising. Major suppliers are Kyocera, Nihon Denpa Kogyo, and Kinseki.

Mechanical Components

While switches for computer keyboards are suffering from stagnant growth, general switches, such as mini-slide switches and DIP switches, are experiencing an annual growth of 11%. Many new participants in the switch industry share the market with major companies, including Alps, Tateishi, and SMK.

Connectors are a strong growth segment in the mechanical component industry with a high annual growth rate of 14%, amounting to roughly 1.58 billion dollars a year. Given that this market is dominated by overseas manufacturers, Japanese competitors will have to develop new products with narrower pitches or modify their products to be adopted to surface-mounted technology (SMT). Nippon AMP, Japan Aviation Electronics, Hirose Electric, and SMK are the main suppliers.

Electronics Materials

Electronics materials are becoming increasingly diverse, especially in such segments as magnetic materials, resin engineering plastics, and ceramics. Because of their versatility and cost-effectiveness, these materials are increasingly replacing traditional materials.

The term "electromagnetic disaster" is not new to our ears, and electromagnetic environments are getting increased attention. In order to solve EMI/RFI problems, applications for electromagnetic absorbing materials are using ferrite, rubber, carbon, and amorphous alloys. In addition, amorphous alloys are playing a significant role in noise filter applications. Major suppliers of amorphous alloys include Nippon Steel, Hitachi Metals, and Nihon Ferrite. Processed products are supplied by TDK, Tohoku Metals, and Fuji Electrochemical.

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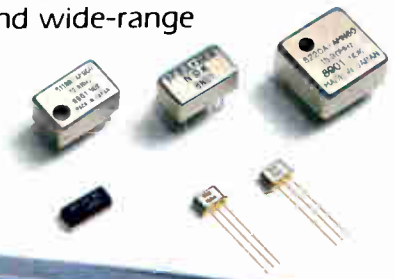

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Circle 21

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Circle 91

COMPANIES TO WATCH

HERE'S ONE GaAs STARTUP THAT HAS FOUND ITS NICHE

In Anadigics' analog IC market segment, GaAs is actually a low-cost option

WARREN, N. J.

The bloom may be off the rose for a number of semiconductor outfits in New Jersey's Gallium Gardens, but for Anadigics Inc., gallium arsenide sales just keep growing.

The Warren-based company's revenues, which doubled in 1988, will double again this year and are expected grow even more rapidly in 1990, says president Ronald Rosenzweig. Although that sort of performance is expected of a startup, Rosenzweig points out that other GaAs hopefuls, including Microwave Semiconductor Corp. of Somerset, N. J., and Gain Electronics Corp. of Somerville, N. J., have dropped out of the market while Anadigics has thrived [*Electronics*, July 1989, p. 102].

The reason for Anadigics' success, says Rosenzweig, is that the company found a niche in analog circuits and stuck with it. "The few merchant competitors left in GaAs have all carved out a niche that they think they can dominate," he says. "There is now very little competition between them." In the analog business, Anadigics is competing against vendors of high-performance discrete components, where "GaAs is actually the low-cost option," Rosenzweig notes.

Anadigics, which was founded in 1986, is still privately held and declines to reveal actual sales figures. While the digital GaAs successes—Vitesse Semiconductor Corp. of Camarillo, Calif., and GigaBit Logic Inc. of Newbury Park, Calif.—lead the pack in gate speeds and array size, Anadigics' analog orientation means it primarily creates devices with ever higher bandwidths—500 MHz and up. "The movement of markets to broadband has made this possible," says Rosenzweig. These markets include fiber-optic telecommunications, direct-broadcast satellite, cable TV, graphics, and, in the future, high-definition TV. "We've always felt comfortable with the choice of analog," he says, "and now the market is starting to get there."

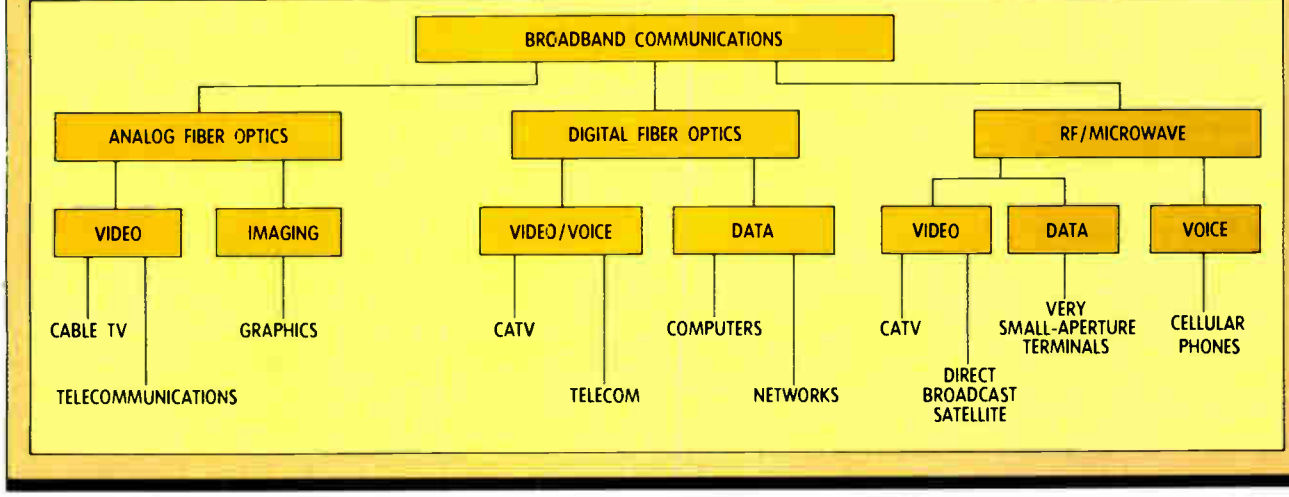
Customers in these markets are not necessarily numerous, but the volumes needed by a single customer, such as a telecommunications company, can be enormous. "Our major market will grow from circuits that are custom designed," says Rosenzweig. The market for a custom chip in the cable TV arena, for example, may be in the millions. "If you're looking at fiber-optic cabling into the home, there will be one [chip] for every dwelling," he says. Anadigics recently won a large contract to supply satellite communications chips in the UK—a win that bodes well for its future in the industry, says John Day, president of Strategies Unlimited Inc., a Mountain View, Calif., market research firm.

