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Electronics

THE WORLDWIDE TECHNOLOGY WEEKLY

MARCH 17, 1986

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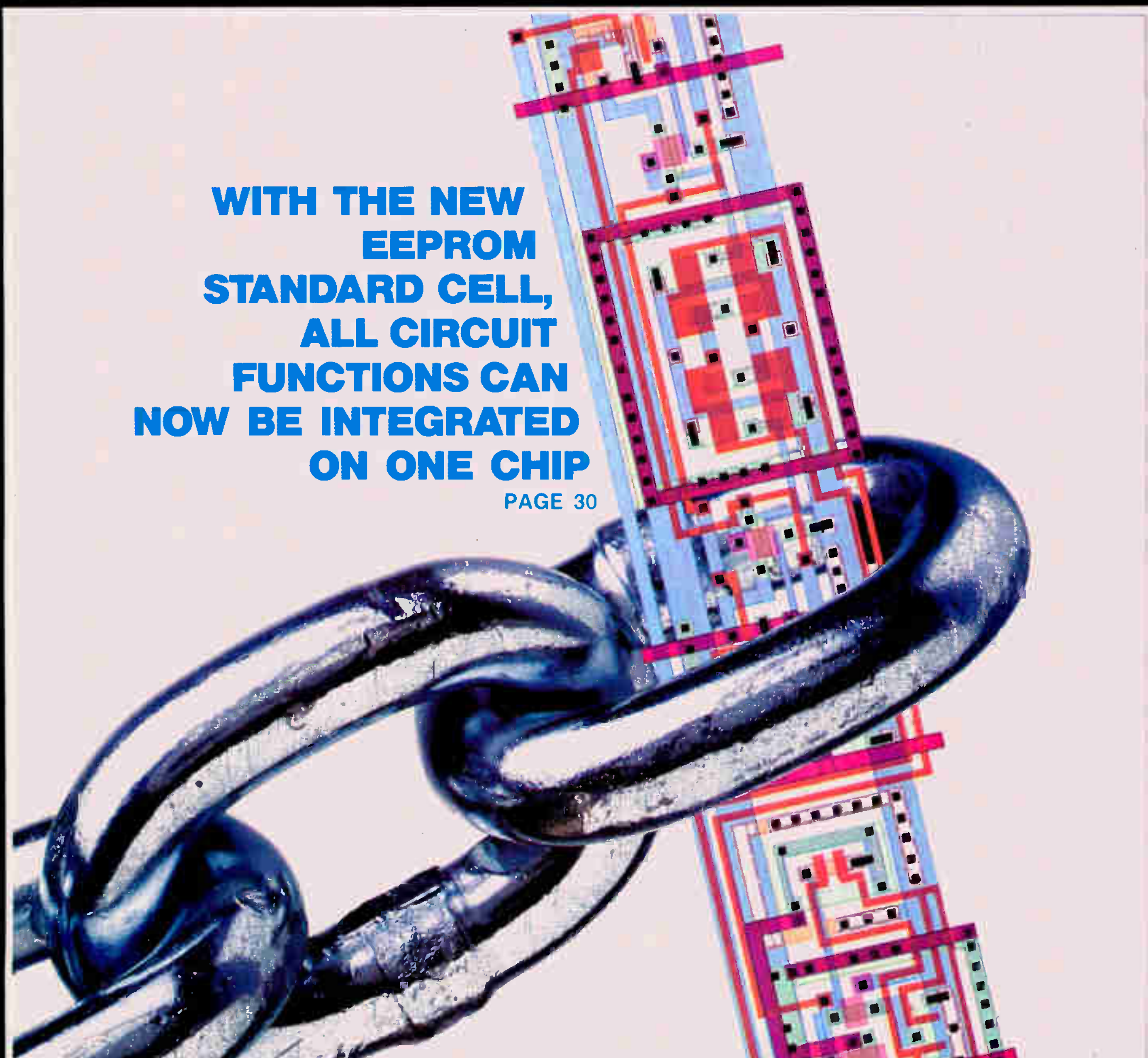

WITH THE NEW EEPROM STANDARD CELL, ALL CIRCUIT FUNCTIONS CAN NOW BE INTEGRATED ON ONE CHIP

PAGE 30

The only thing small about it is its size!

The RTP-650A is the only portable data recorder that gives you bigger performance than a reel-to-reel.

- **DC to 40kHz frequency response on 14 (or 21) channels** — at a 76.2cm/sec (30 ips) on Beta format video cassette tape. Covers twice the IRIG WBG1 bandwidth on any of the other six tape speeds. WBG1 is selectable for an even better S/N ratio.
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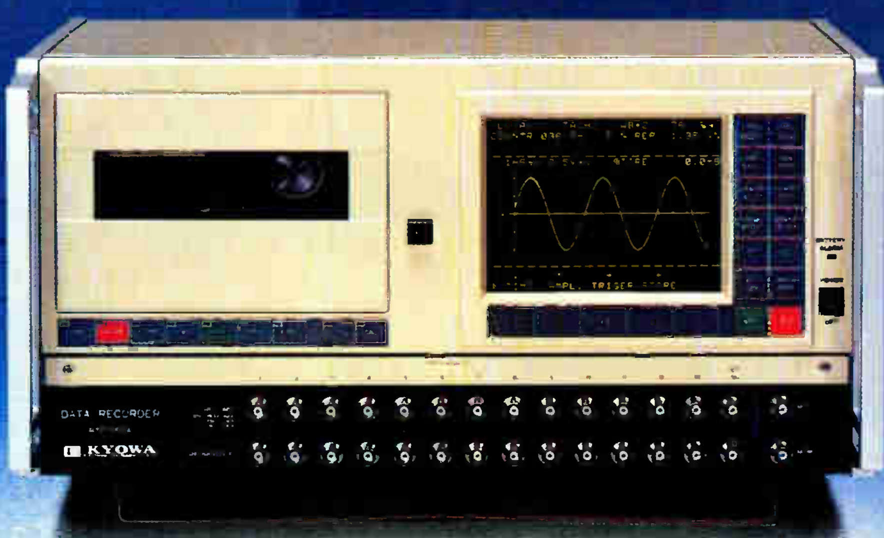
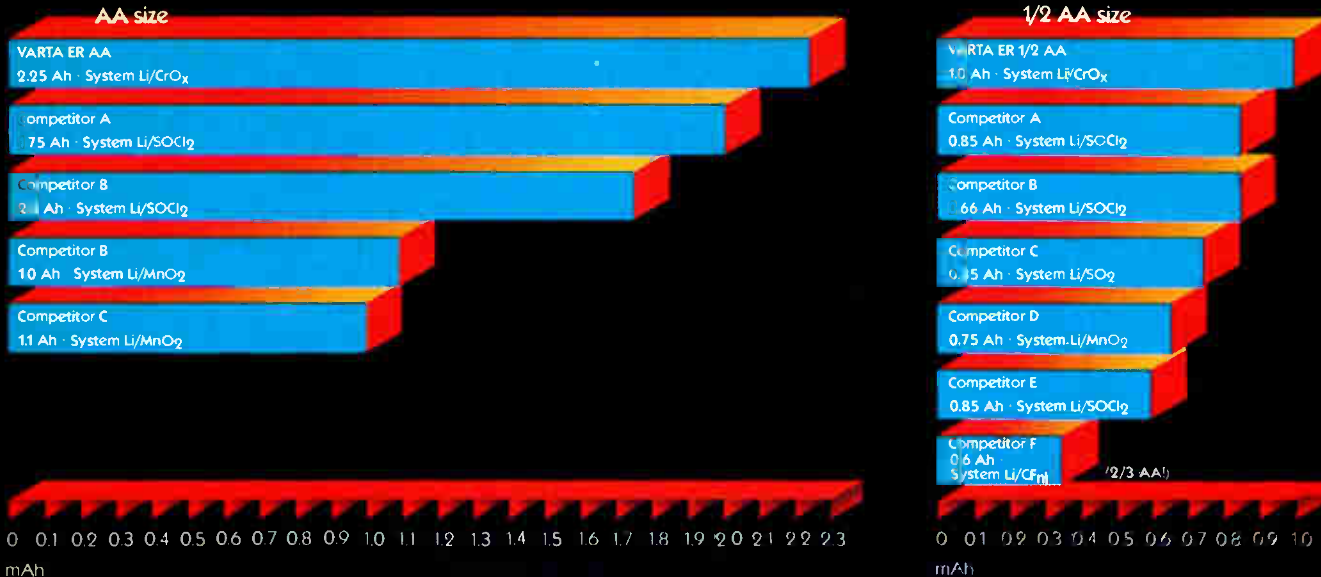


RTP-650A

VIDEO CASSETTE DATA RECORDER

Circle 900 on reader service card

Li/CrO_x – only from VARTA: The battery-system performance leader



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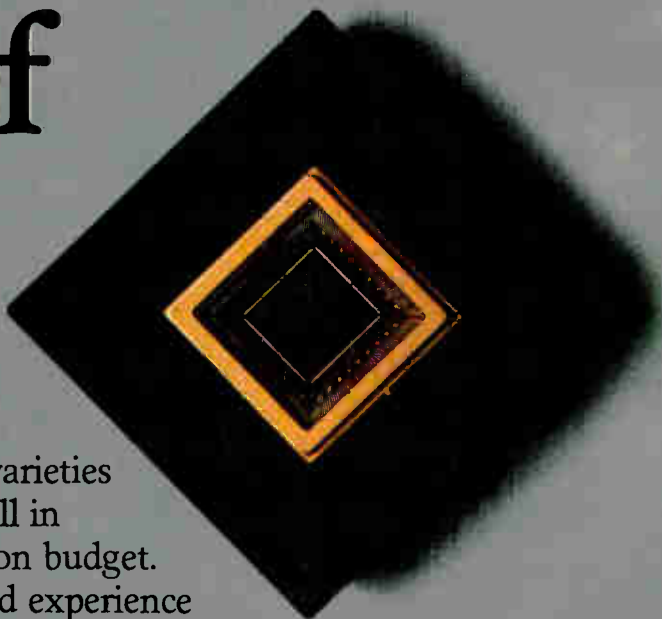
Our Li/CrO_x batteries price/performance ratio are well worth a second look.

Send for datasheets and order your samples now!

VARTA

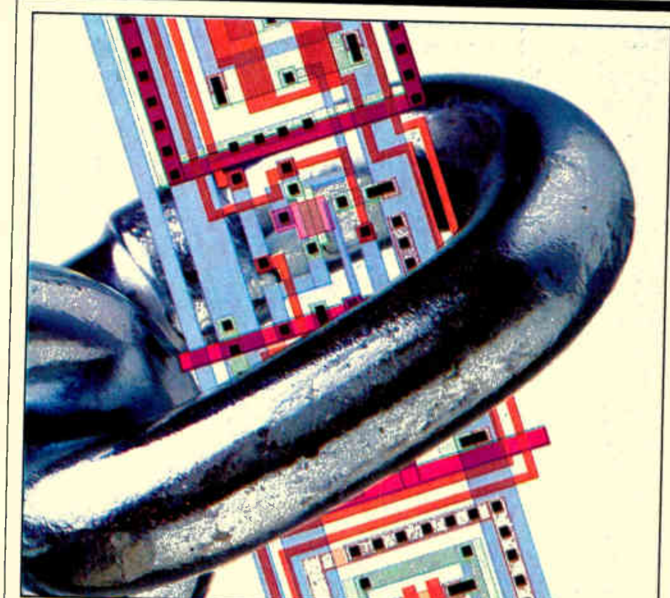
Circle 1 on reader service card



MARCH 17, 1986

VOLUME 59, NO. 11

Electronics



Cover photograph by Nava Benjamini

ELECTRONICS
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Electronics

CRAIG ROSE: Work station watcher.

These are nervous days indeed in the work station business. As Boston bureau manager Craig D. Rose points out in his Probing the News on p. 54, the market is on the verge of a period that can best be compared with the early days of the minicomputer business: a new king of the hill emerges every few months, with no clear-cut leader ready to take over.

Craig, who also wrote the company story on Prime Computer on p. 58, says that things started stirring when IBM entered the market with its RT Personal Computer. Then Apollo, which some market watchers had virtually given up for dead, proved the doomsayers wrong as it fought back with its new work-station line.

"Since then," he observes, "the analysts have been doing such fast turnarounds they have been spraining their ankles. For example, two days before the Apollo announcement, they were saying Digital Equipment Corp. was unbeatable. Post-Apollo, the word was that DEC has price problems and is not at all invulnerable." If nothing else, all this ferment will force Craig to keep his eye on those spinning analysts.

Going two up on Craig is Jerry Lyman, our packaging and production editor, who has no fewer than four articles in this week's issue. In the news section, beginning on p. 17, Jerry is represented by two stories—one about an active filter from Columbia University and the other on wafer-scale integration from Auburn University. Then on p. 41, he has a Technology to Watch on a Micronix X-ray-lithography system that is moving to the production line. This story is followed, on p. 46, by a Special Report surveying the X-ray lithography field.

Jerry feels right at home with this technology. "I've been tracking it since 1978. Back then, I got a graphic view of the difficulties involved in X-ray mask technology. A sample mask furnished for a cover photo was shattered by the energy of a flashbulb."

Now, says Jerry, the real excitement is in the application of synchrotron radiation, which he thought would never make it because of cost and complexity. But, Jerry points out, the West Germans and Japanese are pouring money into this field. And they aren't worried about flashbulbs.

Laurence Altman

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LETTERS

Tracor's 1750 processor

To the editor: The article on the MIL-STD-1750A chip set [*Electronics*, Jan. 20, 1986, p. 50] gave an interesting insight into 1750 processor-development programs. It should be noted, however, that Tracor Aerospace Inc. has both developed and fielded a chip set of this type. Tracor is now in production with a fully operational single-card MIL-STD-1750A instruction-set-architecture computer. The Tracor 1750 processor completed Air Force Seafac validation to MIL-STD-1750A (Notice 1) with no exceptions in June 1982. It is being delivered to General Electric Co. for use in the F-20 Tigershark multimode radar system (AN-APG-67).

A radiation-hardened version of the Tracor 1750A computer has been chosen for evaluation on the Galileo and other spacecraft-related programs. Also, the Air Force has sponsored the enhancement of the 1750A chip set through a Mantech program, which is under way at Tracor.

John Amick
Director of Marketing
Tracor Inc.
Austin, Texas

Fingers in the pie?

To the editor: The letter by Roy H. Propst of the University of North Carolina comparing the virtues of the industry and university sponsored Semiconductor Research Corp. (SRC) with those of the similarly structured Microelectronics and Computer Technology Corp. (MCC) [*Electronics*, Jan. 6, 1986, p. 8] reminds me of two criminals boasting about the horrors of their crimes.

The fact is that the size of the research and development pie is finite. Every contract awarded by industry to a university deprives the employed practitioner of work. If the 100 companies who support the MCC and the SRC had kept the R&D work in house, there would have been far fewer layoffs. Propst boasts that the SRC supports 450 graduate students. Because more than 50% of all full-time graduate students of engineering are aliens, this policy risks unwarranted technology transfer.

Irwin Feerst
Committee of Concerned EEs
Massapequa Park, N. Y.

Correction

In "Chip bookings surpass shipments for the first time since 1984" [Electronics, *Feb. 17, 1986, p. 11], the figures given apply to the U. S. market. In addition, the $610 million quoted refers to bookings.*

TECHNOLOGY NEWSLETTER

WEST GERMAN GOAL: A COMPUTER THAT RUNS AT SEVERAL GIGAFLOPS

A new West German venture has been set up to develop a computer that will perform several billion floating-point operations per second. Suprenum GmbH, Bonn, was founded jointly by the Bremen-based Krupp Atlas Elektronik GmbH, Hamburg electronics company Stollmann GmbH, and the Society for Mathematics and Data Processing in St. Augustin, near Bonn. It will coordinate efforts by more than 10 German companies, universities, and research institutes to surpass the fastest operation yet attained: just over 1 gigaflops. The Suprenum machine will be based on relatively inexpensive parallel microprocessors instead of complex vector-computer principles. The company hopes to have prototypes ready by the end of 1988. ☐

FIVE EUROPEAN COMPANIES LINK THEIR PRODUCTS IN ONE E-MAIL SYSTEM

European hopes for wider use of electronic mail were given a boost last week when five companies demonstrated a heterogeneous application using the open-systems interconnection (OSI) norm. France's Bull; the U. K.'s International Computers; and Germany's Nixdorf Computer, Siemens, and IBM Germany (a subsidiary of IBM Europe) hooked up their gear at Germany's Hannover Fair. Their equipment was linked to a network based on the OSI X.400 message-handling protocols, which allowed messages from one machine to be understood and displayed by the other four companies' machines, each in its own format. The participants say it's the most comprehensive connection of heterogeneous message-handling systems yet realized. ☐

ARGONNE WORK COULD EXPAND USES OF ULTRATHIN-FILM MAGNETIC MEDIA

In a development that could expand the uses of ultrathin-film magnetic media, physicists at Argonne National Laboratory, Argonne, Ill., have simplified work with magnetic monolayers. They grow a one-atom-thick layer of a magnetic material, such as iron, on a single-crystal substrate of a nonmagnetic material, such as gold or copper. The nonmagnetic substrate allows the researchers to use what they say is the first surface-study technique to rely on the magneto-optic Kerr effect, the change a magnetic material will produce in the polarization of light. Though commonly used to study bulk materials, the Kerr effect has previously been unsuitable for studying surfaces because the light penetrates beyond the surface, as deep as 200 Å, notes Argonne researcher Samuel Bader. With Argonne's Smoke (for surface magneto-optic Kerr effect) method, the polarized light still penetrates the substrate. But because the substrate is nonmagnetic, it does not change the polarization, and the light is affected only by the magnetism of the surface monolayer. ☐

ZENITH GOES FOR SURFACE MOUNTING IN 9-IN. COLOR TV

Following the march of Japanese consumer electronics manufacturers, Zenith Electronics Corp. is making a heavy move toward high-density surface-mounted-device technology with a new line of 9-in. diagonal color TV sets known as the Zenith Delights series. Weighing 17 lb, the new sets are Zenith's smallest and lightest ever, and make use of hundreds of surface-mounted components. The single-board design replaces a three-module approach to earlier Zenith chassis designs and marks the Glenview, Ill., company's first use of surface-mounting technology on anything but the TV tuner. Also contributing to the line's compact size is a Zenith-patented integrated injection logic chip that combines in about 2,400 devices the functions of two former large-scale integrated circuits, a new 8-bit microcomputer with built-in nonvolatile memory, and a miniaturized sweep transformer that is 30% lighter than previous designs. ☐

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January
- Philips Uses MBE for Lasers
- Siemens Readies Commercial ISDN
- Japanese Chemical Firm Moves from Soap to Floppies
- Italian Firm Seeks Allies to Crack U.S.
- Japan Pursues Role in Space
- Bellman Switches on Italtel for Expansion
- Robots get Smart in Japan
- ITT Invests in European Units Crack U.S.

February
- Europe's Esprit Finally Sets Sail
- LSI Logic Counts on Sandfort to make its Mark in Europe
- Upstart Vendor Makes Waves in Japan's Robot Market
- NEC Fashions New Fab Process
- Olivetti's Viti Directs ET Designs that Marry Bus & Art
- German Startup's Success Surprises Europeans
- Britons Seek Tolerant Chips
- OBI Rains on IBM's Parade
- Mega's Friedrich Aims to Cut Asian Lead in Memories

March
- British GaAs Chips Go to Market
- NEC's CPU Leapfrogs IBM
- Hitachi CPU Challenges IBM
- France's Lansat Rival Set for Fall Launch
- Olivetti Stakes Claim in Video Typewriters
- Italian VLSI Chip has the Right Accent
- Koreans Try for VCR Replay
- Germans Push X-ray Exposure
- There's Life in Resistors, German Company Finds
- UK Beats a Path for Europe's Race

April
- German System Meets New ICAO Standard
- West Germans Squabble Over Choice of IFF
- Britain Promotes Open Architecture
- US Makes Progress in Japan Telecom Talks
- Japan's Lead in Optical Disks: It's Part of the System
- Daisenberger Guides US Firms through Red Tape
- Asia: It's No Longer Just Japan That Threatens US Markets
- Malaysia: Top Shipper of Discretes
- Indonesia: Domestic Sales are the Lure

May
- Thomson's VCR System Clears Up Doubts
- ICL Banks on Networks and Japanese Chips
- Min Blazes Bright Path for Korea's Gold Star
- Asia: The Four Dragons Rush to Play Catch-up Game
- Singapore Casts Lot with Software
- Philips' Eurom Chip Finally Debuts
- Sagging Prices Sting Japanese Producers
- British Telecom Spreads Its Wings with Mitel
- South Korean IC Maker Seeks World Markets

June
- Plessey Switches Off Flash ADC, Saves Power
- Sony Campaigns Hard for BMM Camcorders
- Japanese Quit on IBM Software, Turn to UNIX
- Apple Tries Again to Blast Off in Japan
- Has the End Come for European Chip Makers?
- SIA Protest May Not Stem Trade Tide
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ELECTRONICS NEWSLETTER

U. S. EPROM MAKERS MAY COMPROMISE IN JAPANESE DUMPING CASE

Advanced Micro Devices, Intel, and National Semiconductor say they will continue to press the Commerce Department to impose antidumping duties on Japanese erasable programmable read-only memories—but industry reports suggest they may go for a compromise settlement with the Japanese chip makers. The Commerce Department last week issued a preliminary decision upholding the dumping charges and imposing "dumping margins." AMD, Intel, and National filed the antidumping charges last September. Japanese EPROM exporters now must deposit enough cash or bonds with the Customs Service to cover the difference between their chips' actual selling price and their fair market value—the cost of research, development, and production plus an 8% profit margin. The deposits were calculated during an investigation by the department's International Trade Administration. The margins range from 21.7% for Toshiba Corp. to 188% for NEC Corp. Hitachi Ltd.'s figure is 29.9%, Fujitsu Ltd.'s is 145.9%. The deposits are intended to ward off a rash of imports before the International Trade Commission determines whether dumping is materially injuring the U. S. semiconductor industry. If it is, Commerce will impose duties. □

BILLINGS RISE FOR FIRST TIME SINCE BOOK-TO-BILL TURNAROUND . . .

For the first time since the U. S. semiconductor book-to-bill ratio turned around last September, the figure for billings rose—from $546.2 million in January to $603.6 million last month—according to the Semiconductor Industry Association. The ratio reached 1.10 in February. The closely watched ratio has been climbing for six months—but the increase came largely because billings were dropping, not because bookings were rising. "It now appears that a semiconductor industry recovery is under way and that all product lines are enjoying increased business activity," says SIA president Andrew A. Procassini. □

. . . AND JAPANESE CHIP MAKERS GET GOOD NEWS, TOO

Semiconductor demand in Japan is showing signs of picking up: the average domestic market price of 256-K dynamic random-access memory products has risen by 11¢ to 17¢ since the end of the year. But chip makers are holding back from sizable production increases until the hoped-for second-half recovery looks more certain. Industry sources say that most makers expect increased market demand of 15% to 20% this year, with inventories absorbing some of the rise. □

FCC DUMPS RULE BARRING BOCS FROM SELLING EQUIPMENT WITH SERVICE

The Federal Communications Commission is moving to ease its restrictions on the sales of customer-premises equipment by the Bell operating companies in order to open the door to one-stop shopping for basic services and equipment. It proposes to eliminate its requirement that the BOCs set up separate subsidiaries for sale of telephone equipment. This structural separation was intended to avoid cross-subsidization from the BOC's phone services. The FCC now says that such safeguards as new accounting procedures, disclosure of network information needed for equipment connections, and nondiscrimination in access to network services will be sufficient. Independent equipment vendors and consumer groups oppose the move on the grounds that it gives the BOCs too much freedom. But the FCC argues that the rule-making procedure, rather than waivers as requested by several BOCs, would provide adequate protection from cross-subsidization prohibited in Computer Inquiry II. □

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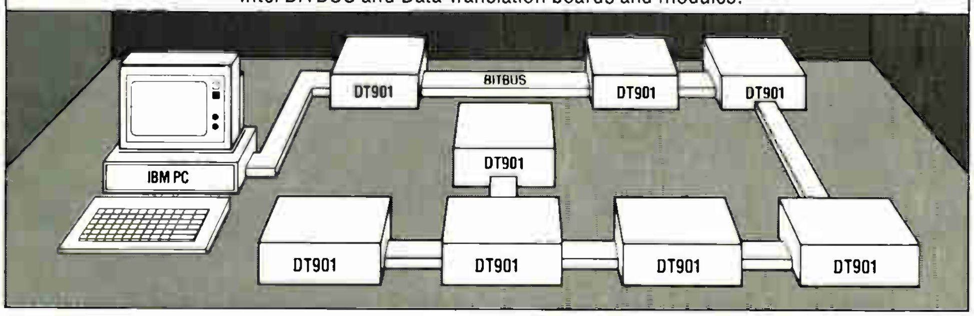

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PRODUCTS NEWSLETTER

FUTURENET TO ADD GOULD AMI'S STANDARD CELLS TO ITS CAD STATION

Come May, users of Dash 3C work stations from FutureNet Corp., Canoga Park, Calif., will be able to design application-specific ICs using the Gould AMI Semiconductors standard-cell library, which consists of 180 cells for designing 3-μm double-metal CMOS circuits. Designers can use the Dash 3C to do schematic entry, logic simulation, and circuit timing, and to prepare netlists. Prototypes arrive 8 to 12 weeks after the netlist is sent to the foundry. Pricing will vary with circuit complexity, quantity, and packaging. ☐

A BERNOULLI DISK DRIVE WILL BE OFFERED FOR HP'S PERSONAL COMPUTERS

Users of Hewlett-Packard Co. personal computers will soon be able to get a Bernoulli disk drive from Bering Industries of Fremont, Calif. Until now, Bernoulli technology, in which a cushion of air separates the flexible disk media from the read-write head, was available only from Iomega Corp., Roy, Utah, and only for IBM Corp. Personal Computers. Bering's 8020-RM uses 8-in. 20-megabyte removable cartridges and works with any HP computer using the CS/80 or SS/80 disk-drive command set—such as the Vectra. The $4,890 drive and $95 cartridges will be available at the end of April. ☐

LANIER LOCAL-NETWORK SERVER GIVES PCs MULTITASKING CAPABILITIES

Harris Corp.'s Lanier Business Products Inc. subsidiary is unveiling a local-area-network server that links up to eight IBM Corp. Personal Computers and Harris Concept 2000 and 2100 personal computers and gives them multitasking capabilities. The 80186-based server features Perspective, the Atlanta company's menu-based interface, which lets users select applications, and even toggle between two applications, without worrying which operating system they must run under—Xenix, MS-DOS, or Harris H-DOS. Priced at $8,190, the server comes with 512-K bytes of RAM, a 28-megabyte Winchester disk drive, and two RS-232-C printer ports. The server is available now. ☐

ZILOG TO UNVEIL PORTABLE IN-CIRCUIT EMULATOR

Zilog Inc., Campbell, Calif., will soon provide in-circuit emulation support for users of four of its chips by distributing the new Sophia Systems SA2000 Portable Universal System Analyzer and In-Circuit Emulator. Sophia Computer Systems Inc., a Santa Clara subsidiary of Tokyo's Sophia Systems, will provide technical support. The system features Sophia's SA-DOS operating system, a resident-in-line assembler, real-time execution, and a built-in PROM programmer. The 32-lb portable unit can handle everything from software debugging to system integration without linking with a host computer. It will work with Zilog's 20-MHz Super 8 and 12-MHz Z8 microcomputers and with its 8-MHz Z80H and 4-MHz Z80C 8-bit microprocessors. The price, including software and one probe, is $9,750. It is available now with probes for the Z80H and Z80C. ☐

COMPETITION FORCES INTERLEAF TO CUT PRICES ON PUBLISHING SYSTEMS

Increasingly fierce competition is expected this year in the market for electronic publishing systems, as more players enter and work-station prices fall. One of the latest indications comes from Interleaf Inc., among the most successful vendors in the field [*Electronics*, Dec. 9, 1985, p. 54, and Feb. 24, 1986, p. 76]. Last week, the Cambridge, Mass., firm announced sharply lower prices for several configurations of its systems. Compared with $46,500 previously, a complete Interleaf system now costs $29,900. A major reason for the price drop is new lower-priced work stations from Apollo and Sun. ☐

Electronics

CHIP MAKERS GREET BIPOLAR SALES SURGE WITH CAUTION

THEY'RE MAKING SURE DEMAND IS REAL BEFORE HIKING PRODUCTION

DALLAS

Sales of bipolar chips, the bellwether of the last major recovery in semiconductor bookings, ran stronger than expected in the opening nine weeks of 1986. But chip makers, wary of false recovery signs, are mixing their joy with cautionary measures to maintain a clearer view of what lies ahead.

By most accounts, bipolar order rates are edging ahead of MOS bookings, partly because of the continued strength of shipments for older defense systems and a resurgence in buying by computer houses that have finally exhausted their overfed inventories. According to a major distributor, IBM Corp. has launched a long-awaited new round of chip acquisitions.

Some suppliers say bipolar and MOS technologies are sharing equally in modest increases. However, distributors are fueling much of the jump in bipolar business with an increase in orders of 20% to 30%, say chip makers. One major manufacturer has seen a doubling of bipolar orders since Christmas.

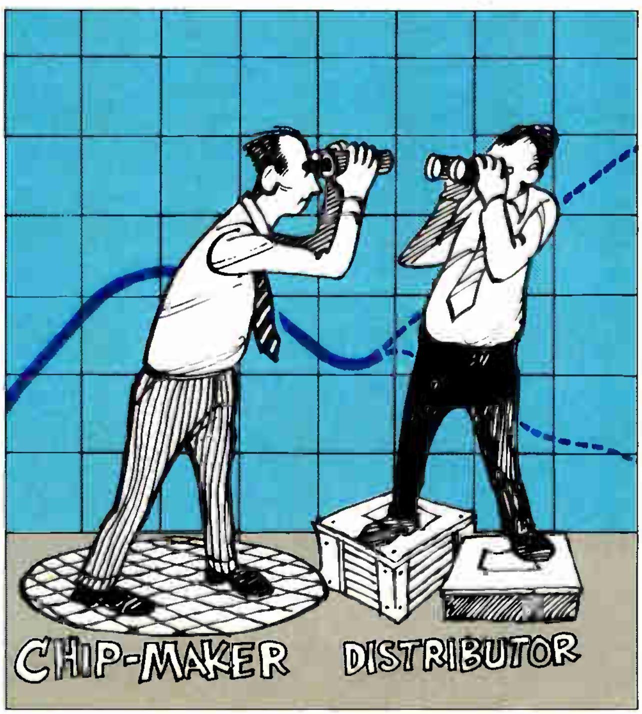
Partly because of distributor ordering, lead times for bipolar logic have stretched from off the shelf to 12 weeks since the start of 1986. When similar signs came on the heels of the 1981-82 recession, chip makers were quick to let the fabrication lines roll. This time, though, silicon houses have slammed the door on eager distributors while establishing data-base links among makers, sellers, and buyers to try to accurately track real-time demand.

"Chip houses have been through a major, major recession and have cut back to where they are lean and mean," explains Howard B. Franklin, senior vice president of distributor operations at Bell Industries Inc., Los Angeles. "I guarantee they will think long and hard about rehiring people and turning on capacity when they are not sure demand is real and sustained."

Since February, short-term moratoriums have been aimed at "heading off indiscrete ordering," says a spokesman for Kierulff Electronics Inc. The Cypress, Calif., company, along with other leading silicon distributors, says it is attempting to cooperate with chip makers to ensure the industry will have ample supplies in the event of a stronger upturn within three to six months.

KID-GLOVES TREATMENT. Recession-riddled semiconductor houses are determined to treat carefully the fragile, five-month rise in general order rates. They still have clear memories of depressed IC prices that resulted from the glut of chip inventories and manufacturing capacity sparked by the record market recovery of 1983.

To avoid the costly errors of past bust-to-boom cycles, many chip makers have built new communication channels with distributors and major direct-sales customers. Most of these links come in the form of new on-line inventory data bases, shared among the computers of silicon manufacturer, seller, and buyer.



Though players in the semiconductor arena are attempting to get more closely in touch with each other's needs, some chip officials admit that automated order-entry systems still must prove themselves. But for now at least, Texas Instruments Inc. has much use for the data-base system it has with large customers and distributors.

"There is still a tendency in the early stages of an upturn for distributors to recognize the probability of a recovery and they try to buy quantities that are disproportionate with their percentage of total historical supplies," says Dwain Chaffin, TI semiconductor vice president and manager of general-purpose logic in Sherman, Texas. "We recognized that early on and discussed the rates with our distributors so we would not get into a situation where we had to say, 'We are not selling you products.' "

LEAD TIMES. TI's computer system, in place since markets boomed two years ago, helped hold lead times on the company's bipolar products to a maximum of 16 weeks, recalls Chaffin. During the latest recession, the Dallas chip maker has expanded the global computer network and is aiming to guarantee that lead times will be no more than six weeks in the event of a market upturn, he says.

The recent moratoriums on bookings to distributors are an early sign of closer cooperation in the marketplace, according to Bell Industries' Franklin. "They just want their backlog to be real, and don't want distributors to get in trouble inventorywise."

Bell Industries was one of the system resellers whose orders for bipolar parts were halted by Motorola Inc. and National Semiconductor Corp. [*Electronics*, March 3, 1986, p. 11]. Signetics Corp. did the same thing to other distributors for three weeks last month. Other major IC houses indicate similar moves could be made throughout the first half of the year. Many are closely monitoring distributor orders, comparing activity there against rises in direct sales to end-equipment companies.

At National Semiconductor in Santa Clara, Calif., incoming orders of 5-V bipolar products doubled in recent weeks from rates recorded in the middle of December. National started the moratorium on distributor orders at the start of February and expects to lift it by the end of this month.

Motorola and Signetics have also lifted much of their ban on new orders, say their national distributors. A spokeswoman for Signetics in Sunnyvale, Calif., explains that the three-week moratorium was an attempt to "avoid the wild kinds of increases that happened two years ago."

While business remains tame by 1984 standards, the big news in the chip markets is about the biggest chip customer. IBM reportedly has slipped back into a buying mood after more than a nine-month absence from bookings. "IBM is back in the market and I know they've started to place some orders," assures Bell Industries' Franklin.

The slow but steady reentry of major chip buyers into the booking stream has helped edge bipolar logic prices up slightly. For example, SGS Semiconductor Corp., which placed a floor on pricing quotes during the depth of the recession, is now winning business without changing pricing strategy, says U.S. operation president Daniel Queyssac.

SGS went without business wins for six months in 1985, but says low-power Schottky logic prices have risen enough that the Phoenix, Ariz., company is now picking up orders for LS parts.

–J. Robert Lineback and Eve Bennett

COMPANIES

GENE AMDAHL GIVES ELXSI A SHOT IN THE ARM

SAN JOSE, CALIF.

