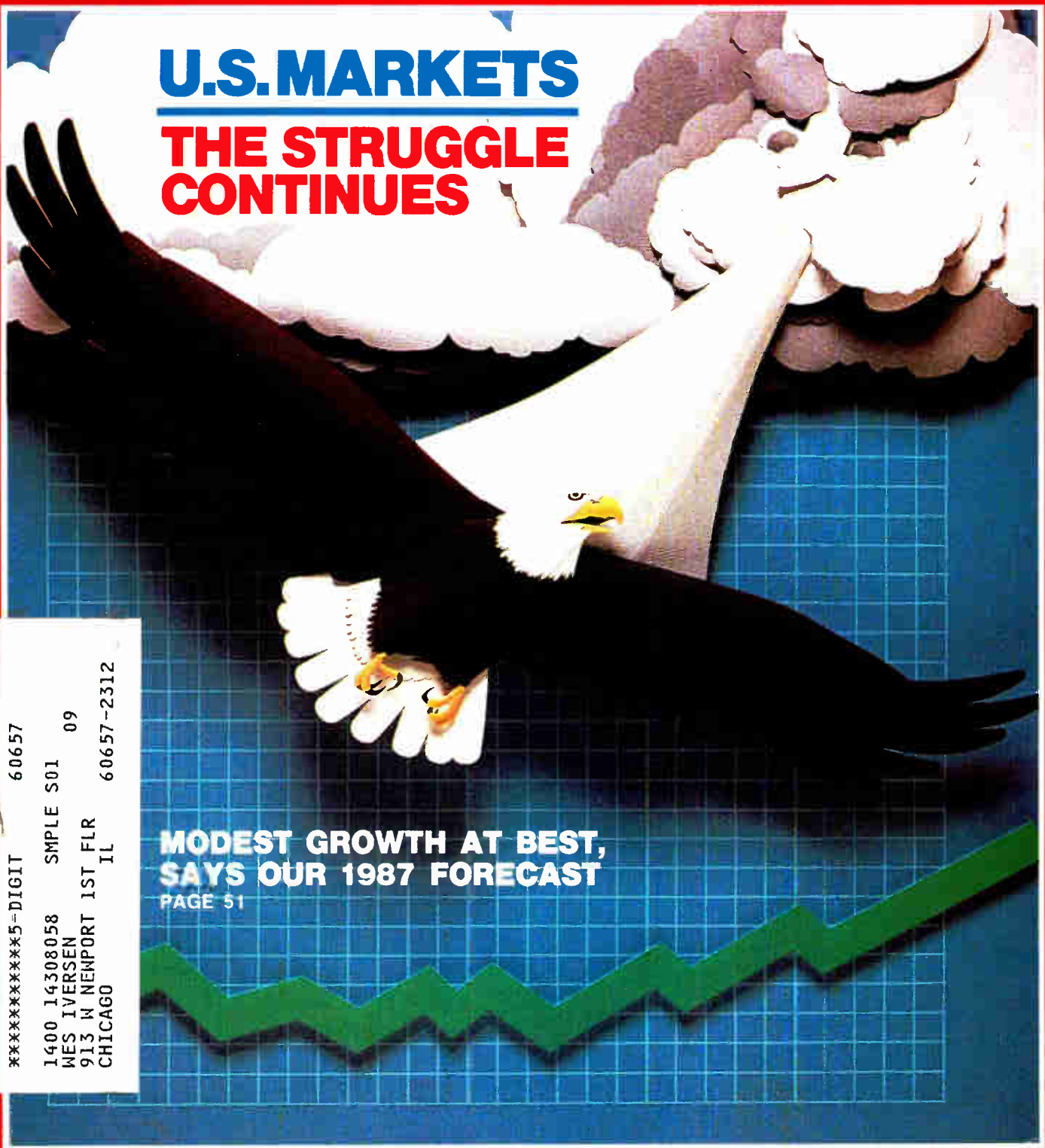
A MODEM CHIP THAT NEEDS ONLY ONE 5-V SUPPLY/81

INOVA BRINGS WAFER-SCALE INTEGRATION TO MARKET/91

A McGRAW-HILL PUBLICATION SIX DOLLARS JANUARY 8, 1987

Electronics



U.S. MARKETS

THE STRUGGLE CONTINUES

MODEST GROWTH AT BEST, SAYS OUR 1987 FORECAST

PAGE 51

In Surface Mountable Components, TDK Quality Is More Than Skin Deep.

As boards are getting thinner, TDK is helping that diet succeed by providing a variety of extra-slim surface mountable components. Nourished by TDK's expertise in ferrite and ceramic materials, these miniaturized components feed on TDK—developed multi-layerization and multi-functionalism.

How do we know the exact needs of high-quality automated board production? Well, a fair share of the world's automatic mounting equipment—the Avimount series—comes from TDK.

Product name		Type	Shape	Dimensions L (mm)	W (mm)	T (mm)	Electrical Characteristics
Multilayer Ceramic Chip Capacitor		C1508		1.5	0.8	1.0	C: 0.5 ~ 470pF, 100 ~ 22,000pF
		C2012		2.0	1.25	0.6	C: 0.5 ~ 1,800pF
						0.85	C: 470 ~ 100,000pF
						1.25	
		C3216		3.2	1.6	0.6	C: 0.5 ~ 270pF
						0.85	C: 470 ~ 220,000pF
						1.1	
		C3225		3.2	2.5	< 1.9	C: 750 ~ 8,200pF, 56,000 ~ 470,000pF
		C4532		4.5	3.2	< 1.9	C: 2,400 ~ 18,000pF, 180,000pF ~ 1μF
		C5650		5.6	5.0	< 1.9	C: 5,100 ~ 33,000pF, 270,000pF ~ 1.5μF
Multilayer Ceramic Chip Capacitor (High Frequency, Low Loss)		FC1414		1.4	1.4	1.6	C: 0.5 ~ 100pF, 150 ~ 3,300pF
		FC2828		2.8	2.8	2.8	C: 0.5 ~ 1,000pF, 470 ~ 22,000pF
		FR1414		1.4	1.4	1.6	C: 0.5 ~ 100pF, 150 ~ 3,300pF
		FR2828		2.8	2.8	2.8	C: 0.5 ~ 1,000pF, 470 ~ 22,000pF
Leadless Inductor (Wound Chip Inductor)		NL322522		3.2	2.5	2.2	L: 0.01 ~ 220μH
		NL453232		4.5	3.2	3.2	L: 1.0 ~ 1,000μH
		NL565050		5.6	5.0	5.0	L: 1,200 ~ 10,000μH
		NLF453232		4.5	3.2	3.2	L: 1.0 ~ 1,000μH (Shielded Inductor)
Multilayer Chip Inductor		MLF321606		3.2	1.6	0.6	
		MLF321611		3.2	1.6	1.1	
		MLF322511		3.2	2.5	1.1	L:0.047 ~ 220μH
		MLF322518		3.2	2.5	1.8	
		MLF322525		3.2	2.5	2.5	
Multilayer Chip Transformer		MTT4532		4.5	3.2	2.8 max.	L: 10 ~ 200μH
Multilayer Chip IFT		MIA4532		4.5	3.2	2.8	F: 455, 459, 464kHz
		MIF4532		4.5	3.2	2.2	F: 10.7MHz
Multilayer Chip LC Trap		MXT4532		4.5	3.2	2.8 max.	F: fo ± 2%
Multilayer Chip LC Filter	HPF (Tuner)	MXF4532H		4.5	3.2	2.8 max.	
	BPF (FM radio)	MXF4532B		4.5	3.2	2.8 max.	
	BPF (VCR)	MXB5050B		5.0	5.0	2.8 max.	Electrical characteristics are representative. please specify value when ordering.
	LPF (VCR)	MXB5050L		5.0	5.0	2.8 max.	
	Equalizer (VCR)	MXB5050E		5.0	5.0	2.8 max.	
	Delay Line (VCR)	MXB5050D		5.0	5.0	2.8 max.	
Multilayer Chip Capacitor Network		MCN7575		7.5	7.5	0.9	C: 1 ~ 1,000pF (TC:CH) (10 capacitors) C:10 ~ 1,000pF (TC:SL) (10 capacitors)
Ferrite Chip Beads		CB201209		2.0	1.25	0.9	Zo: 7, 10, 11Ω
		CB321611		3.2	1.6	1.1	Zo: 19, 26, 31Ω
		CB322513		3.2	2.5	1.3	Zo: 31, 52, 60Ω
		CB453215		4.5	3.2	1.5	Zo: 70, 120, 125Ω
SM Active Delay Line		FDL		12.0	9.5	5.6	Delay time: 20 ~ 250 nsec.
SM Transformer/ Inductor		EE5		7.4	5.3	4.75	
		ER9.5		11.5	9.5	6.3	Electrical characteristics are representative please specify value when ordering.
		ER11		12.5	11.0	6.3	
		T2		7.0	5.0	2.2	
Step-up Inductor (Piezo Buzzer)		OL3.3 × 1.6		5.6	5.3	1.6	Inductance values are representative, please specify value when ordering.
		OL3.3 × 2.1		5.6	3.3	2.1	

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Circle 900 on reader service card

SURPRISE!

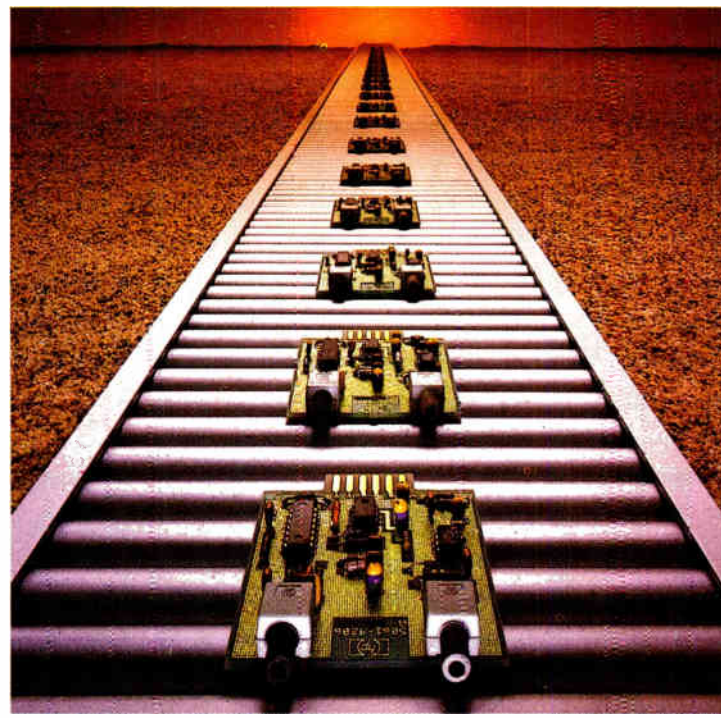
Low-cost fiber-optic components for high-volume manufacturing.

