WILL A 60-MIPS CLIPPER BE THE FIRST ECL RISC? / 104

COMPILERS TURBOCHARGE PARALLEL COMPUTERS / 117

BATTLE OF THE SHOWS
PAGE 87

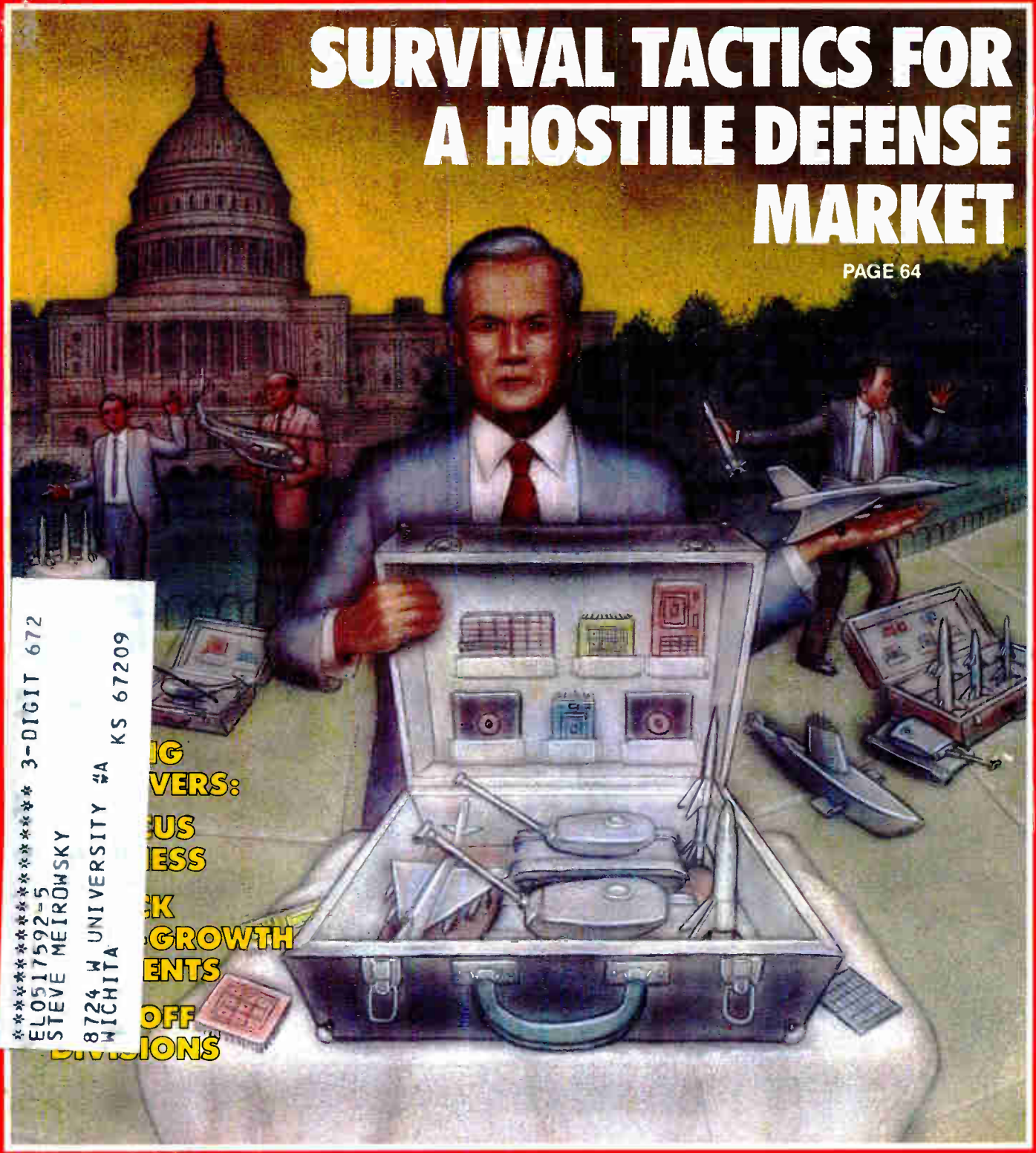
A VNU BUSINESS PUBLICATION

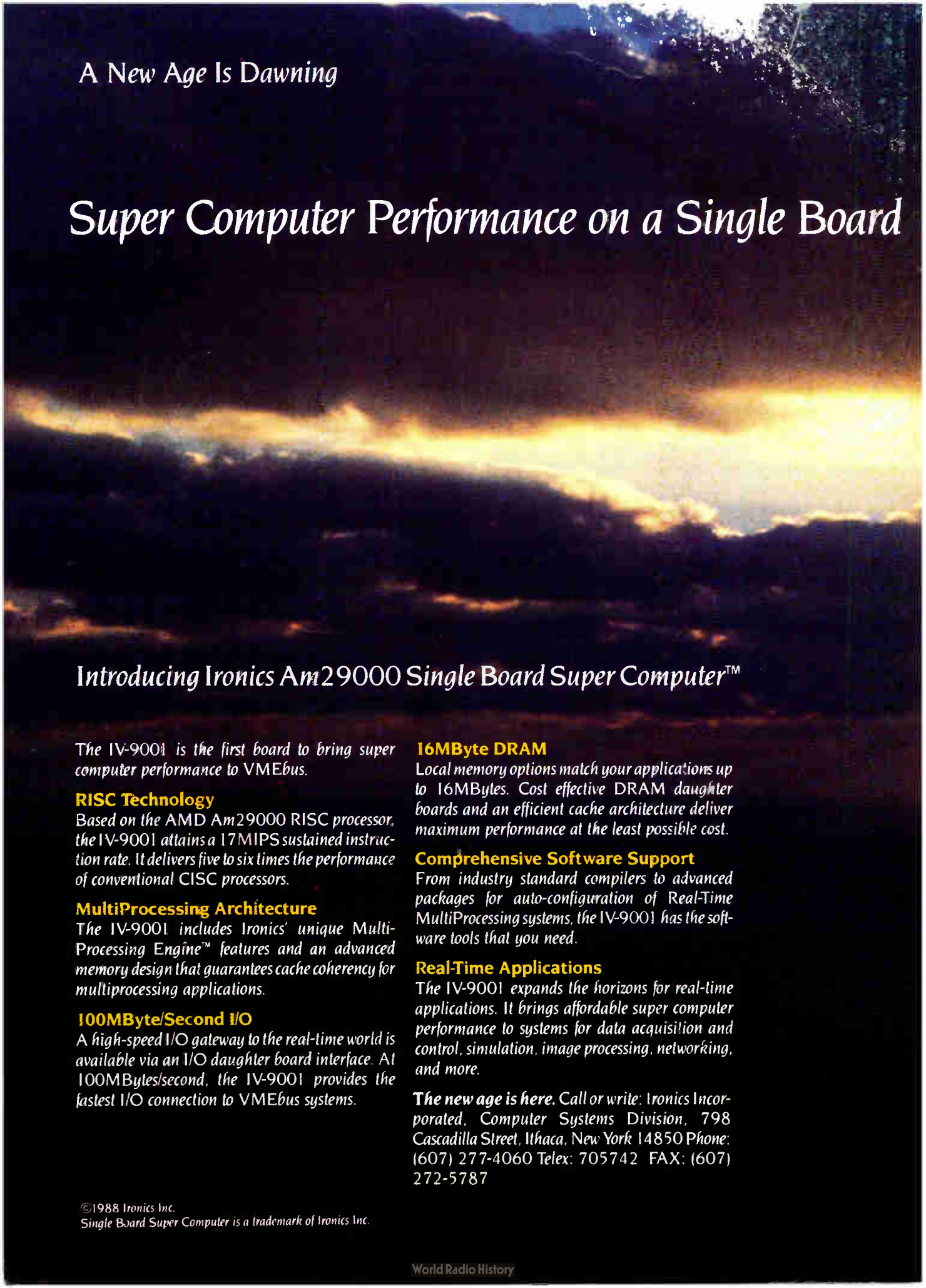
NOVEMBER 1988

Electronics

SURVIVAL TACTICS FOR A HOSTILE DEFENSE MARKET

PAGE 64





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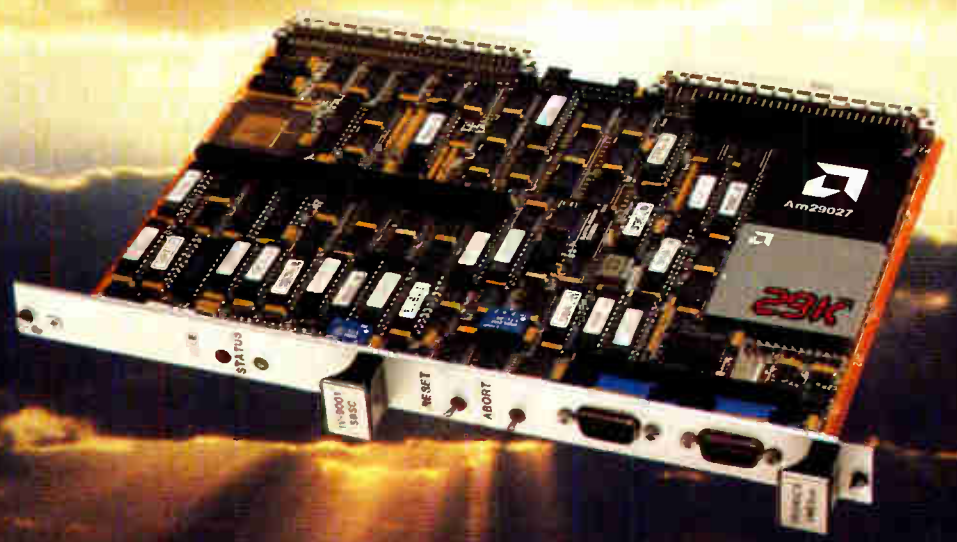

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THE OPEN MOVEMENT ROLLS ON TO BUSES

Hardware this time lags software in the push for standards, but wait—a new industry group plans to remedy the situation

Open sesame: "A seemingly unfailing means of gaining admittance or attaining success." That definition, whose roots lie in the magical formula used by Ali Baba in the *Arabian Nights*, is found in *The American Heritage Dictionary*.

Open bus standards: The fastest way to successfully launch new board-level products and please customers. So says Ray Alderman, acting chairman of a new organization backing nonproprietary systems environments. A movement to bus standards will also work wonders, claims the group of board-product manufacturers that has formed what is called the Institute of Bus Architecture. In dusting off a two-year-old plan to put a wide range of system buses on the open-environment bandwagon, the group is taking its cue from the standards movement in software circles, as well as the collective camaraderie of semiconductor marketeers. Seems appropriate since they must deal with both, huh?

Alderman, marketing vice president at board-supplier Matrix Corp. in Raleigh, N. C., hopes the new organization could attract as many as 150 to 200 manufacturers and a number of key users within a year. After its first meeting is held in October, a steering committee will take up a charter at Buscon West/89 in Santa Clara, Calif., next February. Alderman wants the new organization to create a huge data base of technical and business information. Part of that would be market-tracking services such as those of the Semiconductor Industry Association, which issues a much-watched chip book-to-bill index. The data base would allow board makers to track their own market share, he says, helping them better understand trends. Alderman also plans to propose that the group produce a world directory of board-level executives. The directory, he believes, could help firms establish global contacts in foreign markets that are hard to penetrate.

"Software is becoming standardized much more quickly than hardware. That's where the IBA's bread will be buttered," says Alderman. "We are going to have a tremendous amount of standardized software, and the next area to attack is hardware." This ambitious group will push for a new openness on many bus fronts—8-bit, 16-bit, and the newly proposed 64-bit SuperBus being developed by the IEEE.

Good luck, sesame.

J. ROBERT LINEBACK

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NOVEMBER 1988

Electronics

NEWSLETTERS

FEATURES

COVER: ED SOYKA

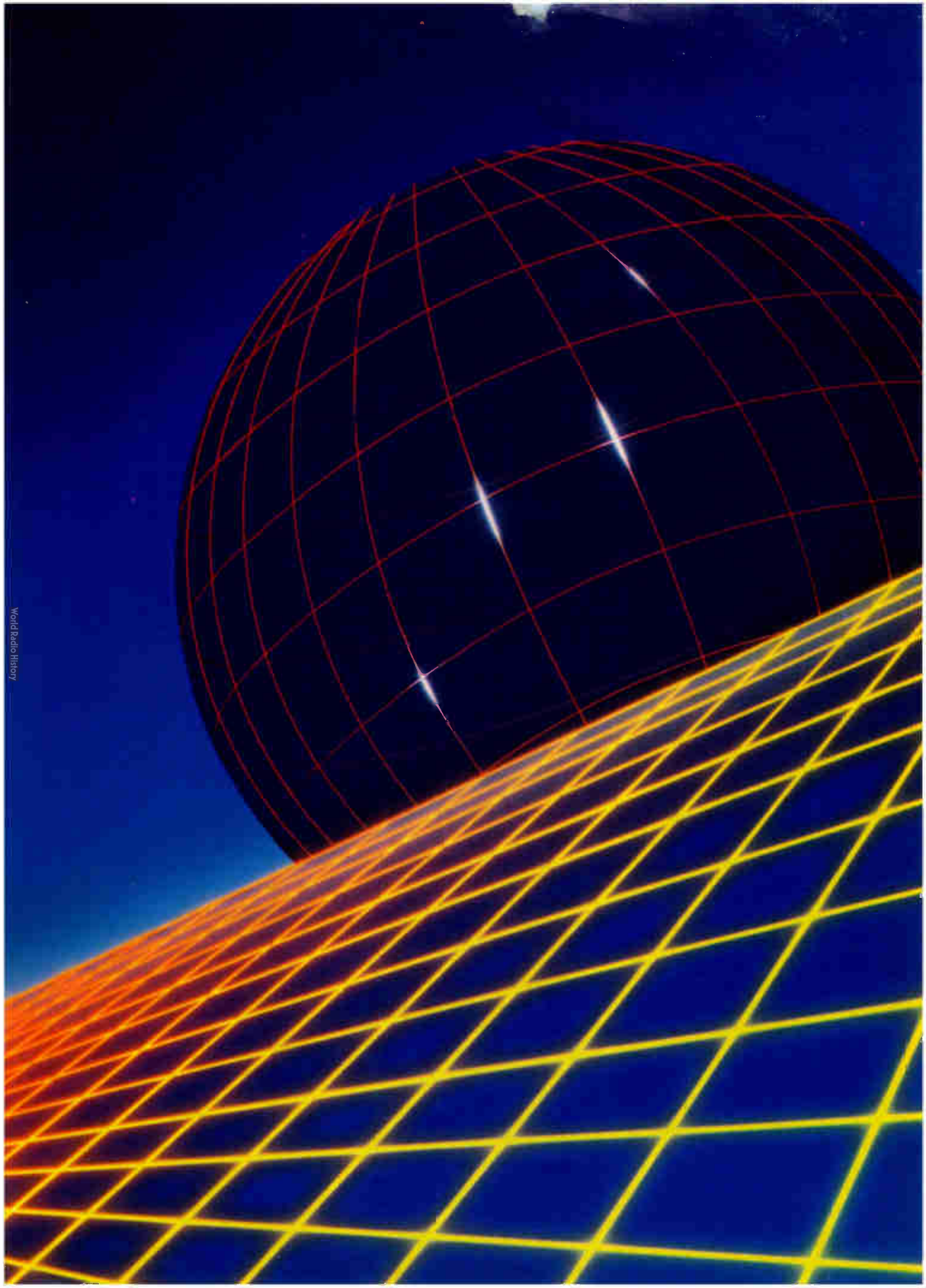
PAGE 64

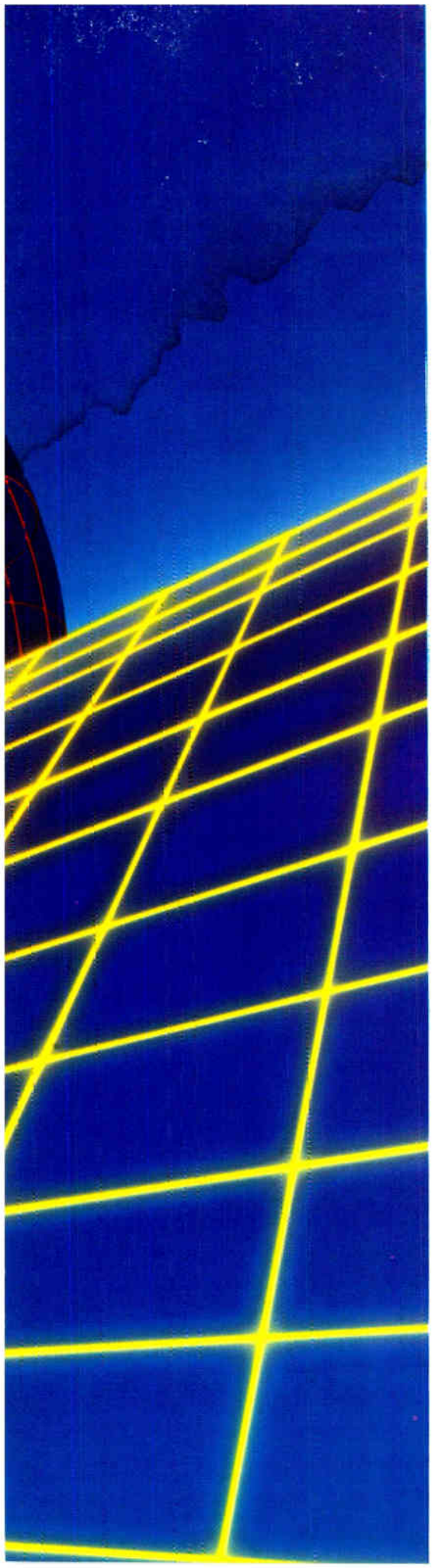
WORLDWIDE NEWS ANALYSIS

COMPANIES

PEOPLE

DEPARTMENTS





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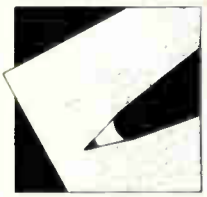
LETTER FROM OTTAWA

THE ENTREPRENEUR IS ALIVE AND WELL IN OTTAWA

OTTAWA, CANADA



Spectacular fall foliage decorating this capital city is succumbing to the grip of frosty nights and a sharp nip in the air. But Ottawa keeps growing, bustling, and buzzing. In particular, the Free Trade Agreement with the U. S. has already ensconced itself as one of a few recurring topics of conversation in the halls of Parliament, along embassy row, and in the high-tech growth areas west of the city.

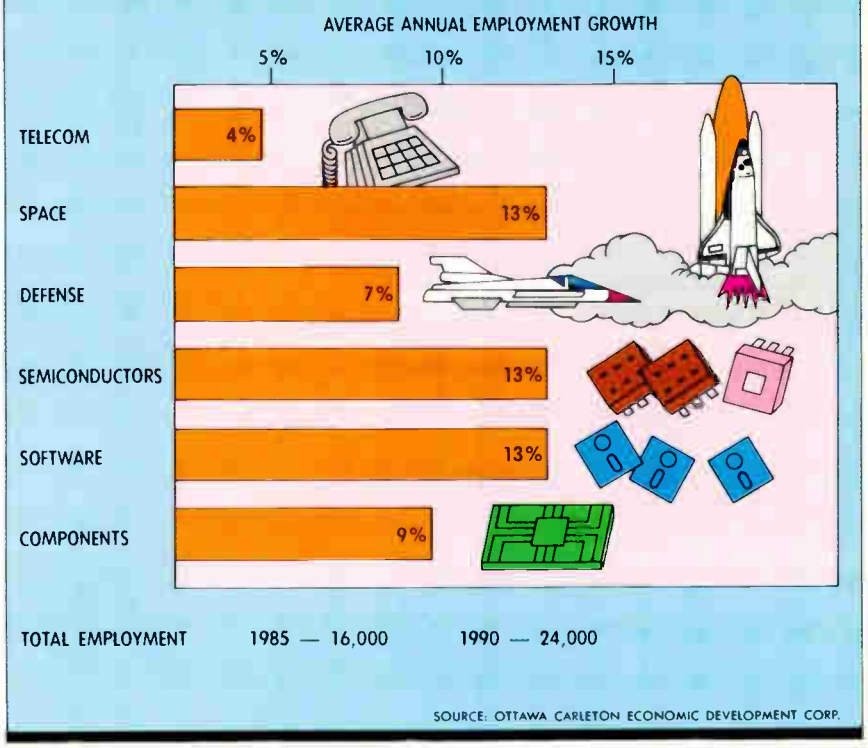
Although Canada's pending ratification of the agreement will be a hotly debated campaign issue right up to the Nov. 21 elections, a visitor circulating in the intensely entrepreneurial electronics industry is hard put to find anyone who is opposed to the treaty. To most, it represents a choice between "developing our knowledge-based industry or retaining an essentially agrarian-based economy," says Al Hawtin, Mitel Corp.'s assistant vice president for semiconductor marketing.

Ottawa's electronics community thinks of itself as incubating the nation's economic future, and makes no bones about the future belonging to those who can handle global competition. That's tough talk for a metropolitan area of perhaps 800,000 souls, but Ottawa has the credentials. On the other hand, some factors make it tough to get along on credentials alone. Canadian companies need practical structures in which to operate. With some government policies encouraging semiconductor companies to disperse rather than centralize and with venture capitalists venturing elsewhere, Ottawans have had to create their own business opportunities. They have formed operating ties with U.S. counterparts.

The U. S. counterparts have some big players to work with. Two world-class corporations—Northern Telecom Ltd. and Bell-Northern Research Ltd.—have built their research and development facilities in Ottawa. Northern Telecom and BNR, which is 70% owned by Northern Telecom, worked as a team in 1979 when they developed the first all-digital central office switch, the DMS-100. Now, Northern Telecom has the largest installed base of digital lines in the world and its scaled down version of the DMS-100 switch, the DMS-10, was the first from North America to be put into use in Japan—after winning out over domestic competition.

"We don't claim to be in the same class

OTTAWA PUSHES BEYOND TELECOM



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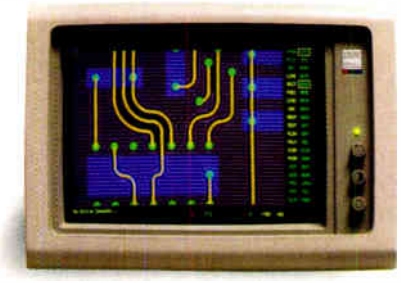

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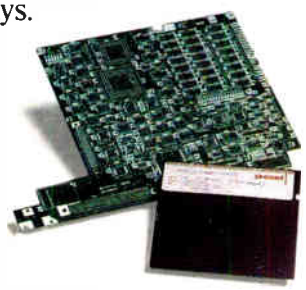

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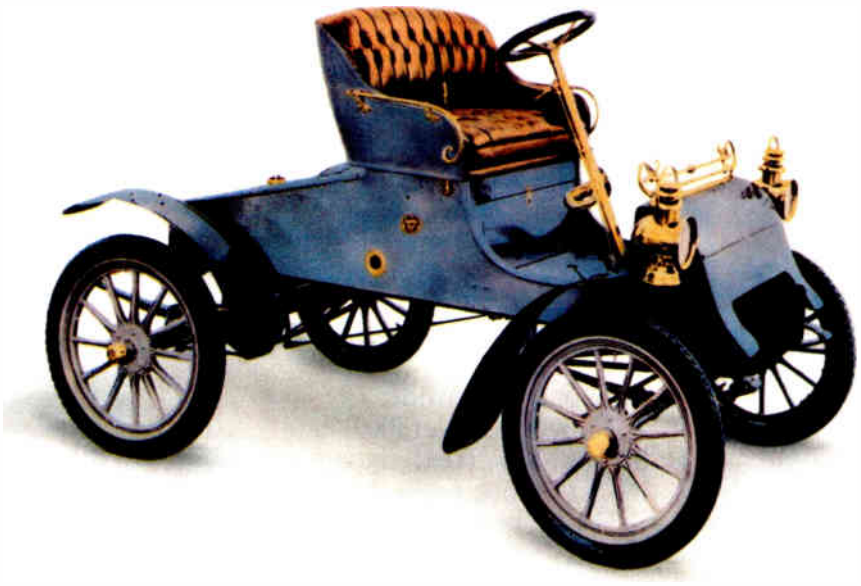

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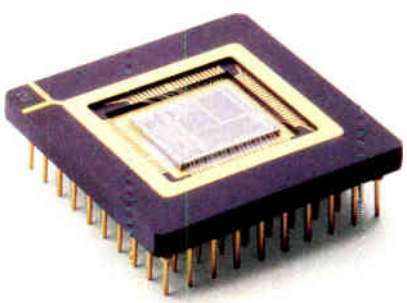

People have always been a little skeptical about giving up their old standards. And today, the same thing is happening to INMOS Transputers.

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as some competitors in terms of raw technology development but we are world-class in technology exploitation," says Peter MacLaren, BNR's assistant vice president of technology management.

Northern Telecom and BNR also have world-class reputation around Ottawa for spinning off new technology companies by supplying the intellectual fuel of the area's entrepreneurial dynamo. They annually skim off about 50% of the top half of Canada's engineering, computer science, and physics graduates. "They hire floor upon floor of them in their facilities, but as they are also bureaucratic organizations, many of the most innovative people leave," says Gordon Hutchinson, editor of the Ottawa-based *Electronics Communicator* newsletter. It's hard to find a chief operating officer of an area electronics firm who isn't an alumnus of the two companies.

As a result, leaving Northern Telecom or BNR does not equate to leaving Ottawa. Concentrated in suburban Nepean and Kanata are 166 software companies employing 7,000 people and 70 electronics manufacturing companies employing 13,000 people. It's a guess that the great bulk of them share an Northern Telecom/BNR heritage. On a per-capita basis, Ottawa boasts Canada's highest density of PhDs, and compares favorably with any city in the world, says Keith McGruer, president of the Ottawa-Carleton Development Corp. "The prevailing environment here is for research and development," he says. "From time to time we talk about creating a research park, but in reality the whole area is one big research park."

Spinoffs abide by the entrepreneur's first rule: find a niche market

ON A ROLL. For the most part, the spinoffs abide by the entrepreneur's first rule for success: find a niche market. Bright stars in recent years include Gandalf Technologies Ltd. in limited-distance modems and computer-interoperability products; DY-4 Systems Ltd., in VMEbus products for air-traffic control; Cognos Inc. in financial software; Systemhouse Inc. in system integration; Computing Devices Co. in defense electronics; Canadian Astronautics Ltd. in flight simulators and radar; and AIT Corp. in optical character reading.

All these companies are working in an industrial and financial infrastructure that is quickly coalescing and insuring continued entrepreneurial growth. Phrases like "we're reaching critical mass," and "there's a real synergy here," inevitably creep their way into conversations with electronics executives.

But Peter Bowie, a Touche Ross & Co. partner who has helped many electronics companies lift off, survive, and flourish, casts a wary eye at the federal government headquartered at the end of Metcalfe Street. "Canada is a large country with a small population," he says, "and the government tends to provide incentives for companies and research facilities to move to other parts of the country. It does not appreciate the synergistic nature of high tech and the need for a region to reach critical mass." For example, politically motivated wealth sharing, which is the government's policy of locating research facilities around the country, recently resulted in two major government research facilities moving to other provinces, and the National Space Agency, which would usually be headquartered in the nation's capital, is likely to be set up in Montreal, he says.

With government incentives almost working against the industry, a real need emerges for private help. And while there's venture capital aplenty in Canada—just try and get some. Of about $1.1 billion in the hands of investors and bankers last year, only $238 million actually found a home in ventures, says Bowie. While venture capitalists grouse about the lack of good high-tech deals, high-tech entrepreneurs grumble about how the capitalists want the safety of a savings bond and the return of a winning lottery number. Actually, funding leveraged buyouts of mature low-tech companies, such as trucking or can production, has delivered higher rates of return with less risk than have high-tech ventures over the past several years, says Bowie.

Ottawa's industrial infrastructure has a shortage of the metal-bending capability needed for system packaging, but has a plentiful supply of skilled labor for board stuffing and most other industrial services, says Bowie. Mitel's Hawtin, on the other hand, sees semiconductor production capability as a major Canadian shortcoming Ottawa must share. Only Northern Telecom has the financial resources to construct and maintain a state-of-the-art wafer-fabrication facility, he says, and its production is entirely for internal use. "If the government had a grand semiconductor strategy," he says, "perhaps it could address [this problem.]"

The Ottawa-Carleton Economic Development Corp. thinks it has answers to some of these problems in its Matchmaker program. The idea is to team greater-Ottawa companies with U. S. corporations by arranging large-scale trips to U. S. technology centers, says McGruer. More than 50 Boston-area companies lined up to discuss deals in October and Ottawans descended on Dallas earlier in the year, says McGruer. An example of the desired result, he says, would be teaming Computing Devices Co. and its fire-control technology with a major U. S. defense contractor. – *Jack Shandle*

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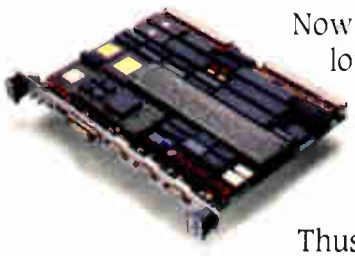

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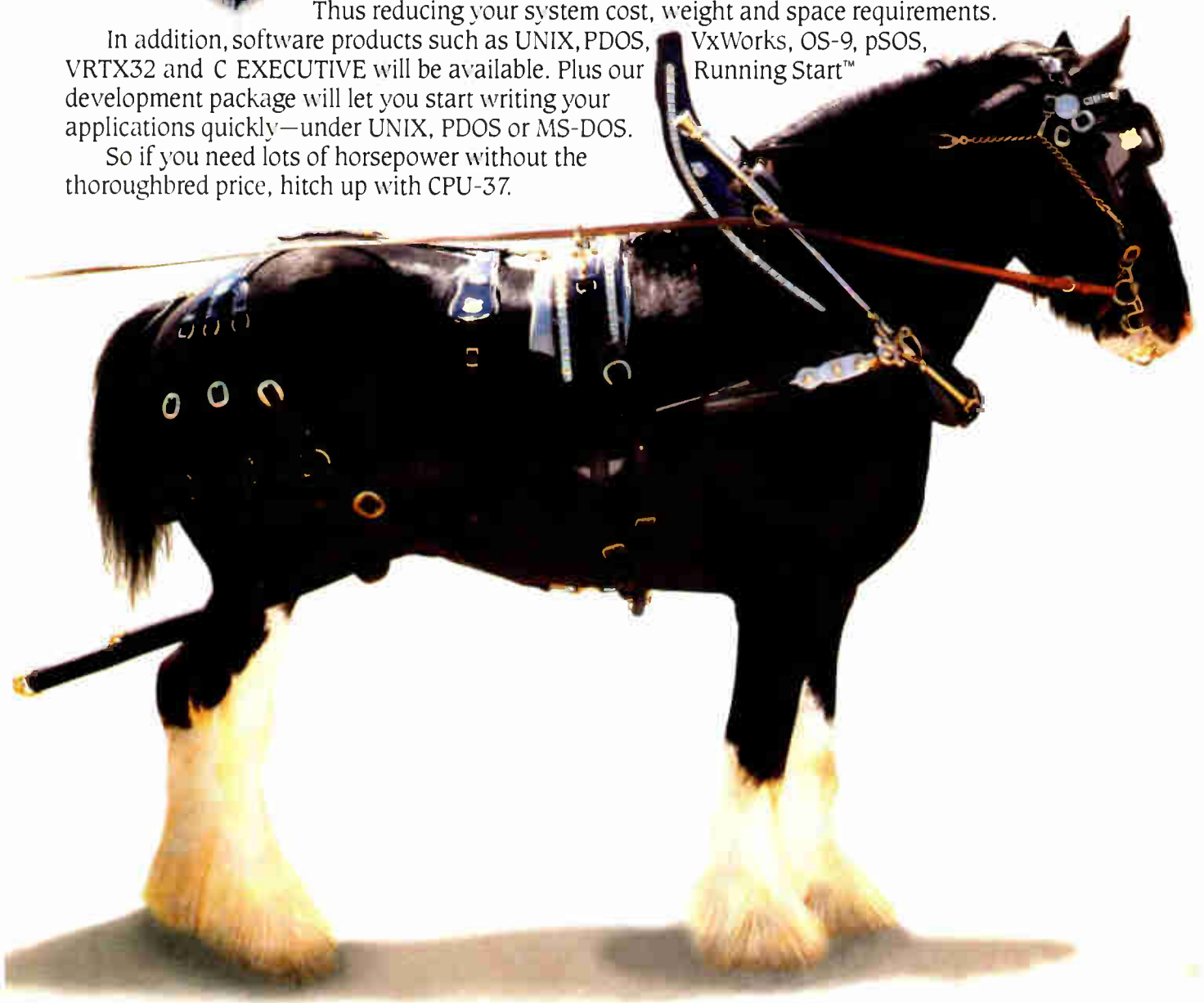

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ELECTRONICS NEWSLETTER

MCC IS LOOKING TO MOUNT A BIG PROJECT IN OPTICAL COMPUTER TECHNOLOGY

Major advances in computer performance will be the aim of an optical computing program proposed by the Microelectronics and Computer Technology Corp. The Austin, Texas, consortium recently briefed nearly 20 companies on several new technologies coming from its labs, and now it's hoping to get enough shareholders—and some potential new members—interested in the optics technology to turn the effort into a fully sponsored program early next year. One of the most promising projects is a photorefractive volume holographic storage system that could hold a gigabyte of data in an array of crystalite fibers, with access times three times faster than magnetic disks. MCC researchers have come up with a nondestructive readout technique and found a way to vastly increase capacity—by using an array of tiny fibers rather than bulk crystals—two requirements that had eluded photorefractive-storage efforts. MCC is also working on a crossbar switch capable of 10-gigabit/s speeds for parallel-processing computers with thousands of nodes, and an optical neural network based on photorefractive techniques. □

TEXAS INSTRUMENTS MOVES FAST WITH PRODUCTS BASED ON A STANDARD TEST BUS

The ink is not even dry yet on the specifications for testability standards devised by the Joint Test Action Group [*Electronics,* October, 1988, p. 57]. But one of the major players in the JTAG effort—Texas Instruments Inc.—is moving agressively into production with a variety of products incorporating the hierarchical four-wire bus and boundary scan protocol described by the specs. First out is a family of biCMOS octal bus-interface functions. Already being evaluated at beta sites, the octal interface devices include TI's 240 series of buffer drivers, the 245 series of bidirectional bus transceivers, the 373 series of transparent latches, and the 374 series of D-type flip-flops. □

THE TEAM THAT BUILT THE FIRST PARALLEL-PROCESSING COMPUTER IS AT IT AGAIN

From members of the design team that 16 years ago produced the world's first massively parallel computer—the 64-processor Illiac IV—now comes another parallel-processing breakthrough, the Cedar. University of Illinois researchers late in October released first results of benchmark tests run on parallel hardware and software developed under the Cedar project. The researchers, headed by David Kuck, director of the school's Center for Supercomputing Research and Development, say that an 8-processor Cedar system performed the widely accepted Gabriel LISP benchmarks two to four times faster than any computer they know of, including a Cray X/MP. □

A NEW CRAY-2 IS READY TO ROLL, BUT THE CRAY-3 EFFORT HITS A RUT

Look for Cray Research Inc. this month to roll out a new version of its Cray-2 supercomputer that will feature the biggest main memory yet. The Cray-2D/4-512 will feature an enormous 4 gigabytes of directly addressable main memory—twice that of the original Cray-2, and equal to the memory size planned for founder Seymour Cray's forthcoming Cray-3 gallium arsenide-based machine. The Minnesota Supercomputer Center Inc., an affiliate of the University of Minnesota, will take delivery of the first four-processor, big-memory Cray-2 system around Dec. 1. Meanwhile, the Cray-3 effort is hitting some costly glitches. Cray has had to redesign some of the machine's GaAs circuits to handle an unexpected cooling problem, and will have to scrap some circuits already produced. The firm has also run into higher than expected costs associated with setting up the Colorado Springs, Colo., plant where the Cray-3 will be built. As a result, Cray says it will take write-offs totaling $10 million in the third and fourth quarters. □

ELECTRONICS NEWSLETTER

CAN NEXT AND IBM CHANGE THE OBJECT-ORIENTED PROGRAMMING LANDSCAPE?

The cause of object-oriented programming in general, and an object-oriented language called Objective C in particular, got a major boost when Next Inc. in Palo Alto, Calif., introduced its work station last month. Steve Jobs, late of Apple Computer and founder of Next, built a lot of leading-edge technology into The Next Computer System—a read-write optical disk drive, on-board digital signal processor, and NextStep, a windowing user interface and development environment, for example. But Next's use of object-oriented programming, a powerful productivity-enhancing development in software technology, may be one of Jobs's most far-reaching choices—especially since he got IBM Corp. to back his decision. IBM has licensed both NextStep and Objective C and plans to provide them for all its AIX-based systems, from personal computers to mainframes. Objective C, from Stepstone Corp., Sandy Hook, Conn., stands to be the big winner. It has been losing in the market battle to C++, the object-oriented version of C from AT&T Co., even though Objective C has stronger object models and C++ "doesn't go as far as some in the object crowd would like," according to an executive at one object-oriented software company. C++, on the other hand, has the momentum, and AT&T can offer stronger support and training, says another software manager. The Next-IBM announcement, though, is sure to have more potential users considering the Objective C alternative. □

FOR SALE: SIEMENS PUTS MICROWAVE SEMICONDUCTOR ON THE BLOCK

Microwave Semiconductor Corp., once one of the rising stars of New Jersey's Gallium Gardens and a symbol of Siemens AG's growing U. S. operations, is for sale. The gallium-arsenide chip specialist, which recently laid off 135 of its 500 employees, is looking for a strategic partner to carry it through what looks like a rough half-decade ahead, says Saul Lederhandler, president and chief executive officer of the Somerset, N. J. company. "The whole GaAs market has basically moved out," he says. "What was projected as a $1 billion market by 1990, now looks like it won't come until 1995." Microwave Semiconductor Corp. got burned in May, when neither Westinghouse nor Unisys—with which it had teamed to bid for the Microwave/Millimeter Wave Monolithic Integrated Circuit program—won Phase 1 contracts. That left Microwave Semiconductor Corp. without a significant role in the seven-year, $400 million program, probably the only major market opportunity for microwave GaAs companies until the Air Force starts buying phased-array radars in the mid-1990s. Siemens has invested aggressively in Microwave Semiconductor Corp., and faced with a long delay before seeing a return, wants to get out now. So Lederhandler is looking for a buyer, "preferably U.S.-based," capable of reviving the downsized company. Lederhandler won't quote an asking price, but sources speculate Siemens would jump at $30 million to $40 million. □

SONY SENDS ITS 5.25-IN. REWRITABLE OPTICAL DRIVES TO MARKET

Sony Corp. is ready to ship commercial quantities of two 5.25-in., rewritable optical disk drives—the first such drives to hit the market in volume. The model SMO-S501 is a self-contained subsystem; the SMO-D501 can be integrated into computers and work stations. Both use 650-Mbyte, 5.25-in. optical disk cartridges. Market researchers expect Sony's move will spur other drive makers to ship rewritable optical disk drives in quantity, as they scramble for a disk-drive market that Disk/Trend Report, a Mountain View, Calif., research firm estimates will grow to 65,000 units next year and zoom to 220,000 units in 1990. Drives, sold individually, will cost about $4,650; cartridges, in lots of 100, will cost about $250 each. □

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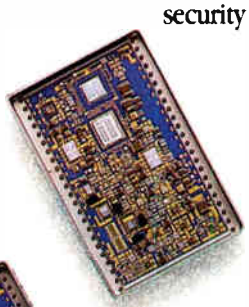
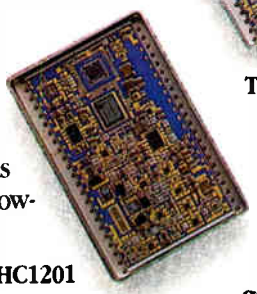


THC1200

THC1202



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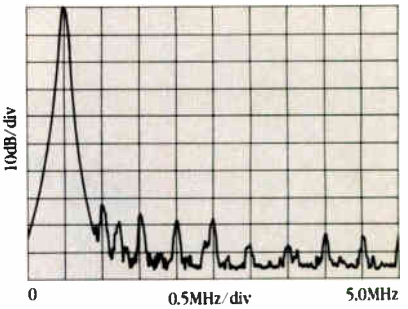

Part Number	Analog Input Range (V)	Package Style	Area (Sq. In.)	Power (W)
THC1202	±1.0	40-Pin DIP	2.3	5
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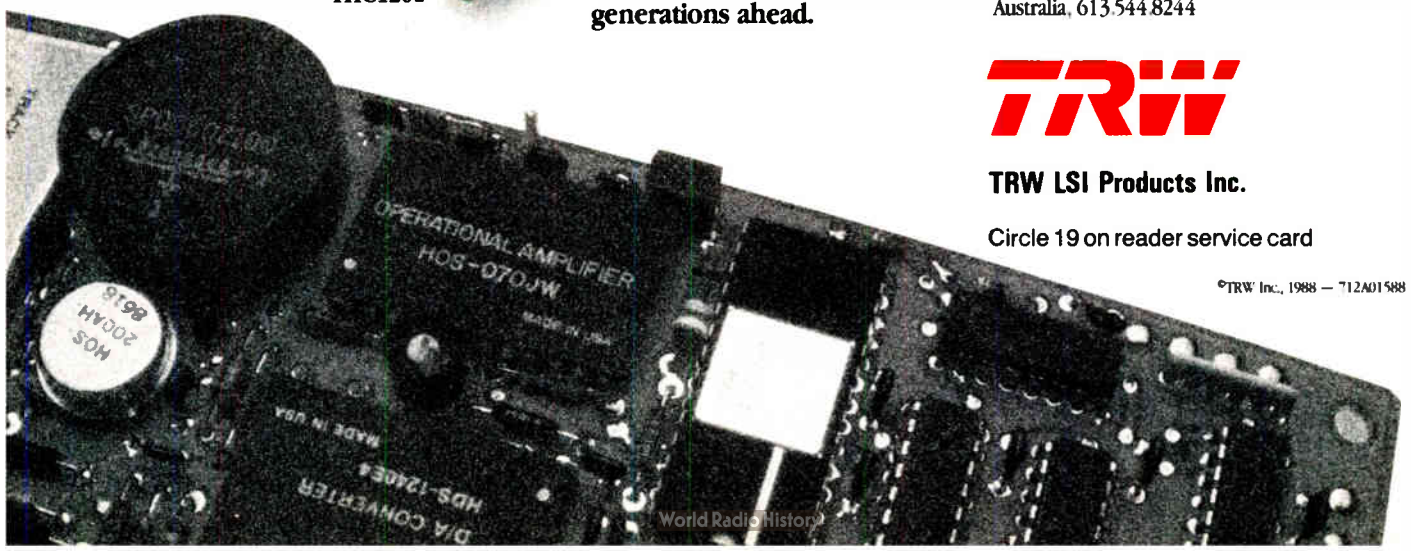

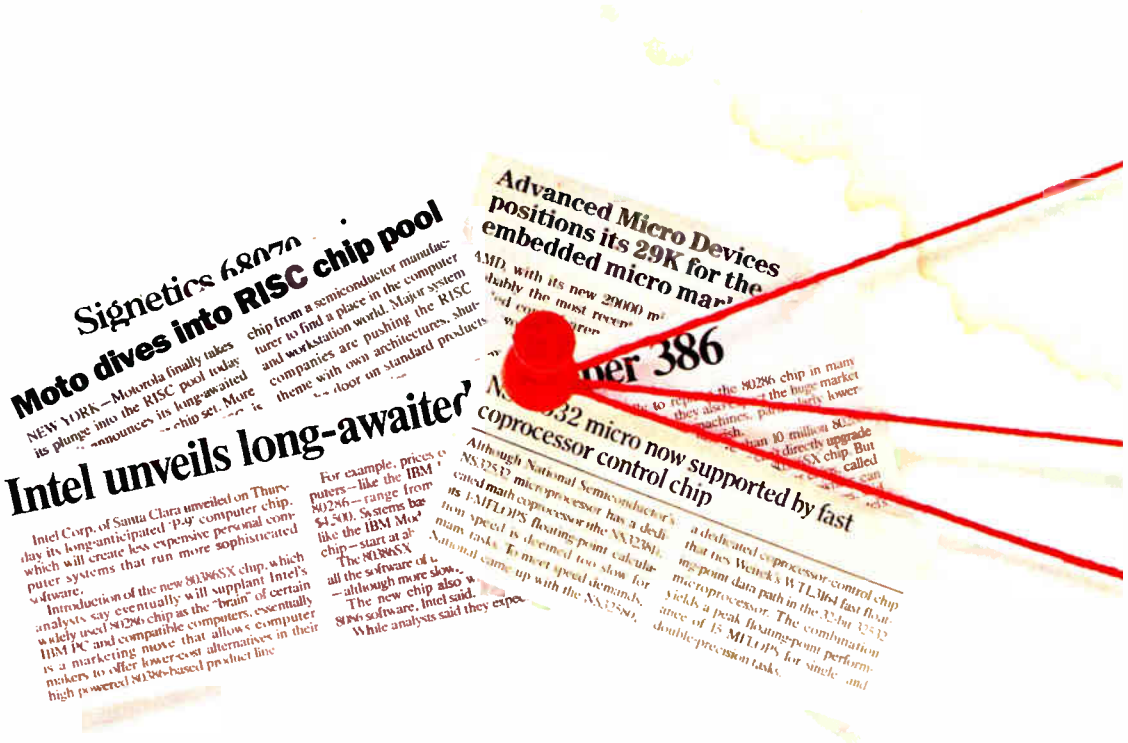

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PRODUCTS TO WATCH

GIGABIT BOOSTS STANDARD-CELL DENSITY AND CUTS COSTS IN HALF

Gallium arsenide is closing the competitive gap with silicon technology. Gigabit Logic Inc.'s SC10000 standard-cell technology offers density of up to 10,000 equivalent gates and is among the first GaAs parts of this complexity to reach volume production. Pricing should also be a come-on, with volume rates as low as 5 cents per gate. That's less than half the previous tab for depletion-mode devices; by comparison emitter-coupled logic goes for 2 to 3 cents per gate. Armed with these competitive tools, the Newbury Park, Calif., firm intends to sell hard among designers of high-performance work stations. The library has 26 precharacterized building blocks: 18 internal cells and 8 for input/output. Built with an enhancement/depletion-mode process and using three-level-metal interconnects, the custom-designed chips have gate delays from 100 ps down to 25 ps. □

RETIX'S E-MAIL SOFTWARE GIVES NETWORKED PCs A GLOBAL COMMUNICATIONS LINK

The migration of wide-area networking from proprietary systems to the standard Open Systems Interconnection protocols is picking up steam. The latest company to fuel the fire is Retix Inc. Its RetixMail system lets personal computers on local-area networks exchange electronic mail worldwide using the OSI X.400 protocols. Until now, electronic mail ran on minicomputers using proprietary software and protocols, which left PCs on LANs as virtual islands. Besides delivering global connectivity, RetixMail offers a big price advantage. A package supporting up to 100 users will cost about $7,000—compared with $400 to $500 per user for software in the proprietary systems. To be shipped in the first quarter of 1989, RetixMail will be marketed to original-equipment manufacturers and third-party applications developers. The Santa Monica, Calif., company includes an application program interface in RetixMail to speed system integration. □

JOINT DEVELOPMENT YIELDS A MORE VERSATILE SMART-POWER IC

By packing more features on-chip than the competition, a new H-Bridge power IC delivers the versatility sought for the next generation of smart-power circuits that are just glimmering in the eyes of designers. Its developers, National Semiconductor Corp. and International Rectifier Corp., have integrated internal current sensing, output short-circuit protection, and two-stage thermal shutdown with a warning flag. Called the LMD18200 by National and the IR8200 by International Rectifier, the part's CMOS and bipolar control circuitry for the front-end logic comes from Santa Clara-based National. The DMOS FET power output device is designed by International Rectifier in El Segundo. Operating at 12 to 55 V with continuous output of 3 Å, the device boasts 100-ns switching times. □

THE COMPETITION IN HIGH-PERFORMANCE DISK-DRIVE CONTROLLERS HEATS UP

The latest entry in controllers for the IPI-2 Intelligent Peripheral Interface standard for high-performance disk drives is Xylogics Inc.'s SV6800 controller. It supports up to eight IPI-2 drives with transfer rates as high as 10 Mbytes/s. The SV7800 handles up to 16 drives and 20 Mbytes/s. The controllers' internal data rate of 80 Mbytes/s, however, will sustain rates across the bus of 40 Mbytes/s for future drives. The Burlington, Mass., company says the SV7800's dual-channel feature is a first, enabling reading from or writing to two drives simultaneously. The Xylogics controllers will compete with the V/IPI 4260 Cougar controller from Interphase Corp. in Dallas, announced in September. The SV6800 sells for $3,995 in single quantities and is available 90 days after ordering; the SV7800 is priced at $4,995. □

PRODUCTS TO WATCH

TI PLANS TO CACHE IN ON INTEL'S 80386 AND CONTROLLER

Texas Instruments Inc. is readying dedicated cache-memory chips to support Intel Corp. microprocessors. Rather than make its own announcement, TI will disclose the news at Comdex, Las Vegas, this month—in Intel's brochure on its 82385 cache controller. TI product managers in Dallas refuse to discuss the ACT2140 cache static random-access memory, but prototype silicon is due by year's end and introduction is expected in 1989. The 33-MHz 2140 will store 147,456 bits. It can be configured as a two-way set—associative 4-K-by-18-bit or direct-mapped 8-K-by-18-bit cache memory for Intel's 32-bit 80386 and 82385 cache controller. The CMOS part will compete against the IDT 71586 from Integrated Device Technology Inc., Santa Clara, Calif., [*Electronics*, August, 1988, p. 64]. One major difference between TI's part and the IDT71586 is that the 2140 will have memory for storage of parity bits. □

RIVALS NCR AND SMC DUEL IN INTEGRATING MORE FUNCTIONS ON ARCNET CHIPS

Competition is heating up between NCR Corp. and Standard Microsystems Corp. in ARCnet local-area network chips. The NCR90C98 from NCR's Microelectronics Division, Fort Collins, Colo., integrates a controller and transreceiver on a single chip. But Standard Microsystems has gone one step futher. The Hauppauge, N. Y., company's COM 90C62 ARCnet controller/transceiver will be offered separately, or as part of a three-chip set called LAN 36258/68. The set includes a driver chip and an application-specific IC that replaces discrete TTL devices used to interface with personal computers. This reduces total device count on an ARCnet board from about 25 to seven. For its part, NCR says its 90C98 incorporates features not found on SMC's 90C62—such as on-chip buffer chaining, reduced wait states, and quadrupled external memory. Standard Microsystem's LAN 36268 chip set sells for $28.05 in 5,000-unit quantities. The COM 90C62 costs $14.40. NCR's 90C98 will be available in February for $23 in 5,000-piece quantities. □

STANDARD-CELL CHIPS FROM S-MOS SYSTEMS BOAST 1.05-MICRON FEATURES

Joining an exclusive club, a four-year-old maker of application-specific ICs is producing standard-cell chips that are designed with an effective channel length of 1.05 μm. The company is S-MOS Systems Inc. of San Jose, Calif., and it is one of the first to ship standard-cell products with features smaller than 1.5 μm. The SSC 3000 offerings are aimed at high-speed and high-volume applications. They offer from 1,000 to 40,000 gates and up to 276 input/output lines per chip. All told, the library includes more than 300 macrocells. The series is available now with prices starting at 19 cents per gate. □

INTEL BEEFS UP ITS iPSC/2 SUPERCOMPUTER'S I/O AND MEMORY CAPABILITIES

Intel Corp.'s Scientific Computers Division is beefing up its iPSC/2 Concurrent Supercomputer with a parallel mass-storage subsystem having powerful input/output capabilities and support software. The Concurrent I/O subsystem comes in options up to 40 gigabytes using multiple disk drives. By delivering the capacity and I/O bandwidth that is needed for large scientific and engineering applications, the subsystem puts the parallel-architecture machine's I/O capabilities into balance with its high computational performance. Up to 500 gigabytes can be supported for applications in aerospace and defense, the petroleum industry, computational chemistry, and mechanical engineering. The Beaverton, Ore., division's software release—the Concurrent File System—makes the new storage system as easy to use as conventional storage systems. The iPSC/2 Concurrent I/O subsystem with software is available starting at $60,800. □

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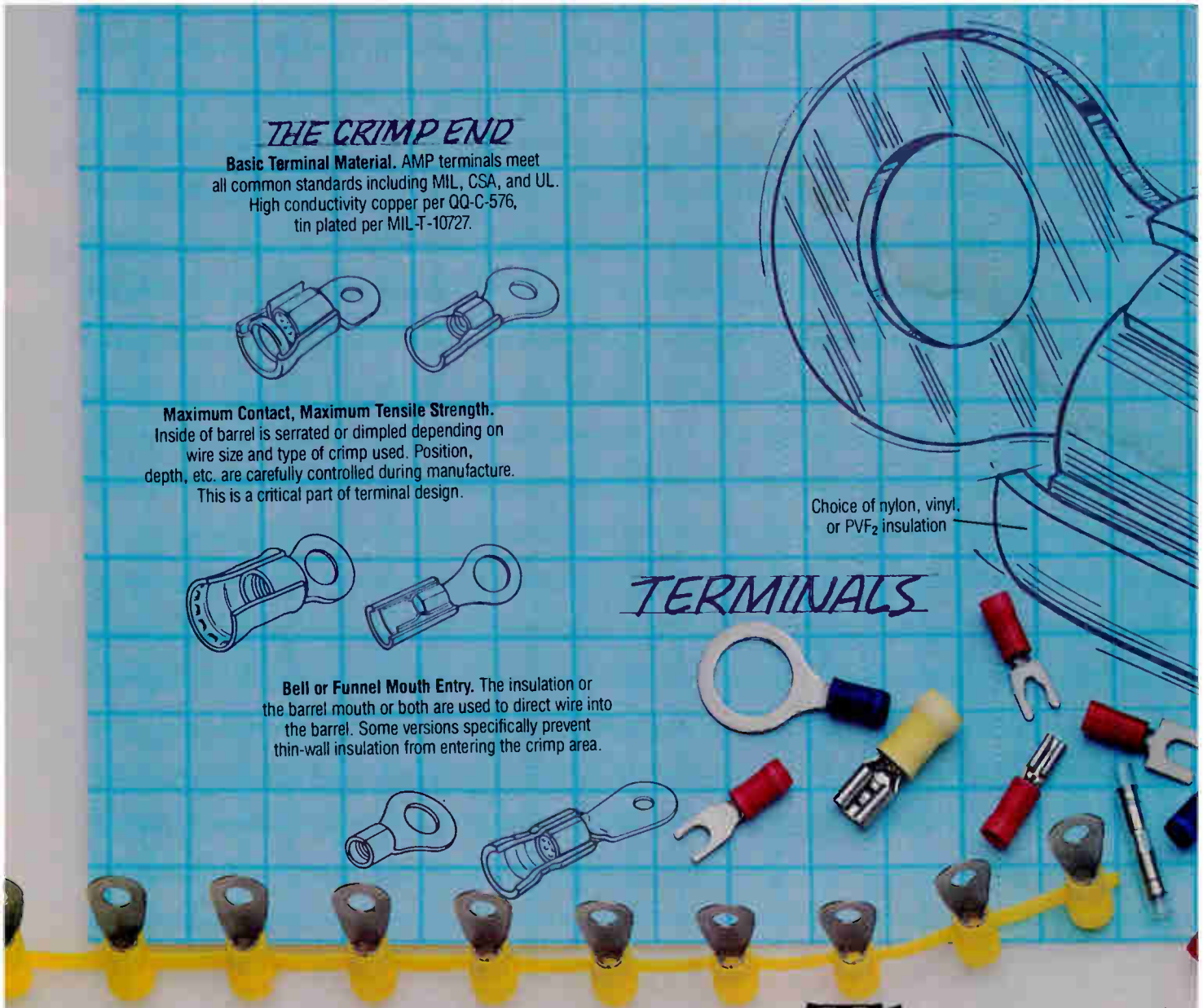

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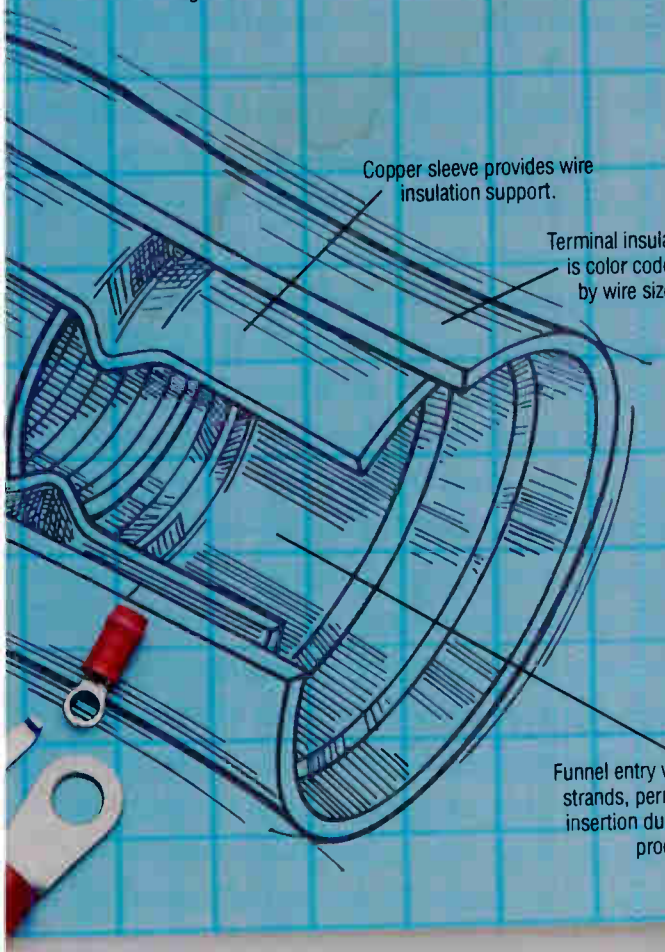

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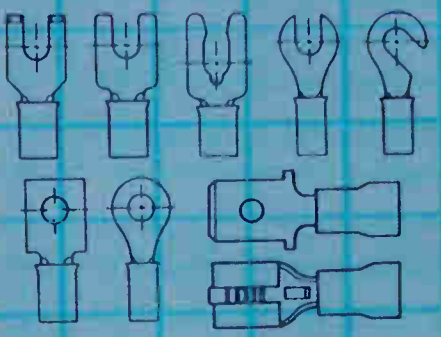

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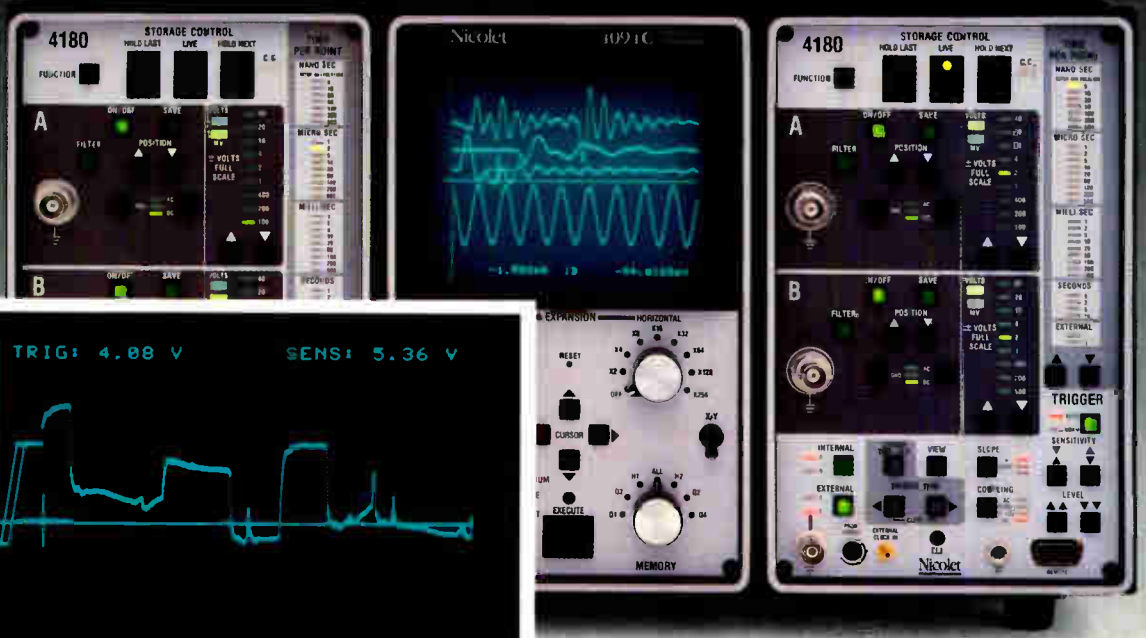

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INSTRUMENTS OF DISCOVERY

Electronics

BEARS ARE IN THE DRIVER'S SEAT AS CHIP SALES FAIL TO REBOUND

'Downturn has started' as book-to-bill figure dips below 1.0

EL SEGUNDO, CALIF.

Is the chip boom over? "The downturn in semiconductors has started," flatly declares analyst Thomas P. Kurlak of New York's Merrill Lynch & Co. That view may be a bit strong, but even the industry executives and analysts who previously held hopes that the boom could reignite after what they saw as the usual summer lull—when the book-to-bill figure dropped from April's high of 1.18 to August's 1.02—concede that slower orders could foreshadow trouble. The irony for system houses is that though the slide could mean lower prices and more available parts, it is caused by slowing sales of systems.

Creating some nervousness is the September report from the Semiconductor Industry Association, which showed the book-to-bill ratio slip to 0.97, the first time in 22 months it has been under 1.0. The boom that apparently peaked in the spring, according to SIA figures, still will give 1988 impressive growth over 1987. The association now estimates it at 35.3%, but Michael A. Gumport, an analyst at Drexel Burnham Lambert Inc., is holding to about 38% growth.

Whatever the figure, the declining order pattern is apparent and new SIA projections now foresee 1989 growth at only 12%. The principal reason for the downturn is softening orders from personal computer manufacturers, especially at the lower-performance end, "which appears to be facing a shakeout," says Gumport. Merrill Lynch's Kurlak points out that "it seems unlikely that PC-related demand can reaccelerate this year."

But this scenario had been predicted. The problem with the semiconductor industry is its familiar one: take boom conditions for granted, gear expansion and operations to it, and then be surprised when the inevitable downturn hits. Says Gumport, "it's [only] shifting from high growth to moderate growth, but it feels like free fall to them."

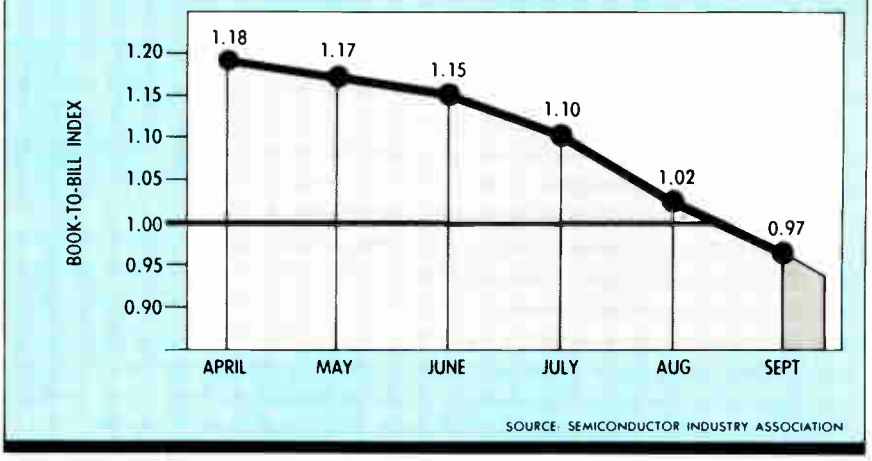
Now the question is whether a new level of orders has nearly been reached or more sliding lies ahead. Kurlak predicts that much more pain is in store for device manufacturers, many of whom have let expansion and operating costs get out of hand. The key to avoiding an earnings debacle now for these companies is cutting back quickly, he says.

One industry veteran who agrees that the market is bottoming out is Charles M. Clough, who has been through three decades of chip cycles. "It's more along classic lines this time, supply catching up with demand fairly quickly," says the president of Wyle Laboratories Inc. in El Segundo, Calif.

He also believes it unlikely that users will repeat the massive inventory buildup of the sort that led to the slump of 1985-86. Clough thinks inventories "are still in pretty good shape." For 1989, he foresees U. S. growth of 6% to 10%.

If bad times do in fact lie ahead, some companies may have the product lines—for the high-performance end of the PC and work-station markets—and financial strength to enable them to weather any turbulence. Among them: Intel, LSI Logic, Motorola, Cypress, and Integrated Device Technology. *–Larry Waller*

THE SEASONAL SLUMP STRETCHES OUT



MEMORIES

DRAM USERS AND MAKERS: SHOTGUN MARRIAGES KICK IN

CHATSWORTH, CALIF.

It was bound to happen. With the shortfall of dynamic random-access memories refusing to go away, agreements designed to bind memory buyers more closely to producers are starting to pop up all over. And though all have in common the need to secure an assured supply for the buyer and locked-in customers for the seller, the details vary widely.

In the wake of last month's developments, speculation is rife about which chip houses and customers are talking with eachother. But there is also the lingering question about whether and for how long such marriages can survive.

Despite that, the exigencies of the marketplace spur the matches. Last month, Japan's NMB Semiconductor Co. announced a unique plan to ensure chip availability. That came after England's Amstrad plc acquired a piece of Micron Technology Inc. NMB, which in just two years has claimed the top worldwide production rung for fast DRAMs, plans to further cement ties with its big computer-maker customers by bringing them into the act as part owners of a separate com-

pany set up in Japan for that purpose.

"We're selling equity positions in a new company managed by NMB," explains William C. Connell, executive vice president of NMB Technologies Inc., the company's U. S. arm, with headquarters in Chatsworth, Calif. The prospective partners—NMB is looking for four of its customers to contribute 10% apiece—"will get a certain percentage of the fab," says Connell. NMB itself has deep pockets; it is a unit of Minebea Co., a world leader in precision ball bearings (see p. 188). Not only that, but its U. S. customer roster lists some big names. Among them are Compaq, NCR, and Sun as well as the leading minicomputer companies.

The Amstrad-Micron deal is more conventional. In it, Amstrad purchased a 9.8% equity position in Micron of Boise, Idaho. Amstrad, a fast-growing personal computer maker that is one of the biggest memory users worldwide, gets for its money a claim on nearly the same amount of Micron's DRAM production, along with a solid investment position in a technology leader.

More deals are coming, in the opinion of Bart Ladd, an industry analyst specializing in DRAMs for Dataquest Inc., the San Jose, Calif., market forecaster. "In time, suppliers and users have to develop some kind of relationship," observes Ladd. U. S. companies in particular, both chip makers and computer firms, need this kind of linkage to get at least some of the advantages of vertical integration enjoyed by offshore competitors.

The list of prospects being talked about in the industry includes most of America's big names, with Motorola Inc. and Texas Instruments Inc. at the top. The most persistent reports link TI with Sun Microsystems Inc. because they have other agreements in force, such as TI's sourcing of the Sun RISC chip. But TI's Wally Rhines, senior vice president in the Semiconductor Group, says there is no deal with Sun.

LONG ODDS. Motorola already has acknowledged that its big buyers have initiated talks about joint DRAM alliances, perhaps even building a new plant together [*Electronics*, October, 1988, p. 18]. But the odds are against such an arrangement: a plant would cost upwards of $200 million, it wouldn't be up and running for several years, and the fickle memory chip cycle could see prices drop quickly.

Although most industry watchers see little to find fault with in accords like the Amstrad-Micron and NMB deals, some with a longer perspective warn that all vistas are not rosy ones. "These are not new things, they did not work before, and I tend to doubt they will work now," says Matt Crugnale of Mountain View, Calif.'s Crugnale and Associates. The sticking point is that technology and product improvements move so fast that it could suddenly turn out that the user's best choices suddenly are those that are available outside the deals. In other words, deals "are okay until they become noncompetitive," he says, which has happened in the past.

Crugnale points to the deal General Electric Co. made with General Motors Corp. in the mid-1960s to supply then-scarce plastic-packaged transistors for under-the-dash consumer electronics units. It foundered within several years as other semiconductor makers, notably Motorola, offered better products at lower prices, recalls Crugnale, who was then a young GE marketer. Then there was the late 1970s IBM Corp. arrangement to foot many of the bills for a line making resistor networks at Beckman Instruments Inc. in Fullerton, Calif. The networks were a key component for mainframes. Product and pricing troubles caused IBM to design the parts out of its units and end the deal, recalls Crugnale, who also worked at Beckman.

> The deals give makers and sellers the vertical integration offshore competitors have

"The point is [the partners] will walk away in a nanosecond, no matter what the investment, unless it makes big sense." In order for the agreements to succeed, Crugnale strongly believes that more than a commodity product has to be the centerpiece. "If there's a proprietary technology that can add value and sustainable leverage, then they have a much better chance." However, Crugnale does not see this element in the new deals.

Nevertheless, NMB officials are confident of their deal's success: construction on the new memory plant is scheduled for February at Toteyama City, Japan, adjacent to two existing NMB fabs. Production initially would be of next-generation 4-Mbit DRAMs, with first parts coming out by early 1990. Eventually, the new plant would move on to 16-Mbit devices and in phase two of the contemplated deal another fab would be built in Japan or the U. S., says NMB's Connell. Existing NMB fab lines would continue to build 256-K and 1-Mbit parts. Back in 1985, NMB turned out its first 256-K memories just nine months after the ground was broken for a plant. *–Larry Waller*

OPEN SYSTEMS

HOPES FOR COMPROMISE ON UNIX STANDARD FADE

LAWRENCE, MASS.

Undeterred by its failure to reach a compromise with AT&T on an approach that would lead to a truly global standard version of the Unix operating system, the Open Software Foundation is moving ahead on an ambitious schedule that would deliver OSF's own standard environment in 13 to 19 months.

The rift in the Unix community could mean that, at least for now, instead of reaching consensus on a single, independent standard, two opposing camps are forming. That forces Unix users to monitor developments in both, and to choose between them in product development.

Hopes for a compromise between Unix developer AT&T and OSF were all but dashed after their representatives couldn't agree on a compromise at meetings in late October at OSF's interim headquarters in Lawrence, Mass. Those meetings took place just a few days after AT&T and 18 other computer companies backing AT&T's Unix formed an opposing group. They will advance their own version of a standard, introducing products based on AT&T's Unix System V Release 4.

Even though AT&T is not an OSF member, the company's Bell Laboratories subsidiary had submitted its Open Look graphical user interface in response to OSF's request for technology proposals. However, in addition to Open Look, AT&T is believed to have tried to convince OSF essentially to adopt the entire System V.4 as the OSF standard.

One member of the AT&T group, Charles Exley Jr., chairman and chief executive officer of NCR, says that AT&T "submitted a proposal to the OSF that we all be-

OSF will go ahead with its own Unix standard, says the foundation's Morrow.

sure a natural migration to
stems standard. While we
an accommodation will be
, our customers are telling us to act
ow and get on with the business of providing Unix System V."

So OSF will continue on its schedule. "We can look back on the last six months and see the positive impact OSF has had on open systems. It's clear to us that we'll continue in our direction and produce the OSF-1 operating environment by the end of 1989," says Alex Morrow, OSF's director of strategic relations. OSF had earlier indicated that its operating environment will use core technology from a future version of IBM Corp.'s AIX Unix variant as a development base. OSF expects to receive AIX evaluation code from IBM this month. Members will also meet this month to recommend their choice of a user interface. The schedule also calls for the initial OSF-1 AIX-based core code to be ready for system tests by next March, which will lead to the late 1989 full OSF-1 implementation.

40 IN OSF. Apollo, Digital Equipment, and IBM are three of the prime movers behind OSF, whose membership has grown to more than 40 organizations. Backing AT&T in the as-yet-unnamed industry association are 18 members including Amdahl, ICL, Intel, Lachman Associates, Motorola, NCR, Sun Microsystems, UniSoft, and Unisys.

One senior executive, who works at an OSF-member company briefed on the recent meetings with AT&T, says that AT&T "wants OSF to use System V.4 because they're afraid that otherwise OSF will adopt [all of] IBM's AIX. But V.4 is not as good as AIX. This is a technical issue," he says, "and all who've looked at V.4 and AIX agree that AIX is superior."

The same executive adds that "while OSF and AT&T may still be trying to work out a compromise, the discussions are essentially over and the two parties have gone their own ways. The chances for a compromise are less than 50-50."

OSF officials have said publicly that AIX won't be adopted lock, stock, and barrel. Ira Goldstein, OSF's vice president of research, has stressed that all of the technical proposals OSF receives for the user interface, as well as the AIX code it will obtain from IBM, are OSF's property to use, modify, or not use, as it wishes. He says OSF-1, the first version of the group's Unix environment, "will consist of more than AIX."

But don't expect a single standard Unix soon. Says Russ Aldrich, director of marketing at Convergent Technologies Inc., "I see at least two major revolving universes—OSF and what I call Unix Inc. The real question the industry faces is what differences there will be. The customer base will have to decide which one it wants to use." *–Lawrence Curran*

DISK DRIVES

IMPRIMIS LANDS FIRST BLOW WITH A 1-GBYTE, 5.25-IN. DRIVE

MINNEAPOLIS

Only a month after unveiling a 766-Mbyte version of its Wren line of 5.25-in. Winchester disk drives, Imprimis Technology Inc. is upping the ante. The next high-capacity model in the Wren line will be the first 5.25-in. drive to break the 1-gigabyte barrier, the company claims.

The Wren VII will feature 1.2 gigabytes of capacity, along with a Small Computer Systems Interface. It won't go into full production until the fourth quarter of next year. But by announcing the drive in time for this month's Comdex show, Imprimis, a Control Data Corp. subsidiary based in Minneapolis, is hoping to steal a march on Maxtor Corp., the Santa Clara, Calif., company that is the current leader in 5.25-in. high-capacity drives. Maxtor has been shipping its 760-Mbyte XT8760 for about a year, while other vendors, including Imprimis, are just beginning production of this capacity.

> Its Wren line of 5.25-in. Winchester drives puts the heat on Maxtor

"In the past, if anybody wanted high, high capacity in a 5.25-in. drive, he went to Maxtor," notes Shawn F. Hook, manager of marketing programs for the Imprimis Small Disk Division in Oklahoma City, Okla. "But today, we're the industry leader in capacity." Like other Imprimis 5.25-in. products, the Wren VII will be specified at 40,000 hours mean time between failures, compared with 30,000 hours for Maxtor's XT8760.