Anadigics has one major advantage over competitors that offer hybrid circuits. Manufacturing hybrids with 20 to 30 discrete components in the package is highly labor-intensive, Rosenzweig says. "We can integrate 50 to 100 components on a [GaAs] chip," he adds. Pricing remains a tricky issue, however. "We can't sell chips in the $1 to $10 range because the material costs more than silicon," he says. Also, the fragility of GaAs means that chips must be made thicker, using more material.

LOOKING TO HDTV. With HDTV's arrival expected to be staged in incarnations such as intermediate-definition and enhanced-definition TV, Anadigics is bird-dogging that technology as well. "Anyone in the business of making high-performance, leading-edge chips is always interested in the top of the 'food chain,'" Rosenzweig says. HDTV will require components with much more bandwidth, speed, and processing power than are available today.

Rosenzweig also sees great opportunity in the reconstruction of the world's communications infrastructure—a massive task now just under way. Conventional

COVERING THE GaAs ANALOG WORLD



broadcast systems will be replaced by fiber-optic cable run into the home or by satellite broadcasts, he says.

"The telephone companies talk more about video than anything else," says Rosenzweig. Bell South Corp. of Atlanta set up a fiber-optic channel for a recent space shuttle launch, for example. "There's a lot at stake for the U. S.," Rosenzweig says. "Europe and Japan have ongoing HDTV projects, and the decision on what components go into HDTV is heavily dependent on where the engineering work is done."

MORTALITY RATE. Although the mortality rate among GaAs vendors has abated somewhat, the shakeout in the GaAs industry has not run its course, says analyst Day. GaAs merchant chip makers must learn how to handle competition from large companies—such as AT&T, Bell Northern Research, and Texas Instruments. "There's still another contraction ahead," says Day, "particularly in the military sector, where there are too many companies in the Mimic [Microwave and Millimeter Wave Integrated Circuits] program for economic survival."

For Anadigics, success is keyed to the needs of the end user. It is not so much a standard-parts business as an application-specific business, says Rosenzweig. But one generality holds: "We're interested in any application that chews up bandwidth." *–Jack Shandle*

AS PART OF SGS-THOMSON, INMOS PUTS ON A NEW FACE

BRISTOL, ENGLAND

New owners could make all the difference to Inmos Ltd. Before becoming part of the French-Italian SGS-Thomson Microelectronics Group earlier this year, Inmos limped along for years with "for sale" signs posted outside its fab facilities. Now, with an infusion of "unlimited funding" from its corporate parent, the Bristol-based company can follow up marketing and product-development strategies that it couldn't afford on its own.

"The company will not, in the future, be held back by lack of financial or marketing muscle," says Pasquale Pistorio, president and chief executive officer of SGS-Thomson. The first new initiative is a range of system-level products built around Inmos's self-contained parallel-processing computer chip, the Transputer, and marketed by a new division, Inmos IQ Systems.

Already Inmos has taken advantage of its parent's abundance of wafer fabrication lines to ramp up output of the Transputer and fast static random-access memories. This month, observers expect deep price cuts across its product line, the IQ Systems launch, enhanced Transputers, and a range of algorithm-specific digital signal-processing circuits.

Set up with British government funding in 1978 to develop the advanced microprocessor that became the Transputer, the semiconductor company has had a checkered history. In the early 1980s, Inmos was bought by Thorn EMI plc, which soon changed its view of high technology and put Inmos's plants and design centers in the UK and the U. S. up for sale. First to go, in early 1988, was its Colorado Springs wafer fab line, which was closed down (Cray Research Inc. bought the plant's clean room facilities for its gallium arsenide program). Finally, early this year, the whole company was disposed of in a complex interchange of paper, promises, and cash to SGS-Thomson.

FIRST PROFIT. Nevertheless, through the semiconductor market downturn of the mid-1980s and against an uncertain business background, Inmos managed to achieve some of its technology goals. It launched advanced circuits, including fast static and dynamic RAMs, specialized color lookup chips—and, of course, the Transputer. The company even made a profit for the first time in 1988, resulting mostly from a world shortage of memories, boosting sales to $125 million, a 33% increase over the preceding year.

But one target it has not managed to hit is the objective stated clearly in its startup business plan 11 years ago, when it set out to become a world leader in VLSI. Its products performed well: the original T200 Transputer offered 10 million instructions/s in 1985, and the latest 32-bit T800 delivers 2.5 million floating-point operations/s. Moreover, the Transputer has found its way into more than 1,000 systems worldwide. But Inmos consistently failed to follow through with a coherent marketing effort and adequate new product development, analysts say.

