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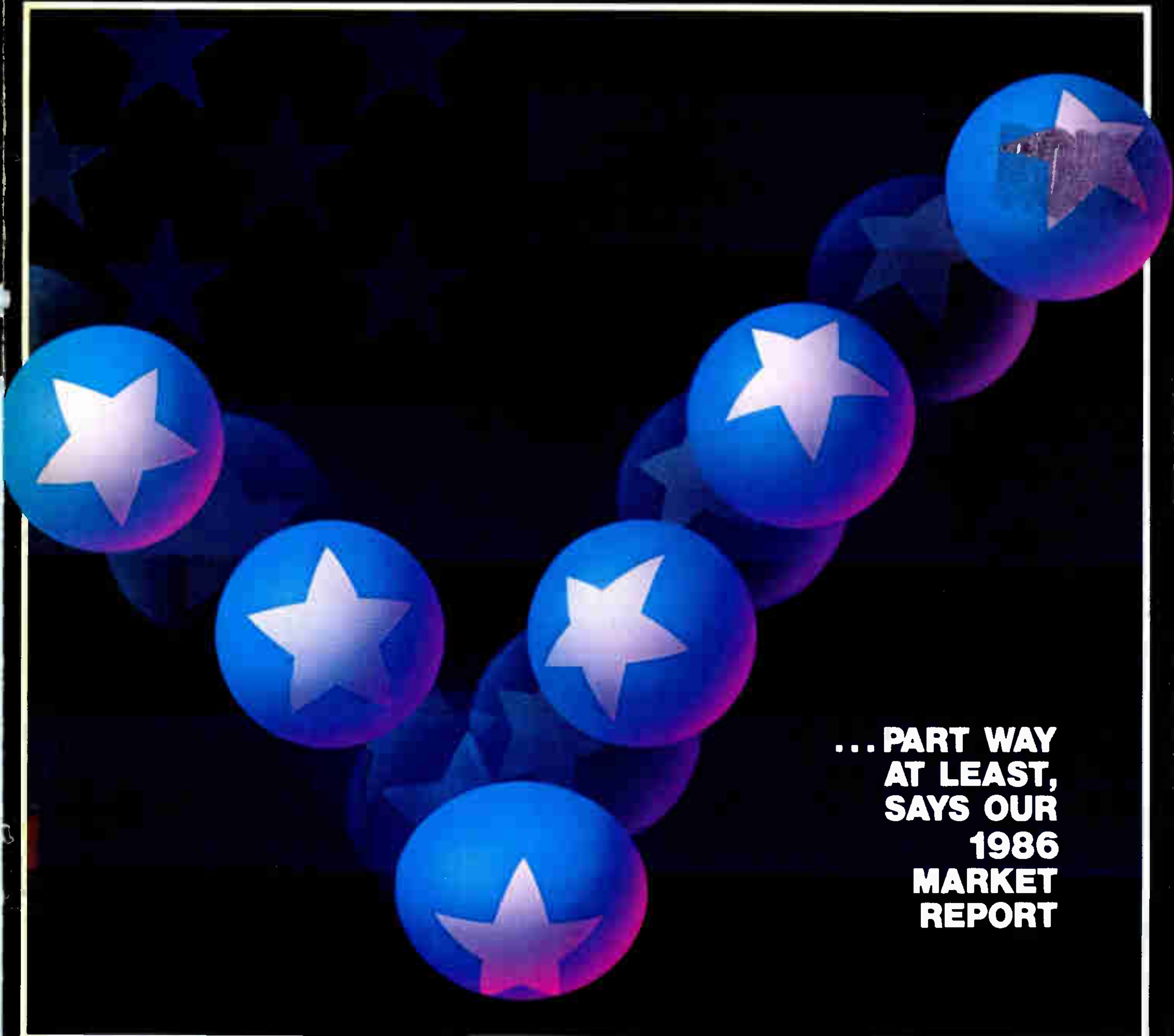
Electronics

THE WORLDWIDE TECHNOLOGY WEEKLY
JANUARY 6, 1986

U.S. MARKETS BOUNCING BACK...



...PART WAY AT LEAST, SAYS OUR 1986 MARKET REPORT

HOW LASERS WILL GIVE CHIP MAKING A BIG BOOST/70

GE-RCA: A NEW WORLD POWERHOUSE OR STODGY GIANT?/73

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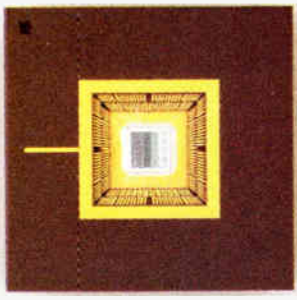
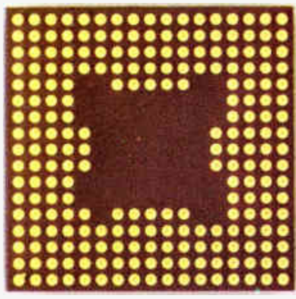


Our new 50,000-gate LCA 10000 Compacted Array Series makes "System Scale Integration" a reality. Now, you can fit an entire system on a chip.



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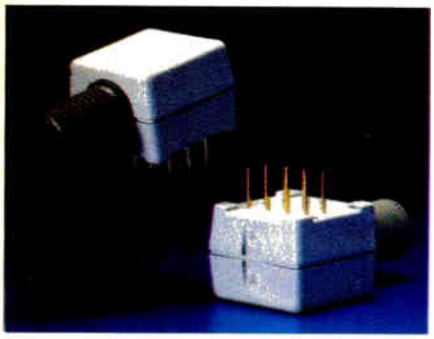

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1/6/86

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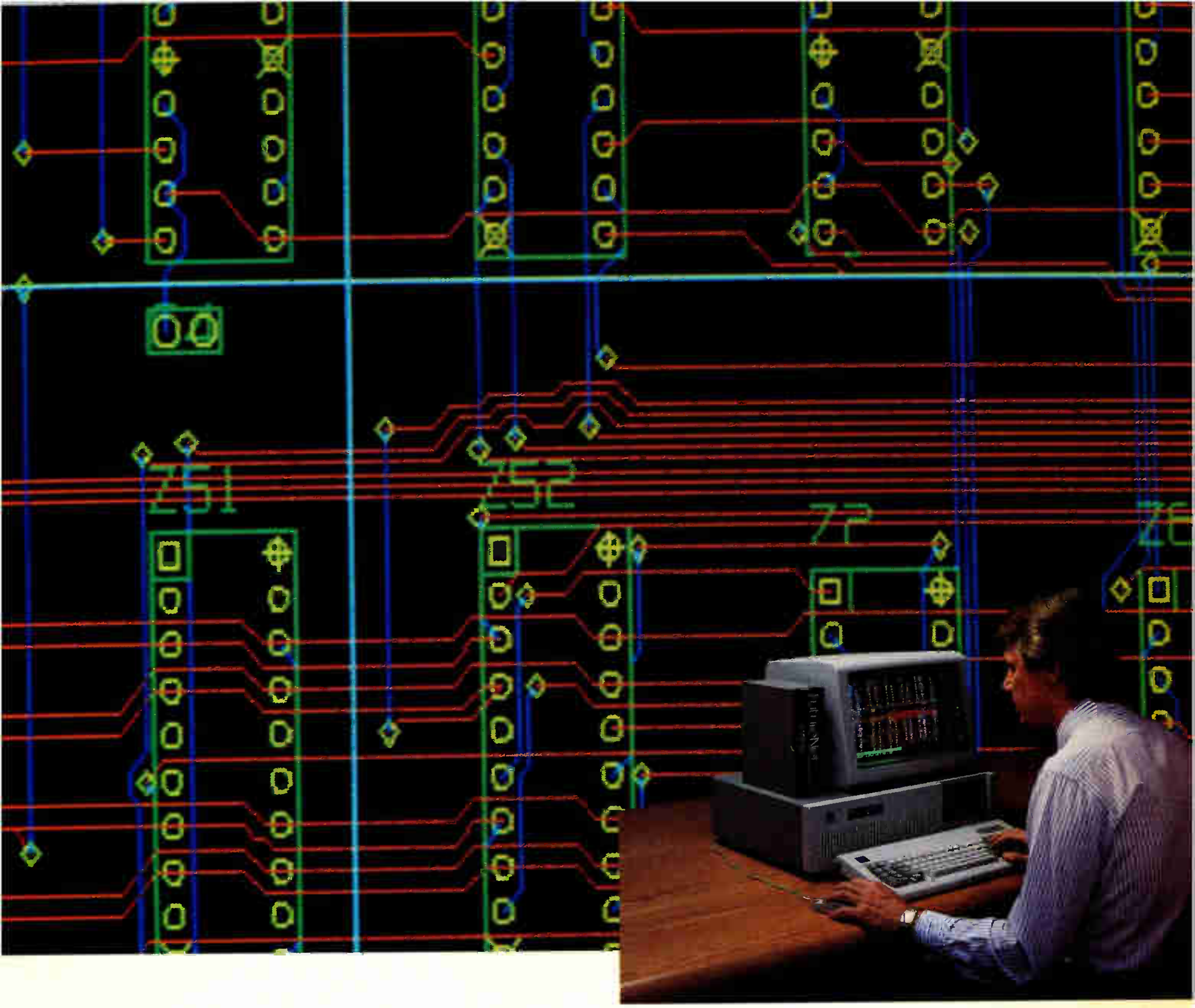

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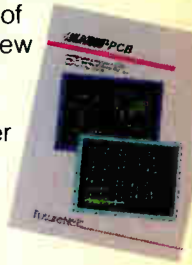

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JANUARY 6, 1986 VOLUME 59, NO. 1

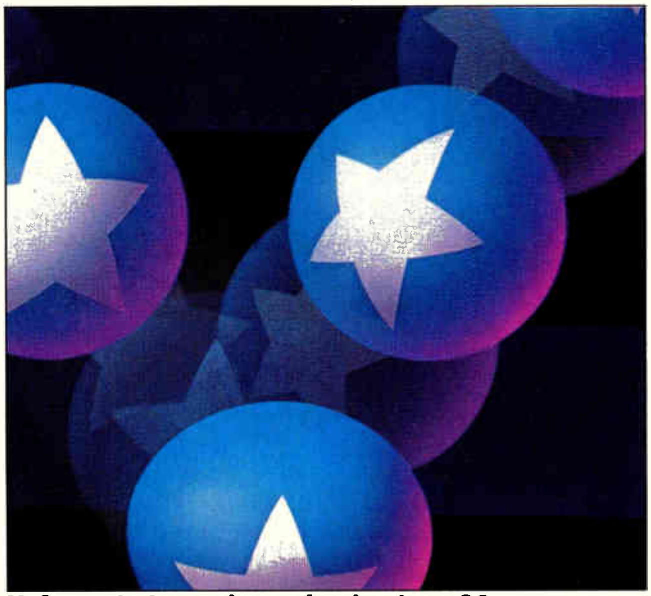
Electronics

NEWS

INSIDE TECHNOLOGY

PROBING THE NEWS

COVER



Cover illustration by Jeffrey Lynch

NEW PRODUCTS

DEPARTMENTS

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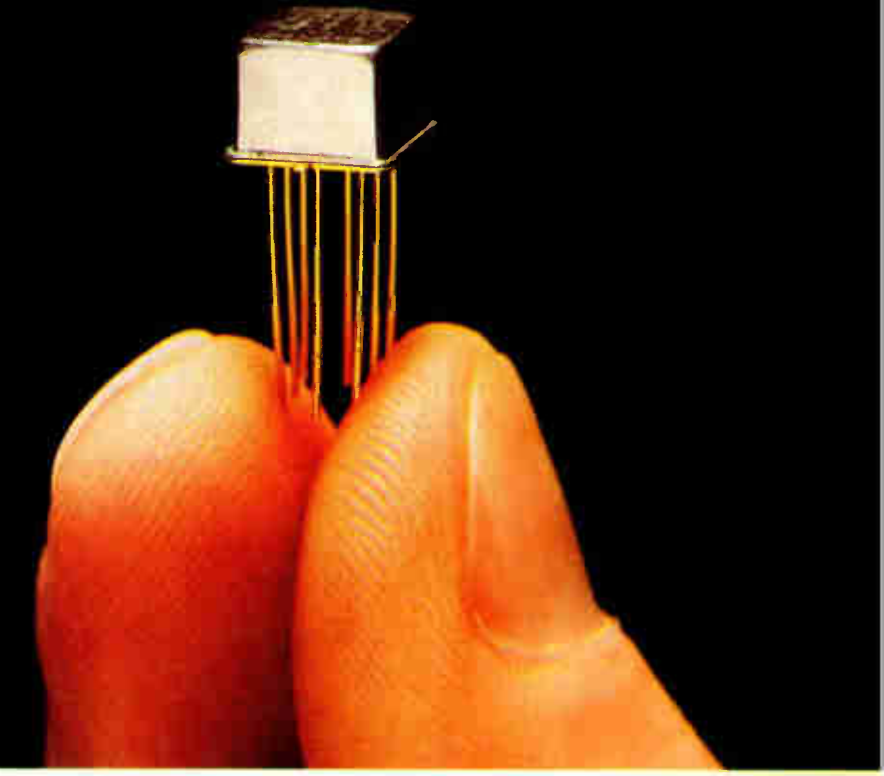

Our Centigrid relay is the vanguard of a new EMR generation. After all, it is the natural outgrowth of all those years of proven Teledyne TO-5 technology.

It is rugged. The uniframe-housed motor assembly is stabilized by the header at four points, making it very tolerant of mishandling during warehousing and assembly.

It is tiny. Takes up less than .15 sq. in. of board space. And its .100″ grid spaced pinout permits direct PC board insertion without lead spreading. Since it is only .275″ high, this makes possible very high board density.

It is an even better RF switch than the classic TO-5, providing high isolation and low insertion losses up through UHF frequencies. And it is fully qualified to levels "L," "M" and "P" of MIL-R-39016.

It draws very little power. The sensitive version dissipates 75% less power than the typical ½ crystal can. That can extend the battery life of your portable equipment by a significant margin.

To make sure you always get the Centigrid quality you expect, we designed our own automated production equipment. For instance, our microprocessor-controlled header assembly system automatically tests the units while they are being produced, minimizing human error and insuring built-in reliability.

For twenty years, Teledyne TO-5 technology has been the standard of the industry. Now the Centigrid has taken that technology one giant step into tomorrow.

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Electronics

After putting together annual market reports for nearly three decades, we know that there are two constants. The first is that a small but dedicated band of *Electronics* editors, artists, and production people will work long, hard hours during the holiday season to complete the job. The other is that beginning around the end of January we will start to get phone calls from market researchers and financial forecasters who will want to know how we put together the data.

For this year's survey of the U.S., beginning on p. 39, the team's point man was business editor Bob Kozma, with executive editor Sam Weber supervising. Our Christmas gift to Kozma was a sheaf of market figures from companies around the world and from editorial consultant Howard Bierman, as well as reports from all our domestic and foreign bureaus. After checking all the figures, Kozma wrapped the whole thing neatly into the 20 pages of text and tables that make up one of the most eagerly awaited forecasts in the industry.

The rest of the team also put in a considerable amount of overtime on the project. It started with art director Fred Sklenar, who designed the section—and came up with the cover concept—to provide an attractive, readable package. Copy chief Susan Levi Wallach earned her stripes by coordinating the production and proofreading of the tables, while associate managing editor Ben Mason kept the whole process moving ahead on schedule.

That leaves the other constant—those phone calls. To save the time, here's a brief explanation of how it works: the process of arriving at a consensus market forecast includes questionnaires sent to key companies in each industry sector, both in the U.S. and abroad. Also, we factor in estimates from scores of other electronics industry sources as well as from market observers. Then we put them together and shake well: the result is the parade of figures that marches through the special section.

GUIDE. Kozma was report's point man.

One problem that such thoroughness creates, however, is that we have to develop a design theme and start collecting figures well before all the numbers are in. So when we decided to illustrate each market's performance with an arrow indicating whether it would rise or fall, we fully expected a wide range of results and established five indicators: good growth, moderate growth, flat, moderate decline, and bad decline.

As it turned out, only two were needed: moderate growth and flat. So you might use the illustration of all five arrows on p. 41 as an indication of how bad things could have been.

And with the U.S. forecast taken care of, next week's issue will complete the picture with a 24-page section examining the UK, France, Italy, Japan, and West Germany.

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The evidence is in, and it's incontrovertible. When it comes to light, Anritsu runs second to the sun.

True, Anritsu's little laser diodes *are* powerful enough to raise more than a few eyebrows.

And Anritsu optical attenuators can cut *almost* any light source down to size.

And Anritsu optical power meters can take anything a *normal* fiber optic system can dish out.

But none of them can hold a candle to the sun, with its 900×10^{23}-or-so calories every second and 10-billion-year MTBF.

Still, if you take a closer look, you'll see a bright side to this story.

For instance, let's talk technology: does the sun have anything like Anritsu's laser-accurate outside diameter measuring system for optical fiber production?

In sophistication, Anritsu also has a clear edge. With optical time domain reflectometers and optical spectrum analyzers that give a clear, accurate picture of an entire fiber optics network.

And in terms of visibility, the Anritsu name has become almost an industry standard.

Thanks to a dazzling range of measuring

instruments and light sources for all facets of fiber optic communications.

What about versatility? Simply no competition: Anritsu has more than 11,000 products and systems, and these extend to areas far beyond light. To rugged radio and telecommunications equipment. To public telephones, computers and data processing equipment. To measuring instruments for communications. The list goes on and on.

The sun is still safely #1 for now.

But we're on the move.

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Anritsu

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As of October 1, 1985, Anritsu Electric Co., Ltd. became Anritsu Corporation.

LETTERS

Equal time for SRC

To the editor: I was delighted to read that the Microelectronics & Computer Technology Corp. is demonstrating that American industry can successfully cooperate in research [*Electronics*, Dec. 16, 1985, p. 49]. However, Mr. Lineback's arithmetic needs some attention. In the lead paragraph, he states that MCC "is doing so well after just one year of operation that it is surprising even its own supporters. . . ." while a little later he claims that "shareholding membership has grown from 12 to 21 since 1982." Because 1986 is now upon us, the MCC has been in operation at least two years and possibly three.

Unless I have missed an issue, I have yet to see an article describing an equally, and perhaps more, successful cooperative industry-university organization. Semiconductor Research Corp. (SRC) sponsors my research as well as that of over 200 other faculty members at 43 universities. Furthermore, SRC supports about 450 graduate students. Can MCC match that? In terms of membership, SRC has about 70 participating companies—over three times that of MCC.

In addition, SRC is run by a small, highly efficient staff and as such can funnel most of its budget into universities where research support is really needed. This is in contradistinction to MCC's conducting research *in situ* and expanding its own facilities.

Research Triangle Park, N.C., is a fast-growing semiconductor area with du Pont, GE, IBM, and others as well as SRC seemingly visible to all but your publication. How about some copy for SRC and Research Triangle Park?

Roy H. Propst, PhD
Research Assistant Professor
University of North Carolina at Chapel Hill
Chapel Hill, N. C.

In response: *The "one year of operation" in the article's first paragraph refers to the time that MCC has conducted actual research operations. The second paragraph on p. 50 makes this distinction clear.* Electronics *has run about a dozen articles on the Semiconductor Research Corp. and its home in Research Triangle Park since the organization's inception in 1982. They include "General Electric is on target with second shot at chip making," [Oct. 29, 1984, p. 51]; "Expanding firms are flocking to North Carolina, but start-ups elude state's efforts to draw them." [Sept. 10, 1984, p. 38]; "SRC drives forward as TI, AT&T sign on," [Aug. 27, 1984, p. 54]; and "Research group grants first awards," [Nov. 30, 1982, p. 50].*

Marconi's clean sweep

To the editor: A few facts were confused in the Products Newsletter item about our new 6310 Programmable Sweep Generator covering 2 to 20 GHz [*Electronics*, Nov. 11, 1985, p. 15]. The time taken to recalibrate the 6310 is only 15 minutes rather than the 8 hours needed by older style sweepers. The recalibration interval is 6 to 12 months. The process, however, can be done *in situ* at the operating ambient temperature rather than in a calibration laboratory. It requires only a power meter, sensor, and frequency counter since the 6310 acts as GPIB controller. Because highly skilled technicians are not necessary, they can be given other tasks, and because the covers need not be removed, reliability is improved.

Up to 20 front-panel settings may be stored and easily reviewed before selection in battery-backed memory. In addition, six user-defined display and control modes can be created and stored. The yttrium-iron-garnet oscillators have current drivers, controlled by three digital-to-analog converters, for scale, offset, and vernier. The digital drives have a frequency that is corrected using calibration data and powerful algorithms with the Motorola 68000 series microprocessor.

Will Foster
Marketing Manager
Marconi Instruments Ltd.
St. Albans, England

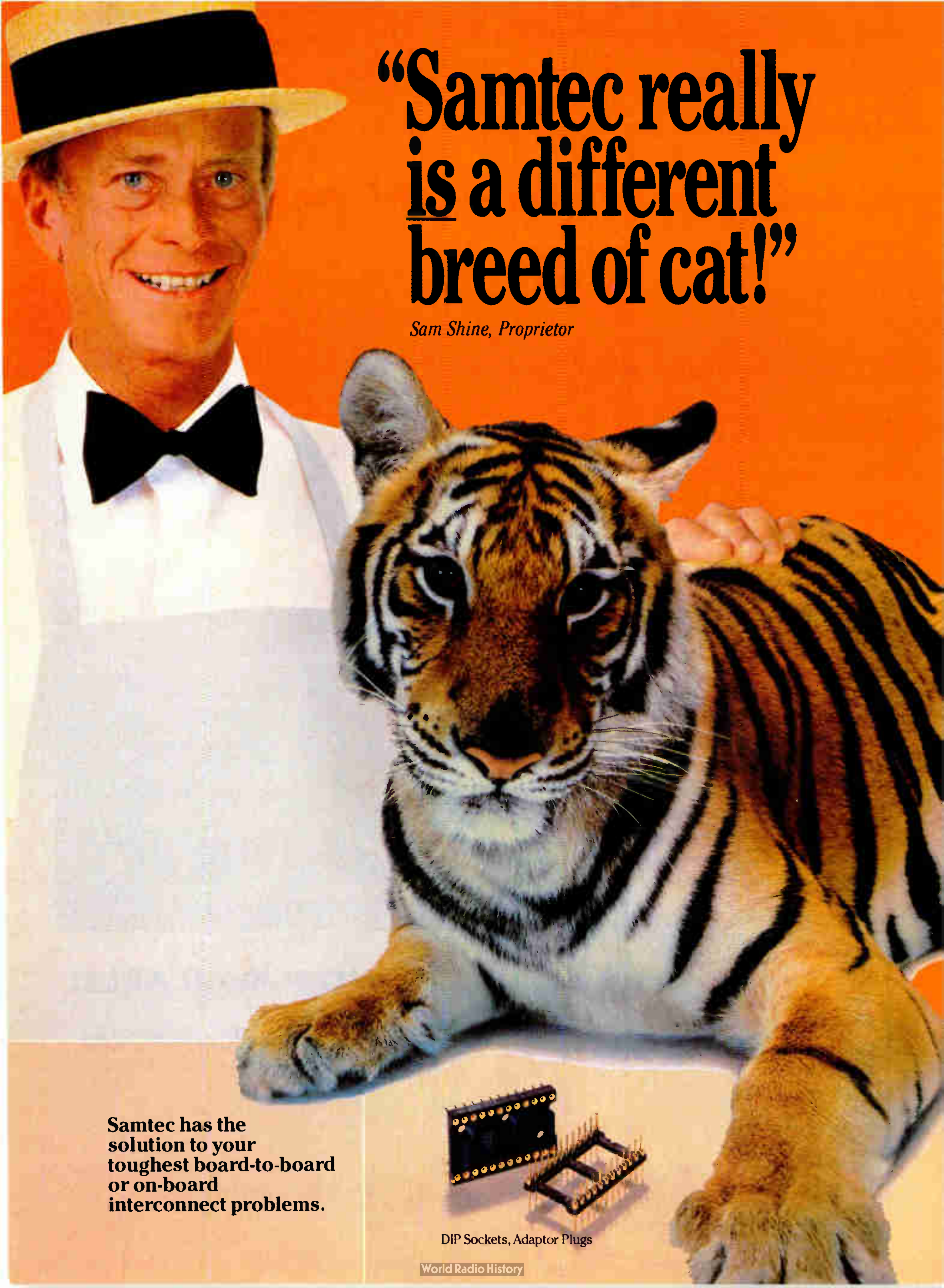
Micron's 256-K DRAMs

To the editor: An Electronics Newsletter brief [*Electronics*, Nov. 18, 1985, p. 19] incorrectly stated that Motorola's decision to leave the 256-K dynamic random-access-memory business "leaves Texas Instruments Inc. as the sole U. S. manufacturer of n-MOS 256-K chips." The article omitted the fact that Micron Technology manufactures n-MOS 256-K DRAMs.

Nancy L. Blackburn
Micron Technology Inc.
Boise, Idaho

Corrections

In the chart "Other products outdo semiconductors" [Electronics, *Nov. 18, 1985, p. 84], incorrect computer sales percentages were printed for NEC Corp. and Oki Electric Industry Co. NEC's computers entry should be 19. Oki's should be 10. This was an editing error; the source, W. I. Carr & Sons, supplied the correct figures.*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IMS1620 16K x 4	45,55,70	440	77 CMOS	CMOS

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TECHNOLOGY NEWSLETTER

TOOLKITS SHOULD HELP MOVE AI PROGRAMMING INTO MAINSTREAM

Two advanced toolkits for artificial-intelligence programming on Digital Equipment Corp. VAX systems promise to give AI another big push toward the mainstream computing market. Lisp Toolkit and Expert Toolkit come from Composition Systems Inc., which developed them to help build its expert-systems package to automate the layout of newspaper advertisements. The Elmsford, N. Y., company will now start marketing its toolkits to those who want to reduce the time and effort needed to build big production expert systems on DEC computers. Lisp Toolkit, which will be available in February, links the VAX Lisp language with several DEC utility products such as those for graphics, form, and menu design, as well as the DECnet network and Automated Reasoning Tool (ART), the expert-system development environment from Inference Corp., Los Angeles. By July, Composition Systems plans to release Expert Toolkit, which consists of five modules for building multiple cooperating expert systems that use large distributed data bases and natural-language interfaces. □

ATARI MAY BOOST RAM ON ITS 520ST TO 1 MEGABYTE

Atari Corp. could turn out to be the most-talked-about personal computer maker at this week's Winter Consumer Electronics Show in Las Vegas. Sources close to the Sunnyvale, Calif., company say it might reveal at CES that it has a new version of its 520ST in the works that will come standard with a full megabyte of random-access memory. Not even IBM Corp.'s Personal Computer can handle more than 640-K of RAM without software rewrites, but the word is that the new ST will be compatible with the present machine and cost roughly the same—about $1,000 for a color version with one single-sided disk drive. Atari only began shipping the "old" 520ST, a Motorola 68000-based microcomputer with standard 512-K RAM, within the past six months and has been faulted for limited software support. □

AI WORK STATION TO SPEED NASA SOFTWARE DEVELOPMENT

A work station now being developed around artificial-intelligence software is expected to speed up the development of software dramatically at the National Aeronautics and Space Administration. The project stems from a joint agreement between NASA and AI-software developer Inference Corp., Los Angeles. The automated software-development work station should increase the productivity of NASA's software engineers by allowing them to both reuse existing code and generate new code efficiently using AI techniques. Expert knowledge of software management will be added to the work station using Inference's ART AI-development environment. The first phase of the project, which will run on Symbolics Inc. 3600 hardware, is under way. Earlier, NASA developed Navex, an expert system that provides navigation assistance for the space shuttle, using Inference's technology. □

CRAY WILL OFFER UNIX ON ALL ITS SUPERCOMPUTERS

With its expected February announcement of a version of AT&T Co.'s Unix operating system for its X-MP product line, Cray Research Inc. will give Unix another nudge toward being the de facto standard for supercomputing. The Minneapolis company already uses Unix on its latest supercomputer, the Cray-2. By offering Unix on its other line as well, Cray will be promoting Unix as the operating system of choice on its equipment. Cray's leading position in supercomputing will likely influence other supercomputer makers to adopt Unix as well. Currently, all supercomputers run on their own proprietary operating systems. □

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Our new AD204 solves your problems. In fact, it represents a whole new design approach to isolation. With performance that does not degrade your signal. A component package size that conserves your board space. Superior reliability and stability of a transformer isolated design. At a price you can afford.

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ELECTRONICS NEWSLETTER

JAPANESE IC EXPORTS TO U. S. DROP 40% IN 1985

The worst fears of Japanese chip makers are proving to be real: official statistics from Japan's Ministry of Finance reveal that last year's exports to the U. S. dropped 40% from 1984's level. That drop, forced by a sluggish market and U. S. trade pressure, doubles the rate reported for the first seven months of 1985 [*Electronics*, Sept. 9, 1985, p. 25]. The ministry estimates those exports will be about $900 million, down sharply from 1984's $1.6 billion. November's IC exports to the U. S. came to $57 million, down 60.8% from November 1984. Trade pressures may have helped slow exports, but they haven't helped U. S. chip makers in Japan. Imports of U. S. ICs totaled $475 million for the first 11 months of 1985, down about 26% from the same period a year ago, according to ministry statistics. □

BATTELLE PREDICTS A 9.5% INCREASE IN R&D SPENDING FOR 1986

At least one estimate of 1986 spending for all U. S. research and development augurs well. Battelle Memorial Institute's Columbus (Ohio) Laboratories forecasts a total expenditure of $116.8 billion this year, a 9.5% jump over 1985 and a 4.4% rise in real terms when the effects of inflation are factored in. In making its just-released annual forecast on R&D, Battelle used National Science Foundation estimates that peg total U. S. R&D spending in 1985 at $106.6 billion. The projected 4.4% rise this year would be slightly higher than the 4% average annual increase in real R&D spending seen over the past 10 years, the report notes. As in every year since 1979, industry will account for the largest share this year, spending $58.2 billion, or 49.8%, of the total. Government agencies will provide the lion's share of the rest at 46.7%, or $54.5 billion, while academic institutions and other nonprofit organizations will pick up the difference. Reflecting the Reagan Administration's defense buildup, Battelle says the Defense Department will account for 67.4% of the federally funded R&D portion this year, up from 62.4% in 1985. □

WEST GERMANY'S BUNDESPOST HOPS ON THE FIBER-OPTICS BANDWAGON

Joining a trend already under way in the U. S. and Japan, West Germany is going all out for fiber-optic communication lines. The Bundespost, the postal authority that also runs the country's public communication networks, until recently had been more conservative about adopting fiber-optics transmission technology. From 1987 on, new lines in long-haul trunks will no longer be copper but glass-fiber cables; by 1990, the authority will lay a total of 480,000 miles. In 1986 alone, about 42,000 miles of optical fiber will go into long-distance networks and 9,000 miles into local nets. □

FAIRCHILD TO ENTER PROGRAMMABLE LOGIC MARKET

Next month, Fairchild Semiconductor Corp. will join the crowd of major and minor players now pushing into the programmable logic market. That's when Fairchild's Memory and High-Speed Logic Division in Puyallup, Wash., will begin volume production on a family of programmable logic arrays based on the high-speed bipolar process used in its FAST series of standard logic. Designated the Fastpla family, the first devices to be introduced will be the 16P8B series of 20-pin PLA circuits, manufactured using the company's isoplanar Z vertical-fuse technology and featuring 15-ns maximum propagation delay times. Fairchild hopes that by using the same FAST technology as in its standard logic devices, it will be able to wedge a niche in the market and compete against companies such as Advanced Micro Devices, Monolithic Memories, Texas Instruments, recent market entries Intel and National Semiconductor, and a host of startups. □

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DT712 SERIES A/D BOARD DESCRIPTION

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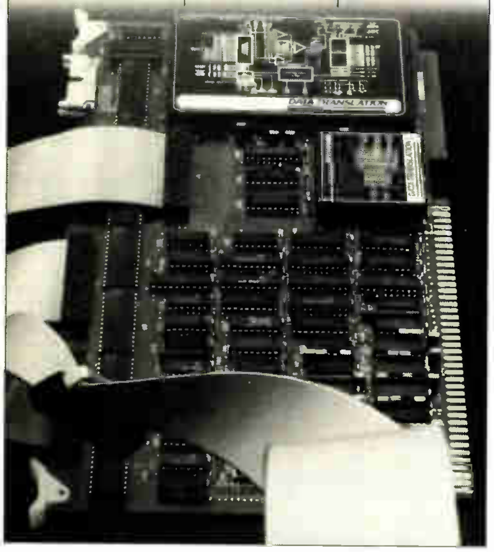
DT712 + DT713	High Level A/D Expanded	512SE/256DI
DT714	Low Level A/D	64DI
DT714 + DT715	Low Level A/D Expanded	256DI



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PRODUCTS NEWSLETTER

TERADATA DOUBLES PERFORMANCE OF ITS DATA-BASE MACHINE

Teradata Corp., the Los Angeles maker of data-base systems, is shipping a second and much faster version of its DBC/1012 parallel-processing database machine. The DBC/1012 Model 2 uses 8-MHz Intel 80286 microprocessors—from three processors for basic systems up to 1,024 processors. The 80286 processors, which are rated at about 1 million instructions/s, give the Model 2 more than twice the performance of the Model 1, which was implemented with 8086 processors. Available now, a typical 12-processor system costs $562,000, about half the cost of a comparable Model 1. □

MODEM MAKES IT EASIER TO TRANSMIT DATA OVERSEAS

A modem module from Micro Power Systems Inc. will ease international data transmission. The MP212AT not only operates in the full-duplex 300- and 1,200-bits-per-second transmission standards of the U. S., but it also supports the International Telegraph and Telephone Consultative Committee V.22 A, V.22 B, and V.21 standards widely used in Europe, Japan, and other countries. The modem module is housed on a single pc board that measures 3 by 4 by 0.4 in. Samples will be available from the Santa Clara, Calif., company this month. In large quantities, the modems sell for $110 each. □

VIDEO ENHANCER LETS DIGITIZER WORK ON SELECTED TONES OF AN IMAGE

With Image Technology Methods Corp.'s model 502 video enhancer, the full-scale response of an image digitizer can be applied to selected tone gradients of an image, improving its contrast. Rather than increasing the digitizer's resolution, the 502, which fits between the camera and the digitizer, lets an operator limit the analog input range—selected as a voltage range—to be digitized. This keeps bits of resolution from being wasted on areas that are not of interest. In addition, the user can display and enhance images with low-contrast areas. The 502 sells for $2,500 and is available now from the Waltham, Mass., company. □

AMD'S 64-K STATIC RAM TEAMS SPEED WITH LOW POWER CONSUMPTION

Advanced Micro Devices Inc.'s 64-K CMOS static RAM boasts 70-ns access times and dissipates as little as 220 mW. The Sunnyvale, Calif., company's Am99C88 operates over both commercial and military temperature ranges and consumes 330 mW when active; a low-power version, the Am99CL88, uses just 220 mW. In data-retention mode, the Am99C88 consumes 50 μA. Prices for the AMD parts—housed in 28-pin ceramic dual in-line packages—are $85 for commercial parts and $245 for the military model in lots of 100 pieces. Versions in leadless chip carriers will be available later in this quarter. □

IBM PC KEYBOARD COMES WITH ITS OWN PROGRAMMABLE-KEY SOFTWARE

Cherry Electrical Products Corp.'s KXN5-C658 keyboard is the first to come with its own programmable-key software. The 126-key board offers increased functionality over the company's earlier 122-key offerings to users of the IBM Corp. Personal Computer line. It features a specialized version of Software Research Technologies' Smartkey software. With it, users can customize the board and can define macros that let a single keystroke do the work of up to 60,000 keystrokes. An accompanying disk plugs into the host machine's floppy-disk drive for programming the macro keys. Available now from the Waukegan, Ill., company, the board sells with software for $125 in lots of 2,500 to 5,000 pieces. □

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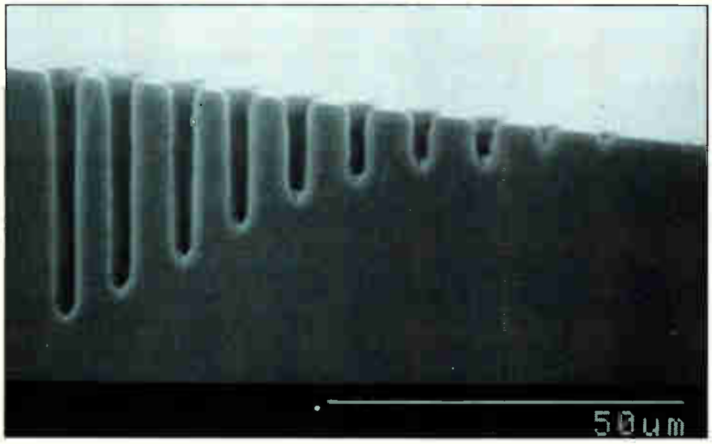
Electronics

A BETTER WAY TO CONNECT OPTICAL FIBER AND CHIPS?

ETCHING HOLES IN CHIP MAKES FOR DENSER, MORE RELIABLE LINK

NEW YORK

Cumbersome fiber-optic couplers could become obsolete in many applications, thanks to new techniques that connect fibers directly to very large-scale integrated circuits. The methods, under development by Columbia University researchers, promise to save space and increase the reliability of chip-to-fiber connections. And, with the increased density, the new technology may make it possible to connect many more fibers to one chip than is now possible. A chip with many such connections could be used in a communications switching system, for example.



DRILLED CHIP. A laser-assisted technique developed by Columbia University researchers etches deep, narrow holes in semiconductor materials.

Using a finely focused continuous-wave laser, the Columbia team etches tiny holes in the surface of the chip, into which fibers are inserted and glued. Before insertion, each cavity is doped to form a p+ layer; the resulting p-n junction acts as a photosensitive detector. Light-emitting devices can also be fabricated in conjunction with such a hole to handle the transmitting end of an optical link, according to team members.

Existing on-chip fiber-optic interconnection techniques predominantly use a V-groove technology in which the fiber lies in a trench on the chip's surface, taking up a lot of real estate. The footprint of the connection developed at Columbia is not much bigger than the diameter of the fiber core.

The connection's performance, in terms of losses, is about equal to other methods, according to Eric Fossum, an assistant professor at Columbia and one of the three-man team working on the project (the others are professor Richard Osgood and associate professor Paul Prucnal). Though it is too early to make reliability projections, Fossum suggests that the glued fiber connections "may be more mechanically stable" than other types. "The big advantage in integration is reliability."

Making a hole between 1 and 10 μm in diameter and up to 250 μm deep was difficult, Fossum says. Using a laser-assisted etching technique developed by Osgood, the group achieved its dimensional requirements without damaging the chip's surface. Surface damage would reduce the circuit's ability to process signals rapidly and lower the signal-to-noise ratio, Fossum says.

The anisotropic laser-etching technique used to drill the hole is still in the research stage, Fossum points out. (Anisotropic etching removes material faster along one axis—the vertical, in this case—to create steep walls.)