Lower manufacturing costs.

Finally you can reap all the benefits of using fiber-optic components for no more than the cost of using line drivers.

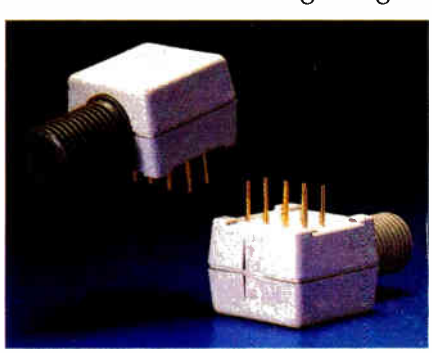
HP's new miniature fiber-optic components are housed in an integrated dual-in-line package designed for high-volume manufacturing—just like any other IC chips.

Auto-insertable and wave-solderable, the HFBR-0400 family of components is molded of high strength, heat-resistant and flame-retardant plastic. Mounting hardware and receptacles are eliminated, saving you money.



Design flexibility.

You have a choice of standard optical power or high-performance transmitters and of analog or digital receivers. You can achieve data rates up to 40 MBaud or analog bandwidths as high as 25 MHertz.



Each component is available for use with five fiber sizes—100/140, 50/125, 62.5/125, and 85/125 micrometre glass cables and 200 micrometre plastic-coated cable.

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A new LED design and efficient double-lens optical scheme allow a low drive current for greater reliability. Our transmitters have a calculated mean time between failure greater than 2 million hours.

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These new receivers cost as little as $12.50* each for 1000 units. Transmitters cost as little as $18* each.

For pricing and delivery, contact your authorized Hewlett-Packard components distributor. In the U.S., call Hall-Mark, Hamilton/Avnet or Schweber. In Canada, call Hamilton/Avnet or Zentronics, Ltd.

For more information, return the coupon below. Or call the HP sales office listed in your white pages and ask for the Components Department.

Please send me my free copy of your brochure *Fiber-Optic Components for Data Communications* and a set of data sheets on the HFBR-0400 family.

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EL 1/8/87

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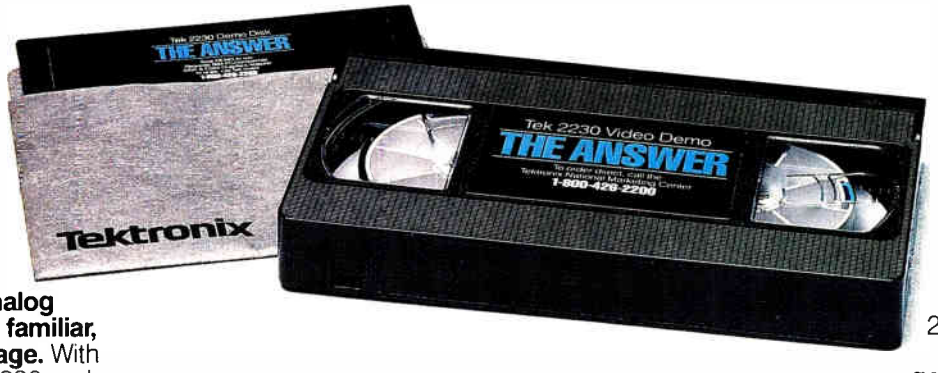

Now get the best of both worlds, analog and digital, in one familiar, easy-to-use package. With the 100 MHz Tek 2230 and 60 MHz 2220 you benefit from 20 MS/s *digitizing* plus analog operation to each scope's bandwidth. Just push a button for real-time display analysis!

Expect the most for your money—and get it—with Tek. You can capture events as narrow as 100 ns at any sweep speed—using Tek's proprietary peak detect mode. Trigger on complex waveforms using variable sweep holdoff. View events prior to or following a trigger event with pre/post trigger. Eliminate noise with built-in signal averaging. Store acquired waveforms as either 1K or 4K records. All with unrivalled convenience and confidence in your measurement results.

Both scopes offer optional GPIB or RS-232-C interfaces. With either option the 2230 also includes battery-backed memory that provides 26K of keep-alive CMOS memory —for storing up to 26 waveform sets.

Features	2230	2220
Analog/Digital Storage BW	100 MHz	60 MHz
Max. Sampling Speed	20 MS/s	20 MS/s
Record Length	4K/1K (selectable)	4K
Save Reference Memory	One, 4K Three, 1K	One, 4K
Vertical Resolution	8 bits 10 bits (AVG mode) 12 bits (AVG mode over bus)	8 bits
CRT Readout	Yes	No
Cursor Measurements	Yes (storage mode)	No
GPIB/RS-232-C Options	Yes ($850)	Yes ($550)
Battery-Backed Memory (save 26 waveform sets)	Yes (inc. with 2230 communications options)	No
Price	$5150	$4150

Call Tek direct to get your free video or diskette demo. Or to place an order! Ask about free Tek digital storage application notes and educational materials. Technical personnel will answer your questions, take an order and expedite delivery. Orders include complete documentation, operating manuals, worldwide service back-up and Tek's 3-year warranty that even covers the CRT.

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COMMITTED TO EXCELLENCE

Circle 2 on reader service card

Strengthening the strongest West Coast bureau

Readers who have been keeping an eye on our masthead have noticed that in the past year we have bolstered our Silicon Valley office in San Mateo by adding a trio of veteran journalists with considerable experience and knowledge. The three—Bernie Cole, Jonah McLeod, and George Sideris—have joined bureau manager Cliff Barney at the Northern California outpost.

Now to make the strongest West Coast news bureau covering the industry even stronger, we are fine-tuning assignments to take even more advantage of the many years of experience represented in the bureau. Jonah, who has been covering test and measurement, will bring his expertise to bear on the computer and peripheral business while retaining responsibility for developments in computer-aided design and engineering. At the same time, George will begin covering the important area of test instrumentation, concentrating on automatic test equipment and bench instrumentation.

Meanwhile, Bernie will carry on his tireless efforts to uncover and describe the latest advances in the semiconductor field, and Cliff will continue to supervise the news coverage in an area that extends north through Oregon and Washington.

Readers will gain from the realignment of duties, says Sam Weber, our technical executive editor. "These moves will give us additional strength. George will be able to concentrate on covering a technical beat that has always been very important to *Electronics*. And the addition of Jonah to our computer coverage will give us much wider scope on technical and news coverage."

New on the masthead this week is the name of an old electronics and *Electronics* hand, Ron Schneiderman. Ron, 48, who has broad experience in journalism, particularly the electronics industry trade press, is returning to the magazine as military/aerospace editor. And marking his return, on p. 105, is the debut of a feature he will put together for each issue: the Military/Aerospace Newsletter.

A native of Portland, Ore., Ron attended the University of Oregon and got his start in journalism in the Air Force, where he spent four years in the Strategic Air Command editing his base newspaper and acting as a news director for Armed Forces Radio. Back in civilian life, Ron worked for radio stations in Georgia and Delaware and on the daily *State News* in Dover, Del.

After switching to the trade press, Ron spent nine years with Fairchild Publications, most of them with *Electronic News*, before coming to work for *Electronics* as New York bureau manager. He left to start a daily consumer electronics newsletter, worked on another magazine, freelanced, and now is back with us.

Ron says, "For the trade and technical journalist, working on *Electronics* is like returning to your roots—this magazine does things the way they should be done. I'm glad to be back."

Laurence Altman

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JANUARY 8, 1987

Electronics

NEWS

1987 U.S. MARKET FORECAST

INSIDE TECHNOLOGY

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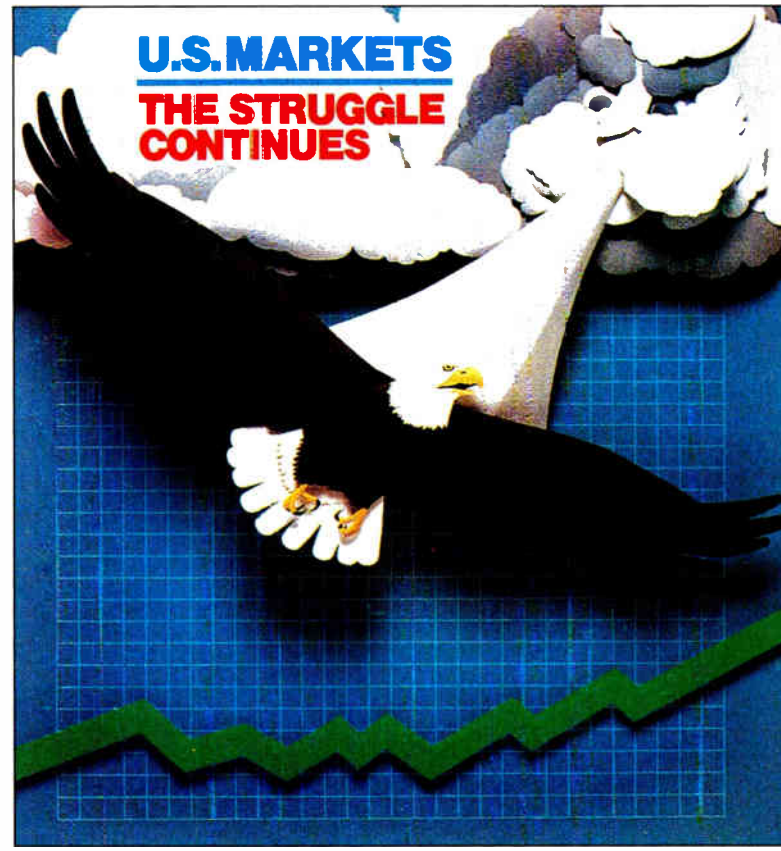


PAGE 51

NEW PRODUCTS

DEPARTMENTS

MOTOROLA

ISDN

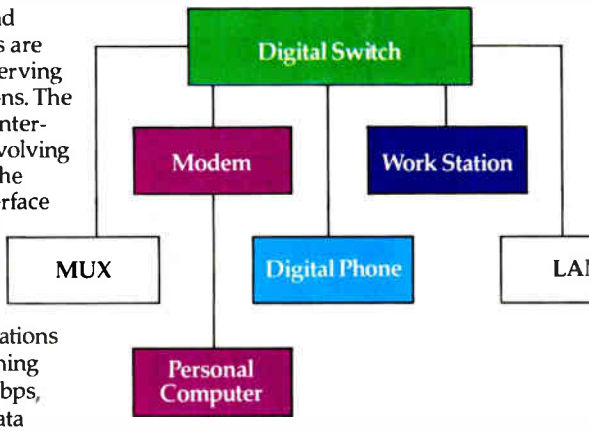
ISDN "Office-of-the-future." Now.

Free Motorola UDLT II evaluation board demonstrates low cost 160 kbps, 2B+2D, twisted-pair voice/data communications.