A powerful computer house seems to be emerging from the marriage of wealthy but idle Trilogy Ltd. and Elxsi, the once-poor but ambitious maker of a 72-million-whetstone number cruncher. The company is named Trilogy, but it consists mostly of Elxsi and its 64-bit multiprocessor.

Elxsi became a Trilogy division only last October, and it has already absorbed $25 million in cash to soup up its 6400 computer and its marketing. It has also acquired the services of Trilogy founder Gene M. Amdahl, who has decided to quit fighting the IBM giant he helped create and instead look for new markets to develop.

Trilogy, which has abandoned attempts to build a mainframe based on wafer-scale integration, will now concentrate on developing and promoting the Elxsi machine, Amdahl said last week. "Instead of trying to take a share of an existing market from a major company, we are turning our attention to building up a new market."

This week, Elxsi will announce what amounts to a repackaging of its basic 7-million-whetstone 6400 module at significant cost savings. A two-processor Dyad is now available for $520,000, or $37,000 per million whetstones; a four-processor Quad costs $695,000, or $25,000 per million whetstones. The Quad, Elxsi claims, has twice the performance of the Digital Equipment Corp. 8800 at about the same price.

Elxsi is taking aim at the near-supercomputer market, which has attracted a whole new class of companies that support engineering and technical computing. "We want to develop the parallel and multiprocessing market," says Peter Appleton-Jones, the former Cray Research Inc. executive who was named president of Elxsi in January. "We have been missionaries."

"They obviously had to do this," says Jeffry Canin, an analyst who tracks supercomputers for San Francisco investment house Hambrecht & Quist Inc., of the Elxsi price cuts. "They have an attractive product, but they have been in a holding pattern for some time and the high-performance 64-bit market has been attracting a lot more participants."

Elxsi faces competition from Alliant, Convex Computer, Culler Scientific Systems, and Scientific Computer Systems, all of which are shipping or will ship high-end machines this year, Canin notes. In addition, Data General, DEC, and IBM are holding their own. "The major impact of the new players is that price/performance ratios are improving by leaps and bounds," he says. "The advantage Elxsi has is in its 64-bit architecture and that its system is modular."

Quad and Dyad represent an attempt to entice customers with the rewards of multiprocessing. About half of Elxsi's sales are of single units, Appleton-Jones says. Eventually, the company would like to make all of its sales in multiple units, using the single processors as relatively inexpensive add-ons.

Elxsi provides two flavors of Unix, AT&T's System V and 4.2bsd, as well as its own Embos operating system, on the 6400. Unlike some competitors, it does not support vector processing.

Amdahl, architect of the IBM 370 and the Amdahl plug-compatible mainframe, saw the powerful Elxsi machine as just what Trilogy needed after its wafer-scale debacle. Trilogy amassed over $200 million to develop the computer and the wafer-scale technology. When it failed, incurring losses of $89 million in 1984 and $46 million last year, it was left with a still-healthy bank account, some interconnection and packaging technology, and no product.

POTENTIAL. Undeterred, Amdahl went shopping for a company and found what he wanted in Elxsi. "We looked at several semiconductor companies, some workstation manufacturers, and some parallel-computer manufacturers. All but Elxsi were designed up to the hilt. But Elxsi has an awfully large potential because its architecture eliminates bottlenecks. It will support one or two more generations of technology."

IN HARMONY. Elxsi's Appleton-Jones (left) is doing missionary work for multiprocessing; Gene Amdahl likes Elxsi's growth potential.

In the Elxsi machine, all processors share up to 768 megabytes of memory on a single 320-megabyte/s bus. The next generation of semiconductor technology will come from the interconnection techniques Trilogy developed for the wafer-scale project.

Trilogy's thin-film multichip modules have shorter interconnection delays than connections made on a chip—because, Amdahl says, the thin films produce an LC transmission line instead of a lossy RC line. Trilogy pegs its interconnections as 60% faster than transmission on a chip. The company is trying to buy back the rights to its technology from the 4,000 limited partners in its original venture.

The multichip packages are still at least a year away for Elxsi. The results of the initial $25 million infusion, due some time this year, will consist of hardware improvements, some functional changes, and additional software, Amdahl says. Elxsi will also seek ways to tie its systems to other machines, such as those from Control Data, Cray, or IBM. *–Clifford Barney*

INDUSTRIAL

SWEDEN'S ASEA MOVES INTO FIBER-OPTIC SENSORS

VÄSTERÅS, SWEDEN

Europe is about to get its first commercial entry in the nascent optical-fiber sensor field—the first, that is, to step outside the field of fiber-optic gyroscopes [*Electronics*, Sept. 30, 1985, p. 38].

ASEA AB, the Swedish robotics and industrial-control giant, will soon begin to test the waters of that market with two new instruments based on novel optical-fiber sensor schemes. These are only the first of what company officials hope will be a product line encompassing a full range of such instruments.

One obstacle facing the venture is the inevitable inertia of potential customers. "The heavy electrical industry is very conservative," says Anders Linge, development manager for ASEA Research & Innovation, the company's research and development subsidiary. "They count on a 30-year life span for a transformer and are reluctant to use new sensors unless they are sure that they will last as long."

Still, Linge is confident that optical-fiber sensors will find their place in the market because they perform well in certain applications where electronic sensors can't fill the bill. The sensors' immunity to electromagnetic noise, for example, not only eliminates the interference problems frequently present in electrical measuring systems, its cables can even be laid alongside power cables.

HAZARDOUS ENVIRONMENTS. Other advantages abound. The galvanic separation between sensor and instrument opens the possibility of performing measurements on objects at high electrical potential, and the dielectric characteristics of optical-fiber cables make them safe for taking measurements in environments subject to fire and explosion. Also, systems can be highly miniaturized and made resistant to corrosion.

ASEA's first offerings will be a temperature sensor and an accelerometer for measuring vibrations. They are based on similar wavelength-multiplexing schemes and are both small and suited to hostile environments.

The temperature sensor is based on the principle that light absorbed by certain semiconductor crystals will be re-emitted with a wavelength spectrum determined uniquely by the crystal's temperature. The sensor consists of a glass capillary tube in which a gallium arsenide crystal, embedded in silicone resin, lies between epitaxially grown gallium aluminum arsenide layers. This sensor is coupled to a standard multimode optical fiber that is, in turn, connected to the measuring instrument.

A 7,500-Å light-emitting diode in the instrument package sends light down the fiber to the sensor. The sensor's crystal absorbs and re-emits this light, sending a light signal back to the instrument package. There, it is detected by a two-channel wavelength-demultiplexing detector. After amplification, a divider circuit converts the detected signal to the temperature of the sensor as a function of the variation in the detected wavelength spectrum compared with the spectrum of the original signal emitted by the LED.

The instrument can measure temperatures from 0°C to 200°C with an accuracy of ±1°C, a resolution of 0.1°C, and a response time of less than 5 ms. Using telecommunications-grade all-silica fiber, it is possible to measure temperatures up to 500 meters away. ASEA offers the system as both a stand-alone instrument for laboratory use and as a 24-channel affair for integration into an industrial control system.

ASEA's accelerometer is also based on a GaAs sensor, though a more complex one (figure). In this case, the sensor takes the form of a cantilever beam—something like a diving board—realized by selective chemical etching and liquid-phase epitaxy on a GaAs substrate and attached to a fiber end. The underlying principle is that light reflected by the sensor will vary in amplitude as a function of the sensor's motion.

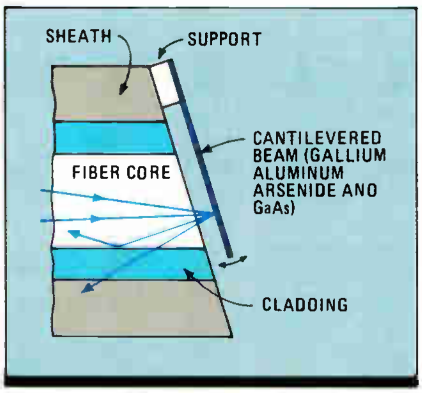
DOUBLE EFFECT. The sensor, which is GaAs and GaAlAs grown on a GaAs substrate, interacts with received light in two ways. The beam's polished surface acts as a mirror, reflecting light from the LED (identical to the part used in the temperature-sensing instrument) back toward the instrument.

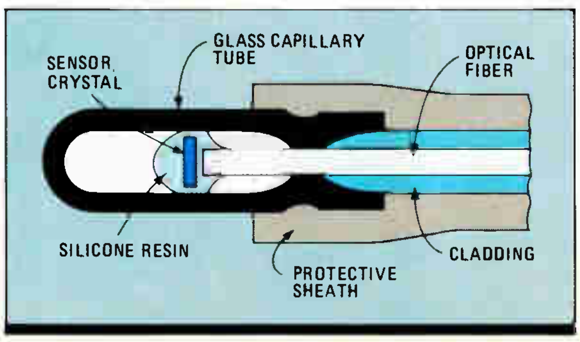
The sensor's motion modulates the light's intensity and this modulation is detected by the instrument as a measure of the sensor's acceleration. As in the temperature sensor, the GaAs surface of the sensor at the same time converts the light to a different, known wavelength. When the signal is demultiplexed, its luminance serves as a reference that allows the detector to correct for any unwanted variables introduced by microbending of the fiber or changes in environmental conditions.

The accelerometer's sensor measures only 22 by 14 by 9 mm and weighs a feather-light 3 g, a major consideration in measuring acceleration. It can be used at up to 200 m with a bandwidth of 0 to 1,000 Hz, a resolution of 0.5 G, and a dynamic range of 70 dB. It will be first offered in a configuration featuring eight measurement channels.

Should the market for these instruments develop as the company expects, it plans to expand its line by moving on to pressure sensors. One encouraging fact for the economic feasibility of these systems is that all components, fibers, LEDs, detectors, and connectors are standard parts. ASEA produces only the GaAs crystals. The instruments are being marketed under the brand name ASEA Meter. *–Robert T. Gallagher*

SHAKE IT. ASEA's accelerometer measures light reflected from a cantilevered beam.





HOT SPOT. A GaAs crystal sensor re-emits absorbed light at wavelengths corresponding to its temperature.

U.S. GaAs MAKERS MOVE TO CATCH UP

COLORADO SPRINGS

With concern growing that the Japanese are pulling away from the Americans in producing gallium arsenide integrated circuits, a group of U. S. researchers and managers involved in GaAs have joined forces to drive GaAs semiconductor processing out of the laboratory and into mainstream production.

The first step will be to sponsor a production-oriented conference. The embryonic industry's future depends on the establishment of a recognized community of manufacturing experts, says He Bong Kim, chairman of the board of directors for the first U. S. Conference on GaAs Manufacturing Technology.

Kim says there are two goals for the conference, which will be held immediately following the IEEE Integrated Circuit Symposium in Grenelefe, Fla., in late October. One is to attract new talent, the other to discuss the industry's biggest stumbling blocks: materials growth, packaging, production yields, processing techniques, quality control, standards, and testing.

Without attacking these trouble spots, industry sources say, U. S. companies will lag behind Japanese chip makers, who many think are already more advanced in GaAs manufacturing techniques than their counterparts in the U. S. and Europe. Worldwide demand for GaAs is growing at a compound annual rate of almost 30%, with demand for GaAs substrates expected to reach 16.9 million in.^{2} by 1988, according to market researcher VLSI Research Inc., San Jose, Calif. (chart).

CITIZENS ONLY. Trying to garner as great a share of that as possible for the U. S., the conference's organizing committee decided to open the forum to U. S. citizens only. As the U. S. GaAs industry progresses along its learning curve, they say, it is essential that U. S. companies share their advances or face ruin at the hands of foreign competition.

Other conferences are not oriented toward pooling such expertise, say the organizers. "All the GaAs forums are research forums," says Kim, who has been involved with the technology since 1959 and is now executive vice president for GaAs operations at Ford Microelectronics Inc. in Colorado Springs.

The annual IEEE GaAs IC Symposium and other conferences consider manufacturing issues "mundane," he says, and as a result discourage research into those areas. "We don't have any recognition in the manufacturing technology area. So university students have this stigma in their minds that the only way they can achieve recognition is in the labs. I'd like to win maybe 10% of these top brains into manufacturing technology, but how do we do it? We have to make sure their work is visible in their field."

ICs WILL SOON LEAD GaAs GROWTH WORLDWIDE

Year	Demand for substrates (millions of in.^{2})	Demand for discrete devices (millions)	Demand for ICs (millions)
1984	5.9	3,172.4	7.2
1985	6.9	3,319.5	12.5
1986 (est.)	8.3	3,441.0	24.1
1987 (est.)	11.0	3,364.3	51.6
1988 (est.)	16.9	3,022.0	125.2

SOURCE: VLSI RESEARCH INC.

Attracting top academic talent to the manufacturing fold is one of the GaAs conference's highest priorities, says treasurer Lester Eastman, an engineering professor at Cornell University. He is working at IBM Corp.'s Thomas J. Watson Research Center, Yorktown Heights, N. Y., while on sabbatical. "The most important reason for the conference is to attract bright young people to the technology—or it won't take off the way silicon did," he comments.

Industry participants agree. The conference's decision to link closely with universities goes beyond the desire to attract academic talent to the technology, says Allan Papz, president of TriQuint Semiconductor Inc., a Beaverton, Ore., GaAs company. "We want universities to have GaAs manufacturing as part of their curriculum." By rooting the study of GaAs manufacturing in the universities, Papz believes, U. S. GaAs companies will need to spend less time teaching their junior engineers the rudiments of the technology.

Besides the closed technical meetings, the conference will feature an open exhibition where GaAs manufacturers can show their wares—the only such exhibition in the U. S., Kim says. "This might not be a final answer for everything, but it's sure going to be better than what we've got." *–Tobias Naegele*

MEDICAL

BUS STANDARD FOR HOSPITALS IS NEXT

WASHINGTON

Just as heavy industry strives to link so-called islands of automation on the factory floor, the medical community wants to connect microprocessor-based hospital instrumentation. This effort, somewhat analogous to the Manufacturing Automation Protocol, aims at development of a Medical Information Bus (MIB) standard that could provide a needed interface between bedside devices and a host computer.

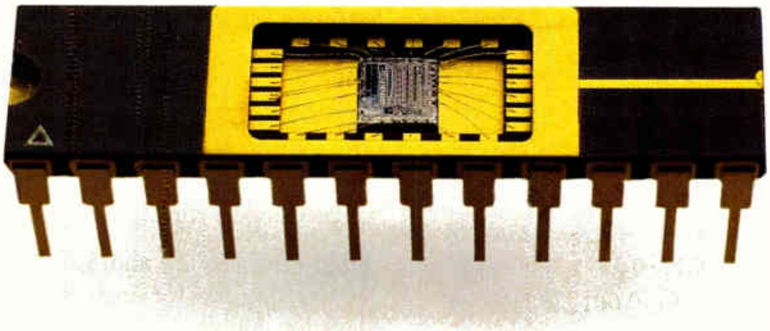
There are two pressures for establishment of the proposed MIB: the present inability to connect medical equipment such as electrocardiogram and blood-pressure monitoring devices to hospital computer systems, and a government drive to reduce health-care costs. Proponents of MIB say it could be ready for submission to the Institute of Electrical and Electronics Engineers' Engineering in Medicine and Biology Society Standards Committee in a year and adopted within two years. The proposed standard has been sanctioned as IEEE P1073.

Standard LANS can't handle the volume of data

First proposed by an interdisciplinary consortium of hospitals and vendors in 1982, MIB will be the subject of a status report to be delivered at this week's Southcon/86 meeting in Orlando, Fla. The need for such a standard stems from the large amount of information produced by health-care devices that now must be painstakingly entered into computers by hospital staff, according to Ben F. Cammack, the report's author.

Cammack, director of clinical computer systems at Crawford W. Long Memorial Hospital, Atlanta, says there are no readily available interfaces to give host computers access to medical information. Moreover, standard local networks cannot handle the volume of data produced by monitoring devices. Data in hospitals is measured in data points,

REVOLUTION BY ANALOGY.



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BVDSS	$>10_V$	$>10_V$
$K' = \frac{\mu c}{2}$ linear region	21–25	6.5—8.5
B_E (Long Channel)	$0.8–1.2_V{}^{1/2}$	$0.4—0.6_V{}^{1/2}$
Cap. Gate 10^4 PF/cm^2	8–10	8–10
Cap. Poly to Sub 10^4 PF/cm^2	0.55–0.65	0.55–0.65
Cap. Metal to Sub 10^4 PF/cm^2	0.27–0.32	0.27–0.32
Junction Depth	$0.4\mu–0.6\mu$	$0.2\mu–0.4\mu$
P-Well Junction	$2.5\mu–3.5\mu$	
Poly P_S	$15–30\Omega/\square$	$15–30\Omega/\square$
Diffusion P_S	$20–40\Omega/\square$	$60–100\Omega/\square$
VTF Poly	$>10_V$	$>10_V$
ΔW	$—1.0\mu$	$—1.2\mu$
LEFF	$1.0\mu–1.4\mu$	$1.3\mu–1.7\mu$
Substrate Resistivity	$2.5K\Omega/\square$	1.2Ω/cm

Feature Size: 3μ

	N-Channel	P-Channel
VTEO	$0.5–1.0_V$	$0.5–1.0_V$
BVDSS	$>10_V$	$>10_V$
$K' = \frac{\mu c}{2}$ linear region	18–21	6–8
B_E (Long Channel)	$0.8–1.4_V{}^{1/2}$	$0.4—0.6_V{}^{1/2}$
Cap. Gate 10^4 PF/cm^2	5.9–7.0	5.9– 7.0
Cap. Poly to Sub 10^4 PF/cm^2	0.45–0.55	0.45–0.55
Cap. Metal to Sub 10^4 PF/cm^2	0.2–0.25	0.2–0.25
Junction Depth	$0.6\mu–1.0\mu$	$0.4\mu–0.8\mu$
P-Well Junction	$3.5\mu–4.5\mu$	
Poly P_S	$15–30\Omega/\square$	$15–30\Omega/\square$
Diffusion P_S	$10–30\Omega/\square$	$30–70\Omega/\square$
VTF Poly	$>10_V$	$>10_V$
ΔW	$—1.0\mu$	$—1.0\mu$
LEFF	$1.4\mu–2.0\mu$	$1.8\mu–2.4\mu$
Substrate Resistivity	$2.5K\Omega/\square$	$1.0–1.5\Omega$/cm

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with one point corresponding to a reading from a machine. Cammack estimates that data values range from 10,000 to 20,000 data points per patient per day.

He says work has focused on creating a standard to allow users "to buy a host computer, a cable, and a device that all state compliance with IEEE 1073, and be able to plug them together with the MIB and software running on the host."

MIB is being designed to support devices using both waveform and non-waveform communications. Key design features include a MIB communications controller—a microcomputer with interfaces to a host computer and the bus—that would poll each device.

As messages are received from devices by the controller, they would be buffered and transferred to the host computer for processing, says Cammack. To poll all device parameters every 10 seconds, a 9,600-baud network bandwidth will be needed.

THREE MAIN FUNCTIONS. Cammack says MIB will serve three main hospital functions: allowing data to be collected from up to 16 devices on the bus by periodically interrogating each one for such information as volume infusion and ventilation rates; allowing alarm information to reach the host computer within 5 seconds; and providing protocols for host control of monitoring devices to allow, for example, closed-loop drug infusion and ventilation control.

Like MAP, the proposed standard will use layers from existing standards models. "We don't want to reinvent the wheel," says Ron Norden-Paul, chairman of the IEEE P1073 Committee. Hence, MIB would be based on the International Organization for Standardization's seven-layered Open Systems Interconnection reference model.

MIB will support waveform and non-waveform needs

Besides the need for interfaces, Norden-Paul says, federal pressure to contain health-care costs have resulted in cutbacks in Medicare, and Medicare funding has given the project added significance. He estimates that 25% of a hospital's budget is spent on patient documentation, while half goes toward labor costs, including operating instruments and performing patient charting. Although he cannot estimate the potential savings, Norden-Paul says automating these tasks would greatly reduce labor costs for data collection and charting while reducing staff workloads.

The MIB effort has also brought competing vendors together, for the first time, to modify their products to the standard. Antitrust strictures meant that "prior to 1073, vendors couldn't even sit down together at the same table," notes Cammack. Now AT&T Bell Laboratories, Hewlett-Packard Co., and others have joined to develop a prototype design for MIB using off-the-shelf hardware. In a separate effort, Latter-Day Saints Hospital in Salt Lake City is developing its own MIB prototype.

Latter-Day Saints and Ivac Corp., San Diego, began prototype bus development just over a year ago, says Bill Hawley, the hospital's director of biomedical instrumentation. Once the U.S. Food and Drug Administration grants approval for clinical trials, he says, infusion pumps, ventilators, and simple monitoring devices will be connected to the prototype to capture data currently hand-charted by nurses. Approval could come as early as the end of March, says Hawley. *–George Leopold*

COMPONENTS

FILTER TUNES ITSELF AUTOMATICALLY

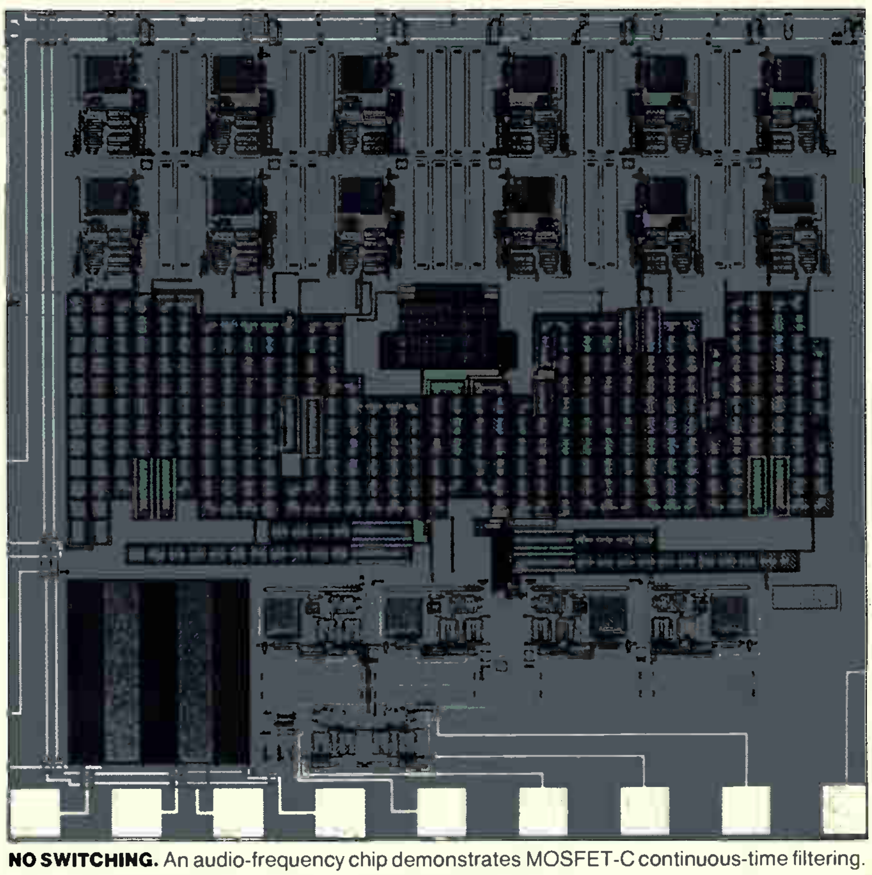
NEW YORK

A new, fully integrated, continuous-time filtering technique could successfully compete with switched-capacitor, digital, and conventional active filters. Automatically tuned MOS transistors take the place of resistors in the new filter type, called MOSFET-C.

Yannis Tsvidis and the group he leads at Columbia University's department of electrical engineering and the Center for Telecommunications Research in New York have been developing filter techniques compatible with processing techniques for very large-scale integrated circuits. On-chip automatic filter tuning or compensation was a critical part of the effort, notes Tsvidis, because the team wanted to design a filter insensitive to fabrication tolerances, environmental variations, and parasitic effects.

ECONOMICAL FILTER. The Columbia researchers also sought a filter with substantial signal-handling capability, good power-supply rejection, and economy—a small chip area and low power use. Concrete results achieved so far with the MOSFET-C technique include a working fifth-order elliptic low-pass filter operating in the audio-frequency range.

The experimental chip was fabricated in CMOS by AT&T Bell Laboratories, Murray Hill, N.J. Tsvidis says the chip



NO SWITCHING. An audio-frequency chip demonstrates MOSFET-C continuous-time filtering.

proves that it is possible to get frequency-response precision on a par with that of a monolithic switched-capacitor circuit—the MOSFET-C filter's principal competition—without the complications caused by sampled-data operation.

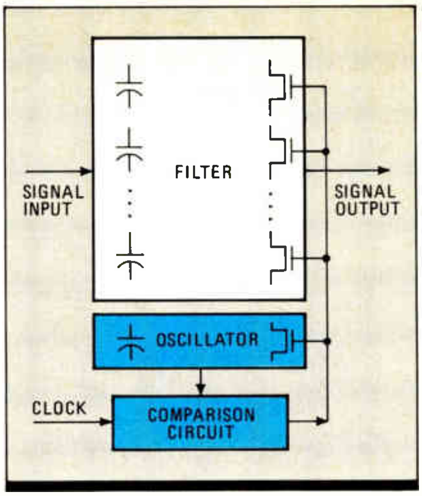
The MOSFET-C technique uses MOS transistors as voltage-controlled resistors. They take the place of resistors in an RC filter circuit, making the RC product in the circuit adjustable.

However, the MOS transistor is a nonlinear element, so there's a second critical requirement: the accurate cancelation of the transistor's nonlinearity. The MOSFET-C circuit uses a special type of balanced structure for each of the filter's integrator elements to achieve linear input/output behavior for each building block.

Control circuitry is used to stabilize the RC products of the filter. The filter and all of its MOSFET resistors, capacitors, and operational amplifiers, along with both an oscillator made of the same structures and a phase comparator, are integrated on one chip. The phase comparator's output adjusts itself until the oscillator tracks the clock input, stabilizing the RC products in the oscillator. The RC products in the main filter, whose components match those in the oscillator, are also stabilized.

Although the frequency response in a switched-capacitor filter can be scaled by varying the clock frequency, such filters exhibit some drawbacks that the new type does not. For example, switched-capacitor filters are sampled-data systems and usually need input anti-aliasing and smoothing filters. Also, switching can alias power-supply and internally generated high-frequency op-amp noise into the baseband and contaminate the signal.

Finally, switching causes clock feedthrough, which is difficult to predict and eliminate. This is especially severe at high frequencies. In a continuous-time MOSFET-C filter, though, the clock frequency can be chosen outside the baseband, minimizing this feedthrough.



TUNED. As a phase comparator stabilizes the oscillator of a MOSFET-C filter, it adjusts the RC products of the filter elements.

Another possible competitor to MOSFET-C, the monolithic digital filter, has the drawback of requiring both analog-to-digital and digital-to-analog converters for input and output, making the overall design difficult and subject to the limitations of the data converters in such areas as quantization noise.

HIGH STABILITY. The 3-dB frequency response of the experimental voice-band MOSFET-C filter was found to vary by more than 40% over the commercial temperature range (0° to 85°C) with its automatic-tuning circuitry deactivated. With the on-chip tuning system connected, the frequency response became stable to better than ±0.1% over the same range.

Amplitude stability for the experimental chip, designed by then-graduate-student Mihai Banu, is better than ±0.4 dB over the same temperature range. With ±5-V power supplies, the filter handles differential signals of more than 15.7 V peak to peak before distortion hits 1%.

Tsvidis's group is developing a filter capable of operation at about 450 kHz using the same technology and has plans to go much higher in frequency. Several telecommunications companies are planning to apply the technology to their high-frequency filter requirements, Tsvidis says. *–Jerry Lyman*

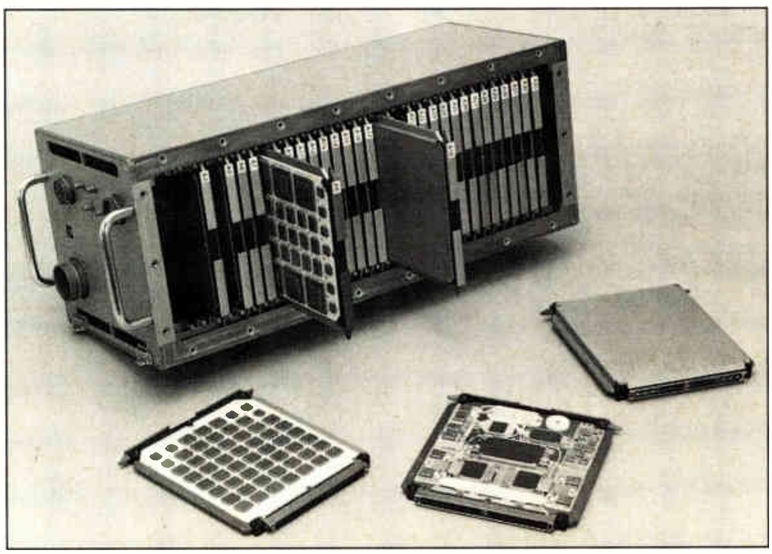
MILITARY

HOW TI IS MOVING INTO POWER SUPPLIES

DALLAS

Texas Instruments Inc. is mounting an assault on the market for military high-frequency switching power supplies. Its effort so far has been low-profile in more ways than one: TI remained quiet during its six years of development work, and the product of its labor is a slim, high-density power supply that measures only ½ in. high and can slip into a standard card rack. Now the company is going public, demonstrating the low-profile power supply to the defense community and talking about it as a strong candidate for a standard supply in what is now a custom business.

Designated the HVS-200, the 200-W power supply aims to reduce the size of modules and lessen the use of costly custom-designed supplies, which have pervaded major battlefield systems in the past three decades. The 1.2-lb module also represents an effort to establish a new high-volume military business for the company.



STANDARD FIT. TI's HVS-200 power-supply prototype will fit into a standard card rack along with other high-density electronic modules.

Reducing the size of power supplies, which is a central theme behind TI's push, has been a top concern of defense procurement agencies. The difference between the amount of space needed for power supplies and that needed for digital electronics has widened as defense contractors begin to deploy very large-scale integrated circuits and pack more ICs on boards by using surface-mount technology.

"Power supplies have not really kept up with digital technology," says Jesse C. Wilson, manager of the Advanced Microelectronics Division in TI's Defense Systems & Electronics Group. "In the future, power supplies will become a predominant part of military systems," he adds,

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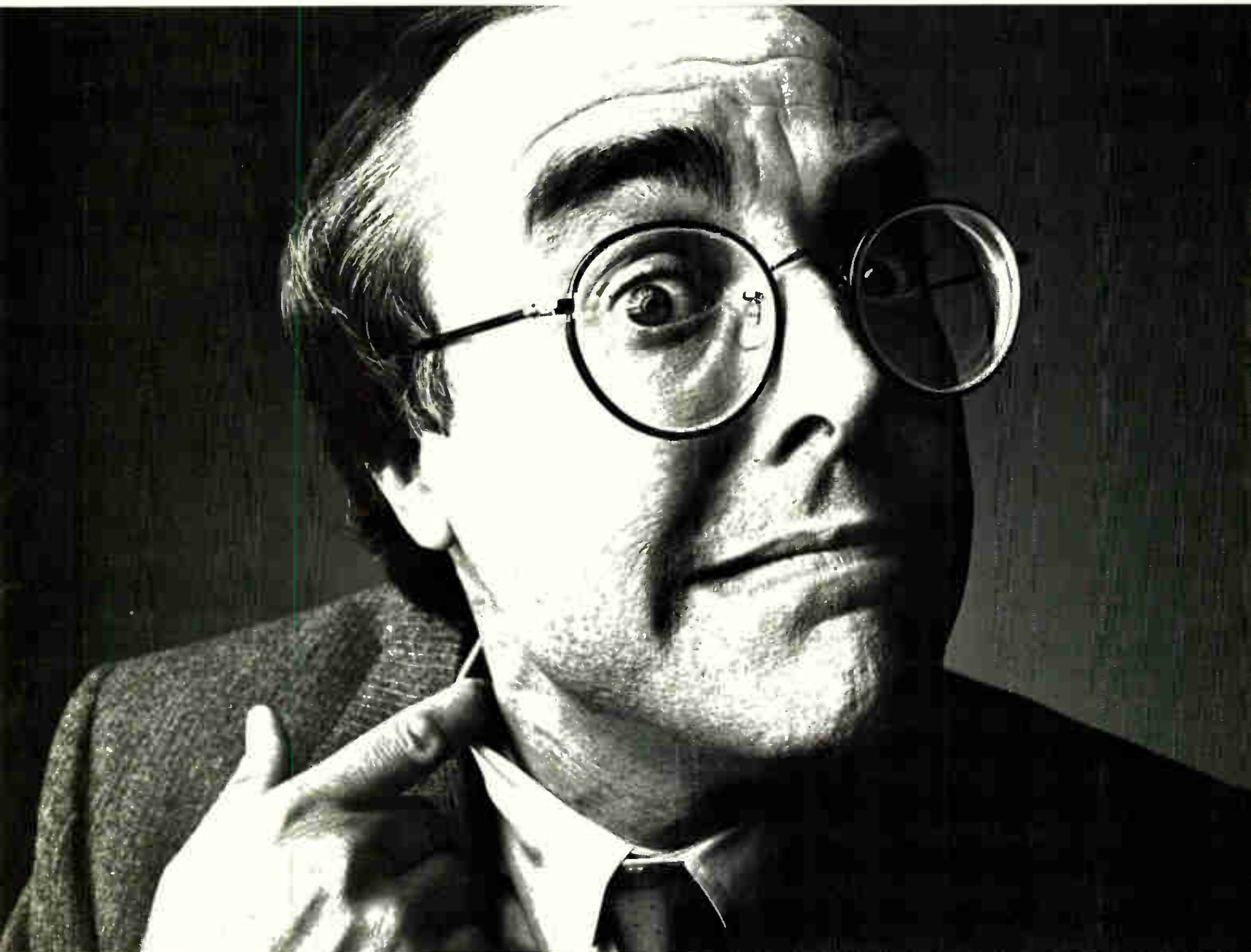

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referring to efforts to accelerate VLSI use, such as the Pentagon's Very High Speed Integrated Circuits program. Wilson says power supplies will take up half the weight of systems, instead of the 10% to 15% that has been common.

Military power supplies—which are usually squeezed into weapon-systems hardware and face a rigorous barrage of environmental tests—do not come cheap. A custom supply for a system can cost from $5,000 to $20,000 in large volumes. A fully qualified off-the-shelf power supply would save custom development costs for each new system, and would pack in more features while taking up less space than a typical custom supply, TI officials argue.

The HVS-200 prototype measures 5.5 in. deep by 6 in. wide by ½ in. high. The single-output supply can be set to provide 2, 3, or 5 V at a power level of 200 W. At 5 V, the module achieves an 80% efficiency rating, says Larry Rosser, manager of advanced power supplies in the defense group.