BIRDS OF A FEATHER. And to bolster its claim to industry leadership, Imprimis is introducing two new 380-Mbyte products, slated for delivery in 1989, that also break new ground, Hook says. One is the Wren Runner, a 385-Mbyte, 5.25-in. drive that features 10.7-ms average seek times, compared with the 16 to 18 ms times typically offered by other vendors. The second is a 383-Mbyte addition to the Wren VI family, which Hook says is the first announced product to hit that density level in a half-height drive format. (The 766-Mbyte Wren VI announced last month is a full-height drive.)

The Wren VII announcement "makes a pretty good case" for Imprimis leadership in the high-capacity 5.25-in. market, says Robert Katzive, vice president at Disk/Trend Inc., Mountain View, Calif. By being first out, he says, Imprimis is likely to snatch market share from Maxtor and other vendors, who are also expected to move to 1-gigabyte-plus 5.25-in. capacities next year. But Katzive also says that "there's no guarantee in this business, because it's truly one in which it only takes one slip and suddenly, the first will be last."

Hook concedes that point. But he is confident that Imprimis will meet its Wren VII schedule, delivering the first evaluation units in next year's second quarter.

EASY SWITCH. The transition path from the 766-Mbyte Wren VI, announced last month, to the Wren VII capacity should be smooth. No major leaps in technology will be required, Hook says. The Wren VII will use the same 8-platter/16-head disk assembly as the Wren VI, with the same 10-μin. head flying height. The only major change, and the one that will push the drive's capacity past a gigabyte, will be the use of zone-bit-recording techniques, or ZBR. ZBR makes it possible to cram more capacity onto a disk by putting more data into the longer, outer tracks of the disk than on the inside tracks, the company says. It's the same technique Imprimis has used without a hitch to boost capacities on earlier generations of Wren products, Hook says.

Maxtor, for its part, is not talking. "What we can say is that we are the only company today in volume production on 760-Mbyte drives, and it goes without saying that we are working on future generations of advanced 5.25-in. products," says Taroon Kamdar, Maxtor's marketing vice president. Maxtor will announce a 1-gigabyte-plus product "when we're ready and we believe the market timing is right. We know how to get there. We have some unique and proprietary technology under development that will take us to where we want to be."

For Imprimis, the Wren VII announcement could cause some tricky marketing problems, since the 5.25-in. drive's 1.2-gigabyte capacity matches that of today's highest capacity 8-inch drives, including Imprimis's own Sabre 8-in. product line. The Wren VII introduction "could very possibly" hurt sales in Imprimis's 8-in. business, says J. Michael Casey, associate director for storage research at InfoCorp., a Santa Clara market research firm. But then again, says analyst Casey, "if it's technologically possible to produce a product that cannibalizes one of your own, you're better off doing it yourself than waiting for somebody else to come along." *–Wesley R. Iversen*

WILL INTERACTIVE VIDEO PAY OFF FOR INTEL?

PRINCETON, N.J.

Intel Corp. is betting that its acquisition of General Electric Co.'s Digital Video Interactive technology will pay long-term dividends with personal computer applications. By creating new PC applications, DVI could expand the market for PCs and the Intel chips that drive them, the Santa Clara, Calif., company's reasoning goes.

Intel hopes DVI's high-quality video, with which a user can interact, will open up new markets for PCs, particularly with people who are put off by the idea of using a computer. "As long as potential users find PCs intimidating, the market will be underutilized. DVI is the future of the PC industry," says Dave House, general manager of Intel's Microcomputer Components group. But Intel's new technology faces a potential challenge from a competing format. Developed by Japan's Sony Corp. and the Dutch firm NV Philips, it is called Compact Disk Interactive technology.

For GE, the sale of DVI reflects its decision to move out of the consumer products business, says Nigel Andrews, GE's vice president for corporate business development and planning. Lacking Intel's prestige in the PC community, GE would have found it difficult to push the technology into widespread use, he says. But GE will get royalties, he adds.

Developed at GE's David Sarnoff Research Center in Princeton, N. J., DVI technology uses a two-chip set and the real-time memory capability of CD-ROMs. It teams a 12.5-million-instruction/s processor with proprietary image-compression/decompression algorithms. Combined with software stored on CD-ROM, it is powerful enough to provide 72 minutes of full-motion, full-color video plus high-performance graphics in an interactive mode [*Electronics*, March 17, 1988, p. 46].

Intel has a three-part strategy. The first markets to be penetrated will be specialized, vertical applications, such as government and commercial training products. The second market will be general-purpose products for horizontal markets such as business and education. The third market is the consumer market.

READY IN '89. The first DVI applications-development kits will be available in the second quarter of 1989. Products from Intel and independent software vendors are slated to arrive in the first half. These products will include DVI-based applications software that integrates video and computer graphics. DVI-based hardware from Intel will come in the form of boards and chip sets from Intel. Near the end of 1989, a custom, 1-μm version of the present semicustom 1.6-μm DVI chip set will be introduced, House says.

An easy way to "play" famous golf courses around the world is via a DVI program. The technology has been acquired by Intel, which hopes to profit from new PC applications.

However, not everyone shares Intel's hopes for the DVI market. Aristide Vitolo, an analyst with the investment firm of C. J. Lawrence in New York, sees continued strong growth in the traditional PC markets over the next five years, as computing shifts away from from minicomputers and toward a PC-based distributed computing architecture. That will keep PC sales growing at 20% to 25% a year, he says. "Interactive video is going to be another application," Vitolo says, "but that is 5 or 10 years in the future."

One hurdle facing Intel is that a similar technology, aimed directly at the consumer market, has already established a standard. CDI technology, developed by Sony and Philips, lacks DVI's processing power and its full-motion video. It is also restricted to half-screen motion pictures. Its attraction lies with canned programs that combine stop-action video with digital audio. Both technologies use standard-format CD-ROM disks but they require different data. CDI does not now compete directly with DVI, but the two will butt heads as DVI broadens into the home market.

When that happens, DVI will be at a disadvantage as long as it hangs on to its identification with computers, says Emiel Petrone, vice president of marketing at American Interactive Media Corp., a software house set up by Philips to specialize in CDI applications. "We carefully avoid using the word computer," he says. Nevertheless, CDI players are powerful machines that integrate Philips' OS-9 real-time operating system and a Motorola Corp. 68000 microprocessor.

On the other hand, some major software companies think Intel is on the right track, among them Lotus Development Corp., Cambridge, Mass. "At Lotus, we see DVI as a catalyst to unleashing creativity, defining new product categories, and creating new markets," says David Rous, vice president of information services. "With DVI, people using computers today will find whole new uses for them and people who never dreamed of using PCs will be drawn to them like never before."

OUT FRONT. On the technology front, DVI clearly holds the lead. The Sarnoff research team found ways to solve the data-transfer challenge posed by full-motion video overlaid by graphics and windows. When a standard screen of analog video measuring 512 by 400 pixels is converted to digital form, the information takes about 600 Kbytes per frame. Full-motion video calls for showing 30 frames/s, so the data-transfer rate needed for full motion is about 18 Mbytes/s. That means that a CD-ROM disk, although it has a capacity of 648 Mbytes, can store only 30 seconds of digital video, and its 150-Kbyte/s data-transfer rate keeps it from displaying full motion.

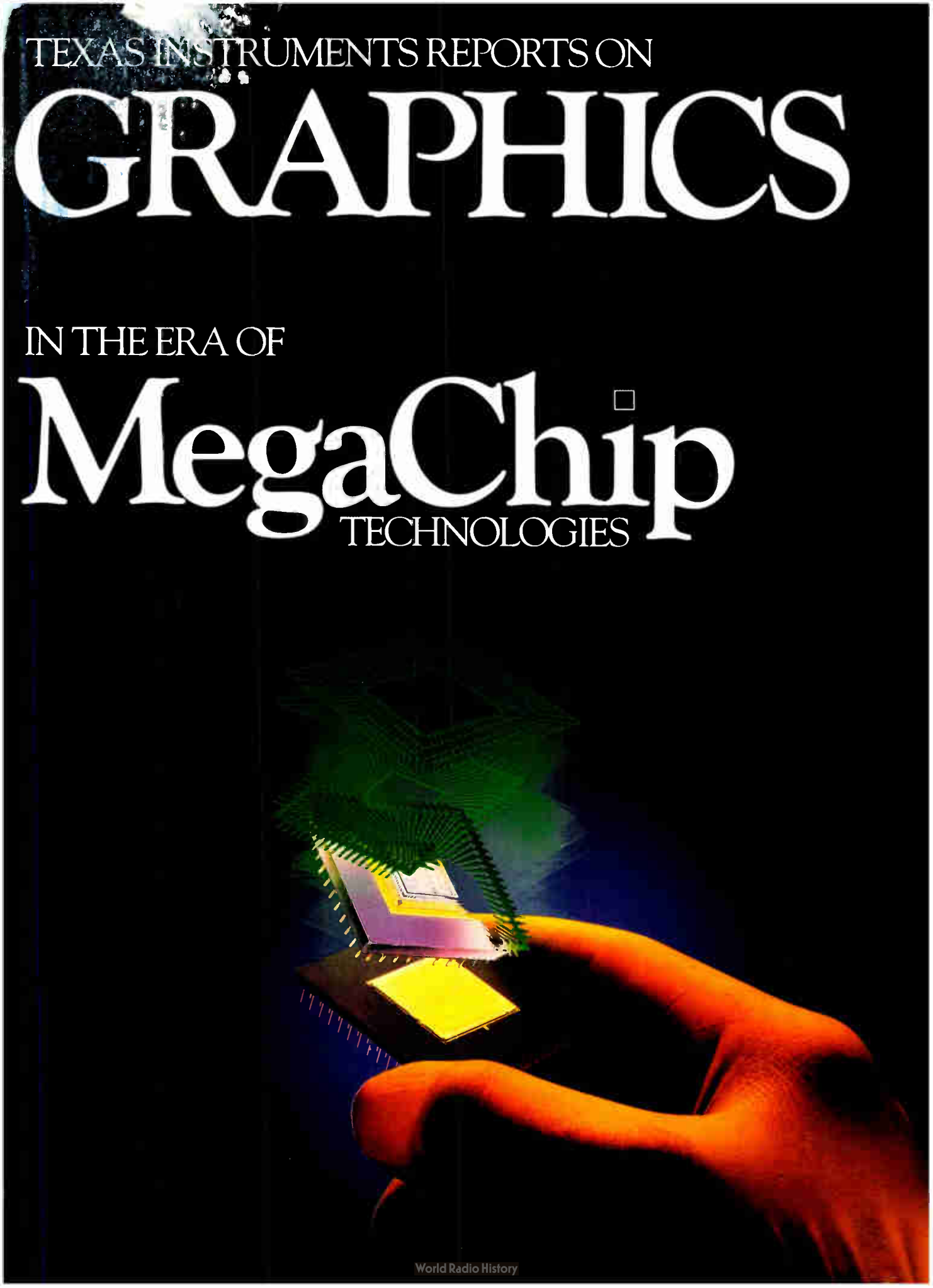
The DVI team's barrier-breaking technology is based on being able to compress data by a factor of 100:1 without significant degradation of quality. Two key factors are involved: the two-chip set, and the compression algorithms that run on one of the chips. Putting on a single die the graphics processor and the firmware that runs the compression/decompression algorithm was also a design breakthrough. *–Jack Shandle*

TEXAS INSTRUMENTS REPORTS ON

GRAPHICS

IN THE ERA OF

MegaChip TECHNOLOGIES



Graphics in the Era of MegaChip Technologies:

Why do industry leade graphics processors from

For everything imaginable!

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ck industry-leading Texas Instruments?

Stretching across the bottom of these pages is but a fraction of the hundreds of systems based on TI's industry-standard TMS340 graphics family. At the left is a Sun-3 utilizing TI's leadership '74ACT8800 building-block processor family. Which only goes to prove designers choose TI graphics products for everything from workstations to PCs, from laser printers to arcade games.

They get design options that allow them to differentiate their products and to better tailor price and performance to their markets.

They also move to market faster with less risk. TI graphics products are proven, available, fully supported—the standard by which others are measured.

Let a few of the designers tell you about their choices:

"The TMS34010 was the only graphics processor that could meet the performance requirements of our laser plotter controller."

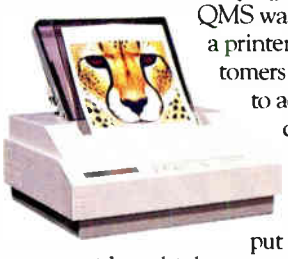
—Al Sabel, Advanced Products Manager, Xerox Corporation

The Xerox 8836 had to produce D- and E-sized drawings with a resolution of 400 dots per inch at a constant speed of one inch per second. The 34010 delivered: Six million instructions per second with a "draw" rate of up to 50 million pixels per second.

"The programmability and architecture of the TMS34010 provide the performance and flexibility we need for color- and graphics-intensive printer products."

—Dr. Donald Parker, Exec. V.P. Products & Technology, QMS, Inc.

Because the 34010 is programmable, QMS was able to build a printer that their customers could program to accept scanned color input and to provide high-speed color output as well as hard copy with multiple printer support.



"TI's ACT8800 technology allows our TAAC-1 application accelerator to significantly boost the computing power of a Sun workstation for imaging and graphics applications."

—Nick England, Director Application Accelerator Group, Sun Microsystems, Graphics Products Division

"The 8800's power lets us combine the functionality of an image processor, an interactive graphics device, and an array processor in a single product and still offer user programmability."

There's more in store from the ACT8800 family. The recently disclosed 8847 floating-point processor combines two 64-bit functions on a single chip: A floating-point multiplier and a floating-point arithmetic logic unit. Its number-crunching capability: 33 MFLOPS.

"In designing graphics systems, you can't forget about tomorrow. And TI hasn't."

—Carl Calabria, Director of Engineering, Truevision® Inc.

"The 34010 enables our True Vista® video graphics boards to bring workstation performance to IBM® compatibles and Mac IIs. It is the only graphics chip that will allow us to migrate our applications software to even higher-performance second-generation TMS340-based systems." *See road map on next page.*

The TMS340 second-generation processor is three to 20 times faster than the 34010. It is user configurable, software and plug-in compatible.

Two other products designed in parallel with the new TMS340 processor are the One-Megabit Video RAM and the industry-first floating-point graphics processor, with on-board, high-level graphics instructions.

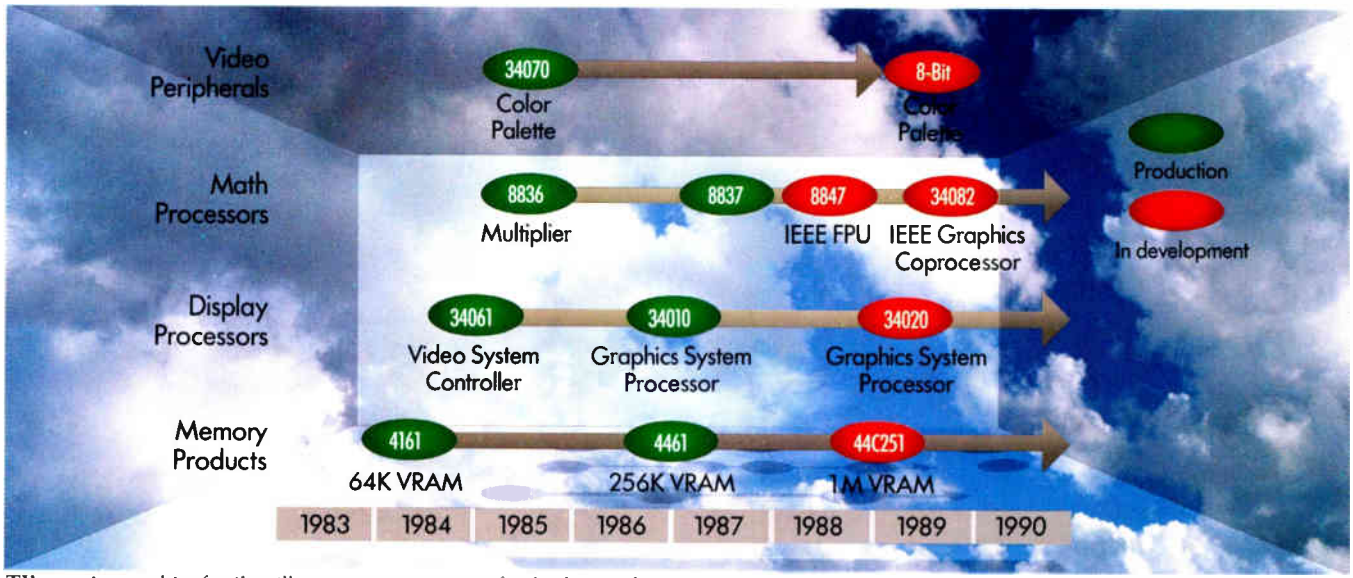
The One-Megabit VRAM enhances the performance of the 34010. And when used in tandem with the second-generation processor, performance is improved up to 50 times over other processor/VRAM combinations.

The floating-point graphics processor executes up to 40 MFLOPS and interfaces directly with the address and data buses of the second-generation TMS340, allowing it to perform computation-intensive functions more than 10 times faster than current PCs.

For details on TI's software and third-party support, turn the page.

RasterOps *Renaissance GRX* *Truevision* *Vermont Microsystems* *Vectrix*

Here's the road map to your graphics future ...



TI's growing graphics family will generate opportunities for the design of an even greater spectrum of graphics systems, matched much more precisely to the price and performance needs of the market. Selected TI graphics products are available processed to MIL-STD-883B. The 4161 64K VRAM is now available only in military versions, and a military-specified 34010 is on the way.

... and TI's comprehensive support will get you there.

Many designers find they complete their designs faster because of the extensive hardware and software supporting TI's graphics products. That for the new TMS340 family includes assemblers, linkers, simulators, compilers, software-development boards, and in-circuit emulators. New additions make this support even more helpful:

An 8514/A Emulation Library enables the TMS34010 processor to transparently emulate the 8514/A high-resolution color graphics add-in board developed by IBM for the Personal System/2™ line.

A CCITT Function Library allows the 34010 to operate as a high-performance embedded controller for image compression and decompression in fax applications.

A new paint program in the 34010 math/graphics function library provides everything necessary for drawing images on-screen.

Equally important, third-party support for the TMS340 family now tops 100 firms. Names and product descriptions are listed in TI's *TMS34010 Third Party Guide*.

ACT8800 evaluation and verification tools include functional and behavioral models and microcode-development software. An 8800 Software-Development Board and supporting software permit users to evaluate performance and write microcode for most ACT8800-family building blocks.

Join the many industry leaders who are using TI's graphics products in applications from plotters to games. An easy way to get started is to complete and return the coupon today. Or call 1-800-232-3200, ext. 3513.

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TEXAS INSTRUMENTS

CASE TOOLS ARRIVE FOR REAL-TIME SYSTEMS

SUNNYVALE, CALIF.

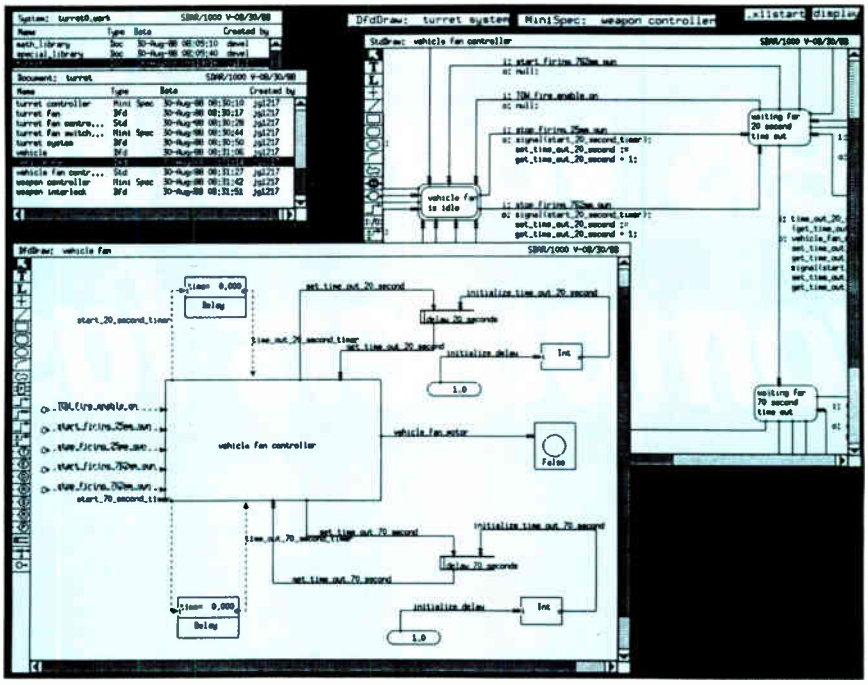
Developing software for complex real-time embedded computer systems is a recurring nightmare of killer bugs, missed deadlines, and ballooning budgets. A new type of computer-aided software engineering tool is emerging, however, that promises great savings in money and aspirin: the type of tool that creates what is known as an executable specification. One such tool has been on the market for some months, a second is arriving that adds a few new twists, and more are likely to appear soon.

An executable specification is a rigorous graphic description of the system's behavior and its software that can be executed. Before a line of code is written, the system can be simulated to see how its software and hardware modules work together. Combinations of simulated external stimuli can be thrown at the "system" to see how it reacts, where internal conflicts arise, and where the bottlenecks that could affect performance exist.

An executable specification can save vast sums of development money because catching an error or specification conflict at the beginning of the specification process makes it possible to fix the error for as little as one five-thousandth the cost of fixing it when caught towards the end of the code-writing process, according to one estimate. Executable specifications let system builders catch errors that are otherwise totally invisible at early stages. Such errors are now caught toward the end of the development cycle, at the hardware/software integration and debug stage, and many times not until the system is already in the field and in use.

Tools that make real-time programming easier are needed badly, and as they become more capable, the market is growing fast. In fact, the market is growing at a 60% annual rate, according to the Case Outlook, an industry report produced by Case Consulting Group in Portland, Ore. "We expect the market for front-end analysis and design tools to reach $370 million from its $110 million high in 1987," says Gene Forte, a principal at the company.

NEWCOMER. Statemate from i-Logix Inc. of Burlington, Mass., is the executable-specification product that has had the market to itself since late last year. That just changed now that Athena Systems Inc., a startup in Sunnyvale, Calif. has come up with a competitive offering called Foresight. Among other companies that have CASE products targeting real-time systems, and that may soon have tools with similar capabilities, are Cadre Technologies Inc., Providence, R.I., and Gensym Corp., Cambridge, Mass.



Two specification views of a real-time system (a fan controller for the turret of a tank) appear in Foresight windows: a state diagram, upper right, and a procedural view, lower left.

Both the Athena and i-Logix products "allow systems engineers to create a model of a large system and interactively apply stimulus to the system and watch the resulting system behavior," says Forte. "The systems are graphics-driven and interactive, thus allowing the system engineer to attempt an exhaustive set of alternative implementations."

> An 'executable specification' can save vast sums of development money

Typical applications include design of avionics, navigation, electronic-warfare, and communications systems—all of which can have thousands of interacting subsystems and millions of lines of program code. "Simulation can be used for system validation and demonstration, evaluation of design trade-offs, predicting timing performance, and detection of constant violations," says Ted Liu, founder and vice president of technology at Athena.

What Foresight brings to the market is a library of reusable modules for input/output, math, and signal-processing functions. "Our library models customized for embedded systems facilitates the rapid construction of the specifications," says Liu. Foresight also has a monitor function, which allows the systems engineer to probe at any data-flow path in his design and view the data being sent from one process to another.

The Athena and i-Logix products differ in the way the modeling of processes is done. Athena offers three approaches: networks, state machines, and procedures. Networks make it easier to comprehend operations that occur in parallel, says Liu. "The network allows the systems engineer to see how events [make the] transition from one process to another. It allows him to determine when a process will be initiated relative to others."

Statemate from i-Logix uses a modeling approach developed by i-Logix's founder, David Harel. The user works with what i-Logix calls a state chart, an extension of state-transition diagrams that adds hierarchy in order to model complex embedded systems. With state charts, a process model can represent states within states; the method accommodates concurrent states to provide the equivalent of networks in the Athena offering. State charts also provide a broadcast mechanism which enables concurrent states to interact.

The one major area in which i-Logix has moved ahead of Athena is in adding a code-generation feature called Prototyper. After a system specification is set up, Prototyper can be used to generate Ada code that can be run as a simulation or on prototype hardware. *–Jonah McLeod*

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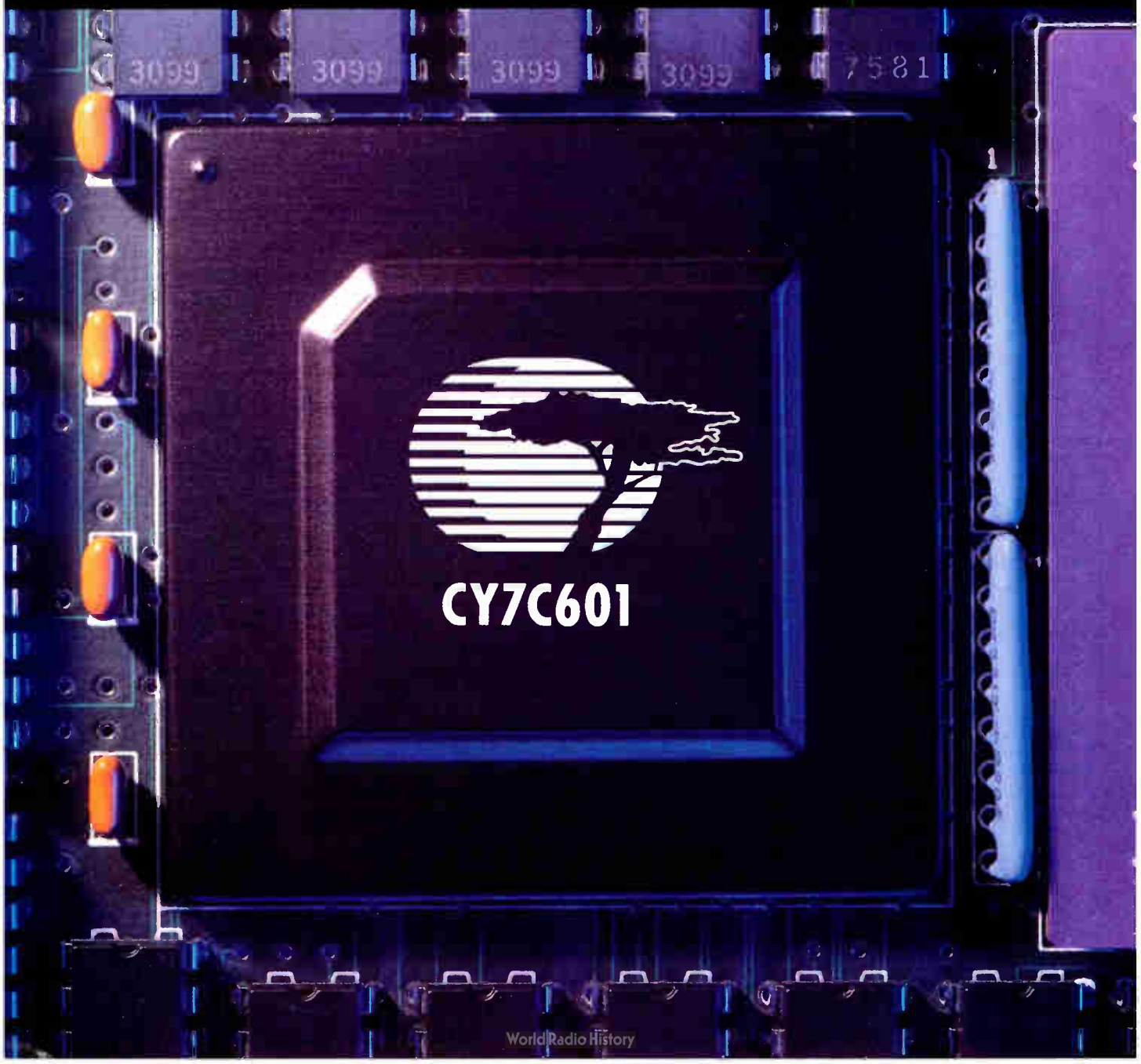

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SERVER PUTS OPTICAL DISKS ON LINE FOR WORK STATIONS

MARLBORO, MASS.

Ask a user of CAD/CAM work stations what improvements he wants in a system and one of the first answers will be more storage. That's what Epoch Systems Inc. was happy to learn in a survey of Sun Microsystems Inc. work-station users, because the results validated the company's approach to solving the problem.

Epoch, a startup in Marlboro, Mass., has introduced a Network File System-compatible storage server that puts as much as 150 gigabytes of on-line mass storage—magnetic and optical—in a server. The system encompasses four levels of hierarchical memory: semiconductor random-access, magnetic disks, optical disk drives, and an optical "jukebox." The server is for networked work station users whose applications range from mechanical and electrical CAD to computer-generated animation.

All four levels—from 30 to 150 gigabytes—are available on line because Epoch converts a jukebox into a virtual magnetic-disk-backing store. The technique controls file-swapping automatically from magnetic to optical media and back again using a caching scheme that regards all the files as residing on magnetic disk.

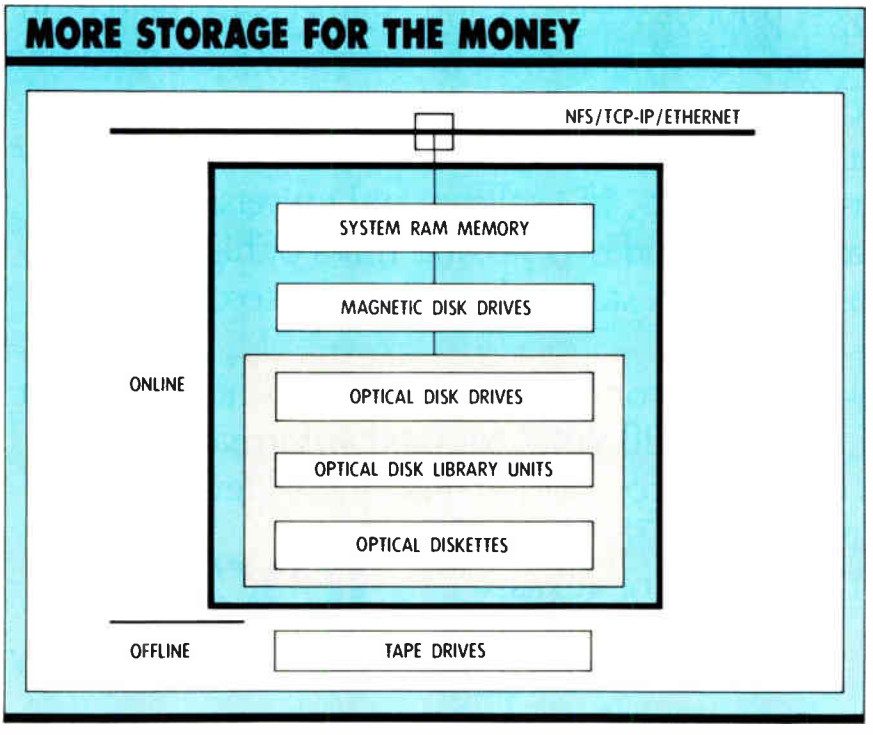
Until now, work-station users have had two main options when they wanted more mass storage: buy a file server that adds less than 4 gigabytes of magnetic disks for about $145,000, or buy a minicomputer that doubles as a computation and file server, with perhaps 10 gigabytes on line, for $300,000 to $600,000. Epoch executives believe their infinite-storage architecture is attractive because all the files are on line and capacity is 5 to 10 times greater than that of the $145,000 network file server for about the same price.

Kenneth Holberger, Epoch cofounder and president, says Epoch's surveys of Sun users show they plan to add large chunks—from 3.7 to 9.6 gigabytes—of mass storage to their network-linked systems. The users are in departments that the company has targeted for its Epoch-1 Infinite Storage server.

LOOKING SOUND. John Dunkle, vice president for work-group computing at the Aberdeen Group, a Boston-based market research firm, says Epoch's technology and market approach appear sound. "They've developed an intelligent file server with a theoretically unlimited storage capacity," Dunkle maintains. "They've also kept the [optical storage] technology transparent. That's important; optical storage has suffered in the past because users haven't been able to deal with it easily."

The central processor in the Epoch-1 uses two 25-MHz Motorola 68020 microprocessors—a file processor and an input/output processor—tied to each other through an 8-to-16-Mbyte shared memory that provides extensive file caching. Additional I/O

MORE STORAGE FOR THE MONEY



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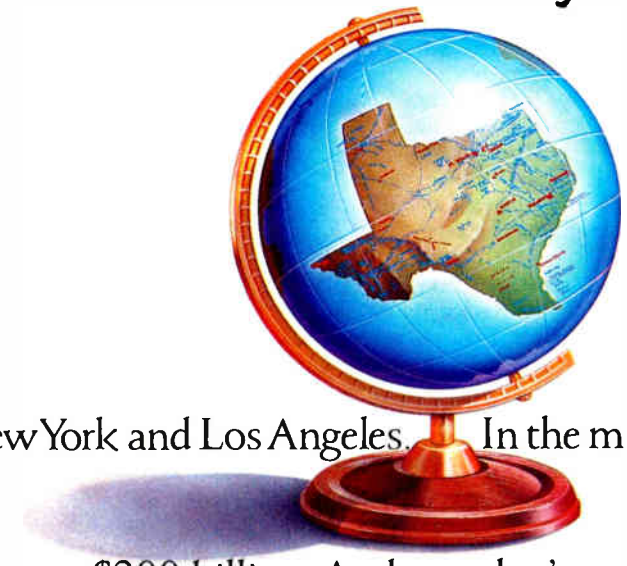

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bandwidth comes from two high-speed, small-computer-system-interface disk channels and two Ethernet local-area network channels. The magnetic disk segment is based on the Berkeley Unix Fast File System to cut disk-seeking time.

Epoch is wisely trying to capitalize on the move to standards by adopting Unix, NFS and Ethernet, says David Vellante, director of storage research at International Data Corp., the Framingham, Mass., market research organization. "The product may be just slightly ahead of its time, but now's the time to start marketing it," he adds.

Each of the four storage levels in the server draws upon caching at the lower level to speed file accessing and to make it appear that the optical storage in the jukebox is the same as the on-line magnetic Winchester disk drives. Magnetic storage in the system can reach as much as 7.7 gigabytes, and Epoch's scheme assures that the Winchesters never completely fill, no matter how much swapping between magnetic and optical storage takes place.

A proprietary "staging" algorithm is automatically activated at preset intervals—say, daily. System hardware and software tracks file usage, retaining on magnetic disk those files that are frequently sought. Files that are infrequently requested are staged out to optical disk at each staging interval, but an index of their identity and location are retained on magnetic disk.

The server gives a fault indication if a request is made for a file that has been staged out to the jukebox. That triggers a request to fetch the optical disk containing that file, which takes 15 seconds. Besides the staging interval algorithm, Epoch employs other algorithms that automatically stage files out from magnetic to optical disk when the magnetic drives reach a "high water mark" so that the magnetic drives are never saturated. Before the high-water mark is reached, the system has monitored file size and usage, preparing an index of files that are candidates for staging. Those are moved to optical storage when the high-water mark is reached. *–Lawrence Curran*

INTEGRATED CIRCUITS

EEPROM IS ATMEL'S TICKET TO NEW ANALOG CIRCUITS

SAN JOSE, CALIF.

A wave of standard parts combining high-voltage analog CMOS functions with nonvolatile electrically erasable programmable read-only memory is building, and Atmel Corp. intends to get its product to market before the wave breaks. The San Jose, Calif., company is going into production with a programmable amplifier/delay equalizer aimed at applications in telecommunications and data-communications. The part is the first in a family of EEPROM-based analog circuits that will include other telecommunications products and programmable devices for use in data communications applications like the integrated services digital network. The company also has a variety of EEPROM-based analog building blocks, which include digitally calibrated analog-to-digital and digital-to-analog converters in the works.

> Its amplifier/delay equalizer is aimed at telecommunications

Atmel is hoping to get a fast start with a technology marketed so far by only one other company, the Intersil Inc. unit of General Electric Solid State in Santa Clara, Calif., which offers a family of one-time ultraviolet erasable PROM-based ADCs and DACs [*Electronics*, Dec. 18, 1986, p. 67].

Although these two are ahead, a number of companies are exploring the use of onboard nonvolatile memory to give system designers the capability for real-time, in-system recalibration. Several standard-cell-based semicustom vendors—among them Exar, NCR, National Semiconductor, and Sierra Semiconductor—already offer EEPROM-based cells in their cell libraries, along with digital and analog functions.

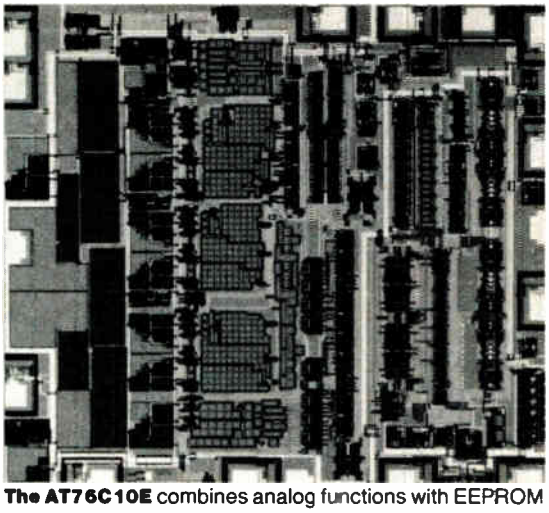
Amtel sees tremendous potential for EE-programmable analog elements in telecommunications applications. They give a user the cost advantages of a commodity-like part but at the same time let him program it to reflect the requirements of his telephone or data communications networks, down to specific segments, says the company's product manager, Tsung Mok.

The approach is also useful in cellular and portable telephone applications, says Mok. The EEPROM capability will allow an appropriately designed system to minimize the bit-error rate, to improve the sound quality of a particular radio channel, and to vary the rate as the portable telephone moves from location to location. When used with standard linear functions such as ADCs and DACs, Mok says, EEPROM-based designs help achieve higher accuracy and linearity—the parts can be calibrated

periodically by modifying code contained in the memory.

The first Atmel part, the AT76C10E, incorporates 4 Kbits of EEPROM on the same chip as two anti-aliasing filters, a delay equalizer, two gain amplifiers, four control registers, a microprocessor interface, and clock-generation circuitry. The amplifier/equalizer is fabricated using a 12-V, double-metal, double-polysilicon CMOS process originally developed for building Atmel's high-speed, high-density, 256-Kbit EEPROMs.

The AT76C10E is designed to be used as part of an adaptive equalizer in medium- to high-speed modems—those operating at 1,200 to 19,200 bits/s, Mok says. By using it a systems designer can minimize bit-error rates over dial-up and leased lines and in cellular telephones. The designer does this by allowing the gain and delay response to be modified in real time, using a serial seven-bit configuration code. The code is loaded into the chip through a serial input port and updated periodically as conditions change. The memory can be changed up to 1 million times, which Mok says is more than enough for any such application.



The AT76C10E combines analog functions with EEPROM in a user-programmable amplifier/delay equalizer.

When the device is powered up, the code stored in the EEPROM sets the delay and the gain steps. Depending on how it is configured at the startup, the gain amplifiers can be configured separately or together. One amplifier can be programmed in gain steps from zero to 7.5 dB, in 0.5-dB increments, while the other provides -8 to 16 dB of gain in 8-dB steps. When cascaded together, the two amplifiers can be programmed over a 31.5-dB range in 0.5-dB steps. The EEPROM can be used to program the equalizer so it provides four group-delay responses calculated to accommodate the majority of conditioned, as well as unconditioned, lines.

Available now in sample quantities, the AT76C10E is priced at about $10 each in 100-unit lots. Mok says in lots of more than 100,000 the circuits will cost less than $5. *-Bernard C. Cole*

DOCUMENT PROCESSING

COPROCESSOR RIPS THROUGH PAPERWORK

SUNNYVALE, CALIF.

A coprocessor that boosts throughput in document-handling applications to hundreds of pages per minute could help clear up some bottlenecks in local-area networks serving big data-storage systems, digital copiers, facsimile machines, and high-performance printers. Advanced Micro Devices Inc., Sunnyvale, Calif., has a new video compression/expression coprocessor that can move documents at speeds five to 20 times faster than what's been available up to now.

The Am95C71 is a 20-MHz processor that uses proprietary algorithmic techniques and specialized on-chip logic to encode and compress page-image data, reducing them to anywhere from one-fifth to one-fiftieth their original size. It then sends the pages over a LAN at speeds ranging from 20 to 85 Mbits/s, says Steve Crane, peripheral products directorate marketing manager at AMD.

Fast document throughput is becoming more and more important, largely because of the increasing use of bit-mapped desktop publishing technology, says Warren Miller, strategic development director for the Logic Products Division. While high-end laser or ink-jet printers churn out hundreds of bit-mapped pages per minute, the current generation of compression/expansion processors can only handle throughput of four to 16 Mbits/s.

The problem is even more acute in document storage and retrieval applications, Crane says. "Where the user is viewing the pages on the screen of a work station or PC, the problem is how to display the pages at a rate that approximates the human reaction time in paging through a physical document," he says. For a standard 8.5-by-11-in. page, this time has been calculated at one-third of a second. Sending a typical page at that speed requires a transmission speed of 45 Mbits/s, Crane says, far beyond the capabilities of today's compression/expansion processors and their top speed of 16 Mbits/s.

> The 20-MHz system lets users scan up to 10 documents a minute

By contrast, the Am95C71's highest speed—using the extreme example of an all-white image—is 106.7 Mbits/s. It slowest speed—at the opposite extreme, an image with alternating black and white pixels—is 20 Mbits/s. In actual applications, the Am95C71's speed ranges from 40 to 85 Mbits/s.

DUAL BUS. The Am95C71's high throughput depends on a pipelined architecture that incorporates on-chip a reference-line buffer that can store from 6,911 to 8,191 pixels and 16-by-16-bit first-in, first-out memories on the dual 16-bit input and output buses. The on-chip reference line buffer allows the processor to operate in both a one-dimensional mode, which provides a lower compression ratio, and a two-dimensional mode, which provides higher compression. Buffered on the input and output by the 16-by-16-bit buses, the processor can therefore be configured as a higher-throughput single-bus slave device or as a more flexible dual-bus device. The dual-bus architecture also permits the device to operate as either a source or a destination device: it can compress data, expand it, or simply let it pass through.

Also contributing significantly to higher throughput is the processor's pattern-recognition scheme. Unlike conventional coding schemes, which process data at one bit per clock cycle, the Am95C71 performs pattern-recognition comparisons on data streams 16 bits at a time, in a single clock cycle.

Finally, the Am95C71 provides four transmission schemes. One is a simple transmission mode, which processes data without compressing or modifying it. In addition, however, three advanced schemes are used: Modified Huffman (MH), modified read (MR), and modified MR (MMR). In a typical image with good black and white definition, such as a page of text, MMR coding offers the best compression, followed by MR and then MH. However, a typical document often contains a wide range of image types, Crane says. It may include well-defined black and white images alongside complex graphics that compress poorly, in some cases resulting in a compressed file larger than the original. By choosing among the three modes, the user can produce the best balance between image quality, compression ratio, and file size. *- Bernard C. Cole*

IT'S SANDWICH TIME AT IEDM AS HETEROJUNCTIONS SPARKLE

SAN FRANCISCO

Advances emerging from semiconductor research laboratories around the world promise no less than to make silicon-based integrated circuits as fast as gallium arsenide devices. In fact, they could be so fast that it will become possible to use 0.25-μm construction features—or smaller—to build them.

A major part of that work is aimed at designing circuits that integrate silicon MOS FETs and GaAs structures onto the same die, as well as constructing heterojunction devices that consist of alternating layers of various types of silicon or germanium and silicon.

> The research may revolutionize thinking about silicon

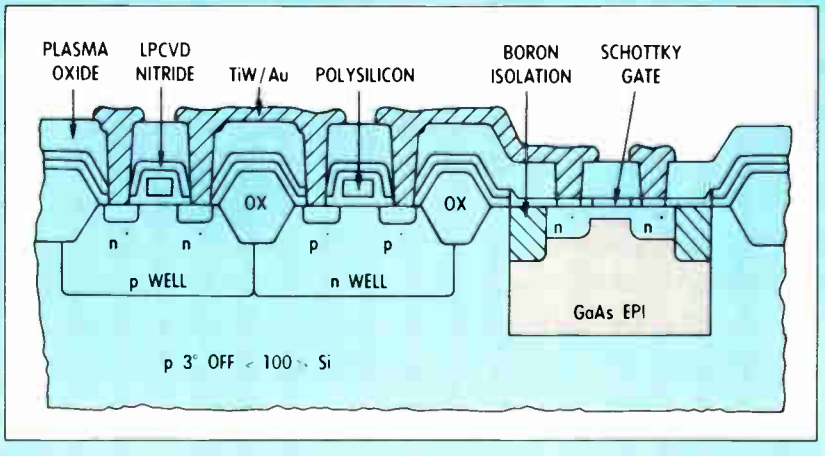
Details of this research will be described at one of the most important of the annual gatherings of the semiconductor clan, the International Electron Devices Meeting in San Francisco, Dec. 11-14. But even though the corridors of the Hilton Hotel will be abuzz with talk of these advanced devices, at this point it is still too early to tell whether any of the new structures might be successful as commercial products, says Jesus del Alamo, publications chairman for IEDM and associate professor of electrical engineering at the Massachusetts Institute of Technology.

But the implications of the research are far-reaching enough, he says, to change forever the way engineers and semiconductor physicists think about silicon and related elemental semiconducting materials. At the San Francisco conference, some of the research that will be discussed will cover:

- Stanford University and IBM Corp.'s silicon/germanium version of AT&T Bell Laboratories' bipolar inversion-channel field-effect transistor, or Bicfet;
- Texas Instruments Inc.'s circuits that actually integrate gallium arsenide and silicon on the same structure;
- Fujitsu Ltd.'s ECL array, which uses a less radical approach than some of the others being described;
- AEG Research Center's bipolar transistors built using molecular beam epitaxy;
- Stanford's work with Hewlett-Packard Co. on transistors built with a chemical-vapor-deposition process using thermal technology; and
- Linkoping University of Sweden's double-heterojunction bipolar transistor.

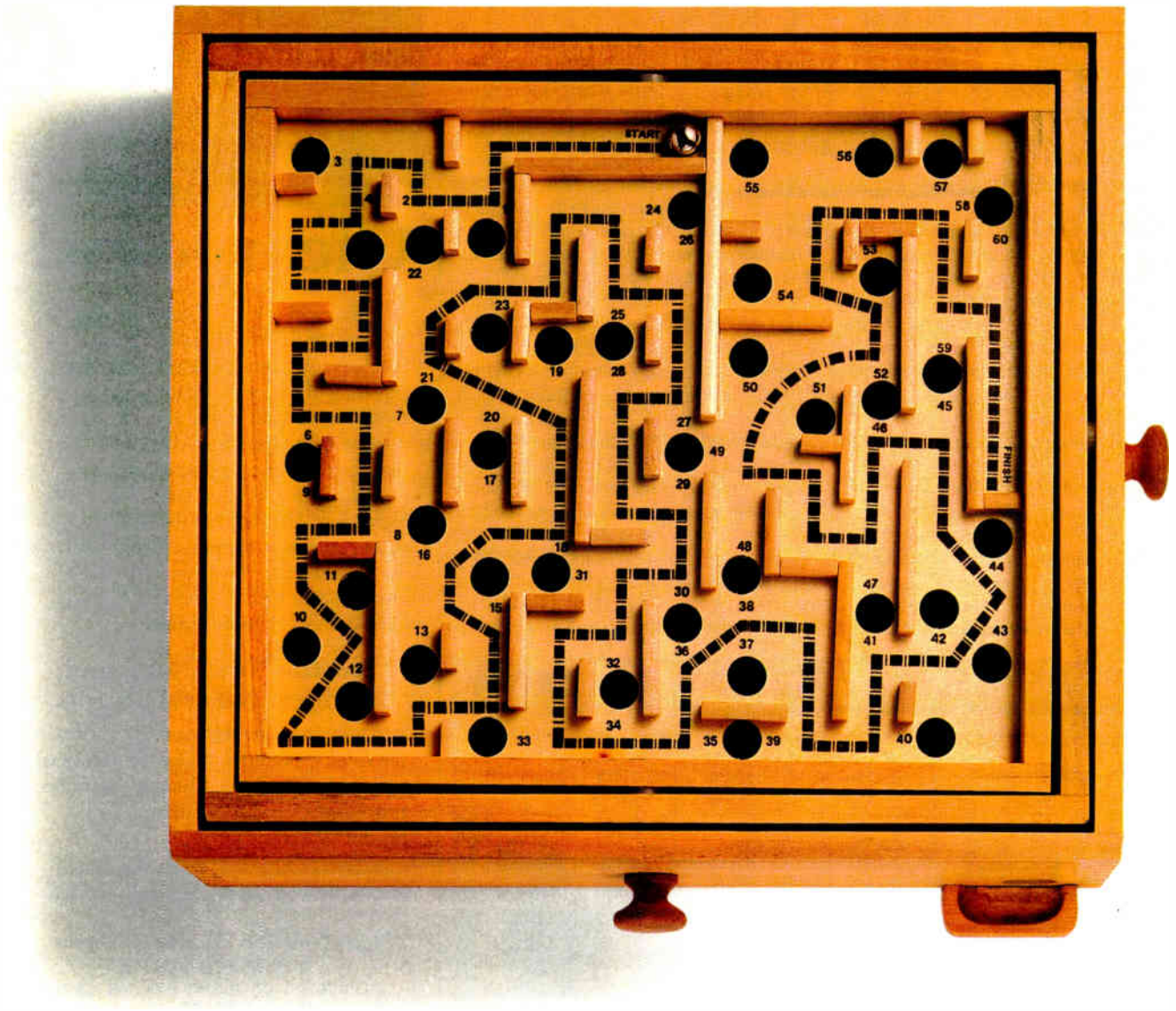
The work is all the more striking because until a year or so ago, it was widely believed that only the so-called artificially structured materials—mixtures of Group III and V materials such as gallium arsenide and aluminum gallium arsenide—could be used to reach the upper range of performance and the smallest geometries. Silicon and the other "natural" semiconductors such as germanium were thought to be incapable of producing performance in the tens or hundreds of gigahertz. They were also thought inadequate for the construction of what are called superlattice heterojunctions that permit nanometer-

SILICON AND GALLIUM ARSENIDE IN ONE CIRCUIT



At the IEDM, TI researchers will describe this structure that integrates GaAs and silicon. It requires only five mask levels more than ordinary CMOS.

The traditional approach to IC design.



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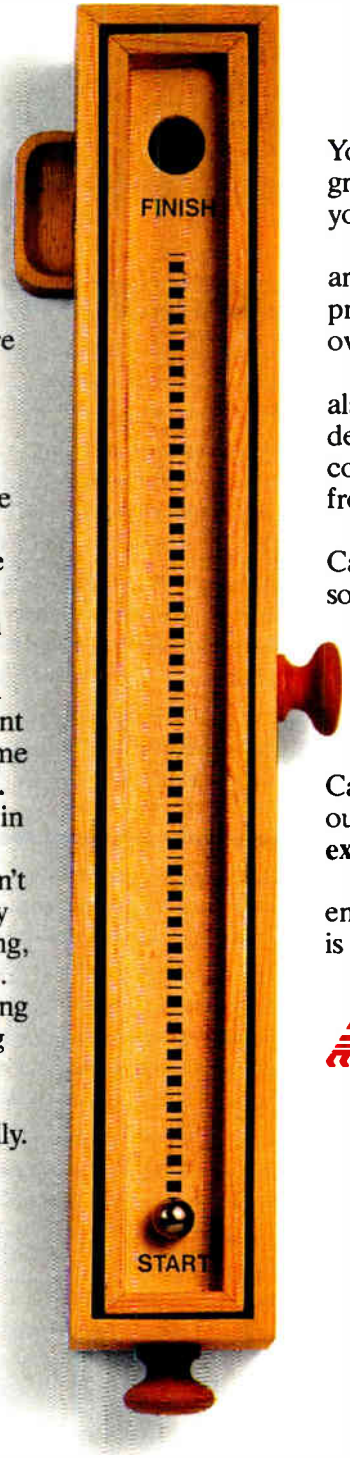

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sized quantum-well structures.

Those beliefs were based on the assumption that building good heterojunction devices depended on being able to layer semiconductor materials that met two criteria, says Jason Woo, assistant profess‡pwere that the semiconductors have a high-quality interface, and that they have sufficient bandgap energy—that is, a strong heterojunction effect.

But the new research is showing that the rules for building multilayer heterojunction devices are a lot less rigid than they had seemed, says del Alamo. They can in fact be violated, or at least modified, if the semiconducting layers are very thin. Now that this has become clear, he says, researchers have found a new freedom to take a fresh look at silicon and related Group IV materials. And they have been discovering that those materials could be used for a variety of heterojunction-based structures.

BORROWED TECHNIQUES. The effort to push the use of silicon into performance areas traditionally associated only with Group III and V materials is benefiting from fabrication techniques originally developed for GaAs and AlGaAs, according to Woo. Those techniques include molecular-beam epitaxy and metal-organic vapor-phase epitaxy.

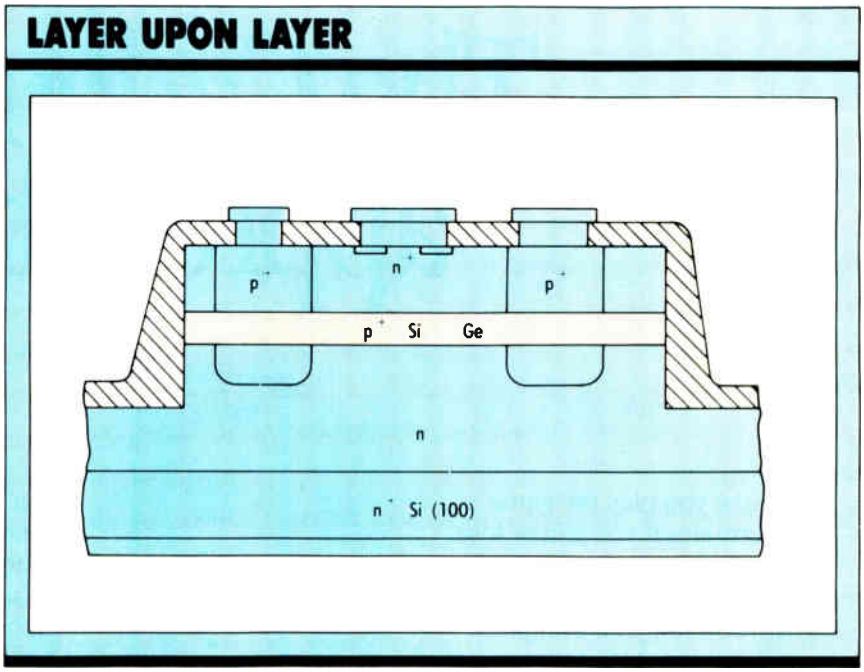
It is turning out, in effect, that the world is not flat. As the latest fabrication techniques are coupled with the new research, says Woo, limitations on silicon that everyone accepted as given are being rethought. "It appears that the traditional barriers or differences between materials such as silicon and gallium arsenide are more conceptual or perceptual rather than real," he says. "The differences are a matter of degree, rather than any fundamental barrier."

The big development—the paper that is likely to generate the most excitement among device physicists—is one describing the construction of a silicon/germanium bipolar inversion-channel field-effect transfer, or Bicfet, Woo says. The paper reports on work done by researchers from Stanford University's Center for Integrated Systems in California and IBM's Watson Research Center in Yorktown Heights, N. Y.

The traditional bipolar-junction transistor is the dominant technology for high-speed, silicon-based devices, Woo says, because of its large transconductance and current-drive capability. In the last 10 years, most improvements in bipolar performance have come from lateral and vertical scaling. But it is becoming clear that without a fundamental change in operating principles, vertical transport through the charge-neutral base is becoming the most dominant limitation to further improvement in switching performance, Woo says.

A way around that limitation seemed imminent about two years ago, when Geoffrey W. Taylor and John Simmons of AT&T Bell Labs in Murray Hill, N. J., came up with the Bicfet [*Electronics*, March 3, 1986, p. 27]. Their device relied on the field-effect inducement of an inversion layer that corresponds to the neutral base of a bipolar transistor. It had a three-terminal structure: a metallic resistor that made ohmic contact to a semi-insulating wide-bandgap semiconductor; a source that contacted the inversion layer formed at the interface between the semi-insulator and the semiconductor depletion region; and the bulk silicon substrate, which acts as the collector. The AT&T researchers said that their device worked by controlling the flow of majority carriers through the semi-insulating region to the collector by the biasing action of charge in the inversion channel.

LAYER UPON LAYER



From Germany comes AEG's silicon/silicon-germanium heterojunction bipolar transistors that were built with molecular-beam epitaxy.

> The rules for building multilayer devices are less rigid than they seemed

But there was a basic obstacle that stood in the way of the development. "Unfortunately, at the time, it appeared that the only way to build Bicfets was with molecular-beam-epitaxy-based gallium arsenide and indium phosphide heterojunction structures," Woo says.

But interest in the technology has not flagged. What makes the Bicfet so attractive is that, unlike a standard bipolar structure, it has no base to limit vertical scaling and, unlike a MOS FET, it has no drain to limit planar scaling. Rather than the conventional neutral base of a bipolar transistor, it relies on the field-effect inducement of an inversion layer. It works by controlling the flow of majority carriers through the semi-insulating region to the collector by the biasing action of a charge in the inversion layer.

The lack of a base makes it ideal for scaling down to 0.1 μm and below. Also, since it has no base, a Bicfet has a much lower capacitance than a conventional bipolar transistor. Coupled with the high transconductance, this results in very high speeds, in the hundreds of gigahertz and hundredths of picoseconds, for both analog and digital applications.

The significance of the Stanford/IBM development goes beyond the fact that it demonstrates that a Bicfet structure can be built from germanium and silicon. With a current gain of 365 at a current density of 24 KA/cm, it is the highest-performing device of its type ever reported. A key element in achieving that performance was the use of a double heterojunction inversion channel to eliminate collector-offset voltages, allowing the device to operate as a lateral p-channel modulation-doped FET with the extrinsic base connections acting as both source and drain.

ATTACK IN TEXAS. On another front, one of the most direct assaults on the barrier between GaAs and silicon is being waged by TI's Central Research Laboratories in Dallas. Researchers will report on a technique that goes beyond simply using silicon as a substrate on which to build GaAs structures of greater hardiness and less sensitivity to processing. The TI scientists have succeeded in building circuits that integrate GaAs and silicon transistor structures into the same circuit. More-

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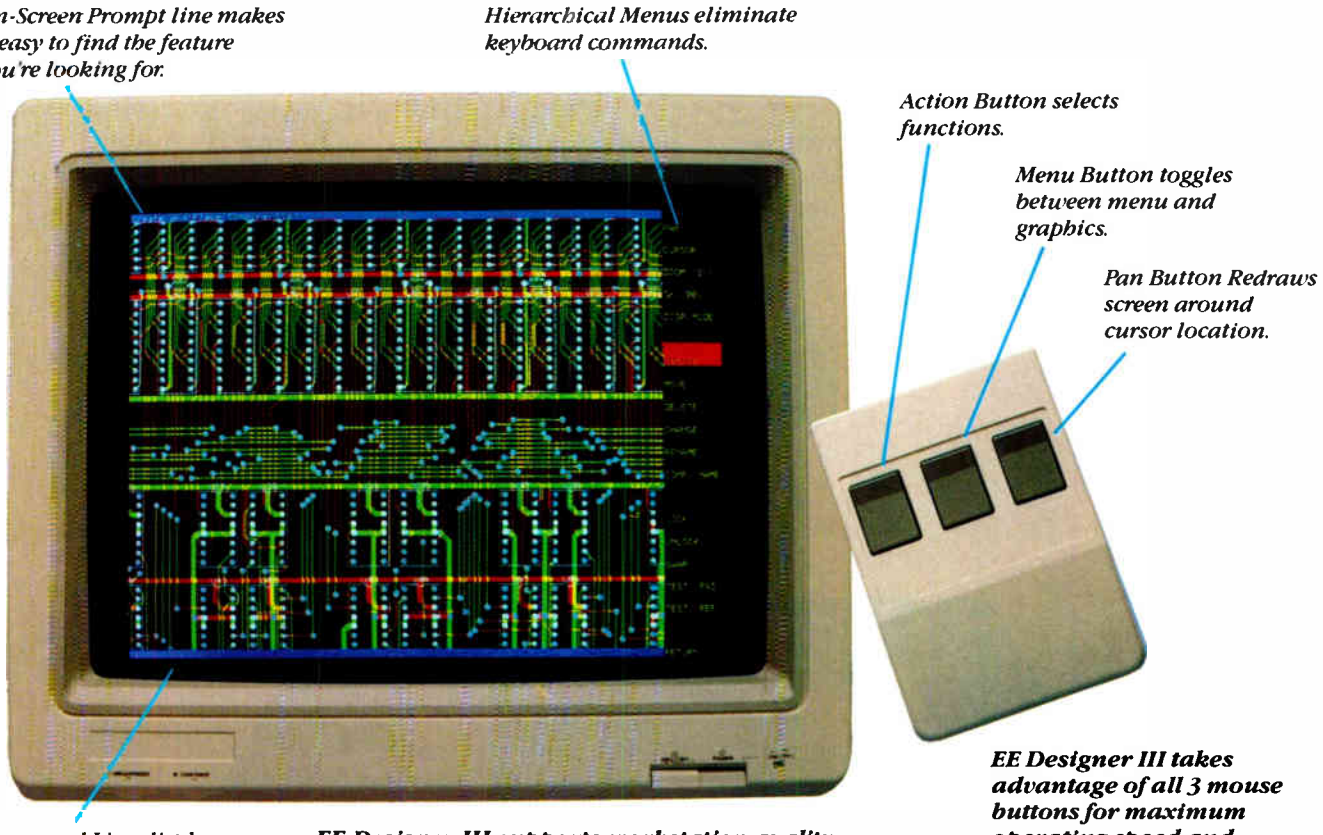

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over, they have done it with the addition of only five mask levels more than are needed in a conventional CMOS process.

The starting point for the Texas researchers is a standard 2-μm twin-tub device, upon which a silicon nitride passivation layer is deposited to prevent gallium diffusion during molecular-beam-epitaxial growth of the GaAs layer. After the growth, polycrystalline GaAs is deposited. Connecting the silicon and GaAs devices are GaAs MES FETs, which were fabricated using conventional recessed-gate processing with titanium-platinum-gold and gold-germanium-nickel metalization. A composite ring oscillator, built with the composite process and consisting of 35 silicon CMOS inverter stages and 12 GaAs MES FET buffered-FET-logic inverter stages, resulted in gate delays as low as 40 ns.

The TI researchers believe their results indicate the process is for all practical purposes generic. They say that they have shown, in principle, that it can be used to integrate any GaAs IC technology with any silicon IC technology—not only CMOS, but biCMOS, bipolar TTL, and emitter-coupled logic as well.

Taking part in IEDM as well will be Fujitsu, which will report on what is probably the most conservative approach. Researchers at Fujitsu's Advanced Technology Division in Kawasaki, Japan, have built an ECL array based on silicon heterojunction transistors that use hydrogenated microcrystalline silicon to build wide-gap emitters. The array fabricated with the process contains about 3,000 transistors that can be interconnected to form up to 400 ECL gates, with a basic delay of 295 ps at 6.5-mW/gate power dissipation.

Fujitsu researchers believe that in combination with such advanced silicon bipolar structures as polysilicon self-aligned structures and U-groove isolation, significantly higher densities and speeds should be possible.

AEG'S APPROACH. More wide-ranging are the efforts to be reported by AEG's research facility in Ulm, West Germany. One group of researchers from the center will describe their work on silicon/silicon-germanium heterojunction bipolar transistors that were built using molecular-beam epitaxy. The devices are intended for use in microwave and digital applications. The basic idea, the scientists say, is to provide an additional energy layer to holes ejected from the p-base into the n-emitter.

Another group of AEG researchers has experimented with a new low-temperature molecular-beam-epitaxy technique. The technique was used to build a variety of sophisticated device structures that traditionally have been associated with Group III-V materials. The structures from AEG include MOD FETs, 100-GHz mixed-tunneling and avalanche-transit-time diodes, and resonant-tunneling devices.

Yet another approach to heterojunction bipolar transistors will be described in a joint report from Stanford and Hewlett-Packard, both in Palo Alto, Calif. Researchers from the school's Electronics Laboratory and engineers from HP have built their transistors using strained layers consisting of silicon/silicon dioxide and germanium/silicon.

Unlike most other silicon-based heterojunction bipolar transistors, which are built using molecular-beam epitaxy, these structures were fabricated using a variation of chemical vapor deposition, a well-known and mature silicon-processing technique. Called limited-reaction processing, this variation is a thin-film growth technique that uses rapid thermal technology, rather than the gas-flow switching that is common in molecular-beam epitaxy. But it still achieves the necessary abrupt changes in layer doping and composition.

TI says its generic process integrates any GaAs and silicon IC technologies

The flurry of papers at IEDM are just the tip of the iceberg as far as silicon-based heterojunction devices are concerned, Woo says. "Virtually every significant industrial and university research laboratory around the world has some sort of research effort going on in this area," he notes.

For example, researchers at the department of physics of Sweden's Linkoping University have built a germanium/silicon double-heterojunction bipolar transistor with strained thin bases. Researchers at the department of engineering at Sophia University in Tokyo have been able to construct MOS devices with multilayer heteroepitaxial layers that consist of single-crystal silicon and boron phosphide.

Meanwhile, at IBM's Watson Research Center, scientists have also built silicon/germanium heterojunction bipolar transistors. With only 12% germanium content, they had six times the collector current of traditional bipolar structures at room temperature and 1,000 times the current at 90 K.

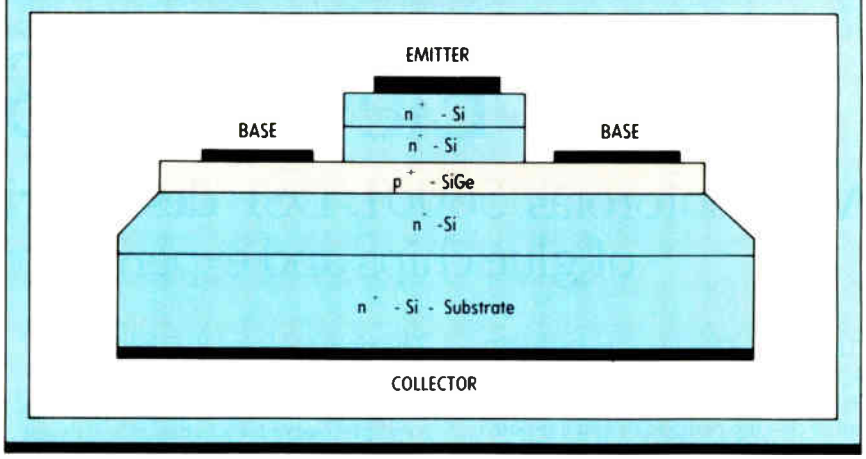
Of even more immediate impact, says Woo, may be work that is taking place at AT&T Bell Laboratories and elsewhere that uses silicide technology. This approach was originally developed in silicon circuits for metal interconnections, but the AT&T team is using it to build a variety of epitaxial silicide/silicon heterostructures from platinum silicide, nickel silicide, and cobalt silicide.

Looking farther out into the future are researchers at the University of California. Under the direction of Kan L. Wang, professor of electrical engineering. The researchers are looking at the construction of silicon-based multilayered superlattice and quantum-well structures [*Electronics*, October 1988, p. 143].

The payoff from all of the work now being done, Woo says, should be seen in two or three years for silicon heterojunctions using traditional processing techniques. The arrival of Si-Ge-based circuits using molecular-beam epitaxy and metal-organic vapor deposition will take five or six years.

Which of the structures now in development will succeed is hard to say. "What is obvious," Woo says, "is that no matter in which way such new technologies are implemented, the most fundamental impact will be that our view of silicon will have gone through a fundamental change. We will be able to look at what is possible to do with silicon without having any conceptual blinders." *–Bernard C. Cole*

ANOTHER LAYER OF ENERGY

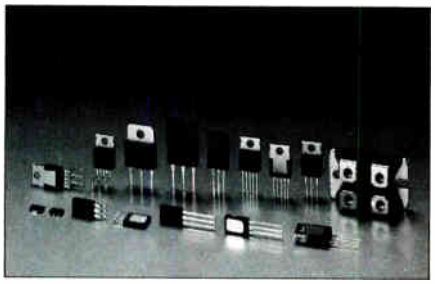


Using chemical vapor deposition, Stanford and HP have come up with an approach to heterojunction bipolar transistors built with silicon/silicon dioxide and germanium/silicon.

High Performance N-Channel PowerMOS Transistors

A new family of nearly 200 n-channel PowerMOS transistors from Philips Components offers the highest performance available, yet costs no more than existing devices. The BUK family of transistors spans low, medium and high voltages (up to 1000 V), and includes devices for use in such applications as automobiles and inverters.

The low-voltage transistors have cell densities of 1.6 million cells per square inch, which results in drain-source on-resistances as low as 25 mΩ. This feature is a key measure for PowerMOS devices, and corresponds to drain currents up to 56 A. Philips' new BUK family includes 14 low-voltage logic-level devices for 12 V battery operation in automotive and industrial applications, and 13 high-voltage FREDFETs for bridge or half-bridge applications in motor control, uninterruptible power supplies and inverters.



There are 74 low-voltage transistors with crystal sizes between 6 mm² and 20 mm², and with maximum drain-source voltages between 50 V and 200 V. Even the lowest voltage transistors in the family, such as the 50 V BUK453-50A, can carry up to 22 A drain currents because of $R_{DS(ON)}$ values as low as 80 mΩ.

There are 72 medium-voltage devices with drain-source voltages between 400 V and 600 V. These devices include 400 V transistors with $R_{DS(ON)}$ values of 400 mΩ and maximum drain-source currents of 14 A, and 600 V devices with $R_{DS(ON)}$ values of 800 mΩ, passing currents of 10 A.

Thirty-eight high-voltage transistors withstand between 800 V and 1000 V. These include 800 V devices with $R_{DS(ON)}$ values down to 1.5Ω and corresponding drain-source currents above 8 A, and 1000 V transistors with $R_{DS(ON)}$ values of 2Ω, passing currents of nearly 7 A.

Switching times are in the low tens of nanoseconds, allowing the transistors to operate at frequencies up to 10 MHz in resonant power supplies, for example. The devices are available in a choice of five packages, from the SOT-186 – a fully isolated version of the TO-220, which dissipates up to 30 W – to the SOT-93 (TO-218), which dissipates up to 250 W. Devices in other packages are in development.

Circle 806

Range of SensorFETs Provides "Loss-less" Load Protection

By dedicating a few of its cells to current sensing, this range of SensorFETs from Philips Components provides "loss-less" overcurrent, or short-circuit, protection for a wide variety of automotive and industrial applications.
Unlike most power MOSFETs, which detect load currents using a high-power resistor, these new SensorFETs use some of their current-carrying cells to direct a proportion of their current – a few milliamps – to an external control-regulation circuit.

The four SensorFETs that make up the BUK700 series can be used whenever current limiting is needed to protect equipment – such as motor drives – from damage. The BUK793 and BUK795 have maximum drain-source voltages of 50 V or 100 V.

These SensorFETs have densities of 1.6 million cells per square inch, the highest in the industry for these types of devices. This density cuts the drain-source on-resistance to between only 40 mΩ and 800 mΩ, depending on the device, and leads to current-handling capacities of up to 40 A for the 50 V devices and up to 25 A for the 100 V devices.

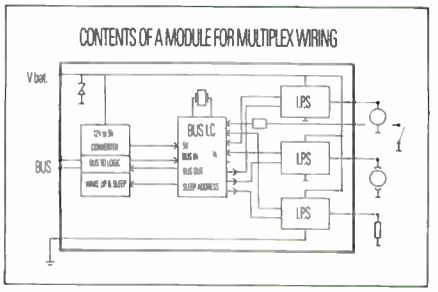
The SensorFETs come in TO-220 Pentawatt packages. Samples are available.

Circle 807

11 A High-side Switch for Automotive Applications

A new MOS Intelligent Power Switch has a drain-source, on-resistance $R_{DS(ON)}$ of only 33Ω, four to eight times lower than that of other such devices. Called the BUK196-50, the new device from Philips Components passes a drain-source current of only 11 A and its $R_{DS(ON)}$ matches the low contact resistance of mechanical relays, making it a suitable replacement for such relays in a variety of automotive and industrial applications.

The BUK196-50 is an n-channel transistor that fits on the battery-side (high-side) of the load. It incorporates short-circuit and thermal protection, and features current-sensing circuits. An integral charge pump boosts the car-battery voltage to ensure that the MOSFET saturates fully, even when the battery voltage falls to 6 V. A status indicator signals that the device is functioning, thus closing the feedback loop between the drive and switch.



The device connects directly to the industry standard decoders for the multiplexed bus systems that will appear in the next generation of automobiles.

The low on-resistance comes from the high cell density – 1.2 million cells per square inch – of the BUK196-50. The high cell density also leads to the device's 11 A rated current, which is maintained even with a case temperature of 85 °C and battery voltage as low as 6 V. The low on-resistance also leads to low losses – the device has a low quiescent current of less than 10 μA.
The transistor also has a maximum drain-source voltage rating of 50 V. Its projected MTBF is as good as the standard Philips MOSFET.

The BUK196-50 comes in a TO-220 Pentawatt package. Samples will be available in November.

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WASHINGTON INSIDER

TRW'S SUPERCHIPS TAKE A GIANT STEP CLOSER TO REALITY

It's been a long time coming, but TRW Inc. finally has first silicon in hand for its superchip—an ambitious project to produce a super-dense 28 million-transistor integrated circuit on a 1.4-in.^{2} chunk of silicon. TRW's foundry, Motorola Inc., has produced working silicon on three of TRW's eight macrocells using a 0.8-μm CMOS technology that eventually will be shrunk down to the 0.5-μm geometries required for Phase 2 of the Very High-Speed Integrated Circuit program. The Redondo Beach, Calif., company still has a ways to go, however. The company scaled down its original goal of 29 macrocells to eight last winter [*Electronics*, April 28, 1988, p. 34]. But this is still an important milestone, says program manager Thomas A. Zimmerman. Despite its difficulties, TRW is holding fairly close to the original VHSIC schedule, he says. Full chips will be ready during the first half of next year, he adds, just in time for brassboard testing late in 1989. Zimmerman is confident those target dates can be met because TRW has used its own funds to build a test chip that includes 0.5-μm gates and other features half that size. □

THE AIR FORCE PLODS ON TOWARD A 32-BIT PROCESSOR STANDARD . . .

