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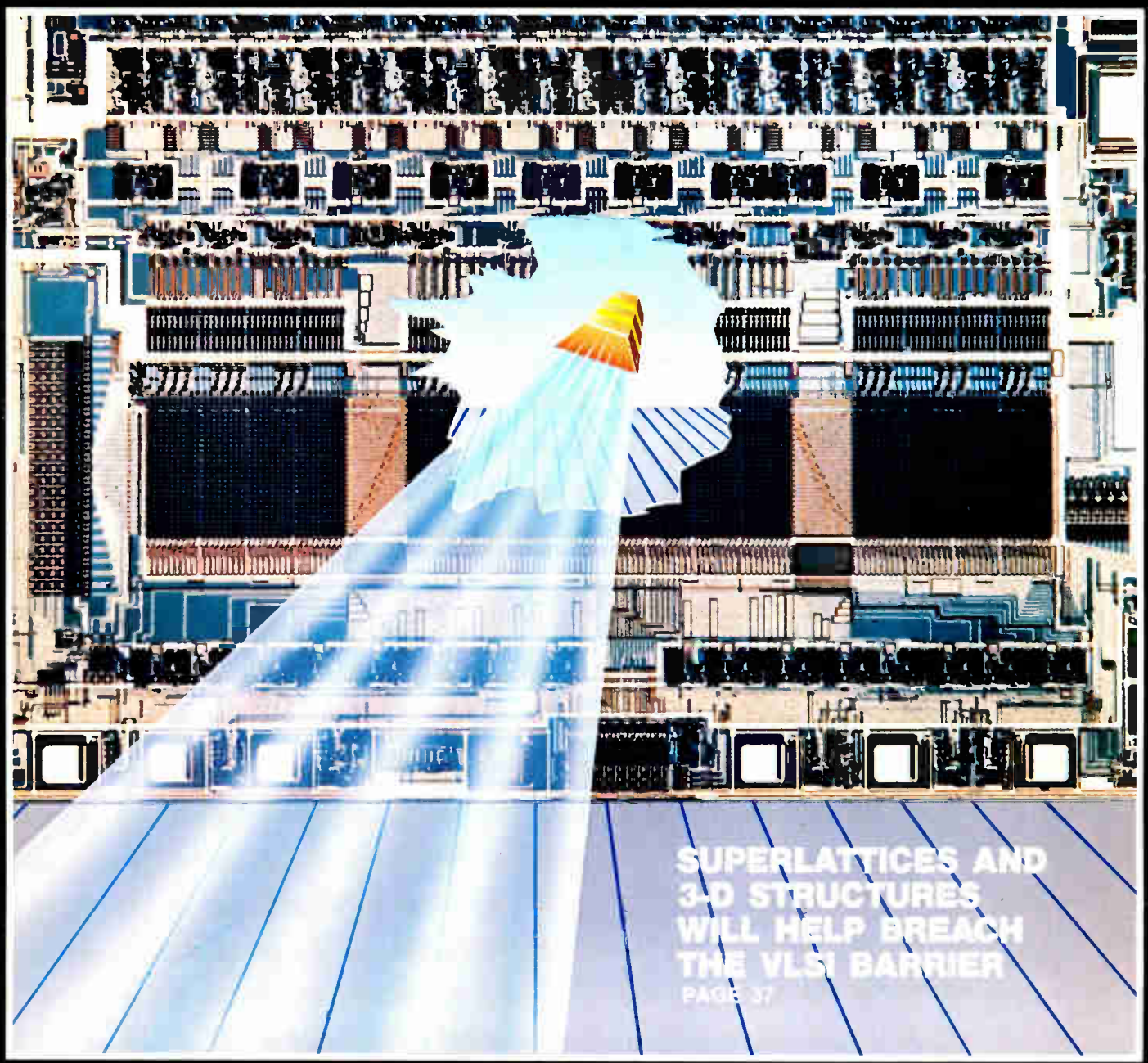
# Electronics

THE WORLDWIDE TECHNOLOGY WEEKLY

APRIL 28, 1986

# ULTRA-DENSE CHIPS: THE DRIVE QUICKENS

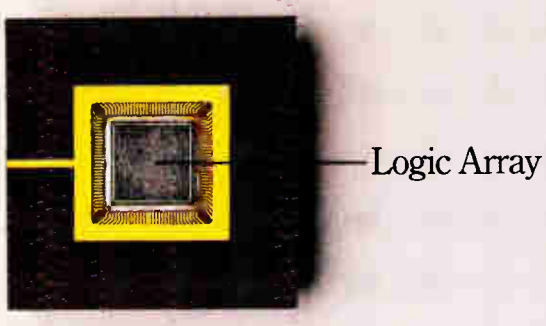


SUPERLATTICES AND 3-D STRUCTURES WILL HELP BREACH THE VLSI BARRIER

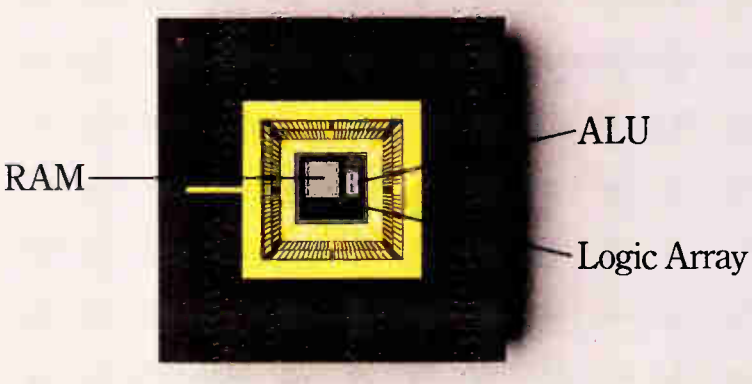
PAGE 37

SENSING ROTARY POSITION WITHOUT ANY MOVING PARTS/26

A NEW WAY TO BOOST A PHONE LINE'S THROUGHPUT/29




Current Logic

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It's a quantum leap beyond current logic.

It gives you all the advantages of full custom with the ease of a gate array.

Start with 6,900 gates of logic. Then add RAM, ROM, ALU, bit-slice microprocessor or multiplier megacells. To get up to 40,000 gates.

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An ingenious marriage of two-micron double-metal gate arrays and highly optimized megacells. To give you the functional density of full custom and standard cell ASICs.

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At 13 design centers around the world, our powerful LDS™ software is the surest road to success. With a 97% hit rate at first pass.

Then we manufacture them ourselves. Any quantity, any package. Ceramic or plastic, flat packs or pin grids—up to 228 I/O pins.

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Check out our new Structured Array family. Call one of the design centers listed below and ask about the LSA2000 Series.

It defies logic. But it makes perfect sense.

LSA2000 Structured Array Family

| Masterslice | Logic Gates | Memory | Logic Megacells |
|---|---|---|---|
| LSA2001 | 3000 | 2304 RAM | 16-Bit ALU |
| LSA2002 | 6000 | 3-port 2304 RAM | |
| LSA2003 | 6900 | 4608 RAM | |
| LSA2004 | 5600 | 9216 RAM | |
| LSA2005 | 3700 | 32K ROM | Four 2901s |
| LSA2006 | 3000 | 64K ROM | Eight 2901s |
| LSA2007 | 5000 | 4608 RAM | 16x16 MAC |
| LSA2008 | 5000 | | Two 16x16 MACs |
| LSA2009 | 4500 | 11,520 RAM | |
| LSA2010 | 3200 | 2304 RAM/ 64K ROM | |
| LSA2011 | 5000 | | 16x16 MAC Four 2901s |

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Circle 900 on reader service card

# A BREAKTHROUGH THAT DEFIES ALL LOGIC.

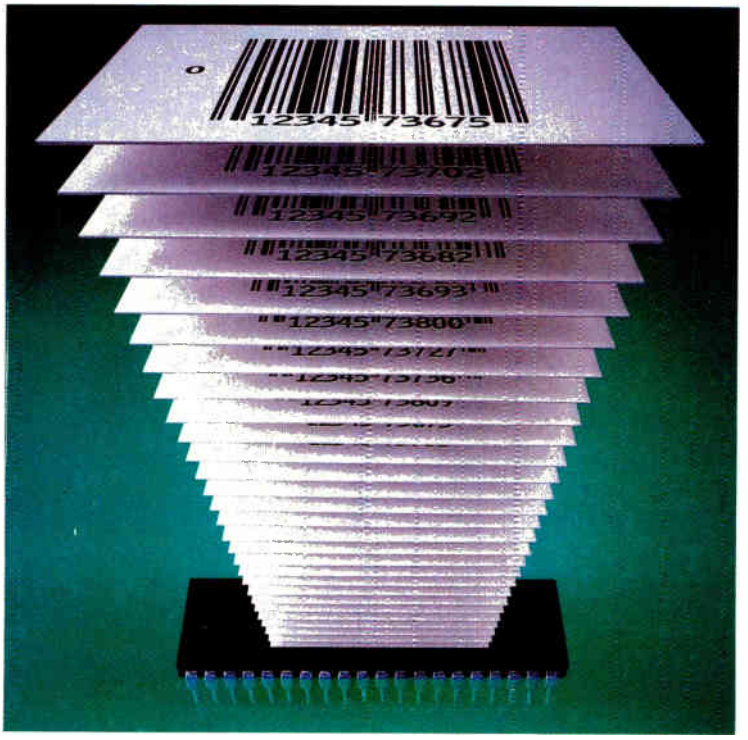
# SURPRISE!

## Introducing the world's most powerful bar-code decoder IC.

**Compatible with most types of scanners.**

Now, you can meet most of your customers' scanning requirements with a single decoder IC.

The new HP HBCR-2000 is compatible with most types of scanners — hand-held laser scanners, wands, or slot readers — used in all types of applications — industrial, retail or medical.



**And a wide variety of symbologies.**

You can address virtually any market because the HP IC supports a wide range of bar-code symbologies. Combine it with the appropriate scanner and your equipment will be compatible with industry standards that specify Code 39, Interleaved 2 of 5, UPC/EAN, Codabar, or Code 128.

**Design simplification.**

By eliminating the need for bar-code software development, the HP IC can save you both time and money. Its flexible, bidirectional serial ASCII interface can be used independently or easily connected to another microprocessor for data processing or data reformatting.

**Broad range of scanners, too.**

HP manufactures a broad line of scanners, including state-of-the-art digital wands and slot readers, so we can also provide you with complete solutions to your bar code reading needs.

For pricing and delivery information, contact the Hewlett-Packard sales office listed in your telephone directory white pages and ask for the Components Department.

**HP: The right choices for bar code solutions.**

HEWLETT PACKARD



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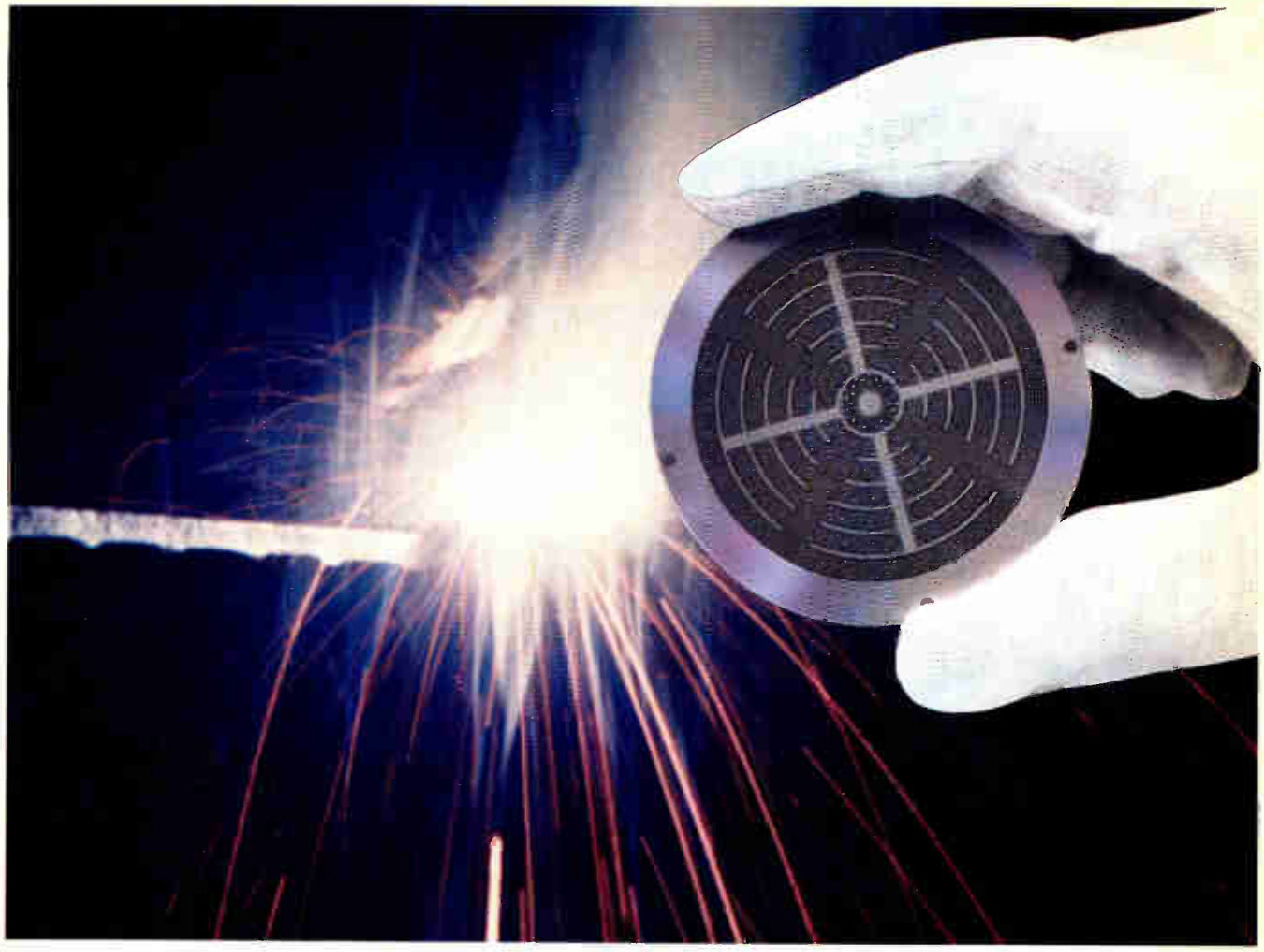

## Improved asymmetric thyristor design packs more into a smaller package ... that's cost effective technology from AEG!

AEG provides the most complete line of asymmetric thyristors found anywhere... a device which packs more power into a smaller package.

This enables products such as electric arc welders, AC motor drives, uninterruptable power supplies (UPS) systems and mid-frequency x-ray machines to be more compact. This, in most cases, lowers production costs and increases efficiency.

The secret lies in the reduced thickness of the N-Base and the introduction of a field stopping layer in the AEG asymmetric thyristor. This design configuration creates lower switching losses, shorter turn-off times and lower on-state voltage.

AEG has been a worldwide source for technological innovation for more than 100 years. We currently supply high technology products which include not only power semiconductors but, optical character recognition systems, solar power, electronic packaging, technical tubes and robotics, to name a few.

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AEG

APRIL 28, 1986 VOLUME 59, NO. 17

# Electronics

## NEWS



## INSIDE TECHNOLOGY



## PROBING THE NEWS



## COVER



*Cover by David Myers*

## NEW PRODUCTS



## DEPARTMENTS

## LETTERS

### GaAs in New Jersey

**To the editor:** "Surprise! GaAs Startups Thrive in New Jersey" [*Electronics*, Jan. 13, 1986, p. 62] explored reasons why south-central New Jersey is becoming a prime location for many new companies, such as ours, that specialize in gallium arsenide technology. The piece, based on interviews with leaders of a few of these companies, was generally very interesting and informative.

But I was very disappointed with inaccurate and misleading references concerning me and our company. I was presented as the single example of "those who don't think you can find anyone in New Jersey" with sufficient talent to work with GaAs.

I said nothing to your interviewer to suggest such a statement. In fact, with organizations such as AT&T Co.'s Bell Laboratories and RCA Corp.'s David Sarnoff Research Center (both pioneers in GaAs research) located in the area, it is obvious that the state has attracted a huge number of GaAs specialists and other technical talent. It is ludicrous to suggest otherwise. The article also says that I "scoffed" at the notion of New Jersey becoming a center for GaAs work. That statement is also untrue.

*Chuni Ghosh*
*President*
*Tachonics Corp.*
*Plainsboro, N.J.*

☐ Electronics *stands by its story.*

### Mixed-process omissions

**To the editor:** Your recent special report on mixed-process chips ["Mixed-Process Chips Are About to Hit the Big Time," *Electronics*, March 3, 1986, p. 27] was most informative, but omitted important information.

You name several Japanese and American chip makers as investing in mixed-process technologies. Sprague probably should have been mentioned since we have been shipping parts to the mixed-process business (bipolar and MOS) since 1977.

You don't mention high-current interface ICs. We see this area as the most active bipolar-CMOS and are aggressively developing and shipping products with output ratings to 4, 5, and 8 A.

Later you describe an Italian company as pursuing high-voltage applications. We have not neglected this area and currently supply standard BiMOS devices with ratings to 100, 140, and 225 V. We have supplied high-voltage bipolar monolithic drivers since 1973.

*F. Raymond Dewey*
*Technical Information Coordinator*
*Sprague Electric Co.*
*Worcester, Mass.*

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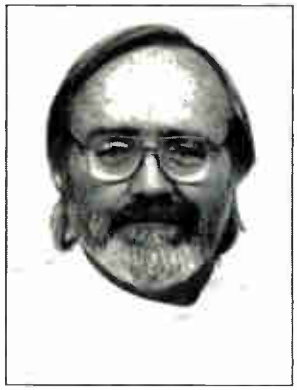
## PUBLISHER'S LETTER

There is still a frontier to explore in Silicon Valley if you know where to look for it. Our semiconductors editor, Bernie Cole, does. From our outpost in Palo Alto, Bernie during the past month or so has been exploring the little-known technological territory that lies beyond very large-scale integration.

Bernie's wanderings, understandably, brought none of the hair-raising encounters with natives and wild beasts that pith-helmet explorers face. But there were plenty of surprises on the leading edge of technology, even for a 13-year veteran of the semiconductor beat.



**EXPLORER.** Bernie Cole knows the technology frontier.

One of the surprises Bernie had while researching his special report on "beyond VLSI" (p. 37) came from silicon-on-insulator technology. "I had assumed its main advantage to device manufacturers was that it enables fabrication of very dense three-dimensional structures. But I learned that other factors are almost as important, such as improved isolation between transistors, boosted speed, and lower power dissipation. Indeed, before it is ever used in the fabrication of production-quality 3-d circuits, SOI will be used to enhance the performance and density of traditional planar structures."

Bernie also was surprised by the intensity of SOI research and development and the haste to get SOI into production, especially by Japanese companies. "Unfortunately, SOI seems to represent another example of a rich technological lode originally discovered and mined by Americans but abandoned for more near-term concerns, only to be taken up and worked with a vengeance by the Japanese as part of another forward-looking, multiyear national research effort," he says. But Bernie notes that the abandonment is not total. "TI, Motorola, HP, IBM, and AT&T are involved, but their efforts are dwarfed by the efforts of the two dozen or so Japanese firms."

Bernie's third surprise was the rapidity with which silicon-based molecular-beam epitaxy has advanced. "Even as late as last year, the prevailing view was that MBE was not really a production-line reality for silicon-based circuits and would not be until a number of problems were solved, which could take years. Now equipment manufacturers are developing silicon MBE systems reliable enough for R&D pilot lines for fabricating advanced transistor structures and circuit designs."

For Bernie, the most exciting impact of silicon-based MBE is its potential for fabrication of so-called superlattices—multilayered structures that make use of quantum wells to create vertical electronic switching devices that allow fabrication of circuits with millions of transistors on the same die. □

Laurence Altman


*April 28, 1986 Volume 59, Number 17*
*95,301 copies of this issue printed*

Electronics (ISSN 0883-4989). Published weekly by McGraw-Hill Inc. Founder: James H. McGraw 1860-1948. Publication office: 1221 Avenue of the Americas, N. Y., N. Y. 10020; second class postage paid at New York, New York and additional mailing offices. Postage paid at Montreal, P. Q. Registration Number 9034.

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

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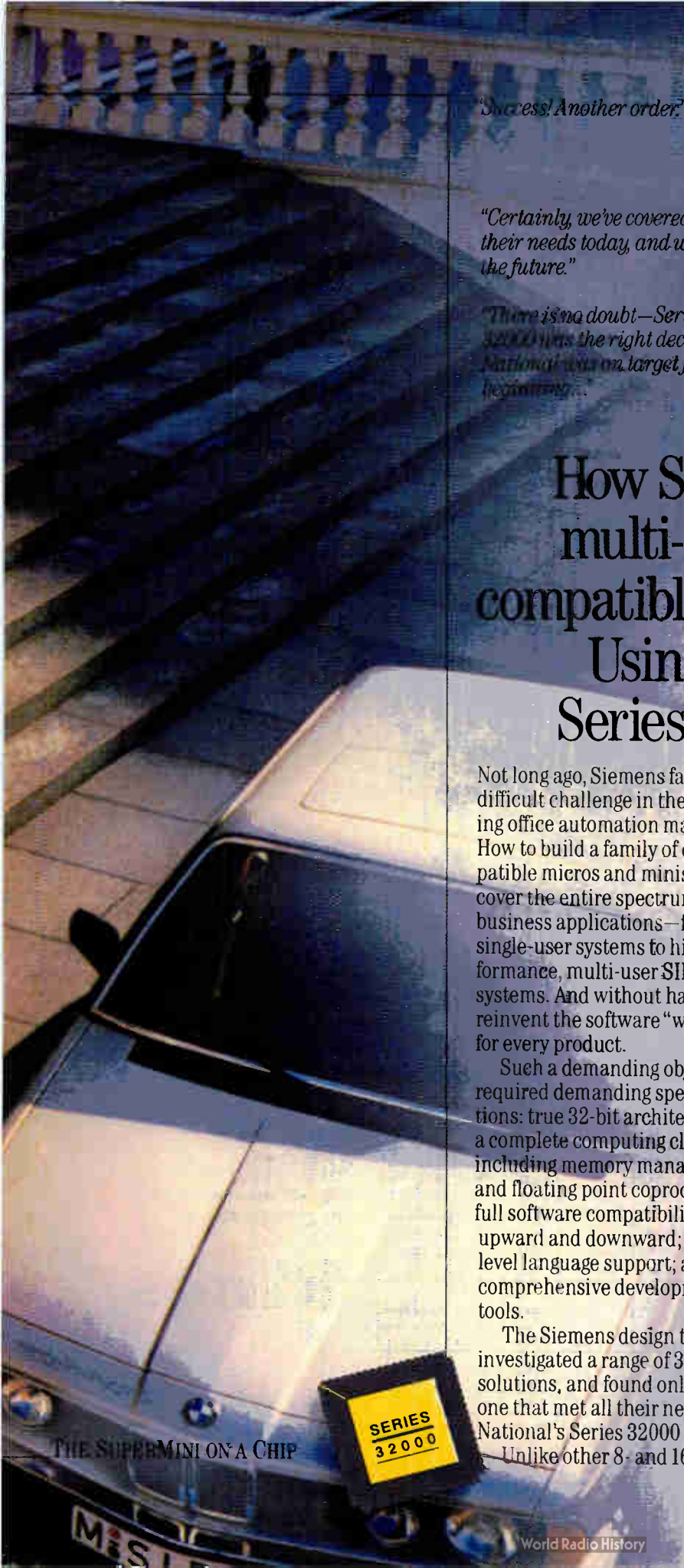


*"Success! Another order."*

*"Certainly, we've covered all their needs today, and well into the future."*

*"There is no doubt—Series 32000 was the right decision. National was on target from the beginning..."*

*"Systems with our kind of power and upgrade potential are difficult to resist."*

*"And that's good for us, too. Software re-writes are totally unnecessary."*

*"...And now, so are we."*

# How Siemens builds multi-user systems compatible with the future. Using National's Series 32000® family.

Not long ago, Siemens faced a difficult challenge in the emerging office automation market: How to build a family of compatible micros and minis that cover the entire spectrum of business applications—from single-user systems to high performance, multi-user SINIX™ systems. And without having to reinvent the software "wheel" for every product.

Such a demanding objective required demanding specifications: true 32-bit architecture; a complete computing cluster, including memory management and floating point coprocessors; full software compatibility, both upward and downward; high level language support; and comprehensive development tools.

The Siemens design team investigated a range of 32-bit solutions, and found only one that met all their needs: National's Series 32000 family.

Unlike other 8- and 16-bit processors being extended upward, the Series 32000 has no programmer-visible changes in architecture—throughout the entire family. So Siemens could develop any application the market demanded, now or in the future, without depreciating its existing software investment.

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# The INMOS 256K CMOS DRAM. Feel the exhilaration of unparalleled speed.

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With $\overline{RAS}$ access times of 60 to 150ns and cycle times down to 121ns, the IMS2800 family maximizes the speed-power benefits of CMOS without compromising traditional DRAM system costs.

INMOS continues to lead with an address multiplexing scheme that eliminates timing constraints while reducing speed loss associated with traditional DRAM designs. INMOS' unique 2ns Row Address hold time saves 10 to 15ns in the address multiplexing sequence. This, in addition to Static Column mode accessing, allows no wait state operation with the new generation of fast 32 bit microprocessors including Motorola's 68020, Intel's 80386 and our own Transputer T414.

The IMS2800 from INMOS. Experience the speed for yourself.

| Part Number | Function | Address Access Time (Max.) | $\overline{RAS}$ Access Time (Max.) | $\overline{RAS}$ Read/Write Cycle Time (Min.) |
|---|---|---|---|---|
| IMS2800-60* | Static Column Decode | 32ns | 60ns | 121ns |
| IMS2800-80 | | 43ns | 80ns | 146ns |
| IMS2800-10 | | 53ns | 100ns | 176ns |
| **Part Number** | **Function** | **Column Access Time (Max.)** | **$\overline{CAS}$ Access Time (Max.)** | **Page Mode Cycle Time (Min.)** |
| IMS2801-60* | Enhanced Page Mode | 32ns | 11ns | 35ns |
| IMS2801-80 | | 43ns | 13ns | 46ns |
| IMS2801-10 | | 53ns | 16ns | 56ns |

Data on Nibble Mode and Extended Serial Mode versions available upon request.

*Contact factory for delivery.

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# TECHNOLOGY NEWSLETTER

## NEW BREED OF MOBILE ROBOTS MAY SOON BE WORKING WITH CHIPS

In a move that foreshadows a new breed of mobile robots, GMF Robotics Corp. is jumping into the automated-guided-vehicle (AGV) business. The Troy, Mich., joint venture of General Motors Corp. and Japan's Fanuc Ltd. announced an agreement with Eaton-Kenway, Salt Lake City, Utah, at last week's Robots 10 show in Chicago (see related story, p. 16) whereby GMF will use the Eaton Corp. subsidiary's proprietary wire-guided technology to manufacture and market AGVs worldwide. GMF will initially supply conventional Fanuc-manufactured AGVs to customers in the automotive industry who want to mount workpieces such as engine blocks on the vehicles for movement between work cells in a factory. But GMF representatives say they plan eventually to merge robot-arm technology with AGVs to create a new kind of mobile robot vehicle. Such a machine might find electronics-industry applications in moving and working with wafer cassettes or printed-circuit boards, according to GMF. The company says that, although commercial introduction is at least a year away, Fanuc has already demonstrated an AGV equipped with a robot arm at a Japanese trade show last fall. □

## CONCURRENT LISP FOR COMMERCIAL USE TO BE DEMONSTRATED

The simple addition of communications ability among single processors has resulted in a parallel version of Common Lisp. Later this week, its first commercial implementation for a multiprocessor will be demonstrated at AI '86 in Long Beach, Calif. The implementation, called Concurrent Common Lisp, is designed for Intel Corp.'s recently announced iPSC-MX series, the expanded-memory configuration of the Santa Clara, Calif., company's iPSC family of concurrent computers. Concurrent Common Lisp is the product of a five-month joint-development effort between Intel and Gold Hill Computers Inc. of Cambridge, Mass. Because the iPSC family employs an array of Intel's 80286 processors, Gold Hill took its existing Common Lisp for single Intel 80286 processors used in personal computers and added the ability to communicate between nodes along a high-bandwidth link. The software can partition one task among many processors and is expected to serve primarily as a tool for conducting research on large-scale symbolic processing. It will be generally available in July for $30,000 per unit. □

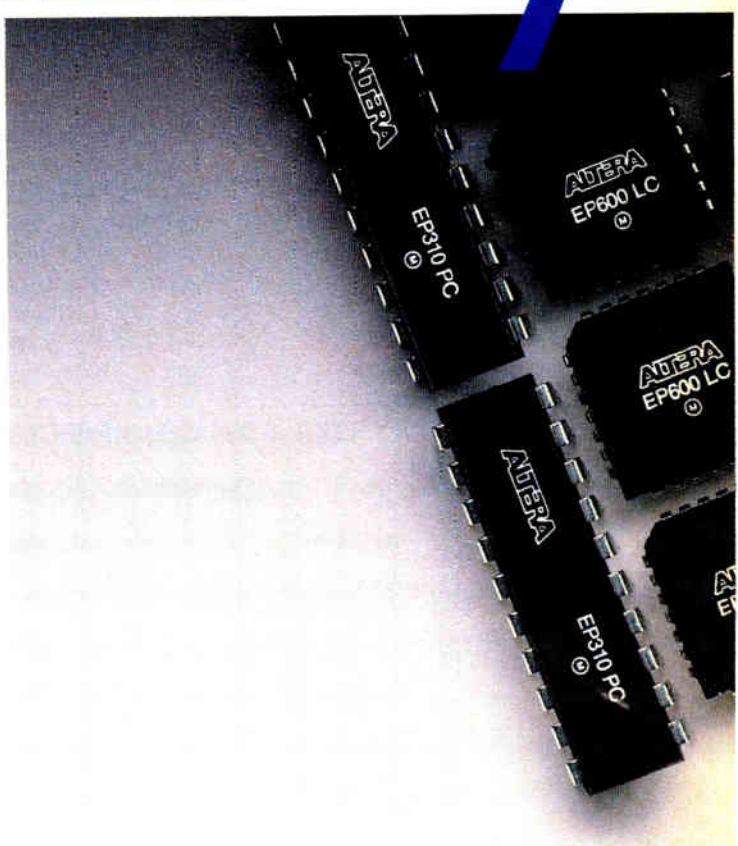
## LOW-COST SYSTEM INTEGRATES CONTROL OF VISION AND ROBOT FUNCTIONS

Integrated control of vision and robot functions in the same robot controller is the key to Prab Robots Inc.'s low-cost approach to vision-equipped robots. Its system is already being used in a $650,000 system for automatic truck unloading at a General Motors Corp. plant designed for just-in-time manufacturing. Prab, Kalamazoo, Mich., says it can provide real-time vision tracking in a robot at an added cost of less than $10,000. That compares with typical costs of $40,000 to $100,000 for stand-alone vision systems, which must be integrated with the robot by the user, Prab claims. □

## POLICE DATA TERMINAL FITS IN A HAND

Surface-mounted components and low-power CMOS semicustom logic have enabled ElectroCom Automation Inc. to come up with a hand-held data terminal for use by police officers. The portable PDT-850ES is based on repackaging and downsizing of systems technology now being used in the Arlington, Texas, company's squad-car data terminals. The unit receives data over a secured FM radio link at 4,800 b/s, and will be available to public-safety markets later this year. The battery-powered terminal contains a 4-line liquid-crystal display. □

# Quantity




A few today. A few tomorrow.
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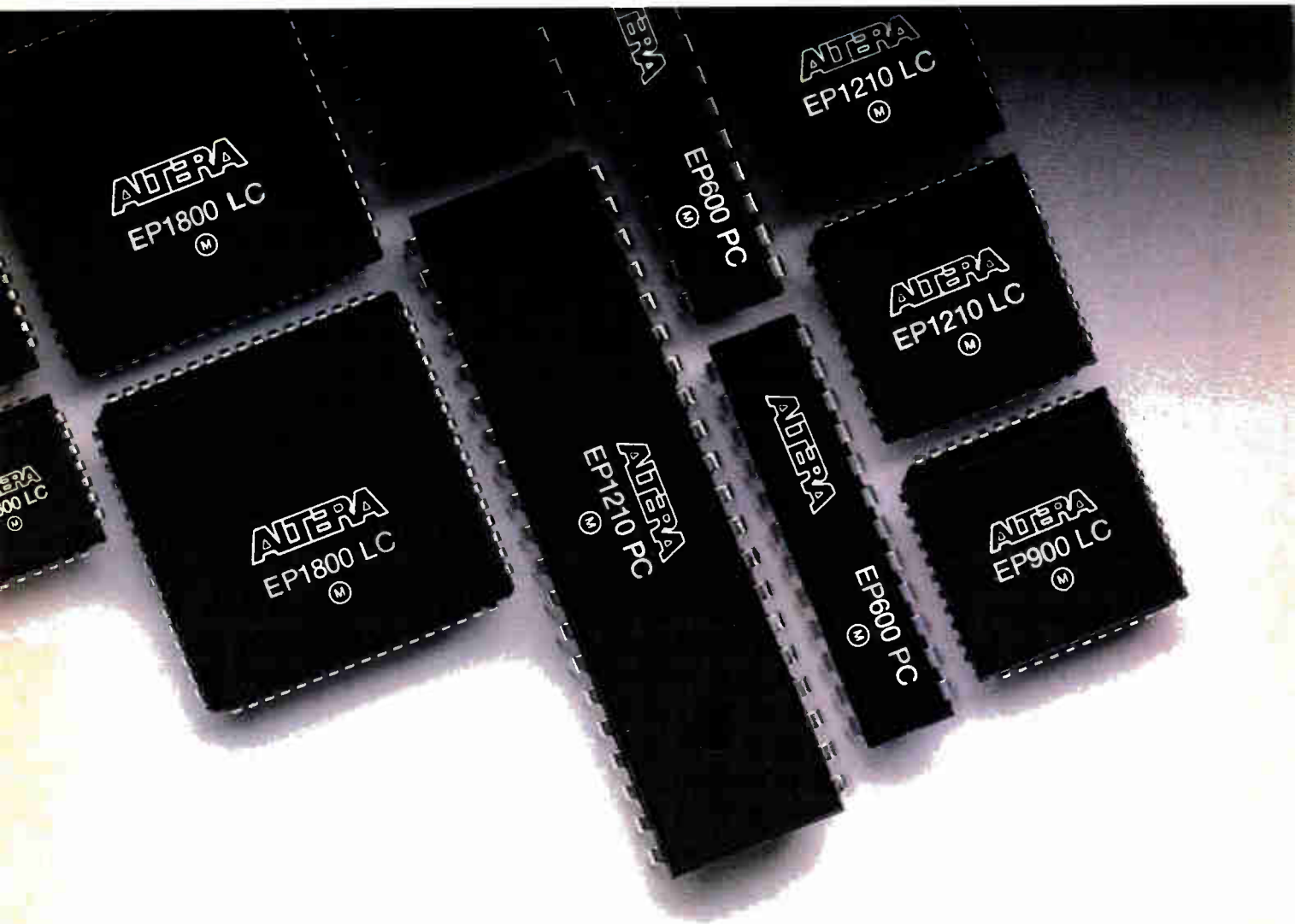
# Assurance.