With SGS-Thomson's takeover, all that is changing. Inmos belongs to a company whose senior executives are real semiconductor people, "with silicon in their blood," as one insider puts it. Apart from having management that seems to understand them, what has put the spring back in the steps of Inmos workers is Pistorio's willingness to give them in effect a blank check to go ahead with plans forced onto the back burner. The first action of Inmos's chief executive, Mike Wright, was to launch a crash recruitment program. About 150 engineering development, applications, and marketing people will be added to the payroll before year's end.

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Circle 41

Inmos and its products on the international marketing map is the appointment of Ian Pearson as director of system products, marking Inmos's entry into the systems and board market. Pearson has formed Inmos IQ Systems, which is slated to open its doors this month. Also this month, Pearson and his marketeers will start a four-week global tour. Beginning in Boston at the Buscom East exhibition, the team will fly on to Korea and Japan for customer meetings and finish in mid-October in West Germany at the Munich Systems Fair.

What Pearson will be showing is a complete range of board-level products based around the Transputer plus DSP and graphics chips. "For around $10,000, and the time it takes to plug eight small modules onto a single motherboard, engineers in a hurry can build a parallel computer capable of sustaining around 100 mips and 12 megaflops on a standard VMEbus card," says Pearson. And they can play "mix and match" with a range of processor, memory, DSP, peripheral and graphics controller, and input/output interface modules to arrive at the optimal configuration for any embedded or standalone processor based on a range of industry-standard bus system boards.

IQ SYSTEMS. With the launch of IQ Systems, Inmos intends to build a catalog of modules and motherboards with which designers can build complete systems. Pearson divides systems functions into what he describes as "seven layers." His first layer, or class of functionality, assumes that a system needs to communicate with other systems. To this end, IQ's class 1 modules will ultimately include units to interface with a variety of local-area-network standards.

Looking inside a system, layer 2 products will comprise a range of what Pearson describes as "general-purpose I/O modules providing interfaces for such standards as RS-232-C, the IEEE 488 general-purpose instrumentation bus, analog-to-digital conversion, and so on."

Processors come next, at layer 3 in Pearson's strategy. At this level in a system's architecture, Pearson includes 16- and 32-bit integer and floating-point scalar processors, along with vector processors—all of them containing memory. Peripheral controllers and interfaces such as graphics modules and controllers to drive the small computer systems interface define Pearson's fourth layer, followed by a more advanced set of products he calls "application-specific modules."

Prices for IQ Systems' offerings vary depending on function. The VME motherboard costs around $2,000, and a "size 2" module—with a 12.5-mips T800, 2 Mbytes of DRAM and 128 Kbytes of SRAM—works out to around $1,000. A 100-mips VMEboard comprising eight modules adds up to $10,000. *–Peter Fletcher*

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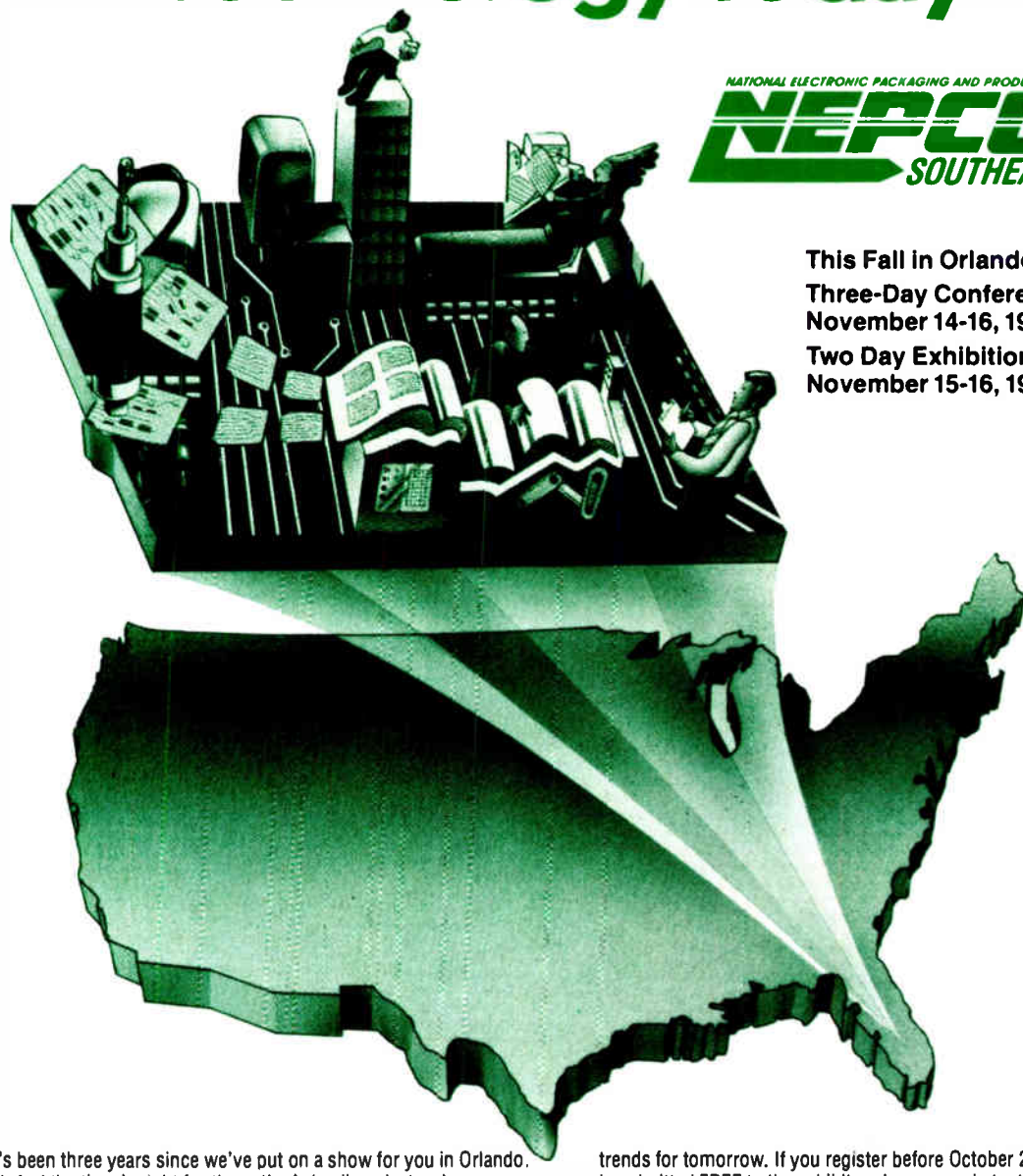

