WHAT AT&T'S BIG TELECOM SALE IN JAPAN MEANS / 27

FIRST 'MODERATELY PARALLEL' SUPERCOMPUTER IS HERE / 83

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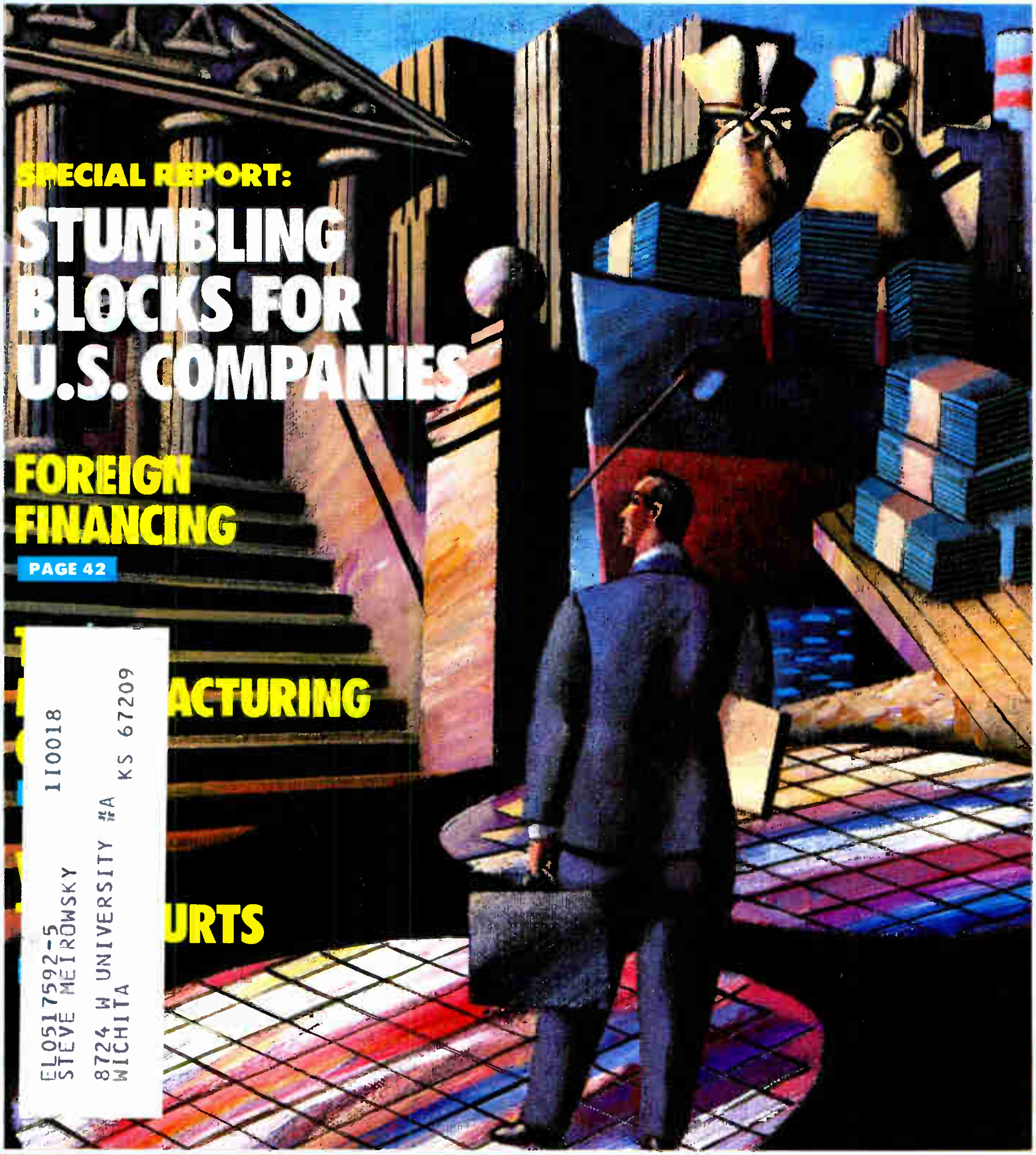

SPECIAL REPORT:

STUMBLING BLOCKS FOR U.S. COMPANIES

FOREIGN FINANCING

PAGE 42

ACTURING

URTS

WHO'S MINDING THE STORE?

The U. S. electronics industry doesn't lack for innovation—but innovation doesn't guarantee business success.

There's what we do," my Uncle Dougal once told me, "then there's business." If what he meant to imply was that the ebb and flow of commercial enterprise is some kind of force unto itself, I now know how right he was. There's what you do—whether it's designing technology, designing budgets, designing strategic alliances, or designing the perfect business plan for the perfect venture capitalist—and there's business. In this issue, our special state-of-the-industry report (p. 41) deals with specific aspects of that force-unto-itself affecting both large and small U. S. electronics companies.

Overseas capital is available in increasing amounts, from increasingly aggressive interests, to finance U. S. startups. Our article on p. 42 delves into the pros and cons along that route—as discovered by those U. S. businessmen who have traveled it. On p. 51 you can review the fate of those unfortunate entrepreneurs—not necessarily an insignificant minority—whose soaring success stories don't end with a soft landing.

On p. 54, you'll get a reaction from key U. S. electronics executives to a Massachusetts Institute of Technology report detailing the ebb of competitive viability from U. S. shores. While there is basic agreement on some of the generic causes for this slippage—managing for the near term vs. the long run, for example—there are significant differences in what various executives, from their different electronics-industry perspectives, are ready to prescribe as remedies. To zoom in from the theoretical to the real world, read the article (p. 61) on the erosion of the U. S. semiconductor industry's worldwide position, which has occurred despite an ongoing record of technological innovation.

Our third area of investigation of stumbling blocks for U. S. companies has little to do with global competition. As you'll see on p. 66, it deals with the waves of key patent and "intellectual property" issues that are converging on the nation's courtrooms. Pending litigation covers the gamut of hardware and software—from the mask works for an SRAM design to the "look and feel" issues surrounding the graphical user interface on desktop machines. Last year, AT&T successfully applied for the first patent granted for an algorithm—actually, a set of mathematical formulas—which remains unchallenged, although some legal scholars believe it is vulnerable. How these cases progress and are resolved through the early 1990s may radically affect and reshape the electronics business.

Despite the pitfalls, U. S. companies continue to excel at the kinds of innovation that push the industry forward in big, dizzying jumps, and that won't change. After several generations on the threshold, parallel processing may finally be moving into the mainstream via systems like the new Evans & Sutherland ES-1 supercomputer (p. 83). Clearly, the technological impetus is there—now if somebody can just take care of business.

ROBIN NELSON

August 1989 Volume 62, Number 8

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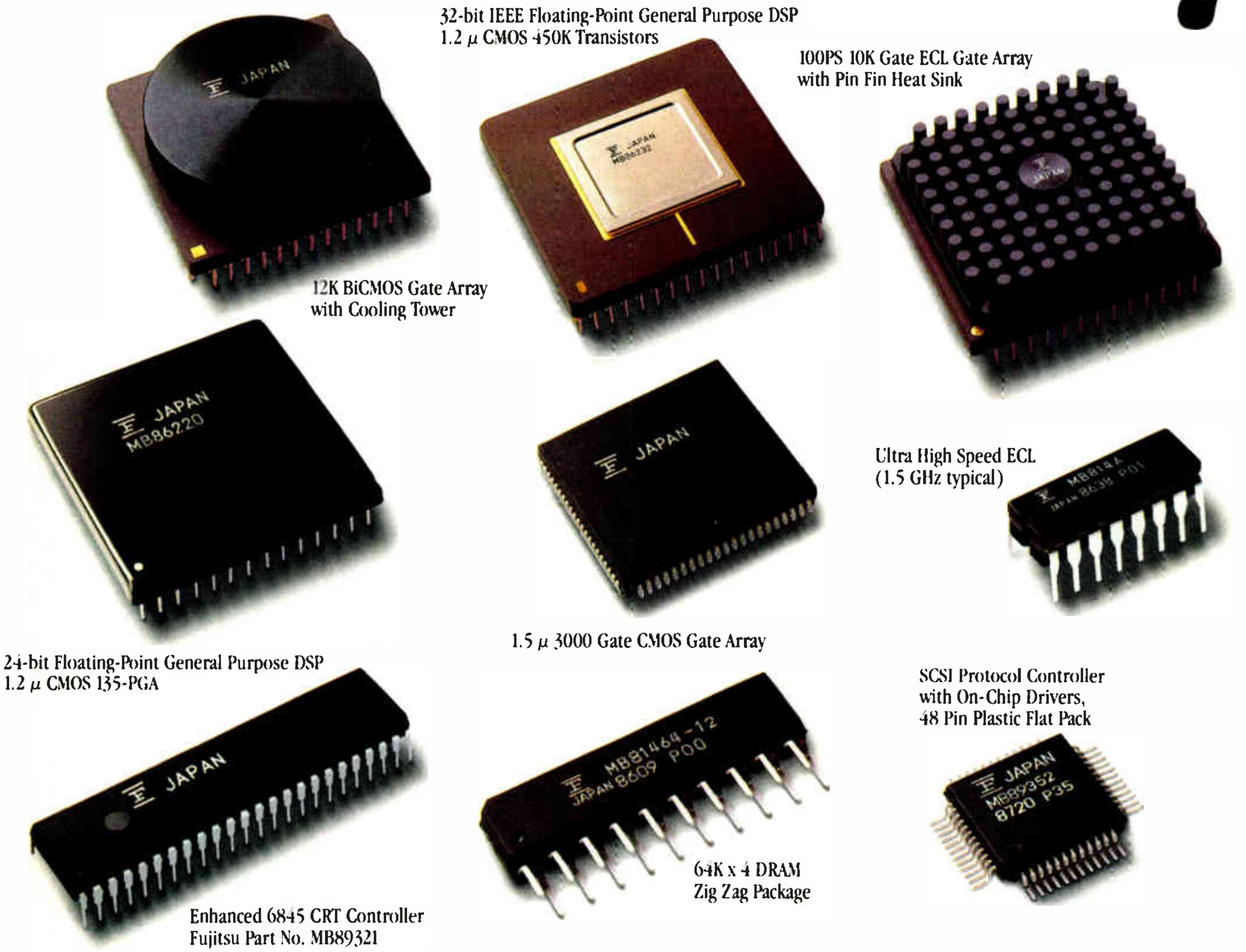

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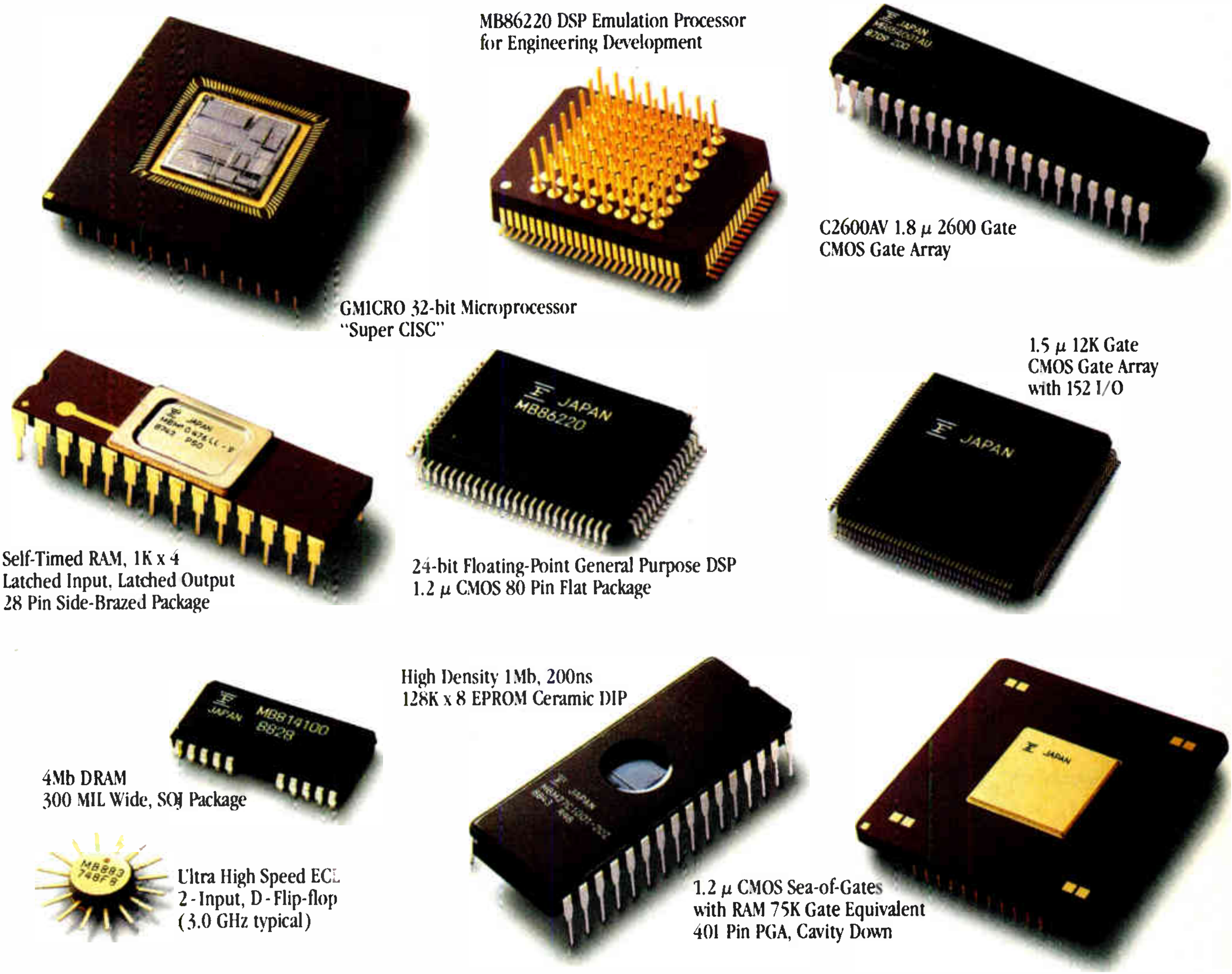

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WORLDWIDE NEWS ANALYSIS

COMPANIES TO WATCH

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DEPARTMENTS

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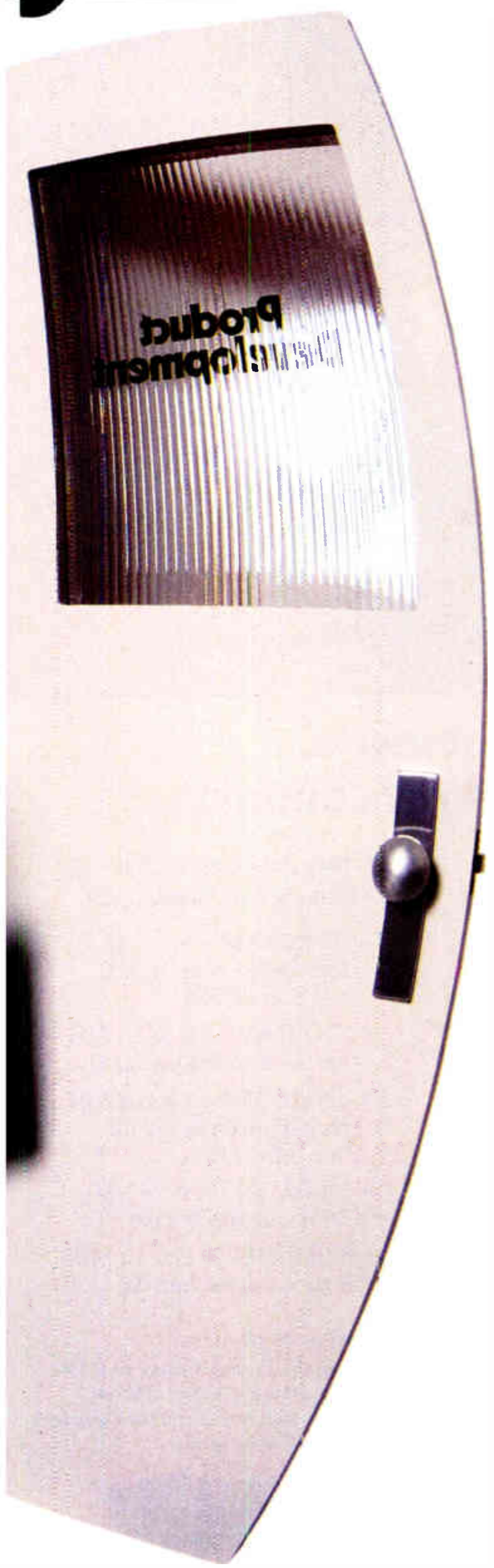
you're finished.



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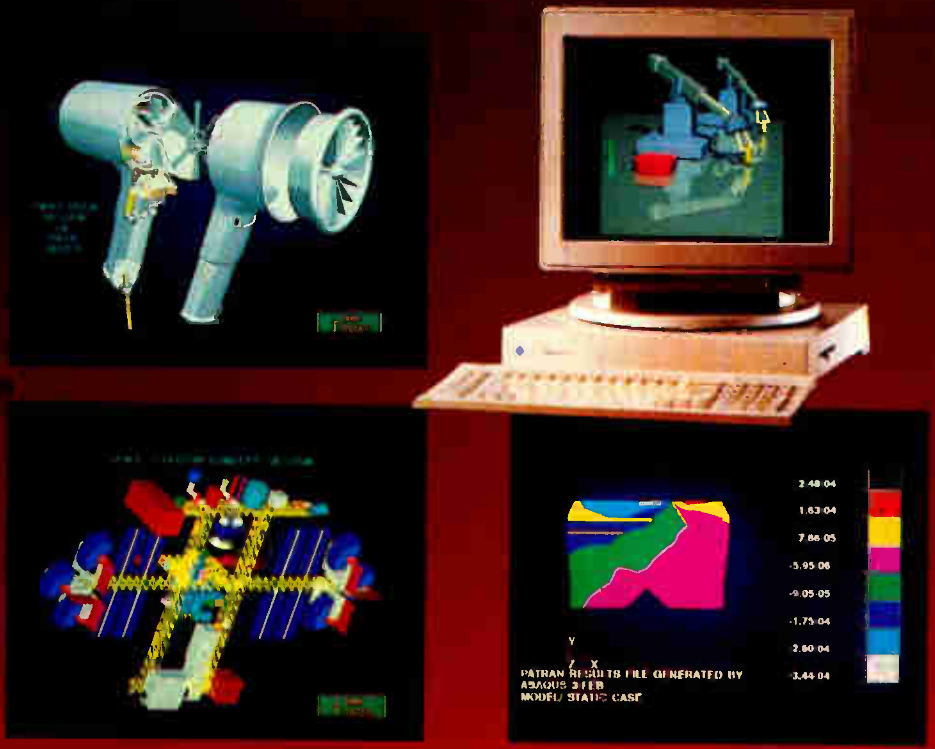

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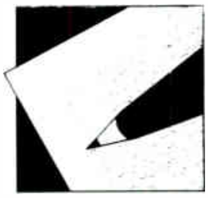
LETTER FROM THE TWIN CITIES

A MAINFRAME MINDSET MEANS TROUBLE IN MINNESOTA

MINNEAPOLIS-ST. PAUL



Most trace the initial seed for the computer industry here to 1946, when William Norris founded in St. Paul the company that would become Sperry/Univac's computer systems division. Norris later went on to form Control Data Corp. As the mainframe computer business took hold, both companies prospered, and they begat hundreds of other high-technology enterprises and spin-offs, which spread out across both sides of the Mississippi River in the Twin Cities of Minneapolis and St. Paul. And the rest, as they say, is history.

But the glory days may be over. The community that built its reputation on mainframes and other big machines over the last two decades has been rapidly losing luster in the 1980s as a high-technology kingpin.

Major restructuring and downsizing have been rampant among traditional big computer and electronics employers: Control Data, Honeywell, and Unisys have laid off or transferred thousands of workers out of the state during the decade. Smaller, once high-flying companies like CPT, Lee Data, and Network Systems have seen their fortunes fall. And Zycad Corp., another of the better-known names, is moving to California.

Downsizing is rampant among the region's big employers

Even supercomputer leader Cray Research Inc., itself a 1972 Control Data spin-off, has recently encountered a difficult market environment. Founder Seymour Cray is again spinning off to form a separate new company called Cray Computer Corp., to be based not in Minnesota, but in Colorado Springs.

"It's really only become visible in the last four or five years," says Roger Redmond, a technology analyst at Piper, Jaffray & Hopwood Inc. in Minneapolis. "The 1970s were really not too bad. But it's just becoming painfully clear now that we have an erosion. And when you look about, you sure don't see many new seeds of growth here."

Not all, of course, take such a pessimistic view. "Certainly, when you look at the mainframe computer industry and large engineering and scientific computing equipment, the Twin Cities is no longer the preeminent center that it used to be," concedes Robert de la Vega, deputy commissioner at the Minnesota Department of Trade and Economic Development.

"But I quarrel with the notion that on a broader range of technology industries that we're no longer a leader. When I look at medium-size technology-intensive firms in Minnesota and the Twin Cities, there are a lot of them. And they are growing."

In agreement is Herbert Johnson, president of the nonprofit High Technology Corridor Corp., which was founded in 1986 to promote development of a technology industrial research park on a 130-acre site in Minneapolis. Like de la Vega, Johnson notes that established employers such as MTS Systems, a maker of specialized test gear; Rosemount, an instrumentation and process-control equipment supplier; and DataMyte, which makes hand-held data recorders, for example, are all doing well.

"And there are still a lot of companies starting up," Johnson says. "But whether there are enough small companies moving up to displace the large ones, I can't really tell you. I don't think that anybody has the data."

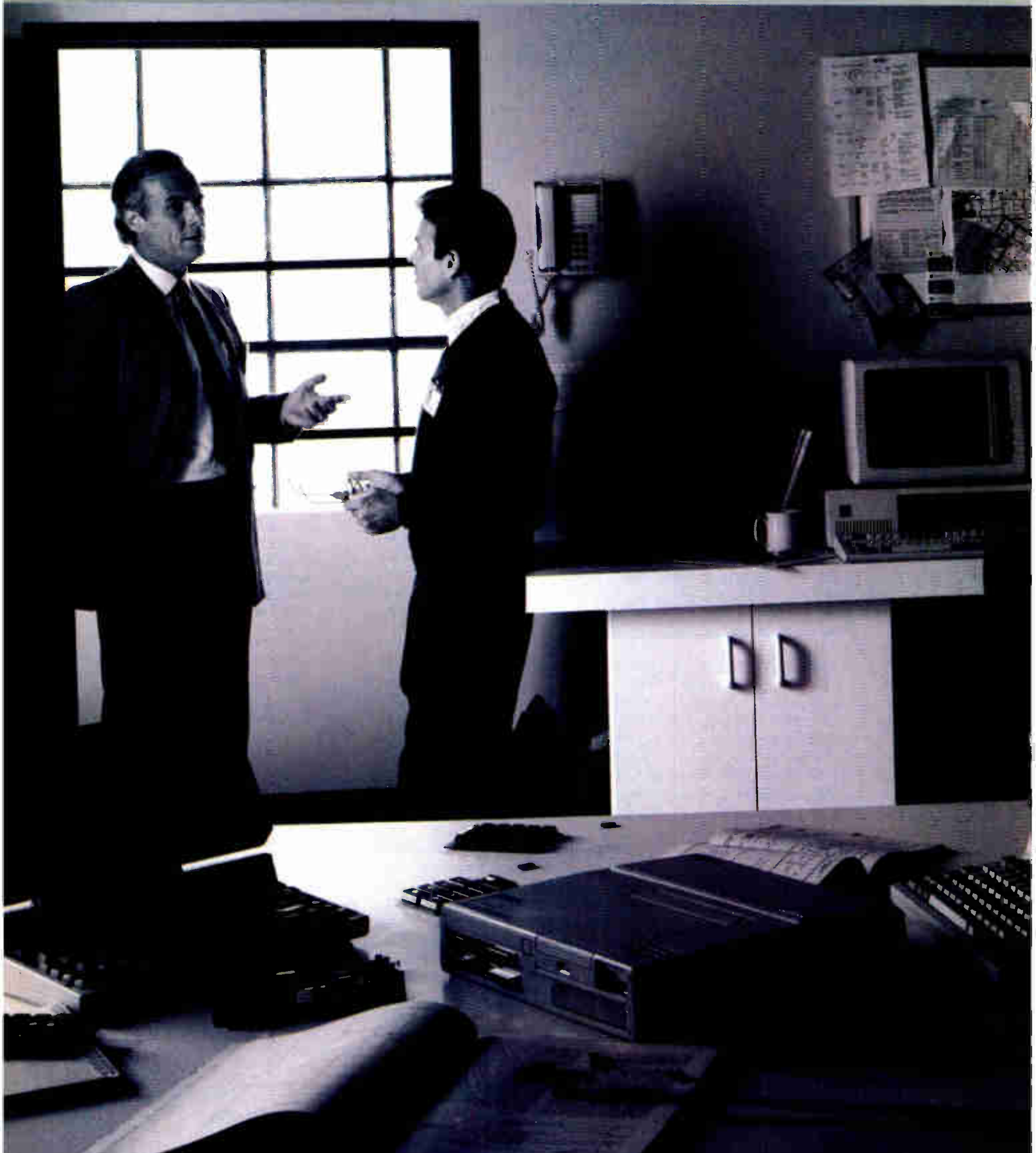
Other observers point to bright spots such as Rochester, Minn., about 70 miles to the south, where an IBM Corp. plant dedicated to Big Blue's midrange AS400 computer family is thriving.

Likewise, many note that the Twin Cities have become a booming center for medical-device technology such as pacemakers, hearing aids, and medical imaging and monitoring equipment—all increasingly electronics-intensive. In all, Minnesota is home to around 400 such companies, many under 10 years old, says Thomas L. Meskan, president and executive director of the Medical Alley Association, a Minnesota health-care-industry trade group. "In the last seven years, the number of jobs in Minnesota's medical-device industry has grown by over 50%," says Meskan, from 9,391 in September 1980 to 14,272 in the same month last year.

That's still a drop in the bucket, though, compared with the state's computer industry, which in 1986 employed 334,400, say officials at the Department of Trade and Economic Development. More recent numbers are hard to come by, says commissioner David Speer. But given the recent round of layoffs, "I'm sure the [computer industry] employment figures are down."

The biggest recent shock came in April, when Control Data shut down its ETA su-

"What do you think of when I say 4 Megabit DRAM?"



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percomputer operation in St. Paul, idling an 800-person technical work force plus 2,300 other Control Data employees, about 700 of them in the Twin Cities. Speer says that move alone could precipitate the loss of another 3,100 Minnesota jobs among ETA and Control Data suppliers and support companies.

Even more worrisome to some is the brain drain of high-caliber computer scientists and electrical engineers. As of early July, according to one sample taken at Control Data's outplacement office, around 80% of some 380 placed in new jobs since April have taken positions outside of Minnesota—in California, New York, and Texas. The other side of the coin, though, is a potentially fertile ground for startups founded by laid-off EEs who want to stay in the region.

So what has gone wrong in Minnesota? Some say the changes in the Twin Cities computer infrastructure are the natural result of a slowing in high-tech markets everywhere and of a global restructuring in the industry. But others lay much of the decline at the door of local management either unwilling or not nimble enough to adapt to industry changes.

"As the computer world matured, it moved away from mainframes," says Chuck Denny, chief executive officer at ADC Telecommunications Inc. in Bloomington and a founder of the Minnesota High Technology Council, an industry lobbying group. As microcomputers were taking hold, "we sat here and were still devoted to mainframes, and moving further into scientific computing with Control Data and Cray."

TAXING CLIMATE. Minnesota's unfavorable business-tax climate has also played a role. The state ranked sixth overall in a recent national study of manufacturing climates and second in such quality-of-life issues as education, health care, cost of living, and transportation. But it came in 47th in state-regulated employment costs such as workers compensation and unemployment insurance benefits.

In the end some local observers are downbeat. "I don't understand what kind of changes the industry could make that could turn things around," says Jeffrey Green, cochairman for the Minnesota Council of the American Electronics Association. "The electronics industry has never developed because someone tried to encourage it. It develops because of a need and people rushing in to fill it."

But Speer, for one, remains optimistic. "The fact that some enterprises are able to sustain themselves through downsizing is not necessarily a defeat," he says. "They are sustaining against the time when they can be competitive again. We are going through some changes now. But once we get through this, the jobs will be there, and they will be high-paying jobs." *–Wesley R. Iversen*

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ELECTRONICS NEWSLETTER

HEWLETT-PACKARD AND HITACHI EMBARK ON RISC VENTURE

In the wake of major announcements by Sun Microsystems and MIPS Computer Systems of accords with semiconductor companies to build their microprocessor architectures, Hewlett-Packard Co. is announcing its own deal. The Palo Alto, Calif., company is licensing Hitachi Ltd. of Tokyo to codevelop a new, high-speed chip set based on HP's RISC technology. The pact gives HP access to Hitachi's latest CMOS processes to build next-generation versions of its RISC-based Precision Architecture devices. Until now, HP has had no strength in CMOS, relying instead on n-MOS technology for the HP PA. The companies plan to build proprietary high-performance computer systems based on the resulting chip set, which will run at a minimum of 100 million instructions/s when it is introduced in 1992. And HP promises other strategic relations to obtain an ECL or a very low-cost version of the HP PA. □

15 SOFTWARE DEVELOPERS LINE UP BEHIND DATA GENERAL'S AVIION

Data General Corp. has accelerated the pace of its efforts to port application software to the firm's Aviion family of RISC work stations, servers, and systems, introduced earlier this year. The Unix-based work stations are built around the Motorola 88000 RISC microprocessor, and to quell buyers' qualms about the availability of software, the Westboro, Mass., minicomputer company has trotted out 15 software firms with products running on the Aviion family ranging from data bases to graphics packages to spreadsheets. Included are Oracle's data-base program, Relational Technology's Ingres data base, Access Technology's 20/20 spreadsheet, and Nova Graphics International's GKS graphics software. □

IS THE SEMICONDUCTOR SLUMP HERE AT LAST?

Semiconductor market seers have chalked up more misses than bull's-eyes of late, but as of midsummer they agree that the oft-predicted chip downslide finally is under way. The seasonal order softness that develops every summer is giving off signals that the usual fall snapback will just not happen, market watchers say. Weakening demand for DRAMs along with the maturing of the computer business and a general slowing of the economy are fingered as the culprits. The result is agreement from the likes of consultant In-Stat Inc. in Scottsdale, Ariz., and the Semiconductor Industry Association in Cupertino, Calif., that up to a year of flat to down chip business lies ahead. Both predict negative growth through the rest of 1989. □

SILICON GRAPHICS UNVEILS DESKTOP PARALLEL SUPERCOMPUTER

Much like their high-end counterparts, desktop supercomputers such as those from Apollo, Ardent, and Stellar traditionally get their computational clout from using up to four vector and scalar processors. Now Silicon Graphics Computer Systems is jumping on the parallel-processing bandwagon; multiple parallel processors in the new Power Center 4D/280 let it execute up to 160 million instructions/s and 28 million floating-point operations/s. "Parallel architectures are going to displace vector processing," predicts Paul Koontz, product line manager at the Mountain View, Calif., company. "Our 28 megaflops are based on the results of actually running the Linpack benchmark, not the unachievable peak ratings others quote." Set to ship in September, the $172,500 machine comes with eight processors, each powered by an R3000 CPU and R3010 floating-point coprocessor from MIPS Computer Systems Inc. The moderately parallel architecture resembles that of the new ES-1 supercomputer from Evans & Sutherland (see p. 83). □

ELECTRONICS NEWSLETTER

UNLIKELY PARTNERS: DARPA AND CRAY LOOK AT MACH

The times they are a-changin' in the U. S. supercomputer industry. One of the latest signs comes with word that the Defense Advanced Research Projects Agency is getting together with Cray Research Inc. to transfer the Mach operating-system kernel to Cray machines. Developed with Darpa funding at Carnegie Mellon University, Mach is designed for networked supercomputers of the massively parallel variety—the type that Darpa has backed in its advanced-computing research efforts, but not the kind made by Minneapolis-based Cray. The project, which signals Darpa's attempt to forge ties with the traditional U. S. supercomputer base, has a long way to go: the scope, timing, and even feasibility of transferring Mach to Cray machines remain to be seen, says an official at the Lawrence Livermore National Laboratory, which will work with Cray and Darpa on the project. Darpa sees Mach as a successor to the Unix operating system. □

NOW, AN INSURANCE POLICY FOR COMPUTER VIRUSES

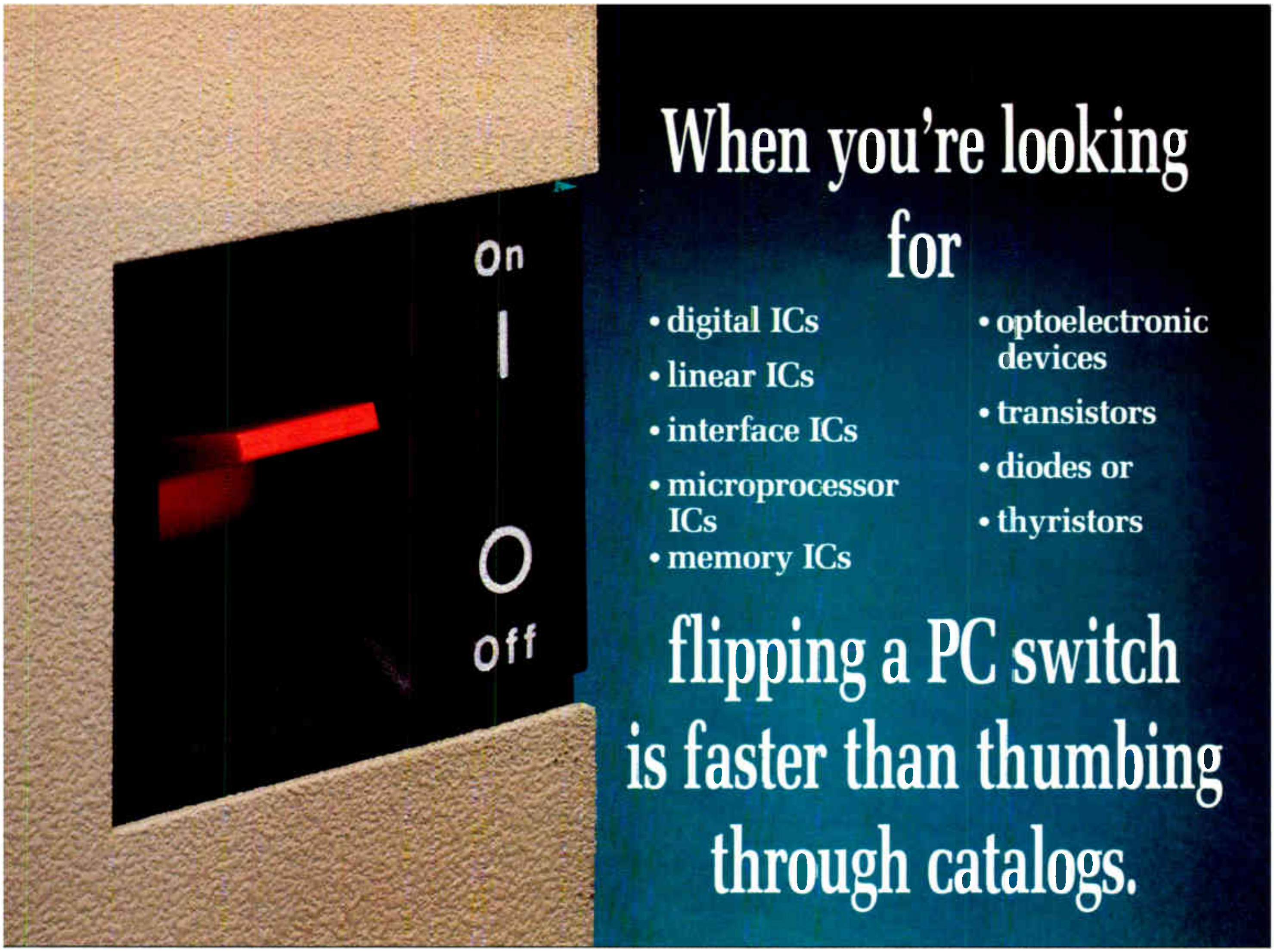
Businesses can now buy insurance covering damages or loss of data caused by computer viruses. Allstate Insurance Co. of Northbrook, Ill., says it is the first to explicitly provide the coverage, which was added recently at no additional cost to owners of the company's standard electronic data-protection policy. "There's a great deal of confusion about computer viruses, and a lot of [insurance] companies are saying maybe it's covered and maybe it's not. So we're putting our money where our mouth is," says Dean Garland, an Allstate manager. But Allstate is covering its hindside. The current package limits virus damage coverage to $100,000. And though additional coverage may be purchased for an added premium, "we're not interested in writing really jumbo kinds of things," says Garland. □

GEC AND PLESSEY CALL A TEMPORARY TRUCE

Last month's agreement between General Electric Co. plc and Plessey Co. plc to form a consortium to bid for a lucrative government license doesn't mean the end of hostilities between the two British electronics giants, but it could signal a warming trend. The consortium is going after one of the Personal Communications Network licenses the UK Department of Trade and Industry will award this year for low-cost digital cellular service based on pocket-sized mobile telephones—a market that could be worth $3 billion annually by the year 2000, analysts say. A third partner is Atlanta-based BellSouth Corp., the world's largest operator of cellular telephone networks. Despite the communications partnership, the two UK companies remain embroiled in a hostile takeover bid, with GEC and cohort Siemens AG of Munich attempting to purchase Plessey. The new move does not signal an armistice but an attempt to ensure that neither firm misses out on a big new market. □

HP LANGUAGE WANTS TO TALK TO ALL INSTRUMENTS

When engineers build instrument systems around the IEEE-488 bus and the newer VXIbus, they must create separate programs to run each tool. Hewlett-Packard Co. is making the job easier by offering its high-level in-house instrument-system programming language commercially. The Palo Alto, Calif., company is releasing the test-and-measurement language, or TMSL, this month. It gives engineers a generic language to direct all types of instruments, from digital multimeters to spectrum analyzers and oscilloscopes, with very broad commands, eliminating the need to write lengthy and detailed programs. HP is searching for an existing standards organization to maintain and enhance the language. □



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Circle 13

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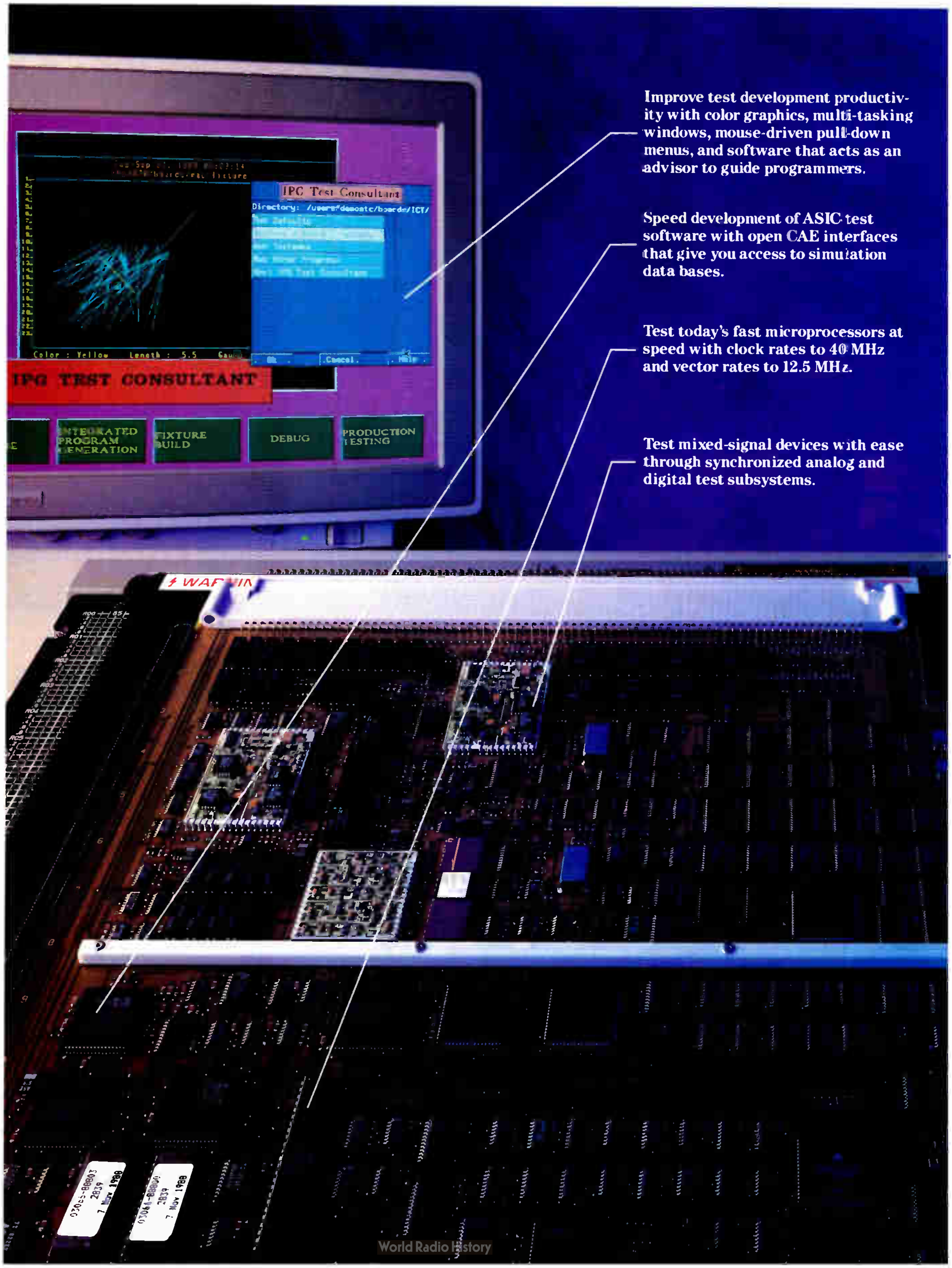

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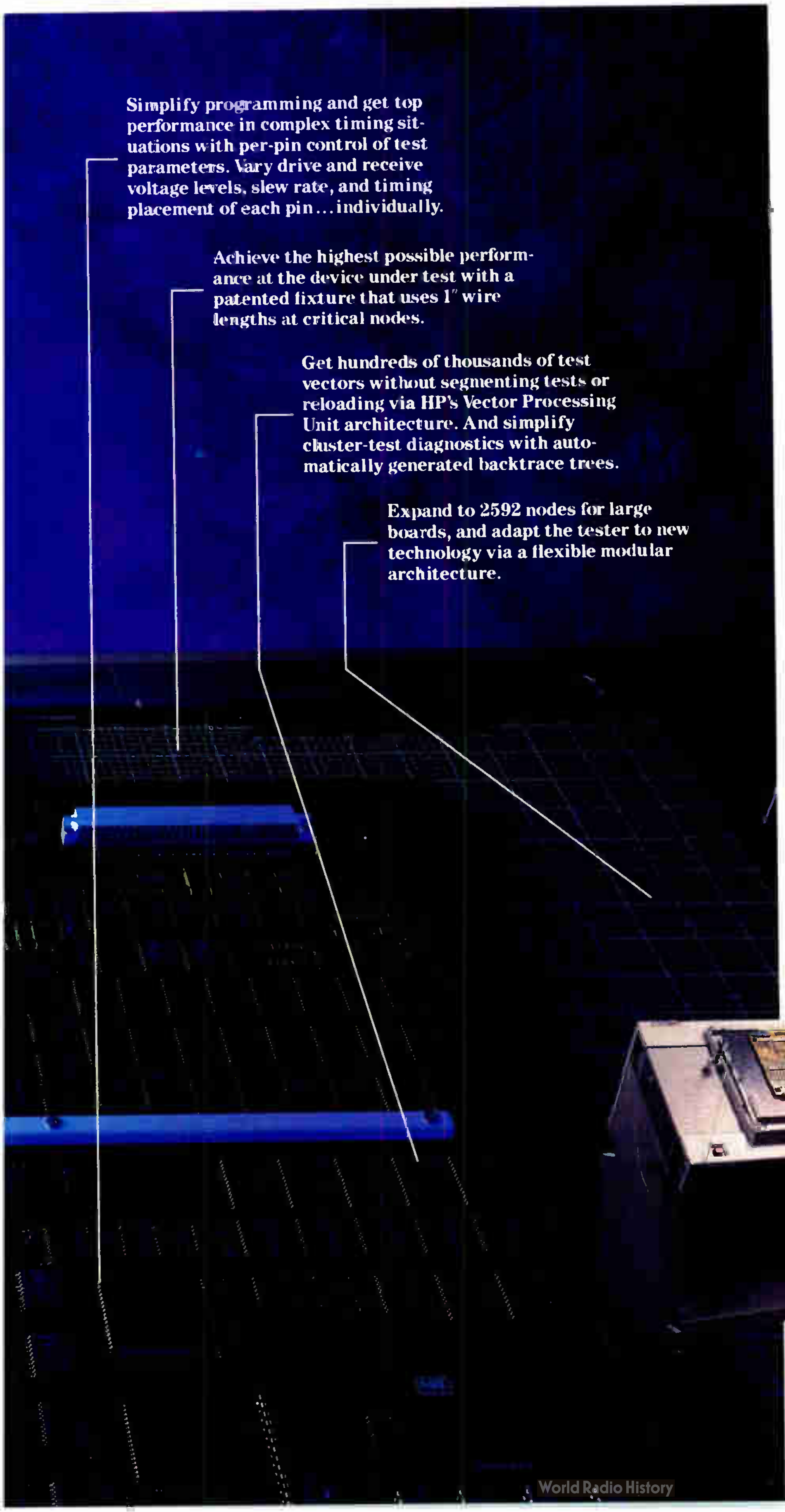