The Air Force's broad search for a standard 32-bit computer architecture continues to rumble along. The Joint Integrated Avionics Working Group, set up by the Defense Department two years ago to coordinate development efforts between the Navy, the Army, and the Air Force, won't issue its decision on CAP-32—a 32-bit common avionics processor—until December 1989. That's when it must issue CAB-III, the common avionics baseline specifications that will be used when full-scale development begins on the Army's Light Helicopter Experimental and the Air Force's Advanced Tactical Fighter. Early details should be clear next month, though, when the group releases a preliminary baseline specification that "will identify the main elements of the common-item inventory," including processors, an Air Force spokesman says. One of the key questions facing the Air Force is whether to develop an original architecture for the military, as was done with the 16-bit 1750A computer, or to standardize on a commercially developed architecture. But there's a strong voice in the industry to take a third approach. "The question is, at what level should you standardize? The higher the level, the easier it will be for the government to take advantage of new technologies," says Robert D. Singer, marketing manager for military operations at Intel Corp.'s Automotive and Military Division in Chandler, Ariz. If the Pentagon can standardize on software, at the Ada language level, he says it will be better prepared to upgrade systems easily as new technology emerges. □

. . . AND LAUNCHES A RAD-HARD 32-BIT PROCESSOR DEVELOPMENT EFFORT

The Rome Air Development Center's RH32 program—for radiation-hardened 32-bit processor—is now fully underway, with IBM, Honeywell, TRW, and Unisys competing to define architectures and design evaluation circuits by next October. The winners—there will probably be two—will get an additional $7 million to $12 million to go on to the next step: incorporating the architectures in silicon. Performance will be the key factor in determining a winner. The competitors will be able to follow either reduced- or complex-instruction set architectures, but have been asked to try to support as many of the advantages of each as possible. "They can use any architecture they want as long as they meet our requirements for 20 million instructions per second on the benchmark," says program manager Heather Dussault. That benchmark is the Defense Advanced Research Projects Agency's Core Mips Instruction Set, a baseline approach to a RISC architecture that lacks some utilities, such as memory management. □

WASHINGTON INSIDER

MIMIC MOVES TOWARD STANDARDIZING ON CADENCE'S CAD FRAMEWORK

Developing a common computer-aided-design framework for chips designed under Mimic—the Pentagon's Microwave/Millimeter Wave Monolithic Integrated Circuit Program—has been a key program goal from the program's start. As the four Mimic teams move toward that goal, Cadence Design Systems Inc. of San Jose, Calif., looks like it's going to be the main beneficiary. Already two of the four Mimic teams—Raytheon-Texas Instruments and Hughes-GE—are using Cadence's Integrated Design Framework, a $50,000 system originally developed for silicon design, and a third—ITT-Martin Marietta—is leaning toward Cadence as well. Now the San Jose, Calif., firm—a newcomer to the aerospace industry and government contracting—is seeking funding under Mimic's ancillary third phase to further develop and enhance its framework for microwave design. The company expects an award by the end of the year. Jim Girand, Cadence's vice president of advanced products, says an award could be forthcoming by Jan. 1, resulting in new functionality by June. What's this new market worth to Cadence? Only about $2 million in 1989, Girand says, but perhaps as much as $10 million to $15 million a year by 1992. □

NOW ADA AND UNIX CAN WORK TOGETHER IN MISSION-CRITICAL APPLICATIONS

The National Aeronautics and Space Administration wants its computers to run Ada software within the multitasking Unix operating system, but so far its wish has hardly been a command. While running the two together is possible in most circumstances, NASA contractors complain that for mission-critical applications—where response to commands must be in the 100-μs range—Unix has too much overhead to react fast enough. Now DDCI Inc., Phoenix, Ariz., has licked the problem by setting up a system where programs can run under both Unix and Ada. DDCI installs the mission-critical functions on systems running under Ada's operating-system kernel and networks those systems transparently to other computers running under the company's DACS-386/Unix, effectively separating the mission functions from the bulk of a system's duties. The vast majority of NASA's applications programs do not need real-time response times, points out Lee Silverthorn, president of DDCI. Control of communications, disks, and peripherals remains with Unix, he says. That preserves the advantages of operating in a highly portable multitasking environment—without limiting the use of Ada code to a few parts of a system. "Everything can be coded in Ada," Silverthorn says. For the code that is not mission-critical, "we just run Ada on top of Unix." □

ANTISUBMARINE WARFARE IS TAKING OFF IN EUROPE TOO

It's no secret that antisubmarine warfare is the top priority for the U.S. Navy—the advent of faster, quieter Soviet submarines has prompted the Navy to invest more and more in ASW technology. But ASW is also attracting sizable spending in Europe, where the UK, France, West Germany, and nine other nations will spend a combined $26.5 billion on technology-rich ASW programs over the next five years, says New York market researcher Frost & Sullivan. New Soviet submarines are an order of magnitude quieter, and current technology "just doesn't do the job well enough or fast enough," says Tom Moir, president of Aptec Computer Systems Inc., Portland, Ore. That means big opportunities for computer makers like Aptec and makers of electronic sensors, Frost & Sullivan says. In Europe alone, Frost & Sullivan projects spending for sensors to rise from $610.7 million last year to $706.3 million in 1993. The biggest chunk of that money will come from the UK, which will account for 41% of the total, followed by France with 16% and West Germany with 13%. □

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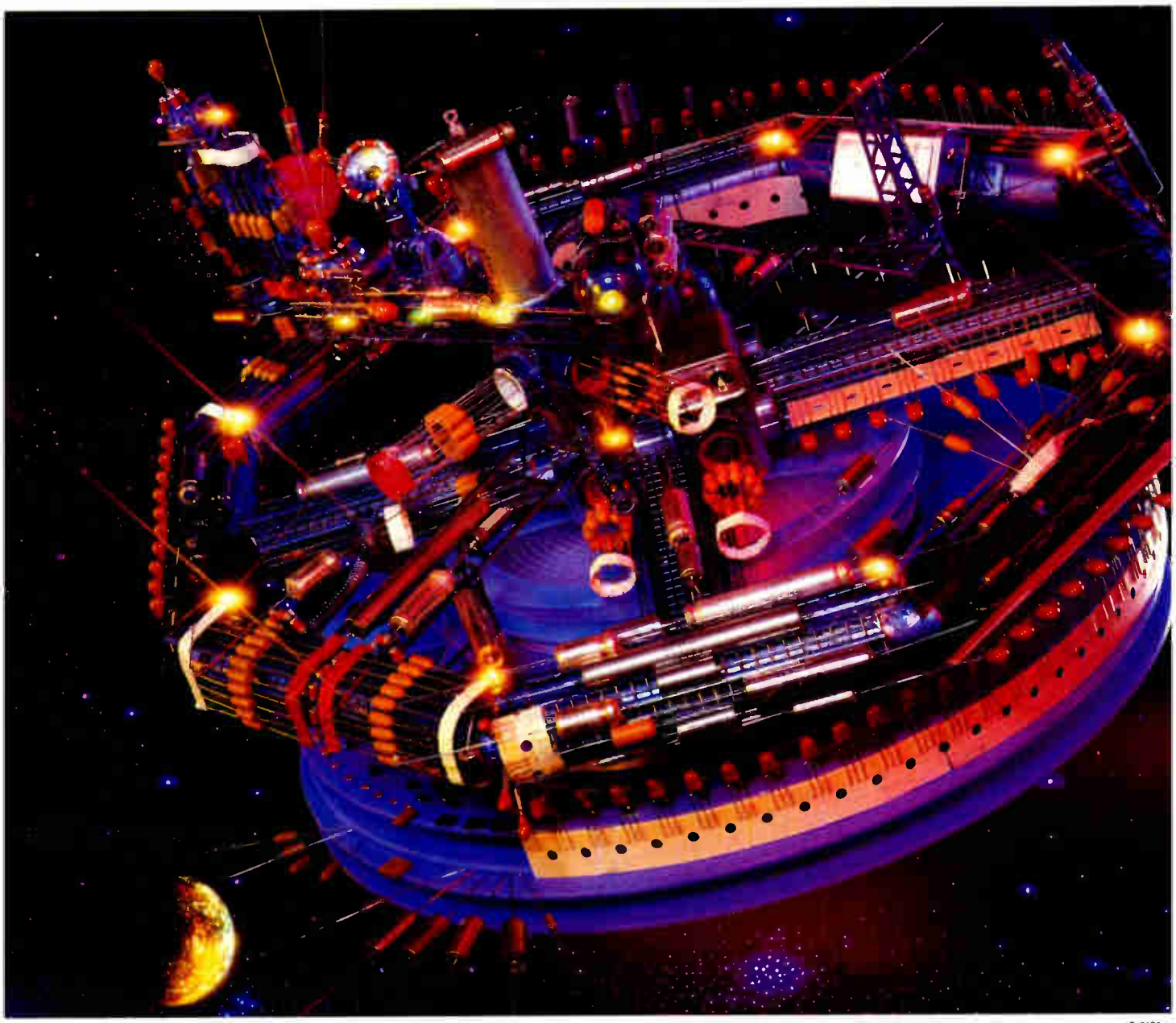

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PACIFIC RIM TRENDS

HP'S JAPANESE SUBSIDIARY PLANS A BIG PUSH IN COMPONENTS

An ambitious plan to boost components sales more than tenfold is underway at Yokogawa-Hewlett-Packard Ltd., Hewlett-Packard Co.'s Tokyo-based subsidiary. The company thinks it can boost sales by leaping into competition with Japanese electronics-component makers in the market for components that are used in office-automation equipment, consumer products, and automotive electronics. As part of the game plan, Yokogawa-HP will build a research and development facility, including a pilot plant, to come up with the components. Meanwhile, Yokogawa-HP is already planning to introduce several products this month, starting with ultra-high-brightness light-emitting diodes, solid-state relays, microwave components, integrated circuits for optical-fiber communications, and ICs for bar-code readers. Right now, Yokogawa's components sales are about 4 billion yen a year which is only 3% to 4% of its total sales—its main business is in test and measurement gear and computer hardware. The company wants to push components sales up to 5 billion yen a year one to two years from now and all the way up to 50 billion yen within five years. □

NEC TARGETS SOUTHEAST ASIA FOR SUPERCOMPUTER SALES

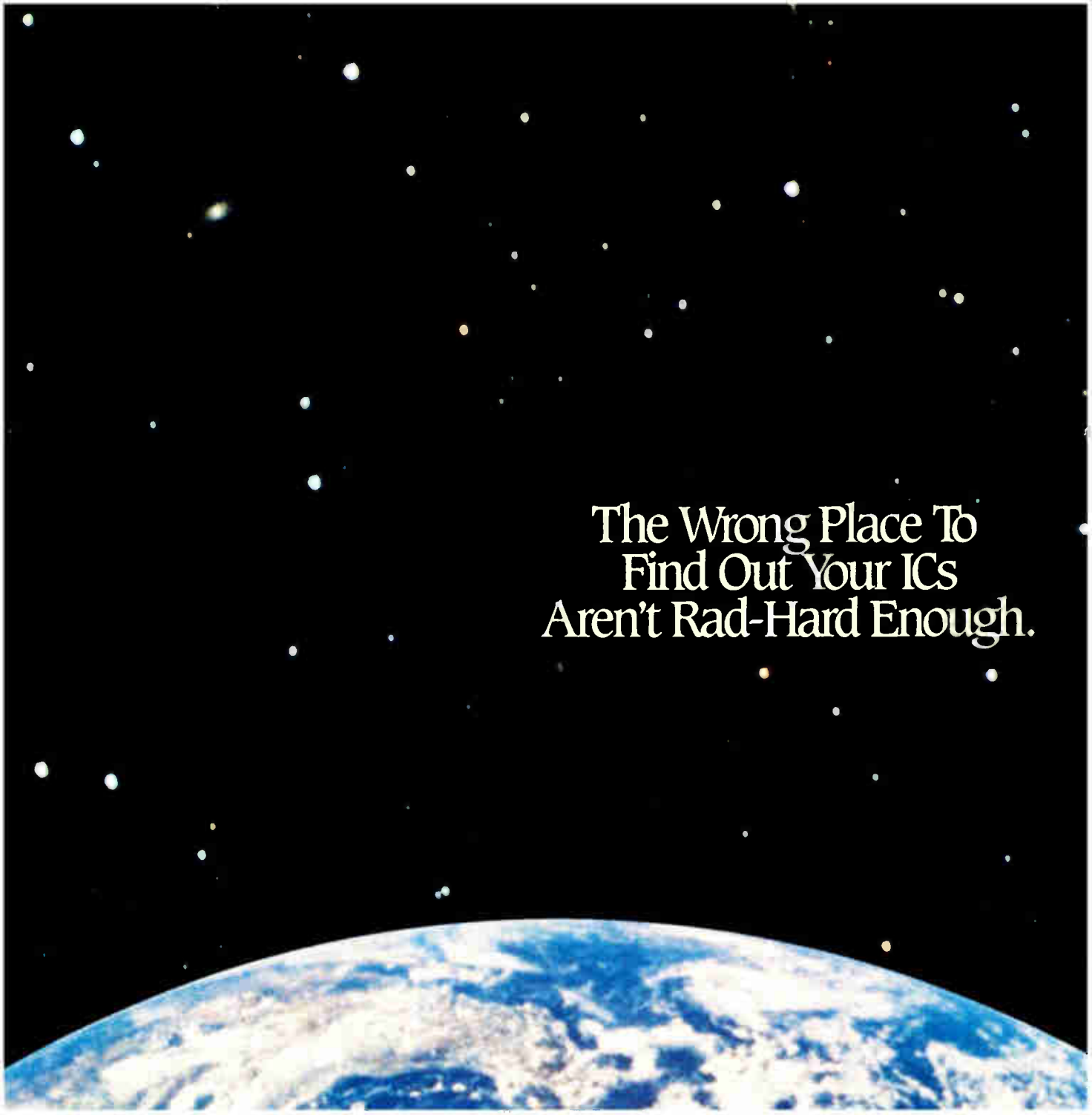
NEC Corp. is pushing to become the leading vendor of supercomputers to countries in southeast Asia. The Tokyo-based firm has already sold one of its supercomputers to the government of Singapore—the first supercomputer export sale in the region by a Japanese company. The SX-1A supercomputer is scheduled to be installed in a government-sponsored computer engineering center by the end of this year. The center plans to use the SX-1A not only in-house but also as the host for a remote-computing service it is planning to start. □

FUJITSU IS ADDING DRAM LINES TO A NEW ASIC PLANT IN OREGON

Another Japanese fabrication facility for memory chips is being set up in the U. S. Following the lead of NEC Corp. and Hitachi Ltd., Tokyo-based Fujitsu Ltd. will add fab lines for dynamic random-access memories to the plant it's opening in Grasham, Ore. The plant originally was established to manufacture application-specific integrated circuits, which it is scheduled to begin producing later this year. The lines for memory ICs will go into operation next spring, first turning out 256-Kbit DRAMs, then producing 1-Mbit DRAMs. Both the memory and the ASIC wafers will be shipped to the Fujitsu Microelectronics plant in San Diego for assembly. The California plant is already assembling 1 to 2 million 256-Kbit DRAMs, with wafers imported from Japan. □

OKI PUTS ITS RISC PROCESSOR INTO A MINICOMPUTER

A reduced-instruction-set microprocessor under development at Oki Electric Industry Co. Ltd. will be used in a minicomputer that Tokyo-based Oki is planning to build. The RISC processor features a Harvard architecture with separate memory-management units for instructions and data. A 64-bit system bus will transfer data at a rate of 160 Mbytes/s; a separate 32-bit input/output bus will move data at 64 Mbytes/s. A prototype processor has been fabricated in 1.5-μm CMOS with 150,000 transistors; Oki claims it performs more than 10 million instructions/s when operated at a 20-MHz clock rate. By next April, the company says, it expects to fabricate a processor using 1.2-μm CMOS technology with 250,000 transistors. That version of the processor will include on-chip cache and will raise the clock rate to 40 MHz. The minicomputer using the processor will be aimed at on-line-transaction and local-area-network-server applications. □



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EUROPEAN OBSERVER

THE MEGA PROJECT'S FIRST CHIPS ARE READY TO ROLL

Samples of the first chips produced by the Mega project, the joint effort by Siemens AG and Philips of Eindhoven, the Netherlands, to develop high-density memories, are starting to arrive. Munich-based Siemens is already delivering samples of its 4-Mbit dynamic random-access memories and Philips will soon ship samples of its 1-Mbit static RAM. Volume production of both chips is set for next year—on schedule, according to the original timetable put in place by the Mega project. The Mega project itself, which the two partners have agreed would run for only five years, is also scheduled to end in the middle of 1989. □

INTERMETALL LOOKS TO THE EAST TO EXPAND ITS DIGITAL-TV CHIP MARKET

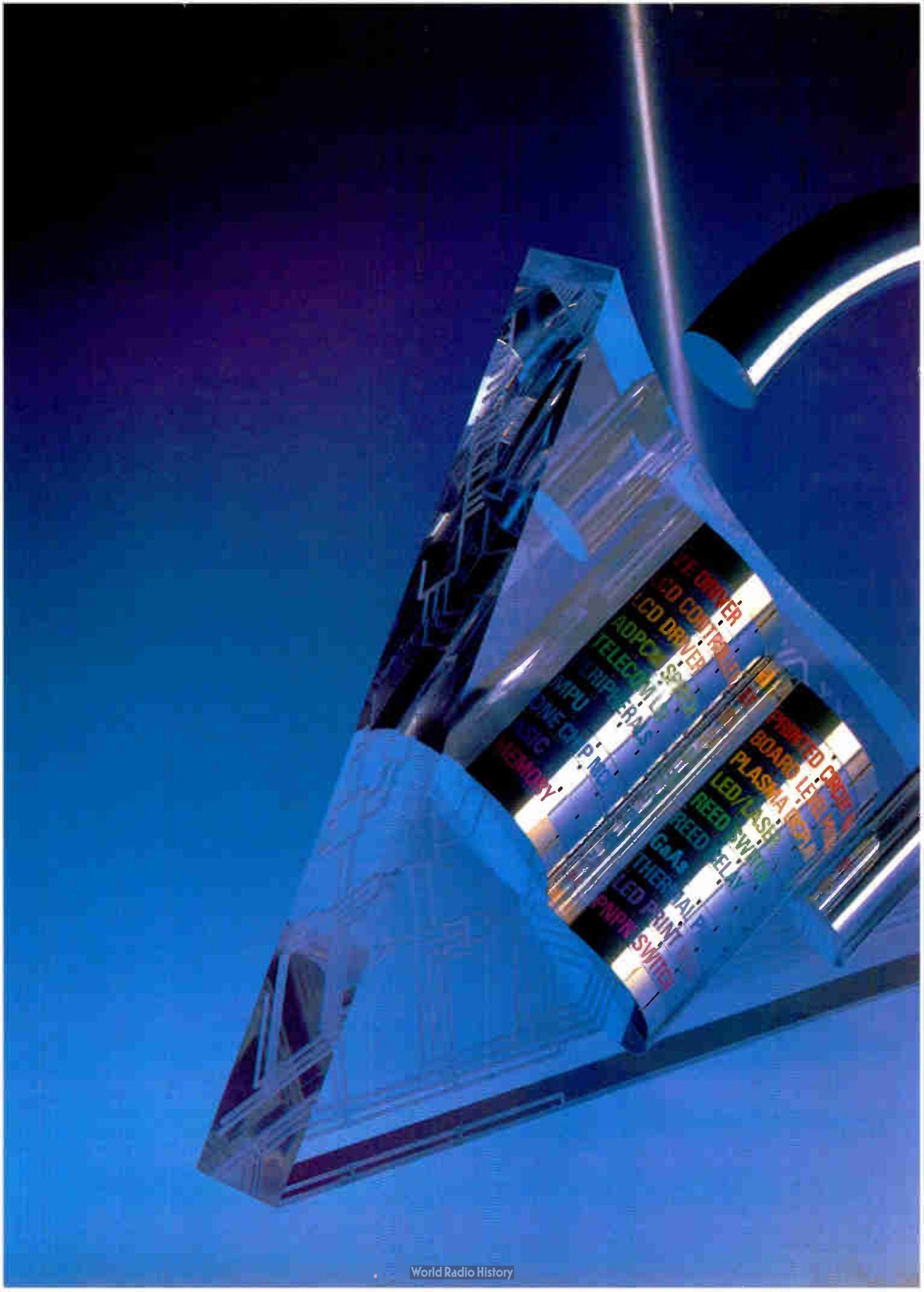
With its Digit 2000 digital TV chips well established in western markets, Intermetall GmbH is turning its sights toward Eastern Europe. Hungary's Selectronic Telecommunication Products Ltd. is already building wide-screen color TVs that use the chips and is selling them through the Skala-Coop department stores in Budapest. The sets are compatible with the PAL, Secam, and NTSC color-signal transmission norms and include a built-in decoder for videotex transmissions. They have 28-in. screens and feature a picture-within-a-picture capability. Intermetall, the lead house of the ITT Semiconductors Group in Freiburg, West Germany, is also negotiating with set makers in other Eastern-bloc countries—East Germany, for one—for deals on the Digit 2000 chips. The chips, which digitize all video and audio functions between the receiver's output stages and the intermediate-frequency stage—will be used this year in more than seven million TV sets built by various manufacturers in Japan, the U. S., and Western Europe. □

WEST GERMANY IS READY TO SIGN UP SYSTEMS FOR EUROPE'S MOBILE-PHONE NETWORK

Two groups are ready to sign contracts for systems that will make up West Germany's segment of the proposed pan-European digital cellular mobile-telephone network. Each group will supply essentially the same kind of systems, comprising switches and base stations for the network, which is slated for operation in 1991. One group consists of Siemens AG plus a consortium made up of Robert Bosch GmbH, ANT Nachrichtentechnik GmbH, and Philips Kommunikations Industrie AG, the latter an affiliate of the Dutch electronics giant. In this group, Siemens will supply its EWSD digital switch and the consortium will provide the base stations. The second group includes West Germany's AEG AG, France's Alcatel NV, and Finland's Nokia. Standard Elektrik Lorenz AG, a member of the Alcatel family of firms, will supply its System 12 digital switch; AEG and Nokia will provide the base stations. The Bundespost, West Germany's communications authority and networking agency, has sent both groups letters of intent informing them it plans to use their equipment; contracts should be signed by the end of the year. □

NORWEGIAN SAVINGS BANKS SET UP A NATIONAL SMART-CARD NETWORK

The Norwegian Savings Banks, a confederation of 150 independent savings banks with 850 branches, is expanding its nationwide automated-banking network to accommodate smart cards. The cards will be used in automatic teller machines, electronic-funds-transfer terminals in stores—more than 9,000 of which will be in place by the end of this year—and some 750 on-line gasoline pumps throughout the country. The banks' jointly owned computer-services company, Fellesdata AS in Oslo, set up the network that will handle the transactions, which links all of the branches except one—a bank on the island of Spitzbergen which uses a satellite link to Oslo. □



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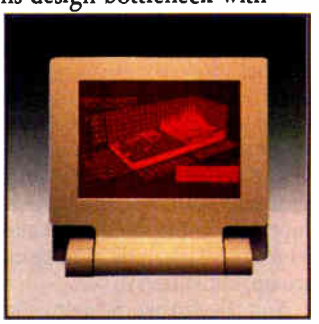

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SURVIVAL TACTICS FOR A

Refocusing business, attacking high-growth segments, and spinning off operations are all winning maneuvers

Harris Corp. executives huddled in a boardroom two years ago and prepared for the worst. Looking at the military equipment market, they reasoned that the good times—record growth in defense spending for the first six years of the Reagan presidency—were all but history. The federal budget deficit was out of hand, Congress was increasingly hostile to the military-industrial complex, and the defense market seemed headed for one of its cyclical nose dives. Harris managers were determined to be prepared.

So what they did that day in Melbourne, Fla., was to begin to map out a new strategy for getting through the tough times ahead. They decided to diversify into nondefense government businesses; to target those military markets—data and technical services, for example—that promised growth opportunities; and to pare down operating costs. With luck they would weather the storm.

Now the storm has struck with a vengeance. Budgetary constraints will keep new military programs on the drawing board and could mean that some established programs may be stretched out or even canceled. R&D funding is also likely to suffer. So like other defense-oriented companies—from the largest systems suppliers to the smallest makers of components—Harris is struggling: profits are up, but sales are flat.

And the future remains cloudy: forecasters don't expect the picture to improve for at least three to five years. Making matters worse are Pentagon policies that have forced contractors to take on more of the financial burdens and risks involved with systems development and a major procurement scandal that has set the industry, Congress, and the Pentagon on edge.

Today, more than ever, defense electronics companies need clear new strategies to help them through the harsh realities of the time. Some are looking at striking second-source deals that offer little or no risk but plenty of rewards. Others are trying to reduce the defense portion of their businesses in order to protect against future uncertainty, while targeting only the top-performing market segments. Many are downsizing. And some are looking to strategic partnerships or acquisitions to help them get into emerging growth markets.

Total military electronics spending is expected to grow at a compound annual rate of 4.3% through 1993—less than half the rate of nonmilitary aerospace electronics—but some technologies will see better growth (see table, opposite page). Civilian aerospace electronics markets, though much smaller than their military counterparts, are growing at a compound annual rate of 8.9%, says Gregory Sheppard, a senior market analyst with Dataquest Inc. in San Jose, Calif. That's prompting many military aerospace specialists to put increased emphasis on commercial opportunities.

Unlike systems and subsystems companies, however, chip makers who sell to the military can look forward to much stronger growth over the next five years, Sheppard says. Military semiconductor consumption, in terms of dollars spent, will rise 9.3% from now through 1993, with some of the most dramatic growth in application-specific parts (see p. 73).

PRIME CONCERNS. But prime contractors and systems suppliers are facing hard times. "The whole atmosphere [for selling to the government] is negative," says Paul Nisbet, an analyst with Prudential-Bache Securities in New York. While the market continues to lose ground, maneuvers to cut costs are severely limited by cumbersome procurement regulations. "Almost 30% of the cost of buying and building weapons is [for record keeping] to keep the Congress happy," Nisbet says. Another limitation is firm fixed-price development contracts, which manufacturers say force them to bet blindly that new systems can be developed for a preset price tag. "The tremendous investments that must be made just to compete are sapping the profitability of those firms that are going after major programs," Nisbet adds.

Programs such as the Air Force's Advanced Tactical Fighter and the Navy's Advanced Tactical Aircraft were structured in recent years to offload development risks onto system contractors. Companies hoping to get a piece of the action when the Pentagon starts buying systems and deploying them in the field are left with little choice: either help fund development work or risk being locked out when procurement starts.

The offload concept originally seemed good for the Department of Defense, because it reduced up-front costs. But now, experts in the Pentagon and in industry are questioning the wisdom of a DOD strategy that asks industry to pay now so that it might reap returns later on. "We can support that up to a point," says John Kreick, president of Sanders Associates in Nashua, N. H., which makes command, control, and communications equipment and electronic-countermeasure devices. "But it could dilute our ability to look more than five years into the future. I'm concerned the nation may be making a mistake by robbing us of that ability. And if the DOD begins to cut back on [support for independent R&D], it could make that problem even more serious."

by Tobias Naegele

HOSTILE DEFENSE MARKET

Kreick's concerns about independent R&D expenses—which can later be billed to the government if the resulting technology becomes part of a procured system—are echoed throughout the industry. And while a measure that would have capped such Pentagon spending at the $5.8 billion level was ultimately eliminated from the fiscal 1989 defense appropriations bill, many are still worried that the Pentagon will simply hold down these reimbursements administratively.

If the Pentagon continues with such policies, industry insiders worry, key industry leaders could well decide the rewards from the military market don't justify the necessary investments. The long-term result could be less competition in the procurement phases of major contracts, meaning that the government could actually end up paying more while getting somewhat less.

So what's the solution for government contractors? "Avoid the major programs that require a lot of up-front money and development risk," Nisbet says. In fact, the financial community now sees such commitments as a liability for a company, says Wolfgang DeMisch, a defense analyst with Union Bank of Switzerland in New York. "Wall Street is putting bidders for name-system contracts at a discount, because they think the big high-profile programs will get squeezed in Congress," he explains.

Upgrades catch the most attention in electronics circles because organizations such as the Electronics Industry Association have long pointed to these electronic goody-bags as being the one bright spot in an otherwise gloomy market picture. "If you have fewer weapons, then you need smarter weapons, and that's where electronics comes in," says Dataquest's Sheppard. "In the components and semiconductor area, the DOD still has a ways to go to catch up to existing technology—they're still sitting there with 1970s technology."

> Some believe firms should seek low-risk 'build-to-print' contracts

Nisbet recommends that in order to survive, companies should seek "build-to-print" contracts—second-source deals that are risk-free because a competitor has already taken on the development risk in an earlier contract with the government. The alternate source just tools up to build identical systems. The result: reduced risk and increased profits.

That's been the formula for success at Raytheon Co. in recent years, and it's paid off royally. The Lexington, Mass., company has some of the highest profit margins in the industry as a result of shunning fixed-price development contracts in favor of second-source agreements, Nisbet says. Raytheon is second-sourcing General Dynamics Inc.'s Stinger missile, for example, as well as Hughes Aircraft Co.'s Amraam missile—a program that stuck Hughes with over $250 million in unrecoverable development costs.

Now, even Hughes—long considered the kingpin of U. S. military and aerospace electronics technology—is looking at the second-source route. Though still the world's top radar equipment company with around $1.5 billion a year in radar sales, Hughes is now avoiding prime contracts whenever possible. "For the first time we're looking hard at second-sourcing, which we disdained several years ago," says Jacques Naviaux, director of marketing at Hughes's Radar Systems Group in El Segundo, Calif. "It's called moving down the food chain."

But the second-source strategies are not always a sure-win option. "Raytheon's strategy has worked very well because it's in tune with the times," says Union Bank's DeMisch. "It's a viable effective strategy because [in the missile business] the volumes are big enough to justify it. It's not clear it would work in nonmissile markets."

So for growth, Hughes is looking to new territories. For example, it is using telemetry techniques developed for aerospace projects to develop controllers for oil wells in the North Sea. It is also looking for ways to transfer technology and products to automotive markets for its car-building parent, General Motors Corp.

But since major growth from those areas is still far away, Hughes is looking at

WHERE THE MONEY IS IN DEFENSE EQUIPMENT

	($ Millions)			Compound Annual Growth Rate (%)
	1988	1989	1994	88-94
Total	81,878	83,336	105,681	4.3
Radar	11,034	11,124	13,316	3.2
Sonar	3,766	3,791	4,631	3.5
Missile-Weapon	10,115	10,360	13,937	5.5
Space	7,041	7,066	9,418	5.0
Navigation	2,272	2,315	2,941	4.4
Communication	7,562	7,801	10,095	4.9
Electronic Warfare	5,461	5,604	7,292	4.9
Reconnaissance	3,689	3,789	4,862	4.7
Aircraft Systems	7,140	7,267	9,489	4.9
Computer Systems	7,873	8,053	10,710	5.3
Simulation and Training	1,029	1,062	1,474	6.2
Other	14,897	15,134	17,516	2.7

other technologies for the short term. In June, Hughes and GM paid $283 million for Rediffusion Simulation, a British leader in flight-simulation technology.

Why simulation? The soaring cost of military hardware is forcing the armed services to invest in simulation and training systems because they can't afford to tie up critical hardware in training. As a result, the simulation and training market is growing at a 6.2% annual clip—50% faster than the overall military market. But it's also attractive for other reasons. "It's an area where your costs are in control," says Dataquest's Sheppard. "You can use commercial-grade components, especially semiconductors." Small- and midsized computer companies such as Elxsi in San Jose, Calif., he says, "can get in there and do their thing very well" without having to make a major investment in specialized equipment or elaborate bookkeeping.

The military market is especially tough for these smaller players, whether they are making components or computer subsystems, Sheppard says, because "they're the tail of the dog." That makes them especially vulnerable to procurement regulations that burden companies, large and small, with extra work. "All of these procurement regulations and scandals and everything else come down to really whack these guys on the head."

Defense industry officials held their breath over the summer and early this fall when many thought the Congress would pass a slew of tough new laws, such as a $430 million cutback in the $3.8 billion scheduled for funds for DOD consultants; a bill that would have required that contractors divulge information about profits in nondefense parts of their business; and a stiff new measure to ferret out fraud and reward employees who turn in their employers.

GOOD NEWS. But Congress proved much more compassionate than anyone had thought, says Dan Heinemeier, director of the Electronics Industry Association's Government Procurement Relations Council. The Defense Appropriations bill turned out to be "very positive" in its treatment of these issues, and none of the threatened measures made it through.

That's good news for everyone in the industry, whether large or small. But it's not enough to guarantee anyone's survival. The key to success for small companies in these difficult times is fourfold, says Tom Moir, president of Aptec Computer Systems Inc., a small maker of input/output computers in Portland, Ore. "You need to be in growing segments; you need to develop exceptional market intelligence so you can go for programs that have long-term political support; you've got to avoid looking like you are a commodity supplier; and you've got to deliver more than you promise," he says.

Moir sees great potential for his systems, which are designed to off-load I/O functions to speed real-time processing in such markets as surveillance, verification, and radar signal processing.

But the decision to target these markets wasn't just based on a few generic market reports. Aptec gets its information from a team of experts—a six-person advisory board headed by retired Air Force Gen. James Stansberry that meets quarterly to critique Aptec's marketing plans and to help decide which government programs it should go after.

Moir says it's still too early to point to any success stories that have come out of the year-old advisory group. But "the direction we have chosen to follow over the long term and the way we're allocating our resources have a lot to do with the advice we've gotten from this group."

Larger companies face different problems. For them, diversifying in a wide range of markets and industries is essential. That's why many aerospace primes are eyeing growth markets in the commercial arena. "Lockheed, McDonnell-Douglas, Westinghouse are all trying to push more into commercial, either through an extension of their own military operations or through acquisitions," Sheppard says. In fact, acquisitions have taken the industry by storm (see table, below). Large defense companies aren't just looking for commercial opportunities either—they're trying to diversify within the defense markets they sell into, in particular by seeking out smaller electronics technology firms with a presence in growth markets.

So in the past two years, Lockheed has bought Sanders Associates; Boeing has

HOW DEFENSE TECHNOLOGY CHANGED HANDS

DATE	TRANSACTION	COST ($ Millions)
11/03/87	Plessey plc acquires Sippican Inc., a specialist in underwater weapons systems based in Marion, Mass.	80.0
1/21/88	Thomson SA of France buys Wilcox Electric Inc., a maker of air-traffic electronics, from Northrop Corp., the struggling U. S. aerospace giant.	N/A
1/22/88	Westinghouse Electric Corp. buys Gould Inc.'s Ocean Systems Division, a manufacturer of advanced undersea weapons and guidance and control systems.	100.0
3/10/88	Talley Industries Inc. buys John J. McMullen Associates, an engineering firm specializing in naval architecture and marine engineering.	15.0
4/15/88	General Motors Corp. buys Rediffusion Simulation, a maker of flight simulators for the military with annual sales of $280 million, from Bet Public Ltd., of the UK.	283.0
4/20/88	Plessey plc buys Leigh Instruments of Kanata, Ontario, in Canada. Leigh manufactures avionic equipment and radio communications systems.	826.0
4/28/88	A private group of investors buys Pneumo Abex, a small maker of aircraft flight controls, brakes, and landing gear, from IC Industries Inc.	1,200.0
4/29/88	Blinder International Enterprises buys 90% stake in Marvin Engineering Co. Inc., a West Coast maker of aerospace equipment with annual sales of $50 million.	85.0
5/17/88	Diagnostic Retrieval Systems Inc. buys Photronics Corp., a supplier of photoelectronics products for the Army with annual sales of $13.6 million.	13.9
7/14/88	Plessey plc acquires the Electronic Systems Division of Singer Corp., a specialist in military communications and electronics and a prime contractor for the Air Force's Joint Tactical Information Display System.	310.0
8/04/88	Plessey plc buys the special defense and industrial activities of Fisher Controls Ltd., which makes measurement and control instruments for the military. Plessey is buying the unit from Fisher Controls International Inc., a subsidiary of Monsanto Co.	N/A

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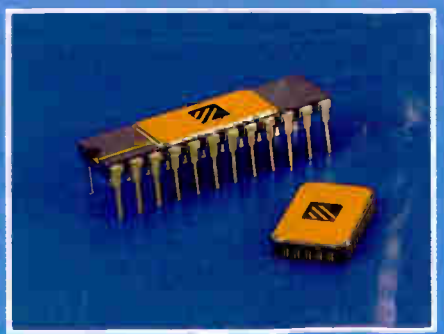

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added Argoystems Inc., an electronics subsystems house in Sunnyvale, Calif.; Chrysler has acquired Electrospace Systems Inc., a satellite communications-equipment maker in Richardson, Texas; and General Instrument has picked up Dalmo Victor Inc., a Belmont, Calif., maker of radar threat-warning equipment that has been part of Singer and Sperry.

More of the same is expected. "One can assume there will be more—there are still companies out there with the very same characteristics," says Bregman of Oppenheimer. And a takeover could actually turn out to be a boon for such a company, points out Daniel M. Heally, chairman of Big-Eight accountant Peat-Marwick Main & Co.'s Government Contracting Practice in Palo Alto, Calif. "The merger and acquisition route may be the only route to success for smaller companies without the financial wherewithall to go it alone," he says.

Two kinds of takeover opportunities exist. One is with niche players, like Electrospace, that were founded by entrepreneurs and maintain a strong hold on their particular markets. The other is with troubled conglomerates or divisions in conglomerates, such as Singer, which is being broken up and sold off in pieces by financier Paul Bilzerian, or Tracor Inc., which was the first in an expected series of acquisitions by Westmark Systems Inc., a holding company set up by retired admiral B.R. (Bobby) Inman to buy defense technology concerns.

Companies that have fallen out of favor with Wall Street have seen their stock prices fall to historic lows, Bregman says, offering good bargains for investors who are willing to wait a few years for a return on their investment. Companies with significant operations outside of the defense arena may sell off parts of their defense business, as Honeywell is doing by putting four units in its Space and Aviation Systems Business up for sale. Honeywell is trying to focus on its strongest markets, such as flight controls and cockpit displays, and get out of some others, such as electro-optics and communications (see "Honeywell refocuses its defense strategy," p. 73).

Likely takeover targets are niche players and pieces of troubled big companies

In addition to Honeywell, he cites Unisys, which is selling off defense units that it acquired when it merged with Sperry; and United Technologies, which is trying to unload its Norden Systems operation in Norwalk, Conn. Norden got into trouble in recent years by bidding on too many contracts and winning more than expected. As a result, it has lost over $600 million on radar contracts, Nisbet says, and "would be sold so fast it wouldn't be funny if someone offered, say, $200 million."

But while U. S. players seem to be second-guessing their commitment to the military market, foreigners are flocking to U. S. shores. Plessey plc, for example, has been actively seeking U.S. opportunities, pushing hard to expand its presence in the U. S., mostly because its home market—Great Britain—is not big enough to sustain high levels of growth in a time when defense budgets worldwide are under pressure (see "For Plessey, the U. S. is a land of opportunity," below). "Foreign buyers seem to have a clearer appreciation of the assets that being a U. S. defense supplier bring," says DeMisch of Union Bank of Switzerland. "We may look at the U. S. market as being in choppy water and approaching difficulty, but to the rest of the world, this is clearly the biggest and best market to be in."

MIDSIZED STRUGGLE. Plessey has picked up several parts of Singer and even made a play for Harris. That bid was particularly interesting because it points up many of the struggles facing midsized defense companies, such as Harris, in the current environment. Like other military contractors, Harris has struggled in recent years. Its Government Systems Sector has instituted tight cost and quality controls "in view of what we see as about four more years of very tight budgets," says Phillip Farmer, senior vice president and sector executive.

"These are tough major undertakings for us," Farmer says. "We're not a supplier of major weapons systems, and our view is that our customers—DOD and the primes—could do just as well without us,

FOR PLESSEY, THE U.S. IS A LAND OF OPPORTUNITY

Some U. S. technology companies may be reconsidering their commitment to serving their country's military market, but foreign-based firms seem to have little doubt about their plans to go after that business. Many are trying to take advantage of a cheap U. S. dollar to buy into the world's biggest defense market—one that accounts for half of the world's defense system purchases outside the Soviet bloc.

No company exemplifies that trend better than Plessey plc. The British defense electronics giant had only the most modest portion of the U. S. market a year ago, with just $34 million of sales in the country. Then it launched a shopping spree, making a series of major acquisitions that have boosted its total defense sales in the North American market to about $450 million in 1988—all but about $30 million to U. S. customers.

Plessey began its acquisition spree in October 1987 with the purchase of Sippican Inc. of Marion, Mass. Since then it has bought Leigh Instruments Ltd. of Ottawa, Ontario, in Canada; a unit of Fisher Instruments and Controls International Inc. in Lewisham, UK; and Singer Corp.'s Electronic Systems Division of Wayne, N. J.

Plessey sought this global presence in response to a pressure-packed market at home in the UK, says Philip Parker, director of corporate development at Plessey. Opportunities for growth were limited by the UK's comparatively small defense budget, he says, and competition was fierce with such other major players as Ferranti International Signal plc and Racal Electronics plc.

"Since the U. S. represents around 50% of the global defense electronics market, we recognized that we would have to address its marketplace" in order to grow, Parker explains.

MOVING IN. But there were problems. The barriers to entry in the U. S. market are formidable, Parker says, "because of existing established suppliers and the general desire not to allow national security assets to move into foreign hands." So Plessey devised a strategy to approach the U. S. market from a strong, indigenous base, rather than as a direct export market. That meant acquisitions, and about two years ago Plessey started to shop around. It immediately set its sights on a giant prize—Harris Corp. of Melbourne, Fla.—but objections from the Pentagon apparently nixed that deal.

With that experience in its portfolio, Plessey looked for less conspicuous acquisitions, searching out companies that complemented rather than mirrored its own technology. It bought Sippican, which Parker calls "a bridgehead into U. S. markets for the products of Plessey Naval Systems Ltd.," and then Leigh Instruments. This gave Plessey a route into the Canadian defense market. And in Singer, Plessey found the sizable operation it considered crucial to success in the U. S.

The unit, which has since been renamed Plessey Electronic Systems Corp., has "inherent growth potential," Parker says, and will become the British company's flagship subsidiary in the U. S. Now company executives say they're looking for another acquisition, but Plessey's purchase spree in North America seems to be over. The next conquest, analysts predict, will be in Europe.–*Peter Fletcher*

so we've got to be more competitive."

So Harris set out to make itself a better supplier. For example, it has cut the time it takes to assemble and test printed-circuit boards from more than 12 weeks to only seven business days by setting up assembly teams that work together to do the full job at a single station. Assembly workers are now encouraged to suggest methods to improve their systems, something Farmer calls "process ownership." Now comes the harder part: "The real test is how to do similar things in the white-collar areas," he says.

Overall, Harris executives say they've held on very well—despite flat earnings over the last three years that have forced the sector to hustle hard just to stay in the black. But the company seems to have recognized that it too must join the acquisition frenzy to survive. In August, Harris announced a deal with General Electric Co. to buy GE's Solid State Division.

The move made Harris one of the top two purveyors of chips to the military [*Electronics*, October 1988, p. 164] and the hands-down leader in vital radiation-hardened chip technology, which is growing in importance for applications in space and electronic warfare. Is Harris shopping around for more? Says Oppenheimer's Bregman: "I wouldn't be surprised to see them buy some other defense electronics companies—they've already got a good base to build on."

Additional reporting by Lawrence Curran, Larry Waller, and Wesley R. Iversen

HONEYWELL REFOCUSES ITS DEFENSE STRATEGY

By and large, the companies losing faith in the defense market aren't the prime contractors who are committed to it lock, stock, and barrel—rather, it's the diversified multi-industry giants who can't stand the heat in the kitchen.

"Multi-industry companies that are in the defense business on a part-time basis—Honeywell, Allied Signal, and United Technologies, for example—have many diverse elements to keep up with in their companies," says Paul Nisbet, an analyst with Prudential-Bache in New York. "In tough times, they are the first to show poor performance, and are likely to spin off some operations if they can't see a good short-term return."

Witness Honeywell Inc.'s Space and Aviation Systems Business, a large unit in 1987 with sales of $1.899 billion—about 28% of Honeywell's $6.679 billion total. It is the larger of Honeywell's two military operations, which make up about 46% of the company's business.

But size alone does not a winner make. Honeywell paid Unisys Corp. over $1 billion for Sperry Aerospace two years ago and has written off over $27 million for contract management and inventory problems since. Now Honeywell charges that Unisys misrepresented the value of the unit, and is seeking $350 million in damages.

Today the company is downsizing and selling off units that aren't in its core markets. "What we're trying to do is focus our operations in those markets where we are the strongest and have the most competitive advantages," says William W. George, president of Space and Aviation Systems Business. These markets include inertial navigation, flight controls, cockpit displays, and avionics integration.

So Honeywell is selling four units in its Space and Aviation Systems Business that, though they have "good financial records" and maintain "reasonable positions in their markets," do not fall within the company's focused outlook. The four units include Honeywell's Electro-Optics Division in Lexington, Mass., which produces infrared imaging components; the Training and Control Systems Division in West Covina, Calif., which supplies maintenance trainers and computer-based flight simulators; the Defense Communications and Production Division of Tampa, Fla., which specializes in high-volume production of military comunications gear; and the Signal Analysis Center in Annapolis, Md., which designs, produces, and tests secure communications devices.

George says the refocusing will also help reduce dependence on military markets. While 1987 sales were split with 50% in military avionics, about 30% in commercial flight systems and avionics, and 20% in space systems, he says that after the sale of the four units, the mix will likely be 40% commercial, 40% military, and 20% space. *–Wesley R. Iversen*

WEAPON UPGRADES ARE A BOON FOR CHIP MAKERS

The U. S. defense market may be set for a nose dive in the next several years, but not everyone will get hurt. Surprisingly, the safest place to be in military electronics markets seems to be chips, historically the most volatile segment of the commercial industry. In fact, analysts are predicting that chip sales will rise 9.3% a year through 1993—better than twice the rate of overall military electronics spending.

Much of the optimism derives from the Pentagon's need to upgrade equipment. Since the military will have less money to spend in general, industry insiders say improving current equipment with the insertion of new technology—faster and denser chips, for example—is wiser than developing all-new gear from scratch.

That means producers of advanced microprocessors and other integrated circuits, such as nonvolatile memories, should do well. But not everyone in the military chip market will be able to cash in. Microwave-circuit manufacturers, already squeezed by an overcrowded market, are preparing for lean times. And purveyors of Very-High-Speed Integrated-Circuit products—the fruits of the Pentagon's high-profile VHSIC program—complain that demand has not been anywhere near levels that they and the Department of Defense had foreseen.

> Military chip sales should grow at twice the rate of overall defense spending

Finally, upgrades aren't guaranteed. While they may be needed to meet an ever-changing military threat, the extent to which upgrade programs can win the funding they need from the Congress and the DOD has yet to be tested, says Wolfgang DeMisch, an analyst with the Union Bank of Switzerland in New York. "In the 1970s, new programs like the F-14, the F-15, and the B-1 bomber took away funding from upgrades," he says. "If the DOD is seriously short of funds on more advanced development, they'll raid the upgrade accounts again."

That kind of thinking doesn't discourage chip makers, though. Companies such as Intel, Harris, LSI Logic, Motorola, National Semiconductor, Texas Instruments, and United Technologies Microelectronics Center are all well-positioned technologically to score in the current environment, says Gregory Sheppard, a senior market analyst with Dataquest Inc. in San Jose, Calif. "Motorola's 68020 microprocessor is getting designed in everywhere," he says. "LSI Logic has positioned itself well as an application-specific IC supplier and UTMC is trying to do some things. There are a lot of niches out there."

One technology that's benefiting from the upgrade phenomenon is electrically erasable programmable read-only memories. Seeq Technology Inc. of San Jose, Calif., has about 35% to 40% of that market, and David Sweetman, the company's director of military programs, says the defense-

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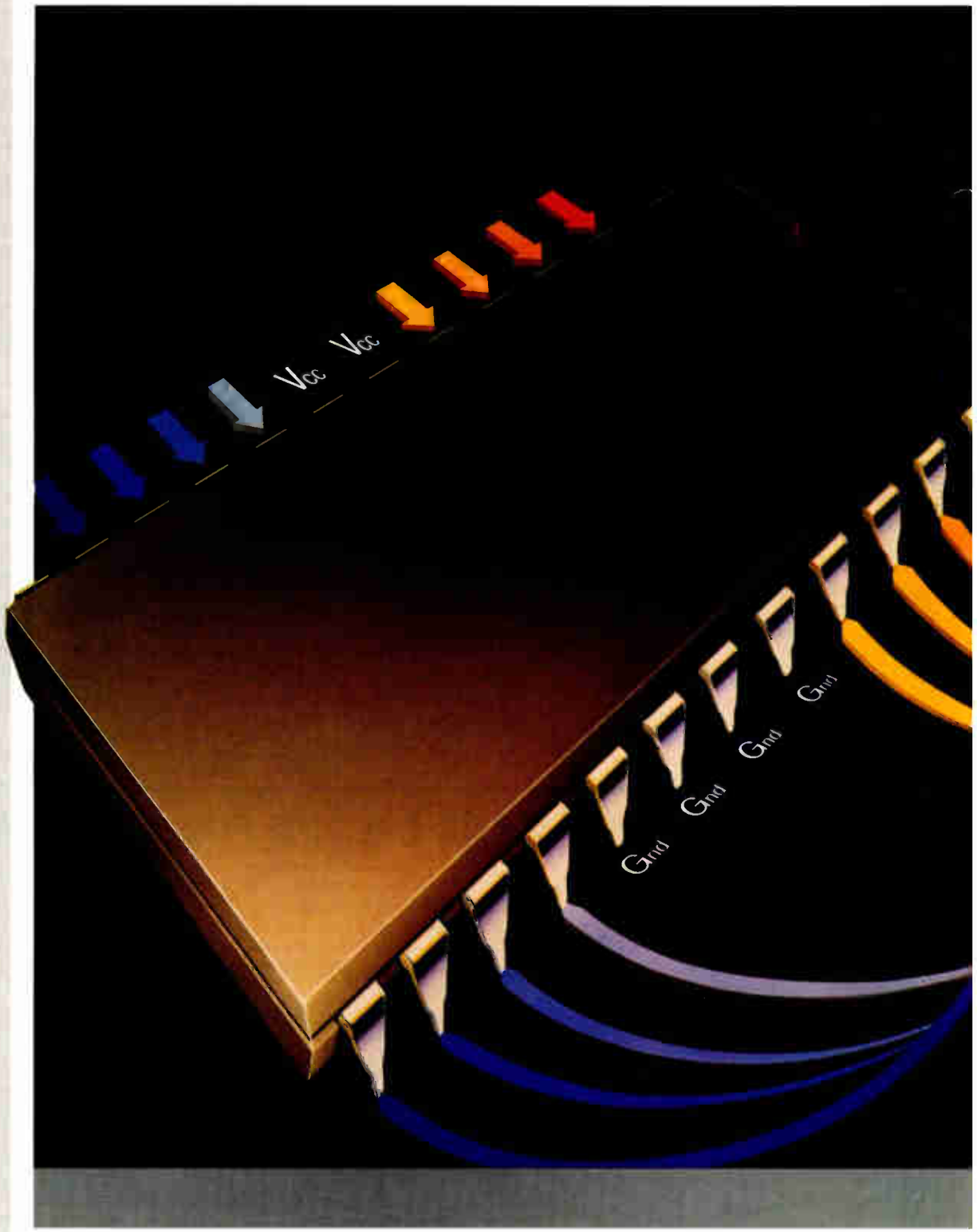

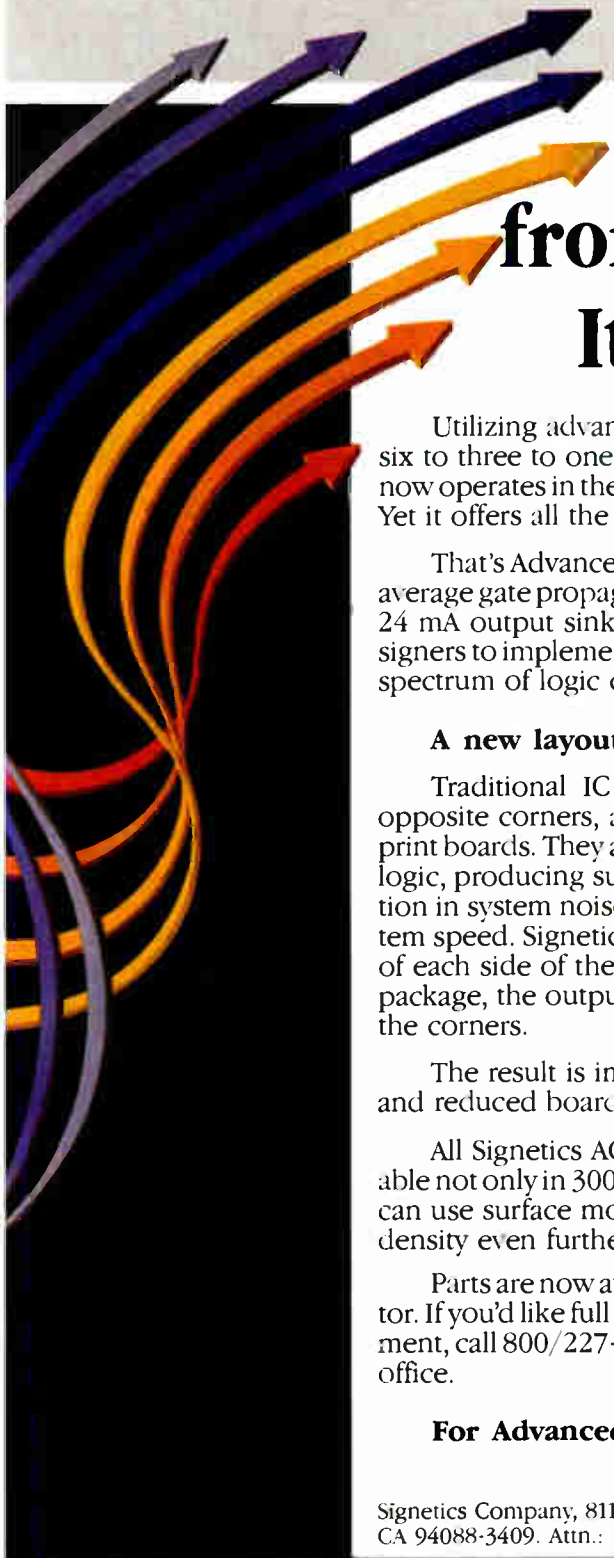

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PHILIPS

PHILIPS

market portion of EEPROM sales is now growing faster than the commercial arena. "Investments we made two and three years ago are paying off now because the upgrades are happening," he says.

One of Seeq's arch EEPROM competitors is Intel Corp., which is also a leader in microprocessor technology. Intel executives say they couldn't be better positioned for current market conditions. "The climate over the next couple of years is playing right into our product line," says Robert D. Singer, military marketing manager for Intel's Automotive and Military Division in Chandler, Ariz. He points again to upgrade opportunities, such as the F-16, which he says now uses some technology that is obsolete and some that offers very poor performance. Singer predicts that the electronics portion of defense spending will grow by 12% to 15% for the next three to five years, and promises that "Intel will track that growth."

ON TARGET. Those feelings are echoed by James R. Adams, the manager of competitive analysis, strategic marketing, and business planning at UTMC in Colorado Springs, Colo. The company has targeted ASICs and radiation-hardened technology as growth markets, and has met new specifications that put its ASIC parts on the Defense Electronic Supply Center's Qualified Parts List— which is a key for winning deals for upgrading systems and replacing obsolete components.

But while these chip makers are thriving, VHSIC suppliers Honeywell Inc., IBM Corp., and TRW Inc. have been struggling. TRW has experienced problems with its technology and hasn't found many customers; IBM, unable to establish itself as a chip supplier with Phase 1 VHSIC technology, hasn't had much success marketing Phase 2; and Honeywell's sales have also been lagging.

Cautious contractors apparently are shunning the use of VHSIC parts

Honeywell's Solid State Electronics Division took an after-tax write-down of $16 million in this year's second quarter, in large part because of overcapacity in its VHSIC processing lines. Late last year, the company decided to idle its 6-in. wafer line and consolidate VHSIC Phase 1 chip production on an older 4-in. line [*Electronics*, Jan. 7, 1988, p. 24].

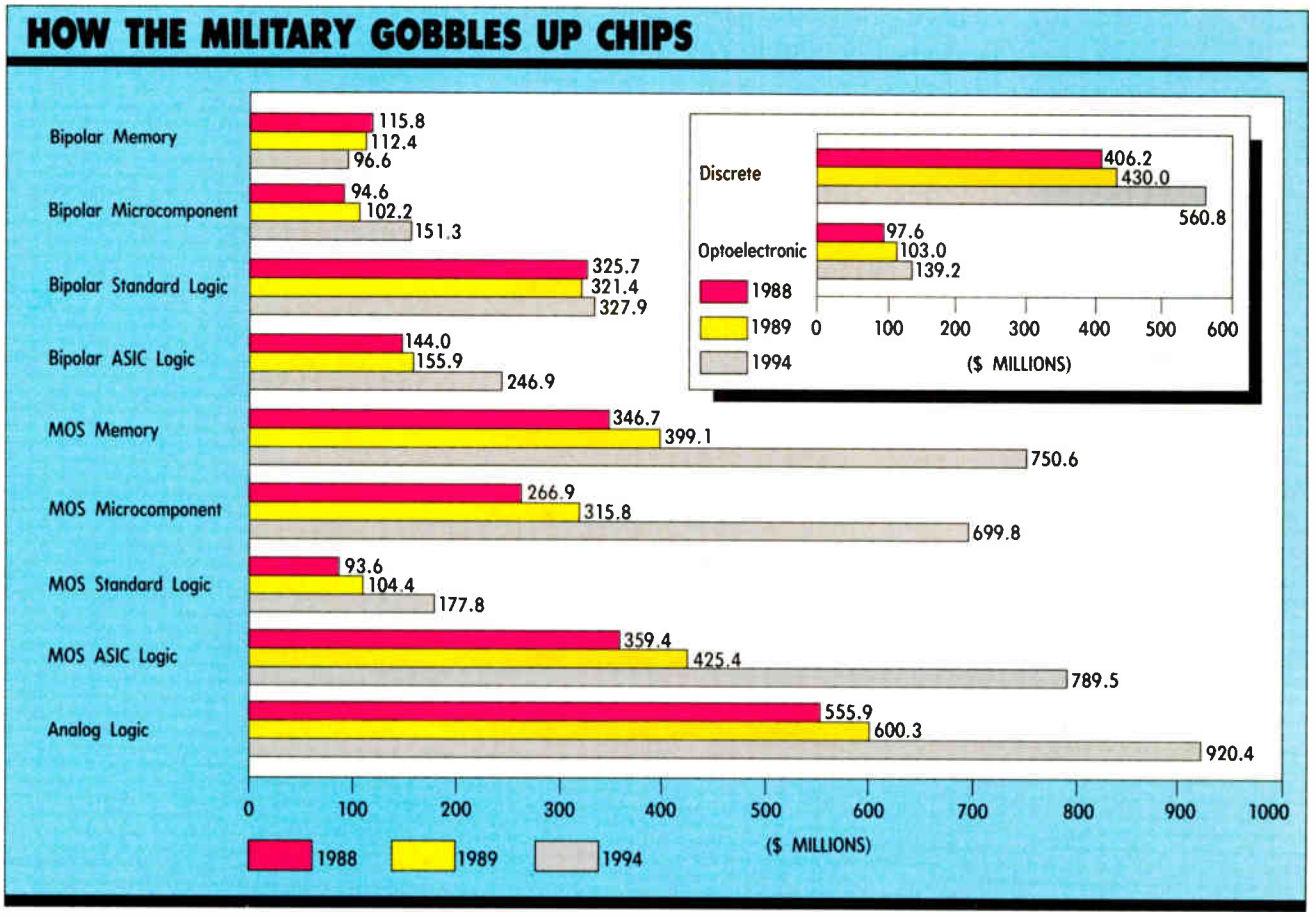
"We still think VHSIC is very important," says Gerald P. Dinneen, Honeywell's vice president of science and technology in Minneapolis, Minn. "But frankly, the Defense Department hasn't integrated VHSIC into as many weapons systems as we thought it would have by now. We still expect that it'll do that, but right now it means that those of us who made big investments in VHSIC aren't seeing the returns."

Cautious contractors, wary of taking on too much risk, prefer better-proven technologies, says Sheppard at Dataquest. And since the startup costs associated with VHSIC chips may be higher than with a more proven technology, a penny-watching contract officer may opt to go for initial low costs and not specify VHSIC parts—even though the life-cycle cost might be up to 10 times less.

Also suffering is the microwave industry, which analysts say is overcrowded and ripe for a consolidation. "When there are pressures on the overall industry, everyone is trying to unload those pressures on their suppliers," says Lior Bregman, a defense electronics analyst with Oppenheimer and Co. in New York. "The microwave component guys are at the bottom of the ladder and they have to absorb a lot of that pressure."

Dataquest's Sheppard puts it this way: "In microwave, there are too many suppliers chasing a market that probably needs half as many. Some of the little ones are getting gobbled up by some of the bigger ones, but the ones that will do best are those, like Watkins-Johnson, that are tagging along with the DOD's Microwave/Millimeter-wave Monolithic IC program." *–Tobias Naegele*

HOW THE MILITARY GOBBLES UP CHIPS



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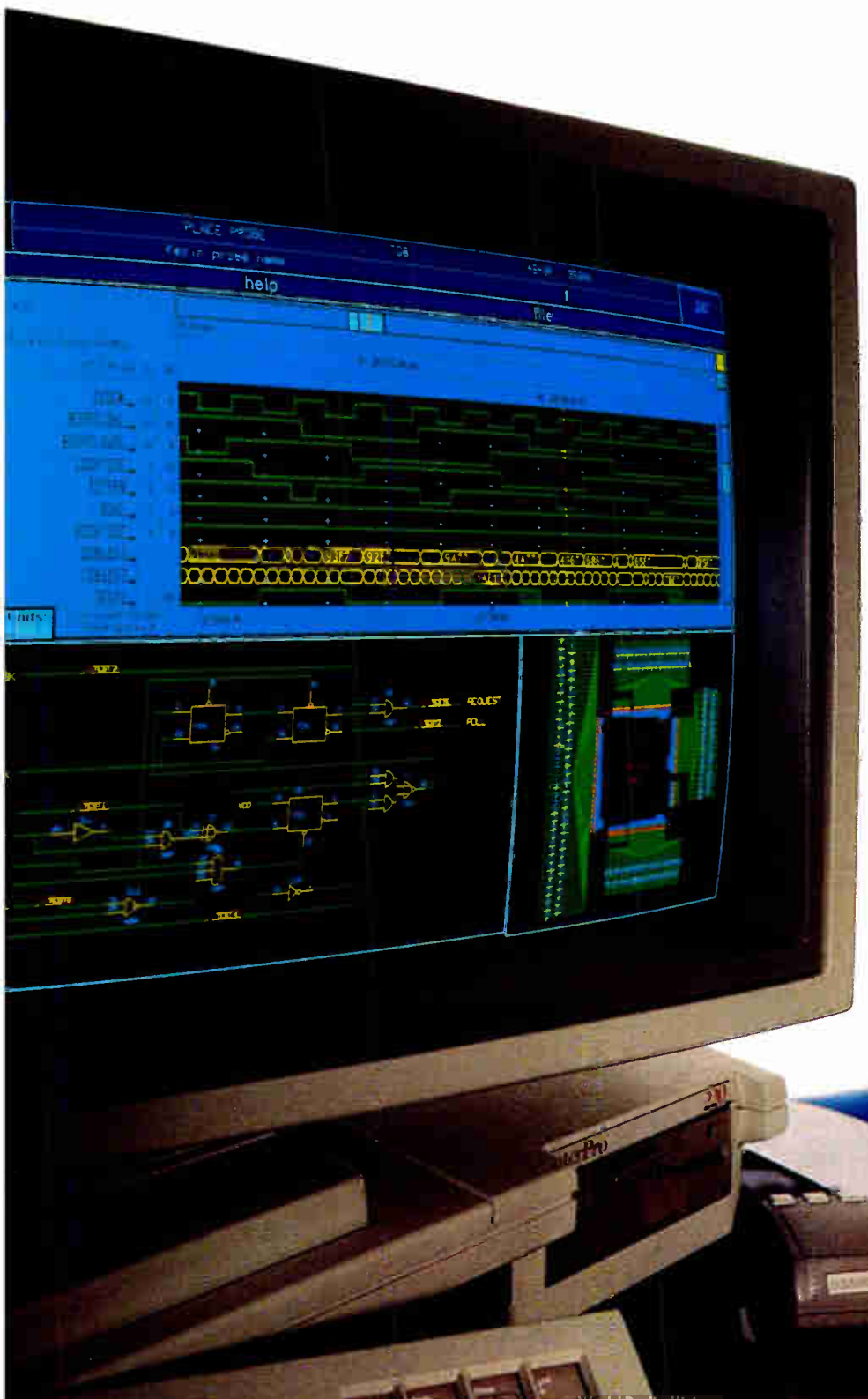

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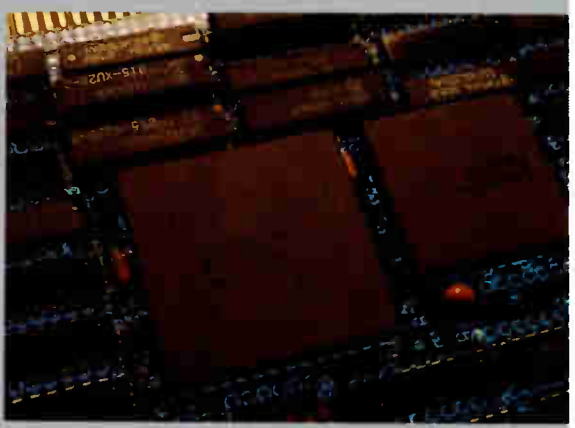

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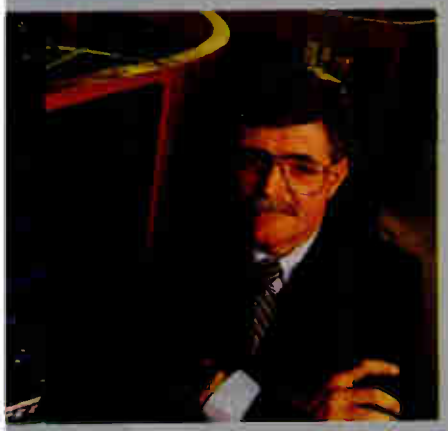

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WHO WILL WIN—OR LOSE— IN THE COMING UNIFIED EUROPE?

Industry managers are far from unified about what will happen, and when

by John Gosch

The vision is about to become a reality: Europe, once a patchwork of economically incompatible societies, will merge into a harmonious deregulated market, free from trade barriers and embracing mutually recognized industry standards. This is not a dream. This is Jan. 1, 1992.

That's the date when a landmark in European economic history is to occur—the birth of a unified European market that will be known to the world as the "Internal Market." It will offer electronics companies more than 320 million consumers spending nearly $150 billion a year—the world's biggest market by far. But what remains to be seen is whether the unification will spur sales growth or slow it, and whether a free-for-all, deregulated market will mean death to small companies as the global giants take a bigger share of the pie. The industry segment most likely to see major changes is communications, observers feel.

Regardless, Europe won't be able to change overnight and, in fact, may not make a full change by 1992. Almost all industry analysts agree that Program 92, as it is called, won't meet its deadline. Indeed, "1992 is not a magic date," says Ed Carey, director of international corporate affairs for Racal Electronics plc in Bracknell, Berkshire, UK. "But deregulation will take place. It's more a question of what degree of deregulation and at what speed it will go—in some countries [it will happen] faster than in others."

Perhaps the nations best prepared for a unified market are West Germany and France, Carey says. "Germans chair 45 of the 80 European standards committees," he explains, "while the French are better prepared than anbyody in terms of mental condition." As for the other 10 members of the European Community—Belgium, Denmark, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the UK—they will have to buckle down and get to work, because 1992 will mean demolishing age-old internal trade barriers and supports.

> Small and medium-size firms will be most affected by the barrier-free Internal Market

The upshot will be a giant homogeneous market, like those of the U. S. and Japan. But its 322 million consumers make the Internal Market almost 30% bigger than the U. S. and nearly three times the size of Japan. In fact, the Internal Market is about the same size as the U. S. and Japan combined.

Clearly, though, the road to unification will have its rocky patches. Industries that were comfortably protected by local norms and regulations will be ill-prepared for the harsh winds of competition. Analysts warn that unless these companies develop new skills, learn to specialize, or turn out innovative products, they will either perish or be gobbled up by stronger and more efficient competitors. The same is true of companies that have held an edge in bidding for government business, such as formerly state-controlled telecommunications-equipment makers.

And even though trade barriers within Europe are being eliminated, outsiders, particularly the Japanese, fear that a unified European market will be able to close itself off from foreign goods. They worry that the Internal Market will move toward protectionism.

European industry executives say that worry is unfounded—they contend that most European countries depend too much on exports to close down internal markets. For example, West Germany ships about 25% of its annual electronics and electrical output of $86.5 billion to countries outside the European Community. "The EC must remain open to the whole world," says Karlheinz Kaske, president and chief executive officer at West Germany's Siemens AG. "On top of

A BLUEPRINT FOR CHANGING EUROPE'S WAY OF BUSINESS

It all started in 1957. That's when Belgium, France, Italy, Luxembourg, the Netherlands, and West Germany signed an agreement in Rome to form the European Community. The accord provided for the creation of a common market in 12 years or so, but no later than 1972. That goal was not reached. Still, the European Community progressed, expanding to include 12 countries encompassing more than 320 million people.

Then, worried by slackening economic activity, rising unemployment, and increasing competition from the Far East, the EC in 1986 passed the Single European Act. It envisioned setting up by 1992 a truly common market: deregulated with no internal frontiers and guaranteeing free movement of people, goods, services, and capital from country to country—in short, a Europe powerful enough to make its economic weight felt on global markets.

The blueprint is a White Paper that the European Commission, the EC's Brussels-based supranational executive body, issued in June 1985. Called Europe's Domestic Market, the paper catalogs about 300 measures ranging from the coordination of industrial standards to the harmonization of taxation and the creation of European company law. The measures will be addressed by the 12 EC countries prior to 1992.

Basically, the 300 items are divided into three categories: material, technical, and tax barriers. The material barriers constitute controls on goods and people at frontiers. The technical barriers are the national standards and regulations as well as practices making public-sector procurement a quasi-national affair. Finally, the fiscal barriers are the obstacles between countries in areas like value-added and excise taxes.

So far, fewer than half of the 300 items have been settled, and most observers agree that they won't be by 1992, even though two concessions have been made to speed things up. One abolishes the need for unanimous agreement on many decisions; the other abandons the idea of common standards throughout the community. "However, whether it is completed by 1992 or 1994 or even later doesn't matter. What does matter is that Europe has a goal, that of setting up a truly common market," says Herbert Stich, executive director of sales and marketing at West Germany's Siemens AG. *–John Gosch*

trade tensions with the U. S. regarding farm products, we cannot afford strained relations in other fields."

Some even go so far as to say an open Europe will benefit the non-Europeans most. "The companies that are going to be successful after 1992 are more likely to be the U. S. or Japanese companies, which are traditionally more used to international marketing," says Nic Birtles, vice president for international operations at Relational Technology Inc. of Alameda, Calif. Birtles, who is based in London and is British, is the chairman of the UK Computer Services Association's 1992 Committee.

GOOD DEFENSE. Trying to prove that theory true, the American Electronics Association is gearing up to help member firms prepare for the 1992 challenge with a series of U. S. seminars this month. But Steve Weiner, the AEA's director of international marketing, has another concern in mind: "As European companies come together, they're going to become a much greater force outside Europe—in the U. S. and in Asia—than we have seen," he explains. "To compete with that kind of force, one thing we think U. S. companies must do is to go over there and be a presence in those companies' home turf."

In fact, Europe's share of its own chip market is likely to decline, from 39.3% in 1987 to 32% in 1992, says Werner Koepf, manager of Texas Instruments Inc.'s European Systems Product Customer Center in Freising, West Germany (see "The chip game will stay the same" p. 83). The beneficiary will be Japan, which he figures will boost its share from 15.2% in 1987 to 23% by 1992.

TI has been preparing for the Internal Market by "moving out of country-by-country marketing and into a pan-European market focus since about 1983," says a TI spokesman in Dallas. That's allowed the company to convert its wafer fabs in Freising and in Bedford, UK, from producing a full range of products to more specialized production that provides better economies of scale. In addition, TI is setting up a warehouse facility in Oporto, Portugal, that will eventually become a warehousing and distribution center for all of TI's European markets.

What will all this mean to other electronics industries? Some industry figures say it won't mean a thing—that the electronics industry has been moving toward a unified Europe for years. They say the change will not cause radical shifts in strategy, except perhaps that it may make doing business a little bit easier. "What's the difference?" asks Carlo Ottaviani, vice president of communications at SGS-Thomson Microelectronics in Paris. "We have always marketed on a worldwide and European level, so what is going to change? I could see changes for the auto industry, for banks, and for insurance companies—but not [occurring] in semiconductors."

Kaske of Siemens AG says more collaboration between companies, not consolidation, will occur in the barrier-free Internal Market.

But this view is in the minority. Many industry watchers say the impact will be vast and swift. London-based market researcher Dataquest UK Ltd. says the Internal Market will accelerate annual growth one to two percentage points above what could be achieved without unification. The 1988 base is an equipment and components market of around $110 billion for Europe's big four alone—West Germany, the UK, France, and Italy.

The small- and medium-size firms will be most affected by the barrier-free Internal Market. For them, technology linkups may be the order of the day. "I believe that cooperation will have greater significance and that concentration will be the exception," says Siemens's Kaske.

The UK's Racal Electronics has been following just such a strategy in anticipation of the Internal Market. "In data communications we are forming a chain of European companies by acquisition or by startup—we're still looking around the continent to fill in the gaps in France, Spain, and Scandinavia," says Racal's Carey. "Practically every one of our subsidiaries has a collaborative deal of one kind or another with someone else."