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Circle 72

PEOPLE TO WATCH

SEIKO HOPES AN R&D DUO CAN CATAPULT IT TO NO. 1

Hightower and Shinozuka are taking on the SX8000

SAN JOSE, CALIF.

Seiko Instruments Inc., No. 2 in the worldwide computer-aided chip-design market, is aiming for the top. To get there, the Tokyo-based company is entering the U. S. market in a big way. Seiko sees the development of a souped-up version of its successful SX8000 design system as the key to its success. That effort, to be undertaken at the company's new research and development department in San Jose, is being led by two R&D heavyweights: David Hightower and Kazuya Shinozuka.

Both come with impressive credentials. Hightower developed the algorithm that revolutionized routing technology in the late 1960s, and Shinozuka led a team of 40 developers to produce Seiko's first design-automation tool set.

Now they're working together on a standard cell-and-block place-and-route tool for the SX8000, to be renamed the SX9000 and shown at next year's Design Automation Conference. Seiko believes that the revamped system will let it overtake the world leader in computer-aided-engineering chip design, Cadence Design Systems Inc. of San Jose.

Hightower's expertise in routing dates back to 1967, when he worked at AT&T Bell Laboratories, his first job out of the Stevens Institute of Technology in Hoboken, N. J. At Bell Labs, Hightower was assigned to develop a printed-circuit-board router that could handle large boards. "Computers in those days had small memory and were slow," Hightower says. To work around the limitations, he created a general-purpose algorithm that used rules to solve the routing problem; it was "the first rules-driven router, as well as the first gridless router," he says. Hightower's algorithm, published in 1969, was 50 times faster than the best method of the time. It ran in minutes on circuits that took hours to execute on routers then available.

Hightower moved from Bell Labs to Texas Instruments Inc. in Dallas in 1976, leaving five years later for General Electric Co.'s Microelectronics Center in Research Triangle Park, N. C., where he created gate-array tools. In 1986, Hightower and five others were assigned to GE's Calma Division in San Jose to develop a standard cell-and-block place-and-route tool as part of Calma's GDS-II full-custom chip-layout system. By the time the project ended, GE had sold Calma to Valid Logic Systems Inc., also in San Jose.

It was at Calma that Hightower, now 45, first met Shinozuka. The 40-year-old

David Hightower, director of product development, and Kazuya Shinozuka, product manager, bring R&D clout to Seiko's effort to revamp its SX8000 chip-design system.

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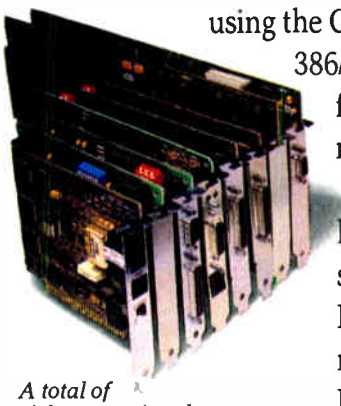

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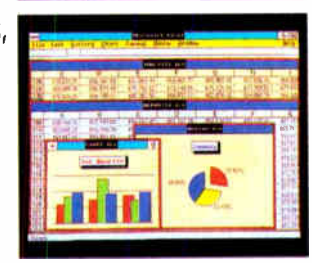

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Japanese national joined Calma after working at GE Industrial Automation Ltd. in Tokyo, a GE division that has since closed. At GE, Shinozuka wrote Venus, a microcomputer-based integrated-circuit-layout system, which stirred interest inside Calma in 1984. "In November 1984, right after the project had been completed, Calma asked me to make a presentation on Venus to its R&D group," says Shinozuka. In March 1986, Shinozuka joined Calma. "I was responsible for making Venus look like GDS-II and porting it to the Sun [Microsystems Inc.] work station," he says. Venus ultimately became the basis for the new EDS-III, launched last December.