EFFICIENCY. Despite the group's success with Osgood's etching techniques and continuing research into the use of alternative lasers, such as more powerful excimer lasers, questions remain about the efficiency of the system in volume production. As a hedge, Fossum says, the group is studying alternative etching methods, such as crystallographic anisotropic etching. The present method allows the use of silicon wafers with the crystal structure oriented in the standard way (called the 100 orientation), but crystallographic methods demand 110 orientation.

The team also had to develop ways to dope the interior wall of the cavity and etch the fiber into a finely tapered point. Calling the doping process "tricky," Fossum will not divulge what method the group used, citing an agreement the researchers have with the Defense Advanced Research Projects Agency, which is funding the study. The single-mode fiber is tapered down to its 9-μm core using a chemical etching technique.

The group has built a silicon fiber-optic receiver, but many major research goals remain. "We would like to put hundreds of fibers into a single chip," Fossum says. "There's no point in going to the trouble to make a single detector unless you're going to put a lot of them together." He would like to find out how densely the detectors can be packed on a chip without causing crosstalk problems.

The team is also interested in bringing the technique to bear on gallium arsenide and aluminum-GaAs ICs, which hold more promise for high-speed processing and optical communication than does silicon. Thus far, Fossum says, they have etched holes in GaAs substrates, but they have not yet built a GaAs receiver.

Prucnal will deliver a paper on the research at the Optoelectronics and Laser Applications in Science and Engineering conference in Los Angeles later this month. *–Tobias Naegele*

COMPANIES

ENCORE'S ALL-STAR ACT LOSES PIZZAZZ

MARLBORO, MASS.

At its launch just two years ago, Encore Computer Corp. had the prestige of an all-star trio of leaders, a strategy of acquiring promising products and technology, and the goal of building a full-service computer company. The combination got the company off the mark in grand style with \$51 million raised in public and private offerings. A later deal with Sperry Corp. that guaranteed the sale of Encore's new multiprocessors looked like icing on the cake.

But when Encore reported its yearly results on Dec. 26, it became clear that, at best, the cake will take a lot more time to bake than most expected. For the fiscal year, Encore lost $22 million on sales of $491,000.

The company already has changed its strategy. It abandoned the work-station market last month and with its software division on the block, Encore now has decided to focus on the multiprocessor-computer niche, where it has not yet sold a machine since its product introduction four months ago.

The yearend results were not the first bad news. The Sperry deal died last summer when Encore failed to deliver a prototype on time, and no new arrangement has been announced.

The founding managers also have contributed to the glum outlook. Only one of the founding trio is working full-time now. Henry Burkhardt III, a co-founder of Data General Corp., has departed from the company. C. Gordon Bell, former chief technical officer at Digital Equipment Corp., is now cutting back on his workload, says Kenneth Fisher, former president and chief executive officer of Prime Computer Inc., who is Encore's chairman and CEO.

"For a risky new technology like parallel processing, the customer wants a good management team," points out George Colony, president of Forrester Research Inc. in Cambridge, Mass. "But the image of the management has been negated by the events of the past year."

Yearend results should be no surprise, Fisher says. "It's pretty much in line with what we've been telling people all along." The Multimax superminicomputer, which links up to 20 processors with one shared memory, has given Encore a toehold in the market, he says.

The firm has not yet sold its first parallel computer

Sales campaigns for this type of product require three to six months, says Fisher. "We're not dismayed or downhearted, we're really just starting the game.... After the first couple of quarters [in 1986] we'll have gained initial sales and be rolling in the second half."

But customers are not looking for multiprocessors per se, maintains Craig Symons, a financial analyst with Gartner Securities Corp. in Stamford, Conn. He finds that customers want application software, compatibility, support, and service. Encore's offering appears either weak or unknown on all three counts, according to Symons, who adds that the company's Unix orientation also won't help because a lack of software has kept that market from developing as projected. *–Craig D. Rose*

GRAPHICS

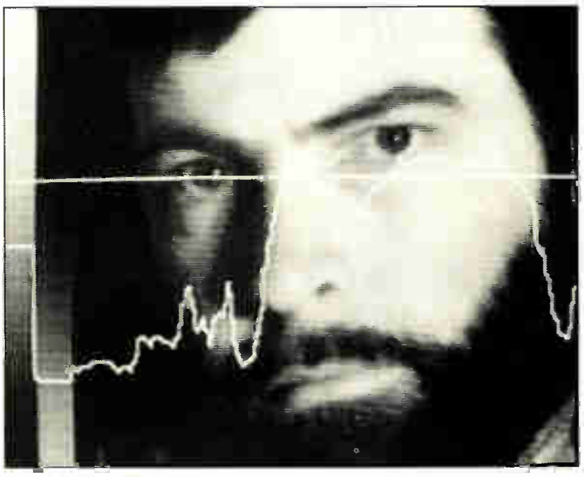
APPLE IIe BECOMES IMAGE PROCESSOR FOR $195

PALO ALTO

Image processing is normally the purview of expensive work stations with high-resolution displays, but inventor Charles P. Springer thinks users of the lowly Apple II personal computer would like such capability, too. So he and a colleague have developed a board and software that give the Apple IIe the same image-processing capability built into high-performance work stations.

The card, called ImageWorks, gives the computer a 256-level gray scale and can be used to display digitized TV and medical images, satellite weather data, or pure graphic creations. Springer's company, Redshift Limited, has also developed a "frame-grabber" board to digitize standard video, and a color board to provide 256 standard colors on a conventional TV screen.

Springer sees applications for the boards in industrial inspection, robot vision, and video games, where he says the gray scale could provide realistic backgrounds. The digitizer board also makes it possible to send photographs by modem. In addition, Springer says, there are many laboratory applications where inexpensive image processing would be a boon. ImageWorks is not expensive—the gray-scale board costs $195, the frame-grabber and color boards $95 each.



APPLE IMAGE. Charles Springer's software enables an Apple IIe to perform complex image-processing tasks.

IBM PC NEXT. Redshift will now adapt the board for the IBM Corp. Personal Computer. Apple Computer Inc.'s IIe was chosen first, Springer says, because it was easier. It uses a standard video interface and a square pixel. Because there are many different video boards for the IBM PC and the ImageWorks board would need to interface with all of them, it is a more complex and expensive job. Also, the IBM color pixel is rectangular, making curves harder to generate.

Springer says he was inspired to develop the boards last spring, when Texas Instruments Inc. dropped to $2.50 the price of its 4161, a 64-K random-access memory with built-in shift registers. That made the project economically feasible, he says. Besides the RAMs, the board includes a digital-to-analog converter made from CMOS latches and 1%-tolerance resistors, and three programmable-array-logic chips for control, timing, and glue logic.

Paul A. Baker, a hardware designer who had worked on Apple's Lisa 2/10 and Apple add-ons at Information Appliances Inc., designed the boards and wrote the PAL equations, and Springer had a working prototype in two weeks. But one week later he took a job at Boeing Computer Services Co. in Seattle and temporarily shelved the project.

It wouldn't die, however, and last fall Springer left Boeing to form Redshift Limited with Baker. In keeping with the Apple tradition of humble beginnings, Redshift started up in Springer's living room. Baker remains at Information Appliances.

The gray scale is generated by the hardware. Images are processed by software routines written by Springer mostly in Forth but also in Pascal, Aztec C, 6502 assembly language, and Basic. Source code for these routines, plus board schematics and a primer on image processing, come with the boards.

Springer admits Redshift's ImageWorks card is slower than work-station digitizers, and its 256-by-256-pixel resolution was chosen to fit the limits of the Apple screen. But the card nonetheless permits the Apple to do any kind of image processing its bigger brothers can, he says, including histogram equalization, edge detection, hidden-surface graphics, shading, and even ray tracing, "if you're willing to let the Apple work a couple of days to do the computation." *–Clifford Barney*

TELEFUNKEN GOES ALL OUT FOR BiCMOS

HEILBRONN, WEST GERMANY

One of the major reasons why Telefunken electronic GmbH—and most other European chip makers—has not been hurt all that badly by the current slump in semiconductors is that it relies on application-specific integrated circuits more than it does on standard parts, which have been hit hardest by the slump. Now the Heilbronn producer is out to enhance its ASIC business even more by going all out for bipolar-CMOS, a technology mix well suited for combining precise analog and complex digital systems on a very large-scale IC.

Telefunken electronic, a joint venture of Frankfurt's AEG AG and United Technologies Corp. in Hartford, Conn., will bring its BiCMOS process on line in late 1986 and plans to come out with its first product, a telecommunications circuit, in early 1987. A BiCMOS device for automotive applications is being contemplated, Arndt says.

BiCMOS components fulfill requirements that ordinarily run counter to each other. On the one hand, they are fast and have high drive power to realize high system speeds. On the other, they boast high packing density and low power dissipation, which are necessary for highly complex chips. In its two years of work with BiCMOS, the company has cut down the process complexity so that high yields and low costs can be expected for future chips. "This should make it possible to apply single-chip VLSI BiCMOS parts even to consumer items like TV sets and radios," says Jürgen Arndt, who heads the MOS process development labs.

All this BiCMOS activity puts Telefunken in the small league of makers committed to mixed-technology chips as alternatives to multiple-chip approaches using chips based on different technologies. Also playing in that league are Hitachi and Toshiba in Japan and Digital Equipment and Motorola in the U. S.

So far, Arndt says, only Hitachi is in volume production of a BiCMOS product, a gate array. It is also gearing up for mass production of 64-K static random-access memories using its 2-μm Hi-BiCMOS process [*Electronics*, June 3, 1985, p. 22]. And Motorola has announced a series of products using Bi-MOS, one of which—a 6,000-gate circuit—is now being offered as samples [*Electronics*, Nov. 25, 1985, p. 18].

Process to start up late this year, with first part to come in 1987

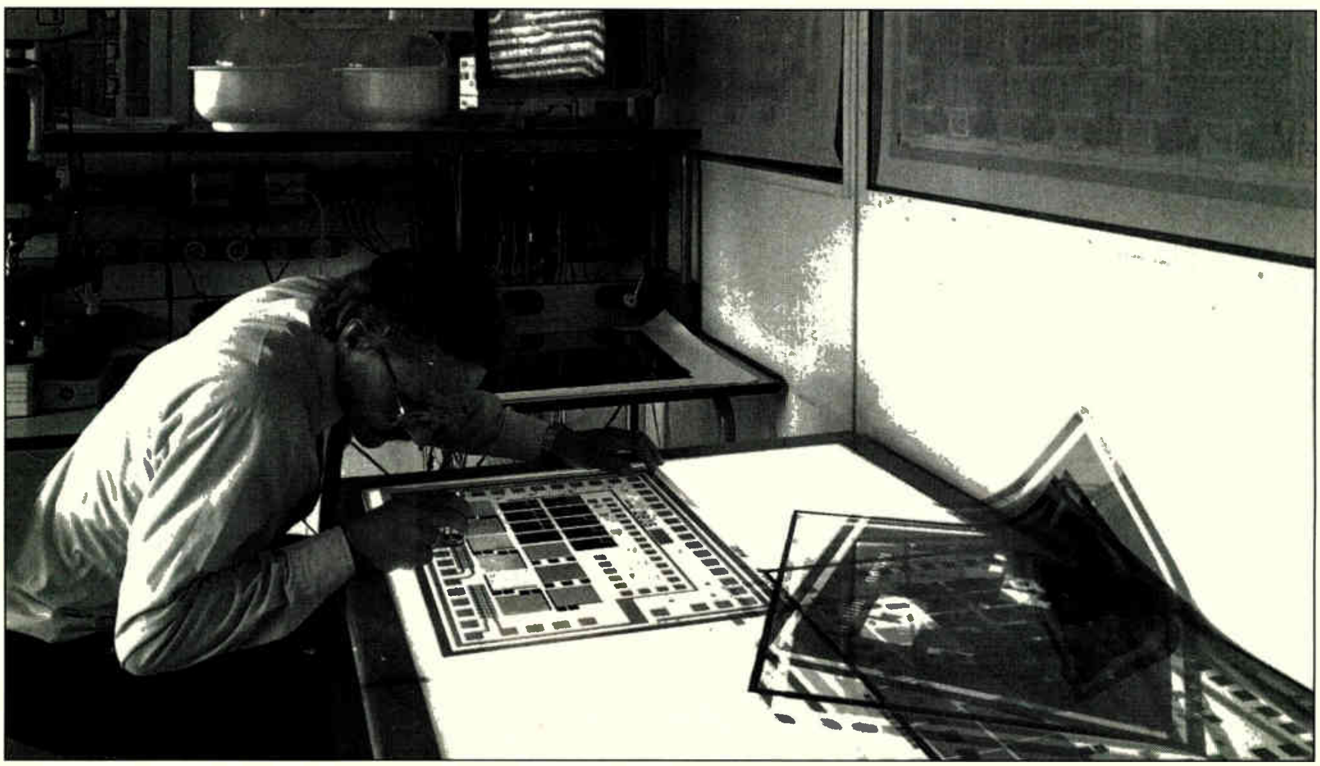
Although the first mixed-technology activities date back to 1973 when RCA Corp. developed BiMOS techniques, it became practical only recently, when chip makers made a big move to ion implantation as the doping source and to polysilicon as a conductor. This has helped solve the bipolar-with-CMOS compatibility problem without appreciably increasing the process complexity.

Telefunken electronic's version of the BiCMOS technology is essentially an n-well process on a p-type substrate with a p-type epitaxial layer. The bipolar side has self-adjusting vertical npn and lateral pnp transistors in their associated n-wells. A highly doped buried layer with a low-resistance collector contact and defined by local oxidation makes for good bipolar characteristics.

Because of the short channel lengths—down to around 1 μm—the MOS transistors have lightly doped source and drain zones. The npn bipolar transistor has a more heavily doped extrinsic base and a polysilicon layer, the latter serving as the diffusion source and contact for the emitter. Ion implantation is used for all doped regions.

To reduce the process complexity and still obtain chip densities of more than 100,000 transistors, multiple use is made of certain processes on the bipolar and CMOS sides. For example, the p-MOS transistor's n-well acts as an active collector region for the npn transistor and as a base region for the pnp transistor.

Reducing process complexity further



DESIGNER AT WORK. Jürgen Arndt, who leads Telefunken's MOS development labs, works with a BiCMOS structure.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is the n-type buried-layer zone, which, besides serving as a low-resistance collector contact on the bipolar side, is used on the CMOS side for improving the latchup behavior. This is achieved by reducing the well resistance and by sacrificing some of the parasitic pnp transistor's current amplification.

Furthermore, the n-doped polysilicon is used both as a MOS gate and as a diffusion source for the bipolar emitters. Arndt believes that as far as such multiple use of certain processes is concerned, Telefunken electronic's BiCMOS technology has an edge over competitive mixed-technology approaches. It leads to less process complexity and thus to high-yield low-cost devices.

The Heilbronn engineers are carrying out their work in BiCMOS in two stages. The first-stage BiCMOS-1 project, scheduled for completion by the end of this year, aims at devices with minimum geometries of 2 μm. Such dimensions can still be achieved without wafer steppers, Arndt points out. Fourteen masking steps are needed.

The npn transistors made so far under the BiCMOS-1 program exhibit cutoff frequencies of better than 1 GHz at a supply of 10 V—in fact, typical values are closer to 1.5 GHz, Arndt says. The CMOS side is being optimized and will, at a fan-out of one, attain a gate delay of less than 2 ns. The packing density for the CMOS side should come to around 3,000 transistors per square millimeter.

REACHING ONE MICRON. The second-stage BiCMOS-2 project, scheduled to be completed by the end of 1988, envisions devices with minimum geometries of 1 μm or slightly below. The epitaxial layer will be reduced from the 4 to 5 μm typical for BiCMOS-1 to about 2 μm.

The Locos (for local oxidation) isolation technique used with BiCMOS-1 will be replaced by a space-saving trench-isolation method whereby narrow, deep trenches etched into the silicon are filled with organic and inorganic isolation material. Use of smaller geometries and better doping profiles should improve the high-frequency characteristics of the bipolar transistors.

With their BiCMOS-2 technology, Arndt and his team hope to build devices with cutoff frequencies well above 2 GHz. Together with a high current amplification, operating frequencies of up to 1 GHz should be possible for the analog stages. The bipolar transistors' breakthrough voltages should allow operating voltages of at least 5 V. Use of 1-μm channel lengths at the CMOS side should make possible gate delays of less than 1 ns.

The 1-μm geometries could lead to packing densities of about 10,000 transistors per square millimeter for the CMOS side. Because of the process complexity involved with the 16 masking steps that are necessary, the chip complexity of a pure MOS circuit cannot be achieved, Arndt says. Still, BiCMOS-2 will enable respectable densities of more than 100,000 transistors per chip.

What makes BiCMOS attractive, the company says, is the variety of applications it allows. Among them are partly digital radio and television circuit concepts, interface and signal-processing circuits for broadband integrated-services digital networks, and data-collecting and -processing circuits for use in automobiles. Others are one-chip approaches to digital signal processing as well as high-quality analog-and-digital arrays for use in telecommunications applications. *–John Gosch*

IC PRODUCTION

MULTIPLE E-BEAM SYSTEM SPEEDS THROUGHPUT

TOKYO

It used to be that electron-beam writing systems for making semiconductors or chip-production masks needed separate pattern-generation systems to control each beam. But engineers at Hitachi Ltd.'s Instrument Division have changed that by enhancing their pattern generator's performance so that it can control several e-beam columns at once, boosting its throughput significantly.

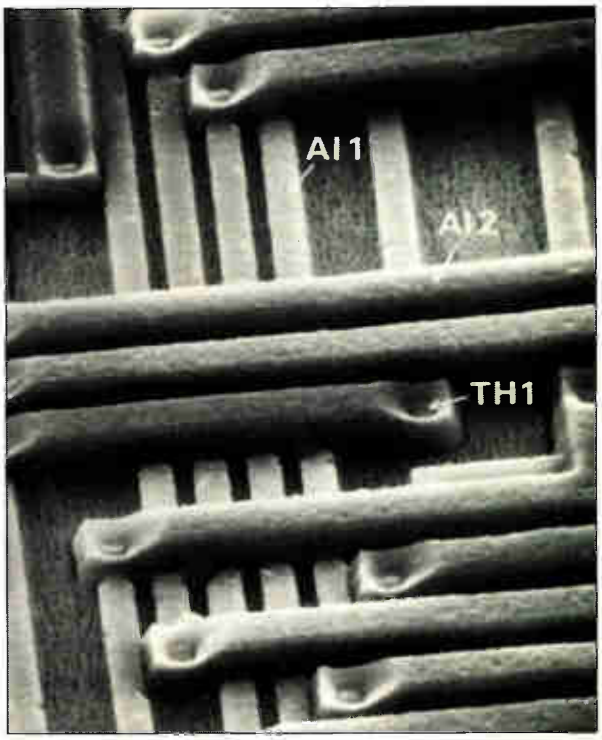
System controls two to five e-beam columns

One of the major reasons for the development is Hitachi's concern that as the use of automated equipment increases in semiconductor production, it must have an especially reliable source. After studying the question, the company found the perfect supplier: itself. Hitachi stepped up its development of the key machinery in-house—which also promised new products for the market (see "Hitachi uses microwaves to create fast plasma etching system," p. 30).

The multiple-column electron-beam system increases productivity in writing directly on wafers to provide short-turnaround time for customized products or small production runs. It can also be used to simultaneously generate multiple masks or reticles for optical or X-ray lithography systems. And like other e-beam systems, it can bypass the reticle step and use the e-beam to write patterns directly on wafers so that devices such as large computer central processing units can be built just two to three weeks after completion of the computer-aided design.

The unit that now supports two to five e-beam columns writing the same or different patterns is Hitachi's vector scan shaped-electron-beam system. This superminicomputer and the e-beam units it controls can achieve a throughput of 10 wafers per hour per column when processing 4-in. wafers, and five per hour for 6-in. wafers.

The system, which can handle both cassette loading with 12 wafers per cassette and continuous automatic loading, is well suited for the submicron era. Its designers rate its nominal minimum feature size at 0.5 μm, but they add that it is possible to use it for features as small as 0.2 μm. Accuracy of the line width is to 0.1 μm and alignment with the previous pattern



ON THE BEAM. This device, made with Hitachi's new electron-beam lithography system, uses 1.3-μm design rules.

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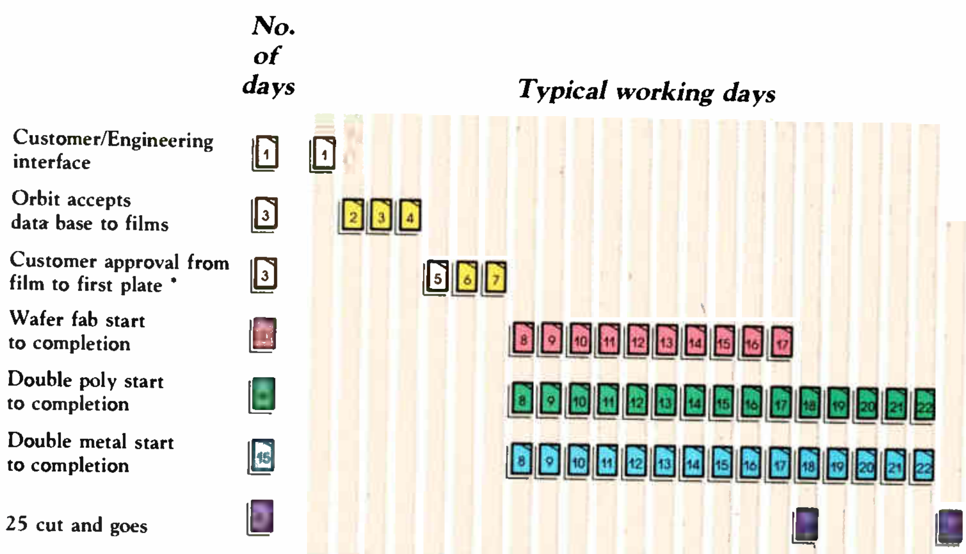

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*QMOS is RCA high speed CMOS logic. Alternate sources: Philips N.V. and Signetics.

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RCA

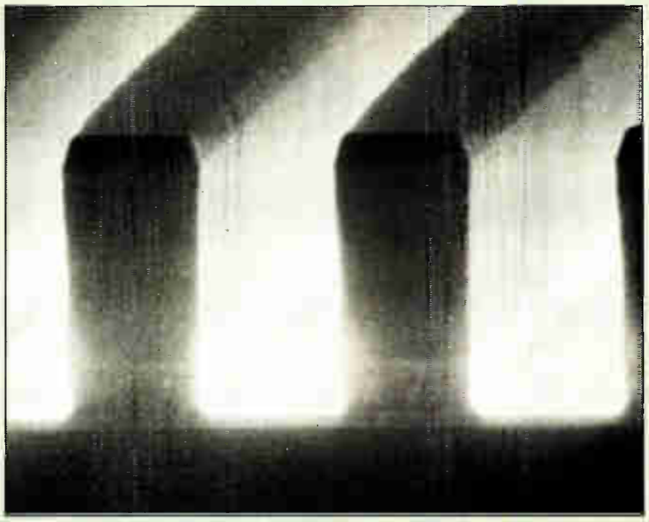
HITACHI USES MICROWAVES TO CREATE FAST PLASMA ETCHING SYSTEM

Hitachi's electron-beam system puts up to five beams to work at once generating the images of a device's features. Those images can be given shape in a production environment with another piece of equipment developed by researchers at Hitachi's Industrial Process Group, Tokyo—a microwave plasma etching system.

The $700,000 etching system fabricates polysilicon, polycide, and silicide gates to submicron lengths. Etching speed is high—typically 500 nm per minute. Moreover, the anisotropic quality of the etching—its ability to hew to the vertical—is extremely high, enabling it to fabricate sharply defined gates with vertical walls. Selectivity between etching gate material and the underlying silicon dioxide is more than 50 : 1 to give a sharply defined gate without cutting into gate oxide. Ion energy is in the range of 20 eV, a value low enough to avoid electrical damage to the device.

The etching mechanism is somewhat different from that in other dry etchers. The plasma is the result of electrocyclotron resonance in which microwave and magnetic fields combine to cause the molecules to spin. Drift is controlled by an rf bias applied to the wafer to be etched. The etching chamber is surrounded by a quartz bell jar; there are no accelerating electrodes whose materials can contaminate the wafers.

A further feature of this system, which will begin shipping in July, is that gas pressure can be 100 to 1,000 times lower than in other systems for clean processing. Pressure during etching is typically 10^{-3} to 10^{-4} torr. With other systems, such a low pressure would make for an insufficient number of ions or cause the ions to gain excessive energy. *–C. L. C.*



PATTERN. Microwave plasma etcher yields sharply vertical walls.

laid down is to within 0.15 µm.

The Hitachi engineers say their system is also suitable for fast turnaround of mask read-only memories and gate arrays. Because each chip position on a wafer is patterned in sequence, several types of chips can be fabricated on the same wafer with the exact number of each type adjusted for demand. Moreover, different layers of the design can be patterned on different columns simultaneously. And because of the fast turnaround and the elimination of a mask, for small batches the cost of processing is lower than that of optical lithography.

The new electron-beam system, with two columns, will start at $6 million; additional columns will run another $2.4 million each. Deliveries are scheduled to start in October. *–Charles L. Cohen*

MILITARY

USAF STARTS TO BUILD $128 MILLION IC STOCKPILE

LOS ANGELES

In a bold move designed to guarantee availability and improve reliability of circuits headed for space, the U. S. Air Force plans to begin buying $128 million worth of spaceworthy semiconductors this year. The procurements would double the market for such devices, predicts Integrated Circuit Engineering Corp., Scottsdale, Ariz.

The purchases—more than twice initial targets—will provide government contractors with an operating stockpile of high-reliability space components, designated in the defense industry as JAN (for Joint Army-Navy) Class-S parts. Each device will be stored in a hermetically sealed container at a defense depot in Ogden, Utah.

The project includes integrated circuits and discrete components. Air Force officials say the Ogden stockpile could save the government millions of dollars in procurement costs by allowing defense and space programs to avoid minimum-purchase requirements and by eliminating devices not on the operating parts list. The project also could do away with the present need for each space-system manufacturer to make a destructive analysis for each part type.

MORE PART TYPES. Originally, the Air Force Space Division in Los Angeles envisioned an operating stock of some 300 part types, accounting for 1 million devices and about $50 million in inventory. But after taking a survey of the defense electronics industry last fall, it increased the program's scope to 544 part types and a $128 million inventory. The Defense Logistics Agency has given "the preliminary go-ahead" to the Defense Electronic Supply Center (DESC) in Dayton, Ohio, to fund the project, according to Capt. Donald Seta, the division's manager for JAN Class-S devices.

This month, Air Force officials expect to complete the operating parts list, which is being compiled from data supplied by 45 space systems manufacturers, representing some 120 different programs. They will spend the $128 million to initiate the stockpile's inventory. When space-equipment contractors purchase from the stockpile, the money will replenish the revolving inventory.

Later in January, DESC will start assigning national stock numbers for the ICs, discrete transistors, and diodes. Certified Class-S chip makers can bid on the procurements between March and August. At least four U. S. chip makers have asked DESC for Class-S certification after learning of the huge purchase plans, says Seta, who declines to identify them. More manufacturers are expected to follow suit.

"Around August, DESC should come out with purchase orders," says Seta. The Ogden depot, which will play the role of a chip distributor, should begin selling parts by September.

The project's primary objective is to reduce the time it takes defense and space contractors to obtain JAN Class-S parts. On average, these space components take chip makers about one year to fabricate, test, and deliver.

"Many times, our programs wait a year and a half to two years for space-qualified parts, only to find out at the end of the wait that the JAN Class-S parts failed testing," notes Seta. "The contractor often has to go to backup

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parts—which could be commercial devices from Singapore—or accept 'failed' parts [those from lots exceeding acceptable failure rates]."

The project cuts costs because purchasers buy only as many chips as they need, instead of a minimum order. Recent calculations show that this measure, combined with elimination of nonstandard parts, could save $67 million over five years. Nonstandard space components, designated by source-controlled drawings, cost an average of $240 each, compared with $40 for Class-S ICs.

Additional savings estimated at $16 million could be gained by eliminating destructive physical chip analysis by each program contractor. When the Air Force purchases a chip type for the depot, it will perform a destructive analysis, potentially satisfying the government requirement that a chip type go through this process at purchase. However, a space project director may order a repeat of this process since space contractors will still be responsible for device reliability. That's because the depot is acting only as a chip distributor and not as a center for government-furnished equipment. *–J. Robert Lineback*

LEGISLATION

SILICON VALLEY EXPECTS TOUGHER TOXICS RULES

PALO ALTO

California, traditionally a trendsetter for laws on handling of toxic materials, is drafting new legislation to tightly control all aspects of the use of toxic chemicals. Some Silicon Valley electronics companies are anticipating legislation that would require tighter handling of toxic waste, decreasing or eliminating its use altogether.

The California legislature has jumped into the issue with both feet, working on the toxics problem with research and legislation. Lt. Gov. Leo McCarthy, chairman of the State of California Commission for Economic Development, will sponsor a dozen bills, now being drafted, in a bipartisan package on toxics for the next session of the legislature, which begins this month. The proposed legislation will be based on a report released in June by McCarthy's office, called "Poisoning Prosperity: The Impact of Toxics on California's Economy."

Already in rough form are proposed laws to establish residual repositories for already treated nonorganic waste residues; to require environmental and health audits of companies that use toxics in the workplace; and to set up an independent technology performance-review group—not unlike Underwriters Laboratories—to test new waste-reduction technologies.

Also as a result of the report, McCarthy's office has developed "The 1990 Plan"—five specific goals that he claims will "improve the management of toxic chemicals in California while minimizing long-term costs."

Those goals include reducing by 20% the present cost of managing toxics; to decrease by 50% the volume of toxic waste entering disposal sites; to "substantially increase" the level of private-sector investment in toxic management technology; to minimize toxic releases to air and water through good management; and to ensure that no state residents drink water that contains "health-threatening quantities" of toxics.

COMMUNITY INPUT. "The bills concern everything from drinking standards to economic incentives for manufacturers and disposers of toxics to use treatment instead of disposal," says Nancy Hart, environmental research assistant for McCarthy's office. "We received a lot of input from people in the business community, the environmental community, and analysts for other legislators. The main idea is to effect a change—and obviously that usually only comes through legislation," she says.

Hart says McCarthy is interested in results through negotiation as well, and has been talking with some valley companies about their waste reduction and handling programs. Two are IBM Corp. in San Jose, and Hewlett-Packard Co. in Palo Alto. Both are designated Superfund sites. Sources say other companies, including National Semiconductor Corp. in Santa Clara and 3M Co. in Sunnyvale, are also working on toxics reduction programs.

Dave Brooks of HP's corporate environmental division says his company is actively involved in a practice known as source reduction: cutting back on the use of toxics in processing products.

"Do you have any idea what pressures we're under for source reduction?" he says. "There is tremendous regulatory pressure to stop using and disposing of wastes the way we've been doing" [*ElectronicsWeek*, March 18, 1985, p. 32].

For example, one division has switched from petroleum- and alcohol-based paint to water-based paint, and the Santa Clara semiconductor division just installed a photoresist system that cuts chemical use 40%.

Brooks says other HP environmental personnel are involved with state government through the Governor's Task Force on Toxics, Waste, and Technology; the Environmental Defense Fund; and the California State Office of Senate Research.

In addition, Ray Kerby, director of environmental programs at IBM, says McCarthy visited the company about a month ago and at that time IBM publicly agreed to reduce its chemical waste stream 50%. "We've been working on this for some time," claims Kerby. "It's part of IBM's corporate environmental objectives worldwide." *–Denise Caruso*

ADVERSARIES. As California's lawmakers prepared to consider new toxic regulations, environmentalist Ted Smith, left, debated the subject with industry representative Leo Kline, right. The moderator is Rich Robinson.


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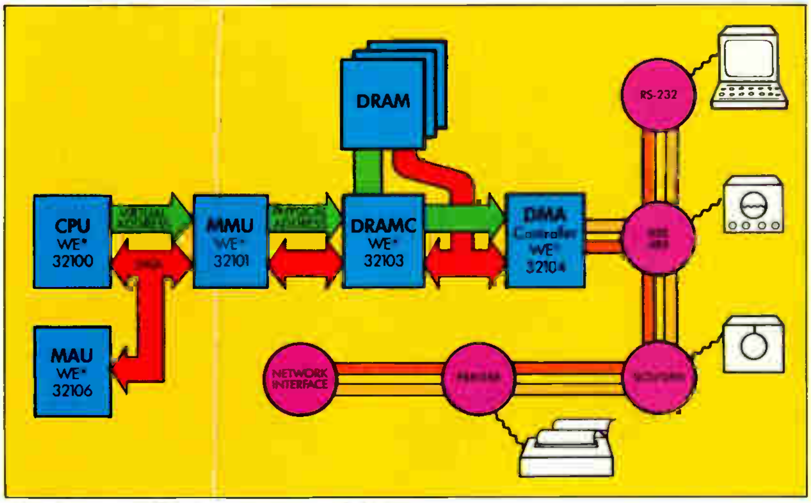

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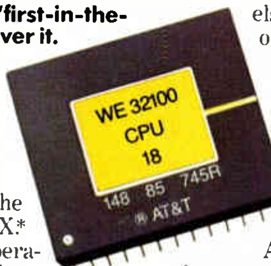

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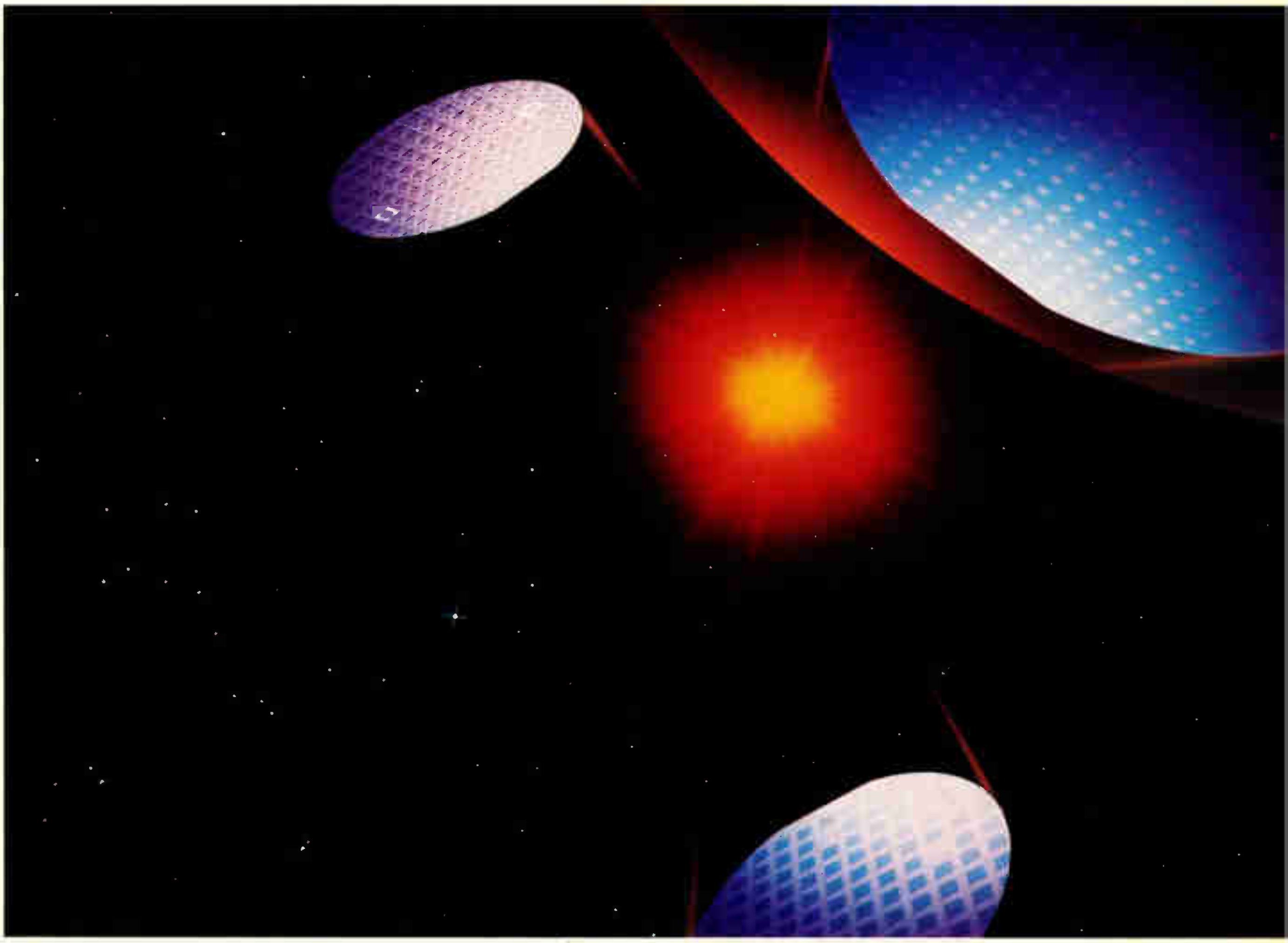

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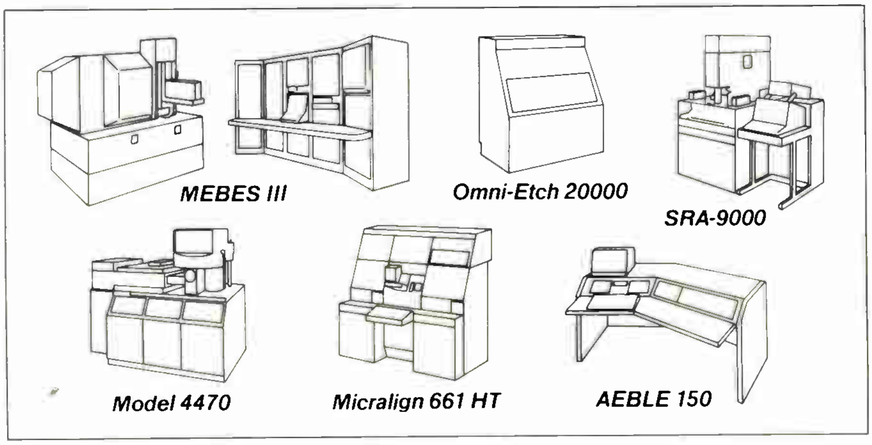

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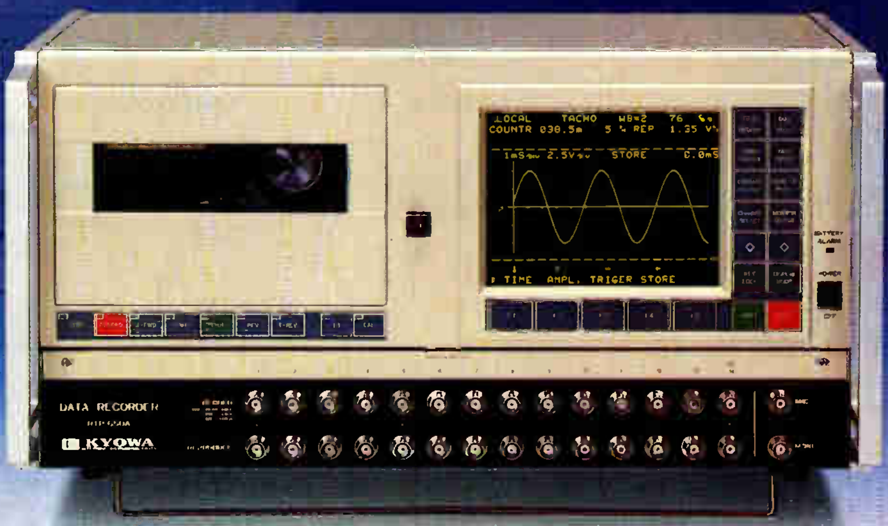

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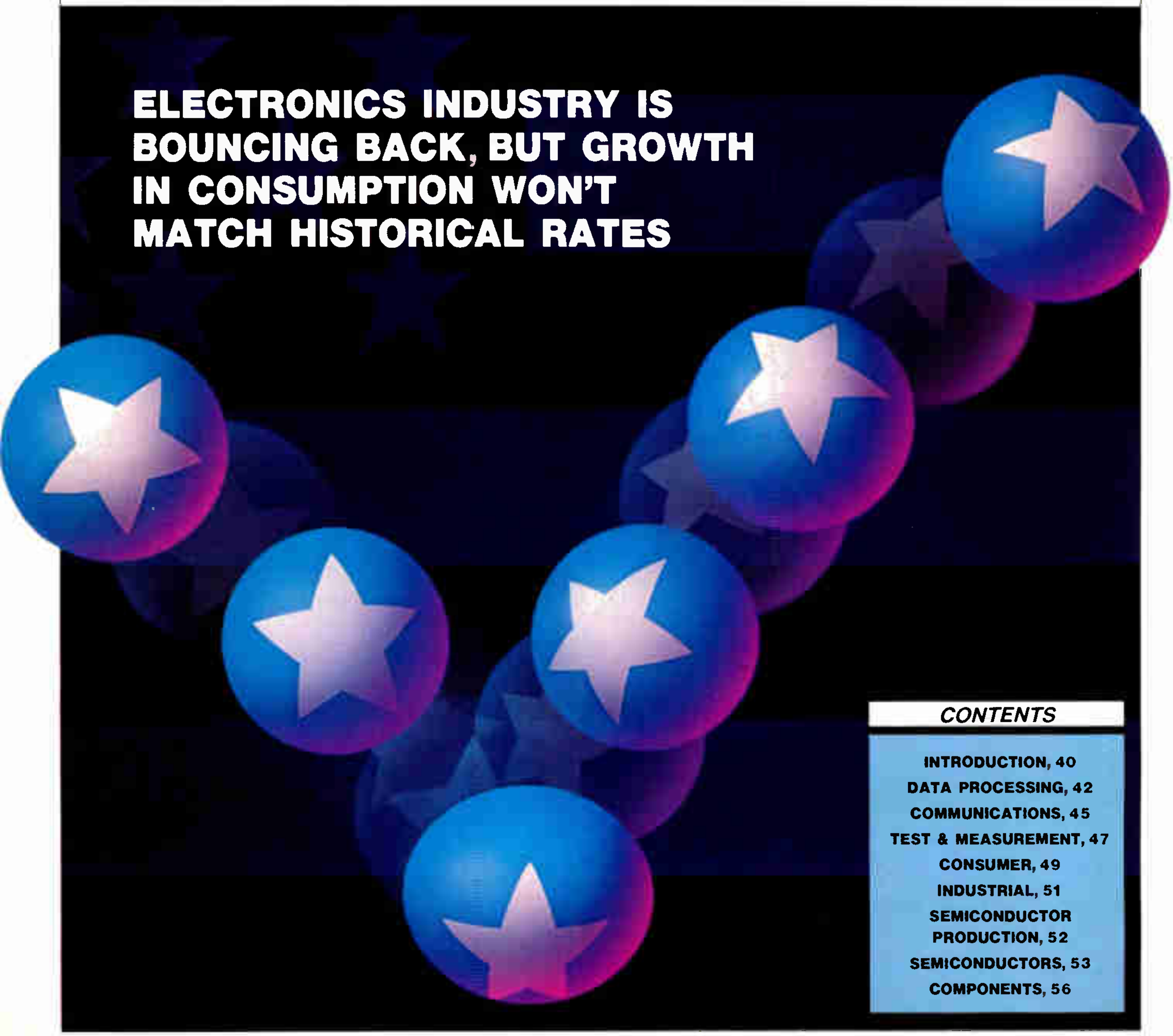
1986 U.S. MARKET REPORT

ELECTRONICS INDUSTRY IS BOUNCING BACK, BUT GROWTH IN CONSUMPTION WON'T MATCH HISTORICAL RATES



CONTENTS

INTRODUCTION

INDUSTRY TO BOUNCE BACK WITH DEMAND UP 13%

The U.S. electronics industry is coming back. *Electronics'* 1986 U.S. Market Report concludes that growth is increasing or returning to just about all segments. Demand for equipment will grow about 2% faster than last year, while component consumption will more than reverse its 1985 downturn. That's good news for the many manufacturers that have seen their sales drop, their losses mount, and their worker ranks slim down.