# ELECTRONICS NEWSLETTER

## COMPUTER CONSOLES INC. WANTS TO BE A BIG-TIME VENDOR

Computer Consoles Inc. is launching a major effort to broaden its product line and move into the ranks of major computer vendors, judging by last week's product unveilings. Betting it can start making money again in the second half of the year after running at a loss during 1985 and the first two quarters of 1986, the Waltham, Mass., company is adding entries at both ends of its computer line. At the upper end, it introduced what it calls the speediest Unix-based superminicomputer, the Power 6/32MP, which is a dyadic processor capable of executing 15 million instructions/s. The company is aiming at an aggressive price/performance ratio: in a basic configuration, the machine costs $290,500. The company also announced an entry-level 5-mips Unix-based computer, the Power 6/32, priced at $124,500. Finally, it introduced a RAM Disk option, a set of boards having up to 64 megabytes of random-access memory for rapid access to large data bases. □

## U. S. SUBSIDIARY OF YUGOSLAVIAN COMPANY JOINS VMEBUS MARKET

The already crowded VMEbus market in the U. S. will get another entrant this week: Iskra VME Technologies Inc., a Farmingdale, N. Y., subsidiary of Yugoslavian electronics conglomerate Iskra. The company is introducing two single-board computers, both double-height 6.3-by-9.2-in. cards. One is an 8-MHz version of Intel Corp.'s 80286/87 processor with an on-board memory-management unit, a half megabyte of read-only memory, and either Xenix or MS-DOS operating systems. The other uses Digital Equipment Corp.'s J11 processor optimized for DEC's RSX-11M operating system. Miki Zivkovic, president of the U. S. unit, says he has more single-board computers and controller products on the way. A VMEbus-based work station that Iskra is marketing in Europe may come to the U. S. later. □

## OLIVETTI TAKES CONTROL OF TRIUMPH-ADLER

Office machines combining the sleek lines of Italian design with rock-ribbed German engineering may be in the offing once Ing. C. Olivetti & Co. completes its acquisition of Triumph-Adler AG, the office-automation subsidiary of Volkswagen AG. The purchase—for 5% of Olivetti's common shares—includes the office-automation holdings of Volkswagen of America Inc. but excludes the holdings of Volkswagen affiliates Triumph-Adler North America Inc. and Pertec Computer Corp. However, Olivetti does plan to collaborate with Pertec in computer peripherals. Olivetti and Triumph-Adler will operate independently under their own trademarks, offer individual lines of typewriters, personal computers, and minicomputers, and sell through separate channels. The two companies will, however, cooperate on research and development and components exchanges. The accord depends on antitrust approval by the Kartellamt in Germany and the U. S. Justice Department. □

## ASCII CORP. AND TOKYO SOFTWARE HOUSE TEAM UP ON UNIX SOFTWARE

Unix-based software will soon get another strong champion. Ascii Corp. and Software Research Associates Inc., a Tokyo software developer, are teaming up to develop and market software written for Unix. After breaking up with its long-time partner Microsoft Corp. [*Electronics*, April 7, 1986 p. 11], Ascii is changing its strategy from MS-DOS to Unix. The two companies will cooperate in planning, developing, and marketing both application software and application-development-support software, using technology and know-how developed by each company. Ascii and Software Research have already started working on support software, as well as a bulletin board for personal computer communications and porting Unix to work stations. □

# "Looking for bus compatible data acquisition boards? You've come to the right guy."

Left to right, Fred Molinari, President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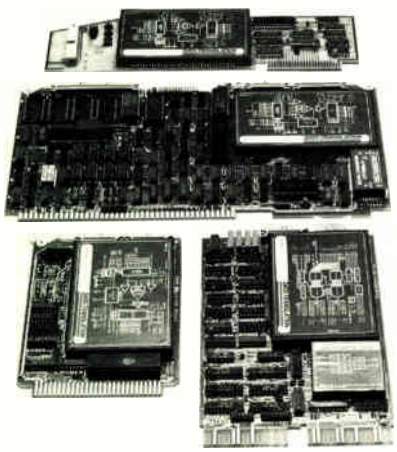

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Circle 14 on reader service card

# PRODUCTS NEWSLETTER

## OKI TO OFFER A 100-NS DIGITAL SIGNAL PROCESSOR

Look for Oki Electric Industry Co. to join the digital-signal-processor market next month with a floating-point chip that can multiply two 16-bit words in 100 ns. It includes a 32-by-1-bit ROM and 128-word-by-22-bit dual-ported RAM. The Tokyo company's MSM-6992 will be faster than other floating-point-format chips from Hitachi Ltd. and NEC Corp., which have 200- and 150-ns multiplication times, respectively, but slightly slower than Motorola's new fixed-point chip, which boasts a 97.5-ns cycle time. The MSM-6992 will be packaged in a 132-pin grid array, and it will be priced at about $343 per unit at current exchange rates. □

## AMD'S MICROPROGRAM SEQUENCER IS BETTER AT REAL-TIME TASKS

A bipolar 16-bit microprogram sequencer from Advanced Micro Devices Inc. is loaded with features that support real-time processing. For example, the 120-pin Am29331 can serve interrupts at the same time it traps the microcode addresses. This means it can reexecute microinstructions and transparently handle interrupts at any microinstruction boundary. The previous generation of 12-bit microprogram sequencers handles interrupts at the macroinstruction level. Those parts have been less suitable for real-time applications because interrupt servicing takes more than a single cycle. The 29331 is available now from the Sunnyvale, Calif., company for $195 each in quantities of 100. □

## MDB CONTROLLER TRANSFERS DATA AT 2.5 MEGABYTES/S

A Winchester disk-drive controller for Digital Equipment Corp.'s MicroVAX II transfers data at rates from 1.2 to 2.5 megabytes/s, which lets it work with the fastest drives available. Moreover, says MDB Systems Inc., its MV-DK11-RM reads and writes data more than 30% faster than any controller on the market. The Orange, Calif., company's controller emulates DEC's RM03 or RM05 protocols and supports two drives ranging from 67 megabytes to over 6 gigabytes. DEC-compatible 32-bit error-correction code plus 16-bit cyclical redundancy checking are used to flag media defects and header errors. Available now, the controller is priced at $2,400. □

## MASK-REPAIR STATION HANDLES 4-Mb RAMs

Nippon Kogaku K. K. is starting shipments on a mask-repair system that has the positioning accuracy needed to repair defects on 4-Mb RAMs. The Nikon LR-1S uses a neodymium yttrium-aluminum-garnet laser to cleanly score or cut a bypass around poorly etched circuit pathways on 5- or 6-in. wafers. The system uses two helium-neon lasers to align the wafer to within a tolerance of 0.3 $\mu$m, says the company. Tests have shown that the machine can fix about 34 wafers an hour. The Tokyo maker of Nikon cameras will sell the LR-1S for $720,000. □

## BRITTON-LEE BOOSTS PERFORMANCE OF ITS DATA-BASE PROCESSOR BY 60%

Britton-Lee Inc. is releasing a CPU board that lets its data-base processor execute instructions 60% faster than its current board. The board is an upgrade for the Los Gatos, Calif., company's IDM 500-series hardware-based relational data-base management systems. The upgrade ranges in price from $25,000 to $35,000. Featuring on-board cache memory and a faster internal cycle time, it boosts system throughput by an average of 38%. The company also is introducing a $200,000 high-end system, the IDM 500XLE, which offers a 40% performance boost over the current top-of-the-line 500XL. □

Electronics

# REPROGRAMMING A ROBOT MAY GET A LOT EASIER AND FASTER

## WRITING SOFTWARE OFF LINE AND DOWNLOADING IT CUTS TIME BY 70%

**CHICAGO**

Reprogramming general-purpose robots for new tasks is a slow, laborious job—a deficiency that no doubt has held back their application in many a factory. Assigning a robot a new job has meant shutting down the line and having an operator take the machine step-by-step through a new process to learn how to do it. But judging from several products announced at last week's Robots 10 show in Chicago, that could soon change.

The job will be speeded up by systems that can write new software off line and then download it to the robot. GMF Robotics Corp., the world's largest robot manufacturer, and Deneb Robotics Inc., a tiny start-up, unveiled plans to bring out systems that merge off-line robot programming with electronic design, layout, and three-dimensional graphic simulation of work cells. And two other companies—McDonnell Douglas Corp. and Robcad—with existing products rolled out enhancements.

Proponents say they can cut up to 70% of the time required to develop a work cell, an area where a specific manufacturing function takes place. And because robots can be programmed off-line to perform as simulated, work cells do not need to be shut down. With traditional program development methods, robots are "taught" a routine by manual walk-through or with a teaching pendant.

GMF Robotics, which last year became No. 1 among U.S. robotics manufacturers with sales of $187 million, showed off a prototype workstation package for off-line robot programming and work-cell layout and simulation. "We're finding a crying need on the part of our customers for someone to do some sophisticated applications work," says Jimmy L. Haugen, a GMF vice president.

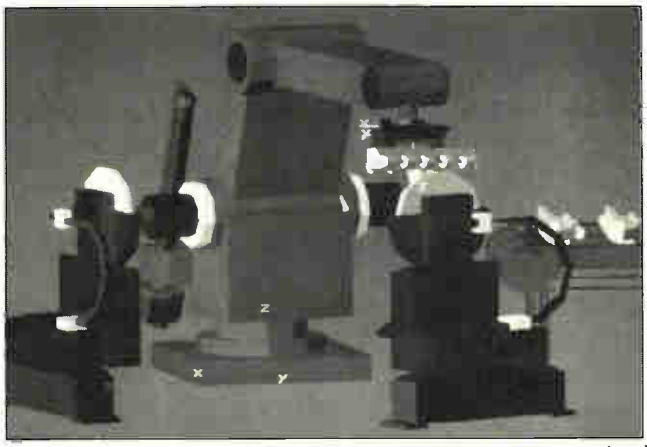
The Troy, Mich., company bases its system on a 32-bit work station from Cimlinc Inc., Elk Grove Village, Ill. Planned for fourth-quarter delivery, the system will incorporate solids-modeling and other computer-aided-design packages from Cimlinc with GMF-developed software that will allow simulation routines to be written directly in Karel, GMF's robot-programming language.

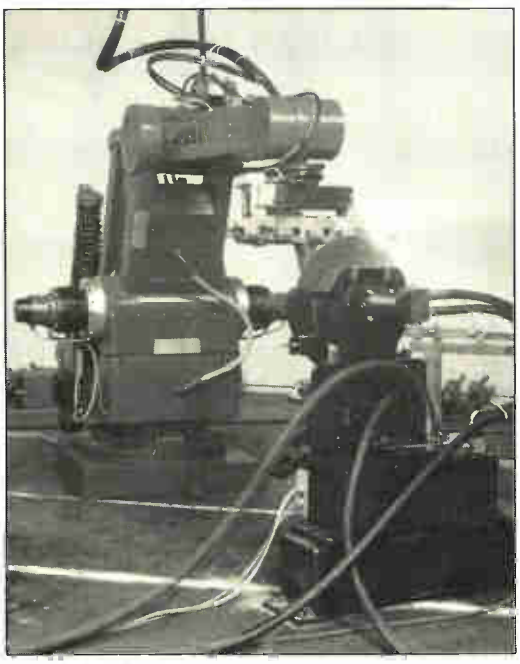
Translators for converting program routines into languages used by other manufacturers' robots can also be supplied, although GMF has not yet decided whether to provide a library of competitive robots on its system, says Michael P. Jacobs, GMF's manager of Karel work stations.

Other manufacturers believe multivendor support is a must because most robot users have more than one brand in house. McDonnell Douglas, for example, offers a library of about 70 robots from a variety of vendors for its three-year-old Place (for Positioner Layout and Cell Evaluator) work-cell simulation software. About 50 of the robots can be programmed off-line using associated McDonnell Douglas software, according to George J. Peters, manager of robotics product development for McDonnell Douglas Manufacturing Industry Systems Co., St. Louis.

Likewise, Robcad, a Birmingham, Mich., subsidiary of Belgium's Oshap Technologies Ltd., announced 17 additional robots for its year-old simulation and off-line programming system at Robots 10. Robots 10 also marked the entry of Troy-based Deneb Robotics into the cell-simulation business. Deneb unveiled its Igrip system (for interactive graphics robot instruction program) that will offer a library of robots from about a dozen vendors when delivered in June. And like McDonnell Douglas and Robcad, Deneb says its system will allow graphic representations of robots not in its library to be created using CAD software on the system or transferred from other files.

Igrip will initially support only work-cell layout and simulation. But by the third quarter, the 9-month-old Deneb promises, translators will be available for Karel and the VAL language used by Unimation Inc., Danbury, Conn., to support off-line robot programming. The Igrip package will run on work stations supplied by Silicon Graphics Inc., Mountain View, Calif., and will cost $90,000 to $120,000 for a





**MODELED MOVES.** Robcad's software models a robot's actions with 3-d graphics, so the real thing (bottom) needn't be taken out of service for reprogramming.

turnkey system, says Rakesh Mahajan, Deneb's director of sales.

Igrip's advantages include real-time automatic collision detection, a feature until now unavailable on other vendors' systems, Majahan says. Igrip simulates, in shaded-surface models, the simultaneous movement of multiple robots and machines. Surface-model representations are less confusing to the viewer than the wireframe models used in McDonnell Douglas's Place and faster than the data-intensive solids modeling of the Robcad system, Majahan contends.

**STIFF COMPETITION.** But judging from Robots 10 announcements, Deneb will face heavy competition. For example, GMF's system will be priced at around $100,000 to compete against others already on the market, says Jacobs.

For its part, Robcad recently added automatic collision detection to its system and a new software release that will run on a 68020-based Silicon Graphics work station to simulate four times faster than its previous package for 68010-based hardware. McDonnell Douglas also unveiled enhancements for its system at the show, including simultaneous motion of multiple devices.

What's more, work-cell simulation and off-line programming systems are expected from other vendors soon. Though the U. S. robot market itself grew by 33% last year to sales of $442.7 million, according to the Robotic Industries Association, the market for work-cell simulation systems is still small. Peters of McDonnell Douglas says it totaled only about $25 million in 1985. *–Wesley R. Iversen*

*MARKETING*

# NYNEX AIMS TO SUCCEED WHERE IBM HAS FAILED

**NEW YORK**

IBM gets rid of a money-loser, Nynex gets a big challenge, and the winners could end up being Apple and Compaq. That's how industry observers boiled down last week's surprising announcement that IBM Corp. is selling its Product Center chain to Nynex Business Information Systems Co.

Nynex, a regional Bell operating company that has operated 21 Datago business centers in the Northeast since December 1984, will initially acquire 81 of 84 IBM Product Centers in 33 states. Nynex will eventually take over the other three centers, currently operated in IBM buildings. Nynex executives expect the deal to be completed by June 30.

The acquisition is "clearly a way for Nynex to establish a presence nationally," says Rick Seikaly, director of consulting services for Telestrategies Inc., McLean, Va. "I think it's a good and calculated move by Nynex," adds Egil Juliussen, chairman of Future Computing Inc., Dallas. "In one swoop, they become a national computer chain."

IBM opened its first U. S. Product Center in 1980 and started an authorized dealer network in 1981. Industry sources speculate that the centers have been a drain on IBM's bottom line and the deal with Nynex frees up that cash.

"IBM is getting rid of a loss in a year that [IBM president John] Akers admits won't be the best," says Seymour Merrin, vice president of The Gartner Group, a Stamford, Conn., market-research company. There's no way of verifying whether IBM lost money on the centers, says Future Computing's Juliussen, and IBM won't say. But "if it was really successful, they would have kept it," he believes.

IBM claims the stores were successful—as far as Big Blue is concerned. "The Product Centers led IBM into the retail marketplace," says an IBM spokesman. The stores' charter was to establish high-quality retail standards and consumer product awareness while a dealer network grew, he says, "and they were successful in doing that. We feel the dealer network has now grown and matured to a point where it can handle retail market coverage."

There are observers who question Nynex's prudence. Asks Washington-based telecommunications consultant Harry Shooshan, "If IBM can't make a go of it, what does that say about the long-term chances of these ventures?"

**ONE OF FIVE.** Still, Future Computing's Juliussen thinks the economy of scale that Nynex will get from the IBM centers will help it succeed in the retail market. "I think there will be five computer retail chains in a few years. Nynex is in a good position to be one of those five."

"Nynex is an aggressive competitor," says Merrin, of The Gartner Group. "Now we'll have to see if they can capitalize on the acquisition."

Getting the IBM centers will allow Nynex to expand its product line while offering "integrated solutions" to IBM's small and medium-size customers, contends a Nynex spokesman. The 81 IBM centers and 21 Datago centers will be renamed Nynex Business Centers, he says, adding that they will continue to sell computers, printers, and telephone equipment from IBM competitors such as Apple, AT&T, and Compaq, along with Nynex's cellular telephones.

This could prove a boon for Apple Computer Inc. and Compaq Computer Corp., thinks Merrin. "It opens up a big market that was previously closed to them." *–George Leopold and Robert J. Kozma*

*COMPANIES*

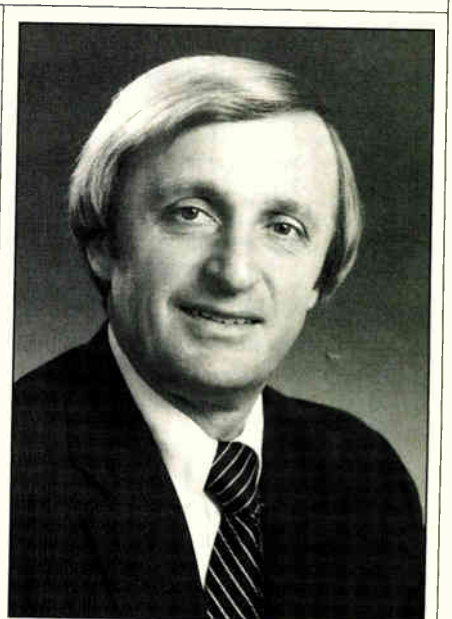
# NATIONAL FORMALIZES ITS THRUST INTO SYSTEMS

**SANTA CLARA, CALIF.**

The major reorganization announced last week by National Semiconductor Corp. actually formalizes developments that had been going on for several years. It decided to put more emphasis on systems and no longer is banking on the chip business alone to keep it afloat.

The Santa Clara company's systems business had already been growing steadily; in the past few years, it had shot up from 10% to 40% of sales. But National does not intend to turn into a systems house with a semiconductor arm like some of its giant Japanese competitors, says company president Charles E. Sporck. "They tend to be 90% systems and 10% semiconductors. That won't be in the books for us."

As part of its reorganization, National



**SYSTEMS MAN.** Martin sees a big opportunity for 32000-based system-level products.

## ELECTRONICS EXECS SHOW A LOT OF DRIVE

**Top U. S. semiconductor** business executives have come up with a real vehicle for boosting their industry: an immaculately restored 1931 Chrysler convertible. Eleven companies are backing the yellow convertible in the Great American Race, which matches some 100 pre-1936 vintage autos in an 11-day rallying contest that starts in Anaheim, Calif., and ends July 4 in New York. A ceremony there will tie into the Statue of Liberty centennial celebration.

The entry, backed by U. S. chip makers and distributors, is the brainchild of impresario Jack Beedle, who heads market consultant In-Stat Inc., Scottsdale, Ariz. Besides pumping up industry spirits, Beedle hopes the entry's swing through Washington, D. C., July 2 will help garner support for industry trade and tax programs.

is moving its board-level microcomputer products operation into a newly created Information Systems Group and has plans to integrate a variety of original-equipment-manufacturer products around its 32000 microprocessor family.

Key to the new strategy is the combining of three operations: National Advanced Systems, a wholly owned subsidiary that markets IBM Corp. plug-compatible mainframes built by Hitachi Ltd. of Japan; the part of the Semiconductor Division that had made board-level products; and Datachecker/DTS, a maker of point-of-sale systems. It will be the job of NAS president, David N. Martin, named executive vice president of the Information Systems Group, to pull these lines together and integrate them with National's semiconductor products.

These products are the responsibility of James Smaha, 50, who has run semiconductor operations for two years and becomes Martin's opposite number, executive vice president of what is now called the Semiconductor Group. Smaha and Martin, 41, have assumed operating responsibility; Sporck, who built National into the world's No. 6 semiconductor maker, says he will now spend most of his time on strategic issues.

The semiconductor crunch belted National hard. The company lost $120 million on sales of $1.1 billion for the first three quarters of fiscal 1986. And although Sporck insists the company is on the road back to profitability, analysts say it is an uphill climb.

But the company is out of the volatile commodity chip business, says Sporck, and now derives half its sales from proprietary products—a percentage that will grow because 80% of its new products are also proprietary. That puts it in a good position to capitalize on the upturn in semiconductor business, Sporck says.

The 32000 family is central to these plans. An early leader in the 32-bit market, the 32000 is expected to fall to a distant third behind the Motorola 68020, which has surged in popularity in the past year, and the Intel 80386, which is expected to hit volume production in the second half of 1986. National is not conceding any markets to these rivals, but at the same time sees its chip set as the focus of its own systems operation.

**MORE SYNERGY.** "The level of synergy that exists today [between the three parts of the Information Systems Group] is quite low," Martin says. "But we see a big strategic opportunity for cross-group utilization of system-level products based on the 32000. All board-level and subsystem-level OEM microcomputer products are based on the 32000 chip set."

Beyond that, National will build 32000-based networking and engineering/scientific products. It is already offering two products that enable its mainframes, which use IBM's Systems Network Architecture, to connect with a variety of local-area networks. More are coming in the next 12 months, Martin says.

The market for engineering and scientific products could be the sleeper. Aside from IBM, National is the only firm with products that range from mainframes to single-board computers. It is already offering a plug-compatible mainframe, the 9100 series, that does vector processing. "Within the next 12 months," Martin says, "we will offer 32000-based products that will allow integrated mainframe-to-microcomputer communications." A typical application will be component development on an engineering work station and high-level simulation on the mainframe.

National has not yet decided whether to build its own work station. Its first commitment is to a board-and-subsystem line that presents an alternative to conventional bus-oriented microsystem architectures.

The systems will be designed at National's Portland, Ore., microcomputer operation, which Martin says will become the company's fastest-growing unit, both in personnel and revenue.

Within a year, the 32000 line will also show up in POS systems with increased functionality, Martin says. "Our scope of interest covers anything in the broad market that you would define as OEM computers. We have to date rejected any end-product entry in office automation because of the tremendous confusion in that market." IBM has eight office-automation architectures, he notes.

Some analysts see National's new track as a forced step, particularly because the 32000 chip set is not considered a winner in the market. "Everybody likes the 32032, but nobody uses it," says Andrew Kessler of Paine Webber Inc.

But Michael Gross, director of semiconductor research for International Development Corp., Palo Alto, likes the strategy of putting the microcomputer unit into the systems group. "NAS has a direct-marketing organization in the mainframe community," he points out. "Now they have a relation between mainframes and the work-station level. IBM is the only other company in the world that does that." *–Clifford Barney*

*PACKAGING*

## IS PLASTIC COMING FOR MILITARY ICs?

**NEW YORK**

The U. S. military has long refused to use semiconductors housed in plastic—not because the packages would melt at the upper end of the −55°C to +125°C military temperature range, but because they do not protect chips from humidity. Now a new effort is under way to convince the military that plastic will do the job when combined with a silicone gel to isolate the chip's surface from humidity effects.

The Computer Packaging Society of the Institute of Electrical and Electronics Engineers is behind the new plastic-package push. The society has been trying to set standards for chip-carrier

packages, and the solder-joint problems that plague hermetic ceramic versions of such packages in military systems have induced it to seek acceptance of plastic chip carriers.

The plastic packages the military has looked at so far have nearly all been of the postmolded variety. The Computer Packaging Society, however, is now touting premolded plastic chip-carriers that permit encapsulation with a silicone gel. AT&T Co. and GM Hughes Electronics Corp. are already using this approach. Among computer makers, Burroughs Corp. and Hitachi Ltd. are also moving toward adopting such packages.

Amp Inc., Harrisburg, Pa., will supply the plastic premolded chip-carriers for the new round of tests. AT&T Bell Laboratories in Murray Hill, N.J., will supply and apply the gels, and some of the testing will be performed by the Air Force's Rome Air Development Center in Rome, N.Y.

The test chip will carry a triple-track resistor test pattern. At least five types of silicone encapsulants, including U.S. and Japanese materials, will be evaluated. The program is scheduled to start late in the year, and results may be available by mid-1987.

After several preliminary meetings, the society succeeded in drumming up enough interest from manufacturers of military systems to request a new round of tests. The government has now agreed, and an IEEE task force has been formed to evaluate the reliability of premolded plastic chip-carriers in military applications.

**MAKING LIFE SIMPLER.** "If successful, this program could significantly improve packaging speed and density as well as bring costs down, making life simpler for many military designers," says Jack Balde, a senior consultant at Interconnection Decision Consulting, Flemington, N.J. Balde is heading up the Gel Task Force. Participants include Fairchild, General Electric, General Dynamics, GM-Hughes, Harris, Honeywell, Loral, Martin Marietta, McDonnell-Douglas, Rockwell International, Sperry, Texas Instruments, Tracor, and Westinghouse.

During thermal cycling over the military range, mechanical failures in the solder joints connecting leadless ceramic chip carriers to organic-material printed-circuit boards become acute. Many attempts have been made to compensate for the thermal mismatch between the leadless alumina carrier and boards made of epoxy glass, polyimide glass, Kevlar, or quartz, or even epoxy-glass and polyimide-glass boards with copper-invar-copper inner layers.

But none of the techniques tried so far is satisfactory for the coming generation of ultralarge, extremely high-lead-count, high-power carriers. In fact, there is industry conjecture that the large Z-axis expansion of the special X- and Y-axis-compensated boards tried may be causing microcracks. Such faults occur in small via or plated-through holes of the dense boards required to interconnect carriers of very large-scale integrated circuits.

In the commercial world, leaded plastic chip-carriers are already in use; such packages are available with as many as 160 leads. The compliant leads of these packages prevent solder joints from cracking, even if there are large differences in thermal coefficients of expansion between the packages and board materials. This allows for the use of inexpensive and readily available FR-4- or G-10-type epoxy-glass boards. *—Jerry Lyman*

*DATA PROCESSING*

# TEXAS SHOOTOUT BEGINS FOR POST OFFICE BUSINESS

**DALLAS**

The competition "is getting exciting," declares Robert S. Buzard. He's president of ElectroCom Automation Inc., one of two archrivals that are beginning to fight it out in a real Texas-style shootout. At stake is more than $320 million in sales and the Texas-size pride of two Dallas-area producers of optical-character-recognition equipment.

ElectroCom and Recognition Equipment Inc. are vying for the next major round of automation equipment targeted for U.S. post offices, which is described by the Postal Service as a "mid-course correction" intended to bolster its struggling nine-digit zip-code system.

It's not the first time the two companies have fought it out. Buzard's company set the stage last year for this summer's battle by beating out its cross-town rival, which had long dominated this business, for $200 million worth of OCR mail-sorting equipment. Now the Postal Service wants to enhance that equipment—to read more than the last line of an address and to automatically generate complete nine-digit zip codes.

The two Dallas companies are the only bidders for the separate contracts to upgrade existing equipment and supply new Phase III OCR gear. Neither is revealing design details, and both are in the final stages of fine-tuning their systems, which must marry OCR-processing with data-base software.

The OCR subsystems, which previously read only a single line of each address, are being expanded to read multiple lines. The image of an address is reduced to alphanumeric data, and if no nine-digit zip is present, software looks

## ZIP-CODE DATA BASE DOES A LOT MORE THAN SORT MAIL

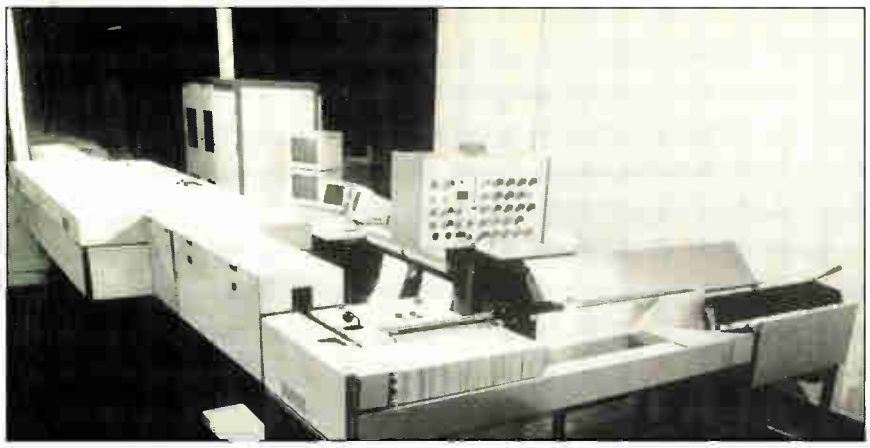
**The nine-digit** zip code may be slow in delivering cost-savings to the U.S. Postal Service, but a six-year-old nationwide data base created for the address-locating system is already serving other information needs. Emerging applications of the zip-code data base range from the obvious task of intraoffice mail distribution to an emergency-call location system merging nine-digit Zip+4 code with a city's telephone directory.

The Postal Service started creating the nationwide data base in 1978 to finely partition and identify every mailing address in the country. The complex data base was completed in 1980. The postal agency is now preparing to solicit hardware bids for an on-line data-base system that will quickly update nine-digit zip codes at all post offices using mail-sorting optical-character-recognition equipment.

Meanwhile, other government agencies and some enterprising software programmers are using the Zip+4 data base to address other problems. A school district in San Bernardino, Calif., for instance, has used the address-locating data base to condense school bus routes, saving the district about $70,000 in bus-leasing costs.

The U.S. Internal Revenue Service is using the zip code to separate the taxpayers who historically make payments on April 15 from those who usually receive refunds. The zip code is used to direct tax-return envelopes likely to contain checks to the payment departments. The IRS estimates it has netted about $11 million by cashing checks quickly and reducing the "float" period taxpayers had been enjoying.

A company the Postal Service will not identify is developing a data-base package that will use the zip code's ability to locate sites in the nationwide 911 emergency call system. Public-safety dispatchers will ask for the telephone number of the caller, and the nine-digit zip code associated with the number will pinpoint the site to within 200 to 400 ft, according a spokesman for the Postal Service. *—J. R. L.*



**READER.** ElectroCom's OCR III system adds nine-digit zip codes to letters in bar-code form.

for the most meaningful address information. The address is then compared with a data base to determine the best nine-digit code. The throughput of these minicomputer-based machines will be in the range of 10 letters/s. Inkjet printers apply the zip codes to envelopes as bar codes, and then bar-code readers are used in sorting the mail.

In two months, the third-generation systems will go head-to-head in closely guarded performance tests in Phoenix, Ariz., known in postal circles as "the big sort-off." Speed and ability to deal with problem mail—pieces with conflicting or missing information—will be measured. Tests of conversion kits for second-generation systems will be conducted in June and July, and tests of the new multiline systems will start in July.

A sole-source contract for conversion of 406 single-line OCR systems will be awarded in September and likely add up to about $100 million. A contract for the new systems, estimated at $220 million or more, will be awarded in October.