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Circle 14

PRODUCTS TO WATCH

SGS-THOMSON'S SMART-POWER IC PACKS MORE FUNCTIONS ON-CHIP

Large-scale integration is coming to smart-power integrated circuits. Latest on the scene is the L6280 from SGS-Thomson Microelectronics Inc. of Phoenix, Ariz. With 4,000 switching transistors and 14 power transistors, the 44-mm^2 chip packs two 1-A motor drivers, a 3-A solenoid driver, and a 5-V, 1-A switching power supply. The L6280 contains an 8-bit microprocessor-compatible parallel bus and can be configured in software to drive different load types. The L6280 will sell for $8.75 each in 100,000-unit quantities. Samples are available now; production will begin early next year. □

YU INSTRUMENTS' DEVELOPMENT SYSTEM CAN GO INTO THE FIELD

With the rapid spread of embedded controllers in all types of equipment comes the need for a portable microprocessor-development system to program and repair controllers in the field. Now, a tiny Cypress, Calif., company is providing one. The FDS-128 from Yu Instruments is not only a portable system with emulation pods for most popular 8- and 16-bit chips, but the self-contained unit has more features for the price than any other development tool, the company says. Less than $4,000 buys in-circuit emulation, 40-MHz multichannel logic analysis, an EPROM/PAL programmer, a built-in graphics printer, plus a rechargeable battery pack. □

SUN AND SYMBOLICS TEAM UP TO MARKET IVORY PROCESSOR

Application developers in artificial intelligence and CAD/CAE using Sun 3 and 4 work stations from Sun Microsystems Inc. will soon have access to the Genera development software and the Ivory symbolic microprocessor from Symbolics Inc. of Burlington, Mass. The two companies will jointly market the UX400S add-in board and Genera software starting in September. AI is a growing market for Sun work stations, accounting for as much as 10% of total revenues, says the Mountain View, Calif., company. The processor board and VMEbus interface sell for $21,900; the object-oriented Genera software environment sells separately for $9,500 per processor. □

CONCURRENT PUTS MULTIPROCESSOR FORTRAN CONVERSION IN THE FAST LANE

Converting Fortran programs running on single-processor hardware to multiprocessor systems should be much easier and faster with Concurrent Computer Corp.'s E/SP programming environment. Scientific programs that used to take months to convert manually can now be done in weeks, says the Tinton Falls, N. J., company. The converted programs run only on Concurrent's Series 3200 family now, but the company is ready to introduce E/SP environments for other multiprocessor systems. Programs are converted on work stations from Concurrent, Sun Microsystems, and Apollo Computer. Prices range from $17,500 for Concurrent's 5000/6000 series to $19,000 for Sun and Apollo platforms. □

TEKTRONIX'S 88000 RISC COPROCESSOR REVS UP MAC II APPLICATIONS

Tektronix Inc.'s RP88 coprocessor board can step up as much as thirty-fold such computation-intensive jobs as modeling, simulation, and image processing on Apple's Macintosh II series computers. The Beaverton, Ore., company is the first to put Motorola's 88000 reduced-instruction-set computer chip on a coprocessor board for the Mac II. With a built-in floating-point processor, the board executes up to 17 million instructions/s and operates at 20 MHz. The board, which is equipped with 2 Mbytes of DRAM and 32 Kbytes of cache memory, sells for $9,575. □

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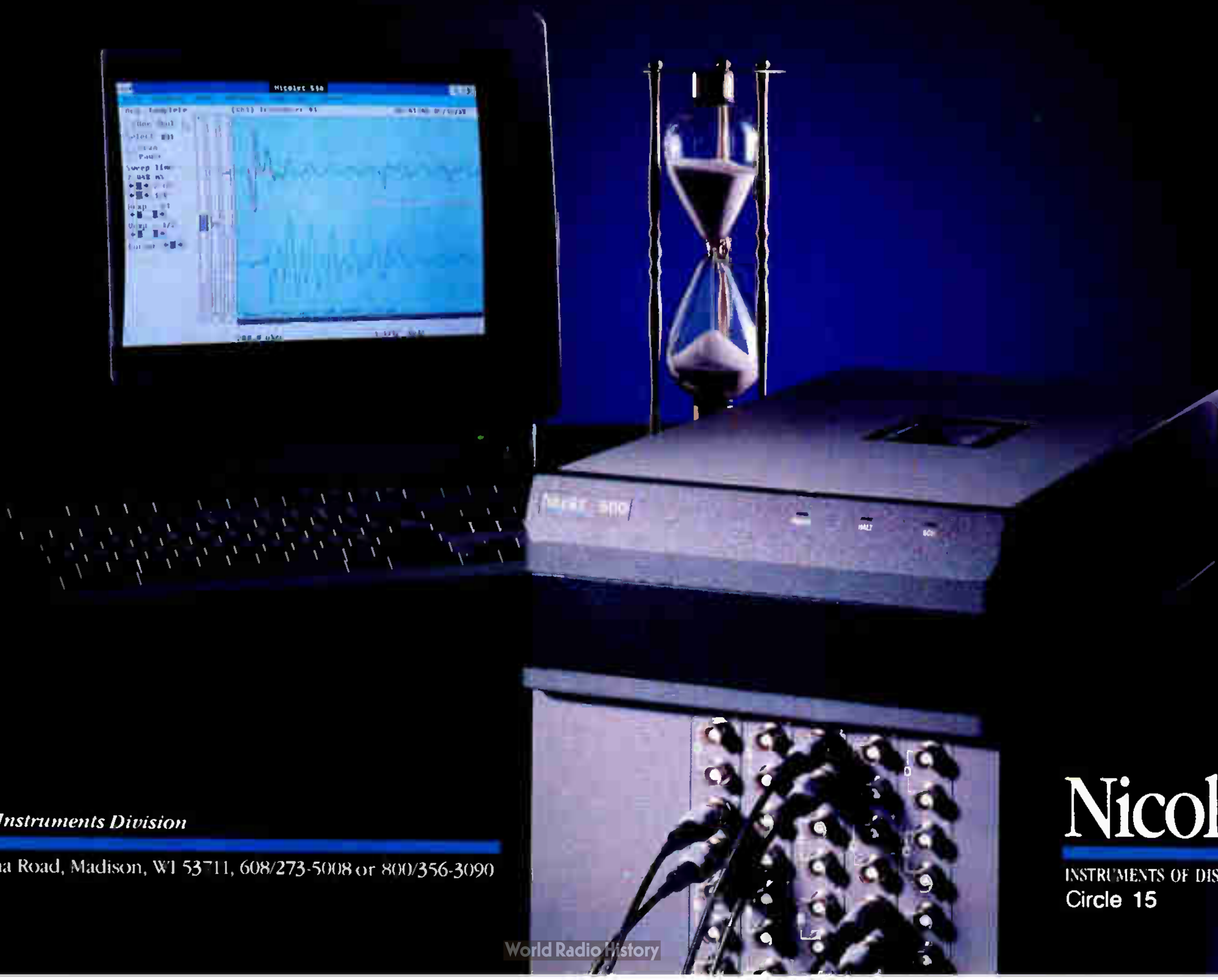

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Circle 15

Electronics

CAN U. S. MEMORIES PULL 4-MBIT DRAMs OUT OF THE HAT BY 1991?

The consortium faces some hurdles first—including finding $1 billion in financing

LOS ANGELES

If there is a bedrock belief to which most American chip makers earnestly subscribe, it is that more dynamic random-access memories should be made in the U. S.—and soon. So the initial wave of support for the U. S. Memories Inc. consortium, unveiled in late June to do just that, was not surprising.

But now it's the morning after. Though most experts expect U. S. Memories to meet its timetable, the powers behind the new company, pushing to get the program on the road, confront formidable barriers, some of which caused U. S. manufacturers to fall behind or quit the DRAM business in the first place.

Start with financing. The entry fee to the DRAM sweepstakes is staggering; U. S. Memories' requirement for upwards of $1 billion requires backing from many sources. Not the least of these is the U. S. government, a notoriously fickle partner that is ticketed for loan guarantees of half the total. The production plant itself likely will cost more than $500 million, the ante for a state-of-the-art fab line capable of the submicron geometries necessary for turning out the 4-Mbit DRAMs slated as the first product in 1991.

HARMONY. Then there is the need to orchestrate harmony in a consortium that eventually could number nearly 20 companies, in itself a daunting assignment in an industry not known for selfless teamwork. Time is of the essence, too, because meeting the 1991 product release date requires having all the fundamental elements—funding, technology, business plan, and antitrust exemption—pretty much in place by the end of this year.

Still, despite the obstacles, the consensus is that U. S. Memories will meet its milestones close to schedule. "I'm not sure it's so difficult to make it succeed," says G. Dan Hutcheson, executive vice president of VLSI Research Inc., the San Jose, Calif., semiconductor manufacturing consultants. "It's not too different from any venture-backed startup, except for the $1 billion entry fee."

Hutcheson is among those who believe that U. S. Memories represents the last, best hope to have an economically sound vehicle to keep pace with advanced memory technology, which has proven to be the driver for all other products. For example, processes involved in 4-Mbit DRAMs will support the next generations of logic and other components. "The U. S. is moving toward the technology wall and risks the danger of being obsolete," says Hutcheson, unless a project such as this opens the way for the majority of companies that don't don't have leading-edge memory skills.

It's that realization that finally forced the power brokers of the U. S. industry to shrug off the false starts and put together a workable plan to produce DRAMs. Insiders say that the breakthrough came when IBM Corp. threw itself wholeheartedly behind the plan that emerged under the auspices of the Semiconductor Industry Association.

One of seven SIA members involved in the plan, IBM will license its own 4-Mbit DRAM design and manufacturing technology to the consortium. The president and chief executive officer of U. S. Memories will be one of IBM's own: Sanford L. Kane, formerly vice president of Big Blue's General Technology Division. Kane also had a leading role in forming Sematech, the design and process consortium based at Austin, Texas.

The IBM link gives U. S. Memories "instant credibility," says a consortium insider. "Without it, there wouldn't be much chance [of success]." Having the 4-Mbit design and process in hand neatly solves what had always been one of the toughest problems any cooperative U. S. DRAM venture faced, he adds.

Other initial backers include Advanced Micro Devices, Digital Equipment, Hewlett-Packard, Intel, LSI Logic, and National

JAPANESE ARE OUT FRONT IN 1-MBIT DRAMs

Rank	Company	1988 Units (1,000's)	1988 Market Share	1987 Units (1,000's)	1987 Market Share
1	Toshiba	48,000	28%	16,000	47.1%
2	NEC	26,000	15%	3,000	8.8%
3	Mitsubishi	25,000	14%	5,500	16.2%
4	Hitachi	19,000	11%	3,500	10.3%
5	Fujitsu	14,000	8%	2,000	5.9%
6	TI	11,000	6%	1,500	4.4%
7	Matsushita	9,000	5%	1,500	4.4%
8	Oki	4,500	3%	0	0%
9	Siemens	4,500	3%	100	0.3%
10	Samsung	4,000	2%	0	0%
11	Micron	2,500	1%	0	0%
12	NMB	2,500	1%	1,000	2.9%
13	Motorola	700	0.4%	0	0%
14	Vitelic	700	0.4%	0	0%
15	Alliance	500	0.3%	0	0%
16	Hyundai	500	0.3%	0	0%
17	Sharp	500	0.3%	0	0%
	Total	172,900	100%	34,100	100%

Source: In-Stat inc.

Semiconductor. The principal motivator behind the SIA committee that recommended establishing U. S. Memories was Wilfred Corrigan, LSI Logic's chairman and CEO, who has been named chairman of the consortium.

On the funding front, Kane and others are writing a detailed business plan needed before members' specific financing commitments can be nailed down. No single firm will contribute more than 10% of the $500 million sought, or less than 1%. The original seven companies will likely provide a good part of the total, with maybe another dozen firms needed to fill in the rest, sources say. Interest is keen enough so that some observers see this phase as one of the easier parts of the organization task. "They'll have no trouble raising the cash," says Adam F. Cuhney, a vice president at Kidder, Peabody & Co. in New York.

The intent is for the government to guarantee another $500 million to complete the financing. Funding agreements will provide that supporters must buy a percentage of device output equal to half their investment share, at a guaranteed competitive price.

The goal for the new cooperative venture is ambitious: 5% to 10% of the world 4-Mbit DRAM market by the mid-1990s. That market, as estimated by Scottsdale, Ariz., market watcher In-Stat Inc., will amount to 876 million units at an average selling price of $11.05 apiece, for a total of $9.7 billion. Thus, U. S. Memories could become a $1 billion company in its own right.

The impact on the U. S. market would be even more dramatic. U. S. Memories' share would be perhaps 20%, which would help satisfy one of the consortium's chief aims: to make U. S. equipment makers less dependent on foreign sources. That popular goal has declawed most of the potential critics at home. Even domestic DRAM competitors Micron Technology, Motorola, and Texas Instruments say the consortium poses little threat to their own efforts, since they cannot begin to take away market share from offshore suppliers at present.

Curiously, analyst Hutcheson believes that the dominant Japanese memory producers will also welcome the new initiative. His reasoning: the Japanese need a competitive DRAM presence in the U. S. beyond the efforts of Motorola, TI, and Micron to help defuse the trade issue. "They want strong U. S. competition—but not too strong," he says.

WELCOME. One top U. S.-based manager of a major Japanese supplier sees the matter in somewhat the same light. "I welcome it [U. S. Memories]," says William Gsand, vice president and general manager of the Semiconductor Division at Hitachi America Ltd. in Brisbane, Calif. "I'd much rather see a U. S. competitor than one from Europe or the Third World." Gsand thinks the development is a way to aid U. S. DRAM buyers and would like to see it succeed. "Who can argue with the enthusiasm for the rebirth of the U. S. semiconductor industry?" he says.

Still, Hutcheson and Gsand see anything but easy sledding ahead as U. S. Memories tries to hit the 1992–95 window when 4-Mbit use will peak. "It's a tough challenge," says Gsand, who thinks the most difficult part will be for U. S. companies to stay the course when competition becomes most intense in peak years. Hutcheson predicts that DRAM pricing will be the problem most likely to trip up U. S. Memories, when all the production capacity now contemplated worldwide hits the market. "There could be a price collapse" lurking in the future, he fears.

But Hutcheson also goes on record with a positive prediction: "It will get up and running, but late like everything else," he speculates. "But in the end, it will produce memories and everyone will benefit." *–Larry Waller*

AT&T NABS A BIG WIN FOR JAPAN'S FIRST SONET

NEW YORK

The next wave in the ongoing reconstruction of the global telecommunications network is about to break in Japan—with a key assist from a leading U. S. technology company. By winning a $154 million contract to supply optical devices and VLSI chips to Nippon Telephone & Telegraph Public Corp. over four years, AT&T Network Systems has boosted its chances of becoming a leading supplier of components for the rapidly evolving, ultrahigh-speed Synchronous Optical Network standard.

NTT will start building its Sonet-based network next year—before the International Telegraph and Telephone Consultative Committee finalizes its Sonet protocol standards. But AT&T's components can be used in the U. S. and European telecom-company versions coming down the pike. "The chips are being designed in cooperation with American and European development teams," says Rudolf Hecken, director of AT&T Bell Laboratories' Radio and Terminal Laboratory in Andover, Mass.

The reason that AT&T teams in the U. S. and the Netherlands took part in the effort, he says, is to ensure that the same chips can be used in North America and Europe. The work is also proceeding according to specifications laid down by NTT. The differences between Sonet Phase 1, which is being implemented in Japan by NTT, and Sonet Phase 2, which will be finalized in 1990, can be resolved in firmware and programmable logic devices, according to Hecken.

When the chip set will become available to anyone besides NTT, however, is another matter. Richard Jacobs, director of application-specific integrated-circuit marketing for AT&T Microelectronics in Berkeley Heights, N. J., says the 10 chips, which are in various stages of design and testing, are considered a proprietary development for NTT, and AT&T Microelectronics has no other plans for marketing them now.

Designed by Bell Labs, the chip set will be manufactured at AT&T Microelectronics' foundry in Reading, Pa. Eight of the 10 chips are fabricated in 0.8-μm CMOS, and the other two are fine-line n-MOS. All are based on polycells. The 8-Mbit/s parallel-processing sections are being designed with automated tools, while the sections requiring faster speeds "are pretty much custom designed," says Hecken. The chips support data rates up to 622 Mbits/s, he says.

An undetermined number of additional chips—not part of the NTT deal—must be designed to support Sonet's uppermost data rate. Sonet standards call for four incremental data rates: 55, 155, and 622 Mbits/s, and 2.4 Gbits/s. The network's synchronous operation is a departure from existing high-speed telecommunications networks, which are asynchronous.

Although the market for Sonet chips and lightwave components is generally assessed as being substantial, actual forecast figures are hard to come by. John Kessler, president of KMI Corp., a Newport, R. I., research firm specializing in fiber optics, says his forecasts do not now include a Sonet category, but that the overall fiber-optic market in the U. S., including cable, is expected to grow to $2.9 billion in 1992, up from $1 billion this year.

> Sonet will be a standard for systems installed in the next 2 to 10 years

"NTT's Sonet installation can't hurt the U. S. market," he says. "It will push the standards groups working on Sonet to finish their work sooner so other telecom companies won't come up with de facto standards." AT&T's Hecken calls the task of estimating the Sonet market "a million-dollar question," adding that the Belgian telecommunications-equipment supplier Alcatel, based in Brussels, is touting Sonet's benefits in Europe as a way to build an intelligent network.

A Sonet signal is made up of two components, one carrying system traffic and the other carrying administration and network-management data. Sonet will help telecom carriers improve maintenance and introduce sophisticated new services more quickly. The standard will also allow equipment from different vendors to communicate, but interoperability will be most pronounced with the Sonet Phase 2 version.

AT&T isn't the only supplier of Sonet chips or lightwave components. Having multiple suppliers is an integral part of NTT's procurement policy, says Shunji Kaibuchi, executive vice president for procurement and supply. Two Japanese chip makers, Fujitsu Ltd. and NEC Corp., both of Tokyo, are also developing Sonet chip sets for NTT. They have not been awarded contracts but are close to getting them, says Kimio Tazaki, executive director of NTT's Network Systems Development Center.

The installation of Japan's Sonet network will begin in the Tokyo area and eventually encompass the entire nation. The chip/lightwave component modules AT&T will supply implement Sonet's 156- and 622-Mbit/s data rates and allow transmissions up to 80 km without regeneration, says Peter Fenner, president of AT&T Network Systems Transmission Systems Group.

In the U. S., AT&T already offers a 1.7-Gbit/s telecommunications backbone, says Fenner, and it has developed prototypes of digital synchronous communications that are Sonet-compatible and run at Sonet data rates. But the NTT deal represents the company's first production-volume Sonet products. The regional Bell holding companies in the U. S. have been slow to order Sonet-compatible systems, he says, because "they all have to work together," whereas NTT is a monolithic telecommunications company. "If we still had one Bell system, we would have Sonet earlier," Fenner says.

While the Sonet chip set represents all new development, AT&T leveraged its existing lightwave technology to supply NTT with photonic devices, such as receivers, transmitters, and regenerators. Photonic devices already exist for Sonet's 55-, 155-, and 622-Mbit/s data rates, says Ed Labuda, executive director of Bell Laboratoriess' Electronic and Photonic Devices Group.

VALUE ADDED. The 2.4-Gbit/s devices will be extensions of AT&T's 1.7-Gbit/s technology, which is already in use in AT&T's existing lightwave transmission systems. The value added in the NTT contract, he says, is in its much higher level of integration of the transmitter and receiver into a single module. "What had been a board-level product has now been fitted into a 2-by-4-in. package," Labuda says. "It's not quite the size of a chip, but we're getting there."

The modules have also been designed for easy installation and maintenance because they will be used more widely than they have in the past.

"Sonet will be a world standard for any transmission system installed in the next 2 to 10 years," says Labuda. The transmitters include the 1230-type Sonet transmitter, a custom design for NTT, and the 1227-type transmitter, both laser-based modules from AT&T's Astrotec product line. The system will use a variety of laser types, including 1.3 μm, 1.5 μm, and multifrequency. *–Jack Shandle*

WORK STATIONS

DEC PUTS ITS WEIGHT BEHIND RISC AND UNIX

MAYNARD, MASS.

When Digital Equipment Corp. unveiled its first reduced-instruction-set computing, Unix-based work station in January, the computer community was a bit skeptical. How heavily committed was the company to a product line that doesn't use DEC's VAX architecture and VMS operating system? But after DEC let go another broadside of products last month, nobody could overlook the fact that the Maynard-based computer giant is backing RISC and the Unix operating system in a big way.

DEC embraced Unix only recently, having long trumpeted the virtues of the VAX/VMS product line as almost the sole solution to any customer's computing needs—from the desktop to the data center. But this latest salvo includes the lowest-priced color RISC work station to date, as well as two series of RISC minicomputers. DEC also beefed up the VAX line with a new processor and added Network Application Support software that eases the networking of computers from different vendors running a variety of operating systems.

YOUR WAY. With last month's product introductions, DEC is sending at least two strong signals to customers and competitors alike. Charles T. Casale, president of the Aberdeen Group, a Boston market research firm, says the company is clearly shifting from its 1980s "one size fits all" VAX/VMS strategy to a "have it your way" approach for the 1990s by allowing customers to choose VAX/VMS, RISC/Unix, or MS-DOS, OS/2, or the Apple operating systems in a network that also includes personal computers.

"If you need RISC/Unix," Casale says, "Digital has thrown down the gauntlet, saying 'why not buy from a robust company and get more while paying less?' DEC has virtually eliminated any doubt about its commitment to VAX/VMS and to the noisy but numerically small Unix fraternity by delivering exactly what each has asked for."

Further, Casale maintains that the price/performance levels of this new round of products "will have Digital's competitors scurrying for a new product or pricing round." DEC is inviting comparisons of the DECstation 2100 with products from RISC heavyweights Sun Microsystems Inc. and Hewlett-Packard Co. The color version of the DECstation 2100 sells for $11,450, compared with $12,495 for the Sun SparcStation 1, Sun's flagship work station, which was introduced in April. A monochrome model sells for $7,950.

With another broadside of RISC products, DEC sets a new price/performance level

The minicomputers include the multiuser DECsystem 5400, for which prices begin at $49,900, as well as two more powerful platforms—the uniprocessor DECsystem 5810 and dual-processor 5820. All of the RISC computers run Ultrix, DEC's version of Unix, and all are binary-code-compatible with one another and with the new DECstation 3100 [*Electronics*, February 1989, p. 49].

The new DECstation 2100 uses a 12.5-MHz (10.4 million instructions/s integer performance) R2000 processor supplied by MIPS Computer Systems Inc. of Sunnyvale, Calif. All the new RISC minicomputers are built around the MIPS R3000 processor and R3010 floating-point chip, which allows integer performance of 16.6 mips; no floating-point rating was available initially. More RISC-based Unix platforms are planned by DEC, which isn't the least bit timid about its push into such industry standards as a strategy to augment its VAX/VMS platforms.

Another DEC watcher, Terry Shannon at International Data Corp., Framingham, Mass., is impressed with the breadth of the RISC/Unix offerings Shannon adds that the fact that DEC "brought out a full family of products in just six months [since the initial introduction] is evidence that it's serious about RISC/Unix. I think one of its primary goals is to become No. 1 in that market." In fact, Shannon wouldn't be surprised to see DEC move back to a single-hardware architecture that's RISC-based rather than VAX-based.

In introducing the new products, DEC president Kenneth Olsen downplayed any conflict with the VAX/VMS line that might be read into DEC's embrace of RISC and Unix: "The new VAX and RISC/Ultrix machines complement one another," he says. "There's no conflict here. We want to give our customers choices. RISC and Ultrix enable us to offer very fast low-priced [smaller] machines, such as work stations." The VAX line, he says, is still the appropriate choice for larger commercial users that need good security, larger main memories, and greater disk capacities.

For those customers, last month's introductions also included a new processor that's the heart of the VAX 6000 series. That processor enables various models of the 6000 line to deliver performance ranging from seven (single-processor Model 410) to 36 times (six-processor Model 460) that of the original VAX-11/780. The pro-

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cessor essentially implements the older VAX 8800 processor in a new CMOS chip set; the 8800 line is being discontinued.

At the same time, DEC promised to add vector processing to the VAX 6000 line "within a year." This capability would help the VAX family compete more effectively with graphics supercomputers like those from Ardent, Convex, and Stellar.

DEC added to the range of services provided in its Network Application Support program, an open-computing software environment that provides services allowing distributed application integration and common programming interfaces among dissimilar multivendor systems.

DEC says the program allows the seamless linking of multivendor computers running VMS, Ultrix, MS-DOS, OS/2, and the Apple Macintosh operating system. Aberdeen's Casale agrees, adding that the network program "is the glue to tie together diverse systems in Digital's strategy." *–Lawrence Curran*

TRADE

GLASNOST GOES HIGH TECH IN A PC DEAL

MUNICH

Historically, the electronics trade between Western countries and Eastern-bloc nations has been moderate at best. Once in a while, however, a Western firm bags an impressive order that picks up the slack. One such deal has just been worked by Siemens AG: the Munich-based company has contracted to deliver more than $500 million worth of personal computers to the Soviet Union over the next three years.

The deal calls for Siemens to provide about 200,000 PCs to Moscow's Ministry for Higher Education and Specialty Training, which will install the machines at the universities, research institutes, and trade schools that come under its wing. The agreement includes an option to extend the supply contract beyond the three-year period.

The transaction is Siemens' largest with an Eastern-bloc nation to date, and may well be the largest deal between any Western European computer maker and the Soviet bloc. What's more, says Hartmut Runge, a Siemens spokesman, "the deal is of strategic importance in that it makes us better known as a PC supplier outside Western Europe."

In West Germany, Siemens ranks second behind IBM Corp. for sales of PCs to professional (non-home) users, and in Western Europe it ranks No. 5 or No. 6. Worldwide, however, the company is an also-ran compared with the likes of Apple Computer, Commodore International, Compaq Computer, and IBM, which together sold more than a third of the 21 million PCs shipped globally last year for non-home use. Even though the contract with the Soviets won't put Siemens in the major league, it will at least raise its image as a PC maker, Runge says.

The Soviets aren't interested in just buying PCs—they are eager to build them, too, and they are seeking help from the West, at least initially. To that end, they are negotiating another contract in which Siemens would help set up assembly lines in the USSR and supply components. Details on this project haven't been hammered out yet, but it's likely that other Western firms will get some of the action.

The improved political climate between East and West helped push the PC deal through, Siemens executives believe. But other factors contributed to the Soviets' choosing Siemens. Chief among these was a key technical point, says Reiner

An easy-to-service design helped Siemens win a $500 million PC contract from the USSR, says Reiner Hallauer.

Hallauer, director of the company's business unit for PCs in Augsburg, near Munich: Siemens' slot-central-processing-unit design makes its computers easy to service. Instead of a motherboard crammed with electronic parts, the CPU has cards that can easily be removed for service or replacement.

A computer-based training program developed by Siemens also helped woo the Soviets. The program allows users to follow screen-displayed operating instructions based on the Cyrillic alphabet. This feature is important to the Soviets, as computer training facilities aren't common in the USSR. As part of the contract, Siemens also will train Soviet service personnel at its Augsburg facility.

The PC involved in the deal is the PCD-2M, a system based on Intel Corp.'s 16-bit 80286 microprocessor and other technologies that may be exported to the Soviet Union under Cocom regulations. The PC uses the MS-DOS Version 3.2 operating system and the Microsoft Windows user interface. In addition to the central processing system, the hardware to be delivered by Siemens includes a 12-in. monochrome display unit and a keyboard with 12 function keys. On the West German market, the machine sells for about $3,160 to $4,740.

The system provides 1 Mbyte of random-access memory, which may be expanded to 4 Mbytes with circuits on the same CPU card. In its basic configuration, the PCD-2M has a 3.5-in., 1.44-Mbyte floppy-disk drive and a hard-disk drive that offers either 20 or 40 Mbytes of storage. The computer features a compact design: the central processing system measures about 4.3 by 15 by 15 in. and weighs about 16.5 lbs.

SECOND SHIFT. Siemens will produce the PCs at its Augsburg facility, which currently has a production capacity of about 80,000 machines a year. To meet production demands, the company will at least have to add a second shift and a second assembly line at the plant. If necessary, Siemens will call on its other manufacturing facilities to help fill the order.

The personal computer deal with the Soviets may be followed by a potentially bigger agreement if current negotiations come to a successful end. Last month, Siemens and the Soviet Ministry of Posts and Communications signed a letter of intent to cooperate in a joint venture aimed at expanding the Soviet Union's telecommunications network.

In this effort, the two partners will use the USSR-developed digital telephone switching system ESS-DNS for local and short-haul communications, and Siemens' EWSD public switching system for long-distance communications and in large local exchanges. Siemens will not divulge further details on the project until negotiations are concluded. *–John Gosch*

PASSIVE COMPONENTS

FORMER RIVALS JOIN TO FORM A POTENT ONE-TWO PUNCH

MUNICH

Announcements of new strategic alliances have become fairly routine in Europe's electronics industry. But the joint venture between Siemens AG of Munich and the Matsushita Electric Industrial Co. of Osaka, Japan, is raising more than a few eyebrows. Set to be launched in October, the venture brings together two giants—and former rivals—in the passive-components market. Analysts expect the alliance to yield a formidable competitor on world markets for a broad range of devices.

The deal gives Siemens access to the Matsushita's manufacturing know-how, which, along with the greater economies of scale, should translate to lower operating costs. "There's no denying that cooperation gives an opportunity to raise volume and attain burden sharing in research, development, and investments," says Karlheinz Kaske, president and chief executive officer at Siemens.

Siemens also gains a foothold in the Japanese market—particularly with Matsushita Electric itself, a major consumer electronics producer. "We aren't just working with a maker of passive components," Kaske notes, "we are also working with one of the biggest buyers."

On its own, Siemens has not been doing too well in the global market for passive components. Business in its passive-device sector has been in the red for some time; this is the first year in a while that the company expects to chalk up some gains.

The alliance, to be based in Munich, provides Matsushita with a European beachhead for its components activities. Such a base inside the European Community is vital in light of the potentially higher barriers to Japanese imports that could emerge when Europe's single market becomes a reality by 1992. By using components made in Europe, Matsushita will also meet local-content requirements for the equipment it assembles in the EC.

Siemens will undertake the joint venture with Matsushita Electronic Components Co., a wholly owned subsidiary of Matsushita Electric. The new firm, to be called Siemens-Matsushita Components GmbH—SMC, for short—must still get the go-ahead from the German Cartel Office in West Berlin, but Kaske expects approval soon.

SMC will be capitalized at $50 million to $75 million, according to Klaus Ziegler, head of Siemens' Passive Components and Tubes Division. Initially, Siemens will own 74.9% and Matsushita 25.1% of the joint venture. After SMC's first business year, however, Matsushita's stake will be raised to 50%. Siemens will retain the majority of votes and the right to appoint SMC's chief executive. Ziegler is a front-running candidate for that job.

SMC, which will initially be staffed by 5,000 employees, will encompass all of Siemens' passive-component activities, including its five production plants in Europe: a capacitor facility in Malaga, Spain, a ferrites production site in Bordeaux, France, a ceramic products plant in Austria, and two production facilities in West Germany that make surface-wave filters, capacitors, and ferrites. Siemens' related development and marketing activities will be assigned to SMC. The deal does not affect the company's tube activities, however.

Designs from Matsushita will gradually be incorporated into SMC's product line. In time, the Japanese company's technology and expertise in automated volume production will be transferred to SMC. The venture's products will be sold and distributed through its parents.

MARKET SHARE. Ziegler expects SMC's sales to reach $370 million to $400 million in the first year of operation. Within two years, business may exceed the $500 million mark, he says. The worldwide passive-components market stood at $15.1 billion in 1988 and should climb to $16.1 billion this year and $16.6 billion in 1990, according to analysts at Siemens. Siemens' share of last year's market stood at about $370 million, with 80% of that total coming from European customers. Matsushita garnered $3.4 billion from the passive-components market last year, chalking up 90% of its sales in Asia.

The entertainment electronics sector accounts for 40% of the passive components bought worldwide, Ziegler says. Almost 20% of the market comes from vendors of communications equipment, while industrial electronics and data processing account for about 15% each and the automotive and household-appliance markets combine for the remaining 10%.

Siemens says Japanese companies bought about $6.3 billion worth of passive components, while the U. S. and Western European markets accounted for about $2.6 billion each. West German companies alone bought $1.05 billion worth of passives. *–John Gosch*

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

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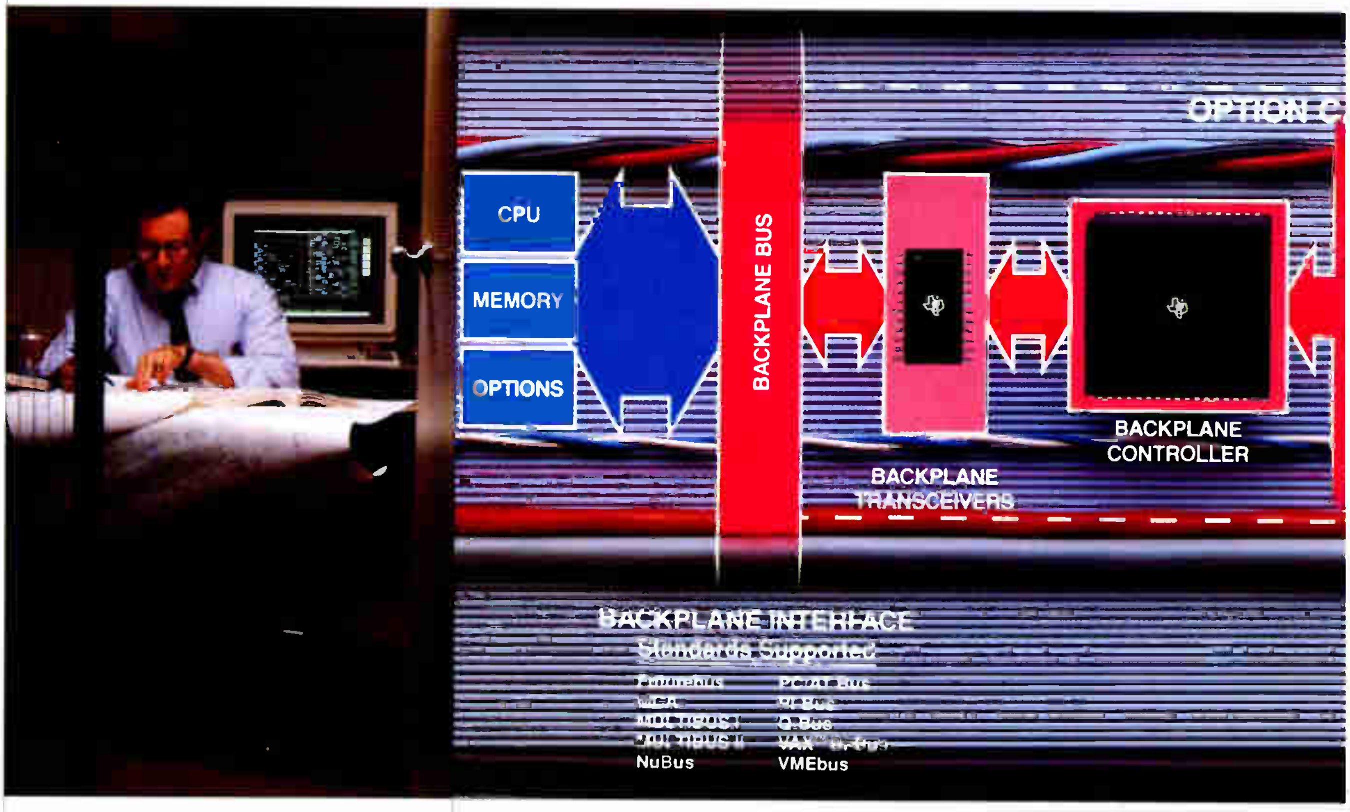

High-speed, low-power implementation of backplane and peripheral interfaces for most popular standards is made possible by TI's comprehensive family of both digital and analog physical-layer

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

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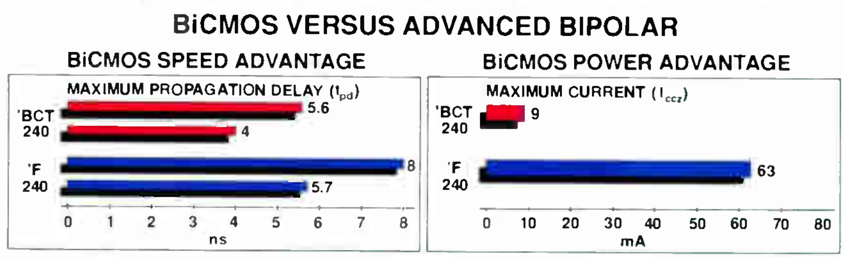
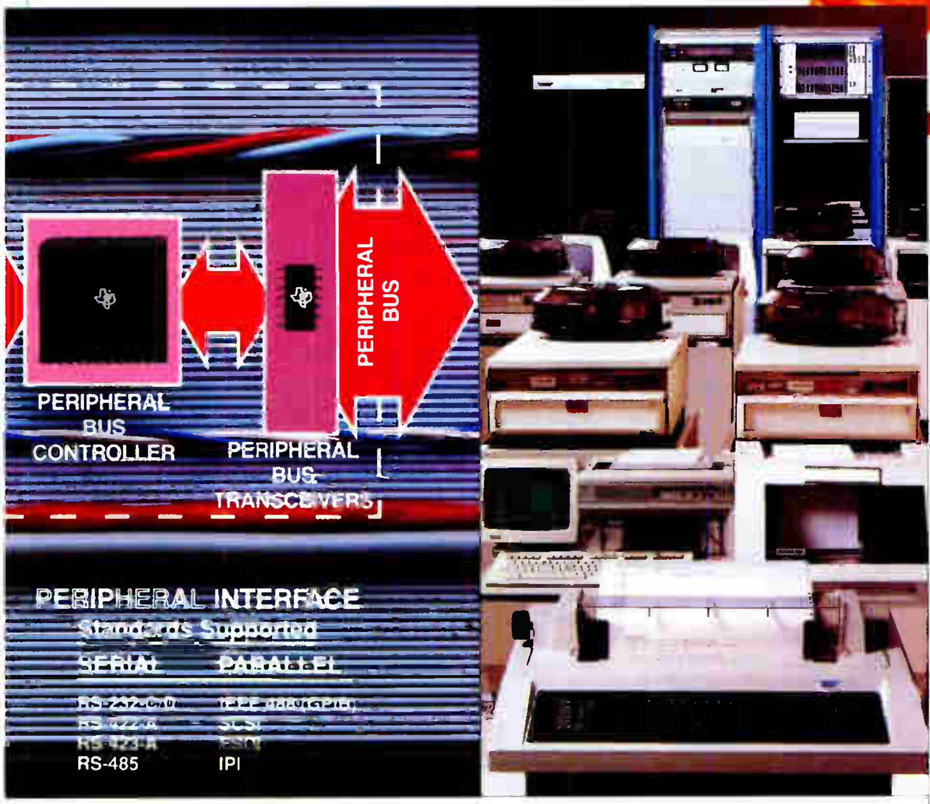


The BiCMOS lead over bipolar is proven by this comparison between TI's '74BCT240 and a comparable advanced bipolar standard device. Typical propagation delay of TI's BiCMOS part is faster (*left*) while power dissipation is less (*right*).

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 multi-phase 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. ■

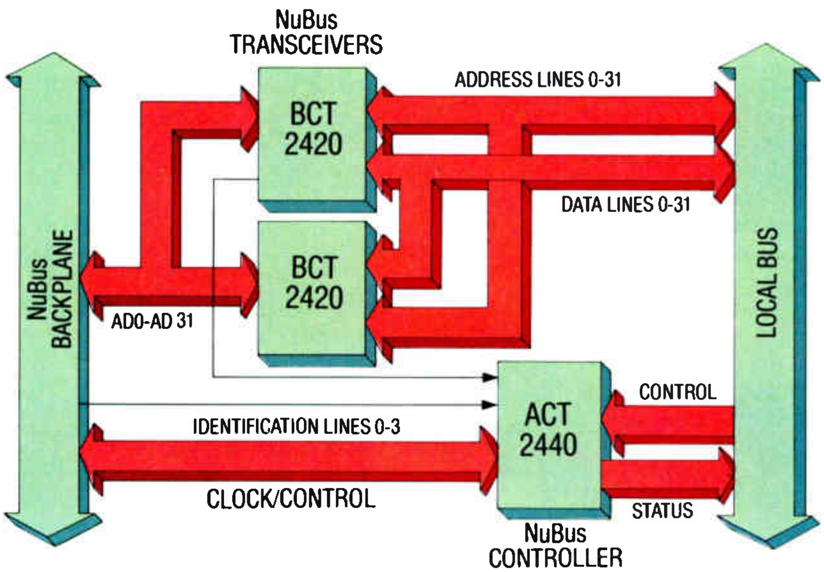
System complexity and the future

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.

Another issue is the increasing difficulty and expense of testing boards in complex systems. Consequently, TI supports the JTAG/IEEE P1149.1 standard with the development of standard products and ASICs having on-chip test cells, as well as with development support software and device models on several leading workstations. ■

TI's 32-bit NuBus Interface Solution



Major space savings are realized by using one TI SN74ACT2440 controller and two SN74BCT2420 transceivers to complete a full 32-bit NuBus master/slave interface. As many as 45 discrete logic devices are replaced, realizing significant reductions in board space, power consumption, and design cycle time.

Please call **1-800-232-3200, ext. 3905**, for your copy of our Bus Interface Devices brochure. Or write Texas Instruments Incorporated, Dept. SSY25, P.O. Box 809066, Dallas, Texas 75380-9066.