Consumption of electronics equipment in the U.S. this year will increase about 13%, to almost $132 billion, according to the *Electronics* report. Last year, equipment consumption in the U.S. was up just 11%, to about $117 billion. On the components side, total consumption should advance 12%, to about $36 billion—compared with 1985's overall 7% decline, to just over $32 billion—as equipment manufacturers fill their depleted pipelines.

The concerns that influenced corporate buyers to defer equipment purchases seem to have abated for the most part, and signs have appeared that coffers are opening, industry executives say. Customers are recognizing that they have to start buying new machinery—from computers to process controllers—to keep their businesses running efficiently.

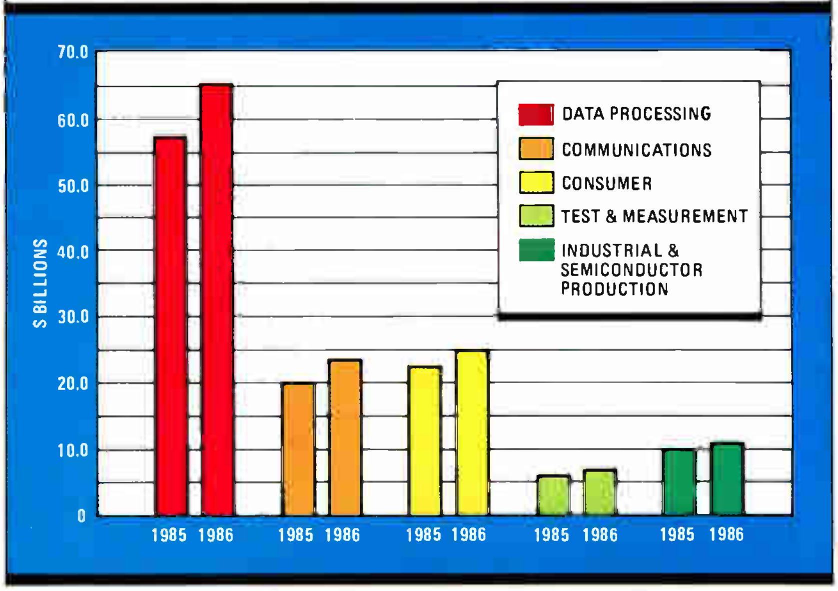
Still, a few clouds have appeared that mean trouble ahead. First and foremost, capital spending plans for U.S. business as a whole are expected to dip slightly this year. The annual survey of spending on new plant and equipment, conducted by McGraw-Hill Inc.'s economics department, found that manufacturing and nonmanufacturing companies this year plan to cut outlays by 1%. This is a harbinger of rough times for the economy this year, say McGraw-Hill economists. That's understandable, considering that 1985 was the third year in a row that the U.S. economy expanded following the recession of 1981-82. The economy could be running out of steam, which could translate into a cutback in spending later this year.

For the electronics community, though corporate spending and consumption of electronics gear should pick up, the pace of business is still nothing to cheer about when compared with growth rates in recent years. Equipment and component makers will have to adjust their thinking and corporate planning to take into account the expected lower growth rates. Expectations will have to be changed, business plans rewritten, and operations pruned to make them even more efficient and profitable. In short, the electronics markets are bouncing back, but it's a whole new ballgame for suppliers.

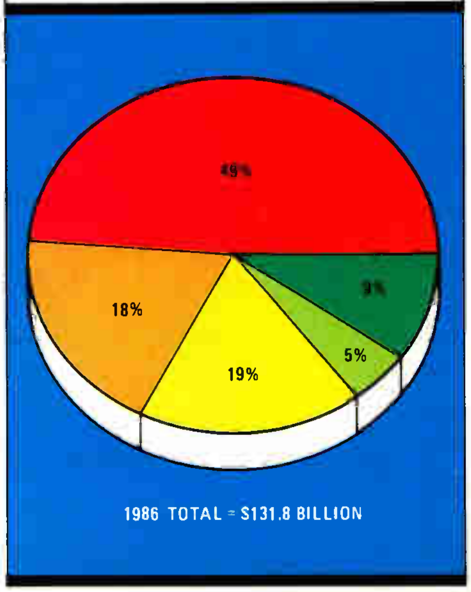
Nowhere is this more evident than in the market for data-processing equipment, which grew just 11% last year, to almost $57.4 billion. Suppliers of computers ranging from mainframes to personal computers saw their businesses slump in 1985—with growth in computer systems of just 10% over 1984, to $28.1 billion—as customers cut back on their spending.

Confusion over new products and product direction, indigestion caused by an oversupply of computers, and economic uncertainty caused buyers to stay away in droves, especially in the low-end of the market. This caused a ripple effect that cut the growth of peripherals, such as disk drives and terminals. Industry executives say they have seen signs that this has ended, with customers coming back into the market in the just-ended fourth quarter. They expect this momentum to carry over into 1986, with consumption growing 14%, to $65.3 billion, a low rate compared with growth earlier this decade.

U. S. EQUIPMENT MARKETS: GROWING IN 1986



HOW THE MARKET IS SEGMENTED



The growth in consumption of communications equipment in 1985 was higher than that of the computer industry, but not by much—it rose 14%, to $20.8 billion. Demand in this sector also suffered from the impact of a wait-and-see attitude by corporate communications managers, who often had their budgets slashed by worried top management. Modem sales were affected by the slump in the personal computer industry, while makers of private branch exchanges faced a nasty fight from the spun-off regional Bell operating companies for the pocketbooks of customers. Customers will continue to be cautious this year, and growth should stay stable at 14%, with consumption totaling $23.6 billion.

Helped by an infusion of new audio and video products, suppliers of consumer electronics gear saw consumption grow a healthy 12%, to $22.5 billion last year, as Americans spent heavily. The advent of stereo TV broadcasting by the major networks—it now reaches 75% of the U. S. households that have sets—helped spur demand for new, stereo-capable receivers, as consumers wanted to take advantage of the higher-quality sound.

The nation's love affair with the video cassette recorder continued apace, though manufacturers think the rate of growth in this market will slow as a saturation point is reached. Still, a new phenomenon is occurring that could add a mid-life kicker to the market: consumers are replacing earlier-generation VCRs with newer models or adding a second machine to their entertainment centers.

Managers realize that they can't stop buying forever

Also, the purer sound of compact disks is exercising its appeal to consumers, who are buying them in ever-greater numbers. This, in turn, is boosting sales of next-generation audio components, as buyers upgrade their total sound systems. Growth in consumption will continue this year, but at a slightly lower rate—11%—to $24.9 billion.

The market for test and measurement equipment should also improve in the coming year and grow at a more normal rate—12%—than last year, when it managed to eke out less than a 1% gain. As a result, 1986 consumption will reach almost $6.8 billion from 1985's $6 billion. The market for test equipment depends on other equipment and component markets for growth, and the weakness in these markets flattened last year's performance. But sparked by an increase in orders for new automated test equipment, this market should rebound nicely in 1986, industry executives think.

Perhaps more so than any other product area, the industrial equipment market lives and dies by the projection for capital spending by U. S. industries. With many manufacturing sectors still not fully recovered from the recession that occurred in President Reagan's first term, demand for many types of industrial electronics equipment has not been as healthy as in the past. On the other hand, healthy industries continue to invest in automation to ward off still-mounting overseas competition. Last year, total consumption of industrial electronics equipment was up 12%, to $7.6 billion, and this should increase by 14%, to $8.7 billion, for 1986.

There's little chance that the market for semiconductor-production equipment will expand at a double-digit rate. Indeed, this market will be lucky if it grows at all. The *Electronics* market report sees consumption of this equipment inching ahead by about 2% this year, to $2.5 billion, following last year's 4% drop, to $$2.4 billion, because chip makers have a whopping amount of new processing equipment sitting unused in their vacant plants.

Those plants will come back on line this year as growth returns to the semiconductor market. U. S. chip consumption fell 17% last year, to $12.4 billion, according to the market report, as customers stopped buying parts and worked off their inventories. As equipment markets return to health and inventories are depleted, demand for semiconductors will increase by 14% this year, to $14.3 billion, though consumption will be below 1984's record pace of more than $15 billion.

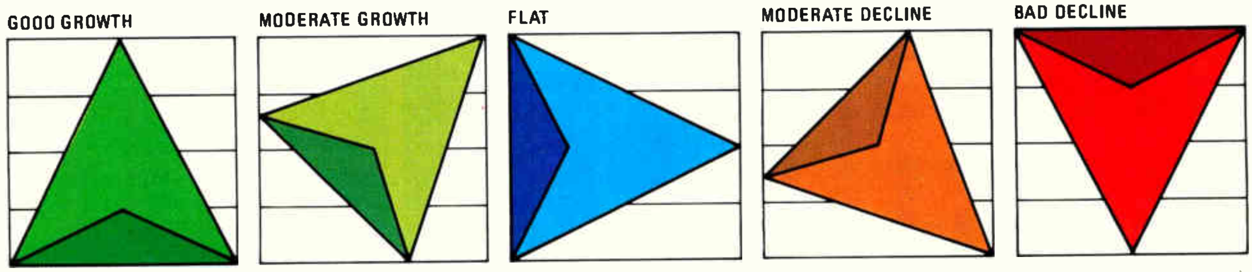
The information contained in the *Electronics* market report is based on estimates supplied by electronics executives of industrywide consumption at the factory level of various kinds of U. S.- and foreign-made equipment. U. S. consumption equals sales in the home market by U. S. vendors, plus imports; it does not include exports by U. S. producers. The survey was conducted through questionnaires mailed to industry sources in early fall 1985, so actual figures for 1985 may be conservative when the fourth quarter's business is factored in.

Estimates from industry sources were then reviewed and tabulated by the *Electronics* staff. In some cases, follow-up calls were made to sources to get a better understanding of their responses. In addition, secondary sources, such as market research companies and trade associations, were contacted to corroborate projections and estimates. Some product categories have been added in this year's survey, while other categories have been deleted, so that totals may not be directly comparable to those of previous market reports conducted by *Electronics*. Amounts are stated in current U. S. dollars. No adjustments for the effects of inflation have been made in this report by *Electronics*, although questionnaire respondents may have factored their inflation estimates into their figures.

INDUSTRY REPORT CARD

When we started examining the various markets in the electronics industry and gauging demand for 1984 through 1986, we expected to find that business in some markets would grow but that consumption in a lot of markets this year would actually fall for the first time. Our market indicators, which appear in each section, point the way to a market's performance, much like the scoring on a report card. Happily, we found that, despite the gloom-and-doom predictions that pervade the electronics industry, only two growth indicators were needed: moderate and flat (for semiconductor production equipment). There's still room for improvement in the industry's performance—that's the way the ball bounces.

ELECTRONICS' MARKET INDICATORS



DATA PROCESSING

DEMAND TO RISE 14%, JUST SLIGHTLY BETTER THAN LAST YEAR'S 11%

For U. S. computer makers, who have reveled in record growth rates in recent years, 1985 was a sobering experience. The data-processing industry did record gains in all product areas except personal computers, but the growth rates that everyone had expected evaporated. "When a company is geared for 100% market growth, it's got a big problem when there's only 30% growth," says Chuck Comiso, vice president of marketing at Wyse Technology, San Jose, Calif. Makers who had hoped for a repeat of 1984's roaring business faced buyer caution instead, as business from corporations and consumers alike slowed.

"The market [in 1985] was hardly a disaster," says Robert F. Holmes, senior vice president at Burroughs Corp., Detroit. "But the industry didn't get the double-digit growth it wanted." The overall 11% growth was dismaying in a business where gains of 18% to 20%—even higher for some market segments—have been the norm. "A lot of people have taken a very real hit in the past nine months," adds Holmes.

In one sense, the success that propelled the computer industry—along with other sectors of the electronics community—to new heights in 1984 was responsible for the disappointing performance in 1985. It would have been impossible to repeat 1984's gains, and the modest increases of 1985 seemed lackluster in comparison. The high times of 1984 show no signs of returning soon: *Electronics'* U. S. market report finds that demand will increase only about 14% in 1986.

The vagaries of the computer market are also spilling into the peripherals segments. For example, demand for floppy-disk drives is slowing, while use of hard disks, which offer more storage at not much higher prices, is rising. Demand for more mature products, such as disk packs, is slowing as their product cycles near their end. And products such as small hard-disk and 3½-in. floppy-disk drives are becoming more of a presence.

Demand for terminals should increase in 1986, pushed by the proliferation of multiuser microcomputers and small business systems, following a somewhat flat year in 1985. But the good news is tempered by cost pressures: the industry also expects depressed profit margins, some company failures, and increased competition from foreign suppliers edging into the market.

The reasons for the slowdown have become a litany for industry executives. Some sectors of the U. S. economy have not recovered fully from the 1980-82 recession, and companies in these areas are still hesitant to commit large sums to computerize their offices. Other sectors—such as some banks and savings-and-loan organizations—ran into trouble in 1985 and deferred buying. Uncertainty over the future of the economy, now past its third year of recovery, has led still other companies to reexamine and in some cases reduce capital-spending programs. Finally, unease over federal tax reform proposals and changes in the tax treatment of investments and depreciation have also slowed purchase decisions.

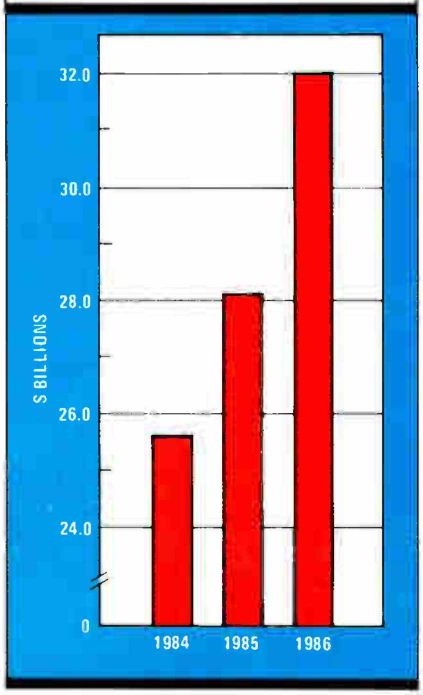
Confusion on the part of the buying public about the future direction of computer hardware, especially from trend-setting IBM Corp., is another reason cited by computer executives for last year's market malaise. A round of new product cycles from major manufacturers, among them IBM, Digital Equipment, and Burroughs, convinced some customers to wait until the dust settles before deciding what to buy.

But the single biggest reason may be this: customers bought a mammoth amount of hardware in 1984, especially in personal and microcomputers, and they're not sure if they got their money's worth. The problem was a lack of communications products and applications software that's still tough for the rookie user to master. "A computer that's not used is an expensive paperweight," notes Holmes of Burroughs.

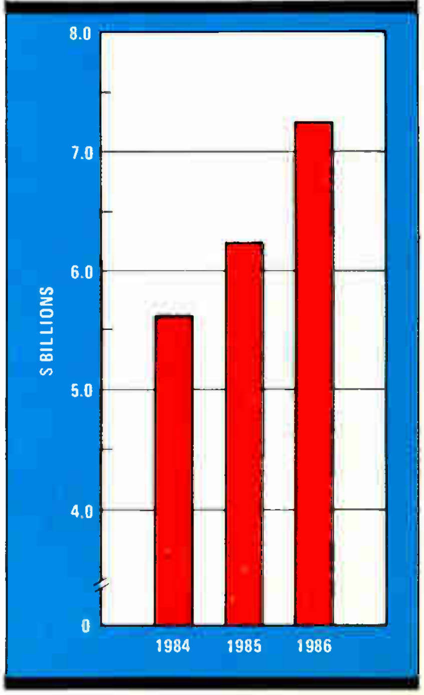
"Last year was not the easiest market," says John L. Doyle, executive vice president of the Information Systems and Networks Division at Hewlett-Packard Co., Palo Alto. "Everyone seemed to suffer some of the effects." Or maybe, he adds, "the growth is just averaging out." The HP executive sees the slowdown as the underside of the 1984 upturn. "People are still wondering what to do with all that equipment."

For the most part, the people doing the wondering are

COMPUTER SYSTEMS



DATA-STORAGE SUBSYSTEMS



corporate users, because the business community continues to do the bulk of computer buying, and not just of minicomputers and mainframes. "We find that a significant majority of personal computer sales—perhaps 80%—are corporate, business-user sales," as opposed to sales for home computers, says Ed Gelb, group marketing manager for Panasonic's Computer Products Division, Secaucus, N. J.

UNDERUSED PERSONAL COMPUTERS

In Gelb's view, computer buying by this market began to dry up in the second quarter of last year as managers realized that all those personal computers they had so enthusiastically purchased weren't being sufficiently used. "Their investments weren't yielding the productivity improvements they thought they would. So corporations froze their purchasing decisions in order to digest their purchases. That's the biggest factor for the decrease in growth."

DATA-PROCESSING GROWTH QUICKENS

	1984	1985	1986
	(millions of dollars)		
DATA-PROCESSING EQUIPMENT, total	**51,741**	**57,373**	**65,289**
Computer systems, total	**25,568**	**28,090**	**31,956**
Personal computers (under $5,000)	1,180	1,090	1,260
Microcomputers ($5,000 to $20,000)	2,374	2,778	3,361
Minicomputers ($20,000 to $100,000)	5,870	6,395	7,099
Superminicomputers ($100,000 to $400,000)	6,545	7,060	7,836
Mainframe computers ($400,000 to $5 million)	8,290	8,870	9,897
Supercomputers	520	840	1,020
Engineering work stations	789	1,057	1,483
Data-storage subsystems, total	**5,624**	**6,274**	**7,312**
Disk pack	657	709	813
Fixed disk, total	2,240	2,533	3,152
14 in.	596	651	738
8 in.	810	895	1,037
5¼ in.	782	857	997
3½ in.	52	130	380
Fixed/cartridge disk, combination	685	760	730
Flexible disk, total	1,422	1,579	1,813
8 in.	605	672	758
5¼ in.	742	815	937
3½ in.	75	92	118
Cassette and cartridge magnetic tape	135	165	210
Reel-type magnetic tape	485	528	594
Data terminals, total	**6,834**	**7,459**	**8,417**
Cathode-ray tube	4,738	5,165	5,836
Graphics, total	1,251	1,367	1,545
Raster scan, total	1,056	1,172	1,348
Color	325	385	494
Monochrome	731	787	854
Storage tube	103	107	112
Vector refresh	92	88	85
Remote batch, job-entry terminals	845	927	1,036
I/O peripherals, total	**5,930**	**6,630**	**7,821**
Computer output microfilm	465	512	557
Digitizers, graphics tablets, light pens	82	93	106
Magnetic character and mark readers	15	15	16
Optical character and mark readers	675	720	795
Plotters, electromechanical	563	712	897
Printers, total	4,130	4,578	5,450
High-speed line printers (faster than 1,000 lpm)	420	468	515
Medium-speed line printers (100 to 1,000 lpm)	1,140	1,270	1,495
Slow serial printers (slower than 100 lpm)	2,570	2,840	3,440
Office automation, total	**7,785**	**8,920**	**9,783**
Copying equipment	4,090	4,525	4,920
Electronic typewriters	865	1,210	1,285
Word-processing systems	2,830	3,185	3,578

All figures in current U. S. dollars.

The market for the $5,000-and-under personal computers dropped 7% in 1985, according to the *Electronics* survey, while the demand for microcomputers, priced from $5,000 to $20,000, grew 17%. This year, those two categories should grow 16% and 21%.

The corporate love-hate affair with computers continues to be a problem for the industry. "A lot of senior managers are concerned about supporting the proliferation of computers in the office," says HP's Doyle. "Networking is not as pervasive as it needs to be. My feeling is that networking is fundamental," especially as executives begin to use computers at home as well as in the office. An additional problem is that the mechanics of operating a computer are "still arcane enough to confuse the casual user."

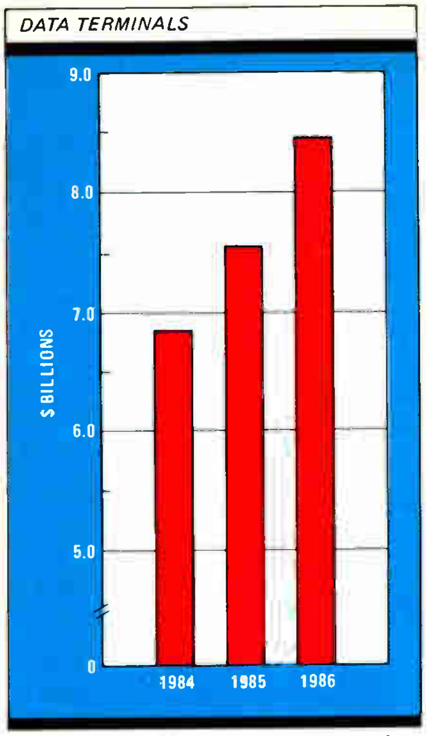
With the exception of the under-$5,000 personal computer market, all other data-processing sectors grew in 1985, *Electronics* found. The growth rates ranged from a low of 7% for mainframes, 8% for superminicomputers, and 9% for minicomputers, up to 34% for engineering work stations and an impressive 62% for supercomputers. In 1986, growth rates will strengthen for all segments. Mainframe sales, led by IBM's push to ship its latest product, the 3090, should rise 12% this year. Superminicomputers and minicomputers each will advance 11%. As the supercomputer market gains, its growth rate will slip to 21%, while the market for engineering work stations will advance a robust 40%.

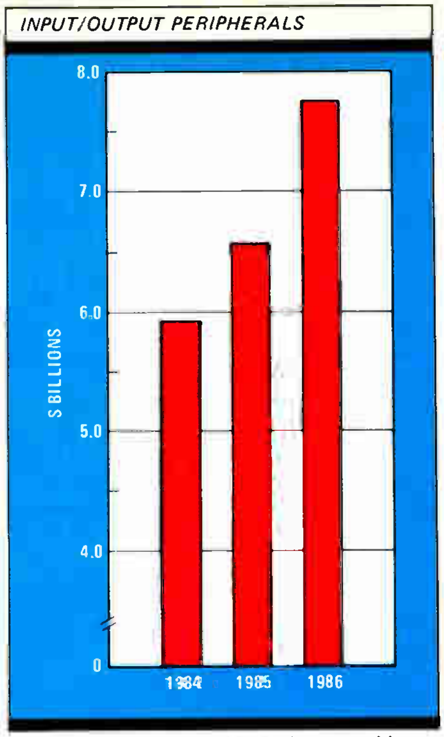
Though Burroughs's Holmes notes that capital-spending cutbacks will continue to have an impact in 1986—"We are, after all, a capital expense"—he counts himself "cautiously optimistic" overall. An upturn can be projected by the fact that computer system orders in the second half of 1985 were better than in the first half. Adds Doyle of HP: "We're getting quite a bit of evidence that customers are coming back into the market. Their ideas about buying computers are starting to crystallize."

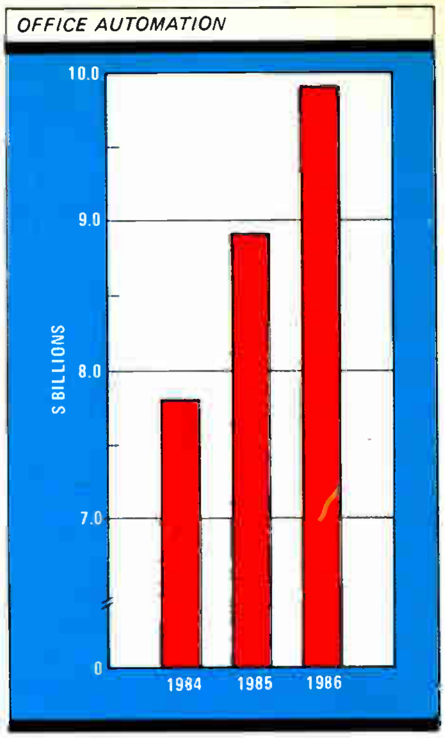
Manufacturing companies, especially, could become a lively market, he says. Factory managers are intrigued by the emerging Manufacturing Automation Protocol being promoted by General Motors Corp. and other large companies as a way to enable industrial machines to communicate. MAP, he says, is "stimulating manufacturers all over the world to see how computers can enhance their operations." This should bode well for suppliers that can meet the MAP standard. In addition, business executives are again evaluating electronic office equipment as a way to enhance worker productivity, Doyle says, and this should boost demand in a particularly valuable market.

The slowdown in demand that hit the hardware market last year appears not to have dented the growth of the software market, however. That market increased by 21% last year, to $10.1 billion, according to International Data Corp. In 1986, growth should increase by 25% to $12.6 billion. The Framingham, Mass., market researcher expects the market for large-scale computer systems to grow 20% this year, to $3.66 billion from $3.06 billion last year, while software for small- and medium-scale systems, which handle from 2 to 128 users, will advance 24%, to $6.22 billion from 1985's $5.02 billion. The big performer will be software for single-user personal computers; this category should grow 34%, to $2.69 billion this year from $2.01 billion a year ago.

In the peripherals segment, last year's news was similarly mixed. The disk-drive industry saw a slowdown in sales of floppy-disk drives and an upswing for hard-disk drives, says industry watcher James Porter, president of Disk/Trend Inc., a market researcher in Los Altos, Calif. Reflecting this situation, the *Electronics* survey found that the 1985 market in the U.S. for hard-disk drives rose 13%, to $2.5 billion, while the floppy-disk market was up just 11%, to roughly $1.6 billion. For this year, industry executives expect the hard-disk market to grow another 24%, to $3.2 billion, while the floppy-disk market will advance only 15%, to $1.8 billion.







Porter adds that the softening in demand for personal computers and microcomputers hurt the market for floppy-disk drives last year, as did erratic buying patterns by IBM, the largest consumer of floppy disks. In addition, systems manufacturers in 1984 built up large inventories of floppy-disk drives, which carried them into 1985 and curtailed new purchases.

Another factor cutting into consumption was the onslaught of small hard-disk drives. Porter points out that personal computers used in the office account for the largest part of the personal computer market and of the disk-drive market as well. And these users are turning to hard disks.

Prices of hard-disk drives "have come down considerably" as a result of industry competition, tougher bargaining by systems manufacturers, and cost-cutting on the part of manufacturers, notes Alan F. Shugart, chairman of Seagate Technology, the Scotts Valley, Calif., maker of 5¼-in. hard-disk drives. The market benefited, however, as lowered prices stimulated sales of these memory devices. "A high percentage of desktop computers can afford to have rigid-disk memories" with increased storage capacity, he adds.

Most of the growth in hard-disk drives came in the last half of the year, according to Shugart. "I look for a big year in 1986," as more and more systems makers, lured by the attractive prices, include the drives in their products.

FALLING PRICES

Industry-watcher Porter agrees with Shugart's summation, but says that the corollary to the improvement in hard disks is a flattening market for floppies. He notes an additional phenomenon that will affect the floppy-disk-drive market. Several captive manufacturers of floppy-disk drives, such as IBM and Tandy Corp., will cease making their own drives and fill their needs on the open market. But with the stimulation in unit demand, prices will continue to fall. Meanwhile, consumption of older drive products, such as disk packs and other removable disk drives, will slow.

In the U. S. terminal market, there's good news for consumers but bad news for manufacturers, who are immersed in a cost-cutting spiral. "It's a rough industry," says Michael E. Marks, president of Micro-Term Inc., a St. Louis terminal supplier. "Selling prices have dropped 40%; costs have dropped 5%. Everybody's cutting prices."

Still, the industry is expected to grow by about 13% this year, to $8.4 billion, following 1985's disappointing 9% gain, to $7.5 billion, according to the *Electronics* survey. Comiso of Wyse Technology calls last year's rate "reasonable," and estimates the growth at about 18% to 30% in terms of units. The price-cutting, he says, reached 10% to 12%, which means "the market in general grew 10% to 18% overall."

If the cost-cutting has been advantageous to consumers so far, there could be a price to pay in the end. Micro-Term's Marks points out that "a lot of U. S. companies are cutting research and development work and product-development activities in an effort to make money at a crummy gross margin." This means that fewer innovative products are in the works.

Peripherals makers expect competition to sharpen this year

Adding to the headaches of U. S. terminal manufacturers is the activity of foreign companies that are producing equipment for U. S. suppliers and large end-users. They're also starting to offer their own line of terminals in the U. S., thus bypassing their American original-equipment manufacturers. "Offshore manufacturers have a need and a desire to sell terminals directly" to end-users, Marks says. This problem plagues not only terminals makers but the entire peripherals industry, he notes. "Eventually your technology will end up in the market with someone else's name on it. This will create big changes in the industry." Marks predicts that ultimately, "strategic alliances will be formed between U. S. and offshore companies" to counter the problem.

One cause for optimism among terminal products manufacturers, however, is the advent of the increasingly popular multiuser computer systems. "An important trend in 1985 was the concept of distributed computing through the multiuser system," says Wyse's Comiso. Such a setup allows a user to access a computer through a low-cost terminal, and Comiso believes the systems "will start to take off nicely in 1986 and provide a greater opportunity for terminal suppliers." Another plus for 1986, he adds, is the increasing demand for advanced high-resolution graphics products.

COMMUNICATIONS

CONSUMPTION WILL RISE 14% THIS YEAR, ABOUT THE SAME AS IN 1985

Faced with confusing new combinations of players in the market and an expected abundance of new products, U. S. buyers of communications equipment cut back consumption last year. The result of their wait-and-see attitude—a sign also of the restraint that marked corporate capital spending in general—was a modest 14% growth rate for electronic communications equipment compared with the 20% growth rates achieved earlier this decade. Growth this year should run about the same as last year's, as executives contemplating expenditures for new equipment continue to be cautious for the same reasons.

Corporate customers will benefit from increased competition—as well as from the proliferation of new products and services—as vendors battle for their share of corporate spending. The market for private branch exchanges will heat up, as suppliers and the regional Bell operating companies all scramble for a piece of the pie. The long-awaited integrated services digital network (ISDN), which unites voice, data, facsimile, and video, is a step closer to implementation. And the increasing use and declining cost of fiber-optics has far-reaching implications.

Suppliers of PBX equipment are facing a number of changes, some hopeful and some ominous. PBX systems are shifting from analog technology to digital, which can operate at up to 64 kb/s and handle the new microprocessor-based telephones. This means the systems are ready to service the needs of businesses demanding voice and data multiplexing. Already, PBX customers can add available peripherals to integrate word-processing, text-editing, and electronic-mail functions into their office communications systems. Meanwhile, voice-mail systems, enabling computer-controlled storage and delivery for verbal messages between two users anywhere in the world, should become a $2.3 billion industry by 1986, says Venture Development Corp., Natick, Mass. Of this, $1.9 billion will be allocated to voice-mail hardware for PBX systems.

But the market is volatile because of increasing competition from the teaming of major players, such as IBM with Rolm and Wang Laboratories with InteCom. In addition, pressure is being exerted by the operating companies as they expand their Centrex stations into more business locations. The North American Telecommunication Association, Washington, predicts that the market for Bell Centrex stations will expand by 9% this year. That's the equivalent of 990,000 PBX extensions—a potential loss of $800 million worth of business for PBX vendors, or almost 25% of the expected PBX market in 1986.

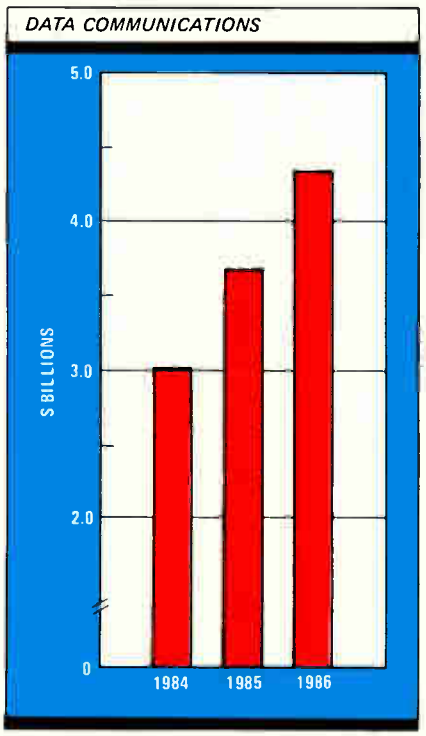
The Centrex expansion is a bit of a nasty surprise for the PBX community. After the 1984 breakup of AT&T Co., it appeared that Centrex—a leased central-office-based telephone system—would lose ground to competitive, upgraded customer-premise offerings such as PBXs. However, the Bell operating companies have fought aggressively to boost their market share. To add more impetus to their marketing thrust, they are readying advanced data services to provide fully integrated voice-data transmission.

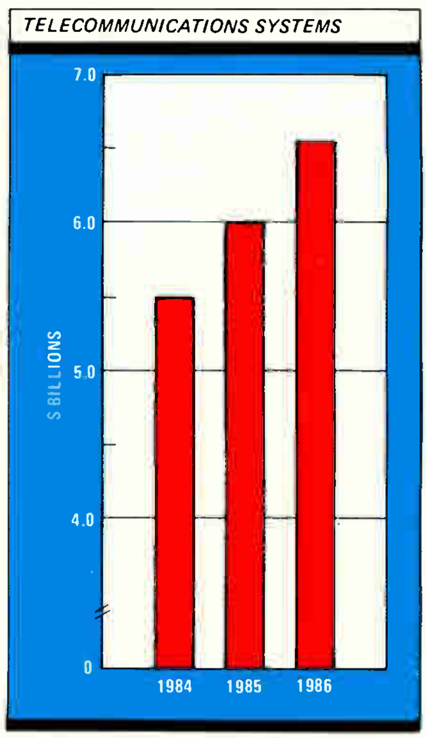
WAITING FOR THE ISDN

Although the precise time of arrival is still unclear, the international telecommunications community is gearing up for the much-heralded debut of the ISDN. Estimates on the startup date of this service vary, but Dataquest Inc., the San Jose, Calif., market researcher, predicts that as many as 10 million ISDN lines will be in service by 1990.