Motorola's MC145421 master and MC145425 slave ISDN UDLT II ICs are the newest in a family of devices serving general ISDN voice/data applications. The UDLT II ICs apply to the ISDN R interface and complement Motorola's evolving ISDN device family, particularly the previously announced I.430 S-interface transceiver (MC145474) and dual-channel LAP-D controller (MC145488), now in development.

The ISDN UDLT II ICs are designed to support varied applications in existing and future digital switching hardware architectures with 160 kbps, 2B+2D, full duplex synchronous data communication for distances to one kilometer over a single 26 AWG twisted-pair wire.

Two 64 kbps synchronous duplex B channels are provided: one for voice transmission and the other for high-speed data. One 16 kbps D channel is available for signalling information using LAP-D or proprietary protocols. A second D channel may be used for additional data or for maintenance and control.



These chips are capable of directly driving twisted pair cable, and employ differential phase shift keying modulation to optimize bit-error rate vs. signal-to-noise ratio.

The MC145421 master UDLT II operates in the PBX line card or data switch, with the MC145425 slave at the remote end in telsets and data terminals. They operate from a single 5 V supply with no external components.

More Motorola voice/data circuits.

• MC145422—80 kbps Master UDLT I • MC145426—80 kbps Slave UDLT I
Single-chip transceivers capable of operating up to 2 Km over a single twisted-pair wire.
• MC145406—RS-232-C & V.28 Driver/Receiver
Combines 3 drivers and 3 receivers on a single CMOS IC.
• MC145428—Data Set Interface Circuit (UART)
Establishes 2-way interface between NRZ asynchronous port and a synchronous transmission link including rate adaptation up to 128 kHz (async) and 2 MHz (sync).
• MC145429—Telset Audio Interface Circuit
Gives MCU control of analog signals between PCM codec/filter and the mouthpiece, earpiece, ring/speaker and auxiliary input/output.
• MC145500 Series—PCM codec/filter Mono-circuits
Enhanced performance with 6-13 V operation, 50 dB PSR, and low idle noise of 13 dBRNCO.
• MC34018—Speakerphone Network IC
Incorporate amplifiers, attenuators and control functions for hands-free system.
• MC34129—Telset Switching Regulator
Provides regulated voltage to the digital telset from the telephone line.

Try them in a free evaluation board.

Now you have a no-risk opportunity to try the ISDN UDLT II ICs in a free fully-assembled and tested board with separate master and slave sections. It generates various data clocks for easy interface to test equipment and prototype circuitry. Appropriate literature is included, of course.

To obtain your free ISDN UDLT II board, simply send your business card and a brief statement of your application with the completed coupon from this ad. The offer expires April 1, 1987, and requests must be postmarked by that date.

One-on-one design-in help.

For an engineer-to-engineer update on designing-in Motorola's voice/data or other telephone/communications ICs, call toll-

1-800-521-6274

free any weekday, 8:00 a.m. to 4:30 p.m., MST. If the call can't handle your challenge, we'll have a local applications specialist contact you.

For more information on these products, write, or send the completed coupon to Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, AZ 85036.

We're on your design-in team.

MOTOROLA

To: Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, AZ 85036

☐ Please send me more information on the UDLT II and other voice/data products.

☐ My business card and application statement are enclosed. Please send me the free UDLT II evaluation board. (Requests must be postmarked by April 1, 1987)

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FYI

This year Electronics *is adding a slew of new editorial features that will make the industry's best-written, best-edited, and best-informed publication even better*

Electronics is definitely back! That's not just the editors talking. The people who really count are telling us that. Readers declare they like the editorial product better than ever. They especially like the staff-written technical articles we call Technology to Watch, which give readers the first word on significant new technical developments and position them in the big picture. They are written in a brisk, compelling, and succinct style, without getting mired in needless detail.

And we're expanding our brand of unique coverage. You'll see more packages that combine technical articles with news stories examining the technical developments from other angles. Companion stories can cover the company and its managers that are responsible for the new technology, or they can comb out the market most affected by the new technology.

But we aren't resting on our laurels. This year we're adding a slew of brand-new editorial features that will make the industry's best-written, best-edited, and best-informed publication even better. This issue is crammed with new features that will widen our lead over other publications. And only this magazine with its worldwide network of editors could handle such an ambitious job.

To begin with, we're adding a newsletter to our already large stable. Recognizing the importance of the military/aerospace market, every issue we will run two pages of short, punchy, interpretive items on the latest in government projects, procurement, and technology. We're also doubling the size of our international newsletter to expand coverage overseas. Foreign readers, all 22,500 of them, are also getting their own products section, as well as International Week, a page of short items that summarize major foreign developments.

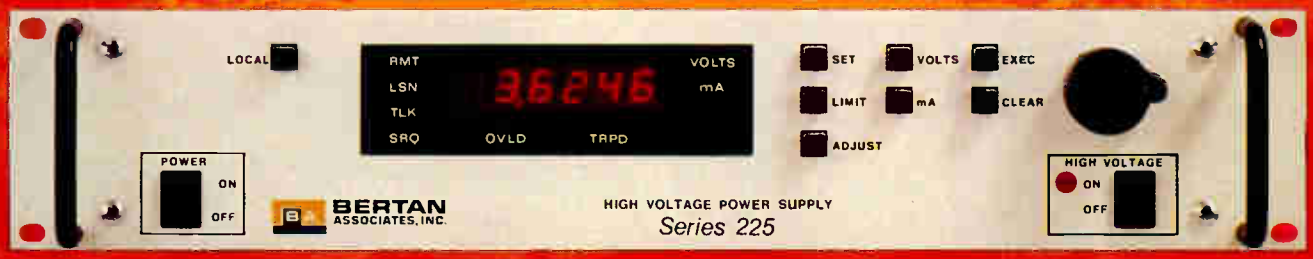
We're also adding another page to expand our coverage of distribution, another critical industry topic. Distribution Week will interpret book-to-bill ratios, order backlogs, inventories, distribution trends, and pricing strategies. And starting next month is a new series of special reports called "What's new in..." These product marketing features will cover leading components, their markets, leading players, and latest technology trends. Finally, *Electronics* is running an editorial index that lists the companies written up in that issue, including their addresses and telephone numbers. We know *Electronics* will be even more vital to its readers in 1987. **ROBERT W. HENKEL**

BERTAN

The New Era in High Voltage

Series 225 ⟷ IEEE-488

Programmable High Voltage Power Supply



BERTAN introduces Series 225 — an innovation that brings together years of experience in precision high voltage and digital processing. The result is an extremely versatile system offering high voltage control and monitoring through a built-in IEEE-488 interface, front panel or remote analog input. Series 225 provides highly accurate user programmable output setting and reporting capabilities. This unit also offers user-selectable overload protection. Series 225 is ideally suited for system or laboratory applications.

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- 0.001% Regulation
- 0.1% Setting & Monitor Accuracy
- Low Ripple & Noise
- Diagnostic Self-Testing
- Load Protective Circuitry
- Laboratory & System Applications

MODEL	HV OUTPUT
225-01R	0 to ± 1kV @ 30mA DC
225-03R	0 to ± 3kV @ 10mA DC
225-05R	0 to ± 5kV @ 5mA DC

Call your local representative or BERTAN'S Application Engineering Department for more information on Series 225. Inquiries about custom designs or OEM requirements are also invited. Ask for latest catalog featuring full lines of precision high voltage power supplies, instrumentation and accessories for X-Ray, CRT, ATE, Medical, Laboratory, Nuclear, E-Beam, Electro-Optical, Analytical and semi-conductor applications.

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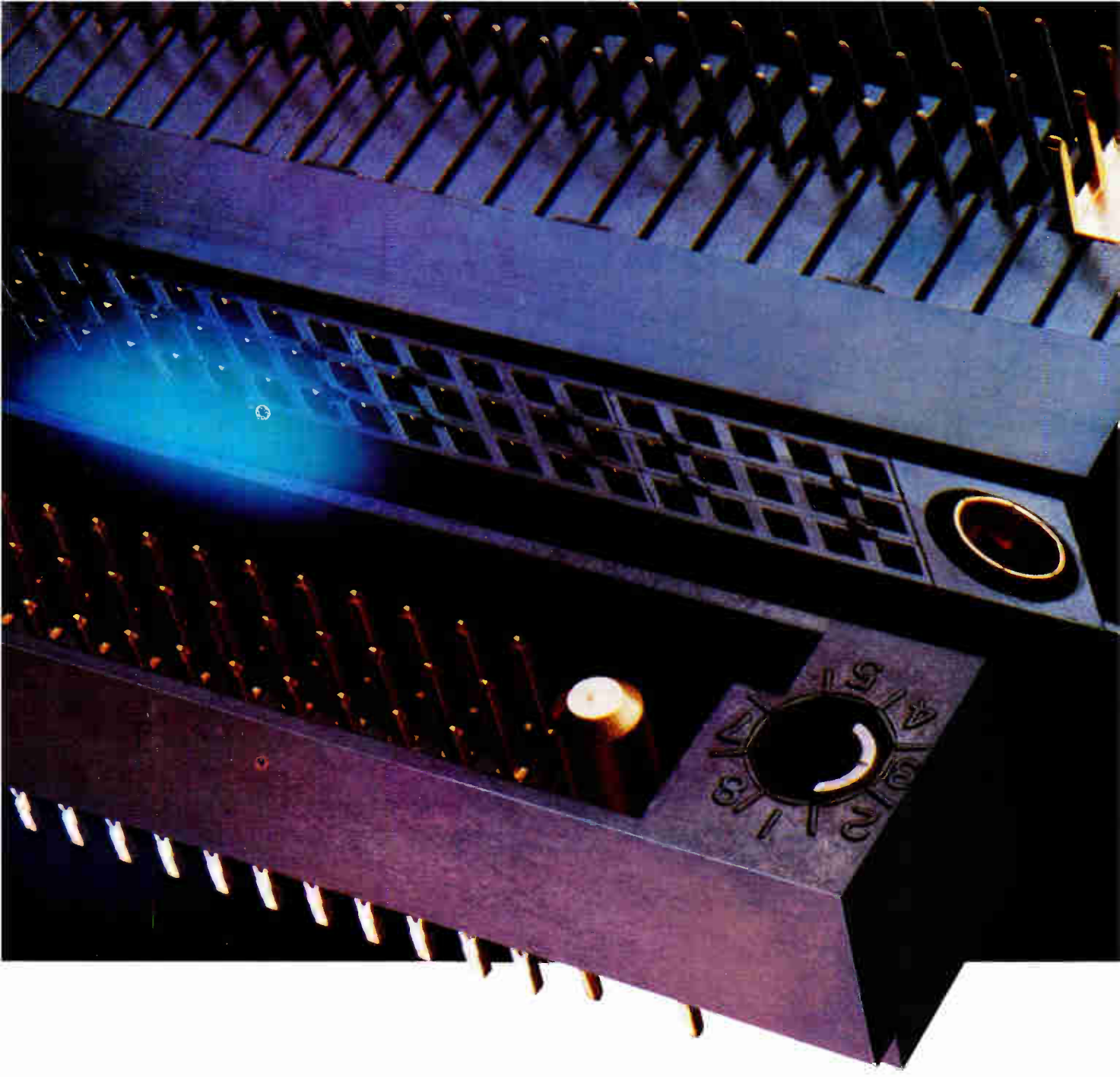