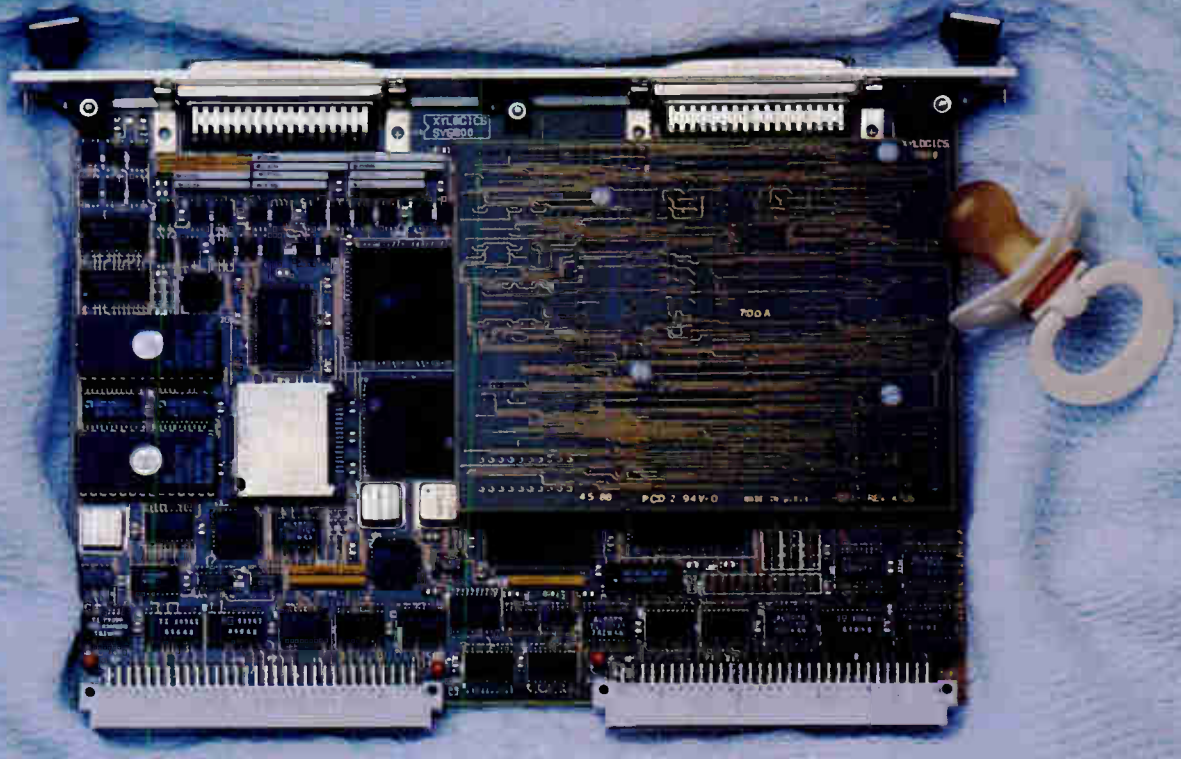
Venus was the second IC-layout system written by Shinozuka. His first was the SX8000 for Seiko, where he was hired in 1978 as the company's first software engineer. He started the SX8000 software development from scratch; he and his team spent five years developing the first version. Seiko Instruments, one of four operating companies in the Seiko Group, is already a major CAD/CAE player, with revenues of $1.1 billion in 1988. The SX8000 is the reason for its success, says Ron Collett, senior market analyst at Dataquest Inc. in San Jose.

LIVELY BUSINESS. "Seiko is different from other Japanese players in the market," Collett says. "Most Japanese, as well as many U. S., application-specific IC companies use their tools to leverage their foundry business. They look at tools as a means of getting and keeping the customer." Seiko isn't using tools to leverage its ASIC business, Collett says; rather, the company has a lively business selling design tools against the likes of Cadence, Mentor Graphics, and Silicon Compiler Systems.

Worldwide, Seiko holds 14.5% of the CAE chip-design market, with Cadence's share at 15.6%, according to Dataquest. Seiko leads in the Asian market for workstation IC-layout tools with 34.7%, against second-place Cadence's 11.2%.

Seiko began marketing its SX8000 in earnest when the commitment of Mountain View, Calif.-based Daisy Systems Inc., now Daisy/Cadnetix Inc., began to wane. Seiko, which had distributed Dazix's Chipmaster product in Japan, moved to fill the vacuum left when Dazix retreated from the IC-layout business.

In joining Seiko, both Hightower and Shinozuka have crossed personal thresholds in their careers. For Hightower, Seiko is the first company in which he and his wife, a mathematician, have not worked together. And Shinozuka is one of the few Japanese workers who have rejoined a previous employer. "It is unusual for a Japanese to leave a company and later rejoin it," he says. "In Japan, if a worker leaves a company, he usually never returns." *–Jonah McLeod*



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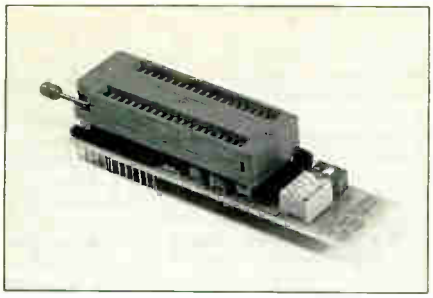