Until all-digital data transmission links are installed around the country, the market for telephone modems will continue to grow at the healthy 20% rate expected for 1986 demand. U. S. consumption, pegged at $1.7 billion in 1985, is expected to reach almost $2 billion by the end of this year. And with the Federal Communications Commission's easing of controls over common-carrier communications, the modem market is a wide-open battleground. Both AT&T Technologies and its various competitors have geared up to supply customers with product innovations at ever-lower prices.

Suppliers of voice-grade modems, expecting heavy business





from personal-computer buyers last year, joined the general industrywide lament when the personal computer business fizzled. Still, statistics show that about one of every eight home computer owners eventually buys a modem, a heartening fact for vendors.

Low-speed modems, which operate at data rates below 2,400 bits per second, are outselling medium-speed versions by about 2:1. In this category, full-duplex models are fast taking market share from the 1,200-b/s half-duplex modems and the 300-b/s versions. Though combined sales of both low- and medium-speed modems should top 3 million units by 1987, the price differential means that medium- to high-speed varieties will capture a major share of market dollars.

Modem manufacturers are aware of the need to incorporate network-management features into their products and are busy designing units that will include digital and analog loopback, automatic and adaptive equalization, and network reporting.

In the facsimile market, manufacturers are facing new competition from electronic-mail services that enable users to exchange messages on their computer screens by means of modems. Additionally, more than half the U. S. consumption of facsimile equipment is supplied by Japanese vendors or their U. S. importers. Still, the facsimile market is growing at a rate of 11.4% a year, with the 1985 market exceeding $428 million. Digital facsimile products are expected to grow even faster in the future, because they can be linked in office-automation systems with intelligent copiers and printers and communicating text terminals.

COMMUNICATIONS RIDES THE CREST

	1984	1985 (millions of dollars)	1986
COMMUNICATIONS, total	**18,282**	**20,792**	**23,607**
Data communications, total	**3,044**	**3,675**	**4,325**
Concentrators	146	173	197
Front-end communications processors	661	753	827
Message-switching systems	106	121	136
Modems, total	1,436	1,651	1,974
High speed (2,400 b/s and over)	1,135	1,297	1,535
Low speed (less than 2,400 b/s)	281	327	406
Radio frequency	20	27	33
Multiplexers, total	477	613	704
Time division	82	96	117
Statistical	395	517	587
Network controllers, total	218	364	487
SNA	97	155	204
Ethernet	72	144	186
Other	49	65	97
Facsimile terminals, total	**382**	**428**	**464**
CCITT Group 1 (6 minutes)	130	135	139
CCITT Group 2 (4 to 6 minutes)	149	163	171
CCITT Group 3 (1 minute or less)	103	130	154
Fiber-optic systems, total	**879**	**1,202**	**1,539**
Complete systems	521	714	943
Modules and subsystems	358	488	596
Radar equipment (antennas, data processing, transceivers), total	**4,470**	**4,872**	**5,408**
Radio, total	**2,745**	**3,209**	**3,742**
Amateur (mobile and base stations)	26	28	30
Aviation mobile (including ground support)	131	143	156
Broadcast equipment	555	618	694
Citizens' band (mobile and base stations)	53	48	46
Land mobile (mobile and base stations)	895	1,086	1,357
Marine mobile (including recreational)	142	164	178
Microwave (complete systems)	470	526	576
Satellite earth stations (including transmitters, receivers, antennas; excluding consumer)	473	596	705
Telecommunications, total	**5,510**	**6,043**	**6,613**
Data-switching systems, total	213	248	273
Central office	73	86	95
PABX	140	162	178
Voice-switching systems, total	5,110	5,490	5,930
Central office, total	2,310	2,570	2,820
Analog	680	760	830
Digital	1,630	1,810	1,990
PABX, total	2,800	2,920	3,110
Analog	870	940	980
Digital	1,930	1,980	2,130
Packet-switching systems	187	305	410
Television equipment, total	**1,252**	**1,363**	**1,516**
Broadcast (studio) equipment	742	811	905
CATV equipment	386	417	462
CCTV equipment	124	135	149

All figures in current U. S. dollars

FIBER OPTICS' LENGTHENING ROLE

Big-time fiber-optic communications became a reality in 1984, when AT&T completed its Northeast Corridor Project linking Boston to Washington. Last year, more than 500,000 miles of the tiny fiber strands were installed in the U. S., and more than 1 million miles are expected to be stretched across the nation this year. The technology today offers the capability of carrying close to 2 million simultaneous phone calls over a single bundle of strands. Because of the ability of fiber-optic links to handle such heavy loads, the lines are in demand by the cable-TV industry, installers of computer-linked businesses and factories, and the military. But the telecommunications market retains the single biggest share: more than 40% of the $1.5 billion fiber-optic market in 1986. The percentage is expected to grow to half the total market by 1990.

Because of the heavily increased demand for optical fibers, price has decreased at the same time that performance has been upgraded, a combination that understandably delights telecommunications planners. Prices for fiber cable have dropped from $8 per meter four year ago to less than 50¢ today, while the cost of leasing a fiber-optic voice circuit has dipped from 60¢ to 5¢. As prices continue to drop, some industry observers see fiber-optics replacing communications satellite services for relaying voice and data within distances of 1,000 miles. They project that after 1990, fewer commercial satellites will be put into orbit.

The telephone industry will also benefit from the high promise of fiber optics. This technology can handle considerably greater traffic within a single cable and also transmit signals over longer distances between repeater stations. The latter is particularly important, because with conventional copper-wire phone lines, losses reduce signal level over long hauls and dictate the need for repeater stations to amplify the signal and retransmit it numerous times. Not only is the arrangement expensive to install, but repeaters are one of the most unreliable elements of telephone networks, expecially when handling computer data. For fiber-optic links, repeater stations are typically spaced 100 miles apart, compared with 20 miles of spacing required with copper-wire cables.

Another service that promises to capture a healthy chunk of the communications equipment market is that of cellular radio. When the first commercial cellular-radio system began in Chicago in the fall of 1983, the rush was on by private business to equip their sales and service staff with mobile phones. That rush will pick up steam as consumers in general flock to the convenience of calling from their automobiles. International Resource Development Inc., a Norwalk, Conn., market research company, estimates that the cellular-radio market, rose to $600 million in 1984 and will soar to $7.1 billion by 1990.

TEST & MEASUREMENT

CONSUMPTION, RISING ONLY 1% IN 1985, WILL CLIMB 12% THIS YEAR

Sparked by rising orders for new automated test equipment, the test and measurement market should grow 12% this year. Last year, consumption of test gear grew less than 1%, which, coming as it did on the heels of a 25% jump in 1984, left some manufacturers reeling.

Still, any growth during the past 12 months can be viewed as an outstanding achievement, given the obstacles the industry faced. A strong U. S. dollar gave imports an edge in the U. S. market; a cutback in factory production of electronic equipment wiped out orders for additional testing tools, especially for ATE; a reduction in research and development programs by both industry and government caused drops in orders for sophisticated—and expensive—test equipment; and the devastating semiconductor industry slump had integrated-circuit manufacturers cancelling plans for multimillion-dollar very-large-scale IC testers as well as for specialized testers for logic and memory production lines.

Suppliers believe these problems will be overcome in 1986 as U. S. consumption of electronic equipment turns around, sparking a rise in demand for products needed to test them. A continued drop in the dollar's value should make foreign goods more expensive here and give U. S. suppliers a further boost.

The largest part of the test-equipment market, general-purpose test equipment, which includes oscilloscopes, digital multimeters, signal generators, and spectrum analyzers, managed to grow 7% last year, compared with 17% in 1984. Part of the slowdown in 1985's growth is attributed to the general sluggishness of the electronics industry, but another key factor has been a shift by the U. S. Department of Defense to funding new weapons programs rather than pouring additional dollars into the maintenance of existing systems.

Export sales of such general-purpose test equipment were hard hit by the strengthened dollar and the resulting more vigorous competition from Far East suppliers, particularly in oscilloscopes and hand-held digital multimeters. U. S. makers responded by cutting production costs while upgrading product quality and performance specs. In the oscilloscope market, for example, Tektronix Inc.'s high-end 100-MHz model 2235 now undersells its Japanese counterparts by 15%, according to Jay W. Cooper, an analyst who tracks test and measurement trends for Eberstadt Fleming Inc., a New York investment company.

Yet Japanese competition isn't a problem in all segments. In the oscilloscope market worldwide, for example, Cooper estimates that Japanese penetration reached only 15% at its 1983-1984 peak and has dwindled by at least a point or two in the past two years.

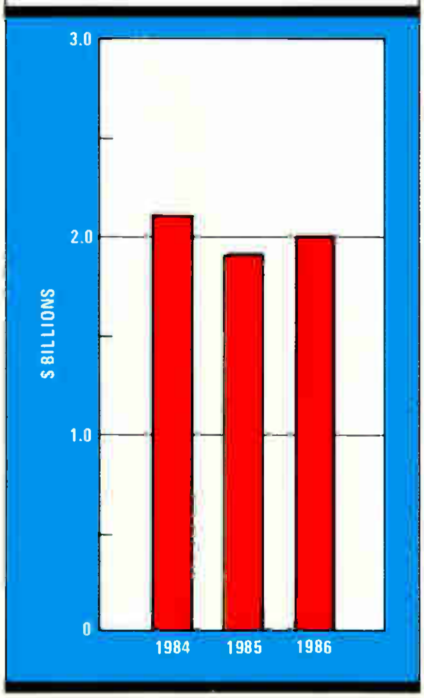
More troubled than the makers of general test equipment were manufacturers of testing tools for the semiconductor industry. When semiconductor manufacturers see orders for their devices first cut back—and then cancelled outright—as computer and other equipment builders pare their inventories, what do they do? They consider layoffs, elimination of salary reviews, pay cuts, forced vacations without pay—but often first on the list is postponing delivery of a million-dollar VLSI tester or several memory or logic testers.

Similarly, as the demand for printed-circuit boards dropped last year, orders for in-circuit, bare- and loaded-board, and functional testers also plummeted. The result was a disappointing 11% drop in the overall ATE business: consumption of IC testers slid 12% in 1985, while board ATE slipped 10% last year. So ATE makers joined semiconductor makers in announcing their own layoffs, forced vacations, and pay cuts.

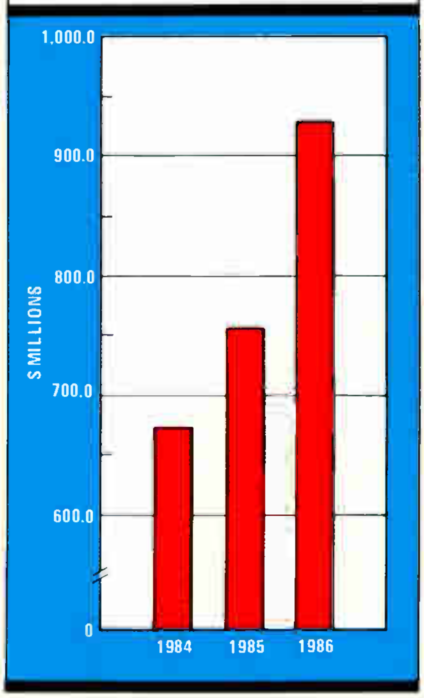
ATE MAKERS OPTIMISTIC

ATE makers are mildly optimistic about 1986, though *Electronics'* market forecast sees demand growing just 5% this year. Manufacturers are gambling that the new chip and equipment boards designed during last year's recession, with their high density and faster speed, will require upgraded test equipment. At last November's International Test Conference in Philadelphia, ATE makers were pressed by semiconductor companies to develop improved hardware and software to validate the complex VLSI chips, CMOS gate arrays, standard

AUTOMATED TEST EQUIPMENT



MICRO DEVELOPMENT SYSTEMS



cells, application-specific ICs, and gallium arsenide devices entering the market [*Electronics*, Nov. 18, 1985, p. 57].

And though the ATE community continues to be plagued by rumors of shakeouts due to the increasing U. S. presence of Japanese competitors—among them, Takeda Riken Co. and Ando Electric Co.—growth in this market should rise 3.4%, which would provide sufficient sales growth for existing vendors.

In the IC market, a key consideration facing test-equipment vendors is the apparent transition from standard semiconductor parts to application-specific ICs. These parts, which account for less than 20% of the semiconductor market, are expected to make up one third of the $100 billion semiconductor market predicted for 1990. Until now, makers of IC testers invested heavily in faster machines with higher pin counts for state-of-the-art lab applications as well as in high-throughput production-line testers for standard parts. To shift to low-volume ASIC testers, makers must couple the abundant data available from design-automation work stations with automatic test-generation tools. Otherwise, test-pattern generation and testing costs will cause the price of ASICs to skyrocket.

TEST GEAR SHOULD DO BETTER

	1984	(millions of dollars) 1985	1986
TEST EQUIPMENT, total	**5,988**	**6,039**	**6,781**
Automated test systems and equipment, total	**2,086**	**1,863**	**1,965**
Active (discrete) component test systems	143	130	136
Automated field-service testers	85	93	98
IC testers, total	1,043	913	946
Benchtop testers	192	170	178
General-purpose systems	491	430	447
Specialized test systems (memory, etc.)	360	313	321
Interconnection and bare-pc-board testers	150	128	137
Loaded pc-board testers, total	665	599	648
In-circuit	300	272	291
Functional	260	231	253
Combined	105	96	104
General test equipment, total	**3,902**	**4,176**	**4,816**
Amplifiers (laboratory)	61	65	68
Analog voltmeters, ammeters, and multimeters	27	26	28
Audio oscillators	25	26	28
Audio power meters	5	6	6
Audio waveform analyzers and distortion meters	100	120	140
Calibrators and standards, active and passive	66	70	72
Dedicated IEEE-488-bus controllers	183	191	207
Digital multimeters, total	278	313	346
3½ digit & below	210	227	252
4½ digit & above	68	86	94
Electronic counters, total	182	185	235
Frequency (500 MHz and below)	36	37	47
Microwave (above 500 MHz)	51	53	68
Universal	95	95	120
Frequency synthesizers (below microwave frequencies)	70	86	93
Generators, function	58	63	87
Generators, microwave-signal (2 GHz and above)	77	92	114
Generators, pulse	27	28	31
Generators, rf signal (below 2 GHz)	141	133	147
Generators, sweep	85	85	89
Generators, word	15	16	17
Logic analyzers	221	246	267
Logic probes	25	25	25
Microprocessor-development systems, total	672	758	933
Dedicated	464	525	644
Universal	208	233	289
Modulation analyzers	29	31	33
Multimeter probes and accessories	14	15	16
Noise-measuring units (excluding sound-level meters)	12	12	13
Oscilloscopes, total	884	887	1,034
100 MHz and below	574	552	607
Above 100 MHz	310	335	427
Panel meters	68	72	70
Personal-computer-based instruments	68	89	115
Recorders and plotters	193	220	255
Rf/microwave network analyzers	42	44	48
Rf/microwave power-measuring equipment	24	28	33
Signature analysis instrumentation	5	5	5
Slotted lines	4	2	2
Spectrum analyzers, total	135	137	151
Up to 2 GHz	72	71	78
Above 2 GHz	63	66	73
Stand-alone in-circuit emulators	72	68	73
Temperature-measuring instruments	34	32	35

All figures in current U. S. dollars.

Suppliers of pc-board testers see the onrush of surface-mount technology as a balm for the wounds inflicted in 1985's market. They predict that sales will rise at least 10% to handle the need for testing equipment for the denser boards. Meanwhile, makers of functional testers hope to wrestle back the market share they lost to in-circuit testers over the past few years, as test engineers give up their struggle to fabricate efficient bed-of-nails fixtures to cope with double-sided boards jammed with SMDs and conventional through-hole components. However, in-circuit test vendors are busy developing double-sided clamshell fixtures and such alternatives as cluster testing to strengthen their position even further.

With the ubiquitous IBM Corp. Personal Computer finding its way onto the desks of executives, accountants, strategic planners, and engineers, it's not surprising that it is also finding active service as an inexpensive controller for test and measurement instruments. Pioneered in 1981 by Northwest Instruments Systems Inc., Beaverton, Ore., the first PC-based test instruments were limited by the computer power available at that time. Now bolstered by the power of the IBM PC AT, such systems are being developed by more than 100 companies seeking a slim piece of the U. S. market for test and measurement equipment.

Although the 1985 estimate for sales of PC-based instruments is less than $70 million, industry observers such as Prime Data, a San Jose, Calif., market researcher, forecast a mushrooming in sales to $500 million by 1989. The trend will be fueled by the continuing dip in personal computer costs as well as the growth of mass-storage capability, enhanced graphics, and factory-to-office networking. A stamp of credibility for this new breed of instrumentation came early last year when Hewlett-Packard Co. introduced eight instruments—including a digital multimeter, function generator, and digitizing oscilloscope—controlled by either an HP 150 touch-screen computer or an IBM PC. The HP offering performs analog measurements. Northwest Instruments' line of PC-based logic analyzers tests and debugs microprocessor-based systems.

DEVELOPMENT SYSTEMS RESPOND

In the area of microprocessor development systems, makers are responding to the problems that emerged in 1985 by changing their marketing strategy. The four major suppliers of these systems—HP, Intel, Tektronix, and Motorola—have replaced their proprietary systems architectures with open architectures. Tektronix, Motorola, and Intel systems are compatible with Digital Equipment Corp.'s VAX as well as with the IBM PC AT; HP's system is compatible with the VAX. Data Media, a San Jose market researcher, projects that sales of all microprocessor development systems will hit $1.3 billion by 1988. These systems complement computer-aided-engineering tools to help design engineers integrate complex microprocessor chips into complete systems.

Because the approach to open architecture allows the designer to use his general-purpose computer rather than buy a proprietary machine, vendors of microprocessor development systems will in reality be selling emulators, logic analyzers, and software. Though the cost of a microprocessor development system will decrease, industry observers expect enough systems to be sold to result in a 24% growth rate.

CONSUMER

SALES TO CONTINUE ROLLING, RISING BY 11% THIS YEAR

U.S. consumers will continue to spend freely on sophisticated electronics products this year, which means that manufacturers and suppliers of such high-ticket items as video cassette recorders, compact-disk players, and stereo and large-screen TVs can expect another year of healthy growth. Consumption of electronic products for the home should increase 11% in 1986, to almost $25 billion. Though the projected growth rate is down slightly from the 12% growth rate reached in 1985, sales are expected to rise $2.5 billion above last year's record level of $22.5 billion.

The increasing trend toward stereo broadcasting by the major TV networks, as well as the consumer's continuing love affair with the VCR, are strong indications that stereo TVs and video cassette recorders will pace the industry's growth. The pricing pressure on these products exhibited in recent years could even ease somewhat in 1986, as manufacturers try to put the brakes on rampant discounting.

Also pegged for strong growth is projection TV, though sales could slow a bit from 1985's fast clip. Even the modest black and white TV will continue to show signs of life. In the audio market, the rising popularity of the compact-disk player will mean a better overall performance this year than last.

In the video sector, another record year is forecast for TV sales, with American consumers expected to purchase $7 billion worth of color sets, a jump of 13% over last year's $6.2 billion. This segment of the consumer electronics industry should "meet or exceed" the last year's record, says Gerald M. McCarthy, senior vice president for sales and marketing for Zenith Electronics Corp.'s consumer marketing group. An RCA Corp. spokesman likewise expects record sales of color TVs.

One of the more notable trends in the TV industry in 1985 was the growth in consumption of the year's new market segment, stereo television, a development that should continue apace in 1986. More than 200 TV stations in the U. S., reaching about 75% of the U. S. households with TV sets, now broadcast programs in stereo. This momentum on the part of broadcasters is expected to continue strongly this year, spurring sales of the new stereo TVs to consumers.

Another 1985 trend that contributed to the boom in color TV sales was the move toward larger screen sizes. A Zenith representative said the company has seen "tremendous growth and interest" in its large-screen TVs, especially the 20- and 27-in. sizes. "We've had a lot of success in the 27-in. size. We're back-ordered very heavily in them," he said. The trend shows no signs of abating in 1986.

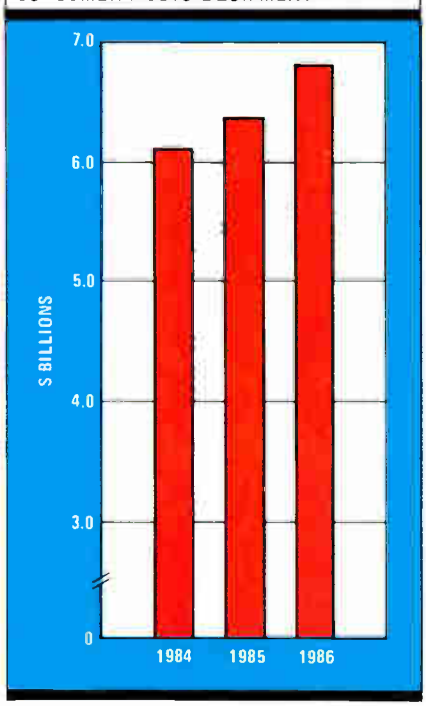
If increasing sales are one source of contentment for manufacturers, the recent strengthening of the Japanese yen is another. The strength of the yen against the U.S. dollar means competing Japanese goods will become more expensive for stateside consumers. "There's no doubt that the changing relationship of the yen to the dollar will change prices" in 1986, says Zenith's McCarthy. And this, industry sources say, could mean higher profits for the U. S. companies. What could be a problem, however, is the possibility that low-priced electronic goods from South Korea could now grab a greater share of the U. S. market.

DIPS IN PROFITS

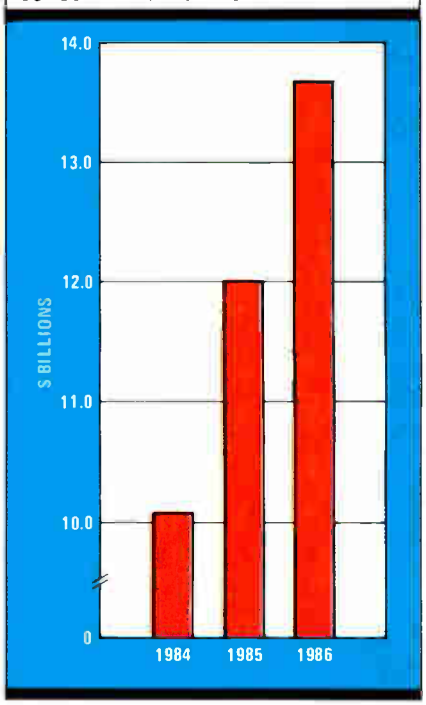
Price erosion, especially in the TV segment of the market, has been "very severe in recent years," one industry expert points out. Prices in 1983 fell 5%; in 1984 they dropped 6.5%, and they were down 6.2% through the first nine months of 1985. Despite the boom in sales, the price slide has severely eroded profitability for many manufacturers, according to the Zenith representative, because "cost-cutting can't totally offset it."

Manufacturers such as Zenith and RCA as well as the Japanese suppliers are planning to raise prices on their consumer electronics gear, sources say, in an attempt to "create some sensibility in the market." This month's Winter Consumer Electronics Show in Las Vegas could provide

CONSUMER AUDIO EQUIPMENT



CONSUMER VIDEO EQUIPMENT



some clues to whether the move toward higher prices will actually stick or whether the action will falter in the face of continuing competition. "We plan to maintain a leading market position," says the Zenith representative. "But we won't let others take advantage of our price rises" to gain market share at Zenith's expense.

For VCRs, pricing may be affected more significantly by the high degree of market penetration already achieved by manufacturers. Last year was yet another record period for VCR sales, with consumption in the U. S. growing a whopping 37%, to almost $4.7 billion (the 1984 total was $3.4 billion). This year, market growth should slow to about 19%, with sales hitting an estimated $5.5 billion.

Sales of stereo TVs and VCRs will pace the industry in 1986

Some 37% of U. S. households—a very high penetration—have a VCR, industry experts estimate, compared with 28% this time last year. Growth in demand, as a result, "won't be as vigorous as in the past" for the 70 or so brands now on the market, according to an RCA official. However, a new phenomenon is being seen in the VCR market that offers the hope of renewed growth: replacement sales. RCA estimates that 17% of all VCR sales last year were either replacement sales or sales of second units for the home. This trend, which is expected to increase this year, "will help level things out," the official predicts.

Another development that could push up VCR sales is the growing popularity of the combination camera and recorder, known as the camcorder. Though high in price—they sell for $1,300 to $1,800—these units are a hit with consumers who don't want to bother buying two separate pieces of equipment. RCA estimates that 350,000 camcorders, worth $500 million at the retail level, were sold in 1985. Unit sales this year could reach 550,000, the company believes.

Makers of projection TV systems can expect to see sales in 1986 continue to rise, the *Electronics* market forecast indicates, though at a slower rate than last year. The market this year is expected to increase 16%, to an estimated $485 million in sales, compared with an 18% growth rate and $417 million in sales in 1985.

Despite their high price tags—$2,000 to $4,000 per system—these products are tantalizing to consumers. The attraction of stereo sound plus the larger, projected picture make these systems a "home theater" center, the manufacturers say. "There is broadening appeal for giant-screen TV" is the understated summation by one source.

Continuing the trend of recent years, consumption of monochrome TV sets will fall this year by 11%, to roughly $278 million. But that performance is better than 1985, which saw demand drop by 19% to $312 million. Actually, unit sales should stay about the same this year as last, manufacturers say: competitive price-cutting will account for the reduced dollar volume in this category. The growth in sales of small, specialty black and white TV sets, such as those with screen sizes of 5 in. and under, will offset the drop in sales of 9- and 12-in. units, executives predict.

In the audio field, demand this year should outpace that of 1985, thanks largely to increased interest in the compact-disk player and consumers' continuing penchant to surround themselves with sound in their cars. Total consumption of audio products in 1986 will increase about 6.5%, to almost $6.8 billion, compared with 1985's 5% growth, to almost $6.4 billion.

Among the various categories of audio equipment surveyed, compact-disk players are clearly the pacesetters. Consumers continue to flock to this technology for superior sound reproduction, while record companies increase the output of digitally mastered recordings. Last year's sales of compact disks rose to $105 million from 1984's $70 million, a 50% increase. In 1986, sales should rise by a still-strong 38%, to an estimated $145 million.

COMPONENT SALES GET BOOST

A spillover effect is being felt in the market for stereo components, since the better sound quality available from a compact disk is only as good as the amplifier and speaker system used with the player. Manufacturers of audio components look to this to help spur future sales. In addition, as prices of compact disks begin to decline following the usual economies of scale on the manufacturing side, more consumers are expected to buy them and upgrade the rest of their sound systems at the same time.

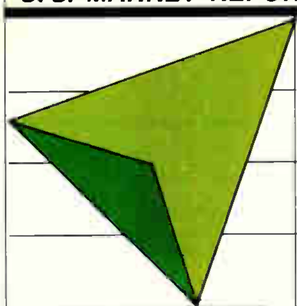
The market for car audio equipment will grow about 10% this year versus 1985's 6%, as American consumers continue to outfit their automobiles with more electronics. Whether taking advantage of car manufacturers' incentives to buy new cars, or holding onto their old ones for a bit longer, drivers apparently want to surround themselves with stereo sound on the road, and they're willing to purchase sophisticated systems to accommodate their tastes.

Both the manufacturers' market—sales to car producers for factory installations—and the aftermarket for car stereo systems has performed well and will continue to do so, according to Business Trends Analysts, a market research company in Commack, N. Y., which tracks the industry. Radios can now be found in nearly 90% of the cars on the road in the U. S., the company estimates, and a big market will open up as consumers start replacing older AM products with newer FM systems.

CONSUMER PRODUCTS STAY ON COURSE

	(millions of dollars) 1984	1985	1986
CONSUMER ELECTRONICS, total	**20,085**	**22,507**	**24,897**
Consumer audio equipment, total	**6,069**	**6,368**	**6,788**
Car audio	1,642	1,737	1,902
Stereo equipment, total	2,067	2,175	2,269
Compact systems	517	541	586
Components	1,461	1,537	1,572
Consoles	89	97	111
Phonographs and radio-phonographs	620	647	693
Radios (including table, clock, and portable)	555	571	592
Radio-recorder combination boxes	523	567	615
Tape recorders and players, total	592	566	572
Personal portable (Walkman-type)	217	201	185
Reel to reel	75	85	95
Standard cassette	300	280	292
Compact-disk players	70	105	145
Consumer video equipment, total	**10,101**	**11,990**	**13,727**
TV receivers, total	5,932	6,549	7,324
Color	5,547	6,237	7,046
Monochrome	385	312	278
Projection-TV receivers	353	417	485
Video cassette players and recorders, total	3,421	4,671	5,535
Beta	655	843	1,011
VHS	2,756	3,826	4,480
8 mm	10	15	44
Video cameras	340	325	358
Videodisk players	55	28	25
Other consumer products, total	**3,915**	**4,149**	**4,382**
Antennas (TV, CB, and radio)	116	121	137
Calculators	743	714	674
Electronic clocks	128	131	145
Electronic games	250	187	142
Electronic musical instruments and equipment	436	472	488
Electronic watches	621	642	667
Microwave ovens	1,474	1,721	1,955
Telephone-answering machines	147	161	174

All figures in current U.S. dollars.



INDUSTRIAL

DEMAND TO RISE 14% TO $8.7 BILLION, A HIGHER RATE THAN 1985

For the industrial electronics equipment market, 1986 is shaping up as an uneven year. With U. S. manufacturers shifting to more automation, the future for the use of industrial robots looks especially rosy. Overall, the demand for industrial electronics should increase 14% this year, to $8.4 billion, following a 12% gain to $7.6 billion. But a number of factors—not the least of which is uncertainty over the health of the U. S. economy—spell caution in the overall market, particularly in the important process-control category.

Industry observers predict that robotics equipment will continue its rapid growth as more and more U. S. factories replace human workers with their steel-and-microchip counterparts. Robot suppliers will concentrate on generating higher profits—even at the expense of their share of the total robotics market—as they reach new levels of corporate maturity.

But the sluggishness of U. S. manufacturing, which has not recovered fully from the 1981-82 recession, and a leveling in demand from petrochemical companies mean a probable slowdown for sales of process-control equipment, a category that includes data-acquisition systems, process instrumentation, sequence controllers, and data loggers. And continued uncertainty over possible tax reform, cautious short-term plans for capital spending on the part of U. S. industry, and a general unease over the state of the economy could combine to produce a so-so year for industrial electronics suppliers.

Besides the healthy prognosis for robotics, a major source of optimism for this market is the commitment of many manufacturers—notably General Motors Corp.—and equipment suppliers to the proposed Manufacturing Automation Protocol system of communications for factory equipment. This system, which allows diverse pieces of industrial equipment to communicate with each other, promises to spur the purchase of equipment built to its specifications.

Capital spending remains the prime mover for big-ticket industrial electronics equipment, however, and here the news is not as good. U. S. businesses plan to shave capital spending in 1986 by 1%, to a total $380.7 billion, according to a survey on spending plans conducted by McGraw-Hill's economics department. By comparison, the 1985 total was $384.4 billion.

Among the categories that traditionally spend heavily on automation equipment, the petroleum industry expects to allocate only $27.7 billion on new plants and equipment in 1986, up less than 1% from the 1985 total of $27.5 billion. Outlays by another big spender—the automotive industry—are expected to drop by 6% this year, to $14 billion. The chemical industry will increase spending by just 0.8% this year, to $17.1 billion.

"On a worldwide basis, 1985 ended up better than I would have predicted at the start of the year, but with some rough spots," says Richard J. Boyle, group vice president for Honeywell Inc.'s Industrial Systems Division, Detroit, which supplies large process-control systems, programmable controllers, and data-collection systems. "Domestically, 1985 turned out to be an OK year" with middle-of-the-road growth. Boyle thinks the market got "some positive impetus from people automating their product lines to increase productivity." But there was a slowdown in the third quarter, as customers started re-evaluating their needs, and it may well carry over into 1986.

UPS AND DOWNS IN THE MARKET

"Each vertical market segment [for industrial automation equipment] performed quite differently" last year, says Boyle. "The mergers and acquisitions in the oil business, as well as the stability in oil prices, caused [these customers] to constantly step back and re-evaluate their game plans." The U. S. manufacturing sector as a whole is an area he identifies as weak. But "the pulp, paper, and chemical industries are particularly strong" buyers. There is "still business to be had" in this market, he says, though customers are being cautious in their spending plans for the first half of 1986. After that, they are likely to rethink their buying needs.

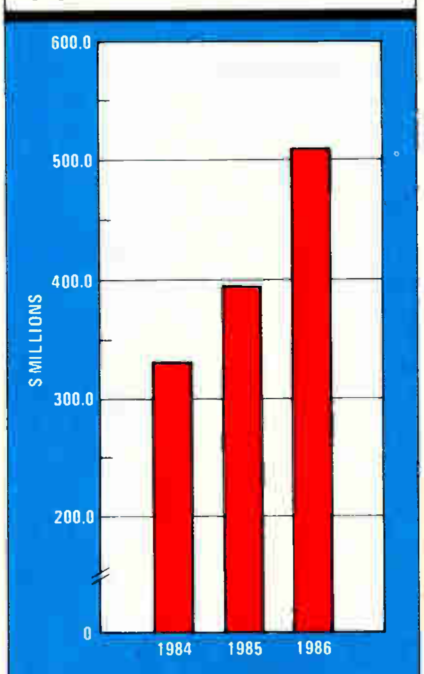
Though declining petroleum prices are causing the oil industry to trim spending on equipment, the cost of oil is still too high for many energy-intensive industries. As a result, suppliers of energy-management systems will see the U. S. market for their products increase 8% this year, the same as last year. The advent of better microcontrollers promises to make these systems even more attractive for buyers.

But their expected growth rate is modest compared with the big performer in industrial electronics in 1986—the robot. "The action is in flexible, computer-based, programmable automation, and that means robotics," as Gerald Michael, a researcher at Arthur D. Little Inc., Cambridge, Mass., puts it.

Other market watchers share his outlook. "There will be pretty substantial growth" in the robot market this year, predicts Laura Conigliaro, a research analyst with Prudential Bache Securities, New York. The *Electronics* survey of manufacturers supports her forecast. It found that sales of robot systems will gain 29% in 1986, on the heels of 1985's 19% rise.

Despite this seeming boom, for suppliers "it's a difficult way to earn a living,"

ROBOT EQUIPMENT



Conigliaro contends. Typically, robotics manufacturers have stimulated demand by cutting prices, a trend she predicts will turn around this year as suppliers hold the line on cost-cutting. "The industry has finally reached the point where vendors are unable or unwilling" to continually cut costs—and profits. "Market share is less important than profitability and survival."

Some segments of the market for industrial robots, such as spot welding in car manufacturing, are becoming saturated. Happily for robotics manufacturers, new demands are starting to emerge. Among them are the use of robots in the assembly of electronic components and systems and in clean rooms at semiconductor makers. "Both of these markets are very small, but they show a lot of promise for the future," says Michael at Arthur D. Little. He estimates the current size of the robotics market for electronics applications at about $30 million and the clean-room market at $3 million to $8 million. "The growth rates [for these markets] is meaningless, since the base is so low. But in spite of the downturn in the chip industry, it's going to be very robust."

Industrial robots are gaining fast in electronics

Intelledex Inc., a maker of robotics equipment and vision systems, hasn't seen this predicted upturn yet. Though chairman S. Stanley Mintz expects "an overall increase in robotics in general as industry automates," he says business has been weak in the computer market and "nonexistent" in the semiconductor arena. The Corvallis, Ore., company, which supplies customers in the aerospace and automotive industries as well as in computers and semiconductors, reports better performance in the more traditional markets. Automotive business remained strong throughout 1985, Mintz says—"They keep building cars"—and the aerospace sector has also been good, fueled by business from military and civil aviation buyers.

"We're ending 1985 on an upturn in orders and preorder activity," Mintz reports. And though he expects "an upturn in almost all areas of operations" in 1986, he concedes that aerospace will doubtless start to slow as budget cuts are initiated. But he believes business will pick up in the computer and semiconductor sectors, where he sees "real signs of life returning." Overall, then, the forecast for this industry is mixed: steady improvement, and a long, slow climb.

INDUSTRIAL PICKS UP THE PACE

	(millions of dollars) 1984	1985	1986
INDUSTRIAL ELECTRONIC EQUIPMENT, total	**6,784**	**7,626**	**8,6[illegible]**
Energy-management equipment	481	519	558
Inspection systems	347	397	456
Motor controls (speed, torque)	771	752	823
Numerical-control systems	278	345	378
Pollution-control equipment	936	1,021	1,183
Process-control equipment, total	3,560	4,111	4,671
Data-acquisition systems	220	256	294
Process instrumentation	1,626	1,977	2,183
Sequence controllers	1,640	1,795	2,112
Data loggers	74	83	92
Robot systems, total	333	395	510
Pick and place	74	84	122
Point to point	40	48	60
Continuous path	64	50	62
Assembly	35	51	64
Flexible machine tools	12	15	17
Tactile systems	25	29	34
Vision systems	83	118	151
Thickness gauges and controls	78	86	93

All figures in current U. S. dollars.

SEMICONDUCTOR PRODUCTION

Consumption of semiconductor-production equipment in the U. S. flattened last year, and demand this year will probably not show much of an increase. In 1985, the total market contracted 4%, to $2.4 billion. This year, an estimated 2% growth rate should bring consumption to $2.5 billion.

The leveling of demand in this sector is due to two factors: the recent rapid buildup in capacity, including manufacturing gear, by U. S. chip makers whose capital budgets were swelled by the boom in the semiconductor market in 1984, and 1985's rapid falloff in sales that forced these makers to curtail chip production, lay off workers, shut down factories, and defer bringing new plants on line. Industry executives say their customers bought enough production gear in the boom years of 1983-84 to meet current needs. In fact, they say, much of the higher-priced equipment that sits in users' inventories—such as plasma etchers and wafer steppers—can handle the next generation of complex integrated circuits.

The evolution of the semiconductor industry from traditional commodity ICs toward the new application-specific ICs is placing new demands on makers of chip-production equipment. Commodity ICs, which are fabricated, packaged, and tested under high-volume high-throughput conditions, are most efficiently made using large-diameter wafers. ASICs, on the other hand, can be processed on smaller wafers, and their production demands a close relationship between vendor and customer to iron out problems that creep up in making small batches of chips. Large semiconductor-equipment makers have sufficient resources to offer equipment for both forms, but smaller firms could be forced to opt for one or the other.

If the current picture seems grim economically, hopes for future growth in demand are sparked by new technological breakthroughs, and announcements last fall make it clear that suppliers are counting on these developments [*Electronics*, Oct. 28, 1985, p. 55]. One such advancement is a chemical-vapor-deposition system from Anicon Inc., San Jose, Calif., which can be used with oxides, polysilicon, tungsten, and high-temperature nitride. It can handle wafers up to 6-in. in size.