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TEXAS INSTRUMENTS

WASHINGTON INSIDER

JAPAN AGREES ON A MONITORING SCHEME TO GUARD AGAINST ASIC DUMPING

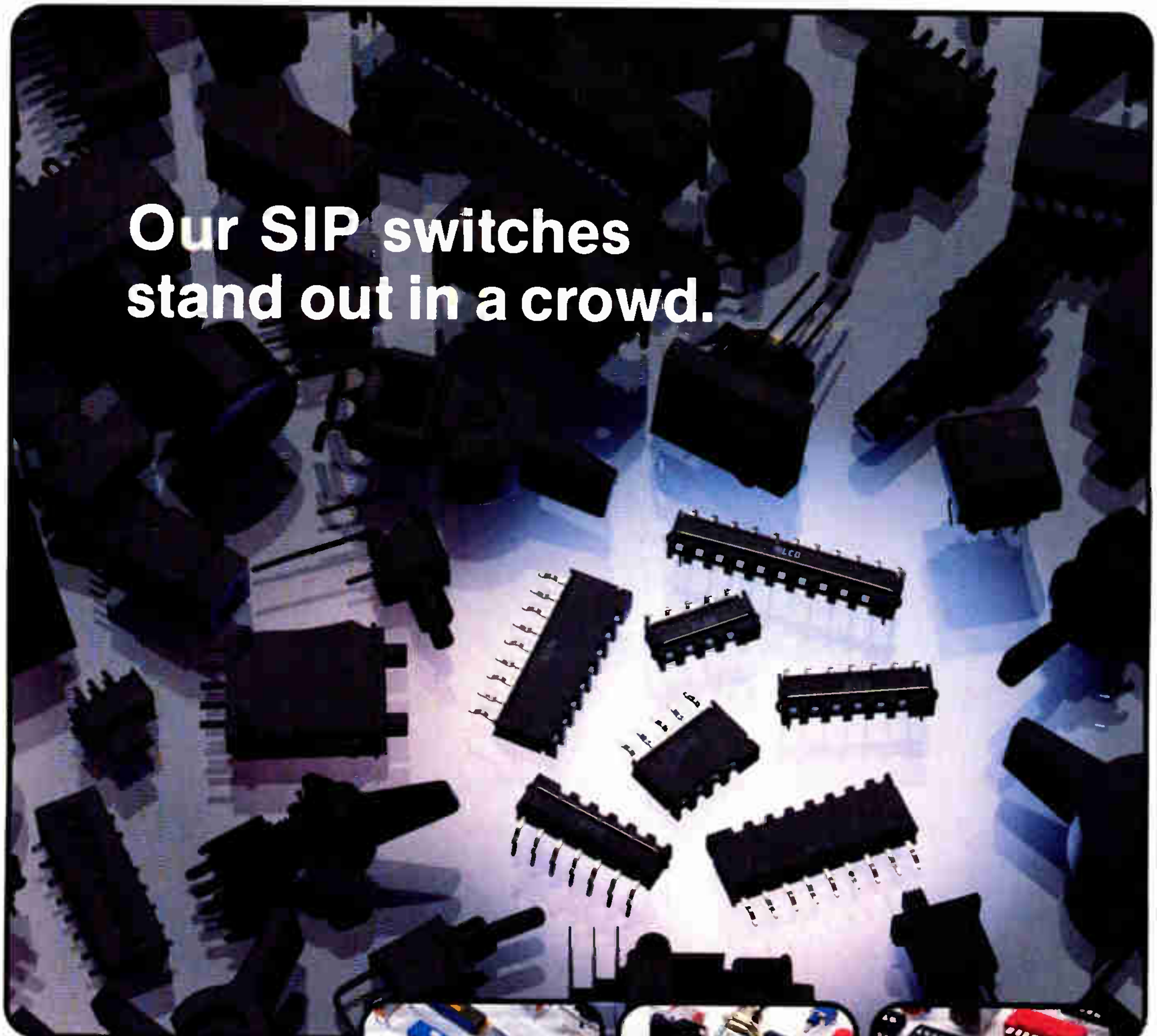
It's been a long time coming, but Japan's Ministry of International Trade and Industry this month will start monitoring the U. S. sales of Japanese-built application-specific integrated circuits. ASICs were one of five product categories the U. S. and Japan agreed to watch under the 1986 Semiconductor Trade Accord. But inherently small volumes and special engineering requirements mean that each ASIC design has its own cost structure. As a result, negotiators at MITI and the U. S. Commerce Department haggled over the monitoring methodology for three years before settling on a complex formula combining costs of design and field-application engineering with those of manufacturing, marketing, and other factors. Under the agreement, MITI will collect cost data from all Japanese ASIC suppliers and share it with the Commerce Department. Should a U. S. maker file dumping charges, those figures would be used to help speed an investigation. However, whether the system can prevent dumping is still an open question, says Daryl Hatano, director of government affairs at the Semiconductor Industry Association. "The value of the whole monitoring concept has not yet been tested," he says. □

IS THE PENTAGON'S PUSH TO USE COMMERCIAL ICs A THREAT TO DOMESTIC SUPPLIERS?

Despite "overwhelming verbal support," the Defense Department has been slow to embrace the use of commercial components—particularly semiconductors, computer equipment, and software—in its systems. That's the verdict of a Defense Science Board study team assigned last spring to investigate the issue. The group blames the Pentagon's intransigence on overregulation and on a growing fear in military ranks of personal criminal and civil liability for authorizing the use of nonconforming products. But buried in the issue is a more pressing question: would the use of commercial-grade ICs increase the Pentagon's dependence on foreign chip suppliers? About 75% of military-standard ICs used by the DOD are already produced offshore in U. S.-owned chip plants, says Robert L. Cattoi, senior vice president for research and engineering at Rockwell International Corp. in Richardson, Texas, who prepared the semiconductor portion of the report. The remaining 25% are Joint-Army-Navy (JAN) certified parts, which must be made in the U. S. However, a shift away from JAN-specified parts could increase Pentagon reliance on the foreign plants, raising questions of national security. Cattoi suggests a solution: increase "selected" use of industrial ICs, limit JAN-grade ICs to applications where the extra performance is essential, and focus as much as possible on certifying processes, and not individual ICs. □

FAA APPROVES HONEYWELL'S AUTOMATIC WIND-SHEAR AVOIDANCE SYSTEM

Forward-looking wind-shear detection systems will be required on all commercial aircraft by 1994, and a number of companies are racing to get a piece of what should be a market worth hundreds of millions of dollars by then [*Electronics*, January 1989, p. 33]. But in the meantime, wind-shear detectors that can warn the pilots as they enter a potential danger zone are the norm, and now Honeywell Inc. has raised the ante by producing the first such system that is fully integrated with an autopilot system. The Federal Aviation Administration certified Honeywell's Digital Flight Guidance system last month. It uses inertial and air-mass accelerometers to identify wind-shear conditions, and like other systems, advises the pilot on how to take evasive action. But unlike other units, the detection system can also be used in conjunction with an automatic pilot, so if the aircraft hits a wind shear while on autopilot, it can respond without a manual override. Safety is assured by a dual-redundant 16-bit computer that backs itself up in case one of the two Zilog Inc. Z-8002 processors fails. □



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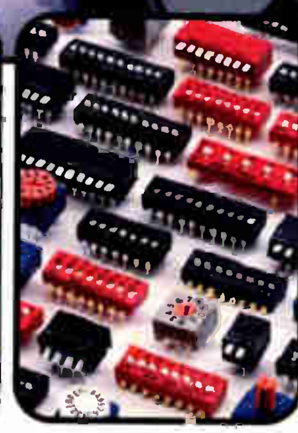

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EUROPEAN OBSERVER

SWISS FIRM BOOSTS SOVIET UNION'S ASIC CAPABILITY

Switzerland's Lasarray SA, the small Biel-based company that's big in application-specific ICs, has started its first ASIC factory in the Soviet Union. The $5 million Leningrad facility will soon be followed by a similar plant in Moscow. Lasarray says the plants, which the Academy of Sciences of the USSR will administer, fill a gap in the USSR's electronics industry. According to the company, a top academy official conceded in the spirit of glasnost that sluggish sales of equipment to Western countries stem from inadequate technology and hardware. Now, with Swiss help, equipment can be individualized and ICs made to order. □

SIEMENS SCORES IN THE U. S. WITH DIGITAL SWITCHES

Siemens AG continues to make inroads into the U. S. market for public telephone switches and is on its way to becoming an established third supplier behind AT&T Co. and Canada's Northern Telecom Ltd. The latest order the West German firm has won is for two digital switches for Bell South, one of the regional Bell Operating Companies. To go on line in 1990 in Middleburg and Fernandina Beach, Fla., the two switches together accommodate about 27,000 subscriber lines. The RBOCs Ameritech and Bell Atlantic decided to use switches from the Munich-based Siemens as third supplier in 1986; it's the only non-American company active on the U. S. public switch market, with digital switches for about 200,000 lines in place in the U. S. and orders for another 300,000. "With these 500,000 lines we are doing better than we expected last year," says a company executive. The firm's goal for the next five years or so is to gain a 10% share of the U. S. public switch market. Last year, that market amounted to 9.4 million lines. Around 90% of the U. S. telecom market is served by AT&T and Northern Telecom. □

EC SLAPS STIFF ANTIDUMPING TARIFFS ON JAPANESE, KOREAN CD PLAYERS

The Brussels-based Commission of the European Community has slapped antidumping tariffs on compact-disk players from 15 Japanese and South Korean producers and exporters that range from 6.4% to 33.9% of the import prices. This action came after a two-year EC study found that the suppliers—11 Japanese and 4 South Korean—have been offering their products in the EC at prices well below those prevailing on their home markets. The study was triggered by complaints from Europe's three largest CD producers—Philips International of the Netherlands, Bang & Olufsen of Denmark, and Grundig of West Germany. The number of CD players imported into the 12 EC countries rose by a factor of 23 from 1984 to 1986, to 2.3 million units. During the same period CD-player production in the EC rose just fivefold. □

RACAL MOVES INTO BRITISH MICROCELLULAR RACE

British mobile communications users could well be spending up to $18 billion a year by 2000, making phone calls from their cars and the street, according to Racal Telecom plc, and its cellular telephone subsidiary, Vodafone, expects to win at least 30% of the market. Now the company has plans to introduce a microcellular network to cope with demand—and, more important, get a head start on three competitors expected to be licensed to build the short-range Personal Communications Networks that will start operations in 1993. Racal's Microcells will use radio base stations emitting no more than 250 mW in the 900-MHz band to keep range down to a couple of kilometers. For users, Racal is working on a telephone with most of the expensive signal-processing and equalizing circuits needed for premium-service mobile telephones stripped out so it can sell for less than $200. □

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Sprague features new SIP Cap and R-C networks.

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Type 201C Conformal-Coated SIP Capacitor Networks include multiple isolated capacitors, and multiple capacitors with common ground. Multilayer ceramic capacitors available in the capacitance range of 10 pF — 1500 pF (C0G) and 330 pF — 0.1 μF (X7R).

Type 206C ECL Terminator, Conformal-Coated SIP R-C Networks feature 10k and 100k ECL Terminator configurations designed for low cross talk and optimum frequency response. Standard resistors to 1 Megohm; capacitor values 0.01 μF (X7R). Both Type 201C and Type 206C networks supplied in standard 8-pin and 10-pin packages; special configurations to 22-pins are available.

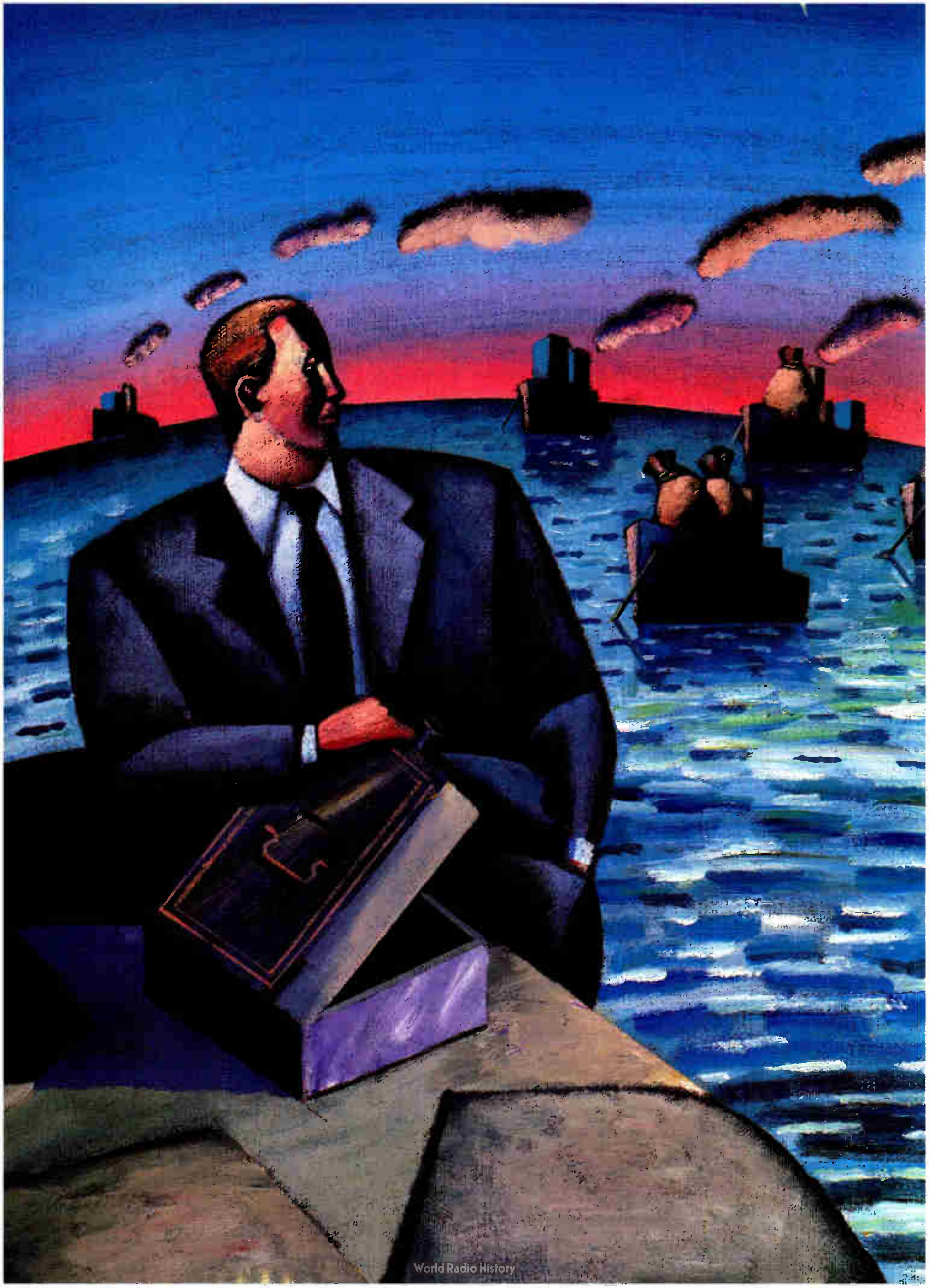
For our Thick-Film Networks Catalog RN-126B, write to Technical Literature Service, Sprague Electric Company, P.O. Box 9102, 41 Hampden Road, Mansfield, MA 02048-9102.

SPRAGUE

Circle 23

TECHNOLOGY STOPS HERE: STUMBLING BLOCKS FOR U.S. COMPANIES

As it has for decades, technological innovation will continue to propel U.S.-based companies competing in the global electronics industry. Unless major gains are made in resolving problems in other areas, however, their technology alone will not maintain a secure position for these companies. The following report examines three areas of prime concern for the American electronics industry: the search for new sources of financing, the viability of manufacturing resources, and the debilitating potential of today's raging litigation over patents and other intellectual property issues. Separate articles deal with the rarely publicized but all too common fate of entrepreneurs, and the pressures on the U.S. semiconductor equipment industry.



OVERSEAS MONEY IS STARTING TO FILL THE FINANCING GAP

FINANCING

As public funding runs dry, startups are finding new sources in the deep pockets of foreign investors

High-technology startups are in the throes of a crisis: the well of public funding has suddenly run dry, cutting off life-sustaining capital to existing fledglings and new ventures. Entrepreneurs are searching desperately for new financial wellsprings to keep their plans alive. The search has led to a potentially deep—and, to some, troublesome—source: foreign investors.

The funding crisis gripped high-tech startups seemingly overnight last summer, when initial public offerings virtually shut down as a source of venture capital. IPOs "came to a screeching halt last August," says Sanford R. Robertson of Robertson and Stephens, a San Francisco-based investment banker for high-tech-

BY LARRY WALLER

nology firms. IPOs, which tap both institutional and individual pocketbooks, have since opened up again, but only for the most promising startups.

"Companies have new concerns about financing growth because they can't go easily to the [public] market anymore," says Adam F. Cuhney of investment banker Kidder, Peabody & Co. in San Francisco. Cuhney is organizing a new arm of Kidder, Peabody expressly to offer technology startups more options for raising capital.

One of those options involves a well-heeled group now coming onto the scene: foreign investors, primarily Japanese firms, eager to carve out a strong position in emerging technologies. Most observers are certain that the profusion of Japanese investments in U. S. high-tech startups will have a major long-term impact on the electronics industry. Many see the present investment stage as just a toehold; as capital needs grow and other sources remain tight, they assert, the stakes will increase to the point where foreign investors gain full control of the startups they fund.

Surprisingly, there is no official body that monitors foreign investments in U. S. startups. Venture Development, a consultancy in Natick, Mass., estimates that Far Eastern sources have invested a total of about $630 million in about 120 U. S. companies over the past three years. The most visible of these investments is the $100 million that Canon Inc. has promised Next Computer Inc. of Palo Alto, Calif.

For its money, Canon gets a sixth of the company, founded by Stephen Jobs of Apple Computer fame, as well as the right to sell the Next machine in the Far East. Another notable investor is Kubota Ltd., a Japanese tractor maker that has put up $69 million for a 44% share of Ardent Computer Corp., a Sunnyvale, Calif., designer of advanced graphics supercomputers. Kubota also has sunk $100 million into other U. S. companies.

In some cases, deals are going beyond the investment stage to actual buyouts. Investment banker Robertson's company recently played a central part in negotiations that led to the buyout of specialty chip maker Silicon Systems Inc. of Tustin, Calif., by TDK Corp. of Tokyo. The deal, which closed in late May, was the first purchase of a U. S. semiconductor company by a Japanese buyer since the ill-fated plan of Fujitsu Ltd. to acquire Fairchild Semiconductor in late 1987. Fujitsu's plan was squelched by strong protests in the U. S. against the takeover of a seminal chip firm by a Japanese rival.

Because political feelings still run high, the Japanese have held back from testing the acquisition waters since then. So Robertson and other involved financiers held their breath until the TDK deal closed.

"But there was no fallout whatsoever," Robertson says. One reason was the perfect match between the two companies—Silicon Systems' mainstay products are key analog chips for disk drives, while TDK is the leading supplier of magnetic read-write heads to the disk-drive market. Another reason: shareholders were ecstatic to reap the $200 million windfall, getting $20 for shares that sold for just over $10 when the deal was announced.

The conditions that led to the Silicon Systems sale are typical of the financing crises that most high-tech concerns now face, says Carmelo J. Santoro, who remains chief executive officer of the company. "Both forms of raising capital—debt and equity—are substantially handicapped," he says. To fuel Silicon Systems' rapid growth, Santoro had to find $150 million over a five-year span to keep pace with chip production needs. Because the equity market puts such a low valuation on semiconductors at present, new stock offerings were ruled out, and high interest rates made borrowing prohibitive. When TDK made its offer, Santoro says, "I had no choice but to go ahead."

AT SOME POINT, OBSERVERS SAY, FOREIGN INVESTORS WILL GAIN FULL CONTROL OF THE STARTUPS THEY FUND

Robertson says more buyouts are inevitable: "We have four in the works, and more of them are going to happen." He adds, however, that Japanese investors are targeting smaller technology companies because the Fujitsu-Fairchild fiasco has made them wary of larger deals.

Some startups are forgoing the foreign investment route for other options. Rick Rugani, senior vice president for corporate finance at Shearson Lehman Hutton Inc. in New York, sees a trend toward burden sharing through research consortia and technology exchanges. Money not invested in R&D, after all, can help in building manufacturing and marketing.

Investments by larger companies in smaller outfits is another trend that is picking up steam, Rugani says. Bigger companies are particularly interested in new firms that can either grow into substantial customers or come up with products that complement the larger companies' lines. IBM Corp. and Digital Equipment Corp., for example, have jumped into such agreements in a big way, correcting what is perceived as an internal weakness by investing in software firms.

Meanwhile, the financing troubles have taken their toll of venture capitalists. Most marginal venture capital funds—defined as those whose profitability record is lower than a 30% to 35% rate of return—are failing to raise substantial new money, and many may go under. "The problems of the public market have caused a venture capital shakeout," says Jon W. Bayless, a partner at Sevin Rosen Management Co., a Dallas group that has backed a number of big winners, including Lotus Development Corp. and Compaq Computer Corp.

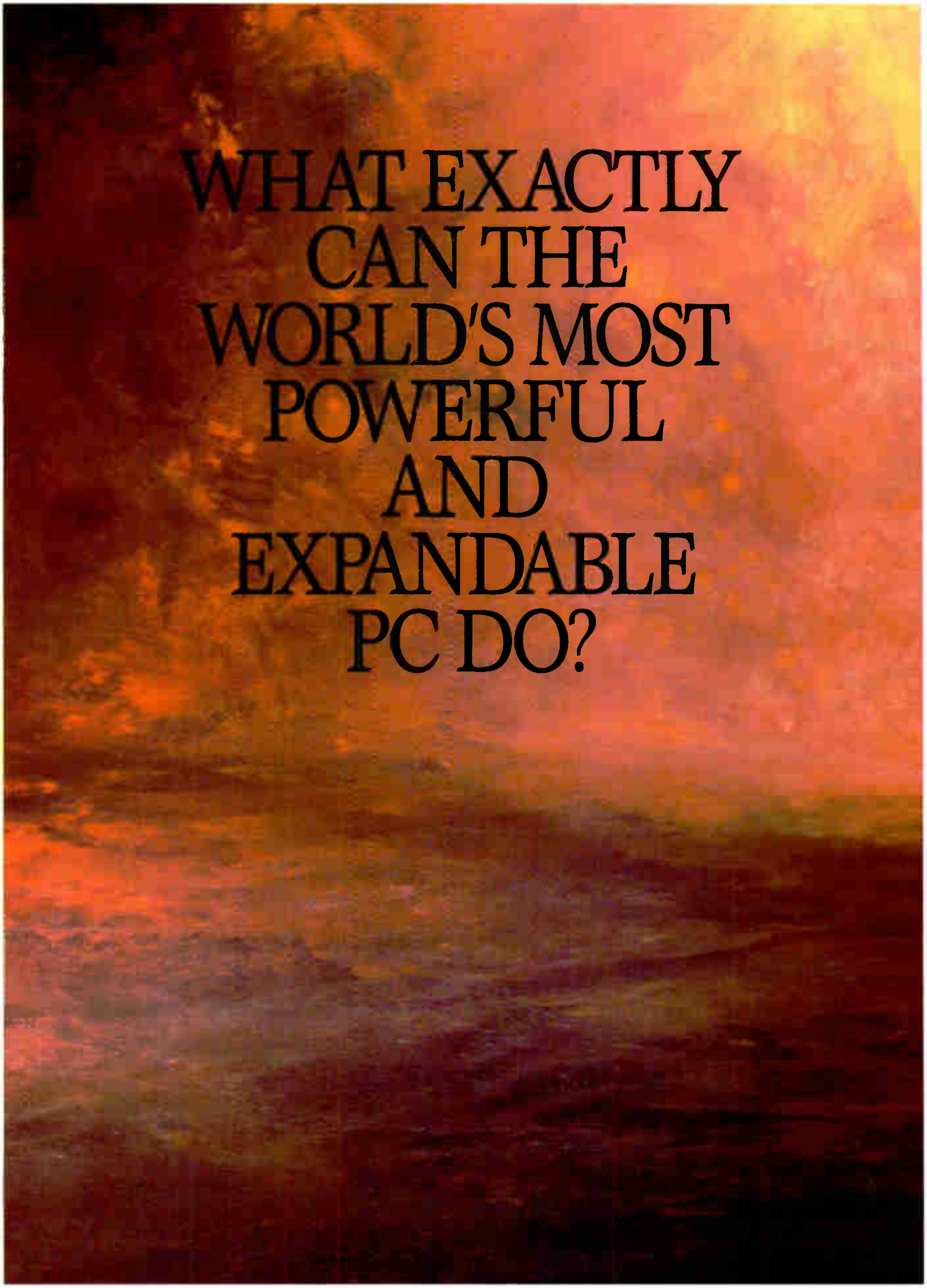
Companies that decide to buck the odds and go the IPO route can still succeed, but they have to be willing to persevere through some harrowing early stages. Genus Inc., a production equipment manufacturer in Mountain View, Calif., opted to take the plunge, even though the offering price of $5 a share was only about half that originally expected. William W. R. Elder, president of Genus, has no regrets about forging ahead, despite the bargain-basement price. Genus employees had been anticipating becoming a public entity, "and we didn't want to turn it off because of their morale." The alternative meant giving away the same advantages to private investors as to the public. "And by going public we got the attention," Elder says.

Genus was growing so fast—about 50% per year—that without the IPO in November, its financing would have been pushed to the brink, Elder says. Since the IPO, the company has done so well that another offering in May of 4.2 million shares raised more than $40 million. "In retrospect, that IPO was the best decision I made all last year," Elder says.

By contrast, Brooktree Corp. of La Jolla, Calif., one of the most successful small makers of application-specific chips, chose the private funding path. Genus and Brooktree are roughly the same size—around $50 million in annual sales—and are growing at about the same rate. Like Elder, Jim Bixby, president of Brooktree, has no regrets about his decision. The company's record of consistent profitability and growth enabled it to tap private markets at about the same terms a successful offering would have brought, he says.

Venture capital officials familiar with Brooktree confirm that the company has been able to finance itself on terms more favorable that most companies its size. Which, considering the current state of startup funding, makes Brooktree a very rare success story indeed.

Additional reporting by Jack Shandle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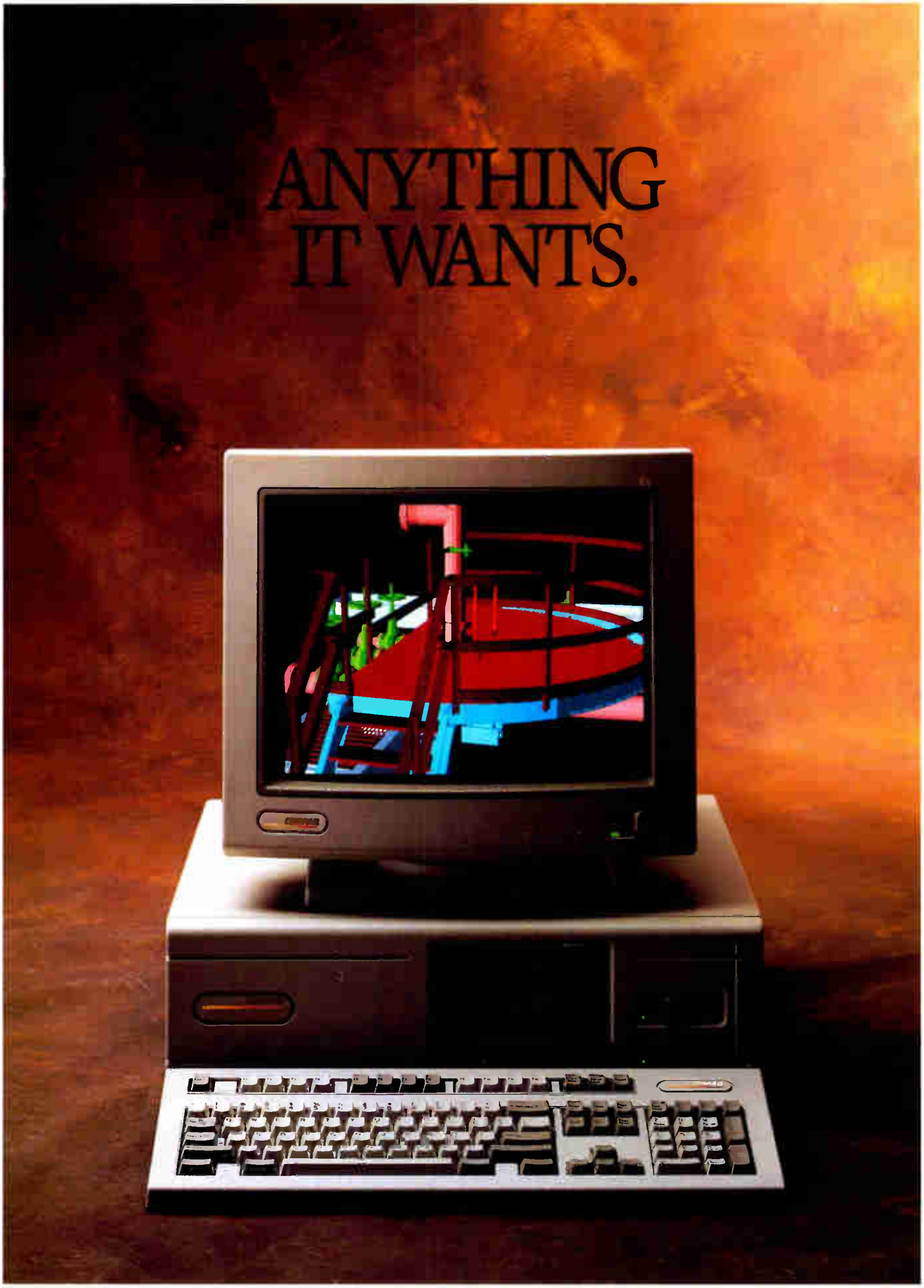
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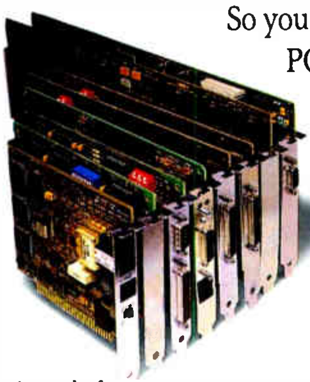

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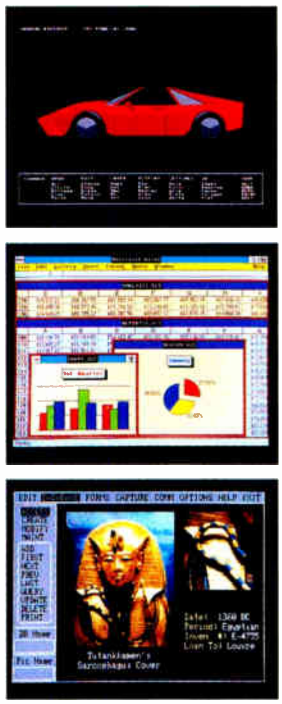

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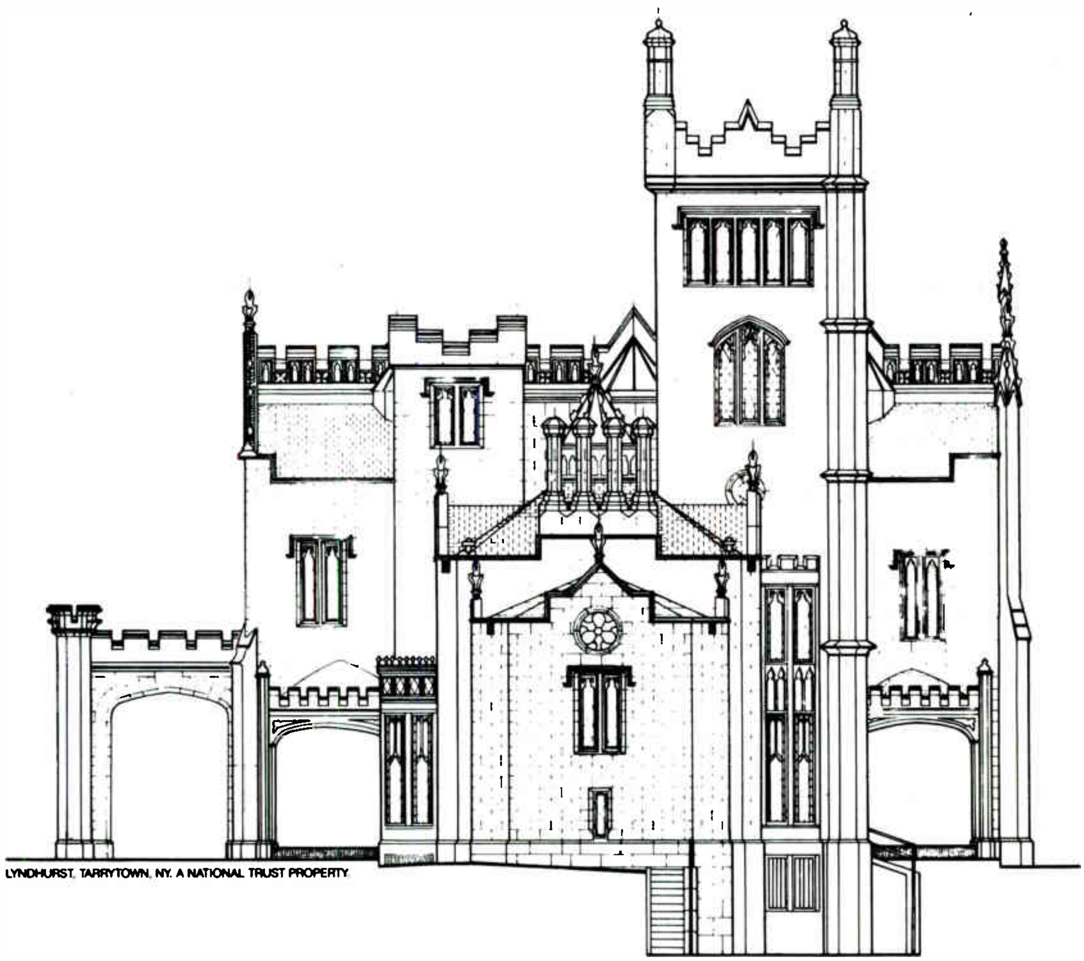

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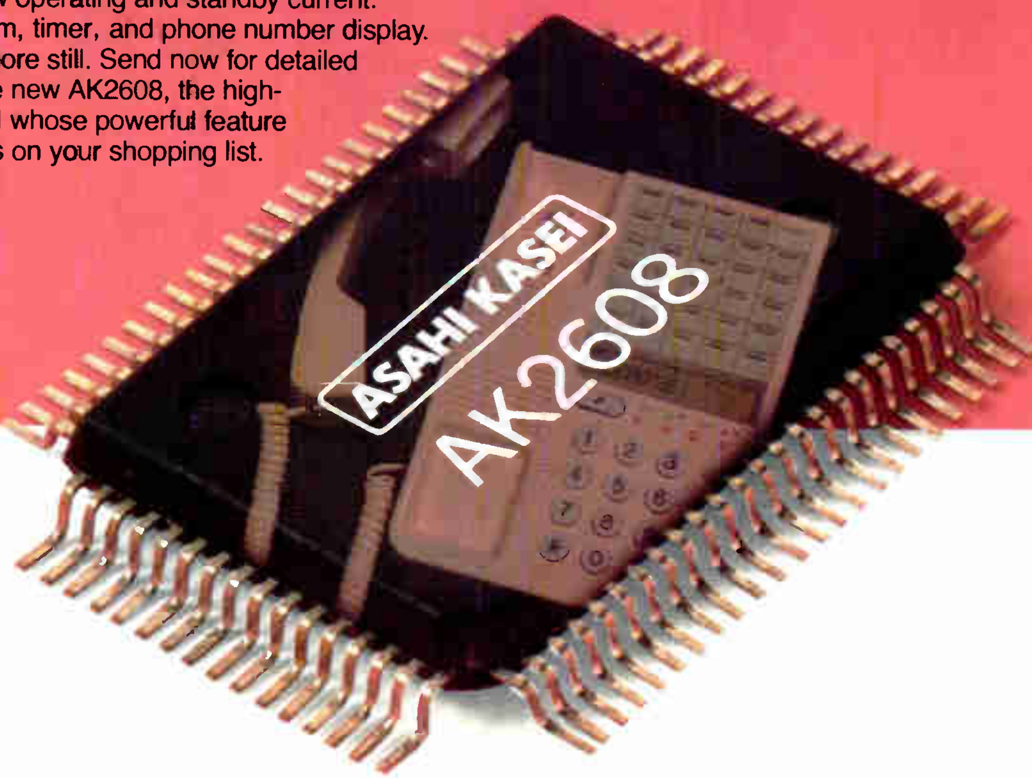

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HORATIO ALGER TAKES A FALL

Founders are often left out in the cold, whether their startups are successful or not; for every Bill Gates, there are dozens of Bill Loesches

William Loesch had an idea: a new company, built of his own blood and sweat, blossoming into a success in the sunshine of Silicon Valley. The time was 1984, and after several years as a vice president at Zymos Corp., Loesch was ready to strike out on his own. He targeted a still unexploited niche in the burgeoning computer-aided engineering market—simulating the operation of application-specifc integrated circuits—wrote a business plan, won the support of a venture-capital firm, hired a staff, and founded Ikos Systems Inc. in Sunnyvale, Calif.

By all accounts, he was enormously successful. In five years, Ikos grew from two employees to more than 70, while sales soared from zero to almost $12 million. With an innovative hardware-based approach to simulation, Ikos gained fans in the engineering community and attracted the interest of prospective suitors in the CAE field. But this spring, just when he should have been sitting back in his corner office enjoying his success, Bill Loesch lost control of his company and resigned under pressure.

He is not alone. More often than not, startups don't succeed. And if they do, their original founders are not around to join in the joys of

BY TOBIAS NAEGELE

success. For every Bill Gates, there are dozens of Bill Loesches.

What goes wrong? It could be any number of things. Company founders and venture capital investors point to personality problems and lack of management experience as the most common blunders. The typical electronics-industry entrepreneur is an inventor who has thrived for years in the protective womb of a large research organization, often completely insulated from the marketing and manufacturing sides. Emerging from that cocoon to confront the realities of the business world can be traumatic indeed.

"Some guys are just good starters," says Howard H. Stevenson, a specialist in entrepreneurial management at the Harvard University Business School in Cambridge, Mass. "There are starting pitchers and relief pitchers, and some who can go nine innings." But it's not always the founder's fault. Sometimes problems stem from the actions of fidgety "27-year-old venture capitalists who don't know what to do but have to do something."

Venture capitalists counter that when management shortcomings exist, they must be dealt with—quickly. Too often, they say, a drowning founder will pull the company and its investors down with him. "If anything, changes are made less frequently and more slowly than they should be," says Bill Poduska, who has started or helped start Prime Computer, Apollo Computer, and Stellar Computer, where he is now chairman.

The bottom line, investors say, is that management is paid to perform, and management that isn't performing should be replaced. The pressure to perform today is linked to the fact that startup costs are so high. "We started Microwave Semiconductor Corp. for $1 million in 1968," recalls Ron Rosenzweig of his first gallium arsenide chip startup. "Adjust that for inflation, and let's say that's $3 million in 1985 bucks. We started Anadigics Inc. in '85 with $30 million, and the business is still not self-propelled." Higher startup costs tend to make investors nervous, often leading them to seek short-term successes—sometimes at the expense of long-term gains.

Bill Loesch says he had no illusions about who was in charge of Ikos. "You know from the start that getting fired is a possibility," he says.

Loesch's troubles at Ikos began early this year, when he found himself in a series of disagreements with his board of directors. He came under fire for the way he handled negotiations—which eventually fell through—to sell the company to another corporation. The board also felt he took too hard a line in relations with allied companies and in fighting a lawsuit with archrival Zycad Corp. of Menlo Park, Calif. That suit alone was sucking up over $50,000 a month in legal fees, a huge sum for a company as small as Ikos. Loesch was forced out at the end of April.

He was replaced by Jerry Casilli, a board member and himself a one-time entrepreneur. Casilli says the problem boiled down to whether Loesch was the right sort of manager for this stage of the company's development. "Bill is a good startup guy," Casilli says. "But it was beginning to be apparent to us that he was not the right guy to take it to the next level." A case in point: once Casilli took over, Ikos settled its legal dispute with Zycad in a matter of days.

This scenario is not uncommon. "Quite often, the person who starts as president does not have the skills to continue past the early stages," says Robert G. Herwick, a senior technology analyst at Hambrecht & Quist Technology Partners in New York. "The wise investor goes through that with the entrepreneur beforehand." Indeed, says Loesch, "Venture capitalists are very simple to understand: the more money they pour in, the faster they want a return." When problems arise, the easiest way out "is to fire the president."

PERSONALITY PROBLEMS AND LACK OF MANAGEMENT SKILLS ARE THE MOST COMMON BLUNDERS

That's not to say that entrepreneurs are aware of all the pitfalls in the road to success. When Gene Gordon left AT&T Bell Labs in 1984, he set up shop at his Summit, N. J., home and went to work as a consultant. He helped IBM Corp. on a display system and Amp Inc. on some optoelectronic device projects.

Gordon's relationship with Amp began to flourish. The Harrisburg, Pa., components giant saw the potential of optical fiber and recognized that a burgeoning market opportunity was at hand for a new generation of optical connectors.

But the company wasn't willing to rely on outside sources for the lasers, light-emitting diodes, p-i-n diodes, and complex receivers and transmitters that it would need. It saw Gordon as its key to obtaining the new technology. Amp executives encouraged Gordon to develop a business plan for a startup company that, with Amp's backing, would address this business. The result was Lytel Corp.

Almost immediately, the startup ran into trouble. Gordon recruited a number of key people from Bell Labs, a move that had AT&T dragging him to court before Amp's financing was secure. It took Gordon four months to clear up the mess, during which time he dipped into his personal savings to pay salaries. Gordon settled his differences with AT&T by agreeing not to raid the talent pool at Bell Labs for at least a year. But he had trouble finding the talent he needed elsewhere. He hired young engineers for their vitality, but found too often they were not experienced enough.

Staffing problems reached to the top of the company. The man Gordon picked to be president and to run Lytel's day-to-day operations proved to be a disaster. "He says he never knew whether I would second-guess him or not," Gordon recalls. Problems mounted, particularly in manufacturing. "I finally fired him [in early 1987]. I had no other option."

By then, the company was in such bad shape that only a last-minute loan from Amp kept Lytel from shutting down altogether. That loan essentially forced Gordon out. As a condition of the loan, however, Amp gained control of the company. Amp installed its own president and chief executive, while Gordon remained for a while as chief scientist. That arrangement didn't last long. "Amp came to me and said, 'Look, people look up to you as the founder, the leader,' " Gordon recalls. "They said their guy wasn't getting the respect he needed to gain control—and they asked me to leave."

Gordon's tale has a somewhat happy ending, however. He still owned a sizable portion of the company, and he served on its board until Amp bought out all of Lytel's stockholders last November. Gordon made more than $1 million from the deal.

Entrepreneurs wouldn't try to start new companies if they didn't think they could succeed. In fact, Gordon has already launched a new venture, Photon Imaging Corp. in Edison, N. J., and Loesch says he may try another startup. What drives these men is the belief that they can and will succeed, that they too can be like Bill Poduska. Poduska was one of the seven founders of Prime Computer Inc. in 1972 and went on to found Apollo Computer Inc. in 1980. Now he is trying to do it again, this time with Stellar Computer Inc., a three-year-old maker of graphics supercomputers in Newton, Mass.

Poduska is very clear about what it takes to succeed as an entrepreneur. "You've got to be willing to paint the walls and change the toilet paper in the bathroom," he says. "It's not a matter of swallowing pride—it's a matter of not letting that stupid kind of pride get in your way. It's a challenge. A singular endeavor. It's just plain fun." □

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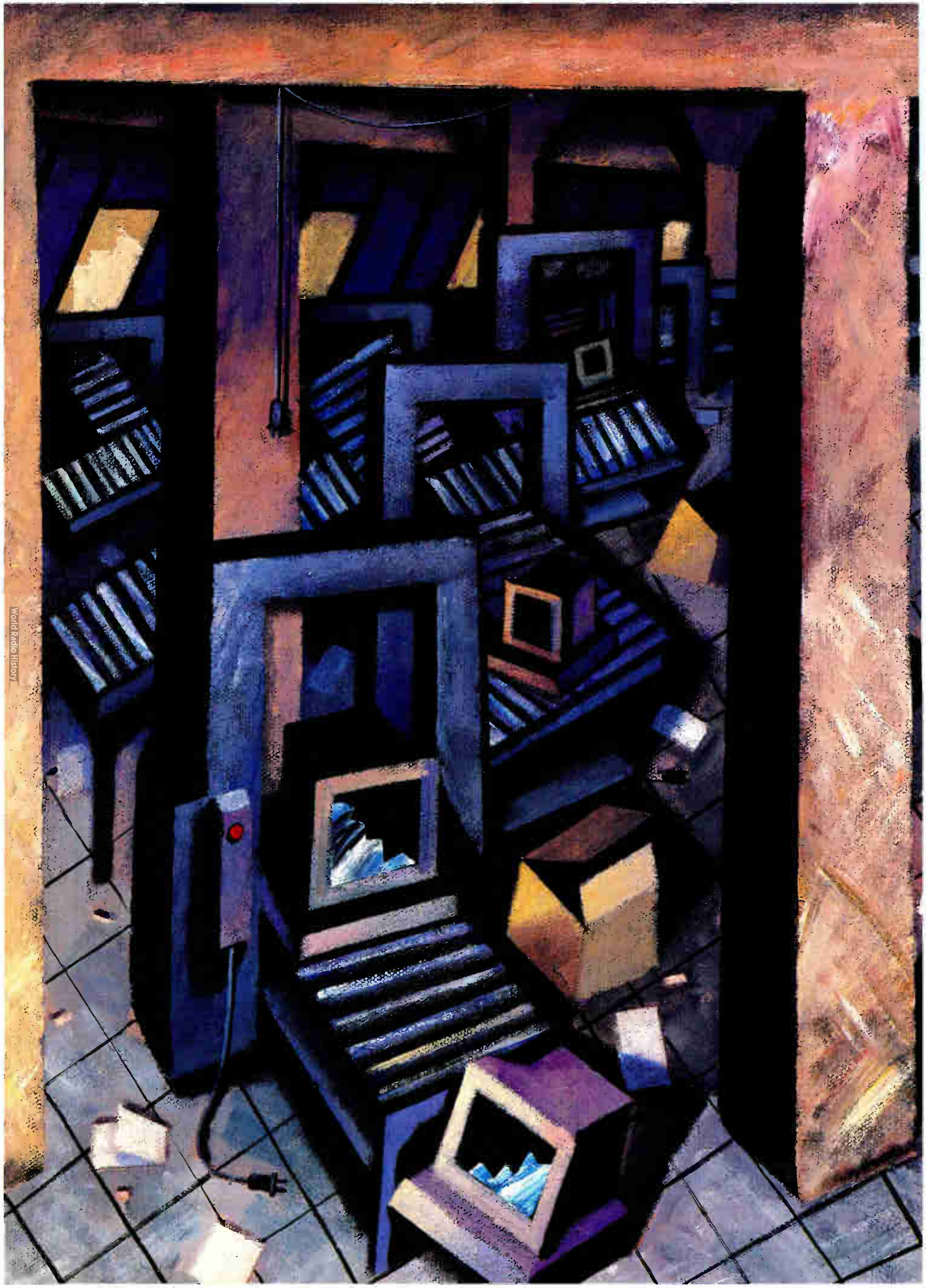


U.S. INDUSTRY REACTS TO A STRONG MESSAGE: CHANGE OR FAIL

MANUFACTURING

Top electronics executives ponder how to restore productivity—and wonder if it can be done at all

Another voice is joining the rising chorus of warnings and gloomy predictions: American industry is showing worrisome signs of weakness, slipping badly in manufacturing capability, and in many important sectors, including electronics, losing ground to competitors abroad.