The Internal Market will affect Europe's electronics markets in varying degrees depending on the existing state of liberalization and companies' marketing and product strategy. The sector that Europe 92 will affect the most is communications by at long last dismantling powerful barriers to trade and opening markets that many suppliers have considered their private, cozy domains. Europe 92 will also liberalize services and procurement practices and sweep away technical frontiers resulting from different equipment and network standards and certification requirements.

The new environment will bring some drastic changes to the communications industry, changes that will be traumatic for many companies. Once 1992 has crystallized, there will be fewer firms left in the field. Particularly hard hit will be makers of public switches, who are already plagued by overcapacity. Also vulnerable are single-customer firms, those who are now serving, say, government-run communication authorities only. To survive, they will have to rethink their marketing strategies and face the competition.

With its $15 billion total in 1986, Western Europe held about 20% of the global market and thus occupied second place, behind the U. S. with 40%. Japanese suppliers, with a nearly 10% share, had a big lead over France, the UK, West Germany, and Italy.

One reason for the gap is Europe's fragmented market. Because of limiting licensing practices by public communication monopolies, restrictive certification rules, differing standards, and national preferences in government buying, there is hardly any cross-border trade in communications equipment in Europe.

That's going to change. The EC's "Green Paper on Telecommunications" proposes a step-by-step transition to a competitive market. It envisions an initial 40% liberalization and after 1992 a full opening of the market.

LEFT STANDING. In the public switch sector, "we still have overcapacity in Europe," says Herbert Stich, executive director in Siemens's corporate sales and marketing department. "A company must have at least 10% of the world market to recoup" the investment needed to develop digital switch technology. Not all of the eight public switch suppliers active in Europe may obtain the 10% level, and Stich thinks that after a shakeout, there may be fewer than five left in Europe and perhaps 10 worldwide.

The Internal Market should also affect terminal equipment suppliers, especially the single-customer firms. With procurement policies to be liberalized, communications authorities and network operators must consider bids from more than one company, and not necessarily native ones. So firms with run-of-the-mill products like simple telephone sets for a single customer—products that Far Eastern producers can supply at little cost—will have to find new areas of specialization.

The shakeout that the open-barrier and

liberalization move will bring to Europe's communications industry does not necessarily mean that the established giants will get bigger. Stich points out that Siemens is already the third largest player in the world, behind the U. S. giant AT&T and France's Alcatel, and won't just expand for the sake of expansion.

Siemens does not want to become a conglomerate with activities in fields other than electrical and electronics engineering. "We'll stick to what we know best," Stich says. What the firm may do, however, is acquire or buy into other companies to round out its business in specific fields, he says. It recently strengthened its hand in automotive markets, for example, with the acquisition of the majority interest in Allied Signal Inc.'s Bendix Electronics Group in Detroit, Mich.

ALREADY BIG. Consumer equipment makers are well set up for the harmonized market. A wave of shakeouts and takeovers during the past decade has left Europe with only three major TV producers: Philips in the Netherlands, Thomson in France, and Finland's Nokia group.

For these giants, Europe already is open, and they are catering to national markets with sets that meet all transmission standards now in use. Enabling them to do so are components producers that can supply parts for all receivers.

But the Internal Market will be an arena not only for the giants but will leave room for niche players as well. "The extreme concentration of the big-three producers opens market niches," says Thomas Fischer, an executive at ITT Electronic Components Corp., Freiburg, West Germany. "And if small firms are flexible and play their cards right, they'll not only survive but prosper."

The computer industry should weather the change in 1992 with little fanfare. Companies like Honeywell-Bull, IBM, Olivetti, and Siemens, have been doing cross-border business for years.

Typical of firms operating, in effect, without borders are IBM, which has production plants and research labs in several countries, and Siemens, with sales facilities almost everywhere and software-development centers in Barcelona, Brussels, London, and Vienna. It's the same for Sweden's L. M. Ericsson, West Germany's Nixdorf Computer AG, Philips, and a number of U. S. suppliers.

Still, the Internal Market will bring about some changes. "Two developments are already discernible," says Hans-Joachim Grobe, analyst at the Frankfurt-based computer consultant Diebold Deutschland GmbH. "One is further standardization of software and operating systems, and the other is a different approach in pricing practices."

Additional reporting by Peter Fletcher, Tobias Naegele, and Deborah Wise

THE CHIP GAME WILL STAY THE SAME

Europe 92 won't change the nature of the semiconductor business as much as it will other business sectors, most industry insiders and analysts say. Semiconductor makers and vendors, be they U. S., European, or Japanese, see the continent as a common marketing and sales entity and have years of experience serving the region and doing cross-border business.

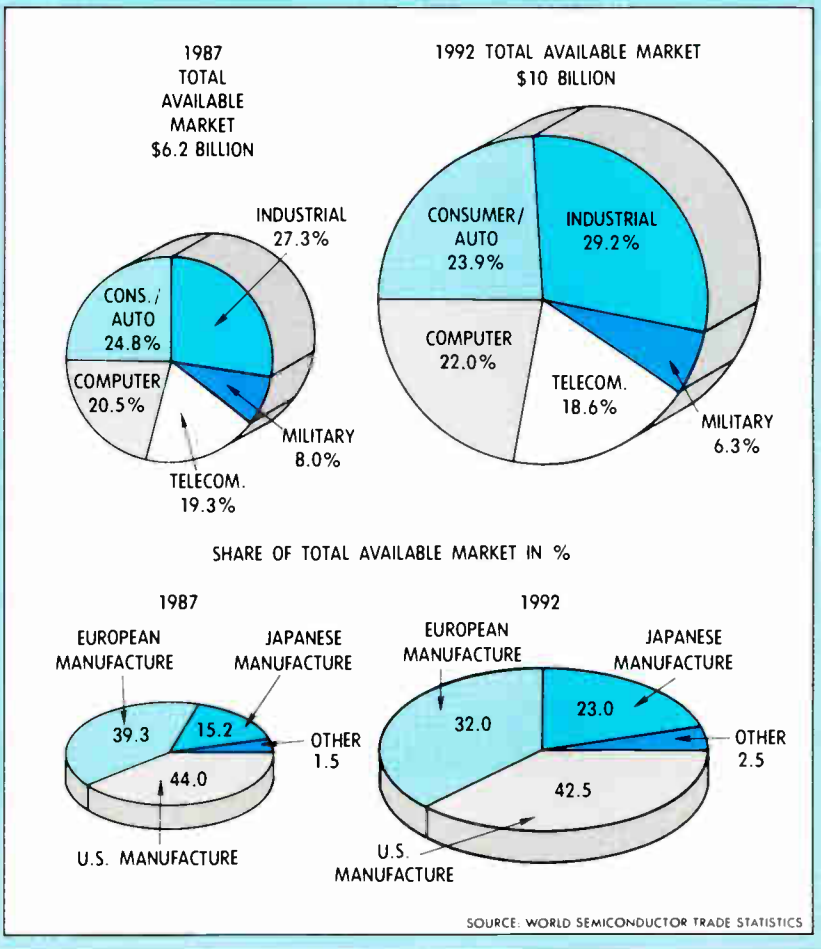
"The industry already views Europe as a single market," says Jim Eastlake, senior industry analyst for semiconductors at the London-based market researcher Dataquest UK Ltd. There's hardly a chip maker without sales outlets, representatives, or distributors throughout Europe—from Scandinavia to the Mediterranean.

The European chip industry has been consolidating for years, says Carlo Ottaviani, vice president of communications at France's SGS-Thomson Microelectronics. Now the consolidation era seems to be giving way to cooperation. Philips in the Netherlands and West Germany's Siemens AG joined to develop 1-Mbit dynamic-random-access-memory technology in their Mega Project, for example. And now Jessi, Europe's chip-making cooperative, is expected to announce an agreement tying Philips, SGS-Thomson, and Siemens together in a project backed by the EC to develop still more advanced semiconductor technology.

"Faced with Sematech in the U. S. and the Japanese [Ministry of International Trade and Industry's advanced semiconductor] projects, Europe needs Jessi with or without 1992," Ottaviani says.

The program is considered vital because Europeans' share of their own chip market is expected to decline between now and 1992. The total European market will grow from about $6.2 billion in 1987 to over $10 billion by 1992, according to the World Semiconductor Trade Statistics, which are produced by the U. S. Semiconductor Industry Association, San Jose, Calif., in conjunction with international trade groups. So while Europe's chip sales will rise from $2.4 billion in 1987 to $3.2 billion in 1992, its share of that total will drop from 39.3% to 32%. *–John Gosch*

HOW EUROPE'S CHIP MARKET WILL GROW



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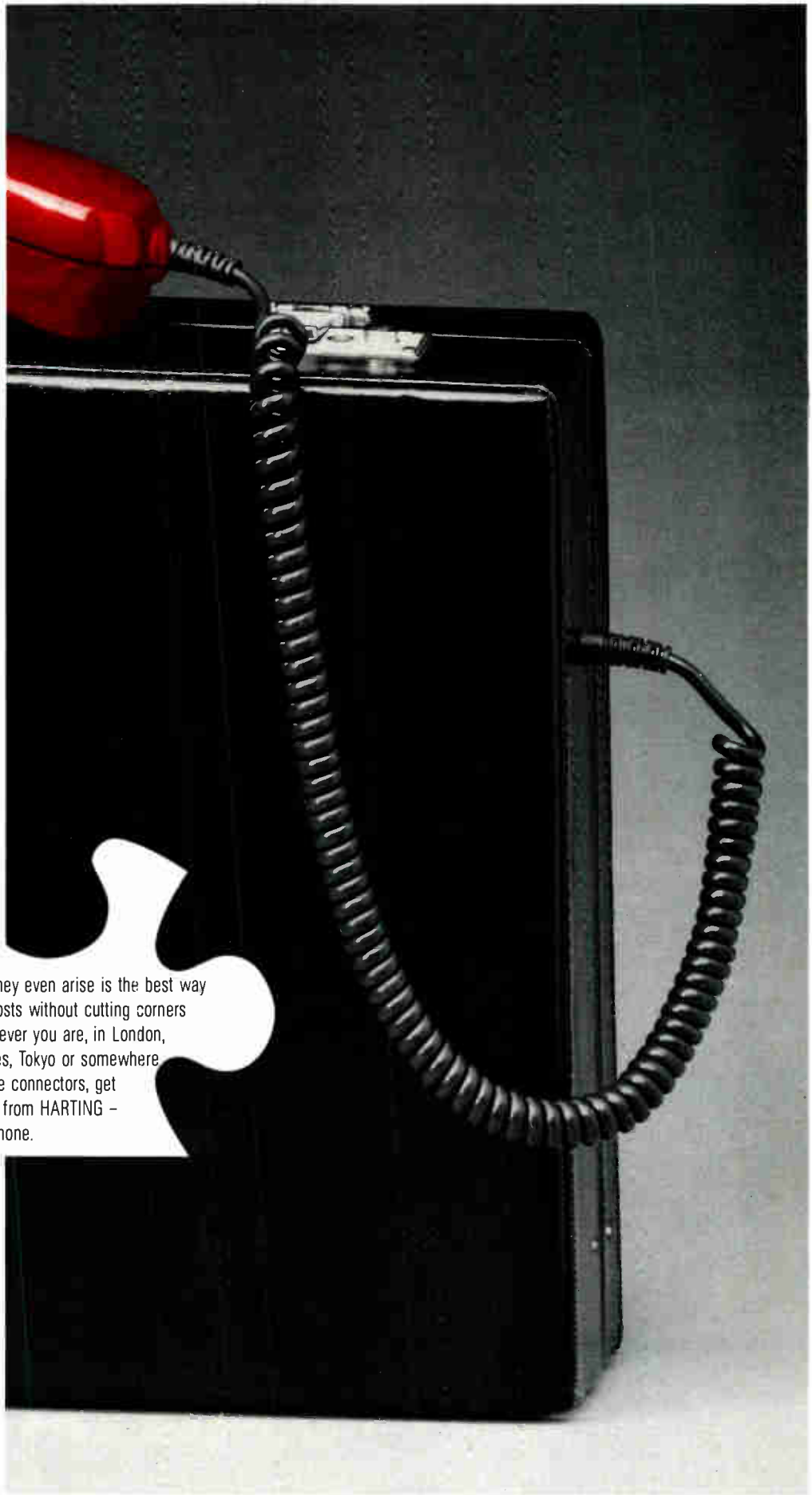

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BATTLE OF THE SHOWS

As Comdex and Wescon collide, it's a tough call for exhibitors and attendees

by Larry Waller

Even for an industry where a breakneck pace is regarded as the norm, the week of Nov. 14 is shaping up as something else. During that week, the two biggest fall shows in the U. S., Comdex and Wescon, are scheduled to take place at Las Vegas and Anaheim, Calif., nose-to-nose for the first time. Since both shows rank as premium events—particularly Comdex/Fall, which has mushroomed to juggernaut status as the best forum for anything to do with personal computers—the conflicting dates are posing some hard choices for showgoers accustomed to attending both. As for exhibitors, show deadlines forced them to make hard choices months ago.

Comdex runs Monday through Thursday of that week, and Wescon Tuesday takes place through Thursday. Why the conflict suddenly exists is perplexing to many and especially vexing to officials at Electronic Convention Management, the Los Angeles-based parent of the "Con Family" of shows that includes Wescon, Electro, and five regional events. A new management look is being installed at Electronic Convention Management, and one goal is to upgrade the shows, starting with Wescon, as forums for new technology. A big step would be to get semiconductor firms back into the swing at Wescon. While chip makers do not generally account for many Comdex booths, they do prowl the aisles and conference sessions in search of business, particularly PC-related business. And their resources for technical sessions are also tied into the show.

So some say that Wescon's wooing of semiconductor firms could be one reason that the Las Vegas show now takes place concurrently, as a defensive reflex on the part of Comdex's organizers—a motive it denies. And indications are that chip makers who did face a quandary in deciding where to go this time around leaned toward attending Comdex, or split their votes.

As if that weren't enough competition, Wescon—and Comdex—are facing increasing competition from what are called vertical shows, tightly focused events that deal with a single area of electronics technology. Many companies say they are finding these shows to be a more cost-effective way of reaching their customers.

Even if the show timing is coincidence, Wescon managers know that they must avoid being trampled by Comdex, which has been fueled by media and industry interest throughout its meteoric growth since the early 1980s. The pivotal role of personal computers in the industry insures that Comdex will pose a formidable challenge to Wescon in getting its share of industry attention.

But Electronic Convention Management managers still believe that the Needham, Mass.-based Interface Group (which owns Comdex) deliberately chose to have things this way, because Wescon dates are selected up to a decade ahead. They add that dates of the competing shows held last May, Electro and Comdex/Spring, also conflicted and will again next year.

Aaron Koslov, who became president and general manager of the Con Shows in January, says Wescon's managers realized then that it was going to be affected by Comdex. "The conflict in dates is no coincidence," he says. Rather, it seems only the first sign of more competition to come.

At first glance, it would appear that Comdex has little reason to target Wescon. The show, by Koslov's account, has few exhibitors or programs that the Comdex crowd wants to pick off, since Wescon centers around components and instruments, with a strong military electronics flavor.

From the Comdex side, Sheldon Adelson, board chairman, president, and CEO of Interface, flatly denies that his organization chose dates to conflict. "We don't consider Wescon remotely competitive with Comdex," he says. Adelson points out that Comdex was founded to provide a forum to get computer vendors together with resellers, and he claims it remains faithful to that aim. "Our dates for the Fall Comdex are booked until 2015; we've always had the show in the week before Thanksgiving . . . It's absolutely without truth that we chose to conflict with any other show."

However, the show's dates have varied more than Adelson admits. In 1986, Comdex was two weeks before Thanksgiving, and in 1987, it was held Nov. 2-6. This

year, the dates fall the week before Thanksgiving because the holiday is unusually early—Nov. 24. But next year, the Fall Comdex is scheduled for Nov. 13-17, two weeks before Thanksgiving and again conflicting with Wescon. The Interface Group would not release the show's dates beyond 1989.

But Adelson's story well could be a straight one, say industry sources, since Comdex presently has such an invulnerable position that it can make decisions without taking other shows into account. Nonetheless, the impact on Wescon is undeniable. Retired Electronic Convention Management president Bruce S. Angwin, who remains as an assistant to Koslov through this year, notes that Electronic Convention Management salespeople report their Comdex counterparts for the first time are going after potential Wescon exhibitors. Because of the scheduling, he thinks "this will become more competitive as the years go on."

Koslov believes that his plans for improving the shows are what is putting the two show-management organizations on a collision course. His top priority, already in the early stages of a crash effort, is to recapture the excitement that Wescon generated in its most successful years by once again turning it into an important platform for semiconductor technology.

The trouble is, many of the chip companies have already gravitated on their own to the Las Vegas show, following important customers in the PC business. They are there, however, largely as non-exhibitors, taking part in programs and private meetings, and making important contacts at the show events. Adelson confirms that Comdex has done nothing to attract the semiconductor manufacturers as exhibitors, nor is it focusing on chip topics in its conference sessions.

Nonetheless, most of the major semiconductor firms will have a presence of one kind or another at Comdex, which is a solid tipoff that the conflicting show dates currently are working in favor of Comdex. The net effect, says Koslov, is that "they are making some segments [exhibitors, program speakers, and attendees] make choices—and it's working for them." He therefore recognizes that it will be harder to win back the chip firms.

WINNING THEM OVER. That the Comdex appeal hits the mark for semiconductor firms is confirmed by James J. Farrell of VLSI Technology Corp., Tempe, Ariz., who counts himself as a long-time supporter of Wescon. He is responsible for show decisions as technical communications manager of the Application-Specific Logic Products Division, Tempe, Ariz. He has opted to put his exhibit at Comdex—somewhat reluctantly, since he serves as vice chairman of professional programs for Wescon. But he still has his company participating in a very active way in the Wescon technical program.

Wescon still retains some solid, old-line support from companies that have been participating for decades, like Tektronix; but in the 1980s it has lost ground to vertical shows.

"Their strategy worked, they forced me into Comdex," he explains, "but only because there will be nearly 150,000 people there and I couldn't ignore that mob." For chip companies looking to sell to computer and board customers, "right now this is where you must be, like it or not," says Farrell, who will be hopping back and forth between the two shows. Although he is close to the show scene, Farrell says that "not until recently did I realize what Comdex is up to, sloting the shows together."

Among the most visible chip companies, only Micron Technology Corp. has committed to a Wescon booth. But the Boise, Idaho, firm also is enthusiastic about its Comdex exhibit of board-level products for adding memory to Apple and IBM PCs. "We're excited about having new products at Comdex," says a Micron marketing executive. The firm intends to continue at both places since they both fill an important role, he adds. Wescon's horizontal scope, which offers a wide audience, makes it the best place to tell Micron's diversification story; on the other hand, despite its size, the focus of Comdex on independent marketing units and end users guarantees a potent sales impact.

Micron Technology does not depend on any single show, but complements a broadly based event with an exhibition and program platform that addresses vertical niches. This is today a common approach. Ten years or more ago, in the heyday of Wescon and Electro, it was a different story, as most companies largely tied their show marketing to these broad, horizontal events. But in the 1980s they have developed sophisticated marketing techniques that target narrow niches. Semiconductor firms, particularly the large ones, have led the way.

The exploding growth of these vertical shows, in fact, is without much doubt the major trend sweeping the industry show scene today, say people in all parts of the industry. Their strength lies in the realization by both suppliers and customers that an event dedicated to a single product area is the most efficient place to buy and sell products and exchange timely information.

The tide is turning toward these vertical shows because of their tightly focused nature and identifiable sales results. The following companies, representing a wide spectrum of industry activity, confirm that this trend is underway:

- The Micro Switch division of Honeywell Inc., Freeport, Ill., has exhibited at Wescon and Electro for decades and regards shows in general as an even more attractive marketing venue than in the past,

AEA RETURNS TO SHOW BUSINESS

Just as the Comdex and Wescon shows are putting the big squeeze on each other for attention, the American Electronics Association—which co-sponsored Wescon in the 1960s—says it's getting back into the show business. The AEA will debut Systems/USA on Feb. 13, 1990, in San Jose, Calif. The aim is to bring together the component and subsystems makers that traditionally attend Wescon with the computer vendors that populate Comdex.

"We think it fits right between the two giants," says AEA president J. Richard Iverson. "It's the wave of the future: we think a lot of the huge shows will be replaced by specialty shows." Iverson admits that there may already be too many shows for managers to choose from, but he says, "Our market research says this niche is not being adequately served."

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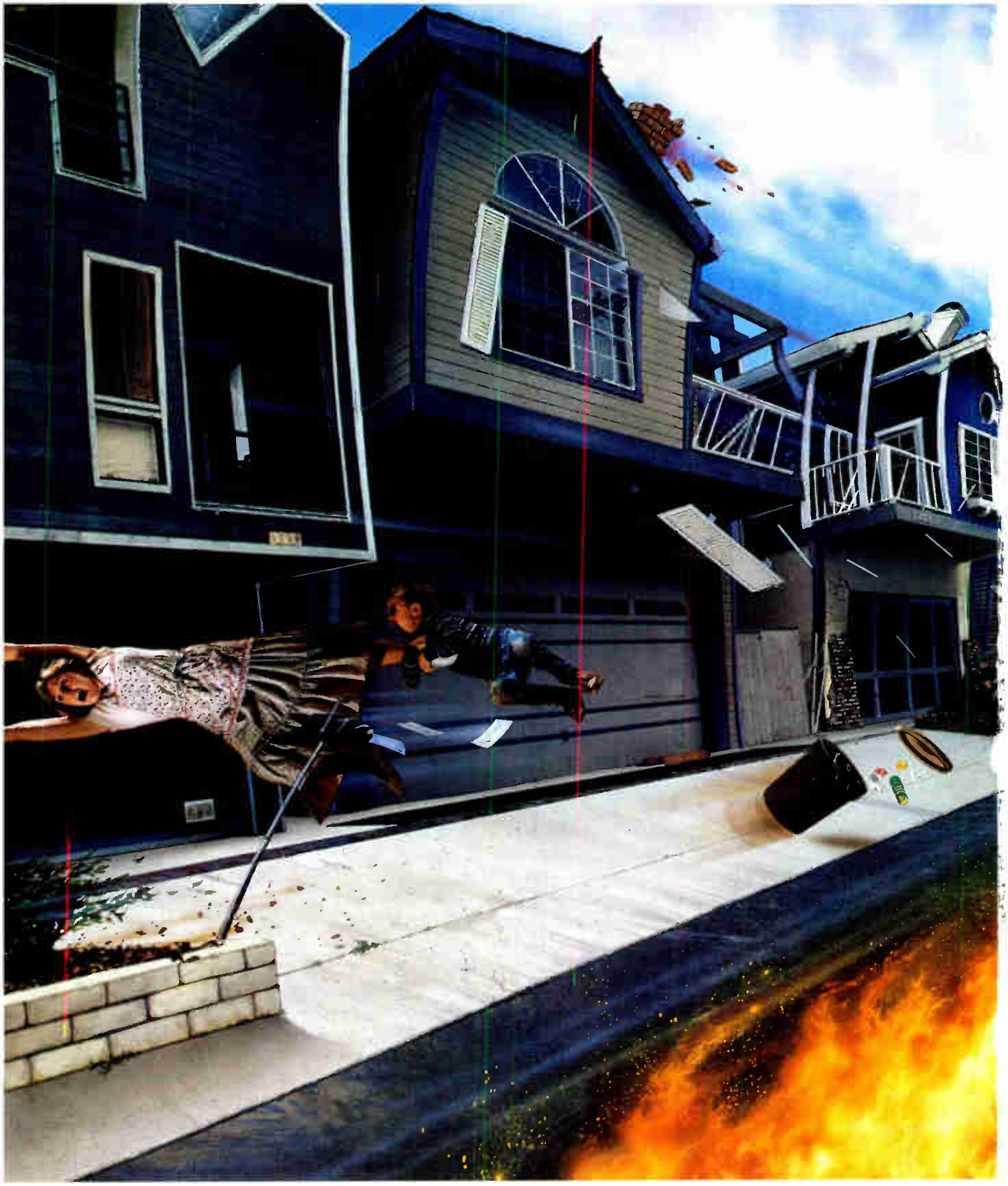

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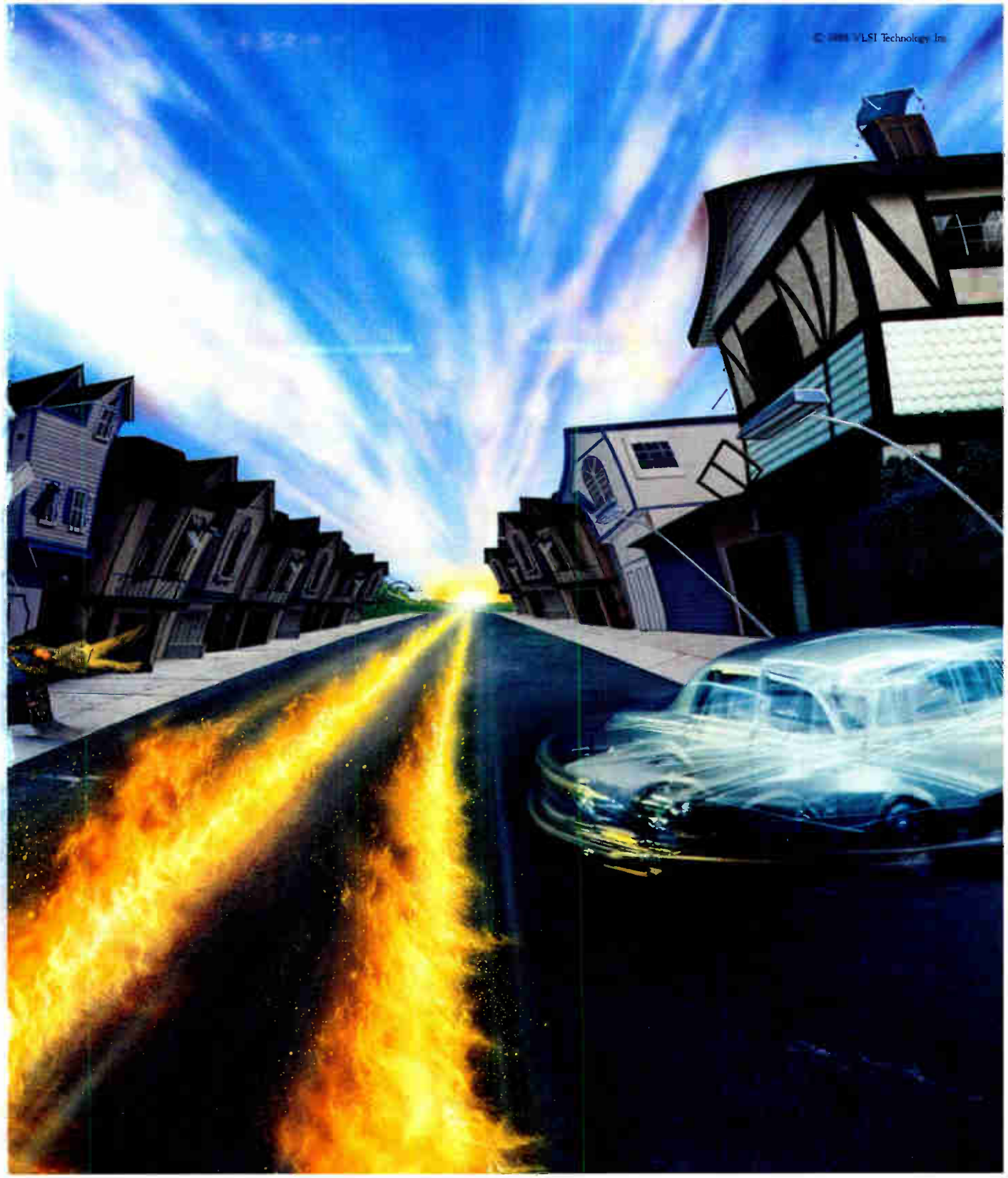

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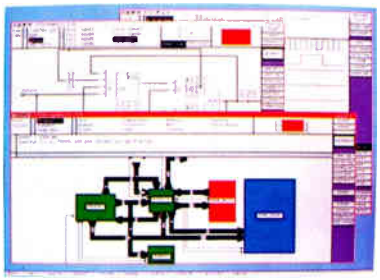
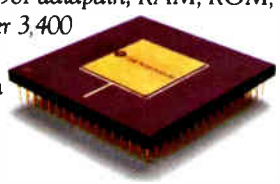


The Concept Express Design System's highly productive logic tools and silicon compilers were used to develop this very-large-scale ASIC. It incorporates a 2901 datapath, RAM, ROM, and over 3,400 gates of random logic.



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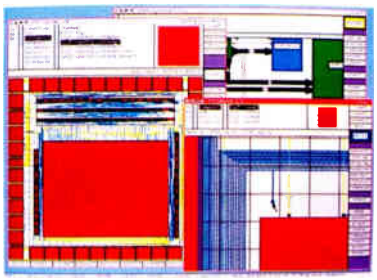

This highly-integrated design combines control logic, a register file, a refresh counter, and five peripheral chips onto a die size of 275x315 mils. The logic design, layout, and verification were completed in only 12 weeks.

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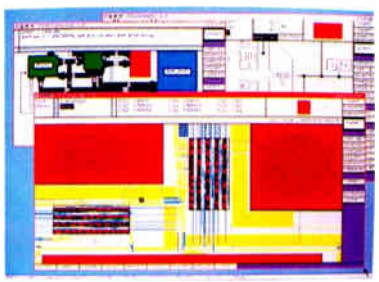


This design integrates all the peripheral chips for an AT computer with six megacells and control logic. Using the Silicon Express Design System, logic and physical designs like these can be implemented in under two man months.

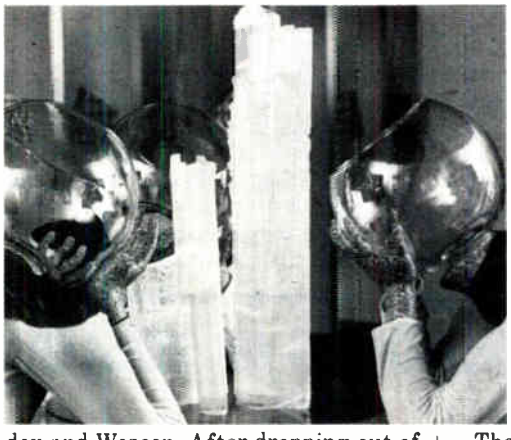
VLSI TECHNOLOGY, INC.

since costs are more controllable than other avenues. But Micro Switch sees the mix of shows changing to favor the vertical ones, many of them relatively new, and is going that route to better market a diverse product line with some 75,000 sensing and switching products. The most important show is Sensors Expo, a three-year old show held in September at Chicago, which generates more leads than Wescon, although only about 6,000 people attend, the division says.

- The Microelectronics division of NCR Corp., Dayton, Ohio, as a niche chip company, does not exhibit at Wescon. But this year for the first time it will take part at the NCR booth at Comdex. It wants to show off and sell the very successful Small Computer System Interface devices invented at NCR. Still, it considers Wescon important enough to have a company engineer chairing a professional program segment on SCSI.
- Wavetek Corp., San Diego, test and measurement equipment, is a devoted Wescon supporter, sold its first product there in 1962. The company regards Wescon as a "broad-based local show," since most people travel 150 miles or less to attend. Wavetek gets some 500 good sales leads from Wescon, and also maintains a heavy vertical show schedule, including the National Conference of Standards Laboratories (for calibration gear) and the Microwave Technical Show.
- Analog Devices Inc., Norwood, Mass., is a components firm that is sticking with Wescon and Electro because of high (50,000 to 70,000) attendance and the need to stay visible at the West Coast show, since its linear IC competitors are clustered there. But it is on the lookout for vertical shows with the sharp focus to spotlight its data-acquisition and conversion products, such as Siggraph and Electronics Imaging East. Coming along fast is the International Conference for Acoustics and Speech Signal Processing, which draws research scientists who set fundamental trends.
- Texas Instruments Inc., Dallas, has not been in the Wescon and Electro shows for years, opting instead for Comdex/Fall, where the Semiconductor Group piggybacks onto TI Data Systems Group exhibits of computers and boards. DSG officials say Comdex delivers some of its best prospects, up to 500 of them, from some 15,000 people who inquire. TI's chip marketeers also make hay at Comdex by treating it like a vertical show, targeting a particular customer type each year and organizing a private show around it. Last year, gear from 33 firms using TI graphics chips was showcased in a "graphics room" where demonstrations were held.

But it is the radically altered show policy of Motorola Inc.'s Semiconductor Products Sector that poses the toughest problem for the organizers of both Comdex and Wescon. After dropping out of Wescon following the 1986 show, Motorola has pushed ahead with an idea often discussed by others, wrapping up its major products and technology in its own show and taking it on the road. Dubbed "Imaginology," the show debuted in January and has been an unqualified success, says Robert Fields, Motorola's director of advertising and promotion, who spearheaded its development. The show includes exhibits of customer equipment incorporating Motorola semiconductors.

Imaginology is the one-company traveling show Motorola is using to replace participation in big shows; if other companies follow its lead, both Wescon and Comdex could suffer.



MOTO'S EXAMPLE. So far in seven dates across the U. S., the package has drawn some 14,000 design engineers attracted by the prospect of getting nitty-gritty data on how to use the latest Motorola technology. The appeal of having these key people all to itself at a Motorola-only show far outweighs any advantage of many people with lesser interest passing through a booth, says Fields. "The Wescon shows became very expensive, too, but here we can control our own show," he notes. Other chip firms, large and small, are closely following Motorola's show, and many say they are considering some version of it soon.

Motorola's success with Imaginology rules out it returning to Wescon as an exhibitor, says Fields, "unless we have a change of heart." This attitude, which typifies that of the other chip majors, points up how hard Koslov will find his task of bringing the big semiconductor companies back to Wescon. Most semiconductor hands are nostalgic about the Wescon shows of years ago, when semiconductors ruled the roost, but they left the shows for a solid reason: the tenor of the shows themselves changed to a lower-technology plane, so they were no longer a forum for unveiling latest chip advances.

The core of Koslov's plan addresses raising the quality of his professional program by giving it a heavy twist towards chip users with a lower level of design sophistication. This means getting more semiconductor-company participation right away, and indeed this year's Wescon program already is stronger in terms of chip-design tutorials than it has been in the recent past.

Another part of Koslov's program is bringing in for the first time the important related technology of automated design of ICs. This is a feature for which supporters of the Con shows have been requesting. The first Con-show attempt, at the Midcon show in late August, was a successful one, and the design-automation presence has been considerably beefed up to some 200 booths at Wescon.

But it is too soon to expect noticeable results from the semiconductor thrust, Koslov concedes. "You'll see more of it at Electro next Spring, and it will be all there by Wescon '89. There is no reason why Wescon cannot get back to where it was before, a prestige place to present technology."

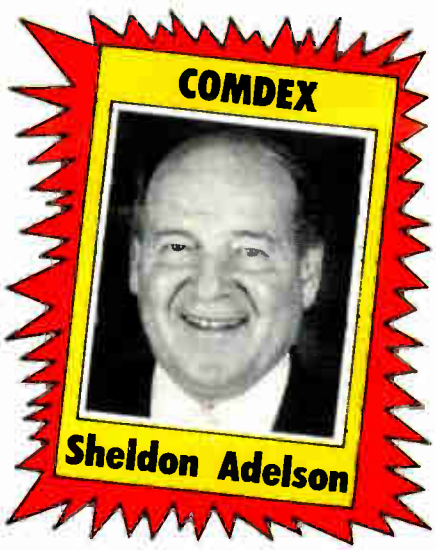
Additional reporting by Wes Iversen, Lawrence Curran, and Tobias Naegele

ADELSON'S AMBITIOUS PLANS TO FIND COMDEX A NEW HOME

Not even a decade ago, the Interface Group Inc. was a only small company that organized trade shows and Sheldon Adelson was its founder, chairman, and chief executive officer. When the idea hit him for a trade show targeted at computer resellers, he went after it with a vengeance. But not even the confident Adelson could have guessed how much the trade show—now known as Comdex—would take off.

Now its very size is creating problems. Comdex is one of the biggest conventions held in Las Vegas, a veritable mecca for conventioneers. The show has burst through the seams of the Las Vegas Convention Center and has spread out to eight other sites, including four major hotels.

The solution is obvious, at least to Adelson. He is now working on a deal to buy the Sands Hotel from MGM Grand for $110 million. The deal includes acquisition of 25 acres adjacent to the Sands, and on that site Adelson plans to build a new home for Comdex—a convention center 50% larger than the existing city convention center.



Those plans are a long way from that April day in 1979, when Adelson was flying from Chicago to Boston. On the plane he happened to see a copy of a new trade publication for original-equipment manufacturers. "Bells went off," he says.

The OEM trade publication was signalling an opportunity for Interface of Needham, Mass. "I couldn't wait for the plane to land," Adelson says. "There was no show then for computer resellers. I wanted to get going on the idea of a show for vendors and resellers."

The first Comdex trade show was held in December of 1979 in Las Vegas. This year, the 10th annual Comdex/Fall Conference and Exposition will be held Nov. 14-18, also in Las Vegas but spread over nine different sites. It is expected to draw more than 95,000 computer-industry vendors, resellers, and users—making it the biggest Comdex held ever.

Exactly how big Comdex has grown is hard to say. Interface remains a privately held firm, and Adelson has never divulged how much revenue it gets from the five Comdex shows now held each year around the world. He will say that "Comdex/Fall is our biggest show by far, and it will become bigger."

And that's where Adelson's deal to buy the Sands Hotel comes in. The deal is typical of the man—no one who knows Adelson well would accuse him of thinking small. He *has* been accused of being brash, cocksure, and an exaggerator. His response: "Some people don't like winners—people who succeed. It's true that I'm very determined and ambitious; I like to move forward." *–Lawrence Curran*

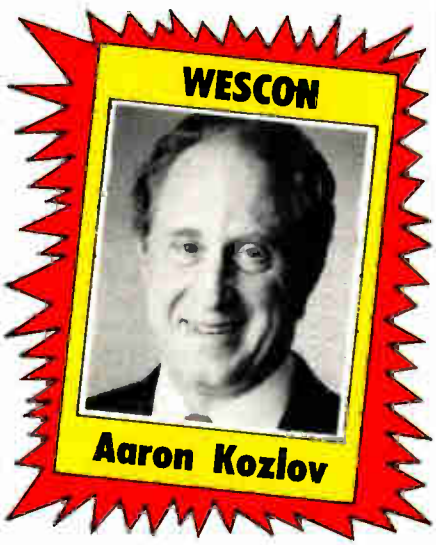
REVAMPING WESCON IS IN KOSLOV'S HANDS

Aaron Koslov has been on the job less than a year, but the directors of Electronic Conventions Management in Los Angeles are already congratulating themselves on finding him. They got what they wanted: a new president and general manager who could generate excitement again for their stable of seven industry shows, among them Wescon.

Koslov has a reputation for not only coming up with new ideas to improve old shows but for putting them into action fast. By all reports, he wasted little time in stirring up things at Electronic Conventions Management. "He's a breath of fresh air," says director Leonard Rosen, a veteran toiler in Electronic Conventions Management affairs and president of Halbar Associates in Glendale, Calif., a manufacturers' representative firm.

At first glance, it's not clear exactly what the problem is that Koslov is supposed to solve. The 1,800 booths at this year's Wescon, to be held Nov. 15-17, are sold out and nearly 60,000 people are expected to attend. "To all outward appearances, Wescon is okay," Koslov says. "But it's not really."

The problem, as he sees it, is that the shows, particularly Wescon and its East Coast counterpart, Electro, settled into a



rut during the 1980s. Increasingly they've become identified with low-tech components instead of the leading edge in semiconductor technology.

His proposed solution is to turn Wescon and Electro into strong design-oriented shows, with a heightened presence of advanced integrated circuits. That will not be an easy task. Koslov will have to lure the major chip companies back in force, which is a hard sell for someone promoting a general-interest, horizontal show like Wescon or Electro.

One thing in his favor is that no single show of major stature now exists solely for semiconductors, and Wescon could fill the void. "It was such a show before and could be again," he says.

DRIVING FORCE. Another advantage is his background. Koslov came to Electronic Conventions Management from the Cahners Exposition Group in Chicago, where he managed 12 high-tech shows. He was the driving force behind the Nepcon show and over a nine-year span helped to build it into the premier event for electronic production equipment. He assembled a team to handle operations for all the shows—a team that did such a good job he ended up without enough work to do. "Frankly, I was feeling vestigial," Koslov says.

His energy is finding a ready outlet at Electronic Conventions Management, where plans for Wescon and other shows are "changes that had to come," Rosen says. If Electronic Conventions Management's shows are not turned around, they face stagnation and decline. As Koslov says: "There is no such thing as a dynamic status quo." *–Larry Waller*

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Worldwide acceptance and field-proven technology demonstrate that the NEAX61 is one of the leading central office switches in today's highly-competitive telecommunications industry.

The NEAX61 is now produced in Argentina, Brazil, Japan, Malaysia and the USA. Future production plans include Thailand and Venezuela. Intensive software development, involving an ever-larger number of engineers, is underway in Argentina, Brazil, Japan, Malaysia, New Zealand and the USA.

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The heart of the system is the CP8Z – a 32-bit custom VLSI that offers over 1,000,000 BHCA. The industry's largest call-handling capacity assures easy expansion and smooth introduction of diverse ISDN services. The enhanced NEAX61 switches are already in the field in two countries.

NUMBER 140

OAI INTEGRATES COMPUTER AND PBX FOR NEW SERVICES.

NEC is introducing a revolutionary gateway interface that enables an external computer to control and extend the operation of a digital PBX. The Open Application Interface (OAI) greatly enhances the data processing power of the PBX, opens many new applications and offers a higher level of user services.

OAI is designed to link the NEAX 2400 Information Management System with most computer systems. Control resides with the computer.

OAI allows two-way data exchange between the PBX and computer. This opens a new world of integrated information services. Multi-function telephones become handy data terminals. Like workstations, they can send or receive data from the computer.

Among the many new OAI services that can be easily implemented are: order entry, inventory management, free location numbering (which allows you to direct your calls to any telephone on the network), and electronic telephone directories.

OAI is accessible to most computer systems because it employs a standard protocol conforming to the OSI (Open Systems Interconnection) model established by the ISO (International Standards Organization).

OAI is supplied as an option with the NEAX2400 IMS and comes with a library of programs that translate standard programming instructions into commands recognizable by the NEAX 2400 IMS processor.

NEW-GENERATION DIGITAL MULTIPLEX AND LINE SYSTEMS.

In the age of digital networks for new services, multiplex equipment must offer a higher level of performance.

Our new N6000 Series multiplex and line systems meet present needs and future demands. They provide leading-edge performance and economy for any network application. N6000 systems incorporate the latest custom digital and analog LSI devices for outstanding reliability. Surface-mount technology and compact unit design dramatically reduce system dimensions and increase flexibility.

The N6000 Slim Rack, measuring 240(W)x2,600(H)x255(D)mm, allows mounting of Multiplexers (MUX) and Optical Line Terminals (OLT) on the same rack. For example, one Slim Rack accommodates a complete equipment set for a 140M fiber optic transmission system — 1 system of 140M OLT with 1 x 1 line protection, 1 system of 140M MUX, 4 systems of 34M MUX, 16 systems of 8M MUX and an orderwire. Further, the 8M and 34M MUX system units fit on the same shelf. Thus a variety of systems for skip, drop/insert and other applications can be built into one shelf.

The N6000 Slim Rack features a side cable duct. It simplifies rewiring for expansion and modification. The Slim Rack centralizes all system alarm and control functions in one maintenance terminal.

The N6000 Series complies with the latest CCITT Recommendations. Compatibility with future requirements, such as TMN (Telecommunications Management Network) and private Network Management System applications, is part of the N6000 concept. For example, standard features of the 140M OLT include a 64kb/s service data channel port and a 1,200b/s service channel port for access to a total Network Management System.

NEW LDs OFFER STABLE SLM OPERATION.

The key to implementing lightwave communication systems with giga-bit speed is the stable single-longitudinal-mode (SLM) oscillation of laser diodes.

NEC opens the way with new 1.3/1.55μm phase-shifted distributed feedback laser diodes. They feature a diffraction grating with a $\lambda/4$-shifted region in the center. This unique grating design produces a stable single wavelength over a wide temperature range: 5°C to 50°C. The sub-mode suppression ratio is 35dB, typical.

Our new light sources offer high output power and fast operation: 8mW (typ) for the 1.3μm NDL5600 and 5mW (typ) for the 1.55μm NDL5650. Rise and fall times for both types are 0.2ns (typ).

The laser diodes come in hermetically-sealed can-type packages with an integral monitoring photo diode or ribbon-leaded chip-on-carriers.

NEC

THE LAPTOP WILL STEAL THE SHOW AT COMDEX

The laptop computer will be the hottest game at the Fall Comdex show this month in Las Vegas, where a surge of new laptops is being rolled out. The show reflects the market—almost a million laptops will be sold this year, according to the San Jose, Calif., research firm Dataquest Inc. That's nearly double the number sold last year.

Several factors are spurring laptop demand, chief among them the improved performance of the machines. More sophisticated disk-drive technology and power-saving CMOS batteries that extend battery life to more than two hours are making laptops comparable to desktop machines in performance.

In addition, laptops are getting better graphics capabilities. Most vendors are providing EGA and VGA compatibility and are using liquid-crystal displays with 8 and 16 levels of gray scale to accommodate the improved graphics.

Finally, laptop makers have identified and are serving the customers who need expansion capability. They are also going after the customers who want the compact package of what has now come to be called the "notebook" computer, which trades functions for extra portability.

The Compaq SLT/286 (upper left), the NEC UltraLite (upper right), and the Grid 1535 EXP (left) are all part of the wave of laptops introduced last month and on display at Fall Comdex this month—aimed at the fastest growing segment of the PC market.

The first announcement came early this year. Zenith Data Systems in Glenview, Ill., announced its battery-operated $7,999 Turbosport 386 and $4,999 Supersport 286 laptops last spring [*Electronics*, April 28, 1988, p. 103]. But the real rush to market began with back-to-back press conferences last month in New York. Toshiba America Inc. of Irvine, Calif., rolled out its 80C286-based T1600 and 80386-based T5200; the next day, NEC Home Electronics USA Inc. of Wood Dale, Ill., announced the ProSpeed 286, ProSpeed 386, and an 80286-based UltraLite, weighing only 4 lb.

Another player jumped into the game a week later when Grid Systems Corp. of Fremont, Calif., unveiled its Gridcase 1535 EXP, a battery-powered 80386-based computer. Later in the month, Compaq Computer Corp. of Houston introduced the long-awaited Compaq SLT/286, an 80C286-based laptop portable.

The outbreak of product announcements are chasing a hot segment of the PC market. The segment will grow 30% in unit sales this year, says Sharon Hashimoto, an analyst at Dataquest, from 645,200 units in 1987 to 977,300 units in 1988, and should reach nearly 3.2 million units in 1992. That is a compound annual growth rate of nearly 38%, more than three times higher than the 10% growth rate for the overall PC market.

What makes the segment even more attractive is the return it offers. In 1987, Hashimoto says, laptop computer sales just topped the million dollar mark. However, she is predicting sales of more than $1.6 million this year and nearly $6 million by 1992. That's a compound annual growth rate of 41%, compared with 11% for PCs overall.

One reason for the lucrative return is the high average selling price of laptops, as opposed to the bargain-basement pricing of full-size PCs. The Toshiba T1600 goes for $4,999 retail; the T5200 has a $9,499 price tag. NEC's Ultralite sells for $2,999, while the ProSpeed 286 and 386 cost $5,000 and $7,700, respectively. Compaq's new SLT/286 starts at $5,399 and the Grid system goes for $7,499.

Except for Compaq, which just started shipping, and Grid, which plans to ship in December, the other new products will begin shipping in February of 1989. That puts Toshiba and NEC, with the second- and fifth-largest installed bases of laptops, respectively, months behind the company with the largest installed base, Zenith.

The laptop segment consists of two kinds of users, says Dan Crane, vice president of marketing at Toshiba. "In one is the mobile professional, the person who uses a laptop on the road as a productivity aid and to access his company's and public data bases," he says. "In the other is the user who takes a portable computer home evenings and weekends."

ON THE MOVE. Crane points out, and Ms. Hashimoto agrees, that the sales of laptops to the former are growing faster than to the latter. "Sales to mobile professional are growing at a rate of 80% a year," Crane says. For this user, high performance, high-resolution graphics, long-time battery operation, and light weight are critical characteristics. For the home user, all of these requirements apply, in addition to expansion capability.

High-end laptop users are performing the same tasks on their portables that they do on their desktop computers. As a result, they are demanding equivalent hard-disk storage and display capability. "A person using two different computers for the same purpose in different places will not trade performance for size and portability," says Chris Espinosa, product marketing manager for advanced technology at Apple Computer Inc. of Cupertino, Calif. "However, he is willing to trade functionality for size."

Apple has been long rumored to be developing a laptop, but has not jumped into

the fray. Industry observers believe that at least part of the problem is trying to package Macintosh capability into a small unit.

Responding to the burgeoning demand for high performance, the more expensive NEC and Toshiba units use the 20-MHz 80386 chip. But both units require ac power for extended operation. The other 80386-based laptops—Zenith's Turbosport 386 and Compaq's SLT/286—operate from batteries. The recently introduced NEC and Toshiba laptops, which operate from batteries, use the long-overdue 12-MHz 80C286 chip from Intel Corp. of Santa Clara, Calif.

These computers all offer 20- and 40-Mbyte Winchester disk drives, with 27-ms average access time, as well as power-saving features that allow the drives to operate on less than 3 W. All five of these computer makers are buying their Winchesters from Conner Peripherals Inc. of San Jose, Calif.

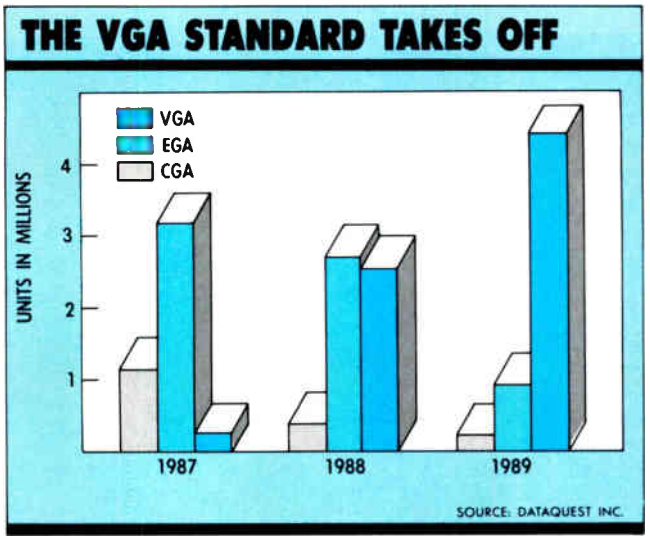
Where the laptops sacrifice the kind of functionality commonplace on desktops is in their displays. LCD displays in the current generation of portables all offer some gray-scale capability and are compatible with the Enhanced Graphics Adapter or Video Graphics Array standards set by IBM Corp. in its PC offerings. EGA calls for a display resolution of 640 by 350 pixels; VGA calls for a deeper 640-by-480-pixel resolution.

Dan Crane of Toshiba says that system suppliers are offering these graphics standards with gray scale because the majority of software running on desktop PCs currently is written for the EGA standard. Gray-scale capability is needed to accommodate applications programs displaying color text on a color background.

But Crane explains that gray-scale capability alone is not sufficient because of color combinations like chartreuse on green. "In our laptops, we have a feature that allows the user to enter a keystroke and the computer will automatically highlight text that might have been obscured when displayed on an LCD display," he says.

The LCD displays on the latest generation of portables make use of a compensated supertwist LCD. These LCDs use an additional compensating layer, says Joe Castellano, president of Stanford Resources Inc., a San Jose, Calif., market-research firm. This feature increases the contrast of the display to embrace a true black instead of the dark blue of conventional uncompensated displays. The layer adds about 10% to the cost of the display, but the trade-off is a crisper screen image.

Castellano says laptop computer suppliers are claiming 8 and 16 levels of gray scale, but in reality are only providing 4 clearly distinguishable levels. "But who needs this gray-scale capability? Where the graphics capability is going is to full-color LCD displays," he says. He cites a 14-in. color display from Sharp Corp. in San Diego, Calif., which offers 512 colors and 640-by-480-pixel resolution. He says the next generation of computers using these displays should begin hitting the market as early as the end of next year.



Besides color, the other capability that laptop must provide is VGA graphics. VGA is important because of the enormous popularity the standard has achieved in a very short period of time. According to Dataquest, 8 million PC-graphics hardware platforms were shipped in 1987, of which 300,000 had VGA graphics capability. This year, Dataquest says, 8.7 million units will ship, and 2.5 million of them will have VGA capability.

Most of the supertwist LCD displays afford 640-by-400-pixel resolution today. An exception is Compaq, which offers eight levels of gray scale with full 640-by-480-pixel resolution and VGA compatibility. Toshiba offers VGA in its high-end T5200, which uses a gas-plasma display and runs off ac power.

MORE SLOTS. Laptop users looking for desktop features in the smaller computers are also demanding expansion-slot capability. Hashimoto of Dataquest says that users are still looking for between two and three slots to add peripherals to their computers, primarily network-communications controllers but also other peripherals as well.

The latest development that has occurred in an expansion chassis is typified by the Docking Station developed by NEC. The chassis allows the user to configure a customized array of expansion cards and peripherals. The laptop "docks" in the chassis for desktop operation and also lifts out for portable operation. Most of the current crop of laptops offer an expansion chassis that can hold two or three cards.

Crane says one reason for having expansion slots is to allow users to customize the system to their application. He cites the case of a corporate customer who needed a laptop with one full-size expansion slot for a token-ring communications card to tie the portable into the corporate network. Currently the token-ring controller card requires a full-size card, not the half card that can hold the Ethernet controller.

Grid Systems, which sells many of its machines to field engineers, needs expansion slots to hold a variety of data-acquisition and instrumentation cards. A field engineer can convert the computer into a logic analyzer or oscilloscope by simply adding the appropriate add-in card, says Matt Lundberg, a product market manager at Grid.

While some customers cry out for expansion capability, others are demanding the most compact package available. One company that has advanced the miniaturization of laptop portable computers to the next level is NEC, with its new Ultralite computer.

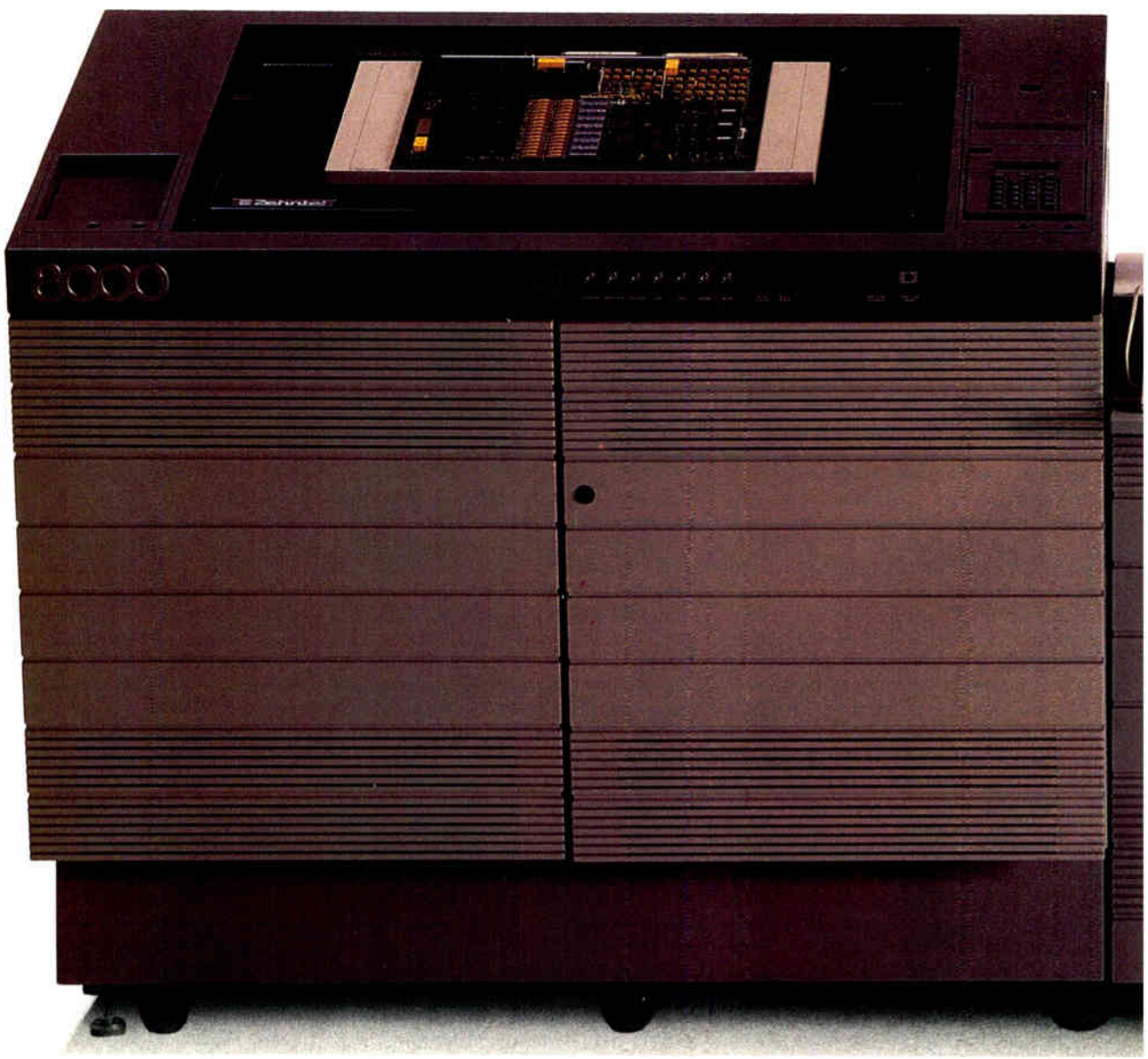
Smaller than a 9-by-12-in. envelope and less than an inch thick, the Ultralite easily fits into a briefcase and represents the first of the next generation of so-called notebook-size computers [*Electronics*, October, 1988, p. 27]. These machines, patterned on the Dynabook concept—a computer the size of a student's notebook—were first developed by Alan Kay, a research fellow at Apple Computer.

DOS-compatible application programs for the computer come in read-only memory packages that are the size of credit cards. Mass storage is provided by CMOS random-access memory. The computer contains a PC-compatible NEC V-30 microprocessor that runs at 9.83 MHz. The unit transfers data and communicates with networks and public data bases via an integral 2400-baud modem.

One drawback is the lack of a floppy disk drive. Users need floppy drives to exchange data and applications between systems. The use of the ROM packages limits the system to software provided by NEC.

In fact, floppy drives are important enough to laptop users for at least one company to take interest. Procom Technology of Costa Mesa, Calif., is introducing an external 5.25-in., 360-Kbyte, floppy-disk drive for laptops, the Procom PLF360. The drive will give users access to data stored on 5.25-in. drives. The company also plans to develop a 1.2-Mbyte floppy drive. *–Jonah McLeod*

"Remember the first rule of testing, Billy..."



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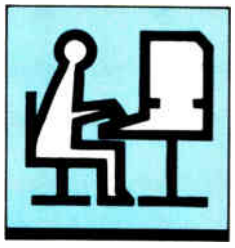
WOULD YOU BELIEVE A 60-MIPS CLIPPER? ECL RISC CHIP IS EXPECTED NEXT YEAR

Intergraph will also introduce a 20-mips CMOS version of the Fairchild-originated processor



Vendors like Sun Microsystems, MIPS Computer Systems, and Motorola have been loudly promoting reduced instruction-set chips—talking up versions of their processors that are not yet in production. And almost drowned out by the noise was another would-be contestant, the Clipper processor developed by Fairchild Semiconductor. But Intergraph Corp.'s Advanced Processor Division, the former Fairchild operation that passed through National Semiconductor Corp.'s hands and then to Intergraph of Huntsville, Ala., now looks to have a chance to beat the other guys at their own game and win support among system builders.

Intergraph has just formally introduced a new version of the Clipper, the C300, that cranks out 15 million instructions per second, and will be shipping a work station based on that chip set starting in December (see p. 105). And news has leaked out in a meeting of industry analysts of the imminent arrival of both a 20-mips CMOS version and an emitter-coupled-logic implementation said to be capable of 60 mips, all manufactured by Fujitsu Ltd., Tokyo. Intergraph declines to comment on future product plans, but sources close to the company confirm that it expects to have systems based on the two new Clipper versions on the market next year. First silicon on the ECL chips should be in hand during the first quarter of 1989, they say.

The high-end ECL version in particular would appear to be well ahead of other RISC chips that would to deliver comparable performance. For example, an ECL implementation of Motorola Inc.'s 88000 processor is not expected to reach silicon until sometime in 1991. In addition, sources close to Intergraph indicate that the ECL Clipper will offer higher performance than the planned ECL version of the 88000. The Sun camp hopes to get a faster version of the Sparc into production during 1989, but it will fall short of the ECL Clipper performance, if it can only do the projected 40 mips.

The RISC game is a serious one. The prize at stake is a market that by 1992 will be worth $505 million, says Robert N. Castellano, president of the Information Network, a market-research firm based in San Francisco. Castellano is predicting that the market for RISC chips will grow at a compound annual growth rate of 96.3% through 1992.

Howard Sacks, vice president and general manager of Intergraph's Advanced Processor Division in San Jose, Calif., believes that the RISC war is still wide open. Each major RISC combatant has a weakness in his battle plan, he says. For example, a weakness he sees in the MIPS and Sparc game plans is that neither has an integrated floating-point processor, cache, and MMU. All are found on the multichip RISC sets from Motorola and Intergraph.

> The ECL chip will beat the competition to market and it'll be downward compatible

What the Clipper offers is what others have been promising but not yet delivering, says Sacks. "Motorola cannot deliver the 88000 solution until 1990," he contends. "On the other hand, we can deliver in volume starting next month. If a designer started designing with the C300 Clipper chip now, he could have a 20-mips system in production by the middle of next year, a full year ahead of Motorola."

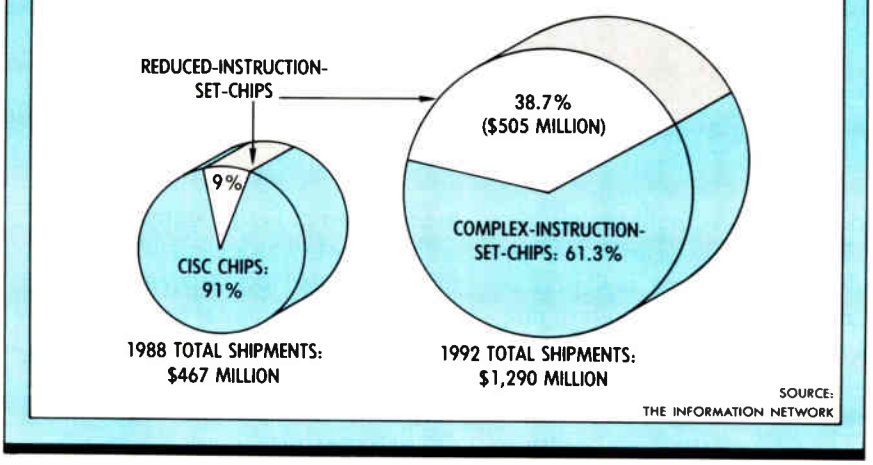
Sacks cautions that to achieve the full 20-mips performance with the C300, a system built with current Clipper parts would have to use non-Clipper cache chips. But sources say that the company is building a cache solution similar to what Motorola plans to have on the 88000 and will be demonstrating the new cache devices, possibly before the end of 1988.

One analyst who supports the belief that an ECL Clipper will arrive next year is Peter D. Schleider, a partner in the investment firm of Wessels, Arnold & Henderson in Minneapolis, Minn. "The processor, a board-level product called the E1, will be 100% software compatible with the existing Clipper," he says.

"Given this timetable, Intergraph has beaten both Sun and Apollo at the price-performance game," Schleider says. "Apollo would say that Intergraph has not beaten them because of the DN10000 [work station]. However, the ECL version of Clipper is completely software-compatible with the C100 and C300. Neither Sun nor Apollo can claim software compatibility with their earlier hardware."

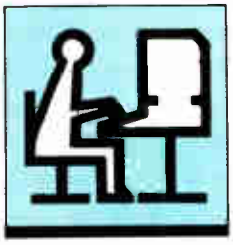
But Intergraph's weakness is credibility as a supplier. It "has to convince designers that the company has a strong production capability in Fujitsu, which will manufacture the chips in sufficient volume to meet demand; that it is still committed to developing new Clipper generations; and that it has a long life expectancy," Intergraph's Sacks says. One sign it is succeeding is the recent decision by DuPont's imaging division to buy up to 50,000 Clippers in the next few years. *–Jonah McLeod*

RISC WILL CARVE A BIG SLICE



A 10-MIPS WORK STATION IS HERE FOR UNDER $60,000

Intergraph's RISC-based system outperforms competitive work stations in its price range and offers engineers an extra-large CRT display



Today's competitive work-station marketing environment has systems houses playing a game of mips-manship. The trickiest part is that the game is based on next-generation reduced-instruction-set-computer chips not yet in production.

But one house, Intergraph Corp., plans to ship production versions of its next-generation RISC-based system next month. These work stations, called the 3000 Series, incorporate the Intergraph's new C300 Clipper chips, and are the first to achieve true, conservatively rated, 10-million-instruction/s performance in the class of work stations that cost less than $60,000, according to the Huntsville, Ala., company. The 3000 will easily outperform other current-generation RISC-based work stations in that price range, says Bruce Imsand, vice president of systems development at Intergraph.

In fact, the 40-MHz C300 Clipper chip allows the work stations to pump out up to 13 mips peak, a big increase over the 300 Series work stations, which run at 5 to 7.5 mips. And a 50-MHz version of the Clipper will boost performance to 15 mips next year during the summer.

Part of the performance boost comes from changes in the way load, store, and branch instructions are implemented, as well as changes in the floating-point processor—changes that do not affect software that was written for the earlier version of the Clipper, the C100. In addition, the 3000 Series work stations come with a 27-in. diagonal display, which allows designers to view much larger portions of their designs.

Intergraph's second-generation system is arriving ahead of the next-generation Sparc-based system from Sun Microsystems, Inc. of Mountain View, Calif., and ahead of the RISC-based stations from Digital Equipment Corp., Maynard, Mass., which will use processors developed by MIPS Computer Systems Inc. Only MIPS Computer, Sunnyvale, Calif., is currently shipping a system—the M/2000—with the new 20-mips versions of its chip, but it is priced at $100,000. Systems based on Motorola's 88000 RISC processor—a chip set with an architecture remarkably similar to the Clipper's—are still a long way off.

Intergraph's entry-level 3000 Series Model 3070, which will start shipping in December, will cost under $60,000, well below the $90,000 price of the 10-mips, Sparc-based Sun 4. The price difference results from the higher level of integration the C300 Clipper affords. "The C300 consists of four chips: an integer and floating-point processor on one chip, two cache and memory-management chips—one for instructions and one for data—and a clock chip. They all fit on a single card measuring 2.5 by 3 in.," says Eugene Grindstaff, senior manager of work-station sales and support at Intergraph.

"To achieve the equivalent of this [functionality] on other RISC-based systems requires a board of 13 by 15 in.," Grindstaff continues. "Besides using discrete-integer and floating-point processors, these designs use larger emitter-coupled-logic cache memories than the Clipper. They achieve a higher mips rating, but at a higher price, and without necessarily running benchmarks faster than our Clipper-based system."

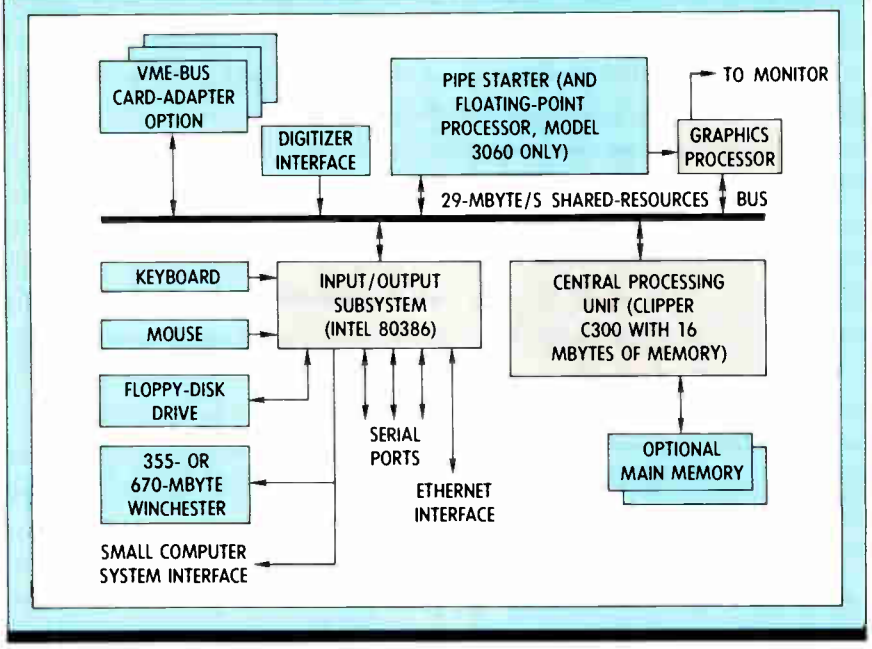
Intergraph's new system enters into a competitive market. One market research firm, Daratech Inc., based in Cambridge, Mass., predicts the market will grow 15%. In 1987, it was worth $4.56 billion and this year is expected to reach $5.2 billion. Daratech, specializing in computer-aided design, engineering, and manufacturing, breaks down that total market into three main segments: mechanical, electronic, and AEC (for architectural, electrical, and civil engineering). The lion's share of the 1987 market was held by the mechanical-design segment, at 59%, the electronics-design portion held 22%, AEC made up 17%, and others made up the rest.

Intergraph sells its work stations and the individual boards in them by themselves (see p. 109). It also sells software targeting the three design-automation market areas Daratech describes—mechanical, electronic, and AEC. Intergraph touts the standards they support—Unix System V, Ethernet networking, transmission-control protocol/internet protocol (TCP/IP), and the Network File System, just like the competitors based on Sparc and MIPS Computer chips.

SAME LOOK. Designing the 3000 Series work station was made much easier by the fact that the performance of the new C300 Clipper RISC-chip set looks the same as the C100, from the system's point of view, in all aspects but its clock frequency. But it is not the same. The new work station has a different memory system design, one that can accommodate the 40- and 50-MHz clock rates of the new and future versions of the Clipper chip.

"In addition, the new C300 can perform some functions in the burst mode to make better use of the memory bus than other

A HIGH-THROUGHPUT THREE-PROCESSOR SYSTEM



The Clipper CPU in Intergraph's 3000-series work stations works faster with support from a graphics processor and a 386 handling input/output tasks concurrently.

RISC processors," says Grindstaff. This is apparent to the user. The cache and memory management units perform a four-word transfer in burst mode, a unique feature. With four-word transfer capability, the units prefetch more instructions into the cache at once to reduce the time penalty resulting from a cache miss.

"The critical characteristics [for a cache system] are how fast the cache operates and how quickly it can reload when there is a miss," says Gary Baum, director of marketing for Intergraph's Advanced Products Division in Palo Alto, Calif. This unit is the Fairchild Clipper group that National Semiconductor Inc. of Santa Clara, Calif., sold to Intergraph after acquiring Fairchild Semiconductor Corp. from its parent Schlumberger Ltd.

Grindstaff also contrasts the Intergraph system architecture, which has processors for computation, input/output tasks, and graphics processing, with the Sun 4, which saddles its Sparc processor with all three jobs. Besides the C300 Clipper, with its integrated integer and floating-point processor, there is a 3-mips Intel 80386 processor for I/O and a 40-mips proprietary graphics processor.

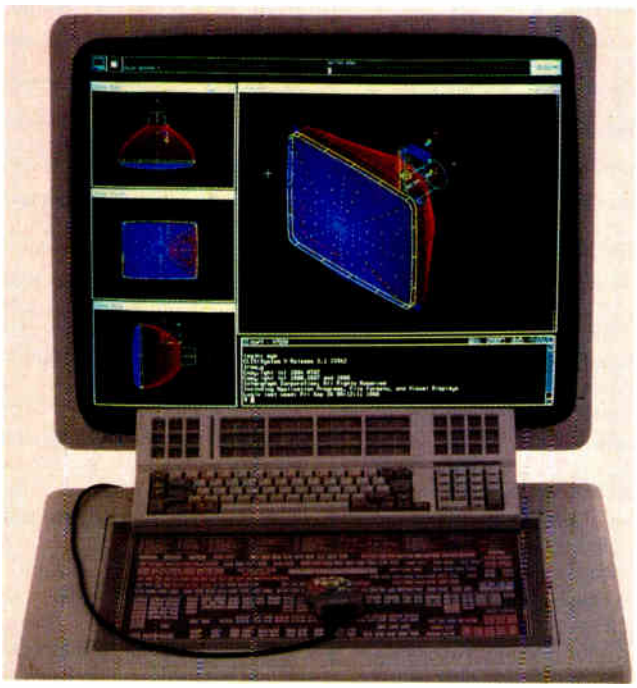
The Intergraph multiprocessor design leads to better performance than some machines with higher mips ratings, Grindstaff maintains. In a real-world application, computation, I/O, and graphics operations all occur concurrently. "The fact that the three processors distribute the load throughout the machine is the biggest reason for the performance advantage over competitive systems," he declares.

The C300 chip also has an advantage over other RISC processors available in that both integer and floating-point processors are on a single chip, so that the two processors can execute concurrently and communicate quickly. Furthermore, the floating-point unit in the C300 has been redesigned. "What we did was reduce the number of clock cycles needed for a floating-point operation significantly," Baum explains.

The C100 performs floating-point operations 2 bits at a time, while the C300 performs them 8 bits at a time. Thus the number of clock cycles needed to perform a double-precision multiply instruction, for example, is significantly reduced. The C300's floating-point performance is two to three times better than that of the C100, Intergraph says.

Another change that makes the C300 chip faster than the previous-generation C100 chip is the fact that the load, store, and branch instructions now execute in one less clock cycle. The academic approach to RISC-processor design holds that all instructions should execute in one clock cycle. So designers of central processing units must find their slowest instruction, typically a load, store, or branch instruction, and make that instruction execute in one clock cycle. Even though the computer could execute simpler operations. such as adds, in less time, they occupy the same amount of time as the slower instructions.