Applied Materials Inc., Santa Clara, Calif., recently unveiled another interesting product: the Implant 9000 ion implanter, which is markedly different from previous designs. It's a distributed-intelligence system that includes a video display and a human-interface computer, connected by a fiber-optics loop controller. In another departure, the system uses dual mechanical rather than rotary scanning.

CHIP-MAKING GEAR STAYS FLAT

	(millions of dollars) 1984	1985	1986
SEMICONDUCTOR PRODUCTION EQUIPMENT, total	**2,538**	**2,442**	**2,501**
Assembly (wire bonders, etc.)	261	225	243
Lithography, total	638	604	620
Aligners, total	560	517	524
Contact (proximity)	43	37	32
Direct wafer stepping	272	235	210
Electron beam	80	85	92
Projection	165	160	190
In-line handling (scrubbers, etc.)	78	87	96
Mask generation (digitizers, etc.)	44	47	52
Wafer preparation (crystal growers, etc.)	55	48	51
Wafer processing (furnaces, etc.)	1,540	1,518	1,535

All figures in current U. S. dollars.

SEMICONDUCTORS

DEMAND TO RISE 13%, A FAR CRY FROM LAST YEAR'S 'FREE FALL' OF 17%

The depression in the U. S. semiconductor market should ease in 1986, and manufacturers should enjoy growth—a welcome change from last year's decline—as customers cautiously edge back into the market. But the growth most certainly will not match the heady increase the industry scored in the boom year of 1984, nor will it be enough to make chip consumption in 1986 match 1984's. Advances will be patchy.

Predictions for total chip consumption vary widely. The Semiconductor Industry Association is the most bullish: it sees a healthy 25% rebound this year. On the other hand, In-Stat Inc., Scottsdale, Ariz., foresees a 2.5% drop. *Electronics'* market research survey predicts a 13.2% gain in 1986.

The cause of last year's 17% decline in semiconductor consumption is really no secret. The computer industry, which uses 41% of the world's semiconductor production, cut down its purchases from chip makers as a result of a double whammy that reduced equipment sales: demand for personal computers declined unexpectedly at the same time that corporate customers put off orders for mainframe computers and minicomputers, primarily to await new products.

Burned by well-publicized semiconductor shortages in 1983, many equipment companies filled their stockrooms with chips in 1984, vowing never to be caught short again. As demand for equipment slackened in 1985, many customers canceled their chip orders and put the piled-up inventory into use instead. With demand for integrated circuits and discrete chips dropping and chip-making capacity skyrocketing, Japanese and U. S. makers began vicious price cutting. That prompted smart buyers to order at the last minute to get the lowest price. So not only did unit volume drop, but prices plunged, resulting in an all-around dismal year for chip makers.

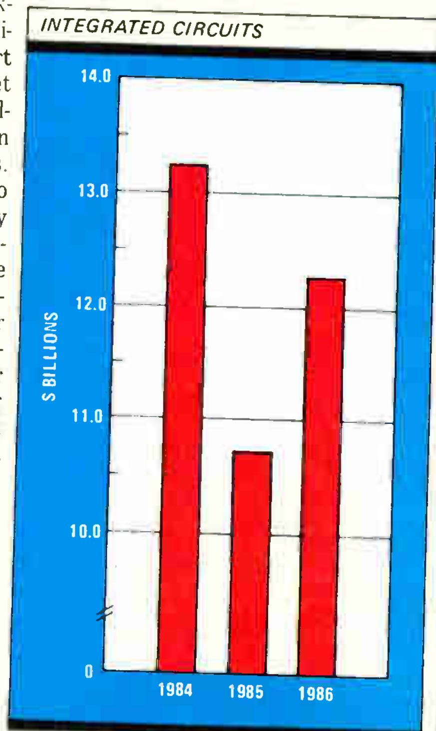
Although prices for logic chips began to firm up late last year because of inventory adjustments by original-equipment manufacturers and distributors, the price decline in memory chips remains unchecked. Japanese companies, still eager to deplete their high inventories of 256-K dynamic random-access memory chips while keeping their production lines running, have been pricing these parts at less than 300 yen, or about $1.50. And there are strong indications that the price might even fall to 200 yen sometime this year.

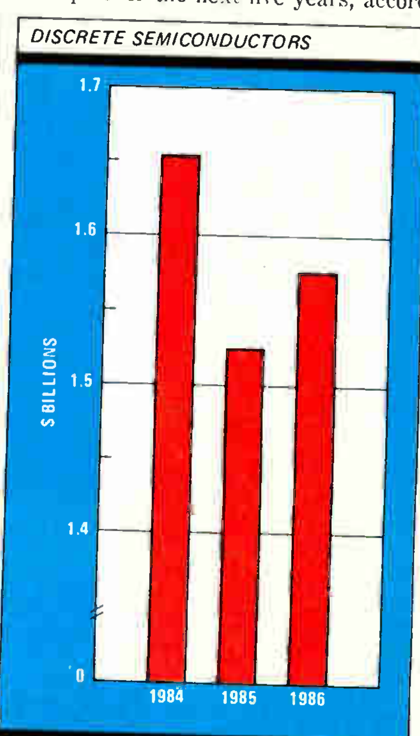
While it took the 64-K DRAM almost 2½ years to decline from 1,000 to 300 yen, vicious price cutting in a slumping 1985 market forced the 256-K DRAM into the same drop in just six months. Despite a growth in volume from 200 million chips supplied in 1985 to an estimated 500 million units this year, makers of 256-K DRAMs will be hard pressed to show any profits from their efforts.

Though demand was poor generally for semiconductor chips in the U. S. last year, it was not a disaster for all segments. For example, consumption of analog ICs in the U. S. dropped just 5%, while data-conversion ICs were down less than 3%.

Communications chips were the big exception: they shot up 17%. These ICs will maintain a 30% average annual growth rate for the rest of this decade, according to International Resource Development Inc. This conclusion comes from the Norwalk, Conn., market researcher's analysis of the rate at which new communications equipment is being installed, coupled with the increasing displacement of densely packed circuit boards by smaller, dedicated telecom ICs. Additional factors include the continuing growth of consumer telephones and communicating computers, plus a heavy push by corporate planners to install local-area networks and fiber-optic links in factories and office buildings.

Data-conversion chips, including digital-to-analog and analog-to-digital converters, account for 35% of the analog-IC market. Because these chips are used in a wide variety of noncomputer-related services, such as automatic fuel-injection systems in autos, test instruments, and telecommunications equipment, they were not hit as hard as other market segments last year. These chips will be the key to linking the real or analog world with the digital interface of microprocessor and logic chips, which will create a healthy annual growth rate of 11.5% for these chips over the next five years, accord-





SEMICONDUCTOR USE TO GROW AFTER DISASTROUS 1985

	(millions of dollars) 1984	1985	1986
SEMICONDUCTORS, total	**15,033**	**12,406**	**14,257**
Integrated circuits, total	**12,994**	**10,609**	**12,384**
Consumer product ICs	1,210	1,020	970
Custom ICs, total	1,315	1,465	1,773
Fully custom	818	837	877
Fuse programmable (including PAL, IFL)	132	135	156
Gate arrays	283	328	447
Standard cells	82	165	293
Analog ICs, total	1,313	1,156	1,323
Analog switches	65	62	66
Communications	156	183	219
Comparators	37	35	36
Data conversion, total	298	294	329
ADCs	87	85	94
DACs	132	129	149
Multiplexers	41	43	46
Sample-and-hold circuits	39	37	40
Instrumentation and isolation amplifiers	15	14	15
Interface	185	133	153
Operational amplifiers	261	183	213
Timers	78	70	72
Voltage regulators	108	82	95
Other (including functional ICs)	110	100	125
Memories, total	3,535	2 600	2,857
CCDs (memory only)	8	7	8
Magnetic bubble ICs (including support circuits)	20	16	17
Random access, total	2,269	1,649	1,784
Dynamic, total	1,680	1,241	1,299
16-K	642	193	263
32-K (partial or hybrid)	78	53	68
64-K	876	829	496
256-K	84	166	472
Pseudostatic (self-refreshing)	29	30	32
Static, total	560	378	453
Bipolar	106	84	94
CMOS	257	196	240
n-MOS	197	98	119
Read only, total	1,238	928	1,048
Ultraviolet-erasable programmable	294	169	191
Electrically erasable, total	42	75	110
EEPROM	28	53	87
Shadow (NVRAM)	14	22	23
Mask type, total	515	421	476
CMOS	383	313	347
n-MOS	121	98	117
p-MOS	11	10	12
Programmable (fuse type)	387	263	271
Microprocessors and microcomputers, total	2,641	2,000	2,444
LSI peripheral chips, total	727	353	585
Peripheral equipment controllers (disk and CRT controllers, etc.)	482	190	372
Processor support devices (DMA, MMU, etc.)	245	163	213
Microprocessors, total	871	779	890
Bipolar	103	95	97
MOS, total	768	684	793
8-bit	348	311	361
16-bit	335	303	351
32-bit	85	70	81
One-chip microcomputers, total	837	681	774
4-bit	292	186	221
8-bit	486	423	451
16-bit	59	72	102
Special-purpose processors (including signal processors, speech synthesis), total	206	187	195
Standard logic families, total	2,980	2,368	3,017
CMOS	649	688	806
ECL	247	187	242
TTL, total	2,084	1,493	1,969
Schottky TTL	1,742	1,228	1,552
Standard TTL	342	265	417

	(millions of dollars) 1984	1985	1986
Discrete semiconductors, total	**1,657**	**1,527**	**1,573**
Diodes, total	591	521	535
Arrays (including bridges)	25	21	23
Rectifiers, total	281	250	262
Fast recovery	86	73	76
High power	72	63	67
Low power (less than 25 A)	123	114	119
Signal	143	128	131
Special purpose, total	30	27	28
Microwave (above 1 GHz)	17	16	16
Tunnel	2	2	2
Varactor	11	10	10
Zener	112	95	91
Protection devices (including solid state, excluding fuses and circuit breakers)	22	19	21
Thyristors	137	127	136
Transistors, total	907	860	881
Bipolar, total	738	693	701
Power (1 W or more)	371	354	366
Rf (above 1 GHz), total	80	70	80
Power (more than 1 W)	45	40	55
Small signal	35	30	25
Small signal (less than 1 W)	287	269	255
Field effect	106	97	100
Gallium arsenide	63	70	80
Optoelectronic devices, total	**382**	**270**	**300**
Imaging arrays	87	58	62
Laser diodes	10	8	11
Light-emitting diodes (discrete), total	94	72	80
Infrared, near-infrared	21	15	21
Visible	73	57	59
Optically coupled isolators	107	63	72
Photoconductive cells (light-dependent resistors)	17	16	17
Photodiodes	6	6	6
Phototransistors	21	19	20
Photovoltaic cells	40	28	32

All figures in current U.S. dollars.

ing to Dataquest, the San Jose, Calif., market researcher.

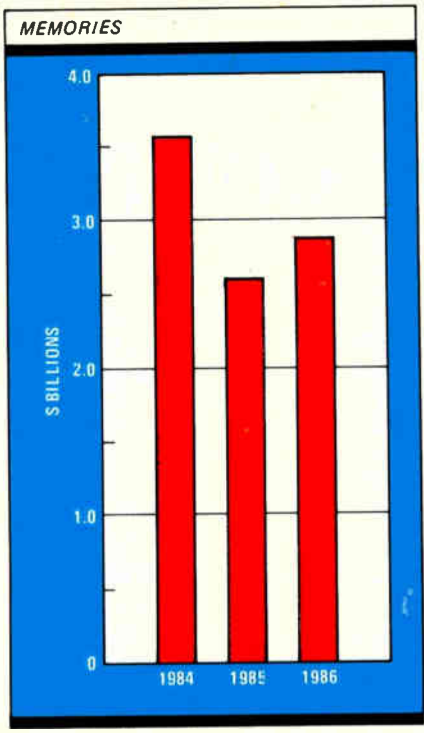
Another factor influencing growth in the data-conversion-chip market is the emergence of digital signal processing. Because a considerable amount of information to be processed with DSP techniques is analog, ADCs will be a necessary ingredient in the process.

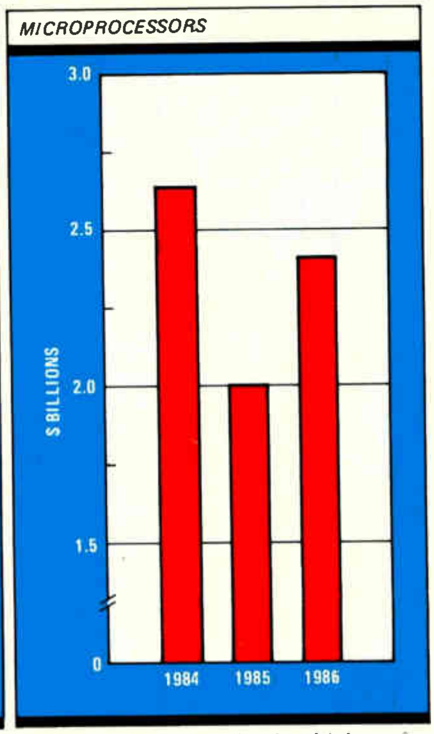
For their part, DSPs and their peripheral chips offer semiconductor makers a market that is expected to reach $500 million by the end of the decade, according to Forward Concepts, a Tempe, Ariz., market researcher. DSPs are used by the military for radar and sonar applications and by the telecommunications industry for tone-key detection and adaptive echo cancellation. Recently introduced DSP chips are being designed into high-speed modems, high-performance graphics systems, industrial robots, and speech synthesizers. Consumers will soon be viewing DSP-equipped color TV sets with options for freezing a picture on the screen, splitting the screen to present two programs at the same time, and captioning dialogue for viewers with hearing problems.

The leader in DSP today is Texas Instruments, followed by NEC, Advanced Micro Devices, Intel, and Fujitsu; AT&T Technologies is also entering the market to capitalize on the company's expertise in producing these chips. Other vendors readying for the battle include Honeywell, Motorola, National Semiconductor, and TRW.

DSP-chip prices have not eroded because their low production levels have not exceeded demand and military and telecommunications buyers appear content to pay what the vendors want. An example of DSP pricing: the 1,000-quantity price of TI's TMS320 is about $40 apiece, compared with about $10 for an Intel 8088 microprocessor. The difference is due in part to the higher speed and complexity of the DSP, and in part to the enormous difference in production runs on a semiconductor fabrication line, because Intel makes more 8088s than TI makes TMS320s.

Both the microprocessor and DSP chip offer users considerable design flexibility by virtue of their programmability. A particular DSP chip can be targeted to enhance the image of a graphics picture, for use in a high-speed modem, or to adjust parameters in a telephone repeater to compensate for changes in line characteristics. Digital networks will employ DSPs for bit-compression multiplexing to remove redundancies from speech, allowing a voice circuit to double its capacity.





Despite the attention given to the emerging battle for leadership in the 32-bit microprocessor race, the 12-year-old 8-bit micro still takes the lion's share of the microprocessor unit market. More than 85% of the microprocessor chips shipped last year were the 8-bit variety, and their sales revenue equaled the total for higher-priced 16- and 32-bit chips.

Several factors are responsible for the continuing popularity of the 8-bit parts. First is the integration of peripheral functions such as direct-memory access and memory management on the basic microprocessor to enhance its performance. Other enhanced microprocessors combine an 8-bit data bus with a 16-bit internal architecture. In effect, designers have cleverly managed to upgrade the 8-bit microprocessor, thus sparing the user the expense of a 16- or 32-bit chip that, in most cases, provides more horsepower than the user really needs. An enhanced 8-bit microprocessor with integrated peripheral functions on a single chip offers obvious savings, both in cost and in printed-circuit-board space.

A second important advantage of 8-bit chips is their ability to use well-established CP/M-based software; it can cost a lot to switch to more-complicated Unix or MS-DOS software requiring the revision of long blocks of microcode.

In microprocessors, 8-bit units still account for 85% of shipments

In the fast-moving world of semiconductor product development, speedy obsolescence is taken for granted. But semiconductor marketing managers tend to agree that the 8-bit chip, popular for applications ranging from cellular phones to low-cost engineering work stations to industrial control systems, has not yet hit its peak; some marketers expect to see it still doing well on its 25th birthday.

In the meantime, more suppliers offer the powerful 32-bit microprocessor. The original lineup had AT&T, Motorola, National Semiconductor, and TI. Intel and Zilog, together with Hitachi and NEC, have joined the list of vendors offering 32-bit versions to interested buyers, who at present are the manufacturers of engineering work stations. Expected to join the crowd are Fujitsu, Oki Electric, Signetics, and Toshiba; more significant are the persistent rumors that captive chip makers such as Data General, Digital Equipment, and Hewlett-Packard could also enter the market.

The incentive is a share of what Dataquest estimates will be a $1 billion market for 32-bit microprocessors and their peripheral chips by 1990; worldwide sales of these chips totaled less than $20 million during 1985. Development costs for a 32-bit microprocessor, its peripheral chips, development systems, evaluation units, and software run up to $100 million, so the players will compete viciously for sales to pay back the investment. Aware that engineering work stations alone cannot carry the 32-bit microprocessor market, product managers are eagerly awaiting the emergence of mass-produced office- and factory-automation systems that suit the high-performance capabilities of the 32-bit chips.

In another emerging area of the semiconductor market, gallium-arsenide ICs are on their way to becoming a $4 billion market worldwide by 1992, says an optimistic study by Gnostic Concepts Inc., a San Mateo, Calif., research company. The U. S. market should account for half of the output. Although U. S. consumption last year—mostly for sophisticated military and defense applications—was less than $200 million, new opportunities have been opened to computer makers by the commercial availability of GaAs chips from suppliers such as Gigabit Logic, Harris, Honeywell, and TriQuint Semiconductor.

With GaAs ICs capable of speeds six times faster than silicon emitter-coupled-logic chips and 10 times faster than silicon CMOS chips, computer designers who want to break computation speed records are anxious to include these new chips in their next-generation machines. Designers of satellite communications systems are busy integrating low-noise GaAs ICs and discrete chips in their earth-station receivers to make communications reliable even with low-power transmitters on board the satellites.

Vendors of GaAs ICs are busy readying automated production lines capable of turning out quality chips at costs competitive with more-mature silicon chips. But Japanese semiconductor giants are heavy contenders in the race to become leaders in this segment. Fujitsu, Mitsubishi, NEC, and Toshiba have demonstrated a wide array of GaAs products stemming from their development efforts. Even more significant, the highest-quality GaAs substrate materials now available come from three Japanese sources: Furukawa Electric, Shin-Etsu Handotai, and Sumitomo Electric. Because of Japan's heavy commitment to GaAs technology, Japanese suppliers will capture at least 50% of the world market by the end of the century, estimates a study group organized by the U. S. Department of Commerce and the National Science Foundation.

So while U. S. demand will spring back this year to a somewhat more normal growth rate, chip makers both here and abroad will have to move fast to keep up with new technologies that hit the market.

COMPONENTS

DEMAND SHOULD PICK UP AS CUSTOMER INVENTORIES DROP

After a 26% expansion in 1984, consumption of passive components in the U. S. nosedived last year as equipment-manufacturing customers worked off swollen inventories. As a result, consumption last year grew a meager 2%.

By the second half of 1986, however, most of the industry will be on an upswing, if industry observers prove correct. That's when the passive-component market will come alive, they say, as customer orders start to come in. And if past business cycles are any measure of the future, prices will rise sharply as lead times for deliveries stretch out and systems builders clamor for parts to get their products out the door. The power-supply market will also jump, but increased competition there is already knocking prices way down.

By 1990, more than half of printed-circuit-board assemblies for electronic equipment will contain surface-mounted devices, both passive and active, predicts a recent study by Electronic Trends. The study from the Cupertino, Calif., market researcher also predicts that more than 41% of all passive and active components will be in the form of SMDs by that time. A growing number of U. S. companies have come to believe that they must make the heavy initial investment for production equipment to handle SMDs in order to remain competitive with their overseas rivals.

More than 57% of surface-mounted passive components used in the U. S. in 1985 were capacitors; resistors accounted for another 38%. American resistor and capacitor vendors, with seven years' experience shipping SMD boards to Japanese producers, claim they can supply the growing needs of the home market. Most of the U. S. companies that provide coils, crystals, and other types of passive components, however, are reluctant to invest in SMD packages and associated tooling until the industry works out broad-based standardization.

Less than 5% of the integrated circuits consumed in the U. S. during 1984 were made with SMDs. But now, a number of computer and communications-equipment makers, accounting for a substantial share of the electronics market, are evaluating prototype SMD designs and production runs, with full production slated to start within two years. By then, semiconductor manufacturers will be able to offer price parity between conventional through-hole devices and equivalent SMDs, predicts Gnostic Concepts Inc., the San Mateo, Calif., market researcher. This will push the market for SMD ICs to $5.3 billion by 1988.

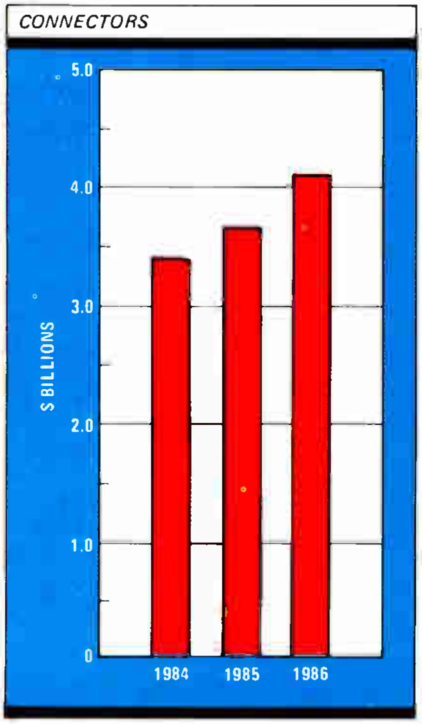
Although the U. S. consumption of resistors should grow a slim 5% this year, domestic resistor manufacturers are concerned about several trends that could seriously damage their future. The first is the reduced resistor content in new electronic systems. Resistors accounted for more than 0.4% of the value of all electronic equipment in 1984, but this could dwindle to less than 0.3% by 1989 as complex digital and linear chips diminish the need for discrete devices.

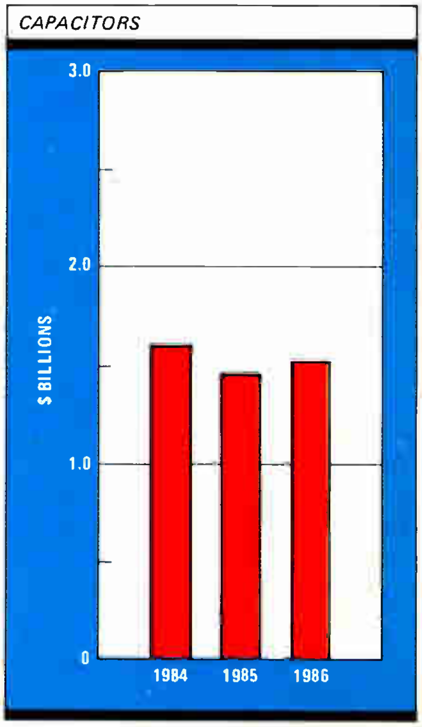
STEADY PRICE EROSION

In addition, imports are finding their way into U. S. equipment in increasing amounts. The trade deficit in resistors last year was close to $150 million, or almost half the U. S. original-equipment-manufacturer market for fixed resistors. A third major concern has been steady price erosion: high-volume fixed-resistor orders fell by more than 8%, and resistor networks sales slid close to 3% in 1985.

Resistor manufacturers that geared up to supply SMD resistors are waiting patiently for large-volume orders. But sales staffs report that users continue to balk at shelling out $20 per thousand for SMD resistors when conventional leaded devices cost close to half as much. Users also are reluctant to allocate funds for expensive automated SMD equipment at a time when their profits are being squeezed.

Capacitors faced the same dismal dropoff in sales as did resistors last year, hampered by both foreign competition and cutbacks in orders as their best customers depleted their inventory stockpile. But most manufacturers think that the market for capacitors has hit bottom and is ready for what





STRONG GROWTH IN COMPONENTS THIS YEAR . . .

	1984	1985	1986
	(millions of dollars)		
COMPONENTS, total	**19,183**	**19,499**	**21,548**
Capacitors, total	**1,627**	**1,445**	**1,538**
Ceramic (except chips)	567	504	527
Chips	101	91	104
Electrolytic, total	613	547	581
Aluminum	247	236	253
Tantalum	366	311	328
Film	153	132	139
Glass and vitreous enamel	21	17	16
Mica	28	26	28
Paper	117	106	119
Variable	27	22	24
Character displays, total	**442**	**426**	**459**
Multiple-character, total	368	350	377
Gas-discharge	142	143	157
Light-emitting diode	121	106	113
Liquid crystal	83	80	83
Vacuum fluorescent	22	21	24
Single-character	74	76	82
Connectors, total	**3,392**	**3,665**	**4,120**
Coaxial (excluding assemblies)	289	341	434
Cylindrical, total	570	556	597
Miniature	207	201	224
Standard	198	193	205
Subminiature	165	162	168
Fiber-optic	65	80	100
Flat-cable	281	328	359
Insulation displacement	254	277	312
Pc edge connectors	693	892	981
Rack and panel	707	696	801
Special purpose	533	495	536
Crystals, total	**182**	**167**	**181**
Assemblies (including mounts and ovens)	121	106	117
Discrete crystals	61	61	64
Electron tubes, total	**2,120**	**2,252**	**2,335**
Cathode ray (excluding TV)	121	114	136
Power and special purpose, total	746	784	824
Gas and vapor	41	45	51
Image sensing (including vidicon and orthicon)	58	61	65
Klystrons	103	99	96
Light sensing (including photomultipliers)	35	37	40
Magnetrons	85	90	90
TWTs (including backward wave)	289	305	321
Vacuum	135	147	161
Receiving	46	35	29
TV picture, total	1,207	1,319	1,346
Color	1,152	1,274	1,309
Monochrome	55	45	37

	1984	1985	1986
	(millions of dollars)		
Hybrid and modular components, total	**989**	**997**	**1,048**
Active filters	21	19	20
Analog I/O (data-acquisition) boards	103	91	97
Custom hybrids and modules	245	314	332
Data conversion, total	466	427	445
ADCs	206	189	192
DACs	151	138	147
Converter subsystems	50	46	49
Multiplexers	17	15	16
Sample-and-holds	42	39	41
Instrumentation and isolation amplifiers	41	40	41
Operational amplifiers	76	72	76
Signal sources (including oscillators)	5	5	6
Other functional circuits	32	29	31
Magnetic, total	**871**	**883**	**972**
Af and rf transformers, coils, and chokes	217	203	241
Ferrite components (coil forms, etc.)	74	80	87
Power transformers	335	349	371
TV magnetic components (including yokes and flyback)	245	251	273
Microwave components, total	**281**	**326**	**372**
Amplifiers	105	126	148
Detectors	17	24	30
Ferrite devices	43	48	54
Mixers	31	36	40
Passive components, total	49	53	58
Coaxial and strip-line	38	43	48
Waveguide	11	10	10
Power limiters	17	18	19
Switches, total	19	21	23
Coaxial and strip-line	11	14	17
Waveguide	8	7	6
Passive filters and networks, total	**210**	**214**	**235**
Delay lines	26	28	30
Electromechanical filters	33	36	37
RC networks	26	32	37
Rfi and emi filters	125	118	131
Power supplies, noncaptive (switching and nonswitching), total	**1,442**	**1,520**	**1,700**
Switching, total	632	582	649
Pc-board mountable (encapsulated)	43	38	46
Open-frame and card	325	294	315
Rack mountable	86	73	88
Industrial (0.1% or worse regulation and over 1 kW)	117	112	134
Programmable	61	65	66
Linear, total	402	390	386
Benchtop	91	87	82
Rack mountable	153	150	138
Industrial (0.1% or worse registration and over 1 kW)	93	87	90
Programmable	65	66	76
Uninterruptible	408	548	665

All figures in current U. S. dollars.

they hope will be a healthy recovery.

U. S. capacitor production dropped 11% last year against 1984's record $1.86 billion in sales, says Gnostic Concepts—a significant portion of which went to the hungry export market. The researcher predicts production will rise 10.2% this year, with multilayer ceramic capacitors taking a 35% share of the market. Because these multilayer capacitors are used widely as decoupling capacitors in ICs, their close link with semiconductors means a high degree of market volatility.

Industry representatives also predict a heavy demand for chip capacitors as surface mounting finds its way into more U. S. and foreign equipment. Chip capacitors represented only 14% of total capacitor sales in the U. S. in 1984, but could reach 35% by 1989. Gnostic Concepts says four major equipment producers—Delco, Northern Telecom, Motorola, and AT&T Technologies—consumed close to 800 million chip capacitors last year; their needs could top 1.5 billion this year.

For connectors, the news was twofold: U. S. production of the devices was down by 3% last year, but the *Electronics* survey found that consumption was up close to 8%. Companies whose stockrooms bulged with $322 million worth of connectors in 1984 relied on their inventories. This meant a dramatic drop in sales to only $9 million last year, Gnostic Concepts says. But now, inventories are now quite low, so 1986 production is expected to grow a healthy 13%, with the government and military sector edging out the computer industry as the largest customer.

Switches were among the few products spared in last year's

. . . AFTER A FLAT 1985

	1984	(millions of dollars) 1985	1986
Printed circuits and interconnection systems, total	**2,754**	**2,324**	**2,650**
Chip carriers	12	11	11
Interconnections, total	536	457	515
Backplanes	221	189	216
Sockets and socket panels for DIPs	315	268	299
Printed circuits, total	2,206	1,856	2,124
Flexible circuits	197	169	203
Rigid boards, total	2,009	1,687	1,921
Double sided	1,172	1,003	1,129
Multilayer	681	549	641
Single sided	156	135	151
Relays, total	**658**	**715**	**794**
Crystal can	102	118	137
General purpose	225	241	278
Reed	58	62	66
Rf	115	131	146
Solid state	74	81	83
Stepping and impulse	11	12	13
Telephone-type	46	51	47
Time delay	27	19	24
Resistors, total	**1,030**	**913**	**962**
Chip resistors	28	26	27
Fixed, total	384	350	356
Composition	51	48	46
Deposited carbon film	34	31	28
Metal film	98	87	89
Wirewound	201	184	193
Resistive networks, total	209	180	184
Thick film	187	161	163
Thin film	22	19	21
Thermistors	72	68	71
Variable, total	337	289	324
Potentiometers	196	168	205
Trimmers	141	121	119
Switches and keyboards, total	**1,236**	**1,276**	**1,358**
Coaxial	41	42	43
Dual in-line	63	65	67
Keyboards, keypads, and matrixes	395	421	448
Lighted	127	132	136
Push-button	181	198	225
Rotary	119	108	117
Slide	70	75	80
Small-movement snap action	100	96	100
Solid state (including Hall effect)	35	35	35
Thumbwheel	36	32	33
Toggle	69	72	74
Transducers (electronic), total	**729**	**997**	**1,362**
Fiber-optic sources, detectors	70	100	150
Flow	100	130	165
Fluid-level	86	110	130
Motion, linear and angular	97	123	147
Pressure (including air, liquid, and mechanical)	240	370	585
Temperature (excluding thermocouples and thermistors)	94	117	137
Vibration	42	47	48
Wire and cable, total	**1,220**	**1,379**	**1,462**
Coaxial cable	293	282	276
Fiber-optic cable	266	417	471
Flat-cable	114	128	143
Hook-up wire	183	185	187
Multiconductor	364	367	385

All figures in current U. S. dollars.

recession in passive components. True, consumption in this sector was up a meager 3%, while U. S. production dropped by about the same amount. But thanks to a relatively brisk demand from military and government customers, the average selling price for switches remained fairly stable, an enviable situation not shared by other passive-component vendors. The manufacturers are apprehensive about their prospects in 1986, however: U. S. consumption is seen growing a mere 2%, just as Japanese manufacturers are poised to make a major effort to dominate this high-volume production-oriented market.

DISASTER FOR PC BOARDS

For producers of printed-circuit boards, the year was more like a disaster. Consumption dropped almost 14%, to about $1.9 billion in 1985 from 1984's $2.2 billion. Among the reasons for the severe downturn were cutbacks in orders from personal computer makers and leaner inventories at large computer and telecommunications-equipment companies.

Because U. S. pc-board producers supply a major portion of overseas customers, the slowdown in growth worldwide also had an impact on their fortunes. If the upturn in U. S equipment markets comes about as expected, demand should pick up this year by about 11%, however, bringing consumption to around $2.1 billion.

The burden on power-supply manufacturers, also hurt by the severe drop in production of personal computers and microcomputer hardware and peripherals, was softened somewhat by increased demand from communications and military-equipment makers. Unfortunately, many smaller companies concentrated on the high-volume market for low-priced switching power supplies for home and personal computers and were put out of business when this market crumbled. More mature companies felt severe price pressure as they and their competitors slashed prices to deplete inventories.

A shakeout looms for makers of power supplies

But industry sources expect a turnaround here as well, along with some bloodshed: the 15 largest rivals dominate more than 80% of the U. S. market and another 500 struggle for a share of the remaining 20%. Strong efforts from Far East startups have driven the price of low-power (under 150-W) switching power supplies to levels of 60¢ per watt, while the high-power (up to 1-kW) models have dipped to less than $1 a watt.

The market share of the older linear power supplies is being attacked by clever switching designs that offer higher efficiency, lower weight, and fewer parts, which means higher reliability. The market share of linear supplies will slip from 40% to less than 30% by 1989, says researcher Frost & Sullivan Inc., New York.

The U. S. market for uninterruptible power supplies will grow at an average annual rate of 23.4% from 1984 to 1990, according to Venture Development Corp., Natick, Mass., as industrial equipment and computer users become more aware of the problems of "dirty power," caused by irregularities on their incoming power lines. As more factories become automated, manufacturers are finding that the computers controlling automated production are extremely sensitive to sharp spikes on the power line. In fact, considerable havoc in production yields already has been traced to long-ignored power transmission systems. After a 34% growth in market demand last year, consumption of uninterruptible power supplies will advance another 21% this year, to $665 million, the survey projects. □

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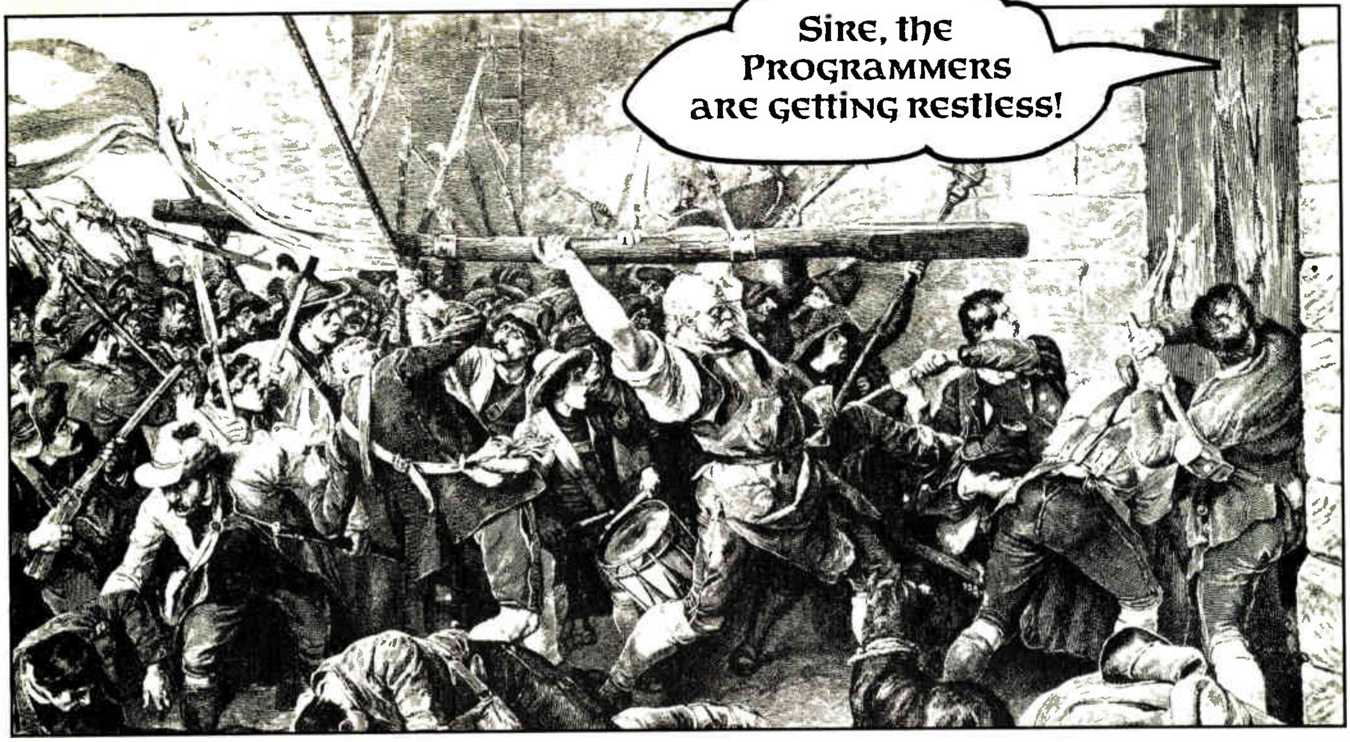

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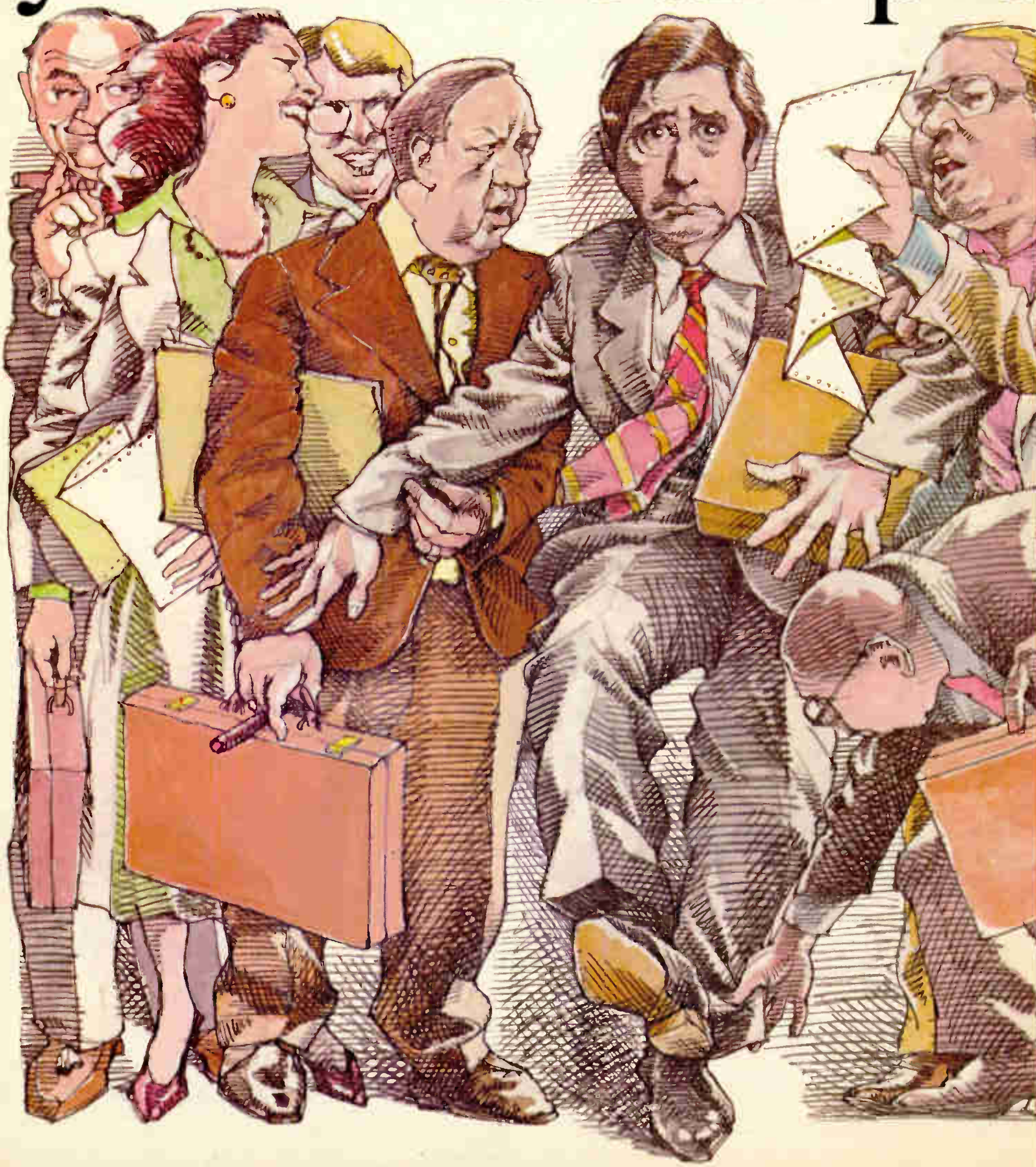

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INSIDE TECHNOLOGY

ION BEAMS REPLACE LASERS IN REPAIR OF IC MASKS

FOCUSED-ION-BEAM MACHINE FIXES OPAQUE AND CLEAR DEFECTS

By applying an exotic technique to a down-to-earth problem, Micrion Corp. has conquered a major stumbling block in integrated-circuit fabrication. The technique—focused ion beams—makes possible the repair of optical masks and reticles, eliminating all defects.