ALL IN ONE. The idea is to make the power supply in the same form factor as high-density electronic modules so all units can be held in a standard card rack. "This is the one we are 'maturing' for production," Rosser says of the HVS-200.

The unit, which takes a 270-V dc rectified input and provides a 5-V output, can be tied by means of its 104-pin connector to work in parallel with redundant power supplies—another advantage over custom supplies. The redundant supplies will allow defense systems to complete missions when harsh battlefield conditions knock out one of a bank of power modules.

Traditional military measurements give an idea of how this new power-supply module stacks up in size against older units. The module has a rating of 10 to 15 W/in.^{3} and 154 to 231 W/lb. Older switching supplies, made from discrete components, have demonstrated only 1 to 3 W/in.^{3} and 20 to 40 W/lb. More important, reliability will increase with high-density power supplies, according to TI estimates, nearly tripling mean time between failures.

TI's power-supply prototype, aimed at applications ranging from communications to digital signal processors, was made possible by the evolution of several key technologies. They include power leadless chip carriers, custom hybrid circuits, low-profile high-density magnetics, high-density capacitor filters, thick-film circuits, and tighter layouts.

TI has one contract to develop high-density power supplies for the Army. In the coming year, the company plans to work closely with defense procurement agencies to establish what TI believes will be the first standard configuration for high-density switching supplies.

The Defense Systems & Electronics Group, which has long made linear and switching supplies for its own equipment contracts, is planning to introduce low-profile power supplies on the military market early next year. From there, TI intends to follow a course similar to the one it has taken in other electronics markets: establish a widely applicable standard based on a highly manufacturable product, then provide more features for less money by producing in volume and moving down the learning curve. *–J. Robert Lineback*

AEROSPACE

EUROPE AIMS FOR LEAD IN INFRARED ASTRONOMY

HEIDELBERG, WEST GERMANY

Europe is gearing up to pull ahead of the U. S. in infrared astronomy, an important area of space research. With money now coming from the European Space Agency, researchers throughout the continent are busy developing the experiments and measuring systems that the Infrared Space Observatory will carry in 1992.

The observatory, Europe's biggest research satellite to date, will be developed by an international consortium under a $250 million ESA contract that includes the expenses for the launch. The 10-odd countries in the project will pay for the experiments and measuring systems.


BIG BIRD. The Max Planck Institute's Lemke says Europe's IR observatory can see a snowball 3,000 km off.

With funding not yet approved for the competing U. S. effort, the Space Infrared Telescope Facility, "we Europeans have a good chance for a top position in the scientifically and technologically important field of infrared astronomy—at least until the launch of the SIRTF," declares Dietrich Lemke, group leader at the Max Planck Institute for Astronomy, Heidelberg. Lemke is one of four prinicipal investigators ESA has picked to coordinate the development of experiments and measuring systems in the participating countries.

Carrying the 1.8-ton, 15-ft-high observatory into space will be an Ariane-4 rocket, which will put it in an elliptical orbit whose most distant point from earth will be 39,000 km. During each orbit, the satellite will make observations for up to 10 hours without interruption. Its mission will last for at least 18 months, its operational lifetime being limited by its supplies of helium and hydrogen.

The ISO aims to investigate the invisible heat radiation from different sources in the universe, which it will pick up with an on-board telescope 60 cm in diameter and cooled to –270°C. The findings of this astrophysical research project will give astronomers a better understanding of such celestial phenomena as the birth of stars.

The observatory will carry devices that measure 2- to 200-μm wavelengths, providing a nearly complete analysis of IR radiation. The tools include high-resolution cameras, spectrometers, and photometers, which will monitor the radiation's distribution, strength, and composition.

Thanks to intensive research work in crystals, European solid-state researchers have made significant advances in IR detector technology in recent years. Since the mid-1960s, when IR astronomy began in earnest, they have raised the sensitivity of de-


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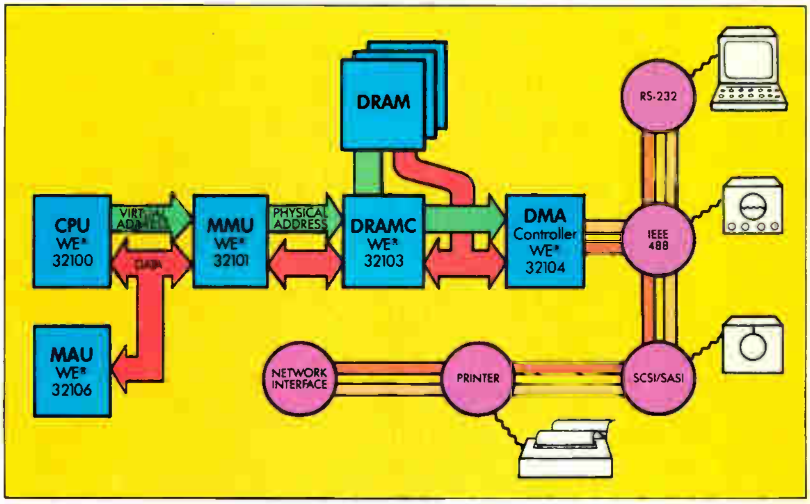

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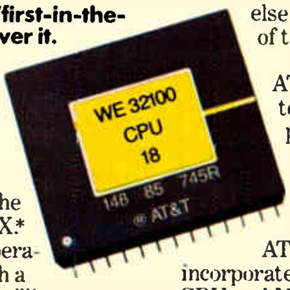

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tectors more than 100 times so that now, depending on wavelength, the detectors can sense radiation power levels of 10^{-17} W.

Most detectors for the observatory's experiments and measuring systems are being developed by the Battelle Institute in Frankfurt, AEG Research Laboratories in Ulm, West Germany, and French industry, in close cooperation with institutes in participating countries. The detectors consist of semiconductor crystals such as silicon or germanium with gallium, beryllium, phosphorus, or other dopants. When low-energy IR particles hit the crystal, they raise its conductivity very slightly.

To make materials for IR detectors, techniques are needed to control doping level, impurities, lattice dislocations, and charge-carrier lifetimes. The material combination of the semiconductor is crucial in detector design because it determines the wavelengths to which the detector responds. For example, silicon with a gallium dopant senses wavelengths of up to 16 μm, and phosphorus-doped silicon works for wavelengths up to 28 μm. For germanium-beryllium and germanium-gallium combinations, the values are 50 and 120 μm, respectively.

Furthermore, by subjecting the doped base material to stress, the operating wavelength can be raised. Researchers at the Battelle Institute applied single-axis pressure to a germanium-gallium material and increased its wavelength sensitivity from 120 to 200 μm.

The detector and other analysis gear are housed in a cryostat cooled to –270°C to shield them from surrounding heat sources. Otherwise, heat sources would generate too much local noise—on the order of 10^{-8} W.

The cooled space observatory offers a thousandfold improvement in sensitivity compared with gear operated on or near the earth's surface. This translates into a 30-times-higher observation range, so that very distant objects can be seen, and a shorter measuring time. As an example of the ISO's sensitivity, Lemke says it can detect a 0°C snowball 10 cm in diameter and 3,000 km distant.

The observatory's sensitivity will also be about 1,000 times better than that of the Infrared Astronomical Satellite (IRAS), the first IR observatory, which U. S., British, and Dutch groups built and launched in January 1983. The prime reason is that the three-axis-stabilized satellite keeps the equipment oriented toward the source. IRAS equipment scans the universe, looking at a single IR source for only a short time during each pass. *–John Gosch*

A major thrust is developing IR detectors

PACKAGING

THE LATEST WAFER-SCALE DESIGN IS A HYBRID

AUBURN, ALA.

The quest continues for a practical way to put entire systems on single wafers, even though the earlier attempts at wafer-scale integration were plagued by intractable problems with yield and discretionary wiring [*Electronics Week*, April 1, 1985, p. 49]. People are not giving up because system performance now depends as much on the connections between the chips as it does on what goes on in the chips themselves. Now a team of Alabama researchers is developing a silicon-based, hybrid wafer-scale packaging technology that they say promises to solve these problems.

The group, which is located at the Alabama Microelectronics Science and Technology Center of Auburn University's electrical engineering department, uses a technique that inserts finished and tested chips into holes cut in a wafer already carrying system interconnection wiring. This work is financed by a contract from Semiconductor Research Corp., Research Triangle Park, N. C. (see story, p. 52) and will be described at the Southcon/86 meeting in Orlando, Fla., this week.

The new technique combines the best features of thin-film hybrid and monolithic technologies. Tested integrated circuits are mounted in holes in silicon wafers and then connected using a standard aluminum two-level metalization process. It is, in fact, a strength of the approach that it calls for no technological breakthroughs. "The biggest problems on this project are engineering and materials selection," says researcher Richard C. Jaeger.

Precise holes are anisotropically etched through the back side of a silicon wafer using wet-chemical techniques. Now the wafer just supports the chips and provides a medium for metal interconnections, but in the future it may be processed to include additional circuitry.

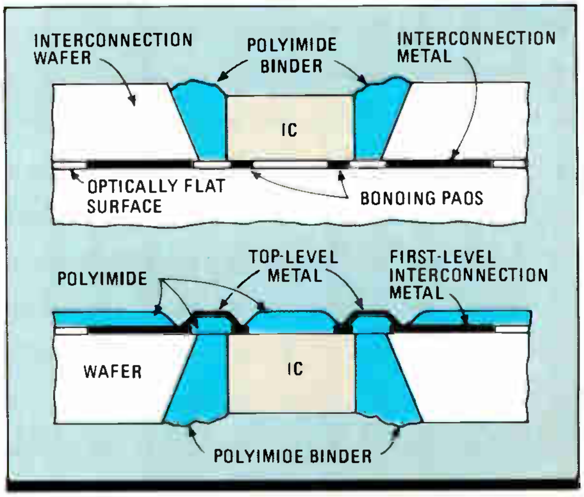
A photoresist process for patterning the metalization around the holes has been developed. Etched wafers have been oxidized at 1,150°C without structural failure, demonstrating that devices can be fabricated conventionally on the wafer after the holes are etched.

FACE DOWN. After the wafer substrate is fabricated, chips are mounted face down in the holes using an optically flat surface to achieve planarity between the wafer and chip surfaces. A binder then holds the chips in place. The wafer is turned over and coated with an interlevel dielectric, such as polyimide. Pads on the chip are connected to wafer pads by the two-level metal process.

Polyimide and epoxy have been used as the binder that holds chips and fills the gap between the edges of the chip and the wafer, yielding steps of less than 2 μm. When used as the interlevel dielectric, polyimide also smooths the chip-to-wafer steps to pave the way for second-layer metal. It is essential to find a polyimide that will not contaminate the mounted chips, yet comes close to matching the silicon's thermal coefficient of expansion. Wire-bonding techniques could also be used, eliminating the need for the second-metal layer.

Possible applications for the packaging technique are large-scale memories and array processors. Large-scale optoelectronic ICs are another possibility, because the wafer-scale technique has inherited from thin-film hybrid technology the ability to combine high-speed GaAs digital and optical devices with high-density silicon devices.

The Auburn group is selecting materials and developing the manufacturing process. It has used test structures to demonstrate basic feasibility; demonstration wafers are due in 1987.*–Jerry Lyman*



FLAPJACK. Auburn University researchers, after fixing tested chips into holes in a wafer, flip it over to add wiring.

INSIDE TECHNOLOGY

FOUND: THE FINAL LINK TO THE ONE-CHIP SYSTEM

EEPROM STANDARD CELL INTEGRATES SET AND RESET FUNCTIONS

A whole new world is opening for systems designers: the true one-chip system. A new line of standard cells based on rugged 1-bit electrically erasable programmable read-only memory will let designers integrate set, wait, and reset operations on the same chip with analog and digital circuitry. Until now, designers of application-specific integrated circuits had to assign such operations to conventional potentiometers and switches—unless they were willing to go the full-custom route.

The new CMOS standard cells, with their nonvolatile flip-flops and latches, do more than provide the first economical on-chip replacements for manually adjustable components, says their developer, Sierra Semiconductor Corp. They also free designers to develop many new kinds of systems. Subsystems with zero standby power, self-calibrating peripherals, self-adapting instrumentation, automatically testable equipment, and remotely maintainable systems are some of the expected applications.

For example, subsystems with serial transmission lines, such as a typical remote-sensor subsystem (Fig. 1) can still have serial transmission lines when reduced to ASICs, says the San Jose, Calif., maker of CMOS ASICs. Such designs could be powered from an ac line—or even from the signal line—with a simple diode rectifier. If the nonvolatile cells are to be programmed remotely, the chip would contain a high-voltage interface cell containing a charge pump.

Each cell contains a full-fledged EEPROM with a total storage capacity of 1 bit [*Electronics*, March 10, 1986, p. 14]. Although a 1-bit EEPROM does not sound like much, it is a universal element for creating a limitless variety of pot- and switch-like circuits in ASICs at a cost of only pennies. Sierra Semiconductor also has developed on-chip programming cells, so circuits can be programmed by data input or by other cells on the chip for self-calibrating peripheral controllers, sensors, and other applications. Depending on chip design, the nonvolatile circuits can serve either as externally programmed replacements for existing designs, or as the starting point for designing self-adjusting circuits.

The cells operate as conventional logic cells and are treated as such by the circuit designer and the host system. Moreover, the minuscule EEPROMs have been ruggedized so the cells can be scattered across a very large-scale IC to adjust or program individual analog and digital functions, much as system designers scatter manual adjustment components across a printed-circuit board.

A conventional EEPROM design could not be used in the cells because high-density EEPROM arrays are isolated from other chips on a board. That allows the EEPROM bit cells to be designed for high density—a single electrically erasable switch per bit and shared sense circuits. But only the fact that the array is so well protected ensures reliable state-sensing and the specified endurance.

In contrast, Sierra Semiconductor's nonvolatile cells are in effect low-density EEPROMs with bit cells scattered among many alien analog and digital cells. The analog and digital functions emit signals that are unfamiliar to an EEPROM cell, so Sierra Semiconductor invented a cell that could not only survive in this unpredictable and potentially hostile environment but also ensure high endurance and nonvolatility (Fig. 2). The cell's electrically erasable switches guard against inadvertent programming by stray signals or parasitics. Moreover, the redundant switch configuration helps the cell hold its state if a switch fails.

The family is part of a new library of CMOS analog and digital cells developed with Triple Technology, Sierra Semiconductor's advanced 2-μm CMOS process. A two-metal-layer, n-well base process

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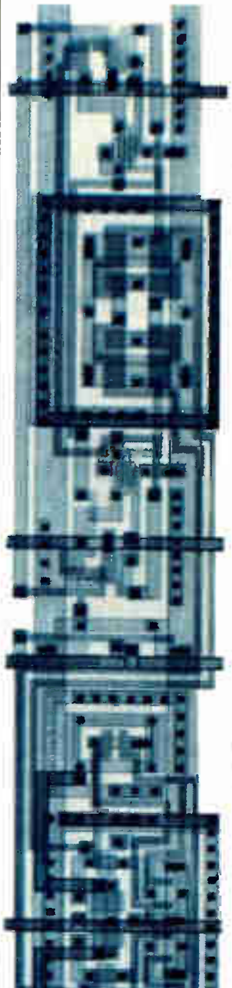
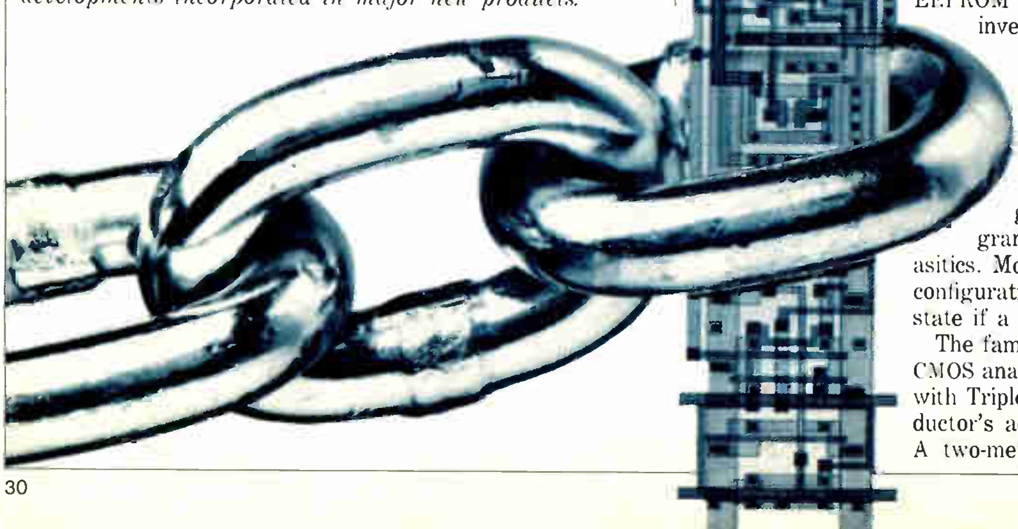
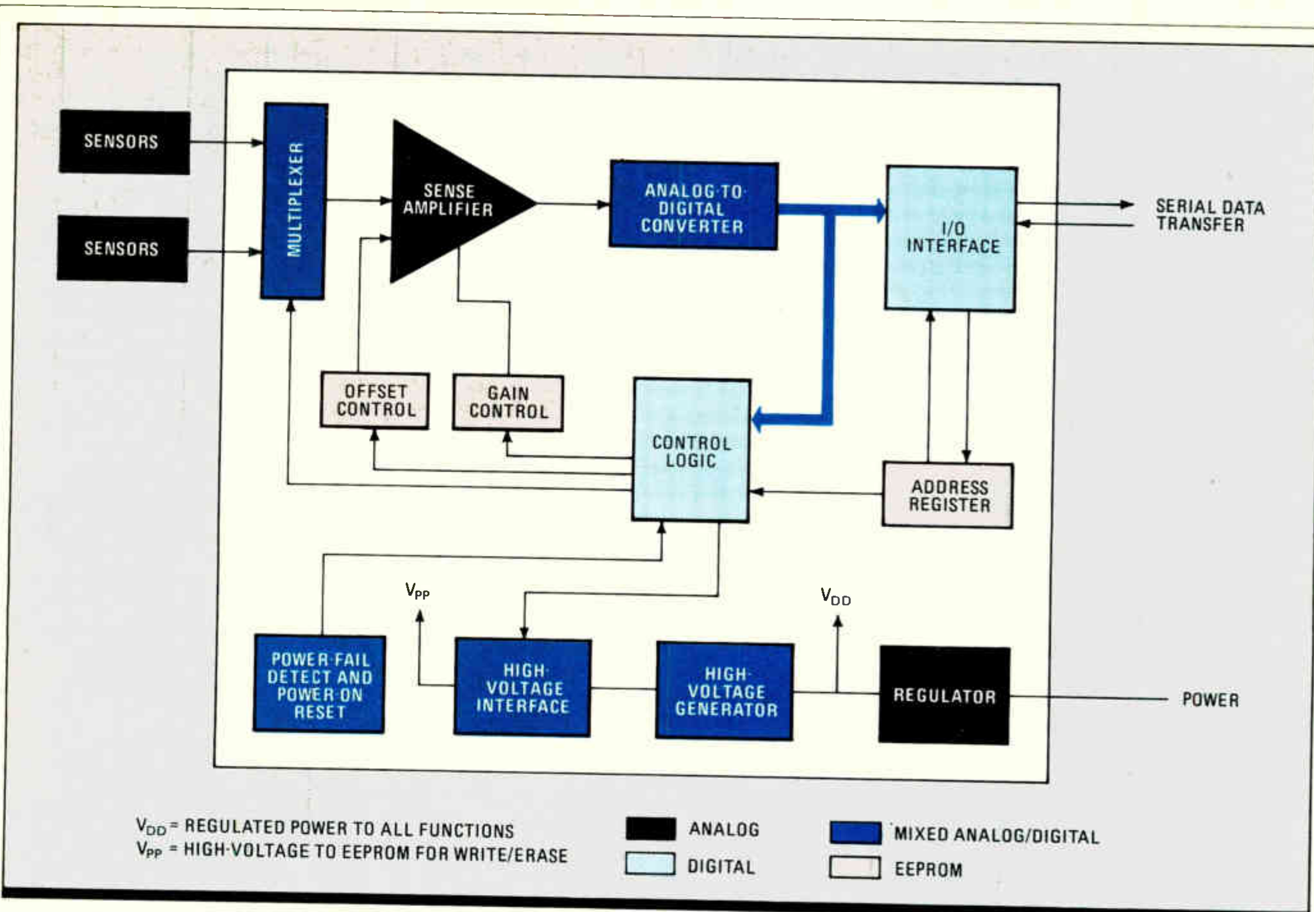





1. REMOTE SENSOR. This remote sensor subsystem could begin operation when it detects a specific input data sequence. Offset and gain of the amplifier can be adjusted to accommodate the multiplexed requirements of each sensor by use of the E² cells as smart potentiometers.

provides high speed and density for both analog and digital cells. Oscillator cells, for example, operate at frequencies up to 25 MHz; the digital cells operate at internal rates of more than 80 MHz. Analog and EEPROM process modules add the more specialized characteristics required by the analog and nonvolatile cells.

Sierra Semiconductor is beginning its ruggedized nonvolatile cell family with a D-type flip-flop, a data latch, and a set-reset latch. These universally applicable macrocells can combine with other members of the library to create various storage cells, specialized circuits, and memory arrays, as well as the simple registers needed to emulate pots and switches. The company says the family eventually will include larger cells, such as byte-wide registers, and compiled arrays. And the Triple Technology process also enables development of low- and high-voltage libraries for micropower and high-noise environments.

Sierra Semiconductor also will make custom chips with the 2-μm technology. The company previously used a 3-μm version of Triple Technology to make the first full-custom parts with on-chip EEPROMs [*ElectronicsWeek*, March 11, 1985, p. 69] The full-custom parts share high-density arrays as though they were a set of registers. Unlike the ruggedized cells, however, these arrays must be designed into the custom chips by EEPROM experts.

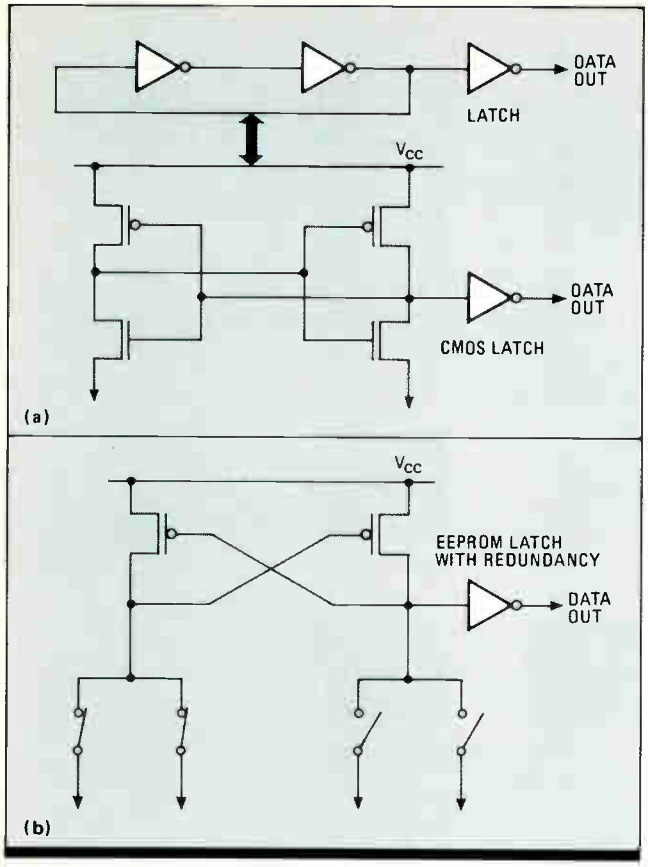
Because the nonvolatile cells are rugged and inexpensive, every on-chip analog or digital function that needs tuning, tailoring, or nonvolatile programming can have its own adjustment circuit. A 4-bit register, for instance, can trim an operational amplifier's gain or offset by means of binary weighted resistors. Or an 8-bit register can provide the same kind of input/output-format tailoring usually provided by a dual in-line-package switch with eight two-position settings.

Sierra Semiconductor expects some board-level system manufacturers to use such functions to make ASICs less application-specific. For example, chips can be designed with selectable functions so that, as is current practice, system houses can deliver customized versions of the same board design. Thus chips and board assemblies could be produced in volume to lower their costs, then inventoried and shipped overnight in small lots.

Nonetheless, the variety of nonvolatile circuits that can be created with the company's library is limited only by the system designer's creativity, says Andrew G. Varadi, vice president for design. Varadi adds that the best is yet to come—with no manual tweaking required, systems can be designed for fully automatic testing and calibration in the factory and remote maintenance in the field. And self-adapting systems—once generally affordable only in military and aerospace applications—can be developed for instrumentation, control, and other civilian systems. "Our custom-circuit customers have some surprisingly good ideas for future applications," Varadi says.

ELUSIVE SYSTEMS ON CHIPS

A few years ago, "everybody in the semiconductor industry was talking about putting systems on a chip with 2-μm CMOS when it couldn't really be done, because you could only integrate the digital functions," recalls James V. Diller, company president. So system designers started putting small EEPROMs in subsystems to store calibration parameters and other board-specific startup data. In terms of system architecture, nothing had changed—the subsystems were tuned and tailored independently. That meant new board designs could also use small EEPROMs in the myriad instrumentation, control, and data-processing systems built with boards and peripherals from multiple vendors.



2. RUGGED. The core of Sierra's EEPROM cell is a CMOS latch (a) but dual floating-gate switches replace the n-channel transistors (b).

But most semiconductor manufacturers were going in the opposite direction, striving to make ever-larger EEPROMs for main-memory applications. Some vendors did use a few bits of erasable memory to trim linear circuits as an alternative to blasting away with lasers. Others developed EEPROM versions of DIP switches, but these cost more than the manually set products.

Sierra Semiconductor decided to pursue the system engineers' approach to the hilt—right into the individual chips. Because ASICs, not packaged EEPROMs, were the goal, the company began process and circuit development with a line of telecommunications products requiring both analog and digital functions. Then came CMOS versions of some of the industry's smallest standard EEPROMs—from 512 bytes with parallel outputs to 256 bits with serial outputs. Next were the custom ICs with small arrays and, finally, the single-bit cells—a record for EEPROM density.

"All the while, we were putting together the pieces of our Triple Technology and our cell library," says Varadi. Many of the company's analog cells are adaptations of circuits developed for telecom products. Although that product line is not large, it covers a wide range—from modems and filters to codecs and video digital-to-analog converters. Sierra Semiconductor's analog-cell family inherited the older circuits' broad applicability. Included are 8-bit DACs, analog multiplexers, and other supercells. The digital cell family came from VLSI Technology Inc., San Jose, in exchange for Sierra Semiconductor's analog cell family.

The company also approached process development from a different viewpoint. Standard linear, digital, and erasable memory parts use different semiconductor processes, each designed for best density and performance. "We needed synergism between the three technologies, so we started from scratch," Varadi says. "If we tried to do a library of digital and analog cells with an E^2 process, digital performance would not be good and analog performance would be hopeless. But we did not have to start with E^2 because we had already decided that the process would eventually include an E^2 module."

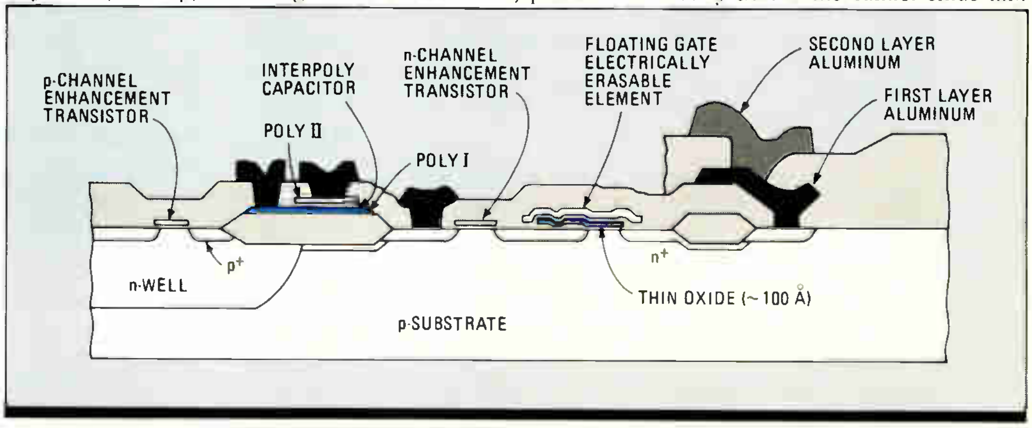
The base process is 2-μm n-well CMOS with a single layer of polysilicon, a single layer of metal, and a module for an optional second layer of metal (Fig. 3). The second layer is added whenever necessary to avoid using poly for connections, resulting in cells with high density and performance. Process architecture and structural innovations were oriented toward "well-behaved" transistors and high-quality capacitors for analog cells, and very reliable EEPROM switches for the ruggedized cells, says Ying K. Shum, vice president for process technology. Analog and EEPROM process modules add the specialized steps needed to optimize these elements.

ANALOG PROCESS MODULE

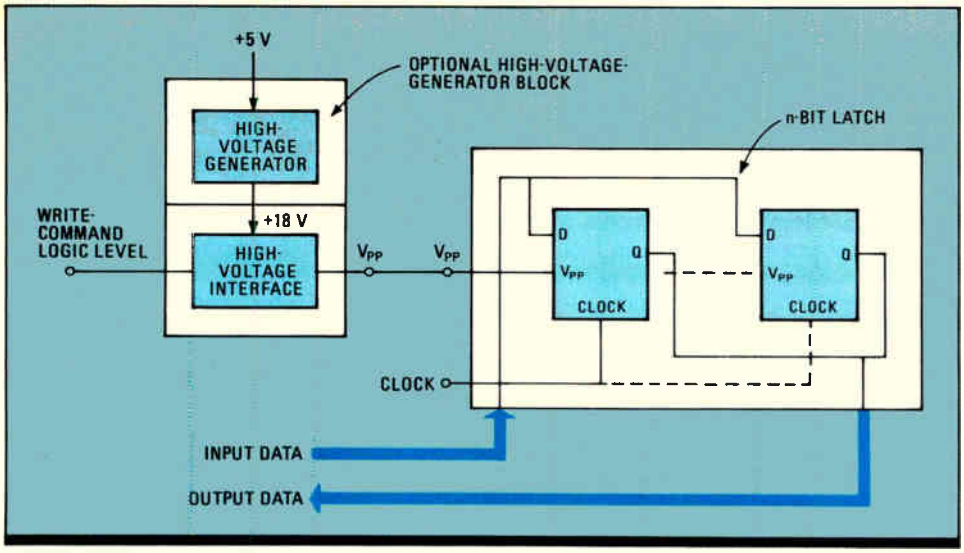
The analog process module adds a second poly layer for high-quality interpoly (dielectric between poly plates) capacitors. The second layer also provides the electrically erasable floating gates. But before that layer is applied, the EEPROM process module provides the tunneling oxide. The EEPROM switch elements were designed to prevent problems that could degrade cell nonvolatility. For instance, the floating gates are positioned to minimize capacitive coupling with nearby elements. Parasitic coupling can reduce the efficiency in tunneling charge onto the floating gate. Also, the oxide is very thin—around 100 Å—to permit easy tunneling. Inherent endurance, Shum reports, is more than 1 million programming cycles.

Each cell's core is a CMOS latch with cross-coupled inverters. The usual n-channel transistors are replaced by dual floating-gate switches. During programming, one pair of switches opens and the other closes. They remain in these positions until reprogrammed, making the latch nonvolatile rather than bistable. With this configuration, a differential sense circuit can determine cell state under adverse operating conditions and with smaller windows, so each cell contains a differential sense amplifier.

In addition, the cells are designed to prevent read-disturb and programming-disturb problems. For instance, when a switch is off, potential is usually across the tunnel oxide and



3. MULTIPLE MODULES. The analog process module adds a polysilicon layer for high-quality interpoly capacitors and floating gates. The third process module adds 100-A tunneling oxide.



4. REGISTER. Access to an EEPROM cell is through a logic-level write-command connection from a volatile latch-type register. Executing the write command loads data from the register into the EEPROM.

The system designer uses the nonvolatile cells like other flip-flop and latch cells, except for choosing the programming method (on- or off-chip high-voltage sources) and specifying connections for the programming power supply and programming enable pins (V_{pp} and PE). A key feature of the rugged bit technology is that it permits system designers to access it in a straightforward manner. Each cell is totally self-contained and is used in a way that is familiar to many semicustom IC designers—for example, as a latch (Fig. 4).

Designers can configure nonvolatile registers simply by providing the write-command connection, as they do with conventional volatile latches. This line then connects through the predefined ramp and timing-control block to the logic-level write command. Executing the write command automatically loads the register's contents into the EEPROM. A high-voltage charge-pump cell is also provided for 5-V-only systems. Once a circuit is designed to emulate any adjustment function, it is simply replicated wherever needed on the chip. Also, cells can be interconnected so that all are written to simultaneously during tests.

For writing, data bits are clocked into the registers or other circuit configurations, as with conventional digital cells. To protect the cells from incorrect programming operations, however, the entire erase/write cycle from program enable to program disable is handled by high-voltage-interface cells. One type of high-voltage-interface cell operates on a 5-V supply, another on an 18-V supply. The high-voltage cells generate the PE signal, condition the programming supply voltage to provide the slowly rising ramp needed to program any electrically erasable memory without rupturing the thin oxide, and disable PE at the end of the cycle. After PE is disabled, readout is conventional.

could slowly program the switch to turn on. So as part of the structural design associated with the EEPROM process module, the tunnel oxide is removed from the switch transistor's drain and has its own controlling terminals. The terminals apply a 0-V bias except when tunneling is required for programming. And because no current flows through the switch when it is on, it cannot be programmed to turn off slowly by hot-electron injection—the p-channel transistor controlling its current is off.

SEPARATED CIRCUITS

Furthermore, the programming and read circuits are not merged, as in a conventional bit cell, but are separated for uncompromised control over—and protection of—the electrically erasable switches. And with two switches on each side of the latch, one can fail on each side without changing the cell's state. The vast majority of failure mechanisms in conventional EEPROMs, including oxide rupture, result in either a neutrally charged floating gate or a gate tied to ground. Sierra Semiconductor designed its switch to go into a high-impedance state if failure occurs. A high-impedance switch in parallel with another switch will not change the cell's state, affect its nonvolatility, or make it less programmable.

The cells are used like any flip-flops or latches

As the final touch, the core latch is embedded within a shell of digital-control circuitry that keeps adjacent cells from inadvertently damaging the sensitive tunnel oxide. The shell not only allows the designer to use the nonvolatile cell like any other digital cell but also protects the core from damage caused by nonrecommended timing and programming operations.