In designing the Clipper chip, which is patterned on the architecture of the Cray supercomputer, the fastest instructions, such as an add or register-to-register operation, are designed to execute in a single cycle. More time-consuming operations, such as loads, stores, or branch instructions, take up multiple clock cycles.



A screen measuring 27 in. on the diagonal, which displays 1,664 by 1,248 pixels, is available on Intergraph's model 3070 work station.

Intergraph's next-generation system is arriving before rivals from Sun and DEC

"In the next generation of products, we may choose to keep the clock frequency fixed and reduce the [number of] clocks per instruction," says Baum. Running faster may not be desirable because of the problem of interfacing with TTL circuits outside the chip. "Imagine what would happen if we could achieve the same number of clocks per instruction that other RISC implementations achieve today, 1.5 to 2 clocks per instruction, with a 50 MHz clock—yet have a higher level of functionality per instruction than other RISC implementations running at 25 MHz," Baum says.

In addition to providing a faster computation engine, the 3000 Series work stations come with the first ever 27-in. workstation cathode-ray tube. In providing the big display, the company is responding to customer demand for a larger contiguous screen-display area in which to work. The new display offers a resolution of 1,664 by 1,248 pixels.

The reason it takes most companies a long time to implement new display technology is that the monitor circuit technology must catch up with the tube and yoke technology. "We have a close relationship with a number of Japanese manufacturers of tubes and yokes and they have been interested in working with us because we can help them develop their tube technology," Imsand explains.

"A year ago, we requested they build for us a 27-in. color tube for a data-display terminal," he says. "We felt that the timing and technology was right for this kind of product."

The implosion-protection and radiation-protection certifications required for data-display applications are major barriers to making these tubes generally available. Without some guarantee of sales, tube makers are not willing to make the investment needed to build and certify them. That guarantee is what Intergraph gave to these tube suppliers.

"After acquiring the 27-in. tube, we went about turning it into a data-display terminal," Imsand says. "We have had graphics-display controllers for two years that would drive 2 million pixels on a 19-in. tube." The display controller board comes with 2 to 8 Mbytes of CMOS RAM. It has bipolar digital-to-analog converters to produce the color drive for the three color guns and it has a number of CMOS application-specific integrated circuits developed by Intergraph.

The company's test marketing showed that there was no demand for a 2-million-pixel 19-in. display because people did not want to spend twice as much for a dot-resolution improvement of 41% over a conventional controller with 1-million-pixel capability. In addition, the light output of such a system decreases because it goes to a finer-pitch shadow mask to fit that many pixels into a 19-in. display. "We wanted to keep the number of dots per inch the same and take advantage of our 2-million-pixel resolution to drive a larger 27-in. screen display," Imsand says. *–Jonah McLeod*

Telecommunications Industry Update

A REPORT FROM THE NETHERLANDS FOREIGN INVESTMENT AGENCY

In 1989, the Netherlands will be one of the first European countries to substantially open up its telecommunications equipment and services market—a response to deregulation and market conditions, globalization, and telematics progress. The Dutch telecommunications equipment market is projected to reach nearly $800 million by 1990, while the European-wide market for equipment and services could exceed $50 billion.

Holland has ensured that its infrastructure — including PTT Nederland which will become a private company January 1 without regulatory responsibilities—will be able to handle not only today's basic speech, text and data exchanges, but tomorrow's needs for fast total digitalization, mobile and other new value-added services.

Here are some examples of Dutch developments in advanced telecommunications services that will be available to consumers, industry and governments.

ISDN Picture Phone—Since 1983, the Dutch have been helping to define the operational standards, compatible with both CCITT and CEPT, for a worldwide small band ISDN videophone terminal. This international effort is being coordinated by the PTT Dr. Neher Laboratories and foresees low-priced picture phones for office and home use in 1992. High-quality moving pictures accompanied by high-quality voice are transmitted over a 64kbit/second network. The bit rate is achieved by data compression techniques that eliminate redundant information using a hybrid method combining DPCM- and transform-coding. Encryption will ensure privacy. To enhance a possible videophone service, high quality videotext images can be transmitted with the same equipment.

Teleports—Designed jointly by Rotterdam's municipal authorities and its business community, the teleport uses the International Transport Information System (INTIS) for the electronic exchange of standardized messages between shippers and suppliers of all modes of transportation. Shippers and freight forwarders already access the network to send shipping instructions to deep-sea carriers and liner agents. They, in turn, communicate electronically with container terminals. Both PCs and mainframes, equipped with a 3780 emulator and a V22bis modem, can access the network. Access by X.25 protocol will be available soon. Amsterdam is also developing a teleport.

Transportation Databases—A standard IBM SNA system with videotext is providing more than 1,500 subscribers throughout Europe with cost savings and real-time information about space availability, type of cargo handled, destinations, departure and arrival times for trucks, trains, ships and airplanes throughout Holland. Called Transpotel, this Dutch database service has expanded through franchising to the United Kingdom, Switzerland, Belgium, Austria, France, Germany and Scandinavia, and soon will extend to Italy and Denmark.

In addition, Holland is a major manufacturing location not only for N.V. Philips's data communications products, but also for Alcatel, N.V., which builds and markets its System 12 for small and medium-sized firms; for Swedish multinational L.M. Ericsson, which manufactures telephones for the Dutch PTT and other telecommunications equipment; for West German multinational Siemens, which produces data communications products; and for the AT&T/ Philips joint venture, which is building a new generation PBX.

Further, three technology universities—at Delft, Twente and Eindhoven—and more than 100 technical institutes along with the Netherlands Organization for Applied Scientific Research (TNO) and major software houses assist companies, regardless of location, with research and development from defining systems needs to designing networks to building prototypes or writing code.

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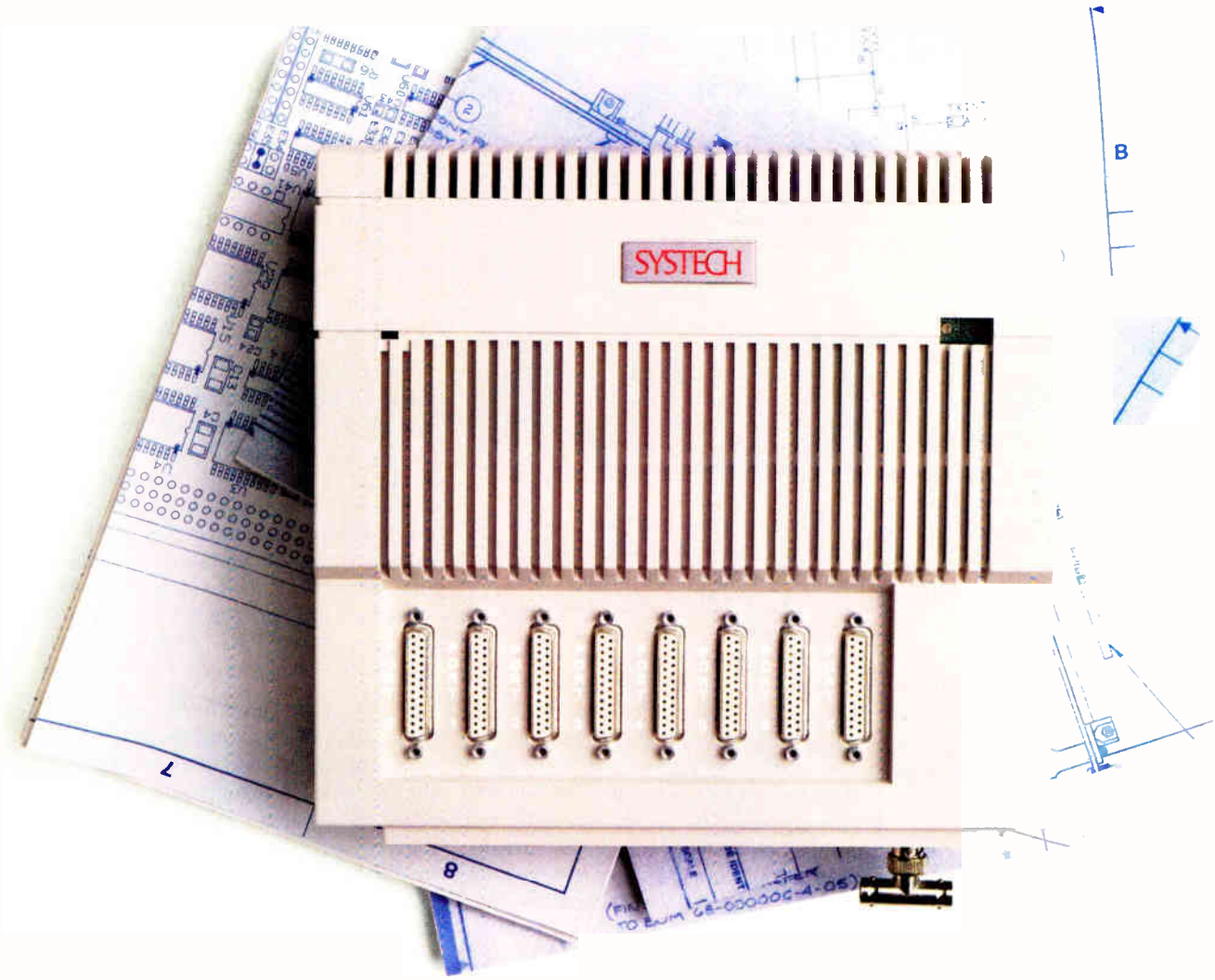

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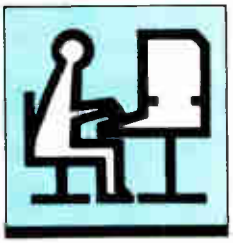
INTERGRAPH'S RISKY STRATEGY IS WORKING



Despite a major strategic decision that flew in the face of industry wisdom, Intergraph Corp. is thriving.

It chose to build its own hardware platform when others in the computer-aided design, engineering, and manufacturing businesses were doing the opposite. With that move, it bet the company's fortunes on a lesser-known 32-bit RISC microprocessor, the Clipper developed by Fairchild Semiconductor Corp. Other vendors chose to play it safe by building work stations around one of the more widely used chips for which more software was available.

The wisdom of Intergraph's tactics looked questionable, but the Huntsville, Ala.-based company has flourished. It flourished even when it became necessary to buy the the Fairchild Clipper operation—in the aftermath of Fairchild's sale to National Semiconductor Corp.—so it could assure a supply of the chips that are at the heart of its new generation of work stations. This year Intergraph will enjoy a 27% growth rate in an overall market segment (CAD, CAE, and CAM combined) that is growing only 15%, according to Daratech Inc., a market-research company based in Cambridge, Mass.

In fact, Intergraph has been a perennial favorite on Wall Street, says Bruce Jenkins, a vice president at Daratech. Its knack for anticipating changes in the CAD, CAE, and CAM markets and for making the right moves under changing market conditions are key factors, he says.

The results are reflected on the bottom line. Net income will hit $93.8 million in 1988, up 34.3% over 1987 income of $69.9 million, according to the projections of Raymond F. Reed, an analyst with Mabon, Nugent & Co. in New York. Reed sees net income rising 25.3% in 1989.

IN THE MONEY. Intergraph sales will grow another 24% in 1989 and break the billion dollar barrier, Reed says. He believes the company can maintain operating margins of 17%, thanks to improved gross margins from increasing shipments of work stations and new application software that offers a high level of added value.

The work stations are key. Intergraph's decision to build its own hardware platforms has proved a profitable strategy. Despite observers' doubts that it would be able to keep up with the price-performance gains offered by big work-station hardware vendors like Apollo Computer, Digital Equipment, and Sun Microsystems, Intergraph has been very successful selling work stations based on the Clipper and continues to introduce competitive systems. In addition, the company is working to strengthen its position in the electronics-design segment of the market with its own and newly acquired tools.

Staying on the hardware side instead of concentrating solely on software that runs on work stations built by a large systems house, as Mentor Graphics Corp. does, has two advantages. One is that the hardware side of the sale of a CAD, CAE, or CAM system carries most of the profit. Software represents a mere 20% of the price of a typical CAD, CAE, or CAM system sale, says Jenkins of Daratech.

> Its proprietary system using the Clipper processor is doing better than expected

A lot of downward pressure on the price of software tools is another advantage. The falling price of hardware has been one factor dragging down prices and profits in the software business, says Jenkins. Users are not willing to buy expensive software for inexpensive hardware, so software prices must drop. Competition has also driven them down.

On the other hand, even though fewer profits are visible for software, the availability of good tools is vital to Integraph's total-system sell. Its efforts to improve its penetration of the electronics CAD and CAE segments are focused on gaining ground in software.

At present the electronics segment is not Intergraph's strong suit. As Daratech breaks it down, the CAD, CAE, and CAM markets include mechanical and electronic design plus AEC—architectural, electrical and civil engineering—into which Daratech lumps mapping and cartography.

The combined mechanical, electronics, and AEC markets will be worth $5.2 billion in total revenues this year, according to Daratech. Intergraph, with a 15.6% market share, or $813 million, will be second only to IBM Corp., with a 25.7% share, says the market research firm. It is in the AEC segment in particular that Intergraph shines, especially in the mapping and cartography markets. In 1987, the Daratech tally put it in the No. 1 position, with $762 million in sales totaling 42% of the segment.

This year, the company will improve its market share in the electronics segment, says cofounder, president, and chairman of the board Jim Meadlock. It plans to build on a strong set of internally developed tools for printed-circuit-board layout, says Jeffrey Edson, director of the electronics division. It has also acquired integrated-circuit layout tools through an 80% investment in Tangent Systems Corp. in Santa Clara, Calif., and an analog circuit simulator in its purchase of Circuit Tools Inc., San Ramon, Calif. In addition, it plans to license programs for thermal analysis and electromagnetic interference analysis. *–Jonah McLeod*

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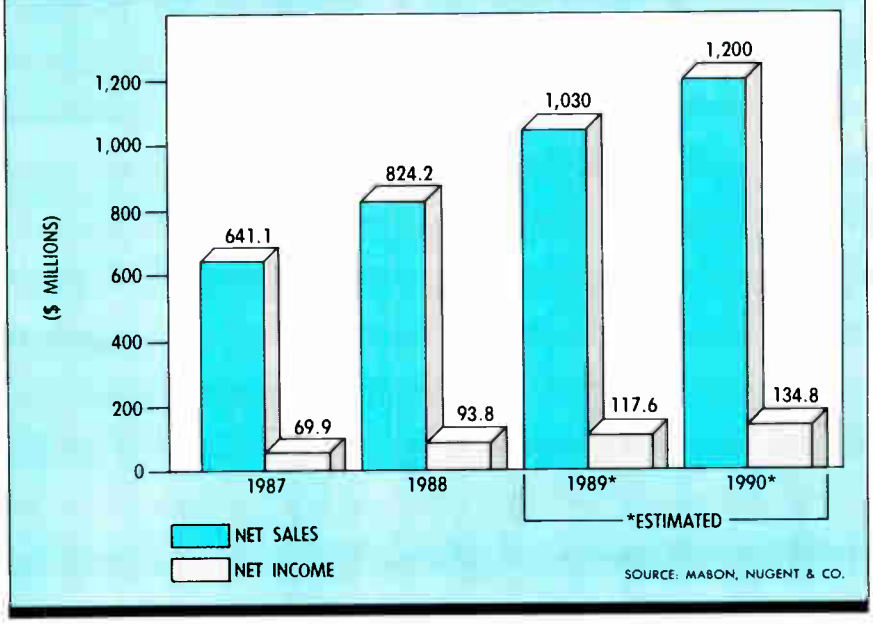

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A BRISK POWER-SUPPLY MARKET DRIVES CONTROL-CHIP PROLIFERATION

Sales for computer-based systems are expected to double to $10.3 billion by 1993

As the proliferation of microprocessors drives down the size of everything from computers to automotive electronics, power-supply manufacturers and the semiconductor firms who supply the basic controls for power supplies find themselves in an exploding market. At the same time, the trend toward smaller systems is pushing supply makers and chip companies to improve output and reduce size, leading them to explore increasingly complex and sophisticated technology. One result is a growing number of high-performance controller and regulator chips.

Total U. S. sales of power supplies for computer-based systems are expected to reach $10.3 billion in 1993, almost double 1987's $5.6 billion, according to Frost and Sullivan Inc. researchers in New York. The market growth is occurring as the venerable linear power supply, the mainstream technology since the mid-1970s, gives way to switching power supplies, which are lighter, cheaper, and more efficient in most power ranges. Switchers in the 1970s were used only in aerospace applications, where portability and small size were essential. Since then they have steadily gained market share, according to Daranell Research Associates in Los Angeles. By 1987, they accounted for 60% of the 12.3 million units sold.

DYNAMIC TECHNOLOGY. Growth in the switcher market has been matched by growing diversity in technology, such as Micro Linear Corp.'s new family of standard and semicustom circuits (see p. 114). The original switching power supplies were so-called voltage-mode systems. Soon after their commercial introduction, they were joined by switching power supplies that were based on newer current-mode designs. In 1982, voltage-mode supplies held 75% of the market; today, they are inexorably losing ground. Current-mode supplies should capture from 50% to 60% of the market some time in the next four years. However, the technology is still advancing, so the market is still changing. An even more efficient methodology, the resonant-mode switcher, is now gaining ground: most researchers think it will grow from 10% or 15% of the market last year to 35% by 1992, with current-mode holding steady at around 50% and voltage-mode diminishing to about 5%.

No single company in this relatively young market has more than a 5% or 6% share, says Venture Development Corp. in Natick, Mass. The top four manufacturers in world sales—Astec U. S. A., Computer Products, Lambda Electronics, and Zenith Electronics—together hold only 20% of the market, with about 50 others holding from 0.5% to 2%. On the component side, there is a similar diversity, with 20 to 25 component suppliers competing for market share.

Until recently, the market was dominated by linear power supplies, the oldest technology available. Linear supplies are controlled by a regulating circuit that typically consists of a transistor and an error amplifier, which gives them the advantage of reacting to line and load changes quickly with low ripple and noise. They have the disadvantage, however, of relatively low efficiency—between 30% and 50%—because of the power wasted in the power transistors and losses in the power transformer coils.

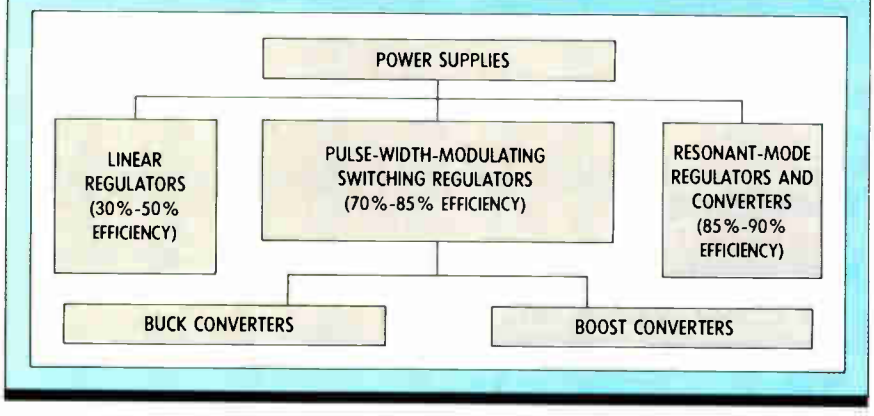
By contrast, the newer switching power supplies are 60% to 80% efficient. They usually run off-line, with a front end consisting of a bridge rectifier to change the external alternating current to a raw direct current. In voltage-mode switchers, a single loop of the circuit is used to sense the voltage at the power-supply output, feed back the value, and correct any deviations. In current-mode switchers, an inner loop that feeds forward is added to regulate the peak inductor current and compensate for deviations in input supply voltage. In effect, the switch duty cycle is controlled not by the output voltage but by the switch current. This allows operation at higher voltages, higher frequencies, higher currents, and lower power dissipation.

MAKING IT WORK. Key to either switcher's ability to operate is the regulator or controller circuitry, which generally uses a pulse-width-modulation technique, implemented in discrete or monolithic form. In this type of circuit, a transistor functions as a switch, controlling the amount of energy sent to the second stage of the supply. When the transistor is on, the current increases linearly in the transformer's primary coil. When off, the current flows in the secondary coil, charging a filter capacitor.

Pwm designs are most often used in switchers that run at 200 to 500 KHz. Since they have trouble maintaining the narrow pulses associated with frequencies in the 1-to-2-MHz range, most higher-frequency regulators use a pwm variation called pulse-interval modulation. In PIM, the interval between pulses varies but the width of the pulses remains steady. Pwm designs can be used for either voltage- or current-mode switchers; PIM generally is used only for the higher-frequency current mode.

Most pwm and PIM designs derive from two basic configurations: the buck converter and the boost converter. In the former, the inductor feeds a steady current to the load, acting as a stepdown regulator in which output voltage is always less than input. In the latter, the inductor charges and discharges, sending current pulses to the load and stepping up voltage. The main difference between the two types lies in the

CHIPS TARGET MANY POWER-SUPPLY TYPES



The power-supply market is split among several different families of devices, from the older linear supplies to the latest resonant-mode devices.

SHARING THE POWER-SUPPLY IC MARKET

Company	Operating Frequency	Regulation Mode	Process
Cherry Semiconductor	1 MHz	Current	Bipolar
Exar	300 KHz	Voltage	Bipolar
GE Solid State	200 KHz	Voltage	Bipolar
Genum	1 MHz	Resonant	Bipolar
Integrated Power Semiconductor	500 KHz	Voltage	Bipolar
International Rectifier	150 KHz	Current	DMOS
Lambda Semiconductors	200/500 KHz	Current Voltage	Bipolar
Linear Technology	40 KHz	Current	Bipolar
Maxim	50/70 KHz	Voltage	CMOS
Micrel**	Customizable	All	CMOS/DMOS Bipolar
Micro Linear*	1 MHz	Current Voltage Resonant	Bipolar
Motorola	100/300 KHz	Current Voltage	
National Semiconductor	100 KHz	Voltage	Bipolar
Plessey	500 KHz	Voltage	Bipolar
Raytheon	75 KHz	Voltage	Bipolar
SGS Semiconductor	500 KHz	Voltage	Bipolar
Signetics	600 KHz	Voltage	Bipolar
Silicon General	350 KHz	Voltage	Bipolar
Siliconix Siltronics	1 MHz 80 KHz	Current Voltage	CMOS/DMOS Bipolar
Teledyne Semiconductor	200 KHz/1 MHz	Current	CMOS
Texas Instruments	Programmable	Voltage	Bipolar
Unitrode	500 KHz/1 MHz 3 MHz	Voltage Current Resonant	Bipolar

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timing of the energy storage in the inductor. To gain the advantages of both techniques, a third variation has become popular, the buck-boost circuit, which can step the voltage either up or down.

Just coming onstage is the resonant-mode controller or regulator, in which energy resonates between being stored as a current in an inductor or as a voltage across a capacitor. Capable of operating efficiencies in the 85% to 90% range, the resonant-mode technique takes advantage of the times when either the voltage across or the current through the switching transistor is zero. When there is no voltage, the transistor turns on without dissipating power. When the current is zero, it turns off without dissipating any power.

With the introduction of voltage-mode power-supply regulators such as Silicon General's SG3524 and Signetics' NE5560 pwm switching-mode designs began to gain ground against linear designs. Voltage-mode regulators came first, and they are now widely second-sourced. They are the least expensive to make because they operate most efficiently only in the lower, 200-to-500-KHz frequency range. However, they are now giving way to current-mode circuits.

Until recently, the only current-mode IC to reach into the megahertz range was the Unitrode UC-1825, with a shutdown delay of no more than 50 ns and output rise and fall times in the 30-ns range. Introduced in 1985, it has given rise to even more flexible and speedier variations.

For example, there is the UC3825, also from Unitrode, which combines both current- and voltage-mode topologies. And Siliconix offers the Si9100, which accepts either low-voltage dc supplies or unregulated higher-voltage, 10-to-70-V, signals and then steps them down to 5 V. Another variation is the CA1523 from GE Solid State, which merges frequency modulation and pwm, essentially compressing the operating-frequency range for a given load range.

Growth in switcher market has been matched by growing technology diversity

And where existing regulators and controllers are oriented at higher voltages—anywhere from 5 to 60 V—Siltronics has aimed its S424 at applications using under 1 V, where it is necessary to run off an alkaline or nickel-cadmium battery This pwm device takes a 0.9-to-1.7-V dc signal and scales it up to 3 V at 15 mA or 5.5 V at 10 mA. At the other end, is International Rectifier's IR2100, a 450-V device powered by a rectified 115-V ac line. It accepts 100 to 450 V of unregulated dc and generates a 15-V dc output with 500 mA of drive.

Taking the current-mode regulator design to its limits of flexibility is the CS320 family from Cherry Semiconductor Corp. of East Greenwich, R. I. Where present current-mode designs use constant frequency control, the CS320, which operates at 1 MHz, gives the designer the choice of constant frequency or either of two variable-frequency methods: hysteretic or constant off time. Where present current-mode designs involve sensing, directly or indirectly, inductor current, the hysteretic technique senses both peak and valley currents; the constant off-time technique senses only the peak current.

Nor is the voltage-mode control methodology being entirely left behind. The newest twist on the mature technology is the 200-MHz CA1523 from GE Solid State, which, for the first time, combines pwm and PIM. In addition, it incorporates features previously only associated with later current-mode circuits, including overcurrent sensing and soft start.

Still another alternative comes from Linear Technology Corp. of Milpitas, Calif. Its LT1070 family of 1.25-, 2.5-, and 5-A current-mode regulators allow the use of what is known as a distributed-power architecture, as opposed to the single-source switching-power-supply approach. The device can operate at up to 45 KHz over a 3-to-60-V range. It can be used in buck, boost, buck-boost, and current-boosted-buck methods.

Now just entering the market to challenge current-mode pwm controllers and regulators are a number of resonant-mode offerings. Genum Semiconductor offers the LD405, which combines the fixed-pulse-width, variable-frequency technique with a frequency range from 10 KHz to 1 MHz.

Taking advantage of the relative fragmentation of the power-supply market are a few analog ASIC firms. One impressive offering is from Micro Linear of San Jose, Calif. Its ML4823 and ML4825 are improved, second-source versions of the Unitrode parts, and the company is also offering a proprietary device, the ML4809, which operates in both the current and voltage mode. *–Bernard C. Cole*

A 'FULL HOUSE' OF SWITCHER CHIPS

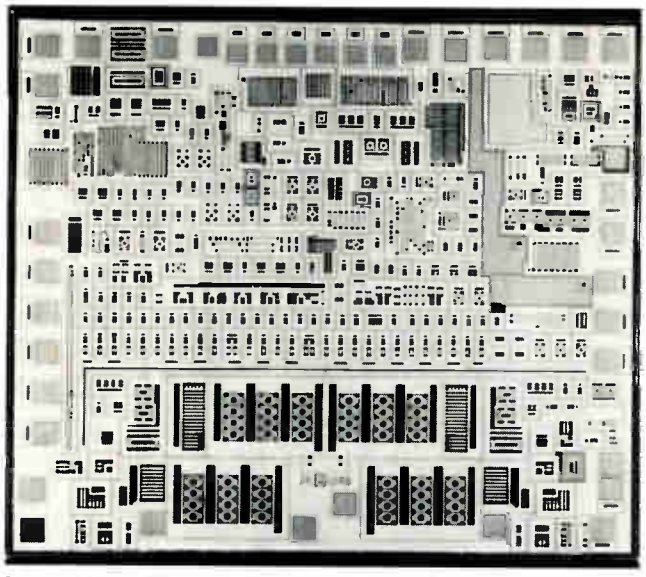
Micro Linear Corp. is fielding a family of chips that could make life a lot easier for engineers trying to decide between standard and semicustom solutions for switching power supplies. The family includes both types of circuits, giving designers a range of costs, functionality, and customizability.

In developing the family for use in pulse-width-modulated power supplies, the San Jose, Calif., company is targeting an area that often confronts engineers with a dilemma. Standard circuits are inexpensive but can't provide system-specific solutions, and adding external circuitry to accommodate a given system's requirements also adds significantly to the cost. On the other hand, semicustom circuits that can be configured to accommodate specific system requirements cost more to start with. And in both cases, designing in the circuit can take too long.

The hard choice between low cost and high functionality is complicated by the different requirements switching power supplies can be called upon to meet: widely varying system topologies, application-specific features, turnaround times, and levels of integration. All of these different and frequently contradictory requirements mean that no one solution, whether standard or semicustom, can serve every user, says Charles Gopen, vice president of marketing.

MANY OPTIONS. That analysis led Micro Linear to develop a family of standard and semicustom circuits that could give customers many options. The first member of the family, and the basis of all of the circuits, is the FB3480, which is a switching-power-supply array. From the FB3480, two specific circuits are derived, the ML4823 and ML4825. These are improved versions of industry-standard circuits—Unitrode Corp.'s single- and dual-ended current/voltage-mode controllers for switching power supplies—which Micro Linear is second-sourcing. A third circuit the company developed, the ML4809, is a proprietary switching-mode power-supply controller. All the circuits are fabricated in the 3-μm, 40-V linear bipolar process that Micro Linear used in its recently introduced FB3400 array [*Electronics*, September 1988, p. 66].

Scheduled to be offered to users in January, the FB3480 array will carry an initial lot charge of $7,500 for design and a supply of 50 prototypes, provided the customer commits to at least a $25,000 production run. The cost is $25,000 for 100 parts with no production commitment. In 10,000-unit volumes, pricing on a typical semicustom controller will range from $4 to $6 each. Micro Linear says turnaround time, from specifications to completed design, should be no more than four to eight weeks, compared with about 12 to 24 weeks for a typical semicustom design—and even longer for a full custom design.



Micro Linear's FB3480 switching-power-supply array has unused devices that can implement logic, comparators, and other functions.

The 16-pin ML4825 will be available in sample quantities this month at a price of $5.50 each in lots of 100; the ML4823 will be available in February. Samples of the 24-pin ML4809 should be available in January at a price of $6.25 each in lots of 100.

Micro Linear makes it easier to choose between standard and semicustom circuits

The FB3480 array is based on Micro Linear's 36-V, double-metal, analog bipolar array, the FB3400. The FB3400 incorporates an architecture based on five different types of minitiles. These can be combined to implement such functional blocks as operational amplifiers, comparators, voltage references, video amplifiers, transconductance amplifiers, modulators, demodulators, various interface drivers, data acquisition and—most important for switching power supplies—pwm circuits.

Where the FB3480 array differs from the FB3400 is in its incorporation of a functional core that contains the circuitry needed to perform all of the functions of the UC1823 and 1825, Unitrode's industry-standard parts. The circuitry includes an oscillator; voltage-reference and undervoltage-lockout circuitry; an error amplifier and lockup amplifier; a shutdown comparator; a limit buffer amplifier; a current amplifier; a pwm comparator; and output drive circuitry sufficient to drive external power MOS FET discrete transistors. The FB3480 contains clusters of unused transistors, resistors, and capacitors that can be connected as gates, latches, comparators, error amplifiers, as well as various other pwm switching-power-supply functional blocks.

Micro Linear elected to use Unitrode's architecture, out of all the switching regulators and controllers available, because it can operate at frequencies in excess of 1 MHz in either the current or voltage mode, Gopen says. But standard parts based on the architecture cannot meet all the different system, environmental, and performance requirements of switching power supplies. Some of their functional blocks are inaccessible such that adjustments can't be made by external parts. To address that problem, Micro Linear implemented its circuitry in special blocks designed and located for convenient modification.

This move is a key element in the improvements Micro Linear made in the ML4823 and ML4825, the standard circuits that are based on the Unitrode UC1823 and 1825. The Micro Linear designers took advantage of the easily accessible function blocks to build in a number of features not available in the original Unitrode parts.

One of these is a fast current-limit shutdown path going directly to the output stage, so system shut-down is faster. Another new feature is that the output lines come up in a known state, making it easier to synchronize operation with the rest of the system. Also, a latching, current-limiting, soft-restart reset circuit has been added. In the original design, the controller had no memory of the previous state after a shut-down—the entire system had to start from zero. The additional circuitry enables the controller to remember the original condition, eliminating considerable delay.

The third family member, the proprietary ML4809, also incorporates special features, Gopen says. Among them is a

blanker circuit to eliminate the leading-edge current spikes that are present in current-mode-sense circuits. A ramp-compensation circuit has also been added, which provides stable current-mode control when it is necessary to operate above a 50% duty cycle. To simplify operation in those applications where external synchronization is required, a preset function has been incorporated into the output-toggle flip-flop. A separate error-amplifier output has also been added to allow the feedback loop to be broken, which is important in microprocessor-based systems requiring self-diagnostics.

A MULTIFUNCTION CHIP. If a more system-specific solution is required, says Gopen, the system designer can fall back on the FB3480 array itself. The array incorporates all the functions of the other three family parts, plus a wide range of additional functions. These include the ability to change the current-sense-limit threshold to improve noise rejection; the addition of an indicator output to determine how often, cycle by cycle, a current limit is tripped; and a comparator with a common-mode range that includes ground, to allow sensing in the ground leads.

In the oscillator section, circuitry has been incorporated to modify peak and valley voltages for improved noise performance. Feed-forward circuitry has been added to improve line regulation in voltage-mode applications.

In the output stage, an inversion circuit can be added that permits the controller to drive larger p-channel DMOS power transistors. Active low-pull-down circuitry has been added to protect the external DMOS power transistors during undervoltage-lockout situations.

Finally, in the undervoltage-lockout section, circuitry can be added to increase the turn-off/turn-on threshold to initiate shutdown before the DMOS FET drive current becomes marginal. Also, the hysteresis of the circuit can be increased to prevent noise spikes from initiating undervoltage lockout.

With the new circuits, "We have anticipated virtually all of the financial and technical needs of the system designer," Gopen says. Future plans for the family are to use the FB3480 array as the basis for even more standard and semistandard offerings, including lower-frequency—200 to 400 kHz—and lower-power applications. The first three family members are aimed at relatively large applications in military/aerospace and data-processing systems, high-power power-supplies—500 W and above—and uninterruptible power supplies. But Gopen thinks the concept can be extended to work stations and high-end personal computers as well. Using a different technology, CMOS or biCMOS, similar semistandard arrays could be developed for low-end PCs, printers and terminals. *–Bernard C. Cole*

MICRO LINEAR TAKES ON BALANCING ACT

A company must have all the instincts of a high-wire artist to succeed in the linear business, says Charles Gopen, vice president of sales at Micro Linear Corp. "It has all got to do with balance. If you expect to be in for the long term, it is necessary to have a balanced marketing and business strategy, as well as a balanced technology portfolio."

It took Micro Linear a few years to find that balance. Founded in October 1983, the San Jose, Calif., company originally sold bipolar tile arrays for use in semicustom high-performance analog circuits. Then, in 1986, the company was reorganized. Art Stabenow, former vice president of the analog components group at National Semiconductor, replaced Alan Grebene, one of the founders, as president. Stabenow helped Micro Linear build its strength in both standard and semicustom products by working with James McCreary, cofounder, vice president, and a recognized authority on linear MOS and MOS data-converter design. The two broadened the company's standard product line and expanded into CMOS and cell-based custom and semicustom circuits.

President Art Stabenow helped Micro Linear move into semicustom and custom parts.

The changes paid off. From its founding through 1986, the company's annual sales had reached $4 million. In 1987, after the reorganization, sales tripled. This year, they should hit $25 million.

The latest and most aggressive example of how Mircro Linear is leveraging its strengths in both standard and semicustom areas is the company's new family of parts for switching power supplies. The new family is based on the work Micro Linear has been doing all along—converting standard linear functions into libraries of macrocells.

These macrocells can be accessed from a computer-aided-design work station, which allows systems designers to map them into silicon to integrate complex analog and mixed analog/digital circuits into a single integrated circuit.

In bipolar, this strategy has been implemented using a tile-array approach, first with the company's FB300 series and more recently with its 3-μm bipolar FB3400 analog and FB3600 analog/digital minitile families. These bipolar arrays are a combination of active and passive components arranged to accommodate specific functions. In addition to serving the lower-volume market for semicustom solutions, Gopen says, the tile array provides a natural path toward higher integration as a standard or custom product. Done transparently to the user and using any of their tile arrays, unused components can be eliminated, providing, he says, a virtually risk-free way of reducing unit cost by reducing the chip's die size.

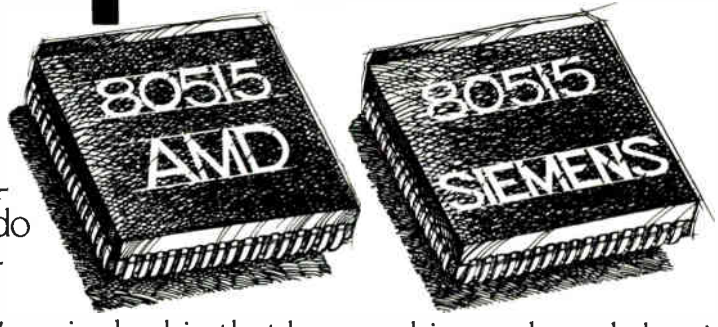
Complementing this effort are Micro Linear's standard product offerings in computer peripherals, telecommunications, and data-acquisition and signal-processing, in which many of the parts are developed using the company's own tile-array technology. An additional benefit of the standard parts is that customers may have them tweaked to further enhance their abilities to satisfy system requirements peculiar to the customer's own needs, says Gopen. These so-called semistandard products bridge the gap between the standard and custom requirements in a way neither alternative can, he says.

The company has also developed a family of mixed analog/digital macrocells, using a 2-μm CMOS process. So far, it has not chosen to market the technology, restricting it to use as an internal development tool.

In computer peripherals, Micro Linear has used its bipolar capability to become a major supplier to the high-volume hard-disk-drive industry, with products such as read/write amplifiers, pulse detectors, data synchronizers, and embedded servo detectors. In telecommunications, the company has used its cell-based CMOS capability to offer a family of logarithmic attenuators and equalizers for use in programmable control of four-wire conditioned lines. In addition, the company has developed a CMOS family of 12-bit analog-to-digital converters based on self-calibrating algorithmic conversion. The family is aimed at data-conversion and signal-processing applications.

A CHALLENGE. The later products test the balance that Micro Linear has begun to acquire. For the industry-specific approach to work, the company has to understand the market it's targeting, Gopen says. To develop that detailed understanding for products aimed at switching power supplies, the company has invested heaviliy in a design and marketing team. "It is a tough market out there, and the only way to succeed is to give value that no one else can offer," Gopen says. "So in switching power supplies, in addition to our process and circuit capabilities, we offer a detailed understanding of the needs of the systems designers. It is an expensive strategy, but in the long run, it will pay off." *–B.C.C.*

Fortunately, you don't have to invent something to perfect it.



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PARALLEL COMPILERS ARE COMING JUST IN TIME

Parallel compilers for multiprocessor computing are starting to emerge in force and that's good news—the effectiveness of multiple processors working on single programs depends on them. In many cases, parallel compilers will boost program execution by orders of magnitude. Parallel Fortran compilers are already arriving and C-language compilers are coming too.

There are two types of parallel programming that compilers can assist. First there are many existing programs written for serial operation on single-processor machines. A few parallelizing compilers have been developed that automatically convert existing serial programs to parallel operation. Secondly, there are compilers with parallel language constructs for writing new programs or converting old programs for parallel operation. Some parallel compilers take care of both.

Although a half-dozen or so parallel Fortran compilers are available for the most popular parallel computers, the technology of parallel compilation is still in its infancy, according to experts in parallel computing. Yet the infant-stage parallel compilers that are running now are delivering some remarkable performance improvements to old programs when they are run on parallel machines.

Still, there have been enough different implementations of parallel Fortran for the industry to start worrying about standardization. A group of about 25 system vendors, called the Parallel Computing Forum, is developing a recommended standard for parallel syntax in Fortran.

Now that several parallel Fortran compilers are up and running, the companies offering them are turning their attention to parallel C-language compilers. In fact, parallel compilers are now available for Fortran and C on both the Alliant Computer Systems Corp. FX/Series and the Convex Computer Inc. family of supercomputers and minisupercomputers.

And now Cray Research Inc. of Minneapolis is introducing an automatic parallel Fortran compiler for its supercomputers (see p. 121). The supercomputer company's autotasking Fortran compiler dramatically improves performance of old serial Fortran programs running on Cray computers—a reduction from 7 hours to 90 minutes, for one example. Other computer companies with parallel Fortran compilers include Sequent Computer, Encore Computer, Silicon Graphics, and IBM.

IBM Corp.'s Parallel Fortran came from work done in a joint effort with Cornell University, says Beverly Moncrieff, IBM's manager of scientific language products. "I believe that parallel compilers are just beginning to surface; they have been in the research organizations for a while, but now major vendors are starting to take the first steps towards offering parallel-compiler products," she says.

IBM's Parallel Fortran is available on a limited basis to a small number of selected external users and a larger number of internal users so that its developers can get feedback on their experience and factor it into further development. Parallel Fortran has extensions for automatically parallizing DO loops. It also has special directives to allow the programmer to give the compiler more information for setting up parallel code.

> The compilers will help multiprocessing achieve its full speed potential

"We are trying to find out from users what extensions are needed to parallel compilers," says Moncrieff. "We gave it our best shot [with Parallel Fortran], and now we are in the early stages of getting feedback and finding out what additional extensions may be needed."

Some parallel processing can be done using IBM's current product line. The MVS operating system for mainframes contains user support for parallel processing with the Multi Tasking Facility, which is activated through subroutine calls to routines in the mainline Fortran library. The Multi Tasking Facility has been available since 1985.

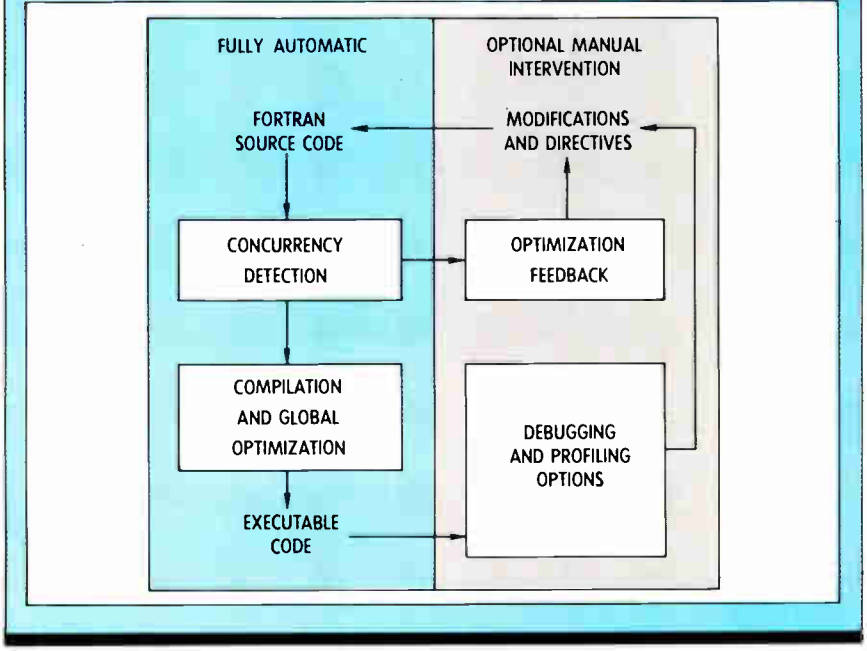
On the other hand, the world's first automatic parallel Fortran compiler has also been available for more than three years. It was introduced by Alliant with the first FX/Series parallel machines. And the company recently introduced a parallel C compiler as well.

"Parallel compilers are here, but in terms of commercial products, most companies are in their infancy," says Andy Halford, director of language development at Alliant. Halford says a parallel compiler is defined as one that is capable of automatically generating parallel code from serial code.

"You really need a lot of experience with parallelism or concurrency," says Halford. "When we first started, we were getting a speedup of 2.9 times using eight parallel processors. Now we get a speedup of between five and six times, which is greater than 90% efficiency as measured against Amdahl's law," which defines the diminishing efficiency of a system that is caused by one or more bottlenecks, as additional resources are added.

"Defining the state of parallel compil-

ALLIANT'S ROUTE TO PARALLEL CODE



The FX/Fortran compiler generates parallel code automatically from serial source code, but it is also designed to facilitate optional manual intervention to improve the results.

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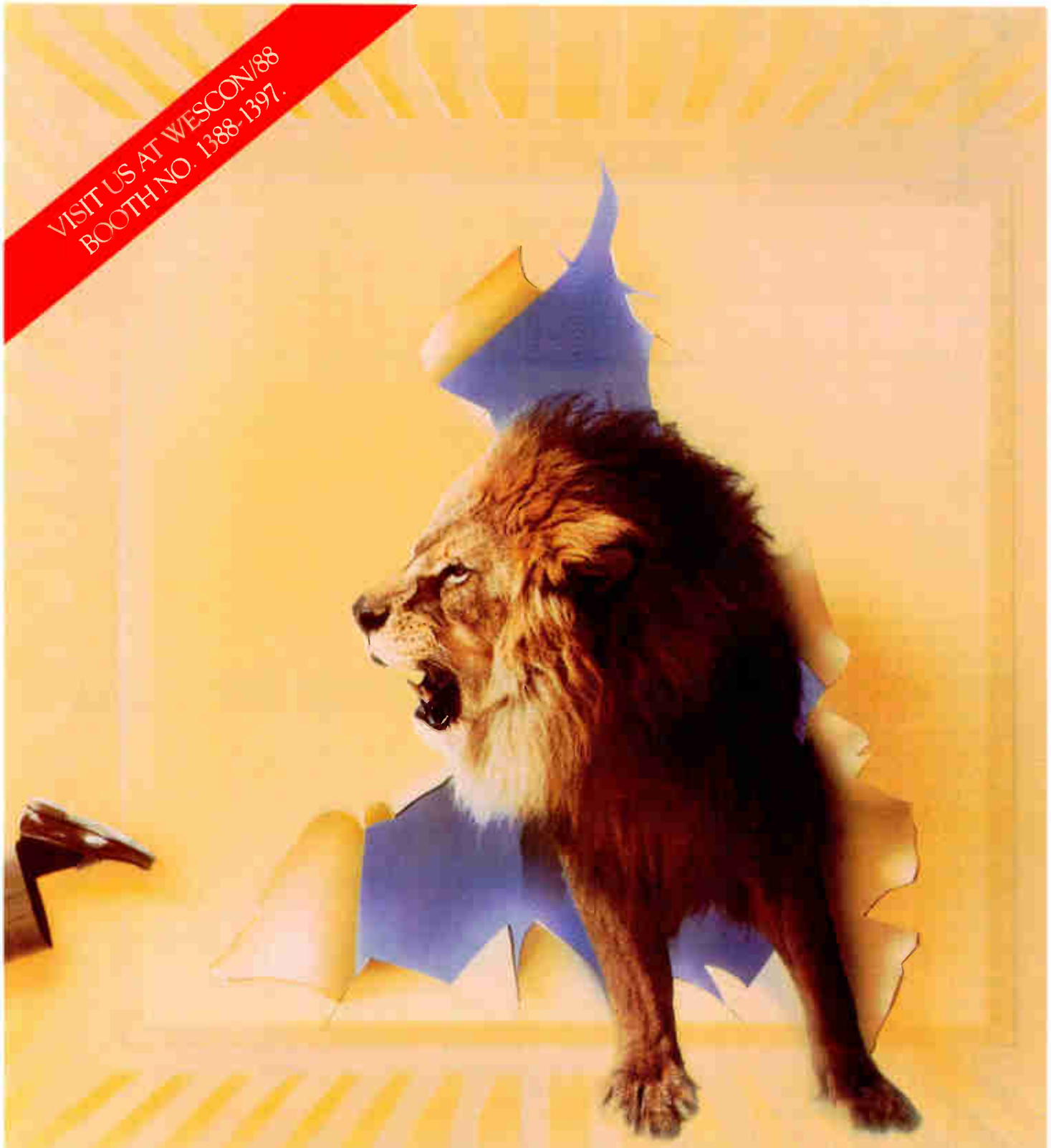

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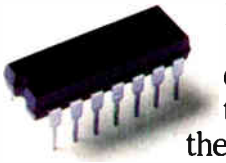

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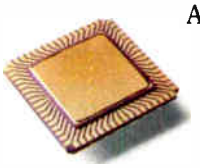

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ers is not as easy as [it is for] vectorization," says Steve Wallach, Convex's vice president of technology. The reason for this difficulty is that the definition of "parallel computer" is not clear cut, he says. There are several kinds of parallel hardware architectures, so the approaches to parallel programming are varied. "If you limit the discussion to multiple-instruction, multiple-data parallel machines with shared memory, then the state of parallel programming is easier to relate," says Wallach. "Automatic parallelization is sometimes as easy as vectorization and sometimes a lot more difficult because there are a lot more options and decisions for optimum code generation."

He says auto parallelization is at a stage where it can provide efficient fine-grained parallelism within DO loops. Convex has just recently released its parallel Fortran and C compilers. Some parallel compilers are also capable of providing some coarse-grained parallelism, such as running subroutines in parallel or defining whole modules or sections of code that can be designated to run in parallel. However, "programs may require a lot of work [by a programmer] to get coarse-grained parallelization," says Wallach.

"A lot of technology for concurrent parallelism is just beginning to be realized," says Gary Graunke, a software design engineer at Sequent. There are many appraoches to making programs parallel, such as parallel loops, pipelining, and other techniques, says Graunke.

TAKING ADVANTAGE. For its parallel programming offering, Sequent offers a Fortran preprocessor developed by Kuck and Associates Inc. of Urbana, Ill. The preprocessor automatically detects chances to run DO loops in parallel and restructures the source code to do that. Then a standard Fortran compiler produces object code that takes advantage of multiprocessors. This part of the process is automatic, but, like other products of this type, the preprocessor also gives advice about what it could and could not parallelize on its own. Then a programmer can use this information to search for opportunities to add directives to the program to run more of it in parallel. Sequent is also readying a parallel C compiler, and shipments are scheduled to begin this month.

Silicon Graphics Inc., the Mountain View, Calif., leader in super graphics work stations, has just introduced a new parallel-processing Power Series of high-end work stations [*Electronics*, October 1988, p. 28]. For its software offering, Silicon Graphics includes the Power Fortran Accelerator, an automatic parallelizing preprocessor from Kuck and Associates melded with the MIPS Computer Systems Fortran compiler—the 4D/240 GTX superworkstation uses four MIPS R3000 reduced-instruction-set computer chips.

With the information added by the Power Fortran Accelerator, the Fortran compiler compiles code with calls to the Silicon Graphics primitives for the processors' synchronization controllers. User-level parallel directives can also be added by programmers, using the information that the accelerator provides to improve parallel performance even further.

Pin Yee Chen, manager of the parallel processing and languages group at Encore Computer Corp., believes it's safe to say that parallel compilers are beginning to come into their own, but there's still a long way to go. Chen directs the development group that handles the Marlboro, Mass., computer company's parallel compilers. To date, Encore offers parallel versions of Fortran, C, and Ada, all developed by outside compiler specialists.

> Most parallel compilers are for Fortran, but C versions are coming on strong

Parallel compiler standards are also coming, Encore's Chen says. He looks to the Parallel Computing Forum, of which Encore is a founding member, to come up with a final draft of a syntax to standardize the way parallel language extensions are added to Fortran. The forum's aim is to develop a parallel Fortran standard.

IBM is also actively involved with the Forum. "It's too early to tell if [the Parallel Computing Forum] can define a standard that fits all the architectures in the industry, but the intent is to establish a standard," says IBM's Moncrieff.

A first draft was presented at the forum's International Conference on Parallel Processing in August. "We hope to have a final draft by the end of the year," says Chen, a voting forum member. He expects that the Forum will then tackle extensions leading to a parallel C compiler standard.

Most parallel compiler work to date has been done in Fortran, still the most popular language for scientific computing. But since the C language is gaining popularity very quickly, parallel-computer vendors are starting to look at parallel versions of it. "IBM will evaluate user requirements for a parallel C language. There is no technical reason why it cannot be done, if there is a requirement for it," says Moncrieff.

"Fortran came first in the academic world because the nature of its code and its prevalence in the scientific market dictated that," says Alliant's Halford. C is next on the horizon, "but it's a much more difficult language to make parallel because of its structure and use of pointers," adds Halford. Alliant's C compiler has just begun to ship.

"The C language is starting to roar into our marketplace," says Mark Furtney, Cray group leader for multiprocessing software. Cray is investigating an approach to parallel C that is like the multitasking it did for Fortran. In multitasking Fortran, the program calls a set of library routines to invoke parallelism—parallelization is not done automatically as in Cray's new autotasking. "If that [multitasking] goes well, we will investigate autotasking for C," he says. *–Tom Manuel with additional reporting by Lawrence Curran*

WHAT SOME PARALLEL CONSTRUCTS LOOK LIKE

PARALLEL DO LOOP

```
PARALLEL DO I=1,N
LOCAL T
 T = A (I) * B (I)
 C (I) = T * (T-1.0)
 END PARALLEL DO
```

PARALLEL SECTIONS

```
      PARALLEL SECTIONS
      LOCAL I
      SECTION
       DO 10 I=1,N
10     A (I) = B (I)
      SECTION
       DO 20 I=1,N
20       C (I) = D (I)
      SECTION
       DO 30 I=1, N
30       E (I) = F (I)
      END PARALLEL SECTIONS
```

PARALLEL CALL

```
      PROGRAM SAMPLE
      COMMON A (100),B (100)
      PARALLEL CALL SUB (A)
      PARALLEL CALL SUB (B)
      WAIT ALL CHORES
      . . .
      END

      SUBROUTINE SUB (A)
      COMMON A (100)
      DO 10 I=1,100
10    A (I) = 0
      END
```

PARALLEL REGION

```
      PARALLEL REGION
       DO 10 J=1,M
        SPREAD DO I = 1,N
         A (I,J) = A (I,J) /A (I,J-1)
        END SPREAD DO
10     CONTINUE
      END PARALLEL REGION
```

Note: These constructs are from the Parallel Computing Forum's language definition for a parallel Fortran standard.

A SPEED HIKE FOR PARALLEL SUPERCOMPUTING

Despite the availability of increasingly powerful multiple-processor systems, the widespread adoption of parallel supercomputing has been stalled by a lack of adequate software support. But if Cray Research Inc.'s latest Fortran compiler performs as well in the field as it has in benchmarks, that might be about to change.

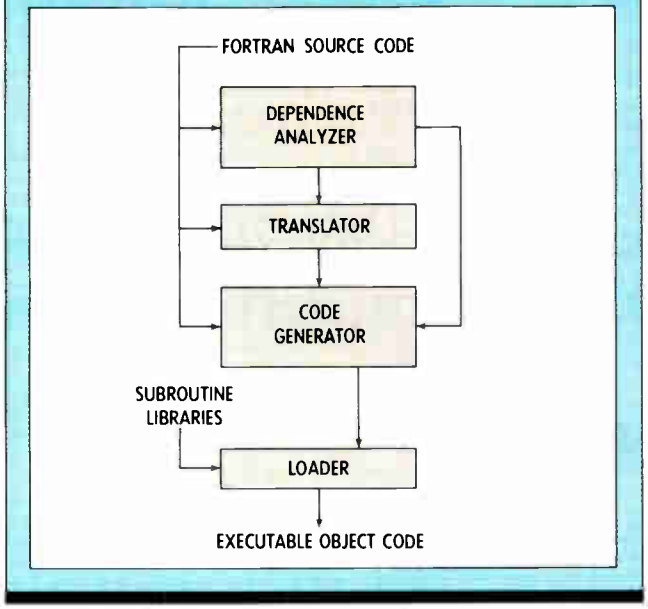
Version 3.0 of Cray's CFT77 Fortran compiler adds a feature that the Minneapolis firm calls Autotasking, which helps the package recognize parallel constructs in existing Fortran programs. The compiler then automatically generates parallel code to exploit the parallelism in Cray multiprocessor systems, including the top-end eight-processor Y-MP/832 introduced this year [*Electronics*, Feb. 18, 1988, p. 31]. In one test run, an Autotasking-produced program hit a blazing 1.9 billion floating-point operations/s, compared with 242 million before automatic parallelization.

Wringing megaflops from multiprocessor machines has been a major stumbling block for even the most sophisticated supercomputer users. With the earlier nonautomatic parallelizing tools from Cray and others, it can still take days or even months of programmer time to manually convert a large existing Fortran program to run effectively on a parallel machine. Autotasking does some part of that job automatically, in seconds.

That could pay big dividends in programmer productivity. And it could allow a broader class of less sophisticated supercomputer users to get in on the parallel-processing game. "With Autotasking, it's very easy to get your jobs to run a lot faster, using multiprocessors when you choose to," says Mark Furtney, Cray's group leader for multiprocessor software in Mendota Heights, Minn. "If you can turn a seven-hour job around in, say, 90 minutes, that means that instead of waiting for a weekend to do a big run, you can run it twice a day if you want to. And probably even more important, it also means that people are still going to run seven-hour jobs, but now they're going to be asking questions [with those programs] that they couldn't ask before."

Minisupercomputer vendors, such as Alliant Computer Systems Corp. and Convex Computer Inc., offer automatic parallelizing compilers for their machines. But Autotasking is the first such package from a high-end supercomputer vendor. And it's likely to be followed by others. "We are relying in the long run on the success of Autotasking, both from this vendor [Cray] and others," says John Barton, whose National Aeronautics and Space Administration division took delivery of the first Y-MP shipped by Cray in August. "I think all the supercomputer vendors will have [software like] Autotasking on their next generation of supercomputers," says Barton, who is high-speed processing manager at the Numerical Aerodynamic Simulation Systems Division of NASA's Ames Research Center, Moffett Field, Calif.

COMPILING FOR PARALLEL CPUs



Cray's three-phase compiler automatically seeks out opportunities for parallelization within a Fortran program.

> Cray's autotasking compiler restructures programs for faster parallel operation

The Autotasking compiling system performs three types of operations. The dependence-analysis module examines source code for parallelization opportunities and then writes special directives into the code to take advantage of what it finds. Next, the translator-phase module rewrites this output into a standard form that can be converted by the code-generator module into machine-executable parallel object code.

As Cray's third generation of parallel-processing software, Autotasking represents a natural evolution from earlier manual tools, says Furtney. "As we get faster and faster central processing units, and more of them, and they cooperate, what many of our users have wanted is to make that cooperation among CPUs fully automatic," he says.

Furtney is the first to admit that Autotasking can't find all of the parallelization possibilities within a program. "There's never going to be a replacement for the well-informed, experienced Fortran programmer who knows the physics, the science, and all the iterations of the program," he says. But with Autotasking, he believes, Cray is taking a big jump: "I guess I feel like with this first release, we're doing about 20% of the work and we're getting maybe 80% of the payoff." Improvements in later Autotasking releases will be more incremental, he says.

In early tests, Autotasking has been impressive. In one of the best examples, an Autotasking-produced program ran 7.8 times faster on an eight-processor Y-MP than it did on a single-processor machine, Furtney says. The benchmark, supplied by the Ademisch Computer Centrum in Utrecht, the Netherlands, hit 1.9 billion floating-point operations/s after Autotasking, and only 242 megaflops/s before.

Not all programs, of course, will show such dramatic improvements. "There are some codes that don't have any parallelism in them, and no matter how hard we work and how clever we are, we just can't make them go any faster on eight CPUs than we do on four—or on one," Furtney says. At the other extreme, "there are going to be some codes that just fall out and get extraordinary performance the first time"—the Utrecht benchmark is an example. The vast majority of codes will fall somewhere in the middle, he notes.

Autotasking is designed to produce speedups just as efficiently for a system with two, four, or eight processors as it will for future systems with even more processors. "We don't really say 'tell us the number of CPUs and then we're going to divide things up that way,'" Furtney explains. "We say 'let's find the amount of work that we can parallelize, and however many CPUs appear, we're going to allow them to help us.'"

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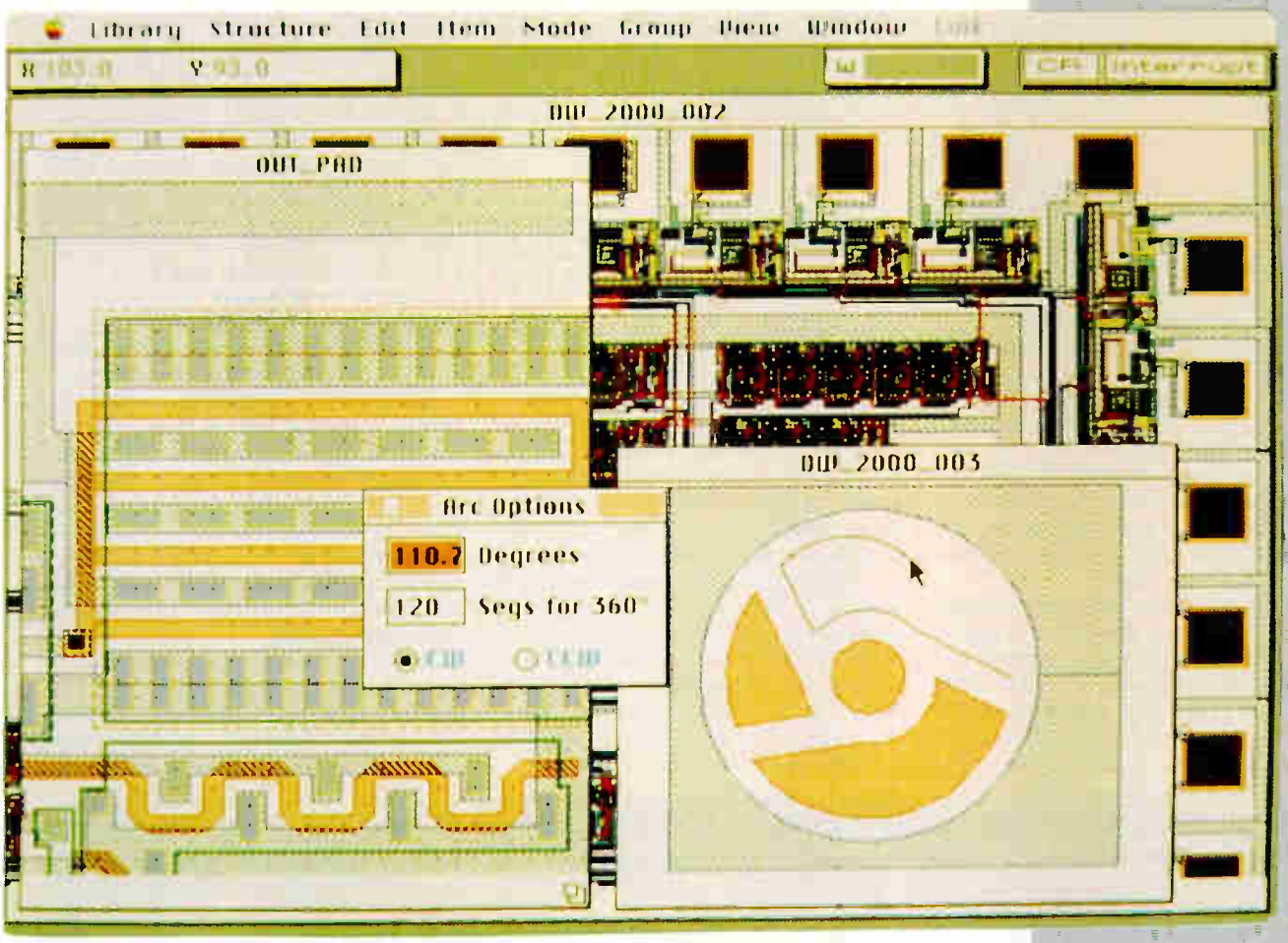

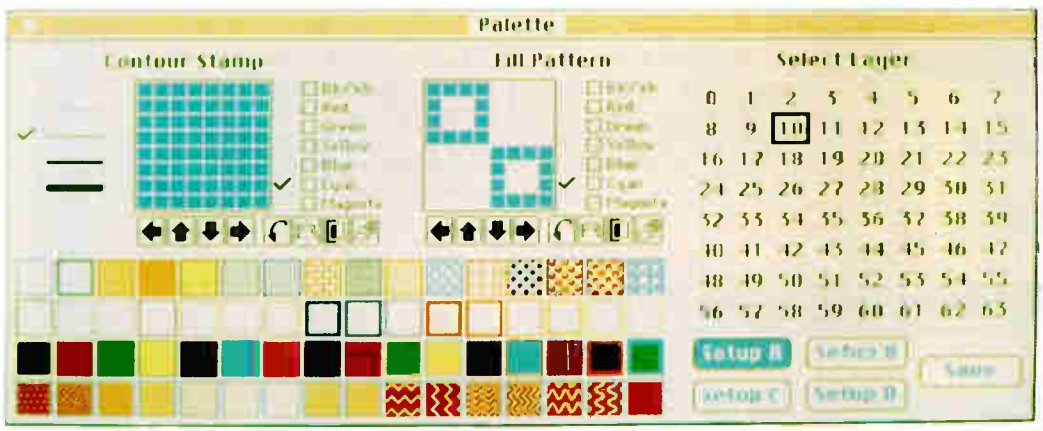

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not only for the Y-MP, but also for older Cray systems; it will be important for portability, and in squeezing performance out of machines running fewer than eight processors. Indeed, using unoutput from the Autotasking compiler, Cray recently leaped to the head of the class in the widely quoted Linpack performance comparisons published by Jack Dongarra, scientific director of the Advanced Computer Facility at Argonne National Laboratory, Argonne, Ill.

In the Linpack report, Cray captured nine of the top 10 positions for calculation speed on straight-vector 100-by-100-matrix Linpack operations. The Y-MP took top honors at 195 megaflops. But four- and two-processor X-MP systems and a Cray 2 four-processor system ranked third, fifth, and sixth, respectively.

Cray is releasing Autotasking initially only on CFT77 3.0 Fortran compilers that run under Unicos (Cray's version of Unix) on the Y-MP and X-MP lines. By early 1989 it will add the capability for Unicos-based Cray 2 multiprocessor systems and for machines running Cray's older COS operating system, Furtney says.

Autotasking builds upon the strengths of Cray's earlier nonautomatic parallel-processing tools. The first generation, known as Macrotasking, was introduced in 1982. It gave users a Fortran-callable library of synchronization routines that provided primitives that allowed a single program to execute over multiple processors. But Macrotasking works only at the subroutine level. It is best applied for systems whose parallelism is implemented at large granularity levels, and where the amount of work to be partitioned over multiple processors is large. And it often requires users to perform significant code restructuring.

Cray addressed those problems in 1986 with Microtasking. That package requires no code restructuring and allows users to more easily and efficiently exploit parallelism down to the so-called DO-loop level, providing finer granularity and less processing overhead. (DO loops are the most common Fortran construct for performing repetitive operations.) Microtasking's main drawback, however, is that users themselves must identify the parallel regions within a program and manually write the appropriate directives—tasks that are automated by Autotasking. Autotasking performs dependence analysis at the subroutine level, but provides fine granularity by allowing parallelization at the DO-loop level.

A test program ran 7.8 times faster on a Cray Y-MP than on a single-processor machine

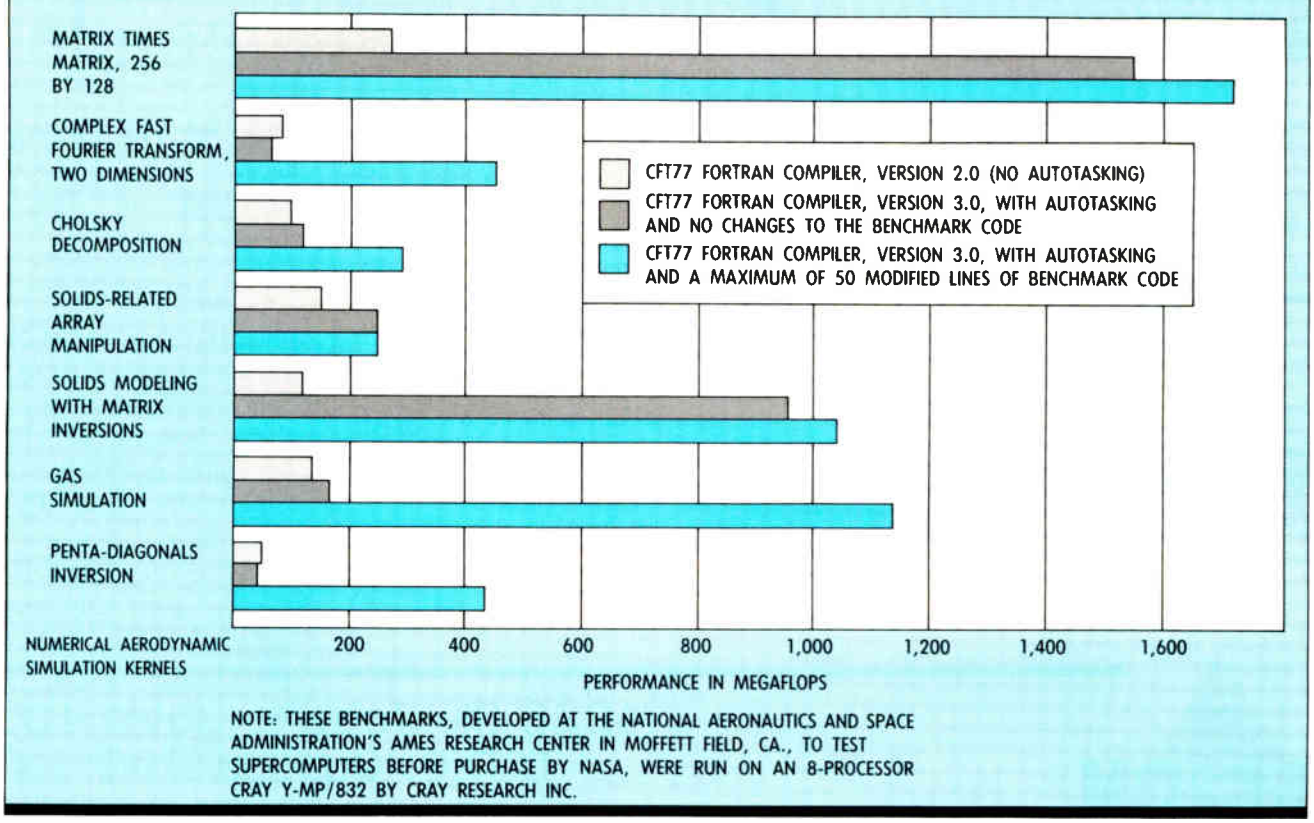
And like the earlier packages, Autotasking allows the number of CPUs a program is using at any given point during a run to vary dynamically under operating-system control, depending on the number of jobs running and job priorities, among other factors.

If Autotasking won't provide users with a fully automatic means to make maximum use of parallel-supercomputing hardware, it will take them part of the way. And in many cases, a human who knows the ins and outs of the program can enhance the performance of Autotasking-produced code even further with a minimal amount of fine tuning.

A set of benchmarks developed by NASA's Ames NAS division provide a good example. Some of the kernels leap immediately to a major performance gain with Autotasking, but others make no headway at all until a small amount of hand program tuning is done—whereupon the speed gains are impressive. In each case, the amount of tuning was no more than 50 lines of modified or added code. The big improvements achieved manually involved locating and exploiting parallel constructs not exposed by autotasking, in some cases loop transformations.

"I think we've taken a giant stride," Furtney says, "and I think the point is clear. We do a lot for you automatically, and then the experienced programmer can do more, sometimes." *–Wesley R. Iversen*

NASA YARDSTICK MEASURES CRAY'S AUTOTASKING



NOTE: THESE BENCHMARKS, DEVELOPED AT THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION'S AMES RESEARCH CENTER IN MOFFETT FIELD, CA., TO TEST SUPERCOMPUTERS BEFORE PURCHASE BY NASA, WERE RUN ON AN 8-PROCESSOR CRAY Y-MP/832 BY CRAY RESEARCH INC.

TI's NEW LINEAR PROCESS POWERS AN ADVANCED FAMILY OF OP AMPS

It integrates several high-performance devices on the same chip for the first time

A new linear process developed at Texas Instruments Inc. that integrates several high-performance devices on the same chip for the first time is spawning a new family of operational amplifiers from the Dallas company. The new family is pin-compatible with standard op amps but outperforms them by a wide margin. TI says the process enables circuit designers to achieve high-performance control circuits with five times the bandwidth and slew rate previously possible; settling times of 200 ns; and input-offset voltage stability within 100 mV.

The process combines high-frequency, isolated, vertical, pnp bipolar transistors that can operate up to 150 MHz with p-channel junction field-effect transistors operating at 45 V, or, by a process variation, with super-beta npn transistors having a current gain 10 times higher than conventional npn transistors. The process also includes fabrication of metal-nitride-polysilicon capacitors that resist breakdown up to 100 V and boast double the capacitance per unit area over standard metal-oxide-silicon capacitors. Although other linear semiconductor manufacturers have achieved these features individually, TI is now first to combine them into a single manufacturable process.

The intensive program TI mounted to develop the new process might look like so much wasted effort to those who thought that by now op amps either would have become low-cost, commodity components or would be gradually swallowed up by integration into VLSI chips. But that's not the case, says Rick Davies, manager of TI's standard linear products department.

AT THE LIMIT. "Looking at increased integration levels in analog as well as mixed analog-digital, you'd think that op amps would be one of the first things you'd pull on-chip," he says. "But in practice, while that happens, the standard keeps moving up. The bit-accuracy rate and speed of the systems increase, so that while more and more op amps are being integrated on-chip, at the same time there is more and more demand for higher-performance and higher-precision op amps that tend to go just beyond the threshold of what you can integrate. They are at the limit of what a designer can do on a dedicated piece of silicon, with all the freedom to do symmetry and matching that you don't get on a larger chip."

As Davies perceives the problem, it's a lot like the overall linear market. "More and more things are going digital," he points out. "Does that mean linear is going away? In a funny sense, the fact that things are going more and more digital is actually pulling linear along and increasing its growth rate because in the end, most systems do interface with a real physical quantity and you need those interfaces. It's a symbiotic relationship."

The first product that uses the new process is a single-power-supply, low-power op amp called the TLE2021. TI says the 2021 will debut in the first quarter of 1989. Plans call for it to be followed soon after by dual and quad versions. The 2021 will combine the best features of Precision Monolithic's OP21 and Linear Technology's LT1013 op amps, but it will outstrip their ac bandwidth and slew rate by a factor of five, says Brad Whitney, the op amp product manager for TI's semiconductor group.