Photolithography—the process of imaging a pattern from a glass mask onto a resist-covered wafer—is the key to today's very large-scale-integration processing. But no matter how precise the optical stepper or 1:1 projection-lithography system, and no matter how tight the clean-room specifications, defects generated in mask fabrication can lower the yield. This leaves IC manufacturers with two choices: scrap the mask or repair it. Because masks cost from $700 to $3,500, in most cases they have attempted to repair the masks, often with lasers. But as mask geometries approach submicron dimensions—particularly on 1:1 types—mask-repair systems based on lasers do not have the resolution and accuracy to do the job anymore.

In response, Micrion, a two-year-old company in Beverly, Mass., has developed the KLA/Micrion 808 focused-ion-beam mask-repair system (Fig. 1). This $1.05 million system, which is being marketed through KLA Instruments Corp., Santa Clara, Calif., is targeted at tiny opaque and transparent defects in conventional glass photomasks as well as in the newly emerging masks for X-ray lithography. The 808 uses a finely focused scanned beam of ions to both mill material off during mask repair and to act as a highly magnified scanning ion-beam microscope. The scanned ion-beam system offers two major advantages: it can repair both clear and opaque defects, and—because of its 0.1-μm positional accuracy and fine spot size—it is suitable for both low- and submicron-geometry mask repairs.

Typically, an optical mask consists of a plate of clear glass with a thin layer of chromium delineating the pattern to be exposed. On 1:1 masks, these features can be in the 0.8- to 2-μm range. However, defect-free masks cannot be produced all the time. Particle density is an inverse function of feature size: as IC geometries get smaller, the number of potential defects increases at a startling rate.

Opaque defects are those in which residual chromium blocks the light to be transmitted through the mask. Such a defect may be caused by dust, by poorly etched chromium, or from several other causes. Clear defects occur when part of the desired chromium pattern is missing and the light is transmitted instead of being blocked. These defects are caused most frequently either by poor adhesion of the chromium to the glass or pinholes in the resist.

Until recently, different processes were needed to repair each type of defect. Opaque defects are removed by superheating them with a focused laser beam—a process called zapping because the defect is removed with a burst of energy. This process has several important limitations.

For one, the violent thermal process is difficult to control, making it easy to damage the underlying glass or adjacent images. Second, the edges of repaired areas are frequently distorted because the target metal is first melted and then vaporized. During melting, the chromium tends to flow and build up around the edges of the repaired area.

Finally, because of the limitations imposed by diffraction of light, it is possible to focus laser beams only to about 1 μm in size. This is no problem in repairing a free-standing defect (that

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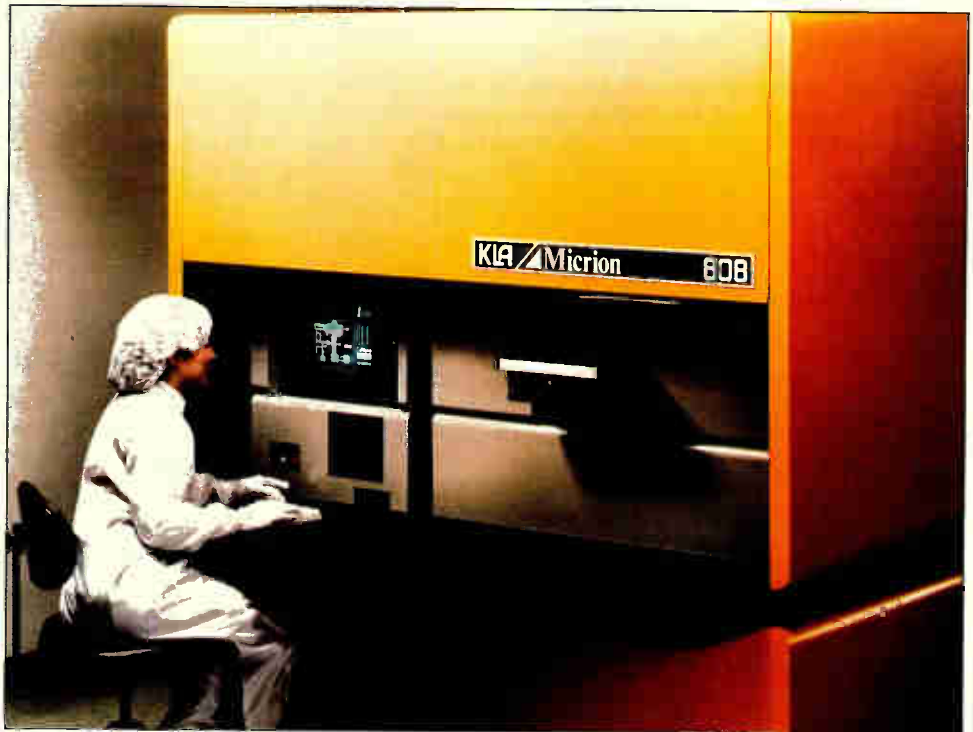
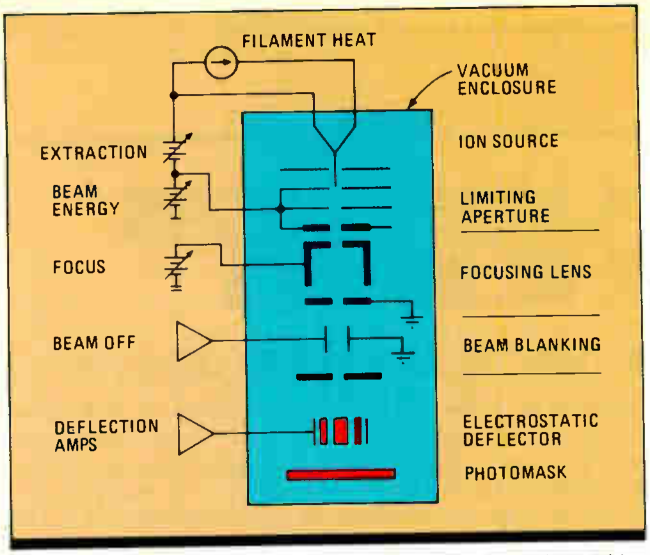
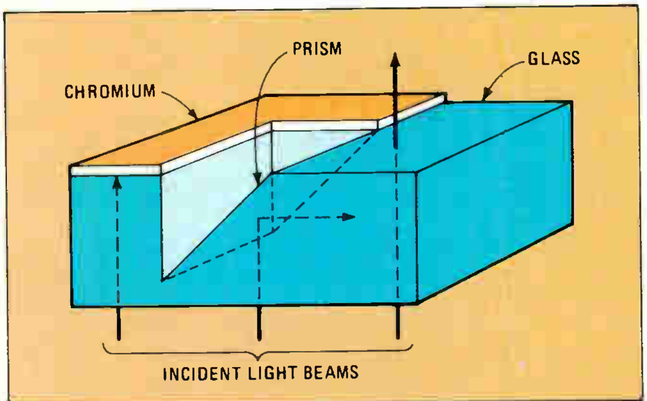


1. FIXER. The KLA/Micrion 808 uses an ion beam to mill out defects in optical and X-ray masks.



2. ION SOURCE. The optical column of the mask-repair machine focuses its ion beam through a single electrostatic lens.



3. BLOCKAGE. Ion-beam milling of a prismatic structure into a glass surface (middle) blocks incident light as effectively as chromium.

is, a defect that is distant from a desired pattern) of any size. But when the defect is attached to a pattern—or worse yet, between two desired patterns—it becomes difficult if not impossible to do an adequate job. As the industry pushes toward smaller geometries, this problem will become even more acute.

Repairing clear defects is even more difficult because the user must add precise amounts of material to very small, precisely defined areas. For the past 10 years, this has been done with a process called lift-off, a multistep process in which the mask is coated with resist that is then exposed selectively over the areas to be repaired. After developing and removing unwanted resist, chromium is sputtered over the mask's entire surface, filling the holes opened in the resist. The mask is then chemically processed, lifting off all the remaining resist and excess metal, and leaving metal where the holes were. This process is time consuming, complex, and often ruins the photomask.

To repair pinholes in a large field of chromium, laser-induced chemical-vapor deposition typically can deposit metal over a 2- to 3-μm^2 area. This is insufficient, however, for critical reconstruction of line edges. Here, repair is most important because line-edge defects and defects within tight geometries are usually fatal. Because only large areas can be deposited by CVD, these must later be cleaned by laser thermal trimming. But the same reasons that defeat laser edge repair for opaque defects hold for this method—the metal edge is distorted by the heat generated by the laser.

These shortcomings in existing mask-repair techniques induced Micrion's founders, all with experience in scanned-ion-beam technology, to look into this high-resolution process as a possible solution to the problem of repairing masks with fine-line patterns. They came to the conclusion that focused-ion-beam repair would succeed for a number of reasons.

First, both opaque and clear defects can be repaired during the same insertion of the mask into the machine, eliminating the cumbersome process steps formerly associated with conventional clear-defect repair. Second, the ability to repair clear defects with submicron accuracy is a significant advantage. Clear-defect removal is done by etching optical microstructures such as phase gratings, prisms, and various lens-like structures into the glass mask using the ion beam. This is a durable repair and cannot be removed inadvertently.

Another advantage is that ion beams can be focused into diameters of 0.1 μm and less, allowing line-edge reconstruction of nearly the same dimension. Mask repair with ions also uses sputtering as the basic process rather than thermal evaporation and so is much easier to control. The positioning of line edges, for example, can be precisely adjusted by careful positioning of the ion beam and control of the sputtering rate. Because the process is nonthermal, only the areas of the mask image touched by the ion beam are affected.

Finally, the ability to use the ion beam in a manner similar to the scanning electron microscope makes it possible to produce mask images with magnification greater than 10,000× on a cathode-ray tube.

The Micrion 808 mask-repair machine consists of several subsystems: an ion column, a work chamber and associated high-vacuum system, an X-Y stage that moves the mask beneath the column, a load-lock system to allow rapid interchange of masks, a charge-neutralization system, a secondary-particle-detection system used for imaging, and control electronics for the system.

The column is a simple one-lens design that provides an inexpensive and reliable source of gallium ions suitable for micromachining operations. The ion optical-beam-forming system (Fig. 2) typically operates at 25 keV and produces 0.5-nA focused currents of gallium ions into 0.1- to 0.2-μm spots.

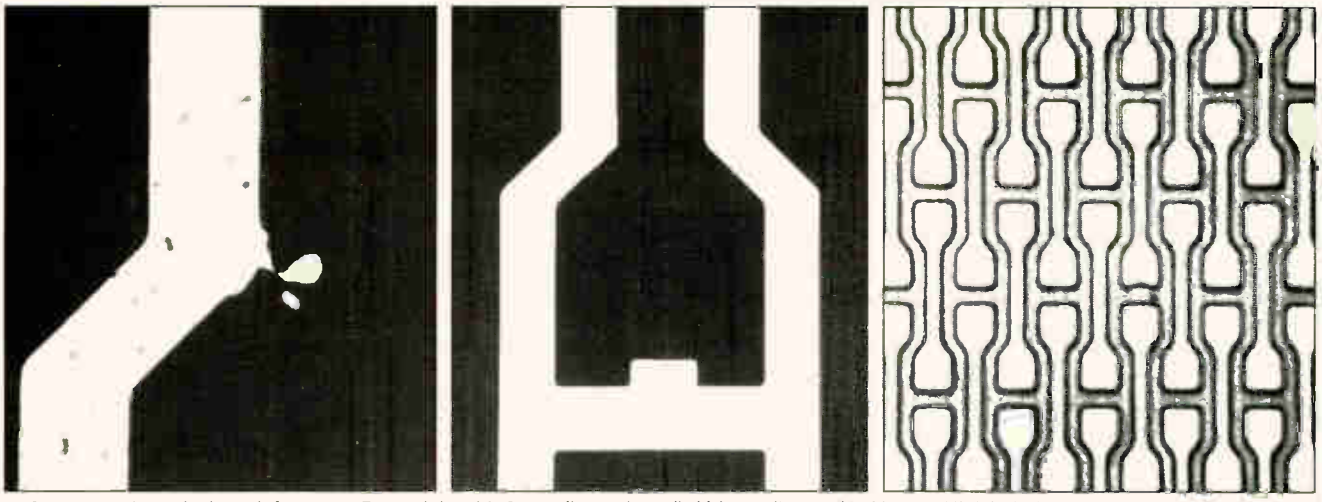
Chromium on photomasks can be removed at about the rate of 1 μm^2 every 3 seconds. For clear defects where glass microstructures have to be milled out, the same area will take about 30 seconds. The ion beam is vector scanned over an 80-μm^2 field to obtain low-magnification images when locating defects. After a defect is found, the beam is positioned by a digital pattern generator having 0.02-μm resolution to make the repair.

All system functions are computer controlled, including column setup and focusing. The computer also controls stage motion, imaging, and the repair process. Defect-location data from KLA Instruments Corp. or other mask-inspection machines can be used by the control computer to position the X-Y stage. This allows the operator to find the defect rapidly without hunting around the mask.

NEUTRALIZING CHARGE

One problem that Micrion's designers had to overcome was charge neutralization. An ion beam is a stream of charged particles, and an insulating object placed in the beam path will charge up, possibly until it reaches the potential of the ion emitter, typically many kilovolts. Unfortunately, photomasks, because they are glass plates, are very good insulators and can absorb charge. The machine's imaging circuitry would be disabled and produce image shifts and distortion. If the mask is charged sufficiently, the ion beam will be reflected away from the mask. Micrion developed a proprietary charge-neutralization system as part of the 808.

Other effects of using ion beams had to be considered. Because the ion beam images the features on the mask and makes repairs, ion implantation, implantation damage, or sput-



4. CLEARED OUT. A clear defect on a 5× reticle with 6-μm dimensions (left) is easily repaired by the KLA/Micrion 808. The user sees the repaired area as black (center, less magnified view). After exposure in an optical stepper, the printed wafer (right) shows no defect.

tering of the mask occur even during imaging. If the ion beam is allowed to scan a small area (a high-magnification image) for even a few seconds, chromium features can be damaged.

To lessen these effects, the Micrion 808 minimizes scanning of the mask by the ion beam. An image-storage system permits high-resolution photomask pictures to be obtained with a minimum ion dose. These images are then displayed on a color CRT monitor. Zooming, panning, and adjusting contrast and dark level can be done using the stored image. Once the operator has located the defect, he can use a mouse to position the cursor on the CRT screen to tell the computer where the defect is. The mouse is the only operator control. The computer controls the imaging and repair process, preventing inadvertent damage to the mask by the operator. The display is also used to monitor the column's electrical and mechanical parameters, which are shown on process-control graphics that can be accessed when needed.

The ion-beam mask-repair system requires special software to take on the two classes of defects. The software has embedded in it all the knowledge of the optimum shapes, sizes, and ion doses to produce clear and opaque repairs of defects indicated by the operator. For clear-defect repairs, prismatic microstructures create opaque areas by total internal reflection. Inside a photomask, a beam of light totally reflects when the angle at which it hits the surface of the glass is greater than the critical angle (Fig. 3). The user observes the repaired area as a black hole: light goes in but doesn't come out.

In an actual mask repair (Fig. 4), defects are located by a photomask inspection system and data is supplied to the Micrion machine. The mask is then inserted, and evacuation of the load-chamber takes about two minutes. The 808 automatically positions the first defect and displays it on a high-resolution color graphics monitor. Screen magnifications range from 10× to 15,000×. Next, the operator uses the pushbutton mouse to set the defect-repair boundaries, select the repair operation, and start the repair. Clear and opaque defects use the same process, simplifying the procedure.

For repairs on a line edge, the system's Edge-Lok software precisely identifies the edge and locks onto it. The rest of the repair process is automatic. An optional software package called Clone-it helps reconstruct missing or badly damaged geometry by acquiring the correct pattern from an adjacent area or even from the same location in the next die.

A large portion of Micrion's future sales target the repair of clear and opaque defects in 1× and 5× reticles and 1× masks used in the large installed base of optical steppers and 1:1 aligners. The Micrion system can also be used to fix design errors in a mask along with its usual mask-repair function. The 808's fine resolution allows it to precisely add or remove fine-line geometries on masks as well as on reticles. This ability was applied recently in the case of a rush mask modification for a last-minute design change to a large U.S. manufacturer's new 32-bit microprocessor prototype chip. □

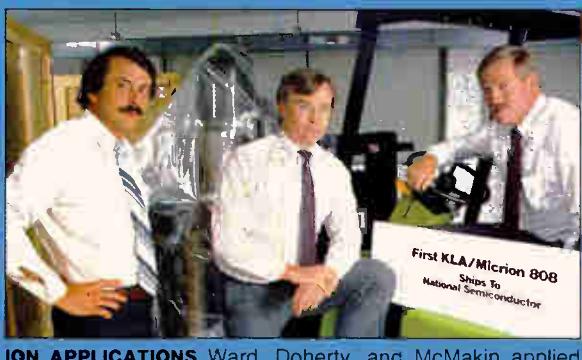
BRINGING ION-BEAM MASK REPAIR TO MARKET

Micrion's founders, William McMakin, John Doherty, and Bill Ward, were the first to commercialize ion-beam techniques in the U.S. In the early 1980s, focused-ion-beam technology was described as a solution looking for a problem. Though such processes had some interesting applications, "mask repair is the first production application of focused-ion-beam techniques," says McMakin, Micrion's president.

All three founders came from Varian Associates, where each had extensive experience with electron-beam lithography. McMakin was general manager of the Lithography Products Division; Doherty was manager of research and development for electron-beam lithography; and Ward was engineering manager in charge of product development for the Ebes system. At Micrion, Doherty is vice president for marketing and Ward vice president and chief engineer.

Building on pioneering work at AT&T Bell Laboratories, where a focused ion beam was used to micromachine residual gold defects on an X-ray mask and later to repair chromium photomasks, the three left Varian and formed Micrion in December 1983. The company shipped its first system in August 1985 to National Semiconductor Corp.

In 1984, Micrion entered into a marketing agreement with KLA Instruments Corp., Santa Clara, Calif., under which KLA is the exclusive worldwide sales and service representative for Micrion's mask-repair equipment.



ION APPLICATIONS. Ward, Doherty, and McMakin applied focused-ion-beam technology to mask repair.

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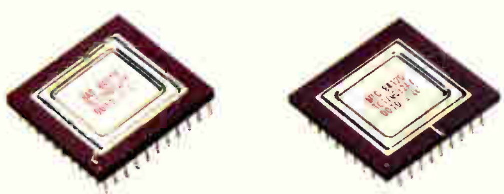

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HOW LASERS WILL GIVE CHIP MAKING A BIG BOOST

NEW SYSTEMS ELIMINATE PHOTOMASKS IN SUBMICRON CHIPS AND ASICs

by J. Robert Lineback

The next wave of laser-assisted and laser-based semiconductor manufacturing processes is moving in. After years of basic research, several new laser systems are nearing the market, sparked by the need for submicron chip geometries and the emergence of application-specific integrated circuits.

Up to now, lasers have mostly been limited to peripheral tasks in IC production—as sensors in alignment systems and for mask repair and measurement—or to programming redundant cells in memories and trimming analog circuits. Now they are getting a shot at tasks such as highly precise diffusion of dopants. Highly focused lasers are also punching and cutting their way into such applications as fine-line micromachining tools for direct repair, dissection, and even customization of ICs.

The growth of ASICs is kindling new interest in flexible maskless processing techniques for low-volume fast-turnaround products. Several startup companies have begun using laser beams fired directly onto silicon surfaces to tailor semicustom chips. Other developments are aimed at refining laser writing techniques for restructurable wafer-scale systems.

Development teams are not stopping there. They are also working on a wide spectrum of techniques to treat and analyze materials. Examples of this work are the forming of high-resolution diffraction gratings for narrow-band laser diodes, the interconnecting of optical-fiber links directly to wafer surfaces, and the development of yield-forecasting systems that detect minute defects in compound-semiconductor materials.

THIN LAYERS. XMR's doping system uses an XeCl gas laser to form controllable diffusion junctions in substrates 500 to 1,200 Å deep.

Excimer lasers, which produce energy beams in the fine-line ultraviolet spectrum, are likely to lead to a new round of processing equipment, according to some predictions. The first commercially available doping system based on excimer lasers should be on the market by April. XMR Corp., Santa Clara, Calif., has developed a UV-laser doping technique that uses pulses of a xenon chloride gas laser. The excimer laser beam can form controllable diffusion junctions in substrates 500 to 1,200 Å deep.

UV energy from the pulsing excimer laser operates in a 1.3-μm-wide wavelength of 308 nm. The energy is absorbed to a shallow depth by semiconductor materials, forming a thin molten layer. Wafers are positioned inside a chamber filled with a dopant gas such as prolytic diborane. The UV-laser pulse dissociates the B_2H_6, causing boron to diffuse into the molten silicon. This process and the subsequent recrystallization occurs in about 200 ns. The preliminary price of the ultrashallow doping system is $450,000.

GETTING A CLOSE SHAVE

"We are still looking for development partners [IC makers] to help refine ultrashallow doping techniques," says John Scott, vice president of marketing at XMR, which last year started marketing LMMC, a UV excimer-laser system for micromachining silicon circuits. The micromachining center, which sells for $170,000 to $250,000, can remove as little as 1 μm accurately in the lateral dimension without damaging substrates or surrounding materials. The excimer beam will also remove thinner layers—down to 0.1 μm—from silicon, gallium arsenide, silicon dioxide, and polymers.

In the past, excimer lasers had slow repetition rates—in the 1-Hz range—partly because of the time it takes for excimer gas electrons to go from a rest state after pulsing to an excited state for lasing. XMR handles this by rotating its excimer gas in a cylinder, blowing away dissociated XeCl particles and repositioning excited ones. The result is a repetition rate of 500 Hz.

Florod Corp., a laser-systems manufacturer in Los Angeles, has seen increases in applications using focused light beams as micromachining tools for device analysis and repair. Florod's xenon-ion gas-pulsed laser is focused through a microscope, enabling areas of 10 μm^2 or less to be boiled and vaporized with an energy density of 10 MW/cm^2 during flashes. One of Florod's laser failure-analysis stations was used by Trilogy Ltd., Cupertino, Calif., as a prototyping method of drilling interconnection vias through multiple layers of metal in its vain effort to develop highly complex wafer-scale circuits.

"This would not be something you'd use for production, but it could be used in a less repeatable environment to provide working prototypes of engineering designs," notes G. N. (Gill) Ravich, manager of Florod customer services, who will present a paper on the work at the Society of Photo-Optical

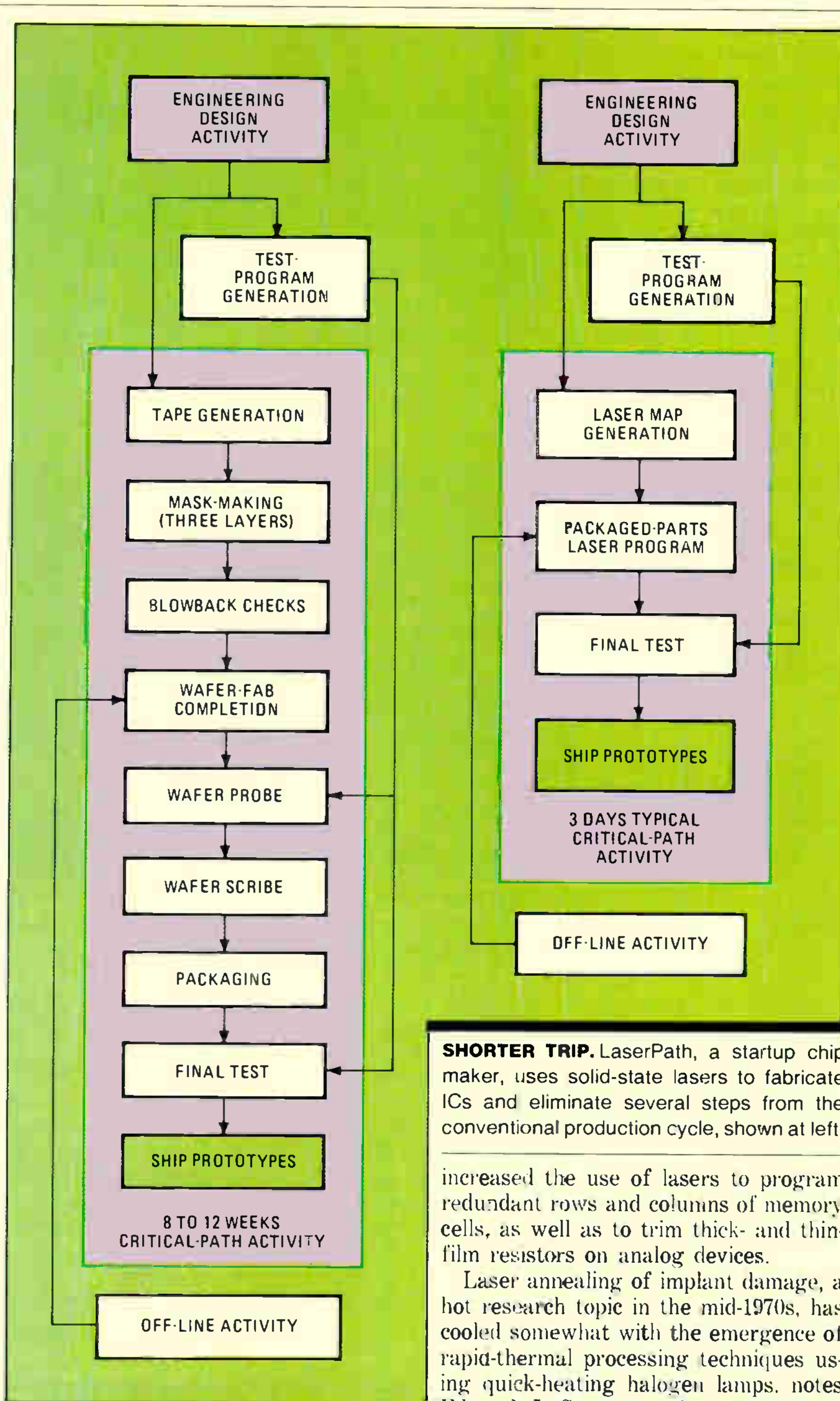
Instrumentation Engineers conference in Los Angeles this month. "To a great extent, lasers are still solutions looking for a problem," he admits. "Lasers are not yet processing workhorses, but they are supportive and analytical devices. In the future, there is an open probability that excimer lasers will become an actual integral part of wafer manufacturing."

Other startup chip makers are pioneering the use of lasers to tailor chips after conventional fabrication. LaserPath of San Jose, Calif., working with Lasarray Corp. of Thundorf, Switzerland, plans to introduce in this quarter CMOS gate arrays that can be prototyped in less than a day with solid-state lasers. The new post-fabrication laser etching technique uses an yttrium-aluminum-garnet infrared laser, which can blow out interconnections directly on arrays of 1,400 to 3,200 gates.

"The die is already in the ceramic package [uncovered], and the material is vaporized by the laser and vacuumed away. We keep nitrogen flowing across the wafer and that is vacuumed up around the laser beam," says Michael Watts, president of LaserPath. "What you could say is we are doing micromachining of material on the die. There are several hundred thousand to a million laser flashes per die." Once gate-array implementations are ready to enter volume production, LaserPath hopes to transfer designs to silicon foundries for higher-throughput conventional interconnection by photolithography masks.

Dallas Semiconductor Corp. has developed a proprietary late-definition system that scribes code words into the silicon of already fabricated chips. The laser-programming technique is being used first to define calibration constants in a new line of silicon delay-line ICs [*Electronics*, Oct. 14, 1985, p. 17].

The Texas company will also use lasers in a fuse-blowing technique to select options on future telecommunications circuits. Setting telecom-chip parameters after fabrication has enabled Dallas Semiconductor to bring out products much faster by reducing the time it takes IC designers to define products, says Michael Bolan, marketing director. About 10% of the final design choices are made by laser programming.



SHORTER TRIP. LaserPath, a startup chip maker, uses solid-state lasers to fabricate ICs and eliminate several steps from the conventional production cycle, shown at left.

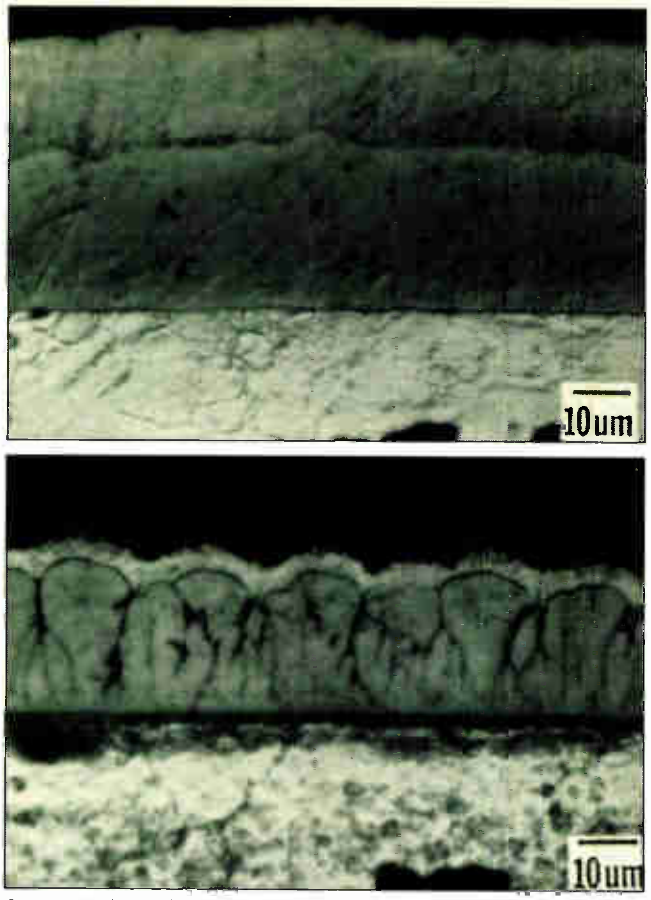
In Campbell, Calif., Inova Microelectronics Corp. has begun using YAG lasers as part of an interconnection process for wafer-scale-integration products [*Electronics*, Dec. 2, 1985, p. 57]. The link-cutting technique is also used earlier in the product cycle for programming redundant memory cells that replace bad bit locations.

Generally, large semiconductor manufacturers see laser systems being used increasingly on production floors. "We are seeing an increase in the importance of lasers in our fabs," says Timothy B. Smith, semiconductor senior vice president at Texas Instruments Inc. in Houston. "What's not obvious is that lasers have found their way into equipment—for example, our wafer steppers are using lasers to do alignment." Over the past decade, semiconductor producers have increased the use of lasers to program redundant rows and columns of memory cells, as well as to trim thick- and thin-film resistors on analog devices.

Laser annealing of implant damage, a hot research topic in the mid-1970s, has cooled somewhat with the emergence of rapid-thermal processing techniques using quick-heating halogen lamps, notes Edward J. Swenson, vice president of advanced technology at Electro Scientific Industries Inc., Portland, Ore., which makes a variety of laser systems for memory programming and analog-circuit trimming. He suggests that laser annealing could still hold promise for III-V semiconductor compounds, however, which often have less predictable thermal characteristics.

Advances in laser-processing technology generally have been made by researchers pressing separately on niche fronts, notes Richard M. Osgood, a pioneer in the field and professor of electrical engineering and applied physics who directs several projects as acting director of the Microelectronics Sciences Laboratory at Columbia University. "Different people have stumbled upon different applications or come up with different applications based on widely different market rationales," says Osgood. "A whole smorgasbord of laser applications is under way."

The Columbia center has demonstrated dry etching of GaAs using large-area projection from laser beams. It also has teamed lasers with plasma reactors to assist plasma etching. Here, the energy beam enhances etching by exciting the surface; this promises maskless etching. Columbia researchers have also used two interfering lasers to form high-resolution optical diffraction gratings on conducting and semi-insulating GaAs. The gratings could be used to produce narrow-frequency fiber-optic transmissions. Focused in a solution, laser beams have also created long, narrow capillary-like features in GaAs that can interconnect optical fibers directly to wafers.



CLEANER. Laser-jet-plated gold spots, top, compared to depositions without use of laser power. In both cross-sections, top layer is nickel, then come gold, nickel plating, and beryllium copper substrate.

At Lawrence Livermore National Laboratory, Livermore, Calif., workers on the S-1 supercomputer project for the U. S. Navy and Department of Energy are directly routing large gate arrays through deposition of conductive polysilicon links on chips using a visible-light argon-ion gas laser. A massive array-programming system automatically calculates routing paths, turning each array into an algorithm-specific attached processor.

Researchers at the Massachusetts Institute of Technology's Lincoln Laboratory, Lexington, Mass., have been exploring laser-writing techniques. They use laser deposition and etching as well as a microwelding process akin to today's laser programming of redundant memory rows on commercial products. MIT's method can not only cut links in silicon, but beams of the argon laser can form 10 links per second. The laser creates conductive paths from fusible targets located on the wafer.

Laser micromachining tools are being used to repair and analyze ICs

The link-forming and -breaking technique was developed while other laser writing processes were still in the early stages of development, says Jack Raffel, director of Lincoln Lab's Digital Integrated Circuits Group. Working wafer-scale systems have been configured from computer-aided-design software and the laser programming system.

Interest in maskless wafer processing has heated up in the past year. Semiconductor Research Corp., the industry consortium in Research Triangle Park, N. C., launched several programs last year in an attempt to speed up advances in maskless IC processing with lasers and other high-energy-beam sources. Its laser programs are under way in research centers at Columbia, Stanford University, and the University of Southern California.

"After hosting a workshop on *in situ* processing [fabrication of wafers contained completely in controlled chambers], we concluded that energy beams were going to play a significant role in future wafer fabrication, especially for the growing ASIC area," notes William C. Holton, director of microstructure sciences for the consortium.

In situ laser-based etching and deposition techniques will likely put small-lot wafer runs in a different light. "It is something totally new, and I think people will have to adjust their thinking about when you want to use traditional processing—which will still probably be a lot—and when you want to use laser writing," says Columbia University's Osgood, who oversees one of the Semiconductor Research Corp. programs. "At one point, there was talk about writing a whole circuit, but I don't think that is a good idea. You might want to write regions, however."

Beyond manufacturing, researchers at Texas A&M University's Institute for Solid-State Electronics in College Station, Texas, are experimenting with two laser-based analysis tools, one of which might help forecast production yields of GaAs wafers. Both techniques rely on the fact that good areas stimulated by a laser radiate more light than do defective areas.

In the GaAs analysis technique, blue laser light scans the material, and light at IR wavelengths comes off the material. Dark areas show regions with anomalies and defects. "With this, we might be able to forecast the yield of GaAs MOS FETs," says Donald L. Parker, professor of electrical engineering at Texas A&M. "We are just now starting to look at what it all means."

The Texas A&M researchers have also developed a nondestructive laser-scanning technique to analyze potential latchup sites in CMOS chips. The technique uses a continuous-wave laser beam that injects carriers into the chip. The device is then imaged for latchup sensitivity.

At IBM Corp.'s Thomas J. Watson Research Center, Yorktown Heights, N. Y., a patented laser-based deposition technique can plate gold and copper materials on circuit-board and chip electrical contacts at high speeds. The system combines the use of a laser beam focused colinearly through a jet of fluid metallic solution. The diameter of the jet's nozzle can be adjusted from 200 to 500 μm. The laser heats up the areas to be plated as the jet sprays the metal solution. Both the deposition rate and morphology of the gold lines are enhanced by the laser beam, says Robert von Gutfeld, an IBM research staff member in the Physical Sciences Department. The use of lasers with jet deposition of copper is expected to reduce defects in the traces.

Potentially, the compact laser-jet gold-plating system could also save manufacturing space and inventory costs. Patterns are drawn directly on materials, eliminating the need for plating masks. Conventional plating techniques require large baths, holding 50 to 60 gallons of molten gold. The laser-jet system needs only a couple of liters, adds Gutfeld, who says IBM has not yet installed the system in production but has received a number of inquiries for possible licensing. □

PROBING THE NEWS

GE-RCA: A NEW POWERHOUSE OR A STODGY BEHEMOTH?

THE ANSWER DEPENDS ON HOW THEY COMBINE THEIR BUSINESSES

by Tobias Naegele

NEW YORK

Now comes the hard part.

After the heady rush to forge General Electric Co.'s mammoth buyout of RCA Corp. in just two weeks, management now has to decide how to make the biggest-ever merger in the electronics industry work. Most of the hard decisions are yet to be made. How GE chairman and chief executive John F. Welch and RCA chief Thornton F. Bradshaw elect to combine their businesses will determine whether the newer, bigger GE will be a world superpower.