All this requires more silicon than a high-density bit cell—the cells measure 72 by around 500 μm. On the other hand, the small number of cells required to emulate pots and switches adds little to the overall chip cost and further saves on system tailoring, testing, calibration, and maintenance.

The cells cost little to test because they don't require the long, involved test programs used to determine the data-pattern sensitivity and endurance of high-density arrays. They can be easily exercised and checked with 1 and 0 write and read operations. And nonvolatility can be tested by turning chip power off and on, then repeating the read operation. Similar approaches can trim and compensate on-chip functions during chip tests, calibrate and set equipment operating parameters, perform remote maintenance tests and adjustments, and so forth.

The company provides the Sierra Custom Design System (SCDS) to turn cell designs into ASICs. The SCDS is a graphics-oriented system that supports hierarchical design with icons and line drawings, so circuits can be designed from scratch on the display screen in a modular manner, similar to assembling circuits on a pc board, as well as with conventional schematic capture. Layout and routing are both fully automatic. During routing, power-supply buses are automatically sized for the amount of current they must handle.

The simulator has mixed-mode capability—that is, it combines software behavioral models with simulations based on device characteristics. Because the simulator has 0.1-ns resolution, behavioral models without the 10-ms write cycle are generally used for simulating nonvolatile cells. Later, the test translation program puts in the write cycles. Other tools also put cell programming operations into the background, keeping the internal EEPROM design transparent to the designer.

Sierra Semiconductor also developed specialized nonvolatile-cell design tools and integrated them into the SCDS. For circuit design, system software currently runs at Sierra Semiconductor's design center in San Jose on Apollo Computer Inc. work stations and on an Elxsi 6400 multiuser system with color-graphics terminals. Cells and design tools are developed on Digital Equipment Corp. VAX computers.

EEPROMs already have many main-memory and on-board applications, so there's no shortage of potential chip-level applications. And on-chip erasable memory can improve such circuits as switch banks, pot emulators, tunable filters, analog-to-digital converters, video DACs, power-on resets, power-failure detection, oscillators, and one-shots.

The humble DIP switch becomes a powerful component in electrically erasable form. For instance, a small tailoring program in a personal computer's system software would enable computer stores and end users to specify peripheral interfaces at the keyboard instead of setting manual switches. Likewise, home appliances could be programmed through a keypad and still hold settings through power outages. Engineers could store instrument setups and sequences. Smart card, electronic lock, data encryption, and other security applications call for frequent access-code changes. Such codes can be changed automatically and remotely with the nonvolatile registers.

SELF-CALIBRATING DISK DRIVES

In pot-like applications, system calibrations and recalibrations can be automated to trim oscillator frequencies, voltage references, and amplifier offsets and gains. Lifetime recalibration functions can be built into peripherals to compensate for mechanical wear. For instance, a smart disk drive could use a calibration track to reset head-positioning controls and adjust analog circuits every time the peripheral is powered up.

Because an industrial system may need to supervise hundreds of such subsystems, system organization can be simplified by storing a unique address and the system synchronization sequence on each chip. The chip would begin operating when it detected a specific data sequence on the input line. Manchester encoding, for instance, may be used to power the chip and synchronize its clock with a remote system's clock. The cell library allows the chip to include power-on reset and a power-fail detect function. Also, critical data can be backed up in nonvolatile memory in case power fails.

In addition, prescaled data can be transmitted to the host system. The analog multiplexer cell allows multiple sensor inputs with a single amplifier. The amplifier's offset and gain can be trimmed at the multiplexing rate to accommodate the requirements of each sensor. Thus each sensor's inputs can be processed by building a smart potentiometer into the chip. This can be achieved by toggling the converter output and switching resistors in the amplifier network with the control logic until the appropriate adjustment settings are reached, then storing the settings in nonvolatile registers. Between adjustments, the chip would run as a normal ADC.

The data-acquisition circuitry provides the data needed to trim amplifier gain and offset. Under logical control, the switches that control offset or gain are sequenced until the proper scaling is provided by the ADC. To increase data precision, a stack of registers could store the adjustments for different types of sensors. And, as an extension of this technique, a temperature sensor's data could be employed to correct drift in other sensors.

The first full-custom chips using E^2 cells went into production in the fourth quarter of last year, says Diller. The first semicustom designs done by the company using this new EEPROM standard-cell methodology are now in design, with first silicon expected sometime during the second quarter. □

THIS TIME, THE RECEIVED WISDOM DIDN'T WORK

The fast-paced world of device design has only a few edicts, but the design team at Sierra Semiconductor violated the most sacred in developing the E^2 standard cell. It added extra silicon to overcome its two major challenges: how to operate high-voltage EEPROM cells' embedded circuitry, which is designed to handle 5 V, and how to make the cells easy to design into semicustom chips.

In a standard, multibit EEPROM design, the cost of adding silicon would be prohibitive. But team members realized that the few bits of electrically erasable programmable read-only memory usually required to implement pots and DIP switches made it feasible to to use extra silicon.

The extra silicon solved both problems. The dsigners could wrap the EEPROM in other digital circuity so that it could not damage the 5-V circuits. They also made the EEPROM cells look like basic flip-flops—familiar and easy to use.

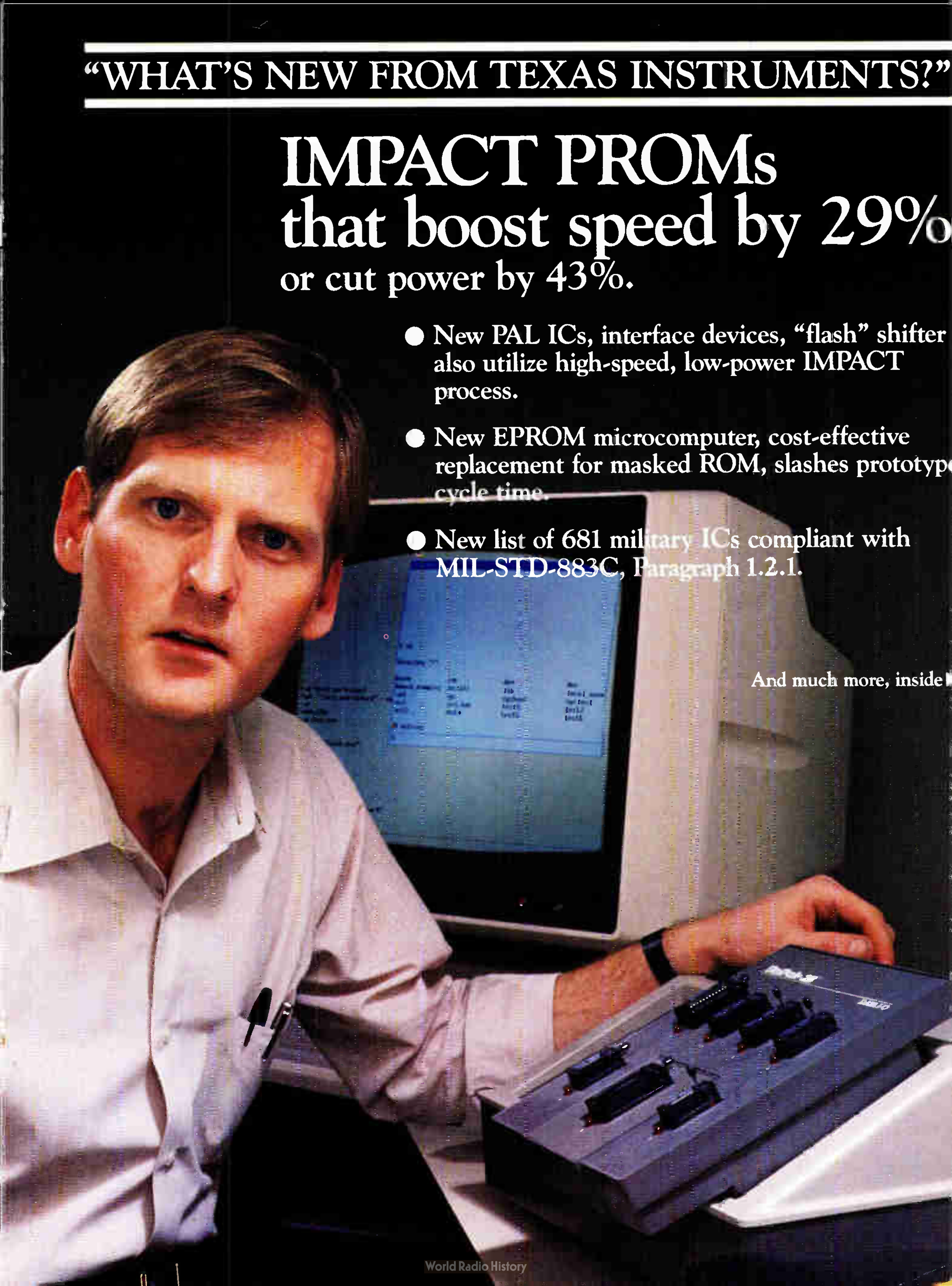
Five key people were involved in the E^2 Standard Cell project. In charge of the group was Mike VanBuskirk, director of nonvolatile digital products at Sierra. VanBuskirk coinvented the rugged 1-bit E^2 cell and has three patents associated with nonvolatile memories. Before joining Sierra, he was engineering manager for EPROMs at Intel Corp. for 6½ years.

Andrew Varadi has 20 years of experience in design and management of semiconductor technology. He is Sierra's vice president for design. Vice president for process development, Ying K. Shum, holder of four patents in semiconductor technology, is a 10-year veteran of the industry.

The other coinventor of Sierra's rugged E^2 cell is manager of EE custom design, Joe Nolan. Besides doing E^2 Cell library development, Nolan works on full-custom IC•programs at Sierra.

Te-Long Chiu is another long-term (18 years) semiconductor veteran on the Sierra team. Chiu is the company's director of process development. He, too, is a collector of patents—two now, with several pending.

CELL MATES. The five key members of Sierra Semiconductor's electrically erasable standard-cell design team were (left to right) Mike VanBuskirk, Te-Long Chiu, Joe Nolan, Ying Shum, and Andy Varadi.


"WHAT'S NEW FROM TEXAS INSTRUMENTS?"
IMPACT PROMs
that boost speed by 29%
or cut power by 43%.
New PAL ICs, interface devices, "flash" shifter also utilize high-speed, low-power IMPACT process.
New EPROM microcomputer, cost-effective replacement for masked ROM, slashes prototype cycle time.
New list of 681 military ICs compliant with MIL-STD-883C, Paragraph 1.2.1.
And much more, inside

IMPACT PROMs deliver 25-ns speed at industry-standard power.

New Series 3 IMPACT™ PROMs from Texas Instruments make 16K-memory performance upgrades quick and easy. If speed is your most critical parameter in a high-complexity PROM, you can achieve it now without paying a power penalty. Just design in TI's new 25-ns, 175-mA IMPACT PROMs: The TBP38S165-25 (2K × 8) or the TBP34S162-25 (4K × 4).

Or use the world's fastest 16K registered PROMs. TI's TBP34R165-18 (2K × 8), with a minimum address-to-clock setup time (t_{su}) of only 18 ns, is nearly 2¼ *times* faster than the closest competitor. And the TBP34R162-30 (t_{su} = 30 ns) is the only 4K × 4 registered PROM on the market.

Standard speed at 43% less power

You can also cut power without sacrificing speed, using TI's new TBP38L165-35 IMPACT PROM. It is pin-for-pin compatible with existing 2K × 8 PROMs and operates at the same 35-ns speed, but instead of 175 mA, it draws *only* 100 mA. TI's broad family of Series 3 IMPACT PROMs also includes 256-bit, 1K and 2K devices.

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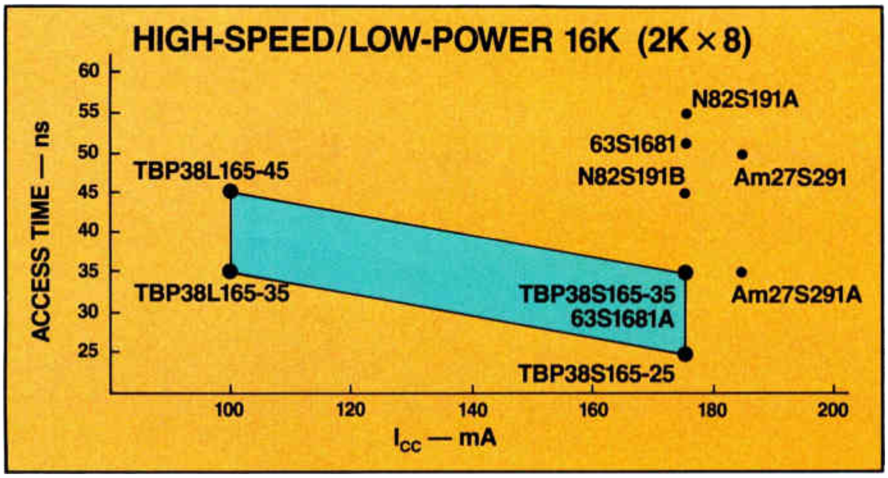
IMPACT PROMs are designed by TI for exceptional reliability. Current densities, metal spacing, and contact sizes are all conservatively designed. Electrostatic-discharge tolerance up to 4,000 V is designed in. During programming, TI-developed titanium-tungsten fuse links insulate themselves with titanium-oxide caps. Electromigration is eliminated by copper-doped aluminum in the first-level interconnection. And you can program any of TI's new Series 3 PROMs on widely available commercial equipment, using TI's standard Series 3 programming algorithm.

Shift 32 positions in less than 29 nanoseconds.

Now TI's 2-µm IMPACT technology also brings you high-speed "flash-shift" operations — with the new 74AS8838 32-bit barrel shifter. Shifting as many as 32 positions in a single 29-ns instruction cycle, it can dramatically increase throughput in such applications as graphics systems, wide-word CPUs, and array processors. At an energy cost of less than 1.5 W, you get higher speed with lower power, in a single 84-pin ceramic pin-grid-array package.

You can program the 74AS8838 for logical, circular, or arithmetic shifts. Its two 3-state, 16-bit outputs give it the versatility to be configured as a 32-bit-in, 32-bit-out barrel shifter, as a 16-bit funnel shifter, or as a 16-bit shifting transceiver. And it can drive buses directly with 24-mA low-level output — with no additional circuitry.

The 74AS8838 barrel shifter, first device in TI's 74AS88XX 32-bit processor chip set, is available today through your local authorized Texas Instruments distributor.



Bracketing the speed/power spectrum, TI's IMPACT PROMs cut power requirements from 180 to 100 mA for "standard" 35- to 45-ns access time. Or at 180 mA, they can give you 25-ns speed.

IMPACT technology doubles speed of new PAL ICs.

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These devices — TIBPAL20L10-20, TIBPAL20X4-20, TIBPAL20X8-20, and TIBPAL20X10-20 — are designed primarily for counter-intensive applications. The exclusive-OR feature suits them ideally to digital voice applications and video-screen information correction. They can also be useful in memory addressing and mapping.

Programmable logic sequencer is 250% faster because of IMPACT processing.

Still another new product in TI's growing line of high-speed programmable logic devices is the TIB82S105B. At 50 MHz, it is 2½ times as fast as functionally equivalent 16 × 48 × 4 field-programmable logic sequencers — at the same 180-mA power. Unlike them, however, it maintains that speed even when using many product terms.

Because of its improved clocking scheme, the IMPACT TIB82S105B is not a direct replacement for the TI or Signetics N82S105A. But it is ideal for those new high-speed state machines designed to control peripheral I/O, dynamic memory systems, and video blanking systems.

For more detailed information about any of TI's growing line of high-speed, low-power IMPACT products, just check the appropriate box on the attached reply card and return it to TI.

8 new ways TI can help sharpen

1

A new alternative for memory-systems design: TI SIP DRAM modules.

Memory-intensive packaging for the future is available today — in TI's highly reliable modules in single-in-line packages (SIPs). With them you can have the many advantages of surface-mount technology (SMT) — while using through-hole-mounted or socketable packages. Thus without changing your manufacturing technology, you can increase memory density by a factor of up to 3.5 over dual-in-line packages (DIPs). And you can simplify board layout while facilitating replacement and future upgrades.

Each SIP module uses DRAM chips in plastic leaded chip carriers (PLCCs), surface-mounted along with decoupling capacitors on an epoxy substrate. Since all connection points are on one edge of the substrate, the module "stands on end" to make the most of your board area.

TI's full line of SIP memory modules — from 64K × 4 to 256K × 9 and 1M × 1 — includes standard DRAMs and Multiport Video RAMs in various organizations. And all are available through your authorized TI distributor.

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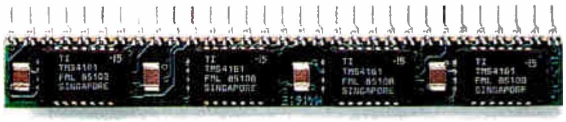


Memory can be 3.5 times denser using fully-qualified, production-proven RAMs configured in SIP modules. TI SIPs combine the density of surface-mount technology with economies of through-hole insertion.

2

Interface performance enhanced by TI.

Also new from Texas Instruments is an improved direct replacement for the UCN5812 vacuum fluorescent display driver. TI's TL5812 is 11% faster and draws 60% less current. With an output voltage swing of 70 V and an output source-current capability of 40 mA.

Only TI's patented BIDFET technology — combining bipolar, double-diffused MOS (DMOS) and N-channel and P-channel CMOS transistors on the same chip — makes these improvements possible. And at a competitive price.

3

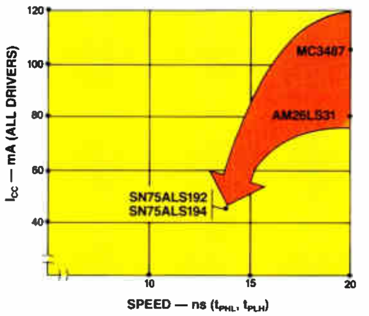
Fast line drivers and bus transceivers from TI.

In the new SN75ALS192/194 quadruple EIA Standard RS-422-A differential line drivers, TI's exclusive ALS 1.5 process technology (oxide-isolated Advanced Low-power Schottky) yields the best speed/power ratio in the industry: At approximately half the power consumption, these devices are 30% faster than the competition.

A new family of differential bus transceivers, SN75176B, 177B, 178B, and 179B, are faster than earlier versions. Designed for bidirectional communication on multipoint transmission lines in noisy environments, they meet EIA Standards RS-422-A and RS-485. Typical propagation time is only 22 ns.

Want to know more about these new interface products from TI? Just check the appropriate box on the reply card.

INDUSTRY'S FIRST ADVANCED LINE DRIVERS USE ALS TECHNOLOGY



Advanced TI line drivers are 30% faster, typically draw only half the power of the devices they are designed to replace.

4

Fast, economical new 8-bit SAR A/D converters.

Now Texas Instruments offers 8-bit SAR (serial-approximation resolution) A/D converters that are as economical as any you can use. And because they use LinCMOS™ polysilicon-gate-process technology, they are unsurpassed in speed. TI's TLC549 analog-to-digital converter performs 40,000 conversion cycles per second (cps), while the new TLC548 pushes speed to an unprecedented 45,500 cps. At any supply voltage between 3 and 6 V. And typical power consumption is only 6 mW.

Performance of the serial-approximation algorithm is not only fast. It's accurate: Conversions are performed with the guaranteed low error rate of ±0.5 LSB (least significant bit) across the temperature range from −55° to 125°C.

5

681 military TI devices comply with 1.2.1.

Now designers of military electronics have the broadest choice ever of devices that comply with the requirements of MIL-STD-883C, Paragraph 1.2.1. The vast majority of TI's military ICs — 681 different devices — now qualify:

Product Type	Number
ALS/AS	83
TTL	131
LS/S	238
HCMOS	80
PAL ICs	16
Linear	113
Memory/LSI	19
MOS DSP	1
TOTAL:	681

For more detailed information on specific TI military devices, just check the appropriate box on the reply card.

Texas Instruments quality recognized in Tokyo and Detroit.

Outstanding Texas Instruments quality-assurance programs were lauded during 1985 both at home and abroad. In June, Ford Motor Company granted TI linear products the coveted Q1 Award. And in November, TI's wholly owned Japanese semiconductor operation received the prestigious Deming Prize. Both awards recognize exceptional levels of quality and reliability, achieved through aggressive defect-prevention programs.

First Ford Q1 Award to a semiconductor supplier

Ford Motor Company's Q1 Award to Texas Instruments Linear is the first ever to a major U.S. semiconductor manufacturer.

Qualification is based on a demonstrated defect-prevention program, along with Ford's review of warranty returns, specifically keying part numbers to failures. Thus it recognizes both initial product quality and continuing reliability.

Both quality and reliability are attributes that TI Linear has pursued aggressively through its "monitor program," begun in 1979. The goal of the program has been to achieve levels of quality and reliability equal to or better than the best worldwide competition. And the Ford Q1 Award is one visible token of its success.

First U.S. winner of Japan's Deming Prize

At ceremonies on November 11 in Tokyo, the Japanese Union of Scientists and Engineers awarded the prestigious Deming Prize for total quality control to TI's bipolar semiconductor operation in Japan.

The prize, never before won by a wholly U.S.-owned company, recognizes outstanding quality-control achievement in all aspects of business — including marketing, engineering, manufacturing, and support. It is named for W. Edwards Deming, the American statistician whose work in defining and measuring quality control in Japan after World War II became the basis for the legendary Japanese commitment to quality. In 35 years, the Deming Prize has been awarded to only 48 individuals and 111 institutions. Texas Instruments Japan, Ltd. was one of only eight companies so honored in 1985.

As is the case with the Ford Q1 Award, sensitivity to customers' requirements is a key factor in selecting winners of the Deming Prize. TI's successful commitment to quality and reliability in support of all our customers' needs has been demonstrated twice again. And TI is justifiably proud of this achievement.

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More news upcoming from TI in the next issue:

- A new CMOS version of TI's trend-setting TMS320 Digital Signal Processor.
- More new additions to TI's growing family of IMPACT PAL ICs.
- New CMOS standard cells and gate arrays that augment TI's leadership in Application-specific Integrated Circuits (ASICs).
- And more ...

For more information...

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From TI's new family of advanced standard cells you'll be able to choose among more than 280 functions and achieve increased system integration and performance.

Or for the performance you need, and quick turnaround to get your product to market fast, there's TI's DLM TAC-H and TAC-VH silicon-gate CMOS gate-array family. These devices, fully alternate-sourced, offer complexities from 440 to 8,000 gates.

Extensive design support

Whatever level of help you need, you get it from TI. In your design cycle as well as in meeting your prototype and production requirements *on time*. TI's proven expertise and worldwide manufacturing facilities are your assurance of dedicated support and products in the volume you require. And you have a wide range of package options: DIPs, SOs, PLCCs, pin-grid arrays — from 8 to 179 pins.

Design your own way

You can reduce your costs and speed your ASIC design with TI because you don't need special proprietary software or design tools. And you can do it at a TI regional design center or at your own work station. Because TI's cell libraries are supported by most work stations, including Daisy LOGICIAN®, MEGALOGICIAN®, and GATEMASTER®; Mentor IDEA 1000®; Valid SCALDsystem®; and P-CAD® and FutureNet® in IBM PC® environments.

TI's worldwide network of 13 training and design centers, staffed with experienced ASIC design engineers, can provide access to work stations, as well as mainframe capability. And you can learn ASIC design in one of TI's unique hands-on workshops. Using TI's semicustom libraries with a real-world standard-cell example, you'll learn every phase of design from schematic capture through test-pattern generation and simulation.

Select TI distributors can also give you local access to TI's leading-edge ASIC options, with dedicated facilities, tools, and trained engineers.

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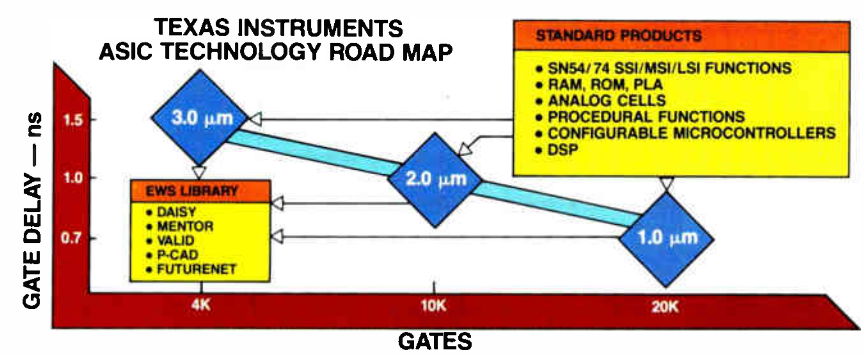


Advancing technology in ASICs need not demand new rules and tools. Your investment in hardware and training is protected when you move up with Texas Instruments to faster, more complex ASIC functions.

7

New series of input-latched and registered PAL ICs lowers parts counts.

Eight new 30 MHz PAL devices from TI are the first input-latched (TIBPALT19XX) and input-registered (TIBPALR19XX) PAL ICs in the marketplace. Functionally similar to TI's TIBPAL20XX series, they include either 11 D-type transparent latches or 11 D-type input registers on chip. This added circuitry allows you to synchronize inputs without external registers or latches. These devices can reduce your parts counts and simplify your design task in a wide range of applications such as random logic, bus-interface logic, and input synchronization to custom controllers.

8

And now, a new, easy-to-use EPROM microcomputer.

TI's new TMS7742 EPROM microcomputer can cut to zero your lead time for development, prototyping, field tests, and product qualification. And it bridges the gap to ROM-based volume production. For low-volume applications, it can be a cost-effective alternative to mask-programmed ROM. Its 4K bytes of on-chip EPROM are identical to TI's TMS2732A — transferred into the chip area vacated by masked ROM. So if you can program the TMS2732A you can program the TMS7742. This new microcomputer provides EPROM capability for the TMS7020, the TMS7040, and the new TMS7042 ROM microcomputer.

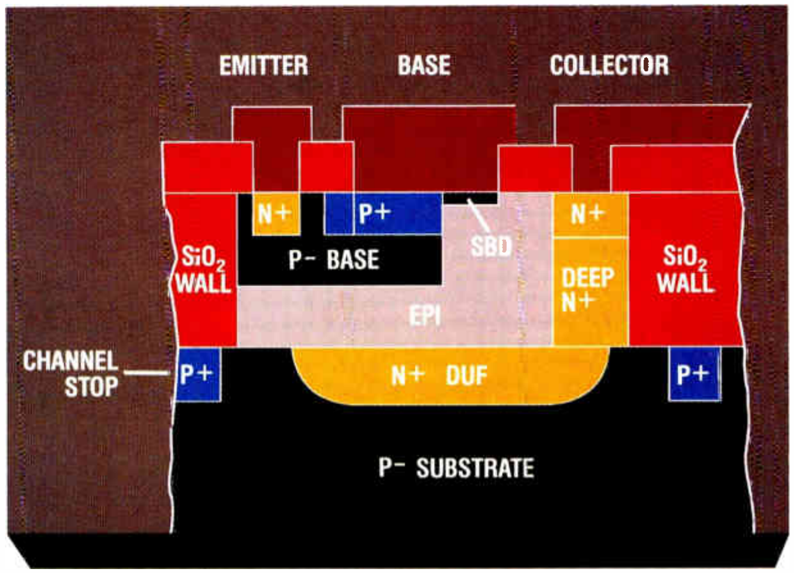
Also new to TI's TMS7000 family is the ROM-less TMS7002 microprocessor. Both the TMS7002 and the TMS7042 feature 256 bytes of RAM, a serial port for USART and serial I/O functions, 32 I/O lines, and three timers. And with their 60% performance increase over earlier TMS7000 ICs, they can improve system performance in such applications as disk and tape drives, printers, and industrial and motor controls.

High-density IMPACT circuits speed logic, memory access.

TI's unique Implanted Advanced Composed Technology (IMPACT) capitalizes on the advantages of ion implantation, oxide isolation, and composed-masking techniques to increase the speed and density of bipolar ICs.

This innovative technology dramatically reduces the size and the sidewall capacitance of circuit elements (*see diagram*). As a result, speed/power ratios are significantly improved: In PROMs that cut power consumption by 43%, or more than double the speed (*see story opposite*). In PAL ICs that reduce propagation delay by as much as 40% — to only 15 ns at 180 mA.

With the high speed and low power that TI's IMPACT process makes feasible, its potential for large-scale integration will reduce package counts in many high-complexity circuits.



A major reduction in capacitance results from the 2-μm feature size which TI's IMPACT processing makes possible. Silicon dioxide is the isolation material. Switching speed is further enhanced by utilizing this silicon dioxide for emitter and base sidewalls.

Composed masking yields high density

In composed masking, critical components are defined on the chip with a minimum number of masks. Thus they can be more tightly defined and more densely spaced than by conventional masking.

The IMPACT process also makes it possible to insulate critical base and emitter components with oxide walls. This insulation reduces sidewall capacitance, which, at the 2-μm dimensions of IMPACT features, can represent as much as half the overall capacitance. Small size and oxide walling together contribute significantly to the increase in switching speed.

DRAM technology spurs IMPACT growth

The IMPACT process is not a direct descendant of DRAM technology. Nevertheless, TI's commitment to DRAM production has provided IMPACT technology with vital processes.

It was the DRAM effort, for example, that drove photolithography to its present advanced state and contributed key dry-etching processes. Ion implanters designed to produce CMOS DRAM ICs enhance the quality — and the economy — of TI's bipolar IMPACT ICs. And this vital "cross-fertilization" from VLSI memory is one reason Texas Instruments — almost alone among U.S. semiconductor manufacturers — is committed to the development and manufacture of DRAM devices.

◀ **More chips per slice** help cut costs. The 150-mm wafers now used on TI's advanced MOS 256K DRAM wafer-fabrication line have 125% more area than the 100-mm slices formerly used.

THE X-RAY STEPPER HEADS FOR THE VLSI PRODUCTION LINE

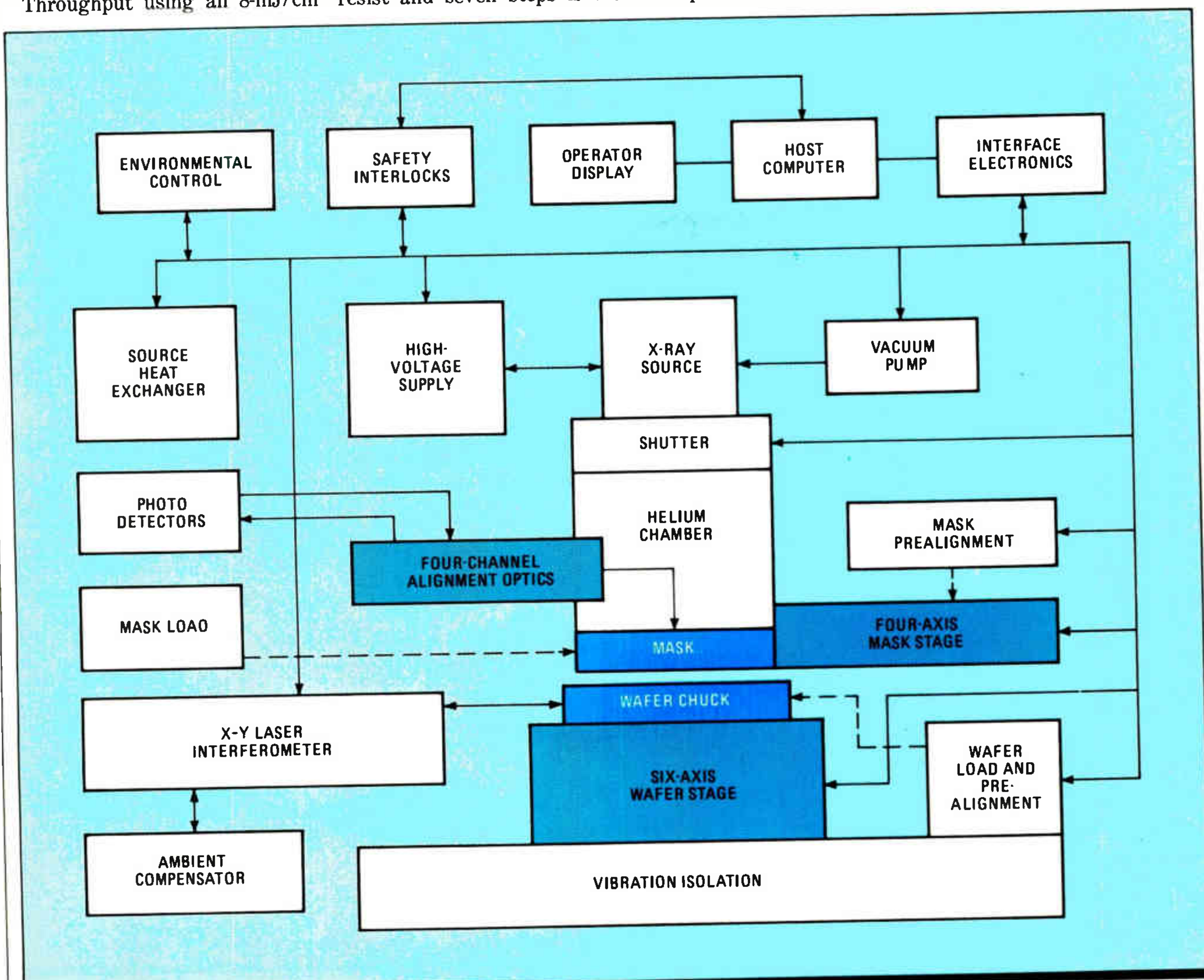
HIGH-RESOLUTION SYSTEM IS READY TO TURN OUT SUBMICRON FEATURES

Step-and-repeat X-ray lithography is coming to the production environment, where it will ease the chip makers' task of achieving the fine lines, accurate registration, and high packing densities needed in the next generation of very large-scale integrated circuits. Drawing on its experience in developing a full-field X-ray lithography system, Micronix Corp. is introducing the MX-1600, a fully automated system that reproduces 1:1 IC patterns on wafers up to 150 mm in diameter.

The most critical part of the X-ray process is the alignment of the mask with the wafer, and it was the biggest challenge the Los Gatos, Calif., company faced in developing the new machine. The automatic alignment subsystem is based on linear-zone plate technology and is accurate to 0.1 μm (2 σ). It combines a laser beam with optical sensors, and it can monitor and adjust alignment during the lithographic process.

Throughput using an 8-mJ/cm^2 resist and seven steps is about twenty-two 150-mm wafers/h. Exposure times are long—typically 13 seconds per step—so the MX-1600 aligns continuously during exposure to keep overlays precise.