**SALVAGING ZIP+4.** For the Postal Service, the goal is to cut costs and accelerate the use of its nine-digit zip code. The move to multiline OCR systems and data-base technology is part of what postal officials term a "mid-course correction" in an eight-year effort to expand the zip-code system from the widely used five-digit codes to the nine-digit system called Zip+4. The four extra digits narrow down the sort to areas within a mail carrier's route, such as a single floor in an office building or one side of a residential street.

The Postal Service estimates that only one sixth of machine-readable first-class mail currently carries the Zip+4 code. Enhanced OCR and data-base processing, it is hoped, will succeed where postage incentives and publicity work have failed since the 1983 debut of Zip+4.

If 90% of the machine-readable first-class envelopes carry the nine-digit zip, the postal agency estimates it will save between $900 million and $1 billion in processing costs each year. Equal savings are expected at local post offices.

The latest round of bidding is generating more than just excitement. There's also hostility because of a patent-infringement suit filed by Recognition Equipment against ElectroCom and other postal-equipment makers. Recognition Equipment, which holds a 1972 patent covering systems that combine OCR and barcode technology to sort documents, claims its technology is being used without proper licenses. ElectroCom denies that it is violating patents.

William G. Moore Jr., Recognition Equipment chairman, has also complained openly about foreign technology in the competing post-office OCR systems.

Last week, ElectroCom showed its third-generation OCR system to the press. Like its earlier equipment, the unit uses OCR technology licensed from AEG-Telefunken of Frankfurt. It also uses a Digital Equipment Corp. PDP-11/83 minicomputer, and its data-base subsystem employs a 16-bit microprocessor and coprocessor from Intel Corp.

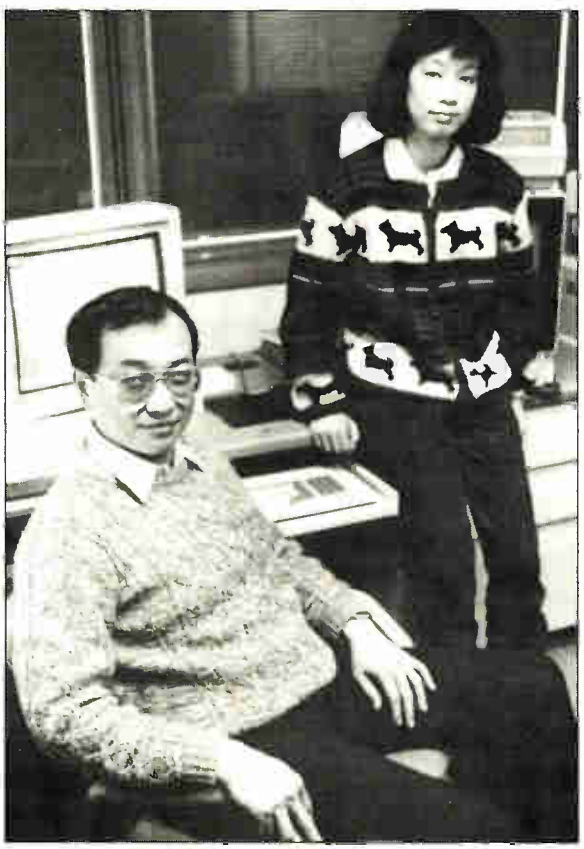
The system will operate at up to 40,000 letters per hour with a typical reading-error rate of about 1%, a spokesman says. *—J. Robert Lineback*

*SEMICONDUCTORS*

# BELL LABS FINDS A BETTER WAY TO SPEED UP CMOS

**MORRISTOWN, N. J.**

CMOS technology may have taken the semiconductor world by storm, but it still has its problems. Static CMOS is too slow for many applications. Dynamic CMOS designs have added speed to the inherent power saving, but charge sharing and current leakage between individual transistors disrupt output signals in most designs. Internal nodes can steal charge from the output transistor of a logic block.



Numerous solutions have been developed to solve current degradation, but for the most part they are costly and complicated. Now Bell Communications Research says it has developed a better way. Charles Lee, research manager for the VLSI Design Methodology group at the lab, claims that a new circuit structure—called Zipper CMOS—is a simpler and less costly answer.

In contrast to earlier solutions—which Lee says sacrificed chip real estate by requiring extra transistors—the Zipper architecture relies on a proprietary clock-driver circuit.

**INVENTORS.** Charles Lee headed the Zipper CMOS team, which included Ellen Szeto, who did much of the simulation work that went into developing the architecture.

It eliminates charge sharing and current leakage by maintaining a residual current between the power source and a circuit's precharge transistor at all times. That enables it to maintain the correct charge on the output node.

During a circuit's precharge phase, Lee explains, the precharge transistor is on full power. Then, as the circuit moves into the evaluation phase, where power would be cut off in other structures, Zipper CMOS's precharge transistor remains partially on. As a result, the circuit's output cannot be altered by an internal transistor "stealing" charge.

**THE DOMINO EFFECT.** Zipper CMOS is an outgrowth of work done at AT&T Bell Laboratories during the development of the Bell Mac 32000, the predecessor to AT&T Co.'s WE32100 32-bit microprocessor. In the mid- and late-1970s, Lee was on the team that invented Domino CMOS, a design that connected dynamic CMOS gates in such a way that one action of the clock edge could be used to turn on all the gates in a circuit. As each gate was turned on, it triggered the next gate, causing a chain reaction similar to that of a row of dominoes when the first block is pushed over.

Though the Domino design became a reality nearly 10 years ago, it was, in fact, a variation on the Zipper CMOS idea. "Zipper CMOS was perceived before Domino CMOS, but it wasn't used because the technology wasn't there. We held it back because we knew there were problems," Lee recalls.

Lee and his colleagues realized that if they could implement fully configured alternating p- and n-channel logic blocks—the Zipper structure—they could boost performance and increase reliability. The p-channel blocks create a second domino-like row of gates that interlocks with and runs parallel to the n-channel blocks. When the first n-channel transistor is triggered, it sets off a chain reaction involving both rows, similar to the meshing of zipper teeth. Yet the 5-μm geometries used in 1977 made p-channel transistors perform three to four times more slowly than their n-channel counterparts.

*The Zipper design relies on a proprietary clock-driver circuit*

So Lee's group settled on the Domino structure, with n-channel logic blocks alternating with p-channel inverters, which were used to maintain phase polarity. Implementing p-channel inverters might have slowed the device down, Lee says, but it was still faster than implementing a p-channel logic block.

With geometries now in the 1-μm range, however, the technology has enabled p-channel logic to improve its performance dramatically. Though it is still half the speed of n-channel logic, Lee says, it is fast enough to make the original Zipper concept practical.

The Zipper driver circuit, Lee says, enables even better performance because of the residual current. "It's like a sniper who files down his trigger to a light touch," Lee says of the Zipper design. "In Zipper CMOS, the threshold voltage is always 0.6 V from full power—like a hair trigger, it takes less time to trigger a gate to the next state."

Such a low threshold voltage can cause instability, of course. That's why the driver circuit also provides a restraint against disturbances that might trigger a gate into the next state, says Ellen Szeto, a member of the technical staff who did much of the simulation work for developing the architecture.

The researchers say they have implemented the Zipper CMOS design in a prototype 16-bit arithmetic logic unit for use in processing communications protocols, and claim that other applications are also possible. *–Tobias Naegele*

***COMPANY STRATEGIES***

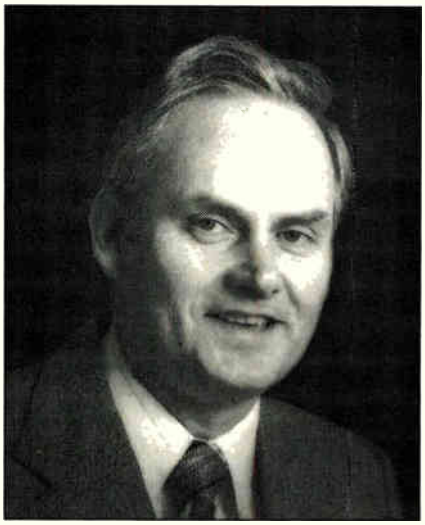
# RCA SOLID STATE SHINES IMAGE FOR GE

**SOMERVILLE, N. J.**

A cloud has hung over RCA Corp.'s Solid State Division ever since the merger with General Electric Co. was announced last December, but the division's management is working hard to build a silver lining. Despite a string of rumors that variously had the Somerville division sold, moved, or closed down, its executives say it's too early to speculate on the future. Instead they're choosing to ignore the rumblings and continue operating "full speed ahead."

A chip maker known for its somewhat plodding ways, RCA is pushing on the accelerator now with unprecedented force. Division vice president and general manager Carl Turner says Solid State unveiled nearly 500 new products or product enhancements last year, and he indicates the pace will continue through 1986. And planned for near-term introduction are application-specific integrated circuits and new high-density power MOS FETs.

Though Turner denies a connection, the division appears to be doing its best to look good for GE. The strategy is to make GE's decision "as difficult—or as easy, depending on how you want to look at it—as possible," says Herb Criscito, vice president of marketing. "If we do the best job we can, we feel GE management has to notice that."



**FAST PACE.** Turner says Solid State will continue its hot pace of product announcements.

Both Turner and Criscito maintain that the long-term plan the division enacted four years ago is the basis for the current strong showing. At that time, RCA chose to concentrate on CMOS technology, particularly in the government and military markets, as well as to serve the domestic automotive sector. It also set about upgrading the division's main manufacturing facility in Findlay, Ohio, and sought out partners who could help polish its tarnished image as a leading-edge supplier.

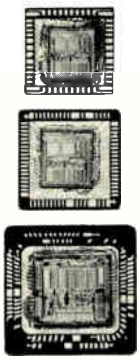
**STRENGTH IN CMOS.** The strategy paid off. CMOS technology, which accounts for about 50% of the division's business, is driving the industry, putting RCA in a leading position among its competitors.

"As CMOS continues to become a more dominant technology, we are strengthened," Turner says, in part because CMOS chips hold their prices better than other technologies. That helps defend RCA from rapid price erosion. Says Turner, "Price erosion didn't hit us as hard as some others" during last year's devastating downturn. He says RCA's 8% price-erosion rate is less than half the industry average.

CMOS was not the only reason RCA's prices held up. Long-term supply agreements with major customers, coupled with a high reliance on government and military orders, also helped. Turner says government and defense orders account for 23% of the division's business.

"We've got good things to show for

# These are Motorola microprocessors.



The M68000 family is supported by many of the world's leading computer operating systems and enjoys a very broad applications base.

the last nine months or so," Turner says. "We're in the black. Our bookings are looking good," and the book-to-bill ratio was 1.22 for March, compared with 1.15 industrywide.

Just being profitable may not be enough for parent GE, however. Chairman Jack Welch is on record as saying he wants his company to be No. 1 or 2 in a market or not in it at all. Turner and Criscito are fully aware that RCA is not an industry leader, but Criscito says the Solid State Division may not have to meet such strict criteria. Because it's an essential service organization for the rest of the company, he says, the division's value goes beyond its ability to boast a big profit. "That fits in with [Welch's] whole concept of vertical integration," he says. "Besides, if you look at CMOS, we're No. 2 in the U.S.," and RCA is also a leading supplier of semiconductors to the military and automotive markets.

*Welch wants GE to be No. 1 or 2 in all its markets*

One major division project that's not going full speed ahead is the ultramodern, fully automated wafer-fabrication plant it is building in Camas, Wash., with Japan's Sharp Corp. It is on hold while GE studies the plan. But the 50-50 joint venture, called RCA/Sharp Microelectronics Inc., is already operating a design center in nearby Vancouver, Wash. An agreement that is moving ahead is one with WaferScale Integration Inc., Fremont, Calif., to manufacture, as a second source to Sharp, the company's new 32-bit microprocessor on a macrocell. Turner says that deal was consummated without consulting GE.

Turner says he has participated in a few preliminary discussions on how his division fits into the GE scheme, but insists that no decisions have been made. Indeed, both he and Criscito are anxious for the U.S. Department of Justice and the Federal Communications Commission to approve the deal so they can get on with business and dispel the cloud of uncertainty that has enveloped them since late last year. *–Tobias Naegele*

*COMPONENTS*

# MICROMACHINING ETCHES A MICROPHONE ON A CHIP

**DARMSTADT, WEST GERMANY**

Even tinier cassette recorders and hearing aids may soon be on the way. Researchers at the Technical University of Darmstadt have built capacitor- and piezoelectric-type chip microphones that are tinier than the head of a pin. Despite their small dimensions, the parts leave enough space to integrate electronic circuitry—an amplifier, for example, for on-chip signal processing.

Working models of the capacitor-type unit have already been made, according to Joachim Franz and Dietmar Hohm, the development team at the university's Institute for Electroacoustics. Though much smaller than the one-chip microphone fabricated in the U.S. by Honeywell Inc. [*Electronics*, May 19, 1983, p. 48], it is actually a two-chip device.

One chip carries the 0.8-by-0.8-mm silicon nitride membrane, which has an area less than one tenth the size of Honeywell's chip. And its thickness—150 nm—is less than one hundredth the thickness of membranes used in other chip-based sound transducers. The second chip constitutes the microphone's back plate, which contains the back electrode, air-gap spacer, and electrical terminals.

The other microphone, still in the early stages of development, has a boron-doped silicon vibrating plate with a piezoelectric layer of crystalline aluminum nitride on top. Again, the small size is its distinguishing feature: the plate measures 0.9 by 0.9 mm and boasts a thickness of only 0.8 $\mu$m. Because of its one-plate structure, the piezoelectric microphone is simpler to fabricate than its capacitor-type counterpart.

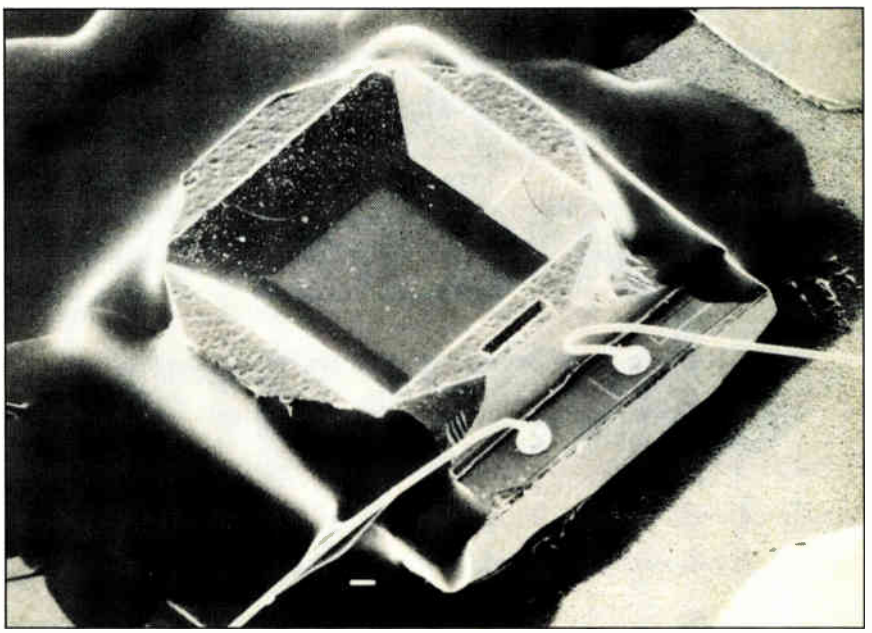
The key to the small size is the use of micromachining, Franz says. Device fabrication entails masking techniques and anisotropic etching processes that depend on crystal orientation and dopant concentration to create three-dimensional structures in silicon layers. The use of similar techniques at Munich's Fraunhofer Institute for Solid State Technology has led to tiny silicon transducers for sensing pressure and acceleration [*Electronics*, May 17, 1984, p. 82]. Close manufacturing tolerances can be achieved by selective etching.

The small dimensions should come in handy for a host of applications. A hearing aid, for instance, can be made even less conspicuous than it is today. The membrane's small mass helps make the device insensitive to environmental vibrations. Small size is also a boon for eavesdropping devices.

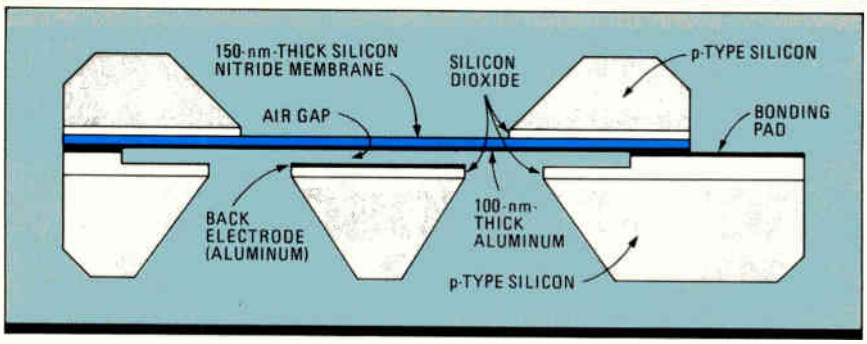
**MICROPHONE ARRAYS.** Another possible application for the devices is in microphone arrays. Such arrays, consisting of a number of elemental chip transducers, can be given directional sound pick-up properties when the output of certain elements is delayed and attenuated.

Besides their compact design, the microphones come with all the advantages that semiconductor fabrication techniques provide: they can be produced in large quantities, they are highly reliable, and they can be manufactured at low cost. When produced in volume, the microphone on a chip should cost less than an electret version does today, Franz claims.

The chip microphone is also insensitive to extreme thermal conditions. It stands up to temperature variations of



**SMALL PACKAGE.** Darmstadt's capacitor microphone measures 1.7 by 2.0 by 0.6 mm.




**GLUED TOGETHER.** The capacitor mike's membrane is upside down atop the back plate.

more than 100°C, a condition under which an electret microphone would fail. What's more, depending on the associated signal-processing circuitry, the device offers frequency sensitivity on the order of 0.1 Hz.

As Franz explained at last week's European Conference on Electrotechnics in Paris, the capacitor microphone is a dc-biased transducer whose two chips are produced on separate wafers. Fabrication of the membrane chip involves oxidizing a p-type silicon wafer, then covering it with a silicon nitride layer by chemical vapor deposition. Next, the wafer is masked from the unpolished bottom side, with the mask aligned to the semiconductor material's crystal orientation.

Through the use of a selective and orientation-dependent etching solution such as potassium hydrate, the wafer is totally etched through. The etching process is stopped by the crystal walls, which prevents undercutting the mask. This leaves the silicon nitride film standing. Its thickness, around 150 nm, can be precisely controlled during the CVD process. Finally, the wafer is coated with a 100-nm aluminum layer and broken up to obtain the individual membrane chips.

**FRONT AND BACK.** The back plate follows similar masking and etching steps. A 2-$\mu$m-thick silicon dioxide film determines the separation between the back electrode and the membrane. To reduce stray capacitance in the finished device, the back plate is covered with a second 2-$\mu$m oxide film. In the last step, the chip is selectively metalized with aluminum.

To complete the capacitor microphone, the membrane chip is mounted upside down on top of the back plate. The two are then glued together at their rims. Two gold wires, bonded to the terminal pads, connect the device to a preamplifier. The finished part measures 1.7 by 2 mm and is 0.6 mm high.

Micromachining also comes into play in fabricating the piezoelectric microphone. Its 0.8-$\mu$m-thick silicon membrane carries a crystalline piezoelectric layer of aluminum nitride about 0.4 $\mu$m thick. This layer is deposited by reactive sputtering, a low-temperature process that cuts down thermal stress in the device.

The process involves sputtering aluminum atoms from a metallic target. The sputtering gas consists of nitrogen and argon. In the glow discharge, reactive atomic nitrogen turns aluminum particles into aluminum nitride that is deposited on the substrate. This step, the trickiest in fabricating the sensor, is still under investigation at the Darmstadt Institute. *–John Gosch*

*COMPUTER-AIDED DESIGN*

# SIMULATING ANALOG ICs GETS PRACTICAL

**LEUVEN, BELGIUM**

A team of Belgian engineers has worked out a solution for one of the more delicate problems holding back the use of simulation in the design of analog integrated circuits.

The engineers are with IMEC, a Flemish acronym for the Interuniversity Microelectronics Center, the research and development facility established in Leuven by Belgium's Flemish government. Their solution is a parameter-extraction program called Simpar. It is said to improve the accuracy of simulated circuit gain by at least an order of magnitude over similar programs based on the standard parameter-extraction approach developed for simulating digital circuits.

Parameter-extraction programs produce values that are used as input for simulation runs of the Spice device-simulation program developed at the University of California at Berkeley. The extraction programs attempt to optimize parameters using a known error criterion, usually the relative current deviation.

This approach gives highly satisfactory results for digital applications such as switching. But in analog applications, small-signal conductance in a circuit's saturation region causes severe problems in modeling output conductance. The conductance parameter is important because it is the factor most responsible for determining a circuit's gain, points out Kristin de Meyer of the Belgian National Science Foundation, who is coordinating the project for IMEC.

Standard parameter-extraction programs, such as Mosaid from Mosaid Inc., Kanata, Ont., Canada, rely on a technique that minimizes relative current deviation for each data point measured. Simpar, however, uses a parabolic interpolation routine to take into account the slope of a device's current-voltage curve, thus minimizing the error at all points on the curve. It does so regardless of the length of the transistor's channel.

*A Belgian team boosts accuracy tenfold*

To illustrate the analog-simulation program's accuracy, IMEC simulated the gain of a CMOS operational amplifier using parameters from Simpar and again using parameters from another program based on the standard approach. The curve from a Spice MOS model that relates drain-source current to drain-source voltage was used by the IMEC engineers in both cases to extract a set of three parameters: threshold-voltage shift due to the applied drain-source voltage, the saturation velocity of the carriers in the channel, and the channel-length shortening effect of the transistor in the saturation region.

**ERROR FACTOR SPREAD.** The researchers then ran simulations to determine the circuit's gain using both sets of extracted parameters at different peak-point current-bias values. The results of the simulation using Simpar-extracted parameters disagreed with actual measured gain values by about 4% to 18%. By comparison, the simulations using the standard method of parameter extraction were off by fully an order of magnitude for low values of current bias, and as the bias values were increased, the simulation error grew worse, to a factor of nearly 60.

De Meyer points out that although IMEC used a Spice MOS model, the strategy should work equally well for any curve describing a current-voltage relationship. *–Robert T. Gallagher*

# INSIDE TECHNOLOGY

# SENSING ROTARY POSITION WITHOUT ANY MOVING PARTS

## FILLING THE GAP BETWEEN POTENTIOMETERS AND OPTICAL ENCODERS

A low-cost rotary position sensor with digitally encoded output and no moving parts appears ready to play a wide role in industrial applications such as remote meter reading, factory automation, and automotive instrumentation. Developed by Cain Encoder Co., the sensor aims to fill the gap between inexpensive but imprecise single-turn potentiometers and costly high-resolution optical encoders. Samples of the device are now going through field demonstrations being held by Consolidated Edison, Southern New England Telephone, and the Electric Light Department of the Town of Rowley, Mass. At the same time, several other electric utilities, telecommunications equipment suppliers, and telephone companies are using the Cain Encoders in demonstrations, interface development, or laboratory testing. The unit now comes in small lots but will be ready for mass distribution early next year, according to Cain.

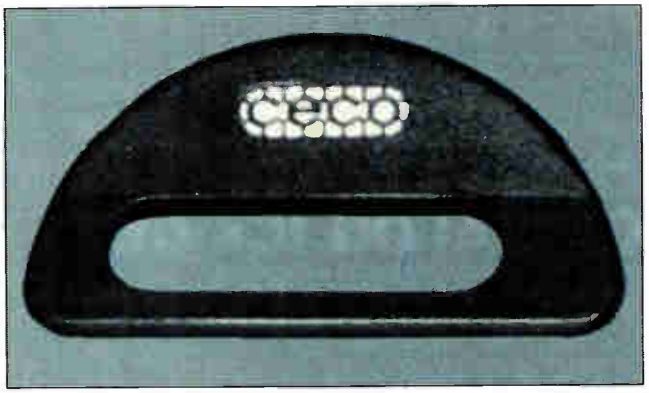
The encoder has been successfully connected to electric and gas meters through telephone, cable-television, radio, power-line-carrier, and portable battery-operated reading units. When a utility wants to read a meter, its computer signals the central-office control equipment to address the network interface at the meter site. The interface recognizes the call and applies a dc level to the encoder's interrogation lead.

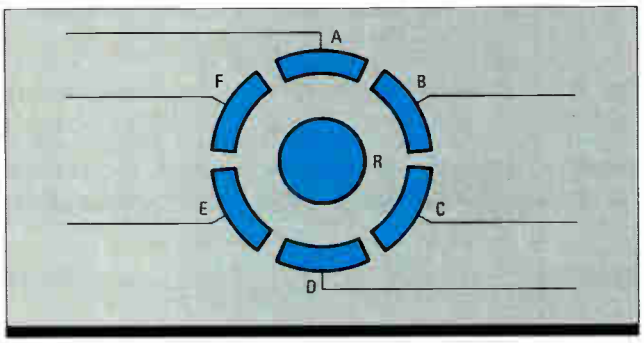
This activates the encoder's logic circuits, and the device reads the meter by taking a straightforward measurement of the electrical phase difference between two signals, yielding a resolution of 3.6°. The logic circuits then convert the data to a code that is transmitted back to the utility company's computer. On completion of the message, the encoder powers down.

The Greenville, N. C., company sees a range of uses for the device beyond meter reading. The unit now comes in small lots, but will be ready for mass distribution early next year, according to Cain.

In two years of actual service, Cain's unit has made over 14 million successive readings with no errors. Experience to date suggests the encoder will operate in commercial use with exceptional accuracy over a temperature range of –40°F to +190°F. It is virtually tamper-proof, immune to electrical noise, and unaffected by fluctuations in power. It has no moving parts and does not need batteries or standby power. Nor does it use light sources, photocells, or optics (see "So-so performance at high cost marks the meter field," opposite).

**1. METERED.** The Cain Encoder consists of a small glass sensor plus circuitry. It mounts over the hands of a utility meter.






**2. CIRCULAR SENSING.** Exciting the electrodes with 4-kHz polyphase signals produces a rotating field for sensing angular position.

The Cain encoder consists of a small rectangular glass sensor plate and its associated digital and analog circuitry, all on the same printed-circuit board. The plate fits between the dials and the meter's protective cover, and each dial is aligned with a circular array of transparent electrodes (Fig. 1). Nothing touches the hands of the dials, which remain visible so the customer can check the meter.

The electrodes consist of seven extremely thin layers of tin oxide, six of them arranged in a circle and one situated at the center (Fig. 2). When the low-level interrogation signal that initiates the reading is received, the encoder's logic circuits convert that impulse to a set of low-voltage, 4-kHz, polyphase signals. When these signals are applied to the encircling electrodes (labeled A through F in Fig. 2), they create an electric field that rotates at 4,000 revolutions per second.

If no meter hand or pointer were present, the electric field would have no net effect on the central electrode (labeled R) because it lies equidistant from the other electrodes. So the vector sum of the field components at this point is zero.

But because the inner tip of the indicator hand lies near the central electrode and the outer tip within the rotating field, the meter hand provides capacitive coupling between the two. So the voltage at R and the voltage at the pointer tip are identical.

The voltage shifts in phase with the dial's hand as its

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

position changes in relation to electrode A, the degree of phase shift corresponding to a degree of angular displacement. Each rotation of the field produces a separate reading, enabling the sensor to resolve the positions of up to five meter hands within 3.6°—a tenth of a digit on a standard utility meter. The hand positions are then digitally converted to dial readings.

The unit's internal sensitivity to phase rather than amplitude (Fig. 3) makes sensor-plate alignment noncritical and ensures that the measurement is unaffected by signal strength. It also accounts for the unit's immunity to tampering and to electrical noise. Because the encoder does not use pulse-counting techniques, it does not need constant monitoring. And because it doesn't need power except when a reading is desired, it can't lose data because of a temporary loss of communication or undetected or false pulses.

Three leads—interrogation, data output, and ground—connect the Cain Encoder to the signal carrier. Power is derived solely from the interrogation signal at +9 to +15 V dc (this will be reduced in later versions of the encoder). The signal must be applied for a minimum of 350 ms without interruption. When the unit receives this signal, it responds with its own 8-bit identification number, a digitized data readout presented in serial, asynchronous, even-parity ASCII code at 300 bits per second.

*The unit can resolve the positions of up to five meter hands within 3.6°*

If the device detects any signs of tampering, it automatically transmits a notification signal to the company. To guard against an incorrect reading, self-diagnostic procedures ensure that if the encoder's internal parameters are not within specifications, it will transmit ASCII-coded question marks.

The encoder is triggered only when the signal reaches or exceeds 9 V, so rise time of the interrogation signal is immaterial. (To accommodate battery-operated host systems, the encoder does not trigger and turn off at the same voltage.) Once triggered, the unit will operate normally and complete its message even if the interrogation signal drops to 8½ V. It draws less than 40 mA during its brief reading cycle, and the company plans to reduce power usage significantly in future models. In its off state, the unit powers down to less than 0.1 mA. If the interrogation signal is interrupted or falls below 8 V during a reading, the encoder disconnects immediately. It will restart if the input signal is brought below 0.5 V before being restored to the requisite 9 V.

Because the unit uses ASCII, the standard code of the American National Standards Institute, it can communicate directly with any terminal, printer, or computer. Its data stream consists of 9 bytes of even-parity ASCII code, each containing one start bit and one stop bit. The data stream is presented as the open-collector output of a 2N2222A transistor, which means that the signals are accepted easily by equipment with a standard RS-232-C interface. The interface converts the output to RS-232-C levels or to tones, depending on the type of phone equipment in use, and transmits them back automatically. As an additional benefit, readings can be obtained over voice-grade lines without special conditioning. The 300-baud output rate is compatible with low-cost modems and other standard equipment.

The company put "very heavy emphasis on accuracy and reliability" in developing the encoder, says president Charles J. Cain. One result is an extensive self-testing system to ensure accuracy. These tests fall into two categories—self-diagnostics and interdial compensation.

In a self-diagnostic check conducted automatically before reading each meter dial, the encoder subjects the corresponding phase-shifted signal to a series of tests to be sure that it meets a number of rigid specifications. If the signal fails any of these tests or if the encoder detects that its internal parameters are out of specification, its output will consist of ASCII-coded question marks rather than the usual numbers. This tells the user that the meter has been accessed but prevents the communication of incorrect data.

If the encoder is reading a utility meter equipped with multiple dials, it performs another test, called an interdial compensation. This procedure consists of determining that all signals are acceptable (meaning no errors have been detected and there are no signs of tampering) and converting them to

## SO-SO PERFORMANCE AT HIGH COST MARKS THE METER FIELD

**Two types of devices** have been used to read utility meters: pulse initiators and special-purpose meters or registers (optical encoders). Neither device gives satisfactory performance at a reasonable price. Both are available from meter manufacturers, although the special-purpose meters are available for experimental use only and are priced accordingly.

Pulse initiators for gas or water meters can be either a magnetically or a cam-actuated switch attached to the least-significant dial. Neither technique works for electric meters, which are easily affected by extraneous magnetic fields and which cannot tolerate even small mechanical loads. So for electric meters, the pulsers consist of a light source and a photocell arranged to produce an electrical pulse for each revolution of the meter's internal disk. Here lies the pulse initiator's sole advantage: watt-hour meters have a high gear ratio that enables the unit to give very high resolution. This makes it useful in the measurement of electrical demand.

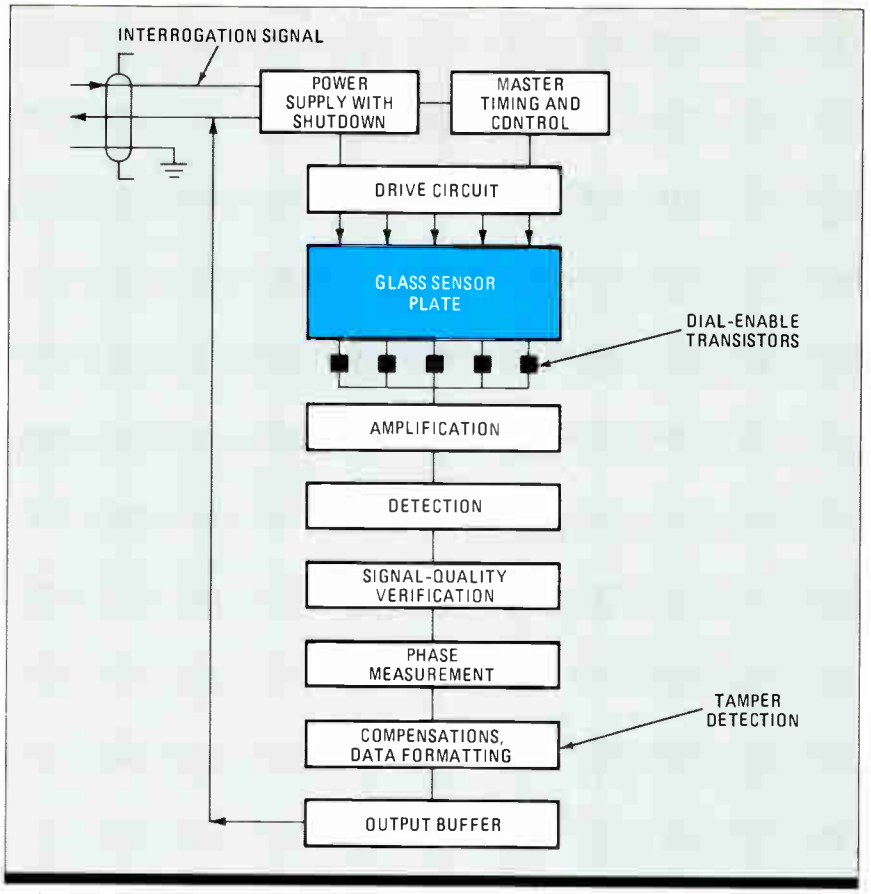
The technique's disadvantages are extensive, however. These problems are the need for uninterrupted power and monitoring, the frequent loss of valid pulses or introduction of spurious pulses, the cumulative nature of its errors, and the reader's high cost (typically $110 to $125).