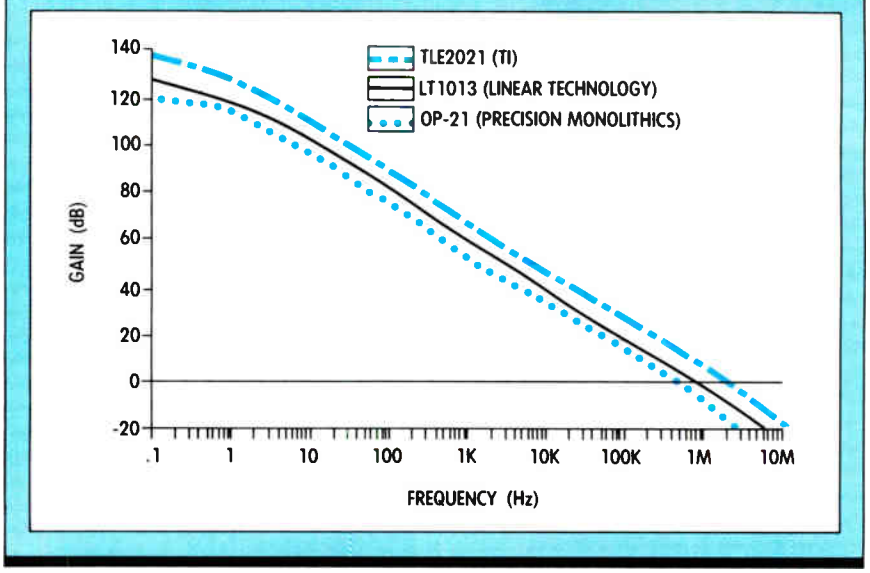
> TI's 2021 sports five times the ac bandwidth and slew rate of competing op amps

To make the 2021, TI process engineers had to develop isolated vertical pnp transistors that accommodate needs for high bandwidth while being capable of operating at 45 V. In addition, it had to be compatible with either p-channel JFETs or super-beta transistors formed on the same chip. The isolated vertical pnp transistor is basically a double diffused structure with an isolated collector that's up-diffused from the substrate and another down-diffused layer which further isolates the collector from the substrate.

The way junction isolation of the vertical pnp transistor is achieved in this process can reduce spacing by up to 25% compared with conventional isolation techniques, resulting in a denser chip. In old conventional bipolar devices the isolation was a p-type diffusion from the top, which meant it had to grow all the way through the epitaxial layer down to the substrate.

In the new process, the first required step is a p-type implantation and diffusion into the substrate. This diffusion grows in an upward direction, forming the buried collector and part of the isolation. The epitaxial "tank" is then grown. Following this is a p-type top-diffusion that grows down and meets the up-diffusion to form the junction isolation. Because the diffusions must grow only half the vertical distance compared with conventional isolation, the distance that would be allowed for lateral out-diffusion

TI's OP AMP BOOSTS BANDWIDTH FIVEFOLD



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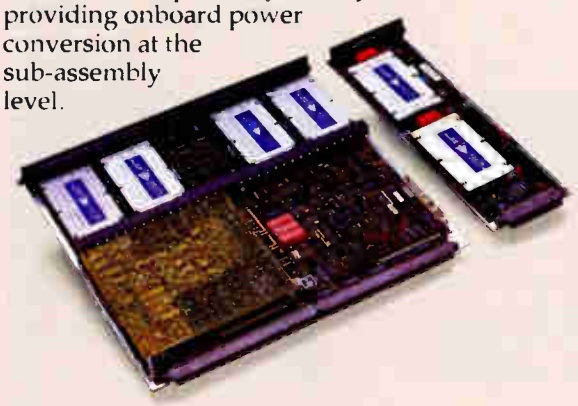

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is greatly reduced; that results in the greater chip density, TI says.

The high-frequency isolated vertical pnp devices are superior to the conventional lateral and substrate pnp transistors in several ways, says Michael Seachrist, one of the developers of the process. "Op amp designers have always been limited in that lateral pnp transistors that are conventionally used can operate only from around 3 to 5 MHz," he says. "This prevented pnps from being designed into high frequency signal paths. The conventional pnp is limited by the very wide base—about 15 μm to operate at 45 V—required by the n-type epitaxial base that is used. Our vertical pnp device's structure has a much narrower base width—only 2 μm—and that makes it possible to push the device to a maximum operating frequency of 150 MHz."

In addition, Joe Trogolo, manager of linear wafer fab development, points out that a vertical parasitic transistor is associated with the lateral pnp and that it contributes as much to bandwidth degradation as the narrowing of the base width. "With a purely vertical structure, you eliminate both," he says.

The super-beta npn vertical transistors are able to achieve a gain of 10 times the usual npn transistor current gain of about 200, as well as allow substantially lower level input signals to be amplified, TI says. The super-beta npn emitter is common with the emitter on the conventional double-diffused npn transistor also fabricated in the process, thus requiring only one additional mask to define the super-beta base. However, the way the super beta deviates is that there is a lightly implanted p-type base diffusion that is used for the base region of the super-beta device; the same emitter diffusion step is used for both devices, but the super-beta diffusion is tailored to get a higher beta than is normally obtained.

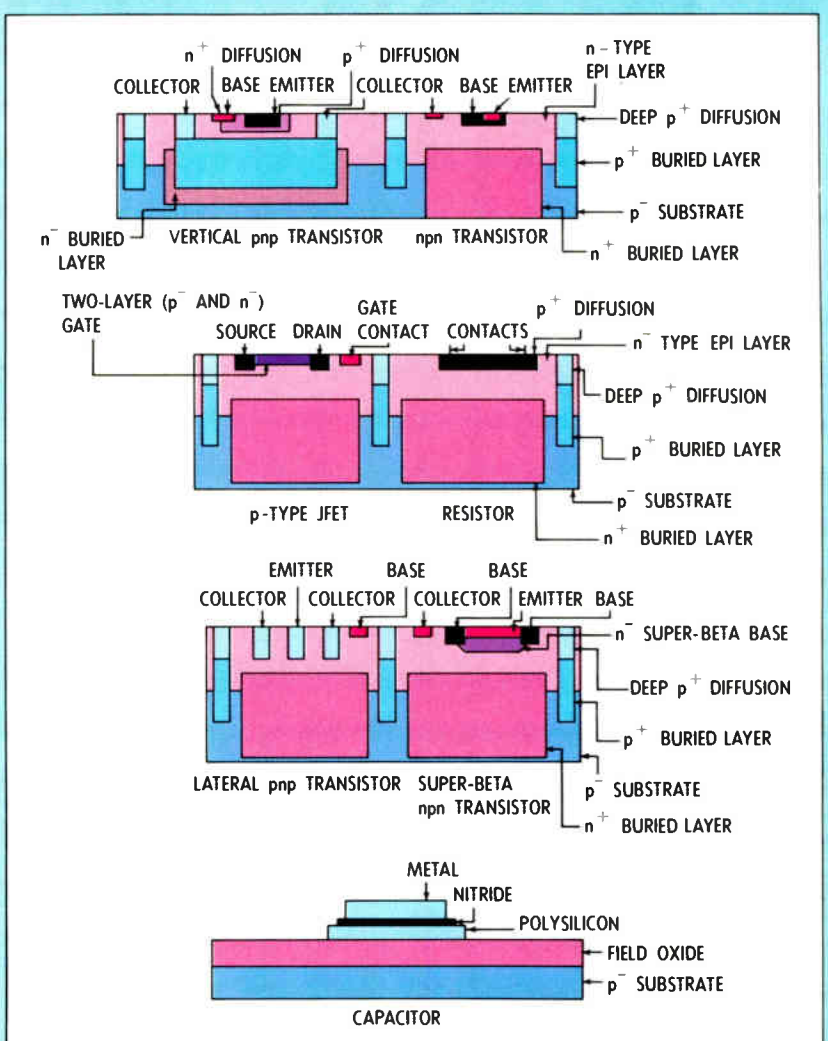
HIGH VOLTAGE. Separately, TI developed a 50-V channel JFET to extend the gate-to-drain breakdown voltage past 45 V. JFETs of this kind are conventionally used as op-amp inputs. These devices are achieved by depositing a thick oxide over the thermally grown gate oxide to reduce the electric field intensification at the top gate-to-drain reverse-biased p-n junction. Doing this increases the gate-drain breakdown voltage from the low 30-V range of previous JFETs to approximately 50 V. The deposited oxides also reduce capacitances caused by gate-to-drain and gate-to-source oxide overlap, and thus contribute to the higher bandwidth and slew rate.

The ability of the transistors to operate at 45 V is an important factor in industrial applications. The higher voltage permits the use of longer connecting lines between remote sensors and a central computer. "Furthermore, more and more systems coming on line are going to higher and higher resolution—14 to 16 bits," says Whitney. "When you have a 5-V high-resolution system, power-supply noise can swamp any single bit. When you go to a higher supply voltage—in our case, 45 V—the signal-to-noise ratio can be a lot higher. System designers can use ±22-V power supplies and get full dynamic range with maximum signal-to-noise performance."

Another desirable aspect of the process is the ability to form metal-nitride-polysilicon capacitors during the process. The capacitors are built on top of field oxide in order to reduce the parasitic junction capacitances and tank leakage currents that are associated with the standard MOS capacitors. In addition, by building these capacitors with nitride instead of oxide, the capacitance per unit area can be doubled. And with nitride as the capacitor dielectric, the dielectric breakdown will be able to substantially exceed the 45-V maximum operating voltage of the other chip components.

GET IT OUT. "Our idea was to get the capacitor out of the silicon," says Seachrist. "When you put the capacitor on silicon, your bottom plate is formed by the epitaxial tank, and there is a lot of parasitic capacitance associated with that. Using polysilicon for the bottom plate takes care of that. We use nitride not only because it yields more capacitance per unit area but because it's difficult to build a metal-oxide-polysilicon capacitor with good reliability. We get an additional benefit in density increase from the capacitor in the availability of poly in the capacitor structure. The poly functions as another level for field plating, for tunnels, and for cross-unders, which yields a denser interconnect." *–Samuel Weber*

TI PUTS IT ALL ON ONE CHIP



A new linear process from TI combines vertical pnp bipolar transistors that can operate at up to 150 MHz with either p-channel JFETs operating at 45 V or super-beta npn transistors that offer 10 times the current gain of conventional npn transistors.

PLANAR DOUBLES THE SIZE OF EL PANELS

The world's largest electroluminescent display is coming from Planar Systems Inc., thanks to two innovations—one in the manufacture of flat-panel displays, the other in the underlying technology to illuminate them. The display, now being produced in prototype quantities by the Beaverton, Ore., company will have an 18-in. screen, measured diagonally. The next-largest displays, which are also made by Planar, have 9-in. screens.

The new display, the EL751214M, will have a resolution of at least 1,024 by 800 pixels, a high contrast ratio of 20:1, a wide viewing angle of 160°, and brightness of 20 fL. The specifications are better than those for most cathode-ray tubes, yet they are embodied in a rugged, long-lived display—it can withstand up to 50 g—that's only 1.25 in. thick and weighs less than 15 lbs.

The display's combination of size, performance, and durability, coupled with very low power consumption—less than 60 W at peak levels—make it an outstanding candidate for a broad range of uses, chief among them military applications, says Planar. "The military will find this new display appropriate for both tactical and strategic applications," says Roland W. Van Stroh, vice president of marketing and sales. Its ruggedness makes it ideal for both fixed and mobile applications in air defense, air-traffic control, radar, surveillance command and control, and vehicle systems, the company says.

Even at the $20,000 prototype price, Planar says the display is attracting the attention of both military and commercial users, because it outperforms CRTs without the bulkiness, fragility, and high voltage associated with CRTs. Volume production is scheduled for early 1989, and by the end of 1989 original-equipment-manufacturer quantities are expected to be priced under $10,000, Planar says.

BIG HURDLE. In manufacturing the display, the primary obstacle overcome by Planar was its sheer size. "This is a major breakthrough in flat-panel technology," says James Hurd, Planar's president. Manufacturing an ac-display such as Planar's is similar to making semiconductors—the work is done in a Class 10 clean room, using a thin-film deposition process to spread several layers of insulating material on a single glass substrate. The insulating layers are less than a micron thick overall, and each layer must be applied with absolute uniformity over the substrate's area. To maintain that consistency over the area of an 18-in. display—which is immense, by flat-panel standards—is extremely difficult.

Moreover, Planar imposed extremely high quality-control standards: it guarantees that each of the 820,000 pixels in the display can be illuminated. Any flaw introduced as the layers are laid down, by a fault in the process or by material contamination as it is deposited, can wipe out pixels—rendering the display unusable.

To overcome the problems inherent in laying down the insulator while guaranteeing perfect pixel illumination, Planar developed a proprietary EL manufacturing process. Unlike most EL manufacturers, who use a series of batch vacuum systems to lay down the insulating layers, Planar uses continuous, in-line vacuum deposition equipment to deposit the layers in one pass through a long, automated vacuum chamber. Particle contamination that can ruin pixels are much less likely to be introduced because there is no vacuum break between the deposition of each separate layer.

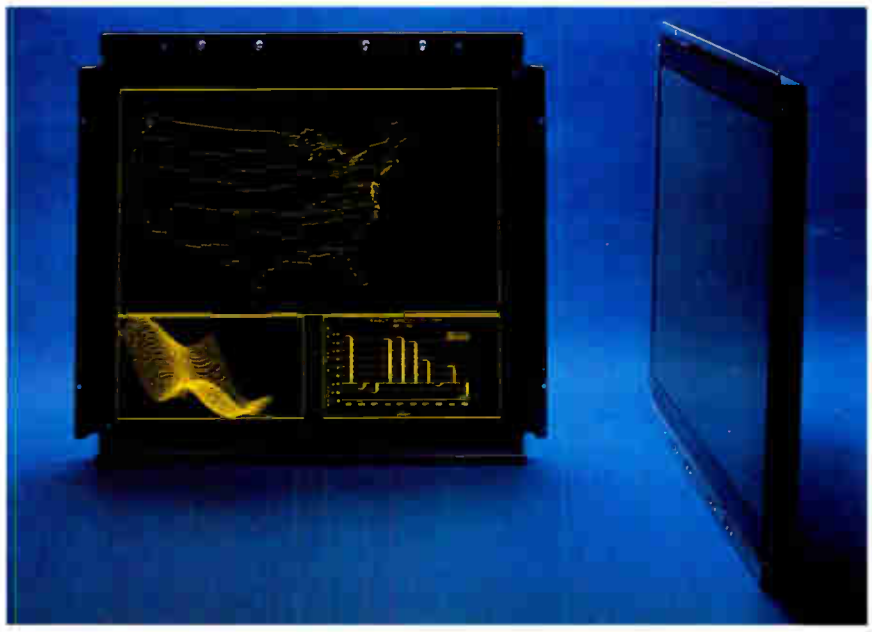
> The 18-in. diagonal screen provides a resolution of 1,024 by 800 pixels

To keep such a large EL display bright, Planar improved conductor formulation and drive architecture. Such a display is a kind of multilayer sandwich, with the two insulating layers enclosing a solid-state phosphor. On the front and back of the sandwich are a layer of solid-state electrodes, configured in rows on one side and columns on the other side. The electrodes on the front are transparent. When ac voltage is applied to a pixel—the intersection of a row and column—the phosphor emits light.

Electronically, the EL sandwich structure is a capacitor with finite charge and discharge times. The dielectric strength of the insulating layers, the phosphor's response time, and the resistance of the electrodes determine the number of rows and columns it is possible to drive and still maintain adequate brightness. To make a 1,024-by-800-pixel matrix over an 18-in. diagonal area, Planar had to dramatically lower the transparent conductor's resistance. To do this, the company developed a new formulation of the transparent conductor material.

Another necessary innovation was needed in the display's driver circuits. Planar does not design special driver circuits, but uses standard CMOS EL drivers. Planar does, however, help driver-circuit vendors, such as its suppliers Texas Instruments and Siliconix, to specify the performance levels of the row and column drivers that it needs for its high-performance EL displays.

For the 18-in. display, though, a single set of these standard drivers was not capable of adequately addressing the display's 820,000 pixels over its large area. To achieve adequate driver power, the Planar engineers split the screen into two halves and provided each with an independent set of drivers. Each half is simultaneously addressed and refreshed from a frame buffer. Doing so produces the required level of brightness over the entire display. *–Tom Manuel*



Planar's latest display boasts resolution of 1,024 by 800 pixels and a high contrast ratio of 20:1—specifications better than those of most cathode-ray tubes.

If you believe EPLDs are constrained by their architecture, this should open your mind.

ORCAD'S PC DESIGN TOOL PUTS COMPLEX FUNCTIONS IN REACH

Personal-computer-based computer-aided-engineering systems for working with programmable logic devices are attractively priced, but suffer from some major limitations. They generally lack the power to handle more than one PLD at a time, and most cannot handle a mixture of PLDs and other types of logic. Orcad/PLD, from Orcad Systems Corp., Hillsboro, Ore., is a tool for PC-based systems that overcomes these limitations.

Both Orcad/PLD and a second new tool called Orcad/MOD bring high-level design functions to the low-priced PC-based design system for the first time. The principal reason that Orcad/PLD is more powerful than other PC-based PLD design tools is that it is the first to offer high-level descriptions of complex logic elements like barrel shifters, counters, or adders. A complex component can be defined and parameterized in one line of alphanumeric text with what are known as indexed equations. These equations simplify a complex design; furthermore, they can be written in a way that allows them to be reused in different designs that require similar functions but with different parameters, such as shifter width or the number of shifter stages.

Orcad/MOD allows the designer, using the Jedec fuse information supplied to a PLD programmer, to construct a simulation model of the PLD. High-end system-level simulators typically accept PLD models, but they require the designer to enter the the fuse information manually.

TOOLING UP. Tools have been a major factor behind the development of the PLD market. When Monolithic Memories Inc. (now part of Advanced Micro Devices Inc., Sunnyvale, Calif.) brought out software in 1978 to simplify design with their PLDs, the market for such devices took off, according to Scott Hudson, market research analyst at ICE Corp., a semiconductor market-research firm in Scottsdale, Ariz. This year the market will be worth $775 million, he says, up from $500 million in 1987. Next year, ICE projections say the market will have reached the $1 billion mark.

A stream of improving tools from companies such as Data I/O and Hewlett-Packard helped the market reach this high level. They let an engineer create his design without considering the particular PLD structure in which it will be implemented, so he is no longer tied to a single PLD vendor. HP, Data I/O, and others also added tools for logic synthesis and optimization.

Orcad's low-cost tools add to the picture by enabling a user to handle more complex designs. No longer must he design one PLD in isolation, and then another; he can work with several PLDs at once and simulate the operation of these devices in a larger design. Orcad/PLD and Orcad/MOD, which are available now at $495 each, operate with the company's schematic-entry program (Orcad/SDT) and simulator (Orcad/VST) or as stand-alone tools in conjunction with other schematic-entry and simulation tools.

Its ability to accept indexed equations as input is one factor that lets Orcad/PLD handle more complex designs. Indexed equations are core boolean descrip-

> Orcad/PLD is the first PC design tool to offer high-level descriptions of complex logic

tions for one stage of a larger structure, such as a multistage shift register or counter, explains John Durbetaki, Orcad's president. Surrounding these core descriptions is information that expands the single-stage equation into some desired number of stages.

Besides regular structures, such as registers and counters, the tool allows the designer to describe irregular structures. "No one else is currently providing this capability," Durbetaki states. A decoder is an irregular structure, for example; "glue" logic for some specific combinational function is another type.

Indexed equations offer major efficiency gains. A four stage barrel shifter that can be described with one line of indexed-equation code requires 64 individual boolean statements. If a 4-bit barrel shifter were to be one stage of a four-stage barrel shifter with four input signals (D0-D3), four output signals (Q0-Q3) and two possible shift-amount inputs (S0 or S1), it could be described with the equation

$$n=3\sim0: Q2=S[1\sim0]==3\text{-}n\&D[(n\text{-}1)\backslash4],$$

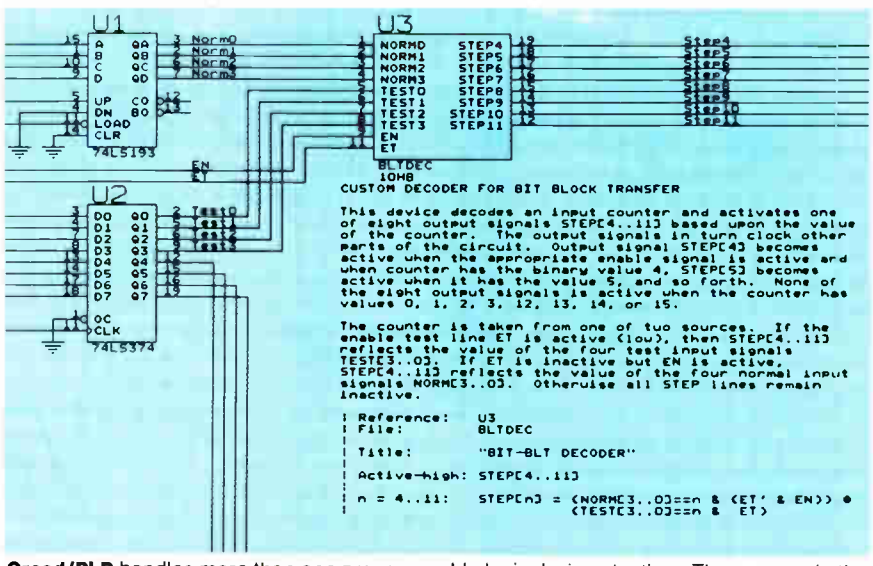
where == is the equivalence operator as it is in the C programming language. The equation states that output Q2 will equal the condition of the input shift amount S ANDed with input conditions D. The variable n is the equivalent of a DO loop in a standard programming language, directing the Orcad/PLD compiler to expand the equation four times.

By adding one more variable, a multiple-stage shifter can be designed with what amounts to a pair of nested DO loops. A third variable added to the equation makes it possible to specify the width of the shifter; by now, the indexed equation is highly generic and can be used in many different designs.

Besides indexed equations, the designer can input state-machine descriptions, boolean equations, truth tables, and schematic symbols. Orcad/PLD produces the Jedec-standard file for programming a PLD as well as vectors for testing the device. Design documentation is integrated in the schematic; the designer enters comments alongside the equation code, within the schematic view provided on-screen.

Once the designer has created a PLD design, he can pick up the design file with Orcad/MOD, a product that produces models of the specific PLD-based circuit for use in a simulation of the larger circuit in which the PLD will operate. Orcad/MOD produces complete timing models of the PLD, so not only can the designer simulate the function of the PLD, he can also simulate its timing.

–Jonah McLeod



Orcad/PLD handles more than one programmable logic device at a time. They appear in the on-screen schematic along with comments and equations describing implemented circuits.

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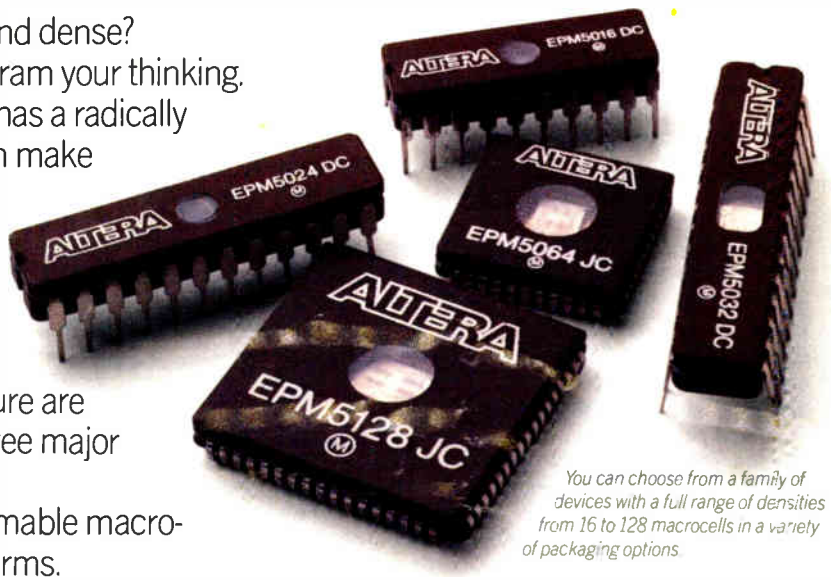

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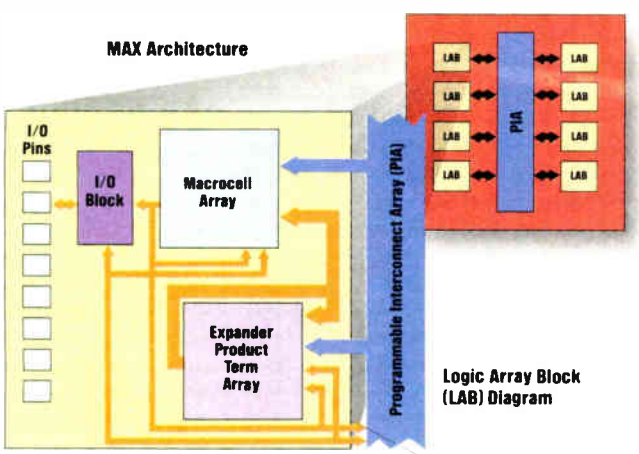

Logic Array Block (LAB) Diagram

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A BIG STRIDE IN MIXED-MODE SIMULATION

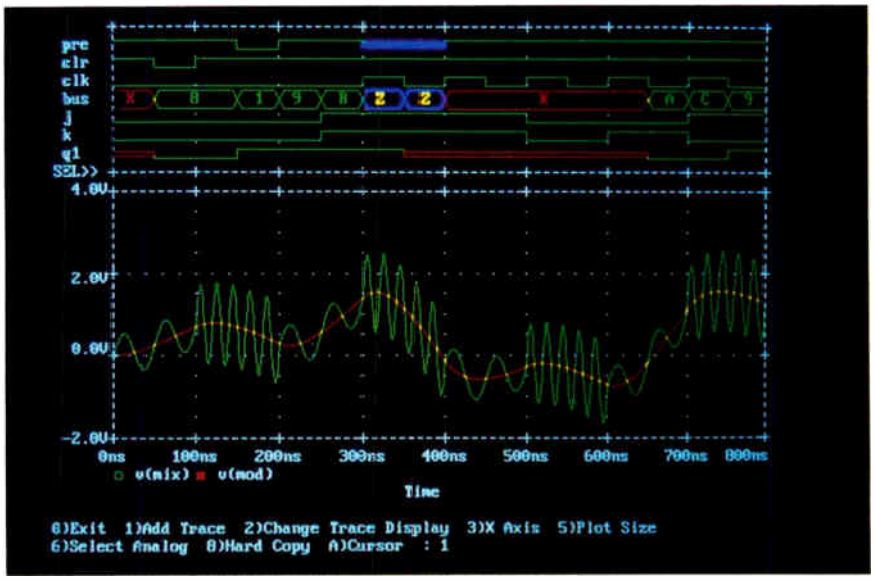
For the first time, an analog simulator has been truly integrated with a digital simulator in a single tool. In Version 4 of PSpice, Microsim Corp. marries what had been a pure analog simulator with a digital simulator to form a tool that can handle both analog and digital circuits in real mixed-mode simulation.

In doing so, the Irvine, Calif., company's tool avoids some of the biggest problems plaguing tool makers who are trying another approach to mixed-mode simulation—tightly coupling separate analog and digital simulators. One of those problems is coordinating the operation of the two simulators. Another is providing a separate netlist for the two different simulators; yet another is finding out which of the simulators faulted when a mixed-mode simulation fails.

Microsim hopes the new tool will put it in the front ranks of the contenders for the mixed-mode simulator market—a market segment that is just now starting to emerge, according to Andy Rappaport, president of the Technology Research Group in Boston. Rappaport says that companies involved in circuit design this year will buy about $28 million worth of tools that are to be used for both analog and digital circuit simulation. But most of those simulators will be used to simulate the two different circuits separately, he says. Only about $5 million worth will be used for true mixed-mode simulation. By 1992, though, those companies will spend about $128 million on simulators, Rappaport says, "almost all of it for mixed-mode simulators."

So Microsim, which is introducing Version 4 of PSpice this month, is staking out its turf early. The company is not relying solely on a head start, though. It tailored the software for the IBM Corp. Personal Computer because of the large installed base of PCs and their compatibles, and it has priced the package aggressively, at $750, $950, and $1,450, depending on the configuration of the PC.

Version 4 of PSpice is based on the earlier, analog-only PSpice, which is itself based on Spice, the public-domain package that has long served as the standard analog-simulation software. A 28-state digital simulator that Microsim developed itself was meshed with the analog simulator to form the new version. To integrate the digital simulator with the analog simulator, Microsim expanded the Spice syntax to accommodate digital components. Just as PSpice previously contained primitives for transistors, resistors, capacitors, and so on, it now also contains primitives for digital components. Combining them in a PC-based package imposed one constraint, says Paul Tuinenga, executive vice president of Microsim: the PC must run the OS/2 operating system, not DOS—the maximum of 640 Kbytes of memory in DOS is not enough to hold the mixed-mode version of PSpice.



PSpice's mixed-mode simulator produces on-screen output of both digital and analog waveforms for easy interpretation by a designer.

Integrating the two simulators solves several of the problems that arise when analog and digital simulators are merely coupled. Chief among these is the difficulty of coordinating the operation of two distinct simulators. The trick is to allow each simulator to operate independently, yet enable each to anticipate the operation of the other.

> Microsim weds analog and digital simulators in a single tool

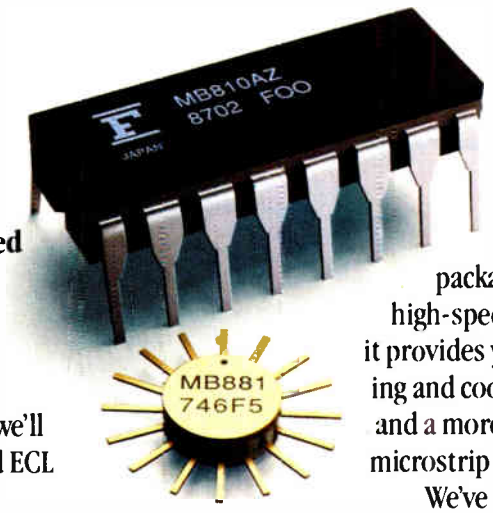
One key is to provide a way for the analog and digital portions of the simulator to move forward independently of each other, not simply proceed in lockstep. A similar tool, the Saber/Cadat mixed-mode simulator from Analogy Inc., Beaverton, Ore., and HHB Systems Inc., Mahwah, N. J., accomplishes this with a proprietary algorithm the companies call the Calaveras algorithm—named after the celebrated jumping frog of Calaveras County in Mark Twain's short story, because it allows one simulator to leapfrog the other [*Electronics*, May 26, 1988, p. 68]. Microsim uses the same technique but not the same algorithm, Tuinenga says. "We implemented an algorithm similar to the so-called Calaveras algorithm, which we introduced a year and a half before the Analogy introduction," he says.

Another problem with coupled simulators is that they require two different netlists, one for analog and another for digital circuit components. In PSpice Version 4, however, the front end that reads in the netlist takes into account the difference between analog and digital circuits. It automatically separates the analog and digital components, provides the interface between the two, and creates the data structures that the digital and analog portion of the simulator operates on. Any schematic-capture package can be used to create the netlist.

Another problem with coupled simulators is figuring out whether error messages are being sent by the analog or the digital simulator. It's hard for the designer to determine which simulator flagged an error and at what point in the simulation the fault that prompted the error message occurred. Since the mixed-mode PSpice integrates the two simulators, it understands both analog and digital operation. When a fault occurs, it sends a "smart" error message that points out where the failure took place.

PSpice interfaces with a designer through a shell providing a great deal of control over the simulation. The designer can initiate a simulation, interrupt it to check the results with a waveform viewer, and resume simulation without exiting the simulator and returning to the schematic-capture program. The output is in the form of both analog and digital waveforms that the designer can easily interpret. *–Jonah McLeod*

Going fast.



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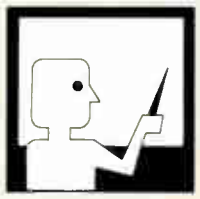
THE ASSAULT ON DATA SECURITY IS GETTING A LOT OF ATTENTION

The spread of networking, personal computers, and optical storage aggravate the problem

As the importance of computerized data increases for virtually every business, so does the danger to the security of that data. Data is under assault on a number of fronts, and figuring out how to protect it is getting harder and harder.



EXECUTIVE BRIEFING is a monthly feature of Electronics *that provides managers with a concise review of developments in fields that are making frequent headlines.*

In too many cases, company executives throw up their hands and do little or nothing. United Software Security Inc., a Vienna, Va., firm that helps companies set up personal-computer security programs, surveyed its own customers—companies that are concerned enough about security to have hired a security consultant—and found that only 70% of them had actually established corporate policies on physical security. Only 45% had established electronic-communications security policies.

The only real bright side to the issue of data security is that it has bred a number of companies like United Software Security who will take the problem off an executive's hands. Various services are available, from protection against fraud and thievery to recovery of data that seems lost when files get corrupted or disks crash. These products and services add up to a growing data-security market. The research firm of Frost & Sullivan Inc. in New York projects that the U. S. market for computer security products and services will grow to more than $1 billion in 1993, from $588.5 million in 1988.

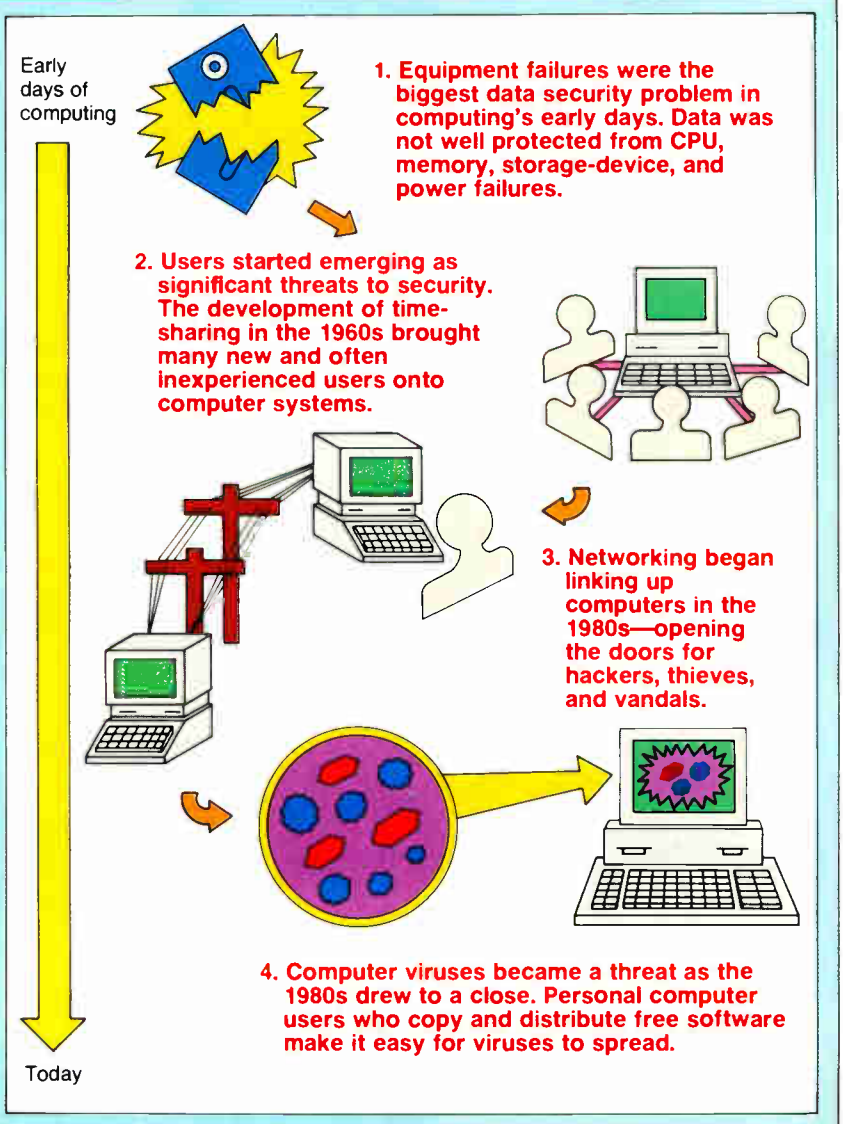
Such services are a natural response to a complex problem. It makes more sense for specialists to try to come up with a solution than for, say, a chip maker to work out a security program that can protect the mainframe-based system that holds its business data, the network of work stations that its designers and engineers use, and the PCs that almost every employee has access to. But even the specialists agree that security begins at home: it's up to each company to devise a basic program that will guard its information.

In the early days of computing, the main threat to data security was that equipment broke down a lot. As the equipment improved, timesharing became possible. Timesharing allowed many more users to fool around with the data, many of whom were inexperienced and a few of whom were crooked or malign. Networking had the same effect on a far wider scale.

The proliferation of PCs spread the problem even further. Each PC is, in effect, a separate security problem. More ominous is the way PC users hand around free software on bootleg disks and electronic bulletin boards. Easy transfer of software makes possible a plague of computer viruses—pernicious programs that attach themselves to other programs and wreak havoc in a system. The fact that many PCs are networked raises the possibility of a virus igniting the computer equivalent of an epidemic.

In sum, widespread access to computer systems, coupled with the vastly larger

THE ESCALATING THREATS TO DATA SECURITY



number of sophisticated users, means that today there are two different kinds of security threat. Besides the older, ever-present threat of equipment or software failure (and the related threat of damage done by inexperienced users), there is now a very real threat from malicious users. That problem, in turn, breaks down into two separate problems—keeping malicious outsiders off the system, and preventing disgruntled or criminally inclined employees from attacking it.

Security programs consist of several interrelated parts. The most basic of these is controlling access—limiting who can use computers in the first place, and which of the users can work on what files. Part of the program should aim at preventing or eliminating damage by unauthorized users; another part with policing the users who must be given access. A separate but related part of the program should deal with unintentional damage—what to do to prevent it and how to recover as much data as possible if it occurs.

BEING THERE. The basic program part, limiting access, is in some ways the hardest. Physical access is hard to control, since terminals are commonplace and PCs everywhere, but such methods as keyboard locks and secure storage for floppy disks can help. Such measures are important now and will become more important soon, as it gets easier to steal a great deal of data by walking off with a single optical disk.

Optical storage is "changing the definition of what we consider critical corporate information," says Del Jones, director of the National LAN Laboratory. The lab is a nonprofit corporation, based in Herndon, Va., made up of local-area network vendors concerned about network security and reliability. The danger lies with the fact that much more data can be crammed onto one 2-Gbyte, 5.25-in. optical disk—potentially, a company's entire data base. Much of today's physical security, Jones says, rests on the assumption that an intruder could walk away with, at most, a megabyte or so of information.

The problem will reach critical mass, Jones says, when the price of erasable optical storage media drops enough for it to be economically installed on many desktops next to a PC or work station. He estimates that will take about two years. Right now, he says, about 5% of corporate data is stored in computers. But when optical storage becomes commonplace—accompanied by input devices that make electronic capture of data as easy as making a photocopy—"managers will start dumping their file cabinets." When that happens, some kind of physical security program better be in place.

The movement toward open systems will make security problems worse

At the moment, though, controlling electronic access is more important. Fortunately, it is more effective and, to an extent, easier. Partitioning the system into various levels of access is relatively straightforward. However, experts agree that partitions need to be accompanied by tight control over the passwords that let users into the different levels.

A computer system's first line of defense in controlling access is whatever security features are built into its operating system. The majority of corporate systems in this country are based on mainframes from IBM Corp. Since 1976, the security umbrella for IBM mainframe systems is a system called RACF, the Resource Access Control Facility, a sort of watchguard for IBM's two main mainframe operating systems, MVS and VM.

Another approach to obtaining operating system security is the KeyTech foundation kernel built by Key Logic, a software startup. The KeyTech kernel and its associated objects enable the Santa Clara, Calif., company to offer security along with performance for a variety of operating systems and hardware platforms. KeyTech is currently implemented for IBM System 370 architecture and the MVS operating system. It also supports Unix and the Motorola 68000 Series microprocessors.

However, operating systems are inexorably caught up in the movement toward open systems. Open systems are intrinsically more difficult to defend—by definition, they are easy to get access to.

For similar reasons, guarding a network is somewhat more complicated than guarding a single computer. In theory, at least, electronic access to a network is available to anyone who owns a PC, a modem, and a telephone.

One simple way to guard network access is a combined password-and-callback feature that prevents unauthorized entry via modem. Implemented on-chip in authorized modems, the feature lets in only those users who key in a password. Then the host disconnects the call, finds the caller's number in a directory by searching for the user's individual password, and dials the number to reestablish communications. This keeps someone who has stolen a valid password from accessing the data base unless he also has access to the user's phone.

Keeping out unauthorized users is, of course, only half the problem. The other half is how to police the authorized user.

This may be the more important half of the access question. Exactly who is doing what kind of damage to data security is

WHEN A VIRUS STRIKES, THERE'S AN Rx

The latest threat to data security—or at least the latest to get widespread publicity—is the computer virus, a program surreptitiously attached to other software and set to activate at a given point. The rogue program can play an innocent prank—flash a rude message on a screen, for example—or do serious damage, from erasing files to crashing entire systems. And the nasty little things can replicate and spread from an infected program to a healthy one. They're contagious.

Choosing effective antiviral products is not easy, but help is on the way. The Computer Virus Industry Association has been formed to help answer questions about the effectiveness of antiviral products. It is an association of eight manufacturers of antiviral products. They have banded together to classify products, define standards, and set up an independent testing and verification body.

A few products are now available that, in effect, either inoculate software against viruses or detect known viruses and kill them.

The inoculation approach keeps a virus from attaching to healthy programs by the use of hardware that controls access to disks and software that monitors writing to executable program files. One such product is the Guard Card, manufactured by NorthBank Corp. in Richmond, Va. Guard Card works by providing user-controlled write protection for selected partitions of a hard disk. It stops either accidental erasure or corruption of programs and data files stored on the disk. It also prevents attempts to format a hard disk. The Guard Card's function is like placing a write-protect tab on the hard disk drive. Guard Card costs about $190.

Another inoculation product is the Vir-Alarm 2000 program offered by Integrity Technologies Inc., in Metuchen, N. J. Vir-Alarm 2000 uses ciphered checksums and a DOS shell utility program to protect files.

Examples of products that both detect viruses and kill them include the family of software from WorldWide Data Corp. of New York. One product, Vaccine, checks for viruses by not permitting any program to remain in memory unless its name has been registered with Vaccine. Another is Antidote, which scans a disk for copies of known viruses on a supplied list and notifies the user if any of them appear to have attacked any programs. *–T.M.*

information that's intrinsically hard to come by—the people involved want to keep it secret. But most experts think the criminally inclined, maliciously minded, or just plain crazy user whose job gives him access is the real danger to security. Robert Courtney, a former IBM Corp. security analyst who is now a private security consultant based in Kingston, N. Y., estimates that in 1987 employees—i.e., authorized users—stole more than $28.1 million using computers.

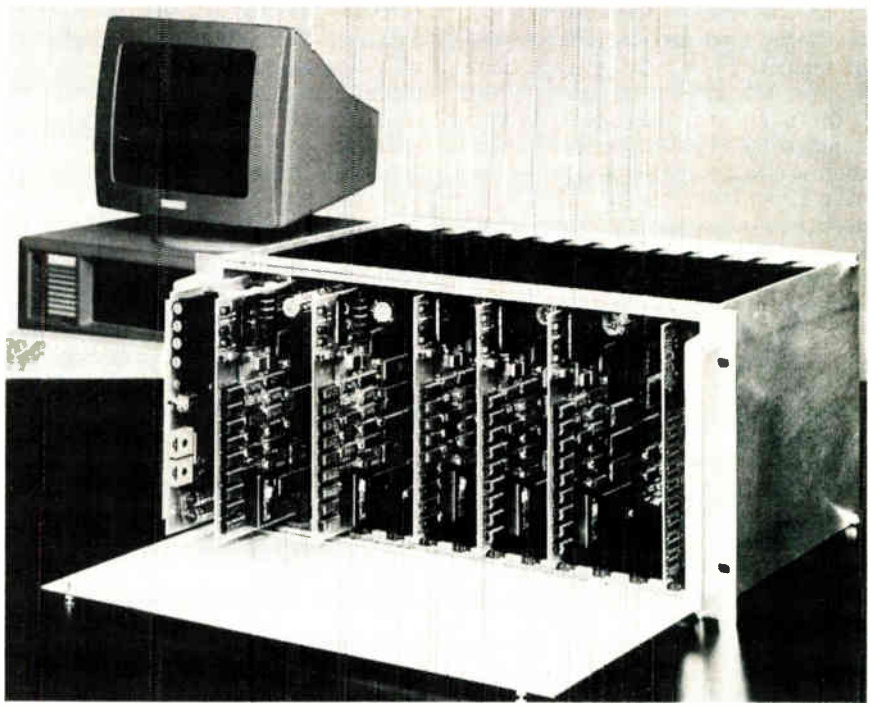
The problem is acute with networks, again because networks offer wider access too more people—people who know how to do damage if they're inclined to. "At the core of the special security problems presented by LANs is the greatly increased number of users and, more important, their technological sophistication," says Del Jones at the National LAN Laboratory. "Many are proficient enough to crack normal security measures—and some are proficient enough to unravel practically any security code."

Ironically, guarding against another kind of security problem—a failure that brings the network down—complicates the access problem. A network failure can be disastrous; a Boston research firm, the Yankee Group, says the cost can reach $50,000. Protecting against a failure usually takes one of two paths: Creating a mirror image of every file locally—that is at the work station or terminal—or, creating a distributed data base and allowing many users access to it. The former approach is also expensive, at least in terms of network resources, so the latter is more often used. But because it gives so many people access, the shared data base significantly heightens the security problem.

The National LAN Laboratory is developing recommendations for manufacturers and users dealing, among other things, with security. Its recommendations so far are that every system should have a site analysis, risk analysis, and disaster-control plan. But the solutions are in many ways more managerial than technological, Jones says. "The most important single issue is people—training and strategy. People who have access have to be constantly reviewed," he says.

IN THE SLAMMER. One potent weapon against abuse by authorized users is getting easier to use: civil and criminal prosecution. Until recently, it was hard to sue a computer malefactor or have him arrested because existing laws were vague or nonexistent. Also, most companies seemed reluctant to publicize the vulnerability of their systems by going to court. The usual course was to fire the offender and try to keep the episode quiet. Both situations are changing: tough laws dealing explicitly with computer abuse are being written, and companies are becoming more inclined to use them.

For example, a programmer at a Forth Worth, Texas. company was recently sued in civil court and prosecuted in criminal court on charges brought by his employer, and the company won in both actions. Donald Gene Burleson was accused by USPA and IRA Co., an insurance and brokerage firm, of planting a virus in the company computer that would wipe out commission records of the sales staff each month. The virus triggered once before it was detected, deleting 168,000 records in the commissions file. In the company's civil suit, Burleson was found liable and ordered to pay USPA $12,000 in damages. In the criminal case, he was found guilty of harmful access to a computer, a third-degree felony under Texas law. He faces up to 10 years in prison and a $5,000 fine.



This rack of Telcor Systems Corp. data-compression modems provide modem-based data security as well as compressed-data communications.

Data-protection and disaster-recovery services for PC users are growing

No matter how good the programs limiting access, though, situations will still arise where the unauthorized user can't be kept out and the authorized but evil-minded user can't be scared off. To deal with such situations, a good data security program must be able to prevent them from doing any damage or limit the damage they can do.

One of the most effective ways to do that is to encrypt the data they might be able to get their hands on. And probably the easiest way to encrypt data is at the entry point to networks—a fortunate circumstance. since network ports to the outside world are generally the weak points through which outsiders, at least, gain entry.

The usual entry is by modem, where it is now relatively simple to implement encryption-decryption schemes. Single chips that implement the Data Encryption Standard, or DES, endorsed by the federal Bureau of Standards, are available. Besides making implementation easier, the chips make it considerably cheaper, too. A few years ago, for example, Telcor Systems Corp. in Natick, Mass., sold separate boxes for encryption and a password-dialback feature; the former cost between $1,000 and $2,000 and the latter between $300 and $500. Today, Telcor sells a 9,600-bit/s modem incorporating both functions for only $995.

More important, the logical place to begin protecting the data is the modem. "We think the modem is the best place to implement data security," says Bo Sullivan, vice president of marketing and sales for Telcor. "You need the modem anyway to transmit your data."

Encryption is accomplished in a two-step process. Once point-to-point contact is made, the modems go through a verification procedure to assure that they both have the same 17-digit master key. Then they develop a 17-digit session key that will be used for that particular exchange of data. This first stage is done in software. The session key is used to initialize the encryption chip. Although the encryption algorithm it implements does not change, the odds of guessing or predict-

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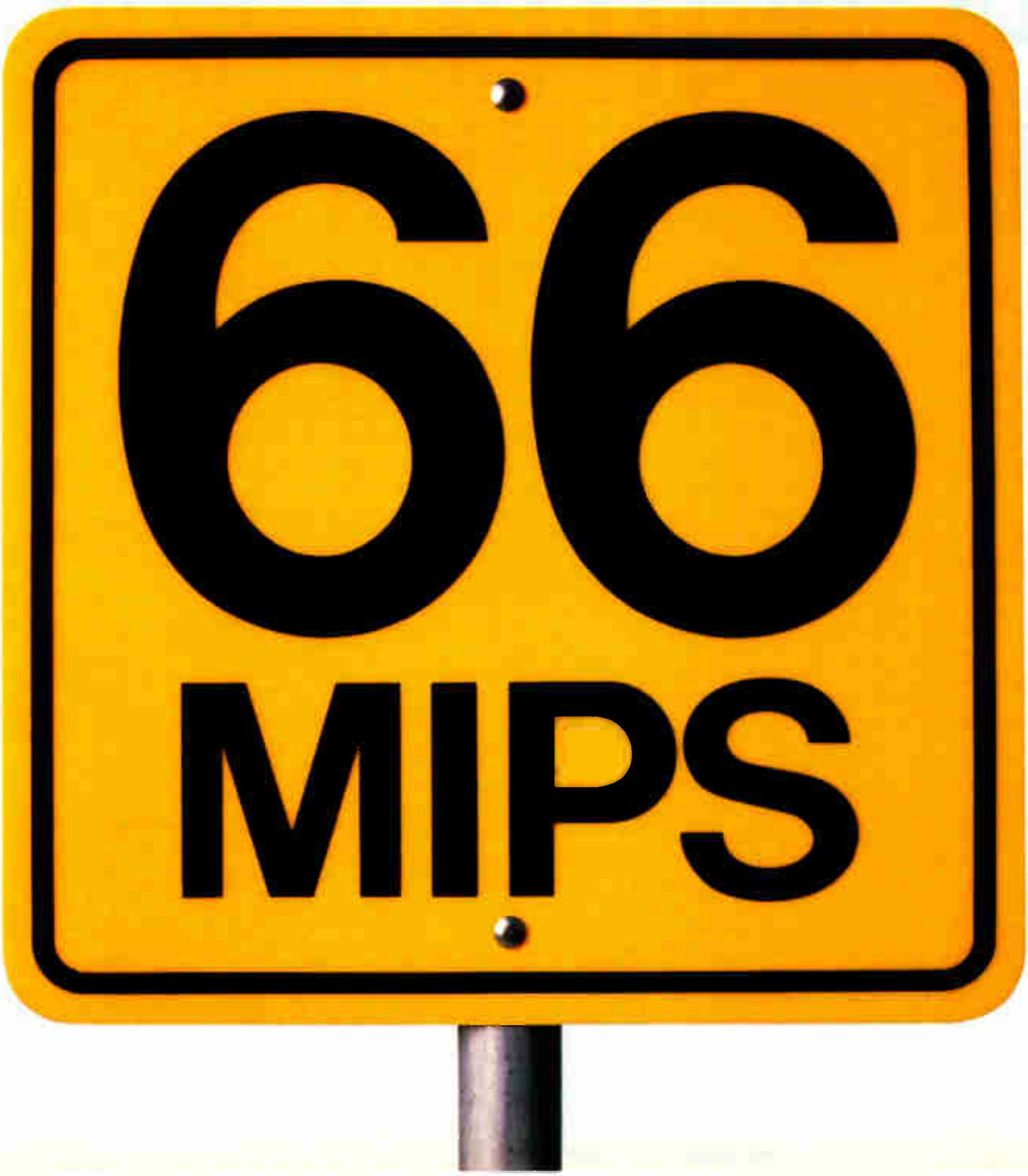

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ing a 17-digit key virtually guarantees an secure transmission. Since encryption take place on a bit-in, bit-out basis—not by reading chunks of data and encrypting them in chunks—the process does not slow down data transmission.

The DES standard has been agreed upon for the algorithm but does not extend to the unit-to-unit level. In other words, encryption units made by different manufacturers cannot talk to each other, even though they might both use the same chip and 17-digit key.

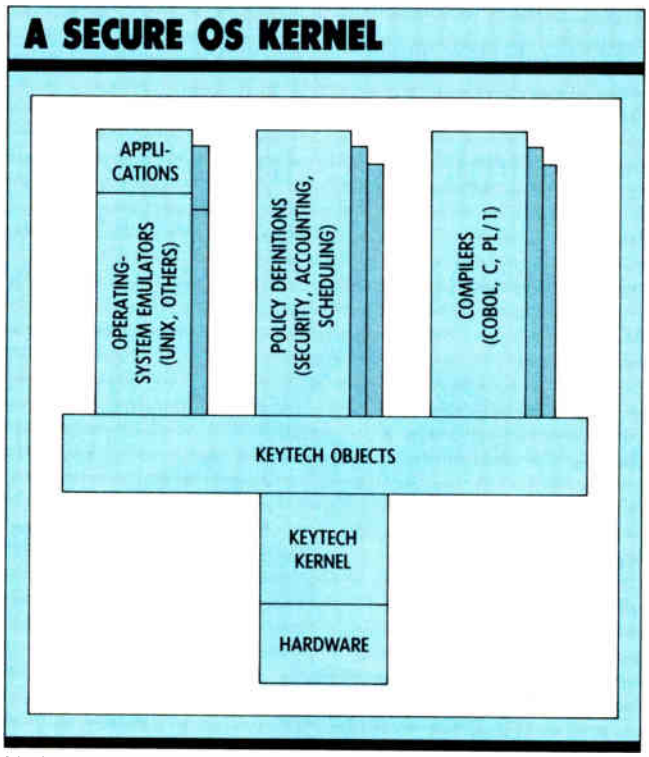
A security program that restricts both physical and electronic access, monitors a system's authorized users, safeguards networks, and encrypts data has gone a long way toward protecting corporate data. However, the program must also be enforced—procedures have to be laid out and adhered to. All the safety measures and rules for usage in the world won't help if the safety measures are implemented haphazardly or the rules aren't followed.

The problems involved in setting policy and enforcing procedure are illustrated by the security program now being worked out by one of the largest users of data processing systems: the U. S. government. The basis of the government's program was set out in the Computer Security Act of 1987. That measure required that all sensitive computer systems owned or operated by or for the federal government be identified, and that some appropriate steps be taken to protect those systems. In theory, that's the right first step, at least.

However, the program is mostly concerned with unauthorized users—in this case, spies who might crack a system from the outside. That is a glaring flaw, says the consultant Robert Courtney. "Every spy that you hear about was authorized to access to the data he took," he says. There isn't enough "concern about data integrity. Their principal concern is the Russians."

In any case, the first milestone for the Computer Security Act occurred on July 8 of this year. By this date all federal agencies were required to identify all their computer systems that contain sensitive information. Not surprisingly, the overwhelming majority of such systems belonged to the Department of Defense. Out of more than 53,000 federal systems identified, 52,000 belonged to the DOD.

Now comes the hardest part: handling reports on these systems that detail how the agencies involved will keep them secure. By Jan. 8, 1989, all of these reports are due. They will be delivered by the truckload. Courtney says it will take the National Security Agency, which will review the plans, "at least a year to just riffle through them." The Office of Management and Budget, which is overseeing the agencies covered in the bill (computers in Congress and in some other agencies are exempt), has tried to limit the trouble with a directive this winter that said it's acceptable to have common security plans for systems that are related logically.



Limiting access is possible with products like KeyTech, which segregates all systems and users across operating environments.

Courtney thinks that's another bad idea. Two systems might be related logically, he says, in that they do the same job, but still use different hardware, different software, and be located in different environments—an office building in New York vs. a suburban warehouse.

So far, the General Accounting Office reports overwhelming compliance with the Act, but that could change. There are absolutely no penalty provisions in the bill, says an aide to the House Committee on Science and Technology's subcommittee on Aviation and Materials Science, which held hearings on compliance with the Act in September. "The only enforcement measure is that OMB has a veto authority on the plan if it doesn't meet NSA standards," he says. Since the OMB also controls the executive branch purse-strings, however, it wields considerable unspoken authority. "OMB controls the funding of these systems so their oversight role is respected," says the aide.

A well-run security program, whether it guards government or commercial systems, needs to concern itself with more than crime and vandalism. The most common threat to data is not the hacker or mole attacking the system, but the well-intentioned user who inadvertently corrupts it or loses it. To cope with such errors or natural disasters, such as fire or floods, a good security plan needs some provision for disaster recovery.

In this respect, most large systems are already protected. Large installations generally back up disks and tapes, store the backups off-site, and in some cases use professional disaster-recovery services that run parallel sites so that if one location is hit by, say, a fire, a second keeps running.

The real sufferers are individuals—PC users who treat their machines and their data casually if not carelessly. Few back up their disks consistently and fewer still have any idea what to do to recover data after a problem arises.

Help is available, however. Data-protection and disaster-recovery services for PC users are being started.

PC users who do not want to do their own backups, for example, can call Fast Track Systems Inc. in New York. The company has just announced the first automatic remote-vaulting system for PC users. Called SafeTrack, the system automatically makes a complete copy of the customer's disks every night, encrypts the data, and transmits it to a SafeTrack host computer. There the data on the disks is transferred to magnetic tapes and stored in a vault.

PC users who suffer a common disaster—disk drive crashes—can get help from Ontrack Data Recovery Inc. The Eden Prairie, Minn., company takes in ailing PC disk drives with data missing, evaluates the recovery process, and then recovers as much data as possible. The cost depends on the magnitude of the job. The initial charge for every job is $200 for one hour to examine the drive. In many cases the engineers can recover the data in that time. The average recovery costs from $500 to $900. The maximum so far was $2,500—that one took as much as 20 hours. Ontrack has done over 100 recoveries since launching the service in mid 1987. "People don't know how much data can be recovered," says Michael W. Rogers, the company's chief executive officer. "We can handle two kinds of recoveries now: from electromechanical disk failures; and resurrection from data and file structure corruption." *–Tom Manuel with additonal reporting by Jack Shandle and Tobias Naegele*

ARIZONA, USA

By Richard D. Filley

Arizona. It's an intriguing juxtaposition of high technology industry and the timeless beauty of the southwest. It's a bellwether state for what American industry is doing right to stay competitive in world markets. And it's one of the best places in the country to live, work, and play.

The high tech heart of the southwest is Phoenix, a sprawling and dynamic desert metropolis now ranked tenth among American cities in population. The metropolitan Phoenix area, known appropriately as "The Valley Of The Sun", consists of around twenty communities, including Mesa, Tempe, Scottsdale, Paradise Valley, Glendale, Peoria, Goodyear, Litchfield Park, Chandler and Gilbert.

Further south is Tucson, known as the "Old Pueblo", and one of America's most beautiful and livable cities. Ringed by mountains, Tucson is both a home to some of the nation's finest resorts, and a diverse palette of leading edge industry and research efforts covering everything from astronomy and aerospace to computer hardware and medicine.

At the gateway to the Grand Canyon is Flagstaff, a northern Arizona city which is a transportation crossroad with industrial potential. In southern Arizona, the cities of Yuma, Sierra Vista, Nogales, and Douglas all aggressively court industry and offer ready access to the amazing maquiladora industry of Mexico.

Arizona is a land of wide open spaces, still a frontier territory with vistas of possibility and horizons of opportunity for pioneers with vision. Arizona's movers and shakers are still accessible, and they will listen to newcomers because so many Arizonans were born elsewhere and haven't lived in the state that long. Change and progress are the bywords here, and it seems like almost anything can happen in this young and vibrant place.

So today, with nature somewhat tamed, the challenge for those of adventurous spirit in Arizona is to harness the future of high technology. And for you, there isn't a better place in America to step into tomorrow and build something new. Come to Arizona and make your mark on the world.

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While the rest of the U.S. grew 11% between 1970 and 1980, our population increased 53%. It's slowed to a more manageable 15% since then.

Arizona has set a national record by leading the country in new job creations for the past 3 years. And Inc. Magazine ranked us #1 in its most recent report on state business climates—based on such factors as transportation, education, competitive wages, high productivity, supportive taxes and government regulations, and low-cost, available industrial sites.

The quality of life in Arizona is tough to beat. That's why so many businesses and people want to be in the state we're in. We invite you to join us. For more information on surprising Arizona, please call or write Arizona Public Service, P.O. Box 53999, Economic Development Dept., Phoenix, AZ 85036, (602) 250-3116.

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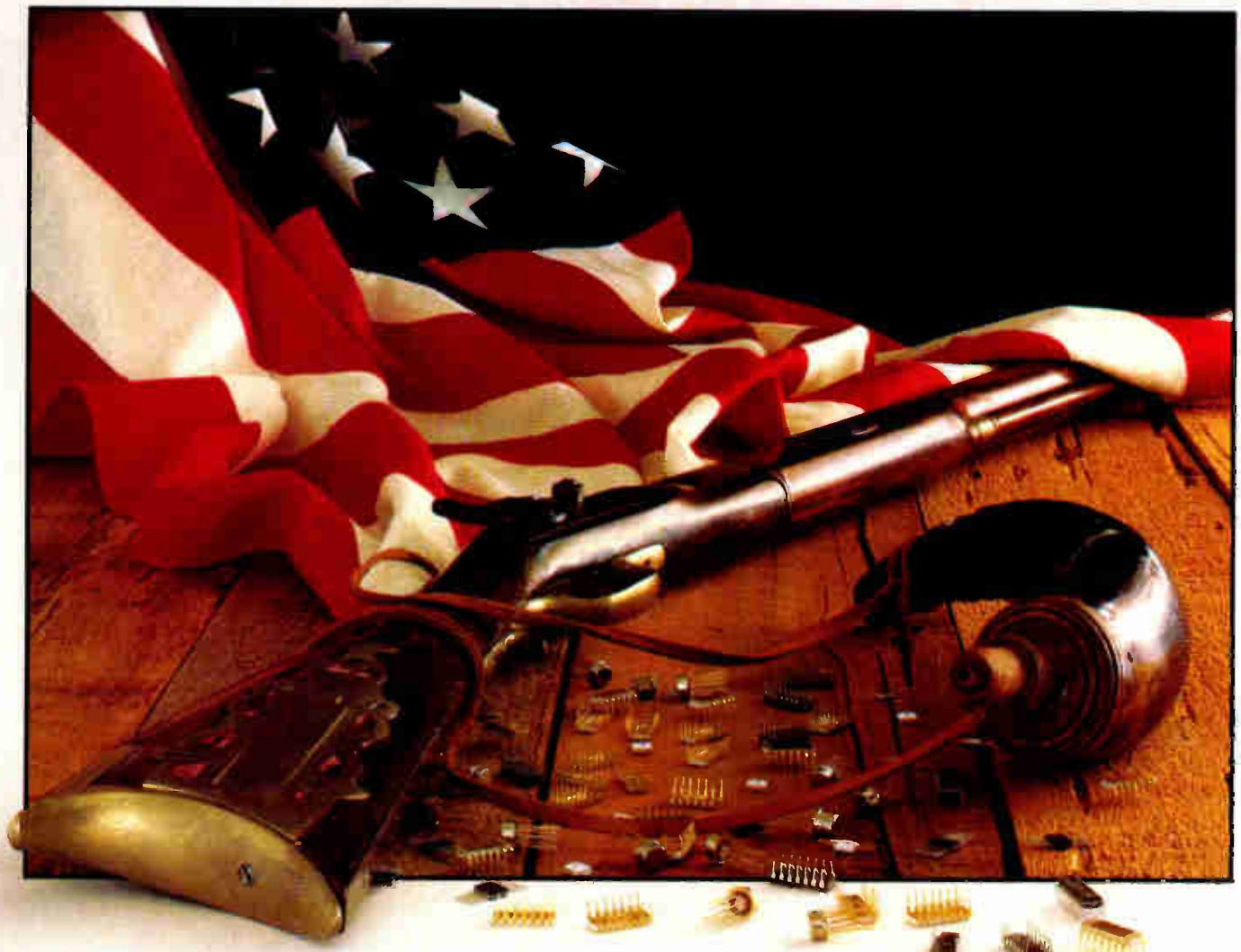

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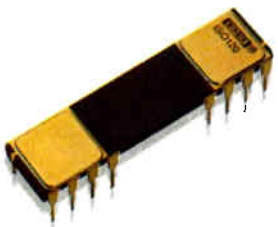

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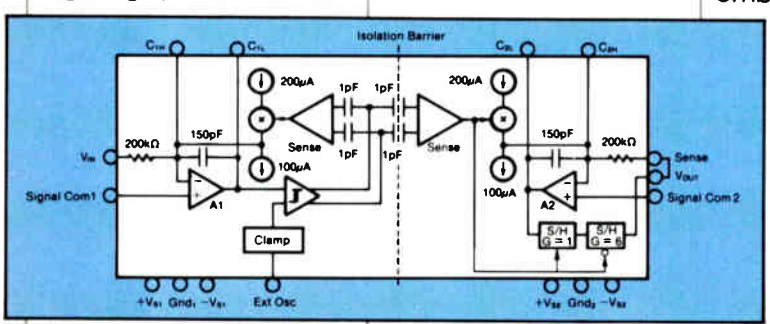

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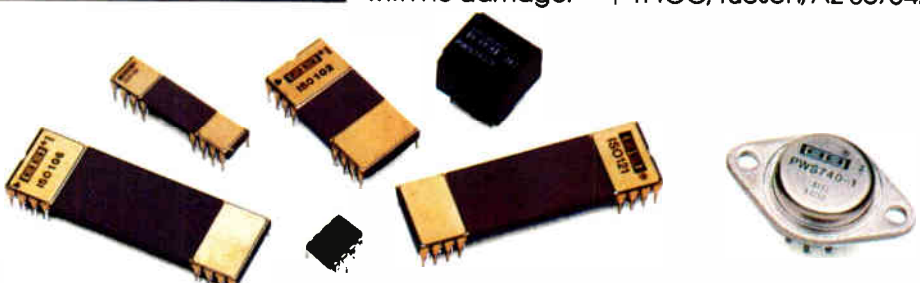

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The sun glints warmly off the copper dome of the State Capitol building on another one of those spectacular Phoenix evenings that ought to be patented, and the rosy hues of sunset start to appear on the glass towers downtown. The magnificent blue sky begins to fade into the night, and no one minds, because what Arizona is all about is blue sky, in weather and opportunity, and there's plenty more where this one came from.

But the metal color of the moment isn't copper, it is gold. Like Olympic gold, because a champion has just been named and there are a lot of proud people in the state government office tower nearby. Arizona, you see, has swept their event. It's just been learned that *Inc.* magazine, for the third year running, has named Arizona home of the nation's top business climate.

This prestigious ranking is based on new job creation, new business "birth rate," and young company growth rates. In other national studies recently conducted by Grant Thornton, Arizona has been ranked from fourth to seventh for overall manufacturing climate among the states.

"This is a great place for electronics firms to do business," says David Jankofsky, director of the Arizona Department of Commerce. "The basic industrial infrastructure of Arizona is excellent for computer and microelectronics firms."

According to Jankofsky, who came to his position from the private sector, some of the factors which make Arizona a profitable place to do business include the availability of a trained labor pool, competitive wage rates, a favorable labor regulatory climate, proximity to major California and southwestern markets, an excellent transportation network, and the low cost and availability of industrial sites.

A State On The Grow

Between 1980 and 1987, Arizona was the third fastest growing state in the nation with a 25% increase in population, according to the U.S. Bureau of the Census. With a population in 1987 of 3.4 million, Arizona's growth into the next century has been predicted with population estimates ranging as high as 5.3 million by the year 2000. Based on Census Bureau projections, Arizona will be the nation's fastest growing state (on a percentage basis) from 1987 to the year 2000.

What this means to industry is a steady source of labor. It is needed, for Arizona businesses led the nation in new job creation for three years in the mid-1980s. Between 1982 and 1986, almost 281,000 new jobs were created, an increase of over 27%. State of Arizona forecasts indicate that this trend will continue for some time.

Over 75% of the residents of Arizona reside in either the Phoenix or Tucson metropolitan areas, and these two locations also account for an even higher portion of the state's jobs and income. As major American cities, Phoenix and Tucson are large and tested markets with diversified economies that have and will continue to serve as engines driving the state's growth.

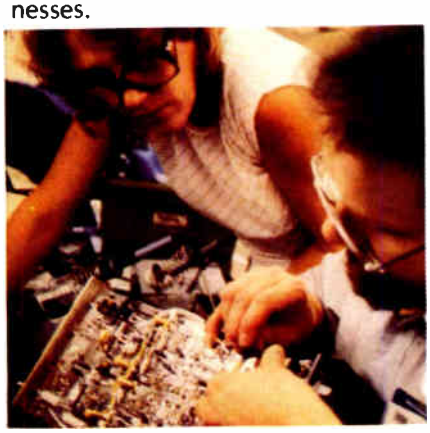
Despite Arizona's reputation as home to a number of well known retirement communities, the fact is that Arizonans tend to be younger and more educated than the nation as a whole. The median age in Arizona is 30.8 years versus 31.2 years for the United States, and the average education in Arizona is 12.7 years compared to the U.S. average of 12.5 years.

Arizona is a right to work state, and its' labor climate is conducive to productivity. Union members comprise less than 4% of the state's manufacturing labor force, and unionization has decreased almost 21% over the last two years. According to a recent study done by Grant Thornton, Arizona's value added per dollar of production payroll ranks number one in the nation.

A Good Place To Do Business

Since 1985, when an interstate banking law was passed in Arizona, the state has become a home (through the purchase of local banks) to several out-of-state financial institutions. These include Citicorp of New York, Chase Manhattan of New York, First Interstate of Los Angeles (operating in Arizona before 1985), Marshall & Ilsley of Milwaukee, and Security Pacific of Los Angeles. Valley National Bank, still locally-owned, is the largest of Arizona's 50 plus banking institutions, with $9.94 billion in assets in 1987, ranking it 37th nationally.

According to John Mitchell, executive vice president of community banking for Chase Bank of Arizona, the entrance of national banks into the Phoenix and Tucson markets has brought an influx of new lending capital to the state, and created a very competitive banking market that benefits Arizona businesses.



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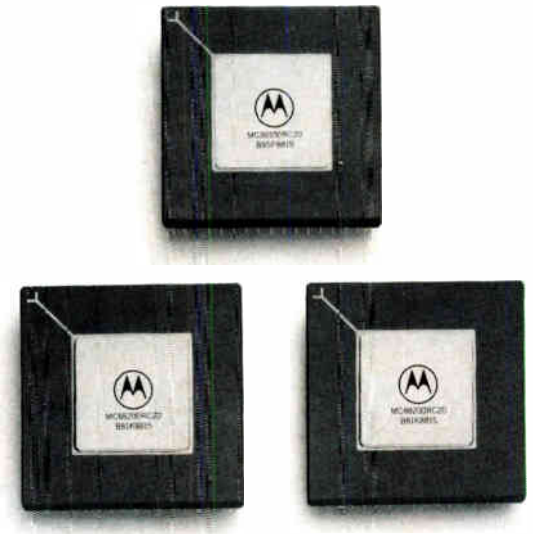

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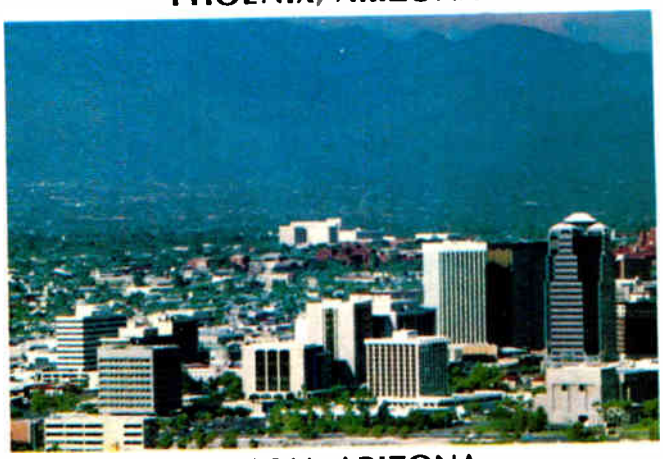
Arizona allows a deduction for both federal and Arizona income taxes when calculating corporate taxable incomes, which reduces Arizona's effective marginal tax rate below that of many other states. Arizona also does not impose an inventory tax, a corporate franchise tax, or a worldwide unitary tax.

The state has experienced tremendous prosperity over the past few decades. But this growth has not come without problems, and the state government of Arizona has been willing to work with the private sector to find solutions. One example of such cooperation has been the technology transfer legislation recently signed into law. This law provides academic researchers better opportunities to develop their ideas in the private sector, thus providing research incentives while creating a "win-win" relationship between industry and the state's institutions of higher learning.