That's the not-so-surprising bad news divulged by a massive report resulting from a two-and-a-half-year study by the Massachusetts Institute of Technology's Commission on Industrial Productivity and encapsulated recently in a book, *Made In America* (MIT Press, 1989). The good news is that with major changes in structure, attitudes, and processes, a new industrial America could emerge, the commis-

BY SAMUEL WEBER

sion says, potentially more productive and a leader in tomorrow's world economy. Some of those changes are already beginning to take place, albeit slowly.

Subtitled "Regaining the Productive Edge," *Made in America* is an unrelenting account of the mistakes, misperceptions, hardened attitudes, and poorly conceived strategies that caused America to lose that edge. One after another of its key industries succumbed—or were abandoned—to foreign competition. To halt the U. S. decline, the commission calls for improving production processes, boosting "economic citizenship" in the work force—that is, more worker involvement—and blending American individualism with cooperation among management, labor, government, and even competitors. Also needed, say the folks at MIT, are faster adjustments to living in a world economy and a stronger willingness to plan for the future.

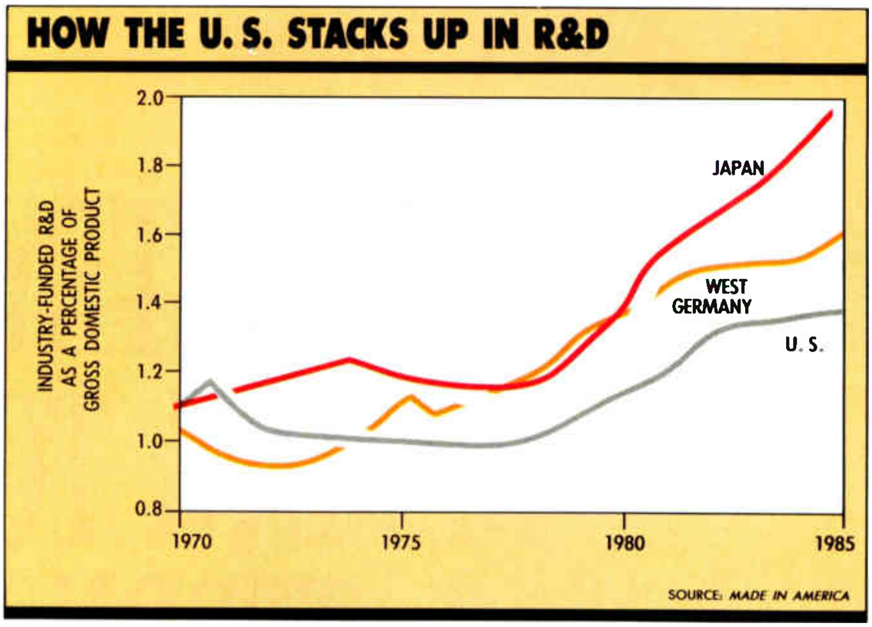
Top electronics industry executives tend to agree with the findings of the report. But they differ about where to focus efforts to restore U. S. productivity. Some doubt that it can be done at all.

The commission comprised 16 professors from various MIT departments, buttressed by 30 other faculty members who participated in study groups. The report and the book are based on hundreds of interviews and visits to U. S. and foreign firms on three continents in the course of a detailed study of eight manufacturing industries. In electronics, that includes consumer electronics, semiconductors, computers, and copiers.

WHAT'S WRONG? "We had a sense, like many others, that things were not going well for America's high-technology industries, with whom MIT has been associated for almost all of our history," says commission head Michael L. Dertouzos, a professor of electrical engineering and computer science and director of MIT's Laboratory for Computer Science. "We wanted to find out what was wrong and see if we could make a contribution."

The commission's indictment of U. S. industry and government is a long one. It includes charges of outdated strategies, favoring short-term profits over long-term growth, failure to overcome technological shortcomings in commercial development and production, neglect of human resources, lack of cooperation among management, labor, government, and within industry sectors, and a government working at cross-purposes with industry.

Clinging to outmoded mass-production methods with their rigid hierarchical division of labor no longer suits today's new economic environment, according to the commission. Foreign competitors like the Japanese, with their much more flexible automation techniques and highly skilled work force, can respond to market demands more rapidly with new product introductions that feature high performance and excellent quality.



U. S. business's focus on short-term results is a major reason that foreign competition has overcome a U. S. technological lead in many areas. In some cases, these "short time horizons" are forced by built-in environmental factors, the commission says; in other important respects, they are simply the result of shortsightedness or greed.

It's no secret that the cost of capital in the U. S. is much higher than in Japan or Europe. And this is one of the major problems for the U. S., says Carmelo J. Santoro, chairman, president, and chief executive officer of Silicon Systems Inc. of Tustin, Calif. "The Japanese consistently have access to capital at rates some 8% cheaper than U. S. firms can get, which is a drag on productivity that cannot be corrected by any company or individual segment of society, no matter how much emphasis is put on manufacturing or production technology." It's a problem, he says, "that must be addressed on a national level." This capital-cost problem makes it "impossible to compete," says Eric Lidow, board chairman at International Rectifier Corp. in El Segundo, Calif.

U. S. companies also suffer from a "systematic unwillingness or inability to 'stick to their knitting' and maintain technological leadership after the first big returns are captured," the commission says. In video cassette recorders, Japanese companies pursued the development of low-cost VCRs for the consumer market over many years, after the first recorders were introduced by a U. S. company—Ampex Corp.—for the broadcast market. The Japanese were willing to invest heavily in product and process development over a long period while returns were low. No U. S. firm followed suit, and the result is Japan's total dominance of the consumer VCR market. The economy of scale, production skill, and technical refinement accumulated by the Japanese with their long-time effort is enabling them to take market share from Ampex in the broadcast market as well.

This pattern is repeated in industry after industry, according to the commission, notably consumer electronics and semiconductors. Unlike the Japanese, U. S. firms have shunned areas where near-term margins are low even where the long-term growth potential is high. What's more, the Japanese have been willing to take on high debt levels to invest in capacity in advance of heavy demand, while pricing aggressively to create demand. U. S. firms are unwilling to do this because of pressure to garner profits for shareholders.

U. S. industry's short time horizons, the commission says, also result from uncertainty and inconsistency in government protection from trade abuses such as dumping, patent protection, environmental regulations, and other factors affected by government that increase risk. Such risk is reduced in Japan by the government's supportive policies. The source of capital in the U. S. also militates against long-term planning. A growing share of the capital for U. S. firms is provided by mutual funds and pension funds, whose participants are far removed from actual decisions affecting the company.

A survey of 500 major Japanese and U. S. companies cited by the commission bears this out. For U. S. executives, return on investment was the corporate objective with the highest priority. For Japanese executives, gaining market share was the primary objective.

"A lot of the problems would go away if we dealt with that short-term problem," says Jim Watson, vice president of quality control at Texas Instruments

Inc.'s Semiconductor Group in Dallas. "A company's strategies and action plans are all based on optimizing that short-term result. That driven nature causes a manager to do things that he absolutely wouldn't do if he didn't have a short-term commitment." What's more, Watson believes that the short-term approach affects how managers deal with human resources, and is responsible for the adversarial relationship that's built up between a company and its suppliers, customers, and even employees.

The U. S. semiconductor industry is characterized by instability and fractionalization, with many new venture-backed companies rising on the strength of specialized innovation and then falling behind for lack of long-term development or resource-building funds. Turnover is high and valuable technical know-how can be lost by defections or layoffs. By contrast, Japanese semiconductor firms are part of larger, highly integrated corporations; independent venture capital as it exists in the U. S. is almost nonexistent, defections and layoffs practically unknown.

Although structural and cultural differences may account for some of the built-in advantages of Japanese competitors, the commission doesn't exonerate U. S. management for its failure to make long-term commitments. The rise of the professional manager, with little knowledge or expertise in any technology, is often responsible for shortsighted, market-driven decisions, the commission says. The manager's tight financial controls permit little R&D or process improvement.

SHORT TIME HORIZONS MAY BE FORCED BY BUILT-IN FACTORS—OR THEY MAY SIMPLY RESULT FROM GREED

Thomas Bruggere, chairman and CEO of Mentor Graphics Corp. in Beaverton, Ore., believes a greed mentality evolving over the last decade and poor management of human resources are the culprits. "If there was one thing I could change about the 1980s," Bruggere says, "I would go to Harvard, Stanford, and Wharton and ban their classes in acquisitions and corporate takeovers. We have cultivated business students with the notion that financial manipulation is a way of making money instead of old-fashioned hard work and innovation."

As to management, Bruggere mourns the lack of human-resource skills among managers. "Of all the programs I've seen in my years at different electronics companies, 95% of the problems in those projects were human-resource problems, because there were managers that did not relate well to people," he says.

While the U. S. is the unquestionable leader in basic research and the source of most new discoveries, U. S. companies lag behind foreign competition in the ability to exploit inventions and discoveries commercially, the commission found. The reasons are many, but in the commission's view, they are collectively the result of "long-term devaluation of production-related functions and skills." In fact, this lack of emphasis on production skills is one of the most serious problems for American industry, says Dertouzos. Deficiencies in our educational system are a close second. Government legislators and educators must share the blame with the nation's industry managers.

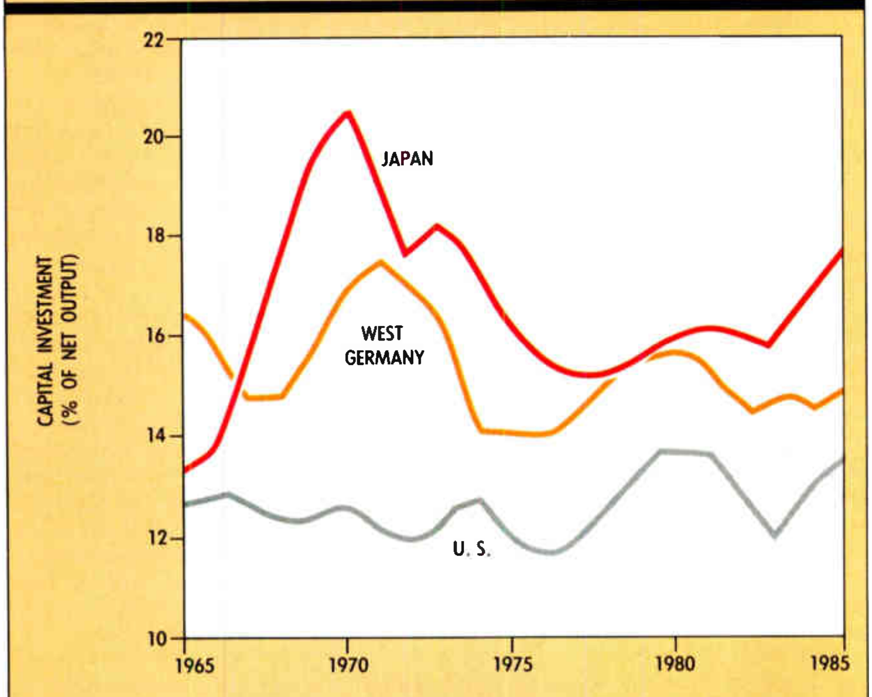
Among the shortcomings in product realization listed by the commission are difficulty in designing simple, reliable mass-producible products, failure to pay enough attention to quality at the design stage, and lack of attention to the manufacturing process itself. Until very recently, U. S. production engineering has been held in low esteem compared with design, and manufacturing R&D has been a relatively small effort. A recent study cited by the commission showed that U. S. firms devote only a third of their R&D expenditures to process improvement, the rest to development or improvement of products. In Japan, the ratio is reversed.

BEST BRAINS. As Alex Lidow, International Rectifier's senior vice president for technology and manufacturing, says, "The entrenched philosophy glorifies the individual, rewards creative thought in making something different, as in the R&D process." This attitude, he says, "is directly opposite to the approach demanded in manufacturing, which is making something exactly the same in great volume. The best brains do not go into manufacturing."

With the formation of such consortia as Sematech, the National Center for Manufacturing Sciences, and the Industrial Base Initiative, the realization may be sinking in that something has to be done about manufacturing. Many large companies such as Hewlett-Packard, IBM, Texas Instruments, and Xerox have instituted changes in their manufacturing structures that embody concepts developed in Japan and elsewhere, and have shown impressive increases in productivity (see p. 58). But in general, the commission finds that U. S. industry exhibits a lax attitude toward process improvement.

The commission's prognosis for the semiconductor industry is bleak. "Without some dramatic realignment of the American merchant industry, its decline is likely not only to continue but to accelerate," states *Made in America*. Point-

U. S. CAPITAL INVESTMENTS: THE LOW ROAD



SOURCE: *MADE IN AMERICA*

ing out that previous economic steps such as tax credits, import quotas, and industry-wide R&D funding haven't succeeded, the commission calls for different measures: incentives for longer-term horizons, encouragement of investment rather than liquidation of assets, and better protection of intellectual property.

The outlook for the U. S. computer industry is also cloudy, although that sector is strong now. Competition from the Pacific Rim is gathering strength, often derived from technology acquired from U. S. firms. Greater protection of U. S. advances may be in order, says the commission. Enhanced production capability and greater cooperation with chip suppliers are needed to ensure access to the latest technology. Maintenance of software leadership is also mandatory.

The dramatic realignment called for by the commission may be under way, signaled by the formation in June of U. S. Memories Inc. In an unprecedented alliance of competing chip makers and users, the venture was formed to recapture the dynamic random-access-memory market from the Japanese. Using advanced DRAM technology from IBM Corp., with at least $1 billion to be invested, the joint manufacturing venture could set the U. S. on a path of self-sufficiency in semiconductor memories.

At least one industry insider disagrees with the commission's dim outlook for the semiconductor industry. "The only area where the Japanese can be said to have a competitive edge is in the production of DRAMs, which constitutes no more than 15% of total dollar production of semiconductors worldwide," says Andrew Procassini, president of the Semiconductor Industry Association. "In virtually every other technology area," he says, "the U. S. semiconductor industry is equal to or far ahead of Japan."

Procassini agrees, though, that the U. S. lead is in product development and basic research; America has fallen behind Japan in manufacturing technology because of financial and unfair market conditions. This problem is forcing U. S. firms back into the DRAM business individually and through cooperative efforts in Sematech, and now U. S. Memories.

"To prevent the U. S. semiconductor industry from losing the competitive edge any further, closer ties need to be developed among companies and between companies and the government," Procassini says. "What is needed is not the constrictive and restrictive environment that the Japanese have evolved to enforce cooperation, [but rather] a looser 'virtual integration' environment, where firms can still compete but at the same time gain from upstream cooperation with customers and downstream coordination with suppliers and equipment vendors."

JAPAN'S LESSON. Gil Amelio, president of Rockwell International Corp.'s Communications Group in Dallas, agrees. "The Japanese have taught us a whole new level of competition. The U. S. has to go about it in a similar fashion but with differences reflecting that we do not operate in the same way."

This optimism is not shared by Silicon Systems' Santoro or by Lidow at International Rectifier. Santoro holds little hope for anything to change under present conditions. He cites the Packard Commission of five years ago, which addressed the same issues and recommended similar solutions. "Everybody at all levels agreed with it, but nothing happened," he laments. "The U. S. is burdened with constituency-related special interests that keep things from happening that are good for the nation as a whole."

Additional reporting by Bernard C. Cole, Lawrence Curran, Jonah McLeod, and Larry Waller

TWO THAT BROKE OUT OF THE MOLD

Changing their manufacturing techniques can bring big benefits for U. S. companies. At least that's the case at Texas Instuments Inc. and at Lockheed Corp.'s Calcomp subsidiary in Anaheim, Calif., a leading maker of plotters.

Jim Watson, vice president of quality control at TI's Semiconductor Group in Dallas, is responsible for Total Quality Control, a Japanese-style program that's more than just paying attention to production. The two-year-old program pervades the entire spectrum of functions in the Semiconductor Group and constitutes a major change in company culture, says Watson. Key is an intense focus on customer needs, but the definition of "customer" is highly unconventional.

"Only a relatively small portion of the company actually deals with the outside customer directly—maybe 10%," he says, "so the other 90% have to deal with what the Japanese call the next-process customer. Whoever benefits from your work is your customer. You have to know who that is, how he measures the success of your performance, and put things in place to make sure you meet his needs." Thus, the design engineer has to produce a design that performs the way the final user wants it to, and he also has to design for his next immediate customer—the manufacturing department.

"In our business," says Watson, "the product is no longer that little black thing with pins sticking out of it. We have to look at everything that goes with it: the customer training, the documentation, the management interface, the field technical support. In other words, the definition of product has to be much more holistic than it has in the past."

Companies can no longer talk about manufacturing quality alone, he says. Instead, they must consider too "the performance and output of everybody in the enterprise. Enterprise connotes more than just the one company—it includes all the company's suppliers. Everyone in that extended enterprise has to produce to increasingly high standards, including the senior managers, human-resource managers, the financial control people, the design engineers, and management.

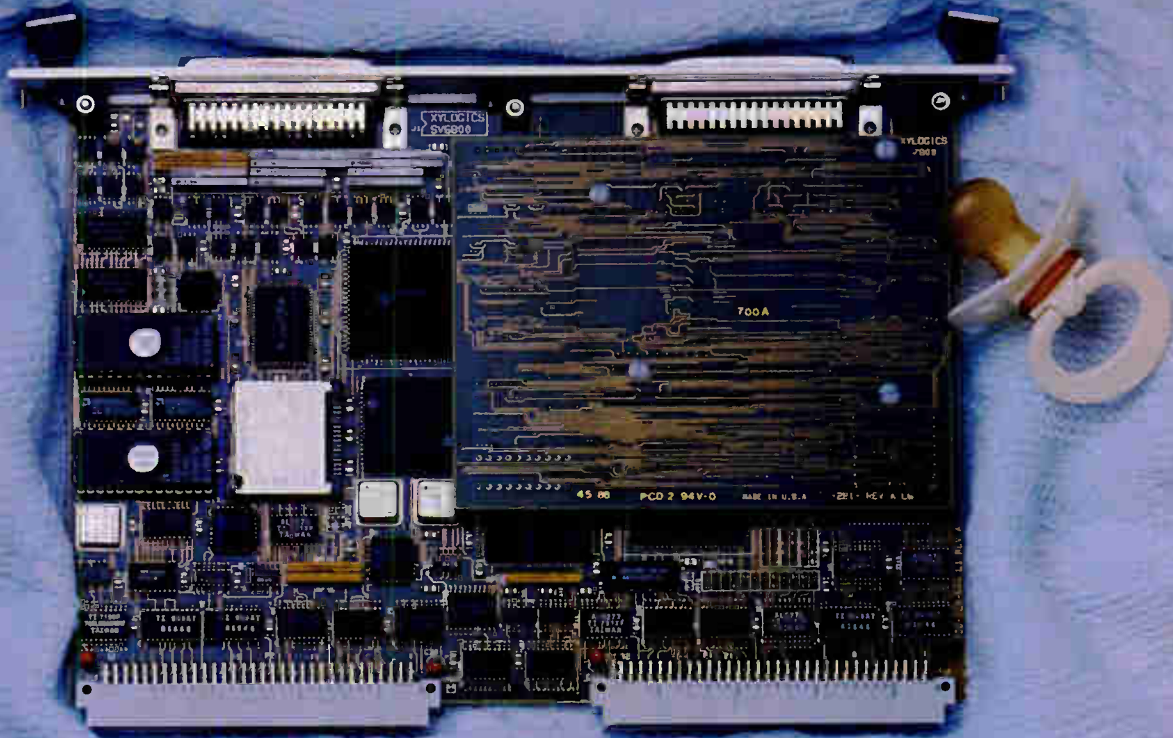
"And if that expanded definition of quality is not recognized, the enterprise will fail," Watson says. "We're working hard to get everybody in the organization to understand what the process is they're involved in, and develop measurements of that process along the way."

> Whoever benefits from your work is your customer

Two prominent results of adopting the TQC methodology, Watson says, are the winning of the coveted Deming prize by TI's Hiji (Japan) plant in 1985 and the strengthening of the company's memory business in 1987 and 1988 by bringing up the DMOS 4 process at sister facilities on a par with the bellwether Niho wafer fab. The methodology is beginning to be applied to TI's 16-Mbit dynamic random-access-memory program, and supplier TQC projects are well under way.

Unlike most U. S. electronics companies, Calcomp's big problem was not foreign competition, but a major U. S. rival—Hewlett-Packard Co. When William P. Conlin took over as president in 1983, he found Calcomp rapidly losing market share because of a high price structure made necessary by an outmoded and costly manufacturing infrastructure. Conlin sought help, and under the guidance of consultant Richard Schonberger, the company adopted elements of the "world-class manufacturing" concept, based on principles laid down by W. Edwards Deming, the quality control guru.

These principles rely on just-in-time delivery from a few certified suppliers, worker participation and teamwork, avoidance of costly automation, flexibility in the workplace with no fixed stations or conveyor belts, and design for ease of assembly and production. In the first three years, Conlin reports, productivity increased 50%, quality rose 40%, and inventory was reduced by 65%, while morale climbed and revenue doubled. Calcomp became a price leader in the plotter market. *–S. W.*



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LOSING THE EDGE IN PRODUCTION EQUIPMENT

Semiconductor production equipment exemplifies the manufacturing dilemma in the U. S. Will the industry give way to Japan?

If the activity at the recent Semicon meetings is any indication, this is the best of times for many semiconductor equipment manufacturers. But appearances can be deceiving.

The Semiconductor Equipment and Materials Institute says some 50,000 people made the trek to its Semicon meeting in San Mateo, Calif., in May to see the wares of an estimated 900 exhibitors. And SEMI has lined up more than 500 exhibitors for an anticipated 8,000 attendees at its Boston show in September. The ebullience of vendors and visitors alike is fed by healthy capital-investment plans of chip makers as they position themselves for the 1990s.

But despite this rosy patina, semiconductor equipment manufacturers—especially U. S. vendors—are contending with serious long-term problems. Many industry watchers believe the health of these vendors can be ensured only by basic structural changes in the way they do business—and concomitant changes in the electronics industry they

BY BERNARD C. COLE

serve. Otherwise, say the pundits, the equipment industry may find itself in the same spot as the machine-tool industry in the U. S.: under the thumb of the Japanese. "That possibility is something that should be of concern to everyone in the electronics industry," says G. Dan Hutcheson, executive vice president of VLSI Research Inc. in San Jose, Calif.

U. S. manufacturers dominated the machine-tool business in the late 1950s, Hutcheson says. A decade later, Japanese vendors were in firm control. "Now, in virtually every system and subsystem built in the U. S., a numerically controlled machine tool built by the Japanese is required," says Carl Kountz, president of the etch division at equipment maker Lam Research Corp. of Fremont, Calif. "What this means is that the cost of fabrication of any product, depending to some degree on the cost of the machine tools used, is no longer under our control."

OUT OF CONTROL. With the sale of Monsanto Co.'s materials operation to West German interests, the U. S. has given up control on the extraction and refining of the basic raw material, silicon, says Stephen Kirtley, manager of Allied Signal Inc.'s Planarization and Diffusion Products Division in Milpitas, Calif. Now the U. S. is on its way to giving up control of the basic tools of fabrication, he says.

The industry is not sitting passively by waiting for the boom to fall. Even as a number of established vendors bow out of the business, others are retooling their development and marketing strategies to hold on to market share and compete with the Japanese. And a slew of startups is energizing the field—some 200 have sprung up in North America since 1983, offering unique technologies for niche markets, says Hutcheson. The trick is to keep the exits and entrances in balance: Hutcheson says that the number of startups is beginning to dwindle while the number of firms folding or leaving the business is starting to rise.

Against this muddled backdrop are market figures that show high times ahead in equipment purchases. The semiconductor equipment industry grew 51% in 1988 to $4.7 billion and should shoot up another 18% in 1989, says Robert McGeary, director of semiconductor equipment and materials service at Dataquest Inc. of San Jose. For 1988 through 1992, he projects average annual growth of 19% for front-end equipment and 21.7% for back-end fabrication gear.

But who will reap the profits from this growing market? By almost any measure, says Hutcheson, the answer increasingly is the Japanese. For example, Dataquest pegs the U. S. share of the wafer-fabrication equipment market worldwide at 45% in 1987, a drop from 62% in 1982, while Japanese share climbed to 44% from 29% in that time frame. By the end of the year, says Hutcheson, Japan's share will probably exceed America's for the first time.

This trend is borne out by a VLSI Research study that compares the ranking of the top 10 semiconductor equipment suppliers (including test-gear makers) in 1988 to that in 1979. Back in 1979, says Hutcheson, there were no Japanese-based firms in the top 10; the top Japanese finisher was test-gear maker Takeda-Riken (now Advantest), at No. 15. In 1987 came the first real sign of a shift when Nikon Inc., a Japanese camera company not even involved in semiconductor equipment 10 years ago, took the No. 1 spot from Perkin-Elmer Corp. of Norwalk, Conn. Last year, Nikon was joined at the top by Tokyo Electron Ltd. and Advantest. Canon Inc., a manufacturer of lithographic systems, also inched up, from seventh place to sixth.

By comparison, U. S. players slipped. GCA Corp., which ranked No. 4 in 1979, has been acquired by General Signal Corp. of Stamford, Conn., a supplier of probers and steppers that itself slid from third place to fifth. Test-gear maker Teradyne Inc. dropped back one spot, to No. 8. And Perkin-Elmer tumbled from the No. 1 position it had held since 1980 to No. 2 in 1987 and No. 8 last year. Within recent months, it has bowed out of the semiconductor equipment market altogether and placed its production operation up for sale.

BIG BREAKTHROUGH. Ironically, says Hutcheson, the withdrawal came at precisely the point of Perkin-Elmer's big technological breakthrough—the Micrascan system. Historically, circuits have been fabricated using one of two techniques: aligners, which trace the patterns for chips line by line across an entire wafer using multiple images of the integrated circuit, requiring that mask and wafer be aligned very precisely; or steppers, in which the mask is a single image of one IC, which is moved across the wafer in step-and-repeat fashion. Micrascan combines these two techniques, rapidly tracing the circuit patterns, but with better resolution than steppers and at higher volume, says Hutcheson.

But the system took seven years and $100 million to develop, too burdensome a cost for a company whose sales had dropped to only $200 million in 1988, from $264 million in 1987. Facing pressure to improve its profitability, Perkin-Elmer first opted to leave the stepper business, and a few months ago it dropped out of the industry altogether.

There are many reasons why the U. S. semiconductor equipment industry is having such a tough time, says Hutche-

WHO'S ON FIRST?

The Top 10 Equipment Makers in 1988 . . .

	(1987 Rank)		Sales ($ millions)
1	(1)	Nikon	520.7
2	(6)	Tokyo Electron	508.3
3	(4)	Advantest	384.9
4	(5)	* Applied Materials	381.7
5	(3)	* General Signal	375.2
6	(7)	Canon	289.7
7	(9)	* Varian	210.9
8	(2)	* Perkin Elmer	205.2
9	(8)	* Teradyne	189.7
10	(10)	* LTX	179.5

. . . and in 1979

		Sales ($ millions)
1	* Fairchild Test Systems	111.4
2	* Perkin Elmer	101.2
3	* Applied Materials	54.1
4	* GCA	54.1
5	* Teradyne	53.4
6	* Varian	50.8
7	* Tektronix	39.2
8	* Eaton	37.7
9	* Kulicke & Soffa	37.0
10	Balzers	33.7

* U.S. company

SOURCE: VLSI RESEARCH INC.

son, including poor balance sheets, faulty market forecasting, poor product planning and marketing, inattention to customers' needs, and "arrogance, pure and simple." Combined with these are factors the industry cannot control. One, he says, is the relatively closed Japanese market, where equipment makers are tied to giant semiconductor companies through ownership, partnerships, or strategic alliances, making it hard for others to edge in. Whereas the share of the U. S. market in American hands has remained relatively constant over the past five years at about 70%, worldwide it has dropped from about 63% to 49%. In Japan, U. S. share fell from about 80% ten years ago to 30% in 1987 and 14% in 1988, Hutcheson says.

Against this overwhelming combination of circumstances, U. S. semiconductor equipment manufacturers are developing strategies to compete. For the large multiproduct equipment makers, says Hutcheson, three routes are emerging: reducing their investments and focusing on a few product areas; getting out of the game altogether; or upping the ante by investing in new technology, expanding product lines, and taking on Japanese companies on their home turf.

Startup Asyst's Smart Traveler boasts automated materials control during the wafer-fab cycle.

In the first category are companies such as Veeco Instruments Inc. of Melville, N. Y., which pulled the plug on its ion-implant business to concentrate on niches in instrumentation and process automation. But more companies are opting for the second route: last year alone, says Hutcheson, 37 U. S. firms dropped out of the equipment sector and at least 20 more folded, among them AED, Beckman, Deltron, FMS, GenRad, LFE, Micronix, and Temescal.

MOVING UP. Somewhat compensating for this abandonment of the market are a number of mature equipment companies that are managing to navigate the treacherous waters. For example, Applied Materials Inc. of Santa Clara, Calif., scored its best year ever in 1988, garnering sales of $381.7 million and moving up on the VLSI Research list from No. 5 to No. 4, just a few thousand dollars shy of Advantest. The secret lies in a two-pronged strategy, says chairman James Morgan: penetrating the Japanese market and aggressive product development.

One of the first U. S. semiconductor equipment firms to establish a wholly owned subsidiary in Japan, Applied now accounts for 35% to 40% of all U. S. semiconductor equipment sales there, according to Dataquest. And unlike many of its competitors, who gave in to investor pressure and reduced research and development spending during the market downturn in 1985 and 1986, Applied placed its bets on developing more advanced products, says Morgan. The gain didn't come without pain: in 1987, investments in product development held profits to just $336,000. But last year came the payoff, in the form of a record $40 million in profits. Applied expects 1989 sales of $486 million and profits of $56.3 million.

Also doing well is Varian Corp. of Palo Alto, Calif. It rolls in at No. 7 on the VLSI Research list, from No. 9 in 1987, with sales of $210.9 million. Varian is no less aggressive than Applied in its product development. Building on a virtual doubling of its sales of sputtering equipment from 1987 and the reemergence of its ion-implanter line to the front ranks, Varian has made major investments in chemical-vapor-deposition equipment and last year began shipping an advanced multiprocess system. But the company has taken a different tack in its marketing. To expand its offerings, Varian has chosen to represent Tokyo Electron's diffusion furnace, etch, and resist processing equipment in the U. S.

A relative newcomer that many believe could push its way into the top 10 is Lam Research. While many of the industry stalwarts—Applied Materials, GCA, General Signal, and Varian, for example—grew up in the 1960s and '70s with the semiconductor industry, Lam came on the scene in 1980. Since then it has moved rapidly from a niche orientation to being a broadly based, multiproduct, multiprocess firm. Building on its original emphasis in the plasma etch market, Lam has quickly expanded into such complementary technologies as epitaxial deposition and specialized chemical vapor deposition. From sales of about $35.5 million in 1987, it is expected to exceed $100 million in 1989.

Eschewing a broad-based approach are the startups, which began sprouting in large numbers in 1983 and 1984. Funded by venture capital, these new companies revolve around niche strategies, focusing on leading-edge technologies that depend on the traditional U. S. strength in R&D as well as product definition and development. "In general, these new companies are adopting the same strategy we are seeing in the semiconductor industry itself," Hutcheson says. "That is, rather than compete head to head with the Japanese where their strength in manufacturing technology is overwhelming, they have chosen to focus on market niches where the Japanese presence is not so overwhelming."

Falling into this category are companies such as Advantage Production Technology, Asyst Technologies, Ateq, Emcore, Insystems, Novellus Systems, Peak Systems, Raypro Technology, and the Silicon Valley Group (see p. 64).

As aggressively entrepreneurial as

MARKING ENTRIES AND EXITS

Among U.S. Suppliers

	1983	1984	1985	1986	1987	1988
Entries	14	47	43	60	15	20
Exits	2	11	28	24	31	37
Balance	+12	+36	+15	+36	–16	–17

Among Japanese Suppliers

	1983	1984	1985	1986	1987	1988
Entries	14	43	39	45	12	7
Exits	1	0	2	4	6	4
Balance	+13	+43	+37	+41	+6	+3

some of these new firms are in finding potentially lucrative market niches, Hutcheson is concerned about a drop-off in their numbers. From 14 new companies in 1983, the number of U. S. startups peaked at 60 in 1986, then tumbled to 15 in 1987 and 20 in 1988. "What's particularly distressing is the number of companies that have gone out of business or exited the market altogether during the same time frame," he says. "Up until 1986, the number of companies coming into the market always exceeded those that left. Since then the trend has reversed."

According to his estimates, 31 U. S. companies exited the semiconductor equipment business in 1987, twice as many as entered. In 1988, the trend was the same. By comparison, he says, the number of new Japanese companies entering the business has been roughly the same as the U. S. rate. But the number leaving is substantially less: two in 1985, four in 1986, and six in 1987.

One of the problems facing startups, says Hutcheson, is a short-term view on the part of venture capitalists that fund them and the investment institutions that provide the financial wherewithal. Another is the lack of a coordinated effort between semiconductor companies and the equipment makers that supply them.

"In the early 1980s, technologically aware venture capitalists, looking at the trend toward higher levels of integration and submicron processes, correctly perceived that a prime growth area would be in the equipment needed to process the circuits," says Hutcheson. "What they didn't see was how competitive the semiconductor equipment industry is, how costly it is to develop a piece of leading-edge equipment, and how long it would take before they could expect a payback for their investments."

For example, he says, it can take as much as $30 million to bring an advanced lithography, implant, or test system to market, and even longer for some of the more advanced, specialized systems. And depending on acceptance in the marketplace and the amount of education required, it can take at least six to eight years to establish a significant market presence—about twice as long as most venture capitalists are comfortable with.

If the venture capitalists are tough customers, so are the chip makers. "More than one venture capitalist has told me that the reason they won't invest in equipment anymore is because the customers are too vicious," says Hutcheson. "U. S. semiconductor makers keep demanding new leading-edge equipment, but when they see the bill, they won't pay for it." Things are very different in Japan, he says: "If [Japanese IC makers] see a piece of advanced equipment, whether U. S. or Japanese, and it is able to solve a problem they can't, they will pay whatever is necessary."

TOO RISKY? There is also an unwillingness on the part of U. S. semiconductor makers to deal with the equipment startups because of concerns about financial stability. "Buying from a venture-funded startup is now viewed as being too risky," Hutcheson says. "U. S. customers in particular will often wait until there are clear signs that the company will be successful. But in order to be successful, the equipment makers need some sort of solid commitment from the semiconductor companies. It's the proverbial catch-22.

"What all this tells me," says Hutcheson, "is that something is very, very wrong structurally, not only with the semiconductor equipment industry, but the electronics industry as well. In many cases, it goes beyond that, to the way we do business in America."

Overall, he says, there is a lack of that sense of being on the same team that is pervasive in Japan. "That does not mean we have to shift to an environment in which we all march in lockstep," Hutcheson says. "What we need to develop is an environment in which companies can maintain their individuality but contribute to the success of the U. S. as a technological nation. A good analogy is a baseball player. Just because he is a member of a team does not mean he can't be a success in playing whatever position he desires. The two do not have to be mutually incompatible." □

THREE CHEERS FOR THE STARTUPS

Much of the juice in the equipment game is coming from the startups, new players pushing innovative or even revolutionary technologies for specific market niches.

One of the newest, Advantage Production Technology Inc. of Sunnyvale, Calif., focuses on surface-contamination removal and thin-film deposition. Key to its strategy is the Chemical Process Module, built using a new form of silicon carbide. This chemically impervious material greatly reduces wafer contamination, lending itself to the in-situ multiple processing that's necessary in advanced processing schemes, says cofounder Michael McNeilly.

> New firms are pushing innovative technologies for market niches

A surface-contamination removal system is set for introduction later this year, followed by chemical-vapor-deposition modules early next year. Based on initial responses from beta-site customers, Advantage should nab $10 million in sales by the end of next year and $30 million by 1991, says cofounder Franc deWeeger.

Another company with a unique solution is Asyst Technologies Inc. of Milpitas, Calif. Submicron processes require Class 1 clean rooms that are 10 to 100 times cleaner than current facilities and represent investments of millions of dollars. Asyst's solution is not to make the clean room cleaner, but to break the clean room down to the wafer level, says Richard Darlow, director of marketing.

Based on a concept called the standard module interface, the company's Smart Traveler System transports wafers in Class-1-environment enclosed pods, which are loaded and unloaded into the various wafer-fabrication systems by robotic arm. With this approach, says Darlow, chip makers can upgrade older Class 10 and Class 100 facilities and build new Class 1 facilities at a fraction of the usual cost. Darlow estimates that the company will garner sales of $10 million to $20 million in 1989.

For Novellus Systems Inc. of San Jose, Calif., the target of opportunity is chemical-vapor deposition. The firm's Concept One, based on a continuous-processing, batch-hardware approach, combines the higher yields and better film quality of single-wafer systems with the throughput—and thus lower costs—of traditional batch processing. The system was introduced in 1987, resulting in sales of $3.3 million that year and $23.2 million in 1988. Most industry analysts expect Novellus to shoot to perhaps $60 million by 1990.

Targeting rapid thermal processing, essential for VLSI, is Peak Systems Inc. of Fremont, Calif. The Peak approach combines an ultrahigh-intensity arc lamp that is matched exactly to the absorption characteristics of silicon with a unique solid-state igniter and a cold-wall processing chamber. Orders are in from about 20 U. S., 8 Japanese, and 3 European companies, says executive vice president Robert MacKnight.

Epitaxial deposition of silicon, important in the next generation of bipolar, CMOS, and biCMOS VSLI logic and memory circuits, is the focus for Raypro Technology Inc. of Fremont. Its Integrated Process System is a single-wafer, multiple-chamber system built around a process reactor, a unique heat source, and a specially designed gas-distribution system. The first in the family is the IPS3000e, which provides the equivalent throughput of traditional batch reactors—15 to 50 wafers per load in about an hour. Limited production should begin later this year, says Fred Wong, vice president of operations. "We expect to be generating significant revenue by the end of next year," he says. *–B. C. C.*

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Circle 29

WHO WILL WEATHER THE GATHERING STORM IN THE COURTS?

LITIGATION

Suits that push copyright and patent protection could have a profound impact on the industry

Major changes in the way the electronics industry will conduct business in the 1990s are being forged not in the marketplace but in the courtroom. The aim of the companies that are filing suits pushing the boundaries of copyright and patent law is to expand the definition of what can be legally protected and licensed for fees and royalties. If they succeed, the intense competition to develop smaller, faster, cheaper products that has characterized the industry for the past three decades may give way to a new strategy: nailing down legal monopolies. But even if they don't succeed, their attempts seem likely to change the way hardware and software advances are perceived. Many key cases have yet to be decided, so

BY JACK SHANDLE

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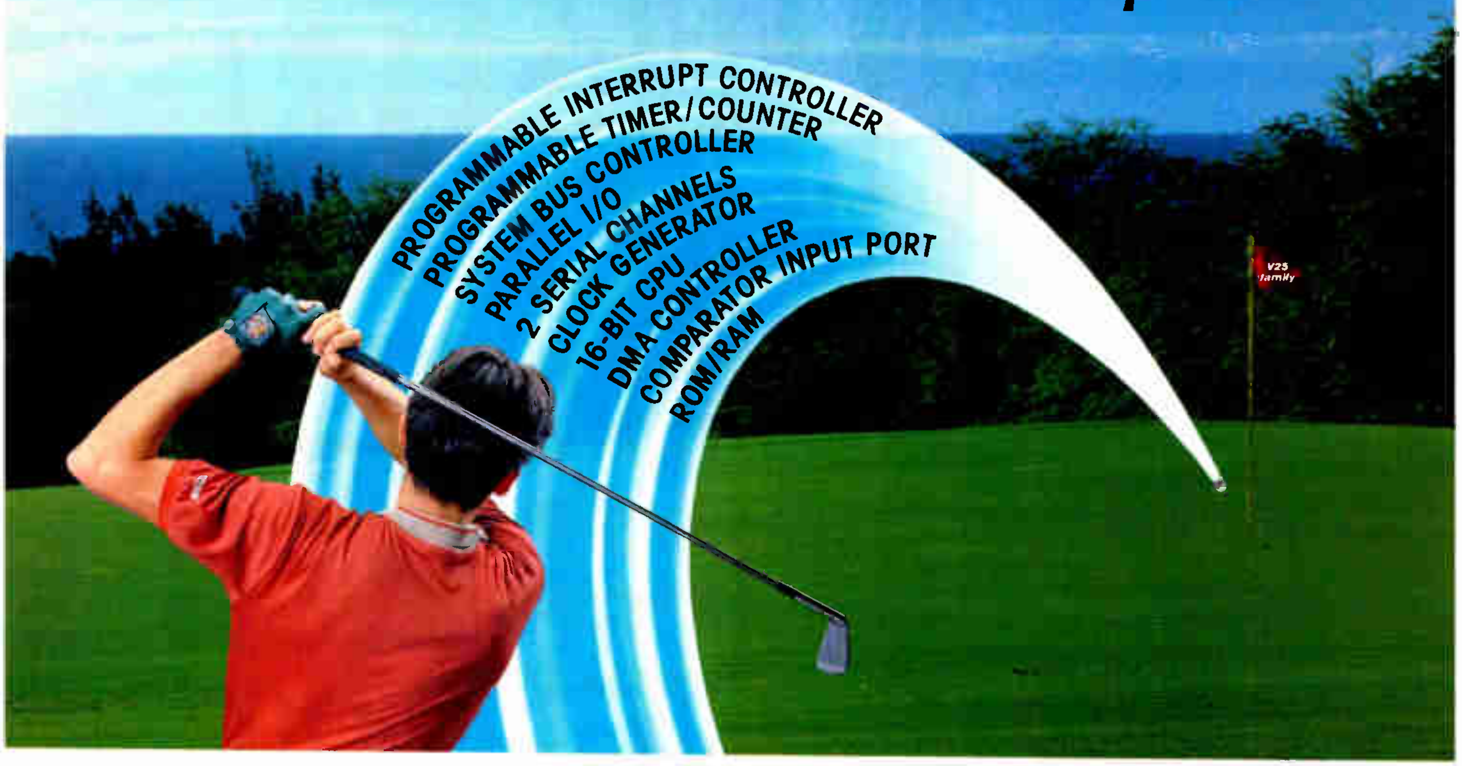

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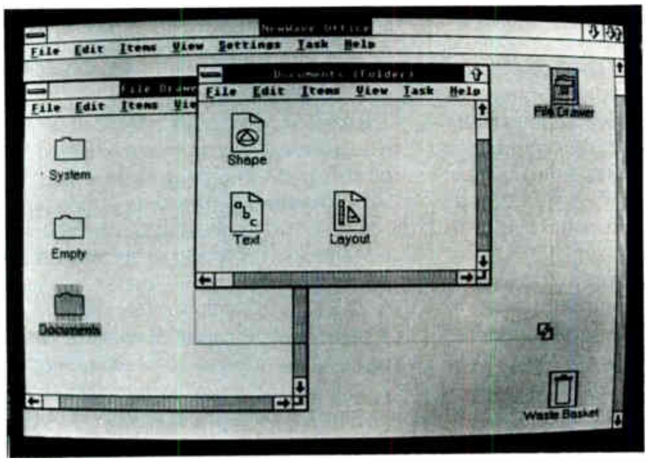

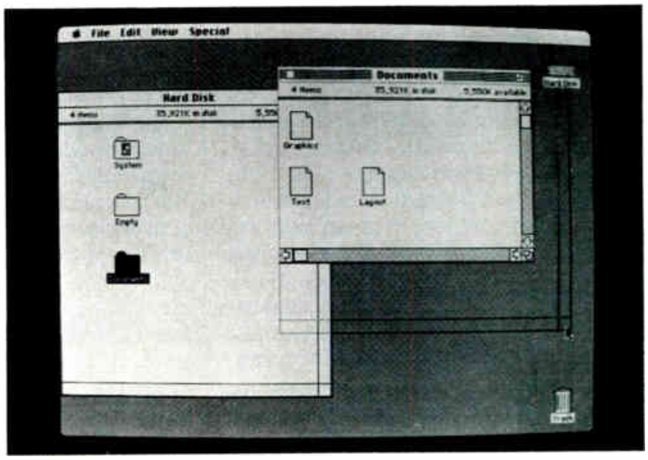

Apple Computer contends that the "look and feel" of Hewlett-Packard's New Wave program (left) are substantially the same as Apple's Macintosh screen, and that New Wave therefore infringes on Apple's copyright.

the ramifications of this legal movement remain unclear. Indeed, the drama unfolding in federal courts nationwide has no historical parallel. And it's perplexing the legal community, which is being forced to confront slippery questions of what constitutes intellectual property using patent and copyright laws that were developed for machines and works of art, not software and microcode.