On balance, then, it is not surprising that the prevailing industry attitude toward pulse initiators is one of reluctant acceptance, notes Charles J. Cain, president of Cain Encoder Co. Most system suppliers, utilities, and regulatory commissions would prefer direct-dial-reading equipment, and many electric utilities using pulse-fed demand recorders are seeking direct-dial-reading capability to allow automatic correction of the cumulative errors introduced by the pulser.

General Electric, NCR, and Westinghouse have developed special watt-hour meter registers that can be read automatically. These registers have two components: optical encoders consisting of slotted code wheels mounted on the shafts inside the meter and a system of light sources and photocells that read the meter by checking shaft position. No similar equipment has appeared for gas or water meters, although Neptune International Corp. and Rockwell International Corp. both offer encoding registers containing segmented switches with sliding contacts. Because the contacts generate friction, these registers will not work with electric meters, which do not have enough torque capability to overcome this frictional load.

This type of register yields direct dial readings and does not require continuous power or monitoring, but it does require replacing all or part of the existing meter. Other disadvantages of optical encoders are high cost, complexity, and reliance upon potential problem components such as light sources, sliding contacts, and other moving parts. In addition, unlike the Cain Encoder, the GE and Westinghouse devices use nonstandard input/output codes, making them essentially unusable with any communications equipment except the experimental power-line carrier systems that their manufacturers offer.

**3. PHASED IN.** The encoder's circuitry reads pointer position using a straightforward digital phase-measurement technique.




numerical values. Next the encoder examines the relationship between successive dials, resolving any ambiguities and removing potential errors that might result from excessive mechanical tolerances within the meter itself—such as from misaligned hands or abnormal gear backlash. Any necessary compensations are made and further checked before the individual dial reading is included in the output message.

Its tampering indication is based on a pin or jumper, which can be connected from the back of the encoder to ground though a breakwire, conductive paint stripe, magnetic field sensor, or other means. The encoder checks this pin before beginning its output message. If the pin is grounded, it transmits the usual identification code. If not, the encoder sets bit 7 in the two bytes containing its identification number; the result is a recognizably different identification code. The encoder's standard ASCII format, data rate, and message length are not affected.

In its present configuration, the encoder's electronic circuitry is based on discrete devices and small conventional pc boards. The sensor is mounted in and electrically connected to one such board, containing both digital and analog circuitry. For developmental convenience, the circuit is controlled by a microprocessor, but this device can be eliminated if economics dictate.

At $195, the current Cain unit is satisfactory for introductory quantities, and the company is working on manufacturing techniques to lower fabrication cost. For example, various functions representing about 35% of the encoder's circuitry, including those in which timing is important, have been embodied in one digital chip designed in-house and based on standard cells. This chip, about 135 mils square, is made with 5-μm silicon-gate CMOS technology. A high-volume version of the encoder should be ready in early 1987 for a cost of about $20.

The final, low-cost configuration will consist of one or two custom integrated circuits mounted directly on the glass sensor plate and then encapsulated. Cain notes that the straightforward assembly process will be readily amenable to high-speed automation. The ICs either will be packaged in small-outline surface-mount-ed packages or will be bare chips. If bare chips are used, either flip-chip or tape-automated-bonding assembly will be employed.

Cain notes that apart from its use in a new family of absolute-angle encoders, he sees uses in such areas as proximity sensing and on-line product inspection in factories. Limited tests suggest that the technique is sensitive over distances approaching 1 meter. This opens the possibilities for a rugged, inexpensive sensor to guide industrial robot arms and a low-cost pattern-recognition system in lieu of expensive artificial-vision systems for machinery. The basic encoder/sensor is capable of much higher resolution than necessary for the meter-reading application, possibly allowing it to compete with present low-end optical encoders. □

## INTEREST IN SENSORS LED TO THE CAIN ENCODER

**"To be at its** best, technology should be invisible to the user," states Charles J. Cain. That credo guides his work as president of Cain Encoder Co. An interest in sensor technology led to the formation in 1977 of his small research and development company in Greenville, S. C., which now holds a broad portfolio of issued and pending patents in 15 countries.

Cain and the company's principal consultant, Thomas D. Watson, who holds a BSME from the Massachusetts Institute of Technology, have broad experience in industrial and manufacturing processes. Cain is a former senior physicist with Du Pont Co., where he spent 12 years developing new products and processes. He has a BA from Vanderbilt University and an MS in physics from Auburn University.

The company's original studies of utility metering practices turned up a need for a reliable, low-cost sensor that could be installed easily in existing meters. "Now it is clear that our new sensing technology is capable of much higher resolution and sensitivity than we first thought," notes Cain. "Next I'd like to see us explore new applications in other industries."

**CHARLES J. CAIN:** Creating technology that's invisible to the user.

In 1983, Cain was appointed by the governor of North Carolina to serve as first chairman of the North Carolina Technological Development authority. His charge is to stimulate the development of new technological entrepreneurships in the state.

# A NEW WAY TO BOOST A PHONE LINE'S THROUGHPUT

## MODEM SPLITS LINK INTO 2 ASYMMETRICAL CHANNELS TO SEND 14 KB/S

A new modem's novel communications architecture promises to pave a fast lane for traffic between host computers and asynchronous terminals. Aptly dubbed RACE (for remote asynchronous computer extension), the modem splits the telephone link into two channels with different bandwidths and compresses data to hike throughput to as high as 14 kb/s.

Developer Data Race Inc. says dividing the telephone link into two asymmetrical channels (Fig. 1) can better mesh the slow input speeds of a human operator and the quick response of a computer. The San Antonio, Texas, company points out that modems currently used with asynchronous data terminals often are limited to around 10 kb/s. That's because the modems, typically half-duplex devices that use identical signaling schemes in both directions across the link, must allow for delay in line turnaround—the time it takes for the echo of a modem's transmitter to die out before its receiver can successfully train upon the distant signal. Not the full-duplex RACE modem.

The RACE modem divides the telephone line's bandwidth by assigning a low-speed frequency-shift-keying channel for passing data from the terminal to the central processing unit and reserving a higher-speed phase-shift-keying channel from the CPU port to the terminal. Depending on the data type, the RACE modem transmits an impressive 6 to 14 kb/s by using compression techniques, including bit stripping and the elimination of redundant characters.

*The modem handles both in-band and EIA flow-control signals*

Data transmitted on the high-speed communications channel conforms to the International Telegraph and Telephone Consultative Committee's V.27 specifications for 4,800-b/s leased-line modems, including signaling rate, encoding, and bandwidth. The low-speed channel uses FSK coding with error-detection bits added to the data stream to ensure integrity.

Data Race has two versions of RACE. The RACE-I is a single-channel modem. The RACE-II adds an independent printer channel that is statistically multiplexed with the main display channel. The company believes both will find a ready market because the lion's share of the installed terminal base remains asynchronous, despite the explosive growth of personal computers. And personal computers frequently are used in asynchronous-emulation mode to query remote data bases.

"We are giving the market a single modem that does double duty," says marketing communications director Evan D. Yoes Jr. "It is an exceptional high-speed full-duplex device for asynchronous communications, and it performs well as a personal computer modem during file-transfer operations."

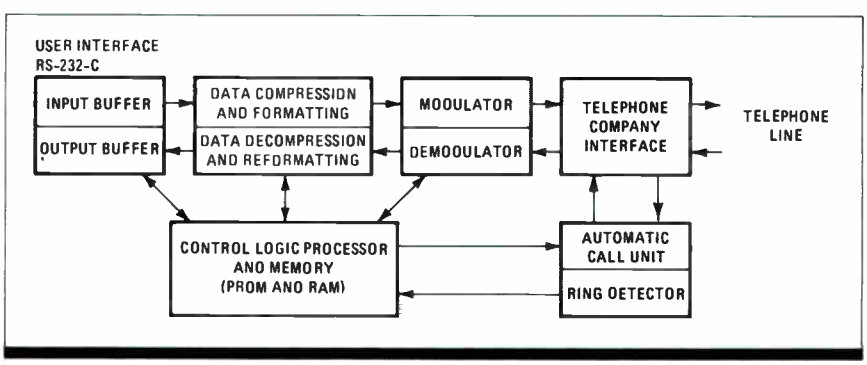
To achieve the modem's high transmission speeds, Leven E. Staples, vice president of development, came up with an adaptive-compression algorithm that triples the throughput of redundant characters and achieves even higher compression ratios under favorable conditions. "We are doing everything we can to decrease the number of bits in a typical frame," explains Staples. "Where we can, we use less than seven bits for an ASCII character. If a character is repeated, we can achieve a 3 : 1 compression ratio. But if we are dealing with the blank spaces or underlines in a formatted document, we can achieve as high as a 20 : 1 compression ratio. This means that while our modem obeys all the V.27 performance standards, the data formats we constructed are proprietary and unique."

Using modified High Level Data Link Control code for ASCII characters, the modem automatically strips out start, stop, and parity bits at the transmitting end and reconstructs them at the receiving end. The modem's intelligence does this regardless of whether the remote device and the CPU port share the same sequence of parity and start/stop bits. Also, recurring sequences of three or more identical characters are compressed by issuing a repeat flag and a count bit. The modem retains the frame-check sequence appended to all blocks and retransmits any blocks received in error.

To prevent loss of data, the RACE has a 2-K-byte buffer on the high-speed channel and a 256-byte buffer on the low-speed channel that respond to buffer-overflow conditions at the transmitting or receiving end. A receiving RACE obeys all flow-control commands coming from its receiving terminal. This includes a manual instruction, as for example, when an operator wishes to introduce a pause in data flow and executes a Ctrl-S, or any sequence that transmits an X-off.

If the sending RACE at the CPU end finds its buffer filling up, it signals its computer port using a method recognized by the operating system. If the CPU port recognizes signals standardized by the Electronic Industries Association, for example, a clear-to-send signal will be driven False. If the CPU port only responds to in-band flow-control signals, the host-end RACE will transmit an X-off until the buffer level is reduced.

The modems handle both kinds of signals, so they effectively translate the critical flow-control information across the link. A terminal capable of only X-on/X-off can control a CPU port that recognizes clear-to-send, and vice versa. If the terminal RACE is connected to a device that displays at a rate of 9.6 kb/s while the CPU port is set to pump out data at 19.2 kb/s, the RACE units translate the data rate across the link by combining their buffering and flow control.




**1. MESHING SPEEDS.** RACE's asymmetrical channel assignments provide a match between user and machine speeds in asynchronous communications environment.

Because of the asymmetrical nature of the signaling paths, the terminal-end RACE frequently detects that the receive buffer servicing the high-speed channel is filling up. When this occurs, the receive modem issues a Pause to the transmit modem and it, in turn, feeds its CPU port an EIA or an in-band signal to pause.

The keyboard buffer on the low-speed modem channel never goes into an overflow condition when the modem operates asynchronously, the company says, because no human operators can outpace the speed of transmitted data. If the buffer content reaches a preset level, however, the two modems assume that the receive modem is no longer in terminal-emulation mode and it is operating as a personal computer executing a file transfer. To accommodate the higher data rate, the two RACE modems begin a flow control of their respective devices by first emptying their output buffers, then assuming control of each other's channels. The terminal-end RACE takes over the transmitter on the high-speed channel while the host end takes over the low-speed FSK channel.

"During the channel swap, the two modems signal a Pause to their respective devices," says Staples. "The modem on the CPU side begins communicating on the low-speed channel and listens on the high-speed channel while the modem on the terminal side is doing the converse. The turnaround time takes less than 2 seconds, and since the operator is not involved, it is not annoying. The modems remain in this mode until a high-speed data transfer from the opposite direction reverses the channels."

To succeed over the limited bandwidth of the telephone line, the FSK channel occupies the low end of the frequency spectrum and is separated from the V.27 signal by a sharp-edged, steep-sided filter (Fig. 2). "Only switched-capacitor filters with rejection slopes as steep as that permit the RACE to give that kind of performance," says Staples.

"These filters enable a host-end modem to pick up the faint murmur of a distant FSK transmitter coming through a hybrid that is also juggling V.27 modem signals coming at its lower edge. The digital signal-processing techniques and the switched-capacitor filters that have only recently become available have made the RACE possible. Building a modem like this even a few years ago was impossible," he says.

Staples chafes at describing the RACE as simply a 4,800-b/s modem. "In a worst-case scenario, let's assume all the data being transmitted from the CPU to the terminal is considered executable ASCII code. All 8 bits are significant, so none may be discarded. Moreover, let's say there is little or no character redundancy in the data stream. Even though none of the parity bits may be discarded to be reconstructed later, compression can still be achieved by stripping start/stop bits. Even under worst-case conditions, the RACE modem can still achieve an effective throughput of 6,000 b/s."

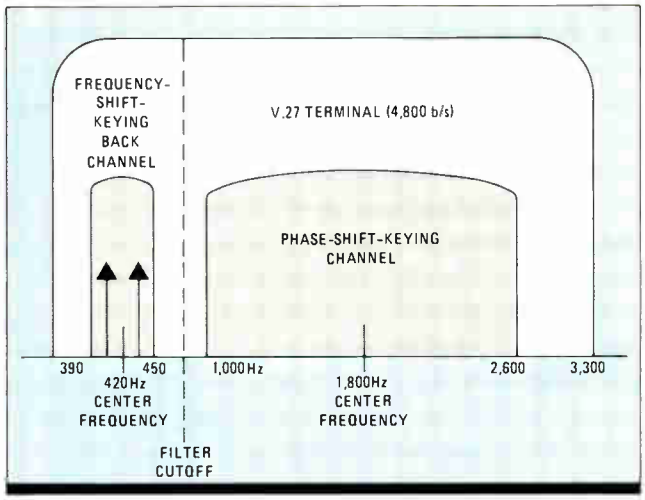
In a more typical situation, if all the data being carried on the high-speed channel is 7-bit ASCII-coded text, it is possible to pump up the actual throughput rate from 680 to 1,000 c/s and beyond by compressing repeated characters. In a best-case transmission scenario, such as a formatted spreadsheet or text, the compression of intercolumnar spaces could raise throughput to as high as 1,400 c/s, or 14 kb/s.

According to Yoes, most of the modems competing in the field are half-duplex, automatic-turnaround units that perform well during file transfer but fail in interactive operation. When trying to match full-duplex performance in an interactive operation, the performance of the half-duplex modems degrades because of the delay involved in line turnaround, which typically takes up to 240 ms. Though such response is fast, it can still create an annoying delay for an operator using an asynchronous terminal in echoplex mode.

Many computer operating systems with attached asynchronous terminals still use echoplex, though it has evolved well beyond its error-checking function. In modern word-processing software, the CPU examines each keystroke to determine whether the character is treated simply or whether it requires a more complex response such as a screen scroll, line-end wrap, or an increment to a counter display. Almost every single keystroke commonly invokes a string of 12 to 15 ASCII characters in reply over the data link.

With such added burdens, many of the high-speed half-duplex dial-up modems cannot keep pace. A way around this is for the half-duplex dial-up modems to operate as a faster V.29 modem, but this sacrifices the better signal-to-noise ratio achieved by V.27 modems like the RACE.

Squeezed between quickening processor speeds and users who demand increasing sophistication from asynchronous terminals, the communications architecture of the RACE modem is putting it well ahead of the pack. □




**2. STEEP SLOPE.** A steep-sided switched-capacitor filter separates low-end from high-end communications channels.

## FRESH IDEA COMES FROM OLD PRO

**"It was so** obvious once you thought of it," recollects Leven E. (Les) Staples, the 43-year-old vice president of Data Race Inc. and inventor of the asymmetrical-channel scheme that gives the RACE modem its speed. Staples—who rightly calls himself an old hand after 20 years of designing communications devices for such outfits as Mohawk Data Sciences, Harris, and Datapoint—says the traditional symmetrical channel designs employed in modems never really meshed well with the asymmetrical relationship between man and machine.

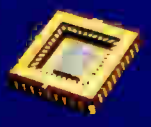
**LES STAPLES:** His asymmetrical-channel idea mimics nature.

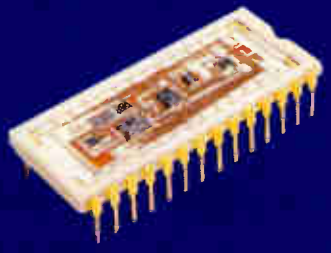
"Machine will always be able to outpace man. The trouble with modem designers like myself was that we were always kept so busy killing alligators that we never really had a chance to drain the swamp" and take a fresh look at modem designs.

Even if he dreamed up the asymmetrical-channel concept earlier in his career, building a RACE would have had to await better hardware, Staples says. "The RACE couldn't work without microprocessors and static random-access memories, and they had to be inexpensive. No one in this business can really say they did it all themselves. We learn from each other and only when we put it all together do we come up with something that is unique."

# 11-Bit Flash Converter

## MPS Single Chip . . . vs. . . . Other's Hybrids





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# HALLEY'S COMET SPACE ENCOUNTER SET FOR MARCH.

The ultimate space encounter is about to begin. Halley's comet, making a brilliant comeback after 76 years, will soon provide scientists with a once-in-a-lifetime opportunity to shed new light on the origins of the solar system.

As part of a global research effort, Japan's Institute of Space and Astronautical Science, the Ministry of Education, has sent out a welcoming mission of twin interplanetary probes—SAKIGAKE (Pioneer) and SUISEI (Comet)—which are due to intercept Halley's comet in March '86 soon after its closest approach to the sun.

The two deep space explorers will obtain invaluable new data on solar wind—waves of plasma emitted by the sun—and its effect on the comet. Simultaneously, SUISEI will reveal the 3-dimensional structure of the hydrogen cloud surrounding the coma with an ultraviolet TV camera and beam the image data to the earth up to 170 million km away.

For its part, NEC's involvement in these space probes included system design, system integration and the manufacture of major subsystems for telemetry and command, the antenna, power, data processing, attitude and orbit control.

With 20 years of experience in space development NEC has contributed, as a prime contractor or system integrator, to 20 of the 32 satellites placed in space by Japan since 1970.

*Photos courtesy of the Institute of Space and Astronautical Science, the Ministry of Education, Japan.*

# NUMBER 134

## KUWAIT CHOOSES NEC CELLULAR MOBILE TELEPHONE.

NEC will install an integrated cellular mobile telephone system in Kuwait by the 3rd quarter of 1986, paving the way for truly high-grade services nationwide.

NEC's total access communications system featuring 25kHz frequency spacing in the 900MHz band will initially serve up to 25,000 subscribers, and can be expanded to accommodate up to 100,000 subscribers.

Awarded by the Mobile Telephone Systems Company (MTSC) of Kuwait, the full turn-key contract calls for NEC to manufacture and install all key equipment, including an advanced digital switching system plus radio equipment for 21 base stations and 15,000 mobile telephones. MTSC is a shareholding company, 49% Government and 51% public, established to run all mobile communications in the State of Kuwait.

Moreover, NEC will also provide the latest microwave radio and fiber optic links to interconnect the central switching system and base radio equipment, and a medium-scale computer for message accounting and communications traffic control.

This massive project is well under way, drawing upon the integrated computer and communications technology of NEC and expertise of all concerned companies.

Upon completion, the new system will provide sophisticated services such as "Call Transfer", "Call in Absence" and "Privacy".

## NEW TTC & M EARTH STATIONS FOR ARABSAT.

An advanced NEC satellite control network is now providing complete tracking, telemetry, control and monitoring (TTC & M) services for the Arab Satellite Communications Organization (ARABSAT) which is comprised of 22 Arab League countries.

The ARABSAT Satellite Control Network analyzes and processes satellite telemetry and tracking data, and commands and monitors operating conditions of the Arab world's first series of communications satellites—the ARABSAT-1A and ARABSAT-1B.

This integrated control system consists of a primary earth station at Riyadh, Saudi Arabia, and a secondary station at Tunis, Tunisia. All necessary equipment including computer hardware and software systems, were developed and installed by NEC on a turn-key basis to assure optimum system performance and long-term reliability.

NEC's contribution to the growing ARABSAT network also includes the completion of three earth stations—one each in Jordan, Bahrain and Tunisia—and it is now manufacturing 7 more for use in other Arab countries.

The ARABSAT system can accommodate 8,000 simultaneous telephone circuits, seven television channels and a community television channel for isolated rural areas. It can also provide telex and data transmission services, and other specialized services.

## 4-BIT MICROS RIVAL 8-BIT POWER.

The new NEC 75000 Series of 4-bit CMOS single-chip microcomputers is the first to bring VLSI expertise and advanced architecture to the 4-bit realm for results that rival 8-bit performance.

The 75000 Series combines added on-chip memory up to 16k-byte ROM/4k-nibble RAM and higher speed—less than 1$\mu$s cycle time at 4MHz. Other high-end features include powerful on-chip hardware, outstanding expandability and an enhanced instruction set.

The 75000 Series comes with a full kit of hardware/software development tools and it also inherits the software of our industry standard 7500 Series through easy conversion.

The first four members of the 75000 family are currently available —the $\mu$PD75104 and $\mu$PD75106 high-performance general purpose micros, the $\mu$PD75P108, an EPROM version, and the $\mu$PD75206, which incorporates a VF controller/driver.

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|---|---|---|---|---|
| Prop. Delay Time (typ) GATE ($C_L$ = 15pF) | 8ns | 9ns | 15ns | 125ns |
| Max. Clock Freq. (typ) J/K F•F ($C_L$ = 15pF) | 60MHz | 45MHz | 20MHz | 2MHz |
| Quiescent Power Diss. (typ) (GATE) | 0.01 μW | 8mW | 0.01 μW | 0.01 μW |
| Noise Margin $V_{IH(min)}/V_{IL(max)}$ | 3.5V/1.5V | 2.0V/0.8V | 4.0V/1.0V | 3.5V/1.5V |
| Output Current $I_{IOH}I(min)/I_{OL}$ (min) | 4mA/4mA | 0.4mA/4mA | 0.36mA/ 0.8mA | 0.12mA/ 0.36mA |
| Op. Volt. Range | 2-6V | 4.75-5.25V | 2-8V | 3-18V |
| Op. Temp. Range | −40-85°C | 0-70°C | −40-85°C | −40-85°C |

*Data believed to be accurate and representative of each logic family.

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## Feature Size: 2μ CMOS

| | N-Channel | P-Channel |
|---|---|---|
| VTEO | 0.5–1.0$_V$ | 0.5–1.0$_V$ |
| BVDSS | >10$_V$ | >10$_V$ |
| $K^1 = \frac{\mu c}{2}$ 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 | 0.4μ–0.6μ | 0.2μ–0.4μ |
| P-Well Junction | 2.5μ–3.5μ | |
| Poly $P_S$ | 15–30Ω/□ | 15–30Ω/□ |
| Diffusion $P_S$ | 20–40Ω/□ | 60–100Ω/□ |
| VTF Poly | >10$_V$ | >10$_V$ |
| ΔW | —1.0μ | —1.2μ |
| LEFF | 1.0μ–1.4μ | 1.3μ–1.7μ |
| Substrate Resistivity | 2.5KΩ/□ | 1.2Ω/cm |

## Feature Size: 3μ CMOS

| | N-Channel | P-Channel |
|---|---|---|
| VTEO | 0.5-1.0$_V$ | 0.5–1.0$_V$ |
| BVDSS | >10$_V$ | >10$_V$ |
| $K^1 = \frac{\mu c}{2}$ 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 | 0.6μ–1.0μ | 0.4μ–0.8μ |
| P-Well Junction | 3.5μ–4.5μ | |
| Poly $P_S$ | 15–30Ω/□ | 15–30Ω/□ |
| Diffusion $P_S$ | 10–30Ω/□ | 30–70Ω/□ |
| VTF Poly | >10$_V$ | >10$_V$ |
| ΔW | —1.0μ | —1.0μ |
| LEFF | 1.4μ–2.0μ | 1.8μ–2.4μ |
| Substrate Resistivity | 2.5KΩ/□ | 1.0–1.5Ω/cm |

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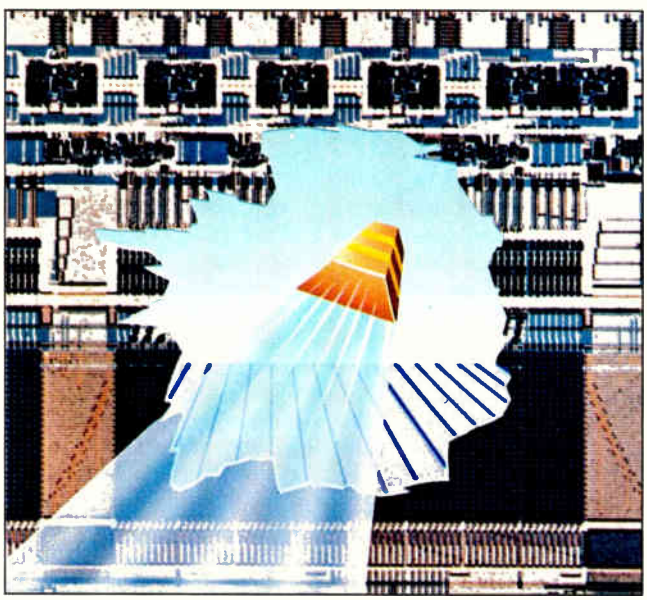
# ULTRADENSE CHIPS: THE DRIVE QUICKENS

## 3-D STRUCTURES AND SUPERLATTICES WILL HELP BREACH VLSI BARRIER

*by Bernard Conrad Cole*

It's bound to happen sooner or later. At least that's what many people in the industry have long predicted. The pell mell push by semiconductor makers to keep raising chip density—which has resulted in a quadrupling of memory density and a doubling of logic integration for every product generation to come along since the early 1970s—was going to run up against a stone wall.

Chip designers would hit that wall once they exhausted the bag of technology tricks needed to keep the density drive going. But they now seem destined to break through with a host of new technologies. To the surprise of not a few observers, developers are perfecting an arsenal of new design techniques at an ever quickening pace. U. S. and Japanese researchers are moving into the realm of three-dimensional structures and exploring such exotic approaches as atom-thick superlattices, which promise unprecedented densities and device geometries. And they are doing it at a clip that should see these devices appearing within the next decade. Technologies such as silicon on insulator and silicon-based molecular-beam epitaxy are near enough to make this progression possible. Prototype chips have already been developed, and improved processing equipment is beginning to emerge that will make such super-dense chips commercially feasible.



With today's designs, chip designers wouldn't be able to move to the world of ultra large-scale integrated circuits, or even to the second generation of very large-scale ICs, for that matter. To keep the ball rolling, designers would have to keep reducing transistor size or go to much larger chips. Yet conventional transistors are beginning to reach their physical limits in size reduction.

Going to larger die sizes would end up being self-defeating, however, since the major reason for the exploding proliferation of electronics during the past two decades was the dramatic reduction in the cost of circuit logic and memory. Making low prices possible was the industry's continuing ability to increase chip density. And prices undoubtedly would rise if the new chips were larger. "The larger the die, the fewer dice per wafer, the increased cost per bit, and the smaller the profit margin; it's that simple," points out George Heilmeier, senior vice president and chief technical officer at Texas Instruments Inc., Dallas. "So really, the only solution here is smaller device sizes."

Recent improvements in optical lithography will allow reductions in device geometries down to 0.3 to 0.5 μm in the early 1990s, agree most industry experts, and electron-beam, ion-beam, and X-ray techniques are expected to follow with even smaller geometries. But well before this point is reached, a host of other factors would limit the scaling of ICs to a minimum feature size of 0.5 μm to 0.8 μm. These limitations include parasitic capacitances, hot-carrier injection, and a host of similar problems.

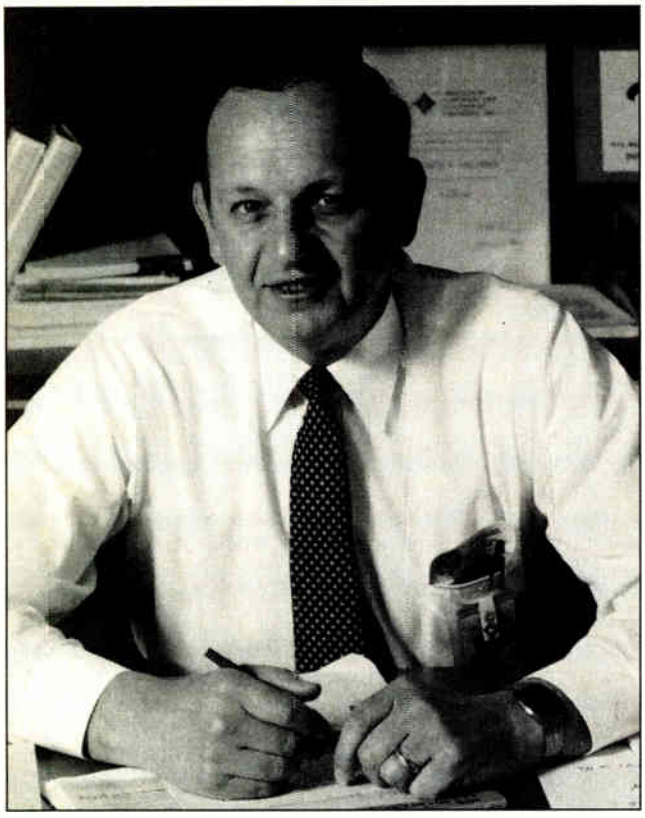
Sticking with traditional transistor structures and present bulk-silicon fabrication techniques would imply a density of less than 20 million devices per chip, Heilmeier estimates. That in turn implies a maximum of 16 Mb for dynamic random-access memories and 4 Mb for static RAMs—and then only if die size is allowed to expand beyond its present limits.

To break through this barrier, semiconductor manufacturers are moving to vertical structures to squeeze the most in the least amount of space. A variety of DRAM cell structures have been proposed to move densities beyond 1-Mb VLSI designs and toward 4- and 16-Mb ultralarge-scale-integration levels. This year's International Solid State Circuits Conference [*Electronics*, Feb. 17, 1986, p. 23], for example, saw TI's cross-coupled trenched-transistor cell design, NEC Corp.'s buried-storage-electrode cell, and Toshiba Corp.'s deeply trenched capacitor design. Other proposed cell designs include NEC's buried-isolation-capacitor cell, Nippon Telegraph & Telephone Corp.'s isolation-merged vertical capacitor cell, Toshiba's folded-capacitor cell, and Hitachi Ltd.'s corrugated-capacitor cell [*ElectronicsWeek*, Feb. 11, 1985, p. 51].

Such designs have two fundamental problems, according to Hui Wai Lam, former manager of TI's Advanced Device Technology Branch in Dallas and now president of Lam Associates, a Dallas company involved in silicon-on-insulator development. "First, most of the solutions only address the problem of DRAM-density improvement. Few if any are adaptable to improvement of digital-logic densities," says Lam. "Second, most of the solutions are bulk-silicon-based and still subject to the same laws of physics. In order to move much beyond 4 Mb, device geometries must also be scaled to submicron densities." The crossover point, he says, is at about 0.8 μm. Below that, some alternative to bulk silicon must be considered.

A solution, silicon-on-insulator (SOI) technology, has been waiting in the wings for almost a decade and is now emerging from the laboratory. SOI refers to a generic class of materials in which a crystalline silicon film is grown epitaxially on an insulating substrate. Several characteristics make SOI an attractive technology to pursue for scaling devices, says Lam.

First, the electrical isolation that is possible with an insulat-



**GEORGE HEILMEIER:** "The only solution is smaller device sizes," says TI's senior vice president and chief technical officer.

**ROBERT BATE:** Quantum-coupled structures could yield extremely dense superlattice arrays, says TI's manager of advanced concepts.

ing substrate gives engineers additional flexibility in the design and fabrication of passive components such as resistors and capacitors. Also, the technology offers the potential of significantly reducing the parasitic capacitances that plague present submicron bulk-silicon MOS designs. This would cut power dissipation further and increase speed to levels near those of bipolar emitter-coupled logic.

"SOI structures are also inherently radiation-hardened, a critical characteristic for military applications," says Lam. And because the silicon portion of the IC is limited to the thin film on the insulating substrate, the silicon volume available for generation of minority carriers is smaller, significantly reducing the soft-error rate, he adds.

SOI also does away with the channel-stop isolations, deep n- or p-type wells, and trench isolations necessary to prevent latchup in the bulk-silicon substrate. And if the substrate insulation is exploited properly, SOI offers the potential of high-density circuits that can handle high voltages.

Finally, says TI's Heilmeier, SOI offers the potential of further vertical integration, with two-, three-, and four-level stacked-transistor designs. By going to such SOI-based 3-d structures, density limits could double—to 32/64 and 8/16 Mb, respectively—while device structures could shrink to 0.5 μm.