PHOENIX, ARIZONA



TUCSON, ARIZONA

Entrepreneurs Are Welcome

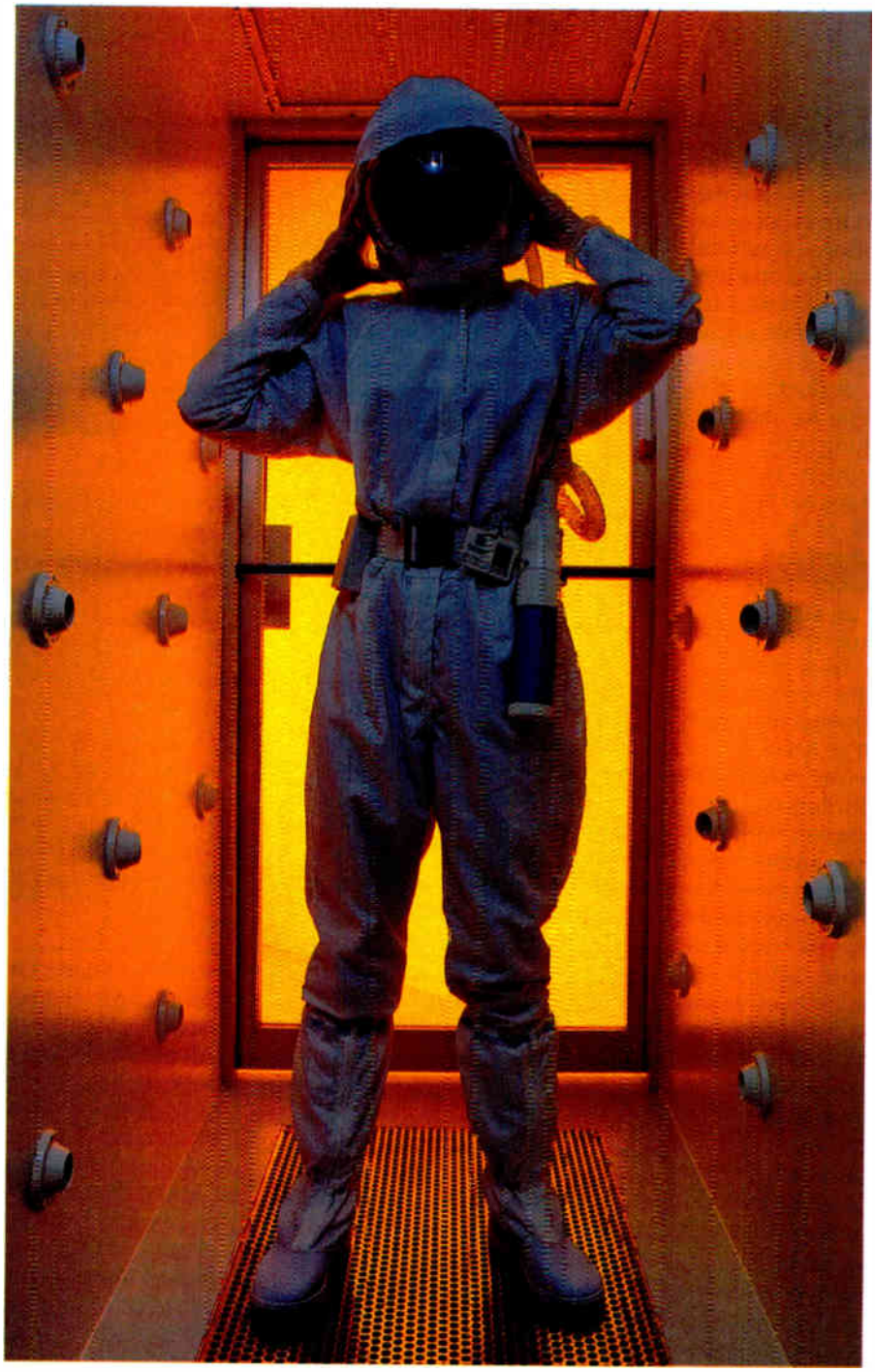
Entrepreneurship is alive and well in Arizona. Three organizations in particular foster and promote entrepreneurial activities within the state. These are the Arizona Innovation Network, the Enterprise Network and the Entrepreneur Forum. The Arizona Innovation Network caters to small high technology companies, while the Enterprise Network and Entrepreneur Forum are open to businesses of any type or size.

"The entrepreneurial community in Arizona is growing fast and getting more sophisticated," says Steven G. Zylstra, president and co-chairman of the Arizona Innovation Network. "Arizona's entrepreneurship organizations are helping to facilitate the creation of a innovation infrastructure, and provide networking, especially for small businesses."

Two other focal points for entrepreneurship in Arizona are the Arizona Technology Development Corporation of Tucson, affiliated with the University of Arizona, and Arizona State University's Hahn Center for Entrepreneurship, located in Tempe. Part of the Hahn Center's operations is a new business start-up incubator and service provider, known as the Center for Innovation.

According to LeRoy Ellison, Center Director, the entrepreneurs of Maricopa County (covering the Phoenix metropolitan area) currently start about 4,000 new businesses per year, not including franchises. He says the Center for Innovation "can provide the right kind of coaching, help and support that will allow many of these start-up ventures to succeed and prosper."

The venture capital situation in Arizona is improving, too. Milton D. Stewart, president of The Small Business High Technology Institute, located in Phoenix, says "there are now professionally organized and managed venture capital pools in Arizona. These operations also help provide a link for Arizona entrepreneurs to venture capital funds across the country."



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A Strategic Place To Locate

Centrally located in the southwest, Arizona provides easy access to the huge markets of California, Texas and Mexico. Direct access to the Pacific Rim is gained through the Pacific ports of Long Beach, California, and Guaymas, Sonora, and Latin America markets can be tapped directly or through Mexico.

Residents of Phoenix and Tucson have their pick of almost 100 flights a day to the Los Angeles area, as well as daily direct flights to over 50 other cities. American West Airlines, the nation's 10th largest airline is based in Tempe, and uses Phoenix as the hub of their national route system.

Michael S. Hammond, president of the Arizona Association of Industrial Development (and the PICOR Corp. of Tucson) points out some other transportation advantages. "Southern California is an overnight truck haul from most parts of Arizona. We're also a net import state, and because of the backhaul situation this creates, it will cost you less to ship your product out of this state."

"It makes sense to take a close look at locating in Arizona when your target is 25 million Californians," he adds. "For instance, the drawbacks of operating in Southern California, such as congestion, bureaucracy, travel difficulties, and high land, utility, building and labor costs, are all positives for Arizona."

Arizona's cost advantage is quantified in an example provided by Jack Tomasik, vice president of economic development and research, for Mountain West Research of Phoenix. "Three identical medium-sized manufacturing plants were compared on the basis of annual operating costs. The bill was $11.1 million in Phoenix, $12.8 million in Orange County, and $13.4 million in Los Angeles."

Thanks to the Central Arizona Project, routing water from the Colorado River to Phoenix since 1986 (and Tucson in the near future), water supply is not the problem in Arizona that you might think it would be. Nor is the energy supply a worry, as both of the state's major electricity providers, Arizona Public Service, and Salt River Project, operate with minimum 20% reserve margins. Arizona's electric power rates are about average for the U.S., meaning they are much lower than those of Southern California.

The supply of industrial and office space in both the Phoenix and Tucson markets is abundant. Competition is strong, with concessions and low lease rates fairly common. Elsewhere in the state, cities such as Casa Grande, Flagstaff, Kingman, Lake Havasu City, Nogales, Prescott, Sierra Vista, Window Rock and Yuma offer ready access to the interstate highway system and aggressively court new businesses.

If high tech research and development is your business, a natural place to locate would be the ASU Research Park, located in Tempe a short distance from Arizona State University. Representing a $40 million investment by ASU, the Park covers 323 acres of prime real estate. Spectacularly landscaped, the Park features attractive palm lined boulevards and three man-made lakes. Current park tenants include ICI Americas, TransAmerica Research Center, VLSI Technology, and the National Association of Purchasing Management. Future enhancements planned include complete conference center and hotel facilities.

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The Area

Warm, sunny, clean, positively beautiful. Phoenix' attraction as a resort and vacation center is internationally known. It is also one of the nation's fastest growing major metropolitan areas and home of the Silicon Desert. Phoenix is a blend of the progressive New West and traditional Old West, magnificent scenery, multifaceted heritage, and diverse cultural offerings. Add to this an abundance of moderately priced homes in incomparable surroundings, excellent schools and universities, and the best in shopping and recreation. And you can see why the lifestyle is such a satisfying one. Major league sports including spring training camps, hundreds of tennis courts and dozens of golf courses plus an abundance of outdoor year-round recreational options are available for leisure time activities. Water sports also play a big role here in the desert playground with the Valley boasting the highest percentage of boats per capita in the nation.

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Education Is A Priority

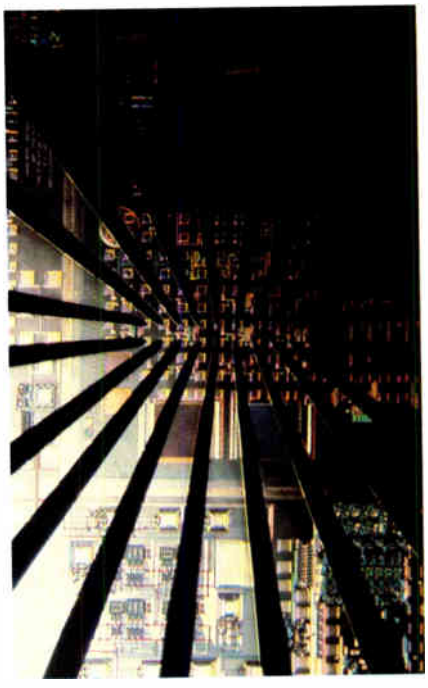
Arizonans talk a lot about the importance of education, but more importantly, they put their money where their mouths are: nearly two thirds of the annual state budget is allocated to education. Education standards have risen, too, as both high school graduation requirements and state university admission requisites are tougher in the areas of English, math and science.

Training, retraining, and continuing education are critically important elements of the education infrastructure in Arizona. At the state government level, for instance, the Industry Training Services Program, operated by the Departments of Education and Economic Security, offers up to $20,000 seed money per project to provide short term training for entry level employees.

Occupational education is one of the key missions of the Arizona Community College System. Comprised of nine districts, 15 colleges, 29 campuses, three skill centers, and hundreds of instructional sites located across the state, the System provides occupational training to about 88,000 Arizonans each year. Arizona is ranked sixth in the nation in percent of the population enrolled in vocational training.

Arizona has three state universities, one in each of the state's three main population centers. Arizona State University, the nation's fastest growing and sixth largest institution of higher learning, sits in Tempe, centrally located in the Phoenix metropolitan area. The University of Arizona, in Tucson, is the state's major research institution and has gained international recognition in a number of high technology areas. Northern Arizona University, located in Flagstaff, is a multi-purpose institution with recognized expertise in several areas, including vocational education.

The University of Arizona and Arizona State University complement each other nicely in their aggressive efforts to work with the nation's electronics industry in areas of mutual interest such as education, research and competitiveness. It's a winning combination.



University of Arizona: Industry-Friendly

Industry feels right at home on the beautiful Tucson campus of the University of Arizona (UA). One measure of this is the fact that, over the past decade, the University has ranked sixth among public universities nationally in industrial funding provided for research and development. A leading campus recipient of corporate funding at both the local and national levels has been the highly regarded Department of Electrical and Computer Engineering (ECE).

Over the past two decades in particular, the Department has distinguished itself nationally in the field of microelectronics research, with programs in electronics packaging, microcontamination control, integrated circuit design, and device and process technology.

Other Department research projects in electronics include VLSI design and the generation of efficient test vector sequences, analog circuit design and circuit simulation. Local industry and the Department of Defense are supporting research on the effects of radiation on microelectronics, an important issue for spaceborne electronic system.

The Department also supports research efforts in the area of computer communications and networking. This includes the study of internet gateways, high speed fiber optic backbone networks, and the use of artificial intelligence methodologies in the development of network protocols and simulation models.

Since 1986 the Department has been housed in the spectacular five story, $12 million Electrical and Computer Engineering Building. The building holds more than 100,000 sq. ft. of classroom, office and laboratories, including 4,000 sq. ft. of class 100 clean room facilities. The ECE Department currently has more than 40 full-time faculty, and an enrollment of 1,300 undergraduates and 300 graduate students. About 200 bachelor's degrees, 40 master's degrees, and 10 PhDs are awarded by the ECE Department each year.

Kenneth F. Galloway, Professor and Head of the Department of Electrical and Computer Engineering, says that "our programs range from electromagnetic scattering to communications and information processing, from semiconductor electronics to computer engineering, from circuits to control systems. For nearly 100 years this Department has conducted a dynamic program of teaching and research, earning us an international reputation for excellence."

CEO'S COMMENTS

GARY DRIGGS, President
Western Savings and Loan
"A strong, highly-skilled labor force, convenient transportation and access to the southwestern lifestyle are key reasons why the East Valley region of the Metro-Phoenix area offers excellent opportunities for industrial growth."

WILLIAM STEVENSON
Tucson Del
"Tucson cannot be matched as the location for R&D manufacturing. Examine our location, the top ranked university, low cost electricity, no cost training, it's great recruitability factor."

MR. DAVID J. KINCAID, Executive Director
Yuma Economic Development Corporation
"Yuma offers high tech firms, particularly in the Southern California area, the advantages they are seeking, including excellent transportation and quality labor force."

DAVID P. JANKOFSKY, Director
Arizona Department of Commerce
"High technology and all of its components such as computers and aerospace is finding Arizona to be an area appropriate for expansion, now and into the 21st century."

GLENN HOELZ
NKK Switches
"Arizona, and particularly Northeast Phoenix, provides us with an excellent quality of life, a good labor market, a progressive business climate and a mix of operating costs that is conducive to the growth of our business. It also provides us easy access to major markets in the west."

DANIEL QUEYSSAC
SGS Thomson Microelectronics
"Arizona fits the style and goals of our company. The physical environment — the climate, the affordability and availability of housing — provides the right quality of life for our employees. Taken together, these elements make for a productive atmosphere."

R. DALE LILLARD, President
Lansdale Semiconductor, Inc.
"We operate plants in both Arizona and California. I speak from experience when I say that from every aspect Arizona is outstanding as a location for high technology operations."

IOANNA MORFESSIS
ITM Comment
"Phoenix has what it takes to serve the competitive needs of America's electronics industry, Some of the nation's leading companies have been drawn here by our moderate operating cost environment, an expanding skilled and productive labor force, Arizona State University's engineering excellence initiative and the ability of companies to recruit engineering professionals."

JUDY GIGNAC, General Manager
Bella Vista Ranches, Limited Partnership
"Arizona is a young, vibrant, and growing state with elected officials, at all levels, willing to listen and to assist industry in its search for success."

R. MICHAEL WELBORN, Chairman & CEO
Citibank Arizona
"Arizona enjoys a dynmamic business environment, loaded with professional talent, where a strong entrepreneurial spirit is alive and well. Citibank is proud to be part of it."

"Call Us For Information On ARIZONA!"

JAMES A. NORLING, Executive Vice President, Gen. Mgr.
Semiconductor Products Sector, Motorola

"There are more than 100 electronics companies located in the Phoenix-Tucson "Corridor," and the list grows longer each year. Quality of life in Arizona draws successful electronics facilities to the area as well as highly-qualified engineers and scientists. The diversity of size, product offerings and markets served by these companies have provided a relatively stable employment base that represents the largest and fastest growing segment of Arizona's industrial economy. In a relatively short period of time, the area has emerged as one of America's major electronics centers — an achievement viewed with envy by many industrialized states across the land."

MATTHEW A. DIETHELM, Ph.D.
Intel Corporation

"Arizona is recognized as a leading place for technology companies because of its strong economic infrastructure, its excellent technical education as represented by the state universities' recent programs over the last ten years to focus on engineering and science areas, and its supportive state and local government."

CHARLES B. HICKCOX, President
The Feldman-Hickcox Company

"Arizona wants high technology industries to locate here. To encourage this expansion in our state we have selected excellent sites that are easily zone for specific applications, construction firms that are experienced in building for high tech installations, plus a number of "smart" buildings ready for occupancy."

PETER C. DRESSEN, Vice President
Systems Development Operations, Phoenix Operations

"The continuing ability to recruit and keep high-quality employees has been one of our traditional strengths at Honeywell Bull's Phoenix operations. Setting aside our own company's qualities, I have to give some credit to the attractiveness of Arizona as a place to live, work and raise a family. Arizona's climate, sense of openness, strong economic base, year-round recreational opportunities and strong educational system at all levels make it one of the most desirable places to live and work in the United States."

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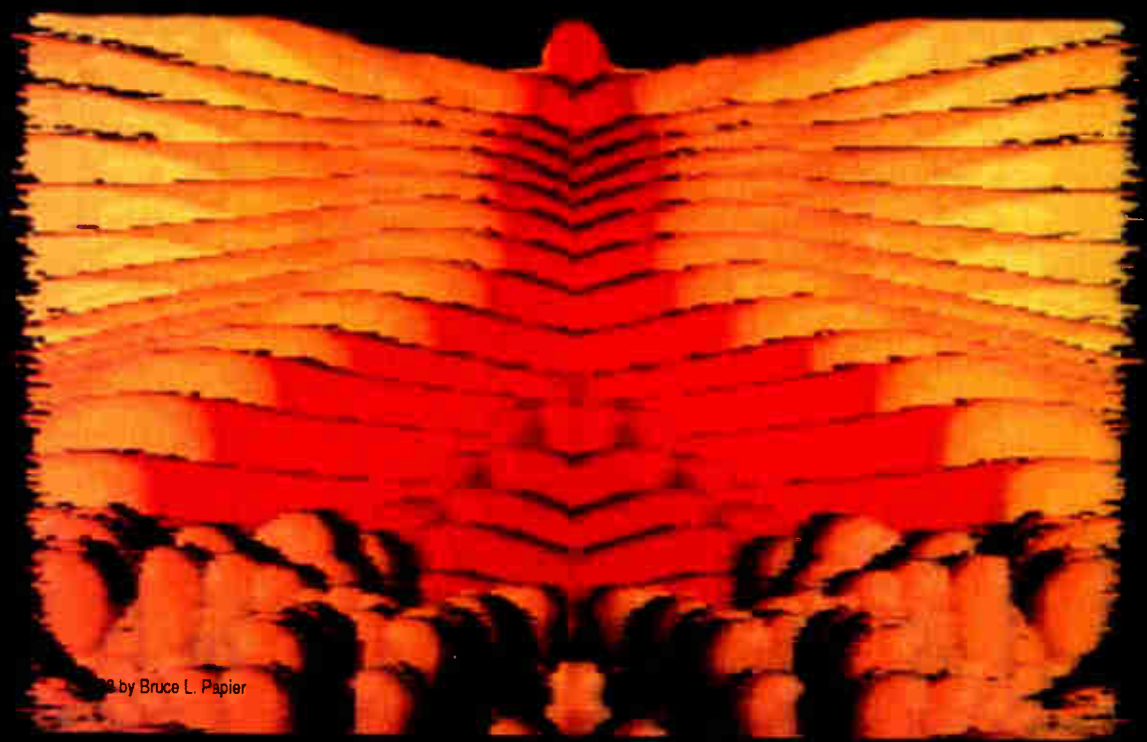

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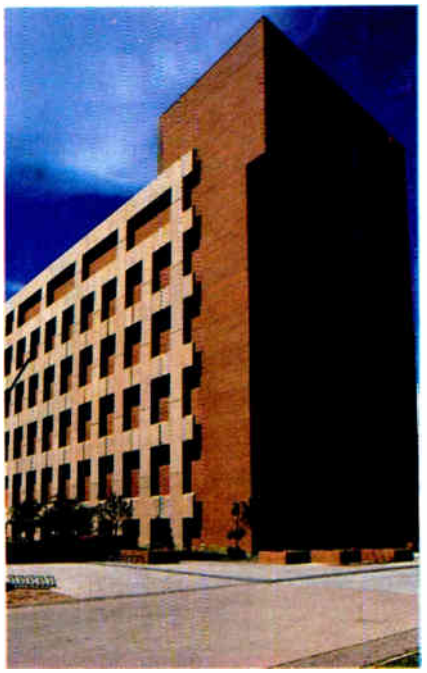


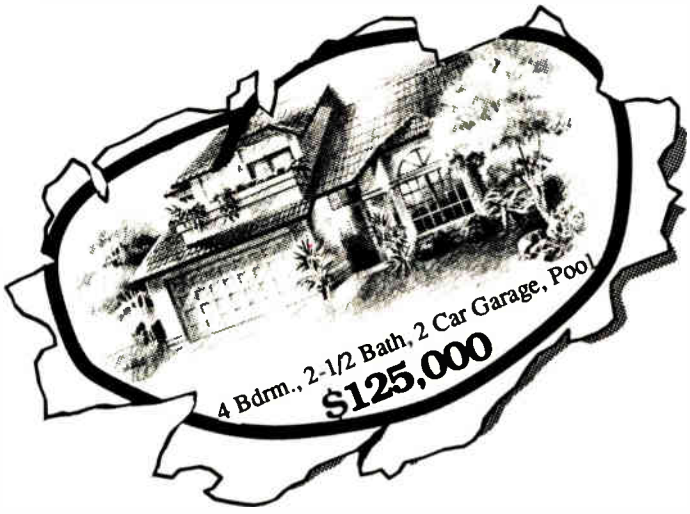
Arizona State University

SEMATECH Sponsors UA Research

This summer the Department was awarded a multi-million dollar contract to assist the SEMATECH consortium in its quest to improve the competitiveness of the American semiconductor industry. The UA SEMATECH Center of Excellence for Contamination/Defect Assessment and Control will address semiconductor manufacturing quality and yield problems.

Research underway include developing methods of measuring and removing impurities in the gases, chemicals and water used in semiconductor manufacturing; a search for improvements in controlling contamination in semiconductor manufacturing vacuum systems; and innovative approaches towards the identification of defects caused by the contamination of integrated circuits. These efforts nicely complement other research programs already underway at the interdisciplinary UA Center for Microcontamination Control.

The College of Engineering and Mines at the University of Arizona offers one of the most extensive engineering education programs in the nation, with a portfolio of 17 undergraduate and 15 graduate degree programs. Among the College's 160 faculty are four members of the National Academy of Engineering.



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Design Engineer for aircraft electrical power distribution and power management systems.

AVIONICS SUBSYSTEM ENGINEERS
Development of avionics subsystem requirements and management of avionics equipment suppliers.

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Test Design Engineers

For more information, please contact Linda Lee at 602-891-7921 or send a resume to her attention at McDonnell Douglas Helicopter Company, 5000 E. McDowell Road, Mesa, AZ 85205-9792. For additional position listings, call our 24-hour Job Hotline, 602-891-3100. Equal Opportunity Employer M/F/H/V.

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The College provides an impressive array of continuing education activities through its Division of Special Professional Education. Courses on topics such as clean room technology, practical microlithography, VLSI-CMOS design, microelectronics packaging, vacuum systems, reliability engineering and management, and knowledge-based systems design, are offered to practicing engineers both on campus or through the Microcampus instructional television network.

Many other UA departments are involved in research related to electronics. For instance, researchers in the departments of chemistry, physics, materials science and engineering, and the Optical Sciences Center have collaborated on a number of projects. These have resulted in the development of new materials and processing techniques for optical electronics; tests of new specialty ceramics, metal alloys and high temperature superconductors; and the development of lower cost technologies for the synthesis of tantalum oxide capacitors.

Arizona State University: Engineering Excellence

Symbolic of the lead role Arizona State University (ASU) has played in Arizona's development as a high technology center was their recent acquisition of the first two supercomputers in the state. Valued at over $11.3 million, the Cray X-MP/14se and IBM 3090-500E/VF systems will be used both by ASU, and, on a timesharing basis, by local industry. Establishing and cultivating such corporate connections is a hallmark of ASU today.

The College of Engineering & Applied Sciences, for example, has created a number of successful industry-oriented programs. Dean George C. Beakley notes that "the Arizona economy is becoming more and more dependent upon engineering-based manufacturing for its progress and growth."

Working with both local and national industry, ASU's College of Engineering & Applied Sciences created a visionary "engineering excellence" program a decade ago. Now entering phase III, this program has been responsible for bringing over $110 million in new funding to the College, $43 million of which was contributed by industry and other private sources.

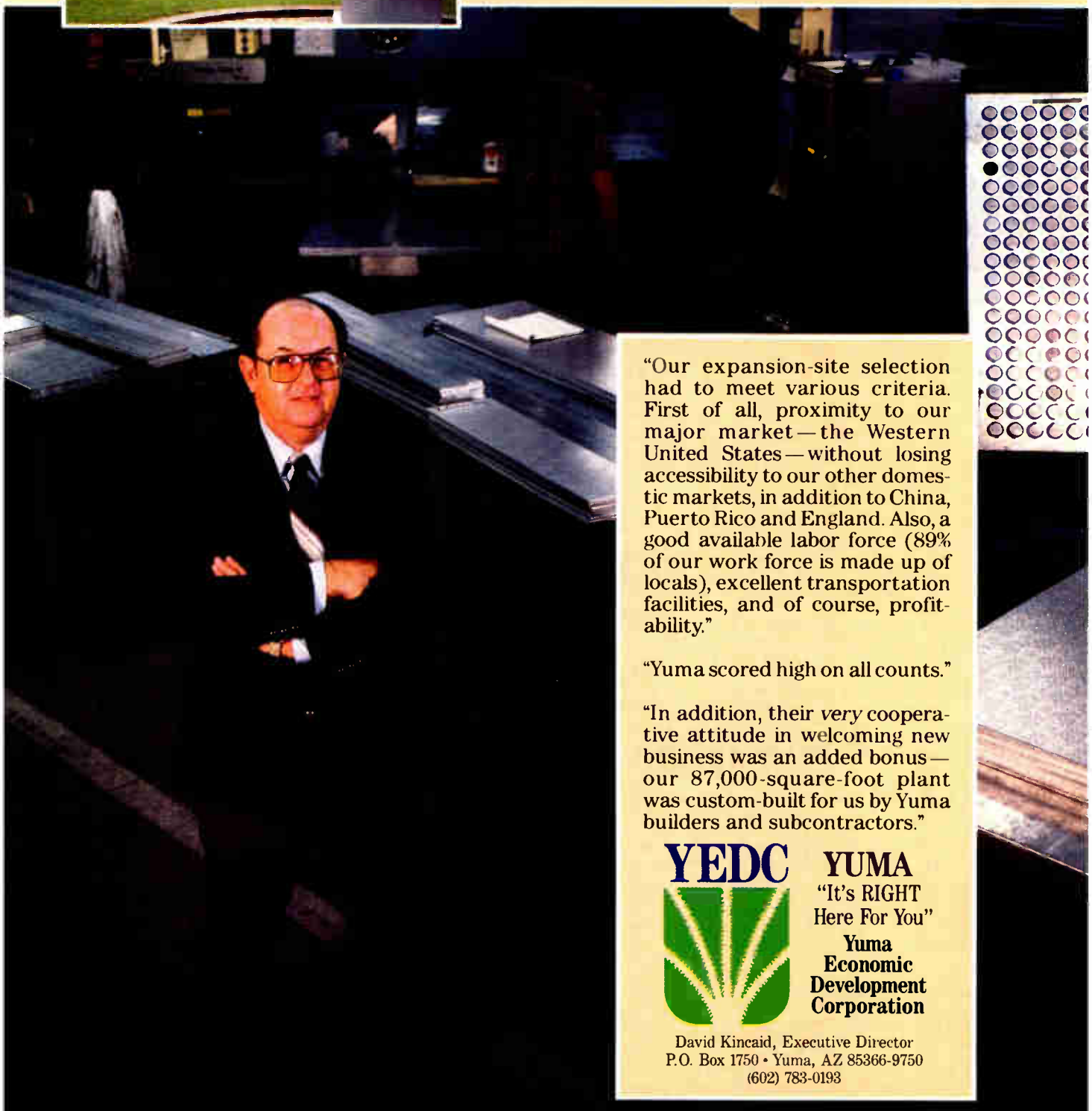
The College offers undergraduate and graduate degrees in all major disciplines of engineering, and computer science, technology and construction. The College currently has a full-time faculty of 222 and an enrollment of about 4,800 undergraduates and 1,700 graduate students. In FY 1988 the College's sponsored research expenditures totaled $11.6 million.

Two impressive engineering facilities built at ASU in recent years have been the Noble Science and Engineering Library, and the five story Engineering Research Center, home of several research centers. Also housed in the Engineering Research Center is the ASU Engineering Computer Center, which operates a $60 million plus collection of state of the art hardware, which includes IBM, Honeywell, Harris, DEC and Tandem mainframe computers, a Convex minisupercomputer, supporting peripherals, and an extensive and current software product library.

The latest addition to the ASU engineering complex will be the $25 million Barry M. Goldwater Center for Science and Engineering, scheduled to open in 1990. The 200,000 sq. ft. building will be devoted primarily to research activities in engineering and the physical and life sciences.

"When we expanded, we looked strongly at 6 cities—then chose Yuma, Arizona."

—Bob Neff
Vice President, Russell Coil Co.



"Our expansion-site selection had to meet various criteria. First of all, proximity to our major market—the Western United States—without losing accessibility to our other domestic markets, in addition to China, Puerto Rico and England. Also, a good available labor force (89% of our work force is made up of locals), excellent transportation facilities, and of course, profitability."

"Yuma scored high on all counts."

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ASU Leads Solid State Research

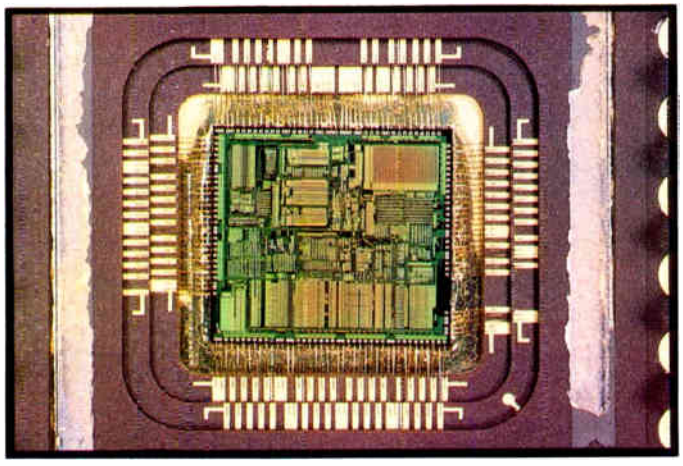
Conducting over $3 million per year of microelectronics research is the College's Center For Solid State Electronics Research (CSSER). This Center offers state-of-the-art capabilities in both fabrication and analysis of devices, materials and surfaces/interfaces. Occupying 36,000 sq. ft. in the Engineering Research Center, CSSER facilities include 4,000 sq. ft. of class 100 clean room, and another 4,000 sq. ft. of clean area. CSSER staff includes 25 faculty associates, among whom are five IEEE Fellows and three Young Presidential Investigator award winners.

"An independent review team ranked this Center among the best in the nation last year," says CSSER director David K. Ferry, a Regent's Professor of Electrical & Computer Engineering at ASU. "One of our strengths here is the interest we have in the research problems facing the microelectronics industry, such as the limits to scaling in VLSI, for example."

Ferry quickly rattles off a list of CSSER achievements, including: the world's first university-based gas phase molecular beam epitaxy (MBE) facility, fabrication of the world's smallest transistors, a VLSI group that has designed chips with as many as 47,000 transistors, and international recognition for research in the areas of expert system controlled Gallium Arsenide crystal growth and the design of synthetic neural systems in VLSI.

Also involved in research related to the semiconductor and electronics industries is the College's Computer-Integrated Manufacturing Systems Research Center (CIMSYRC). Working closely with CSSER, the activities of CIMSYRC focus particularly on the information, quality, and competitiveness aspects of the manufacturing enterprise.

Another industry outreach is the Semiconductor Manufacturing Automation Consortium (SemiMAC) program, which will eventually be located in the ASU Research Park. Supported by the microelectronics industry, SemiMAC was formed with the objective of establishing an advanced modularized "microfactory" research facility to improve



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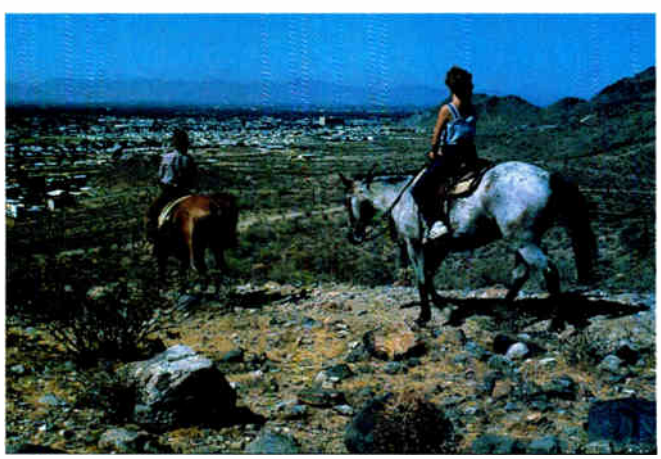
The state is known for its recreation possibilities, from hiking and boating, golf and tennis, horseback riding and fishing, to skiing and hot air balloon flying. With two national parks — Grand Canyon and Petrified Forest — and more national monuments than any other state, you can spend many happy days exploring the natural beauty and fascinating history of Arizona. This isn't just a state with a future; its' past can be found in beautifully preserved ruins of ancient Indian civilizations, ghost towns and lost mines, all waiting to be discovered.

Arizona's weather and superb facilities make it a fine place for just about any sport. Professional teams include the NFL's Phoenix Cardinals, NBA's Phoenix Suns, and major-league baseball's Cactus League spring training season, featuring a number of teams including the Giants, Cubs, A's, Brewers, and Mariners. The state boasts over 150 golf courses, and Phoenix and Tucson are major stops on the PGA and LPGA tours.

WCT and Virginia Slims tournaments bring professional tennis to Arizona several times each year. The Phoenix International Raceway hosts a full schedule of Indy, NASCAR and Sprint car racing. The professional rodeo circuit includes several Arizona stops. Horse and dog racing can be found at several tracks across the state.

A great way to start the new year is attending the Sunkist Fiesta Bowl Football Classic in Tempe featuring the best in championship college football. The University of Arizona and Arizona State University are both members of the prestigious PAC-10 Conference.



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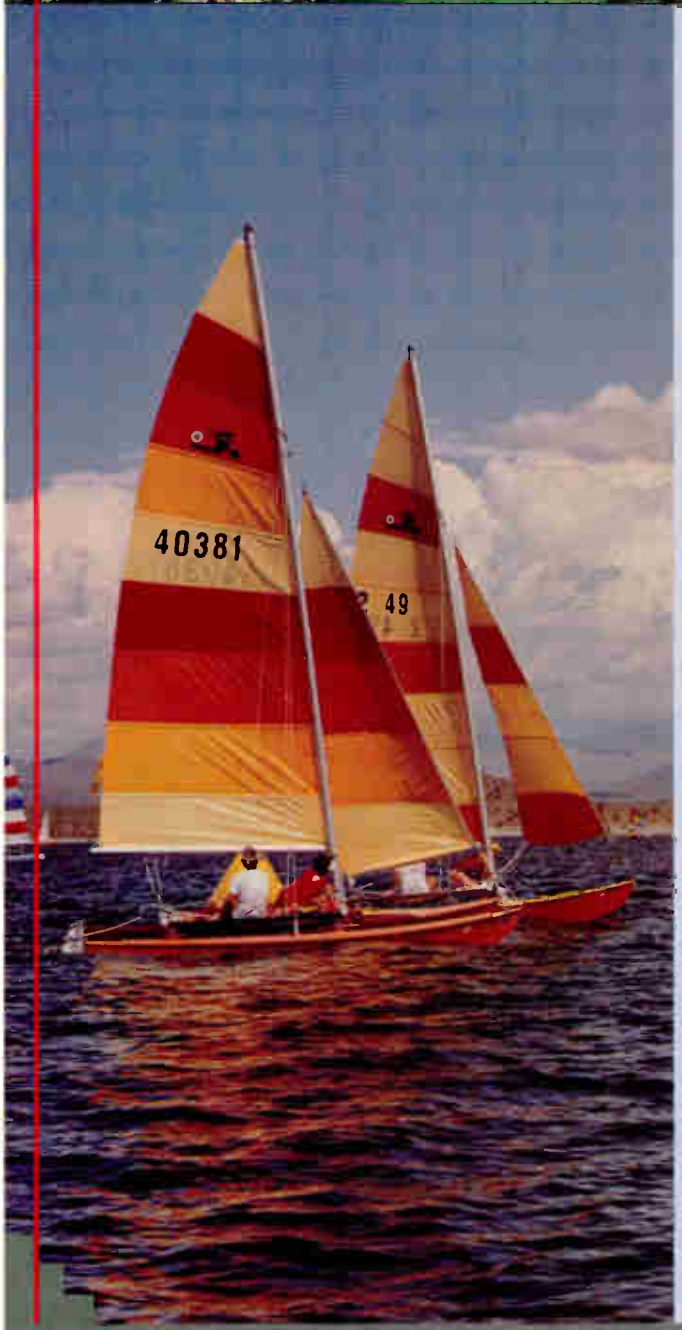

The beautiful climate of the Southwest was a major attraction in bringing early settlers to Arizona. From that early love of sunshine and beautiful sunsets has evolved a major metropolis; continuing to grow and flourish. Honeywell Bull and its ancestors have been a part of this "Valley of the Sun" for over two decades, changing and growing with it.

We are developing new directions and reaffirming our commitment to the market of large systems computers. Our Phoenix facility will be focusing on the development of hardware and software programs. We are seeking professionals in the following areas:

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Arizona: It's A Class Act

Cultural opportunities in Arizona are diverse. In Phoenix alone there are over 20 museums, including the internationally acclaimed Heard Museum, featuring the arts and lifeways of the American Indian. The Phoenix Art Museum has a permanent of more than 18,000 paintings, sculptures, and other works of art, and the Scottsdale Center for the Arts has continuous displays and cultural festivals.

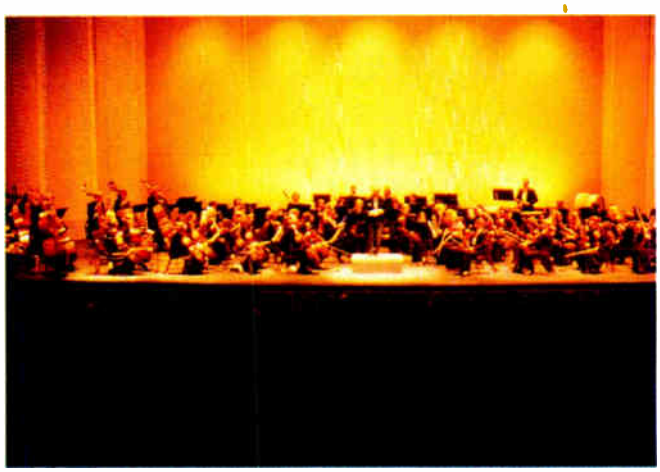
In addition, top rated displays of Western and Indian art and sculpture can be found in many art galleries in Phoenix, Tucson, and many other Arizona cities. Artist colonies in Bisbee, Jerome, Lakeside, Sedona and Tubac, for example, are major tourist attractions.

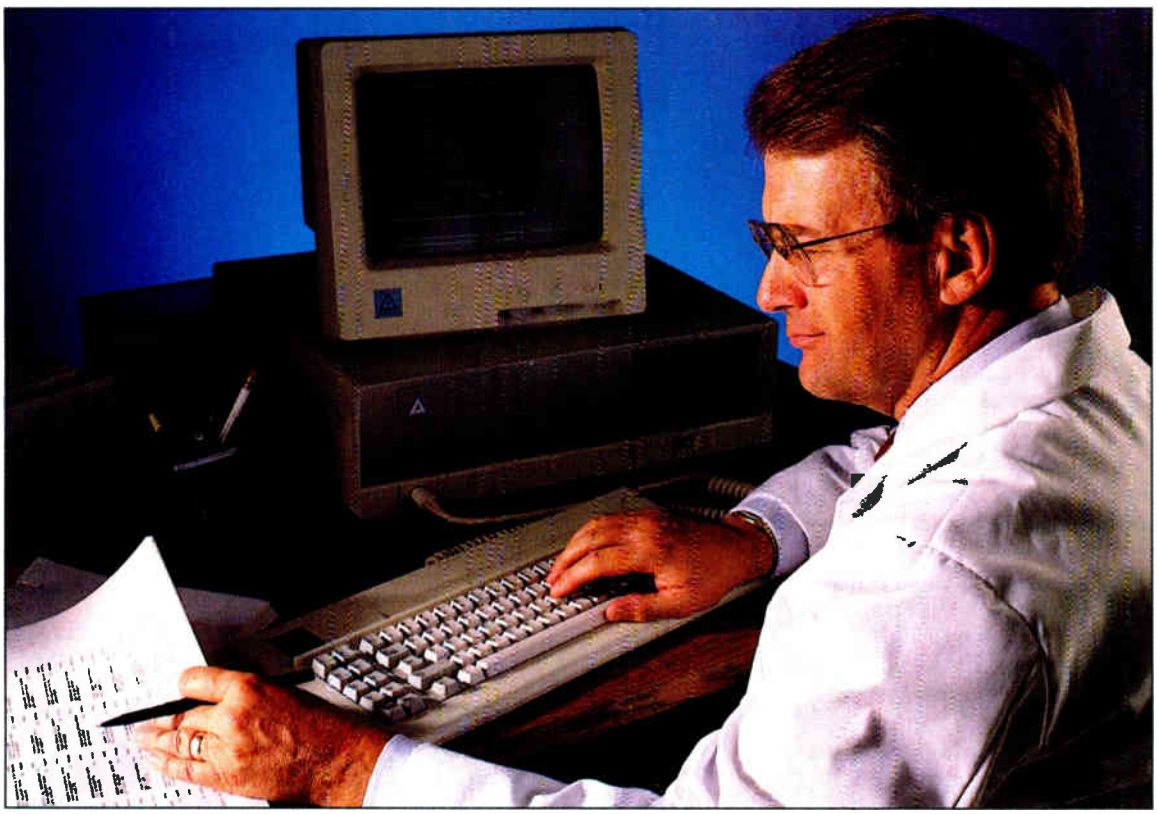
The Arizona-Sonora Desert Museum is Tucson's most popular tourist attraction. Featuring living animals and plants of the Sonoran Desert region, the Desert Museum has been called the "most distinctive zoo in the United States". Other Tucson attractions include the San Xavier del Bac Mission, Saguaro National Monument, and Old Tucson, a frequently used movie set built to resemble the late 1800's.

The Phoenix Symphony presents a full season of concerts featuring internationally renowned guest artists. More than 20 performing arts companies, including the Arizona Opera, Ballet Arizona, Phoenix Little Theatre, the City of Phoenix Theatre, and the Artes Belles bring the world's finest music and stage performances to Arizona audiences.

Phoenix and Tucson are important stops on national tours ranging from the best of Broadway to rock, country-western, jazz and classical acts. Performing arts venues in the Valley Of The Sun area include Phoenix's Symphony Hall, ASU's Gammage Center for the Performing Arts, the new Herberger Theater Center, Celebrity Theatre, and Kerr Cultural Center, the Sundome, and the Scottsdale Center for the Performing Arts.

It's all in place: a golden business climate, a setting ripe for the growth of high technology research and development, a set of superb life-style options, and lots of friendly people. Make your next move to the blue skies of Arizona.





MULTIPLY BY 300,000

Possessing a highly-skilled, dynamic labor force of more than 300,000, the East Valley area of Metropolitan Phoenix offers you an invaluable resource for your business.

And the premier location for you to take advantage of this invaluable resource is **Superstition Springs,** a 1700-acre, master-planned development, in Mesa.

Superstition Springs, less than 30 minutes from Sky Harbor International Airport, offers a 125 acre light industrial/employment area ready for your business expansion or relocation.

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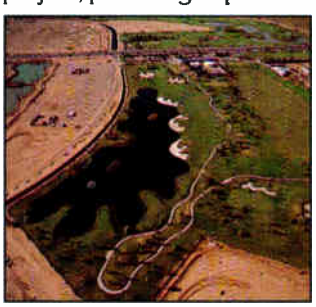
- Educational support from Arizona State University and an **outstanding community college system.** Also, Mesa Public Schools has received more awards for excellence than any other school system in the nation



- Selected site of the **state's second largest regional shopping mall,** scheduled to break ground in early 1989
- Companies such as **McDonnell-Douglas Helicopters, Talley Defense Systems, Inc.** and **Motorola** are nearby, enhancing the high-tech environment
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We'd like the opportunity to discuss how **Superstition Springs** can play an integral role in your business future. Give us a call today.

We've already given you more than 300,000 good reasons. We'd like to give you a few more.

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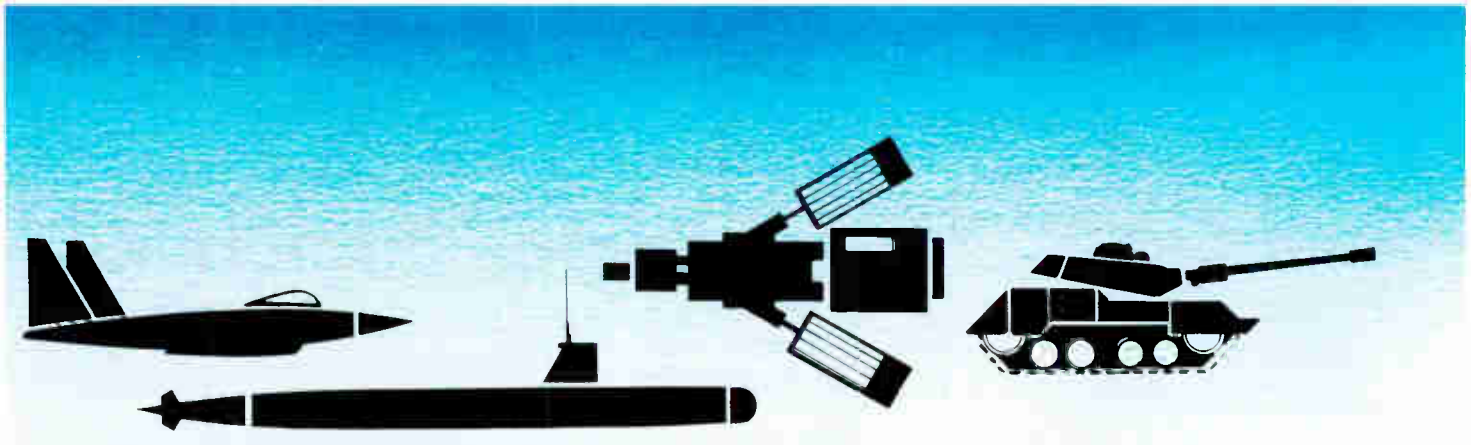

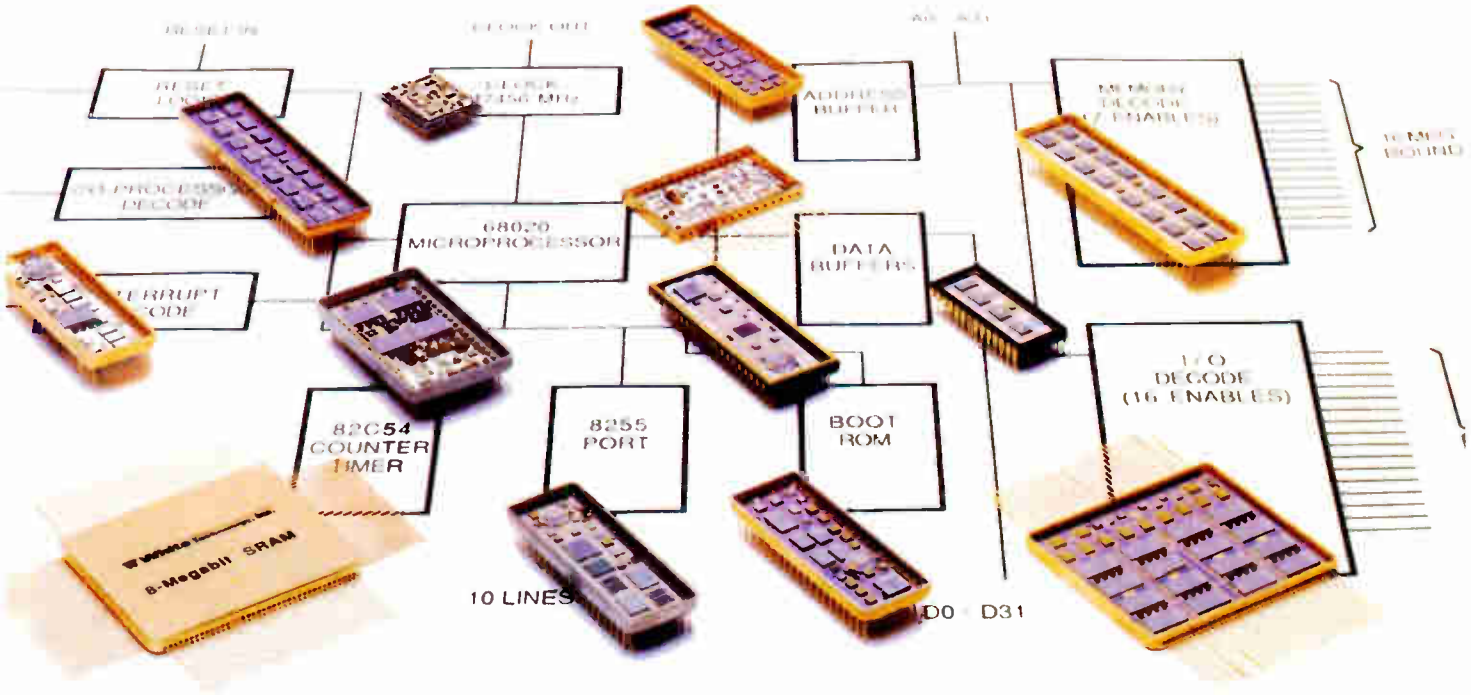

MEMORIES AND SYSTEMS

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There's a whole new family of rugged, high-performance memories and hybrid computer systems available right now, and they're from White. Whatever your application, configuration, or package requirement, it's probably part of this unique family. From relatively simple off-the-shelf memories, to elaborate designs you might have dreamed about and never thought you'd see, every member has something special to offer. Here are just a few we're now producing or have in design.

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A Message From: ARIZONA CHAPTER AMERICAN ELECTRONICS ASSOCIATION

By Dale Lillard
President, Lansdale Semiconductor Inc.

Arizona provides an ideal climate in which to make a business successful. Not only are the metropolitan areas some of the most rapidly growing in the country, they also provide just the right mix of benefits to attract only the best as far as business is concerned. "INC." magazine recently rated Arizona as number one in new jobs and businesses. The magazine noted that Arizona ranked above such states as Florida, California and Virginia in job growth.

Arizona's labor laws are conservative and most communities will bend over backwards to attract quality businesses. The laws within Arizona allow business to function as a reasonable and prudent partner with the community. It is an ideal mix. Also, Arizona is a "Right To Work" state, thus allowing employees the opportunity to either ascribe to or deny union membership.

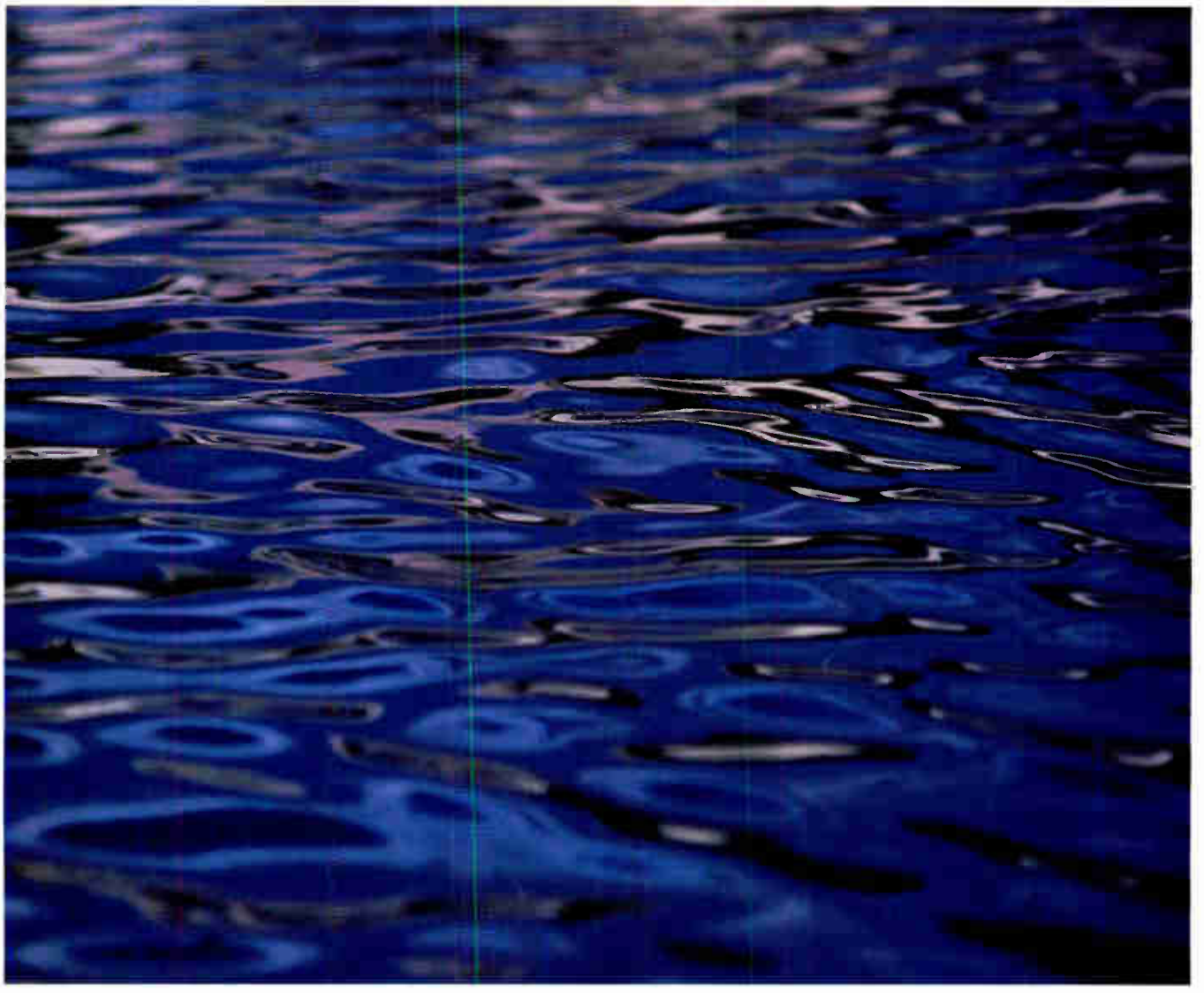
Government regulations offer minimal interference and there is a large business/government trust. This trust has built over the years - leading to the government to believe that Arizona business will not take advantage of the trust that has been placed in them.

Expenses are also significantly lower. Building expenses are some of the lowest in the country. This is due to recent over-expansion within the state. Coupled with the building expenses, the cost-of-living is much lower than many other business centers in the country. This is felt graphically when compared with nearby technical areas like southern California. The maximum state tax rate is eight percent which is a strong drawing card for both businesses and individuals.

Apart from the financial benefits, there is the climate. With a predominately sunshine-oriented culture, the state attracts both businesses and people for many of the same reasons. The good weather provides maximum recreational opportunities, a strong benefit for any company to attract quality personnel.

The Phoenix-area is the home of two major airlines and is a hub for many others. It is a short and inexpensive commute to Los Angeles, San Diego, San Francisco, San Jose, Las Vegas and Albuquerque. In addition, Phoenix's Sky Harbor airport is currently expanding again to accommodate the valley's growth.

Arizona is the ideal area for any business to develop.



THE TRUTH ABOUT ARIZONA

We're not "thirsting for water", as some have claimed. The truth is:

Arizona has enough replenishable surface water to meet its needs well into the next century.

What else is true about Arizona?

- Ranked No. 1 by Inc. Magazine for a growing business climate – an *unprecedented 3rd consecutive year*
- A right to work state, with a young (median age 29.2), highly-skilled labor force
- Strategically located at the hub of the Southwest's transportation arteries with an abundance of inexpensive, available land
- The lifestyle includes everything from golf and tennis to boating and snowskiing

It all makes for a thriving business climate. Complemented by our pro business attitude.

And we wouldn't say it, unless it was true.

For more truths about Arizona, contact: Bill Maxwell

Arizona Department of Commerce
1700 W. Washington
Phoenix, Arizona 85007
(602) 255-5374 or
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Bill Stephenson,
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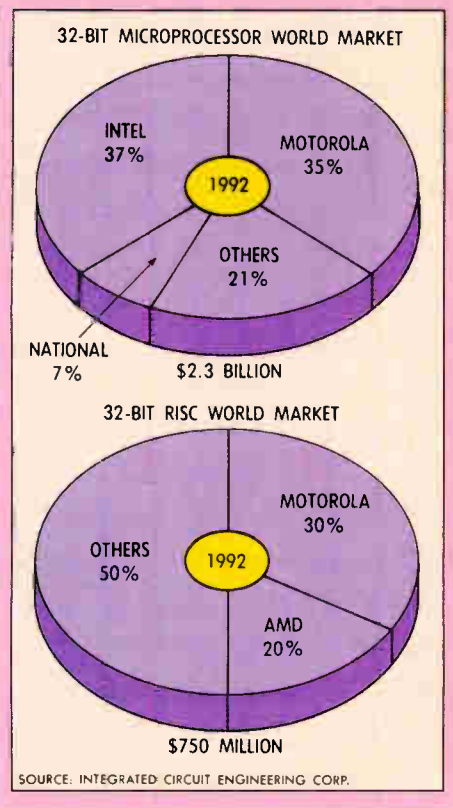
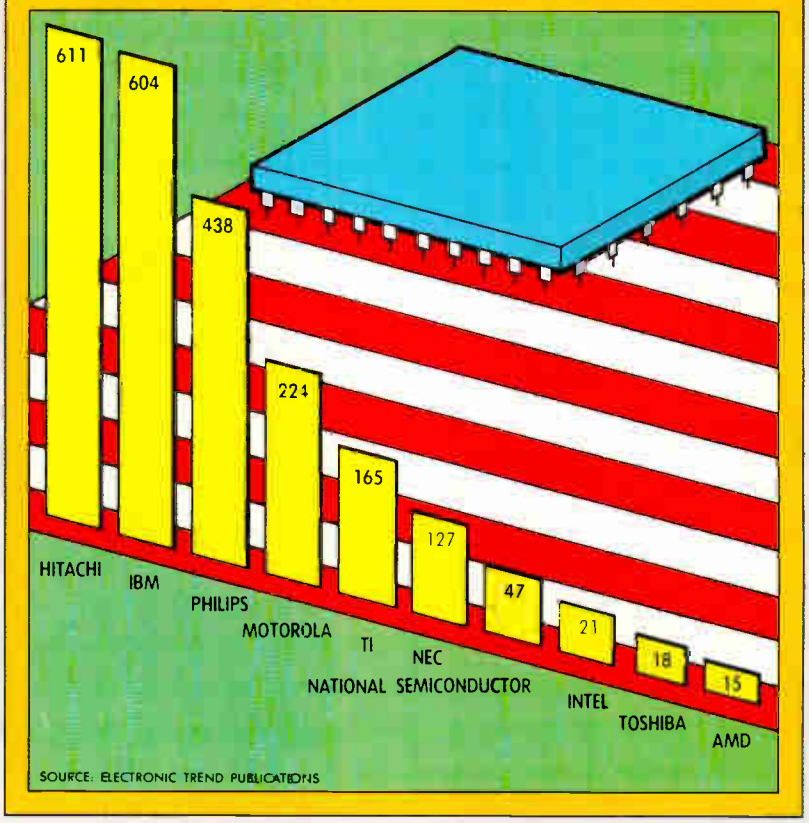
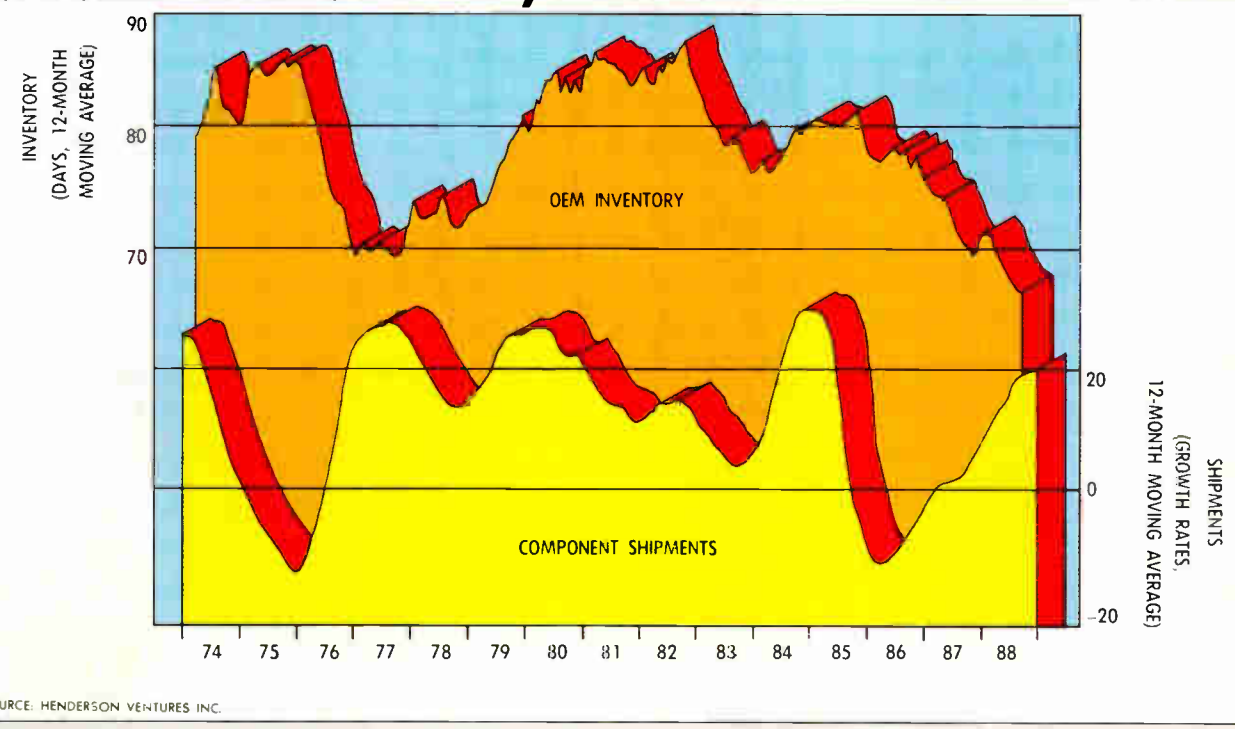
A VIEW OF '92



HITACHI IS NO. 1 IN U.S. CHIP PATENTS



COMPONENT INVENTORIES DROP, SHIPMENTS RISE IN 1988'S SECOND HALF



FORUM

ADVANCED TV: A GAMBLE WORTH TAKING

This may sound crazy, but it's plain fact: it's time for the U. S. to get back into consumer electronics.

Why now, when the U. S. has lost almost all its consumer-electronics manufacturing, distributing, and marketing infrastructure, is the American Electronics Association calling for U. S. re-entry?

Because the nation has no other choice. At stake are not only some 700,000 new jobs that a successful re-entry could bring, but also thousands of jobs in the electronics industry that Americans have today.

The threat—and the opportunity—comes from Advanced Television, or ATV, which offers a wider screen, about twice as many scan lines, and digital-quality sound. If left to foreign importers, technological advances from ATV will ripple out into other markets, probably to our disadvantage. The result could devastate U. S. semiconductor makers because of the high chip content of ATV products. But U. S. chip companies wouldn't be the only ones affected. As foreign competitors applied the techniques gleaned from ATV advances to other areas, almost every key electronics industry segment would be affected.

The AEA's ATV Task Force projections make clear the need for a concerted, industry-wide effort to promote ATV, if only to protect those segments of the electronics industry where the U. S. is an acknowledged leader, such as personal computers. Today the U. S. owns 70% of the world PC market. Assuming at least some technical knowledge from ATV can be applied to PCs, we believe that for the U. S. to maintain its 70% market share for the next 20 years it will need to control 50% of its home ATV market. If the U. S. captures only 10%, the share loss in PCs by the year 2010 could run as high as 50%.

Predictably, the semiconductor industry will feel the effects of the new technology first. ATV units will gobble up memory and rely on large numbers of custom integrated circuits. Current Japanese high-definition TV sets, for example, contain 40 custom ICs—an awful lot of chips when you consider that the potential market for ATV could be 100 million American homes. The AEA estimates that worldwide ATV-memory consumption will surpass that of personal computers by the mid-1990s. Foreign companies will produce and buy their own ICs, leaving U. S. chip makers high and dry.

The impact on U. S. chip makers will be twofold. First, they'll lose market volume, and then they'll lose the leading position in technological know-how. That loss is the big danger. Executives at one major U. S. semiconductor company who recently previewed a family of Japanese-developed HDTV chips say the quantum leap in their technology may already have put them ahead of U. S. know-how.

What does all this tell us? It's increasingly clear that foreign purveyors of ATV technology aren't just trying to get rich by fattening up couch potatoes all over America. Their goal is a technological superiority that will give them command of the lucrative U. S. computer and telecommunications markets.

Other countries seem to have understood long ago what the U. S. has been reluctant to grasp—that the economies of scale of the low-end consumer market can reap rich rewards. The Japanese have proven that consumer electronics markets provide a step up into commercial electronics markets—the opposite of what many companies in the U. S. have thought.

What will it take to get the U. S. back into consumer electronics? Who's going to do it?

Good questions. Members of the AEA's task force range from the biggest computer and communications corporations in the U. S.—IBM and AT&T—to some of the smallest chip makers, such as Anadigics. The group's members have just two things in common—none is eager to begin making TV receivers, but all are convinced that someone has to do it. This ATV challenge could take on the proportions of the disaster that struck the U. S. dynamic random-access memory market five years ago and began forcing production off-shore.

Perhaps if we had wrestled with the DRAM question when it arose—if we had found a way to get memory makers back on track at home—we wouldn't have to worry about ATV today. But that's not the case.

Our task force understands why no single company is going to take on this challenge alone. With foreign governments subsidizing their ATV manufacturers, a lone U. S. effort would be like John Wayne facing a tribe of angry Comanches with his hands tied behind his back.

Because Americans love the notion of the self-sufficient cowboy winning on grit alone, and collective action runs counter to U. S.-industry culture, suggesting that industry might be looking for a government handout doesn't sit well with many. But it is time to give up our reverence for the lone cowboy who sits tall in the saddle and rides into town to gun down the bad guys, as former Deputy Assistant Secretary of Commerce Clyde Prestowitz says. Prestowitz maintains the settlers, who moved together, circled the wagons, and built towns, are the ones who won the West.

Most likely it was the cowboys and the pioneers, each doing their part, that claimed the West. It will take that kind of cooperation to win the battle for ATV superiority. Maybe we'll need a collec-

PAT HILL HUBBARD

Age: 44
V. P., Science and Technology Policy, American Electronics Assn., Santa Clara, Calif.
Career path: Twelve years at AEA, nine of them as vice president. Started AEA's engineering and technical education program.

HUBBARD'S STANCE:

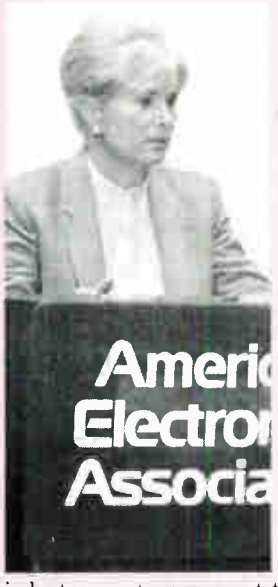
"The U. S. must get back into consumer electronics"

tion of companies joining the U. S. government in a research consortium. Or maybe we'll form a new entity, under a limited partnership, that would actually manufacture products and license technology to pioneering entrepreneurs.

The task force will be seeking answers to these questions in the months ahead. It will approach the new Congress and the White House in January. And maybe together we can convince the world that we have the energy it will take to beat what are seemingly insurmountable odds, and that without a doubt, we can be a player in consumer electronics before the twentieth century is out.

Q *ELECTRONICS*: TVs are being made in the U. S. by companies such as Zenith (see p. 191) and by foreign firms. Why aren't you counting these players?

A HUBBARD: The question is how you define "making." There are 11 million TV tubes being manufactured in the United States, and there are foreign-owned companies that do what they call "manufacturing" in the U. S. In reality . . . they basically bring foreign-made components over here and then assemble them into receivers.



We have some private information that says the foreign companies actually use about 10% U. S. content. Thomson is reputed to use 35% to 39% . . . But it puts us at risk anyway, should the company decide to pull these operations back to their home territory. Also, of course, they take their profits out of the country, and it's these profits that drive R&D and state-of-the-art advances. Creating jobs for Americans is great, but the number of jobs created by foreign companies is not going to replace the number of jobs lost if they take over the industry.

Q *ELECTRONICS*: It strikes one as a little ironic that here we have a bunch of American electronics companies saying, on one hand, 'we need a good strong consumer electronics industry in this country,' and on the other, 'not me, I don't want to do it.' How can companies that aren't in the industry demand that someone get back in without making the commitment themselves?

A HUBBARD: I think that comes out of the basic U. S. corporate culture. There are stockholders who want a return on investment within a very short time frame. An individual company, with pressure from investors for a return on investment today, can't take the long view, [but] companies in countries where there are government subsidies can . . . Our whole corporate structure is set up for today, and not for tomorrow. What's happened is, we're now in tomorrow.

Q *ELECTRONICS*: Doesn't it all come down to the cost involved? How much money are we talking about?

A HUBBARD: I don't think anybody has put the price tag on it yet, but it's definitely in the billions.

Q *ELECTRONICS*: In the tens of billions?

A HUBBARD: I don't think that's far fetched. I just got information that says that MITI [Japan's Ministry of International Trade and Industry] and some Japanese companies are committing ten billion yen—over $76 million—to research and development of active-matrix [liquid-crystal-display] technologies. About 70% is coming from MITI and 30% from companies . . . They've already spent about $600 to $700 million.

Q *ELECTRONICS*: So how much will it cost to set up a U. S. industry—how much is the AEA hoping to pry out of the U. S. treasury?

A HUBBARD: We're trying to come up with those figures now. I think it's at least $1 billion, and likely more than that. I don't think we've set a price tag on what we're looking for from the government. There is no agreement that money from the government is called for. There are things the government can do in addition to providing capital.

Q *ELECTRONICS*: Would that include product subsidies—say $100 for each TV produced and sold in the U. S.?

A HUBBARD: You're asking for specifics about what we are trying to explore with Washington right now. We are asking for a study by the National Academy of Engineering to explore ways that government and industry might cooperate to get back into consumer electronics. We're not looking for a big government handout; it's not the aim here.

Q *ELECTRONICS*: A lot of people will look at what you have to say and decide that it's just Japan bashing. How do you defend yourself against such criticism?

A HUBBARD: It's not Japan bashing at all. Actually, it's the opposite—it is admiration, I suppose. I don't think anybody resents Japan for what it's done. We just have admiration for its efficiency and steadfastness of purpose. □

Electronics

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To aid progress in the electronics industry by promoting good management.

To give the electronics industry managers valuable perspective, insight, and interpretation of industry events and trends, which help make their jobs easier and more productive.

To provide a central source of timely electronics information.

To promote communication among members of the electronics community.

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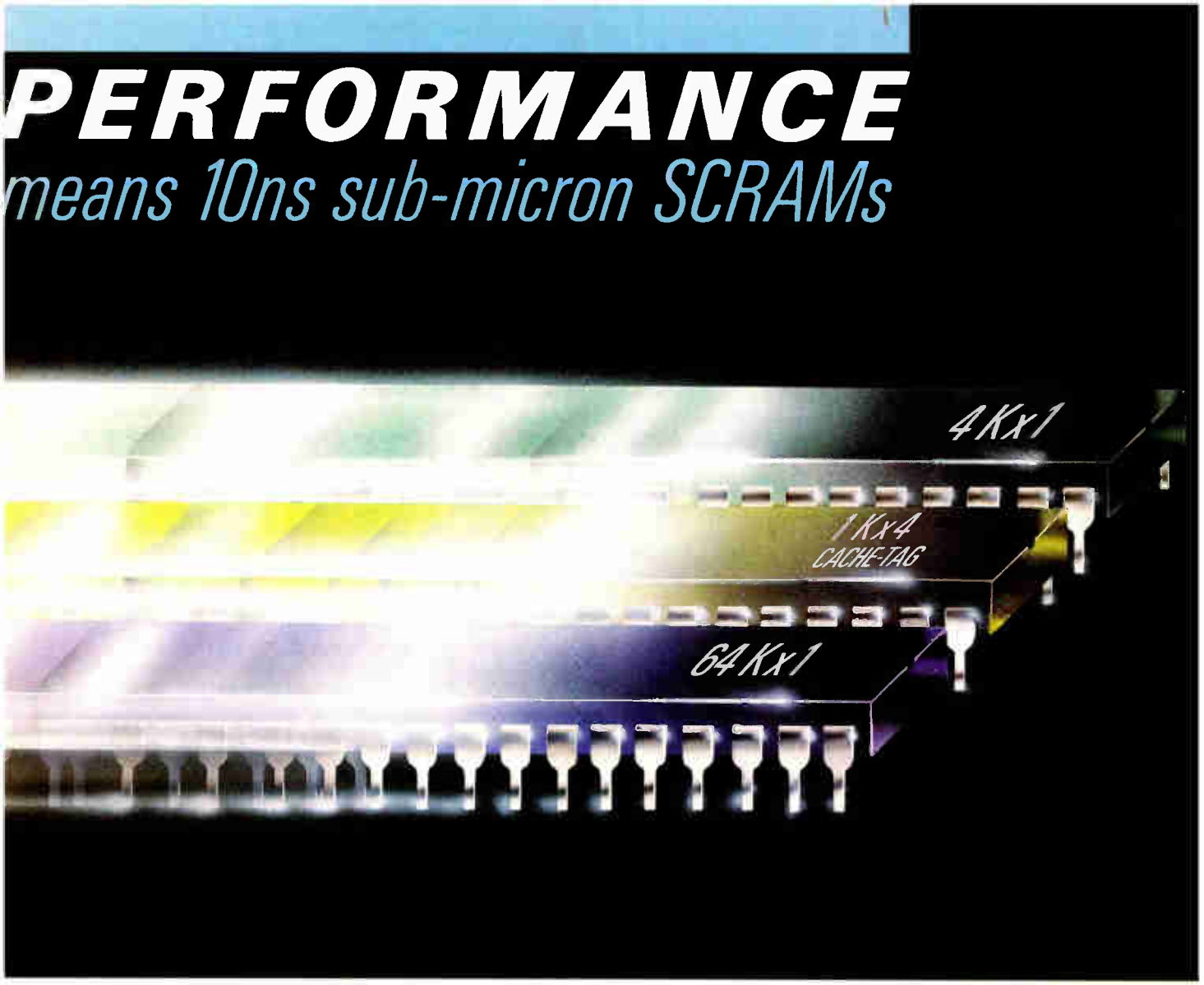

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A NETWORK HELPS ROOKIE OWNERS FIND AID

Roundtable spreads business know-how

You have started a company devoted to getting your world-beating idea for the next great breakthrough in electronic technology to the market. The company has managed to get a handhold; it is now two years old, has 50 employees, and $5 million in sales. It has become obvious to you that to grow you must take the next step: expansion. For this you need advice about financing, counsel on marketing, answers to your questions about sales, and tips about manufacturing. Where do you go?