The most celebrated—and most critical—suits involve copyright protection of software. In their so-called "look-and-feel" suits, Apple Computer, Lotus, and Ashton-Tate are seeking control beyond the actual code itself to include file structures, command names, and the images that the code causes to be displayed on a screen. Although most legal scholars and technical consultants familiar with litigation aren't impressed by look-and-feel arguments, some early rulings have gone in their favor.

NEW ROUTES. On another front, AT&T Co.'s success in patenting an algorithm has opened a new, some say perilous, avenue for protection of intellectual property (see p. 70). And Xerox Corp. further muddies the waters by attempting to license its windowing environment, sidestepping the look-and-feel suits altogether.

Legal battle lines are also being drawn on the hardware front. Intel Corp.'s successful patent-infringement suit concerning its erasable programmable read-only memory established that a design house could not piggyback on a technology license held by a foundry. Meanwhile, Brooktree Corp. of San Diego has brought suit against Advanced Micro Devices Inc. of Sunnyvale., Calif., alleging infringement of mask works for a special static random-access-memory design. Such litigation is not uncommon in recent years, but all cases have been settled out of court. If a court rules in the Brooktree-AMD case, it will set the first mask-work case law on several major points.

Some observers fear that if the envelope of protectable intellectual property extends much beyond its present limits, the U. S. will become even less competitive in global markets. "In Japan, consortia of companies work together to have similar architectures and interfaces," says Rich Belgard, a technical consultant to attorneys. "In this country, we have court battles to restrict standardization."

Companies seeking to expand protection counter that they shouldn't be forced to stand by while less innovative competitors freely pluck the fruits of their labor. "These are not short-term projects," says Tom Dunlap, vice president and counsel for Santa Clara, Calif.-based Intel. A competitor's usurping the design of a product like Intel's 80386 processor and its instruction set is "equivalent to wanting to jump into a marathon at the 13th mile," he says. "Everyone should compete fairly."

Legal observers view the aggressive trend in litigation as a sign that the computer industry has matured. "Patents and copyrights have become very important in the past two or three years because the computer market has reached a plateau," says Robert Clinton, a law professor at the University of Iowa in Iowa City. "Expansion into new technology frontiers has not been as aggressive, and at that point the players start jockeying for competitive advantage. One way to do this is to get a monopoly."

Copyrights and patents provide limited monopolies—patents for 14 years and copyrights for 75. Patent protection is much more easily enforced. The first company to patent a technology has exclusive rights to its use. In contrast, a viable defense against a copyright-infringement action can be built by proving that the defendant's product was developed without detailed knowledge of the plaintiff's product and how it works.

Copyright case law regarding software is in greatest disarray regarding the argument that a program's "look and feel" and its "structure, sequence, and organization" are protected under existing copyright law. Cases like Apple's action against Microsoft Corp. and Hewlett-Packard Co. over the windowing environment focus primarily on one of the criteria for copyright infringement: that a defendant's program is "substantially similar" to the plaintiff's.

Two court decisions handed down in 1986 bolster the look-and-feel argument, notes Esther Schachter, attorney-editor of the *Computer and Tax Law* newsletter. In *Whelan Associates v. Jaslow Dental Laboratory*, the U. S. Court of Appeals of the Third Circuit concluded that copyright protection extends beyond a program's literal code to include its "structure, sequence, and organization."

In the other case, *Broderbund Software Inc. v. Unison World Inc.*, the U. S. District Court for the Northern District of California ruled that although the defendant's software contained a few embellishments that the plaintiff's software lacked, the "total concept"—that is, the look—"and feel is virtually identical." On this basis, the court found the two programs substantially similar.

TWO WAYS. But similarity is only one criterion for copyright protection; another is that the plaintiff's work be novel and creative. In a 1988 case involving video games—*Data East USA Inc. v. Epyx Inc.*—the U. S. Court of Appeals of the Ninth Circuit ruled that because functionality dictated the look and feel of both games' screens, anyone writing such a program would come up with substantially the same result. Since that result was thus neither novel nor creative, it could not be copyrighted, the court decided.

While Apple contends that its "unique audiovisual display"—windows, icons, and screen arrangements—is protected, Lotus Development Corp. pushes the envelope a little further. The Cambridge, Mass., software house contends that not only the screen display but also the command names and the sequence and range of choices offered in its 1-2-3 spreadsheet are protected by copyright. It has filed suit against Mosaic Software Inc., also of

Cambridge, to win that protection.

Ashton-Tate Co.'s suit against Fox Software Inc. of Perrysville, Ohio, adds another twist. The Torrance, Calif., company is seeking copyright protection of the intermediate file structure of its dBase data-base management system, says consultant Belgard. A ruling in Ashton-Tate's favor would mean that any company that markets a dBase-compatible product would have to license the file structure. "This would be a very negative trend," says Belgard. Ashton-Tate is also trying to copyright its dBase programming language, a move that has no precedent, says Pam Samuelson, a law professor at Emory University in Atlanta.

Despite all the activity, it will be a while before precedent-making decisions are made. "The Lotus case is scheduled for trial in September," Samuelson says, "and Apple won't go to trial for at least another year. And Ashton-Tate is probably hoping by the time its case goes to trial, there will be a victorious decision for either Apple or Lotus."

WRONG CONCEPT. Observers such as Schachter believe that look and feel is not going to fly. "It's a marketing battle taking place in the courts," she says. "Lawyers themselves are going to want to abandon that philosophy." Functionality is critical in the arguments against look and feel, she contends.

Samuelson too calls look and feel a "bogus" theory. "It's an inappropriate basis for copyright infringement—it's not a precise way of defining what is unique about a product, and 'structure, sequence, and organization' does nothing but obscure the application of copyright law to software," she says. "We should recognize the functional nature of software; and except for computer programs, all functional things are outside the realm of copyright."

Look and feel has become an important enough issue to prompt law scholars to meet last February in Arizona. Dennis Karjala, a law professor at Arizona State University in Tempe who is in charge of drafting a consensus document from the conference, says the group will recommend that optimally functional interfaces not be protected by copyright. Regarding look and feel, he says, "we agreed there are a number of doctrines that may limit the scope of protection, but there was no consensus on the need or desirability of standardization efforts."

The structure, sequence, and organization argument fared little better with the group. "We believe SSO is not helpful," Karjala says. "It's just a phrase that doesn't really tell you anything. You have to determine the scope of protection on a case-by-case basis." Since computer programs are unique in being the only functional works that can be copyrighted, he says, the law should be stretched gingerly.

Clinton of the University of Iowa thinks the look-and-feel argument will fail for a simple legal reason: the copyright act makes a distinction between literary works and pictorial, graphical, and sculptural works. "Generally, software has been considered a literary work," he says. "But when you're dealing with screens and pictures, that doesn't make much sense." There is a specific exclusion from copyright protection for pictorial, graphical, and sculptural works, he says, adding that copyrights cannot be legally granted on these expressions unless they are separate from utilitarian functions of the work. Regarding software, he argues, it is clear that utility and expression cannot be separated.

The look-and-feel issue may well be settled out of court. Xerox, which invented the windowing environment at its Palo Alto (Calif.) Research Center, has jumped into the picture not with a suit, but by offering licenses to what it considers its intellectual property. Xerox's move, observers say, may undercut the look-and-feel suits.

COPYRIGHTS FOR CODE. Hardware cases have not generated as much comment as look and feel, but a few have made news—particularly Intel's suit against NEC Corp. of Tokyo for copyright infringement of the microcode for the Intel 8088 and 8086 microprocessors. Although the case went generally in NEC's favor—the court decided NEC did not copy the microcode—Intel won a big point when the court ruled that microcode can be copyrighted. If it holds up, the ruling will give microcode developers the chance to seek the 75-year protection of copyright law, Belgard says.

After the Intel/NEC ruling, IBM Corp. decided to copyright all the microcode for its mainframe computers and now licenses the microcode in the machine. "Third-party vendors and resellers can't resell the microcode because they don't own it," he says. A more obvious fallout is that Intel and other firms with microprocessor designs have now protected themselves with both patents and copyrights.

In a more recent case involving Intel, a U. S. International Trade Commission decision keeps independent design houses from arguing that a license held by a foundry for some basic circuit—in this case EPROMs—acts as an umbrella over all devices manufactured in the foundry. Atmel Corp. of San Diego had included EPROM circuitry and had the circuit manufactured in an offshore foundry that holds an Intel EPROM license. Intel's victory makes independent design houses tread more softly—and adds to Intel's licensing revenues.

Because the case was not decided by a federal court, Intel's victory is limited to keeping the chips from being imported into the U. S. The final step—endorsement of the decision by President Bush—is set for next month. Although the ITC is not a federal court, its decision can be cited as precedent in U. S. courts.

Mask works—a form of intellectual property unique to the semiconductor industry—may be on the verge of precedent-making case law. Brooktree alleges that AMD infringed on its mask work for SRAM circuits used in Brooktree's Bt451 and Bt458 color-palette chips. On June 19, a U. S. District Court in San Diego ruled that Brooktree could amend its suit to include the charge that patents (which had not been granted when the original suit was filed) have been infringed. □

AT&T'S KARMARKAR: PATENTING AN ALGORITHM

Perhaps the most radical attempt to stretch the definition of intellectual property is AT&T Co.'s patenting of an algorithm. The Karmarkar algorithm, developed at Bell Labs, can optimize solutions to a slew of complex problems, such as airline scheduling, distributing materiel in the armed forces, and mixing complex chemical combinations. Expressed in linear equations, these problems have thousands of variables and hundreds of thousands of constraints. Other algorithms can be used to attack them, but Karmarkar yields significantly better results.

Still, seeking a patent—which AT&T received from the U. S. Patent Office in May 1988—was a bold move. Mathematical formulas have traditionally been considered "facts of nature," not creative works, and therefore unpatentable, says Michael Shamos, a lawyer and adjunct professor at Carnegie Mellon University in Pittsburgh.

Clearly, AT&T made the move to hold on to a very valuable piece of property. "Computer programs implementing other linear programming algorithms sell for $1 million or more," says Shamos. But AT&T is likely to charge licensing fees "on a reasonable basis" for Karmarkar, says Pam Samuelson, a law professor at Emory University in Atlanta. The reason: "So that no one sues." Legal scholars believe a challenge to AT&T's patent would succeed. All three cases in which the U. S. Supreme Court has considered the patentability of algorithms have gone against the companies seeking patents, says Samuelson.

But such a move is unlikely. Fighting AT&T would cost millions of dollars, says Shamos, and companies will probably find it more prudent to simply license the algorithm. "The patent office is now issuing patents on anything," says Samuelson. "At some point, the patent office will issue enough algorithm patents that the law will have been changed without the cases being tried." *—J. S.*

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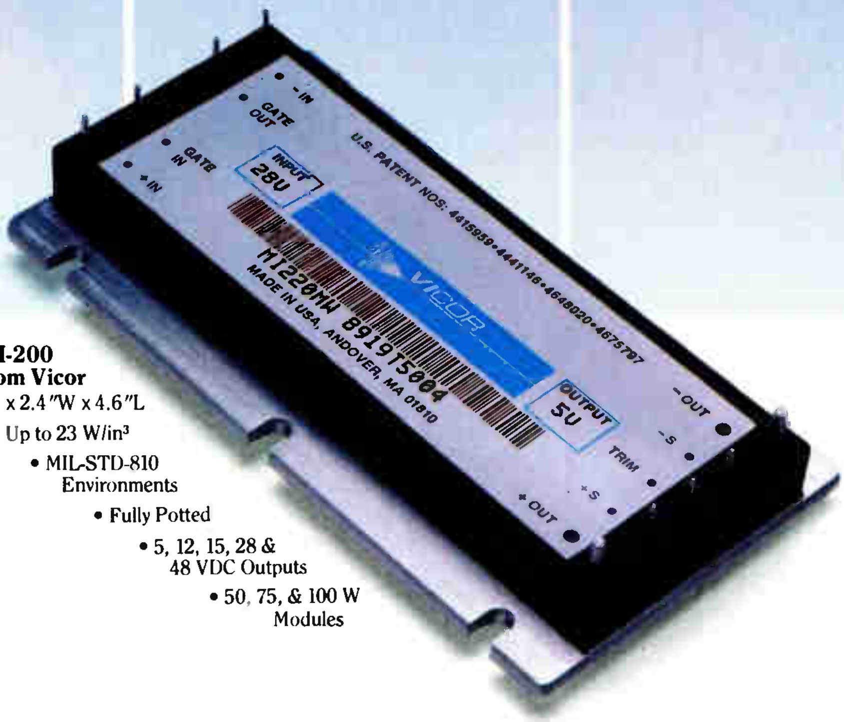

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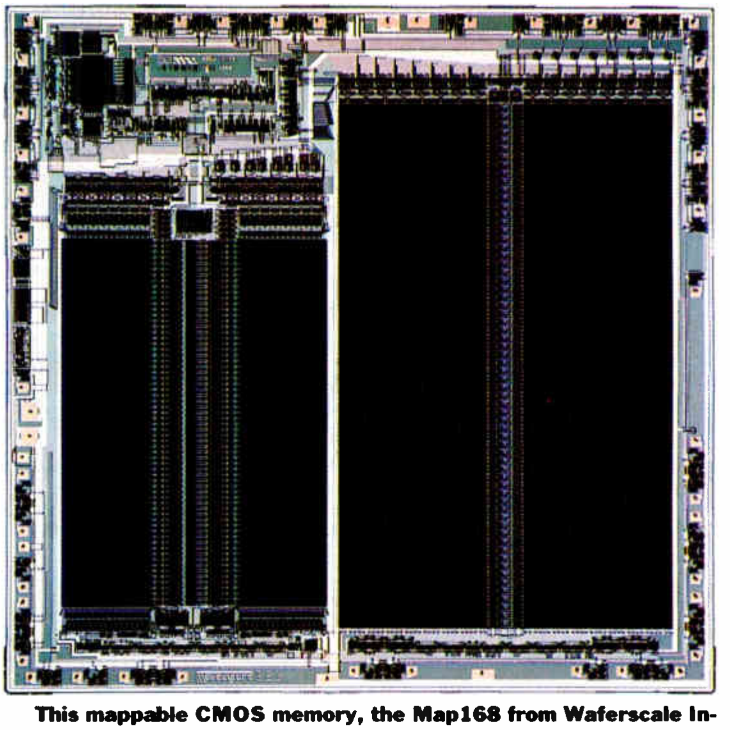
Memories Go ASIC

SPECIALTY MEMORIES, NOT COMMODITY PARTS, MAY HOLD THE KEY TO THE FUTURE FOR U.S. VENDORS

The current turmoil over the U. S. lag in producing commodity dynamic random-access memories has diverted the attention of many American semiconductor companies from a newly emerging memory segment: specialty or application-specific parts.



This mappable CMOS memory, the Map168 from Waferscale Integration, combines EPROM, SRAM, and logic on the same chip.

Indeed, many analysts believe that the future of U. S. memory makers lies not in commodity parts but in these special-architecture, special-process designs. The market figures bear this out: from sales of just $200 million to $250 million in 1987, specialty static RAMs and DRAMs will account for some $1.1 billion this year, says Fred Jones, the senior analyst for memories at Dataquest Inc., the San Jose, Calif., market research firm.

In general, he says, it is a market that works to all of the U. S. strengths. "This is a very fast-moving and volatile market, with market and product definitions and user needs changing rapidly," says Jones. "It needs companies that can shift gears rapidly and that are comfortable in smaller-volume niches, where the Japanese strength in high-volume production cannot be brought into play very easily." In the future, commodity memories, now an

BY BERNARD C. COLE

$11 billion annual market, will continue to represent a very large share of the memory market overall, says Jones. "But they will have to share the market with numerous specialty devices."

And where the commodity segment will be dominated by a handful of vendors, the specialty market will be shared by as many as two dozen manufacturers going after the profits possible in devices with much higher selling prices and more stable pricing than generic DRAMs.

Driving the trend toward specialty memories with increased levels of on-board logic are a number of significant market trends, says Jones. First is the proliferation of microprocessors and microcontrollers into diverse applications, each with its own memory requirements. Second is the push for lower component count and higher performance in embedded microcontroller and processor applications. A third market driver is the emergence of the new high-performance 25-to-60-MHz complex- and reduced-instruction-set computers, creating a speed gap being filled by new categories of memories that eliminate wait states.

Yet another factor is the trend toward multiprocessing, says Jones, in everything from advanced computer architectures to personal computers incorporating embedded controllers and processors—all of which require memories allowing them to transfer and share data quickly. Finally, there is the sheer size of the integrated circuit market, where even specialized memory segments are projected to grow into the hundreds of millions of dollars by the early 1990s.

The move started with SRAMs, then DRAMs, and now nonvolatile erasable and electrically erasable programmable read-only memories targeting specific niches, differentiating in terms of organization, speed, and degree of on-board intelligence. And new memory options are emerging, combining, for example, SRAM and EPROM or SRAM and DRAM.

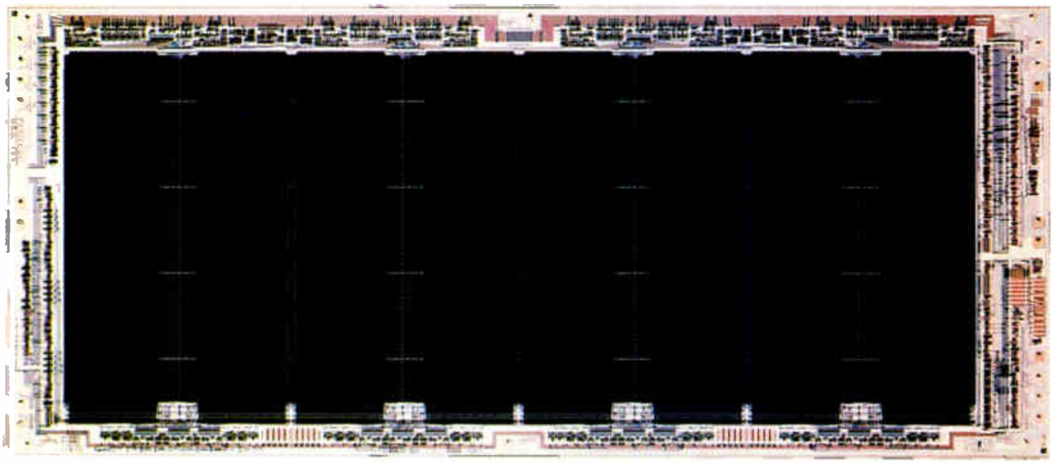
In addition, devices melding memory and logic are blurring the boundaries between these two categories. Designers at a number of companies are considering the possibility of building mixed memory/logic circuits that defy categorization. Where structured gate arrays and compiled standard cells have advanced to the point where up to 64 Kbits of memory can be embedded within the heart of the logic, special-application memory designers are now considering configurations where anywhere from 128 Kbits to 1 Mbit of memory will be surrounded by a periphery of uncommitted logic gate arrays. Such a scheme would let the system designer customize the memory array to a particular system configuration.

The fuzzy line between logic and memory, among memory types themselves, and between what is a niche product and what is a commodity memory is reflected in analysts' attempts to define what constitutes a specialty memory. Dataquest, which has kept tabs on these devices since 1987, has refined its definitions over the years. Where in 1987, specialty memories included such things as dual-port SRAMs, other types—including SRAMs with on-board logic for separate input and output functions, resettable latches and registers, and self-timing logic—have been classified as standard SRAMs. Similarly, SRAMs desgined for cache-tag and cache-data applications are also in the standard-SRAM grouping.

However, with the emergence of specialized cache-data and cache-tag RAMs specific to particular architectures, says Jones, there is some thought to separating these out as specialty memories. Similarly, video DRAMs until last year were grouped with standard DRAMs but have now found their way into the specialty-memory category. Another specialty memory still included under standard DRAMs is DRAM-based first in, first out devices targeted for use in the embryonic high-definition TV market and other image-scanning applications.

A new memory type that will be added to the specialty RAM list, says Jones, is high-density content-addressable memories, the first commercial versions of which have just been introduced.

The difference in classification, says Jones, lies in how widespread the use of the modifications to the basic architecture become and the degree to which these parts are used in particular applications. For example, SRAMs with on-board logic for separate input and output functions, resettable latches and registers, and self-timed or asynchronous SRAMs are usually built by adding logic to the basic architecture via metal mask options. Similarly, in DRAMs, makers have been offering faster access modes such as nibble, byte, static column, and modified page, along with the standard page-access mode, using a similar metal mask option.



NEC's µPD42601 silicon file combines a 1-Mbit DRAM array along with the support logic to make the device look like a magnetic disk.

However these devices are categorized, the common denominator, says Jones, is the incorporation of additional logic to reduce component count, simplify packaging, increase system performance, or simplify interfacing. "The trend is toward more intelligent memories, and memories with more of the logic on board," he says.

One memory segment that emerged early to satisfy the speed gap between microprocessors and main memory was data and tag SRAMs for use in direct-mapped single-level caching in first-generation RISC and 68010/020 and 80286 CISC processors. Initially the bailiwick of smaller U. S. firms such as Integrated Device Technology, Mosel, Saratoga Semiconductor, and Vitelic, this segment is now luring the big players: Advanced Micro Devices, Fujitsu, Hitachi, Motorola, NEC, SGS-Thomson, and Texas Instruments.

Always fast on their feet, IDT, Mosel, and Vitelic, as well as VLSI Technology, have moved onto the next generation, developing specialized reconfigurable cache-data RAMs. These parts are organized into two banks of independently controlled 2K-by-16-bit SRAM arrays, with a bidirectional data path and on-board address latches and transceivers. They can be configured as a single 4K-by-16 direct-mapped cache or as a two-way set-associative design. Hot on their heels are such competitors as Austek, Chips & Technologies, Cypress Semiconductor, Hitachi, and Micron Technology.

Even as the battle lines form on this

generation of cache tag, some companies are looking to the next market opportunity in advanced 32-bit CISC processors such as Motorola Inc.'s 68030/040 and Intel Corp.'s 80486. This generation raises many opportunities and questions, says Bill De Matteis, director of operations for application-specific memory products at VLSI Technology Inc. in San Jose. Because the new processors incorporate significant amounts of first-level cache on-chip, that market will disappear; at the same time there's a need for second-level cache that is both deeper and wider, although slower, than first-level cache.

Still to be resolved is the type of caching algorithm to be used: it is not yet clear that two-way set-associative is efficient enough. It may be necessary to go to even more sophisticated three- and four-way set-associative algorithms.

A relatively well-defined specialty segment is dual-port SRAMs. Originally the province of small firms such as IDT, Mosel, Vitelic, and VLSI Technology, this category is attracting the attention of such high-volume SRAM and DRAM producers as Fujitsu, Hitachi, Micron, Motorola, NEC, and TI. From a market of only $7 million in 1987, this segment is projected by Dataquest to grow to $18 million this year and $44 million in 1992.

As shared memory circuits with logic, dual-port SRAMs are used between microprocessors, between central processing units and digital signal processors, or between either CPUs or DSPs and intelligent I/O controllers. By the addition of a second I/O port, two addresses can be read or written independently to link two asynchronous systems running at different speeds but sharing the same memory.

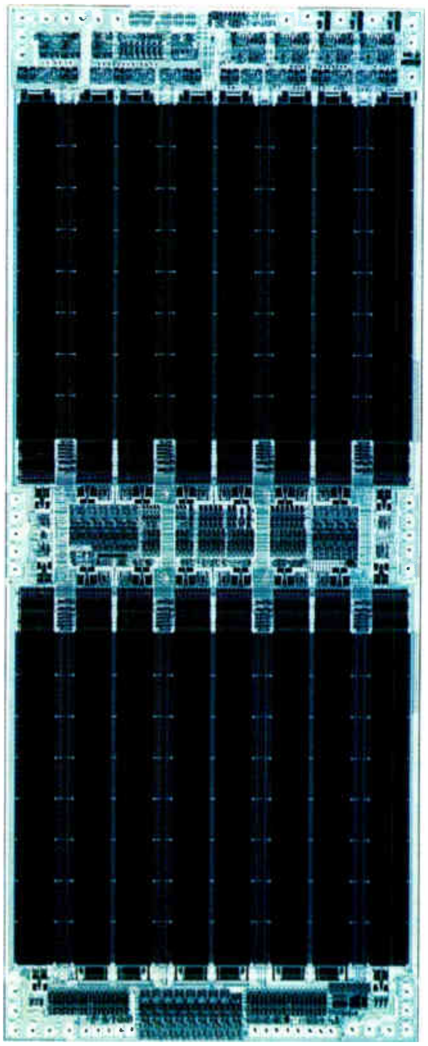
Initially available only at relatively small densities, dual-port SRAMs have grown rapidly, and 16-bit-wide devices are now entering production. Some vendors are evaluating 32-bit-wide dual ports.

Market leader IDT Inc. of Santa Clara, Calif., has upped the ante in this segment with the introduction last month of the industry's first four-port SRAMs, the 1K-by-8 IDT7050 and the 2K-by-8 IDT7052. The 7052 sets new records for speed and system flexibility, says Bob Cushman, SRAM strategic business-unit manager. "These four-port SRAMs allow true simultaneous access of any memory location from any of the four ports, allowing tremendous system speed improvements," he says. "Using four 7052s to interface to multiple 32-bit processors results in an effective bandwidth of 640 Mbytes per second, 10 times faster than any interprocessor communications method available."

With independent asynchronous address, data, and control lines, each port communicates via a standard SRAM interface that can access any location in memory simultaneously. This lets multiple processors access the same space at once.

Looking to bring the same benefits to microcontrollers that IDT's four-port devices bring to multiprocessor systems is a unique quad-port serial SRAM from Dallas Semiconductor. The DS2015 supports transmission rates of up to 4 Mbytes/s over a three-wire serial bus, standard in most microcontrollers.

Containing four 8-byte "mailboxes," the device performs three functions, says Michael Bolen, vice president of marketing at the Dallas-based company. First, it routes information from a given channel through the chip to any of the four mailboxes. Then it stores that data until the intended recipient is ready for it. Finally, it distributes the information and signals when a message transfer is done.



From Hitachi comes the 1-Mbit HM571000, which combines the density of CMOS with the speed of bipolar.

To achieve these multiple functions on the same chip, he says, Dallas makes use of a new multiport memory cell that differs from standard SRAM cells in that it has multiple pass-transistor pairs per cell, multiple word lines per row of cells, and multiple bit-line pairs per column of cells.

Another specialty SRAM segment that is on the verge of significant growth is SRAM-based FIFO memories. Dataquest's Jones says this category grew from $40 million in sales in 1987 to an estimated $70 million this year and should double that amount by 1992. The pattern of competition here is the same as in the other segments. The small companies that carved out the market—Cypress, Dallas, IDT, Mosel, Saratoga, Vitelic, and VLSI Technology—are now facing down larger players, including AMD, Fujitsu, Hitachi, Micron, Motorola, NEC, and TI.

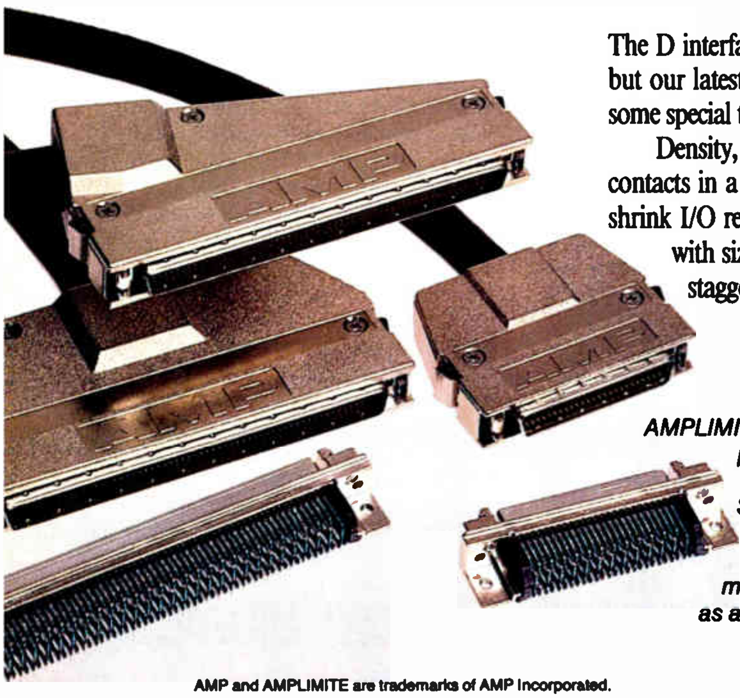
All the market activity has resulted in a proliferation in the kinds of features offered by these FIFOs, though the capacity of the SRAM core has remained relatively small, no more than 64 Kbits at best. SRAM-based FIFOs now range in density from 1 to 4 Kbytes and boast widths up to 9 bits, a significant improvement over the relatively small serial in, serial out devices containing a few tens of words and no more than 4 bits in the early 1980s. Speeds now border on 40 MHz, against 1 to 5 MHz in the early parts, and a variety of serial and parallel inputs and outputs are offered.

While both dual-port and multiport SRAMs target systems where two or more processors randomly access information in the same memory space, FIFOs meet a different need. They are generally used as an elastic buffer between two synchronous or asynchronous systems for passing data back and forth, where it is important that it be stored and retrieved in the same order. Such systems include hard-disk, tape-drive, and CD-ROM controllers, as well as bidirectional serial data-communications applications such as voice-band modems, data buffers for local-area networks, and fiber-optic and satellite microwave links.

With competition moving in on all sides, industry leader IDT has chosen to go upscale into a new, smaller, market with fewer competitors: bidirectional FIFOs, a segment that's expected to grow from about $1 million this year to as much as $20 million by 1992. These devices are used in matching lower-speed, narrow-bus peripherals to the new high-speed, wide-bus microprocessors. They are also used in new computer architectures built around parallel multiprocessors. Although current FIFOs can be operated in either direction, they can shift data through only one direction at a time. The bidirectional FIFOs let data move in both directions at once, allowing full-duplex communications.

IDT has moved into these application areas with two new families of bidirec-

.050 centerline shielded I/O.



The D interface may look familiar, but our latest I/O connectors have some special temptations all their own.

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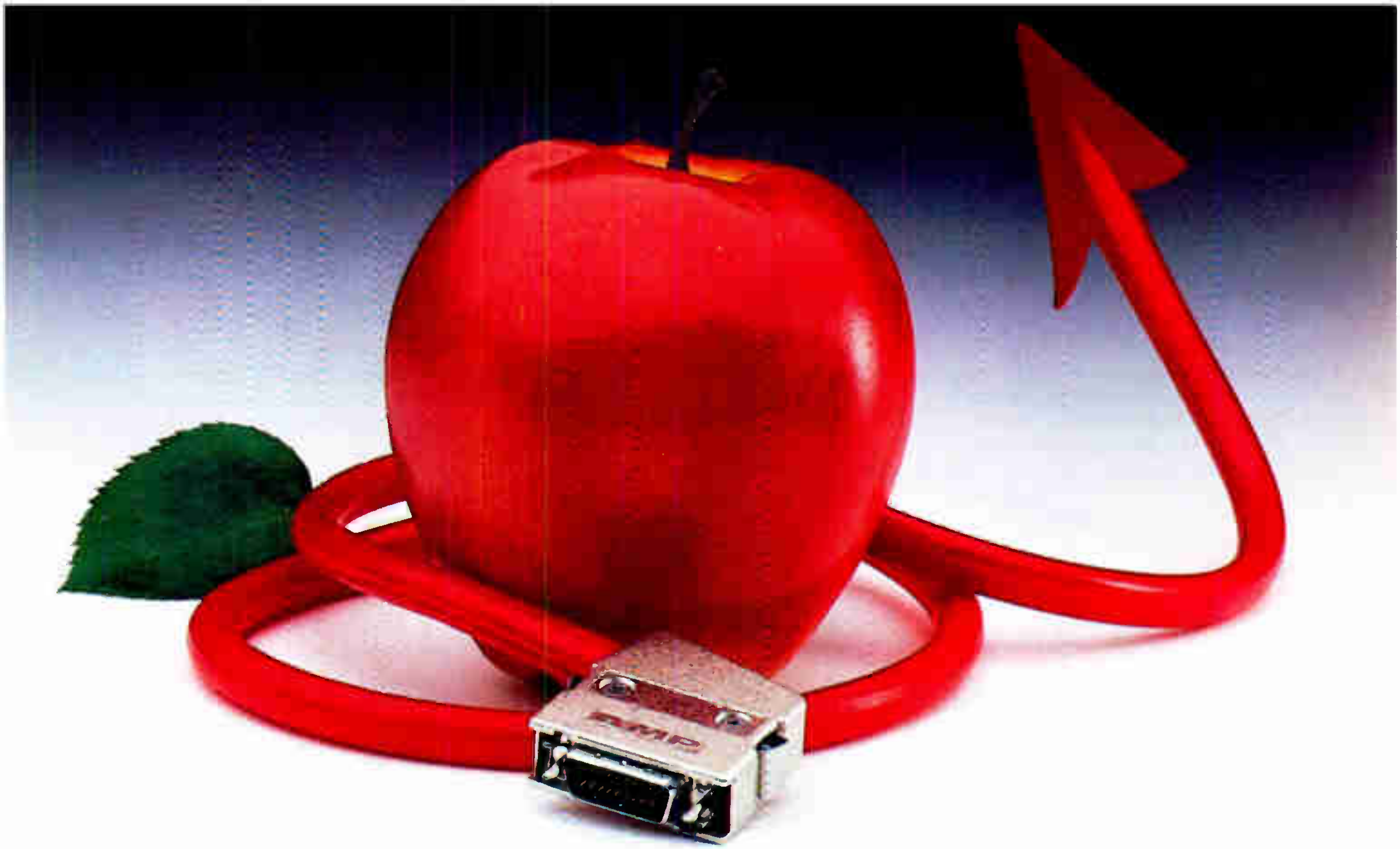

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AMP Interconnecting ideas

Circle 8

tional FIFOs. For bus matching, the company has introduced a series of parts including the 512-bit IDT7251 and 72510 and the 1-Kbit IDT7252 and 72520, which act as funnels for interfacing 16-bit systems with 8-bit systems. Two other devices, the 512-bit IDT75211 and 1-Kbit 72521, match 16-bit CPUs operating at different speeds in multiprocessing systems. Also looking to enter this niche is AMD, which has introduced the Am4701, a 512-by-8-bit bidirectional FIFO.

The segmentation into niche markets that has energized SRAMs is now beginning to make itself felt in DRAMs. In fact, major portions of the DRAM market are flaking off to form specialty-memory segments in and of themselves. By far the largest and most mature of these is the dual-ported video RAM.

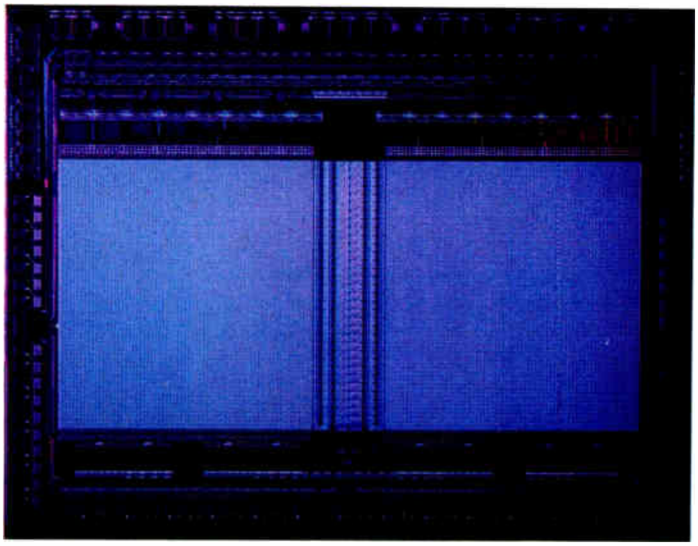
From sales of about $100 million in 1987, says Jones at Dataquest, this category should hit $475 million this year and $650 million by 1992. A video RAM is a specialized DRAM in which a second read-only serial port complements the parallel I/O port.

Designed for high-performance graphics and video applications in work stations, high-end PCs, and the like, video RAMs transfer serial data from a row of memory cells into a shift register during the horizontal retrace time of the display. Then, as serial bits are output at the horizontal port, the normal I/O port is used for reading and writing. This means the memory remains available 100% of the time for both normal read and write operations and for the video display as well.

The first video RAM was a 64-Kbit device introduced by TI in 1984. By 1987, both TI and NEC were offering 256-Kbit devices combining a 64K-by-4 DRAM with a 256-by-4-bit parallel in, serial out data register and capable of running at 15 to 20 MHz. This year marked the introduction of a 1-Mbit version from TI, NEC, and a number of other players, including Fujitsu, Hitachi, Mitsubishi, Micron, Motorola, and Oki. The new TI part boosts performance to 25 to 33 MHz, initially with an internal architecture consisting of a 256K-by-4-bit DRAM and a 512-by-4-bit parallel in, serial out register. Another variation combines a 128K-by-9-bit DRAM array with a 256-by-8-bit register. The parts include such additional features as block write, fast paging, and, in some designs, flash-write capability, says Don Russell, TI's video RAM design manager.

Work is already under way at a number of companies on higher-density video RAMs. The big question, says Russell, is whether to go for 2 or 4 Mbits. "Even at the 1-Mbit level, the chips are almost outstripping the capabilities of the display technology in terms of resolution," he says. "At 2 Mbits, we will just about match the evolution of the display hardware. But if we jump to 4 Mbits, we will be almost a generation ahead."

Whatever the route, the industry is trying to settle on a common configuration and set of features. For now, the only agreement is on the overall architecture. At the 2-Mbit level, two configurations seem likely: a 256K-by-8-bit DRAM array with a 512-by-8-bit register targeted at conventional video RAM applications, or a 128K-by-16-bit DRAM with a 256-by-16-bit register targeted at a variety of embedded-processing applications, including laser printers, fax, and HDTV. At the 4-Mbit level, a configuration comprising a 512K-by-8-bit DRAM array with a 512-by-8-bit register is being considered.



IDT has just introduced the industry's first four-port SRAMs, the IDT7050 and 7052, which allow true simultaneous access of any location from any of the ports, boosting system speed.

DRAM makers are also targeting the market for cache-data and cache-tag specialty SRAMs to solve the speed discrepancy between DRAM-based main memory and the high-speed 16- and 32-bit RISC and CISC processors.

Aiming to gain back some of this market share without sacrificing the economies of scale they have achieved in commodity DRAMs, many manufacturers are looking to offer higher-speed DRAM alternatives that will eliminate the need for cache-tag and data SRAMs.

On the brute-force side are the efforts of such companies as Vitelic and Alliance Semiconductor, both of San Jose; Paradigm Technology of Santa Clara; and NMB Semiconductor in Japan. These outfits are going for 50-to-70-ns, 1-Mbit DRAMs—two to three times faster than most commodity DRAMs—by pushing the CMOS process and DRAM-cell design to their limits.

Alternatively, Hitachi Ltd. of Tokyo has developed a family of 1-Mbit DRAMs fabricated in a biCMOS process and yielding access times of 35 to 45 ns, totally eliminating the need for complex and expensive caching schemes necessary to reduce the number of wait states between main memory and the CPU. Another alternative, now under development at Japan's Mitsubishi Electric Corp., is a 1-Mbit DRAM with a built-in cache memory using an 8-Kbit SRAM. It allows for one-cycle data transfers with an access time of 12 ns—more than enough to meet the needs of most of the advanced 32-bit designs.

A number of vendors are looking to emerging new niches for DRAMs in a potential new volume market: HDTV. Besides the new forms of video RAMs, companies such as Hitachi, Micron, Motorola, and TI are exploring DRAM-based FIFOs for use as line and frame buffers.

TI expects to have samples later this year, and Hitachi is already sampling two parts—the HM63021P, a 2K-by-8 serial access memory for line buffering, and the HM53051P, a 256K-by-4 frame-buffer memory.

The HDTV market may be vast. By the mid-1990s, says Integrated Circuit Engineering Corp. of Scottsdale, Ariz., the average PC will require 2 to 4 Mbits of DRAM-based memory, while HDTV systems will need 32 to 40 Mbits apiece. Even by 1995, when only a million HTDV receivers are expected to be shipped worldwide, that represents at least 20 million 4-Mbit DRAMs or frame RAMs per year.

As in DRAMs and SRAMs, specialized designs are emerging in CMOS-based nonvolatile memories to address the same component-count and performance requirements. To serve embedded-processor applications using high-speed 20-to-30-MHz RISC designs, TI has borrowed a concept from DRAMs in its 1-Mbit EPROM. With its 32-byte line buffer and associated control circuitry, the part allows the microprocessor to access cache data in as little as 20 ns. A similar device, optimized for use with the 80386 and 80486, is expected later this year. □

Circle 21

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LOOK OUT, CRAY: HERE COMES A SUPER-PRICED SUPERCOMPUTER

UP TO NOW, SUPERCOMPUTER GIANT CRAY RESEARCH Inc. has defended its turf pretty successfully. With its competitors offering about a quarter of a Cray's performance at a tenth of the price, Cray's high-end niche seemed secure. But that niche is now under siege, as parallel-processing machines begin to match Cray's power at a much lower price.

Leading the charge is Evans & Sutherland of Mountain View, Calif., a company known until now for graphics modeling and simulation (see p. 86). E&S is poised to attack Minneapolis-based Cray head on with its first supercomputer, the ES-1. Slated for release by year's end, the ES-1 matches a Cray XMP or a Cray-2 in performance—it's rated at 1.6 billion instructions per second and 1.6 billion floating-point operations per second. And at $8 million, the ES-1 sells for less than half the price of a Cray-2.

This type of price/performance advantage is driving the supercomputer industry toward parallel-processing architectures, says Electronic Trend Publications, a Saratoga, Calif., research firm. Parallel processing also appears to be the only way to continue to increase total performance of computers by factors of 10 every few years [*Electronics,* March 3, 1988, p. 51].

A new machine with moderately parallel architecture aims at the high end of the market, long Cray's domain

While Cray supercomputers are built around a few high-speed vector processors, the ES-1 is based on a moderately parallel architecture with up to eight processors, each featuring 16 computational units that run different parts of a program simultaneously. A three-tier memory scheme keeps integer and floating-point pipelines on each computational unit continually busy. The ES-1 also has a high-speed input/output facility with a cumulative bandwidth of 1.6 Gbytes to and from its 2.048 Gbytes of random-access memory. Crossbar switches route data between processors and memory at up to 3.5 Gbytes per second.

What makes the ES-1's design work is the availability of compilers that can exploit the machine's parallel processors. Parallelizing compilers, which operate automatically or interactively with a programmer, convert an application into multiple independent routines that can run con-

BY JONAH McLEOD

currently on the computer's individual processors. This division of labor gives parallel-processing machines their great speed.