## REVOLUTIONARY SOLUTION

But to achieve structures below a half micron requires "a revolutionary digital IC solution that solves the interconnection problem, can be scaled to limits dictated by fundamental physical laws, and continues the downward trend in cost per device," says Heilmeier. Scaling limits aside, continuing the hundredfold increase in density per decade would require minimum geometries near 0.1 μm in the mid-1990s, reaching 300 to 500 Å by the end of the century. At these dimensions, the wave nature of the electron takes over and quantum-level effects occur. "Indeed, they are already occurring in the vertical dimension, being responsible for two-dimensional electron gas effects in MOS FET inversion layers," he says.

Until recently, no technology seemed able to take device physicists and circuit designers down below a half micron, says Kan L. Wang, professor of electrical engineering at the University of California at Los Angeles. "The one potential category of structures that offered a way out was superlattices—vertical switching elements consisting of multiple layers, each perhaps only a few atoms thick." But such structures can be fabricated only using molecular-beam epitaxy, a process technology developed originally for the fabrication of gallium arsenide heterojunctions and aluminum GaAs integrated optical superlattices [*Electronics*, Nov. 18, 1985, p. 39]. MBE has found only limited use in silicon-based circuits because of problems relating to wafer processing.

Most silicon-based MBE processing systems up to now have been "jury-rigged affairs built by researchers and they are adequate enough to prove the potential and to produce a number of silicon-based heterojunction structures and superlattices," says Wang. But a number of breakthroughs in wafer preparation and processing have brought equipment closer to commercial and production-line reality. Now that the concepts have been proven in the laboratory, a number of equipment manufacturers are building MBE systems suitable for use in a laboratory or on a prototype research and development line. With their introduction perhaps no more than a year away, Wang expects to see interest and activity in silicon-based superlattices to increase significantly.

But SOI will get things moving first. The classic example of SOI technology is silicon on sapphire (SOS), pioneered by RCA Corp. for use in LSI digital and analog circuits. But SOS has not made it to the mainstream of VLSI and ultralarge-scale fabrication because of its cost. Currently, a processed sapphire wafer costs about $450, compared with less than $100 for a bulk-silicon wafer. SOS is used primarily in military and aerospace applications, where the cost per component is less critical than the ability to perform at very high speeds.

Three main SOI techniques are being considered as alternatives to bulk silicon for use in advanced VLSI and ultralarge-scale circuits: beam-recrystallized SOI, implanted buried oxide, and full isolation with porous oxidized silicon.

Beam recrystallization starts with the deposition of a polysilicon film on top of a dielectric layer, usually an oxide layer thermally grown on top of a single-crystal silicon wafer. Part of the underlying silicon wafer is exposed so it makes contact with the deposited polysilicon. A heat source is then scanned across the surface, melting the polysilicon. When the beam moves away, the molten polysilicon freezes and crystallizes, forming large single-crystal grains.

Various types of heat sources are used in the recrystallization process, including a scanning continuous-wave argon ion laser, graphite heaters, scanned tungsten lamps, and scanned mercury arc-lamps. The various heat sources differ only in the degree of controllability and how much this must be traded off for the area coverage.

Though significant progress has been made, some problems remain to be solved before this technique is useful on the production line. The most critical is stress to the wafer during recrystallization. Stress forms slips beneath the wafer's surface, which cause the wafers to deform slightly and result in pattern-alignment problems during photolithography.

In the implanted-buried-oxide SOI approach (also called silicon implantation by oxide, or Simox), oxygen ions are planted beneath the surface of the silicon wafer, forming a continuous oxide layer that separates the bulk from the surface. The surface's crystalline structure is maintained during the implantation process through a thermal self-annealing process.

One of the effects of this step is to enhance solid-phase epitaxial regrowth from the crystalline-surface region down to the damaged region near the buried-oxide layer. The thermal anneal also completes both the out-diffusion of implanted oxygen toward the interface between the silicon and silicon dioxide as well as the chemical reaction necessary to form the $SiO_2$.

One problem with this approach, however, is that between the $SiO_2$ and the regrown top silicon layer, where the oxygen concentration is very high, there is always a defective layer of silicon. This is created by the formation of oxygen precipitates that inhibit the solid-phase epitaxial process, causing the random nucleation of the silicon into a polycrystalline, or defective, state. For this technique to be successful, says Lam, it is necessary to find some way to limit the oxygen-formation phenomenon.

There are also limits on the beam current and density of present ion-implantation systems. Current equipment can deliver a beam current of 5 to 20 mA of ionized oxygen at 160 keV. For the oxygen-ion-implanted process to be successful, an implantation machine must be able to deliver at least 100 mA at 150 keV.

The third SOI process—full isolation with porous oxidized silicon, or Fipos—involves converting selected surface areas of a p-type wafer to n-type and covering them with silicon nitride. The wafer is then immersed in a hydrogen fluoride solution, where the wafer serves as the anode and a platinum electrode serves as the cathode. The exposed p-type surface regions are converted into porous silicon, leaving the covered n-type regions intact. When done properly, the anodization process etches out the uncovered areas and undercuts the n-type regions.

Following the anodization process is a high-temperature oxidation step in which the porous silicon layer is oxidized rapidly. This results in complete dielectric isolation of the n-type islands, which form the body regions for subsequent device fabrication.

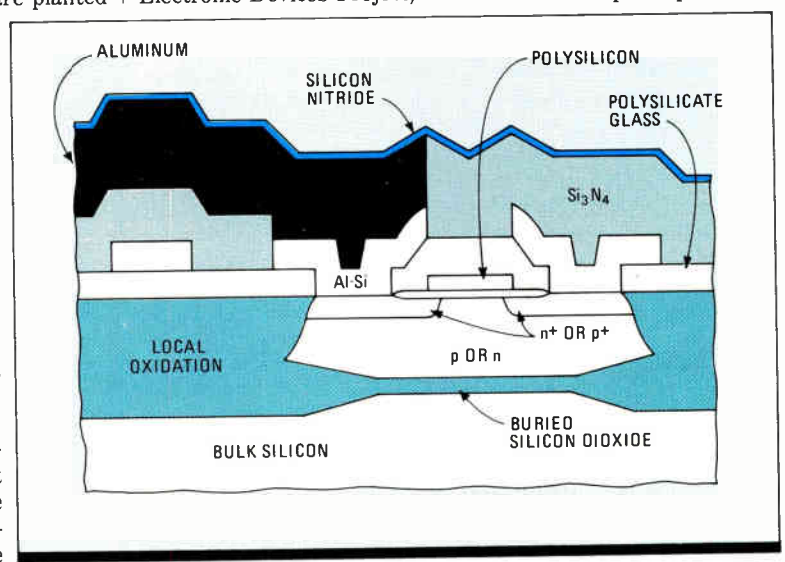
A problem encountered with Fipos, says Lam, is that the isolated islands of porous material are undercut in the fabrication process to a degree that is directly proportional to the thickness of the layer. The result is that the larger the island, the thicker the porous layer, which causes the wafer to warp after oxidation becomes excessive.

The solution to this problem is to grow an epitaxial layer on the porous layer. The epi layer is then patterned and etched. But because such conventional epitaxial-growth techniques as chemical-vapor deposition are high-temperature processes, the unoxidized porous layers collapse, restricting the oxidation through the porous layer. Now, however, low-temperature MBE techniques for fabricating silicon ICs are becoming available, eliminating the need for such high temperatures.

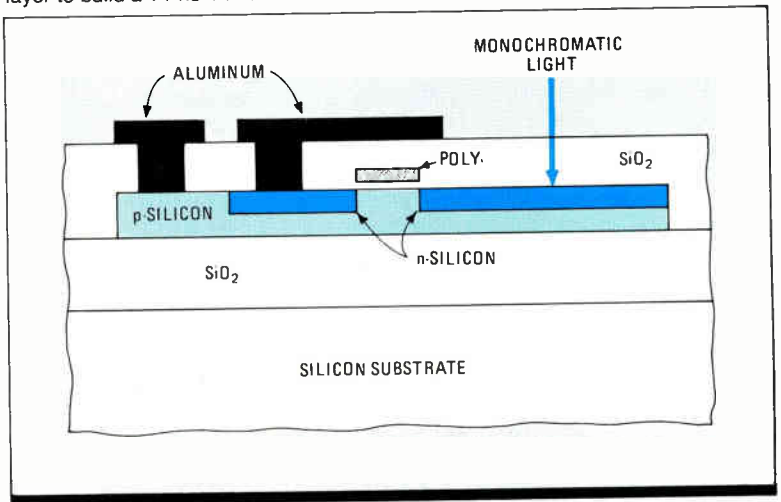
## JAPANESE EFFORT

Over the past year or so, prototype ICs that take advantage of the benefits of SOI technology have begun to emerge from the laboratory. And it should be no surprise that many of these devices are from Japanese companies—they have put the most effort into it so far.

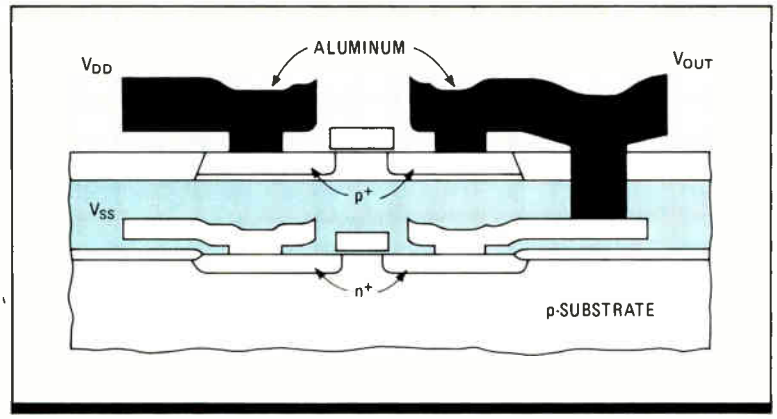
Much of the Japanese effort is part of the National Future Electronic Devices Project, which includes 24 participants and




**1. OXIDE IMPLANT.** NTT uses a silicon implantation by oxide, or Simox, insulating layer to build a 14-ns 4-K CMOS static random-access memory cell.




**2. LASER BEAMED.** Using laser recrystallization, Mitsubishi researchers built an image sensor that has two active layers, rather than one.




**3. E-BEAM SOI.** At Toshiba, electron-beam recrystallization has been used to build a two-layered image processor using silicon-on-insulator technology.

has been funded to date to the tune of 6.3 billion yen, or roughly $35 million. Focusing on the development of superlattice devices, 3-d circuits, and hardened ICs for extreme conditions, its goal is to produce working devices ready for transfer to production by the early 1990s. Among the most active participants in the project are the country's major semiconductor manufacturers: Canon, Fujitsu, Hitachi, Matsushita, NEC, NTT, Oki Electric Industry, Ricoh, Seiko, Sharp, and Toshiba. From 1981 to 1985, some 250 patents were applied for in Japan relating to 3-d circuit fabrication using SOI techniques.

Using a Simox-type process, researchers at NTT's Atsugi Electrical Communication Laboratory, Kanagawa, Japan, have fabricated a 4-K-by-1-bit CMOS SRAM (Fig. 1) that uses a six-transistor 43-by-37.5-$\mu m^2$ cell and contains 26,000 transistors on a 3.47-by-3.59-$mm^2$ die. Access time is 14 ns with a 45-mW active power dissipation and a 200-ns cycle time.

Going their colleagues at Atsugi one better, researchers at NTT's Musashino Electrical Communication Laboratory, Tokyo, have used the Fipos approach to fabricate a 16-K-by-1-bit CMOS SRAM that has an access time of 16 ns. With 2-$\mu m$ design rules, the device also employs a six-transistor memory cell that occupies only 25.6 by 37.8 $\mu m^2$. Signal-propagation delay along the word line is 7 ns, access time is 35 ns at a power dissipation of 250 mW, and cycle time is 300 ns.

*The Japanese have made the most effort in SOI technology*

A beam recrystallization technique, selective laser-beam recrystallization, has been used by researchers at Mitsubishi Electric Corp.'s LSI Research and Development Laboratory, Itami, Japan, to fabricate a 1.1-K gate (3,432 transistor pairs) CMOS array with 3-$\mu m$ design rules. Gate delays for the SOI device measure 2.6 ns—a 10% to 15% improvement over comparable devices fabricated using bulk-silicon techniques.

In the same laboratory, using the same SOI technique, a 10-bit linear image sensor has been fabricated with two active layers instead of the usual one (Fig. 2). In this structure, a 50-by-50 array of photodiodes with shallow pn junctions is formed in the SOI layer and shift registers are formed in the bulk-silicon layer. The lab has also fabricated a 3-d 256-bit SRAM which uses the bottom layer in the bulk silicon to build the array of six-transistor SRAM cells in n-MOS while the upper layer contains all of the peripheral and support circuitry. Cell size is 50 by 70 $\mu m^2$ and die size is 2.6 by 1.9 $mm^2$. Address access time is 120 ns and active power dissipation is 100 mW.

Researchers at Toshiba's VLSI Research Center in Kawasaki, Japan, have combined electron-beam recrystallization with a seeded lateral epitaxial technique to fabricate single-level aluminum stacked CMOS structures (Fig. 3). These structures use 2-$\mu m$ design rules. The SOI CMOS process is being used to build an image processor with the logic circuits, such as adders fabricated on the upper layer and the memory array on the lower substrate. Effective channel lengths are 1.3 $\mu m$ for the n-channel device and 1.7 $\mu m$ for the p-channel device. In a 23-stage ring oscillator fabricated with the process, propagation delays of 218 ps per stage were measured at 10 V.

In a stacked-transistor design from Fujitsu Ltd.'s IC Development Laboratory in Kawasaki, researchers have combined beam recrystallization with a 2-$\mu m$ CMOS process in which the n-channel transistor is placed directly above the n-channel device, with an insulating layer between them and with separate gates. Ring oscillators have been fabricated that feature a propagation delay of 430 ps per stage with a 5-V supply.

Oki Electric Industry Co. has taken two routes. Aiming at extremely high speeds, researchers at the Tokyo company have combined a 1-$\mu m$ bulk-CMOS process with a Fipos technique to build a stacked-transistor design for a 100-stage inverter chain featuring delays of 60 ps per stage at 5 V. Another team of researchers at the company's Central Research Laboratory in Kokubunji, Japan, has used laser beam recrystallization to fabricate a 3-d DRAM cell measuring only 16 $\mu m^2$. The cell maintains a storage capacitance of more than 100 fF, two to three times the minimum necessary, even when the cell size is reduced to 5 $\mu m^2$, the expected size for a 16-Mb DRAM cell.

### 3-D SOI IN THE U. S.

In the U. S., most of the effort in SOI research is spearheaded by such schools as Stanford University, the University of California at Berkeley, UCLA, and the Massachusetts Institute of Technology. Corporate participation is limited largely to AT&T, Hewlett-Packard, IBM, Motorola, RCA, and TI.

At Stanford, a novel crossed-CMOS transistor structure uses a recrystallized silicon layer to isolate the sources and drains from latchup and radiation-induced soft errors. Here, two CMOS transistors cross at right angles, so that the sources and drains stick out, forming a structure resembling a plus sign. Only the exposed tips of the cross are doped p+ or n+. The top gate controls the current between the p+ source and drain, while the bulk silicon below the SOI layer acts as the bottom gate controlling the n+ source and drain.

Hewlett-Packard Co. researchers in Palo Alto have developed a new type of current-switching element that combines features of a transistor and a capacitor. This "transpacitor," as HP calls it, makes extensive use of SOI techniques. In this structure, a recrystallized silicon insulating layer controls the capacitance between two gates that are separated from it by layers of $SiO_2$. By changing the electrical properties of the insulating layer, it is possible to control the flow of electrons from one gate to another in a nonlinear fashion. This is similar to the action of a classical transistor switching element in that a small voltage change in the insulating layer results in a much larger signal change between the gates.

TI is playing both sides. While it focuses its efforts on extending existing bulk-silicon CMOS technology with a unique space-saving cross-point trenched-transistor structure, it continues to work in SOI structures such as its transverse injection, two-electrode transistor structures, called TITE [*Electronics Week*, Oct. 1, 1984, p. 11].

"It is clear that bulk-silicon CMOS will only get us so far before running out of gas, probably around the 0.8-$\mu m$ region, even with the help of trenched capacitors and trenched isolation and even trenched transistors," says P. K. Chatterjee, director of TI's Semiconductor Processing and Design Center. "Eventually we will have to go to SOI, if only for its speed

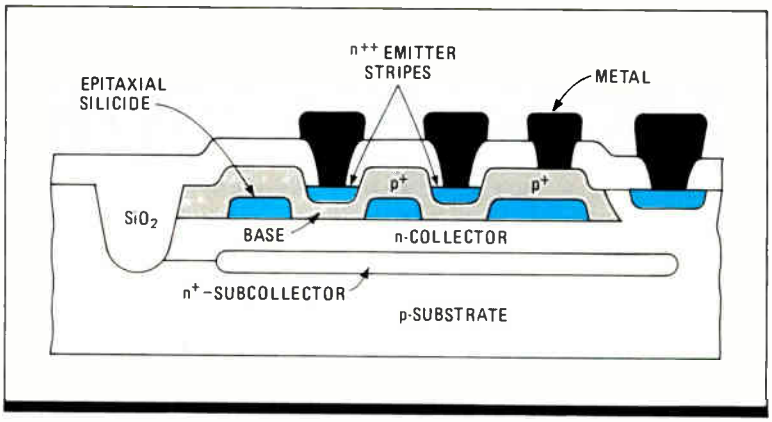
enhancement, isolation, and alpha-immunity features. Longer term, the ability to build vertical stacked structures will be useful. Indeed, one can conceive of some very interesting combinations of trenched and stacked structures."

The question is when any of these laboratory prototypes will transfer to production devices. "Except for the procedures necessary to produce the insulating layer, all the steps necessary to build stacked SOI structures are those of ordinary bulk-silicon CMOS processing," says Lam Associates' Lam. What limits further commercial development is not device physicists' and circuit designers' ability to produce innovative designs, he says, but rather the limitations of current fabrication equipment and lack of proper starting materials.

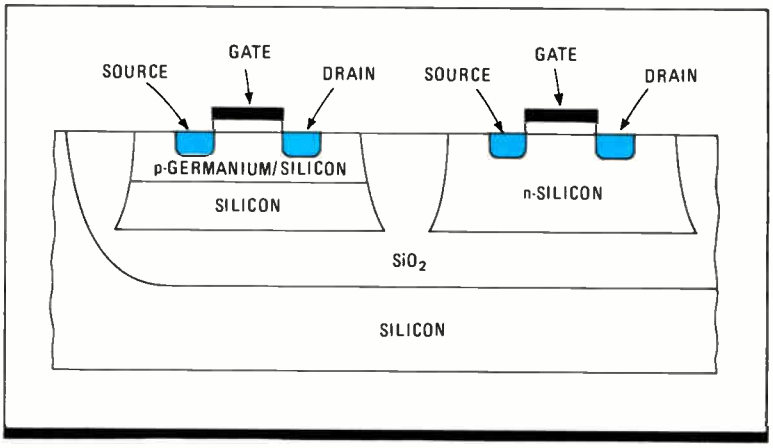
But this is changing, he says, and within two years the material and equipment will be available for manufacturers to move quickly into production with SOI-based circuits. "Right now, a company wanting to manufacture SOI circuits would have to modify the equipment and prepare its own wafers," says Lam. "This is okay in the laboratory but not in the production environment. On the material side, several established vendors and a few startups are working to come up with the procedures and equipment to generate wafers properly prepared for SOI. Similarly, on the equipment side, manufacturers such as Eaton, Perkin-Elmer, and Varian are in the design phases of systems that will allow material suppliers to prepare wafers for fabrication with SOI."

Though laser-beam recrystallization seems to be the best candidate because of its maturity, Lam believes the Simox approach will likely move to production first. This is because the implanters are simply extensions of what is already available.

The smaller the device structures, however, the more critical the processing techniques become. The high temperatures of SOI do not allow building the superthin layers that make superlattices possible. Silicon-based MBE appears ready to pick up where SOI leaves off.




**4. GRIDDED BIPOLAR.** UCLA improves bipolar performance by using molecular-beam epitaxy with a silicide grid between the base and the emitter.




**5. CMOS-LIKE.** Using silicon-germanium heterojunction layers, UCLA's MBE technique can build CMOS-like structures that use hot-electron effects.

In contrast to the progress being made using MBE in the fabrication of GaAs-based compound semiconductors, this technique until recently has not been used for the growth of silicon structures because of some initial difficulties in substrate preparation prior to growth as well as to doping control during growth. Within the past year or so, says UCLA's Wang, enough progress has been made that researchers in the field have not only been able to grow high-quality silicon MBE films but to build demonstration prototypes of a number of different transistor structures and circuits.

"High-quality silicon MBE films can be grown if the initial substrate preparation provides a clean starting surface," says Wang. "Also required is a consistently steady-state ultrahigh vacuum and a clean environment throughout growth."

To clean a silicon surface, the usual procedure calls for removing contaminants such as oxygen and carbon by heating the substrate to over 1,200°C. But for silicon MBE to be useful, the surface of the silicon cannot be subjected to such high temperatures.

This seeming Catch-22 has been resolved, says Wang, by the discovery that repetitive oxidation of the surface in boiling hydrogen nitrate followed by the removal of the oxide in hydrogen fluoride prior to loading is as effective as high temperatures in removing carbon and heavy-metal contaminants. Protection against further contamination is ensured by laying down a thin oxide in the chamber at temperatures no higher than 850°C.

Doping control is another area of research that has improved the prospects for silicon MBE. The method by which n- and p-type dopants are laid down in MBE, thermal evaporation, has in the past resulted in incorporation ratios too low to be useful—that is, the amount of dopant concentrated in the grown film compared to the amount in the corresponding surface layer was too low. The result was that MBE could not provide the high doping densities and abrupt doping profiles necessary for VLSI and ultralarge-scale circuits.

One way to improve doping control and to increase the incorporation ratios, says Wang, is to complement MBE with doping by secondary implantation. In secondary implantation, silicon ions interact with the dopant layer and increase the incorporation ratio, unlike the commonly used direct low-energy ion-implantation technique. Another way to achieve the same goal has been to use electron bombardment.

## MBE-BASED TRANSISTORS

Bipolar devices are among the first transistor structures to benefit from the recent breakthroughs in silicon-MBE processing. As designers push bipolar structures to their speed and density limits [*Electronics*, April 7, 1986, p. 24], they are finding it hard to overcome a number of physical limitations, especially as they push toward the half-micron limit. One difficulty, says Wang, is reducing base resistances, which result from the low doping densities needed to maintain desirable injection ratios as the devices get smaller. Another problem is how to reduce base widths without collector-emitter punch-through and reduced reliability.

One likely solution, according to Wang, is a silicon-based metal-base transistor. This device uses a thin metal base consisting of alternating layers of cobalt silicide and nickel silicide. The result is a transistor with an extremely narrow, half-

micron base, and therefore lower resistance. This gives delays in the subpicosecond range.

Other interesting structures that have promise, Wang says, are variations on the permeable-base transistor used in some GaAs designs. One approach is an implementation of GaAs where the substrate is silicon but the grid pattern consists of epitaxially buried NiSi and CoSi layers.

Another variation, being investigated by Wang and his researchers, has been designated a gridded bipolar transistor. In this device, a standard bipolar structure (Fig. 4) is modified by the insertion of an epitaxial pattern of CoSi or NiSi between the emitter and the base structures.

Wang says the use of MBE techniques to fabricate analogs of AlGaAs heterojunctions using doped layers of silicon and germanium silicide also bears watching. Silicon bipolar structures have been fabricated similar to those in III-IV compound semiconductor structures, but Wang believes the most important application for doped silicon-germanium heterojunctions is in the construction of CMOS-like structures (Fig. 5) in which gridded heterojunction layers are inserted underneath the CMOS devices.

Perhaps the most exciting application for silicon-based MBE, says Wang, is in the fabrication of silicon-based multilayered superlattice and quantum-well structures, which offer the promise of memory circuits with densities in the hundreds of megabits and device geometries in the picometer range. Two types of superlattice structures—compositional superlattices and doped superlattices—are under intense investigation, says Robert Bate, manager of advanced concepts at TI's System Components Laboratory in Dallas.

Compositional superlattices are structures somewhat like those fabricated with GaAs and AlGaAs. Two basic variations are under development in various corporate and university laboratories. One, an alloyed superlattice using silicon and germanium silicide combinations, has a bandgap similar to that of the familiar AlGaAs structures of many advanced integrated optoelectronic circuits. The other has a bandgap similar to that in current ICs and consists of alternating silicon and silicide layers, particularly NiSi and CoSi.

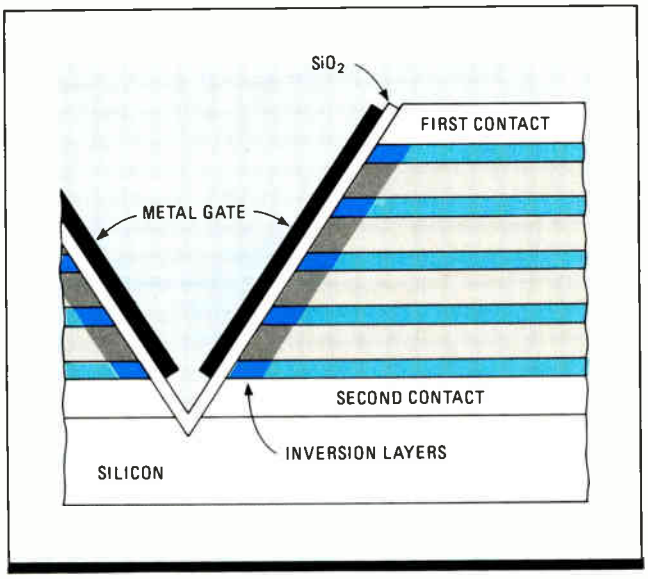
In compositional superlattices, arrays of ultrathin layers of two different semiconductors, each layer only a few hundred atoms thick, are fabricated in alternating periodic pattern. The semiconductor materials are chosen with bandgaps sufficiently different that alternation of layers creates a similar alternation in electric potential. Each layer with the smaller bandgap produces a potential well. Inside the well only certain states are available to conduction-band electrons, and each state is split into smaller minibands.

What has increased researchers' optimism about the possibility of silicon-based superlattice structures is the discovery that a second type of artificially structured material, the doped superlattice, can be fabricated and used as an electronic switching device. They can be fabricated with procedures that are more compatible with silicon-type manufacturing than those of the compositional type.

Bulk silicon is used as the starting material for doped superlattices. It is used to fabricate an array of periodic n- or p-doped layers separated by intrinsic, or undoped, layers. A certain fraction of the donors and acceptors are ionized. This is because electrons leaving the donors recombine with holes, leaving the acceptors as long as the process continues to lower the total energy of the material. The resulting charge in the doped layers produces a periodic electrostatic potential, which then modulates the conduction and valence bands in a manner similar to the compositional superlattice.

The one big advantage of the doped superlattice is that even more than the compositional superlattice, it can be tailored with great flexibility. In compositional superlattices, the structure is constrained by the choice of the semiconductors and the relationship of their bandgap values to one another. In a doped superlattice, any semiconductor material can be the host for the doping superlattice. The only requirement is for n- and p-doping.

In addition, the effective bandgap of a doped superlattice can have any value—from zero to that of the host semiconductor—simply by properly combining the doping concentration and the layer thickness. Even after fabrication, a doped-superlattice structure can be fine-tuned. This means the superlattice can be designed to have certain values and that these values can be modulated within varying limits by tuning the crystal structures.




**6. SILICON LATTICE.** A V-groove silicon superlattice operates by means of electrons and holes tunneling through thin barriers.

A problem in using silicon superlattices as switching elements in 0.1- to 0.5-μm circuits is operating them as three-terminal devices. A contact to the third terminal must be provided. One configuration proposed by Wang of UCLA uses a V-groove tunneling structure to achieve the three terminals (Fig. 6).

The V-groove structure's advantage is that it can be used with either compositional or doped superlattices. In the structure, extremely thin high-bandgap silicon is interleaved with layers of germanium silicide, which act as the well regions. The third terminal, the metal gate, serves as the gate for controlling the barrier height of the tunneling. Electron holes or electrons can tunnel through the thin barriers.

Below 0.1 μm, says TI's Bate, quantization effects impose restrictions in both the lateral and vertical dimensions, leading to the formation of bound states. These states are discrete in energy, replacing the continuum of electron states by which present devices operate with a series of discrete levels, or quantum wells. If these laterally confined quantum wells are spaced closely enough, electrons can tunnel between them, says Bate. Furthermore, the discrete nature of the electron-energy spectrum in the wells leads to resonant tunneling, in which the current depends more on voltage than it does in present semiconductor devices.

Bate believes this phenomenon can be used to make what he calls quantum-coupled structures, which lend themselves naturally to organization into extremely dense superlattice arrays. In these arrays, individual quantum wells can be linked to one another by tunneling structures into superlattice arrays. If such structures prove feasible, says TI's Heilmeier, by the mid-1990s quantum-based DRAM technology will have evolved to the point that laboratory prototypes of DRAMs in the 100-Mb range will be possible. □

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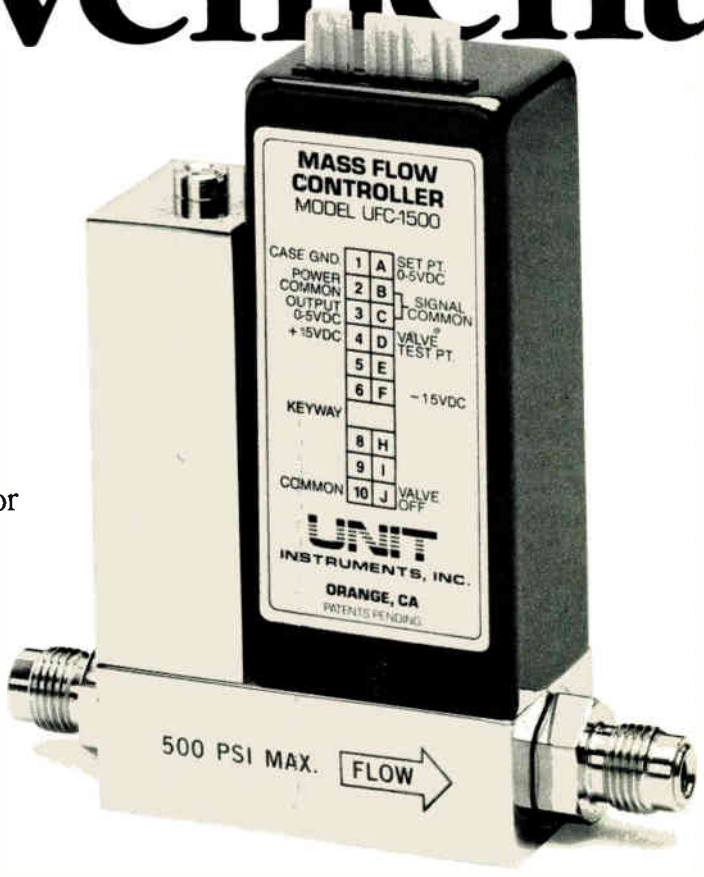


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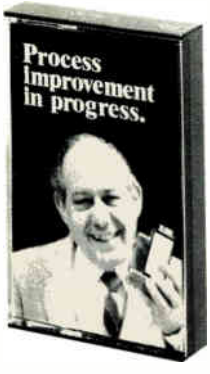


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PROBING THE NEWS

# MIRED IN RED INK A YEAR AGO, DISK-DRIVE MAKERS ROAR BACK

## SUPPLIERS OF 5¼-IN. HARD DISKS COULD GROW 40% THIS YEAR

*by Larry Waller*

**LOS ANGELES**

As recently as a year ago, the suppliers of 5¼-in. Winchester disk drives were mired in the gloom and red ink of their largest customer—the slumping personal computer industry. But now the business pendulum has swung so far in the opposite direction that it has surprised some vendors inured to the rapid rags-to-riches-to-rags cycles that hit their business.

The picture has brightened so much, in fact, that many observers now predict the business will grow 40% this year. That would mean something like 3.1 million drives will be shipped in the U. S. this year.

Helping to push sales higher and higher are the exploding demands of personal computer users who feel strapped for memory and who want to add higher-capacity hard-disk drives. In addition, executives believe, new generations of work stations for engineering and office applications will continue to fuel their business. IBM Corp.'s unknown buying plans, however, continue to cloud the picture, as do the sometimes cutthroat pricing patterns designed by suppliers themselves.

But all told, executives and observers see the industry—which hit $4.4 billion in 1985—achieving annual double-digit growth for the next few years. Annual growth rate of 20% or more seems assured for years ahead, predicts James Stone, research analyst at New York's Shearson Lehman Brothers Inc.

The improvement in the hard-disk drive business is underscored by strong financial performance of the companies involved, notably Seagate Technology. The Scotts Valley, Calif., company reported big increases in its first-quarter results, based on mushrooming sales of its 20-megabyte drives (see "How Seagate is prospering without IBM"). Micropolis Corp., Chatsworth, Calif., which has the lion's share of sales in the higher-capacity 85-megabyte market, also turned heads with its performance. Its first-quarter revenues more than tripled to nearly $51 million, while profits reached $3.75 million, compared with a $411,000 loss a year ago. Other leading disk companies report similar gains.

Not surprisingly, most disk-drive company executives wax euphoric. "A quick turnaround, huh?" gloats John Clonick, manager of product marketing at Maxtor Corp., a San Jose, Calif., company that specializes in the highest-capacity 5¼-in. units—up to 380 megabytes—with its new XT3280 model. He believes the drive business "is now entering a new cycle, with plenty of demand for everybody."