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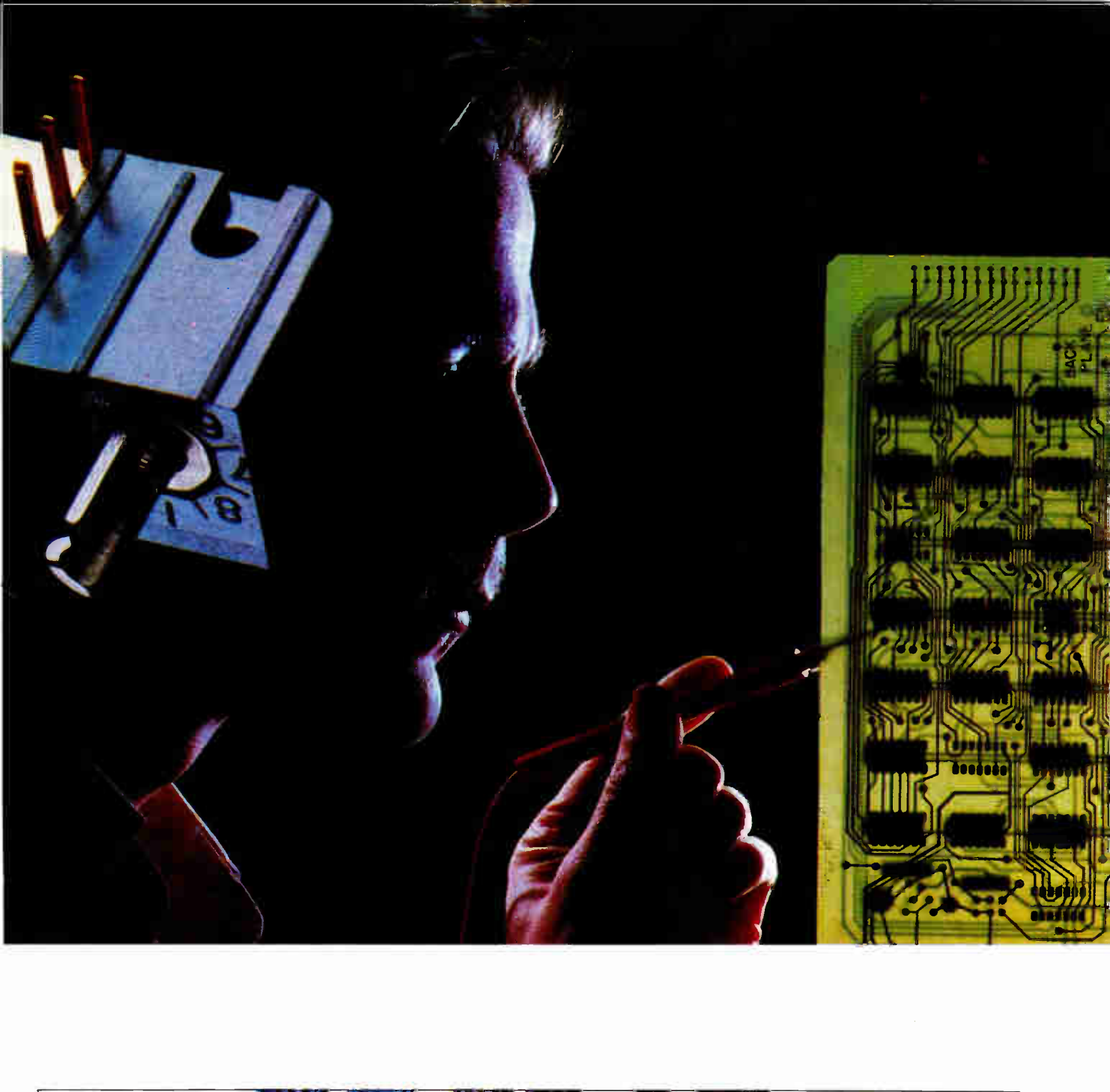
Name your application—our two-piece connector schedule covers every stop on the map.

Need maximum reliability and flexibility in a medium-to-high pin-count application? AMP Box Contact Connectors and high-density AMP-HDI Connectors feature four-way contact on every pin. Very reliable. Very forgiving of pin angle during mating and unmating. And both also offer power and coax contacts—big design help in those crowded little corners.

Headed for design-wide compatibility? AMPMODU two-piece connectors are part of a complete, cost-saving, modular system, featuring shortened signal paths for high-speed designs. Or, go Eurocard. The European standard for over 10 years, now used everywhere. And now available everywhere—from AMP.

Whatever your destination, AMP has the two-piece connectors you need, engineered for quality, reliability, and—especially with our compliant-pin option—increased productivity.

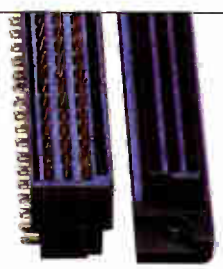


At left:
AMP-HDI Connectors

- To 684 positions on standard .100″ grid
- Selective gold plating
- Press-fit ACTION PIN contacts available
- 10A and 30A power contacts
- Miniature coax contacts

Box Contact Connectors

- .100″, .075″, .050″ center lines
- MIL-C-55302 versions available
- Power and miniature coax contacts



Eurocard Connectors

- Compatible with DIN 41612 connectors
- Selectively gold-plated press-fit contacts
- Standard and inverse mating

AMPMODU Connectors

- Standard .100″ grid, 12-200 positions, horizontal or right-angle versions
- Duplex or selective gold plating
- Press-fit ACTION PIN contacts available

Call (717) 780-4400 and ask for the AMP Two-Piece Connector Desk. AMP Incorporated, Harrisburg, PA 17105.

AMP **Interconnecting ideas**

AMP, AMPMODU, AMP-HDI and ACTION PIN are trademarks of AMP Incorporated.

Circle 11 on reader service card

LETTERS

Who's counting what??

To the editor: Your Dec. 18 article on the power MOS FET business [p. 97] is an excellent overview. But the breakout of sales really mixed metaphors.

International Rectifier reported revenues from power MOS FETs sold in the merchant marketplace. Several other companies reported figures that include revenues to distributors, products that do not meet the Semiconductor Industry Association's definition of power MOS FETs, and sales to captive markets. Consequently their reported figures inflate both their respective market shares and the total market size.

Derek N. Lidow
Executive Vice President
International Rectifier Corp.
Semiconductor Division
El Segundo, Calif.

Copyright or wrong

To the editor: As long as the computer software industry wallows in the comfort that its intellectual property is somehow protected by copyright, we will see more of Broderbund vs. Unison [Unison is appealing a decision that it infringed on Broderbund's copyright of a graphics program because of a similarity, not in computer code, but in screen appearance—*Electronics*, Oct. 30, 1986, p. 104]. You may recall that late last year Apple Computer Inc. got an out-of-court agreement from Digital Research Inc. saying that DRI would make its GEM screen less like that of Apple's Macintosh.

Historically, copyright protects expression, and that is precisely what a screen layout is. Contemporary legislation and precedents merely extend coverage to source codes and to translations and compilations thereof. Such extensions in no way detract from the intention of copyright as a protection for expression.

But software practitioners such as Unison are arguing that there is a how-it-works angle in software that is distinct from the how-it-looks angle. One argument is that reverse unlicensed copies of code using reverse engineering are legal. However, one need only read copyright laws and decisions to note that reverse engineering is not within their purview. You do not reverse-engineer a Rembrandt! But you do reverse-engineer a device or a process, both of which are protected by patent laws and not by copyright laws. Which is why, despite legal consensus to the contrary, I do not think copyright alone can speak for software.

K. C. Toh
Managing Director
Unidata Sdn Bhd
Singapore

It's crystal clear Cherry has your switch.

Because you demand maximum reliability in the latest state-of-the-art components; cost effective and delivered on time, clearly your choice is Cherry. Take a closer look. Send for catalog.

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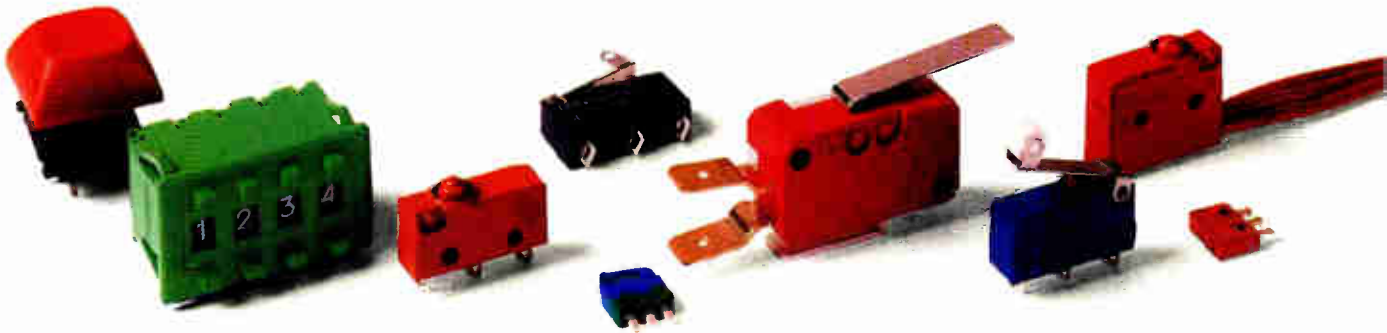
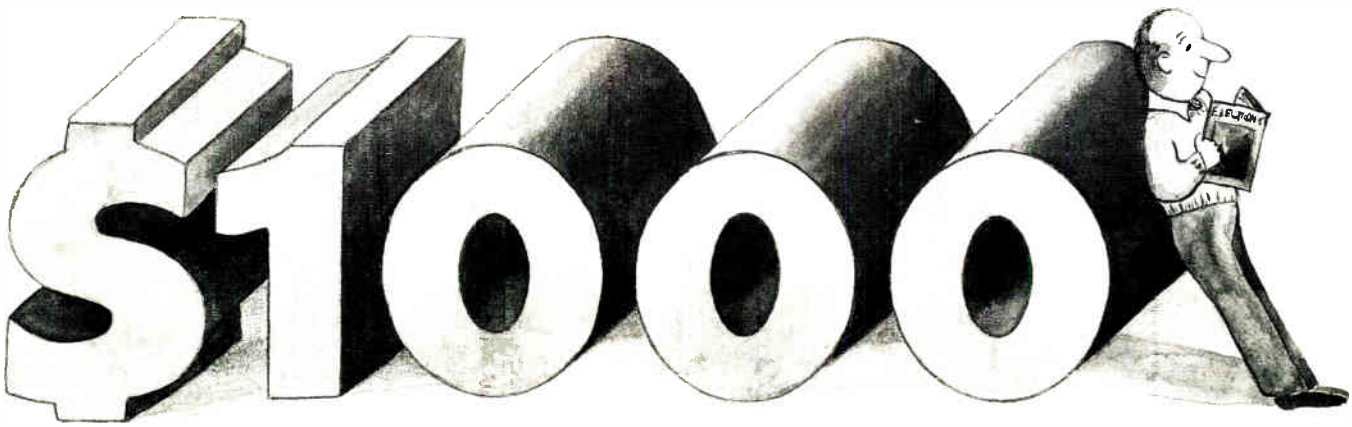


Circle 13 on reader service card

Win $1,000 Cash In *Electronics'* Annual Advertiser Audit Contest!