By using a moderately parallel architecture and high-density VLSI chips, Evans & Sutherland can keep the price of its ES-1 at $8 million. Cray's XMP, a 1.2-gigaflops machine, costs up to $16 million, and the 1.6-gigaflops Cray-2, introduced last year, carries a $20 million price tag. The newest Cray offering, the YMP, offers peak performance of 3.6 gigaflops and costs $23.7 million.

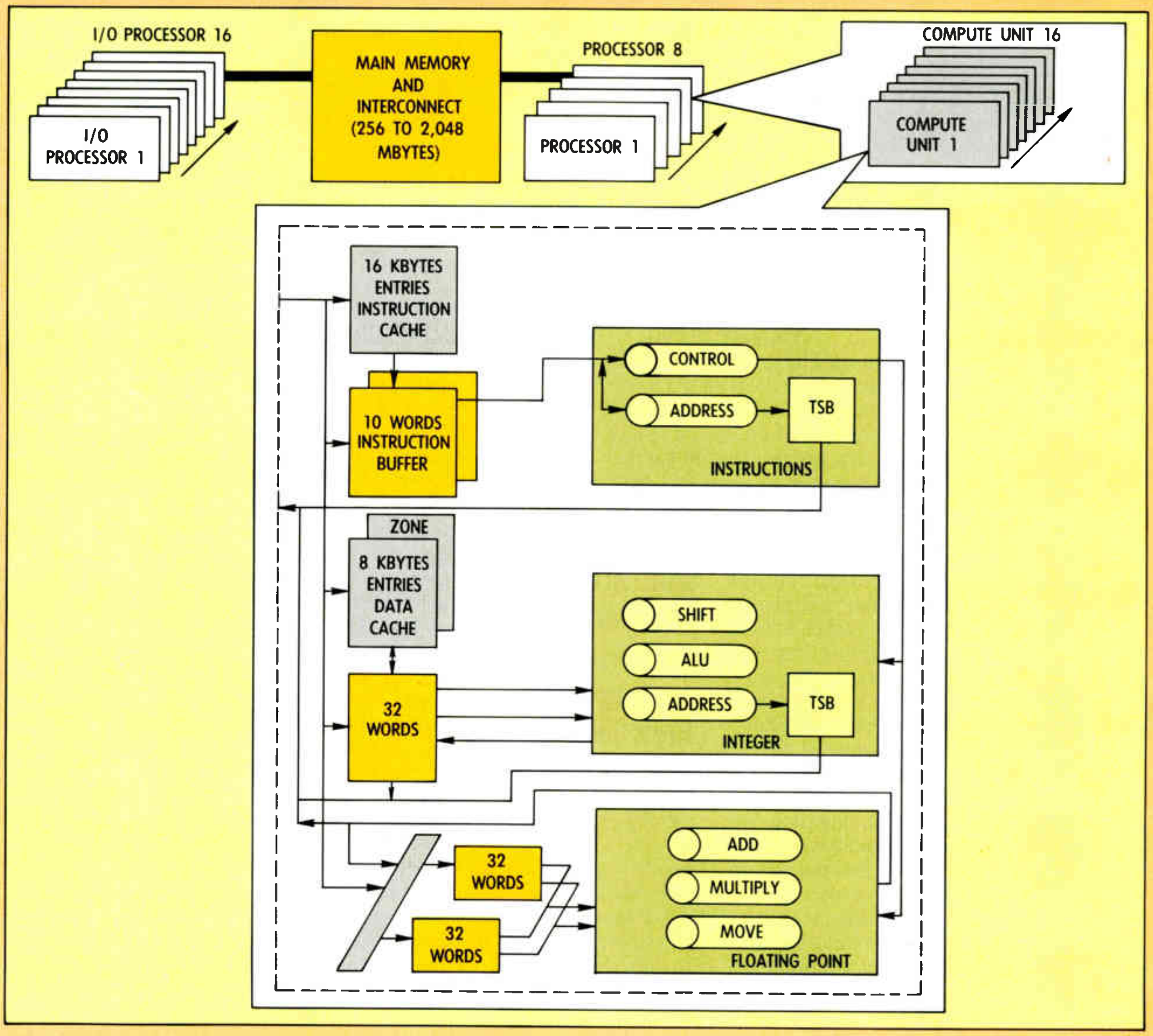
The ES-1 comes with the ESIX operating system, which is Unix version 4.3 BSD enhanced with the Mach kernel for the parallel version of Unix, developed by Carnegie Mellon University in Pittsburgh. The ES-1 comes with Fortran and C compilers that automatically or interactively restructure existing application programs to make use of the ES-1's parallel architecture.

With the influx of companies carving out performance niches below that of Cray, market demand has slowed somewhat. Christopher Williard, senior analyst at Dataquest Inc., the San Jose, Calif., market research firm, says that sluggish demand is most obvious in the low end of the market, but midrange minisupercomputers are beginning to experience the same lethargic demand.

CRAY VS. CRAY. Williard notes that the first part of the year saw a slowdown in Cray sales, partly because of the introduction of the new Cray system. "Buyers may have waited for the new YMP instead of buying the older XMP," he says. Further adding to the confusion was Cray's split into two companies last May. Cray Research will offer the YMP line, while the new Cray Computer Corp. of Colorado Springs, with Cray Research founder Seymour Cray at the helm, will continue to develop the Cray-3. That machine, which may begin shipping next year, is expected to perform at about 16 gigaflops and is being built around gallium arsenide chips [*Electronics*, June 1989, p. 30].

Despite the recent slowdown, the supercomputer market is expected to show strong growth. Williard estimates that the segment, worth $1.28 billion last year, will reach $3.5 billion in 1993—a 22.3% compound annual growth rate in estimated worldwide factory revenues. Nearly 50% of all supercomputers are sold to users in the U. S., while about 25% are

HOW THE ES1 IS PUT TOGETHER



Supporting the processors in Evans & Sutherland's ES-1 supercomputer are two to eight fast I/O processors, which shuttle data between processors and system peripherals, especially the high-speed disk drives.

bought by European customers and 22.5% go to Japanese users.

Cray's machines feature a scalar unit and multiple special-purpose vector processors. These processors have single-instruction, multiple-data architectures (SIMD). Each adder or multiplier can execute one instruction at a time but can handle a large pipeline of data. Vectorizing compilers search through a program's code looking for opportunities to create vectors to fill the pipeline. If an instruction doesn't make use of all these pipelines, not all of the computer's resources are being used.

Olaf Lubeck, a scientist at Los Alamos National Laboratories in Los Alamos, N. M., found that after 10 years of working with vector machines, the three national laboratories—Los Alamos, Livermore, and Sandia—were able to achieve about 70% vectorization on their application code. "That's a high-end number, since the labs are specialists in supercomputers and have been working for the past 10 years to vectorize their code," says Robert Stevenson, vice president of marketing for the computer systems division at E&S. In business applications, he asserts, the average amount of vectorization that occurs is lower.

Another estimate comes from the model named after Gene Amdahl, founder of Amdahl Corp. of Sunnyvale, Calif., plotting peak computer performance against percent of vectorization achieved. At 70% vectorization, the model found, only 12% of a supercomputer's resources are actually being used. The rest are idle.

One way to increase processor use is to parallelize the code that cannot be vectorized, says Bruce Leasure, vice president of technology at Kuck and Associates, a Champaign, Ill., software company providing compilers for supercomputers.

FAST I/O. As a complete scalar computer, the E&S system does exactly that. Built with a multiple-instruction, multiple-data (MIMD) architecture, the ES-1 can be configured with two to eight processors. Supporting the processors are two to eight fast I/O processors for moving data to and from the processors and system peripherals, especially the high-speed disk drives.

"Each processsor contains 16 computational units, each with the scalar processing power half that of an IBM Corp. 3090," says Stevenson of E&S. The aggregate performance of all computational units on each processor is 200 mips and 200 megaflops; as a result, a fully configured system provides 1,600 mips and 1.6 gigaflops of performance.

Along with a moderately parallel architecture, E&S is using less expensive integrated-circuit technology—a high-speed 1.0-µm CMOS production technology. "As a result, we can provide a much lower-cost alternative to [that offered by] supercomputer makers like Cray, which relies on brute-force speed increases from using high-speed emitter-coupled logic and GaAs ICs," says Jean-Yves Leclerc, president of the company's computer systems division.

Each computational unit contains an instruction pipeline that feeds two integer pipelines—shift and arithmetic logic unit—and three floating-point pipelines: add/subtract, multiply/divide, and move. There is no dedicated vector processor.

To feed data to the pipelines, the system employs a three-tier memory scheme, high-speed register files, intermediate cache, and system RAM. Nearest the pipeline of the individual computational units are 32-word-deep register files feeding the integer and floating-point units. In front of the instruction unit is also a 10-word-deep buffer. "The register files and buffers are all on-chip with the instruction, integer, and floating-point units to minimize the delay in going on and off chip," says Leclerc.

Between system RAM and the on-chip registers in the memory hierarchy is high-speed cache, which is located off chip but near the pipelines on the computational unit. "There are 16-K word [entries] of instruction cache and 8-K word [entries] of data cache," Leclerc explains. In addition to the data cache, the computational unit has an 8-K zone that the computer uses as a large register file, managed by the compiler, he says.

One use of the zone is to maintain constants used repetitively. Another is to

TAKING ANOTHER TACK IN SUPERCOMPUTING

While Cray relies on vector processing and Evans & Sutherland builds on a moderately parallel architecture, another player in the supercomputer sweepstakes takes a different path. Bolt Berenek & Newman constructs its massively parallel supercomputers around high-speed 88000 processors and its Butterfly switch.

Key to the speed of the new TC2000 system from BBN Advanced Computers Inc. is the Butterfly switch, a crossbar switching system that provides a 38-Mbyte path to all processors on the switch. The TC2000 can have up to 500 processors, each of them powered by a Motorola Inc. 88000 reduced-instruction-set processor.

> Getting each processor to communicate with the others is important

The switch offers a solution to the biggest problem with massively parallel supercomputers—computers with hundreds to thousands of processors working in parallel—that is, how to get 60 processors to do in a minute what one processor can do in an hour. Although the performance of individual processors is critical, getting each processor to work on individual tasks and efficiently communicate results to others working concurrently is equally important.

In the TC2000, all the processors communicate through the switch. "With the Butterfly switch the amount of time to reach another computer in the system is very deterministic," says Judy Larocque, director of marketing at the BBN computer subsidiary, based in Cambridge, Mass. "It is unlike a bus, which is nondeterministic and can degrade in performance with heavy loading." With the switch, any processor in the system can get to any other processor in two steps. The switch also reduces the amount of cabling and connections required for a large system.

BBN has targeted simulation applications in the aerospace industry, as have competitors Cray and Evans & Sutherland. Larocque points out, "The cost of simulation is coming down with the falling price of computing hardware, while the cost of live testing is rising."

The average system price for an eight-node BBN system with four disks is $450,000. For a 16-node system the average selling price is $875,000; for 32 nodes, it's $1.7 million; and for 63 nodes, $3.3 million. So far, the company has installed machines at three beta sites with 8, 16, and 32 nodes. Production is to begin later this year.

At the heart of the TC2000 are function cards built around an 88000 RISC processor with up to 32 Mbytes of memory, and some cards come with VME input/output functions on board. The system is constructed by inserting function cards onto a midplane, below which is the Butterfly switch. A test and control system runs throughout the system to monitor system operation in real time.

Each function card runs either BBN's own NX multiprocessor Unix operating system or a real-time operating system called pSOS Plus, from the Software Components Group of Santa Barbara, Calif. In operation, processors are grouped into clusters. An NX cluster performs compute-intensive tasks, while a pSOS cluster performs real-time operations: I/O, data acquisition, and so forth.

With the help of interactive tools called XTRA, a programmer partitions an application into different parts, each running on different clusters. In addition, he further partitions the portions of the program on individual clusters into subroutines and DO LOOPs that can be run on individual processor nodes within the cluster.
—J. McL.

contain register states of different tasks sharing time on the computational unit.

Farthest from the pipeline is main memory. Residing with each processor is 256 Mbytes of RAM, accessed by each computational unit by means of a local crossbar. This RAM is part of 2.048 Gbytes of virtual RAM available in a fully configured system. A local computational unit accesses the RAM of other processors within the system through an interprocessor crossbar. This device allows high-speed data transfer between the multiple memory banks, computational units, and I/O channels. Data moves in and out of memory via eight I/O channels. Each I/O channel has its own I/O processor, each of which runs I/O programs. Once set into action by the computational units, these programs in the I/O processors direct data movement in and out of memory.

MORE JOBS. In the MIMD architecture, a group of computational units can be tightly coupled to process one application concurrently. At the same time, other computational units can be used on other applications. This translates into greater throughput for users, who can do more jobs at once.

Key to the ES-1's speed is software that can split an application into many independent routines that can operate concurrently on more than one computational unit. One company working in this area is Pacific Sierra Research Corp., an Eaton Corp. subsidiary in Placerville, Calif.

"You can parallelize more code than you can vectorize, since anything that can be vectorized can be also be parallelized," says John Levesque, Pacific Sierra's vice president of computer science. "In addition, many programs have sequences of code that can be run in parallel but cannot be vectorized."

The technology for parallelization is well understood, but it is more difficult to parallelize code automatically than to vectorize it, Levesque explains. The compiler must understand the program flow and which routines depend on others before it can assign different routines to different processors, he notes.

E&S is offering a Fortran compiler that can automatically parallelize an application to run on the ES-1 using more than one processor concurrently. In the past, converting an application to run on a moderately parallel architecture required that the programmer insert directives into the source code that expresses parallelism so that the compiler could use it at compile time. Today's commercially available preprocessors detect parallelism and put in the directives automatically.

"We purchased the front end of the parallelizing compilers," says E&S's Leclerc. "However, we are creating the back end, the part of the compiler that generates code for the machine. This includes all the optimization and parallelizing routines."

Levesque, whose company offers a tool called Vast that automatically finds routines in a program that can be run in parallel, says that such tools work well on programs with a modest amount of parallelism. But for more complex programs, he says, the programmer must intercede to help the tool.

Aware of this limitation, Leclerc says that the Fortran compiler can also be run in interactive mode with the programmer helping to locate opportunities in the code for parallelization. "To do the most effective optimization, the programmer runs the program and compiles statistics on its run-time characteristics," says Levesque, whose company also offers an interactive Fortran compiler, called Forge. "The programmer then interacts with the tool to parallelize the code."

Compiler technology to handle moderately parallel machines is more developed than that for massively parallel machines, the other alternative to Cray in the high end (see p. 85).

"For moderately parallel systems, compilers exist, but improvement needs to be made to make them easy to use by novice programmers," says Levesque. Compilers for massively parallel systems for use by novice programmers are still three to four years away, he says.

That's another reason that the ES-1, leading a trend toward parallel architectures, is likely to challenge Cray in the supercomputer world. □

EASING THE CONCEPTUAL PHASE OF A DESIGN

Supercomputers can blaze through mountains of data but fall short when presenting the results of their labor in graphic form. And many engineers still resort to pencil and paper when embarking on the conceptual phase of a design. Now comes the Evans & Sutherland Conceptual Design and Rendering System, which runs on the company's new ES-1 supercomputer or as an add-on to a Digital Equipment Corp. VAX minicomputer. This system shrinks the time needed to create and evaluate new designs.

The E&S design system can render a photorealistic image in 16 to 20 seconds.

Developed by the E&S Interactive Systems Division in Salt Lake City, Utah, the system will first be used in designing the next generation of automotive bodies. Until now, in designing an automobile a product designer created an initial specification of the car: size of the passenger compartment, wheel base, engine compartment, and so forth. He gave the specification to the automobile stylist, who then drew different body styles to fit it. Management selected one to develop further and the design team built a full-size clay model of the body by hand and digitized the model for industrial engineers to use later to build the car.

The new system eliminates this process, which took months. With the E&S design system, a stylist enters a conceptual body style into the system, which drives a numerically controlled tool to sculpt a full-size clay model. It also creates mathematical surface descriptions of the model that industrial engineers can use later to build the body. A designer can interactively change an image on screen, and the system renders the new version in seconds.

The automotive market comprises about 20 automobile companies, each with 100 or so designers who could use the system, says Bruce Jenkins, vice president of Daratech, a market research firm in Cambridge, Mass. At an average selling price of around $225,000, the total market for the system is around $450 million; E&S can expect to capture a 40% share or around $180 million, he says.

E&S, which developed the system under contract with Chrysler Corp. and Ford Motor Co., plans to sell the system to other automakers worldwide and then to other industries, including aircraft manufacturers.

Conventional mechanical computer-aided-design systems using techniques like ray tracing can take 10 to 30 hours to render an image. Real-time interaction with a ray-traced image is impossible. Each time the stylist moves the image, the system must render the image in the new orientation.

With the E&S system, the stylist can create a full-color, high-resolution, three-dimensional model of the body style and rotate it in real time, using various lighting models to view the 3-d image in different settings. The stylist can interact with the image on screen without relying on the host computer. *–J. McL.*

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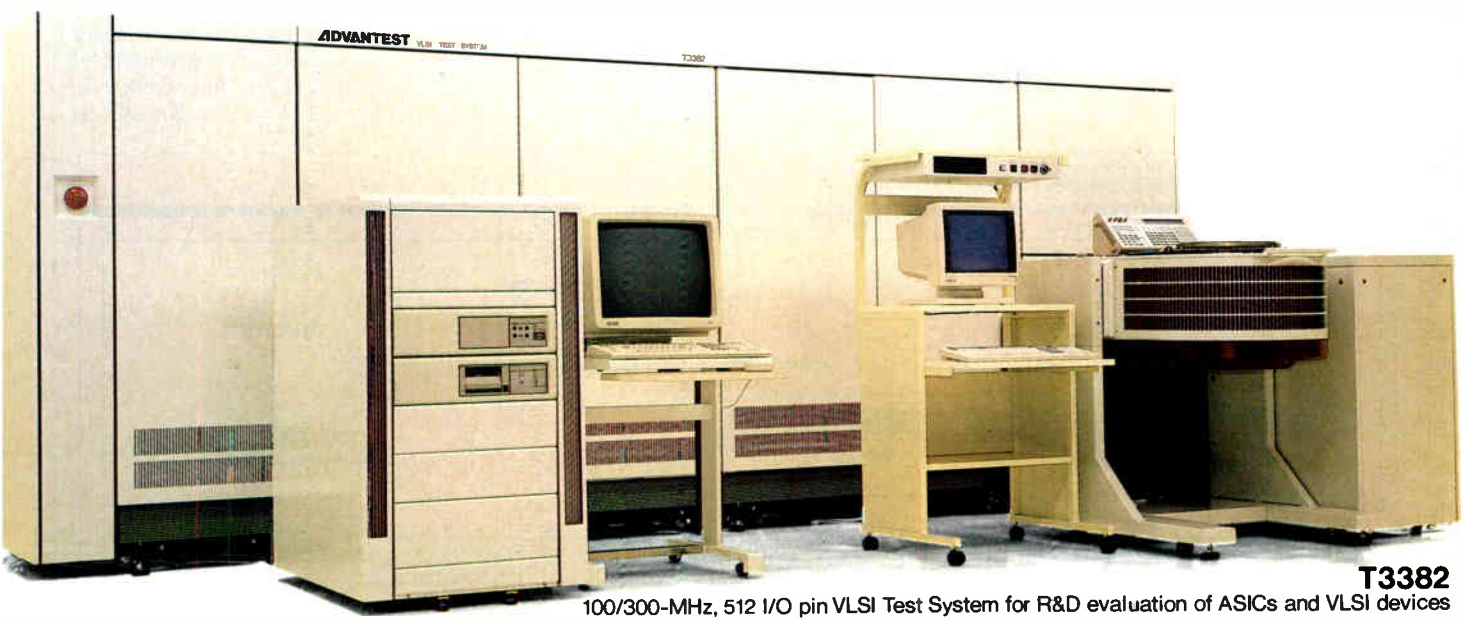

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BY BERNARD C. COLE

Finally, it's ferroelectric!

A handful of products are here—or soon will be—that offer a simple route to nonvolatile storage

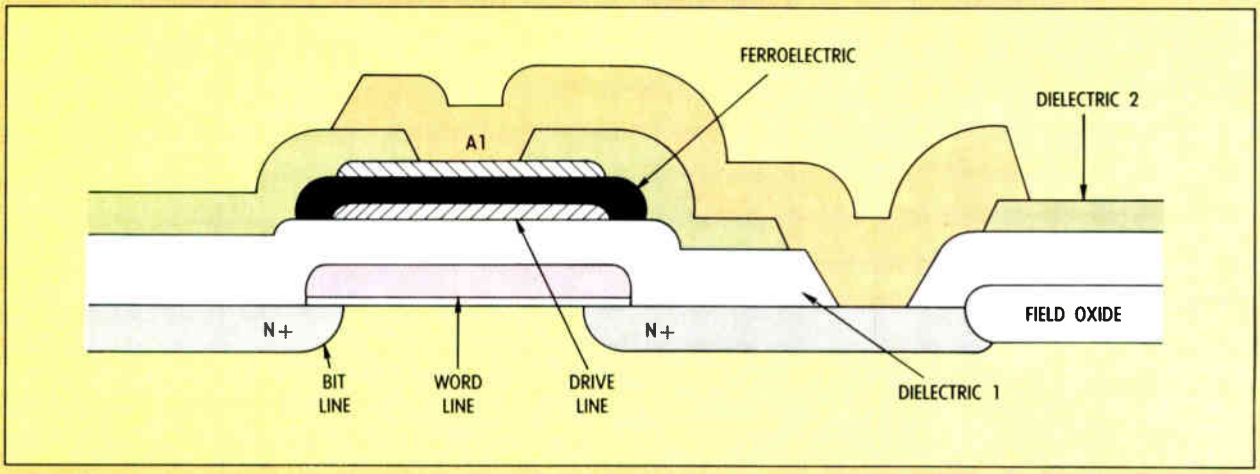
A Silicon Valley startup is now making what it hopes is an irresistible offer to engineers and system designers: experiment with nonvolatile ferroelectric technology simply by swapping a standard CMOS logic in an existing system for a ferroelectric part.

The startup—Krysalis Corp. of Santa Clara, Calif.—is looking to spur interest in ferroelectric technology as it develops a number of large-scale-integration logic and memory products based on the technology. Ferroelectric technology, some 30 years in the making, has long tantalized designers by promising an easier route to nonvolatility than any now available: nonvolatile memory using ferroelectric materials can be made to store binary information based on polarization state rather than stored charge.

Krysalis is set to introduce this month the first in a line of nonvolatile logic circuits based on the industry-standard 7400 CMOS TTL-compatible logic series. By year's end, it expects to offer a 16-Kbit ferroelectric static random-access memory. Meanwhile, a second startup, Ramtron Corp. of Colorado Springs, is slated to release next month a 4-Kbit ferroelectric SRAM.

Unlike previous nonvolatile alternatives, the logic and memory products from Krysalis and Ramtron are fabricated with a process that is virtually identical to that used for standard CMOS logic and memory parts, says Gordon Force, president of Force Engineering, a San Jose, Calif., consultancy that is working with Krysalis on

HOW A FERROELECTRIC MEMORY CELL IS BUILT



Krysalis Corp.'s 7400-compatible memory circuit is fabricated with a process virtually identical to that used for standard CMOS logic and memory parts, except for one to three thin-film layers atop each circuit.

the introduction of its devices. For instance, CMOS electrically erasable programmable read-only memories and EPROMs require a special high-voltage-tolerant CMOS process and the fabrication of large transistors for nonvolatile storage.

Those requirements prevent such devices from achieving high densities. Nonvolatile ferromagnetic bubble memories, introduced in the mid-1970s, require special processing lines incompatible with standard bipolar and CMOS processes. They also are more expensive and have not kept up with standard processes in either speed or density.

But William Miller, vice president of marketing for Krysalis, says the ferroelectric process developed by the company is compatible in speed and density with present CMOS processes, holding out the promise that implementing high-speed VLSI-level nonvolatile memory and logic will require no special expertise on the part of engineers and system designers.

The first of Krysalis's ferroelectric logic devices to come to market is the K74CF372, an octal D-type edge-triggered flip-flop with recall that performs a nonvolatile store on every positive clock transition. The device recalls the stored state to the output on the rising edge of each clock signal with the output high and retains that information for up to a year without power from an outside source, says Miller. The 372, available as samples now, is priced at $8.50 each in quantities of 100 or more.

By the end of the year Krysalis is slated to release at least three other small- and medium-scale-integration 7400-type logic circuits, all of them octal D-type flip-flops: the K74CF373, with a clear function that allows it to stabilize with the last output state stored before power loss; the K74CF374, with three state outputs; and the K74CF377, with clock enable. Typical propagation delay on all the devices is 25 ns with a 300-KHz clock.

These logic parts can serve where present nonvolatile memory and logic are not the best solution, Miller says. For example, the 374 could be used to latch the outputs of a counting circuit for metering applications. It could also replace a dual in-line package switch, in which eight input states are clocked to the outputs, so they will always be there in power-down and power-up situations.

Force believes the ferroelectric-based 7400 devices should find wide use, if only as a means of evaluating the new technology. "Many engineers will be intrigued with the possibility that they can keep both their microcodes and logic states nonvolatile in EPROMs and EEPROMs," he says. "And they'll want to work with MSI-level circuits to see what they can do." Force adds that the parts also offer a way of making certain critical nodes in a board-level design nonvolatile, without the use of a complex procedure involving battery-backed SRAM or EPROM.

On the memory side, Krysalis expects to start sampling late this year a 2K-by-8-bit nonvolatile SRAM with an access time of 200 ns. With two memory cells per bit and one transistor and one ferroelectric capacitor per cell, the SRAM incorporates a bit-parallel architecture in which the common plate of the capacitors runs parallel to the bit lines and connects all bits in a given column.

The memory array itself is divided into 32 blocks, each organized as 64 by 8 bits and linked by a common drive line. A sense amp is placed in the middle of the bit lines, with 32 bits on each side. Pass transistors isolate the sense amp from the half of the bit line that is not addressed, while the drive-line signal is switching and while sensing is taking place. The pass transistors are turned on to pass the sensed data through the inside bit lines and the column decode, which is then latched at the outputs. Two cells are used in a double-ended sense scheme to create a self-referencing differential signal between the bit line and its complement.

For a write, the sense amp sets the bit lines to the correct state. The capacitors' common plate is taken high to write a 0 into the cells with low bit lines; the drive line is taken low to write a 1 into the cells with high bit lines. For a read, the bit lines are charged to ground.

A major concern for writable nonvolatile memories is maintaining data integrity during uncertain power conditions, says Miller. Krysalis has added features to reduce the chances of losing data during power transitions. A circuit detects when the supply voltage starts to fall below 3.6 V; the device is not disabled until the cycle is completed.

Where Ramtron's current 256-bit ferroelectric RAM [*Electronics*, Feb. 18, 1988, p. 91] relies on conventional six-transistor SRAM cells shadowed by nonvolatile ferroelectric cells, the Krysalis logic and memory parts are based on a cell consisting of a single transistor and an accompanying ferroelectric capacitor. The Krysalis approach makes it easier to scale up to higher-density 64- and 256-Kbit CMOS-based ferroelectric SRAMs.

Miller says the material used in the fabrication of Krysalis's logic and memory products is based on a perovskite crystalline structure that is a derivative of lead zirconate titanate. The material is deposited using a method compatible with conventional CMOS processing techniques. A ferroelectric thin film adds only about 5% to 10% to the cost per wafer of a standard 12-mask, 2.0-μm CMOS process, according to Miller. Currently, three additional masks are needed to form the ferroelectric cells; as techniques improve, however, only one added step will be needed, further trimming the cost differential.

The Krysalis strategy, says Miller, is to focus on niche markets for its logic and memory products where it can find sockets quickly and start moving ferroelectric down the learning curve. "We really did this first series just to introduce the concept, and we're hoping that the market will tell us what it really wants," he says.

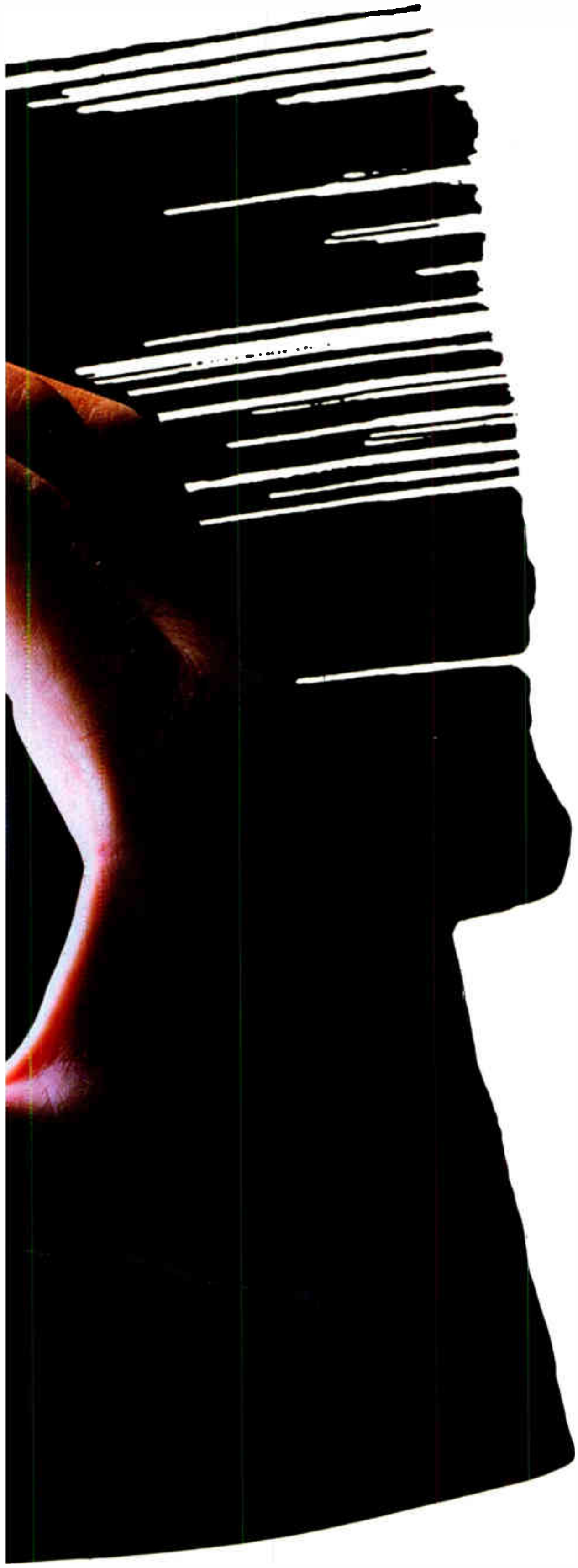
In the short term, Miller says, ferroelectric devices should find use in "write-mostly nonvolatile memory," as opposed to EEPROMs, which are read-mostly. The write-mostly applications targeted by Krysalis are now served by battery-backed technologies or, in some cases, mechanical controllers. Examples include odometers or controls for consumer appliances, such as washing machines. Also in the works are a variety of other logic offerings, one of which will run at 35 MHz and take a snapshot of the state of all the lines on a bus when power goes down. The snapshot could be used for failure analysis or maintenance.

Krysalis is also looking at a market for parts that could be direct replacements for nonvolatile shadow RAMs, such as the 2001 and 2004 sold by Xicor Inc. of Milpitas, Calif. Instead of an SRAM shadowed by EEPROM, the Krysalis parts will write directly to a ferroelectric cell. These parts, which may be in production by early next year, will be able to do the same job that NOVRAMs do but at lower power, lower price, and with better features, Miller says.

Avionics is another prime market in which ferroelectric products could replace battery-backed SRAMs, Krysalis says. Because of ferroelectric technology's radiation hardness, the military has approached the company with an eye to replacing magnetic core and plated-wire memory, according to Miller.

Krysalis, which already has a long-term second-source and foundry relationship with National Semiconductor Corp. of Santa Clara, is now looking for other strategic partners, including a semicustom software or hardware vendor that will incorporate the technology into its cell library. The company is also considering using its ferroelectric memory embedded in microcontrollers.

Miller says ferroelectric parts could also find a place in solid-state disk applications. "One of the fundamental problems in solid-state disk is getting nonvolatility and random access combined in a cost-effective memory," he says. "Ferroelectrics could provide a solution." He sees ferroelectric solid-state disks being used in harsh environments and in applications that require very rapid access. □



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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Circle 55

PACKING MORE SYSTEM IN LESS SPACE

UniStructure's VHDI scheme produces board density rivaling that of the chips

BY LARRY WALLER

In the rush to make smaller, faster chips, semiconductor designers and manufacturers are unleashing a flood tide of integrated circuits featuring ever higher clock rates and greater functionality packed into smaller spaces. Chips with submicron design rules are now commonplace; however, many of the packaging and interconnect schemes used to package them date back to the days of 3.0-to-5.0-μm design rules. As a result, the full power of the new chips has remained largely untapped.

But improvements in packaging and interconnect technologies will release that power. One such advance comes from UniStructure Inc. of Irvine, Calif. The company says that with its very high-density interconnect technology, board and module densities at their best can match those of the chips themselves.

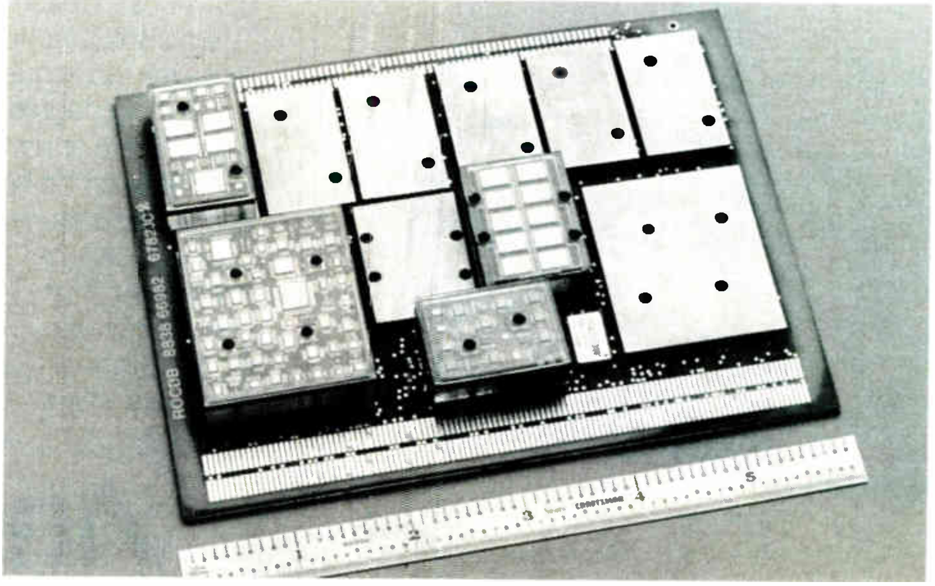
An important component of UniStructure's VHDI scheme is a proprietary multilayer interconnect technology, supported by liquid-organic dielectric casting. In the process, an adhesion-promoting material is sputtered along with copper onto a substrate coated with liquid-organic resin. The result is that the entire surface of the substrate becomes electrically conductive.

UniStructure obtains the fine-line geometry advantages of photolithography by imaging and developing the signal pattern right on the substrate. The conductors are grown to the right width and thickness in an electroplating copper solution.

The use of copper posts, called vias, to connect adjacent layers in the multilayer structure also is critical to the VHDI process. Vias are plated on the signal pattern at this stage, before the substrate is stripped of photoresist. Etching away sputtered metal provides for electrical isolation before the panel is planarized to expose the tops of the vias. These steps are repeated for each layer of a module. Vias can be as thin as 2 mils—the same dimension as the line widths.

And that's where the payoff is, says Michael W. Busby, vice president and chief technology officer for UniStructure. The advantage of building interconnects with dimensions this small is evident, he says, when compared with present boards; they are based on technology that lays out the conductive grids on a 100-mil scale.

Moreover, the boards that carry the small interconnect geometries can measure up to 10 by 10 in. Neither thick-film ceramics nor thin films can match the fine-line dimensions or get the same electrical performance. In addi-



UniStructure's very high-density interconnect technology can bring significant system compression: this module was reduced from 15 by 15 in. to just 4 by 5 in.

tion, the substrate sizes they can produce are limited.

The upshot is that UniStructure designs and produces substrates and chip-packaging units that dramatically slash the size of final modules. In some cases, prototype projects show, the packaging density can be improved up to 20 times over what is possible with conventional interconnect schemes.

For instance, an avionics package built by Rockwell International Corp. of Pittsburgh for an Air Force program took up 6,000 in.^{3} of board space, far more than the 600 in.^{3} allotted to it in the design scheme. Using all the same chips that Rockwell included, UniStructure redesigned the module with VHDI, shrinking the package to about 300 in.^{3}.

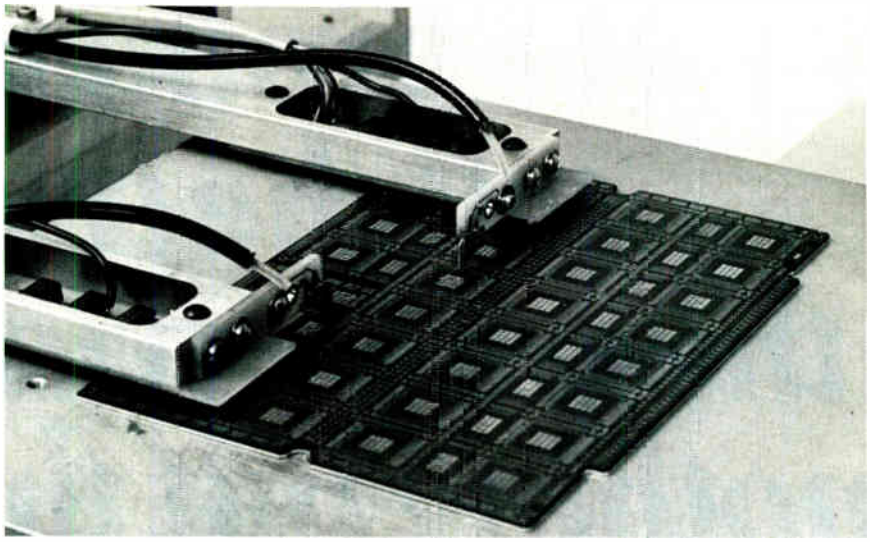
"The days of chip makers operating in a vacuum are gone," says William D. Baker, president and chief executive officer of the two-year-old company. "No matter how small the chip is, it still has to go into a package, and somebody has to put it on a substrate." Interdisciplinary cooperation is the key, he says, with the emphasis on integrating technology formerly employed separately by chip makers, board manufacturers, and system designers.

Taking aim at the merchant market, UniStructure intends to carve out this entire territory as its province, with products and assemblies for every step of the process—from bare chip to completely populated substrate to final system architecture.

At present, its products include substrates, packages, and modules in what amounts to an application-specific interconnect approach. The company believes itself to be the only independent supplier that offers all these interconnect technologies to the merchant semiconductor market.

FRONT-RUNNER. The VHDI process could be a front-runner in the race for advanced interconnect solutions in the form of multichip modules [*Electronics*, April 1989, p. 106]. "Clearly, VHDI is a unique technology that perhaps will lead to multichip modules, which are the coming thing in this business," says William I. Strauss, president of Forward Concepts Inc., a consultancy in Tempe, Ariz. Many additive processes were launched in the past decade, but "nobody made a nickel on them," he says.

The tooling available for earlier efforts required too much development and was too expensive. Already proven in completed projects, the UniStructure method of building additive boards that can mount the new generation of semiconductors in multilayer three-dimensional stacks pretty well tracks the way chips are made.



UniStructure's specially modified flying probe tests a printed-circuit-board signal layer before plating up additional interconnect levels.

Another advantage of the UniStructure approach is that it is done throughout all steps, including copper metalization, as an additive process that needs no special equipment. It piggybacks on semiconductor fabrication, using the same gear found in production and process technologies. The additive process also allows for control of the sizing of package and interconnect dimensions in the same way that has evolved for successively smaller generations of chips.

Even with the smaller dimensions, the additive approach in general provides more consistent yields than are realized with existing interconnect boards by employing the fine-line capability offered by photolithography. It also does away with the need for potentially disruptive steps associated with subtractive techniques, such as etching, drilling, and punching the substrates and boards, UniStructure says.

For thermal management, the VHDI substrates can be built on various heat-dissipating cores, including copper, aluminum, and graphite-metal matrix materials. The dielectric thickness is 0.0016 in., and the dielectric constant is 2.5. Typical impedance is 50 Ω. Because the dense boards could present a testing challenge to today's equipment, the company has modified a wafer tester for this purpose that works through a flying probe.

The solid copper vias, at 2-mil minimum dimension, take up no more space than the line width. Because their job of interconnecting the layers replaces drilled through-holes requiring up to 25 mils in present multilayer circuits, the vias help boost channel capacity for each layer. This cuts the number of layers needed to connect the densest of substrates. With its VHDI approach, UniStructure can reduce a 12-layer board to just four or five layers, according to Busby.

Indeed, important density increases are possible "if [VHDI] can match the geometries inherent in new chips," says Gunther Weber, engineering manager at Unisys Corp.'s semiconductor and packaging operation in Rancho Bernardo, Calif. He considers UniStructure's via interconnect scheme particularly promising because "it looks to permit sequential layering techniques [in building multilayer boards] that can cut the number of layers required."

Weber doesn't doubt that the new technology will work as claimed; his only question is cost-efficiency. If the process is too costly, he says, it would be ruled out for the volumes that a company like Unisys must produce.

UniStructure's Baker foresees little trouble in that area, once production ramps up. Exotic solutions to interconnect and packaging boards of up to 40 layers now cost from $20 to $35 for each square inch of board space. "We're in the high end of that range now and will come down," he says.

Both Baker and Busby say UniStructure's additive VHDI technology covers all the interconnect levels needed in any system: single and multiple (or hybrid) chip packages, large and small (mother- and daughter-) boards, and hybrid connectors. Says Baker, "It all comes from one basic technology and the same equipment." □

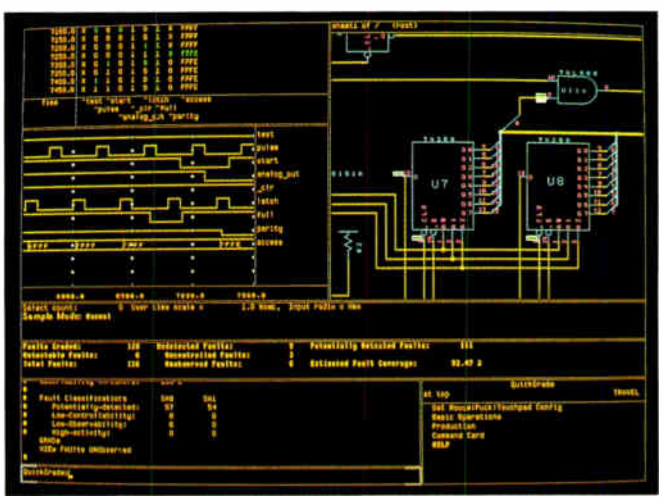
ASIC TESTING JUST GOT EASIER

BY JONAH McLEOD

These tools get nearly 100% fault coverage, without levying a steep real estate penalty

Several products are now on the scene to vanquish the great bugaboo in testing application-specific integrated circuits: fault coverage. Until now, the one proven technique for achieving high fault coverage has been scan design. But this method requires following a strict design methodology and increases silicon area by as much as 20%—limitations most designers find unacceptable. The new offerings promise to bring fault coverage to nearly 100% while removing many existing testing barriers.

One new solution is a fault grader from Mentor Graphics Corp. that trims the time it takes to determine where fault coverage is needed from hours or even days to minutes. Products from Silc Technologies Inc. and Motorola Inc. cut the real estate penalty of scan design to a mere 3% and automatically generate the test vectors required for over 95% fault coverage. Another new tool from HHB Systems Inc. produces similar results while eliminating the need to adhere to a rigid design methodology. Finally, startup CrossCheck Technology Inc. offers a scheme that gives designers access to every node in a design for close to 100% fault coverage. It also detects open and shorted transistors and interconnection failures, a functionality previously unavailable.



Mentor Graphics' QuickGrade displays fault coverage on a logic schematic, enabling fast test-vector creation for ASICs.

The fault-coverage hurdle stems from the way designers generate a test program—namely, by running a fault simulation using a design netlist and input vectors created during the functional simulation. These vectors provide fault coverage of only 60% to 80% of a design. Also, because fault simulators use compute-intensive deterministic techniques, fault simulation can take hours or days to complete. As ASIC designs get more complex, fault simulation becomes more time-consuming.