Creating strong demand for the 20-megabyte and larger Winchesters at the lower-capacity end of the market are shipments of personal computers, which continue to grow 20% annually, according to drive makers. Shipments of this size drive are being sparked by what analyst Stone calls "insatiable demand for additional disk storage." Users are switching in droves from memory-limited floppy-disk and smaller hard-disk systems to the larger-capacity drives.

This trend is opening up more than 4 million personal computers as prospects in an aftermarket that is becoming a major target for drive marketeers. The market for add-on hard-disk drives might absorb up to 1 million units this year, some industry observers estimate.

But it is the high-end segment—drives with storage capacities of 85 megabytes and up—that excites most vendors. "It's starting to explode," enthuses Stone. Pacing product demand within this segment are the first sizable orders from vendors of desktop work stations for engineering and office tasks.

"They're the successors to the minicomputer business, and the strongest part of the computer industry," says Stuart P. Mabon, chairman and president of Micropolis. The resurgence in disk drives is rooted in work stations, in his view, as all the computer heavyweights follow the lead of pioneers Apollo Computer Inc. and Sun Microsystems Inc.

**BOOM.** The disk-drive market is in a new growth phase, fueled by high-capacity drives such as Maxtor's XT-3280 for products like IBM's PC AT.

The major computer companies are now in varying stages of bringing out initial or improved products. Micropolis has snagged the plum order to date for work stations with its Model 1320, an 85-megabyte drive. Stone says the hot-selling MicroVAX II, built by Digital Equipment Corp., comes with two 1320s. DEC alone will buy $50 million to $75 million of these drives this year, he estimates, but that's just the tip of the iceberg. Higher-capacity 175-megabyte drives are now being designed into new computer generations and will add a further kicker, starting later this year.

Micropolis and Maxtor are leading the charge, but other 175-megabyte entries are coming from Priam, Quantum, and the leading drive supplier of the 1970s, Control Data, which is beginning to regain the ground it lost in recent years, according to some experts. Miniscribe and Seagate also have dealt themselves into the high-capacity game, while the U. S. operations of major Japanese manufacturers are, without much fanfare, making inroads into the original-equipment and add-on subsystem business.

All told, more than 400,000 disk drives with capacities of 85 megabytes and over will be sold this year, double the 1985 total. Interest from potential customers is so brisk, in fact, that suppliers will be hard put to fill customers' needs, predicts Mark Wilson, director of marketing at Fujitsu America Inc.'s Storage Products Division in San Jose. "The big issue is having enough sales guys to cover the leads."

Despite the rosy vistas, drive makers are still troubled by some developments. Topping the worry list are the drive procurement plans of IBM, which typically keeps closemouthed about its purchases. It is an irony not lost on the industry participants that the 5¼-in. drive business is perhaps the only market where suppliers go to lengths not to sell too much product to the largest buyer in the market. "Most survivors have learned to live without IBM—in some cases by studiously avoiding it," notes Maxtor's Clonick.

The size and influence of IBM make it a force to be watched closely, all agree. The behemoth buyer has dealt serious blows to numerous drive producers in the past by suddenly phasing out contracts. Last year, for example, IBM bought one out of every three disk drives made. Now the computer giant has stepped up its in-house disk drive manufacturing efforts and produces a majority of its 20-megabyte disk drive needs. This step-up in its production will likely hurt such vendors as Seagate, which supplied drives for use in IBM's products, since IBM is putting factory-supplied drives on its Personal Computers.

Other victims of IBM's practice of phasing out contracts in favor of in-house production include Tandon Corp. and Computer Memories Inc. The result is that both Chatsworth, Calif., companies, once regarded as survivors in the disk-drive wars, have slipped to positions well behind the leaders. Tandon has shifted its sights to manufacturing personal computers and Computer Memories is struggling to find new business opportunities.

While IBM is filling its own needs in the 20-megabyte arena, questions abound as to where the company will get the larger drives it will need for next-generation computers currently in design. At present, the computer giant is buying products from several sources for its RT Personal Computer, though mainly from Micropolis, as Mabon reluctantly acknowledges. But he declines to label IBM "a major customer."

Another concern, most executives say, is that prices fall too fast for their tastes. For instance, the 80-megabyte Q280 from Quantum Corp., Milpitas, Calif., sells for $995 in quantity, but some equivalent products are probing the $900 barrier. "It's commodity pricing now," observes Fujitsu's Wilson. Similar products sold for $1,100 in November and up to $1,500 a year ago. It is not yet clear what volume prices will be when the 175-megabyte drives go into wide use, but the betting is they will drop fast. "Ruinous price cutting. . . is a real danger," notes Maxtor's Clonick.

Even with some worries clouding the now-blue skies of the disk-drive market, most observers think the growth potential remains bright for some time. The industry will have "two to three years of good times," says Mabon, a prediction his peers also favor. □

## HOW SEAGATE IS PROSPERING WITHOUT IBM

**Dumped two years** ago as a supplier of 10-megabyte hard-disk drives by its biggest customer, IBM Corp., Seagate Technology fell off a cliff in the first quarter of fiscal 1985. Its sales dropped to $50.6 million from $100.5 million the quarter before.

But this month, the Scotts Valley, Calif., company reported its best quarter ever, with sales of $126.9 million and earnings of $11.8 million. And founder, chairman, and chief executive officer Al Shugart says the latest boom is far from over. "I don't see anything slowing it down.

"The percentage of [desktop] computers with hard-disk drives went from 35% to 65% in the past six months," he says. "We've got the other 35% available to grow the market and a large installed base for retrofit." Seagate capitalized on the falling prices of 5¼-in. Winchester drives to nab a bigger share of a growing market, Shugart says, and now produces 8,000 drives a day.

"Seagate survived because it had an extremely tough management," says James N. Porter of Disk/Trend Inc., a Los Altos, Calif., market researcher. "Tom Mitchell [Seagate's president] seriously inconvenienced a lot of people—fired a couple of thousand, moved production to Singapore, abrogated contracts with vendors making heads and motors. During the entire period, Seagate was profitable—one of the neatest accomplishments our industry has seen. Seagate is in beautiful shape today."

**SHUGART.** The boom is far from over.

Frozen out by IBM, Seagate hired a telephone sales staff and sold drives directly to IBM dealers, who would order IBM Personal Computer/XTs with a floppy drive only and add a hard-disk themselves, Porter says. Later, Seagate sold 20- and 30-megabyte drives for the PC AT. It has, however, cut its dependence on IBM from 48% of sales to 16% today.

But Seagate isn't entirely out of the woods, Porter notes. With up to 60% of sales going to value-added resellers and dealers, Seagate is vulnerable to any changes IBM may make in the way drives attach to its PC.

IBM also offers a low-cost 30-megabyte drive for the PC AT, which could affect the aftermarket Seagate is now targeting. And Porter expects IBM to come out with a 3½-in. Winchester for the PC/XT this year, leaving Seagate in the cold. It does not yet make a 3½-in. drive.

Shugart is unperturbed. Porter, he says, has been predicting IBM's 3½-in. drive for two years. And as for the AT's 30-megabyte drive, Shugart won't concede anything yet. "It's all a matter of marketing and salesmanship, isn't it?" he says. And Seagate has shown it can do that. *–Clifford Barney*

# SEMICONDUCTOR INDUSTRY TRIES TO MOVE TO SINGLE SOURCING

## STOPPING THE DOUBLE ORDERING THAT MARKS BOOM-AND-BUST CYCLES

*by Steve Zollo*

During a downturn is as good a time as any to experiment in the semiconductor industry—there's not as much to lose. But more than a few chip makers and their customers don't want to wait for the next market decline. They are starting an important test of a new strategy just as the industry is coming out of its latest recession. The strategy: drastically reduce the number of sources for their component buys, down to just one in some cases.

The aim is to eliminate the double and triple booking of parts during business upswings that compounds the industry's boom and bust cycles. But the roller-coaster cycle is not the only driving force behind the changing strategy. The push to customer-specific integrated circuits, the growing interest in just-in-time manufacturing, and the costs of vendor qualification all are combining to change the shape of emerging arrangements in procurement.

A number of equipment makers are narrowing their supply bases from a half dozen companies or more to just one or two. And chip makers are looking to strengthen relations with their customers, often offering guaranteed delivery in return for a set share of the customer's business.

Many companies are asking about single sources, says Will Strauss, president of Forward Concepts, a market researcher in Tempe, Ariz. "Each has to be looked at individually." Even on such commodity parts as large- and medium-scale ICs, companies want to reduce their lines of supply. "I think the customers in the past probably were encouraging six or eight vendors on large-volume commodity families. I doubt that we will feel that kind of pressure today," says Jim Watson, vice president and U.S. marketing manager in Texas Instruments Inc.'s Semiconductor Group in Dallas.

Stephen Whitney, marketing manager at Cooper Industries Inc.'s Bussmann Division, a fuse maker in St. Louis, figures that 70% of parts buyers want just two suppliers and another 25% will settle for just one supplier or try novel ways of guaranteeing their supply. To persuade equipment makers to pick only one supplier for a particular component, TI has set up a fast-turnaround facility for commodity logic parts to keep the customer supplied at all times. And National Semiconductor Corp. hopes to achieve the same relationship by sharing know-how with Xerox Corp.

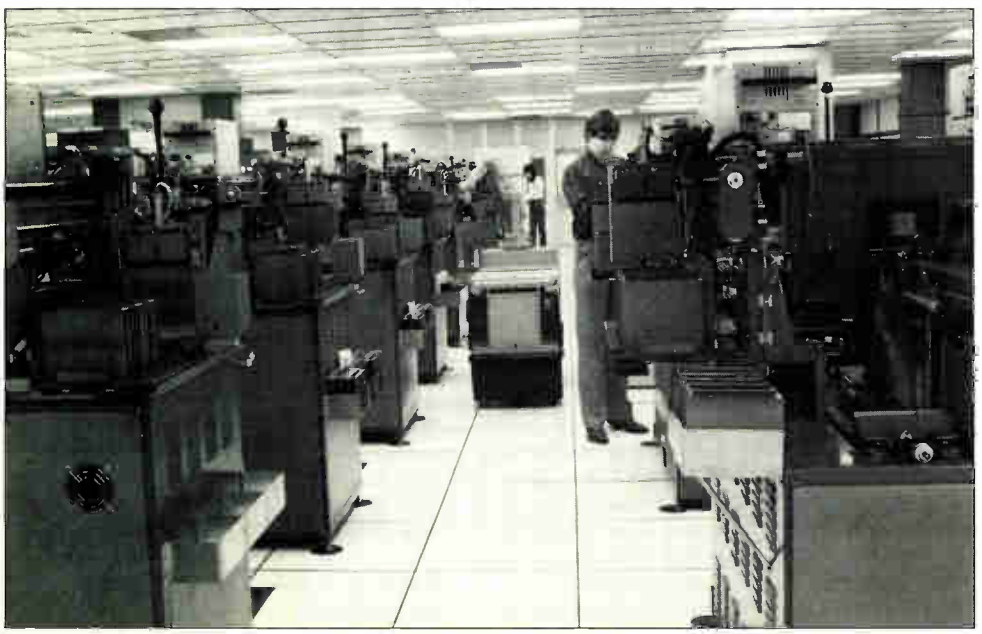
By and large, companies that are willing to count on a single vendor for their needs have done so mostly on a chip-by-chip basis. InteCom Inc., for example, generally requires multiple sources for commodity high-volume semiconductors, but it has recently begun relying on specialty houses for a number of key analog/digital gate arrays, says Bill Collinsworth, senior vice president of operations for the Allen, Texas, private-branch-exchange maker.

"There is probably more single-sourcing today in these gate-array markets than there has ever been. That's a change from a year ago," he says.

**OVERSTOCKING.** But companies that do go with a single supplier are careful to take precautions. "The best way to protect yourself when entering a single-source arrangement for semicustom and custom chips is to overstock your inventories," says Robert J. Paluck, president of Convex Computer Corp., who five years ago was on the other side of the silicon-systems fence as a Mostek Corp. vice president. Convex bases minisupercomputers on gate arrays it buys from Japan's Fujitsu Ltd. Although the Richardson, Texas, company protects itself with inventory, Paluck feels more at ease with his single source knowing the Japanese vendor has nearby TI as an alternate source for the chips.

The sourcing strategy at Cordata Inc., Thousand Oaks, Calif., which makes IBM Corp.-compatible desktop and stand-alone computers, is similar. The company still has two active suppliers for its commodity memories, but it will depend on only one source for custom gate arrays that will go into a generation of computers it has under development. This does pose "a new dimension of risk," admits Gerry Babb, vice president of marketing.

Much the same philosophy prevails at major Japanese companies. Iwatsu Ltd., a Tokyo oscilloscope and test-equipment maker, generally buys standard parts from multiple



**FAST.** TI sees its FAM line as a means to 100% on-time delivery for its commodity-logic customers.

sources. But if a superior off-the-shelf part is available from only one source, Iwatsu will buy it. This has meant single-source purchasing of semicustom and custom parts from one source, largely because Iwatsu has found that parts from different manufacturers are not the same.

Many equipment makers, however, have found it hard to shed their wariness about single sources. To win them over, parts suppliers are coming up with imaginative solutions. Whitney says Bussman is willing to guarantee a portion of the output of one line to a customer.

Motorola Inc.'s Semiconductor Products Sector made high-level commitments to sign up Apollo Computer Inc. as a single-source customer for its 68000-family microprocessor products. "We're strategically aligned with them," says Peter Galvin, purchasing manager at the Chelmsford, Mass., work-station maker. "We feel that they will support us—we got assurances straight from the top." Galvin points out that Apollo is changing the way it second sources, and wants to narrow its supplier base from 10 to only three or four.

**CONSERVATIVE.** Prime's Calhoun will not commit to a single source.

**TI'S PACTS.** TI, however, has made the strongest pitch to win over single-source supply contracts for commodity logic components. It has built a fabrication facility dedicated to customers it signs up for its program (see "How TI is building closer relationships with its customers"). In return for preferential treatment with short lead times, high-volume customers are being asked to swing most, if not all, of their commodity-logic business to TI under a series of partnership pacts. These partnerships and TI's extensive investments in automation for 100% on-time chip deliveries are further evidence of closer relationships coming out of the boom-and-bust cycles in silicon markets.

Another new twist in single-source relations turns the equipment maker into its own second source. National Semiconductor, Santa Clara, Calif., and Xerox have such a relationship. Xerox's Electronics Division in El Segundo, Calif., develops the electronics for Xerox products and does its own chip manufacturing. But more than half of the application-specific ICs that Xerox needs will come from National, which has been building gate arrays for Xerox for some time. It is essentially an ASIC partnership: National will make its entire ASIC technology—software, tapes, and the like—available to Xerox. Xerox checked out 20 companies before it chose National.

This kind of deal will probably never become widespread, however, because there are fewer than a dozen equipment makers in the U.S. that have the wafer-fabrication facilities to second-source their vendors, says Claude Prosnier, marketing manager for bipolar and analog circuits at Motorola.

Despite the strong commitments and the blandishments of the chip houses, many equipment makers are opposed to the whole idea of single-sourcing. Prime Computer Inc., for one, does not want to get locked into single-source agreements with chip vendors.

"It's not practical," says William Calhoun, director of corporate procurement at the Natick, Mass., company. "You never know what's going to happen out there—a vendor could lose his chip recipe. You always want to have a backup." Calhoun admits, however, that the possibility for single sources exists in the custom-chip area, where all vendors may not offer the technology his company needs.

At Litton Industries Inc., too, second-sourcing is a touchy issue, "especially with the gate-array people, who are jealous of their technology," says Gary Mallaley, program manager for research and development. The Data Systems Division in Van Nuys, Calif., designs and builds command and control gear for the military. But Litton's military customers demand second sources on all components, and the new equipment is filled with semicustom and even some custom devices. "The big danger is a supplier going out of business, losing its magic process," says Mallaley.

Will the new single-sourcing pacts have an effect on the stability of the market? "Any time you have a contractual agreement, you minimize the ups and downs in the demand. There would be no surprises," says Motorola's Prosnier. □

*Additional reporting was contributed by J. Robert Lineback in Dallas, Clifford Barney in Palo Alto, Debra Michals in Boston, Larry Waller in Los Angeles, and Charles Cohen in Tokyo.*

## HOW TI IS BUILDING CLOSER RELATIONSHIPS WITH ITS CUSTOMERS

**Texas Instruments Inc.'s** Flexible Assembly Module in Sherman, Texas, is designed to build closer relationships with the company's commodity-logic customers. TI is doing this by ensuring 100% on-time deliveries and keeping shorter lead times from order to delivery.

The goal is to keep lead times to a maximum of 12 weeks in the next upswing, down from the average 16-week high recorded in the 1983-84 chip boom. And within two to three years, TI intends to cut lead times to just six weeks. In the middle of the last boom, TI was making on-time deliveries of commodity bipolar logic about 80% of the time; by the end of 1985, on-time deliveries rose to 100%.

To achieve such performance, the module—known around TI as FAM—has been loaded with TI-made robots, automatic guided materials handlers, machine-vision-equipped assembly gear, and expert-system software, along with specially tailored commercial systems. The domestic assembly line is at the same site as two wafer-fabrication front ends, crystal-growing equipment, and chip-design centers. TI's semiconductor vice president, Dwain Chaffin, believes the plant is the world's only volume-production site equipped with all the steps—from ingot growing to assembly and test—needed to turn out commodity-IC products.

Routinely, cycle time for products in FAM is one week. In emergencies, FAM can turn around a product in less than 48 hours, says Chaffin.

FAM is also TI's leading driver in advanced IC assembly and testing techniques. Already, the company is considering a fanout of FAM-pioneered assembly and test techniques to some of its offshore facilities.

Among the automated systems in the facility are intelligent vision systems for bonding inspection and a new effort to have expert systems automatically control machines and perform self-diagnostics. For three years, TI has also been attacking manufacturing-planning hurdles with automated scheduling systems that have turned monthly production cycles into weekly starts.

TI's ultimate goal with FAM is to separate itself from its competition as a commodity-chip supplier. Says Chaffin, "The customers will know by the next upcycle that we're doing it the way we say we are."

*-J. Robert Lineback*

# EUROPE FINALLY GETS MOVING ON STANDARDS MAKING

## TURNING A COLLECTION OF SMALLER MARKETS INTO A BIG ONE

*by Robert T. Gallagher*


**BRUSSELS**

The Commission of the European Communities (EC) is acting swiftly to turn Europe into a truly common market for information-technology components and systems. Armed with a potent new voting procedure, it is establishing a sweeping body of norms and standards for electronics, communications, and data-processing equipment.

In the past, the hope of European standardization has fallen victim to the EC's cumbersome ratification process—notably, the requirement of unanimity among EC members. Now, with an overhauled approval system that strips individual nations of their veto power, the EC is pulling out the stops. And European manufacturers with a stake in an expanded market are embracing and contributing to the move as well.

This unprecedented effort is covering everything from nuts-and-bolts items such as physical connectors through the applications levels of sophisticated telecommunications and computer systems. The EC is also hammering out a conformance-testing scheme to verify compliance with the standards established. These norms would then be given the weight of law in each of the 12 member countries.

The move would mean a drastic change from the present situation in Europe, where standardization for such equipment—when it exists—is handled by national organizations for their respective countries. Keeping standardization a national—even a chauvinistic—matter has turned Europe into, at best, a collection of small- to medium-size markets difficult for any electronic equipment manufacturer, even European native companies, to attack. At worst, it has created a labyrinth of sometimes incompatible and even contradictory regulations and requirements, which has resulted in the disastrous combination of high prices and reduced profit margins that commonly afflict companies trying to establish a strong position in the European data-processing and telecommunications markets.

Michel Audoux, the coordinator of the EC's normalization and standardization effort, has little difficulty demonstrating the concrete nature of the problem. With a practiced gesture, he removes from the wall of his office a cardboard sheet on which are glued three radically different connectors used for identical telecommunications and data-processing equipment.

*New standards will cover everything from connectors to software*

"This one is German, this one Italian, and this one French," he explains, indicating the three components from left to right. "You can't believe how difficult it is to get an agreement to standardize something even as basic as this." Audoux then goes on to muse that agreement on complex protocols is, predictably, even more difficult to come by.

Talk of executing a program of Europe-wide norms and standards is nothing new. But what is new is that action is finally being taken. The eternal problem in getting a program off the ground has always been the cumbersome bureaucratic process that has been endemic in the EC since its inception. Until now, matters of this nature have been handled exclusively on the principle of unanimity, a fact that gave each country veto power and has always effectively paralyzed the decision-making process.

Symptomatic of this situation is the EC's effort to establish the International Organization for Standardization's open systems interconnection (OSI) norms as the European standard for interfacing data-processing and telecommunications equipment [*Electronics Week*, Feb. 25, 1985, p. 35]. Though resolutions supporting the approach were passed in Brussels as early as 1983, it is only now that the EC is managing to put into place the mechanism that will make OSI norms a practical reality.

**PROCEDURAL CHANGES.** During the past six months, member countries have agreed upon an alternative to unanimity voting. This will get the Europeans away from the discouraging morass that structure imposed on the EC's decision-making process. The Commission has seized upon the opportunity this presents to make two essential changes on the European normalization and standardization scene.

The first change is the process of restructuring existing European standardization bodies into a coherent group with a clear framework for mutual consultation and decision making. The second is that it has embarked upon the all-important work of constructing a body of known and verifiable technical standards that will be applied to information-technologies equipment sold within its member countries.

In its structural moves, the Commis-

sion has wisely opted for rationalizing and streamlining the existing European standardization organization infrastructure rather than trying to create a new one.

At the center of the new standardization mechanism are the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (Cenelec), and the European Conference of Postal and Telecommunications Administrations (CEPT). Normalization priorities are set by the EC and its member states, and the three organizations will, as a function of these priorities, generate European standards in consultation with national standardization organizations and telecommunications authorities. CEN, Cenelec, and the CEPT will in turn be advised by a technical committee consisting of both electronics industry officials and users.

**MAJORITY RULES.** Two essential elements have changed here. One is that for the first time a single body is setting normalization and standardization priorities for EC member countries as a whole. In the past, these originated with the various national bodies, often on an ad hoc basis. The other is that agreement on these norms will be carried out by a majority vote weighted as a function of each country's population.

When a standard is agreed upon, conformity to it will then have legal weight in all of the member countries. All member governments will make these standards a requirement for their own equipment procurement. And with government consumption of data-processing and telecommunications gear as high as one third of the total national market, few manufacturers can afford to be excluded from competing for that business. Another key point is that, as the standards become available, only equipment that conforms to them will be permitted to be connected to the national telecommunications networks.

Putting teeth in these plans is the EC's determination to verify a given piece of equipment's conformance to established standards. Last month, the organization awarded contracts to 15 different laboratories scattered throughout its member countries to develop facilities and cooperative procedures to check conformance of computer and communications equipment to international standards. The object is that equipment passing the agreed tests would be capable of interchanging data throughout the EC. In addition, it will help to promote the implementation of standards in products by providing harmonized conformance-testing facilities in all EC countries.

The majority of the contracts awarded are geared to fixing OSI norms, mostly within the first three layers of the seven-layer model. Audoux points out that the four upper layers are not yet well enough defined to be translated into technical specifications.

The other two major efforts of the program are directed at local-area networks and software language compilers. Initial funding for the venture is coming from EC grants, though participants will be encouraged in the future to continue their work on a commercial basis.

An example of just how these standards are being implemented can be seen in France, where the Direction Générale des Télécommunications has already instituted its program to make conformance obligatory.

## *A single body now sets up priorities for the EC*

According to Jean-Marc Chaduque of the Centre National d'Etudes des Télécommunications (CNET), the French have developed their own set of norms, called Architel, based on the already finalized OSI specifications and completed by a set of French specifications that will be updated as international standards become available. "We specify that all systems used in our research and development contracts must conform to these standards," confirms Chaduque.

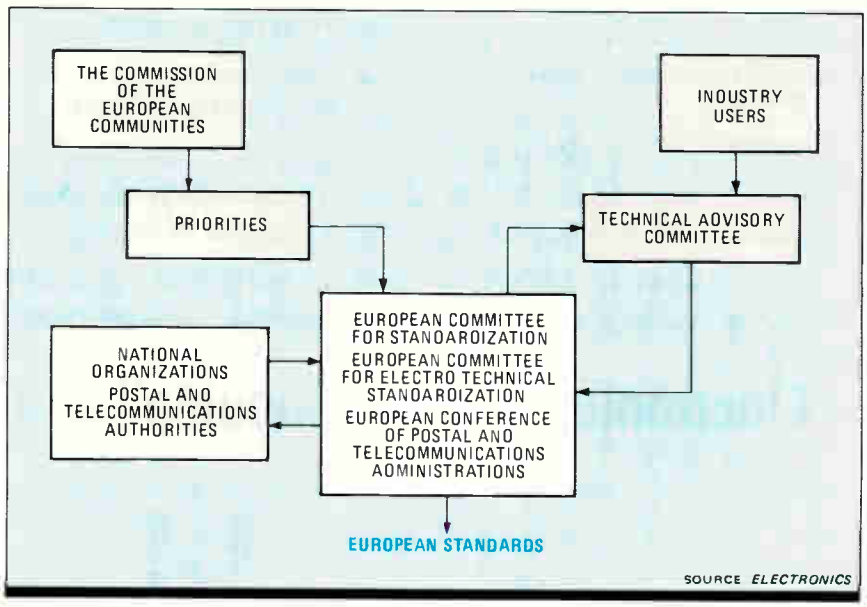
In addition to being one of the laboratories working on the EC's conformance-testing program, CNET has begun work on a number of projects to develop tools for conformance testing of equipment to Architel. This national program is being carried out with the cooperation of nationalized data-processing and telecommunications equipment manufacturers Bull and Alcatel, respectively, and is being made open to any systems producers that would like to certify their equipment as compatible with Architel.

**WORLDWIDE EFFORT.** Gérard Robin, technical director for network systems at ITT Europe in Brussels, says that his company is committed to this standardization movement. He expresses confidence that the movement will be generally accepted—first in Europe and then worldwide. Robin points out that ITT Europe is the center of the company's worldwide standardization effort simply because Europe is more advanced in this type of equipment than the U.S.

The company has a network of 200 standards experts throughout its subsidiaries who participate in international standards work and who stay current with changes so that ITT can integrate these standards into its own equipment as they become ready. The company's recently announced office-automation marketing effort, tagged Office 2000, is largely based on these norms and standards.

Charles Zimmerman, manager of networking and communications at Bull, asserts that his company, along with such European partners as ICL plc in the UK and Siemens AG in West Germany, have forged a cooperative effort with a number of software-development houses to produce conformance-testing programs for their equipment. The company is in the process of integrating international standards into its products as they become available. □

**BY BALLOT.** For the first time, a single body is setting normalization and standardization priorities for EC member countries as a whole, and implementation will be by a majority vote.



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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
Now It's Korea's Turn in the Robot Market

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# ANALOG DEVICES HOLDS TO ITS NICHE STRATEGY

## WITH THE HELP OF ITS NEW DIGITAL SIGNAL-PROCESSOR LINE, THE CHIP MAKER REACHES FOR $1 BILLION IN SALES BY 1991

**NORWOOD, MASS.**

Analog Devices Inc. has long adhered to a simple product strategy—build semiconductor devices, mostly analog-to-digital converters, for niche markets that aren't big enough to attract the big producers. So when the Norwood company jumped into the digital signal-processor business in February, some observers were visibly shocked.

It seemed to them that the company had suddenly departed from its highly successful market strategy. Instead of matching its new product with those from such traditional small competitors as Burr-Brown Corp. and Analogic Corp., Analog Devices was proudly comparing its new DSP with products from giants such as Texas Instruments Inc. and Fujitsu Ltd.

Analog Devices is definitely not changing its market strategy, insists Ray Stata, who is the company's president, chairman, and cofounder. The bottom line, he says, is that Analog still won't go toe-to-toe with a semiconductor giant in a commodity part business. He is confident that his company will find profitable niches in higher-performance and specialized DSPs. Though some analysts predict that success in digital signal processing will be essential to the company's future, Stata prefers to call it "icing on an otherwise very delicious cake."

While Analog Devices is making a substantial commitment to the DSP market, it is not a make-or-break-the-company thrust, declares Jerald Fishman, Analog's components group vice president. "It could be 10% to 15% of our business, but it's not going to be 40%," he predicts. In five years, he says, "DSP could be a $100 million business, but by then we expect to be a billion dollar company."

The DSP market appears to be fragmented, and parts of it will require more custom and high-end products, predicts Fishman. "Those are the parts of the market we will gravitate toward," he says. "If that doesn't happen, we won't be in the business."

Texas Instruments and most of the other leading chip makers have leaped into the DSP business. And in a worldwide market that some forecasters predict will hit $1.5 billion by the end of the decade, Analog Devices expects to corner only about $10 million in sales this year with its 20 DSP products.

**STATA:** Driving harder than ever to make Analog Devices more competitive.

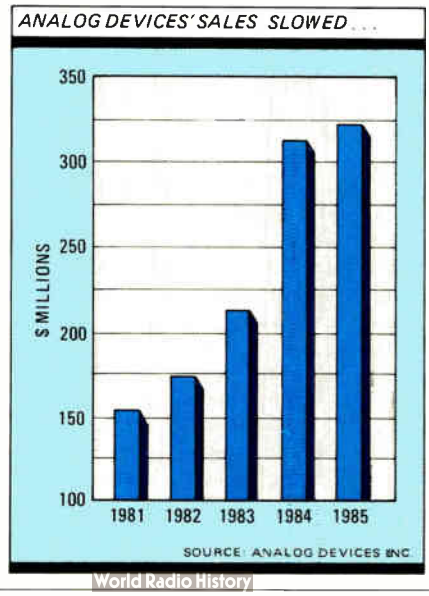
And even if it fails in the DSP market, Analog's investment will yield dividends, predicts Stata, because the work is synergistic to Analog's core business of data acquisition. And the next big plays in data acquisition, he says, are in factory and laboratory automation—applications that require mixed signal processing, both analog and digital. "That's the place where Analog really wants to make sure it wins," Stata notes.

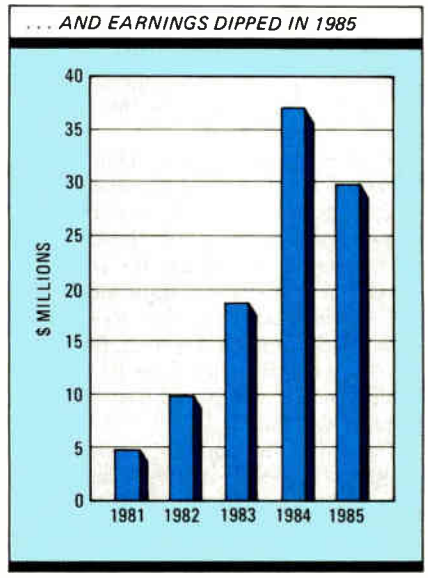
The conservative product strategy has paid off in recent years, even during the semiconductor industry depression over the past year. Analog came through it relatively unscathed. The year-end tally showed a slight increase in revenue to $322 million and only a modest drop in earnings to $29.7 million.

Analog has come as far as it has largely by virtue of its analog-to-digital converters, not a highly competitive business and one in which no single company competes with Analog across its broad product line. "It is really good at designing, making, and testing devices that no one else can make," says Timothy Allen, industry analyst at Eberstadt-Fleming Inc. "A lot of the products that Analog sells, there's not enough value for a National or Texas Instruments to get into."

Although an upturn is now under way in the semiconductor business, Analog management—led by Stata—is driving harder than ever to tighten the company into a more competitive operation. This includes a broadening of product lines into what the company considers important and profitable niches that exploit its analog chip-design capabilities, such as DSPs. A major corporate thrust is also under way to cut product cycle time from an average of 36 months to 39 weeks. And the company is also shifting its emphasis from product development to process development. Analysts view these efforts as akin to scrubbing a very clean house. Stuart Johnson, a vice president of research at Wertheim and Co., New York, credits management with a "well thought-out strategy."

The company is currently under growing pressure in its core business of analog-to-digital converter chips from customers who want more and more interfaces on board. This creates requirements for more logic on chip, something that is not compatible with the processes required for analog conversions. The



**FISHMAN:** Analog won't go toe to toe with a semiconductor giant in commodity chips.

competing demands have led to Analog's emphasis on a combination bipolar and CMOS technology that provides for both needs.

Between 1980 and 1985, Analog sales more than doubled (charts, p. 51), but this growth was far below what the company had earlier projected for itself. While noting that the growth rate remains among the highest in the business, Stata blames a combination of three semiconductor recessions in five years and internal mistakes for the failure to reach his more optimistic targets.

Internal mistakes were made in diversification efforts, says Stata. The main driver here was Analog Devices Enterprises, a joint venture-capital company set up with Amoco Corp. to locate and exploit technology developed by start-ups. Though this represented the continuation of an important Analog tradition—the company got into the integrated-circuit business by bankrolling and later incorporating a startup—ADE's 10 ventures have not yielded the expected return on investment.

Stata says the original plan was to affiliate with companies far along in development. But the hot venture-capital market priced many of them beyond ADE's reach. In linking up with less-developed companies, Stata says, "We are forever learning the lesson that even though electronics is a fast-paced industry, it still takes 7 to 10 years to enter a new business and have it impart significant results."