Details and complete contest rules appear in this issue.

It's easy to enter, and fun to win! Simply select the 10 ads in this January 8, 1987 issue of *Electronics* that you think will be best-read by your peers. List your selections on the entry card bound in this issue, or a reasonable facsimile. Whoever comes closest to selecting the 10 winning ads collects $1,000 cash!

Electronics

Attention Advertisers: You can win $1,000 too!

All advertising and marketing personnel in companies and agencies are invited to participate along with our readers by checking the box marked "Advertiser Contest" on the entry blank bound in this issue. Whoever comes closest to picking the 10 winning ads in this special advertiser's contest will receive an award acknowledging their skill in evaluating advertising, plus a free ad for their company—and $1,000 cash!

Electronics Advertiser Audit Study Contest

Win $1,000 Cash By Selecting The Best Remembered Ads In The January 8, 1987 Issue Of *Electronics*

Reader Contest Rules

1. After you have examined this issue of *Electronics*, pick the ten ads that you think will be best remembered by your peers and enter your selections on the entry blank bound in this issue or on a 3" x 5" index card. Your entry should include: 1) the name of the advertiser; 2) the advertiser's Reader Service Number; and 3) the page number the advertisement appears on. Ads placed by *Electronics* or McGraw-Hill, Inc. should not be considered in this contest.

2. Check the box on the entry blank marked "Reader Contest." No more than one entry may be submitted by any one individual. All entries must be postmarked no later than midnight, February 27, 1987.

3. The winner of the $1,000 cash prize will be determined by POSTCOM, (conducted by Signet Research, Inc.), *Electronics*' method of measuring readership. The winner will be notified by mail.

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

5. In case of a tie, the earliest postmark will determine the winner. Decisions by the judges will be final.

Advertiser Contest Rules

1. All advertising and marketing personnel in companies and agencies (other than McGraw-Hill, Inc. and its advertising agencies) are invited to participate in a separate contest for advertisers. All rules for the Reader Contest will similarly apply for this contest, with one exception: the box on the entry blank marked "Advertiser Contest" must be checked.

2. Examine this issue of *Electronics* with extra care. Choose the ten ads that you think readers of *Electronics* will best remember and enter your selections on the entry blanks bound in this issue or on a 3" x 5" index card. No more than one entry may be submitted by any one individual.

3. All entries must be postmarked no later than midnight, February 27, 1987. Each individual's qualifying entry will be matched against the winning ads as determined in the Reader Contest. Whichever individual in this Special Advertiser Contest comes closest to picking the 10 winning ads will receive $1,000 cash, and a plaque acknowledging their skill in evaluating advertising. The winner will be notified by mail.

4. This special Advertisers Contest is open to all advertising and marketing personnel in companies and agencies (other than McGraw-Hill, Inc. and its advertising agencies), whether or not their companies or agencies have an advertisement in the January 8, 1987 contest issue.

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

6. In case of a tie, the earliest postmark will determine the winner. Decisions by the judges will be final.

Winning Advertisers Earn Free Ad Reruns

The ten winning advertisers will receive a free rerun of their winning ads in *Electronics* and a plaque commemorating their achievement.

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

SCHLUMBERGER MANAGER TACKLES A TOUGH MARKET

TOKYO

Alex Beavers left his job as a consultant in corporate strategy "to get involved in hands-on management," and in his latest job he has his hands full. He's vice president and general manager of Schlumberger Computer Aided Systems-Asia, an operation that is fighting to regain market share in Japan's highly competitive chip-tester market.

When Schlumberger Ltd., the diversified French-U. S. oilfield-equipment company, took over what was then Fairchild Camera & Instrument Corp. eight years ago, surging Japanese tester makers had seriously eroded Fairchild's market-leading position. Beavers' task when he went to Japan a year ago was to engineer a turnaround. Last year, he says, "we increased our market share in the printed-circuit-board tester market from 20% to 25%." However, he foresees only nominal growth this year, largely as a result of the continuing chip-market slump.

CUSTOMERS WONDERING. Schlumberger's future in the electronics industry has also been affected by the company's pending sale of an 80% interest in the reorganized and renamed Fairchild Semiconductor Corp. to Fujitsu Ltd. [*Electronics*, Nov. 13, 1986, p. 29]. The sale did not change the status of the subsidiary that Beavers runs. It has, however, "caused our customers to wonder about our position as a test equipment and computer-aided-systems supplier," Beavers says. "But our new chairman [Euan Baird] has assured us that Schlumberger believes that CAS has strong growth potential. We're fully committed to the Japanese market."

Although Schlumberger's share in Japan's memory-tester market is less than 5%, Beavers predicts that the company's new megabit-chip tester, due out by June, will strengthen its position. He claims that the megabit model is the first tester that can handle different types of chips with differing tolerance levels on the same testing board, thus speeding throughput.

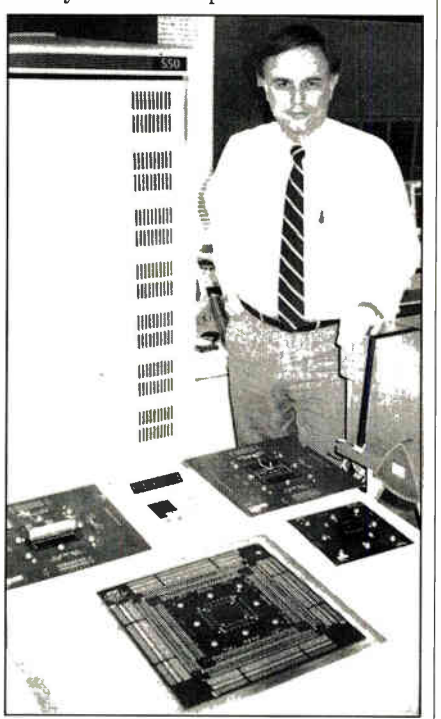
Beavers is also confident that he's the right person to guide the company's growth. A graduate of Vanderbilt University in his native Tennessee, he structured his education with certain goals in mind. His doctorate in electrical engineering from the University of Houston gave him the background to move into his specialty fields of industrial electronics and factory automation. His MBA from Boston University gave him the business background to move into management.

He began his career as a corporate consultant with Booz, Allen & Hamilton at what he describes as "an extremely interesting time, the 1970s, when major structural changes were taking place, especially the decline of U. S. productivity. Many manufacturing companies became alarmed and began to seek new markets. They came to us for guidance."

One of those companies looking for advice was General Electric Co. Beavers liked what he saw GE doing in the field of factory automation, so he made a major move, "to put theory into practice." In his four years with the company, he advanced to general manager of intelligent vision systems at the GE lab in Orlando, Fla.

Beavers left GE to join Schlumberger two and a half years ago, "because I felt I'd have more impact in this job," he says. He was right. Within a year and a half, he was on his way to Japan, his first overseas assignment.

His strategy for long-term growth in Japan, he says, has been to end the relationship with former distributor Tokyo Electron and go into direct sales and service, "to establish ourselves as a local company committed to working closely with our Japanese customers to



BEAVERS. Letting them know that Schlumberger is staying in Japan.

meet their individual needs." Those customers are much more sophisticated now than they were five years ago. "It used to be that an [automatic test equipment] prototype was designed by engineers," he said, "and then handed to the manufacturing group, which often found it impossible to manufacture because the quality standards were too high. And then, you sold standard units."

That one-dimensional approach, he says, "just doesn't work anymore. If you don't customize, you don't make sales. That's why we've increased our engineering and service staff from 180 to 220 in a year. We're obviously in Japan to stay." *–Michael Berger*

DONOVAN BUCKS DECLINE IN JAPAN'S IC MARKET

TOKYO

This year, while practically everyone else in the semiconductor industry is watching sales sag, Steve Donovan of Monolithic Memories Inc. is reporting strong growth, and he's doing it in the toughest market around—Japan.

"We've increased sales in Japan from 3.4 billion yen last year to 3.8 billion for our fiscal year ending this September, and my goal for '87 is a very realistic 5 billion yen," says the 35-year-old Donovan, who took over as executive managing director of MMI Japan Ltd. just five months ago. That would be 30% growth, at a time when other semiconductor executives are scratching for sales. It's also 10% of Monolithic Memories' projected $204.9 million in sales worldwide, a ratio Donovan intends to increase to 15% by fiscal 1989.

DONOVAN. No Japanese competition for PALs.

MMI Japan is growing while others are struggling because its product line, anchored by its patented programmable array logic (PAL) technology, has no Japanese competitors. With a 50% market share in Japan (its major competitor is Signetics Corp.), MMI Japan's customer base has doubled in the last three years to about 1,000 companies. In a Japanese computer market that has grown faster in the past two years than that in the U. S., Donovan says demand is firm in those high-performance digital-systems applications for which PAL devices are designed, including logic controllers for disk, graphics, or interface functions.

He sees an especially strong market for the new PAL 20D series, introduced earlier this year, with 10-ns maximum propagation delay times, faster than the 15-ns speeds that most of his customers are seeking. Next year, MMI will introduce a CMOS family for users who need low power consumption, and it plans to balance its product line between bipolar and CMOS by 1990.

To beef up his company, Donovan has hired four engineers to work with his sales force on customer-specific applications, and in 1987 he plans to hire six or seven more people for engineering, sales, and administrative tasks. "I've heard it's hard to find good Japanese engineers, but we find so far that younger ones, especially, are looking more often to work with a foreign firm. We offer them the responsibility and chance for advancement that they can't find when they start out with a Japanese company."