Mentor Graphics' new tool, QuickGrade, is 1,000 times faster than a fault simulator, says Frank Binnendyk, product marketing manager at the Beaverton, Ore., company. The tool employs statistical methods to estimate the amount of fault coverage a set of stimulus vectors provides to within 5% accuracy, he says. It pinpoints circuits that need fault coverage, making it easier for designers to generate the vectors needed to improve fault detection. Then, rather than rerunning the entire stimulus pattern set, it evaluates only the new patterns, providing rapid feedback on added vectors affecting test coverage, Binnendyk says.

QuickGrade provides the wherewithal to improve test coverage, but designers must take the initiative to make the improvement. To ease the job of creating test coverage even further, suppliers of computer-aided engineering tools are starting to offer products that automatically generate tests. One such tool is integral to the Silc-Syn logic synthesis package from Silc Technologies. The tool consists of a test inserter and a test generator, says Jeffrey Fox, vice president of engineering at the Burlington, Mass., company.

The inserter automatically installs scan cells into a design, connecting them to edge pins. But rather than inserting them at all inaccessible nodes, as in scan design, it places them selectively, only as needed—thereby saving on silicon real estate. Using a partial scan-design technique called register-transfer scan, the inserter analyzes the design, identifying feedback paths in sequential logic and breaking them up with scan cells. During testing, the cells apply stimulus to, or read results from, circuit nodes that are inaccessible from the chip's input/output pins.

The Silc inserter also installs test circuits during design synthesis. When the logic of a synthesized design is optimized, the testability circuits are optimized along with all the other circuits, Fox says. The second tool, for test synthesis, boasts a built-in fault grader; the test-generation circuit can be directed to produce up to 99.9% fault coverage, if needed.

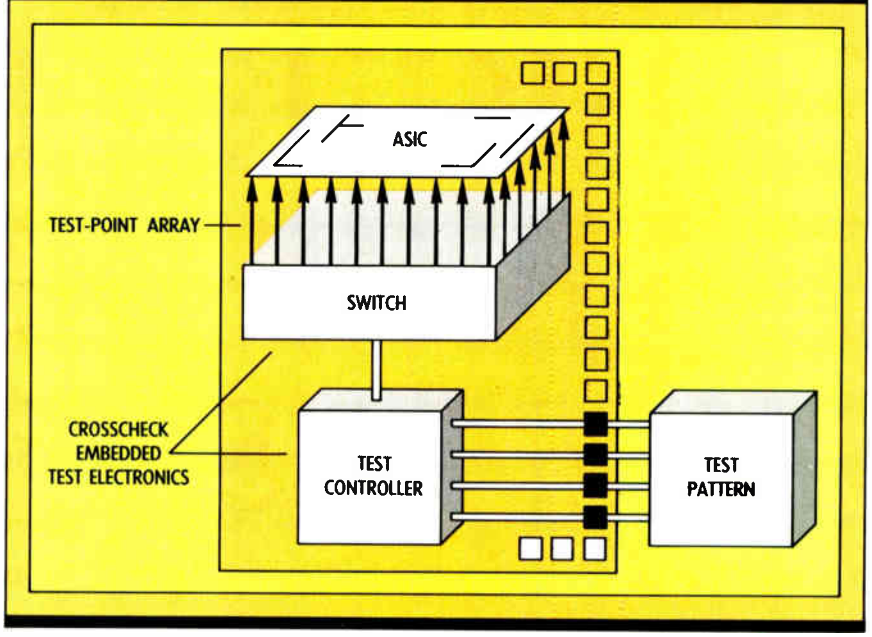
SMALL PENALTY. Also boasting a silicon real estate penalty of only 3% is Mustang, from Motorola's Semiconductor Products Sector in Austin, Texas. Like the Silc tool, Mustang makes judicious use of scan techniques to improve testability while keeping silicon area to a minimum.

It performs a rules check of a circuit to make sure the design conforms to scan-design rules, a capability it shares with TestScan from Gateway Design Systems Corp. of Westform, Mass., says James Garvey, manager of system-design tool development at Motorola. After the rules check, Mustang's Random Test Generator, a random-path sensitization algorithm, selects a point in the circuit—either an output pin or an input to a scan element—and works backward through the logic, determining the levels needed to enable the current node. This is done for every output pin and every input to a scan element. The tester produces 60% to 80% fault coverage; Mustang then invokes a deterministic algorithm to increase fault coverage to close to 100%.

For all their advantages, partial scan techniques like those from Silc and Motorola still require designers to embrace the restrictive scan-design methodology. Intelligen from HHB Systems of Mahwah, N. J., removes this restriction entirely. In fact, Intelligen makes little demand on designers: they don't need to use scan and they also don't need to use the logic test vectors generated during design simulation—although the more designers interact with the tool, the less time the tool spends generating vectors.

Intelligen accomplishes this magic with a diagnostic capability that analyzes a circuit and provides data on areas that are the most untestable. "Other systems tell you where the tough faults are, and you have to figure out what to do," says Steve Pollack, director of automatic test-generation marketing at HHB. "Intelligen not only tells you where the blockages are, but it also gives you a rank order of nodes, arranged in order of toughness." Intelligen boasts what Pollack calls a unique unidirectional back-trace algorithm that sets a fault in a design and then proceeds backward toward the input pins to determine the qualifying conditions needed at each design stage.

HOW CROSSCHECK TESTS ASICs



In the CrossCheck approach, a test-point array—effectively an x-y matrix—is applied to a base ASIC; the test points can stimulate or read any node in the chip.

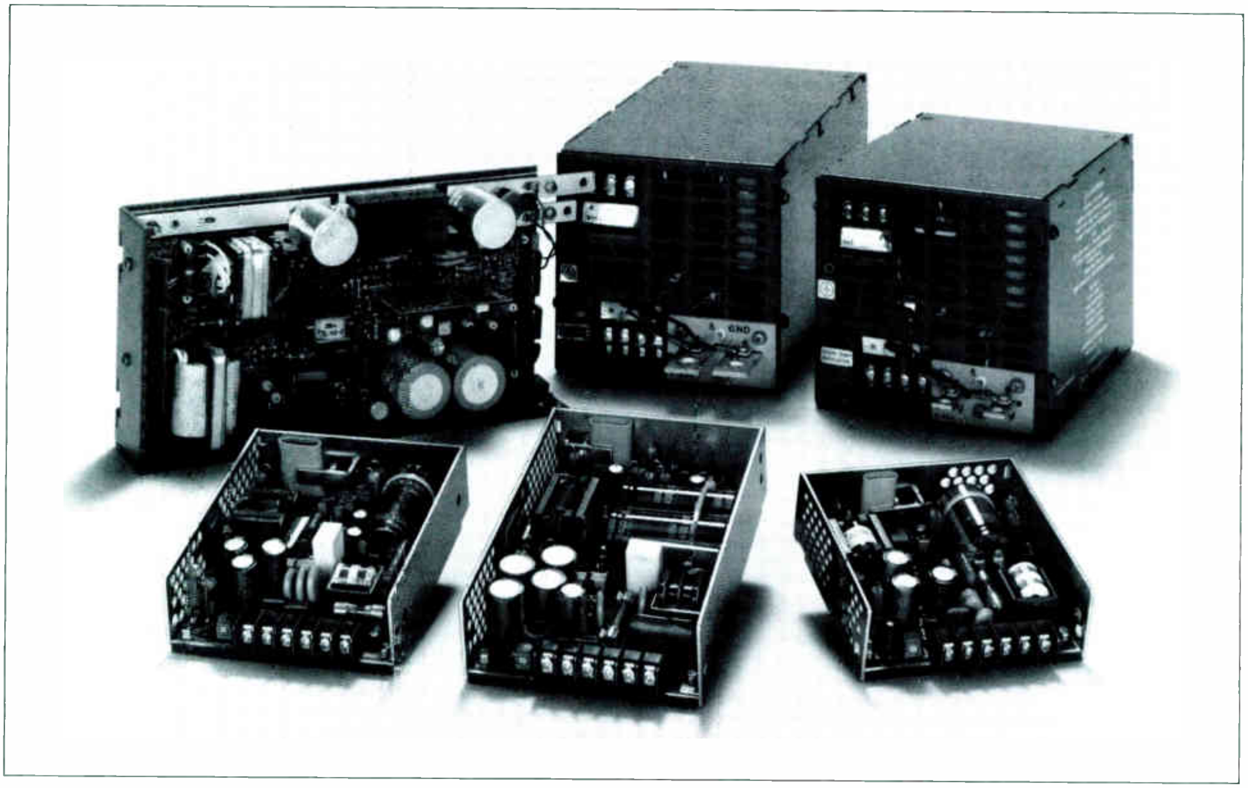
Meanwhile, from CrossCheck Technology of San Jose, Calif., comes an automatic test-generation technique that the company claims can achieve greater than 98% fault coverage with a fixed 10% increase in silicon area on any design. In the CrossCheck approach, a test-point array—effectively an *x-y* matrix—is applied to a base ASIC, and a test controller directs all operations of the matrix. When a design is laid out on the ASIC, each node is located at an intersection of an *x-y* line, providing a test point into the circuit. During a test, the controller can use these points to stimulate or read any node.

The CrossCheck process greatly simplifies test generation—every node in the design is accessible via the test points—and makes for faster debugging. But its main value is the ability to test for more than simple "stuck-at" faults. All test-generation programs presume that a logic circuit fails with a gate being stuck at a logic 1 or 0 level.

"Studies have shown that with 100% stuck-at fault coverage, only 80% of actual faults are covered," says Michael Carroll, vice president of marketing and cofounder of CrossCheck. The CrossCheck approach, by contrast, analyzes for seven conditions: stuck high and low, open and shorted FET, open and shorted interconnection, and noise margins. □

LFS Series:

THE INTERNATIONAL SOLUTION FOR INDUSTRIAL POWER SUPPLY APPLICATIONS



Industrial electronic equipment used in applications such as factory automation, process controls, etc., must be reliable. The consequences due to a failure can be costly and sometimes dangerous. Choosing the right power supplies for new equipment is a key element in the design process — especially when the operating conditions and geographical deployment are diverse and unknown. For example, line and load transients happen frequently in AC supply networks throughout the world, and it is generally accepted that the situation varies from country to country for a given type of industrial application.

Operating conditions for switching power supplies also vary for each application according to the ambient operating temperature, the possibility of AC line interruptions, and the characteristics of the DC load. The worst case combination occurs when switching power supplies are used at their maximum operating temperature and a step function of DC load (up to the maximum rated current) occurs at the moment an AC line interruption severely reduces the input voltage. Random failures can occur in power supplies which might otherwise appear suitable in terms of rating versus temperature, QA/QC standards etc.

Reliability starts with the design, and the LF Series embodies a unique control concept developed by Lambda which provides inherently reliable operation in transient line and load conditions. In addition, the LF Series allows increased power density up to 5 watts/inch^3. This design approach, coupled with the controlled manufacturing and quality standards (always expected of Lambda) makes the LF Series the natural choice in demanding industrial applications.

Now the LFS Series has been extended to include five new packages at 19W, 30W, 60W, 90W, and 125W.

FEATURES:
- Priced from 38¢/W.
- Up to 2.4kW
- Up to 5W/in^3
- International input of 85-265VAC on 19W, 30W and 60W models and 85-132VAC/170-265VAC on 90W and 125W models.
- Meets UL/CSA/TUV/IEC
- Industrial isolation ratings: 3750VRMS input to output; 1500VRMS input to ground; 500VRMS output to ground.
- Protection from short circuits; overvoltage; fan failure
- Remote Operation: Remote sense; programming; TTL comp. shutdown.
- Guaranteed specifications from 0-60°C operating ambient and start up from −10°C.
- Guaranteed for the full range of line and load regulation.
- Components and ratings rigidly specified by Lambda including Class H insulated magnetics, high grade electrolytic capacitors, high quality fans (where used), Lambda PWM controller and CC4 printed circuit boards. All mounted in heavy gauge sheet steel enclosures.
- LRA-18 19" rack mounting accessories and custom assemblies available from Lambda.

LFS SERIES

Specifications

DC OUTPUT
Voltage range shown in tables.

REGULATED VOLTAGE

regulation, line	0.1% from 95 to 132VAC or 187 to 265VAC on LFS-43, 44, 45, 45A, 46, 47, 48. 85 to 265VAC on LFS-38, 39, 40. 85 to 132VAC or 170 to 265VAC on LFS-41, 42. 170 to 265VAC or 3 phase on LFS-49, 50.
regulation, load	0.1% from 0 to full load.
ripple and noise	15mV RMS, 75mV pk-pk for 2V, 5V and 6V models. 20mV RMS, 150mV pk-pk for 12V through 28V models. 35mV RMS, 200mV pk-pk for 48V models.
temperature coefficient	0.03%/°C.
remote programming resistance	1000Ω/V nominal.
remote programming voltage	volt per volt.

AC INPUT

line	95 to 132VAC / 187 to 265VAC, 47-440Hz. 85 to 132VAC / 170 to 265VAC, 47-440Hz on LFS-41, 42 (user selectable). 85 to 265 VAC, 47-440Hz on LFS-38, 39, 40 (wide range input, no tap change). 170 to 265VAC, 47-440Hz single phase or three phase on LFS-49 and LFS-50.
power	LFS-38: 31.5 watts maximum. LFS-39: 45 watts maximum. LFS-40: 89.5 watts maximum. LFS-41: 120 watts maximum. LFS-42: 186 watts maximum. LFS-43: 326 watts maximum. LFS-44: 440 watts maximum. LFS-45: 682 watts maximum. LFS-45A: 682 watts maximum. LFS-46: 882 watts maximum. LFS-47: 1103 watts maximum. LFS-48: 1470 watts maximum. LFS-49: 2457 watts maximum. LFS-50: 3220 watts maximum.
RMS current	0.4A RMS maximum on LFS-38. 0.75A RMS maximum on LFS-39. 1.5A RMS maximum on LFS-40. 2.0A RMS maximum on LFS-41. 3.7A RMS maximum on LFS-42. 5.7A RMS maximum on LFS-43. 7.5A RMS maximum on LFS-44. 12.0A RMS maximum on LFS-45. 12.0A RMS maximum on LFS-45A. 15.0A RMS maximum on LFS-46. 18.0A RMS maximum on LFS-47. 25.0A RMS maximum on LFS-48. 22.0A RMS maximum (single phase); 16.0A RMS maximum (three phase) on LFS-49. 30.0A RMS maximum (single phase); 20.0A RMS maximum (three phase) on LFS-50.

EFFICIENCY
40% minimum on 2V model of LFS-38. 45% minimum on 2V models of LFS-39, 40, 41. 55% minimum on all other 2V models. 60% minimum on 5V and 6V models of LFS-38. 67% minimum on 5V and 6V models of LFS-39, 40. 68% minimum on 12V through 20V models of LFS-38. 70% minimum on 12V through 20V models of LFS-39. 71% minimum on 24V through 48V models of LFS-39. 72% minimum on 5V through 15V models of LFS-42. 73% minimum on 12V through 20V models of LFS-40. 74% minimum on 24V through 48V models of LFS-38, 40. 75% minimum on 5V through 15V models of LFS-41, 42, 43, 44, 45, 45A, 46, 47, 48, 49, 50. 78% minimum on 20V through 48V models of LFS-41. 80% minimum on all 20V through 48V models of LFS-42, 43, 44, 45, 45A, 46, 47, 48, 49, 50.

DC INPUT
110 to 370VDC on LFS-38, 39, 40. 230 to 370VDC on LFS-41. 260 to 370VDC on LFS-42, 43, 44, 45, 45A, 46, 47, 48 (unit must be wired for 220V configuration). 240 to 370VDC on LFS-49, 50.

OVERSHOOT
No overshoot at turn-on, turn-off or power failure.

OPERATING TEMPERATURE RANGE
Continuous duty 0° to 60°C with suitable derating above 40°C. Guaranteed turn-on at −10°C with reduced specifications.

OVERLOAD PROTECTION
ELECTRICAL
External overload protection. Automatic electronic current limiting circuit limits the output current to a preset value, thereby providing protection for the load as well as the power supply.

HOLD UP TIME
2V, 5V and 6V models will remain within regulation limits for at least 16.7 msec. after loss of AC power when operating at full load, Vo max and 105VAC input at 60Hz. 100 msec hold up when operating at maximum output power and 210VAC input at 50Hz on LFS-38, 39, 40 and 41. (When configured at 220V input: 20 msec holdup when operating at maximum output power and 210VAC input at 50Hz.)

IN-RUSH CURRENT LIMITING
All models are provided with in-rush current limiting to limit the current to a preset value.

OVERVOLTAGE PROTECTION
Non-crowbar, inverter shutdown type OV protection is standard on all models.

COOLING
LFS-38, 39, 40, 41, 42, 43, 44, 45 are convection cooled. LFS-45A, 46, 47, 48, 49, 50 are fan cooled.

DC OUTPUT CONTROLS
Simple screwdriver adjustment over the entire voltage range.

INPUT AND OUTPUT CONNECTIONS
All input, sensing and remote on/off connections are made via PC board mounted terminal block. DC output connections are made via heavy duty bus bars (LFS-38, 39, 40, 41 are PC board mounted terminals). Ground connections are made via chassis stud.

MOUNTING
One mounting surface and one mounting position on LFS-38, 39, 40, 41, 42, 43, 44, 45. One mounting surface, multiple mounting positions on LFS-45A, 46, 47, 48, 49, 50.

REMOTE TURN-ON / TURN-OFF
TTL compatible signal enables remote turn-on/turn-off of the power supply. A voltage of 2.8V to 5.0V applied to remote on/off terminals will initiate turn-off. Open circuit or short circuit condition, or a zero to 2.8V signal will cause turn-on.

REMOTE SENSING
Provision is made for remote sensing to eliminate the effects of power output lead resistance on DC regulation.

ISOLATION RATING
3750V RMS input to output (8mm spacing). 1500V RMS input to ground. 500V RMS output to ground.

CURRENT SHARING
The LFS-49 and LFS-50 have internal circuitry that allows units operated in parallel to share load current. Effects of different supply ambient temperatures are compensated for. For example, the hottest unit will automatically supply less load current. A single additional connection must be run between the supplies. This connection is available on the terminal block.

PHYSICAL DATA

Package Model	Weight Lbs. Net	Weight Lbs. Ship	Size Inches
LFS-38	0.58	1.58	1.38 × 3.82 × 3.54
LFS-39	0.74	1.74	1.38 × 3.82 × 4.53
LFS-40	1.03	2.03	1.46 × 3.82 × 6.02
LFS-41	1.25	2.25	1.78 × 3.82 × 6.30
LFS-42	1.30	2.30	1.9 × 4.75 × 5.687
LFS-43	3.00	4.00	1.9 × 4.75 × 9.125
LFS-44	3.50	4.50	1.9 × 4.75 × 11.75
LFS-45	6.00	7.00	1.9 × 4.75 × 16
LFS-45A	6.00	7.00	4 × 4 × 9
LFS-46	8.75	11.75	5 × 4.875 × 7.25
LFS-47	9.19	12.19	5 × 4.875 × 8.875
LFS-48	12.31	15.31	5 × 4.875 × 11
LFS-49	16.00	19.00	7.375 × 4.875 × 11.50
LFS-50	18.00	21.00	7.375 × 4.875 × 12.875

FINISH
Gray, Fed. Std. 595, No. 26081.

ACCESSORIES
LRA-17 and LRA-18 Rack Adapter available. LRA-15 Rack Adapter also available for LFS-38, 39, 40, 41, 42, 43, 45A, 46, 47, and 48 only.

GUARANTEED FOR 3 YEARS
Three year guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end of three years.

UL / CSA / TUV / IEC
Most units have received formal agency approval or have passed all tests and are waiting for formal notification.

LFS SERIES Switching Power Supplies

	MAX CURRENT AT AMBIENT OF (A)			DIMENSIONS	PRICE					
	40°C	50°C	60°C	(inches)	QTY. 1	QTY. 10	QTY. 100	QTY. 250	QTY. 1000	MODEL
2V ±5% ADJ.	3.8	2.6	1.9	1.38 × 3.82 × 3.54	$ 76	$ 72	$ 63	$ 55	$ 51	LFS-38-2
	6.0	4.2	3.0	1.38 × 3.82 × 4.53	103	98	80	70	65	LFS-39-2
	12.0	8.4	6.0	1.46 × 3.82 × 6.02	147	140	115	99	92	LFS-40-2
	18.0	12.6	9.0	1.78 × 3.82 × 6.30	195	185	148	130	120	LFS-41-2
	25.0	21.8	17.3	1.9 × 4.75 × 5.687	247	235	170	155	140	LFS-42-2
	40.0	33.5	25.0	1.9 × 4.75 × 9.125	294	280	228	207	189	LFS-43-2
	60.0	45.0	33.5	1.9 × 4.75 × 11.75	378	360	297	270	252	LFS-44-2
	90.0	67.5	45.0	1.9 × 4.75 × 16	504	480	392	371	342	LFS-45-2
	90.0	67.5	45.0	4 × 4 × 9	504	480	392	371	342	LFS-45A-2
	120.0	112.0	93.5	5 × 4.875 × 7.25	609	580	450	428	403	LFS-46-2
	150.0	142.5	120.0	5 × 4.875 × 8.875	714	680	560	478	450	LFS-47-2
	200.0	185.0	157.0	5 × 4.875 × 11	840	800	680	600	560	LFS-48-2
	335.0	318.0	291.0	4.875 × 7.375 × 11.50	1145	1090	900	780	760	LFS-49-2
	400.0	375.0	350.0	4.875 × 7.375 × 12.875	1365	1300	1100	940	920	LFS-50-2
5V ±5% ADJ.	3.8	2.6	1.9	1.38 × 3.82 × 3.54	76	72	63	55	51	LFS-38-5
	6.0	4.2	3.0	1.38 × 3.82 × 4.53	103	98	80	70	65	LFS-39-5
	12.0	8.4	6.0	1.46 × 3.82 × 6.02	147	140	115	99	92	LFS-40-5
	18.0	12.6	9.0	1.78 × 3.82 × 6.30	195	185	148	130	120	LFS-41-5
	25.0	21.8	17.5	1.9 × 4.75 × 5.687	247	235	170	155	140	LFS-42-5
	40.0	33.5	25.0	1.9 × 4.75 × 9.125	294	280	228	207	189	LFS-43-5
	60.0	45.0	33.5	1.9 × 4.75 × 11.75	378	360	297	270	252	LFS-44-5
	90.0	67.5	45.0	1.9 × 4.75 × 16	504	480	392	371	342	LFS-45-5
	90.0	67.5	45.0	4 × 4 × 9	504	480	392	371	342	LFS-45A-5
	120.0	112.0	93.5	5 × 4.875 × 7.25	609	580	450	428	403	LFS-46-5
	150.0	142.5	120.0	5 × 4.875 × 8.875	714	680	560	478	450	LFS-47-5
	200.0	185.0	157.0	5 × 4.875 × 11	840	800	680	600	560	LFS-48-S
	300.0	285.0	261.0	4.875 × 7.375 × 11.50	1145	1090	900	780	760	LFS-49-5
	400.0	375.0	350.0	4.875 × 7.375 × 12.875	1365	1300	1100	940	920	LFS-50-S
6V ±5% ADJ.	3.2	2.2	1.6	1.38 × 3.82 × 3.54	76	72	63	55	51	LFS-38-6
	5.0	3.5	2.5	1.38 × 3.82 × 4.53	103	98	80	70	65	LFS-39-6
	10.0	7.0	5.0	1.46 × 3.82 × 6.02	147	140	115	99	92	LFS-40-6
	15.0	10.5	7.5	1.78 × 3.82 × 6.30	195	185	148	130	120	LFS-41-6
	21.0	18.3	14.5	1.9 × 4.75 × 5.687	247	235	170	155	140	LFS-42-6
	35.0	28.0	20.5	1.9 × 4.75 × 9.125	294	280	228	207	189	LFS-43-6
	50.0	37.5	28.0	1.9 × 4.75 × 11.75	378	360	297	270	252	LFS-44-6
	75.0	56.0	37.5	1.9 × 4.75 × 16	504	480	392	371	342	LFS-45-6
	75.0	56.0	37.5	4 × 4 × 9	504	480	392	371	342	LFS-4SA-6
	101.0	94.5	79.0	5 × 4.875 × 7.25	609	580	450	428	403	LFS-46-6
	126.0	120.0	107.0	5 × 4.875 × 8.875	714	680	560	478	450	LFS-47-6
	168.0	155.0	132.0	5 × 4.875 × 11	840	800	680	600	560	LFS-48-6
	260.0	244.0	224.0	4.875 × 7.375 × 11.50	1145	1090	900	780	760	LFS-49-6
	345.0	325.0	300.0	4.875 × 7.375 × 12.875	1365	1300	1100	940	920	LFS-50-6
12V ±5% ADJ.	1.6	1.1	0.8	1.38 × 3.82 × 3.54	76	72	63	55	51	LFS-38-12
	2.5	1.75	1.25	1.38 × 3.82 × 4.53	103	98	80	70	65	LFS-39-12
	5.0	3.5	2.5	1.46 × 3.82 × 6.02	147	140	115	99	92	LFS-40-12
	7.5	5.2	3.7	1.78 × 3.82 × 6.30	195	185	148	130	120	LFS-41-12
	10.5	9.5	8.0	1.9 × 4.75 × 5.687	247	235	170	155	140	LFS-42-12
	19.0	15.0	11.0	1.9 × 4.75 × 9.125	294	280	228	207	189	LFS-43-12
	26.0	18.5	13.5	1.9 × 4.75 × 11.75	378	360	297	270	252	LFS-44-12
	40.0	30.0	20.0	1.9 × 4.75 × 16	504	480	392	371	342	LFS-45-12
	40.0	30.0	20.0	4 × 4 × 9	504	480	392	371	342	LFS-4SA-12
	51.5	48.0	40.0	5 × 4.875 × 7.25	609	580	450	428	403	LFS-46-12
	64.5	61.5	55.0	5 × 4.875 × 8.875	714	680	560	478	450	LFS-47-12
	86.0	79.5	67.5	5 × 4.875 × 11	840	800	680	600	560	LFS-48-12
	145.0	138.0	126.0	4.875 × 7.375 × 11.50	1145	1090	900	780	760	LFS-49-12
	190.0	180.0	170.0	4.875 × 7.375 × 12.875	1365	1300	1100	940	920	LFS-50-12
15V ±5% ADJ.	1.3	0.9	0.65	1.38 × 3.82 × 3.54	76	72	63	55	51	LFS-38-15
	2.0	1.4	1.0	1.38 × 3.82 × 4.53	103	98	80	70	65	LFS-39-1S
	4.0	2.8	2.0	1.46 × 3.82 × 6.02	147	140	115	99	92	LFS-40-15
	6.0	4.2	3.0	1.78 × 3.82 × 6.30	195	185	148	130	120	LFS-41-1S
	8.5	7.5	6.3	1.9 × 4.75 × 5.687	247	235	170	155	140	LFS-42-1S
	15.5	12.0	9.0	1.9 × 4.75 × 9.125	294	280	228	207	189	LFS-43-1S
	21.0	15.5	11.5	1.9 × 4.75 × 11.75	378	360	297	270	252	LFS-44-1S

NOTE: 15V models continued on next page.

LFS SERIES Switching Power Supplies

	MAX CURRENT AT AMBIENT OF (A)			DIMENSIONS	PRICE					
	40°C	50°C	60°C	(inches)	QTY. 1	QTY. 10	QTY. 100	QTY. 250	QTY. 1000	MODEL
15V ±5% ADJ. (cont'd.)	32.5	24.5	16.0	1.9 × 4.75 × 16	$ 504	$ 480	$ 392	$ 371	$ 342	LFS-45-15
	32.5	24.5	16.0	4 × 4 × 9	504	480	392	371	342	LFS-45A-15
	42.0	39.0	33.0	5 × 4.875 × 7.25	609	580	450	428	403	LFS-46-15
	52.5	50.0	44.5	5 × 4.875 × 8.875	714	680	560	478	450	LFS-47-15
	70.0	64.5	55.0	5 × 4.875 × 11	840	800	680	600	560	LFS-48-15
	115.0	108.0	100.0	4.875 × 7.375 × 11.50	1145	1090	900	780	760	LFS-49-15
	153.0	143.0	133.0	4.875 × 7.375 × 12.875	1365	1300	1100	940	920	LFS-50-15
20V ±5% ADJ.	0.95	0.65	0.45	1.38 × 3.82 × 3.54	76	72	63	55	51	LFS-38-20
	1.5	1.05	0.75	1.38 × 3.82 × 4.53	103	98	80	70	65	LFS-39-20
	3.0	2.1	1.5	1.46 × 3.82 × 6.02	147	140	115	99	92	LFS-40-20
	4.5	3.1	2.2	1.78 × 3.82 × 6.30	195	185	148	130	120	LFS-41-20
	6.7	6.1	5.1	1.9 × 4.75 × 5.687	247	235	170	155	140	LFS-42-20
	11.8	9.2	6.8	1.9 × 4.75 × 9.125	294	280	228	207	189	LFS-43-20
	16.0	11.5	8.5	1.9 × 4.75 × 11.75	378	360	297	270	252	LFS-44-20
	25.0	19.0	12.5	1.9 × 4.75 × 16	504	480	392	371	342	LFS-45-20
	25.0	19.0	12.5	4 × 4 × 9	504	480	392	371	342	LFS-45A-20
	32.0	30.0	25.0	5 × 4.875 × 7.25	609	580	450	428	403	LFS-46-20
	40.0	38.0	34.0	5 × 4.875 × 8.875	714	680	560	478	450	LFS-47-20
	53.0	49.0	41.5	5 × 4.875 × 11	840	800	680	600	560	LFS-48-20
	85.0	80.0	72.0	4.875 × 7.375 × 11.50	1145	1090	900	780	760	LFS-49-20
	111.0	104.0	97.0	4.875 × 7.375 × 12.875	1365	1300	1100	940	920	LFS-50-20
24V ±5% ADJ.	0.8	0.55	0.4	1.38 × 3.82 × 3.54	76	72	63	55	51	LFS-38-24
	1.3	0.9	0.65	1.38 × 3.82 × 4.53	103	98	80	70	65	LFS-39-24
	2.5	1.75	1.25	1.46 × 3.82 × 6.02	147	140	115	99	92	LFS-40-24
	3.8	2.6	1.9	1.78 × 3.82 × 6.30	195	185	148	130	120	LFS-41-24
	5.7	5.1	4.3	1.9 × 4.75 × 5.687	247	235	170	155	140	LFS-42-24
	10.0	7.8	5.7	1.9 × 4.75 × 9.125	294	280	228	207	189	LFS-43-24
	13.0	10.0	7.5	1.9 × 4.75 × 11.75	378	360	297	270	252	LFS-44-24
	20.0	15.0	10.0	1.9 × 4.75 × 16	504	480	392	371	342	LFS-45-24
	20.0	15.0	10.0	4 × 4 × 9	504	480	392	371	342	LFS-45A-24
	27.0	25.0	21.0	5 × 4.875 × 7.25	609	580	450	428	403	LFS-46-24
	33.5	32.0	28.5	5 × 4.875 × 8.875	714	680	560	478	450	LFS-47-24
	44.5	40.5	35.0	5 × 4.875 × 11	840	800	680	600	560	LFS-48-24
	72.0	68.0	63.0	4.875 × 7.375 × 11.50	1145	1090	900	780	760	LFS-49-24
	97.0	90.0	84.0	4.875 × 7.375 × 12.75	1365	1300	1100	940	920	LFS-50-24
28V ±5% ADJ.	0.7	0.5	0.35	1.38 × 3.82 × 3.54	76	72	63	55	51	LFS-38-28
	1.1	0.77	0.55	1.38 × 3.82 × 4.53	103	98	80	70	65	LFS-39-28
	2.2	1.5	1.1	1.46 × 3.82 × 6.02	147	140	115	99	92	LFS-40-28
	3.3	2.3	1.6	1.78 × 3.82 × 6.30	195	185	148	130	120	LFS-41-28
	5.0	4.4	3.7	1.9 × 4.75 × 5.687	247	235	170	155	140	LFS-42-28
	8.6	6.8	5.0	1.9 × 4.75 × 9.125	294	280	228	207	189	LFS-43-28
	11.5	8.5	6.3	1.9 × 4.75 × 11.75	378	360	297	270	252	LFS-44-28
	17.5	13.0	8.5	1.9 × 4.75 × 16	504	480	392	371	342	LFS-45-28
	17.5	13.0	8.5	4 × 4 × 9	504	480	392	371	342	LFS-45A-28
	23.0	21.5	18.0	5 × 4.875 × 7.25	609	580	450	428	403	LFS-46-28
	29.0	27.5	24.5	5 × 4.875 × 8.875	714	680	560	478	450	LFS-47-28
	38.5	35.0	30.0	5 × 4.875 × 11	840	800	680	600	560	LFS-48-28
	64.0	61.0	56.0	4.875 × 7.375 × 11.50	1145	1090	900	780	760	LFS-49-28
	86.0	80.0	75.0	4.875 × 7.375 × 12.875	1365	1300	1100	940	920	LFS-50-28
48V ±5% ADJ.	0.4	0.28	0.2	1.38 × 3.82 × 3.54	76	72	63	55	51	LFS-38-48
	0.65	0.45	0.32	1.38 × 3.82 × 4.53	103	98	80	70	65	LFS-39-48
	1.25	0.87	0.62	1.46 × 3.82 × 6.02	147	140	115	99	92	LFS-40-48
	1.9	1.3	0.9	1.78 × 3.82 × 6.30	195	185	148	130	120	LFS-41-48
	2.8	2.6	2.1	1.9 × 4.75 × 5.687	247	235	170	155	140	LFS-42-48
	5.0	4.0	3.0	1.9 × 4.75 × 9.125	294	280	228	207	189	LFS-43-48
	6.5	5.0	3.8	1.9 × 4.75 × 11.75	378	360	297	270	252	LFS-44-48
	10.0	7.5	5.0	1.9 × 4.75 × 16	504	480	392	371	342	LFS-45-48
	10.0	7.5	5.0	4 × 4 × 9	504	480	392	371	342	LFS-45A-48
	13.5	12.5	10.5	5 × 4.875 × 7.25	609	580	450	428	403	LFS-46-48
	17.0	16.0	14.5	5 × 4.875 × 8.875	714	680	560	478	450	LFS-47-48
	22.5	20.5	17.5	5 × 4.875 × 11	840	800	680	600	560	LFS-48-48
	37.0	34.0	31.0	4.875 × 7.375 × 11.50	1145	1090	900	780	760	LFS-49-48
	48.0	45.0	42.0	4.875 × 7.375 × 12.875	1365	1300	1100	940	920	LFS-50-48

LFS SERIES Assembled Cover Option "K"

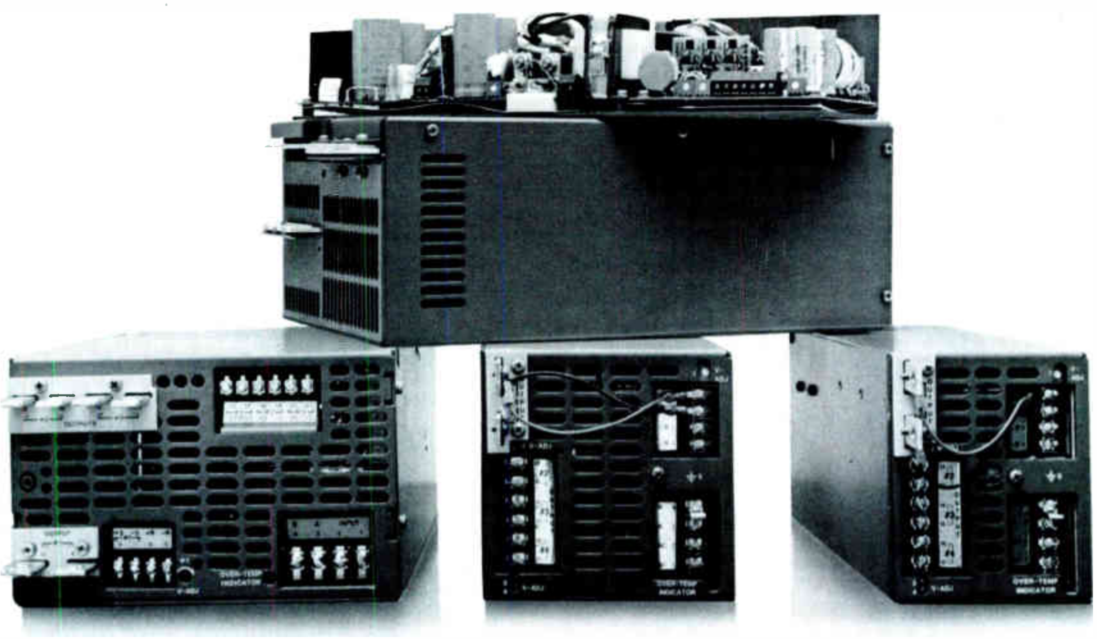
Safety requirements for industrial applications impose a need for enclosed power supplies. Covers provide extra protection that ensures the end user is safeguarded from dangerous voltages. The LFS Series is designed with a cover on all models exceeding 450W. In the power range of 107W to 240W, Lambda can provide an LFS-42, 43, 44 with a protective cover option. As these models are convection cooled, they require derating when covers are used.

	MAX CURRENT AT OPERATING TEMPERATURE OF 40°C	50°C	60°C	QTY. 1	QTY. 10	PRICE QTY. 100	QTY. 250	QTY. 1000	MODEL
2V ±5% ADJ.	21.3	17.4	13.0	$255	$243	$176	$161	$145	**LFS-42-2K**
	34.0	28.5	21.3	303	289	235	213	194	**LFS-43-2K**
	48.0	38.3	20.1	387	369	304	277	258	**LFS-44-2K**
5V ±5% ADJ.	21.3	17.4	13.0	255	243	176	161	145	**LFS-42-5K**
	34.0	28.5	21.3	303	289	235	213	194	**LFS-43-5K**
	48.0	38.3	20.1	387	369	304	277	258	**LFS-44-5K**
6V ±5% ADJ.	17.9	14.6	10.9	255	243	176	161	145	**LFS-42-6K**
	29.8	23.8	17.4	303	289	235	213	194	**LFS-43-6K**
	40.0	31.9	16.8	387	369	304	277	258	**LFS-44-6K**
12V ±5% ADJ.	8.9	7.6	6.0	255	243	176	161	145	**LFS-42-12K**
	16.2	12.8	9.4	303	289	235	213	194	**LFS-43-12K**
	20.8	15.7	8.1	387	369	304	277	258	**LFS-44-12K**
15V ±5% ADJ.	7.2	6.0	4.7	255	243	176	161	145	**LFS-42-15K**
	13.2	10.2	7.7	303	289	235	213	194	**LFS-43-15K**
	16.8	13.2	6.9	387	369	304	277	258	**LFS-44-15K**
20V ±5% ADJ.	5.7	4.9	3.8	255	243	176	161	145	**LFS-42-20K**
	10.0	7.8	5.8	303	289	235	213	194	**LFS-43-20K**
	12.8	9.8	5.1	387	369	304	277	258	**LFS-44-20K**
24V ±5% ADJ.	4.8	4.1	3.2	255	243	176	161	145	**LFS-42-24K**
	8.5	6.6	4.8	303	289	235	213	194	**LFS-43-24K**
	10.4	8.5	4.5	387	369	304	277	258	**LFS-44-24K**
28V ±5% ADJ.	4.3	3.5	2.8	255	243	176	161	145	**LFS-42-28K**
	7.3	5.8	4.3	303	289	235	213	194	**LFS-43-28K**
	9.2	7.2	3.8	387	369	304	277	258	**LFS-44-28K**
48V ±5% ADJ.	2.4	2.1	1.6	255	243	176	161	145	**LFS-42-48K**
	4.3	3.4	2.6	303	289	235	213	194	**LFS-43-48K**
	5.2	4.3	2.3	387	369	304	277	258	**LFS-44-48K**

NOTE: For vertical mounting in free air only. Consult factory for other mounting positions and for external fan cooling for increased ratings. Safety ratings are with cover fitted. All prices are with cover fitted by Lambda.

WattBox™ LFQ SERIES:

IMMEDIATE SOLUTIONS FOR QUAD OUTPUT INDUSTRIAL APPLICATIONS. FROM 325W TO 1200W.



Reliability starts with the design. The WattBox LFQ Series embodies a unique control concept, developed by Lambda, which provides inherently reliable operation in transient line and load conditions. In addition, the WattBox allows increased power density up to 2.8W/in^3 for a quad output. This design approach, coupled with the high quality standards you've come to expect from Lambda, makes the WattBox LFQ Series the natural choice in demanding industrial applications.

Now the LFQ family has been expanded to include two new packages: The LFQ-29 @ 920W; and the LFQ-30 @ 1200W. All of the outputs from each LFQ WattBox are floating and regulated. Dynamic performance is guaranteed for each output over the full AC input range and from zero to full load (up to the maximum total power for the individual package). Cross regulation between outputs is controlled within 0.1% with respect to the other.

FEATURES:

- Priced from 63¢/W
- High power up to 1.2kW
- Power density up to 2.8W/in^3
- Meets UL/CSA/TUV/IEC
- Short circuit, overvoltage and fan failure protection
- TTL compatible signal enables remote turn-on/turn-off
- Performance guaranteed for the full range of line and load regulation
- International Input: 85–132VAC/ 170–250VAC/ 47–63Hz/ 250–370VDC
- Industrial Isolation Ratings: 3750V RMS input to output; 1500V RMS input to ground; 500V RMS output to ground.
- Continuous duty from 0 to 60°C. Guaranteed turn-on at −10°C.
- All components and ratings are rigidly specified by Lambda including Class H insulated magnetics, high grade electrolytic capacitors, high quality fans (where used), Lambda PWM controller and CC4 printed circuit boards. All mounted in heavy gauge sheet steel enclosures.
- LRA-18, 19-inch rack mounting accessories and standard assemblies available.

LFQ SERIES

Specifications

DC OUTPUT
Voltage range shown in tables.

REGULATED VOLTAGE

regulation, line .... 0.1% for line variations from 187 to 265VAC and from 95 to 132VAC. On LFQ-29, 30, 0.1% for line variations from 85 to 132VAC and from 170 to 265VAC.

regulation, load ... 0.1% for load variations from 0 to full load for main output; 0.2% for fourth output (5V) of LFQ-26-1, LFQ-27-1, LFQ-28-1; 1% for 12V/15V outputs*; 2% for 24V/28V outputs*; (*5V outputs require a preload of 12.5A on LFQ-26, 19.0A on LFQ-27, 25.5A on LFQ-28 for full power on other outputs, and 4.0A on output #2 of LFQ-29, 30 for max power out on outputs 3 and 4. Output #2 must be greater than or equal to output #3). 0.2% for second 5V output of LFQ-29-1, 30-1.

ripple and noise ... 15mV RMS, 100mV pk-pk for 5V outputs. 25mV RMS, 150mV pk-pk for 12V/15V outputs. 25mV RMS, 250mV pk-pk for 24V/28V outputs.

cross regulation ... 5V outputs: 0.1% max for load variations on auxiliary outputs from no load to full load; Auxiliary outputs: 0.1% max for load variations on 5V output from preload to full load current.

remote programming resistance ...... 1000 Ω/V nominal (main output and output 1, 2, 3 on LFQ-29, 29-1, 30, 30-1).

remote programming voltage .... volt per volt.

temperature coefficient ...... 0.3%/°C.

AC INPUT (User selectable)

line .... 95 to 132VAC/187-265VAC, 47-440Hz. 85 to 132VAC 170 to 265VAC on LFQ-29, 29-1, 30, 30-1.

power .... LFQ-26, 26-1: 434 watts maximum.
LFQ-27, 27-1: 633 watts maximum.
LFQ-28, 28-1: 880 watts maximum.
LFQ-29, 29-1: 1310 watts maximum.
LFQ-30, 30-1: 1710 watts maximum.

RMS current ...... LFQ-26, 26-1: 7.0A RMS maximum.
LFQ-27, 27-1: 11.0A RMS maximum.
LFQ-28, 28-1: 15.0A RMS maximum.
LFQ-29, 29-1: 20.0A RMS maximum.
LFQ-30, 30-1: 26.0A RMS maximum.

EFFICIENCY
75% minimum on LFQ-26, 26-1, 27, 27-1. 72% minimum on LFQ-28, 28-1. 70% minimum on LFQ-29, 29-1, 30, 30-1.

DC INPUT
260 to 370VDC. (Units must be configured for 220V input.) 250-370VDC on LFQ-29, 29-1, 30, 30-1.

OVERSHOOT
No overshoot at turn-on, turn-off or power failure.

STORAGE TEMPERATURE RANGE
−55°C to +85°C.

AMBIENT OPERATING TEMPERATURE
Continuous duty 0° to 60°C with suitable derating above 40°C. Guaranteed turn-on at −10°C with reduced specifications.