The other miscue in diversification came in systems. Analog planned its Macsym measurement-and-control work station for such uses as laboratory and factory process control, before IBM Corp.'s Personal Computer changed the entire structure of that industry. The Macsym included a computing platform and operating system, features rendered irrelevant by the ubiquitous PC.

Analog also learned the hard way that a sales team geared to selling components is not necessarily the best for selling systems. But the company has now pared down the Macsym to PC-compatible board-level products, dubbed the μMAC series. Stata says the boards can be marketed successfully and that Analog will release a second generation as it phases out the complete work stations.

The failure to grow at projected rates curtailed some plans for the future. "You pull in your flanks and become less opportunistic," says Stata. "We won't take chances at the margins until we know clearly where we are." At the same time, he adds, "We don't want to become a conservative company.... We'll be less inclined to start new businesses, but we will take risks in our core business."

**SPENDING CHANGE.** Another important shift involves the emphasis on process development. As recently as 1984, some 70% of Analog's research and development funds went for product development. Now 50% is spent on process development. Fishman says the company recognized that this area is as important as product development in getting a device to market. A byproduct of the process push, he says, is that it "creates barriers to others entering the market, because the analog processes are very difficult."

Product development has not been abandoned, of course. A campaign to shorten product-cycle time is now in its second year. Already, the new-product cycle has been reduced to about 18 months, half the time of past years but still short of the 39-week goal. "We've taken out the easy part, the fat," says Fishman. "The last nine months are the toughest." To make further reductions means trimming manufacturing times, he says, since a new product might go through two or three manufacturing cycles before it is ready for market.

The company is also pushing hard to improve its on-time product delivery performance, something Fishman acknowledges that Analog was too casual about in the past. "As the market gets more mature, customers are less willing to put up with late deliveries," he says.

Essential to all these management and operational changes is a sense of urgency among employees, maintains Stata. "It comes down to believing that we are truly in a race for some important long-term goals and with some good athletes that we can't take for granted or push aside whenever we want," he says. *–Craig D. Rose*

## BOTTOM LINES

### ENGINEER HIRING MAY BE LEVELING OFF

After climbing to its highest level in a year in January, demand for engineers and scientists eased in February, suggesting that "there may not be enough momentum in technical hiring at this time to sustain a strong, long-term upward trend." So says Deutsch Shea & Evans Inc., a recruitment advertising arm of Foote, Cone & Belding Communications Inc. in New York. Deutsch Shea has been conducting research on employment since 1950. Demand for engineers and scientists dropped from January's rating of 128 to 119 in February on the New York company's index.

### RETAIL PC SALES DOWN IN FEBRUARY

Personal computer makers that were hoping for better business got some bad news last week. Retail sales of personal computers in the U. S. declined in February, with unit sales down 27% and dollar sales off 31% from January. So says InfoCorp, the Cupertino, Calif., market research company, which added that February's retail dollar volume "was the lowest it has been in over a year." Counting February's 134,900 units, sales volume so far this year totaled 315,300 units, down 11% from 355,800 units in the same two-month period last year. Apple is the unit leader in the first two months of this year with 29% of the market, down from last year's 39%. IBM Corp. has 27% of the year-to-date revenues, versus 30% last year.

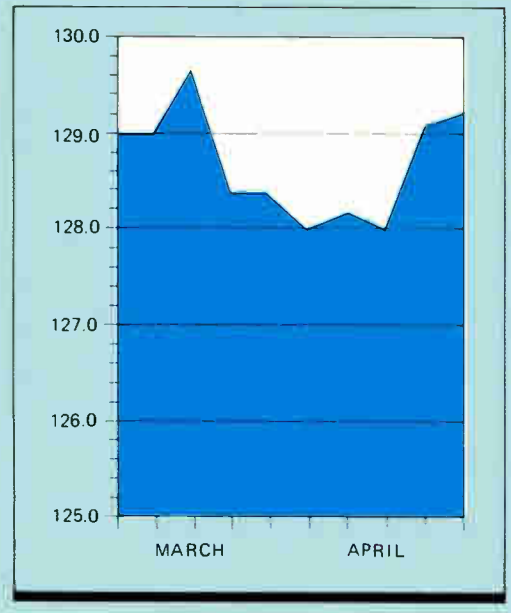
### STRONG GROWTH SEEN FOR TAPE DRIVES

The outlook is good for data-cassette and data-cartridge tape-drive suppliers. The market for these products should reach $1 billion by 1990 from 1985's $438 million, says Freeman Associates Inc., the Santa Barbara, Calif., research company that tracks the tape-drive industry. "Quarter-inch cartridge streaming-tape drives will be the big winners," the company says, with shipments of these units growing at a 23% rate from 1985's 410,000 units to 1,150,000 units in 1990.

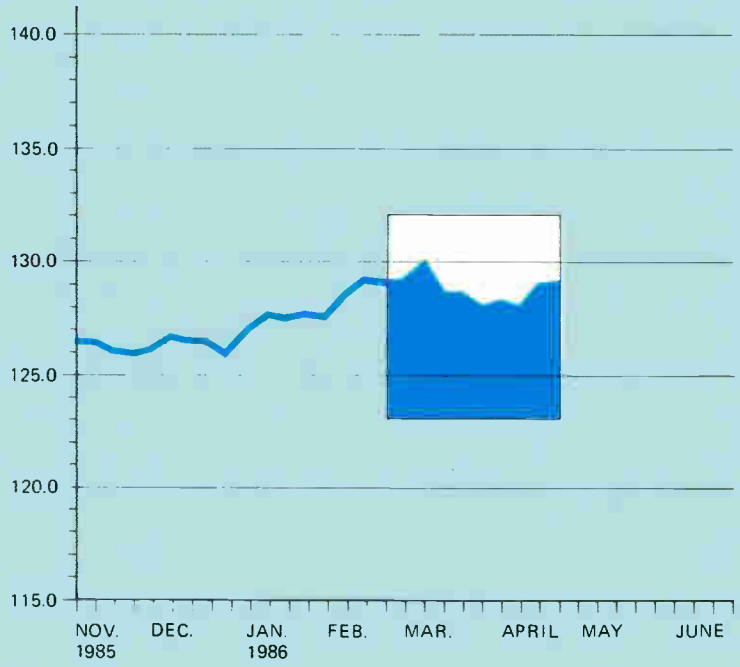
### NEW TEXET FUNDING YIELDS $7.2 MILLION

Texet Corp., a maker of electronic publishing systems, raised $7.2 million through a fourth financing. The Arlington, Mass., company said this brings its total capitalization to more than $17 million since its founding in 1982.

## ELECTRONICS INDEX




THIS WEEK = 129.2
LAST WEEK = 129.1
YEAR AGO = 127.7
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 COMPONENT-PRODUCER PRICE INDEX

| | March 1986 | February 1986 | March 1985 |
|---|---|---|---|
| Digital bipolar integrated circuits | 62.1 | 62.1 | 60.3 |
| Digital MOS ICs | 31.8 | 31.8 | 40.7 |
| Linear ICs | 58.1 | 57.9 | 60.6 |
| Capacitors | 184.9 | 185.3 | 190.8 |
| Resistors | 192.6 | 194.1 | 188.0 |
| Relays | 313.2 | 313.1 | 312.6 |
| Connectors | 238.0 | 237.0 | 233.4 |

## U. S. GENERAL ECONOMIC INDICATORS

| | March 1986 | February 1986 | March 1985 |
|---|---|---|---|
| Average prime rate (%) | 9.10 | 9.50 | 10.50 |
| Retail sales ($ billions) | 116.556 | 117.454 | 111.941 |
| Unemployment rate (%) | 7.1 | 7.2 | 7.2 |

March was another good month for component manufacturers: overall prices in the U. S. edged upward for the second straight month. Of the six product categories tracked, prices for two moved up slightly, three remained steady, and one slipped a bit, resulting in an overall 0.1% gain for the month. As a result of the component price increase, the *Electronics* Index rose fractionally last week.

Connectors led the pack in March with a strong 0.4% price increase. Connector prices are now 2% higher than this time last year, the industry's best year-over-year gain. Prices of linear integrated circuits also improved in the month with a 0.3% advance. Though this rise was not nearly as good as February's 1.4% gain, it was quite vigorous compared with some of the price plunges witnessed by the industry in recent months. Following big price gains in February, makers of digital bipolar and MOS ICs were stuck with stagnant prices in March. Relay makers, who haven't had a price rise in six months, saw prices remain level once again.

# IBM'S HENRY: COMING UP WITH A 'FRIENDLIER' PC

**AUSTIN, TEXAS**

Glenn Henry has a gut feeling there's some kind of breakthrough possible that will make the personal computer a lot easier and more fun to use than it is now. This in turn, he believes, would create an explosion in the use of computers. Most people would find it difficult, if not impossible, to find the time to follow up such a hunch, but Henry is something else.

**G. GLENN HENRY:** He's trying to make a PC easier and more fun to run.

He was named an IBM Fellow a year ago, following his role as a prime mover in the development of IBM Corp.'s RT Personal Computer. As a result of his gut feeling, the 43-year-old native of the San Francisco Bay area is devoting his Fellowship project to changing the way users and personal computers interact. His hunch is that video recording technology could play a major role in this breakthrough, but he doesn't know how or in what form. This is what he wants to find out.

What started Henry on this line of thinking was the realization that many people who use computers on the job often are unhappy with this work. So he started on a search for a new way of communicating with PCs—using some video, audio, or other computer interface rather than just a keyboard and video monitor. "I've always worked in systems development, but technology is maturing to the point that we are now asking more fundamental questions," he explains. "The question I have posed is, what will you be doing in a couple of years with 20-mips processors, optical disk, and whatever all sitting on your desk? What are the applications for the users of this technology?"

The origin of Henry's questions was the reaction of users to programs he wrote for his wife's business. He thought he had written some pretty good code for the PC, but many of the users were dissatisfied. At about the same time, something else caught his attention—the audio-video craze. "There is another world alongside computers that is technology-driven and very pervasive. There is an explosion going on in audio and visual markets with the likes of compact disks, low-cost television cameras, and higher-quality TV monitors," Henry says. "We [the industry] sell more television cameras and VCRs than personal computers in the U.S."

So the angle Henry's project team is taking comes "from the viewpoint that hardware technology is here. Just building bigger, faster, cheaper PCs is not going to be the answer to increasing the user base."

This is a turnaround for a man whose career has been in research and development to increase the power of hardware and software. He joined IBM in 1967 with an MS in math from California State University, Hayward. After managing a number of software and computer projects during the 1970s, he moved to Austin in 1980 to manage the Laboratory for Office System Strategy and Architecture.

In spring 1982, Henry headed an advanced-technology group attempting to create a technical work station based on a reduced-instruction-set-computer microprocessor and a new memory-management chip then under development. In May 1983, the work-station project became an official product thrust as IBM looked to enter a new market, and Henry became software manager for the system that later emerged as the RT PC.

To Henry, the challenge over those four years was to ensure that the RT PC stayed on track and in the same direction the market was headed. "Remember, the PC at the start of this project in 1982 had not yet taken over the world," says Henry. "We began seeing a tremendous change in the customers, their requirements, and competitive products. Developing a product in parallel with that climate, making sure it was positioned where customers were going, was a brand of excitement." *–J. Robert Lineback*

# HENDY'S LAST-DITCH TRY TO SAVE TEXET

**ALLEN, TEXAS**

It was the kind of day that all technology entrepreneurs fear, and for Jeff Hendy it came without warning. That was the day two weeks ago when Hendy, the president of Texet Corp., a four-year-old power-semiconductor maker in Allen, near Dallas, suddenly had to pull the plug on his company.

The reason was that General Instrument Corp. unexpectedly backed out of what looked like an almost certain acquisition. Now Hendy and several other unpaid executives expect to make a last-ditch attempt to revive Texet with a transfusion of new capital.

For the British-born Hendy, it was a particularly frustrating development. He had joined the fledgling company in 1982 after 21 years at nearby Texas Instruments Inc. Hendy, 50, one of Texet's six founders, thought the company was on its way out of Chapter 11 financial reorganization. Since the end of 1985, GI had

## PEOPLE ON THE MOVE

**STANLEY REICH**

☐ Fiber-optics components manufacturer Math Associates Inc., Westbury, N.Y., has named Stanley Reich director of engineering. For the last four years, Reich was vice president for new product development and director of research at Bulova Watch Co.'s Electronics Division. He has worked in designing laser- and fiber-optics-based systems for 30 years.

**ROBERT C. ENRIGHT**

☐ The Avnet Technology Group, Peabody, Mass., has appointed Robert C. Enright to the position of executive vice president of operations. He was vice president and general manager of the Commercial Interconnect Division at ITT Cannon Electric in Canada.

**DANIEL YORKE**

☐ Materials Research Corp. has promoted Daniel Yorke to corporate vice president. Yorke, who has been with the Orangeburg, N.Y., company since 1979, was general manager of the Process Equipment Division, which manufactures sputtering and etching equipment for the semiconductor industry.

**JAMES D. NORROD**

☐ CGX Corp., an Acton, Mass., work-station vendor, has appointed James D. Norrod president and chief executive officer. Norrod had been vice president of sales for Auto-trol Technology Corp.; before that, he spent 10 years with IBM Corp. in a variety of marketing, sales, and management positions.

**ANTHONY J. CHERNOSKE**

☐ GTE Government Systems Corp. has named Anthony J. Chernoske general manager of its Advanced Semiconductor Center, which processes extremely high-density, super-high-speed integrated circuits. He had been director of operations for Commodore Ltd., Costa Mesa, Calif.

**JEFF HENDY:** Searching desperately for survival capital.

been keeping Texet going with a development contract aimed at continuing work on new smart-power MOS FETs.

The day the proposed acquisition fell through, Texet was immediately shut down. Parts were left partly finished on Texet's production lines, and 65 employees went home.

"Letting key technical people go is a hard thing to do," says Hendy. "On one hand, you are trying to look out for the company, but from the personal point of view, you understand the fact that these guys have to make a living."

Texet, backed originally by French investors (there is no relation to the similarly named electronic publishing systems house in Arlington, Mass.), had been attempting to break into power-semiconductor markets with a triangular-shaped MOS FET cell design called Trimos. With plants in Texas and France, it had planned to start off with an older technology, bipolar discrete devices. The revenue from sales of discretes was earmarked to finance a move into smart-power devices [*Electronics*, June 30, 1983, p. 53].

**TOO MUCH TOO SOON.** But the task of simultaneously starting up two plants a world apart and developing two technologies proved too much for the young company. Hendy, then vice president of marketing at Texet, had favored a delay in the French plant. Shortly after becoming president in 1985, he refocused the company more heavily onto its long-term smart-power objectives.

"That was working, and we made significant gains in product development and production yields," says Hendy. Texet's French investors encouraged the company to court a large U.S. corporation for additional funds and a possible acquisition. General Instrument seemed to be a perfect match because it had expressed interest in the same types of products Texet was pursuing.

So Hendy's team narrowed its efforts to find new capital and had rebuilt Texet's work force to 65 after trimming the payroll to 35 late last year. The company had started promoting its new catalog of power products only a few days before GI called off the deal.

Hendy expects to hold many meetings with the company's leading secured creditor, MBank Dallas NA, in an effort to keep Texet under the protection of Chapter 11. If unsuccessful, he says he may have no choice but to liquidate the company.

If he could do it again, Hendy would still join Texet, but he'd do things differently. "Start off in a much smaller way and try to do it with much less debt so you are more in control of your destiny."

The destiny that took Hendy to Texet started with his joining TI at its UK headquarters in Bedford, a little over a year after graduating with a bachelor's degree in electrical engineering at the University of Southampton in 1961. He first worked as an engineer on small signal devices, then shifted to power semiconductors when he transferred to Dallas. In the mid-1970s, Hendy became marketing manager for TI's Latin America Division, handling all the company's products except consumer electronics in the Southern Hemisphere.

"It would probably be hard to go back to a TI or large company," Hendy admits. "I'm not really exploring my own options at this moment because I'm still trying to save this company. It will probably take two or three weeks to see if it is feasible."

But Hendy is keeping his sense of humor. Adopting the attitude of L. J. Sevin, the Dallas venture capitalist and Mostek Corp. founder, he says, "Once you've been a god, it's hard to go back to being a prophet." *–J. Robert Lineback*

# NEW PRODUCTS

# CIM SOFTWARE NOW HANDLES CHIP MAKING AT MANY SITES

## PROMIS ALSO ADDS REAL-TIME SCHEDULING, BETTER COST ACCOUNTING

Promis Systems Corp.'s latest release of its computer-integrated-manufacturing software lets users know exactly what is happening at their wafer-fabrication sites immediately, even if the sites are geographically dispersed. This software gives a boost to materials requirements planning, an increasingly popular technique for managing a company's resources.

In addition to multisite reporting capability, Release 4.2 of the Process Management and Information System (Promis) adds factory-floor scheduling, better cost accounting, dynamic quality-control charts, and task management. The overall planning system has been enhanced, and an optional module called Scope adapts the software to fully automated fab facilities.

The system is targeted at semiconductor manufacturers, but "we will be moving to printed-circuit-board manufacturers," says Henry Watts, vice president of semiconductor systems.

With Promis, a real-time shop-floor-management system, managers can get information on production performance, product availability, and accounting, all the way down to the lot level. Unlike competing systems, which are collections of independent packages, Promis is an integrated software system with extensive planning, tracking, engineering analysis, reporting, and automation capabilities. Optional modules are designed to be seamlessly added.

The Promis architecture is designed for a variety of semiconductor-manufacturing automation applications, from local control of selected processes using a Digital Equipment Corp. MicroVAX II computer to full automation of multiple plants using several full-size VAX computers. Process engineers can use Promis to change processing instructions; managers and sales staff can use it to optimize delivery to customers' needs. On the factory floor, Promis's extensive reporting capability tracks all activity and provides data on productivity, yield, cycle time, and inventory. Individual automation modules are available for a variety of process equipment.

**AROUND THE WORLD.** With Release 4.1, Promis can support manufacturing at many sites simultaneously, even when plants are in different countries. The new scheduling module automatically develops optimum lot-processing schemes for each fab line. The enhanced cost accounting includes multisite support using worldwide or local standards, with both wafer and die cost information, and it provides more precise cost data than the previous version.

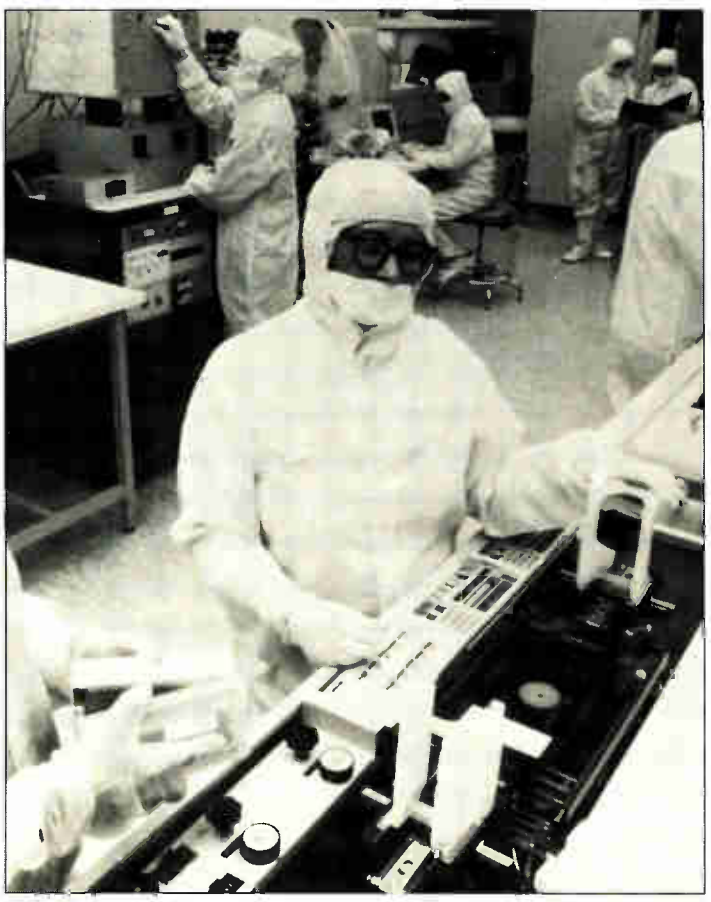
Real-time statistical quality-control charts are available to provide instantaneous data on process measurements and yield. Other new reports are available, covering lots in transit, customer shipments, and faulty equipment.

A new task-management system module helps in schedule maintenance and similar activities. The ability to track both lot-related data and general data (such as equipment or personnel) expands Promis's ability to document any event that could affect productivity.

LSI Logic Corp. is using Promis and will be one of the first to use the multisite capability, which will link all three of its facilities. "I'm quite positive on it," says William Jensen, manager of computer-aided manufacturing systems at the Milpitas, Calif., gate-array company. "It is one of the most professionally written and professionally supported pieces of software around. It doesn't do everything, but it works. It does all the things we need in work-in-progress tracking. It lets us track material throughout the factory reasonably accurately."

A typical Promis package goes for about $350,000—roughly 40% less than such competing systems as the Comets system from Consilium Associates Inc., Mountain View, Calif. Exact prices, which depend on the size and configuration of the facility, range from $138,000 to about $700,000, excluding computers.

Scope, an architectural extension to Promis, provides a well-planned pathway toward future equipment automation. It simplifies the development of equipment interfaces, and it addresses the need for a more cost-effective inter-



**AUTOMATION.** With the Scope architecture extension, Promis Systems' CIM software will be able to work with fully automated wafer-fabrication lines.

face implementation, Watts says.

Scope supports the Semiconductor Equipment Communications Standard for factory automation and accommodates custom communications protocols. If the Manufacturing Automation Protocol, Ethernet, or DECnet gain in popularity, these protocols could easily be added.

The standard Promis system consists of several modules: work-in-progress tracking, engineering data collection, specifications, data analysis, standard reports, inventory management, and equipment management. The optional modules are a corporate planning system, a factory-floor scheduling system, a manufacturing performance system, standard cost accounting, dual machine networking, facility monitoring, a data link, a task-management system, multisite networking, multipart assembly, and the Scope extension. Release 4.1 is available now. *–Steve Zollo*

Promis Systems Corp., 4699 Old Ironsides Dr., Suite 300, Santa Clara, Calif. 95054. Phone (408) 748-9822 [Circle reader service number 338]

# LOW-COST PICTURE PHONE MAY SPARK BUSINESS USE

A still-frame picture telephone from Luma Telecom Inc. may have a low enough price to get the market moving. Called Luma, the phone costs $1,450 each and works on the public switched telephone network without any additional equipment, wiring, or special lighting. All that's needed for two-way use is a picture phone on each end of the line. And the picture phone still works for voice communication with a regular phone, if that's all the other party has.

**SHOW AND TELL.** With a wide-angle lens, users can transmit business charts and graphic information.

The phone holds a ½-in. vidicon-tube camera and a 3-in.-diagonal display screen in a case that measures 12 by 11½ by 9¼ in. The screen can simultaneously display two snapshot-size images: one a closed-circuit image of the person using the device, the other a freeze frame of the last image received. Or it can show a full-screen version of only the still picture being received. Transmission of the still picture is entirely within the subject's control; a sliding panel can be used to cover the camera when privacy is desired. And with a forthcoming wide-angle lens, users can show documents, charts, or visuals instead of themselves.

Picture telephones have been slow to gain commercial acceptance, primarily because of their high cost. But the Luma phone, which is targeted at businesses, has a price comparable to what business users are willing to pay for sophisticated electronic typewriters and low-cost personal computers.

Luma's phone is considerably less expensive than a recently introduced still-frame picture phone from Robot Research Inc., San Diego [*Electronics*, Aug. 15, 1985, p. 31]. At $4,990, that company's model 3012 can transmit black and white frames in 8 or 16 seconds, but at a resolution of 256 by 256 pixels and 64 gray-scale levels on a 12-in. screen. Also, the 3012 requires a separate camera.

Though Luma's screen resolution is only 70 pixels/in. with 16 levels of gray, it is adequate for the purpose, says Larry Emmons, director of research and development. "A snapshot photo in a newspaper is not as high in resolution, but it carries information and is acceptable. In the same way, we weren't trying to build a high-resolution data-compression device or a fancy facsimile machine. We designed the Luma to be a cost-effective personal communications tool and this required some strategic compromises along the way," he says.

To send a picture with Luma, the user frames an image of himself in the live-action portion of the screen, then presses the send button. This freezes the image and stops voice transmission until the image transmission is complete. Users can send three different picture sizes, so transmission time of an image varies from 1 to 5 s. The company says that its tests show users were not uncomfortable with the voice delay, even at the full 5-s transmission time.

**VIDEO MODEM.** The important compromise struck by designers was the trade-off between resolution and transmission speed. Luma takes a traditional video rather than digital approach to the problem of transmitting video images over the limited bandwidth of voice-grade phone lines. Eschewing high-resolution pictures requiring high bit-transmission rates and expensive compression techniques, designers opted for a lower resolution using fewer bits. To meet this design goal, they implemented a video-optimized modem using standard gate-array technology. Though he is tight-lipped about design details, Emmons does say that modem circuitry accepts a higher rate of errors than could be tolerated in a digital data device while still delivering pictures of acceptable quality.

Emmons says the lessons from the early days of TV inspired its design: people are more concerned about getting information than they are about getting it with high resolution.

Another important component of the design is the custom image-control processor, which functions much like a TV display circuit. It controls signal output to the screen, handling pixel mapping and the control of gray levels.

Luma's picture phones are available now. *–Robert Rosenberg*

Luma Telecom Inc., 3350 Scott Blvd., Building 49, Santa Clara, Calif. 95054. Phone (408) 970-9555 [Circle 340]

# AN OPTICAL ENCODER THAT SAVES TIME AND MONEY

Many equipment makers typically build their own motor-shaft encoders to save money and time. Now Hewlett-Packard has developed an optical incremental encoder that it claims is so easy to use and mount—and is so inexpensive—that it will attract roughly half those companies that now build homebrew units.

The HEDS-9000 series is aimed at such high-volume, price-sensitive markets as printers, plotters, and copiers. It sells for $20.50 each and is available now. The price drops to $8 in lots of 10,000 pieces, much less than what many homebrew units cost, HP claims.

The HP optical-incremental encoder is

# The world's most advanced

# CMOS macrocells have arrived.

## Introducing a state-of-the-art selection of standard cells, including a 32-bit slice μP.

You can now design ASIC systems-on-a-chip using a library of CMOS LSI standard cells. Included are the world's first 16-bit and 32-bit bit-slice processor cells, EPROMs and peripherals. All manufactured using a 1.2 micron channel length CMOS process.

The LSI cells were developed by WaferScale Integration Inc. (WSI) and will be alternate sourced by RCA. WSI will also offer RCA's CMOS standard cell library.

**First 32-bit bit-slice processor cell.**

The 32-bit CMOS CPU cell replaces eleven discrete bipolar ICs. It beats the performance of the 2901C bit-sliced-based system by 20% and saves 97% of the power, yet it is software compatible.

The 16-bit μP slice cell runs faster than bipolar speed, and replaces five off-the-shelf bipolar devices. Without rewriting microcode. Without adding glue parts.

The 4-bit μP slice cell is functionally identical to the bipolar 2901 4-bit slice, yet runs 25% faster. You can replace the bipolar part directly for instant improvement in system performance and power consumption.

Each μP is available as a cell in the library or as a standard IC.

**CMOS EPROMs.**

Another new LSI cell is a 1K x 16 CMOS UV EPROM with 55ns access time. Providing on-chip microcoding capability, this cell interfaces with 8-bit, 16-bit or 32-bit buses. An intelligent algorithm allows fast programming, achieved within 4 seconds. The EPROM cell uses only 20 μA in the standby mode and only 15mA in the active mode.

And it's also available as a 70ns 8K x 8 standard EPROM in 28-pin ceramic DIP or 24-pin bipolar PROM footprint...at very competitive prices.

**Complete standard cell library.**

The WSI cell library has been combined with the RCA library of over 300 verified cells to give you a very broad choice of LSI, MSI and SSI standard cells. Our CAD tools are extremely advanced and user-friendly. Our software supports all of the major workstations: Daisy,™ Mentor,™ Valid,™ even the IBM PC.

With our small geometry CMOS technology, you can reduce an entire PC board of capability onto a single ASIC chip. You benefit with smaller power supplies, lower system cost, smaller system-level boards and higher system reliability.

Working through one of our design centers, you get fast, accurate service. Simulation and testability steps built into the design flow allow us to achieve almost 100% first time success.

**Data base scaling upgrades without redesign.**

Your design can take advantage of next generation 1-micron CMOS geometries without redesign. So you'll sit back and watch your ASIC get faster all the time.

**High Rel, too.**

These standard cells are also characterized over the full military temperature range.

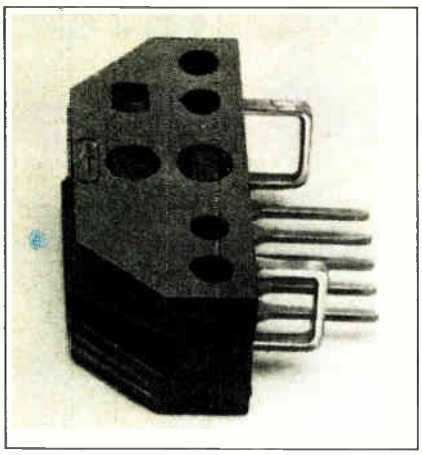
**Choose your source and call today.**

For more information, or to get started on your design, call your RCA or WSI sales office or design center today.

WaferScale INTEGRATION, INC.

RCA

Circle 59 on reader service card



**PRICE SENSITIVE.** At $8, HP's encoder will be attractive to makers of low-cost peripherals.

a small C-shaped plastic module. Competing modules are completely round metal-encased units.

The module incorporates a lensed LED emitter and a detector IC. When operated with a code wheel, it translates the rotary motion of a shaft into a two-channel, digital quadrature output. The HEDS-9000's quadrature states typically vary by a maximum of 5°.

The LED's light is collimated into a parallel beam by a single lens located directly over the LED. Opposite the emitter is the detector circuit, which consists of multiple sets of photodetectors and signal-processing circuitry. This arrangement permits the unit to be misaligned without losing signal integrity. Such high tolerance for variation avoids complications of signal adjustment, with its requisite oscilloscope test setups.

As a result, the module is easy to assemble and mount, and therefore low in price. Competing encoders require that a mechanical phase plate be aligned with the LED, detector, and code wheel. The HEDS-9000's photodetector has a pattern that matches the code wheel.

Initially, the module will be available with standard resolutions of 500 and 1,000 counts per revolution for use with the HEDS-6100 series code wheel or equivalent, and 360 and 500 counts per revolution for use with an HEDS-5100 series code wheel or equivalent. The user customizes the complete encoder by selecting a code wheel and external housing to use with the HEDS-9000. Users can also use their own code wheels.

The quadrature signal is guaranteed over −40° to +100°C and has a frequency range up to 100 kHz, compared with the 10-kHz limit of many competing systems. *–Steve Zollo*

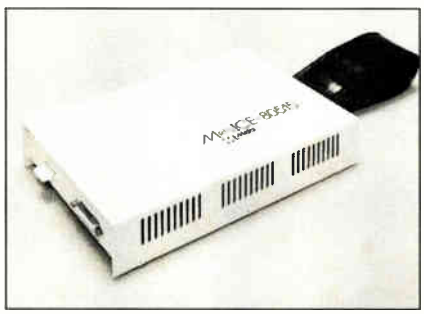
Hewlett-Packard Co., Inquiries Manager, 1820 Embarcadero Rd., Palo Alto, Calif. 94303. [Circle 339]

## EMULATOR BOWS FOR SIEMENS' 50515 CHIP

An in-circuit emulator for developing and debugging programs for Siemens AG's new SAB 50515 one-chip microcomputer plugs into any IBM Corp. Personal Computer or compatible machine. The MetaICE-80515 emulator, the first system to support the Siemens chip, has a menu-driven interface that is fault-tolerant and simple to use, says its maker, MetaLink Corp.

Using a standard RS-232-C interface, the emulator performs real-time, transparent emulation from 1.2 MHz up to the maximum 12-MHz operating frequency of Siemens's 80515 chip. Other features include 4,000 trace frames with start/end/center trigger points, up to 64-K pass counts, and 64-K bytes of emulation memory for both program and external data memory.

The emulator box offers separate mapping of program and data memory



in 16-byte blocks, support for all four of the 80515's operating modes, and 15 functional breakpoint or trace-trigger conditions.

An assembler, the MetaWare-ASM51, that fully supports the 80515 chip is also available.

The emulator is priced at $4,995 and is available now.

MetaLink Corp., 33 W. Boxelder Pl., Suite 110, Chandler, Ariz.
Phone (602) 926-0797 [Circle 341]

## DOT-MATRIX PRINTERS RUN AT 200 C/S

Two dot-matrix business printers that stress speed and flexibility offer a dual-nine-pin printhead. The head's staggered vertical-pin configuration permits the placement of fully overlapped dots for clean output of nearly letter quality. In the utility mode, two columns of nine pins alternate for diminished wear on the printhead, producing 200 characters per second. In the near-letter-quality mode, the rate is 100 c/s.

The Okidata 290 series accepts a broad range of paper types, from single-sheet, hand-fed letterhead to four-part continuous forms up to 0.014 in. thick.

Options include single-sheet and tractor feeders, and a 32-K byte buffer that, when added to the unit's integrated 8-K buffer, provides about 20 pages of text-storage capacity.