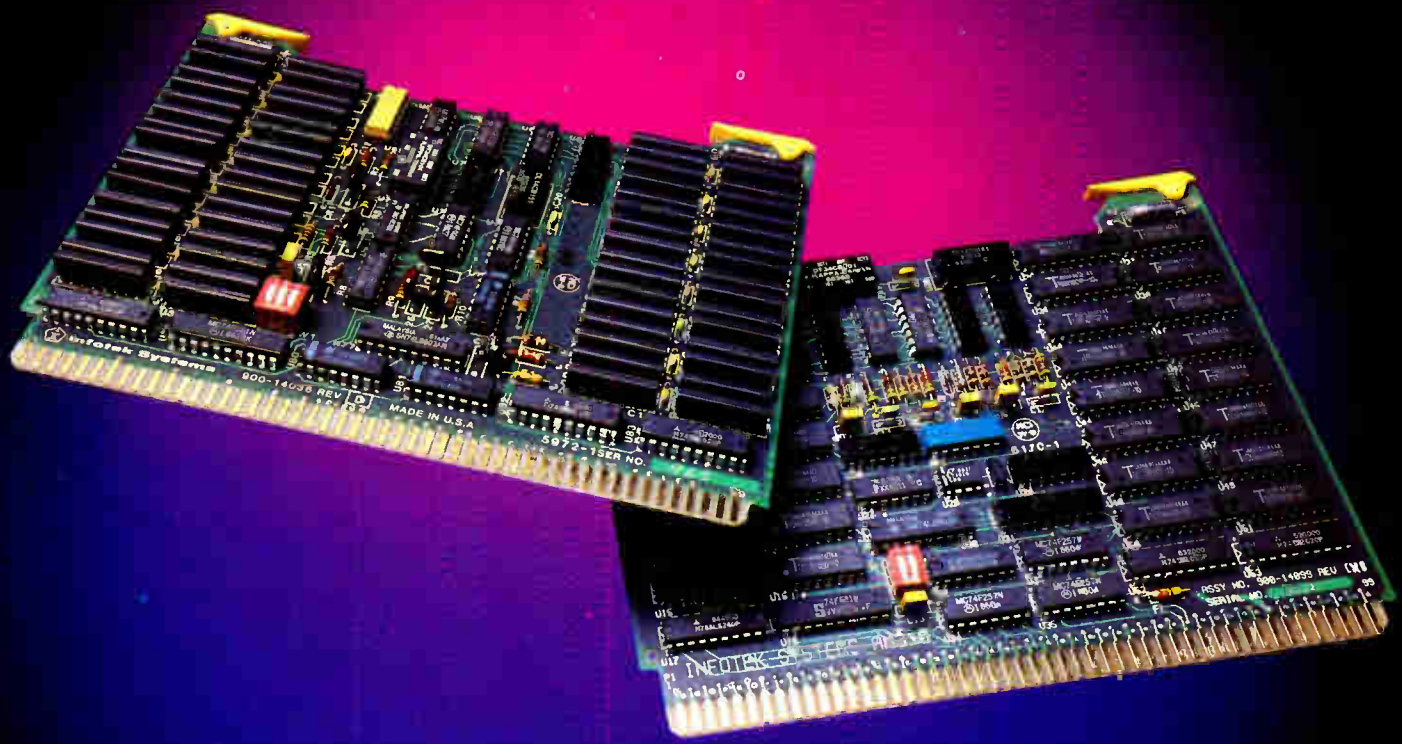
Donovan, British-born with an undergraduate honors degree in electrical engineering from the Liverpool Polytechnic Institute, is accustomed to operating in foreign environments. A former sales manager for NCR Corp. in the United Arab Emirates sheikdom Abu Dhabi as well as a marketing manager for Advanced Micro Devices Inc. in California, Donovan joined MMI in 1983 as marketing manager for programmable read-only-memory products and later became manager for PROM and PAL products. "Having mastered American English," he says jokingly, "I'm now taking on Japanese, so I can handle at least some of the day-to-day tasks with our staff of 60 people, most of whom don't speak English."

He took this job, he says, because it was his first chance to handle a total operation, "and because I'd be operating among some of the major semiconductor makers in the world." The only non-Japanese in MMI Japan, Donovan says that his familiarity with operations at the company's base in California is improving his operation's customer service, "because I know whom to call to get something done. One of my goals is to integrate my whole staff so that they can do the same thing."

When he's not studying Japanese, Donovan and his wife enjoy skiing and swimming. One of his early 1987 goals: to organize the first MMI Japan staff ski trip. *–Michael Berger*

IMPROVE YOUR MEMORY

New Infotek 8 and 4 MByte Memory Cards Give Lowest Cost per Byte for HP 200/300.



Now, get all the memory you need for the most complex programs—CAD, CAE—all on a single, compact card. And, at the same time, get the lowest cost per megabyte of memory on the market.

Infotek's new AM380 is the first 8 megabyte single-card memory available for HP 200/300 computers. It allows you to take advantage of the full storage capacity of your HP workstation without wasting valuable backplane space. ZIP packaging of 1 MByte monolithic DRAMs makes the low cost per byte possible.

For the many applications requiring 4 MBytes of memory, Infotek again uses 1 MByte DRAMs in single in-line packages to reduce costs. That means you can now have Infotek quality in the lowest-cost 4 MByte board available! Of course, Infotek's popular 1 MByte and 2 MByte memories are also available.

Memory for even the most complex CAD and CAE programs on a single board.

The literally famous reliability of Infotek memories is evidenced by our full two-year warranty. So improve your memory with state-of-the-art DRAM boards from Infotek. Call today to Infotek Systems, 1400 North Baxter Street, Anaheim, California 92806-1201, (714) 956-9300, (800) 227-0218, in California (800) 523-1682, TELEX: 182283.

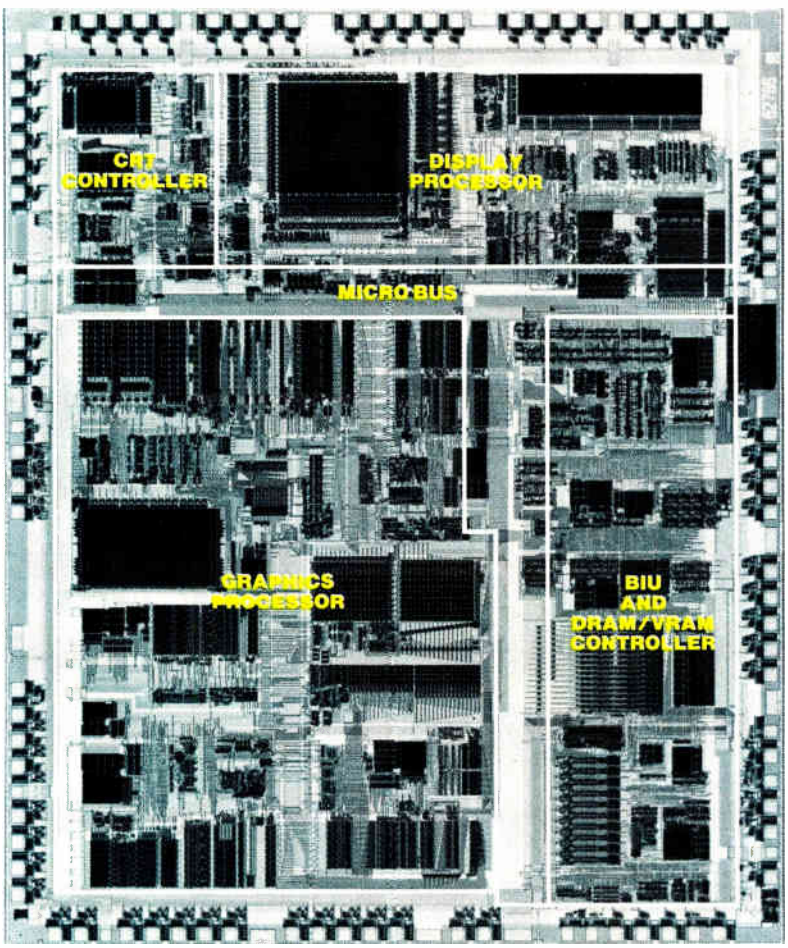
While you're at it, ask to receive our Infotek newsletter.

INFOTEK SYSTEMS
A DIVISION OF ALS CORPORATION

Your Second Right Decision.

Circle 21 on reader service card

DOES WINDOWS.



Intel's 82786 graphics coprocessor supports its family of 16- and 32-bit central processing units.

"Two completely different kinds of end customers seem to be fueling the embryonic graphics chip market: the personal computer user in business, and the designer on a work station. Intel Corp., long reported to be developing a graphics-oriented microprocessor, is finally announcing its 82786 graphics coprocessor for both applications.

Demand for multiple-windowing capability is on the rise, especially for multitasking chores in the office environment. The 82786 implements this capability in hardware. Each application can have its text and graphics drawn into separate regions of memory, which are then combined within windows of the same display. Large amounts of overhead associated with graphics tasks can be offloaded from the main system CPU by storing more text and graphics information in memory than is shown in the display..."

Excerpted from an exclusive article in the May 19, 1986 issue.

Electronics

THE LEADER IN NEW TECHNOLOGY COVERAGE

ELECTRONICS NEWSLETTER

A SHOWDOWN IS SHAPING UP ON WINDOWING STANDARDS

A storm is brewing over windowing standards for work stations, pitting IBM Corp. and others against Sun Microsystems Inc. and Intel Corp., which is owned in part by IBM. X Windows, a windowing and graphics software package developed in the public domain as part of the Athena project at the Massachussetts Institute of Technology, gained IBM support late last year when Big Blue announced that the package will be included in Andrew, an advanced distributed computing environment developed jointly by IBM and Carnegie Mellon University. Also supporting the package is BBN Advanced Computer Inc., which added X Windows as an enhancement to its Butterfly parallel computer in the fall. Meanwhile, Sun Microsystems, the work station company that in the past has been quick to back pending standards, is pushing to make its own windowing package a standard. The Sun Network extensible Window System (NeWS) won Intel's support for use on the Intel 80386 processor. Other major computer makers, including Hewlett-Packard, Digital Equipment Corp., and Apollo Computer Inc. are expected to cast their votes for a window standard in the next few weeks. □

WILL EQUIPMENT NEEDS LEAD TO A SHAKEOUT AMONG CHIP MAKERS?