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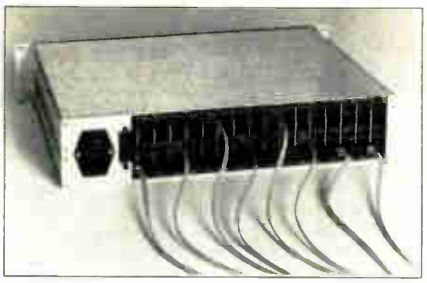

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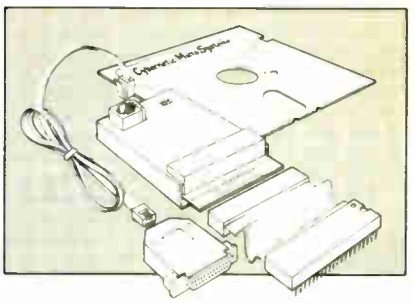

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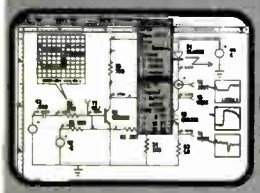

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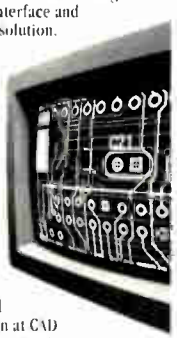

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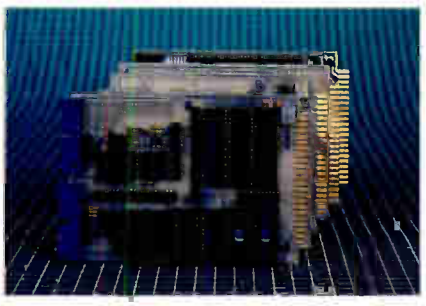

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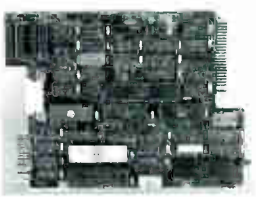

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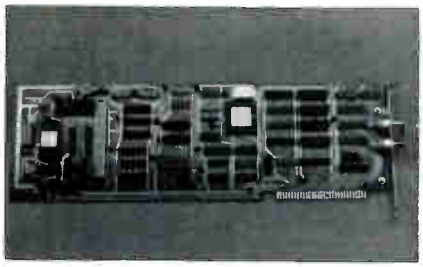

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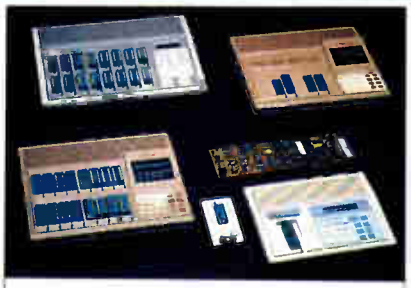

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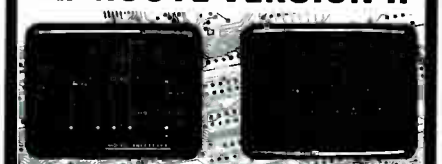

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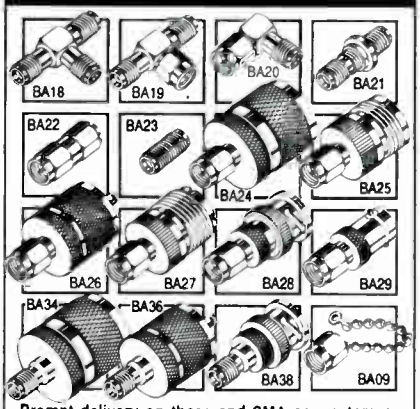

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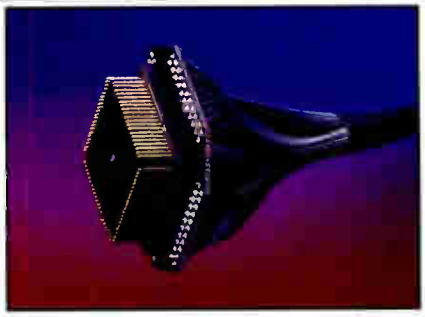

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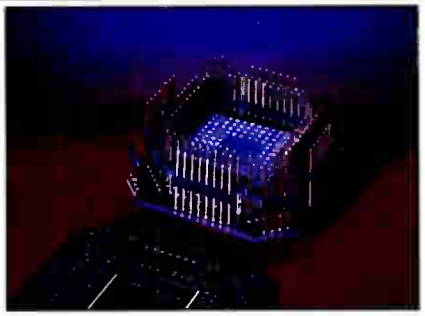

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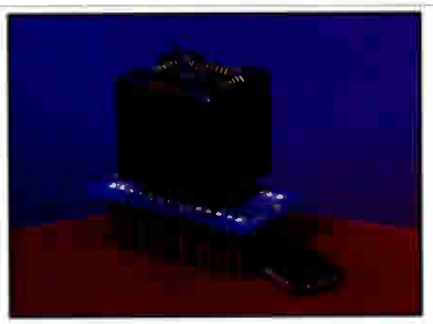

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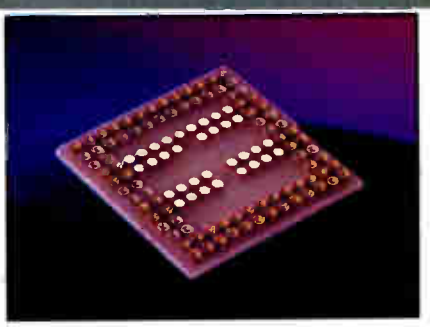