OVERLOAD PROTECTION
ELECTRICAL
External overload protection. Automatic electronic current limiting circuit limits the output current to a preset value, thereby providing protection for the load as well as the power supply.

HOLD UP TIME
All outputs will remain within regulation limits for at least 16.7 msec after loss of AC power when operating at maximum output power and 105VAC input at 60Hz. (When configured at 220V input: 20 msec holdup when operating at maximum output power and 210VAC input at 50Hz.)

IN-RUSH CURRENT LIMITING
The turn-on in-rush current will not exceed 40 amps peak on LFQ-26, 26-1. (75 amps peak on LFQ-27, 27-1, 28, 28-1, 29, 29-1, 30, 30-1.)

OVERVOLTAGE PROTECTION
Main 5V outputs only. If output voltage exceeds a preset value, inverter drive is removed.

COOLING
The LFQ-26, 26-1 are convection cooled. The LFQ-27, 27-1, 28, 28-1, 29, 29-1, 30, 30-1 are fan cooled. A fan failure circuit will shut down the inverter in the event of fan failure or interference of fan rotation. AC input power must be momentarily interrupted to reduce output after fault condition is corrected.

LED INDICATOR
An LED fan failure indicator will illuminate in the event of fan failure or interference of fan rotation.

DC OUTPUT CONTROLS
Simple screwdriver adjustment over entire voltage range.

INPUT AND OUTPUT CONNECTIONS
PC Board mounted barrier strip: AC input, 5V DC sensing and remote turn-on/turn-off of LFQ-27, 27-1, 28, 28-1; AC input, remote turn-on/turn-off, DC sensing outputs 1, 2, 3 of LFQ-29, 29-1, 30, 30-1. DC output 4 of LFQ-29, 29-1, 30, 30-1; Auxiliary outputs of LFQ-27, 27-1, 28, 28-1.
PC Board mounted terminal block: AC input, 5VDC, sensing and remote turn-on/turn-off and auxiliary outputs of LFQ-26, 26-1.
Chassis stud: all ground connections.
Bus Bars mounted on PC Board: 5VDC outputs of LFQ-26, 26-1, 27, 27-1, 28, 28-1; DC outputs 1, 2, 3 of LFQ-29, 29-1, 30, 30-1.

MOUNTING
Two mounting surfaces and two mounting positions on LFQ-26, 26-1. LFQ-27, 27-1, 28, 28-1, 29, 29-1, 30, 30-1 have one mounting surface. Forced air cooling will allow multiple mounting positions.

REMOTE TURN-ON/TURN-OFF
TTL compatible signal enables remote turn-on/turn-off of the power supply. A voltage of 2.8V to 5.0V applied to remote on/off terminals will initiate turn-off. Open circuit or short circuit condition, or a zero to 0.5V signal will cause turn-on.

REMOTE SENSING
Provision is made for remote sensing to eliminate the effects of power output lead resistance on DC regulation. (Main 5V outputs only of LFQ-26, 26-1, 27, 27-1, 28, 28-1 and outputs 1, 2, 3 of LFQ-29, 29-1, 30, 30-1.)

ISOLATION RATING
3750V RMS input to output, (8mm spacing).

EMI
Conducted EMI conforms to FCC Docket 20780 Class A and VDE 0871 Class A above 150 kHz.

PHYSICAL DATA

Package Model	Weight Lb. Net	Weight Lb. Ship	Size (In.)
LFQ-26, 26-1	6	7	2.5 × 4.75 × 13
LFQ-27, 27-1	12	14	4.0 × 4.875 × 11
LFQ-28, 28-1	13	15	5.0 × 4.875 × 11
LFQ-29, 29-1, 30, 30-1	17	20	7.75 × 4.875 × 11.5

FINISH
Grey, Fed. Std. 595, No. 26081

GUARANTEED FOR 3 YEARS
Three year guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end of three years.

UL/CSA/TUV/IEC
All models are approved for UL/CSA/TUV, except for LFQ-29, 29-1, 30, 30-1 which are under evaluation.

WattBox™ LFQ SERIES

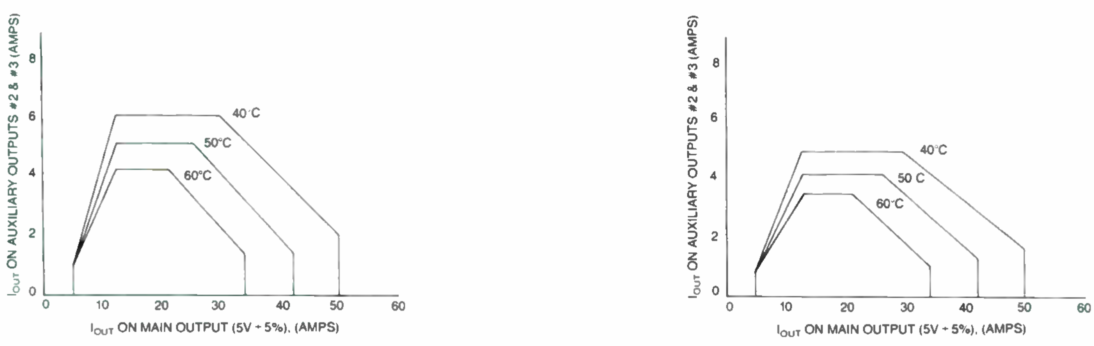
Switching Power Supplies

MODEL	OUTPUT NUMBER	ADJUSTABLE VOLTAGE RANGE (VDC)	VOLT NOMINAL (Vo)	MAX OUTPUT POWER (WATTS) 40°C	50°C	60°C	MAX CURRENT (AMPS AT) 40°C	50°C	60°C	DIMENSIONS (INCHES)	PRICE QTY. 1	QTY. 10	QTY. 250	QTY. 1000
LFQ-26	1	5V ± 5%	5	325	276	227	50.00	42.00	34.00	2.5 × 4.75 × 13	$ 473	$ 450	$375	$325
	2	11.4-15.75	12				6.00	5.10	4.20					
			15				4.80	4.10	3.40					
	3	11.4-15.75	12				6.00	5.10	4.20					
			15				4.80	4.10	3.40					
	4	22.8-29.4(1)	24				1.00	0.85	0.70					
			28				0.86	0.73	0.60					
LFQ-26-1	1	5V ± 5%	5	325	276	227	50.00	42.00	34.00	2.5 × 4.75 × 13	473	450	375	325
	2	11.4-15.75	12				6.00	5.10	4.20					
			15				4.80	4.10	3.40					
	3	11.4-15.75	12				6.00	5.10	4.20					
			15				4.80	4.10	3.40					
	4	5V ± 5%	5				5.00	4.20	3.50					
LFQ-27	1	5V ± 5%	5	475	420	362	75.00	66.00	57.00	4.0 × 4.875 × 11	599	570	485	435
	2	11.4-15.75	12				9.00	7.90	6.90					
			15				7.20	6.40	5.50					
	3	11.4-15.75	12				9.00	7.90	6.90					
			15				7.20	6.40	5.50					
	4	22.8-29.4(1)	24				1.50	1.30	1.10					
			28				1.30	1.15	1.00					
LFQ-27-1	1	5V ± 5%	5	475	420	362	75.00	66.00	57.00	4.0 × 4.875 × 11	599	570	485	435
	2	11.4-15.75	12				9.00	7.90	6.90					
			15				7.20	6.40	5.50					
	3	11.4-15.75	12				9.00	7.90	6.90					
			15				7.20	6.40	5.50					
	4	5V ± 5%	5				7.50	6.70	6.00					
LFQ-28	1	5V ± 5%	5	635	578	502	100.00	91.00	79.00	5.0 × 4.875 × 11	709	675	575	510
	2	11.4-15.75	12				12.00	10.80	9.50					
			15				9.60	8.60	7.60					
	3	11.4-15.75	12				12.00	10.80	9.50					
			15				9.60	8.60	7.60					
	4	22.8-29.4(1)	24				2.00	1.80	1.60					
			28				1.70	1.50	1.40					
LFQ-28-1	1	5V ± 5%	5	635	578	502	100.00	91.00	79.00	5.0 × 4.875 × 11	709	675	575	510
	2	11.4-15.75	12				12.00	10.80	9.50					
			15				9.60	8.60	7.60					
	3	11.4-15.75	12				12.00	10.80	9.50					
			15				9.60	8.60	7.60					
	5	5V ± 5%	5				7.50	6.70	6.00					
LFQ-29	1	5V ± 5%	5	920	830	700	150.00	130.00	105.00	7.75 × 4.875 × 11.5	882	840	710	635
	2	11.4-15.75	12				18.00	15.70	12.60					
			15				14.40	12.50	10.00					
	3	11.4-15.75	12				18.00	15.70	12.60					
			15				14.40	12.50	10.00					
	4	22.8-29.4	24				2.70	2.30	1.90					
			28				2.30	1.80	1.60					
LFQ-29-1	1	5V ± 5%	5	920	830	700	150.00	130.00	105.00	7.75 × 4.875 × 11.5	882	840	710	635
	2	11.4-15.75	12				18.00	15.70	12.60					
			15				14.40	12.50	10.00					
	3	11.4-15.75	12				18.00	15.70	12.60					
			15				14.40	12.50	10.00					
	4	5V ± 5%	5				10.00	8.70	7.00					
LFQ-30	1	5V ± 5%	5	1200	1050	850	170.00	148.00	120.00	7.75 × 4.875 × 11.5	1050	1000	835	750
	2	11.4-15.75	12				20.00	17.40	14.00					
			15				16.00	13.90	11.20					
	3	11.4-15.75	12				20.00	17.40	14.00					
			15				16.00	13.90	11.20					
	4	22.8-29.4	24				3.30	2.90	2.30					
			28				2.80	2.40	2.00					
LFQ-30-1	1	5V ± 5%	5	1200	1050	850	170.00	148.00	120.00	7.75 × 4.875 × 11.5	1050	1000	835	750
	2	11.4-15.75	12				20.00	17.40	14.00					
			15				16.00	13.90	11.20					
	3	11.4-15.75	12				20.00	17.40	14.00					
			15				16.00	13.90	11.20					
	4	5V ± 5%	5				10.00	8.70	7.00					

NOTE: (1). Peak output current (40°C) for 5 sec.: LFQ-27 — 4.5A; LFQ-28 — 6.0A.
(2) All outputs are floating and regulated. They can be configured in either a positive or negative mode.

WattBox™ LFQ SERIES

OUTPUT CURRENT ON AUXILIARY OUTPUTS 2 AND 3 VERSUS I_{OUT} ON MAIN OUTPUT
(Auxiliary output 4 and maximum output current at appropriate ambient temperature.)

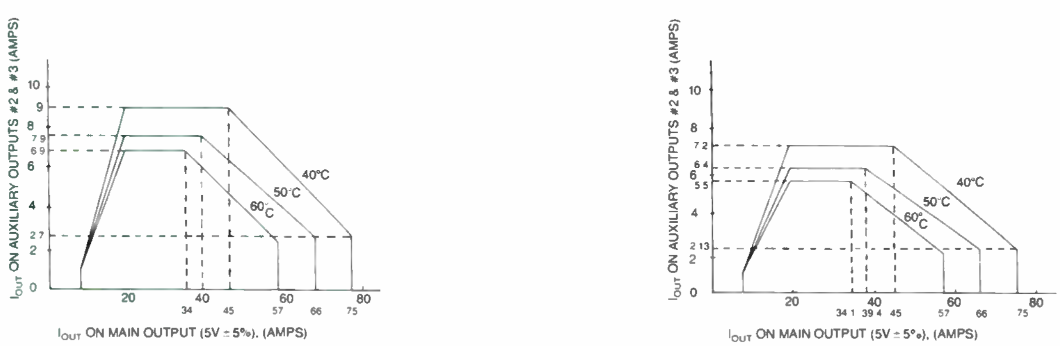


Auxiliary Outputs #2 and #3 Adjusted to 12V ±5%

Auxiliary Outputs #2 and #3 Adjusted to 15V ±5%

Figure 1. LFQ-26 Output Current Profile

OUTPUT CURRENT ON AUXILIARY OUTPUTS 2 AND 3 VERSUS I_{OUT} ON MAIN OUTPUT
(Auxiliary output 4 at maximum output current at appropriate ambient temperature.)



Auxiliary Outputs #2 and #3 Adjusted to 12V ±5%

Auxiliary Outputs #2 and #3 Adjusted to 15V ±5%

Figure 2. LFQ-27 Output Current Profile

MINIMUM LOAD REQUIRED

The minimum load specified for the LFQ Series is not required for reasons of cross regulation. Line and load transients happen frequently in industrial applications throughout the world. This imposes the need for a wide variation in duty cycle and precise control under all circumstances, including the effects of power supply load variations. Minimum loading requirements are specified for the LFQ Series (shown for the main 5V output on single inverter designs employed in LFQ-26, 27 and 28, and output number 2 in LFQ-29 and 30 which use a double inverter approach). The minimum loading specified is required to ensure that the minimum duty cycle of the inverter does not fall below the design limit when maximum current is required from the dual auxiliary outputs. In the majority of applications, where the full rated output is not required from the auxiliaries, the minimum loading on the main output can be reduced. Figure 1 (a) and 1 (b) thru 5 (a) and (b) exemplify these options for the LFQ Series.

WattBox™ LFQ SERIES

OUTPUT CURRENT ON AUXILIARY OUTPUTS 2 AND 3 VERSUS I_{OUT} ON MAIN OUTPUT
(Auxiliary output 4 and maximum output current at appropriate ambient temperature.)

Auxiliary Outputs #2 and #3 Adjusted to 12V ±5% Auxiliary Outputs #2 and #3 Adjusted to 15V ±5%

Figure 3. LFQ-28 Output Current Profile

OUTPUT CURRENT ON AUXILIARY OUTPUTS 2 AND 3 VERSUS I_{OUT} ON MAIN OUTPUT
(Auxiliary output 4 at maximum output current at appropriate ambient temperature.)

NOTE:
MINIMUM PRELOAD OF 4.0A IS REQUIRED ON OUTPUT #2 IN ORDER TO OBTAIN I_{MAX} ON OUTPUTS #3 AND #4.

Auxiliary Outputs #2 and #3 Adjusted to 12V ±5% Auxiliary Outputs #2 and #3 Adjusted to 15V ±5%

Figure 4. LFQ-29 Output Current Profile

OUTPUT CURRENT ON AUXILIARY OUTPUTS 2 AND 3 VERSUS I_{OUT} ON MAIN OUTPUT
(Auxiliary output 4 at maximum output current at appropriate ambient temperature.)

NOTE:
MINIMUM PRELOAD OF 4.0A IS REQUIRED ON OUTPUT #2 IN ORDER TO OBTAIN I_{MAX} ON OUTPUTS #3 AND #4

Auxiliary Outputs #2 and #3 Adjusted to 12V ±5% Auxiliary Outputs #2 and #3 Adjusted to 15V ±5%

Figure 5. LFQ-30 Output Current Profile

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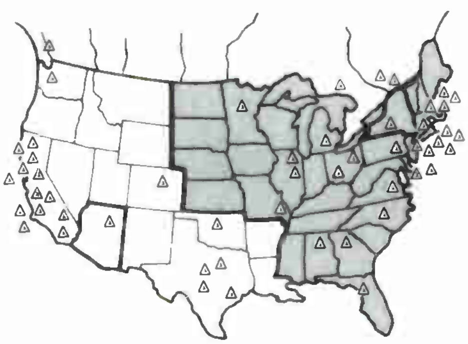

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COMPANIES TO WATCH

AN INTERNATIONAL GIANT FLEXES ITS U. S. MUSCLES

SGS-Thomson is moving front and center—right into the DRAM fray

PHOENIX

For a company that's an acknowledged semiconductor giant on its home turf in Europe, SGS-Thomson Microelectronics has kept a low profile in North America. That's true despite a solid record in the U. S.: steady growth from only $13 million in sales in 1980 to $312 million last year, with a $400 million year in sight. Now, however, the giant appears ready to step up and be noticed.

Two factors have kept SGS-Thomson from attracting attention in the U. S.: its lack of a hot product and its absence from the hectic dynamic-random-access-memory market. Both those conditions may soon change. This year, SGS-Thomson will unveil additional smart RAMs—static RAMs with on-board intelligence. It plans to aggressively promote the 32-bit Transputer, a prize it acquired when it bought out Inmos Ltd. earlier this year. And it's poised to plunge into the high-stakes worldwide DRAM business.

NO MYSTERY. SGS-Thomson's gathering momentum is fueled by time-tested methods, says Daniel Queyssac, president and chief executive officer of the U. S. arm. "There's no mystery: if management is reasonably competent, it comes down to resources," he says. Size is important in the chip business, he adds, "to generate the resources for new technology and manufacturing, to grow and survive."

SGS-Thomson believes it has the assets to go head to head against world-class competitors. The company continues to enjoy the support of the French and Italian governments, which backed the two firms that merged in 1987 to form the current outfit: Italy's SGS Microeletronica and France's Thomson Semiconducteurs. Both governments are determined to be represented at the leading edge of chip technology, Queyssac says, which means SGS-Thomson has the financial resources needed for the long haul. Even headquarters functions, shared by offices in Paris and Agrate Brianza, near Milan, mirror the company's pan-European roots and backing.

The company now ranks 13th in the world among chip makers, with about $1.2 billion in sales worldwide in 1988, according to Dataquest Inc. of San Jose, Calif. It is the second-largest chip supplier to the European merchant market, behind Philips International NV of the Netherlands. That's quite a jump from the No. 24 spot that SGS held in 1980. That is also the year that Pasquale Pistorio took over as chief executive of SGS's worldwide operation; he was soon joined by Queyssac. Both came from Motorola Inc.'s Semiconductor Sector in Phoenix, so it was natural for them to select that city as U. S. headquarters.

SGS-Thomson's U. S. revenues now account for about a third of the corporation's worldwide total, according to Queyssac. The entire organization operates according to a plan devised by Pistorio after the 1987 merger to make SGS-Thomson one of the top 10 semiconductor suppliers by the early 1990s.

To implement that strategy, SGS-Thomson had to fill some holes. Pistorio identified two must-have products: 32-bit microprocessors and DRAMs. The first was taken care of with the Inmos deal. Queyssac notes that the Transputer has sold steadily in its five years on the market, despite the lack of software and Inmos's instability and failure to promote the chip vigorously. Dataquest estimates that more than 125,000 Transputers have been sold through midyear, more than any other reduced-instruction-set processor. A design win with a major computer maker would send the Transputer on its way; Queyssac expects just such a "big hit" to come soon.

At the same time, the company has been working hard to master DRAM design and production technology, Queyssac says. One intriguing question concerns where it will produce DRAMs. A possible site is a 285,000-ft^2 Class 1 structure in Phoenix that was built to handle 6-in. wafers with 0.7-μm features but that remains unequipped.

The facility figured in Arizona's unsuccessful bid in 1987-88 to have Sematech's headquarters located in the state. Chip production with 0.8-μm geometries is at the early stages at SGS-Thomson's Dallas plant, which Thomson acquired when it bought Mostek Corp. in 1985.

Another objective is to develop a strong presence in the Pacific Rim—Queyssac says the company has to be important "in all the major markets in order to understand the products they need." To help accomplish that, a separate organization has been set up as an autonomous unit in Japan similar to the one in the U. S. The way Queyssac sees it, Japan is important for the consumer lines, the U. S. for personal computers; in addition,

THE CHIP PACK FIGHTS FOR SHARE

Rank	Company	(1988 North America) Revenue ($ Millions)	Market Share (%)
1	Motorola	1,305	9.7
2	Intel	1,125	8.3
3	Texas Instruments	1,090	8.1
4	National	920	6.8
5	AMD	862	6.4
6	Toshiba	675	5.0
7	Harris (incl. GE)	630	4.7
8	NEC	490	3.6
9	Hitachi	435	3.2
10	Philips/Signetics	395	2.9
11	Fujitsu	345	2.6
12	Mitsubishi	320	2.4
13	SGS-Thomson	312	2.3
14	LSI Logic	256	1.9
15	Analog Devices	251	1.9

SOURCE: IN-STAT INC.

both are active in telecommunications, as is Europe. But it's not going to be easy: SGS-Thomson is braced for a particularly tough battle on the Pacific Rim, the only market where the Japanese are not hampered by political restraints placed by governments on their aggressive chip efforts. "That's where the Japanese go for the throat," says Queyssac.

As new strategic moves unfold, the company continues to build on its strengths. One such strength is smart RAMs, much in demand to cut part counts and increase equipment speed. SGS-Thomson's newest data multiplexer, the MK48T87, features built-in timekeeping and alarm functions and replaces 17 components; it costs about $10. These are built in Dallas.

SMART POWER. In erasable programmable read-only memories, SGS-Thomson's offerings range up to the 1-Mbit size, with 4- and 16-Mbit chips in the works. The company is second only to Intel Corp. of Santa Clara, Calif., in EPROM sales worldwide, according to Dataquest. As for intelligent power, the company holds the top spot worldwide, with sales of about $200 million for 1988. Moreover, it is solidly profitable in this field, while most of its competitors wallow in red ink [*Electronics*, June 1989, p. 107].

Although SGS-Thomson remains relatively unknown outside its niches, industry insiders have noted the improvements made during the 1980s—and especially since 1987. "Pasquale and Daniel have done a good job" at SGS-Thomson, says consultant William I. Strauss, president of Forward Concepts of Scottsdale, Ariz. And they've pulled off their sweeping changes, he says, without the bloodshed that often results from such moves. Even the predicted chip recession, which Queyssac thinks might finally be here, "would push our plans back a year or two, at worst," the SGS-Thomson executive says. *–Larry Waller*

STARTUP LEPTON UNVEILS AN E-BEAM FOR THE '90s

MURRAY HILL, N. J.

Here's a new formula for a high-tech startup. License a technology that AT&T Bell Labs has poured $75 million into over a decade; hire the cadre Bell Labs' engineering team to finish its work; and top with a full measure of market demand. Incubate two years and call the company Lepton Inc.

The Murray Hill company's electron-beam pattern-generation machine, the EBES4.1, is precise enough to create masks for a 1-Gbit dynamic random-access memory, but company founder and president Martin Lepselter has more immediate markets in mind. "Out to the 16-Mbit DRAM, it will still be an optical world," he says.

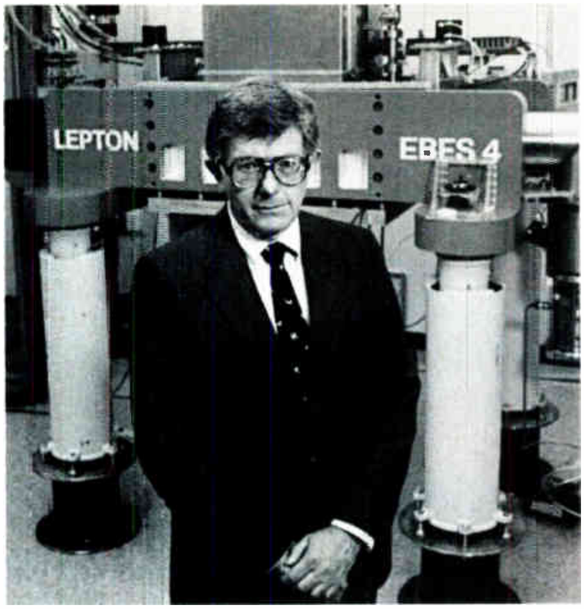
So Lepselter is eyeing application-specific integrated circuits. The EBES4.1 delivers a powerful beam—1,600 A/cm^2—and its throughputs are high enough for direct-write-on-silicon applications as well as for making masks. Comparable machines have current densities of only 10 A/cm^2. "If you're going to make 1,000 chips, why worry about masks?" Lepselter asks. "Go to direct write. I know one ASIC maker who needs 1.5 miles of [linear storage] space for his reticles." So even at a price of about $6 million, Lepselter expects a relatively lively market.

It could happen only in America. While the AT&T divestiture may have dropped long-distance rates for consumers, it also dropped a neutron bomb on Bell Labs: the buildings are still standing but many of the projects are gone. "The loss of Bell Labs as a heavily funded research institution is a great national tragedy," says

Lepselter. One of the projects that didn't quite line up with the trimmed-down labs was e-beam.

So in 1986, Lepselter, who holds 90 patents in semiconductor technology, left Ma Bell with the blueprints for a world-class e-beam machine under his arm and a license to build it in his portfolio. "We're the only e-beam company in the U. S. that knows who its boss is," he says, referring to the fact that Perkin-Elmer Corp., maker of the Mebus e-beam machines, is up for sale.

"In this country, no one is willing to fund technology development," says Lepselter. "Sematech doesn't fund or work on new development. They're interested in putting in new technology that exists or will be built anyway. We have been singularly unsuccessful with Sematech—or the government, for that matter." Instead, funding came from Japan, with Canon Inc. providing the first round of Lepton's capital financing.



Martin Lepselter, founder of Lepton Inc., says the EBES4.1 is precise enough for 1-Gbit DRAM masks.

Sematech's official position is that it expects particle-beam lithography technologies such as e-beam to play a crucial future role in semiconductor manufacturing, but that investments in particle-beam technologies are best put off to the future. Avtar Oberai, director of the consortium's Competitive Strategies Group, says optical equipment can be stretched to the 0.5-μm feature sizes required for 16-Mbit DRAMs, and perhaps lower.

But as IC feature sizes shrink, the need for higher-resolution mask-production equipment will become critical. Much of the present-generation business is going to offshore manufacturers such as Nikon. Its optical steppers, which cost about $15 million, brought in over $500 milion in revenue last year, "and it is American companies that are buying them," Oberai says.

Lepton hopes to end that trend with its EBES4.1, which can produce chips with 0.5-μm features. Besides adding new performance capability to writing masks and reticles for DRAMs and SRAMs that have production runs in the millions of chips, the machine's direct-write capability suits it well for ASICs. "The median number of ASICs [per design] is getting down around 1,000," Lepselter says. Typical costs for reticles in the $50,000 range mean that the price per ASIC, with a production run of 1,000, is at least $50 (that's without considering any other fabrication costs).

Lepton's system has other benefits as well. "Adjusting line width or channel length is just a software change," Lepselter says. "If you find an error, you don't have to make a new set of reticles." However, once a chip maker of a high-volume IC is sure the design is right, it can create the reticles. *-Jack Shandle*

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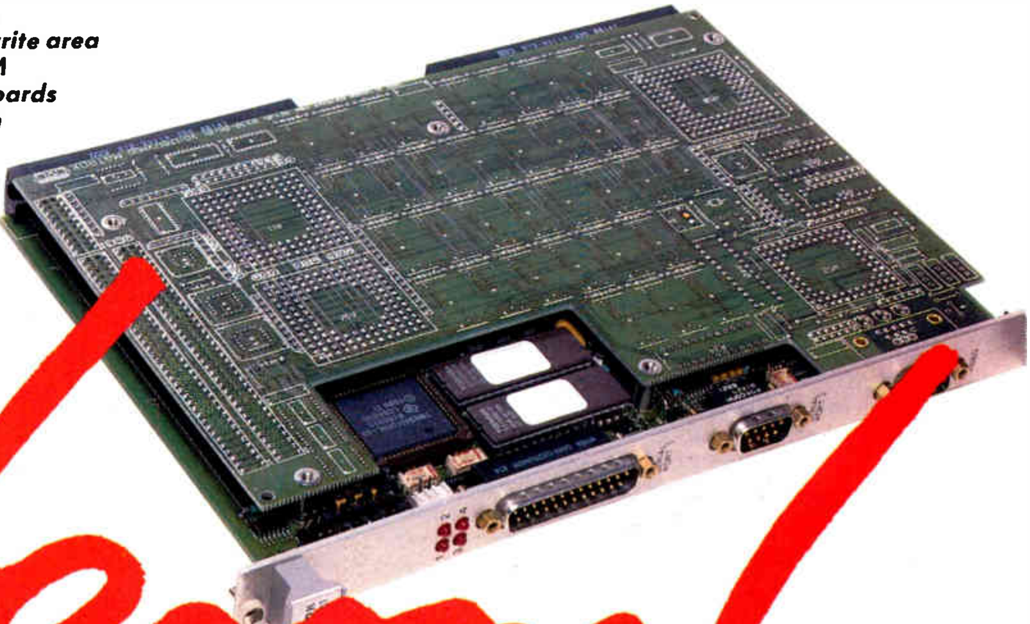

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PEOPLE TO WATCH

APOLLO'S PEROZEK: HIS JOB IS TO BLEND IN THE HP CULTURE

The result will be a unique amalgam of the two, he predicts

CHELMSFORD, MASS.

The signs on the buildings still say "Apollo," and David M. Perozek wants to maintain the essence of the Apollo spirit. But Perozek, who has been running the operation since May [*Electronics*, June 1989, p. 20], is beginning to infuse an HP flavor at the Apollo Division of Hewlett-Packard Co.

A 16-year HP veteran, Perozek's initial task is to manage the integration of Apollo into Hewlett-Packard, which acquired the pioneering manufacturer of engineering work stations in May. At 47, he seems to have the right mix of tact, pragmatism, and hard business experience to bring it off and revitalize Apollo at the same time.

Perozek notes that before the merger, Apollo employees probably tracked the company's stock price, order rates, and general vitality as part of their sense of competitive spirit. "We want to maintain that spirit by meeting a division profit-and-loss goal. But Apollo is large enough [so that its results] have an effect on HP's stock price." Apollo's revenues last year were $654 million, but the company has had a spotty profit record and lost market-share leadership to Sun Microsystems Inc. of Mountain View, Calif.

With a BSEE degree from the University of Detroit and an MSEE from the Massachusetts Institute of Technology, Perozek understands electronic technology. He was instrumental in both management and product development at the Andover Division, Andover, Mass., which is part of HP's Medical Products Group.

In Andover, which is just up the road from Apollo's Chelmsford location, Perozek started as a development engineer in 1973, became engineering manager, and in 1980 division general manager. Under his direction, the division developed an expertise in phased-array ultrasound imaging for medical diagnostics.

As division general manager, Perozek assumed responsibility for the development, manufacturing, and marketing of HP's ultrasound-imaging products made in Andover and in Boeblingen, West Germany. With Perozek at the helm, HP is generally credited with achieving worldwide leadership in the cardiology-ultrasound market. Perozek's former business unit is one of HP's more profitable operations, as well—and that clearly figured in HP's decision to place him at the Apollo helm.

He believes another reason for his selection is that "employees say that I embody the 'HP way,' and I consider that a supreme compliment." And just what is the HP way? Perozek says it includes mutual respect and equitable treatment of employees as well as integrity in business practices. And he's careful to point out that he sees more cultural similarities than differences between Apollo and HP.

Perozek believes that a business unit should maintain its uniqueness as much as possible. "We don't plan to somehow transfer Apollo people into HP's culture," he says. "I've often said that the HP culture has a different spin in each location worldwide that's a product of the people and local influence. I expect a unique Apollo-HP culture."

Perozek has realistic near-term goals for the division: maintain market momentum, which could be lost in the merger; merge product-development programs where possible; and have Apollo a fully integrated division of HP a year from now. In product development, Perozek says it's important to merge programs for the long term: "We want to make sure that what we're doing here three years from now is leveraged across HP."

An early step in that direction is that independent teams developing products using the Motorola 68000 microprocessor family have been integrated in a joint effort to produce a family of compatible desktop 68040-based work stations sometime next year. Perozek says he was heartened in June when Mentor Graphics Corp., the Beaverton, Ore., supplier of design-automation systems, said it will support the 68040 HP-Apollo platform.

Come next summer, Perozek wants the integration of Apollo to be essentially complete, "so that we're a smoothly functioning entity of HP, but with a great deal of Apollo's identity and uniqueness." The integration is going well, he says, "but this isn't a short road—there's still a lot of work." *–Lawrence Curran*

The new boss at Hewlett-Packard's just-acquired Apollo Division, David M. Perozek, sees a unique Apollo-HP culture emerging. He wants the integration to be complete by next summer.

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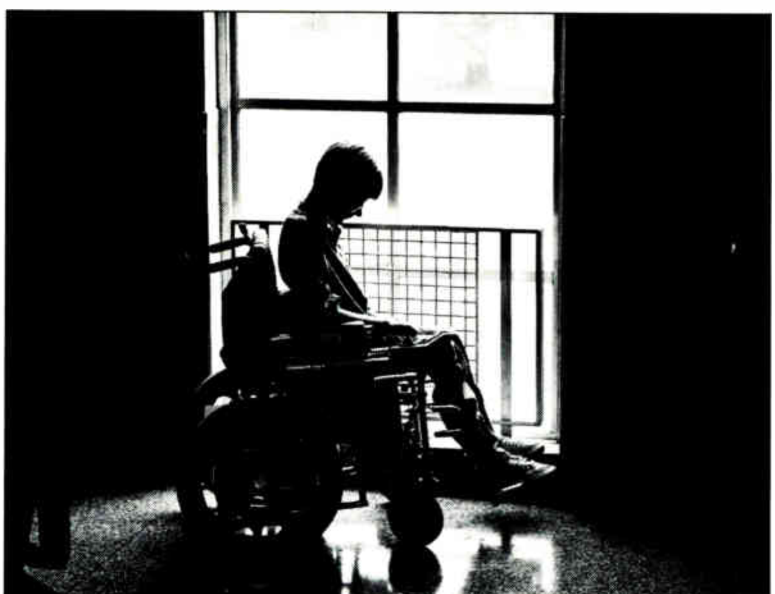

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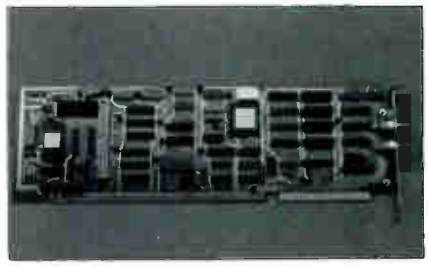

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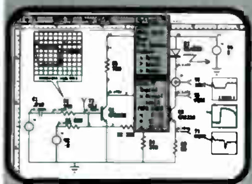

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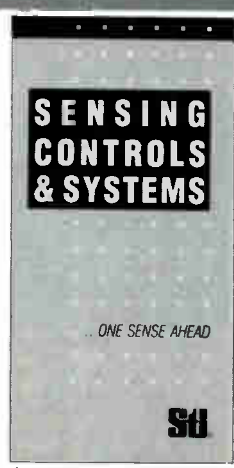

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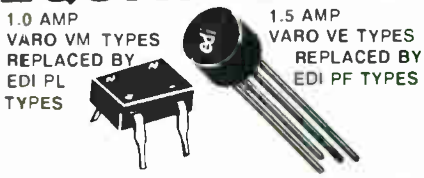

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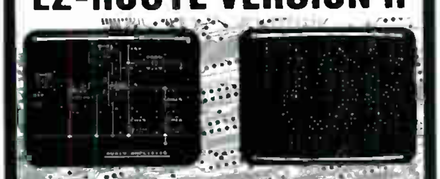

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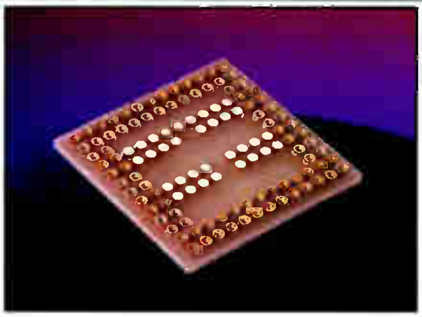

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UPDATE: MAP MAKES STRIDES, BUT 'THE JURY IS STILL OUT'

The hoopla attending last summer's Enterprise Networking Event in Baltimore has proven to be largely justified. The big news at Enterprise was that the Manufacturing Automation Protocol Version 3.0 would not change for six years in any fundamental way—but that fully compatible enhancements would be forthcoming. Last year's interoperability demonstrations by several major computer companies using MAP 3.0 have been followed by a more solid look of real products, and a healthy MAP market seems to be developing.

"The jury is probably still out on MAP," says Bryce Clark, network solution manager at Hewlett-Packard Co.'s Roseville, Calif., Network Division, "but there are plenty of reasons to be optimistic. Products are ready, and many companies have held off making investments [in competing technologies]."

With the completion of standards for file transfer, access, and management (FTAM) and manufacturing messaging specification (MMS), MAP 3.0's protocol stack is as complete as any network conforming to the International Standards Organization's seven-layer Open Systems Interconnection model. Racing along toward development are the X.500 electronic-mail directory service and the virtual terminal protocol.

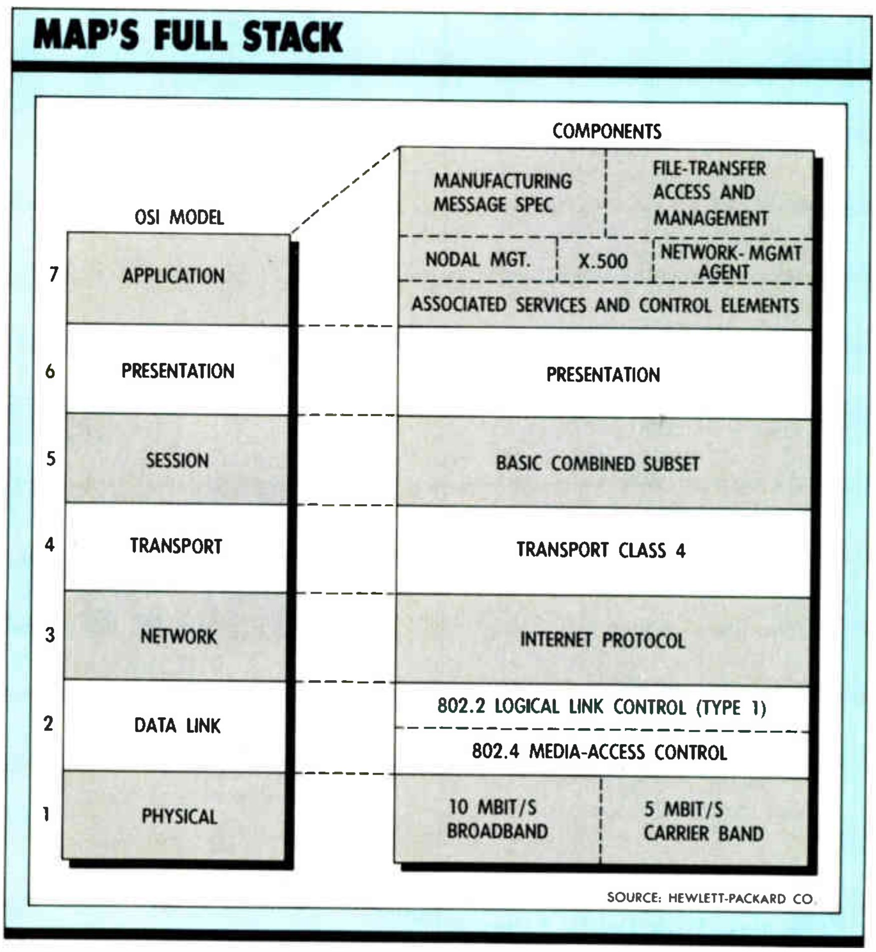
Users are still waiting for proof that MAP is economically justifiable, however. "It's too early to give a real-world example of economic justification," says Clark. But companies in the process of installing MAP 3.0 networks are being watched closely, and next month's meeting of the MAP Users Group in Oshawa, Ont., near Toronto, will feature a tour of a MAP-based General Motors Corp. plant complete with economic feasibility figures, says Clark.

The man most closely associated with the Enterprise Networking Event—HP's Paul Accampo—has ridden the crest of the MAP wave [*Electronics*, June 1988, p. 151]. Accampo, now national sales manager for HP Networks, says enterprise-wide networks are virtually ready. "I think we will be seeing more applications development as developers begin to appreciate what a cooperative computing environment has to offer," he says.

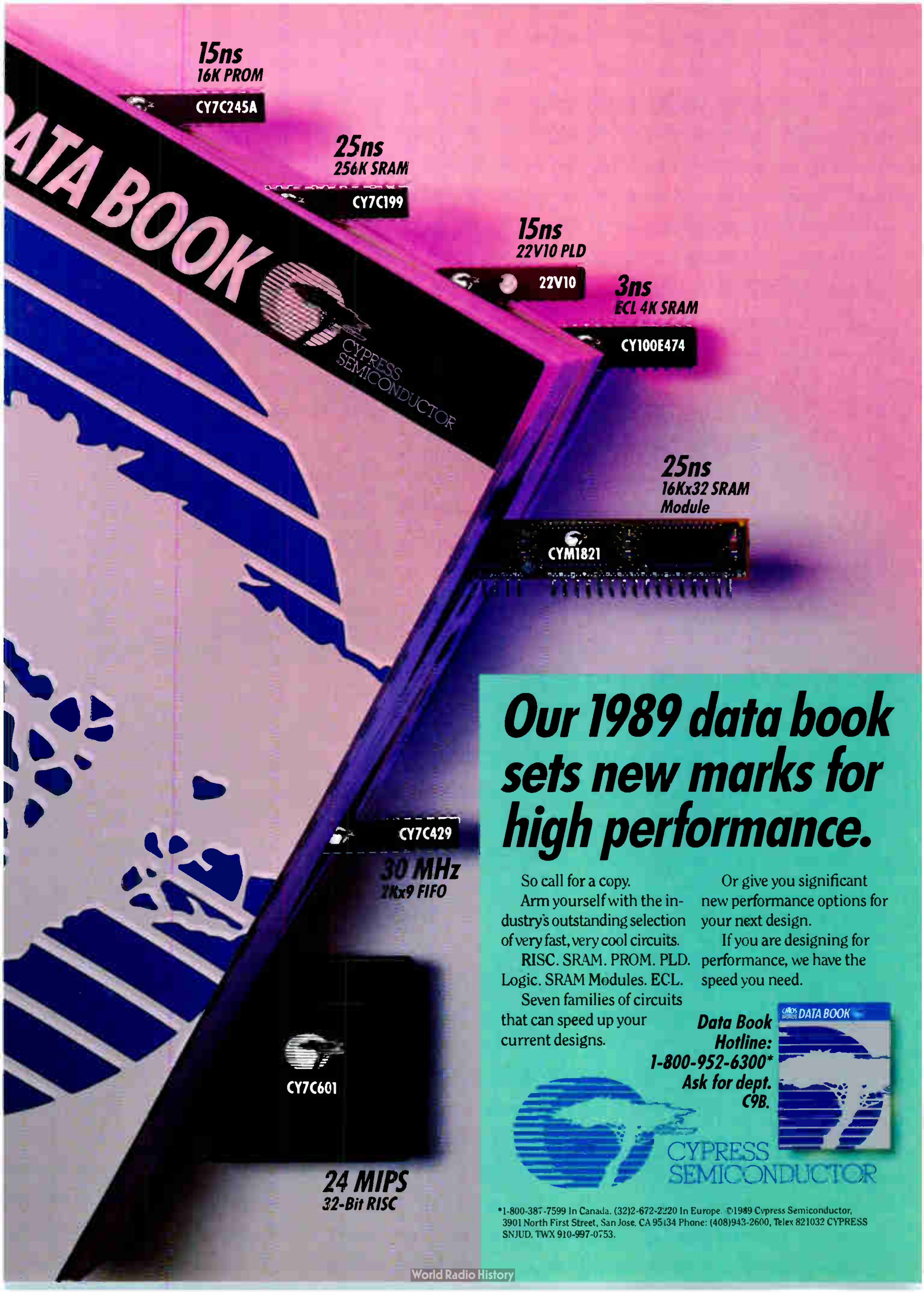
Boeing Co.'s decision in June to use DECnet in one of its installations sent shock waves through the MAP community, but Clark says the damage was minimal. "That application already had a large installed DECnet base," he says. "I can tell you for sure that Boeing will be installing MAP-based applications as well."

MAP reached a major milestone in April, when the Corporation for Open Systems in McLean, Va., inaugurated its COS Mark Program. The program serves as a seal of approval that products based on specific implementations of OSI's protocol stack do, in fact, interoperate. MAP products received the first COS Marks. Concord Communications Inc. now has a COS Mark for its Series 1200 Modular Modem Card, marketed as MAP-ware. COS has also certified HP's OSI Express MAP 3.0 software and Motorola Inc.'s MBME372 MAP controller.

Will there be another Enterprise Networking Event? "Right after Enterprise we held a meeting," recalls Accampo. It was determined that nothing radically new would be available until vendors started to deliver standard products. The conclusion in 1988 was that 1991 might be a good target date. Although MAP seems to be running ahead of schedule, no firm plans for Enterprise II have been announced. *–Jack Shandle*



Conforming to the seven-layer Open Systems Interconnection model, Hewlett-Packard's MAP 3.0 software has been approved by the Corporation for Open Systems.



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