In an industry built on the ability to move quickly and make rapid-fire decisions, merging giant conglomerates such as GE and RCA into a single, harmonious unit can be dangerous. The new GE will have ample cash and tremendous corporate muscle, but it could get lost in its own bulk. Even before the proposed merger, neither company had a reputation for moving fast.

The deal, in which GE agreed to buy RCA for $6.28 billion in cash, gets mixed reviews from analysts. Citing the wisdom of pairing the companies' complementary businesses, some praise the move. Others fear that redundant business lines will cause a host of problems.

Another potential problem lurking in the background is antitrust investigation by the Justice Department, the Federal Trade Commission, or Congress. Sen. Howard Metzenbaum (D., Ohio), former chairman of the Senate Antitrust Subcommittee, says "the deal raises serious antitrust questions," but most observers on Wall Street believe the Reagan Administration will stay clear.

There seems little reason for the White House to intervene in a move that just might nip a potential disaster in the bud. Strong management at GE has kept it a mainstay of American industry, offering products in a wide variety of markets. But in the last decade, it has become another kind of symbol—that of the growing erosion of U. S. industry as it comes under increasing pressure from Japan, and now from Korea, in many of its strongest business

lines. Since Welch took command of the company in 1981, GE has been forced out of small appliances (sold to Black & Decker Manufacturing Co.) and air-conditioning equipment. And this summer it will stop making its own TV sets.

"GE was being eaten by the ants," says James Magid, an analyst in New York at L. F. Rothschild Unterberg Towbin. "It was—and is—in serious trouble."

RCA's STRENGTHS. RCA, on the other hand, although historically weak in marketing, offers technological leadership in such areas as semiconductors and a secure position as one of only three major players in satellites. Most important for GE's profit picture is a very strong National Broadcasting Co. subsidiary, which is fully insulated from foreign competition. "GE may be the surviving company, but RCA was the more valuable property," Magid believes.

No one expects RCA to answer all GE's problems, nor will GE step in and save RCA's failing businesses either. The consensus among industry watchers is that though the merged company will be stronger, it won't be a lot stronger. In defense, for example, GE will not be any more powerful, says Joseph Campbell, aerospace analyst at Paine Webber Inc., New York—"just bigger."

"Big" is an understatement to describe the new combine. GE and RCA together totaled sales of $38 billion in 1984 in business areas ranging from aerospace electronics to entertainment, and from jet engines to semiconductors. In some segments the overlap is complementary, as with the defense businesses; in others, such as semiconductors and consumer electronics, there is considerable duplication of efforts (table, p. 74).

The business area with the greatest potential for consolidation is semiconductors, where the two companies have separate manufacturing and design facilities and are direct competitors in several product areas.

RCA is already consolidating its semiconductor-manufacturing operation, which has been criticized as outmoded and inadequate. The company will close its West Palm Beach, Fla., works this year and move all manufacturing to its Findlay, Ohio, plant.

At the same time, RCA is investing about $100 million over five years in a joint venture with Sharp Corp., Osaka, Japan. The chip-making venture, RCA/Sharp Microelectronics Inc., is scheduled to begin operations in Camas, Wash., during the first quarter of 1987. It will be 51% owned by RCA and will be outfitted with state-of-the-art manufacturing equipment [*Electronics*, June 24, 1985, p. 17]. That venture, coupled with GE's five-year-old semiconductor plant in Research Triangle Park, N. C., leads analysts to believe the Findlay plant also will soon be expendable.

GE has its own deal with Westinghouse Electric Corp. and Mitsubishi Electric America Inc. to make thyristors, rectifiers, and power transistors. In addition, a second joint venture with Silicon Compilers Inc., San Jose, Calif., will provide automated foundry and design facilities using the smaller company's design methods. And GE owns semiconductor-equipment maker Calma Co., Milpitas, Calif.

GOOD FIT. The integration of semiconductor businesses will provide a good, if unexciting, fit. "But I don't see any great shakes coming out of it. This won't be the second coming of a TI," says William McClean, manager of market research at Integrated Circuit Engineering Corp., Scottsdale, Ariz.

McClean says the merger will make GE the eighth-largest U. S. maker of ICs and, according to Dataquest Inc., the San Jose market researcher, it will be the seventh-largest manufacturer of discrete circuits (table, p. 75). RCA had sales of $303 million in ICs during the 1984 boom, and McClean estimates that figure dipped to $235 million in 1985. GE's semiconductor business was less affected by the 1985 slump: the company took in $136 million in 1984 and about $110 million last year. McClean projects combined 1986 sales to be $360 million to $370 million.

Despite such reservations, there is enough potential on each side to add up to a promise of greater strength. The union would seem to be ideal: RCA's technological prowess merged with GE's manufacturing abilities. "In MOS, RCA's got the revenue and good design technology and GE's got the facilities," says Howard Bogert, vice president and director of Dataquest's Semiconductor Industry Service. GE has made a modest foray into custom and semicustom ICs, a new area for GE but one in which RCA has 20 years' experience.

"The purchase of RCA fits fairly well for GE in that RCA has some good CMOS technology that GE could use," McClean says. "The Solid State Division has been lost in the shuffle for years: it never had a big place in the company; it's always been a weak-sister relationship." As for discrete circuits, "they'll probably consolidate," says Bogert.

The combination of GE's and RCA's military sectors has provoked the most criticism from the merger's opponents. Sen. Metzenbaum worries that competition for defense contracts could be narrowed significantly. "The administration should be encouraging new entrants into the defense market. This merger eliminates RCA as an independent competitive factor in the defense industry."

The defense sector may be the business that is most insulated from the effects of the combination. Although the deal makes GE the fourth-largest defense contractor in the nation (without RCA, it is fifth), representatives of both companies say there will be no immediate impact on the separate operations. With $1.5 billion in 1984 government sales, RCA does not approach GE's $4.8 billion, and analysts say the defense operations are more often complementary than not.

"There are no obvious programs now or coming along where Cherry Hill, N. J., and King of Prussia, Pa., are natural competitors," says Paine Webber's Campbell, referring to RCA's Aerospace and Defense Division and GE's Space Systems Division.

In space systems, the two companies are an especially good marriage, with RCA a heavyweight in communications satellites and GE strong in software. "Aside from the technological synergy, you obviously have deeper pockets now," says James Samuels, a space-industry analyst at New York's Shearson Lehman/American Express Inc. Deeper pockets means the new GE will be able to pursue new programs and contracts more actively.

Space systems should also bring one of the first tests of cooperation between the two groups: they are on opposite sides of a bidding war for an upcoming contract for the National Aeronautics and Space Administration's space station program. Both are set to receive study contracts from the Goddard Space Flight Center, Greenbelt, Md., for a component of the space station Work Package 3, which involves analysis of space-laboratory design and software. Although the current contracts are small, the space station could develop

WHAT GE AND RCA PRODUCE

Business	General Electric	RCA
Consumer electronics		
Color TV	yes (by Matsushita)	yes
Black and white TV	no	yes
Video recorders	yes (by Matsushita)	yes (by Hitachi)
Video cameras	yes (by Matsushita)	yes (by Hitachi)
Radios	yes (Singapore)	
Commercial products		
Display tubes and monitors	no	yes (U.S., Mexico, Brazil)
Electric motors	yes	no
Diesel locomotives	yes	no
Semiconductors		
ICs	yes	yes
Discretes	yes	yes
MOS	yes	yes
Optoelectronics	yes	yes
Household electric		
Lighting	yes	no
Major appliances	yes	no
Communications equipment		
Commercial satellites	no	yes
Closed-circuit TV cameras	no	yes
TV cameras	no	yes
Broadcast transmission	no	yes
TV tape recording/playback	no	yes
Communications services		
Terrestrial microwave	no	yes
Domestic and international satellites	no	yes
Private telephone systems	installation, service	yes
Defense and government		
Electronics	yes	yes
Aircraft engines	yes	no
Broadcast		
Network TV	no	National Broadcasting Co.
Local TV	one station	five stations
Network radio	no	three NBC networks
Local radio	no	eight stations

SOURCE: *ELECTRONICS*

into an $8 billion program.

RCA's satellite and communications businesses include the Earth Observation Satellite Co., a joint venture with Hughes Aircraft Co. (now part of General Motors Corp.) to produce two Eosats over the next five years for less than $200 million. In 1984 these businesses accounted for just 4% of RCA's sales but were responsible for 17% of the company's profits, according to Standard & Poor's Corp., New York. That translates into earnings of about $58 million on sales of $404 million.

These businesses are not necessarily sacred cows, however. The satellite business is so capital-intensive that it can swallow a hefty portion of the company's resources, making it a potential liability in lean times, according to Mark Hassenberg, vice president for consumer electronics at DLJ Securities in New York. GE will have to balance the satellite sectors' market values as independent business units, their high profitability, and their leading positions in the industry against their appetite for capital.

BROADCASTING IS STAR. GE chairman Welch stressed NBC's attractiveness in terms of its high profit potential as well as its niche in an unthreatened domestic market when he announced the RCA buyout at GE's New York offices. Broadcasting, which includes RCA-owned TV and radio stations as well as its networks, accounted for 23.4% of the company's revenue in 1984, and with $2.37 billion in sales was the biggest single money maker in the RCA organization. Welch's hope, it appears, is that GE will use the network to provide the cash needed to contend in other competitive world markets.

In research, both companies maintain major facilities—RCA at its David Sarnoff Research Center in Princeton, N. J., and GE at its Corporate Research and Development Center in Schenectady, N. Y. These are considered to be untouchable. "The Princeton Labs are one of the most fertile grounds of new technologies anywhere," says Hassenberg. "They are one of the most valuable parts of RCA, [and one] which has not been able to have the type of impact it should on RCA. To destroy that would be a mistake; to nurture it should be GE's intent."

To protect itself from foreign competitors that can produce goods for less, GE has been withdrawing from manufacturing as part of a strategy to divide its business into 80% service and technology and 20% manufacturing. It is no secret that GE is more interested in RCA's technology and NBC TV network than in its other concerns, such as consumer electronics.

And although it is unlikely that GE is eager to give up the RCA brand—which is No. 1 in the U. S. TV set market—it allowed for the possible sale of RCA's consumer electronics business in the merger agreement, probably to head off possible antitrust problems. Should such problems arise, a likely scenario would be for GE to run the consumer electronics business as a wholly owned or majority-owned subsidiary company, a representative said.

Ultimately, the merger should leave behind a stronger General Electric Co., one geared to compete in more diversified markets and strengthened by its healthy positions in some protected ones. But the key to success of the deal lies in management's ability to mold the new company into the kind of business it envisions.

"This is a global market game," Welch says. "And one needs to deal with world markets from a position of strength." It will be up to Welch to exercise that muscle. □

GE AND RCA ELECTRONICS-RELATED BUSINESSES (1984 sales in $ millions)

Business Sector	General Electric	RCA
Total sales (all businesses)	27,947	10,111
Net income	2,280	341
Consumer electronics[1] (total sales)	**3,858**	**2,188**
Color TV[2]	400	1,000
VCRs	180	575
Other[3]	3,000	600
Military (total sales)	**4,785[4]**	**1,552**
Electronics	2,100	1,552
Programs		
OTH-B long-range surveillance radar	67	–
DSCS-3 military satellite	100+ (est.)	–
SEEK Igloo surveillance radar	40 (est.)	–
Re-entry systems operations for Peacekeeper, Trident, and Minuteman programs	not available	–
Engines for F-16, KC-135R, C-5B	2,685	–
Aegis air defense system	–	303[5]
TCAC, ASAS tactical surveillance	–	60 (est.)
GWEN (Ground wave emergency network)	–	97
Communications (total sales)	**–**	**404[6]**
Semiconductors (total sales)	**136**	**402**
Total discrete	104	88
Small signal transistors	17	2
Power transistors	16	64
Power diodes	13	3
Thyristors	35	15
Other	231[7]	–
Total ICs	4	303
Optoelectronics	28	11
Linear circuits	–	93

[1] RCA total includes service plus some appliances
[2] For 1985 model year, ended June 1985
[3] For GE, includes mobile communications, radios, black and white TV, and batteries; for RCA, includes black and white TV, videodisk players and disks, and services
[4] Includes satellites
[5] Since 1983
[6] Includes satellites and terrestrial microwave communications
[7] Includes $204 million from Calma Co.

SOURCE: *ELECTRONICS*

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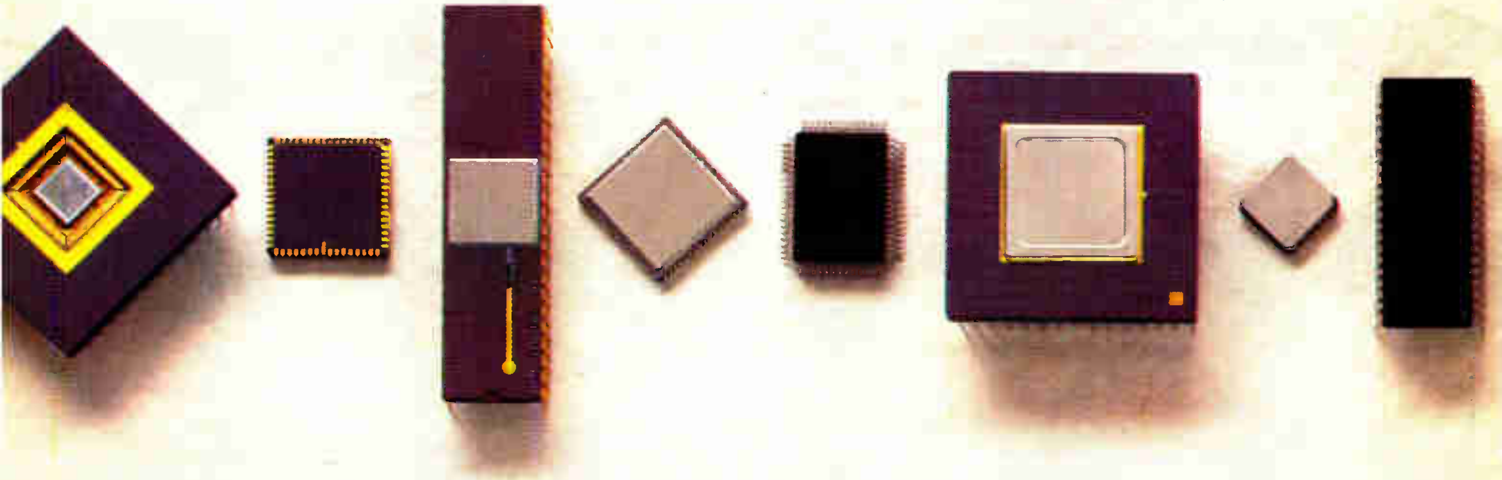

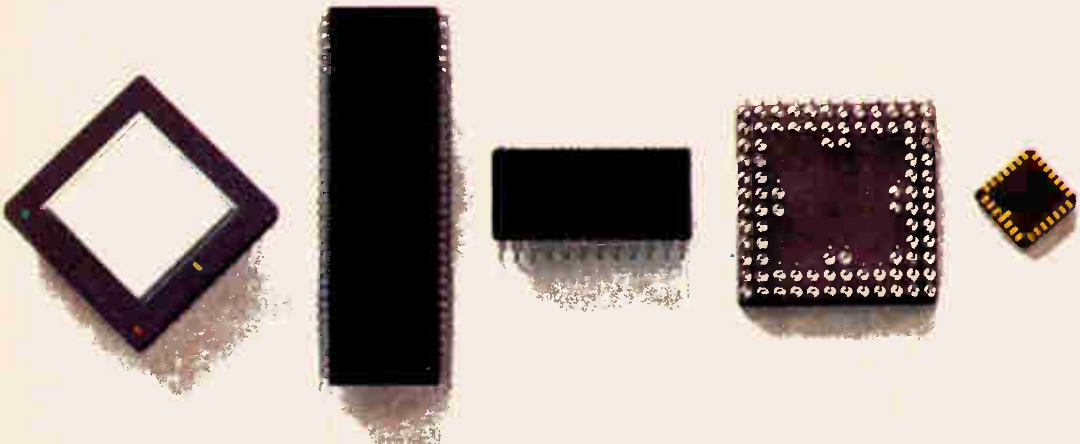

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WELL-HEELED DIXY STRUTS INTO DISPLAY MARKET

THE JAPANESE STARTUP'S GAMBLE: PARLAYING PATENTED TECHNOLOGY INTO A 30% CUT OF THE GROWING MARKET

YOKOHAMA, JAPAN

Dixy Corp. has set itself a lofty goal for a startup barely in production: 20% to 30% of the rapidly growing market for plasma-display panels by 1989. Impossible? An international group of investors thinks not. They have poured in almost $20 million in capital, a third of it from foreign sources. The Japanese company also got a $20 million credit line from local banks for operating funds.

Dixy's investors are betting on the advanced plasma-display technology patented by founder and president Yoshifumi Amano, a former Sony Corp. engineer. Their money is also riding on the company's ability to automate the key manufacturing steps in its own plant while orchestrating a team of subcontractors to handle the rest of production. Finally, they are betting that the company's development team can stay ahead of competition, even though Dixy is turning out a mere 300 panels a month now.

Dixy's main product is a monochrome dc plasma-display panel with a resolution of 640 by 400 dots in 9-, 10-, and 12-in. sizes. A two-page model with a resolution of 640 by 800 dots is also available. The panel features higher pixel density, lower driving voltage, and higher contrast than competing technologies.

The envelope is made of ordinary window glass, which can be uneven or even scratched. Thick-film electrodes 30 μm thick are screened onto the glass, as are 100-μm-thick webs to separate the cells. The webs determine cell thickness, and the gap around the edge is closed by frit. Use of the window glass and thick-film technology keeps production costs down. Amano estimates it will take three years to develop a color version.

BRIGHTER DISPLAY. The Dixy panel is brighter than NEC Corp.'s refresh-type ac plasma display, according to observers. And it doesn't have the background glow of the dc plasma-display panel from Matsushita Electric Industrial Co.

The panel connects with a variety of hosts through standard controllers designed for cathode-ray tubes, which it is intended to replace in such equipment as personal computers, factory-automation products, medical electronics equipment, test and measurement systems, and banking terminals.

MAESTRO. Amano is building Dixy Corp. on his own plasma-display work.

Today's price for a 10-in. panel with driver is somewhat less than $1,000, but when volume production starts it should drop to $500, says Amano. This is in line with the price of "more than $500" quoted by Matsushita for the panel used in its Executive Partner computer as well as with the sample prices from other manufacturers, including NEC. Dixy plans to increase monthly production to 20,000 panels by the end of 1987 and to 30,000 in 1988. Estimated price at that time will be $200. Amano has no doubts that he can sell the panels; he says that at least one potential customer is looking for quantities of 100,000.

At the Tokyo office of market researcher Dataquest Japan Ltd., analyst Yuichi Murano says Dixy is well armed to compete in the rapidly growing plasma-display market with its increasing number of applications. He expects plasma displays to compete strongly against electroluminescent displays, whose prices aren't coming down as expected.

In addition, the panels are going to eat into the market for liquid-crystal displays, which have the twin limitations of low visibility in large sizes and of not emitting light, he says. Manufacturing them is also tricky: the tiny gap within LCDs requires extremely flat glass. Flat CRTs are not a real competitor because their high vacuum requires extremely thick glass panels, Murano says.

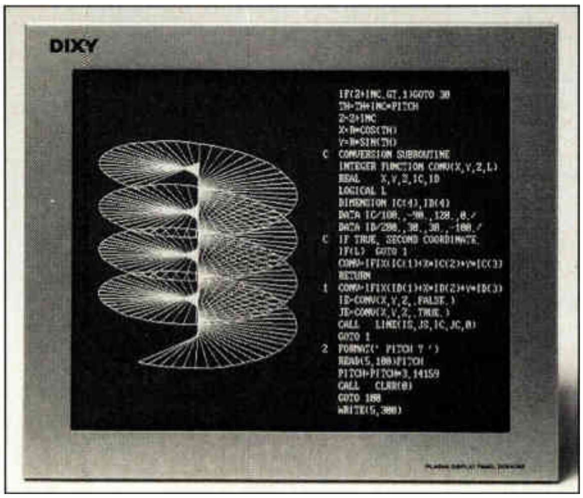
An even more spectacular testimonial is given by *Nikkei Venture*, a magazine that annually selects the most promising startup funded by venture capital. It has named Dixy its latest winner. What makes the selection impressive is that it is made through a survey that includes 60 leading financial and securities companies, economists, think tanks, and scholars. Also, Amano was picked as the fourth most promising venture business leader of the future.

Dixy's management comes with solid industry experience. Tadahiko Sekigawa, the No. 2 man in engineering after Amano, specialized in gas-filled display-tube manufacturing at Okaya Electric Industries Co. Yoichiro Sugii, the marketing and sales chief, came from tape-recorder manufacturer Akai; Akira Furuya, the finance chief, came from Sony.

DROPPED AT SONY. Surprisingly for a product with potential for such high demand, the plasma-display panel was discarded by Sony, where it was developed. The time was August 1983, and the Tokyo company was feeling squeezed by falling revenue. Sony was spending 12% of sales on research, and Amano says it jettisoned its plasma-display efforts to concentrate on color picture tubes.

A display without color capabilities didn't appear to have a place in its future. This was before Sony decided to go into office data-processing systems in a big way and before it decided to emphasize component sales.

At this point, Amano decided to break away from Sony and continue to develop and produce the panels. His work on the panels led to his winning



GOOD PICTURE. Dixy's 640-by-400-dot plasma display boasts high contrast.

a fellowship in the Society of Information Display in 1983 at the relatively young age of 42.

Early in his years at Sony, where he started upon graduating from Keio University with an MS in electrical engineering, Amano developed numerical display panels using fabrication techniques similar to those in the plasma panel. He then went into planning, taking a break to collect an MS in business administration from the Massachusetts Institute of Technology, from which he graduated in 1976.

Although Amano had earlier done research on plasma panels, the team with which he developed the present ones didn't start work until 1980. Progress was rapid, and a paper on the displays was presented at the SID conference at San Diego in May 1982.

Amano orchestrated Dixy's startup, but he was fortunate in receiving backup from Sony. He remained an employee until he obtained first-round financing and completed construction of Dixy's Yokohama facilities. Sony also loaned the company four engineers, one of whom stayed with Dixy.

Dixy expects to turn out 30,000 panels a month by 1988

Sony is the largest investor in Dixy, but got most of its money back by selling equipment to the company. Second is Italy's Olivetti, which got into the deal after approaching Sony to buy plasma-display panels. The third-largest investor is Pacific Technology Venture Fund Inc. The Burlingame, Calif., fund, which consists entirely of American money, has invested in 10 Japanese high-technology companies. Its chairman is Patrick McGovern, also chairman of International Data Corp. and CW Communications Inc., both in Framingham, Mass.

The company has just completed its second round of financing, which will support plant expansion—all the way from buying land and constructing the building in an industrial park in Susuno City at the foot of Mt. Fuji to equipping the plant, scheduled to start operation in October. After that, present facilities at the Yokohama headquarters will be used exclusively for research.

Dixy is now hiring and training key personnel so that it can start volume production when facilities are completed. The initial labor force of about 100 persons will be sufficient to produce 10,000 panels per month. This rate will be doubled when needed by shift work and equipment additions and then increased to 30,000 in 1988 through automation. *—Charles L. Cohen*

BOTTOM LINES

MILITARY ELECTRONICS SALES UP 12.5% IN '85

Sales of defense electronic equipment in 1985 increased 12.5% over 1984, to $42.8 billion, and double-digit growth rates will continue through 1989, according to a study by Gnostic Concepts Inc., the San Mateo, Calif., market researcher. Active and passive components totaled $2.1 billion and $2.4 billion, respectively. Gnostic Concepts estimates that the military's share of total active-component consumption has increased 3.1%, to 16.8% over 1984, while total passive-component consumption rose 0.8%, to 18.3%.

MARTIN MARIETTA BOOSTS VERDIX STAKE

Martin Marietta Corp. has increased its interest in Verdix Corp. from 17% to 22% by buying another 500,000 shares of the Chantilly, Va., company's common stock at $2 each. The Bethesda, Md., company also received a 10-year warrant to buy 1 million Verdix shares at $6 each. Verdix develops computer systems and software and specializes in Ada development systems. In March 1985, Martin Marietta bought 1.3 million Verdix shares, plus a debenture that is convertible into 250,000 shares and warrants to buy 3 million additional shares. Verdix says an agreement between the two companies limits Martin Marietta's ownership to 25% until December 1987 and to 35% until December 1989.

POWERTEC ACQUIRES POWER-SUPPLY MAKER

Powertec Inc., a Chatsworth, Calif., maker of switch-mode ac/dc power supplies, has acquired Semiconductor Circuits Inc., a privately held Windham, N. H., company that makes encapsulated dc-dc converters and low-power ac/dc supplies. Terms of the sale were not disclosed. Powertec, which had revenue in fiscal 1985 of about $22 million, says SCI will be operated as a wholly owned subsidiary. SCI had sales in 1985 of about $10.5 million.

3M BUYS PART OF EOTEC CORP.

3M Co. has purchased an undisclosed amount of stock in Eotec Corp., a West Haven, Conn., maker of fiber-optic sensors for military and factory-automation uses and fiber-optic data links for telecommunications. The St. Paul, Minn., company said its TelComm Products Division, which also offers fiber-optic equipment, will work with Eotec to develop and market fiber-optic products.

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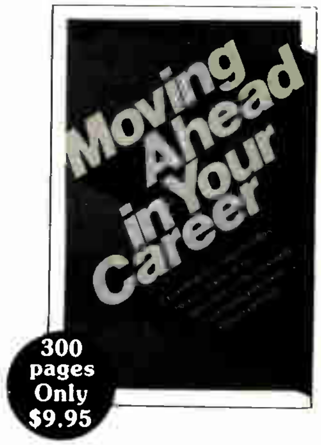

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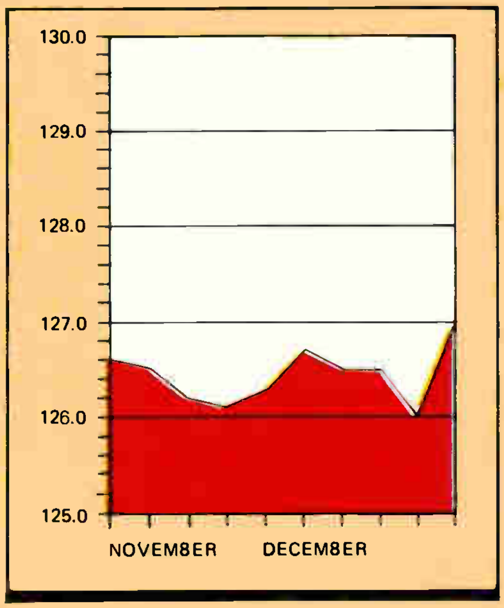

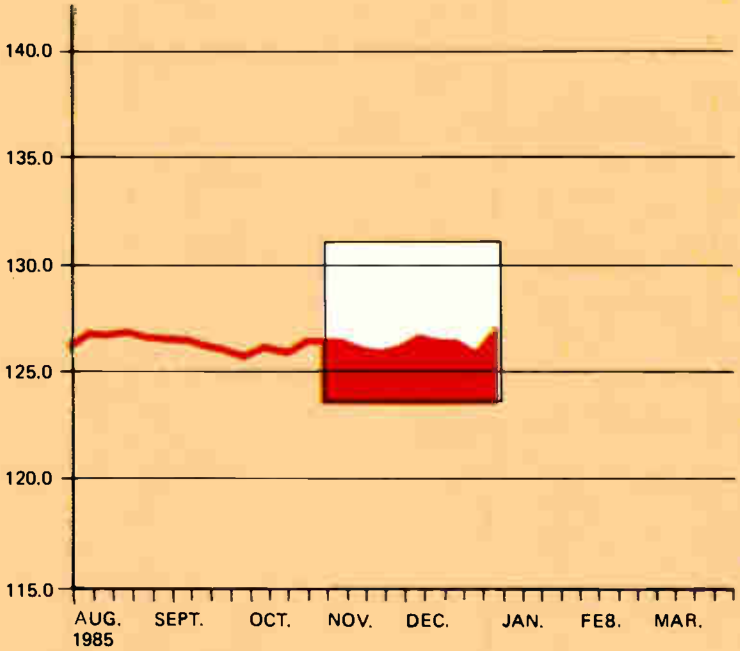

THIS WEEK	=	127.0
LAST WEEK	=	126.0
YEAR AGO	=	130.3
1982	=	100.0

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

U. S. ELECTRONICS COMPONENT-PRODUCER PRICE INDEX

	November 1985	October 1985	November 1984
Digital bipolar integrated circuits	60.7	60.7	62.3
Digital MOS ICs	31.7	31.6	44.1
Linear ICs	60.0	58.1	64.1
Capacitors	185.6	186.7	192.2
Resistors	189.5	189.6	186.7
Relays	313.2	313.1	319.3
Connectors	236.1	235.9	232.7

U. S. ELECTRONICS PRODUCTION INDEX

	October 1985	September 1985	October 1984
Office and data-processing equipment	255.9	265.4	259.3
Communications equipment	224.1	221.7	211.5
Radio and TV equipment	133.6	127.2	166.5
Electronic and electrical instruments	138.0	138.9	138.6
Components	240.7	245.3	302.3

Though a 2% drop in the U. S. production of electronics goods in October pushed the *Electronics* Index down 0.4% last week, favorable developments in electronic components subsequently raised it a full point. Component prices in November, which were up an average of 0.1% from their October levels, were still 2.2% lower than they had been in November 1984.

The firming of component pricing could indicate increased manufacturing activity by suppliers, but this won't show up in government statistics for another month.

MONSANTO'S ENDO TAKES A NONTRADITIONAL ROUTE

TOKYO

All his working life, Eiichi Endo has been an atypical Japanese executive. Rather than choose the security of guaranteed lifetime employment, which is traditional at the largest Japanese companies, he has taken jobs with four different organizations to get ahead. Now 56, Endo has made perhaps his biggest move yet, one that could bring his biggest challenge.

As the new director and vice president for marketing at Monsanto Japan Ltd. [*Electronics*, Dec. 9, 1985, p. 58], Endo has set for himself a formidable goal: he aims to build his company's less than 2% share of the Japanese silicon-wafer market up to double digits.

"I want to get a 10% share and eventually build that to 20%," he declares. Endo, who left a secure job as semiconductor marketing director for Nippon Motorola Ltd., has around $100 million backing him up. That's how much Monsanto has invested in a new wafer-fabrication plant being built at Utsunomiya, north of Tokyo. The plant is scheduled to start up next August, with a technical support center under the same roof and production capacity of 20 million in.^{2} of silicon a year.

SHORT WORK. Eiichi Endo wants to make Monsanto Japan a power in five years.

"When I realized that Monsanto was prepared to make this investment in such a long-term commitment to the Japanese market, I made up my mind to move," Endo says. Even so, he agonized for half a year before making the plunge. "Most Japanese are conservative. They hesitate to change jobs," he says, acknowledging that he has made a career of being the exception to the rule.

A graduate of Tokyo's Chuo University with a degree in engineering, Endo began his career as a government official with the Ministry of International Trade and Industry and later worked in the early 1970s as the New York representative for the Electronic Industries Association of Japan. He returned briefly to MITI in 1973 but then made another move, to private industry.

"I always had wanted to put my engineering background into practice, and when the president of Toko Electronics Corp. offered me a job as director of semiconductor operations, I couldn't resist," Endo says. He worked for Toko until it was bought by Motorola Inc., and stayed on with the new company, merging the two staffs and finally taking over marketing.

NEW LIFE. Endo could have stayed at Motorola until retirement, but the Monsanto offer proved to be too tempting. "I knew that at my age I never would get another opportunity like this again." It also helped that his three daughters have now graduated from college, he admits. "I feel that I've finished my obligation to them. Now I can start a new life."

The most difficult part of that new life will be building the confidence of the Japanese, who are among the most demanding customers in the world. "We will produce 6-in. wafers from the start, and when the 8-in. market begins to develop, we will be ready. But ours isn't just a manufacturing problem. I will be very active in visiting customers and proving to them that we can deliver the products they want at the specifications they want." *–Michael Berger*

PEOPLE ON THE MOVE

EDWARD L. MARINARO

☐ Edward L. Marinaro has been promoted to executive vice president of Western Digital Corp. He will be responsible for engineering, manufacturing, and marketing operations, as well as for product development and strategy for the company's business units. Marinaro, who joined the Irvine, Calif., company in June 1984 as vice president, was named senior vice president of operations in March 1985. He had been president and chief executive officer of Momentum Computer Systems International in San Jose, Calif.

ROBERT A. DAVIS

☐ Cadtrak Corp. has named Robert A. Davis executive vice president and chief operating officer. Davis joined the four-year-old software house in Sunnyvale, Calif., in August. He had been vice president for branch operations and vertical markets at Qantel Business Computers Inc., Hayward, Calif. Earlier, Davis served 10 years at Olivetti Corp. of America, leaving as national sales manager for the Computer Systems Division.

COLIN D. PATTERSON

☐ The board of directors of Gandalf Technologies Inc. has appointed Colin D. Patterson vice chairman with special responsibilities for technology. Patterson, a co-founder of the Wheeling, Ill., company, had been president and chief operating officer for Gandalf, a designer, manufacturer, and supplier of data-communications equipment and information network systems. He will now be involved in long-term strategy for product development.

DONALD BOND

☐ Pacific Monolithics Inc., a Sunnyvale, Calif., startup, has named industry veteran Donald Bond president and chief executive officer. Bond, 50, brings 27 years of electronics and microwave experience to the company, which designs and manufactures gallium arsenide monolithic integrated circuits. He had been vice president and general manager of the Microwave Division of Sanders Associates Inc., Manchester, N. H. Bond will be responsible for the overall management and operation of Pacific Monolithics, succeeding Allen Podell as president.

ALLEN M. LEVANTIN

☐ Marking 30 years with Rohm & Haas Co., Allen M. Levantin has been made the company's vice president and director of corporate development. The 53-year-old executive will oversee the Electronic Materials Group, Corporate New Ventures, and New Research Developments. Levantin began working for the Philadelphia company as a research chemist fresh from the City College of New York, where he had earned a BS in chemistry. He has held a number of key positions, including sales director for the Chemicals Division, business director for Polymers, Resins, and Monomers; for the past seven years, he has headed the European Operations of Rohm & Haas from its office in London.