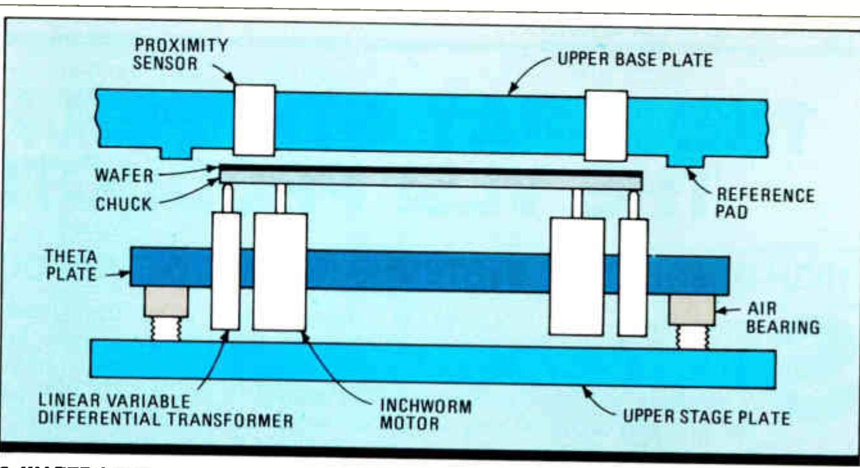
The MX-1600 may be the first X-ray stepper to make it to market, but other companies are hard at work on competing machines and on even more advanced systems using synchrotron radiation (see p. 46). An X-ray stepper is a desirable production tool for two reasons. First, the step-and-repeat method is mandatory for today's wafer fabrications, which use wafers 125 and 150 mm in diameter. The practical limit for a full-field X-ray system is 100 mm, above which the difficulty of fabricating the fragile X-ray mask is compounded. Second, the step-and-repeat system delivers better accuracy on larger wafers with less distortion than full-field lithography systems. As circuit tolerances are tightened, it gets harder to hold the tolerance on a large mask. A mask with a smaller patterned field, whose image can be stepped onto a



1. COMBINATION SYSTEM. Micronix' X-ray stepper merges mechanics, electronics, and optical and high-vacuum technology.

wafer, has lower distortion than a full-field mask.

The MX-1600's computer controls the fully automated subsystems (Fig. 1), which load, align, and expose the mask on the wafer. The computer is an IBM Personal Computer AT working with a network of microprocessors. With suitable masks and resists, system resolution is 0.5 μm. The X-ray source has a palladium target anode with an effective source diameter of 3.5 mm. It is placed 250 mm from the mask. Using a mask-to-wafer gap of 30 μm, the system penumbra is 0.35 μm, adequate for the desired resolution. The source-to-mask distance and mask-to-wafer gap can be changed to optimize resolution or throughput and to minimize the geometrical distortion factor.



2. WAFER-LEVELING PLANE. The wafer-leveling system precisely levels a prealigned wafer to the required gap plane. Three inchworm motors move the wafer until it is in the desired position.

The MX-1600's X-ray masks are made of a boron nitride membrane less than 5 μm thick. The mask field can be square or rectangular, with a maximum field size of 50 by 50 mm. The minimum recommended field size is 20 by 20 mm, primarily because of throughput considerations.

Micronix' X-ray stepper differs in significant ways from the more familiar optical systems. For example, in a comparable optical stepper, the distance between mask and wafer is at least three orders of magnitude greater. Therefore, in the X-ray system, the mask and wafer must be aligned with a very small mask-to-wafer alignment error. In optical lithography, transparent plastic covers called pellicles protect the reticle from particles. But because X rays are inherently transparent to organic particles, pellicles are unnecessary in X-ray lithography.

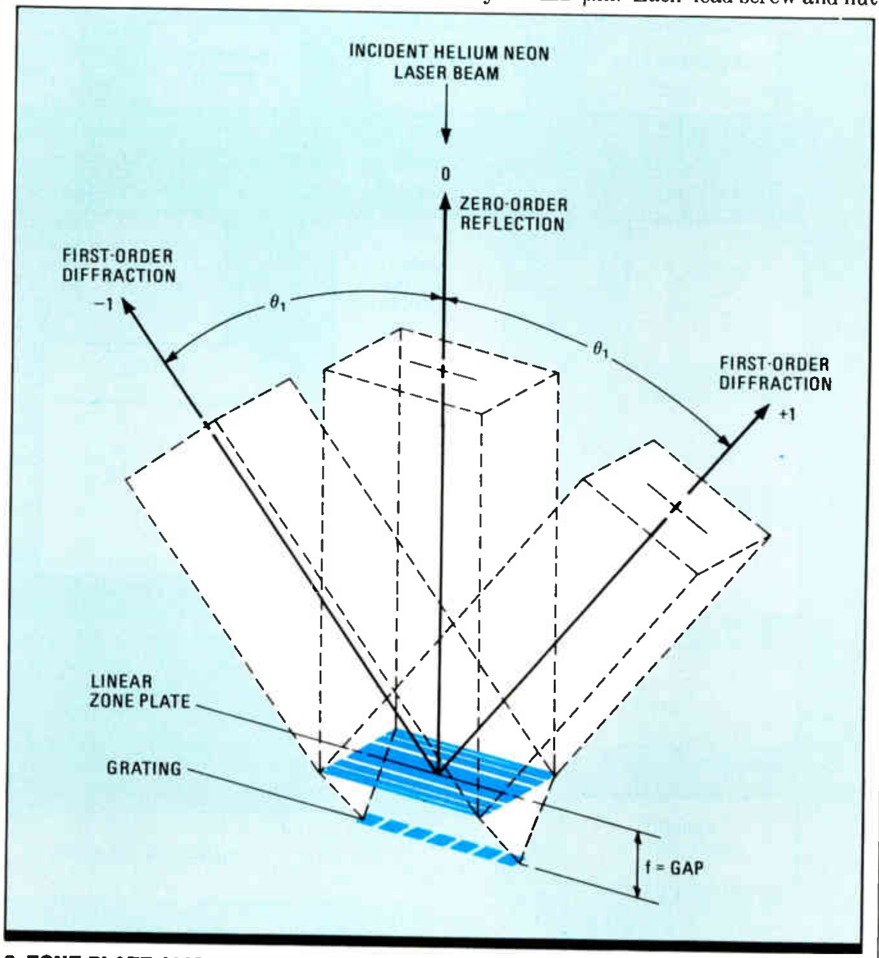
In the X-ray process, limiting the gap between mask and wafer is essential to controlling the magnification of the printed image, caused by inherent spreading of the image as the substrate moves away from the mask. The mask and wafer must be flat, because deviations will distort magnification. Error correction in an X-ray system is done by simply adjusting the mask-to-wafer gap, and gap control improves overlay accuracy in the many processing steps. In optical systems, by contrast, magnification distortion is controlled by the collimation of the light source.

Because exposure times per step are typically two orders of magnitude longer than in an optical system, X-ray fields are made as large as possible to maximize throughput. So such concerns as stage velocity, stage settling time, and field-by-field alignment time are less important than in an optical stepper system.

The system accomplishes its delicate alignments by adjusting both mask and wafer stages in several directions. The mask stage has freedom of motion along four directions: vertically (Z_1), two rotations around the vertical axis (Z_2 and Z_3), and horizontally around the mask center. Piezoelectric transducers drive the stage over a Z-travel range of 200 μm and a rotational range of 2.1 mrad.

When the mask is loaded, a subsystem prepositions it in the X-Y plane with an accuracy of ± 20 μm. This subsystem then retracts. As a safety feature, it captures the mask in case of vacuum or power loss. During wafer site-by-site alignment, a motion subsystem positions the mask in an X-Y-θ horizontal plane providing a continuous three-axis alignment.

The wafer stage has six degrees of motion: three motions in the vertical direction, and X, Y, and coarse rotation in the horizontal direction. Conventional air bearings support the X and Y stages. The Y stage rides on the X stage. Dc servo motors drive the lead screws that position the stages for coarse motion with an accuracy of ± 2 μm. Each lead-screw-and-nut



3. ZONE-PLATE ALIGNMENT. Mask-to-wafer alignment is accomplished by sending a laser beam through zone-plate targets on the mask and reflection-grating targets on the wafer.

assembly has an accompanying piezoelectric motor that provides fine X-Y motion. The three Z-inchworm drivers can travel 500 μm. The coarse rotation is 15 mrad.

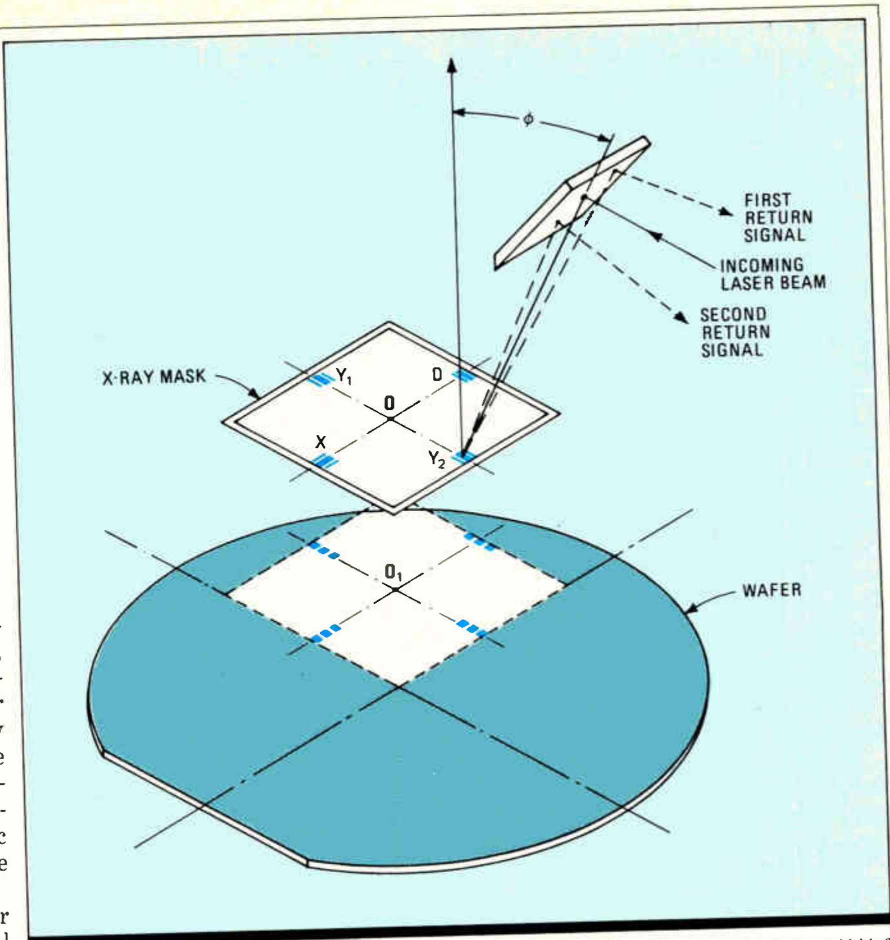
Eight linear variable differential transformers monitor the Z and θ displacements of the mask and wafer stages. A two-axis laser interferometer monitors the wafer-stage X-Y position with an accuracy of ±0.01 μm. When there are no wafer targets, the stage locks onto the interferometer signal. This most likely case of missing targets is with a blank wafer during the first step of the lithography process.

Once the mask has been positioned on the X-Y-θ axes, the alignment system next levels the mask precisely to the plane of X-Y travel. An upper base plate holds the mask stage, the X-ray source, and the optical alignment modules. Three vacuum caps hold the mask from the top. The leveling plate, containing three previously calibrated mask-proximity sensors, moves under the mask. This plate contacts three reference pads on the upper base plate, which are first mechanically aligned to the stage travel as part of the machine setup. The mask-proximity sensors sense the mask membrane. Concurrently, three independent piezoelectric transducers move the mask, fixing the mask in the zero-gap plane.

The electronics and software monitor the three linear variable differential transformers of the wafer-leveling stage and move the piezoelectric transducers to hold the mask rigidly in the zero-gap plane throughout the subsequent alignment and exposure steps. After leveling, the plate withdraws.

Next the system must precisely level the wafer to the required gap plane (Fig. 2). A vacuum pin chuck holds the wafer. The chuck is attached to three inchworm motors, which control the wafer's Z position and allow tilting about the X and Y axes. The motors then move the wafer toward three wafer-proximity sensors until it is in the programmed plane, where the wafer is leveled. Next, the X and Y stages move the leveled wafer under the mask until the wafer reaches the first step position.

Three of the linear variable differential transformers monitor the chuck's Z position. If the chuck moves along the Z axis, the three inchworm motors move the chuck back to the nominal gap. If it becomes necessary to move the chuck vertically, for distortion correction or other reasons, the transformers control the chuck motion.



4. TARGETED. Three sets of mask targets in each individual field are used for an X-Y-θ alignment. A fourth target measures mask-to-wafer linear distortion.

LINING UP

Getting the required mask-to-wafer alignment tolerance in six dimensions was no easy task, says technical director Bernard Fay. The solution was direct sensing of the relative positions of mask and wafer using optically interactive mask and wafer targets, with dynamic alignment during exposure and with extremely high repeatability and accuracy in the staging systems.

Linear-transmission Fresnel zone plates are the mask targets, and reflection line gratings are the wafer targets. The zone plates have a first-order focal length equal to the proximity gap. The optics concentrate a laser beam on the mask into a line focus on the wafer surface (Fig. 3).

The light reflected by the wafer line grating is diffracted into its various orders. This diffraction allows an alignment signal to be spatially separated, freeing it from optical interference with the zero-order light reflected by the mask target. Without the diffraction, the mask-target reflection would be the dominant signal.

The alignment signal, usually the first-order diffracted signal, peaks when the mask and wafer targets are aligned. If the proximity gap is not exactly equal to the zone-plate focal length, the light reaching the wafer surface is not at optimum focus and therefore the amplitude of the peak signal is reduced. The alignment signal is used to adjust the proximity gap to a nominal value with an accuracy of 0.5 μm or better. Furthermore, because the defocusing is symmetrical, the alignment accuracy is preserved when the gap is purposely made different from the nominal value. This is sometimes necessary to compensate for small linear-magnification errors between the mask and wafer.

Because the alignment targets are one-dimensional, three sets are required to achieve in-plane X-Y-θ alignment. The system achieves out-of-plane alignment based on the gap dependence of the three available alignment signals to level the wafer and to set the proximity gap at three points with an accuracy better than 0.5 μm. The three alignment targets (X, Y_1, and Y_2) are oriented radially near the edge of the field (Fig. 4).

With this configuration of marks, the MX-1600 always aligns the centers of the mask and of the wafer fields—0 and 0_1, respectively. It is unaffected by relative linear distortion between mask and wafer. Each target set has its own optical channel and its own laser beam. Each laser directed at targets X, Y_1, and Y_2 is tilted at an angle ϕ. Each optical channel can detect two return signals, which allow the use of two different wafer-grating pitches or two different alignment wavelengths for higher process latitude.

Because of the forward tilt of the laser beam and the divergence of the X-ray beam, alignment targets inside the field (typically up to 5 mm from the field edge) can be sensed with no shadowing of the X rays onto the exposure field. This makes it is easy to generate multiple alignment targets. If the bisecting scribe lines of the mask and wafer have a width of 100 μm, then 20 sets of targets can be accommodated.

The relative linear distortion between mask and wafer is measured with the help of a fourth, transversely oriented target pair, D, and an associated optical system. The change in the gap required to compensate for measured distortion is determined and implemented before final alignment.

To achieve closed-loop automatic alignment, the system uses scanning mirrors and simple optics to modulate the incidence angle of the laser beam on each mask target, resulting in a transverse sweep of the focused line spots. Digital phase-locked detection of the modulated signals produces error signals that drive the wafer and mask fine stages in closed-loop modes.

The wafer targets can be etched directly into the silicon wafer, producing a phase-contrast grating, or they can be defined in the circuit layers, producing a combination of phase contrast and reflection-coefficient contrast. As in all alignment systems based on laser diffraction, the nature and thickness of the layers involved in the wafer target's definition have a great effect on the alignment signal's intensity. But the system's high signal-to-noise ratio minimizes these problems.

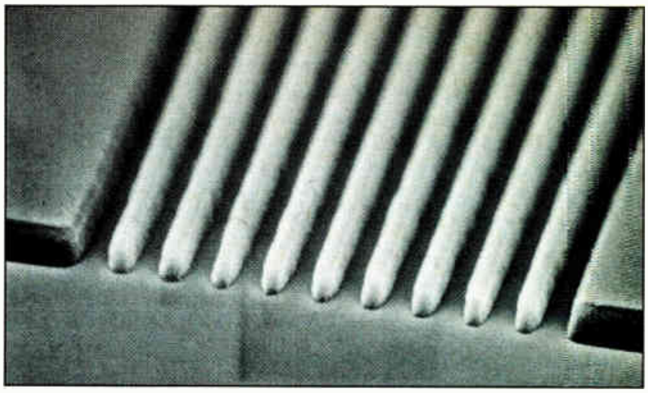
Micronix's initial testing on its X-ray stepper prototype evaluated alignment and overlay capability. A 40-μm proximity gap was used with a source-to-mask distance of 230 mm. The system penumbra under these conditions was 0.6 μm.

The system penumbra affects the printing resolution of an X-ray system, and so do the mask and resist characteristics. For line widths below 0.75 μm, the profile of the absorber pattern and the resist swelling characteristics are critical to resolution.

The negative copolymer resist DCOPA, with a sensitivity of 20 mJ/cm^2, is the fastest commercially available resist. But because of excessive swelling during development, it is unreliable below 0.75 μm. In addition, the dry etching resistance of DCOPA is too low to make it usable as a single-level resist.

Micronix recently tested a new experimental resist, under development at a major resist company, with promising results. A scanning electron microscope photograph (Fig. 5) shows a pattern of 0.6-μm line width with this resist under 0.4-μm-penumbra conditions. The resist is 1 μm thick and the exposure dose was 35 mJ/cm^2. Its dry-etch resistance is comparable to AZ-1350 resist. Further improvements in speed and resolution are expected when the full optimization study is completed.

The alignment tests were conducted in the three-target alignment mode using a test mask pattern allowing two-level printing and containing optical verniers with 0.1-μm increments for alignment evaluation. The mask's field size was 40 by 40 mm, consisting of a 5-by-5 array of 8-by-8-mm chips. The 100-mm wafers were exposed in four steps. One preliminary test, measured by aligning and exposing a group of four wafers each day over 10 days, yielded a repeatability of 1-d alignment at each target of less than 0.1 μm (2 σ). Mean alignment errors for this test were 0.04 μm (σ).



5. SUBMICRON DETAILS. The MX-16 exposed this 0.6-μm-line, 0.8-μm-space pattern on an experimental negative resist.

Throughput of the MX-1600 is a function of resist sensitivity, wafer size, and the number of steps per wafer. Early demonstration results on the prototype stepper show a throughput of 13 wafers/h on 4-in. wafers having four steps per wafer, using a DCOPA resist.

Micronix is building two steppers and expects to deliver several systems this year. In the U. S., the new X-ray stepper will sell for about $900,000. Aubrey C. Tobey, vice president of sales, predicts that the first production use of the MX-1600 may be on 4-Mb read-only memories in Japan. □

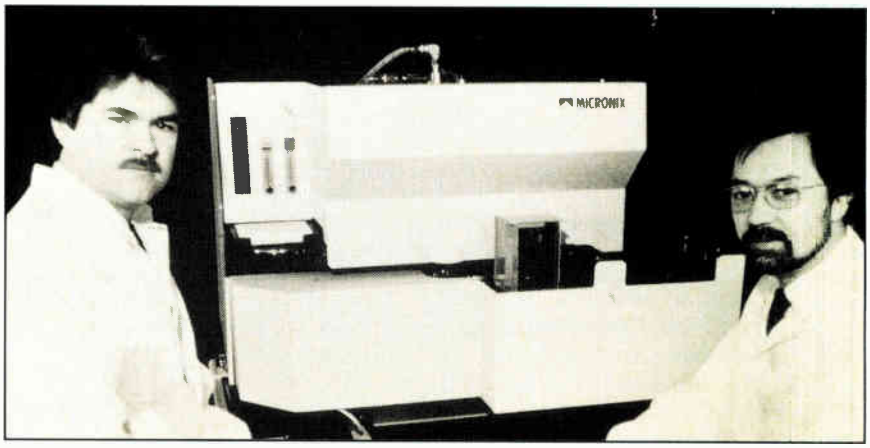
NOW THE HARD WORK BEGINS

Bernard Fay and Thomas Novak, the prime movers on Micronix Corp.'s MX-1600 project, both have solid experience in advanced lithography systems.

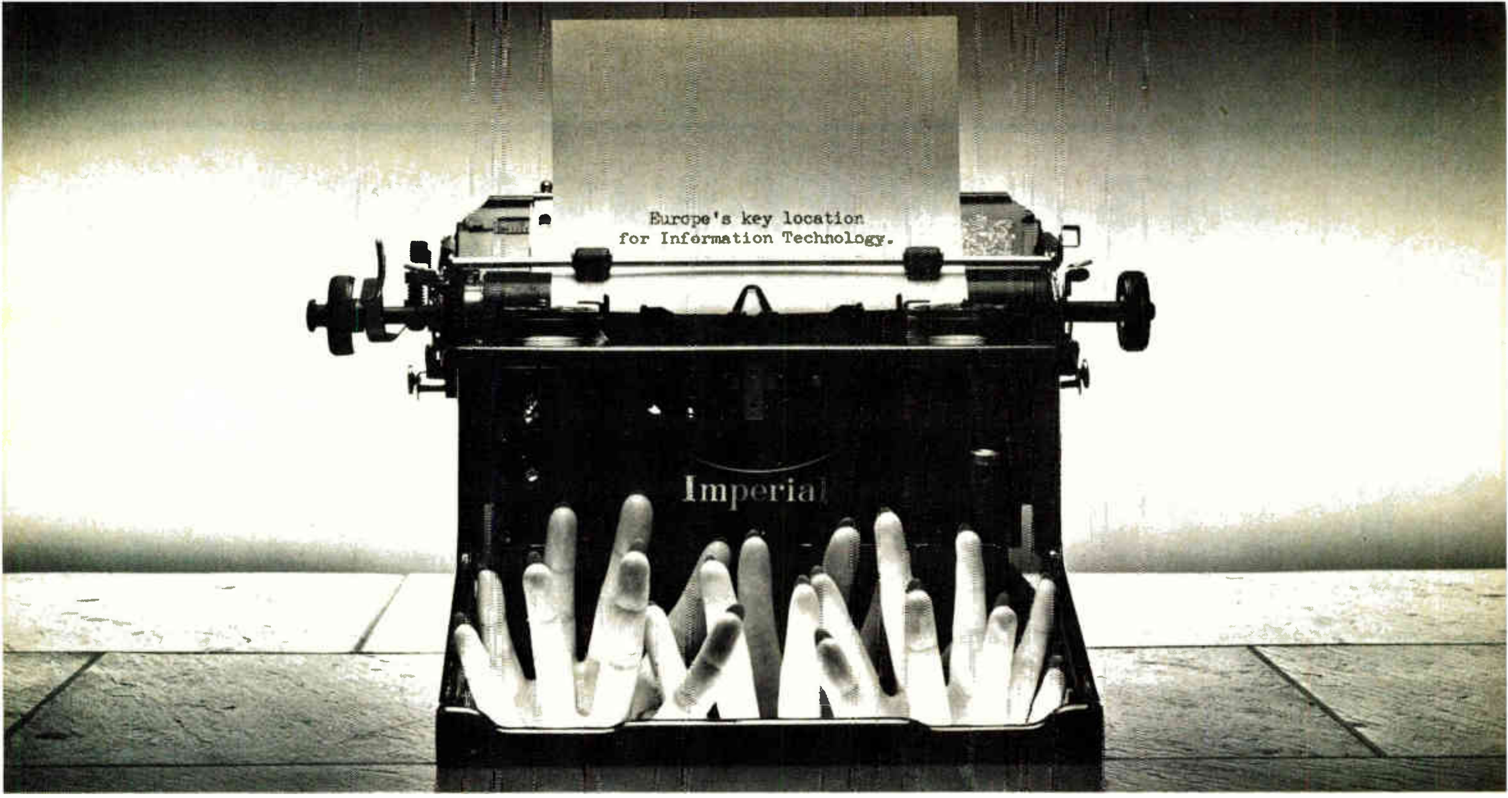
Fay, who has a PhD in electrical engineering from Stanford University, is the company's technical director. He led the development of Thomson-CSF's X-ray lithography program. Before that, he did research in electron-beam lithography at Thomson.

Novak, vice president of engineering, had been vice president of advanced engineering systems at the Cobilt Division of Computervision Corp., Bedford, Mass. At Cobilt, he was responsible for alignment technology and X-ray exposure systems. He holds an MS in physics from Florida Atlantic University.

The most difficult task remaining is to phase X-ray lithography into semiconductor production lines. "It is generally accepted that the technology will be necessary for future production of very large-scale integrated circuits," Novak says. Nonetheless, he adds, many semiconductor process engineers are not sure how soon it will be usable. "Micronix' job is to develop X-ray lithography and generate the experimental and practical evidence needed to expand its use beyond the few large companies that are aggressively preparing to use it to produce VLSI devices."



GUIDES. Tom Novak and Bernard Fay guided the MX-1600 through its development phase.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IT'S A THREE-WAY RACE IN X-RAY LITHOGRAPHY

WILL THE U. S., GERMANY, OR JAPAN BE FIRST WITH THE ULTIMATE SYSTEM?

by Jerry Lyman

The race is on to produce production X-ray lithography systems. On one track are the U. S. and Japanese companies trying to produce X-ray steppers based on conventional radiation sources—and here the U. S is ahead, so far.

On the other track are advanced research efforts in West Germany, Japan, and to a lesser extent the U. S., using synchrotron radiation as an extremely high-intensity X-ray source to radically speed up throughput. The high intensity comes from magnetic fields accelerating electrons around a storage ring, or synchrotron, at near the speed of light. Many engineers think storage-ring technology will produce the ultimate X-ray system. The large-scale storage-ring projects in West Germany and Japan have government backing; the U. S., as usual, is depending heavily on private enterprise. West Germany and Japan look to be comfortably in the lead.

The U. S. has four main participants developing X-ray lithography systems. Micronix Corp. is concentrating on supplying commercial lithography equipment and X-ray masks. Perkin-Elmer Corp. is developing an X-ray stepper for the Very High-Speed Integrated Circuits program. IBM Corp.'s Thomas J. Watson Research Center has an extensive program on applying synchrotron radiation, and AT&T Bell Laboratories has had a continuing program on the feasibility of X-ray lithography since the late 1970s.

Micronix is the only commercial lithography company in the U. S. actively trying to turn out both X-ray hardware and mask substrates. The Los Gatos, Calif., company has already produced a full-field X-ray exposure system that can work with both subtractive and additive patterned masks on boron nitride membranes [*Electronics*, Sept. 16, 1985, p. 48] and it has just announced an X-ray stepper for producing devices with 0.5-μm geometries (see story, p. 41).

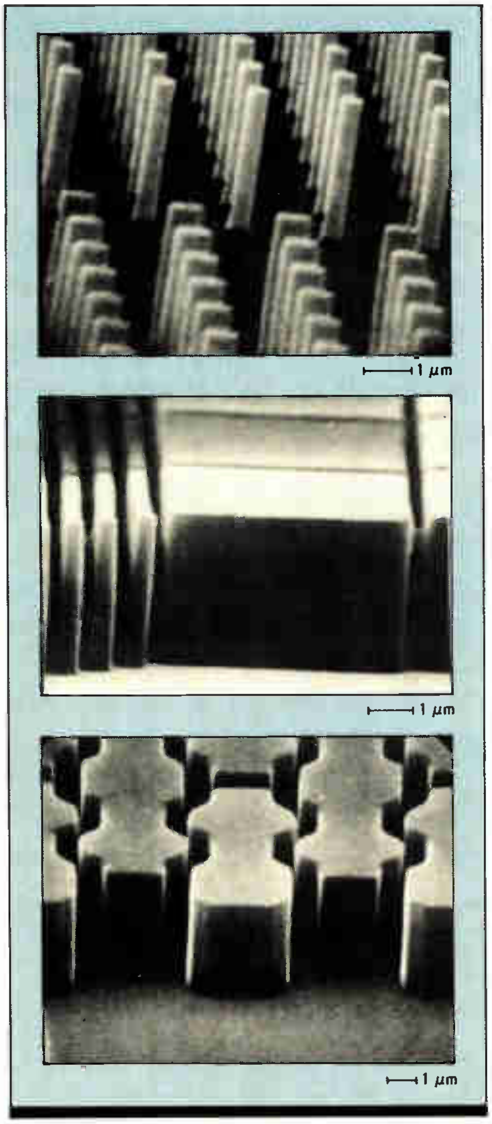
Perkin-Elmer is one of the few U. S. companies involved in all forms of IC lithography—optical, electron-beam, and X-ray. It has two major VHSIC contracts to produce lithography equipment. The first is for a high-speed high-resolution e-beam system, the Aeble 150, to be delivered to a VHSIC Phase 2 participant in mid-1986; the Norwalk, Conn., company is taking orders for the machine [*Electronics*, March 10, 1986, p. 15]. The second was for an X-ray stepper. In 1984, Perkin-Elmer won a VHSIC Phase 2 contract to deliver a prototype step-and-repeat aligner to the Army's Laboratory Command, Ft. Monmouth, N. J., in mid-1986. The company has the prototype system under heavy wraps. This machine could end up on a pilot line at a Phase 2 participant.

"The objective of this program is to address Phase 2 0.5-μm chips," says Dave Huchital, vice president and general manager of the microlithography division. "Part of that is to see whether X-ray will be more cost effective than e-beam in Phase 2 work." To meet Phase 2 requirements, the stepper must have sufficient alignment accuracy to achieve at least 0.5-μm resolution and a throughput of about 20 wafers/h. Perkin-Elmer is aiming for a throughput of 40 wafers/h. But "throughput is extremely dependent on X-ray resists," notes Carl Fencil, the company's director of government programs.

The Perkin-Elmer stepper has a conventional rotating-anode X-ray source. However, the company has an add-on to its Phase 2 contract to explore the possibility of a plasma source, and it has subcontracted development work in this area to Maxwell Laboratories, San Diego. A plasma source would raise the system's thoughput by an order of magnitude over that of the same system with a conventional source [*Electronics*, Dec. 2, 1985, p. 46], and it would do so at a much lower cost. Fencil points out that the biggest questions about the plasma source concern its reliability.

Part of the Perkin-Elmer VHSIC Phase 2 contract is to develop a suitable mask technology for the stepper. Perkin-Elmer is looking at a boron nitride mask with a gold absorber. The company has the contractual right to make a commercial version of the VHSIC X-ray stepper but this has not been decided on at this early stage.

While other researchers in the U. S. work on theoretical studies of X-ray lithography operation on a synchrotron. engineers and physicists from IBM's Watson Research Center in Yorktown Heights, N. Y., have been doing actual research. Since 1980, the company has been a participant in the National Synchrotron Light Source vacuum ultraviolet ring project at Brookhaven National Laboratory, Brookhaven, N. Y., which specializes in



1. SUBMICRON LITHOGRAPHY. IBM Corp.'s X-ray lithography beam line at Brookhaven Research Laboratories does submicron exposures.

high-energy particle accelerators and neutron sources (Fig. 1).

IBM is the principal user of the sixth port on the storage ring, which can have up to 16 ports. This means that IBM must support this port and do the capital investment to make it usable. IBM supplies its own equipment and the operating team and pays the government for the use of the hardware. One quarter of that time is given to other users, such as Cornell University and Rensselaer Polytechnic Institute, who have done X-ray exposures on the line supported by IBM personnel. Except for proprietary work, all IBM's results must be published.

"We are attempting to see if X-ray lithography based on synchrotron radiation is a possible technique for manufacturing, and to that end we are attempting device programs with 0.5-μm design rules," says Alan Wilson, manager of chip lithography at the Watson Research Center. "In addition, we are looking at the entire technology for operating on a storage ring. We are studying storage rings and beam line design [equipment that focuses the beams] and have made prototypes of alignment systems and steppers."

IBM's researchers have already turned out many prototype devices on the storage ring's X-ray lithography setup. The alignment tool in place at Brookhaven is an IBM-designed vertical stepper housed in a clean room fed by the beam line (Fig. 2). The prototype stepper uses a dark-field optical alignment system that Wilson says is accurate enough for submicron-line exposures. IBM has worked extensively on membrane and absorber technology to make distortion-free masks, developing both boron silicon and boron nitride additively patterned types. The company has used its long experience with e-beam patterning to create the clear submicron patterns needed for X-ray mask making.

A synchrotron is cost effective only for high production runs

"A critical advantage of a storage ring is that the high X-ray intensity of its 8- to 10-Å radiation lets it be used with standard optical and e-beam resists like polymethyl methacrylate," says Wilson. Thus a resist can be selected for process compatibility rather than for sensitivity, as in lithography systems based on conventional X-ray sources.

Wilson thinks synchrotron technology has high potential for very large-scale integrated circuits, but he warns that the only way to find out if it is usable in manufacturing is to practice it on a pilot-line environment. The biggest obstacle to X-ray lithography is not the power source or the ultraprecise alignment mechanism, he says. The problem lies with the mask, which is hard to make, hard to pattern, and fragile.

AT&T Bell Labs, Murray Hill, N. J., is one of the pioneers in X-ray lithography in the U. S., having developed a water-cooled electron-impact palladium source, boron nitride mask technology, high-sensitivity X-ray resists (negative copolymer), and three generations of alignment systems for full-field X-ray systems. Micronix has a similar full-field system.

The lab is looking at the limitations of sub-0.5-μm X-ray lithography, says W. A. Johnson, supervisor of the X-ray Mask Fabrication Group. Efforts have concentrated on the understanding of pattern distortions caused by stressed X-ray absorber features and on the stability of the mask materials when they are exposed to high-energy high-flux X-ray sources, such as from a storage ring.

FIRST PRODUCTION USE

Johnson sees full production use of X-ray lithography on ICs with design rules of 0.5-μm or less in the early 1990s; most researchers in X-ray lithography agree. He thinks the economics of producing these devices will dictate the use of the storage ring because it has the highest wafer throughput of all the possible X-ray techniques. He notes that by the early 1990s, these ICs will be made on 6-in. wafers. This will dictate the use of a stepper because full-field X-ray systems cannot expose such a large wafer. To be used on a storage ring, the stepper must be vertical, because a ring produces a horizontal beam, so the stepper's stages must be perpendicular to the the horizontal plane.