The family's 292 and 293 machines can emulate an IBM Corp. 5152 graphics printer with the addition of a personality module. Bit-image graphics are created at a density of 288 dots/in., and 46 different typefaces can be created from the two resident character sets that include superscripts and subscripts.

The 292 sells for $589; the wide-carriage 293 is priced at $789, and personality modules cost $110. The printers are being shipped now.

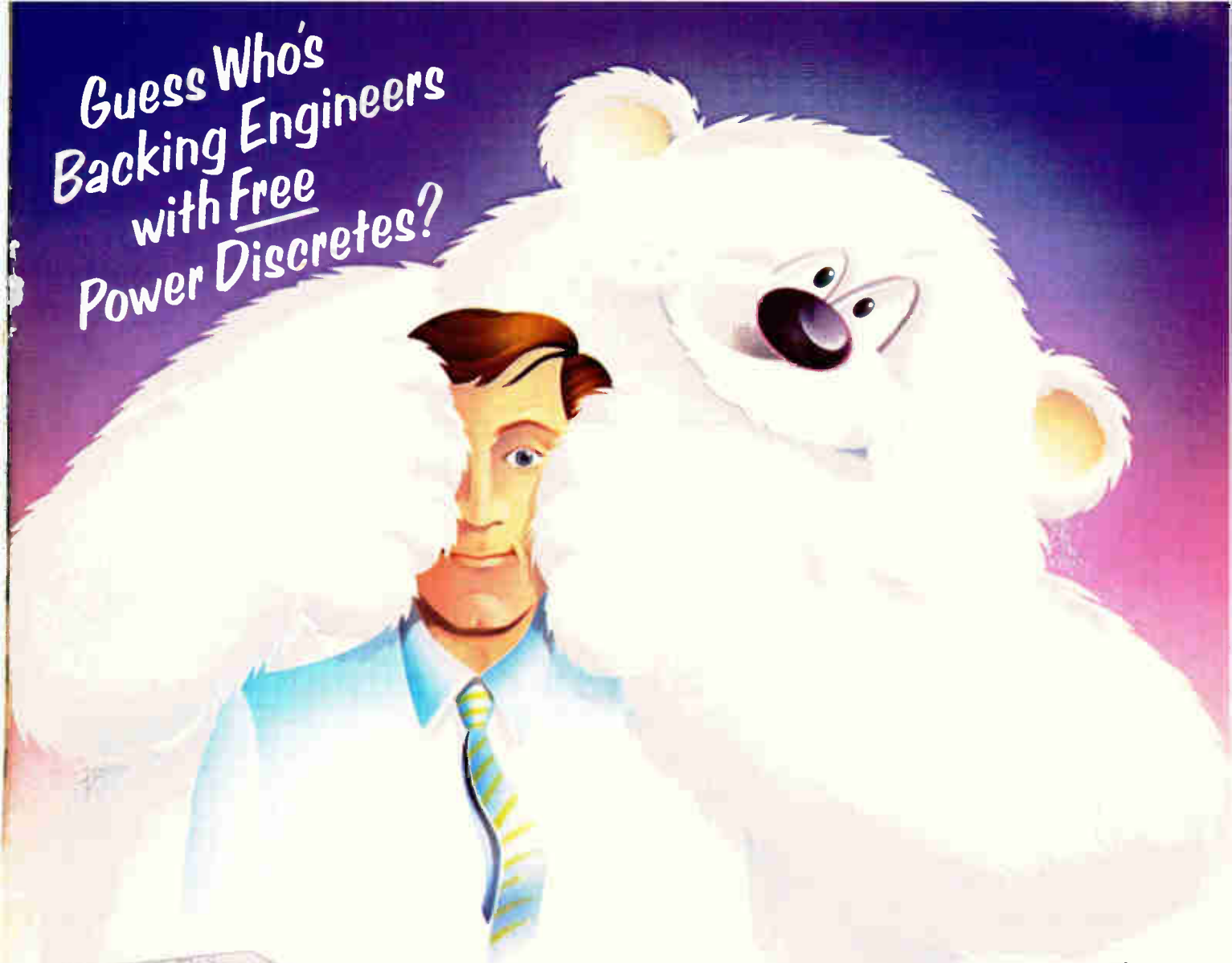
Oki America Inc., 532 Fellowship Rd., Mount Laurel, N. J. 08054.
Phone (609) 235-2600 [Circle 362]

## BACKUP TAPE HOLDS 536 MEGABYTES

With its capacity of up to 536 megabytes, the HP 35401A ¼-in. tape drive provides unattended backup for mid-range systems. Equipped with an autochanger mechanism, the drive automates cartridge loading and unloading and allows the use of up to eight cartridges from a removable magazine. Its primary use is as backup for HP 3000 and 9000 systems.

The HP 35401A is priced at $7,000 and

# Guess Who's Backing Engineers with Free Power Discretes?

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EL: 4/28/86 Offer expires 45 days from this issue date

will be shipped four to six weeks after ordering.
Hewlett-Packard Co., Inquiries Manager, 1820 Embarcadero Rd., Palo Alto, Calif. 94303. [Circle 361]

## CONTROLLER DRAWS 6 MILLION PIXELS/S

The Omega 3610, a graphics-display controller for minicomputers and mainframes, supports a displayable resolution of 1,280 by 1,024 pixels. The device draws vectors at the rate of 6 million pixels/s and fills rectangles at up to 160 million pixels/s. Its speed comes from the use of three lookup tables and a custom bit-slice processor.

Other features include portrait or landscape display orientation and independent text overlay. Each functional element of the controller is a separate board, and each board connects to a triple-bus architecture. The standard Omega 3610 comes with eight bit-planes, but by adding boards, configurations with up to 32 bit-planes can be created.

For development of applications software, the company has libraries available in C and Fortran.

Shipments began last month at prices ranging from a base of $16,950 to unit costs of $20,000 to $30,000 for a typical configuration. Quantity discounts are offered.
Metheus Corp., 5510 N. E. Elam Young Pkwy., Hillsboro, Ore. 97124.
Phone (503) 640-8000 [Circle 350]

## BOARD CREATES 16 MILLION COLORS

The V68K line of intelligent graphics boards is built around the 68010 processor and supports displayable resolutions of 1,280 by 1,024 pixels. The V68K+ has a palette of up to 16 million colors and a capacity of up to 2 megabytes of video RAM. The V68K has 4,096 colors and 512-K bytes of RAM. Either card fits a large slot in an IBM Corp. Personal Computer or compatible.

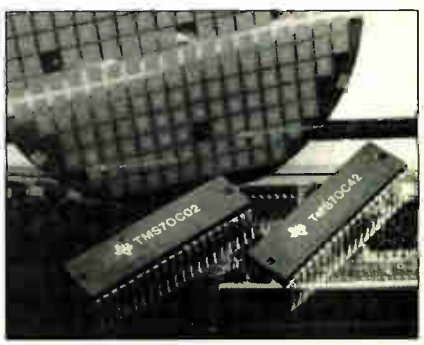
Palettes may be reloaded at every scan line with no degradation in screen performance. This means that more than a quarter of a million different colors can be displayed on a single screen.

Refresh rate is 60 Hz for both the V68K and V68K+, interlaced and noninterlaced, respectively. Both boards also do vector-to-raster conversion.

The V68K sells for $3,450 and the V68K+ for $7,450, and volume discounts are available. The graphics boards are available now.
Pacific Data Products, 8545 Arjons Dr., Suite I, San Diego, Calif. 92126.
Phone (619) 549-0136 [Circle 351]

## MICROCONTROLLER RUNS AT 6 MHz

For real-time control and communications applications, two CMOS chips operate at 6 MHz maximum. The one-chip TMS70C42 microcontroller and the TMS-70C02 microprocessor operate from a supply voltage of 2.5 to 6.0 V over −40°C to +85°C. The chips' noise immunity



suits them for use in harsh or low-power environments.

The maximum power consumption for both ICs is 120 mW when operating; in low-power mode, consumption drops to 16 mW. Other on-chip features include 256 bytes of RAM, a software-programmable serial communications port, and three timers. One timer, with 10-bit resolution, can also function as a continuous baud-rate generator.

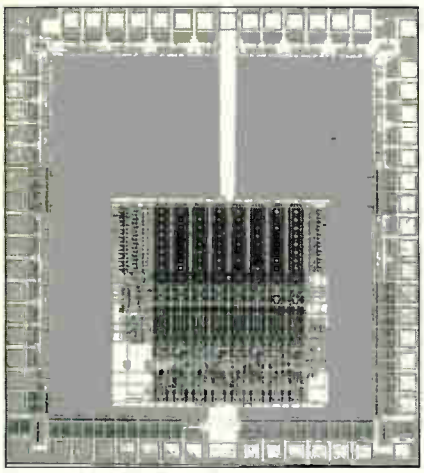
Interrupt handling is flexible, and two external interrupts provide software-programmable interrupt sensing for logic high or low. The microcontroller's RAM is available as general-purpose registers to reduce software overhead, thereby speeding interrupt response.

The TMS70C42 and TMS70C02 will be available in the second quarter in 40-pin plastic DIPs. The ROM-less TMS70C02 costs $8.75 in quantities of 100; the version with factory-programmed ROM, the TMS70C42, is priced at $7.95 each for orders of 10,000 pieces.

Texas Instruments Inc., Semiconductor Group (SC-606), P. O. Box 809066, Dallas, Texas 75380. Phone (800) 232-3200, ext. 7000 [Circle 354]

## BIT-SLICE PROCESSOR CAN BE CASCADED

The Am29C101 is a cascadable 16-bit microprocessor slice for achieving word widths of 32 bits or more. Because it is compatible with the Am2901 bit-slice's microcode, designers can use it to enhance Am2901-based systems.



In such enhancements, the CMOS Am29C101 reduces power consumption from 4 to 0.5 W and reduces the pin count from 172 to 64. These reductions lower system-design costs, the manufacturer says, and also save board space and increase reliability.

The Am29C101 is in production now in a 64-pin ceramic DIP, with plastic DIPs and plastic leaded chip-carrier packages to come later this quarter. In the ceram-

ic DIP, it costs $35 each in lots of 100. Advanced Micro Devices Inc., 901 Thompson Pl., P. O. Box 3453, Sunnyvale, Calif. 94088.
Phone (408) 732-2400 [Circle 355]

## FUNCTIONAL TESTER GOES FOR $30,300

A low-cost tester offers up to 272 digital channels for board-edge functional testing. The manufacturer claims that the model 100, at $30,300, is priced up to 80% lower than competing large automatic-test-equipment systems.

The model 100 simulates up to four independent card-edge interfaces operating simultaneously by means of its four programmable port simulators. Any port simulator can be used for bus-cycle emulation, microcomputer emulation, or custom timing-cycle emulation.

Cards that contain microprocessors can be fully exercised using a control

pod and Read or Write instructions. No modeling or simulation is required—the 100 will learn what the correct responses are from a good card or test pattern.

The base price of a system includes a universal test fixture. Available options include control pods for different microprocessors and various interfaces. Delivery takes about eight weeks.
Talon Instruments, 1910 D St., La Verne, Calif. 91750.
Phone (714) 596-1874 [Circle 369]

## IBM PC AT DRIVES BOARD TESTER

A benchtop board-test package based on the IBM Corp. Personal Computer AT lets technicians create board tests in as little as two days. The heart of the series 635 tester is a comprehensive software package that uses easy-to-follow status-at-a-glance menus. For high-level users, the 635 is equipped with advanced diagnostic tools and test-program modifications.

Test programming is based on the company's Chips language, and one of the software utilities translates test programs from other test systems by the same manufacturer into Chips. The test-sequence processor allows the user to program more than 24,000 uncompromised test vectors into a single test burst at 4 MHz.

A standard model 635 bundled with a PC AT, hardware, and software sells for about $50,000. The price of a test-execution model 635A, designed for remote locations, is about $35,000.
Factron/Schlumberger, 1 Fairchild Sq., Clifton Park, N. Y. 12065.
Phone (518) 877-7042 [Circle 360]

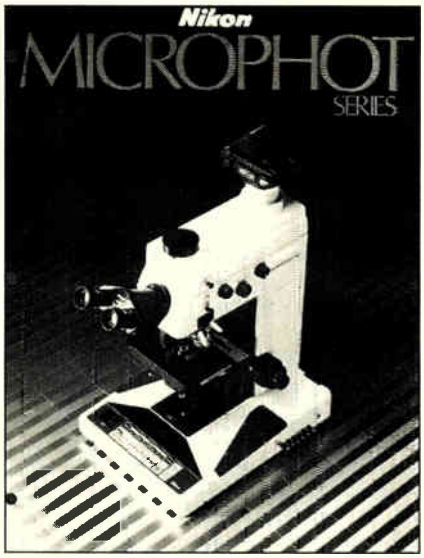
**TEST GEAR.** Marconi Instruments' 350-page catalog details its complete line of test instrumentation. Included are descriptions, specifications, illustrations, and ordering information on such products as signal generators, radio test systems, modulation meters, power meters, signal sources, sweep generators, counter timers, analyzers, and TV test equipment. A tutorial section precedes each major category of instruments; another section includes application notes on topics such as radio testing, microwave measurement, and telecommunications. For a copy of the catalog, call Marconi Instruments at (201) 934-9050 or write to 3 Pearl Ct., Allendale, N. J. 07401. [Circle reader service number 421]

**MACHINE VISION.** A free brochure, "Intelligent Vision Engines," describes a line of vision equipment for the Multibus and VMEbus for original-equipment manufacturers and end users. The vision engines consist of modules for image acquisition, storage, and processing by means of intelligent pipelined pixel processors. The literature also describes Rtilib, the software support for these modules, which consists of more than 300 callable subroutines. To receive the brochure, write to Recognition Technology Inc., 335 Fiske St., Holliston, Mass. 01746. Phone (617) 429-7804. [Circle 422]

**SAFETY LABELS.** Bulletin 1605 explains and illustrates Ashland Chemical Co.'s Infochem safety labeling system. Developed for the microelectronics industry, the labeling system gives color-coded information on product storage. The bulletin also displays symbols that furnish first-aid, protective-equipment, and fire instructions. To receive a copy, write to the company at P. O. Box 2219, Columbus, Ohio 43216, or call (614) 889-3333. [Circle 423]

**OEM PROGRAM.** A free brochure titled "It's good business to be in business with Versatec" describes the company's training programs; documentation; replacement-parts policy; sales, service, and information support; and quality assurance. Versatec Inc., a manufacturer of electrostatic plotters, processors, and software, will send a copy of the brochure to original-equipment manufacturers calling (800) 538-6477; in California, (800) 341-6060. The mailing address is 2710 Walsh Ave., Santa Clara, Calif. 95051. [Circle 425]

**MICROSCOPES.** A free color brochure details two microscopes that perform photodocumentation for scientific and industrial applications. The Microphot instru-




ment has a photoport mount for any of Nikon's FX-attachment cameras. The Microphot-FX is equipped with a built-in automatic-exposure photomicrographic system. To receive a copy of the eight-page brochure, write Nikon Inc., Instrument Group, Inquiry Response Center, P. O. Box 52, Oceanside, N. Y. 11572. [Circle 431]

**RUGGEDIZED VMEBUS.** For the systems integrator, a free brochure from DY-4 Systems Inc. describes the company's ruggedized VMEbus product lines. These are the SVME series, based on a double-Eurocard form factor, and the DVME family of extended 233-by-220-mm modules. The six-page brochure contains information on quality assurance, configuration management, environmental qualification testing, and reliability standards. Call the company at (613) 728-3711 or write to DY-4 Systems at 888 Lady Ellen Pl., Ottawa, Ont., Canada K1Z 5M1. [Circle 424]

**LASER MARKING.** Laser marking of metals, ceramics, plastics, rubber, coated surfaces, and other materials is the subject of an eight-page color brochure. "Evermark Laser Marking Systems" discusses uses of the model 815 laser for required coding on large and small parts during on-line production. On electronic components, the 815 creates codes that resist chemicals and soldering processes. Because it is a noncontact method, the laser will not harm substrates. Copies are free from Coherent General Inc., 1 Picker Rd., Sturbridge, Mass. 01566. Phone (617) 347-2681. [Circle 429]

**NEW STANDARDS.** The following standards have recently been released by the Electronic Industries Association and can be ordered by writing to the Standard Sales Office, 2001 Eye St. N. W., Washington, D. C. 20006, or calling (202) 457-4981:

"General Requirements for Distributors of Military Integrated Circuits" (JEP-109, $7) [Circle 426]

"Color Coding of Discrete Semiconductor Devices" (EIA-236, Revision C, $5) [Circle 427]

**PRODUCTS QUARTERLY.** The Technical Products Division of Data General Corp. has created *Technique*, a quarterly magazine illustrated in full color. *Technique* will cover major applications areas, with emphasis on their newsworthiness. Thus the lead story for the Winter 1986 issue describes how the Boise, Idaho, Interagency Fire Center fights forest fires with the help of computers. *Technique* is free to readers who fill out the request card on the magazine's back cover. The address is 6300 S. Syracuse Way, Englewood, Colo. 80111. Phone (303) 694-2900. [Circle 430]

**CATALOGS.** The following companies are offering product catalogs, all of which are free:

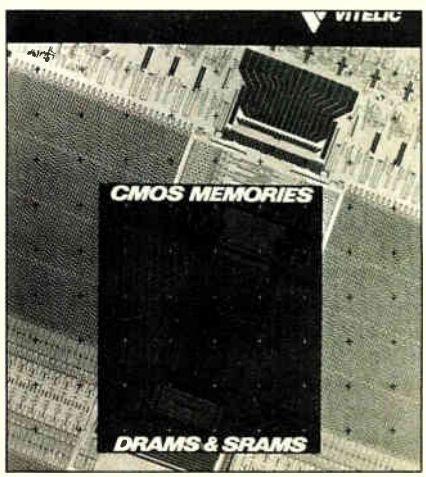
Interactive Microware Inc., P. O. Box 139, State College, Pa. 16804. Phone (814) 238-8294. Data-acquisition hardware and data-analysis and graphics software for IBM Corp. microcomputers. [Circle 450]

RAD Data Communications Ltd., 8 Hanechoset St., Tel Aviv 69710, Israel. Phone 972-3-483-331. Micro Products Guide. [Circle 452]

Sensotec Inc., 1200 Chesapeake Ave., Columbus, Ohio 43212. Phone (614) 486-7723. Pressure transducers, load cells, accelerometers. [Circle 453]

Timeco Inc., P. O. Box 8036, Huntington, W. Va. 25705. Phone (304) 523-5149. Timers and time-delay relays. [Circle 454]

Vitelic Corp., 3910 N. First St., San Jose, Calif. 95134. Phone (408) 433-6000. CMOS dynamic and static RAMs. [Circle 455]



*MEETINGS*

## ICCE FOCUSES ON TV AND HOME BUS

Home bus technology will compete with developments in television as the most significant topic of discussion at the International Conference on Consumer Electronics June 3-6 in San Diego. The conference will also devote a session to smart cards for the first time, says chairman David M. Lewis.

Six of the ICCE's 20 sessions will be related to television: high-definition broadcasting, cable-interface standards, displays, video signal processing, and two on digital TV, which will foster the "next wave of consumer applications," he says.

Three sessions will cover home-bus technologies and an evening discussion will reveal "the absolute latest" on development of a home bus, according to Lewis, laboratory head of the Physics Division at Eastman Kodak Co.'s Research Laboratories. A paper from the Matsushita Technology Center will review work by the Electronic Industries Association's Consumer Electronics BUS Committee to develop standards for a unified remote control system for consumer electronic products. Lewis says the fact that the EIA recognizes the need for a standard will entice others to develop one.

The session on smart cards features five papers and represents "a good cross-section" of work, Lewis says. It will discuss both the technology and efforts toward standardization.

Japanese companies will dominate the session on digital audio tape, with papers from Aiwa, Hitachi, Matsushita, Sanyo, Sony, TDK, and Toshiba. And at one of two video sessions, Sanyo Electric Co. will describe its electronic still camera that records audio signals.

**Recent Advances and Applications of Speech Recognition,** Ugo Bordoni Foundation *et al.* (D. DeAngeli, Face Research Center, 10 Via Nicaragua, 00040 Pomezia, Italy), Central Research and Development Laboratory of Pomezia, Pomezia, Italy, May 27-29.

**1986 ACM Sigmod:** International Conference on Management of Data, Association for Computing Machinery (ACM, 11 W. 42nd St., New York, N. Y. 10036), Hyatt Regency Crystal City, Washington, May 28-30.

**ICA Telecom '86,** International Communications Association (12750 Merit Dr., Suite 710, Dallas, Texas 75251), Georgia World Congress Center, Atlanta, June 1-6.

**3rd International Network Planning Symposium,** IEEE (Warren Falconer, AT&T Bell Laboratories, Crawfords Corner Road, Holmdel, N. J. 07733), Innisbrook, Tarpon Springs, Fla., June 1-6.

**Syntopican XIV,** Association of Information Systems Professionals (1015 N. York Rd., Willow Grove, Pa. 19090), St. Francis Hotel, San Francisco, June 2-5.

**Printed-Circuit World Convention IV,** Japan Printed-Circuit Association *et al.* (Institute for Interconnecting and Packaging Electronic Circuits, 3451 Church St., Evanston, Ill. 60203), Tokyo Prince Hotel, Tokyo, June 2-5.

**Vision '86,** Machine Vision Association of the Society of Manufacturing Engineers (SME, 1 SME Dr., Dearborn, Mich. 48121), Cobo Hall, Detroit, June 2-5.

**Communications Week '86,** Datapro Research Corp. (Raymond J. DeAngelo and Lynn T. Sadlon, McGraw-Hill Information Systems Co., 1221 Ave. of the Americas, New York, N. Y., 10020), McGraw-Hill Building, New York, June 2-6.

**Circuit Expo '86,** Worldwide Convention Management Co. (Mary Burns Sheridan, Worldwide Convention Management Co., 17730 W. Peterson Rd., Libertyville, Ill. 60048-0159), Convention Center, Long Beach, Calif., June 3-5.

**Power Europa '86,** TCM Expositions Ltd. (33 Station Rd., Liphook, Hampshire, GU30 7DN, England), Rhein-Main-Halle, Weisbaden, Germany, June 3-5.

**International Conference on Consumer Electronics,** IEEE (Marvin Gottlieb, M. Gottlieb Associates, 6009 N. Milwaukee Ave., Chicago, Ill. 60646), Westin Hotel, Rosemont, Ill., June 4-6.

**1986 IEEE International Symposium on the Applications of Ferroelectronics,** IEEE (Wallace Arden Smith, Philips Laboratories, 345 Scarborough Rd., Briarcliff Manor, N. Y., 10510), Lehigh University, Bethlehem, Pa., June 8-11.

**Vacuum Processing Technology '86,** American Vacuum Society (Terri Berker, Micrion Corp., P. O. Box 485, Beverly, Mass. 01915), Sheraton-Tara Hotel, Nashua, N. H., June 9-10.

**VLSI Multilevel Interconnection Conference,** IEEE and University of South Florida (Thomas E. Wade, College of Engineering, University of South Florida, 4202 Fowler Ave., Tampa, Fla. 33620), Santa Clara Marriott Hotel, Santa Clara, Calif., June 9-11.

## POSITIONS VACANT

**Control / Research Engineer, Mossville, Illinois** — Engineering service group has a full-time position for an Electrical Engineer with MS degree in control theory and graduate work in microprocessing and knowledge of electromagnetic theory. $15.19 per hour. Send resume to: Beckly Leucht, 220 N.E. Jefferson, Peoria, IL 61603. An Employer Paid Ad. Job Order #5089259.

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## POSITIONS WANTED

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# ELECTRONICS WEEK

## DAEWOO BUYS CONTROL OF ZYMOS

Daewoo Corp., the giant Korean industrial conglomerate, will buy a controlling interest in Zymos Corp., a Sunnyvale, Calif., maker of application-specific integrated circuits. In a related deal, Intermedics Inc., Freeport, Texas, a Zymos shareholder, will sell back to the company 6.3 million shares of Zymos stock.

## SALARIES RISE FOR HIGH-TECH GRADS

Bachelor of science graduates who take jobs in the U. S. electronics industry can expect an average starting salary of $29,300, according to a survey by the American Electronics Association. That figure is up 3.9% over 1985. In northern California, where about half of the 540 companies surveyed by the AEA are located, starting salaries will average $29,600, the highest in the country. The Los Angeles area was second, at nearly $29,000, and New England third with $28,300.

## TOSHIBA OPENS THIRD U. S. CENTER

Toshiba Corp. has opened its third large-scale integrated-circuit design center in the U. S., this one in Dallas. A Toshiba spokesman says the center will handle the rising demand in the Southwest for semicustom LSI chips. The center is linked by satellite to host computers at Toshiba's LSI design center in Kawasaki, near Tokyo. Toshiba plans to open other LSI design centers in Chicago, Los Angeles, and Boca Raton, Fla., within two years.

## AMPHENOL FORMS JAPANESE VENTURE

Amphenol Products Inc., Lisle, Ill., is forming a joint venture with Daito Shoji Co., Tokyo, to manufacture Amphenol's Bendix connectors for the U. S. and Japanese military and aerospace markets. The new company, Nippon Interconnect Co., will be based in Tokyo, with a production plant in Ritto. The venture expects $8 million in sales this year, growing to $28 million by 1990.

## JVC TO BUILD 2ND ALABAMA PLANT

Victor Company of Japan will produce compact disks at a new plant to be constructed in Tuscaloosa, Ala., where the company is already building a plant to produce video cassette tapes. The new plant, which will house the entire production process, will open next January with an initial capacity of 10 million disks per year. JVC produces 30 million CDs annually in Japan.

## GERMAN FIRM MAY TAKE OVER WIDCOM

Widcom Inc., the financially troubled Campbell, Calif., maker of advanced video teleconferencing systems, may sell a controlling interest to its West German distributor, Telefonbau und Normalzeit GmbH, a member of the Bosch Group of Companies. Widcom's financial backers forced out founder Robert D. Widergren two months ago on grounds the four-year-old company had not generated enough sales to justify the funds spent in developing its 56-kb/s video codec. Widcom faces a loss of more than $1.5 million in the quarter ended March 31.

## RICOH MAKES FAX MACHINES IN U. S.

Ricoh Co. has become the first Japanese company to manufacture facsimile equipment in the U. S. The company, a leading manufacturer of office-automation equipment, has begun local production of high-speed G-3 facsimile machines at Ricoh Electronics Inc., its subsidiary in Santa Ana, Calif. Initially, production of the Rapidcom 210 and 230 models will use key parts imported from Japan, but the company says it will increase its local procurement ratio. Ricoh is also the only Japanese maker of plain-paper copiers in the U. S.

## IBM MAKES 1-Mb CHIPS IN GERMANY

IBM Deutschland GmbH, a subsidiary of the U. S. computer maker, has started volume production of 1-Mb memory chips at its factory in Sindelfingen, near Stuttgart. The chips are intended for the 3090 series of IBM computers built at Montpellier, France, for the European, Near East, and African markets. IBM makes 1-Mb memories at its Burlington, Vt., plant for equipment marketed in the U. S.

## NTT SUCCESSFULLY TESTS FIBER CABLE

Nippon Telegraph & Telephone Corp. has successfully conducted transmission tests for its F-1.6G very high-capacity fiber-optic cable transmission system over an experimental 120-km route. The system can transmit 23,040 voice channels bidirectionally, using only one pair of single-mode optical fibers. High-definition TV and test pulse signals were also transmitted. A distributed-feedback laser diode keeps operation in the single-longitudinal mode despite the high-speed modulation and suppresses pulse broadening degradation.

## EDS, C. ITOH START JOINT VENTURE

Electronic Data Systems Corp., the Dallas information-processing subsidiary of General Motors Corp., has formed a joint venture with Japanese conglomerate C. Itoh & Co. The new company, called Systems Integration Management, Tokyo, will market, sell, and service information-processing systems for multinational corporations. The first clients will be Japanese companies.

## TI WILL BUILD AUTOMOLDERS

Advanced Semiconductor Materials International NV, Phoenix, Ariz., and Texas Instruments Inc., Dallas, have signed a technology licensing agreement that will let TI manufacture a new generation of automatic molding systems for semiconductor components for its internal use. TI may also make production units when ASM can't meet demand.

## SOFTECH ACQUIRES AMG ASSOCIATES

Softech Inc., a Waltham, Mass., software consulting house specializing in Ada, has acquired AMG Associates Inc. through the purchase of an undisclosed amount of stock. AMG, Arlington, Va., develops custom software systems and related applications for the automatic test equipment market. It claims its Atlas Retargetable Compiler is the most widely used compiler for the Abbreviated Test Language for All Systems (Atlas), a standard development language for test software. Founded in 1976, the company posted revenue of $3.4 million in 1985.

## IR REPORTS QUARTER LOSS

Despite signs of an upturn year in 1986, International Rectifier Corp. has reported a net loss of $1.9 million on sales of $35.9 million for its third fiscal quarter, ended March 31. The Los Angeles power-semiconductor maker blamed the loss on price erosion, reduced shipments of certain Hexfet power MOS FETs, temporary production problems, and costs of converting production lines to larger silicon wafers.

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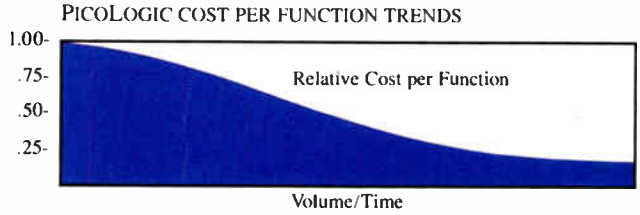


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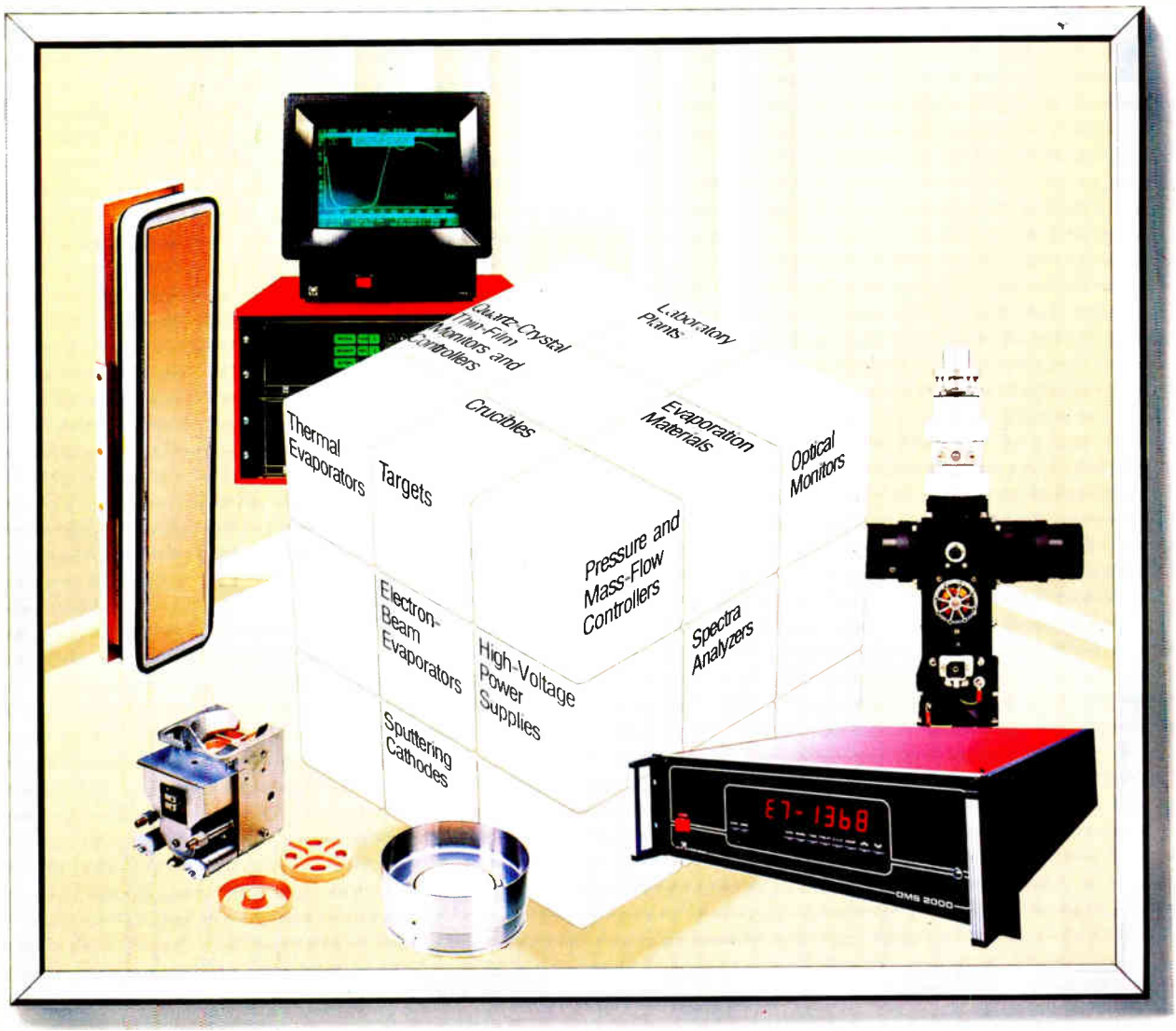


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