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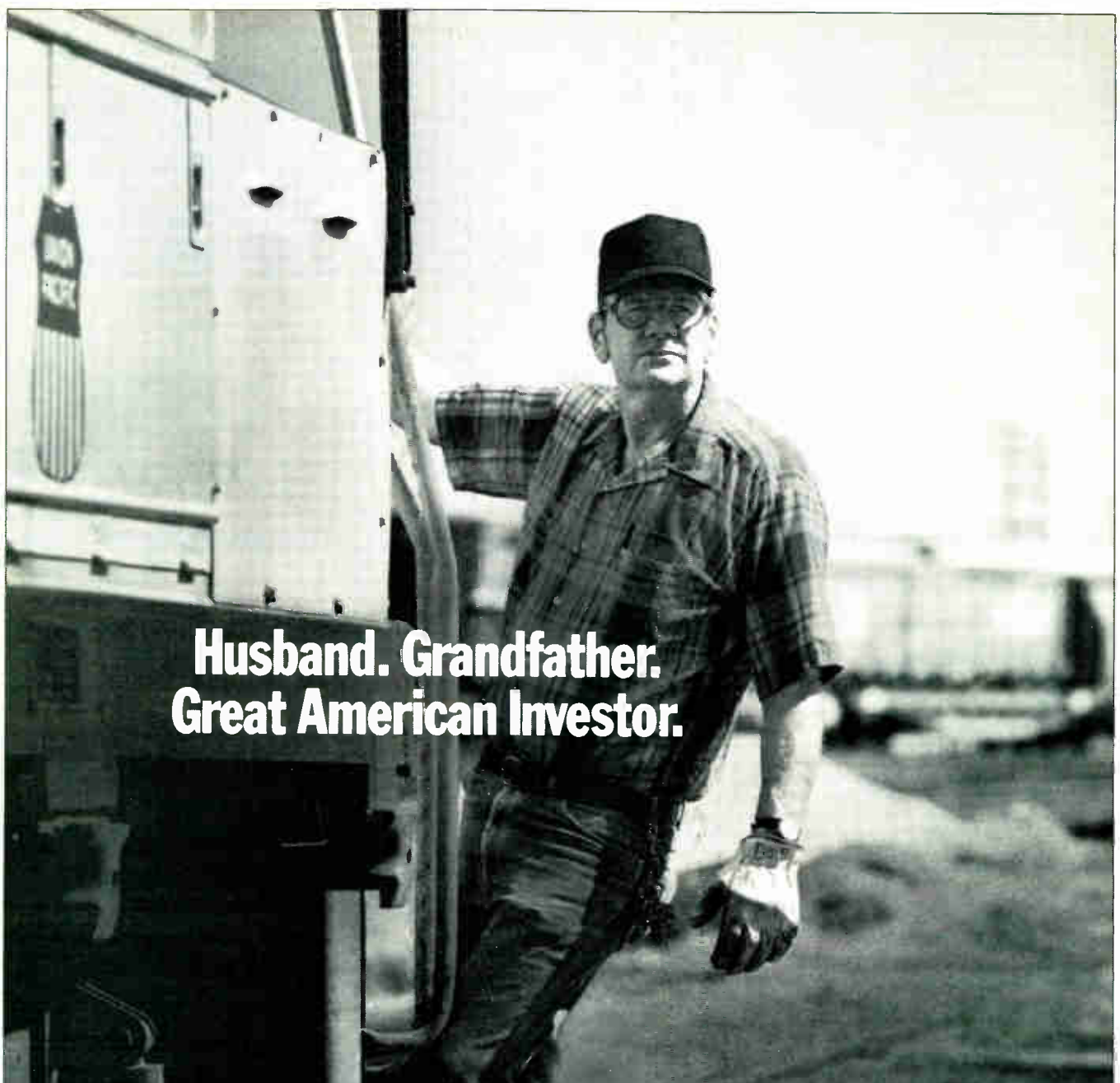

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UPDATE: TESTING MARKET TAKES A SLUGGISH TURN

After a wildly successful 1988, the roller coaster that is the automatic-test-equipment business has reached a plateau, almost as if it were pausing to catch its breath. The question for 1989 is: which way will the market go now?

But, oh, that 1988! The market was in the midst of a major boom, with American companies duking it out with Japanese competitors both in the U. S. and overseas [*Electronics*, September 1988, p. 89]. VLSI Research Inc., a market researcher in San Jose, Calif., listed stellar growth for every segment of the component testing business. Total sales for logic, memory, linear, discrete, and burn-in test equipment last year came to $1.395 billion. Logic tester sales surged 30% and those of memory test systems—driven by sales in the Japanese market—grew 71.5%, exceeding the predictions handily.

Now comes the lull. G. Dan Hutcheson, president of VLSI Research, predicts total 1989 sales will reach $1.465 billion, up barely 5% over last year. Nearly all revenue growth will come from continued sales increases in memory testers, which Hutcheson says will reach $327 million in 1989, up 22% over the $268 million achieved in 1988. Though the growth rate is impressive compared with the flat growth in other segments of the ATE business, it's still a much more modest uptick than last year's market explosion.