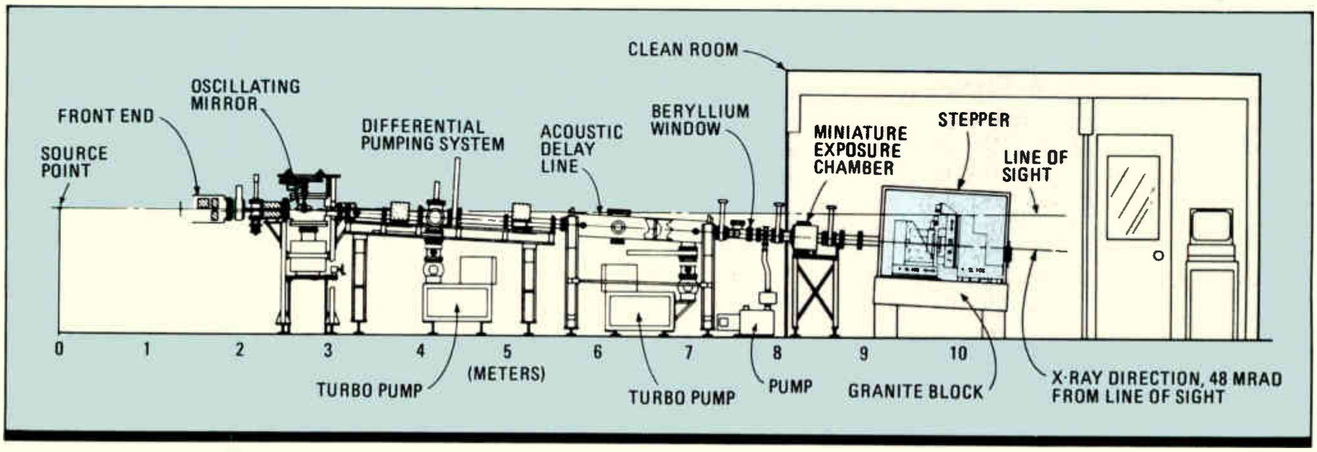
Steppers with a plasma source could be suitable for extremely complex devices that don't need a high throughput rate, he says. A plasma source, which gives a fair throughput at a much lower cost, is suitable for low production runs. A synchrotron, which is expensive, can be justified only for extremely high production runs.

Though IBM is the only U. S. company doing X-ray lithography on a storage ring, the governments of West Germany and Japan are behind massive synchrotron programs.

X-ray lithography has come a long way in West Germany in the past year. The original near-term goal of a major research effort in X-ray systems using synchrotron radiation has been redefined for smaller feature sizes. Also, the first commercial X-ray lithography systems based on a synchrotron energy source will be available next year.

X-ray lithography started as a multicompany, government-supported project at the Fraunhofer Institute for Microstructure Technology, West Berlin [*ElectronicsWeek*, April 15, 1985, p. 34], with the institute coordinating the efforts of virtually all West German semiconductor makers—Eurosil, Siemens, Telefunken electronic, and Valvo, a Philips subsidiary. Contributing to the effort as subcontractors are a number of research institutes and technical universities as well as other companies.

The original near-term goal, to be reached by 1988, was to show that X-ray lithography is a workable technique for making chip structures as small as 0.7 μm, not only for laboratory work but also for the production line. But such progress has



2. ON THE BEAM. X-ray lithography at Brookhaven is done in a clean room fed from a beam line. The system uses a vertical stepper.

THE COSY X-RAY LITHOGRAPHY SYSTEM

Preliminary data for the COSY storage ring	
Critical wavelength	12 Å
Maximum field (orbit)	4.5 T
Maximum electron energy	630 MeV
Bending radius	44 cm
Storage time	≤ 10 h
Time for refilling	15 min
Maximum radiation power (distance of 5 meters)	250 mW/cm²
Geometrical size length width	 4 meters 2 meters
Floor space (including injection, shielding; excluding remote power supplies)	30 m²
Number of beam lines	≥ 8
Data of a typical X-ray stepper for COSY	
Wafer diameter	≤ 200 mm
Stepper field minimum maximum	 20 x 20 mm² 90 x 90 mm²
Alignment accuracy (3 δ)	50 nm
Proximity gap	20 to 100 μm
Typical gap	50 μm
Footprint (excluding control unit)	1.5 m²
Alignment time	1 s
Stepping time	1 s
Overhead time (including wafer change)	10 s
Exposure time (resist sensitivity of 100 mJ/cm²)	2 s per 30 x 30 mm² field

SOURCE: COSY MICROTEC

been made in the past year "that we think we can get structures down to 0.5 μm by the end of 1987," says an institute researcher. The goal by the mid-1990s is to demonstrate that X-ray lithography can be used for fabricating memories and other parts with features of 0.3 or perhaps 0.2 μm. Nothing similar is known to be planned in the U.S.

One major problem being addressed by the Fraunhofer Institute and participating semiconductor houses is mask technology. Thermal stresses occur in the mask between the substrate foil, made of either silicon or a silicon compound, and the X-ray absorbing material, which is either gold or tungsten. These stresses lead to mask distortion, which impair the chip quality.

All four semiconductor producers are trying to solve this problem together with the institute. They are also engaged in testing and evaluating the experimental samples. The big chemical company Hoechst AG, Frankfurt, is producing the X-ray resist, and Munich's Karl Suess GmbH is working with Siemens AG on the X-ray stepper.

ALTERNATIVE SOURCES

The Fraunhofer Institute decided against laser-induced plasma as an X-ray source after research showed it would be difficult to produce reliably. It is now looking at pinch-plasma sources as a possible alternative because equipment using it can be made smaller and would be less expensive than a synchrotron storage ring. It would not be able to attain feature sizes below 0.5 μm, however, because its light is not collimated as in a synchrotron. Synchrotron radiation does more than achieve feature sizes approaching 0.2 μm. It also lends itself to mass-production techniques: not only does its high intensity make for a high throughput, but multiple beam lines can be set up. The X-rays are parallel, so exposures can be made in one shot. Plasma, on the other hand, is a point source—meaning that it results in shadowing.

Meanwhile, researchers at the Fraunhofer Institute have developed a practical synchrotron. Called COSY, for compact synchrotron [*Electronics*, Dec. 2, 1985, p. 45], the system has an oval storage ring about 4 m long and 2 m across. It occupies about 30 m² of floor space. A prototype COSY is being built by West Berlin's Bessy GmbH; the institute will use it for further experimentation.

COSY's maximum field strength is 4.5 Tesla and its maximum electron energy is 630 MeV. Its X-ray stepper handles wafers up to 200 mm in diameter. The minimum and maximum step fields measure 20 by 20 mm and 90 by 90 mm. Alignment accuracy is 50 nm (table).

In experiments, a COSY prototype has attained 0.2-μm pattern sizes. Whether it will be possible to commercially produce such fine resolutions in the near future depends on the mask and on the alignment apparatus. But COSY will go commercial, with first units to hit the market by the end of next year. Handling the marketing of the compact ring will be COSY MicroTec GmbH, which will be set up in West Berlin sometime next month. Leybold-Heraeus GmbH, a vacuum equipment company in Hanau, near Frankfurt, will be the majority shareholder in COSY MicroTec. Bessy and the Fraunhofer Institute will transfer their know-how to COSY MicroTec.

While MicroTec will build the storage ring, the main control unit, the power supply, and other gear related to the synchrotron source, Karl Suess is likely to make the X-ray stepper for the market. Price information on COSY is not yet available. But MicroTec plans to market it at an amount "competitive with that of high-performance optical equipment of the same productivity level," says Stefan Reineck, COSY MictoTec's designated vice president for sales and marketing. The system will be introduced at the Semicon West show on May 22 in San Mateo, Calif.

West Germany's competition in the race to win the market for commercial X-ray systems is Japanese, Reineck says. "But because of the work done at the Fraunhofer Institute, we believe we have about a year's lead in getting a system to market." No commercial competition in X-ray lithography based on a storage ring is yet in sight from the U.S., he adds.

TWO THRUSTS

X-ray lithography in Japan has two main thrusts. One is a stepper using an X-ray source consisting of a beam of accelerated electrons from an electron gun striking a heavy-metal target. Development has been a cooperative effort of the Electrical Communications Laboratories of Nippon Telegraph & Telephone Corp. and Nippon Kogaku (Nikon); Nippon Kogaku is the sole vendor.

The other thrust is synchrotron radiation. First experiments were conducted in 1977 or 1978 by Susumu Namba of Osaka University's Faculty of Engineering Science using the storage ring at Tokyo University's Institute for Nuclear Study. Much work has been done at the Electrotechnical Laboratory operated by the Agency of Industrial Science and Technology of the Ministry of International Trade and Industry. This laboratory and the Atsugi Electrical Communications Laboratories of NTT are at the forefront of efforts to develop storage-ring systems for industry.

Nippon Kogaku has sold four X-ray lithography systems, including at least two to NTT and one to NEC Corp. Purchasers of the X-ray stepper, which is available for $1.1 million and up in Japan, are using it for research on fine-pattern lithography and resists—not for production.

The stepper is designed for use with wafers up to 6 in. in diameter and has an exposure area of 25 by 25 mm. The X-ray source has peak radiation wavelength of 7.1 Å. With this system, devices can be fabricated with line widths of less than 0.5 μm. Three-sigma positioning accuracy is better than 0.15 μm. Delivery time for the machine is about 10 months. A source at Nippon Kogaku says that the size of the exposure area makes it look like the product is lagging U.S. competition such as the Micronix stepper, which has a 50-by-50-mm exposure area. But the company says that 25 by 25 mm is the maximum realistic exposure area.

So far, only laboratories have been interested in the equipment, says Shoichiro Yoshida, general manager of Nippon Kogaku's Industrial Supplies and Equipment Division. So he doesn't expect it to be an attractive business in the near future. X-ray lithography will definitely not be needed for production until line widths reach 0.5 μm and may not be needed until dimensions hit 0.25 μm.

At the Electrotechnical Lab, researchers say that the X-ray stepper with a vertical beam and a conventional source could well be a transient product for research until rings are developed. Rings should come along before there is a real need for use of X-ray lithography for production, they believe.

Two projects are under way at the Electrotechnical Lab to build and to evaluate rings for lithography. An experimental ring with a normally conducting magnet for use as a vehicle for ring development will be completed in a year. The $1.1 million project is financed about equally by the Agency of Industrial Science and Technology and the manufacturers.

The second project involves transferring technology to manufacturers to build a practical ring with superconducting magnets. This four-year $6.7 million project is financed by Research Development Corp. of Japan, which funds commercial development of original technology developed by universities and public laboratories. Research Development's budget is included in that of the Science and Technology Agency.

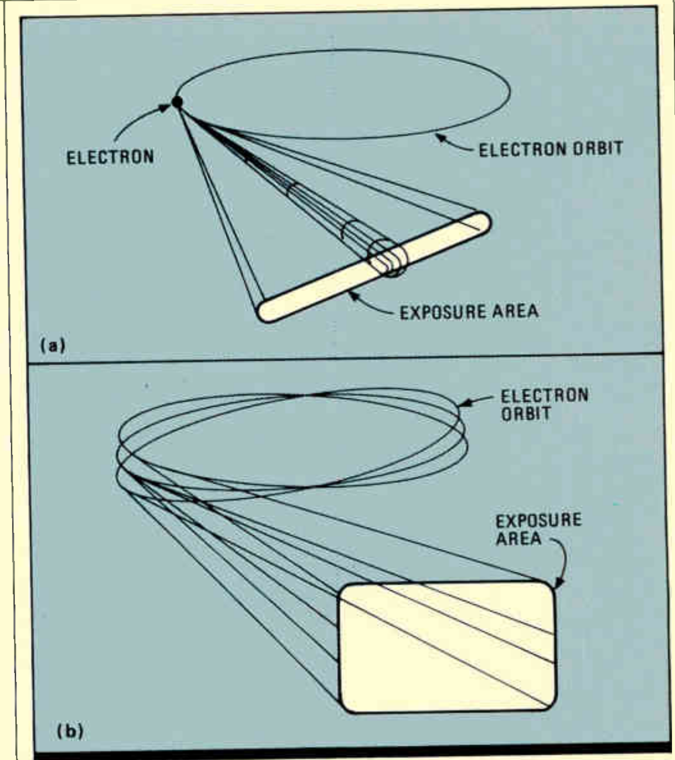
OCTAGONAL CONFIGURATION

The Electrotechnical Lab's storage-ring research is based on the work of Takio Tomimasu, director of the lab's Quantum Technology Division. The ring that he designed is now in use at the lab in R&D. It has an octagonal configuration with an average diameter of 10 m. Its electron path is about 31 m, but the radius of the curved sections connecting straight sections is only 2 m. It is the acceleration of electrons around these bends that produces radiation with a peak output in the 5- to 10-Å region used for exposure. Electrons are injected by a 70-m linear accelerator whose extraordinary length is attributable to the fact that it was designed to serve a number of purposes, including use in research on basic atomic particles.

This ring was first put into operation in October 1981. One of its major contributions to the art is that it undulates the electron beam to increase the width of X-ray beam (Fig. 3), from about 5 to about 25 mm at 10 m. This makes it possible to expose a larger area. Electrotechnical Lab researchers say that the 25-mm width is sufficient because it is more than the maximum dimensions of the individual chips to be exposed, even though users would probably prefer an area as large as in the stepper—40 by 40 mm.

But the researchers contend that wafer-size X-ray masks cannot realistically be made in the manner of optical masks because X-ray masks are made with thin membranes, at most 2 to 3 μm thick, rather than the glass or quartz plates used for optical masks. The problem is that membranes are too delicate. It is possible to make large, thicker masks, but researchers do not think that devices with adequate dimensional accuracy can be fabricated with them. This is because a thicker mask would stop X rays and degrade contrast. A vertical stepper will be needed to expose multiple chips on a wafer, but development of vertical steppers in Japan is not yet well advanced. This is one area where the Japanese lag the West Germans and IBM's operation at Brookhaven.

New rings are to be developed under contract to a consortium of four manufacturers—Mitsubishi Electric, Shimadzu, Sumitomo Electric Industries, and Toshiba. Both projects are being coordinated by Tomimasu. The experimental room temperature ring will be completed in about a year at a cost of about $1.1 million. It will have an average diameter of about 4



3. ELECTRON ORBITS. An X-ray beam produced by a storage ring is long and narrow (a) unless undulated by a magnetic field (b).

m and a linear accelerator less than 10 m long with an energy in excess of 150 MeV. Seven exposure ports are envisioned.

The superconducting-magnet ring will accelerate electrons around a 10-m-long circular, or racetrack, path. The linear accelerator for injection will be several meters long. It is advantageous to make the ring small because the length of tangential ducts tapping off the X-ray source for exposure in general need to be at least twice the ring's radius to provide room for exposure equipment.

Toshio Tsurushima, director of the Electronic Device Division of the Electrotechnical Lab, says that mixed optical and X-ray processing may be used initially. Studies are under way on mask technology and steppers. This stepper research is on basic technology, rather than on the development of stepper equipment. In addition, researchers are working on mark detection and alignment, including the use of sensors and actuators. These projects are aiming for alignment accuracy as fine as 0.01 μm.

The resists now being used have not been optimized for X-ray lithography. Work on the development of X-ray resists is being done by Japan Synthetic Rubber Co., among others. Tsurushima says that for the most part conditions for sensitivity and resolution are in conflict because high-sensitivity resists have the poorest resolution.

Little is known about NTT's storage-ring project. The company will say it is developing a room-temperature ring with an electron path of 50 m as a prelude to a superconductive ring with a 10-m path in a racetrack or a circular configuration, to come in five or six years. Whereas a room-temperature ring runs with its magnetic coils uncooled, a superconductive ring's coils are supercooled to get near-zero resistance for much higher magnetic fields. Other experiments have been carried out at other facilities that have rings, including the Education Ministry's National Laboratory for High Energy Physics and the Education Ministry's Institute for Molecular Science. □

Additional reporting was provided by John Gosch in Frankfurt and Charles L. Cohen in Tokyo.

PROBING THE NEWS

HOW THE JAPANESE BECAME A POWER IN OPTOELECTRONICS

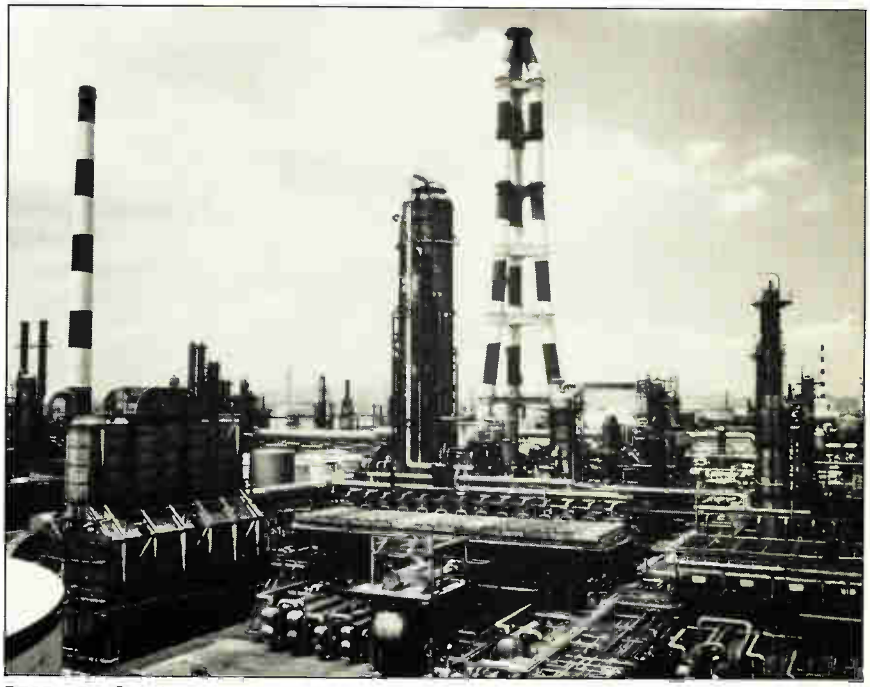
A SEVEN-YEAR MITI PROJECT LAUNCHES AN INDUSTRY

by Jonathan Joseph

TOKYO

The final act is being played out in Japan's massive optoelectronics research project. At the end of the month, a small team of engineers will pack up and leave an Okayama oil refinery, where they had set up an experimental optoelectronic process-control system as the finale of the government-funded portion of the effort. Though the government cut off its backing a year short of the scheduled eight-year run, the companies involved are seeing the project through its final year.

Called the Optical Measurement and Control System Large Scale Project, the undertaking has sparked Japan's emergence as a dominant world force in this technology. "Japanese companies would have gotten into optical fiber even if we had not done the project," according to Kiyoshi Hasegawa, executive director of the Engineering Research Association of Optoelectronics Applied Systems, which runs the program. "But the project really made the Japanese industry take off."



TEST SITE. Culmination of MITI's optoelectronics project was tests at the Okayama refinery.

The project was intended to create momentum in a new industry on which Japanese companies could build. It has done its work well. Japanese manufacturers have become leading producers of such optoelectronic products as laser semiconductors, light-emitting diodes, compact and laser disks, and optical fiber. They are also increasingly encroaching on the high end of the market.

CLOSING THE GAP. "The Japanese are closing the gap by continuing to develop and deliver the high-speed optoelectronics demanded by the market," says Stephanie N. Johnson, head of The Yankee Group's Tokyo office and a telecommunications expert. And a report done last year for the U.S. Department of Commerce concludes, "In the component area of optoelectronics, the Japanese have already surpassed the United States." A big reason was the optoelectronics project.

The project's roots go back nearly a decade, when the Japanese Ministry of International Trade and Industry targeted optoelectronics as a growth industry of the 1980s. In 1979 it got the experiment under way, ultimately spending $84 million in seed money and coordinating the research efforts of 14 Japanese companies. The culmination came when the project moved from the lab to the real world of the Nippon Mining Co. refinery. There the researchers' work on a total optoelectronics system for a complex process industry was tested.

The harvest from all this activity has been bountiful. Five years ago, only a handful of Japanese electronics concerns was working on lasers, fibers, and LEDs. Since then, production of optoelectronic components and systems has grown an average of 190% per year. Output was valued at $4.8 billion in 1985, according to the Japanese Optoelectronic Industry and Technology Development Association, itself founded only in 1980.

That is impressive. Nonetheless, figures attempting to characterize the market for optoelectronic systems can be misleading. The reason is that such systems can be defined as nothing more than fiber, cable, transmitters, and receivers, or the definition can be expanded to include just about everything that is needed anywhere, including installation. The result is that most market watchers limit their measurements to components. However, in Japan's case, the industry association takes the broad view, breaking the market into three groups—components, optical machines, and systems.

Components include three kinds of lasers, LEDs, solar cells, optical fiber, connectors, and discrete receptors. Optical machines and equipment include transmitters and equipment, measuring equipment, sensors that use optical fibers, sensors that use lasers, optical-disk memories, optical disk and compact disk equipment, optical switches, and medical-laser and laser-process equipment. Systems include public and private data-transmission networks.

But no matter how it is reckoned, the growth in the number of optoelectronic systems in Japan has been even more impressive (table). In 1979, there were 52. By 1985, there were well over 1,000, most of them used in telecommunications and factory automation.

Success can be measured in different ways, such as the number of patents granted. As the funding source for the optics research, MITI gained over 300 patents from the work done by the participating companies. These patents are available on a fee basis to anyone, even foreigners, says Masami Tanaka, senior officer for development programs and overseer of the project at MITI.

Among the noteworthy developments that emerged from the project are Fujitsu Ltd.'s optoelectric integrated circuits, or OEICs. The OEICs combine on a single substrate multichannel devices that receive light signals from fibers, convert them to electrical signals, switch channels, and drive laser diodes [*Electronics*, Nov. 18, 1985, p. 39].

BEST DEVICE. The OEIC is the best single device to come out of the project, says Sho Tokoyo, on loan from Fujitsu to the trade association. "It could not have been developed if one company had tried to do it alone," he says.

Hitachi Ltd. picked up the device for a laser-diode driver that will form the core of an experimental 1-Gb/s local-area network. When the project began, Japan's fastest LAN was 32 Mb/s. Though several U. S. companies have experimental systems nearly twice as fast, the Japanese have been quick out of the starting gate before and may do it again in the race to be the first with a commercial 1-Gb/s net.

Another product to grow out of the project is the visible-light semiconductor laser to replace the helium-neon model that requires a bulky glass envelope and a high-voltage power supply. NEC Corp. first developed both pulsed and continuous-wave versions, and later Hitachi developed its own visible-light semiconductor laser, which it is using in its 1-Gb/s LAN.

Then there's Sumitomo Electric Industries Ltd., which did significant work on the optical-fiber sensor. The device originally was developed by Corning Glass Works and used widely by physicians for internal examinations without major surgery. Sumitomo several years ago developed a light-fiber optical device that transmits an image that has been broken down into 50,000 elements for viewing on a TV screen, where it is reconstituted into a very high-resolution picture. It recently improved on that with an experimental fiber that transmits up to 250,000 elements. But Corning has sued Sumitomo, charging it with patent infringement; Sumitomo has countersued, charging interference with its rights.

Sumitomo says the matter concerns only fiber that transmits signals, which it sells in the U. S. Its other fiber, which transmits images and is sold only in Japan, is not involved, says the company. Both actions are currently working their way through New York State courts.

Japanese companies are harvesting a rich crop of products

The ending of government support for the project does not mean all cooperative work will end. The participating companies agree with Tokoyo when he says, "Fundamentally, the project ended too early," so they have agreed to use their own money to keep the joint research lab going for one more year.

Also, given the long lead time, research topics naturally drifted away from the central game plan. For example, NEC built a subsystem, a very high-speed image information distribution system tied to a visible-light laser hologram, that uses 20 beams to transmit information. But the subsystem, which demonstrates its function by reading and transmitting large printed letters on a turning cylinder, is not necessarily suited to a process-industry application and was never tested in Okayama.

MAJOR SUBSYSTEMS. Still, most of the important subsystems and components did make it into the refinery experiment. Sumitomo used its optical-fiber image sensor to observe conditions inside an oil-refining furnace. Mitsubishi Electric Corp. installed a wideband transmitter loop that handled on-line input from scores of temperature, pressure, flow, and on-off light sensors. Yokogawa Hokushin Electric Corp., Japan's leading maker of specialty sensors, supplied key optical switches. And Fujitsu's image-processing subsystem gathered imaging feedback from infrared and visible-light cameras.

Of course, the project did not always run smoothly. The companies, highly suspicious of each other in their home market, were sometimes reluctant to share the results of their research. They also balked at handing over to MITI and their competitors patents for devices they had developed.

Yet overall, cooperation was the rule. The reason, says Tanaka, was the fact that few of these technologies are immediately marketable. "If they were working together on market products, they wouldn't have cooperated as much," agrees Hasegawa.

Looking back, MITI's Tanaka says, "The project was very far-reaching, forward-looking. If we wanted to catch up to the U. S. and Europe, we knew we couldn't do it without being unified." □

OPEN. Masami Tanaka, MITI's overseer of the project, says patents are available to all.

NUMBER OF FIBER SYSTEMS INCREASES

Year	Number of systems
1979	52
1980	79
1981	146
1982	200
1983	340
1984	742
1985	973

SOURCE: OPTOELECTRONIC INDUSTRY AND TECHNOLOGY DEVELOPMENT ASSOCIATION OF JAPAN

JAPANESE OPTICS OUTPUT GROWS ($ millions)

Products	1980	1983	1984	1985
Optical components	345	1,341	1,549	1,714
Machines and equipment	100	871	1,574	2,516
Optical-fiber systems	62	380	445	572
Total	507	2,592	3,568	4,802

SOURCE: OPTOELECTRONIC INDUSTRY AND TECHNOLOGY DEVELOPMENT ASSOCIATION OF JAPAN

RESEARCH CO-OP TO BEEF UP ITS SEMICONDUCTOR R&D

SEMICONDUCTOR RESEARCH CORP. TO BRING IN GOVERNMENT AGENCIES

by George Leopold

RESEARCH TRIANGLE PARK, N. C.

Cooperative research and development in U. S. semiconductor technology has rarely involved companies, universities, and government agencies in one unified effort. Now Semiconductor Research Corp. wants to bring all three together in its drive to outpace Japan's more coordinated R&D efforts.

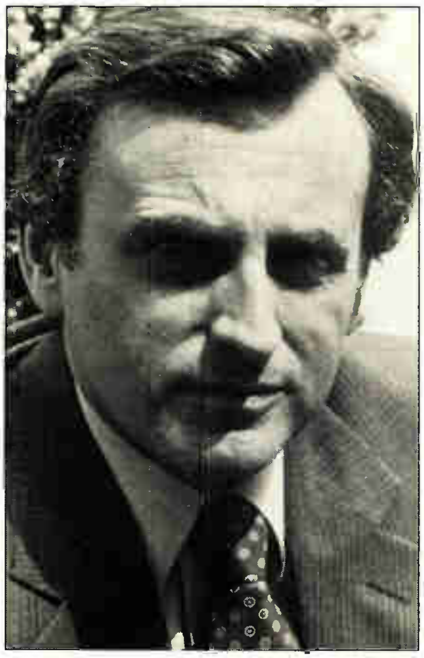
The SRC, which sponsors university-based generic research on behalf of its industrial members, is on the verge of admitting government R&D agencies to its ranks. At the same time, the consortium continues to push toward an ambitious set of technology goals it hopes to meet by 1994. It is sponsoring research in advanced microelectronic technologies, in a variety of chip designs, and in manufacturing technologies. It's garnering generally favorable review in its efforts.

Bringing in government R&D agencies has been in the works since SRC was founded in 1982, says president Larry W. Sumney. The National Science Foundation will be the initial focal point for government involvement, providing the research funds for the participating agencies and acting as their contact with SRC.

Slated to join SRC would be the NSF, the Defense Advanced Research Projects Agency, the National Security Agency, the National Aeronautics and Space Administration, and the Department of Energy. Sumney is "pretty confident" that details will be worked out by September. The agencies would pay higher fees than SRC's industrial members

These agencies would join the top five U. S. merchant chip makers—Advanced Micro Devices, Intel, Motorola, National Semiconductor, and TI—as SRC members. The consortium also includes major system houses such as AT&T Technologies, Burroughs, DEC, Hewlett-Packard, Honeywell, and IBM.

SRC hasn't been waiting on the expansion of its membership rolls to come to the aid of the beleaguered semiconductor industry. "The problem for the U. S. industry has been that the merchant semiconductor companies who were leading the technical surge to new products have become increasingly restricted, as competition has limited their ability to generate funds for R&D," observes Sumney, who was the first director of the Defense Department's Very High Speed Integrated Circuits program. The alternative, he says, is to spread R&D costs more evenly throughout the industry through a mechanism such as his organization.



LARRY SUMNEY: Getting government in.

PRIMARY MISSION. SRC's primary mission is to identify the technology needs of the U. S. semiconductor industry and pull together fragmented research resources. Its research helps support graduate students and so will build up the industry's manpower resources. It also disseminates information and transfers technology to members as fast as possible.

"I think it's done very well in a number of ways," says NSF director Erich Bloch, who was SRC's chairman from 1982 to 1984. For example, SRC has invested more money in university research than was anticipated at the beginning, says Bloch. By last November, SRC was sponsoring research at 35 U. S. universities conducted by 200 faculty members with nearly 400 graduate students. Three "centers of excellence" have been established at Cornell University, Carnegie-Mellon University, and the University of California at Berkeley.

One of SRC's major accomplishments so far, officials of member companies say, is that it has for the first time provided a forum within the industry for R&D discussion. "That has been a very great accomplishment of SRC: bringing the industry together on a technical level," says Thomas J. Sanders, vice president of R&D at Harris Corp.'s Semiconductor Sector in Melbourne, Fla.

ANTITRUST CHALLENGE. SRC's formation was one of the earliest challenges to U. S. antitrust laws, which placed restrictions on joint research and made companies reluctant even to discuss such projects, maintains a Commerce Department official who oversees industrial partnerships. The consortium was part of a groundswell that resulted in passage of the National Cooperative Research Act of 1984, says Lansing R. Felker, director of the department's industrial technology partnership program. He says the legislation opens the door to more cooperative research by reducing damage awards in third-party lawsuits against research consortiums.

SRC's membership roll currently totals 35 semiconductor, computer, and materials manufacturers. One of the members, a chapter of the Semiconductor Equipment and Materials Institute, itself includes 33 companies. SRC's 1986 operating budget will be between $18.5 million and $19.5 million. Sumney says 90% of membership fees go directly to university research; the rest covers administrative costs for the consortium's 23 staff members.

Moreover, its officials say SRC can better leverage members' R&D investment than federal agencies sponsoring similar work. One reason, says D. Howard Phillips, SRC's director of manufacturing sciences, is that the consortium is driven by what the industry says it needs. In 1985, for example, SRC divided a budget totaling $14.5 million among research on microstructures (40%), design sciences (30%), and manufacturing technologies (30%). Sumney says those percentages will stay the same in 1986.

SRC has set up a research program

with ambitious 1994 targets. Chief among them is development of 0.25-μm CMOS technology, a 256-Mb dynamic random-access memory, and gallium arsenide ICs to supplement high-speed bipolar technology and for optical interconnections (chart). Complexity and performance goals include achieving 20 million transistors/cm², 50-ps logic gate delays, and a 16-bit analog-to-digital converter operating at 100 MHz.

Research programs at Cornell and the Massachusetts Institute of Technology have thus far developed research vehicles as a focus for this research (for example, a cell on a chip that demonstrates a technology). In February, SRC's Microstructure Sciences Committee reported that Cornell researchers were using a six-transistor, 1-K static RAM that had a circuit density equivalent to a 4-Mb SRAM, and MIT was using a 16-bit, 10-MHz ADC as the basis for its work.

A 0.5-μm process using electron-beam patterning was demonstrated in 1984 and 0.25-μm MOS transistors were fabricated last year at the SRC-sponsored Cornell Microstructure Sciences Center of Excellence, according to William C. Holton, director of microstructure sciences. Cornell's Noel MacDonald, a professor of electrical engineering, says researchers are developing new growth techniques using thin-film oxides and electrical characterization techniques for an array of cells that will be compatible with a 16-Mb RAM.

MUTUAL RESPECT. MacDonald, who heads the 0.25-μm effort, says the interaction between the school and SRC over the past three years has spawned mutual respect. "They've really come to grips with working in the university environment," he says, adding that unlike many individual corporate sponsors who often want a quick turnaround on sponsored research, SRC has learned that educating engineering students takes time. "I give them extremely high marks."

SRC is putting about 30 students through the Cornell program. "The payoff is that they [SRC] are getting more students," explains MacDonald. That happens because, when SRC-sponsored graduates begin interviewing with electronics companies, "they give the SRC companies the first shot."

Universities are ideal for this type of work, adds Robert M. Burger, SRC's staff vice president for research, because the pace of research in silicon during the 1960s and 1970s left U. S. universities behind and they now want to catch up with industrial research. Moreover, Burger thinks cooperative research conducted by university laboratories will help eliminate wasteful research duplication. "If we increase R&D efficiency by 10%, it would have a major impact," he argues.

SRC is working hard to boost the quality of chip manufacturing

Still, some SRC members express concerns about the immediate usefulness of SRC-sponsored university research. The applicability of initial research results often seems to be five years away, says Stephen W. Michael, general manager of the General Electric Co. Semiconductor Division's custom integrated circuit department. He suggests that SRC focus on basic research that can be moved more quickly out of the lab into the developmental stage.

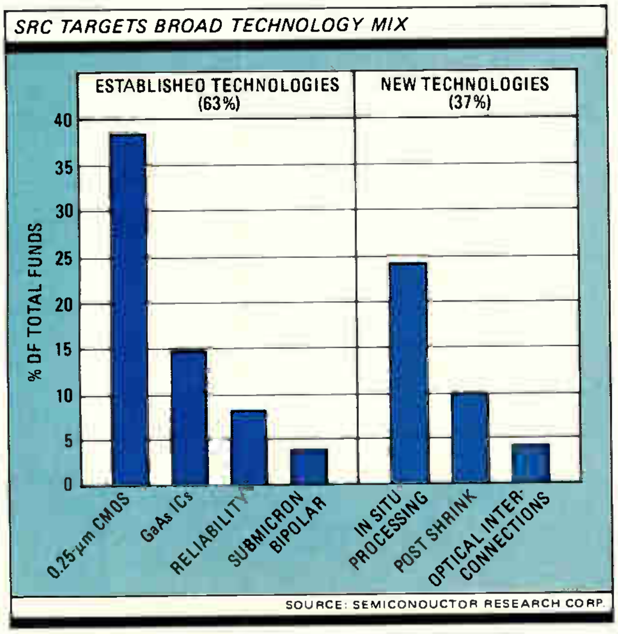
Meanwhile, SRC is trying to improve the quality of U. S. semiconductor manufacturing and its professional status in engineering schools, as the Japanese have. According to manufacturing director Phillips, SRC is trying to develop advanced production techniques so U. S. companies can better compete with their Japanese counterparts.

"SRC has done a very good job in the areas of microstructure sciences and design sciences," says Harris's Sanders. "They've had less success in the manufacturing area." The reasons for that gap, he says, are that the chip industry was slow to develop an adequate definition of manufacturing and, once a definition was agreed upon, the industry had problems convincing universities that manufacturing is important.

MANUFACTURING RESEARCH. SRC has established a "core program" at Stanford University, a project on IC manufacturing technology at the Microelectronics Center of North Carolina, and chip-manufacturing automation studies at the University of Michigan, among others. "We're still not doing enough manufacturing research," says Mohan Rao, senior vice president of Texas Instruments Inc.'s Semiconductor Group in Dallas and an SRC director. "But I think you'll start seeing the impact [of SRC research] four or five years down the road."