What's good news for the makers of semiconductor production equipment may not be good news for all of their customers. The equipment industry will grow 8% in 1987 and a whopping 33% in 1988 to nearly $4.3 billion, according to industry forecasters. G. Dan Hutcheson, vice president of VLSI Research Inc., San Jose, Calif., says the 1988 spurt is inevitable, because current equipment will be obsolete by then. However, the price tags on next-generation production equipment may be too much for some struggling chipmakers—and a shakeout in the semiconductor industry could be the result, argues one observer. Dataquest Inc. president Manny Fernandez, who agrees with the VLSI Research projection, warns that the pressure to replace outmoded equipment will pose a serious problem for chipmakers, who have endured two devastating years and whose current capacity lies largely idle. "Not everyone will have the money to put in the next-generation fab equipment," Fernandez said at the recent forecast meeting of the Semiconductor Equipment and Materials Institute. He predicts a consolidation of the chip industry and more alliances between major manufacturers, such as the pending purchase of Fairchild Semiconductor Corp. by Fujitsu Ltd. and the agreement between Motorola Corp. and Toshiba Corp. that gives the U. S. company greater access to Japanese markets. □

FCC PROPOSAL TO REGULATE ENHANCED SERVICES STIRS A CONTROVERSY

Operators of value-added networks and users of computer bulletin boards are flooding the Federal Communications Commission with objections to a proposed rule change that would subject some enhanced packet-switching services to FCC or state regulation. Operators of value-added networks and their users fear that the change would classify their nets as interstate common carriers and force them to pay extra access charges to local carriers, such as the seven regional Bell operating companies. The proposed regulation could throttle some protocol enhancement services, such as X.25-to-asynchronous conversion, that have previously been unregulated. GTE Telenet, one of the largest value-added network companies, says regulating packet services could double or triple the costs of accessing on-line commercial data bases. Adapso, the Association of Data Processing Service Organizations, has formally opposed any change in the status of packet services and urged the FCC to keep present regulations in force. A final ruling is expected early this year. □

ELECTRONICS NEWSLETTER

DEC STUDY SHOWS SOME WORKERS FACE HIGHER RISK OF MISCARRIAGE

A study sponsored by Digital Equipment Corp. reports that production workers at DEC's Hudson, Mass., semiconductor plant face a significantly higher chance of miscarriage than other women. The study, conducted for DEC by the University of Massachusetts School of Public Health, found a miscarriage rate of 39% among women doing ion-implantation and diffusion work, compared with an average miscarriage rate of about 20% in the national population. Women involved with photolithography processes had miscarriage rates of 29%, but DEC says that departure from the national average is not statistically significant. Interviews with more than 80% of all production workers who have been employed at the facility also revealed a significantly higher-than-normal incidence of self-reported arthritis and diabetes and complaints of headaches, nausea, and sore throats. The two-year study found no evidence of other health risks. The Maynard, Mass., company has notified the Semiconductor Industry Association of the results, and the company says it will continue a long-standing policy allowing pregnant or concerned female employees to transfer to comparable nonproduction jobs. □

AT LAST, A SIZABLE U. S. SMART CARD EFFORT

The U. S. smart card business is about to get a shot in the arm. The Department of Agriculture will award a contract Jan. 9 for 100,000 wallet-sized plastic cards with built-in microprocessor and memory circuits, and 1,000 readers. The cards will be used by peanut farmers for marketing their products as part of a program [*Electronics*, Oct. 21, 1985, p. 26] managed by Applied Systems Institute Inc., a Washington-based software firm. The peanut market was chosen for its complexity: the goobers are sold through 577 private buying points. If this program works, the Agriculture Department may extend it to other, larger agricultural industries, including tobacco. □

FORD MICROELECTRONICS PLANS SECOND SOURCE IN GaAs LSI...

Ford Microelectronics Inc. is hoping to use a second-source pact with a West Coast gallium-arsenide chip maker to infuse life into the sluggish market for commercial GaAs devices. The company is expected to announce a deal next week covering foundry services for custom large-scale integrated circuits based on enhancement-/depletion-mode GaAs technology—believed by some to be the industry's first second-source arrangement for commercial GaAs LSI chips. Officials with Ford Microelectronics in Colorado Springs admit that an agreement is pending, but won't identify the partner. Ford almost sold off its GaAs fabrication line six months ago, but this deal signifies its renewed commitment to become a major factor in the slowly developing commercial markets for GaAs integrated circuits. □

...AS THE GaAs CHIP INDUSTRY SUFFERS GROWING PAINS

While Ford Microelectronics is showing renewed vigor in its gallium-arsenide venture, Honeywell Inc.'s decision to drop the technology [*Electronics*, Dec. 18, 1986, p. 21] may be the beginning of a new trend. According to Robert Castellano, an analyst with The Information Network, a San Francisco market researcher, cutbacks in military investment in GaAs have hurt some suppliers, while others have been harmed by a weak market for home satellite dishes, heavy users of analog GaAs ICs. Many cable TV carriers now scramble signals to fight air-wave piracy, causing sales of dishes to tumble. Some early estimates proclaimed the GaAs market would be worth billions of dollars by 1990, but Castellano says worldwide sales of all GaAs chips will reach only $188 million by the end of this year. □

TO PLUG IN THOUSANDS OF COLORS, FOLLOW OUR LEAD.

INMOS has taken the lead in video display enhancement. Our IMSG170, IMSG171 and IMSG172 Color Look-Up Tables let you and your RGB analog display plug in a palette of more than a quarter million colors. And we're already setting the standard with major industry leaders designing our tables into their systems.

Our programmable DAC conforms to RS170A standards with pixel rates up to 50MHz in the IMSG170 and 80MHz in the IMSG171 and IMSG172. The new IMSG171 also features a read-back path for content verification.

The IMSG170 family gives you high quality images by integrating a 256 word x 18 bit color-mapping table with three 6-bit DACs, 75Ω drivers and micro-processor interface. And it's all on a monolithic CMOS device for reduced board space and power consumption, lower costs and design ease.

Plug in the INMOS Color Look-Up Table and view your system in a whole new color.

COLOR LOOK-UP TABLE

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Take Image Processing and Data Acquisition to MACH speed on the IBM PC with our new Array Processor.

Fasten your seat belts! Our IBM PC array processing board and software fly! And they're completely backwards compatible with our Image Processing (frame grabber) and Data Acquisition (A/D, D/A) boards and software.

Our MACH Series DT7010 Floating-Point Array Processor is general-purpose, and performs IEEE 32-bit floating-point arithmetic at 6.5 Mflops. The DT7010 is particularly good at crunching data acquired by a Data Translation frame grabber or A/D board.

And with our MACH Series software, you don't have to program the board. The MACH Vector Subroutine Library contains 118 general-purpose subroutines for digital image processing/signal processing, and vector/matrix operations. Our MACH Assembler and MACH Simulator ease writing custom algorithms.

So hold on to your hat, and call us, at (617) 481-3700. The age of supersonic, desktop Image Processing and Data Acquisition is flying.

Fred Molinari, President

To learn more, see us in Gold Book 1987, or call to receive our first-ever 1987 3-Book Set, including 1987 Catalog, Product Summary Price List, and Applications Handbook.

Call (617) 481-3700

MACH SERIES SUMMARY

Hardware					Software
Array Processing Board	FFT* 1024 Point Real	FFT* 1024 Point Complex	FFT* 256 x 256 Image	Price	
DT7010 Floating-Point Array Processor	30ms	50ms	4.6s	$4995	

*All execution speeds are real-world, not theoretical, and include overhead times.

Software	
MACH Vector Subroutine Library	.....for end-users ($1495)
MACH Microcode Assembler And Simulator	.....for algorithm developers ($1495)
MACH Library, Assembler And Simulator	.....($2495)

DATA TRANSLATION

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European Headquarters: Data Translation, Ltd., 13 The Business Centre, Molly Millars Lane, Wokingham Berks, RG112QZ, England Tlx 851849862 (#D)
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PRODUCTS NEWSLETTER

NEC GRAPHICS CHIP USES FIRMWARE FOR COLOR FILL-IN

Work stations and high-end personal computers are the targets of a NEC Corp. advanced-graphics controller chip that uses firmware instead of software for graphic-pattern generation, data transfer, and color fill-in functions. A preprocessor on board the μPD72120 works in parallel with the chip's graphic-pattern-generation processor to achieve high-speed operation. NEC engineers claim the μPD72120 is among the first graphics-controller chips to incorporate data transfer and color fill-in functions on chip. Its system interface is a data bus of either 8 or 16 bits plus a 20-bit address bus, and the display-memory interface is a 16-bit data bus and a 24-bit address bus, for a total address space of 32 megabytes. Although designed to run with Intel Corp. processors, the μPD72120 has glue logic that permits the controller to be used with other processors. The Japanese company will start shipping the μPD72120 in April at a sample price of about $123. □

CONTROLLER CHIP SPEEDS PRINTERS' REACTION TIMES

A 16-bit microcontroller from Siemens AG improves the reaction time of high-resolution matrix printers and printer terminals by at least an order of magnitude while simultaneously processing up to eight tasks, ranging from paper transport, forward and backward printing, and line spacing to keyboard interrogation. The SAB 80199 boasts an instruction cycle of 0.5 μs. Its multifunction unit eliminates the need for peripheral components such as an interrupt controller, a multiple counter, and the controller for serial data transfer. The 40-pin device integrates 40,000 transistor functions on a 45-mm² chip. Available now, the 80199 sells for about $30 each in 500-unit lots. The price drops to $20 in 10,000-unit lots. □

EMULATOR TURNS EPSON PRINTERS INTO IBM EQUIVALENTS

Avatar Technologies Inc.'s $695 plug-in emulation module transforms Epson FX, RX, EX, and LQ printers into the equivalents of IBM Corp. 3270 printers to reap significant savings in equipment costs. The 4-by-4.75-in. Ep-87 Coax Adapter converts IBM control and character codes into ASCII. It attaches to IBM 3270 mainframes via an IBM 3274 or 3276 cluster control unit and is compatible with IBM's Systems Network Architecture and BSC communications protocols. According to the Hopkinton, Mass., company, the Ep-87 incorporates many of the features of Avatar's larger PA1500 protocol converter for IBM 3270 emulation. But programmers can still take full advantage of Epson printer functions such as dot-addressable graphics, alternate character sets, and bar code generation. Using an Epson printer with an Ep-87 adapter board that will become available in February can result in savings of up to 75% over IBM printers, Avatar says. □

DIODES COMBINE FAST RECOVERY TIMES WITH HIGH BLOCKING POWER

Two new fast-recovery diodes from International Rectifier Corp. combine the quick response of Schottky diodes with the high voltage-blocking capability of p-n diodes, the El Segundo, Calif., company says. The 30-ns 11DF and the 35-ns 31DF can handle reverse voltages from 100 to 200 V, with forward currents of 1 and 3 A. Typically, p-n diodes rated for comparable blocking voltage and current have recovery times on the order of 100 to 200 ns. Schottky diodes provide recovery times comparable to the 11DF's and 31DF's but top out at a blocking voltage of 100 V. The 11DF and 31DF are intended for applications such as switching power supplies and inverters. Both devices are in axial-lead packages. The price, in 100-piece quantities, is 60¢ for the 11DF and 68¢ for the 31DF. □