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As the high yen holds back the Japanese, innovative U.S. vendors try to regain market share

HOW JAPAN'S VLSI TEST MARKET SHARE GREW

Memory testers are a bright spot, with sales expected to rise 22%

One U. S. company benefiting from this business cycle is Teradyne Inc. of Boston. Ed Rogas, general manager of Teradyne's Semiconductor Test Division, says his company is selling testers for 4-Mbit dynamic random-access memories in the U. S., Japan, and South Korea. In addition, there is demand from manufacturers of static RAMs and video RAMs.

Rogas believes that the memory tester business is being driven by the insatiable appetite for computer speed and the increased use of more sophisticated operating systems and graphical user interfaces. There is a rule of thumb, he says, that every million instructions/s of computer performance demands 1 Mbit of RAM.

The emergence of operating systems such as IBM Corp.'s OS/2 will drive the demand for memory even higher. A minimum configuration for OS/2 is 2 Mbytes and a more typical configuration is 4 Mbytes. In addition, graphical user interfaces such as Open Look and sophisticated windowing systems such as X Windows are all driving the demand for larger amounts of RAM.

That means the long-term outlook is better than that for the short term. "With a book-to-bill ratio among memory manufacturers of 1 [$1 worth of orders received for every $1 worth of devices shipped], there is sufficient testing capacity to meet current demand," says Jim Mulady, sales and marketing manager at Ando Corp. in San Jose. Memory tester customers tend to buy a large number of systems at once, then leave the market for several quarters as they absorb the equipment they purchased, Rogas explains.

Mulady says memory makers are not currently buying testers to increase production capacity, but to test faster. Hutcheson concurs, observing that the 100-MHz memory tester is starting to sell well. One factor fueling this growth is the advent of central proccessing units with clock speeds over 20 MHz. "Beyond 20 MHz, you start requiring high-speed SRAM for cache," he says. "The high-speed SRAM business is beginning to grow, with companies such as International Device Technology and Cypress Semiconductor both selling large amounts."

Beneficiaries of this growth in sales are Advantest, Ando, and Teradyne, all of which offer memory testers with 100-MHz capability. Ando showed its 100/200-MHz Model 9047 memory testers for the first time late last month at the International Test Conference in Washington.

In other segments of the component ATE market, the picture is not as bright. Logic testers especially are suffering. Hutcheson of VLSI Research predicts their sales will reach $701 million in 1989, down from $705 million in 1988.

Logic tester customers are all demanding high pin count—typically, 512 pins—and test speed of 100 MHz, Mulady says. He sees Ando's biggest competitors as Tektronix Inc. of Beaverton, Ore., and Advantest, with Tektronix coming on faster. One reason is that the Tektronix LS1011 512-pin machine, with an average selling price of $2.3 million, is a veritable bargain beside the $3 million to $5 million of an Ando or Advantest unit. Hutcheson says Tektronix's tester-per-pin architecture has significant advantages over earlier designs.

One unexpected market for the LT1201 is testing new-generation CMOS and emitter-coupled standard logic. "Signetics has a number of LT1201 systems for their standard logic products," says Mike Kondrat, marketing manager at Tektronix's Semiconductor Test Systems Division. "Newer CMOS and ECL standard logic components offer significantly higher performance, so demand is on the rise again." *–Jonah McLeod*

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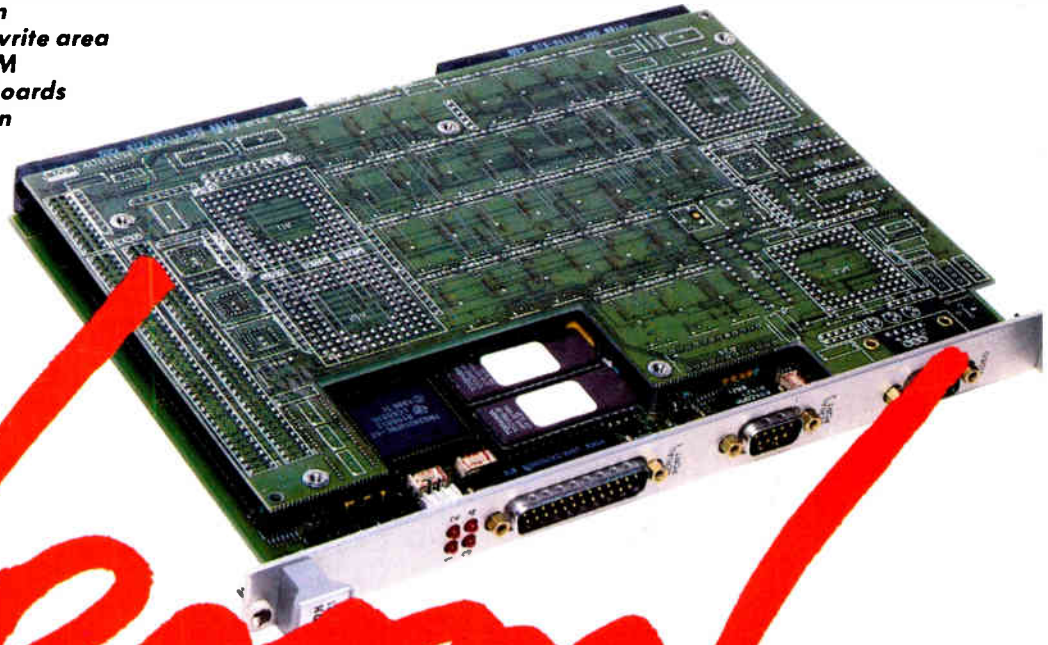

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