If the U. S. chip industry lags in manufacturing, it still maintains a clear lead in semiconductor design. "We're trying to build on this strength," says Ralph K. Cavin, director of SRC's design sciences effort. To accomplish its 1994 design goals, Cavin's group spent more than $2.5 million in 1985 to establish the centers of excellence in design science at Berkeley and Carnegie-Mellon, along with other projects.

But in the current environment of tight federal R&D budgets and restrained antitrust enforcement, SRC will also lead a push toward new partnerships for universities, industry, and the government in order to improve such areas as the quality of engineering education. The consortium's importance will grow, believes the NSF's Bloch, because of the need to attract private R&D funding. Adds Commerce's Felker, "If there is a slowdown in [government] R&D funding, [co-operative research groups] will become more important." □



ROBERT BURGER: Cooperative research conducted at universities will eliminate wasteful duplication.

IT'S HIGH NOON FOR WORK-STATION MAKERS

THE BIG GUYS SHOOT IT OUT WITH A HOST OF SMALLER SUPPLIERS

by Craig D. Rose

BOSTON

It's high noon for the growing legion of suppliers of engineering work stations. The players have unholstered their products and are gunning for a share of a market that should exceed $1 billion this year.

IBM Corp. and Digital Equipment Corp. are the two biggest names in the battle, but they are up against some smaller rivals that could emerge as the market's big winners. Still, observers expect that any gains or losses scored now will be relatively short-lived, as the work station business rolls into a topsy-turvy phase with particularly stiff competition on the low end.

"What we see now is the official start of something that is like the minicomputer business," says Richard Lewan, work station marketing manager for DEC in Maynard, Mass. "Every six months, you'll see similar things. We will be out front for awhile, then someone else, and back and forth."

TIGHT FIELD. Although all major combatants have introduced new products in the past three months, it's doubtful whether anyone can soon break out of the closely grouped field. "I don't think anyone made the kind of play that will pull them away from the pack," says Michael Gallup, vice president of marketing at Apollo Computer Inc. "I think the business will grow more dependent on the general business climate."

Within the work station market, the greatest amount of growth should come at the low end. Customers with fixed amounts of capital want to know how many engineering "seats" can be automated for those dollars. "New customers are looking at $10,000 to $20,000 per seat," says Vicki Brown, senior analyst at market researcher International Development Corp., Framingham, Mass. "I think you'll see a lot of activity at the low end," agrees Dave Burdick, an analyst at Dataquest Inc., San Jose, Calif.

The leader in this crucial market segment is Apollo, agree Brown and Burdick. The Chelmsford, Mass., company, which saw its sales growth and profitability slip during last year's downturn, offers the strongest price/performance ratio at the bottom end of the market, they say. The analysts believe Apollo

The big winner could be one of the smaller players

has opened a window at the low end with its Series 3000 Personal Workstations, which will soon be compatible with IBM personal computers.

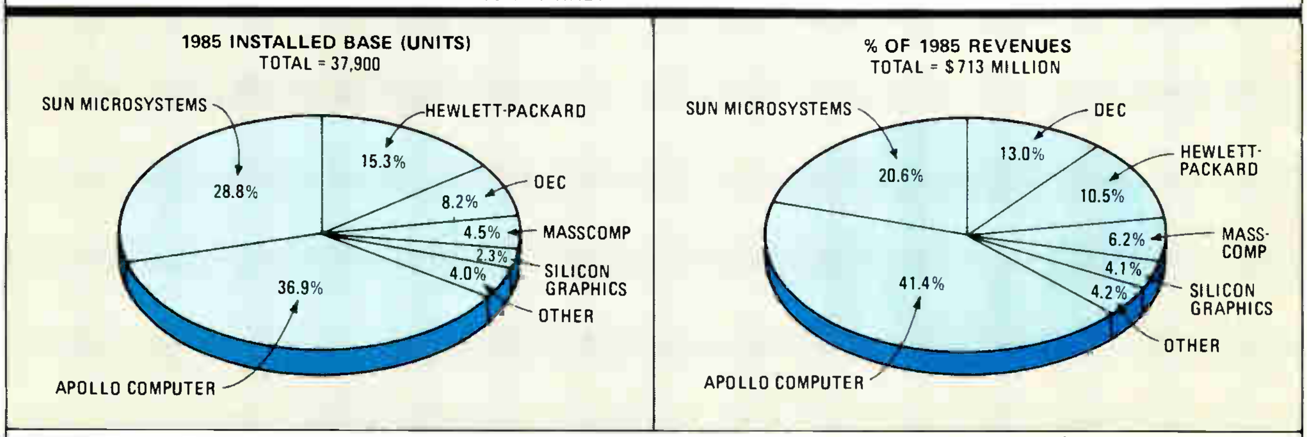
The Apollo machines offer significant color capability for about $15,000; the monochrome version sells for about $10,000. Though not the least expensive work stations on the market—Sun Microsystems Inc. offers a machine for $7,900—the analysts believe the Apollo line's superior performance for the price make it extremely attractive to buyers. The company's lead in this market could be short-lived, however. Other companies are moving so quickly that Brown estimates Apollo's window for the 3000 will be open for just a few months.

Apollo has responded to complaints that a closed architecture limited its appeal by opening up its product line. Its new machines [*ElectronicsWeek*, Feb. 24, 1985, p. 20] offer both the system V and 4.2bsd versions of AT&T's Unix operating system, which observers say is a definite plus. The company promises to deliver by April a bridge to DEC's VAX machines; an IBM PC-coprocessor board for the 3000 is due later this year. Apollo further broadened its range on the high end last month by adding multiprocessors from Alliant Computer Systems Corp. as computation servers.

TOO LIMITING? Still, some observers wonder if Apollo would have been better off tying into several computer engines, rather than limiting its high end to Alliant's product. There is also speculation that personnel defections have hurt product development at Apollo—for instance, the VAX bridge had been slated for delivery in late 1985. Finally, says IDC's Brown, concern about Apollo's long-term stability could be a handicap in a changing sales environment.

The decision to buy work stations is moving out of the hands of engineers into the control of corporate management-information-systems people, she notes. "The question is whether Apollo

APOLLO STILL LEADS IN WORLDWIDE WORK STATION MARKET



SOURCE: INTERNATIONAL DATA CORP.

has relied so much on original-equipment manufacturers that it will not be able to establish multiple layers of penetration" now required for a sale.

Apollo maintains that its OEM sales no longer dominate. Last year, reports company vice president Gallup, 70% of its sales were to end users, versus 70% to OEMs in 1984. Although he agrees the decision to buy engineering work stations is rising to higher levels within corporations, he says "it's still within technical-professional ranks." Among the biggest issues for large corporate customers is a work station vendor's ability to integrate with other vendors' equipment, says Gallup. Apollo's recent integration efforts work in its favor, he adds.

If Apollo's strength is in the business's low end, that segment is DEC's weakness. With a starting price of about $35,000, the Vaxstation II/GPX is expensive. Moreover, DEC doesn't offer a diskless version to compete with offerings from Apollo and Sun. DEC also appears outclassed at the high end, where it does not offer 3-d graphics and its general performance is said to be inferior to Apollo's.

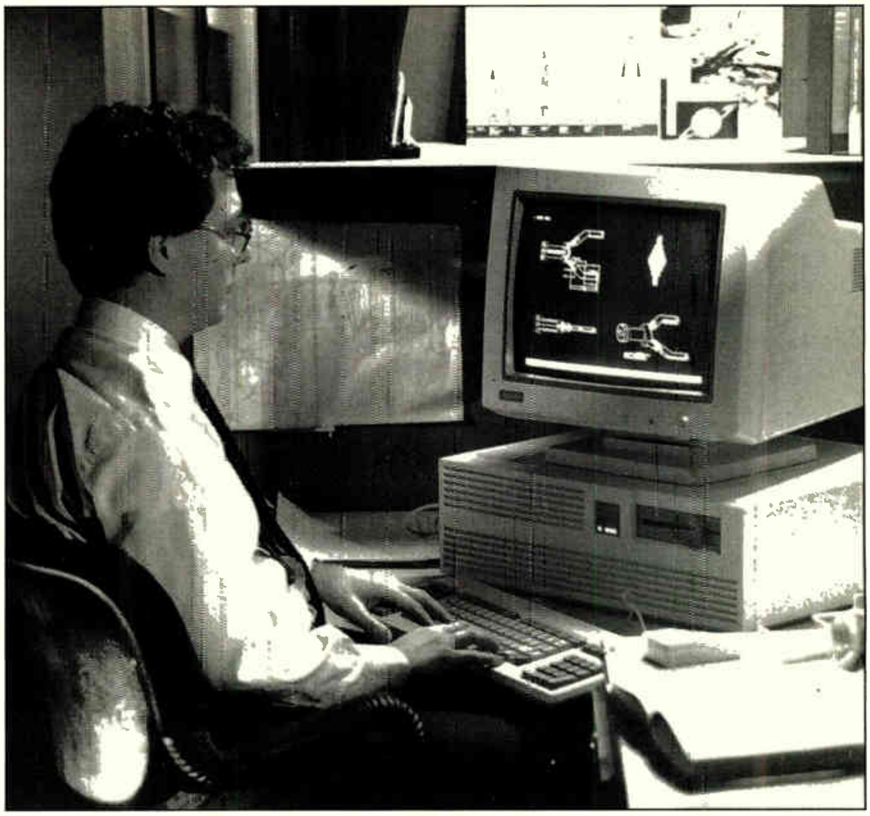
LOYAL USERS. For committed DEC customers, these issues are irrelevant. VAX customers are so loyal that they'll buy a VAX product no matter what. But if the company wants to expand its work station base, the gap at the low end could be a handicap. "It's not an invalid observation," says Lewan of DEC. "We recognize that."

Market observers expect DEC to quickly close that gap, perhaps as early as this spring. And although the official DEC line is that the increased performance of a disk-based work station is worth the extra cost, IDC's Brown suspects DEC will respond to the demand for a diskless product. "I expect to see them do that this year, because the competition has gotten so intense."

IBM's new PC RT [*Electronics*, Jan. 27, 1986, p. 14], meanwhile, is not considered a direct threat by any existing work station vendor. Within the engineering marketplace, the machine is viewed as an incomplete product, lacking adequate networking and graphics capabilities. "I don't know of a single piece of business we've lost to the RT," says Apollo's Gallup.

For the moment, rival companies are more concerned about IBM's potential, rather than what it's offering now. "Most vendors will see little or no effect" from the new IBM machine in the next six months, says Burdick of Dataquest. He adds it may have its greatest impact as a multiuser office machine.

Analyst Brown agrees that the RT is not a strong performer for engineering applications, because of its high price (a typical configuration costs $40,000). But



CONTENDER. Apollo's Personal Workstation competes in the low end of the market.

the RT will have an impact with what she calls "hybrid business-technical" customers and so could broaden the market. "Apollo and Sun had never considered targeting the office where someone had the need for doing technical analysis," says Brown. "These people who never considered a work station before will do so now because IBM is offering it. Apollo and Sun will benefit."

Sun Microsystems in Mountain View, Calif., already does more than half its business in such markets as computer-aided software engineering, computer-aided publishing, and artificial intelligence, says John Hime, director of product marketing. Sales to universities account for a reported 25% of its revenue. Its market distribution "is peculiar to Sun and puts us in a very strong position, as opposed to being overly dependent on the engineering segment," he says.

Hime downplays the importance of high-end graphics capability, which observers consider a weak spot in Sun's products. "We feel that won't be a big part of the work station market," he says. But Hime acknowledges that engineering represents the greatest market opportunity for work station vendors. Without 3-d or high-performance 2-d graphics capability, Sun leaves this market wide open for other suppliers.

At the low end, Sun's 3/50 work station is the least expensive machine available, at $7,900 a full $2,000 below Apollo's cheapest product. But observers believe Sun will have to improve the product's performance in order to compete successfully. Dataquest's Burdick expects that improvement shortly. "Apollo's low-end lead will be leapfrogged by Sun in about two months," he predicts. But Sun's efforts to slash product costs will put pressure on its profit margins, says Brown.

STANDARD SUPPORT. Still, Sun's adoption of industry standards, such as Unix and the Small Computer Systems Interface, will continue to be a plus and the company's effort at championing its network-file standard will also undoubtedly win customers. With a large installed base and its low prices, Sun will continue a strong challenge to Apollo's installed base leadership.

The work station industry's dark horse is Silicon Graphics Inc., which last year installed just under 900 systems. The relatively small Mountain View company has an estimated 12- to 18-month lead in graphics technology and its products—which start at about $39,000—are priced at the market's high end. But Burdick says it is a mistake to view the company as a niche player. "They are really starting to gain some momentum," he says. Adds Brown: "Silicon Graphics is going after major OEMs and computer companies to become the de facto graphics standard." That goal may be within reach if the company can avoid getting shot down by the other players. □

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CAUTIOUS OR NOT, PRIME'S STRATEGY IS A GOOD ONE

WITH REVENUE UP 20% LAST YEAR, THE MINICOMPUTER MAKER POSITIONS ITSELF TO MOVE INTO MULTIBILLION-DOLLAR LEAGUE

NATICK, MASS.

Last year was one that many computer companies would like to forget. Most were hit with sluggish sales and declining profits. But not Prime Computer Inc., the Massachusetts minicomputer maker. By following a strategy that parlays management skills with tightly focused R&D and an emphasis on system integration, Prime was able last year to boost its revenue by 20% and its net income by 10%. To cap the upbeat year, the company ended up shipping more high-end superminicomputers than any other company save Digital Equipment Corp. and IBM Corp.

Industry observers increasingly see Prime as the exemplar of successful risk minimization, a cautious strategy that might produce solid results but one that entails a risk of its own—being left behind by companies that take their chances in the fast lane.

However, president Joe Henson disagrees. "Name any other company in the industry that in 1985 increased its sales force by 20% and its R&D by 28%," he says. "Name any other company that has embarked on such an aggressive pursuit of market share. Name anyone who has been more aggressive in new technologies."

Prime's performance has already put the maker within shouting distance of the billion-dollar revenue mark, and it's laying the groundwork for a drive into the ranks of multibillion-dollar corporations. Armed with a spiffier look—aided by an new ad campaign and a new windswept corporate logo—Prime is following a successful thrust into computer-aided design and manufacturing by making a dramatic surge in research and development spending and beefing

JOE HENSON: Prime Computer's president is willing to take risks for quicker growth.

up its sales staff. But it won't risk its current position. "If we stick to our knitting and demonstrate consistent gains, industry watchers will conclude that performance is what counts and not a hell of a lot of talk," says Henson.

To raise awareness of its success, Prime launched a radio campaign, increased other advertising, and upped its level of trade-show activity and sales promotions. The move, reports Henson, has tripled public awareness of the company. Prime also developed a new logo to project the image of a "dynamic, youthful, and successful innovator," says Henson, whereas the old one implied "conservatism and financial stability."

More substantially, Prime has increased its sales force by 40% in the last two years, and plans to add at least another 20% this year. With salary and training costs of $75,000 per person and about a year's time to get a productive sales representative in the field, this represents a hefty investment and a risk, says Henson.

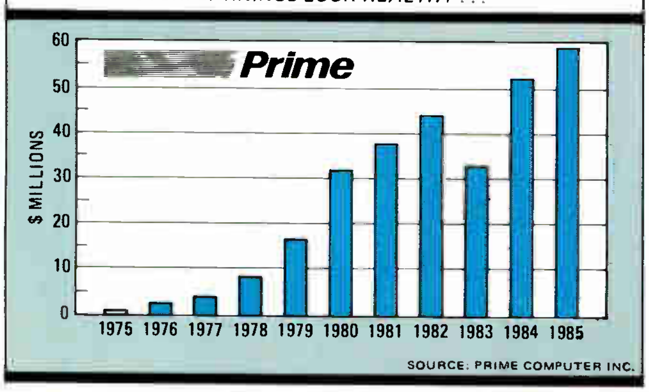
Besides sales, the other big area for Prime is R&D. It will raise R&D spending this year at a rate similar to last year's increase, pushing expenditures to about 15% of product revenue or about 11% of total revenue. High on the list for development is a minisupercomputer, which Prime wants as the top end of its product line. Its existing superminicomputer line—the 50 series, topped by the model 9955 at 4 million instructions per second—will carry Prime to the end of the decade, Henson believes.

DILIGENCE. Also high on Prime's product development list is an engineering work station, due later this year, which the company needs to strengthen its position in the CAD/CAM market. Prime has done well here so far. Starting nearly from scratch in 1981, its CAD/CAM revenue reached $141 million in 1985, a rise of 33% in a market that grew overall by about 24%. "Prime has been diligent in assembling the applications-support vehicles—sales and applications engineers—necessary to support the CAD/CAM marketplace," says Dave Burdick, associate director of CAD/CAM services for Dataquest Inc., San Jose, Calif.

Prime, whose operations are headed by vice president Andrew C. Knowles, up to now has offered customers systems based on its superminis. These systems have allowed Prime to penetrate the mechanical CAD market but not the electrical CAD segment, which developed around the work station. Burdick believes Prime's host-based CAD/CAM business, which accounted for 18% of 1985 revenue, is under pressure from vendors peddling lower-priced engineering work stations. Prime is not developing the work station internally but instead is working with MIPS Computer Systems Inc. and Silicon Graphics Inc., both in Mountain View, Calif.

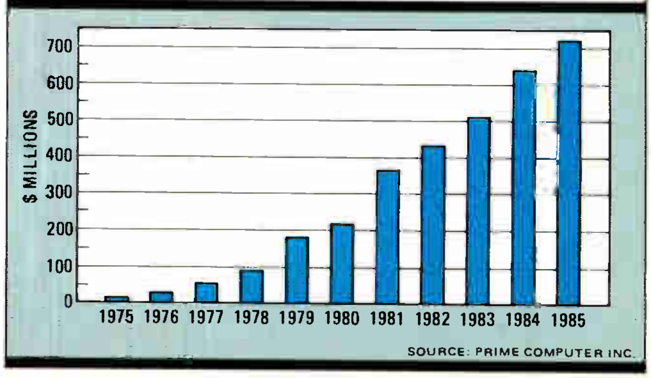
The practice of buying technology from other sources is a departure from

PRIME COMPUTER: EARNINGS LOOK HEALTHY . . .



SOURCE: PRIME COMPUTER INC.

. . . AS REVENUE REACHES FOR THE STARS



SOURCE: PRIME COMPUTER INC.

Prime's origin as a superminicomputer pioneer. The company, which was started in 1972, was among the first to offer demand-paged virtual memory and, much later, an emitter-coupled-logic machine.

Prime was one of the industry's great success stories under the leadership of Ken Fisher, a charismatic executive who joined Prime shortly after its founding. In 1981, however, after a disagreement with the board of directors over the company's future direction, Fisher left (he then started Encore Computer) and was replaced by Henson. A veteran of 27 years at IBM, Henson has brought stability to Prime in the form of steady revenue and earnings growth.

BYWORD IS BALANCE. Stability and balance appear to be the bywords in almost all phases of Prime's operations. For example, the company's sales mix is 53% domestic versus 47% overseas. Of total sales, 54% comes from the technical market, while 46% comes from the commercial side.

Even its heavy emphasis on selling directly to end users—which accounts for more than 80% of its sales—is maintained for stability. Gale Aguilar, vice president of corporate business strategy and development, acknowledges that the OEM business can provide better rewards than the end-user business as an economy heats up. But the OEM market also presents a greater risk in the event of an economic downturn, he notes. As a result, Prime prefers its orientation toward direct end-user sales. "It smooths things in the good years and the bad years," he says.

For the same reason, Prime pursues a cash-generating, fiscally conservative approach, preferring to take its risks in technology. "You may move ahead quickly if you leverage both financial

GALE AGUILAR: Going for the slower-growing but more stable end-user business.

and technical growth, but what happens if you have a bad year?" asks Aguilar.

Marketing strategy is another closely played hand. Prime withdrew from the office automation business in 1984, after stumbling with a seriously flawed product. The software that Prime offered for use on its superminis—software acquired from one of its OEM customers—performed poorly. Rather than a direct assault in this market, Prime is instead trying to back into office automation through data processing. "We really do believe that almost everyone using data processing will need office-automation functions," says Aguilar.

SIMILAR RESULTS. Prime's concern about overreaching extends even to technology. The company recognizes the necessity of being a leader in superminicomputer performance but downplays the need to lead the technology race. Commenting on the success others have had in putting their computers on a single chip, Aguilar says, "It's technically interesting and it's the right direction. But when you get right down to it, we can get close to the same results and cost" without going this route.

As part of its product and technology strategy, Prime wants to reach agreements with smaller companies that are developing promising technologies. This trend to buy and integrate other suppliers' products is making Prime more of a distributor than a manufacturer, says Stephen Smith, a vice president at Paine Webber Inc., New York. "I think that's the appropriate strategy" for a company the size of Prime, he adds. Agrees Henson: "We can't afford to be all things to all people."

But others wonder if Prime can grow fast enough to keep pace with the likes of DEC or even Data General without taking potentially higher-payoff, albeit riskier, roads, such as a major push into the office-automation market. Despite a boost in its R&D activities, the downside risk of Prime's careful strategy is the threat of "being outclassed from a technical point of view by companies such as DEC and Hewlett-Packard," says George Colony, president of Forrester Research Inc., in Cambridge, Mass.

Aguilar says Prime took its chances several years ago just by staying in business. "A few years ago, Prime was less than half what it is today," he says. "At that size, just being in the general-purpose computer business was a risk. The risks we're taking now are in growing the breadth and distribution of our products." *–Craig D. Rose*

BOTTOM LINES

ALLIANT RAISES $11.5 MILLION

Alliant Computer Systems Corp., Acton, Mass., has raised an additional $11.5 million in its third round of venture financing. This brings the total investment in the entry-level supercomputer company to $26 million since its founding in 1982. Alliant, which brought out its first product last July, will use the funds to expand its manufacturing capacity.

LOCKHEED INCREASES EQUITY IN INFERENCE

Lockheed Corp., Burbank, Calif., will invest an additional $2 million in Inference Corp. This raises to $6 million Lockheed's minority equity position in the Los Angeles supplier of commercial expert-system development tools and applications. The two companies also maintain a cross-licensing agreement for developing artificial-intelligence technology for the defense and industrial sectors.

EMHART BUYS CHIP EQUIPMENT SUPPLIERS

Seeking to broaden its electronic component assembly manufacturing operations, Emhart Corp., Farmington, Conn., has acquired two suppliers of semiconductor production equipment for a total of about $4 million. Delvotec SA, of Les Brenets, Switzerland, and Amedyne Inc., of Irvine, Calif., both make high-speed automatic assembly systems for use in semiconductor production lines. The two operations will become part of Emhart's Dynapert Division, which has its headquarters in Beverly, Mass.

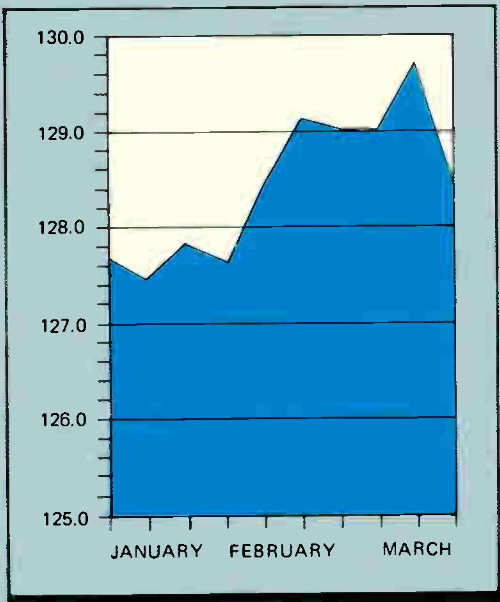
SCOTTISH STARTUP GETS MORE FUNDS

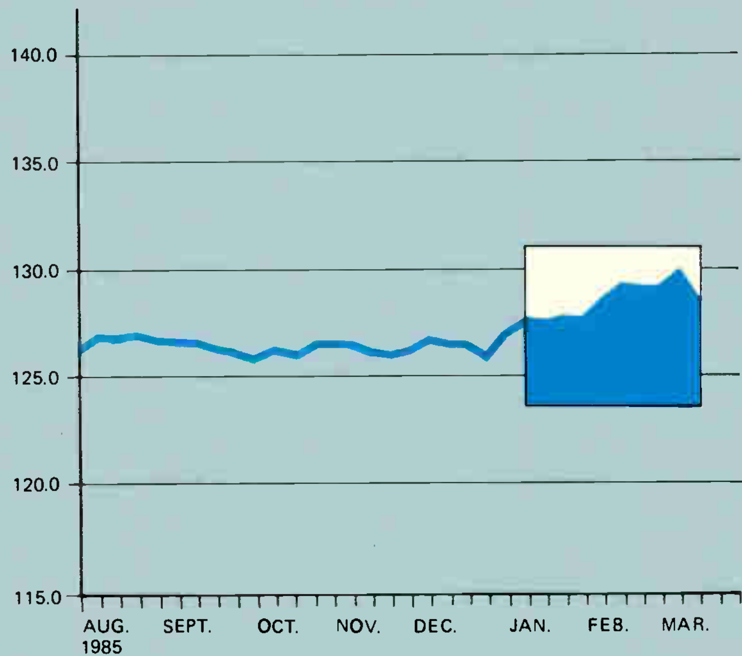
Integrated Power Semiconductors Ltd., Livingston, Scotland, has received $7.5 million in a second round of financing. The company, which was founded in 1984 to make custom-designed power integrated circuits, expects to start shipping products in the second quarter.

AST ACQUIRES DEC ADD-ON SUPPLIER

Diversifying into a new market for add-on computer equipment, AST Research Inc., Irvine, Calif., has acquired Camintonn Corp., Santa Ana, Calif., for an undisclosed amount. AST Research is a supplier of board-level enhancement products for IBM Corp. and Apple Computer Inc. personal computers; Camintonn makes memory products for Digital Equipment Corp. computer systems.

ELECTRONICS INDEX





THIS WEEK	=	128.4
LAST WEEK	=	129.7
YEAR AGO	=	129.3
1982	=	100.0

The *Electronics* Index, a seasonally adjusted measure of the U.S. electronics industry's health, is a weighted average of various indicators. Different indicators will appear from week to week.

U. S. ELECTRONICS SHIPMENTS

Shipments ($ billions)	January 1986	December 1985	January 1985
Communications equipment	4.705	5.860	4.664
Radio and TV receiving equipment	1.111	1.036	0.951
Electronic and electrical instruments	4.862	4.908	4.542
Components	3.095	3.077	3.392

U. S. ECONOMIC INDICATORS

	January 1986	December 1985	January 1985
Index of leading economic indicators	173.0	174.0	166.3
Budgeted outlays of the federal government ($ billions)	82.849	84.079	76.838
Budgeted outlays of the Department of Defense ($ billions)	20.945	23.915	19.367
Operating rate of all industries (% capacity)	78.5	78.5	79.0
Industrial-production index	126.7	126.3	123.6
Total housing starts (annual rate in thousands)	2,088	1,804	1,804

Following several months of good omens, the industry's optimistic predictions for 1986 hit a snag as January sales took a downturn, lowering the *Electronics* Index 1% in the latest week. But though overall electronics industry shipments showed a dip of 7% in January, it was the brutal 20% plunge in communications equipment sales that did most of the damage. The only other electronics sector that lost ground was instruments, with a far more modest 0.9% decline.

Components aren't doing so well either. It's turned out that January's 0.6% gain in shipments was no more than fool's gold. Revised figures show that these shipments actually declined 4.4% in December instead of increasing, as previously reported. The result is that semiconductor sales remain at their second-lowest level in over a year.

And now for the good news. Optimists have no reason to alter their predictions just yet. Consumer electronics companies were the big winners in January: radio and TV equipment shipments rose 7.2% to a level nearly 17% higher than in January 1985.

CHANG'S NEW CHALLENGE: LEADING TAIWAN'S R&D

TAIPEI, TAIWAN

His move to the Far East has been more than just a return to familiar surroundings for Morris Chang—it has been a challenge quite unlike any he has faced before in his career. After moving into the circle of top semiconductor executives in the U. S., the native of China moved to Taiwan last August to become president of the Industrial Technology Research Institute (ITRI). Organized 15 years ago, the institute is the country's main center for research and development in electronics and other high technologies.

MORRIS CHANG: Meaningful work instead of monetary gain.

The 54-year-old Chang says he has entered a new phase in his career, which includes stints as vice president at Texas Instruments Inc. and as president of General Instrument Corp. Now, instead of being concerned with the fortunes of a single company, he finds that he is a key to whatever progress the entire electronics industry of a whole nation may enjoy. "Financially, it's a personal sacrifice, because the pay scales in Taiwan can't compare with those in the U. S. But that's not a burning issue for me at this stage in my life. I welcome the challenge of doing something that I think is meaningful."

Chang believes his experience in the U. S. enables him to bring to ITRI what the institution needs most: modern management techniques related to high-tech operations and a practical business perspective. The largest research center within the 4,000-employee institute is for electronics. Other centers are devoted to mechanical, chemical, materials, and energy research.

ITRI has played a central role in developing the electronics industry in Taiwan. A nonprofit organization that gets two thirds of its funding from government appropriations and one third from client fees, it undertakes research projects for private enterprise, helps them build up R&D capability, and promotes technology transfer from abroad. Because of the small scale of most native industry, few Taiwanese corporations can afford major R&D operations of their own.

Chang fled his native Shanghai in 1948, spent a year in Hong Kong, then emigrated to the U. S. to go to college. He received BS and MS degrees from the Massachusetts Institute of Technology and a PhD from Stanford University. Before signing on with TI, he worked at Sylvania Electric Products Inc., Woburn, Mass.

During his 25 years with TI, Chang rose through the ranks to become senior vice president for productivity, training, and quality before leaving in 1984 to become president of General Instrument. He left that position after eight months and won't discuss the reasons for his abrupt departure, saying only that "I have the kind of personality that if I feel a job is no longer satisfying, I'll resign."

Besides his duties as the institute's president, Chang serves as an informal adviser on technology development to the Taiwan government. He is also heading a task force that is planning the establishment of a joint venture between government and private industry to produce very large-scale integrated circuits. *–Donald Shapiro*

DEBAKEY HITS ROAD FOR U. S. INDUSTRY

WASHINGTON

Anyone who doubts that the electronics industry is of global importance to the government need only look at George T. DeBakey's travel itinerary. Since joining the Commerce Department last July as deputy assistant secretary for science and electronics, DeBakey has gone to China and West Germany to discuss telecommunications trade. Later this year, he'll return to China and then visit India.

All this globetrotting is part of what DeBakey sees as his primary mission: promoting U. S. high-technology exports and helping U. S. companies to better compete abroad. His office has been educating small- and medium-size companies trying to break into overseas markets about hurdling obstacles foreign governments might place in their way.

As part of the department's International Trade Administration, which is handling unfair-trade-practice petitions filed by U. S. chip makers against Japa-

PEOPLE ON THE MOVE

TETSUO MARUYAMA

☐ The troubled Tokyo robotics company Dainichi Kiko Co. has named Tetsuo Maruyama president, replacing founder Toshio Kohno, who was named chairman. Maruyama, 51, had been president of Energy Conversion Devices' Japanese subsidiary, Thermovonics Co., and previously worked for NEC, Toshiba, and Kyocera. The move, which is part of a new finance and technology package designed to revive the company, also links Dainichi with Energy Conversion Devices, Troy, Mich.

RANJIT SITLANI

☐ Microcomputer-drive maker Tandon Corp. has promoted vice president of planning Ranjit Sitlani to the new position of executive vice president. Sitlani joined the Chatsworth, Calif., company in 1982 as executive aide to Sirjang Lal Tandon, the company chairman and chief executive officer. Before joining Tandon, he spent 19 years with IBM Corp.

ROGER N. OESTERLING

☐ The new director of engineering for network management systems at Racal-Milgo Inc. is Roger N. Oesterling. He has more than 20 years' experience in systems analysis and management of software development. Before joining the Sunrise, Fla., telecommunications company, he served as business manager for packet switching at Timeplex Inc. Oesterling also held senior positions at Gould Inc. and Bailey Control Co.

LEROY D. YOUNG

☐ Racal-Milgo Inc. has also promoted Leroy D. Young to director of modem development. Young joined the company in 1974 as a design engineer specializing in large-scale-integration applications; he has also been involved in the evolution of the modem product line. Young spent five years as a design engineer with Western Electric/Bell Laboratories and holds three patents in electronic musical synthesis.

R. G. GODFREY

☐ TRW Electronic Products Inc. has named R. G. (Rick) Godfrey vice president and general manager of its Colorado Springs operation. Before joining TRW, he was director of production for Honeywell Inc.'s Space & Strategic Division in Clearwater, Fla. He was also director of production and logistics at Honeywell's Military Avionics Division, Minneapolis.

nese companies, DeBakey's office has also participated in trade negotiations with the Japanese government. DeBakey has taken his cues in those talks from the Reagan administration's free-market trade policy. "Our push is to open up [foreign] markets, not to put barriers around ours."

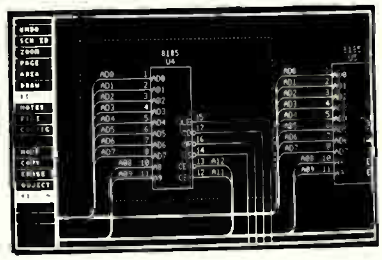
However, the administration recently departed from its free-market rhetoric in an attempt to settle a trade complaint filed against the Japanese chip makers by the Semiconductor Industry Association last year [*Electronics*, June 17, 1985, p. 13]. U. S. trade negotiators proposed that Japan guarantee U. S. companies a larger share of its market, a proposal the Japanese reportedly rejected.

MARKET ACCESS. Nevertheless, insists DeBakey, "Any agreement must include [Japanese] market access for U. S. companies." He also predicts the SIA petition and other pending trade complaints could be resolved in as little as three months.

DeBakey, 36, heads a 50-person organization serving three sectors crucial to the electronics industry: the offices of computers and business equipment, microelectronics and instrumentation, and telecommunications. As part of its efforts on behalf of U. S. exporters, his office also compiles industry analyses.

The Fort Dodge, Iowa, native came to Commerce from Providence, R. I. There he had served as vice president of Fleet National Bank's international trade services, which he organized in 1983. He spent the previous nine years with Rockwell International Corp. DeBakey, whose father is a cousin of heart surgeon Michael DeBakey, holds master's degrees from the American Graduate School of International Management in Phoenix, Ariz., and Southern Methodist University in Dallas. *–George Leopold*

GEORGE DeBAKEY: A voice for electronics.