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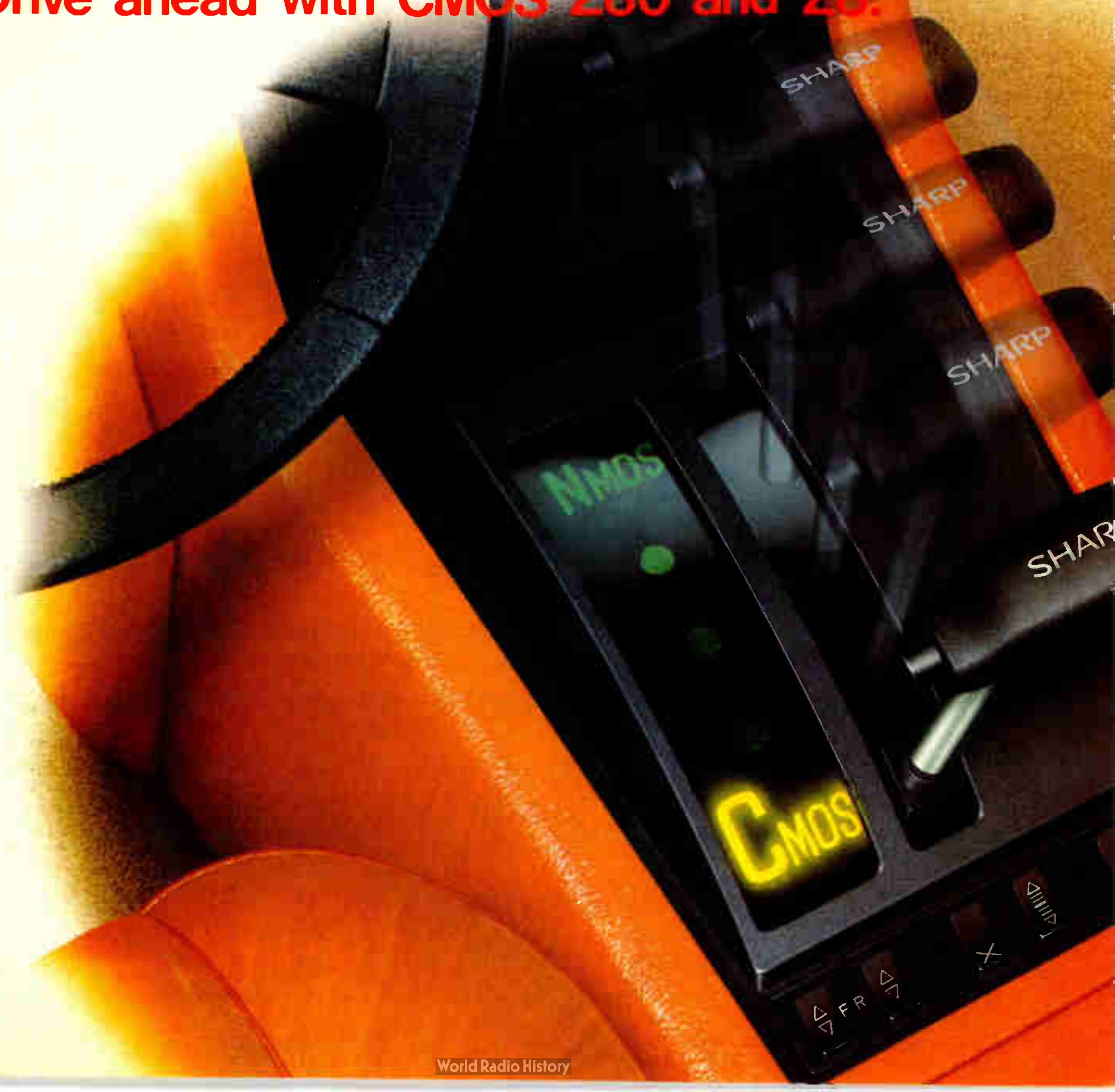

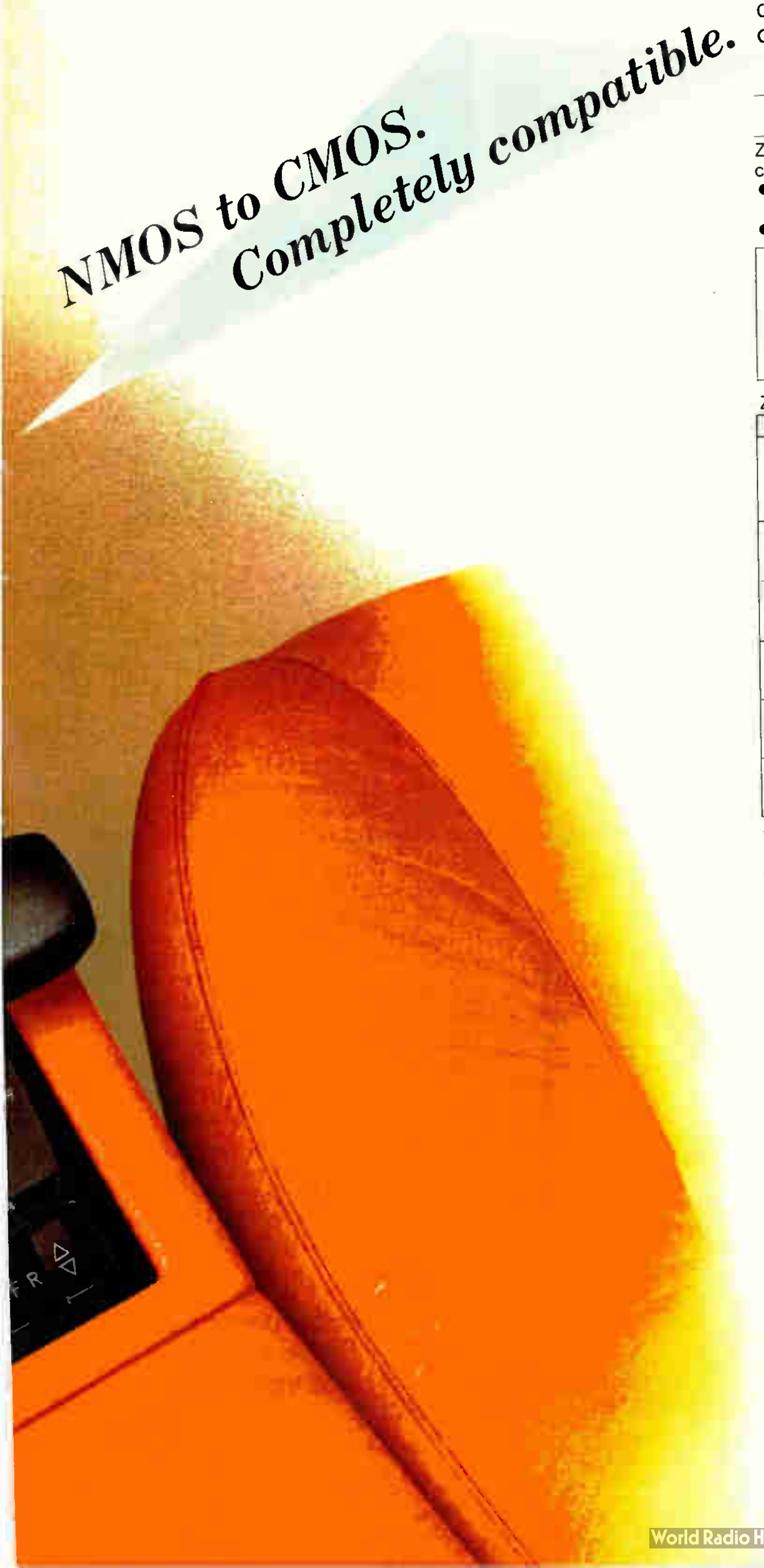

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Type No.	Description	Features	Package
LH5080 LH5080M LH5080A LH5080AM	Central processing unit	● 8-bit microprocessor compatible with LH0080 (Z80 CPU) of NMOS process. ● Fully static operation. ● 10mA (TYP.) supply current. ● 2.5MHz (MAX.) clock frequency. (LH5080, LH5080M) ● 4.0MHz (MAX.) clock frequency. (LH5080A, LH5080AM)	40 DIP 44 QFP
LH5080L LH5080LM LH5080AL LH5080ALM		● Equivalent to LH5080. ● Power-save mode with the execution of HALT instruction. ● 50μA (TYP.) in power-save mode.	
LH5081 LH5081M LH5081A LH5081AM	Parallel I/O controller	● Compatible with LH0081 (Z80 PIO) of NMOS process. ● Fully static operation. ● 2mA (TYP.) supply current.	40 DIP 44 QFP
LH5081L LH5081LM LH5081AL LH5081ALM		● Equivalent to LH5081. ● Power-save mode with the execution of HALT instruction. ● 50μA (TYP.) in power-save mode.	
LH5082 LH5082M LH5082A LH5082AM	Counter timer circuit	● Counter/timer device which is compatible with LH0082 (Z80 CTC) of NMOS process. ● Fully static operation ● 2.5mA (TYP.) supply current.	28 DIP 44 QFP
LH5082L LH5082LM LH5082AL LH5082ALM		● Equivalent to LH5082. ● Power-save mode with the execution of HALT instruction. ● 50μA (TYP.) in power-save mode.	

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SM803	2.2	5	2.4	32	4096x8	144x8	Uses RAM area	40DIP 44QFP	Z8 CMOS type (pin compatible to NMOS Z8)
LU800V1	2.2	5	12	32	—	128x8	Uses RAM area	40DIP 44QFP	For development of SM803 For pilot production

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CARDS MANIPULATE COMPLEX IMAGES WITHOUT A COMPUTER

DATACUBE'S BOARDS WORK IN REAL TIME AND COST LESS THAN $5,000

Up to now, the basics of image processing, such as digitizing the image, have been available in board-level systems, but fancy image manipulations have remained out of reach. In the complex task of signal processing for video imaging, engineers interested in precise image rotation, translation, and scaling had only two options: they could spend a lot of money on a dedicated computer system or spend a lot of time waiting for a minicomputer to crunch through cumbersome software. Now a set of video-signal-processing boards from Datacube can perform all these operations in real time without the aid of a computer. With the three new boards, which sell for less than $5,000, designers can build imaging systems for half the cost of systems that depend on computers.

The new products—an interpolator, an address generator, and a transposing frame-store module—perform image transformations with spatial resolutions of up to 32 bits, allowing for precise sub-pixel gauging (for measuring images) and warping (for image translation, scaling, and rotation). Monochrome is standard but pseudocolor is possible.

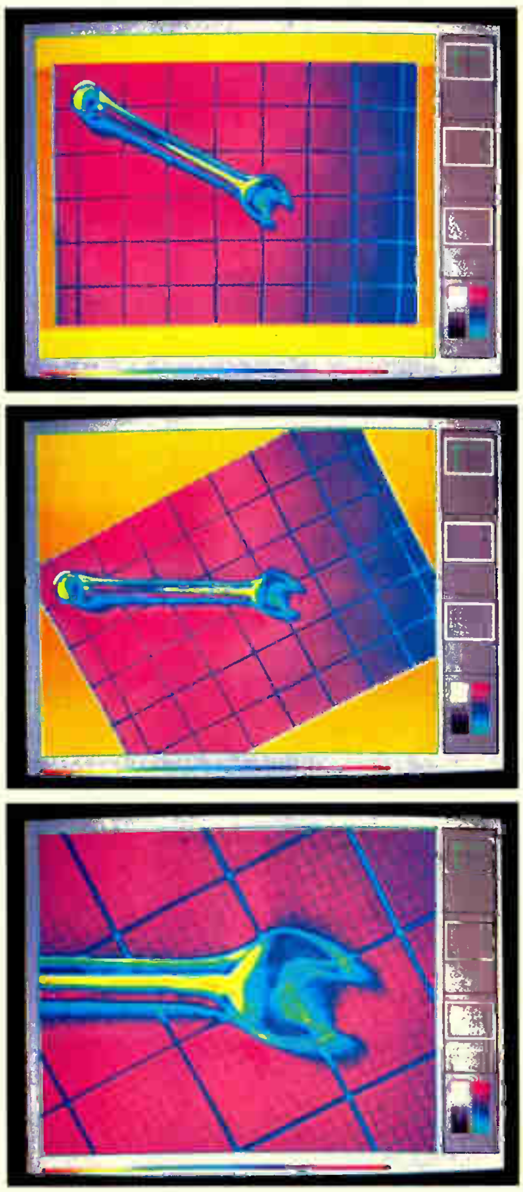
Like most pipelined video processors, the Interpolator works in a single dimension. But when augmented by the address generator and transposing frame store, horizontal and vertical transformations in real time become possible.

THREE BOARDS. Among the products, the interpolator board is likely to attract the most interest. It uses sinc interpolation algorithms and has some 90 ICs—including 40 programmable logic arrays—that perform translations, rotations, and other warping operations in real time. Datacube says the interpolator has an eight-point aperture and 1,024 on-board coefficient sets. Data and coefficients are each 8 bits, but the board produces 16-bit results.

Much of the credit for that performance goes to the 20-MHz CMOS multipliers and 20-MHz PLAs, says Shep Siegel, principal engineer for signal processing at Datacube. Even with those devices, significant obstacles remained in shrinking the design to board size.

"Data and the coefficient inputs of each multiplier normally require extensive multiplexing," says Siegel, who led the board's development. "If we followed that approach, then multiplexing would require large amounts of medium-scale integrated TTL circuitry and it would not fit on the board. We knew we had to get around that because it would have added about 40 ICs."

The way to reduce multiplexing was derived from the mathematical fact that multiplication commutes: two times three yields the same result as three times two. Applying that idea to multiplexing, Siegel scrambled the data and the coefficients in a known order by changing the memory-address lines in which the data is stored. The configuration he used exploited the commutation principle and reduced the amount of multiplexing needed.



All sets of coefficients are stored in PROMs, and it is possible to bank-switch among them to pick the most appropriate set for the operation. Datacube says the board itself performs all operations without burdening the host computer after the initial instructions are downloaded.

Along with the Interpolator, Datacube has introducted the Addgen-1. This companion card creates the addressing required for the Interpolator to do first-order transformations to 32 bits of spatial resolution. Because it can generate first-order equations to 32-bit precision, the Addgen-1 implements highly accurate template matching; for example, in inspection systems, template matching is used to compare a known-good part with the one being examined.

The third product is the Max-XFS, a transposing frame store that contains two complete frames of video storage and can rotate images in real time by doing 90° inversions of data. With this module, users can create separate data for horizontal and vertical digital video-processing pipelines. The transposing frame store complements the functionality of the Interpolator, giving it its rotational capability.

The products are extensions

FAST MANIPULATION. Datacube's signal-processing boards take an image of a wrench (top), rotate it (middle), and enlarge it (bottom), all in real time.

of Datacube's Maxvideo VMEbus product line, which includes acquisition, storage, and display modules for real-time video-signal processing. All Maxvideo boards can communicate within the image-processing subsystem over a proprietary digital video interconnection.

The Interpolator and Max-XFS boards together sell for $3,195. The Addgen-1 card lists for $1,200.

Standard resolution for the boards is 512 by 512 bits, but a 384-by-512-bit resolution is available at a discount of about 25%. *–Craig D. Rose*

Datacube Inc., 4 Dearborn Rd., Peabody, Mass. 01960. Phone (617) 535-6644 [Circle reader service number 338]

$9,950 PLOTTER DOES ELECTROSTATIC COLOR

Electrostatic color plotting until now has been restricted to large-format plotters that usually had to be shared because of their high price. Now a desktop system can do the same job. Versatec has incorporated the same technology it uses in its large plotters in an 11-in.-format color printer/plotter called Spectrum.

Versatec sees a ready market in engineering work stations, which are coming down in price so rapidly that most engineers can each have one. But until now they have had to share high-quality peripherals. "Versatec has reduced the cost of reliable, high-quality, full-color output, making it affordable to most workstation users," says Dale Richmond, Versatec's marketing manager for plotters. The desktop plotter, which will be available in March, will sell for $9,950, compared with $26,000 to $53,000 for the company's large-format plotter.

Spectrum quickly produces high-quality color or monochrome text or graphics on standard A-size pages (11½ by 8 in.) or B-size pages (11 by 17 in.). It prints or plots on paper or polyester film at 2 in./s with a resolution of 200 dots/in—almost the equal of photographic film. Color A-size pages can be produced in 60 seconds, monochrome in just 5 seconds. Color B-size pages take 90 seconds and monochrome pages take 10 seconds.

Spectrum produces seven line colors. Versatec's Color Random software, which uses multidot pixels, adds 256-predefined and an additional 256 user-defined colors from a palette of over 1,000.

Spectrum produces an A-size color drawing for a total materials cost of about 7¢ to 10¢. This comes to less than half the cost per page for color thermal transfer and two thirds the cost for ink-jet hard-copy printers, the company says.

Features include an automatic media cutter for standard A- or B-size plots. While the unit is running, it can change output sizes in monochrome or color—all without operator intervention. A character generator produces standard ASCII characters.

NO PENALTY. Users don't have to pay a penalty in control features just because the electrostatic plotter has been reduced to desktop size. An operator panel provides the user with indicators for running status, power-on status, paper or film media, and supply status. Controls include a contrast knob along with buttons for pause, form feed, and test. The test mode initiates an internally generated color pattern.

Other controls enable modification of the raster-data input—line enhancement, mirror imaging, and raster-data translation. The line-enhancement features adds dots to increase line width and includes a smoothing algorithm that produces bolder lines for overhead-projector transparencies and microfilms. The mirror-image feature shows plot data in reversed order for better copies or sharper overheads. The raster-data translator converts 100-dot/in. data into 200-dot/in. data, so the data source can generate less data for a "quick-look" plot.

Borrowed from Versatec's larger plotters is multipass plotting technique, which reduces plotter size, complexity, and cost by eliminating the need for multiple writing heads and associated electronics. And because the plotter processes data in stages, it reduces I/O, data-handling, and data-storage requirements.

Spectrum also operates as a line printer, emulating the company's popular V-80 printer/plotter in monochrome mode. It prints text with 132 characters/line at 1,000 lines/min. When equipped with an optional video interface, it can print out what is displayed on a color or monochrome CRT. *–Steve Zollo*

Versatec, 2710 Walsh Ave., Santa Clara, Calif. 95051. Phone (800) 538-6477; in Calif. (800) 341-6060 [Circle 339]

ON TOP. Versatec's color electrostatic plotter is small enough to fit on an engineer's desk.

DENSITY TRIPLED IN ECL GATE ARRAYS

Advanced Micro Devices claims its new family of bipolar ECL 4,988-gate arrays offers as much as twice the density of similar ECL arrays, such as Motorola's Macrocell family. The Am3500 is also three times denser than its first gate array, the Am1850. One variation of the part sacrifices some gates for on-chip RAM; a second offers TTL compatibility.

The 3500 gate-array family is made with AMD's proprietary IMOX-II 1.5-μm process technology, using three layers of metal interconnection—a feature that the company claims is best for distributing current and routing channels. The arrays' speed-power options allow adjustment of gate delays and current consumption.

In addition, all Am3500 family members support the unlimited use of high-power macrocells. The internal ECL macrocells in the Am3500 family have maximum gate delays of 0.65 ns.

INTEGRATED CIRCUITS

The ECL-only array can be used for designs with up to 4,988 equivalent gates and 134 I/O buffers. "It will be used mostly in large ECL systems, like minicomputers," says Stan Drobac, marketing manager for bipolar gate arrays.

ECL and standard TTL can be interfaced as desired on the Am3550. Its I/O buffers can be mixed in any combination, a feature that is useful in situations that require TTL compatibility with ECL speed. Density is up to 5,228 gates and 124 I/O lines.

The Am3525 differs from the 3500 in that some of its internal cells have been replaced with 1,152 bits of RAM, configured in four independent blocks, each with 16 words that are 18 bits wide. It can be used in designs with up to 3,178 equivalent gates and 135 I/O lines.

AMD says the use of RAM speeds system performance because it avoids the delay in going off-chip to access memory. Such on-chip "scratchpad" memory can, for example, allow the CPU of a minicomputer fast access to a small block of register files. Its worst-case access time is said to be 5.5 ns. "Off-chip, even with a fast ECL RAM, access time would probably be 9 or 10 ns," says Drobac.

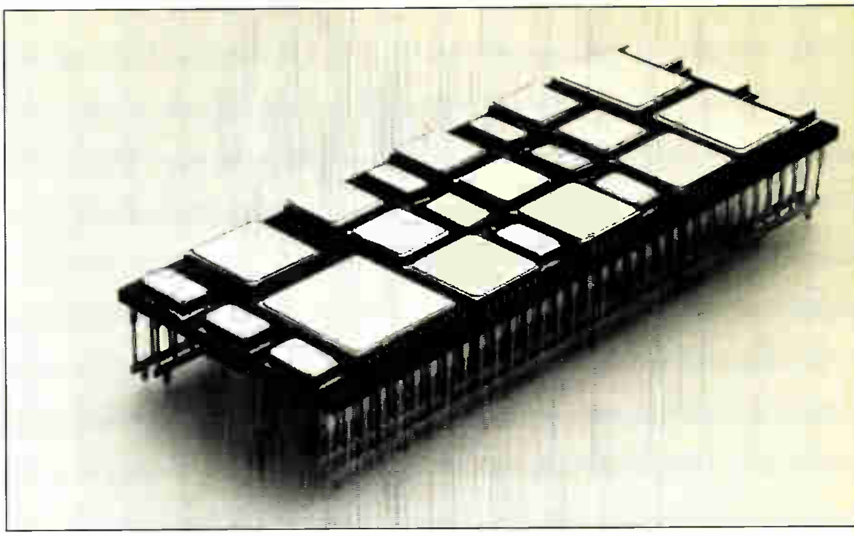
The company says its first set of customer codes are already in-house. Software support for the 200-plus macrocell library is now available for use on Daisy Systems Corp. and Valid Logic Systems Inc. work stations, and will be on Mentor Graphics systems in the second half of 1986. *–Denise Caruso*

Advanced Micro Devices Inc., 901 Thompson Place, P. O. Box 3453, Sunnyvale, Calif. 94088.
Phone (408) 732-2400 [Circle 340]

COMPUTER PACKED ON 5-SQ-IN. HYBRID

Powerful Multibus-based computers have long been available on pc boards; now Electronic Designs is putting such a system in a single hybrid module measuring under 5 in.^{2}, housed on a quad in-line ceramic substrate. The four compact microcomputers, targeted at high-speed low-power applications, are built around members of Harris Corp.'s 16-bit 80C86 microprocessor family. The company is condensing the heart of a computer, including processor, coprocessor, bus structure, RAM, ROM, and even EPROM "onto a quad in-line ceramic substrate," says Derek Best, vice president of marketing.

Electronic Designs' 680C86 μPak se-



SPACE SAVING. Electronic Designs' microcomputer module fits in a 134-pin package.

ries comes in a 134-pin quad-row in-line package measuring 1.4 by 3.4 by 0.28 in. The product's small size is ideal for such applications as fuel control, engine monitoring, mobile communications systems, and data collection and management.

The use of all-CMOS modules ensures power dissipation of only 500 mW. The 680C86 products also feature Multibus architecture, which is supported by the 82C88 controller chip for decoding internal status information and generating Multibus-compatible bus timing and control signals. All four versions of the 680C86 microcomputer modules offer versatile bus structures: multiplexed data and address buses and demultiplexed buffered data and address buses.

INTERFACE UNIT. Also included in the μPak products is the Harris 80C86 address/data-bus interface unit, which supports a multiple-bus scheme and any fast address decoding requirements. Two of the 680C86 μPak products offer 8-K by 16 bits of static RAM on-board; the other two versions feature 192-K bytes of SRAM and 64-K bytes of EPROM on-board. One module in each of the two pairs carries an 8087 numerical coprocessor.

The company will also offer an application-development package and evaluation board for the 680C86 μPak series. When these products are available, the system designer will be able to use an IBM Corp. Personal Computer as the host and the 680C86 module as the target in a cross-assembler development mode.

Operations available with the development package include writing application software, debugging software on the module, downloading software to the PROM programmer, and programming the on-chip PROMs.

The 80C86 is the second processor that Electronic Designs has used in its microcomputer modules. The company, which is known for its military-grade memory modules, last fall moved into military-grade microcomputer modules with a version built around the Intel Corp. 80C31 microcontroller.

The 680C86 μPak products have single +5-V (±10%) supply operation and meet MIL-STD-883 processing specifications. Prices for military-grade μPak products start at $2,200 in lots of 100 pieces. Samples of the modules will be available in March. *–Debra Michals*

Electronic Designs Inc., 35 South St., Hopkinton, Mass. 01748.
Phone (617) 435-9077 [Circle 341]

REAL-TIME CPU CARD RUNS ON G-64 BUS

The Gesmpu-18 CPU card, built around the 80286 microprocessor, is compatible with the processor-independent G-64 bus for midrange industrial use. The single-height Eurocard, which can address up to 16 megabytes of physical memory on the bus, is supported by real-time multitasking monitor software.

A subsystem contains one programmable RS-232-C serial interface, 10 parallel I/O lines, five 8-bit timers, and external-interrupt controls—two vectored, three autovectored, and one nonmaskable interrupt for power failure. It also has two sockets for up to 128-K bytes of EPROM.

The Gesmpu-18 will run any software written for machines based on the 8088 or 8086, such as the IBM Corp. Personal Computer and its compatibles. In single units, it sells for $1,350, and evaluation cards are available now.

Gespac Inc., 100 W. Hoover Ave., Suite 11, Mesa, Ariz. 85202.
Phone (602) 962-5559 [Circle 360]

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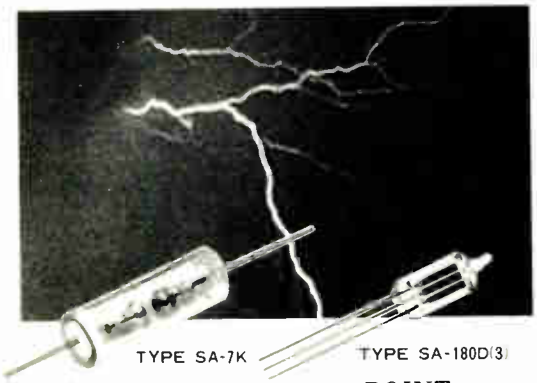

TYPE SA-7K

TYPE SA-180D(3)

● *TYPE*

Type	Breakdown Voltage (V)DC	Insulation Resistance (Ω)	Maximum Surge Current (8 x 20us) KA	Life Times at 500A
SA-80SS	80 ± 10%	10[illegible] min	1.0	1000
SA-200SS	200 ± 10%	10[illegible] min	1.0	1000
SA-80	80 ± 10%	10[illegible] min	1.5	1000
SA-140	140 ± 10%	10[illegible] min	1.5	1000
SA-200	200 ± 10%	10[illegible] min	1.5	1000
SA-250	250 ± 10%	10[illegible] min	1.5	1000
SA-300	300 ± 10%	10[illegible] min	1.5	1000
SA-7K	7000 ± 1000V	10^{10} min		5000
SA-10K	10000 ± 1000V	10^{10} min		5000
SA-180D(3)	180 ± 10%	10^{10} min	2.5	1000

SA-180D(3) is a three electrode discharge tube
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● *POINT*

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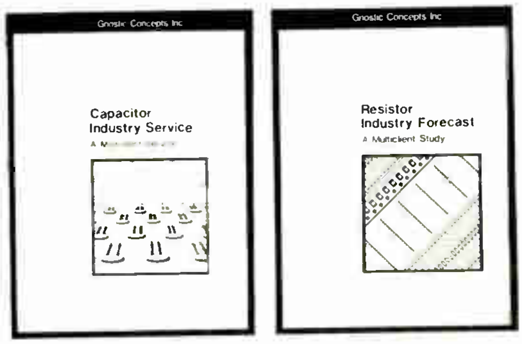

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MEETINGS

RELIABILITY MEETING TO STRETCH AGENDA

The 32nd Reliability and Maintainability Symposium marks a departure from the style of its predecessors: it has a much broader outlook, says program chairman J. Edward Anderson, senior engineer in IBM Corp.'s Federal Systems Division, Owego, N. Y.

Instead of emphasizing one area, the theme of this year's meeting is "Design, Production, Support: Let's Put It All Together." In past years, the focus was mostly on design. Another trend is toward greater participation by the commercial sector. Whereas military papers used to predominate, this year a roughly equal number of commercial papers will be presented, says Anderson. "A lot of practices initiated under government programs [are] being picked up and used in commercial applications."

Nonetheless, a government session on the National Aeronautics and Space Administration's approach to life-cycle reliability and maintainability should be a major draw. Haggai Cohen, NASA's chief engineer, will moderate the session, which features an appearance by astronaut Kenneth Cameron. Anderson says most of NASA's programs have featured "excellent reliability without maintainability in orbit," but maintenance is more critical now. "In the past, they relied on redundancy. But if [a spacecraft is] up for an extended period of time, repair resources are needed, especially for such missions as satellite repair." Anderson expects Cameron will "bring us some war stories" on the satellite repair pulled off by astronauts in the last space shuttle mission.

World Conference on Electronic Printing and Publishing, George Washington University (Henry B. Freedman, Electronet Information Systems Inc., 2000 Pennsylvania Ave. N. W., Washington, D. C. 20006), George Washington University, Jan. 22-24.

1986 SCS Multiconference, Society for Computer Simulation (Simulation Councils Inc., P. O. Box 2228, La Jolla, Calif. 92038), Bahia Hotel, San Diego, Jan. 23-25.

Crosstalk '86, EIA (EIA, Crosstalk '86, 2001 Eye St. N. W., Washington, D. C. 20006), Hyatt Palm Beaches, West Palm Beach, Fla., Jan. 26-29.

32nd Reliability and Maintainability Symposium, IEEE (Norman Kutner, Westinghouse Electric Corp., 401 E. Handy Ave., Sunnyvale, Calif. 94088), Riviera Hotel, Las Vegas, Jan. 28-30.

Communications Networks '86, CW Communications Inc. (P. O. Box 880, Framingham, Mass. 01701), Washington Convention Center, Washington, Jan. 28-31.

ASTM International Symposium on Semiconductor Processing, American Society for Testing and Materials (1916 Race St., Philadelphia, Pa. 19103), Red Lion Inn, San Jose, Calif., Jan. 28-31.

Robotic Industries Association Meeting, Robotic Industries Association (P. O. Box 1366, Dearborn, Mich. 48121), Sheraton, Scottsdale, Ariz., Jan. 29-31.

RF Technology Expo, *RF Design* magazine (Jim MacDonald, *RF Design*, 6530 S. Yosemite St., Englewood, Colo. 80111), Anaheim Hilton and Towers, Anaheim, Calif., Jan. 30-Feb. 1.

Aerospace Applications Conference, IEEE (Warren Schwarzmann, TRW Inc., 4 Aurora Dr., Rolling Hills Estates, Calif. 90274), Four Seasons Lodge, Steamboat Springs, Colo., Feb. 1-8.

Power Engineering Society Winter Meeting, IEEE (J. G. Derse, 1030 Country Club Rd., Bedminster, N. J. 07921), New York Penta Hotel, New York, Feb. 2-7.

Compdec '86: International Conference on Data Engineering, IEEE (P. Bruce Berra, 111 Link Hall, Syracuse University, Syracuse, N. Y. 13210), Westin Bonaventure Hotel, Los Angeles, Feb. 2-7.

3rd Automated Manufacturing Conference, Frost & Sullivan Inc. (106 Fulton St., New York, N. Y. 10038-2786), Don CeSar Hotel, St. Petersburg Beach, Fla., Feb. 3-4.

WTS 86: World Telecommunications Showcase, U. S. Telephone Association (1801 K St., Suite 1201, Washington, D. C. 20006), Dallas Convention Center, Dallas, Feb. 3-5.

ATI '86: 7th Annual Symposium on Automation Technology, CAD/CAM, and Engineering Data Handling, Automation Technology Institute Inc. (Jeff Smith, ATI, P. O. Box 242, Pebble Beach, Calif. 93953), Monterey Conference Center, Monterey, Calif., Feb. 3-7.

UniForum, /usr/ Group (4655 Old Ironsides Dr., Suite 200, Santa Clara, Calif. 95054), Anaheim Convention Center, Anaheim, Calif., Feb. 4-7.

1986 IEEE International Solid-State Circuits Conference, IEEE *et al.* (Lewis Winner, 301 Almeria Ave., Coral Gables, Fla. 33134), Anaheim Hilton Hotel, Anaheim, Calif., Feb. 19-21.

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ELECTRONICS WEEK

HITACHI TO MAKE VCRs IN U.S.

Hitachi Ltd. confirmed that it will build video cassette recorders in the U.S. Last month, the company acknowledged that it was considering the move [*Electronics*, Dec. 16, 1985, p. 88]. Its Hitachi Consumer Products of America Inc. subsidiary is installing VCR assembly equipment at its Anaheim, Calif., plant at a cost of about $1.5 million. Initial production will run 100,000 units annually, a rate that will increase to as much as 600,000 VCRs over the next four to five years. Toshiba Corp. and Matsushita Electric Industrial Co. also indicate they might launch U.S. production plants, and Sony Corp. already makes professional-use VCRs in the U.S. In addition, Hitachi is building an $8 million plant in Norman, Okla., to produce disk drives.

NTT SETS BIGGEST OVERSEAS ORDER

Northern Telecom Inc. has made its first major long-term sale in Japan to Nippon Telegraph & Telephone Corp., which will purchase an estimated $225 million of DMS-10 digital switching systems. Under the five-year deal, NTT's largest single purchase of foreign equipment since it opened up its procurement policies to non-Japanese manufacturers in 1981, the Nashville, Tenn., subsidiary of Canada's Northern Telecom Ltd. is scheduled to deliver each year systems equivalent to 300,000 circuits. The equipment will replace analog switches in the Japanese telephone network.

GERMANY BACKS OUT OF SDI

Although the West German cabinet is giving political support to the U.S. Strategic Defense Initiative, it has backed away from participating in the SDI project and will not make public funds available for any cooperative deals. Instead, in negotiations to begin this month in Washington, the Bonn government will seek ways that would make it easier for German companies to get SDI-related contracts.

AMPHENOL BUYS THOMSON-CSF UNIT

Thomson-CSF is selling its Socapex subsidiary to Amphenol Products Inc., Lisle, Ill. Socapex, a licensee of Amphenol, is already tooled to produce the company's line of Bendix circular environmental connectors, as well as its own line of connectors that are complementary to Amphenol's. The move was made to strengthen Amphenol's competitive position worldwide. Purchase price was $25.9 million, which included $19.8 million in assumed debt.

MONSANTO TO SELL GaAs WAFERS

Monsanto Electronic Materials Co., Palo Alto, has signed an agreement with Mitsubishi Monsanto Kasei of Japan to begin marketing III-V materials, such as gallium arsenide, in the U.S. MMK is a joint venture between Monsanto Co. and Mitsubishi Chemical Industries Ltd. and is the world's largest supplier of III-V electronic products. Paul Golden, director of III-V Material Market and Sales, says MEMC will concentrate on emerging integrated-circuit applications.

GENRAD IN MAJOR REORGANIZATION

GenRad Inc., Concord, Mass., has completed a major corporate reorganization that has seen reductions in its U.S. work force, consolidations, and downsizing of its operations. About 525 employees, or 19% of its U.S. work force, have been let go. Two product-development and manufacturing operations—in Concord and Bolton, Mass.—were merged. Two other product operations, in Santa Clara and Milpitas, Calif., were also merged, with the Santa Clara facility being vacated. GenRad has reorganized its engineering and marketing units into two new groups—Electronic Manufacturing Test and Semiconductor Test. The move is expected to save $20 million a year, lowering GenRad's break-even revenue base by $40 million annually.

FLOPPY-DISK DRIVE SALES DIP

Worldwide shipments of floppy-disk drives will decline from 1984's peak, but the dip will be short-lived, according to a report by Disk/Trend Inc., a Los Altos, Calif., market-research firm. Total shipments are estimated at 18,081,600 drives for 1985, down 5.8% from the year before. Industry growth will pick up for the next three years, however, with 1988 worldwide shipments reaching 29,290,000 drives. But despite increased unit sales, Disk/Trend says that competition and new, lower-cost drives will keep revenue down. Sales in 1985 are estimated at $2.9 billion, compared with $3.5 billion in 1984; revenue in 1988 will grow to only $3.2 billion.

STC GIVES UP ON OPTICAL-DISK DRIVES

What were once bright hopes for big sales in optical-disk drives at Storage Technology Corp. have been suddenly squelched. The troubled Louisville, Colo., mass-storage maker has dropped the scaled-down development project after concluding it would not have production quantities of quality optical media in three years. After more than a year of searching, STC also was unable to find a buyer or investment partner for the optical-disk division. The laser-based optical memory subsystem had been designed for at mainframes that could hold 4 gigabytes of write-once data on 14-in. platters. Following many delays in media development, STC sold its disk-media technology early last year to E. I. du Pont de Nemours & Co., which had inked a second-source pact in 1983.

BULL, OLIVETTI JOIN IN BANKING

Two of Europe's leading data-processing equipment makers will join forces this year in a drive to penetrate the international automated-banking market. Groupe Bull of Paris and Ing. C. Olivetti & C., Ivrea, Italy, will form a joint-venture company to design and produce a new generation of cash dispensers, automatic teller machines, and inquiry terminals, many of them based on the Bull CP8 "smart card," an embedded microprocessor and memory in a standard credit-card format. Bull and Olivetti expect to have products on the market as early as 1987.

FRANCE MAY SWITCH OFF AT&T

A preliminary report from the technical evaluation department of France's Direction Générale des Télécommunications casts doubt on the economic feasibility of the national network operating AT&T Co.'s No. 5 ESS PRX telephone exchange. DGT estimates the U.S. switch, marketed in Europe by AT&T and Philips Telecommunications BV, will cost 15% to 20% more than French digital exchanges and would require as much as two years of development to integrate into the French network. The French are determined that any new switches should be comparable in cost to those currently in operation from the Alcatel-Thomson subsidiary of the nationalized Compagnie Générale d'Electricité.

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TDK H7C4 Cores for Switching Power Supplies Up To 500kHz

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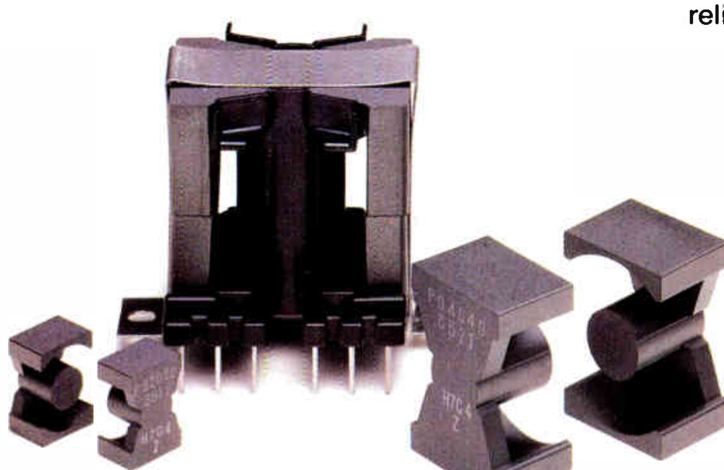
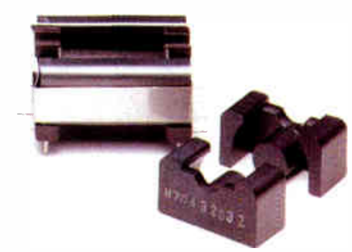
Trust TDK, the ferrite experts, to come up with the stuff that a power supply designer's dreams are made of. H7C4 has a saturation flux density of B_S=5100 Gauss (510mT) and a low-power loss of P_L=410kW/m³ at 212°F (100°C), 2000 Gauss (200mT), with a 100kHz sine wave. Temperature surge under load conditions is limited by this material's favorable core loss characteristics. Especially in the 212°F (100°C) range, power loss is extremely small.

Easily adapted to all core shapes, TDK's H7C4 permits higher on-board densities while maintaining top reliability.



PQ Cores

- Highest output power per unit of space.
- Help save PCB space and volume.
- Pin-equipped bobbins for easy terminal access.
- High voltage resistant bobbins meet international safety standards.



LP Cores

- On-board mounting height only 0.5, 0.7 or 1 inch. Ideal for flat packed boards.
- Surprisingly high output power for their compact dimensions.
- Pin-equipped bobbins for easy terminal access.
- High voltage resistant bobbins meet international safety standards.

EEC & ETD Cores

- Cylindrical in side wall and center pole permit highly efficient winding operations. The ETD core has become Europe's new standard.
- Low leakage inductance and low winding loss.
- Conformity with IEC standards.
- Easy terminal access. International safety standards can be met where required.

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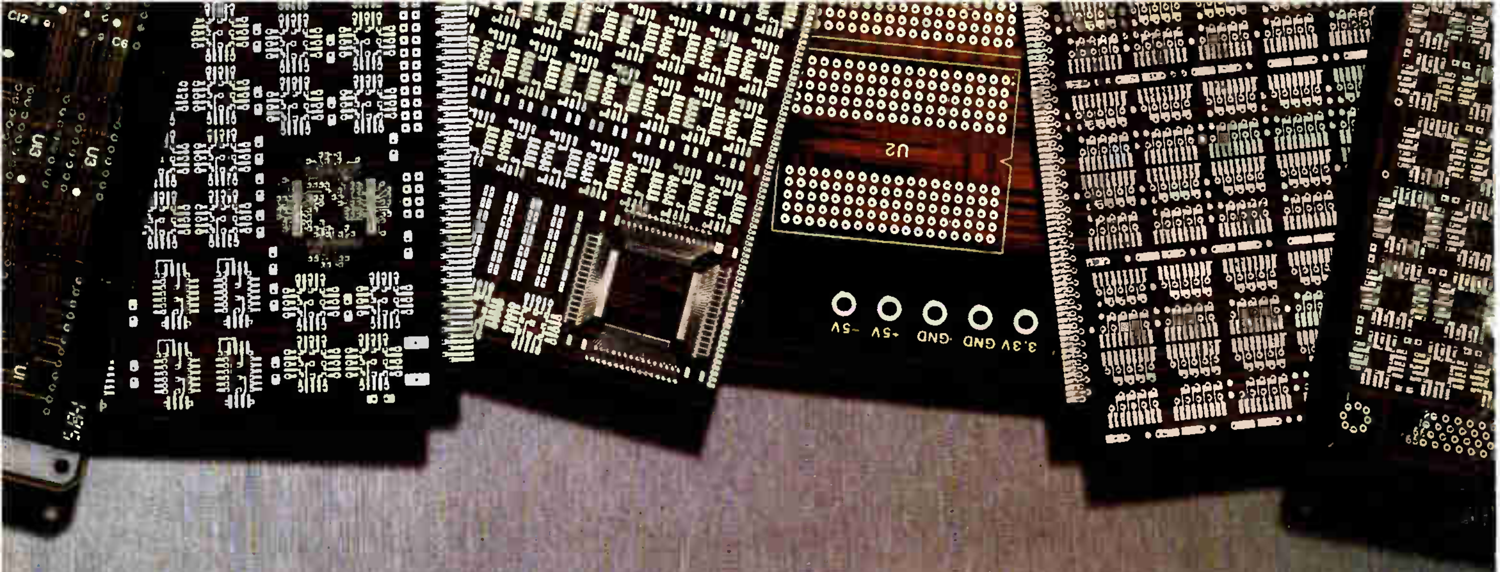
Circle 901 on reader service card



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