The ideal route is to hire a consultant or some experienced senior management. But that takes money, and there isn't much cash left after startup costs. Besides, venture capitalists and bankers are not easily attracted to companies whose products are already out there, yet not solidly established. There just doesn't seem to be anyplace to turn for advice and information.

That's where the Technology Executive Roundtable comes in. Founded by Digital Equipment Corp. in Boston in 1984, the group now has chapters in Atlanta, Dallas, Orange County (Calif.), and northern California—and it's likely that there will be more in the near future. Each chapter is cosponsored by a nearby university. The group's charter is to gather together its members—they must be founders, chief executive officers, chief operating officers, or active board members of companies with fewer than 300 employees—so that they may exchange information or listen to outside experts invited to meetings. In short, the group is a means of networking for electronics executives.

The man behind the concept is Robert Weisman, who, with the help of a permanent staff of four, is the Technology Executive Roundtable program manager at DEC. The motives behind the Westboro, Mass., computer maker's investment in the roundtables—a figure officials will describe only as "sizable"—is partly altruistic, partly self-interested. Weisman points to the failure rate of small companies, which he says is "astronomical," and notes that DEC itself, now a $9-billion company, started in an old mill and was once in need of nurturing. "We have to be responsive to small companies," he says; "someday they will be big companies." As for DEC itself, it is in the company's interest to expand the marketplace with companies that could become customers. Still, DEC strives to keep its presence low-key.

Monthly meetings of each of the groups are issue-oriented. "These meetings are very much down to earth," says Weisman. "They're not theoretical at all. They're gut-level solutions." And in addition to the face-to-face opportunities, members receive a wide variety of backup material. There are monthly chapter bulletins that reprint notes from each of the smaller discussion groups that evolve at a meeting, and also a national quarterly newsletter that reports on chapter activities, outlines legislative changes, and spotlights trends.

For the members themselves, the aid they get at their gatherings covers a broad spectrum. Topics range from developing niche markets to profiting from patents. They cover planning the next product, budgeting, getting products from research and development to manufacturing, and how to get initial financing without "giving away the store." However, a study of the subjects covered shows that there are five broad areas of greatest concern.

- Money: how to find it;
- Marketing: how to enter new markets;
- Management: how to manage growth;
- Staffing: how to find, attract, and keep key people;
- Directors: how to select them and use their knowledge.

Money is far and away the subject that draws the most interest. That it tops the list is no surprise. An estimated million new businesses start in the U. S. each year, and depending on which study is doing the figuring, anywhere from 60% to 80% of them fail within five years—mostly because they run out of money before they run out of ideas or let the market get a look at those ideas. So the entrepreneurs typically show up at roundtable meetings hungry for any information they can get on the financial side.

Generally, they are not disappointed. For example, chairman Alan Morse of US Trust Co. in Boston told members of that city's group that loan seekers should concentrate on six points when selecting a bank:

- Make sure you are comfortable with the bank. "The relationship should be a two-way street. You should be interviewing us at the same time as we are interviewing you."
- Put your best foot forward. Before meeting with a banker, send him or her your projections, strategy, product literature, articles, and other background information. Try to get the bank to visit your company.
- Evaluate noncredit services. Does the bank have cash-management, investment options for pension/profit-sharing programs, international services, and credit-information services?
- Understand the banker's conservatism. "One of the reasons that bankers feel conservative is that it's the public's money they're lending out."
- Try to involve more than one bank officer. Then you won't have to reeducate a new loan officer if the one you've been dealing with leaves.
- Look to your banker for business ad-

by Howard Wolff

vice. "The most valuable information any manager gets in any business is information about solving problems."

Experts also share insight ranging from the encouraging (Morse of US Trust: "Banks really do want to make loans. That's how we make most of our money") to the fanciful (Roger Smith of the Silicon Valley Bank: "What do bankers want to know? Is there any way to get our money back if you don't win the lottery?") to the cautionary (Rob Reis, a member of the advisory board in Santa Clara and a veteran of the venture-capital chase: "When you bring in the venture-capital community, you bring in a firing squad; you can't afford to make mistakes").

Well, is it a good idea to dodge those bullets and raise the cash by going public? The rules of that game have been somewhat altered by the October 1987 stock-market collapse. Members of the Boston roundtable were advised by Dennis O'Connor, an attorney with the Waltham, Mass., firm of O'Connor, Broude & Snyder that "the climate has definitely changed," but "it would be inaccurate to describe the situation as an open or closed window."

The prospects depend on what part of the country you are in, O'Connor advises. For startups looking to raise in the range of $3 million to $7.5 million, he says, "travel west to Denver, and you find the window is open all the way." In New York, on the other hand, the outlook is pinched, he says.

Networking of the sort offered by the Technology Executive Roundtable has been particularly successful in helping rookie company owners and managers avoid considerable pain and suffering. Now, to help spread the balm, the group is seeking to expand by adding new chapters. Though people connected with the group won't say where they are looking, a spokesperson says that even New York City Mayor Ed Koch has telephoned to urge them to establish one in his city.

One requirement that makes it a bit more difficult to establish new chapters is the university cosponsor arrangement. The way the system works, funds from the Technology Executiuve Roundtable's secretariat at DEC earmarked to keep each chapter going are channeled through the cosponsor. These universities then use the money to set up and maintain each operation. The universities also take an active role in actual monthly meetings, providing consultants, experts, and even graduate students who act as note-takers.

The organization has completed the list of cosponsors for each of its chapters. They are the Advanced Technology Development Center of Georgia Technical Institute in Atlanta; Babson College's Center for Entrepreneurial Studies in Boston; Southern Methodist University's Edwin L. Cox School of Business in Dallas; the Graduate School of Management of the University of California at Irvine in Orange County; and San Jose State's business school in northern California.

HOW VALLEY ENTREPRENEURS TEACH THEMSELVES

Depend on the Silicon Valley, where a company seems to start up every 20 minutes or so, to have not one, but two networking organizations for entrepreneurs. Not only is the Technology Executive Roundtable thriving in that valley's fertile soil, but a roughly parallel organization called the Silicon Valley Entrepreneurs Club Inc. is doing well at its headquarters in Santa Clara, Calif.

A little more than a year old, the Entrepreneurs Club already has a charter to assist the efforts of the 246 fledgling companies and individuals making up its membership. As members they have the opportunity to get together once a month to exchange ideas, find the key talent they need to complete a startup team, speak to capital providers and venture capitalists, and track down the best sources for legal, tax, and market advice. Whether a member's venture is still in the formulation stage or already a going concern, the information exchanged at the meetings is tailored to provide valuable insights into the workings of marketing and venture capital.

For example, at a recent meeting Chuck McMinn, a general partner in the Menlo Park, Calif., investment firm of InterWest Partners, laid out the do's and don'ts of seeking venture capital. McMinn advised would-be company owners to determine what role in a startup they are best qualified for. Also, McMinn suggested keeping the initial plan short—about 20 pages maximum—with about half of it on the market, sales expectations, and competition. Be honest about the market as well—a statement such as "a $500 million market with no direct competition" is a red flag.

At another session, Rahul Sud, who was the founder and first chief executive officer of Portland, Ore.-based Lattice Semiconductor Corp. and is now vice president of marketing for Microchip Inc. in Chandler, Ariz., described his hunt for capital without using venture capitalists and some of the pitfalls that can be encountered. He said the search took several years and used every channel and personal contact he had. At yet another meeting, club president Bob Hansens told his listeners that effectively launching a high-tech company takes three things: expert advisers to evaluate the idea, careful testing of potential team members, and care in building the startup team. Once the concept and team are put together, said Hansens, the startup is ready to look for funding by creating the business plan. As an example he used Tabit Inc. of Santa Clara, which specializes in tape-automated bonding for high-density circuit packaging.

Just how valuable is meeting with other executives to hear such advice? "It has allowed us to make contact with key financial and technical advisers, letting us add to the impact of the company in the marketplace," says Rudi Wiedemann, president of LaserSense Inc. of Santa Clara, which has developed laser-based inspection equipment that accelerates optical microscope inspections of flat surfaces.

To sharpen the focus of the information interchange, at each monthly meeting small focus groups called expert tables are set up to permit specific topics to be dealt with. To make it easier for members to locate top executives, companies looking for a key player such as a chief financial officer, legal adviser, or engineering manager can outline their requirements during a relaxed self-introduction session that usually kicks off the meeting.

In addition to monthly meetings, which are typically held on a Saturday and draw about half the club's members, the organization's resource center and meeting room are available to members for advice and private talks. The resource center includes various office support services and a library of management and financial data of interest to startups. An educational program for entrepreneurs including time in the classroom and in the workshop is in development.

Several levels of membership are available depending on company size—individuals or service firms with fewer than 10 employees can join for $300 per year. Corporate and institutional memberships cost up to $1,000, allow up to three company members to attend the monthly meetings, and permit the company to have some voice in the planning and advisory activities. Even entrepreneurs from outside the area can join the club at a special rate. Since the club is a nonprofit organization, donations in the form of money or equipment which will help keep the support services humming are also welcomed.

–Dave Bursky

PC I/O BREAKTHROUGHS

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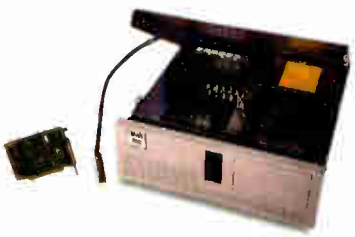

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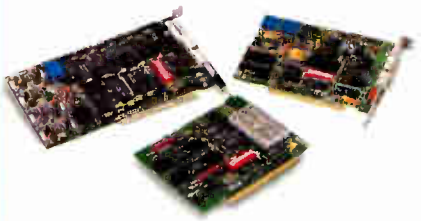

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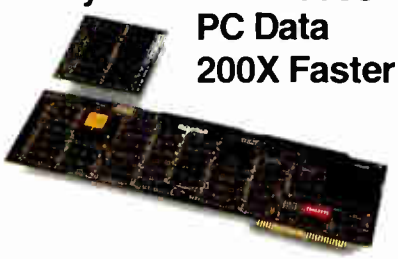

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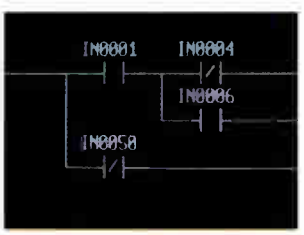

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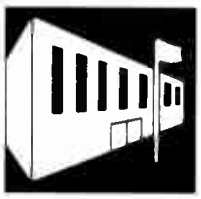
COMPANIES TO WATCH

A TRANSATLANTIC DEAL THAT'S WORKING FOR BOTH SIDES

The alliance between Philips' Test and Measurement Division and Fluke has both in the money

EVERETT, WASH.



Last October, John Fluke Manufacturing Co. struck an alliance with the Test and Measurement Division of Philips, the giant Dutch electronics company. The two companies agreed to pool their sales forces, sell each other's test and measurement products, and share technology for future products. Industry wits immediately dubbed the result "Flu-Lips" and settled back, with some skepticism, to see what the combination would be able to accomplish.

In theory, each company wanted the same thing, the only difference being that Fluke wanted to accomplish in Europe what Philips wanted to do in the U.S. "In the alliance, there were two goals for both companies," says Ronald R. Wambolt, senior vice president and director of worldwide sales at Fluke. "The goal for Philips was to improve its market share in the U.S. For Fluke, it was to improve the efficiency of our sales force by giving them a wider variety of products to sell. In Europe, the objective was to improve Fluke's market share, and Philips wanted to improve its sales efficiency."

So far, the results look good, but it's hard to tell whether that is because the companies joined forces or simply because the market for test and measurement gear is booming. However, the fact that the allies have the same goals doesn't mean each is seeing the same results. Analysts at two investment firms located near Fluke headquarters in Everett, Wash.—Cable, Howse & Ragen in Seattle and Gallagher Capital Corp. in Portland, Ore.—think Philips is the winner, at least up to now. The analysts' reasoning is based on the terms of the deal.

Each company, in effect, has become a distributor for the other's products. Philips buys Fluke products at the distributor's discount for sale in Europe; Fluke does the same with Philips products in the U.S. Fluke has its own salespeople in Europe and Philips its own in the U.S. So each in a sense is competing against itself—selling products to its ally at a discount, on the one hand, and to other retail customers for full price, on the other. However, both companies assume that they will gain in the long run by racking up much higher sales volume, since each now has more salespeople hawking the products.

Fluke president and CEO Winn looks for long-term benefits such as technology transfers from his alliance with Philips.

"As the European distributor, Philips has benefited from the improved discount for selling Fluke products in Europe, so its profits are up," says Peter Musser, senior vice president at Cable, Howse & Ragen. "Growth of the test and measurement business is highest in Europe." Musser points out that Fluke has prospered as a result of the market growth, too, just not as much as it would have by selling the products in Europe directly.

In any case, the prosperity is showing up on Fluke's bottom line. Gross sales reached a high of about $225 million in the fiscal year ending in September 1988, according to market analysts at Value Line Inc. in New York, and should go even higher in fiscal 1989, to about $260 million.

The improvement is even more dramatic compared with the company's record in fiscal 1986 and 1987. Gross sales declined in 1986 to $209 million from 1985's $216 million, and they dropped again in 1987, to $206.3 million. However, Musser says, the reasons have more to do with the business Fluke is in than anything else. Test and measurement is a cyclical market; 1986 and 1987 were bad years, 1988 is a good year, and 1989 is expected to be a better year.

NO RETURN. Those figures measure overall Fluke sales. However, they do not indicate how well Fluke is selling Philips products in the U.S. In that respect, Fluke has not yet gained much from the alliance, says Marc Robins, vice president of research at Gallagher Capital. But this is an assertion that Fluke's Wambolt takes issue with. "The alliance has shown immediate dividends in the U.S. And our business has been able to grow substantially."

Philips tends to agree that Fluke's sales of its products—a subject that the company is naturally interested in—is on track. The increase in sales has been significant, says William R. Hoffman, vice president and group manager of the Philips T&M Group. But the increase hasn't had that much effect on the market overall because "our percentage of

the total is negligible," he says.

The real benefits from the alliance will be long-term, the companies feel, such as the broader product line both companies can now offer. "There was only a small amount of overlap between Philips and Fluke product lines," says Wambolt. "In the new catalog of both companies' products, we have as broad an offering as Hewlett-Packard Co. Short of the microwave product line, we have everything else that HP has."

And over the long term, says George Winn, president and chief executive officer of Fluke, both companies will eventually share more than a sales force and complementary products. "Philips has thousands of research engineers, and we intend to take advantage of technology transfer between the two companies as a result of the alliance," Winn says. "We had some technology that Philips wanted as well, and we have been making the exchange."

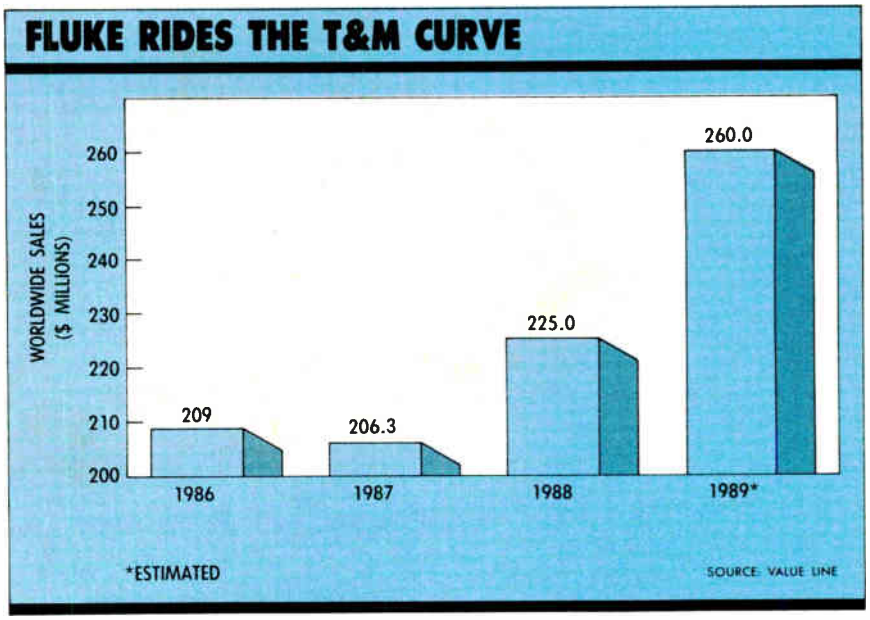
TWO TEAMS. In addition, the two companies have funded a study for a joint venture to develop at least one new product. The project will be staffed at both the Fluke plant in Everett and at Philips headquarters in Eindhoven, the Netherlands. "We had some sessions together early on, two management teams talking about areas of mutual interest," says Hoffman of Philips. "We narrowed down to two or three classes of instrument that we wanted to fund." Actually, the number was four: field service, manufacturing, research and development, and calibration.

What the alliance will not do is merge Fluke with Philips, as some accounts have implied. Philips purchased 7.5% of Fluke's stock, but the agreement contained a provision that it could purchase no more. Philips also acquired representation on the Fluke board of directors. In addition, Fluke has representation on a departmental planning policy board inside Philips.

However, the companies continue to operate and develop products independently of one another. For example, Fluke acquired a 25% interest in two firms—HiLevel Technology Inc. of Irvine, Calif., and Innovage Microsystems Inc. in Calgary, Alberta, Canada—to acquire new technology.

For its part, Fluke has rolled out a barrage of new products aimed at keeping it competitive in an increasingly tougher market. In September, the company unveiled the 5700A Multi-Function Calibrator, the first new product to be added to its calibration line in nearly 10 years. "The hiatus between future products will be much shorter than in the past," promises Richard Pirret, product marketing manager for the calibration and communications group.

In October, the company introduced a new family of 3.75-digit, hand-held RMS multimeters, the 80 series, made up of the low-end 83, midrange 85, and high-end 87. This month, the company is introducing a new interface pod for its 9100A digital tester, which allows the tester to handle the 32-bit 80386 and 68020 microprocessors by using a proprietary high-speed random-access-memory test algorithm. In addition, it is bringing out the 900 Dynamic Troubleshooter. This new digital circuit-board tester that isolates faults to the component level without programming and without a detailed knowledge of the board under test. *–Jonah McLeod*



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AT NOVELLUS, THEY SHATTERED A STEREOTYPE

SAN JOSE, CALIF.

Manufacturers of semiconductor equipment have been out of favor with investors for some time because those companies are especially sensitive to the chip industry's feast-or-famine business cycles and tend to go into the red during a downturn in the economy. In addition, the financial community does not think that the equipment makers have been particularly adept at running their businesses. The result is that start-ups in the industry have had difficulty raising money.

But then along comes Novellus Systems Inc. to spoil the scenario by demonstrating that a semiconductor equipment company can be made very profitable while shipping at low volume, and can even survive downturns in the market. So the investors have responded: the San Jose, Calif.-based company has completed the first successful initial public offering in the industry since Lam Research Corp. of Fremont, Calif., went public in 1984—the year Novellus was founded.

And Novellus isn't doing too badly with the customers for its chemical-vapor-deposition systems, either. One measure of Novellus' reputation is a survey done by VLSI Research Inc., a San Jose research firm that follows the chip and chip-processing-equipment industries. Novellus won high marks from its customer base, says J. Dan Hutchinson, president of VLSI Research.

In its survey, respondents were asked to score companies using a scale from 1 to 10 on several factors. Compared with archrival Applied Material Co., a well-established company that is considered to be a leader in the CVD arena, newcomer Novellus did remarkably well. It scored 8.0 on overall company image compared with 8.2 for Applied Materials. In product performance, both scored 7.0. For technology leadership, customers gave Novellus an 8.5 and Applied a 7.3. And the customers rated Novellus 6.5 and Applied Materials 7.8 for support in programming the machine for a given process.

THE FORMULA. Novellus' secret of success is no secret at all: take an innovative product that meets a need, raise startup cash, assemble a good management team, and you're on your way. The CVD system developed by company founder Brad Matson competes with those from Advanced Semiconductor Materials, Applied Materials, and Watkins Johnson. Novellus says its system, which uses a continuous-processing technique in which wafers are sequentially moved under different deposition heads within a single processing chamber, achieves better film uniformity across the wafer—±1%. By contrast, other equipment can achieve anywhere from ±2% to 15% uniformity.

The total market for CVD equipment in 1987 was $275 million, according to VLSI Research. In 1988, the market will grow to $412 million and by 1992 to $707 million. Novellus competes in a segment making up about two-thirds of that.

Here's a maker of chip equipment that proved it could attract venture capital

VLSI Research apportions the CVD market into low-pressure, atmospheric-pressure, and plasma-enhanced equipment. Low-pressure CVD operates in the temperature range between 600° C and 1,100° C. In operation, low-pressure CVD equipment uses a diffusion furnace in which a layer is deposited onto the wafer under vacuum. In 1987, sales of this equipment was $124 million, in 1988, $214 million, and in 1992 it will be $325 million, says the market-research outfit.

In atmospheric CVD equipment, a layer is deposited as each wafer moves through. It operates at lower temperatures as well. In 1987, the market for this class of equipment was worth $37 million; it will grow to $38 million this year and up to $60 million in 1992, according to VLSI Research.

The Novellus product falls into the plasma-enhanced class, which operates at 400° C and below. That segment was worth a total of $113 million in 1987, $160 million this year, and should reach $322 million in 1992, says VLSI Research.

The Novellus equipment does compete in the other markets. "We can replace all of the atmospheric CVD and about 10% to 15% of the low-pressure CVD, which can be operated at lower temperatures," says president Robert Graham. In 1987, Novellus viewed its market as worth $170 million. In 1988, company executives believe, the market will grow to $230 million. In 1992, they expect it to reach $431 million.

On the management side, it was the first Matson system that attracted the talent. Matson was able to build two demonstration models by the middle of 1986

relatively inexpensively: just $1.2 million in financing. "Not only did he come up with an innovative system design, he also managed the development program on the slimmest of possible budgets," says Graham.

Graham is the kind of executive that a startup needs. He was an early arrival at Fairchild Semiconductor and one of the founders of Intel Corp., and he did a stint at Applied Materials—where, according to industry-watcher Hutchinson, he was a member of the team responsible for turning the company around.

"It was while I was at Applied that I first encountered Novellus," Graham recalls. "I tried unsuccessfully to have Applied acquire the company," then joined it as president and chief executive officer.

Graham was not the only Applied employee Novellus impressed. Evert van de Ven, now Novellus' vice president of technology, was another. Graham says that customers and others in the industry recognize van de Ven as the foremost technical person in the CVD field worldwide. He was with Philips for 12 years, after which he joined Applied to head up the company's CVD effort. "Evert was given the task of evaluating the Novellus system when Applied considered buying the startup," says Graham.

One of the first tasks for Graham was to get the young company funded. Half of the $1.2 million seed money came from Monsanto Co. and the other half from the venture group Gateway Mid-America, both of which are located in St. Louis, Mo. But these investors wanted a new group of investors to come forward to help with the second round.

Graham raised $6 million through TA Associates in Boston, El Dorado Ventures in Cupertino, Calif., and Sigma Partners, in San Jose, Calif., with a small amount coming from the original investors. The infusion of cash allowed the company to get into production and was sufficient to make it profitable with a positive cash flow.

Novellus shipped seven units total in 1987. It was profitable in December 1987, remained profitable through the first and second quarters of 1988, and should continue its profitability into the third quarter. Meanwhile, Matson, who is still a part owner, has left the company.

BIG YEAR. According to an analysis by New York City investment firm Shearson Lehman Hutton, the company had net sales of $3.26 million in 1987 and showed $0.26 million in gross profit (see figure, p. 185). This year, the investment house predicts, Novellus will have net sales of $21.37 million, and its gross profit will come to nearly half that. By 1989, sales will reach $50 million; gross profit again will total about half that sum.

Analyst Stephen J. Balog at Hutton says that Novellus has the best chance of any of the semiconductor equipment companies to negotiate the new semiconductor capital-spending downturn without a revenue and earnings decline. Balog makes this statement while predicting a flattening in demand in the first half of calendar-year 1989, followed by a gradual falloff in the second half of the year.

Balog says that the company has spread its manufacturing capacity over a broad base of customers to ensure that it will not be adversely affected by the cancellation of a single order—that in a business where equipment is expensive and each order represents a considerable expenditure. In addition, Novellus is in a part of the semiconductor equipment business where buyers will continue purchasing capital equipment as their semiconductor demand increases because they can receive an immediate return on investment in the form of higher yield, lower cost, and better-quality parts, Graham explains. *–Jonah McLeod*

VICOR'S IDEA: INTEGRATED POWER COMPONENTS

ANDOVER, MASS.

The power-supply business historically hasn't been regarded as one that rocks along on the leading edge of technology, as computers do. But now there's a development in power-system components that is beginning to have an impact similar to that triggered in computers by the advent of the integrated circuit. It's built around a zero-current-switching concept developed and patented by Vicor Corp., and it enables system builders to greatly shrink the size of—and more broadly distribute—power-system components.

Evidence is building that the Andover, Mass., firm is convincing customers its approach works. Since shipping the first VI-100 dc-dc converter in August 1984, Vicor revenues have almost doubled virtually every year. Patrizio Vinciarelli, the founder, chairman, and president, expects the firm to top $40 million next year. The company has been profitable since last year.

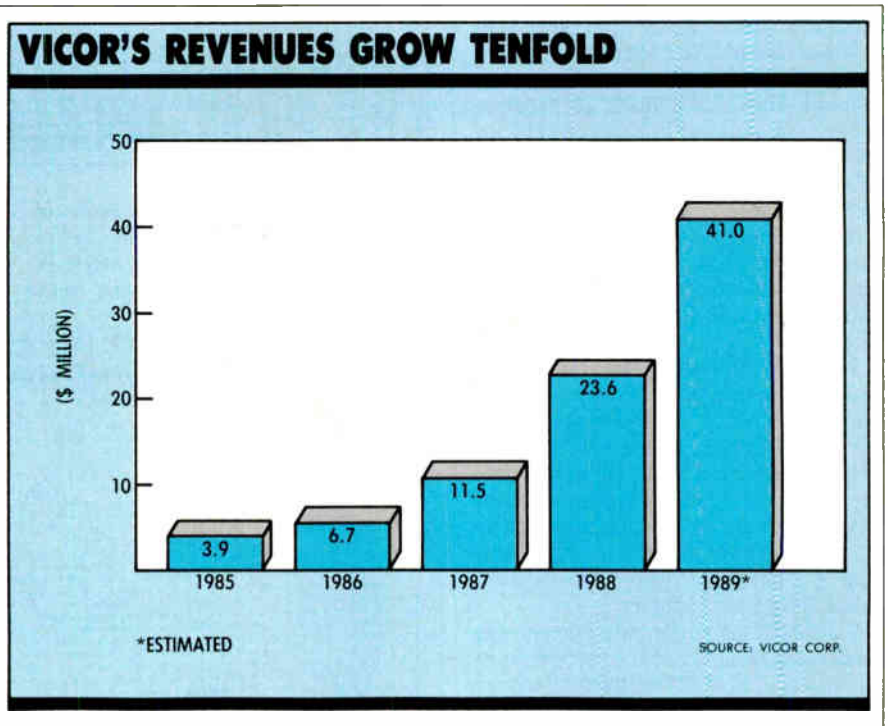
Vicor introduced its second-generation VI-200 dc-dc converter family in 1986. Output power for models in the family range from 50 to 200 W and output voltages from 5 V to 48 V. A VI-300 family, which Vinciarelli says will double the VI-200 performance at half the price, is planned for around the middle of 1989.

Vicor's zero-current-switching dc-to-dc converters enable the design of power subsystems much smaller than conventional units. They operate at high frequencies (1 MHz), efficiencies, and power densities, allowing an unprecedented degree of power distribution.

HURDLING BARRIERS. In essence, Vicor's approach overcomes the frequency and power barriers of conventional switch-mode converters by implementing forward-converter switching at zero current. Each switch cycle delivers energy to the converter output, with the switch turning on and off when no current is flowing. Zero switching results in a switch that is virtually lossless, allowing the converters to operate at frequencies greater than 1 MHz, efficiencies of more than 80%, and power densities that are 10 times greater than those of conventional converters (as much as 36 W/in.^{3} for the VI-200).

Vinciarelli says that power dissipation during switching in conventional converters increases directly with operating frequency. What that means is that efficiency rapidly declines at frequencies above 100 kHz, and drastically limits power density.

Vinciarelli made some early converts to Vicor's approach in the venture-capital community, where fund managers are notoriously blasé about power-supply technology. Michael Shanahan, a partner in Boston's Eastech Management Co., says, "In the venture-capital community, we rarely see an order-of-magnitude change in technology, but Vicor's approach brings about a 10 : 1 size reduction in power systems. That's dramatic



enough to make us pay attention." Eastech was an early Vicor backer.

So were Venture Founders Capital and Faneuil Hall Associates in Boston. "There's no reason Vicor can't be at least a $100 million company," says David Riddiford, a general partner in both. "Their technology is strong enough, the market is large enough, and their patent protection is solid. We don't often put a lot of stock in patents, but we did our own search, and their breadth and depth are very good."

Vinciarelli likes to make the analogy between the converter and the IC. "Our converters are the power-component analog of a digital or linear IC," he says. "They condense a lot of capability into one block. We're not a power-supply company; we're a power component company. We think we have the basis for the beginning of a new industry—the distributed-power component industry."

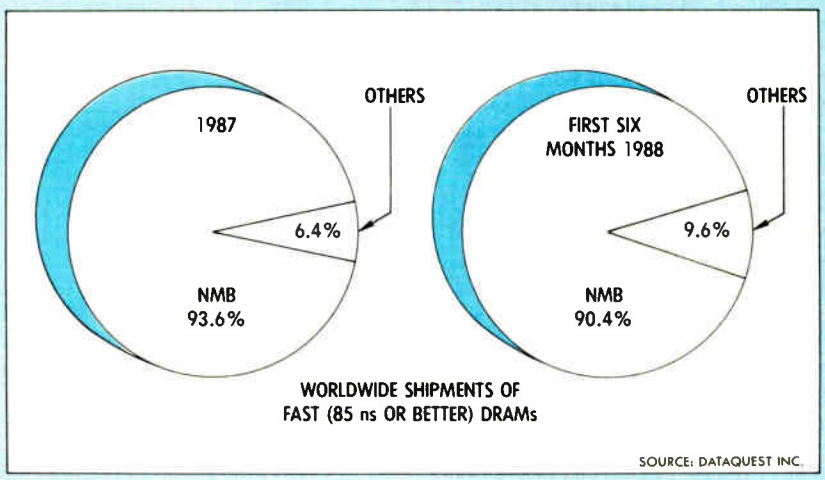
Vinciarelli says distributed power conversion will bring "dramatic changes to future power systems." Two-thirds of today's power supplies are designed in house by system builders, he says—a practice he likens to "making custom shoes to fit each customer's foot. Now, there's a standard shoe to fit every customer's foot. This makes it very compelling to build power systems from these standard building blocks." *–Lawrence Curran*

HOW NMB TOOK OVER THE FAST-DRAM MARKET

CHATSWORTH, CALIF.

By now, executives at NMB Technologies Inc. know the question people usually ask first: "What's a nice ball-bearing company like you doing in the wicked DRAM business?" The question is asked often, because in less than three years NMB has come from nowhere to having what market watcher Dataquest Inc. says is more than 90% of the fast dy-

NMB HOLDS ONTO ITS LION'S SHARE



namic-random-access-memory business. That translates into worldwide sales of $250 million for 1988, and company executives predict the total will double next year. In the U. S., the increase is running at a 450% clip over 1987, according to William C. Connell, NMB's president.

But answering that question is not as simple as asking it. Basically, drive and determination got NMB into the business; good technology, good luck, and good timing have kept it there.

In 1983 NMB's parent, Japan's Minebea Co., knew exactly what it wanted, says Connell. "They are very ambitious, very aggressive, and are always looking for growth," he says. Minebea had demonstrated these qualities in its core business, precision ball bearings with outside diameters up to 30 mm, where it holds some 65% of the world market.

For Minebea's management, fast DRAMs certainly fit their growth plan at that time, since the world computer business was thriving and speedier parts always find favor. However, their resolve soon was put to the test as a surfeit of new products sent computer sales tumbling in 1984 and 1985, taking chip suppliers with them. Memory producers, particularly in the U. S., dropped out in droves, and even the vertically integrated Japanese had to pull back substantially.

But Minebea stayed the course, investing heavily even for a profitable $1.5 billion company. That outlay for its new unit, NMB Semiconductor (NMB stands for Nippon Miniature Bearing, Minebea's original name), eventually totaled some $250 million. Most went into a world-class fabrication plant, at Tateyama City, which is located in a remote area of Japan famous for its clean water. The plant reached volume output early in 1985.

PRICED TOO HIGH. Then came the hard part. Right in the middle of the 1985-86 chip-industry depression, NMB was trying to sell an 80-ns 256-Kbit part, for 30%-plus more than the competition, to customers whose ironclad first rule was to beat the price down. No matter that the first of the 2800 series was 40-ns faster than its nearest rival, which was leading a pack running at 150 ns and up, the price tag of $4 and up was too much for most buyers to swallow.

On top of that, most personal computers at the time ran with 12-MHz or slower processors, and the NMB memory speed has little advantage at that rate, notes Myron Jones, vice president for sales and marketing. The final burden was that "it was so far ahead of the pack, we had to teach designers how to use it," he adds.

Connell recalls, "There was a lot of derision and lots of folks said we couldn't do it." But the U. S. marketers kept plugging away, gained some reputation, and won some prestigious customers. Among them: Lockheed Aircraft Corp., for advanced data-encryption equipment in a still-secret project, and IBM Corp., for its RT work station. The most important was starting its relationship with Compaq Computer Corp., NMB's biggest customer. Other customers include top work-station and minicomputer makers.

The boost in sales roughly parallels the rapid inroads made into top-of-the-line PCs beginning in 1986 by the new 32-bit processors, mainly the 68030 family from Motorola Corp. and Intel Corp.'s 80386. Their 16-MHz-and-up speed requires commensurate performance from memory for the computer to operate properly.

Still, NMB's rise from nonentity to dominance in fast DRAMs has attracted little notice except from customers. That's because, says Jones, "it happened without hype; there was nothing big or splashy." But industry consultants, ever alert for the next shooting star, were quick to pick up NMB on their screens. They generally like what they see. Notes

Bart Ladd, analyst at Dataquest in San Jose, Calif., "They do seem to be overshadowing others [in fast DRAMs]." Zohar Roz, vice president for technology at In-Stat Corp., Scottsdale, Ariz., is impressed that NMB has exploited "a niche market in a classic commodity, DRAMs."

Still, the picture is not all bullish. Some industry observers think NMB's market share could come under siege as the big chip houses get around to giving fast DRAMs their best shot. During its startup period, NMB didn't have to cope with non-DRAM woes of the semiconductor slump, a decided advantage. "Their success may be a function of [narrow] focus," says Dataquest's Ladd. In-Stat's Roz believes that NMB's manufacturing strength underpins its success, and should continue to. Examples abound in the semiconductor industry of small firms that got out of the gate early to take a lead over larger but slower rivals, then were overtaken by the strength of superior financial and production resources combined with the advantage of long-term relationships with customers.

Then there is NMB's technology. One executive insists that there is "no single secret" design or production technology driving it, other than rigorous attention to maintaining standards." Rather, "NMB from the start aimed for speed, bit the bullet and did it," says Jones. To this end, the company initiated a number of improvements in process technology, starting with the use of tungsten silicide film for gate electrodes. With this material it is possible to reach higher operating speeds than with silicon gates, through reduced capacitances on-chip, thus shortening signal delays, say the company's designers. NMB also claims to have the best DRAM yields in the business; that would put them above the 50%-to-60% range, says In-Stat's Roz.

OUTSIDE HELP. While NMB itself is proud of breaking new ground in process and manufacturing technology, it hasn't hesitated to go outside for top expertise, getting design help in partnerships with specialists. For example, the first 256-Kbit part was done with a design from Inmos Corp., Colorado Springs, Colo.; the 100-ns 1-Mbit design came from Vitelec Corp., San Jose; and the 60-70-80-ns 200 Series now being shipped in sample quantities is the work of Alliance Semiconductor Corp., also in San Jose. For the next-generation 4-Mbit DRAM, the company has just signed up with Ramtron Corp., Colorado Springs.

But even amid all the good news, there is the ever-present specter of the chip business's down cycles to deal with. So the company is hedging any future case of memory blahs by widening its product line. The result has been a gradual decrease in the proportion of the company's overall business that is brought in by memories. Today, within all of NMB Technologies, DRAMs account for about 65% of sales, with the rest coming from other components sold to manufacturers of personal computers, including keyboards, fans, motors, hybrid chips, and even speakers built by a unit bought from Sony Corp. in 1986. Last March this division was set up from separate operations to streamline the marketing.

"We want to be the leader in breadth, as parts supplier for PCs," explains Connell. With the one-stop-shopping concept, only one NMB salesperson now calls on each customer. But DRAMs are the door-openers for NMB, which does not intend to let its edge get away. The new 200 Series 1-Mbit chips, debuting this month as samples, have versions with maximum access times of 60, 70, and 80 ns and will sell for $20. It will be produced in the company's second fab, which started production of the 100-120-ns 1-Mbit memory earlier this year. *–Larry Waller*

PEOPLE TO WATCH

LUPLOW IS SPEARHEADING ZENITH'S CHALLENGE IN ADVANCED TV

The company's technology has all the trimmings to meet evolving standards, he says

GLENVIEW, ILL.

The last remaining major U. S. television manufacturer proved this fall that it's not giving up yet when it comes to technology innovation for the next hot consumer market: high-definition television. And Wayne C. Luplow, the man leading the effort for Zenith Electronics Corp., figures the company has a leg up.

"The requirements for what this country is looking for in high-definition [television] are coexistence with existing receivers, spectrum utilization, and high performance," says Luplow, executive director of electronic systems research and development for Zenith. "And we think we are the only ones who have successfully addressed all three of those things."

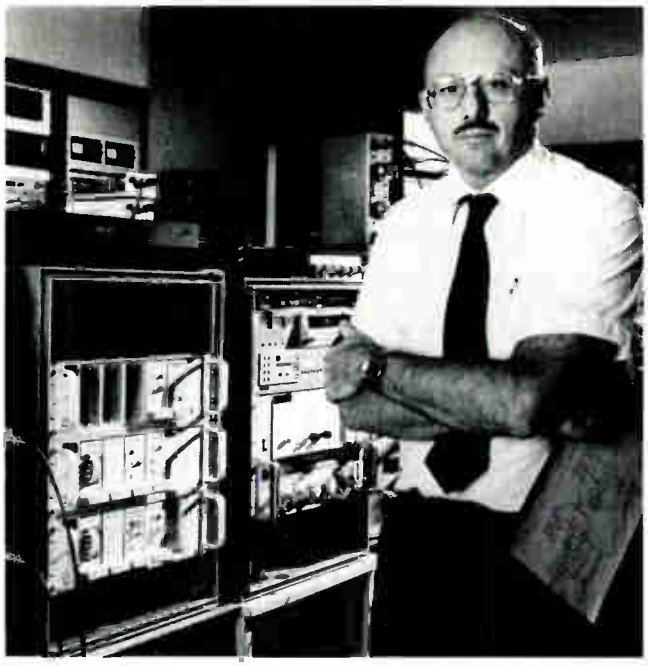
Luplow's reference is to Zenith's Spectrum Compatible System. The scheme was rolled out Sept. 1, just in time to meet the Federal Communications Commission's deadline for consideration as a U. S. standard for what is becoming generally known as ATV, for Advanced Television.

A Zenith veteran, the 48-year-old Luplow took over responsibility for the spectrum-compatible development effort last December, when he was named to his current post after a 13-year stint as the firm's director of component and reliability engineering. But Luplow's prior Zenith experience included two years as a section manager for advanced TV development, and a company source notes that he quickly became one of the driving forces behind the firm's ATV effort.

Luplow will need all that drive in the upcoming standard-setting process because the Glenview, Ill., firm's system faces a tough fight against more than 20 other proposals received by the FCC. But the Zenith system is drawing high marks in some circles for its technical ingenuity. "A lot of people are impressed with the Zenith system. If nothing else, it's an imaginative approach," says William Hassinger, assistant engineering chief for the FCC's Mass Media Bureau in Washington, D. C.

Zenith didn't begin its ATV development effort in earnest until about a year ago. "If you ask how come we waited so long and how come we're so late, one of the things we were doing was watching what the other guys were doing," Luplow says.

"We could see that a lot of people had systems out there, but there wasn't a home for it in the spectrum," he explains. "So we said that's silly, and that what we developed would have to be something that fits into the spectrum and still has the high performance." Of course, the system would also have to be compatible with NTSC receivers.



Zenith's Luplow gives credit for the company's ATV technology to "several guys who had a lot of innovative ideas."

SPLIT TRANSMISSION. The keys to the Zenith approach are advances in both encoding and transmission techniques, Luplow says. Zenith engineers use a variety of encoding methods to squeeze 30 MHz of ATV information into a single 6-MHz channel that can be broadcast simultaneously with existing NTSC programs. But the thing that makes the Zenith system stand out from others is the transmission scheme used.

By splitting the 6-MHz ATV signal into two frequency bands, Zenith is able to dramatically reduce the power required to transmit the signal. "It turns out that the majority of power required in an NTSC system is associated with the low-frequency portion of the video signal," Luplow says. So for its ATV signal, Zenith separates video frequencies that are below 200 KHz and transmits them in a more power-efficient digital form during the 22.5-line vertical-blanking period. The standard high-frequency video information is transmitted in conventional analog format.

The result is that the average transmitter power required for the ATV channel is only 0.2% of that required by an NTSC transmitter with the same service area, Luplow says. Because of the small carrier power, the ATV signal can be broadcast without interfering with other TV signals, even on adjacent channels.

What that means is that unlike competitive ATV proposals that call for simulcasting or auxiliary ATV channels, the Zenith approach can deliver ATV performance without the need for additional spectrum space, Luplow says. Instead, the ATV signal can be transmitted on existing VHF and UHF spectrum that is currently unassigned due to FCC channel spacing restrictions. The Zenith system produces a 787.5-line, progressively scanned 59.94-Hz display, which is comparable in resolution to a 1,000-plus line interlaced display.

For his part, Luplow is modest. "I was in the right place at the right time," he says. "There were several guys who had a lot of innovative ideas on this, and I just happened to be the guy in the position of kicking them and making it happen on time."

–Wesley R. Iversen

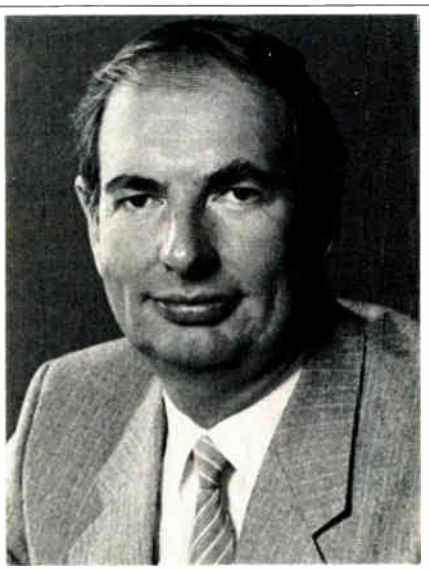
FOR CROOK, 'ASPARAGUS' IS THE MODEL

WESTBORO, MASS.

Growing asparagus and cultivating a telecommunications venture, believe it or not, have something in common. At least so says Colin Crook of Data General Corp.

For one thing, he'll tell you that they both require patience. Asparagus takes two years "to mature into a bountiful harvest, but then you've got a perennial," a crop that renews itself, he says. Appropriately, the first project undertaken by Crook's unit—whose charter is to merge computers and telecommunications in a venture that generates substantial new revenue for the Westboro, Mass., manufacturer of minicomputers—is codenamed Asparagus.

Crook came on board in 1984 as the senior vice president of the Communications Systems Group of the company, which has been afflicted lately with stagnant sales and earnings [*Electronics*, Sept. 3, 1987, p. 42]. Project Asparagus, now poised to enter its second phase, stems from a contract with Japan's NTT Corp. As NTT's technology partner, Data General is developing hardware and software to go into NTT private data networks, some 5,000 of which have already been installed in Japan for customers ranging from banks to manufacturers.



Private data networks will be a massive market in the 1990s, says Crook.

The initial value of the award has not been disclosed. However, analysts and other industry watchers believe that it could be worth as much as several hundred million dollars to Data General.

Crook's background brings Data General a blend of experience in computers and telecommunications. "I first got into communications in the early sixties, working on projects for the U. S. Defense Communications Agency for Canadian Marconi," he says. "Then I designed my first computer in 1966 when I was at Plessey Ltd."

MOTO CHIP. His track record includes work on Motorola's 68000 microprocessor, of which he describes himself as the "father." "I have a nice letter from Motorola to prove it," Crook says. He was with Motorola from 1969 to 1979, where he directed the microcomputer group and its product marketing.

From Motorola, Crook headed back to his native UK. His assignments included working as managing director of Rank Precision Industries and chairman of Rank's Nestar Inc., a local-area network firm. Then, before he crossed the Atlantic once more to join Data General in 1984, he was managing director of British Telecom Enterprises, where he headed up all of the nonregulated businesses, a job that included mobile communications.

"So I've worked in computers and com-

munications," he emphasizes, adding that the companies that possess an understanding of how to merge those two broad disciplines "will be strong in the nineties." In fact, he predicts, "this whole area of private data networks will be a massive market" in the next decade. "It will be a major battleground in the nineties," Crook asserts.

He thinks one of the requisites to be a major player in that very competitive market will be people who have both vision and discipline. "It takes guys like me to drive the vision in the first place—to be able to conceptualize the needs—and then bridge the vision to the people who actually write the code. The 68000 was very much an intuitive move at first," he recalls. And intuition tempered by experience guided him in assembling the early talent pool in Data General's Communications Systems Group.

KEY CONTRACT. For the group, the NTT deal was the first big win. Like asparagus, it didn't spring up overnight. The group had been formed about 16 months before NTT gave Data General the nod. Phase one of Data General's task calls for delivery and demonstration next spring of an intelligent network processor (INP) and the software interfaces to couple the INP to computers worldwide over a wide-area private data network.

Crook points out, however, that the INP is a completely new hardware and software platform that will enable a private data network to accept various inputs (voice, data, facsimile, teletype), perform all the protocol conversion, "and put it out over a digital [wide-area network]. It doesn't matter whether you want to do terminal access, file transfer, or move fax messages; the network does it all dynamically."

"We're hellbent on preparing phase-one products for the first delivery and we're on schedule," Crook says. "But I don't want to tempt the gods by saying more." Phase two, which is still being negotiated, will extend the capabilities developed in phase one.

"But eventually you have to draw hard lines to define deliverables versus the constant inclination to ask, 'Wouldn't it be great if we could add X, Y, and Z features' to the task? It's my job to say that we deliver X to the customer, and not X plus. I feel very proud that we've gone from the conceptual to actual deliverables to NTT."

Crook's next task is to make sure that the new crop of features being nurtured for NTT under Project Asparagus meets the company's needs. Once accomplished, they should evolve into a renewable resource—just like the vegetable—to be used for private data networks elsewhere. *–Lawrence Curran*

DO YOU LIKE KNOBS AND DIALS? SO DOES LECROY

CHESTNUT RIDGE, N. Y.

Walter LeCroy knows that in many ways his $50 million company is the new kid on the block when it comes to the electronics-applications market in high-performance oscilloscopes, waveform digitizers, and the like. But he doesn't think the road to success lies in copying.

Besides putting the high-end instrumentation firm that bears his name into head-to-head competition with the likes of Hewlett-Packard Co. and Tektronix Inc., he is also outspoken on the philosophy of scope design. In short, he thinks digital scopes should hang on to that old analog feel. "Oscilloscopes are, in large part, visual instruments," he says. "It's a screen-to-eyeball environment. The feel of our instruments is very much like a direct connection between fingers and trace."

As a result, LeCroy Inc.'s digital instruments are full of knobs rather than the competition's single-knob products that use push buttons, software, and menu screens. Twiddling knobs and seeing the waveform react is an inherently

more satisfying user interface, contends LeCroy.

Similarly, LeCroy is a strong advocate of the vector display instead of the less costly raster-scan displays found in most digital scopes. The display, he feels, also plays a key role in the user interface, since its crisper images make users more comfortable. By contrast, the technological problems inherent in delivering sharper images in raster-scan displays can be overcome, he says, but the cost is high. For starters, the screen must be updated faster, which requires higher-performance processors. And as the resolution of a bit-mapped display rises, the memory requirement rises even faster.

SMALL SHOP. Though LeCroy Inc. may be a relative fledgling in the electronics market for scopes, its technological lineage is beyond reproach. Founder and president LeCroy started his career as a research scientist in Columbia University's physics department. In 1964, he set up shop as LeCroy Inc. to measure high-energy particles in nuclear and particle-physics laboratories such as CERN in Europe. But after capturing 80% of that market, LeCroy began looking for something new, and settled on electronics.

For most of the past two decades, LeCroy Inc.'s instruments—tailored for capturing the movement of neutrinos—were really just too fast for anything electronics engineers needed. "For a long time," he says, "not many people in electronics were interested in anything above 100 MHz." But now LeCroy is building on this expertise in measuring ultrafast events and building analog-to-digital circuits.

It seems to be working. Since LeCroy Inc.'s foray into the electronics market four years ago, its name recognition has risen to 11%, according to a survey that it sponsored. *–Jack Shandle*

LeCroy likes crisper images of vector displays over raster-scan screens.

WEIS IS LEADING IBM INTO SUPERCOMPUTING

WHITE PLAINS, N. Y.

As jobs in the supercomputer industry go, the one that Allan H. Weis just got has to rank right up there. Weis is in charge of supercomputing at the world's largest computer company, IBM Corp., which is at the brink of finding a place for itself in this important market.

His new title is a mouthful: vice president of the Data Systems Division, IBM Enterprise Systems. What the title means is that Weis has worldwide responsibility for the strategy, development, and technical support of IBM's large systems for engineering and scientific computing.

Even though Weis says that "it is premature to announce changes I plan to make in the job," he's not loath to put

forth some definite views on supercomputing in general and IBM's future in it in particular. The company currently offers no Cray-class supercomputers, but has signed an agreement to develop one with Steven Chen, the former designer for industry-leader Cray Research.

"One really important thing in supercomputing, beyond the machines themselves, is the environment in which supercomputing takes place," says Weis, who joined IBM in 1961 as a trainee in the New York service bureau. In his view, this environment includes "the user interface on the work stations used to access the supercomputer [all the way] through to the supercomputer hardware. And that includes all the interconnects—the communications part—all the software, the compilers, and applications."

Supercomputer makers today must take steps to address this whole environment, Weis says. Users want to access the big machines through graphics-oriented work stations, so that simple interactive user interfaces are able to run supercomputer applications. The graphics work stations are also important for scientific applications, he says, where visualization is increasingly being used to track the progress of applications and see nd evaluate the results.

"I believe, in order to succeed, we must be looking at all dimensions that make up

The total supercomputer environment is vital, says IBM manager Weis.

the supercomputer environment and be working on all those dimensions," adds Weis, who majored in electrical engineering at the University of Kansas. He then recieved a master's degree in science at the Massachusetts Institute of Technology on an Alfred P. Sloan Fellowship.

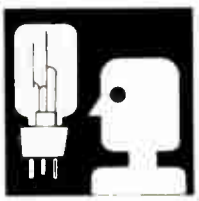
He has started things rolling in that direction. "We now have an interconnect lab in my organization that focuses on graphics and visualization, an area I have become enthusiastic about," he says. Visualization helps get problems solved more quickly. "I think if you can steer your computation you will get it done a lot faster," says Weis.

SUPER DEAL. IBM wants to include the highest-performance machines in its plans, and that's where the deal with Chen's company comes in. IBM has signed an agreement with SuperComputer Systems Inc. of Eau Claire, Wis., to develop a new multiprocessor supercomputer. Weis's group will coordinate the work between the two companies.

Weis's career at IBM has been a busy and well-traveled one. In 1968, he moved to the Research Division, where he managed several advanced technology projects in communications and data management. He then went to the Zurich laboratory in 1972 as assistant to the director, and two years later was appointed manager of the European Laboratory Computation Network in England.

Upon his return to the U. S., Weis was appointed to the corporate engineering program and technology staff, and became acting director of systems and programming. In 1980 he joined the Systems Communications Division, and in 1983 he became director of computing systems at IBM Research. Weis made his move to the IBM supercomputing spot earlier this year. *–Tom Manuel*

LOOKING BACK



Thirty years ago this month, automobile worship was in full swing. Encouraged by a new interstate highway system, Americans were in love with their chrome-bedecked cars.

The time was ripe for *Electronics* to report on devices and systems being designed into cars to improve their safety, performance, reliability, and sales appeal. "Autos Enter the Electronics Age," said the cover of the Nov. 21, 1958 issue. The cover photo was of an experimental rear-view road scanner TV system developed by Universal Broadcasting for the Buick Centurion. The system, intended to solve blind spot problems, included a dashboard TV screen and trunk-mounted camera. Alas, it never made it out of research and development labs. It was not alone.

General Motors had developed the Unicontrol system, in which tiller controls replaced conventional steering wheel operations, as well as the brake and accelerator pedals. As GM planned: "Sideways motion of the spring-centered control stick controls steering; fore and aft motion controls the engine throttle or the brakes. Intracardinal stick displacements permit various degrees of braking and accelerating during turns. A 20-degree rotation about the vertical axis in either direction puts the car in reverse, an 80-degree turn puts the car in park." Not to be outdone, Ford—in the midst of the Edsel debacle—was developing a system that also had two tiller sticks.

WRONG WAY. Even more elaborate plans were in the works. RCA was demonstrating a highway guidance system that employed an array of wire loops embedded in roadways. And Bendix's research people had built an experimental model of a proximity radar system designed to warn drivers of imminent collisions.

But that issue also previewed technology that did make its way into the best Detroit was churning out: headlight controllers, converters, voltage regulators, temperature controls, and electronic indicators were all showing promise.

LOOKING BACK is a feature that explores *the history of electronics through the pages of* Electronics *magazine, which has been published since 1930.*

CLASSIFIED

STRUGGLING AMD SHUTS DOWN A PLANT

Advanced Micro Devices Inc. will close its Sunnyvale, Calif., chip plant by the end of the year. The closing marks the end of a 19-year history at the plant, known as Fab 3, which opened in 1969 as the principal manufacturing facility of Monolithic Memories Inc., which AMD took over in 1987. AMD has enjoyed rapid growth since then, but now seems stalled: profits are expected to be down for the third quarter and about 1,400 jobs are being eliminated in the company's Far East plants. Employees in Sunnyvale will be offered new posts within the company or a variety of retirement and resignation incentives. AMD officials say Fab 3's capacity can be made up easily at other, more efficient plants.

AMSTRAD PICKS UP A CHUNK OF MICRON

England's Amstrad plc is buying a 9.8% stake in Micron Technology Inc., the Boise, Idaho, chip maker that is one of just a few manufacturers of merchant memory chips still based in the U. S. The deal will allow Amstrad to purchase up to 9% of Micron's monthly output, and will put Amstrad chairman Alan Sugar on Micron's board of directors. But it is not expected to effect Micron's output or its regular allocations to existing customers.

THIS COULD BE THE RADIO OF THE FUTURE

The National Association of Broadcasters has developed prototypes of what it calls "the radio of the future," a unit that incorporates continuous tuning from AM and FM bands, a tuneable antenna, provisions for two AM stereo technologies, AM noise blanking, and FM noise reduction. The unit, commissioned by the NAB, was designed by Richard Sequerra Associates of Bayside, N.Y. The NAB commissioned the prototype because "we have been concerned for many years that manufacturers were not producing high-quality receivers, especially for AM," says L. Lowry Mays, chairman of NAB's Radio Board. He says the NAB wants to share its know-how with manufacturers to reverse that trend.

RAYTHEON QUITS THE MEDICAL MARKET

Raytheon is getting out of the medical equipment business. The company says its small Raytheon Medical Systems unit was suffering from increasing competition brought on by an industry consolidation, in which major players such as General Electric Co. had expanded by gobbling up smaller competitors. GE got Thomson SA's medical equipment business last year as part of a deal to offload its consumer electronics business. Raytheon is selling three medical units to different buyers. The Lexington, Mass., company is selling Machlett Laboratories, a Stamford, Conn., unit that makes X-ray tubes, to Varian Associates of Palo Alto, Calif. It also is splitting its Raytheon Medical Systems unit between Fischer Imaging Corp., of Denver, Colo., which is buying its X-ray operation and Summit Service Technologies Inc. of Hudson, Ohio, which is buying the nuclear diagnostic equipment business. For Raytheon, the divestiture won't have much effect on the bottom line. The medical equipment division had sales of $7.7 million in 1987; the company total was $7.7 billion.

READER'S REPORT

Cypress vs. Motorola

To the editor: The article "Cypress Gets off to a Fast Start with Sparc Integer IC" [*Electronics*, July 1988, p. 32] contains several inaccurate statements concerning the Motorola 88000 RISC family. First, the article makes a price comparison of $2,984 for sample quantities of a typical nine-chip implementation of the Cypress version of the Sparc architecture and $6,855 for sample quantities of the 88000 RISC processor.

To compare apples to apples, a typical 88000 implementation consists of three chips, not nine: one 88100 processor with the floating-point unit on-chip and two 88200 cache/memory-management units. (Each 88200 offers 16 Kbytes of fast static random-access memory that offers a higher hit rate with a smaller amount of cache, so an 88000 implementation will require less cache than a Cypress implementation with direct-mapped cache.) At the published sample prices of $495 for the 88100 and $795 for the 88200, a three-chip Motorola implementation costs only $2,085 while the Cypress costs $2,984. For $899 less, the 88000 offers a built-in floating-point unit and fully integrated cache/tag/MMU functions.

The article also claims that the Cypress virtual-caching scheme performs better than the 88000 physical caching scheme. A virtual cache is only utilized if one cannot build a no-wait-state physical cache. The 88100, in fact, has a no-wait-state, 16-Kbyte physical cache with MMU all on one chip. Physical caches are more efficient in multitasking environments since cache flushes are not required as in virtual caches following context switching.

Jack W. Browne Jr.
Motorola Microprocessor Products Group
Austin, Texas

"New" chip already old

To the editor: While Jonah McLeod's article "How Schlumberger/ATE Hopes to Bounce Back" [*Electronics*, September 1988, p. 162] did a good job of explaining how the company's new Advanced Manufacturing Center in Simi Valley focuses on quality via advanced manufacturing concepts and techniques, there were two errors that need to be corrected. First, the company's vice president of operations is Tom Waechter, not Weiter. Second, and more important, the fact that the IDS 5000 is referred to as a "good example of the new technology that will be coming out" is potentially misleading. In fact, this reference should have been made to the newer IDS 4000, which was introduced at Semicon/West in May 1988 as a tool for semiconductor failure analysis featuring dynamic fault imaging. The IDS 5000 was introduced in April 1987 (on an *Electronics* cover) and has been installed at more than 30 sites worldwide.

Steve Harari
Schlumberger Technologies ATE Division
San Jose, Calif.

On-chip tests to 50 GHz

To the editor: Considering the effort Cascade Microtech has made to extend on-wafer testing to 50 GHz, you can understand our disappointment in your article "Mimic Winners Get To Work" [*Electronics*, June 1988, p. 37] where you stated that on-wafer rf testing is currently limited to "less than 40 GHz." The first probe of our WPH-200 Series, introduced in April 1987, has let designers and manufacturers of FETs and MMICs to perform accurate, nondestructive, on-wafer measurements in the 0- to 50-GHz range.

Dale E. Carlton
Cascade Microtech Inc.
Beaverton, Ore.

Correction

In "The Pentagon is Hot on the Trail of a Better Way to Design Avionics" [Electronics, *September 1988, p. 25*], *the name of an Air Force program was incorrectly stated. The correct name is Advanced Tactical Fighter.*

BOOK REVIEW

BASIC MANAGEMENT GROVE'S WAY

ONE-ON-ONE WITH ANDY GROVE
by Andy Grove
New York: Penguin, $7.95

One-on-One with Andy Grove is a welcome relief from most books on management. Grove offers no grand, all-encompassing theory of business to apply to every problem in every office. Instead, he gives specific advice about individual situations, based on experience he's accumulated in almost 30 years in the electronics business, most recently as president of Intel Corp.

The bulk of the text comes from a column that Grove writes for the San Jose, Calif., *Mercury News*, where he tries to answer questions from readers about problems at work. Excerpts are stitched together with new material in which Grove expands on his original replies and explains some of the thinking behind them. The format makes this new paperback edition an ideal book to slip in a bag and take on a business trip—it can profitably be read the same way it was first written, two or three questions at a time.

Intel's Grove says management slogans don't work.

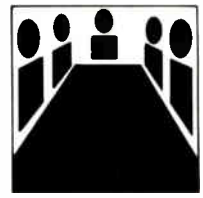
For the book Grove has added explanatory passages to make clear his train of thought. His prose is devoid of jargon, whether technical or managerial. When he swung through New York recently to promote the book, Grove described writing it as putting "random-order questions into content-addressable form"—but he laughed as he said it.

Grove avoids fuzzy thinking as well as fuzzy language. He does not rely on a few generalities as the basis for all his answers, although some common themes do emerge. As a rule, these do not consist of startling innovations in managerial thinking. For example, Grove, like virtually all managers, believes nothing substitutes for two-way communication between manager and managee with each making his position clear.

But for the most part, he urges managers to forget formulas. He says "most of managing is like driving down a bumpy road that's full of potholes. You have to get around the potholes." In other words solve each problem as you come to it, on its own terms—an approach he favors, and which he traces to his training as an engineer. "By the time I got my engineering degrees," he says, "I'd taken maybe 200 midterm and final exams, and on each one of them I had to follow a certain approach to solve a particular problem."

He thinks other technically trained managers in high-tech industries ought to remember their early training, too. "Use all those midterms and finals," he said. "Approach all the problems fresh. Set them up in simple terms. Forget all the fads and slogans. They are the mind-altering drugs of management, and they don't do you any good." *–Larry King*

MEETINGS



The National Telecommunications Association's Unicom 2 Exposition and Conference will focus on management problems in connectivity and distributed information systems.

Included in the three-day conference are events and seminars targeting executive and managerial strategies to make the most of the market opportunities which are the result of the industry trend away from centralized computing resources.

Some 80 experts will address the concerns of the range of players from manufacturers to users. To be held Nov. 29-Dec. 1 in Dallas the conference is being cosponsored by NATA and TeleStrategies Inc. a specialist in executive conferences. For further information, contact NATA, 2000 M St. N. W., Washington, D. C. (800) LET-NATA.

In January, the 1989 Optical Disk Systems Conference will cover the entire breadth of optical disk storage, which includes technology, marketing and specific industry uses.

Presented by CAP International, the first day focuses on a technology overview including standards, media scanners, processors and work stations. The second day features speakers from system vendors; the last day will be devoted to industry applications, cost justification, and purchasing procedures.

The conference will be held Jan. 23-25 at the Point at Tapatio Cliffs Convention Center, Phoenix, Ariz. For further information, contact Kristin Fischer, CAP International, One Longwater Circle, Norwell, Mass., 02061; (617) 982-9500.

Also on *Electronics*' calendar of key conventions, shows, and expositions:

Asian Semiconductor and Electronics Technology Conference, Nov. 6-8, at the Hotel Shilla, Seoul, Korea. Contact Dataquest Inc., Conference Dept., 1290 Ridder Park Dr., San Jose, Calif. 95131; Phone (408) 437-8245.

IEEE International Conference on Computer Aided Design (ICCAD), Nov. 7-10. For information contact Al Jimenez, Pro CASE, 3130 Dela Cruz Blvd., Suite 100, Santa Clara, Calif. 95054; Phone (408) 727-0714.

Supercomputing '88, Nov. 14-18 at the Hyatt Orlando, Kissimmee, Fla. Contact George Michael, Lawrence Livermore Labs, P.O. Box 808, Livermore, Calif. 94550; Phone (415) 422-4239.

Computer Security Conference, Nov. 14-16 at the Fountainebleau Hotel, Miami Beach, Fla. Contact Computer Security Institute, 360 Church St., Northborough, Mass. 01532; Phone (508) 393-2600.

9th Real-Time Systems Symposium, Dec. 6-8. Huntsville Marriott Hotel, Huntsville, Ala. Contact Walter Heimerdinger, Honeywell SRC, 3660 Technology Dr., Minneapolis, Minn. 55418; Phone (612) 782-7319.

International Electron Devices Meeting (IEDM), Dec. 11-14. Hilton Square, San Francisco, Calif. Contact Melissa Widerkehr, Courtesy Associates Inc. 655 15th St. N. W., Suite 300, Washington, D. C. 20005; Phone (202) 639-5089.

ATE West Exposition and Conference, Jan. 24-26 at the Disneyland Hotel Convention Center, Anaheim, Calif. Contact MG Expositions, 1050 Commonwealth Ave., Boston, Mass. 02215; (800) 223-7126.

Asia Telecom '89, Feb. 20-25, at the Westin Stanford Hotel, Singapore. Contact the International Telecommunications Union, Place des Nations, CH-1211, Geneva 20, Switzerland; Phone (22) 99524.

Semicon Europa '89, March 7-9, at the Zuspa Convention Center, Zurich, Switzerland. Contact Semiconductor Equipment and Materials International Inc., 805 E. Middlefield Rd., Mountain View., Calif. 94043; (415) 964-5111.

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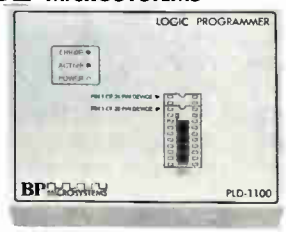

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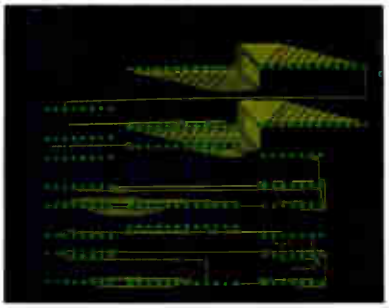

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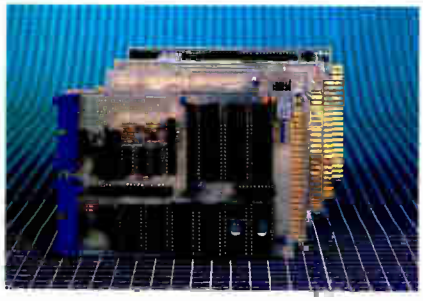

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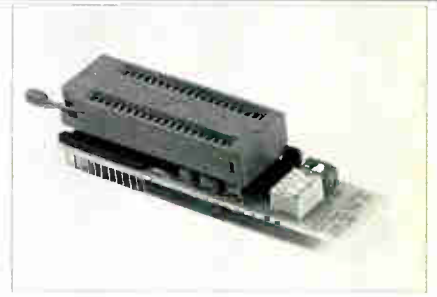

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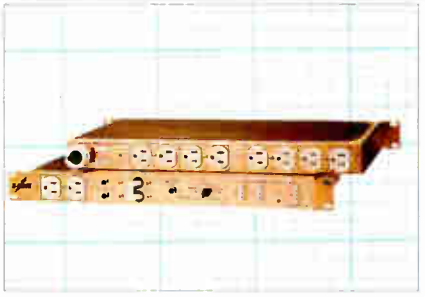

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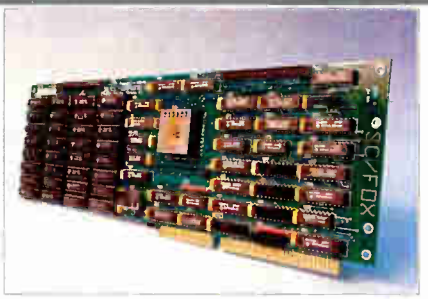

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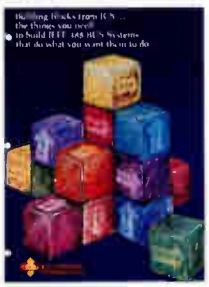

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UPDATE: QUICK GATE-ARRAY PROTOTYPERS PROVE OUT

It has been an eventful year for most of the makers of systems that provide prototype gate-array chips within 24 hours. The most important event for the two U. S. companies that still make laser-based, quick-turnaround production units was getting the equipment up and running. They succeeded. They confounded the skeptics and showed potential customers the technology [*Electronics*, Nov. 12, 1987, p. 69] is for real.

"We've proven the technology works, which was a big step," says E. Tim Fitzgibbons, president of Lasarray Corp. of Irvine, Calif. Because the new equipment is complex and expensive, convincing critics it was a solid approach is a milestone. Now Lasarray and its remaining rival, Lasa Industries Inc. of Santa Clara, Calif., can get on to the business of marketing the gear.

Both Lasarray and Lasa have racked up first sales of the big-ticket units—Lasarray's sells for $4.2 million, Lasa's slightly over $3 million—and say they have more live prospects. It hasn't hurt that one of the four companies originally in the business, Laserpath Corp. of Sunnyvale, Calif., was knocked out of the market by the high cost of making its machine. Elron Electronic Industries Ltd. of Haifa, Israel, apparently has been slower off the mark in the U. S. One industry watcher, G. Dan Hutcheson of VLSI Research Inc. of San Jose, Calif., which tracks the market for semiconductor production equipment, says he has seen few signs of Elron in the U. S. Meanwhile, others in the industry say the company is seeking a working arrangement with several chip companies here.

But despite the progress of the past year, ultimate success depends on riding out what appears to Hutcheson to be a partly cloudy first five years. VLSI Research projects revenue to grow from $3.8 million this year to only $17 million in 1992—not much in the way of unit sales. But then the picture should change. A few years into the next century, says Hutcheson, sales will zoom to 5,000 units.

The stumbling block, he says, is doubt about the dependability of the complex laser-driven technology. A few errors in the critical cutting process for connecting the gates can ruin an entire logic device, he says. "If they can get past this problem, and build momentum, [the equipment] could be a winner." That accomplished, Hutcheson says, the systems could permeate world industry, with every company having virtually "its own little gate-array shop" on site. Not surprisingly, Lasarray's Fitzgibbons foresees good things happening sooner. However, the business turned out to be something other than just selling an expensive piece of hardware, as initially envisioned. Instead, the Lasarray strategy has changed so that the front-end part that deals with producing the key pattern-generation tapes now has generated a full-fledged service business in itself. Customers want the prototype ICs in a hurry to test system designs and are willing to pay for them.

As Fitzgibbons explains, "We're still a capital-equipment company, but we're running a service business to sell the hardware." All five of his company's customers are systems firms, which use the equipment for numerous programs. So they are considered live prospects for hardware. In fact, says Fitzgibbons, Lasarray's initial sale—to a company he declines to name—came about that way.

Producing the key pattern-generation tapes is a growing service business

Lasarray's system completely produces application-specific ICs, from design approval to finished chips, in as little as 24 hours. The key to the maskless unit is its direct-write laser pattern generator. It translates the design into an interconnect metalization pattern on preprocessed base wafers by directly exposing the photoresist. Metal is removed in the etching of up to 16 patterns written on each wafer. The entire task, through testing and packaging, is done in Lasarray's "Microfab," a 750-ft^2 self-contained processing module [*Electronics*, Nov. 12, 1987, p. 69].

By contrast, Lasa's unit uses an additive technique, with the laser putting down the final two metal interconnect layers on prepackaged standard gate arrays. An upgrade to three-level metal is in the works. Presently, it can handle geometries down to 1 μm and arrays of up to 100,000 gates, according to Paul Petach, vice president of service, sales, and marketing. Another improvement in the last year is optimizing the process for better throughput by using four chambers instead of the original three. It takes about six hours for the process sequence to do a load of eight parts, at the 5,000-gate density level, he says.

The San Jose firm has gone after 12 major semiconductor houses as prime targets, and scored with one it cannot yet identify; the unit is currently being installed, says Petach. Two others have signed up for strategic partnerships in which the chip firms use a machine, at Lasa's plant, for prototyping. That arrangement, should it prove successful, would be all the encouragement that a chip maker needs to acquire a system of its own, the way Petach spins out his scenario. The advantage to big chip houses is that they can offload the design/prototype requirement from their fabrication lines and save a lot of money. *–Larry Waller*

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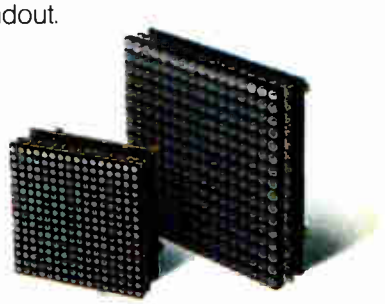
Color Display*	Red, Green, Amber	Green	Red	Red, Green, Amber	Green	Red
Dot Size	ø5mm			ø3mm		
Dot Pitch	6mm			4mm		
Weight (Typ.)	170g	165g	165g	95g	85g	85g

*Amber color is made by a mixture of red and green



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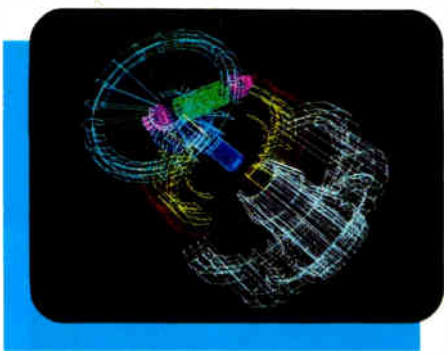

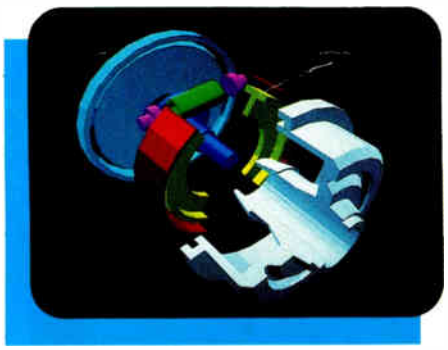

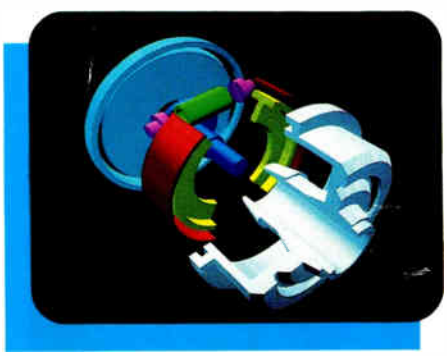

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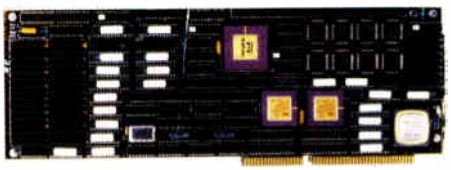

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