NEW PRODUCTS

CVD SYSTEM'S REMOTE PLASMA SOURCE IS GENTLER ON WAFERS

IT AVOIDS THE RADIATION DAMAGE OF DIRECT PLASMA DEPOSITION

Isolating plasma generation from the deposition chamber gives Machine Technology's AfterGlo/CVD a leg up on the competition. The chemical-vapor-deposition system uses the plasma's afterglow to trigger deposition, thereby protecting wafers from the radiation damage that direct plasma deposition can cause [*Electronics*, March 3, 1986, p. 18].

In addition, the new machine eliminates several nagging problems that have plagued other CVD systems, says Ken Linxwiler, vice president of MTI's AfterGlo Division. These are keeping deposition layers even, maintaining low processing temperatures, and cleaning the process chambers quickly.

The AfterGlo/CVD builds on the company's first AfterGlo product, a photoresist stripper [*Electronics*, Oct. 28, 1985, p. 64]. It uses the afterglow phenomenon—in which excited atoms passing through the processing chamber can be controlled to cause chemical reactions—to deposit a thin layer of silicon dioxide on a wafer's surface.

To get even deposition, the company found an alternative to the "shower head" commonly used in CVD systems to spray SiO_2 onto the wafer. "We're using the design of the slope in the hood to let the gases flow in a normal path, so we get an even coating," says Linxwiler.

Temperature is also important in achieving uniform coverage. The system heats the wafer to between 250°C and 275°C, says Linxwiler, compared with the 350°C temperatures common in the industry. By processing at lower temperatures, "you can avoid the hillocks you get at higher temperatures."

One important feature of the AfterGlo/CVD is not directly related to deposition, however. The machine is programmed to pump fluorine through the system to etch away hard deposits in 5 to 15 min—most other CVD systems take two hours or more.

By passing nitrous oxide through a microwave chamber, the deposition system generates a highly excited plasma in which the original N_2O is broken down into dissociated nitrogen and oxygen ions. The gases are then pumped through a tube into the process chamber, where silane is introduced to the still-excited atoms. The plasma's afterglow breaks down the SiH_4, and oxygen atoms react with silicon on the wafer's surface, creating a layer of silicon dioxide at a fast 5,000 to 10,000 Å/min. Other systems have deposition rates ranging from 100 to 1,000 Å/min.

CLEAN HOUSE. The AfterGlo/CVD chemical vapor deposition system has a self-cleaning function.

A laser interferometer serves as the end-point detector, signaling the machine when the deposition process is complete.

The company's Multi-Fab handling system then withdraws the wafer and returns it to its cassette. Because it has no load-lock, the system must pump down the chamber to between 100 and 500 mTorr for each new wafer. Throughput is not affected, however; MTI claims a rate between 30 and 60 wafers/h. An optional load-locked chamber will be available in August.

By separating all reactions, the company was able to give the user independent control of four parameters: concentration of atomic oxygen, concentration of SiH_4, regulation of the temperatures of the substrate and the chamber's walls, and regulation of the processing time for each reaction.

All these controls regulate the reaction in the chamber, improving results. Careful control of the production of free oxygen ions, for example, produces a heterogeneous chemical reaction in the chamber. Such a reaction eliminates "snowing," a phenomenon that occurs in homogeneous reactions when the free oxygen atoms merge with SiH_4 to create SiO_2 too far above the wafer surface. When snowing occurs, particles latch onto the chamber walls rather than form on the wafer's surface.

AfterGlo/CVD is available in 10 to 12 weeks for $250,000. *–Tobias Naegele*

Machine Technology Inc., 25 Eastmans Rd., Parsippany, N. J. 07054. Phone (201) 386-0600 [Circle reader service number 338]

1-Mb SRAM CARTRIDGE CHALLENGES BUBBLES

Dallas Semiconductor is introducing a 1-Mb RAM cartridge aimed at bursting bubble memory's grip on high-density nonvolatile storage. The cartridge uses lithium battery cells, which keep data alive for more than a decade.

The DS1217M teams 16 low-power 64-K CMOS static RAMs with a redundant dual lithium battery system inside a plug-in cartridge, which measures 3 in. long by 2.3 in. wide. The chips are surface-mounted on both sides of a motherboard.

"The gap between CMOS semiconductor technology and bubbles is about to close," says Michael Bolan, vice president of marketing at the two-year-old company. Bolan says the cost of the battery-backed RAM cartridges—$357.50 each in quantity for the 1-Mb version—is slightly higher than the cost of bubble memory modules of similar density. "But the cost of the interface electronics necessary to use bubble technology can exceed the cost of the storage media," he says, referring to the circuits needed for conditioning the signals and handling the timing. Prices for bubble-memory systems that include the interface electronics start at around $2,000.

BURSTING BUBBLES. Dallas Semiconductor says its battery-backed RAMs are cheaper than bubble memory to design into a system.

"Because the company is using SRAMs, there is no additional interface cost for conventional byte-wide semiconductor sockets. SRAMs have faster access times than bubble memories, which are nonrandom-access storage," notes Bolan. In addition, bubble-memory technology is often restricted to a temperature range that cannot exceed +55°C, he says.

The 1217M nonvolatile memory cartridge can write or read 1 byte of data in 250 ns. It operates over a temperature range of 0° to +70°C. Maximum operating current is 75 mA.

Bolan predicts that Dallas Semiconductor will be producing a 4-Mb cartridge by the end of this year, and the company is planning future generations of the cartridge with as much as 16 Mb of nonvolatile RAM; the unit will still plug into the same socket. The pinout compatibility with future generations is made possible by treating the total memory in 32-K-by-8-bit banks. The bank switching, which is controlled by software, allows the host processor to map data to specific memory locations.

DIRECT REPLACEMENT. Besides the 1-Mb unit, the company is currently offering a line of lower-density nonvolatile cartridges—from 16 K to 512 K. All the read-write memory cartridges have identical card-edge pinouts that accommodate a standard 30-pin ribbon-cable connector. At the other end of the cable, users can attach a 28-pin dual in-line plug that fits into a byte-wide socket. This configuration makes the cartridge a direct replacement for any 28-pin RAM, ROM, or erasable programmable ROM.

Up to 64 cartridges can be connected on a common bus for applications needing more than 1 Mb of nonvolatile storage. When cartridges are stacked along a bus, each 1217M unit will contain an address signature that is written by a laser beam into one of the chips of the module. The laser-written value makes each cartridge recognize a different sequence of bank-switching addresses, explains Bolan.

The cartridge contains logic to check the status of its batteries. If the main lithium battery supply slips below 2 V, the data-protection duties are turned over to the second battery. When the supply voltage falls below 3 V, a power-switching circuit connects the SRAMs to the battery until system power returns.

The cartridges also contain an automatic write-protect switch on the side of the unit, making the module a read-only device. The cartridge, which fits into the palm of a hand, has a shock-resistant housing designed for factories and other harsh environments.

Bolan says possible applications for the battery-backed nonvolatile memory cartridges include industrial robots, customized personal computer work stations, and speaker-dependent voice-recognition systems. In voice-recognition applications, for example, the battery-backed memory module could hold a digitized voice template of a system's user.

In lots of 100, the 16-K cartridge sells for $19.50 each, the 1-Mb DS1217M for $357.50. *–J. Robert Lineback*

Dallas Semiconductor Corp., 4350 Beltwood Pkwy., Dallas, Texas 75234. Phone (214) 450-0431 [Circle 340]

SOFTWARE-BASED SWITCH CAN REPLACE DATA PBXs

There's a double punch built into the LanSwitch/1 from Bridge Communications. The switch can serve as a low-cost multiple-port link to local networks, but it also can replace a data private-branch exchange.

Like PBXs, the LanSwitch/1 provides data switching and connection through telephone-industry-standard distribution panels, punch-down blocks, or modular splitters, for centralized switching. But there the similarity ends. The LanSwitch/1 is software-based, rather than using the hardware circuit-switch approach of PBXs. So it provides much more flexibility in how and what devices can be connected.

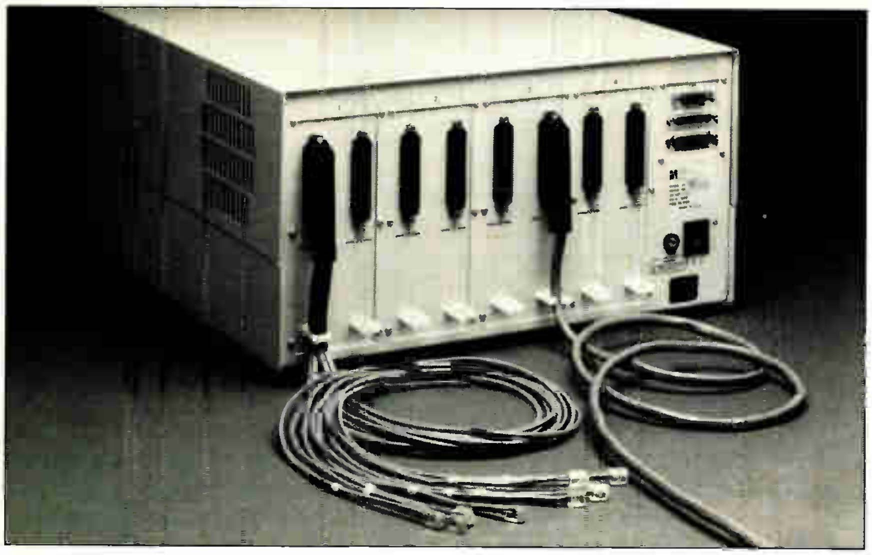
The basic 64-port LanSwitch/1 provides local-network connections for just $250 per port and runs at a data rate of 19.2 kb/s per port. The switch is priced substantially below the typical $695 per-connection charge for Ethernet—but those switches offer 10-Mb/s data rates.

Bridge Communications will unveil the LanSwitch/1 at the Interface '86 show next week in Atlanta. What makes the LanSwitch/1 possible is cramming 16 data I/O ports onto a single card, says president William Carrico. A standard LanSwitch/1 box contains four such cards, for a total of 64 ports. From these ports, individual computers, printers, modems, and terminals can be hooked up over RS-232-C cables, modular RJ-11 phone jacks, or other connectors.

MATCHED SPEED AND FLOW. In another divergence from PBXs, port speed and flow control are matched across the system, giving devices with different band rates of transmission the ability to communicate. This is done transparently, so to the user it seems looks like a direct connection. Also, the LanSwitch/1 can support a total of 96 virtual sessions—so users at the 64 ports on the network can toggle to the extra sessions, up to eight per port, while holding onto their primary links.

The LanSwitch/1 comes with a 5¼-in. floppy-disk drive for booting the network system if it is used alone, or it can be driven by a separate Bridge Network Control Server. The LanSwitch/1 is compatible with all of Bridge's more sophisticated LAN-management gateway products and with IBM Corp.'s Systems Network Architecture host interfaces.

The user can modify the system by



MANY TYPES. In addition to RS-232-C, Bridge's data switch accepts a variety of connectors.

replacing the system's built-in microinstructions with easy-to-understand macro commands for the benefit of nontechnical users. Parameter status displays and call queuing also help make the switch easy to use.

As an option, the customer can request connectors other than the system's 25-pair units and mix a variety of outputs from the same box using different data I/O cards. In addition, the system can support bisynchronous and bit-synchronous communications as well as asynchronous, again by means of different I/O cards.

LanSwitch/1 initially comes with an Ethernet (IEEE 802.3) network controller board, but Bridge Communications plans to introduce token-ring and broadband-controller cards later in the year. The LanSwitch/1 can provide local transmission over a backbone network using fractions of a network's bandwidth, so as many as 500 switches could be connected over a single Ethernet through gateway servers, providing a total of 32,000 ports.

Each of the data I/O cards, the network controller card, and the central processor card has a 12-MHz 68000 microprocessor, giving individual circuit session speeds of up to 19.2 kb/s per port. All told, the system contains 640-K bytes of memory, about 250-K bytes of which are taken up by system code. The rest are for buffer memory, to maintain the system's performance.

A LanSwitch/1 supporting 64 ports plus network controller card and floppy drive is $16,000. Bridge's CS/1 network servers can be upgraded to LanSwitch/1 for about $2,000 per data I/O card, cable, and connector module. Delivery takes 60 days. *–Eve Bennett*

Bridge Communications Inc., 2081 Stierlin Rd., Mountain View, Calif. 94043.
Phone (415) 969-4400 [Circle 339]

MILITARY ATE ANALYZER CUTS PER-CHANNEL COSTS

Interface Technology's digital word generator and analyzer, which fits into Military Automatic Test Equipment (MATE) configurations, checks in with a lower cost per channel than competing solutions. The modular System 45, which supports up to 1,024 channels, performs the standard MATE Atlas language digital tests defined by U. S. Air Force specification MATE-STD-2806763 Revision B.

The company credits the reduced per-channel cost to a bidirectional-I/O-card design that increases the card's channel density. "This reduces the cost per channel by a minimum of 30% compared with systems using unidirectional cards," says Bette Dragoun, marketing services manager. Those systems typically require more cards, making them more costly.

The 32-channel universal-I/O card provides real-time digital comparison testing through the use of expected-value memories. These contain data that is expected from the unit under test in response to the stimulus provided. A mask memory allows bits to be excluded from the compare function. Additional modes such as edge-sample, edge-compare, and window-compare can also be programmed using the mask memory.

Because the System 45 is modular, the user can combine the basic building blocks—the Test Module Adapter, control chassis, and expansion chassis—to build a digital test system that matches his testing requirements. The adapter, an integral part of the system, is linked to the host computer over an IEEE-488 instrument bus. Acting as both talker and listener, it conforms with and validates the MATE standard protocol.

EXPANDABLE. Starting with a Test Module Adapter and a single control chassis containing from 64 to 128 bidirectional channels, the system can be expanded to contain 1,024 channels. In doing so, the user can add new capabilities. For example, a single control chassis can do synchronous testing; with a second control chassis, dual asynchronous clocking is available, making it possible to set up and execute concurrent independent tests.

The adapter converts algorithms, which the user programs in the Atlas test language, to Control Interface Intermediate Language commands. Those commands are transmitted from the host to the device under test.

In addition, the adapter separately adapts each control chassis to appropriate modes of operation. It also channels binary stimulus-and-comparison data to and from the control and expansion chassis.

The MATE requirement for arbitrary channel-to-pin correspondence frequently results in extremely slow operation. The System 45 surmounts this problem by using multiple Motorola 68000 microprocessors and a bit-slice processor running in parallel to convert ASCII data to binary. This achieves a data transfer rate in excess of 10-K bytes/s, which is about 2½ times faster than competing systems that transfer the ASCII data unconverted.

The Atlas digital tests—such as stimulus only, response only, response compare, and stimulus-response match—do not make full use of the System 45's capabilities, says Interface Technology. So the company will add features. Those planned include pattern-data compression, interactive testing, and segmented test execution.

Typical System 45 configurations range in price from $44,000 to $300,000. Delivery takes about 12 weeks after receipt of order. *–Steve Zollo*

Interface Technology, 2100 E. Alosta Ave., Glendora, Calif. 91740.
Phone (818) 914-2741 [Circle 342]

WIN $1,000 CASH
ADVERTISER AUDIT

Electronics' unique new contest makes it easy to win big.

The rules are simple. Each issue this month contains a ballot asking you to select your three favorite ads in the issue. All you do is fill in your choices and drop it in the mail. Your returned ballot or reasonable facsimile is automatically entered in the prize drawing at the end of the month. If your name is drawn at random, you win one thousand easy dollars.

Ads receiving the most votes each week and during the course of the contest will be rerun for free.

You can win money *and* let advertisers know what you think of their selling messages. Advertisers can win extra insertions.

So watch for contest ballots and rules in each March issue. And get ready to win big this month.

ADVERTISERS: YOU CAN WIN $1,000, TOO!

All advertising and marketing personnel in companies and agencies are invited to participate along with our readers by filling out a special Advertisers Ballot included in each March issue. Whoever comes closest to picking the 15 winning ads for the month (3 from each issue) in this special Advertisers Contest will receive an award for skill in evaluating advertising, plus a free ad insertion for his or her company, and $1,000 cash!

Electronics

THE ADVERTISERS AUDIT STUDY CONTEST

Enter a drawing for $1,000 cash by selecting your favorite ads in the March issue of *Electronics.*

Reader Contest Rules

1. After you have examined this issue of *Electronics,* pick your three favorite ads and enter your selections on the entry blank bound in this issue or on a 3" x 5" index card. Your entry should include: 1) the name of the advertiser; 2) the advertiser's Reader Service Number; 3) the page number the advertisement appears on; and, 4) if you would like, your comments explaining what you like most about the ads you selected. Ads placed by McGraw-Hill, Inc. should not be considered in this contest.

2. Check the box on the entry blank marked "Reader Contest." No more than one entry *per issue* may be submitted by any one individual. All entries must be postmarked no later than midnight, April 18, 1986. The winner will be notified in May, 1986.

3. The winner of the $1,000 cash prize will be selected in a random drawing from among all eligible entries. Winner will be notified by mail. Odds of winning depend on the number of entries received.

4. No purchase necessary. Contest void where prohibited or restricted by law. Liability for any taxes on the $1,000 cash prize is the sole responsibility of the winner. Employees of McGraw-Hill, Inc., its advertising agencies, and their families are not eligible to participate.

Advertiser Contest Rules

1. All advertising and marketing personnel in companies and agencies (other than McGraw-Hill, Inc. and its advertising agencies) are invited to participate in a separate contest for advertisers. All rules for the Reader Contest will similarly apply for this contest, with two exceptions: 1) the winner of the Advertiser Contest will *not* be selected in a random drawing from among all eligible entries; and 2) the box on the entry blank marked "Advertiser Contest" must be checked.

2. Examine the March issues of *Electronics* with extra care. Choose the three ads in each issue that you think readers of *Electronics* will pick as their favorites and enter your selections on the entry blanks bound in each issue or on a 3" x 5" index card. No more than one entry *per issue* may be submitted by any one individual.

3. All entries must be postmarked no later than midnight, April 18, 1986. Each individual's qualifying entries will be matched against the winning ads as determined in the Reader Contest. Whichever individual in this Special Advertiser Contest comes closest to picking the 15 winning ads for the month of March, 1986 will receive: 1) $1,000 cash; 2) one free full-page ad in *Electronics* for their company or client; and 3) a plaque acknowledging their skill in evaluating advertising. McGraw-Hill, Inc. reserves the right to schedule the free ad at its discretion.

4. This special Advertisers Contest is open to all advertising and marketing personnel in companies and agencies (other than McGraw-Hill, Inc. and its advertising agencies), whether or not their companies or agencies have an advertisement in the March, 1986 contest issues.

5. No purchase necessary. Contest void where prohibited or restricted by law. Liability for any taxes on the $1,000 cash prize is the sole responsibility of the winner. Employees of McGraw-Hill, Inc., its advertising agencies, and their families are not eligible to participate.

Winning Advertisers Earn Free Ad Reruns

The three advertisers receiving the most votes in each March 1986 issue of *Electronics* will receive a free rerun of their winning ads and a plaque commemorating their achievement. Since there are five issues of *Electronics* in March, there will be a total of 15 winning ads.

After all the March Reader Contest ballots are received, the three ads that scored the highest over the course of the entire contest will be determined and announced in May, 1986. These three Grand Prize Winners will receive a special plaque, plus a free rerun in *Electronics* of *all* the ads they ran in *Electronics* during the entire month of March.

All reruns will be made from existing plates or negatives. If the advertisement qualifying for a free rerun is an insert, the winner may run up to a four-color, two-page spread on R.O.P. stock from existing plates or negatives. McGraw-Hill, Inc. reserves the right to schedule reruns at its discretion.

ELECTRONICS
Advertiser Audit Contest

Entry for the **March 17, 1986** issue contest.

☐ Reader Contest ☐ Advertiser Contest

☐ I have read the contest rules. My three favorite ads in this issue are:

1. ______________________ | ______ | ______

Advertiser (Company or organization) — Reader Service Number — Page Number

Why I chose this ad: ______________________

2. ______________________ | ______ | ______

Advertiser (Company or organization) — Reader Service Number — Page Number

Why I chose this ad: ______________________

3. ______________________ | ______ | ______

Advertiser (Company or organization) — Reader Service Number — Page Number

Why I chose this ad: ______________________

Your entry must be postmarked no later than midnight, April 18, 1986

Name Date

Title Company

Street address

City State Zip

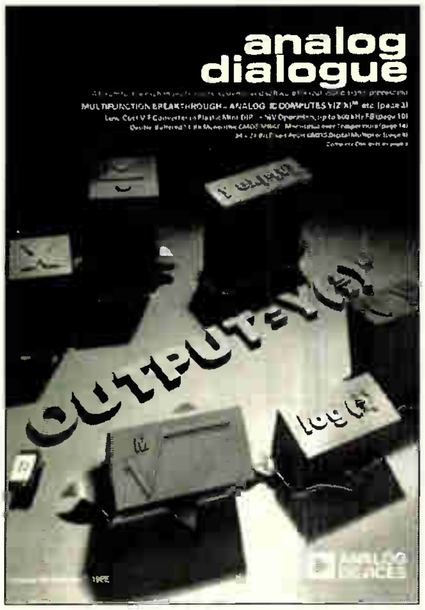
No Postage Necessary If Mailed in the United States

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 64 NEW YORK, NY

Postage will be paid by addressee

Electronics
1221 Avenue of the Americas
New York, NY 10124-0027



ANALOG JOURNAL. A monolithic analog computational chip and its applications are the featured story in the latest issue of *Analog Dialogue*, the quarterly journal of Analog Devices Inc. The journal describes how the AD538 performs division and multiplication and computes powers, roots, logs, and antilogs. This issue also features a monolithic dual 12-bit CMOS digital-to-analog converter. For a free copy, write to Analog Devices Literature Center, 70 Shawmut Rd., Canton, Mass. 02021. [Circle reader service number 421]

WORKING WITH WATER. "Electronics Water Guide" furnishes standards for conductivity and resistivity according to guidelines for electronics-grade water set by the American Society for Testing and Materials. The free brochure also contains a key to the relative sizes of particles as well as pure-water guidelines set by the Semiconductor Equipment and Materials Institute. Request it from Millipore Corp., 80 Ashby Rd., Bedford, Mass. 01730, or call Technical Services at (800) 225-1380; in Massachusetts, (617) 275-9200. [Circle 422]

GaAs SERVICES. A year-old company, Anadigics Inc., distributes a free brochure describing its services as a full-service gallium arsenide IC manufacturer. The focus is on microwave, analog, and digital preprocessing, for which Anadigics offers 0.5-μm foundry service. For a copy of the brochure, call (203) 242-5697 or write to 167 Duncaster Rd., Bloomfield, Conn. 06002. [Circle 428]

MANUFACTURING CAPABILITIES. A free eight-page brochure, "Elgin Electronics Contract Manufacturing," describes this company's assembly capabilities in computers, office equipment, industrial control, and telecommunications. Services offered include computerized pc-board design systems and computer-aided design and manufacturing. The company's quality-assurance system meets the requirements of MIL-Q-9858. For a copy, call (814) 864-4921 or write to Elgin Electronics at 5533 New Perry Hwy., Erie, Pa. 16509. [Circle 424]

BRITISH PUBLICATIONS. The Institution of Electrical Engineers, whose membership also includes electronics engineers, offers a catalog of its books, conference proceedings, and journals. New titles include *Expert Systems* and *Properties of Amorphous Silicon*. Besides materials and control systems, other major subjects covered are medical electronics, telecommunications, and electromagnetic waves. Copies of the catalog are free from the Books Administrator, IEE, P. O. Box 8, Southgate House, Stevenage, Herts., SG1 1HQ, England; phone (0438) 313311. [Circle 425]

PIEZOELECTRICITY DATA. A 40-page softcover manual, "Piezoelectric Technology: Data for Designers," explains both circuits and piezoelectric ceramic materials. Tables present typical room-temperature data, temperature and time stability, high signal properties, and thermal effects. The applications discussed include a high-voltage generator, underwater sound transducers, an ultrasonic cleaning transducer, and a shear accelerometer. Copies of the manual are $6 from Vernitron Piezoelectric Division, 232 Forbes Rd., Bedford, Ohio 44146; phone (216) 232-8600. [Circle 426]

FET DATA BOOK. Siliconix Inc. has just published the latest in its data-book series, the *FET Data Book* for designers who use small-signal FETs. More than 350 products are described, and eight application notes, new to this edition, feature FETs as amplifiers, current protectors, constant-current sources, and analog switches. The $12 data book can be ordered from the company at 2201 Laurelwood Rd., Santa Clara, Calif. 95054, or call (408) 988-8000. [Circle 423]

POWER CONVERSION. For the engineer who uses power supplies, "Principles of Power Conversion" has 24 illustrated pages on power supplies and dc-to-dc converters plus a four-page glossary. Application topics include testing and thermal management and reliability. The brochure is free from Computer Products Inc., Power Conversion Group; call (305) 974-5500 or write the company at 2900 Gateway Dr., Pompano Beach, Fla. 33069. [Circle 427]

ROBOTS 10 WILL STRESS SYSTEM INTEGRATION

Robots 10 has a new focus. This year's conference, to be held in Chicago, will center on integrating robotics into the production of automotive and electronics assemblies as well as into military systems. Past conferences put the emphasis on the robot itself and the tasks it can perform singly. The change was prompted by "the realization and the reality that robots are part of integrated systems," says program coordinator Michael Tew.

The conference is sponsored by Robotics International of the Society of Manufacturing Engineers, where Tew is an administrator in technical activities. It's divided into 16 sessions, 4 forums, and 2 tutorials. Attendees are expected to come from industry, the military, and academia.

Tew says one area that's growing fast is the application of robotics to military technology. "There will be a lot of new information at Robots 10 on how robotics are being used by the military." One of the conference's forums is devoted to military systems, and three papers at the session on remote robotics will be on military applications. There are endless possibilities for using robotics to improve a military system, Tew says, citing applications in battlefield situations as well as construction.

Tew emphasizes that most of the 90 papers at the conference come from industry. Two sessions will explore how the automotive industry is using robotics for assembly, another explores use in the assembly of printed-circuit boards. Another two sessions are devoted to using robotics in the academic environment.

CEPS III: Corporate Electronic Publishing Systems, Cahners Exposition Group (999 Summer St., Stamford, Conn. 06905), Los Angeles Convention Center, April 9-11.

Electronics & Electrical Engineering '86, Hannover Fairs USA Inc. (103 Carnegie Center, Princeton, N. J. 08540), Hannover Fair Grounds, West Germany, April 9-16.

Computer-Aided Design Conference, Georgia Institute of Technology (Trish Stolton, Georgia Institute of Technology, Atlanta, Ga. 30332-0385), Atlanta Hilton & Towers, Atlanta, April 10-11.

40th Broadcast Engineering Conference, National Association of Broadcasters (1771 N St., N. W., Washington, D. C. 20036), Dallas Convention Center, Dallas, April 12-16.

CDROM-based Information Distribution, Institute for Graphic Communication (IGI, 375 Commonwealth Ave., Boston, Mass. 02115), Sheraton International Conference Center, Reston, Va., April 13-15.

Intermag '86, IEEE Magnetics Society (Diane Sutters, Courtesy Associates Inc., 655 15th St., N. W., Washington, D. C. 20005), Hyatt Regency, Phoenix, Ariz., April 14-17.

EIA Spring Conference, Electronic Industries Association (Herbert J. Rowe, EIA, 2001 Eye St., N. W., Washington, D. C. 20006), J. W. Marriott Hotel, Washington, April 14-17.

3rd International Symposium on Optical and Optoelectronic Applied Sciences and Engineering, International Society for Optical Engineering (P. O. Box 10, Bellingham, Wash. 98227), Kongresshaus Innsbruck, Innsbruck, Austria, April 14-18.

Spring Meeting of the Materials Research Society, Materials Research Society (John Ballance, Materials Research Society, 9800 McKnight Rd., Suite 327, Pittsburgh, Pa. 15237), Palo Alto Hyatt, Palo Alto, Calif., April 15-18.

Nepcon Southeast '86, Cahners Exposition Group (Jan Schafer, Show Management, CEG, 1350 E. Touhy Ave., Des Plaines, Ill. 60017-5060), Orange County Convention Center, Orlando, Fla., April 15-17.

Midwest Electronics Exposition Conference, MG Expositions Group (1050 Commonwealth Ave., Boston, Mass. 02215), St. Paul Civic Center, St. Paul, Minn., April 16-17.

Eurocon '86: 7th European Conference on Electrotechnics, IEEE (L. J. Libois, IEEE French Section, c/o Society of Electronic Engineers, 49 rue de la Procession, 75724 Paris, Cedex 15, France), Palais des Congrès, Paris, April 21-23.

34th National Relay Conference, National Association of Relay Manufacturers and Oklahoma State University (School of Electrical and Computer Engineering, 202 Engineering S., Oklahoma State University, Stillwater, Okla. 74078), Oklahoma State University, Stillwater, April 21-23.

Robots 10, Robotic Industries Association (Robotics International/Society of Manufacturing Engineers, 1 SME Dr., Dearborn, Mich. 48121), Chicago Hilton & Towers, Chicago, April 21-24.

Comdex/Spring, Interface Group Inc. (300 First Ave., Needham, Mass. 02194), Georgia World Congress Center *et al.*, Atlanta, April 28-May 1.

Advertisers Index

Classified and employment advertising

For more information of complete product line see advertisement in the latest Electronics Buyers Guide
* Advertisers in Electronics International
‡ Advertisers in Electronics domestic edition

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633-0155 Mobil Phone
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ELECTRONICS WEEK

ITC WILL HEAR TI COMPLAINT

The International Trade Commission last week decided to investigate charges filed by Texas Instruments Inc. that nine chip producers in the Far East are infringing its patents [*Electronics*, Feb. 3, 1986, p. 19]. The Dallas company paired its ITC petition with lawsuits it began filing in late January against manufacturers of dynamic random-access memories—eight Japanese and one South Korean. ITC chairwoman Paula Stern says the TI complaint "indicates that this investigation could possibly involve more trade by value than any previous [patent-infringement] investigation."

APOLLO, TI JOIN IN AI DEVELOPMENT

Apollo Computer Inc. and Texas Instruments Inc. will work together to bring artificial-intelligence technology to work stations, according to an agreement signed last week. As a first step, the two are working to tie TI's Explorer Lisp machine into the Chelmsford, Mass., company's Domain distributed networking environment, with a tightly integrated product expected in six to nine months. Longer term, Apollo hopes to integrate into its work station line the chips TI is developing with its Explorer technology.

GI SIGNS HYUNDAI TO MAKE NEW CHIPS

General Instrument Corp. has signed up Hyundai Electronics Industries Co. to make a new line of chips now under development at GI's Chandler, Ariz., microelectronics facility. Hyundai, a wholly owned subsidiary of Hyundai Group, South Korea's largest business organization, will initially make 64-K CMOS silicon-gate erasable programmable read-only memories and electrically erasable PROMs at its facility in Inchon, South Korea.

PAC BELL TO USE NEC GEAR FOR ISDN

Pacific Bell will use a digital adjunct system, the NEAX 6E, from NEC America Inc., in its first demonstration of Integrated Services Digital Network functions next week in San Francisco. The NEC system provides analog-to-digital conversion for an analog central-office exchange. Pacific Bell will use a prototype system that transmits simultaneous 64-kb/s voice and data and 16-kb/s packet-switched data. The demonstration will run through May 31 in San Francisco and from June 30 to Sept. 1 in Los Angeles. A full trial is set for 1987 using a Northern Telecom DMS 100 switch and a production NEC system.

MORROW DESIGNS GOES CHAPTER 11

Portable-computer maker Morrow Designs Inc., which provided the technology for the Zenith Data Systems laptop computer chosen by the Internal Revenue Service last month [*Electronics*, March 3, 1986, p. 16], has filed for reorganization under Chapter 11 of the U. S. bankruptcy law. The San Leandro, Calif., company had hoped to win the IRS contract for its own Pivot II, but instead saw the award go to Zenith, Glenview, Ill., for an identical machine built with technology licensed from Morrow.

HUGHES PLAYS KEY ROLE IN NEW PACT

Hughes Aircraft Co., a General Motors Corp. subsidiary, will play a central role in the technology agreement announced last week by GM and Seattle Silicon Technology Inc., Beaverton, Ore. For $2.5 million, Hughes, GM's Research Laboratories, and Delco Electronics Corp., another GM subsidiary, will link their design tools with SST's Concorde silicon compiler. The agreement also calls for GM and SST to jointly administer a $5 million research and development fund and gives GM the option to buy up to 15% of SST's common stock for $10 million.

CARNEGIE JOINS BOEING IN AI PUSH

In an effort to move its artificial-intelligence activities into the defense arena, Carnegie Federal Systems Corp., the recently formed Pittsburgh subsidiary of Carnegie Group Inc., has teamed with Boeing Computer Services, Bellevue, Wash., to provide AI technology to the Air Force. Boeing's contract with the service's Rome (N. Y.) Air Development Center calls for the development of tools and techniques to aid in AI software production. The project is part of the Strategic Defense Initiative Battle Management program.

ROCKWELL SWITCH USES TANDEM GEAR

Fault-tolerant computers from Tandem Computers Inc., Cupertino, Calif., will see their first use as back-end data-base machines for automatic call distribution in a system to be sold by Rockwell International Corp.'s Switching Systems Division, Downers Grove, Ill. Under terms of an agreement unveiled last week, Rockwell will supply a system using a Tandem NonStop computer, Rockwell's Galaxy Automatic Call Distributor, and a software package developed by Rockwell to link the two. The system is aimed at high call-volume applications such as telemarketing, collections, and order entry.

SME ADDS ARM FOR COMPONENTS

The Society of Manufacturing Engineers, Dearborn, Mich., has set up an Electronics Manufacturing Group to serve as an information center for the manufacture of electronic components. The group, called EM/SME, will cover manufacture and assembly of printed-circuit boards, silicon manufacturing and packaging, and the integration of these technologies with lasers and fiber optics.

U. S. TELECOM DEFICIT GROWS

The trade winds continue to blow in the wrong direction for the U. S. telecommunications equipment industry. The Washington-based Computer and Business Equipment Manufacturers Association last week said the industry's trade deficit rose 4% last year, to $1.31 billion from 1984's $1.258 billion. Since 1983, the first year of the telecommunications equipment trade deficit, the deficit has grown at an average annual compound rate of 43.8%. The culprits, Cbema argues, are "monumental trade barriers in other countries." Hence, Cbema is supporting trade legislation in the House of Representatives aimed at opening international telecommunications markets to U. S.-made products.

MOTOROLA GETS CHINA CONTRACT

Motorola Inc. has been selected to supply a cellular radio-telephone system to be installed in Beijing. The Schaumburg, Ill., company won out over an international field of competitors for the contract, valued at about $3.7 million. Though Sweden's LM Ericsson has announced plans to install a 450-MHz system in China, Motorola says its system will be more extensive, and will be the first 800-MHz cellular system in the People's Republic. The contract gives Motorola an important foothold in the country, since a number of other cities are expected to install cellular systems soon.