PRODUCTS NEWSLETTER

WANG MINICOMPUTERS GET UNIX CAPABILITY

Add Wang Laboratories Inc. to the list of companies offering Unix on minicomputers for business applications. The Lowell, Mass., company's VS IN/ix, which is a derivative of AT&T Co.'s Unix System V, resides along with Wang's proprietary VS operating system on Wang minicomputers. Users can move between operating systems with a single keystroke, and utilities allow file transfer between environments. VS IN/ix supports as many as 64 users on Wang VS 85 and VS 100 systems. Wang will license the option at $15,000 for 16 users, $24,000 for 32 users, and $33,000 for 64 users. □

MOSTEK CACHE-TAG SRAM HANDLES FAST PROCESSORS

Thomson Components-Mostek Corp. has fabricated a cache-tag static random-access memory fast enough to be used with the new breed of processors, that run at 16 to 25 MHz. Mostek added a 4-bit comparator to a fast 4-K-by-4-bit SRAM to achieve the cache-tag MK-41H80 with access speeds as low as 20 ns. The 22-pin chip can determine a cache hit—determining if the data being sought is already in its memory space—30% faster than discrete implementations of cache-tag design using separate SRAM and comparator components, says the Carrollton, Texas, company. The 1.2-μm CMOS MK41H80 is slated for introduction later this month. □

MULTIPLEXER FROM EMULUX DOUBLES MICROVAX TERMINAL INTERFACES

An asynchronous multiplexer from Emulux Corp. lets the Digital Equipment Corp. MicroVAX II and other Q-bus systems interface with twice as many terminals as is possible with DEC's DHV11 asynchronous multiplexers—eight lines to the DHV11's four. The CS08's single-board configuration makes the increase possible by better utilizing the MicroVAX's bus-interface slots, says the Costa Mesa, Calif., company. The dual-width board makes possible RS-232-C connections to most existing asynchronous terminals. It costs $1,000 without modem control and $1,200 with modem control. It will be available in mid-March. □

SOFTWARE CUTS IBM PC NETWORKING TO $100 PER CONNECTION

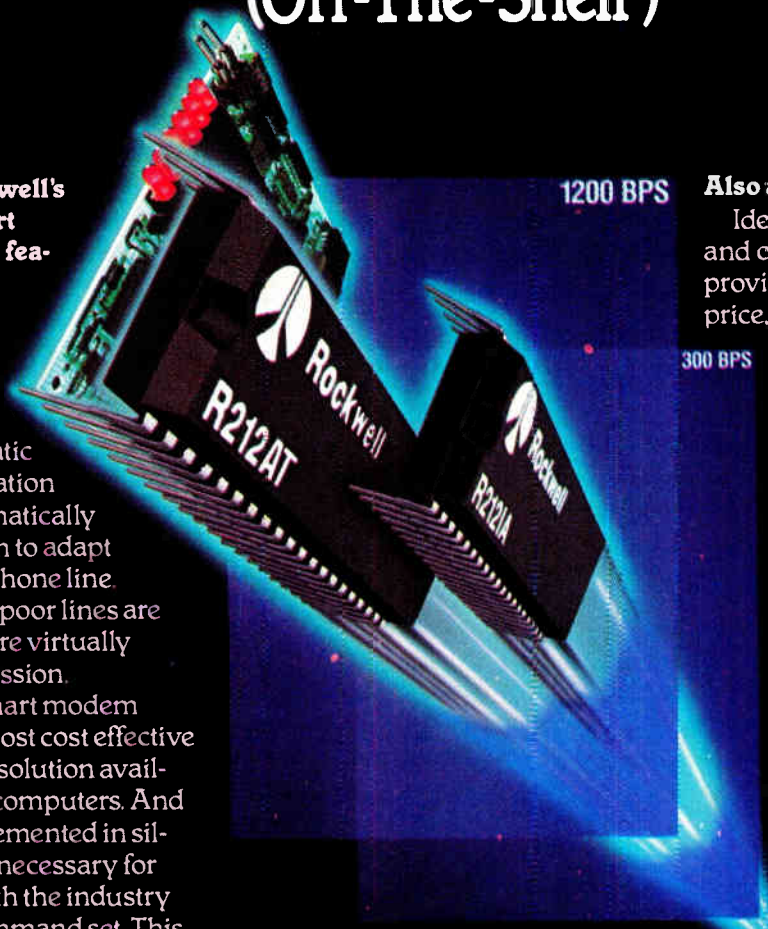
Server Technology Inc. has slashed the cost of network software for IBM Corp. Personal Computers, PC XTs, PC ATs, and compatibles to $100 per connection with its EasyLAN Version 3.0. Users can run applications programs written to IBM's Netbios standard over low-cost RS-232-C serial communications links, as well as develop their own Netbios-compatible applications, says the Sunnyvale, Calif., company. EasyLAN also lets as many as 20 PCs share network resources, such as laser printers. Available now, EasyLAN 3.0 is priced at $99.95 for single copies. Users of EasyLAN 2.0 can upgrade to the 3.0 version for $25. □

ZYCAD SIMULATOR HANDLES 1.1 BILLION EVENTS PER SECOND

Zycad Corp.'s System Development Engine (SDE) runs logic simulations on up to 1.1 million modeling elements at a blazing 1.1 billion events/s—80 times faster than the company's Logic Evaluator model LE-1032. That speed makes it feasible to run software on a simulated hardware system, and therefore slash a year or more off the three to four years required to develop large computer systems, says the Minneapolis company. A full-blown SDE-8032 will sell for $2.5 million. The SDE-8016 will offer 500-million-event/s performance on up to 512,000 modeling elements for a price of $1.7 million. Zycad plans to ship its first SDE system in February. □

ROCKWELL SEMICONDUCTOR TECHNOLOGY DELIVERS 1200 BPS AT 300 BPS PRICES.

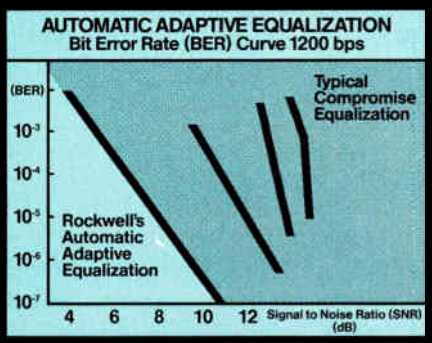
(Off-The-Shelf)



Introducing Rockwell's new R212AT smart modem device set featuring Automatic Adaptive Equalization.

Rockwell International's exclusive Automatic Adaptive Equalization Algorithms automatically enable the modem to adapt to any quality of phone line. Even signals over poor lines are enhanced to ensure virtually error-free transmission.

The R212AT smart modem device set is the most cost effective communications solution available for personal computers. And R212AT has implemented in silicon the software necessary for compatability with the industry standard "AT" command set. This allows quick design-in because we've presolved all the "AT" dialing functions. It incorporates auto dial, auto answer and can dial DTMF tones or pulses.



The R212AT smart modem offers lower system cost because it incorporates the controller and analog filter circuitry required for modem communications in the device set itself. This reduces parts count, enhances total system reliability and meets low power requirements for portable applications.

As well as operating asynchronously, the R212AT has synchronous mode operation for higher transmission throughput.

Also available: Rockwell's R212DP.

Ideal for remote diagnostics and other integral applications, it provides specific advantages in price, performance and system cost savings.

The R212DP, like the R212AT, has automatic fall back to slower speeds and an RS232C interface. Both these Bell 212A and 103 compatible device sets are available at any level of integration from devices to boards or customized private label systems.

For ease of evaluation, Rockwell provides a board level evaluation modem for laboratory analysis to assure the performance and quality of R212AT and R212DP.

Call your local Rockwell distributor today for off-the-shelf delivery of an evaluation board complete with a Designer's Guide Kit.

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Circle 29 on reader service card

To know the environment of your power source is the first step to noise countermeasures

NDR-544 has broadened the power line monitoring range.

Only by connecting the unit to a power line (single phase or 3-phase, AC/DC line), you can obtain accurate data on the power line such as voltage fluctuation, frequency fluctuation and superimposed impulse noise. In addition, the unit catches an abnormal value beyond the threshold and prints data on such an abnormal state.... "When the abnormal value occured", "How long it continued" and "Fluctuation value". The NDR-544 is the latest model with upgraded measuring functions designed to extensively monitor various power line disturbances. You can immediately check and monitor the environmental conditions of electronic devices before installing them and can also clear up the cause of troubles.

Features

- AC voltage fluctuations of single phase and 3-phase can be monitored.
- ON-OFF at 4 places other than power line can be monitored. (Event function)
- Time at which abnormal state occurs and recovers is printed at a unit of 1/100 second or more.
- Editing function enables user to obtain the whole day's accumulated data.
- Clock, threshold and measurement data are backed up by battery.

Main specifications

- Voltage fluctuation measuring range : 600 V AC max.
  Two ranges; 0~±10V DC, 0~±100V DC
- Frequency fluctuation measuring range : 45.0~65.0 Hz
- Impulse voltage measuring range : ±2500 V (Simultaneous monitoring of positive and negative)

NOISE
NOISE LABORATORY CO., LTD.

The harmony of reliability

2662-1, NOBORITO, TAMA-KU, KAWASAKI CITY, KANAGAWA PREF. 214 JAPAN Tel : (044)933-4311
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Circle 30 on reader service card

Electronics

EVERYMAN'S LAN: FAST, EASY TO INSTALL, AFFORDABLE

1-Mb/s TOKENSTAR USES PHONE LINES, COSTS $130 PER CONNECTION

WESTLAKE VILLAGE, CALIF.

A young California company has come up with what might be called everyman's network for personal computers, one with the speed and power of bigger and more costly ones. Tokenstar, from Telegence Corp. of Westlake Village, moves data at 1 Mb/s, works simultaneously with voice traffic over telephone lines—and costs as little as $130 per connection.

Tokenstar is an expandable and reconfigurable add-on to existing computers, terminals, and telephone systems. It uses existing telephone lines for data transmission and can be extended by connecting modems to it.

Two other local-network products that also do not involve rewiring a building, EasyLAN and GridNet, have been on the market, but they are both considerably slower than Tokenstar. EasyLAN, introduced by Server Technology Inc. in July 1985, runs at 19.2 or 56 kb/s, depending on which personal computer it is connected to [see p. 28]. GridNet, offered since last February by GridComm Inc., carries data at 23 kb/s [*Electronics*, Feb. 17, 1986, p. 21].

HIGH SPEED. Tokenstar—with aggregate throughput well above 10 Mb/s—can match the performance of such local nets as Ethernet and the IBM Token Ring. It gets its speed by buffering 1-Mb/s data into packets and shipping each packet out at radio frequencies. But because there are multiple packets and connections, the effective throughput can be more than 1 Mb/s.

Neither of the other two systems uses phone lines directly for short-distance transmission. EasyLAN moves data via special cables connected to the RS-232-C serial ports on personal computers when the machines are in the same or adjacent rooms, through modems and over voice lines when they are farther apart, or on digital voice-and-data private branch exchanges. The GridNet network uses a building's electrical wiring.

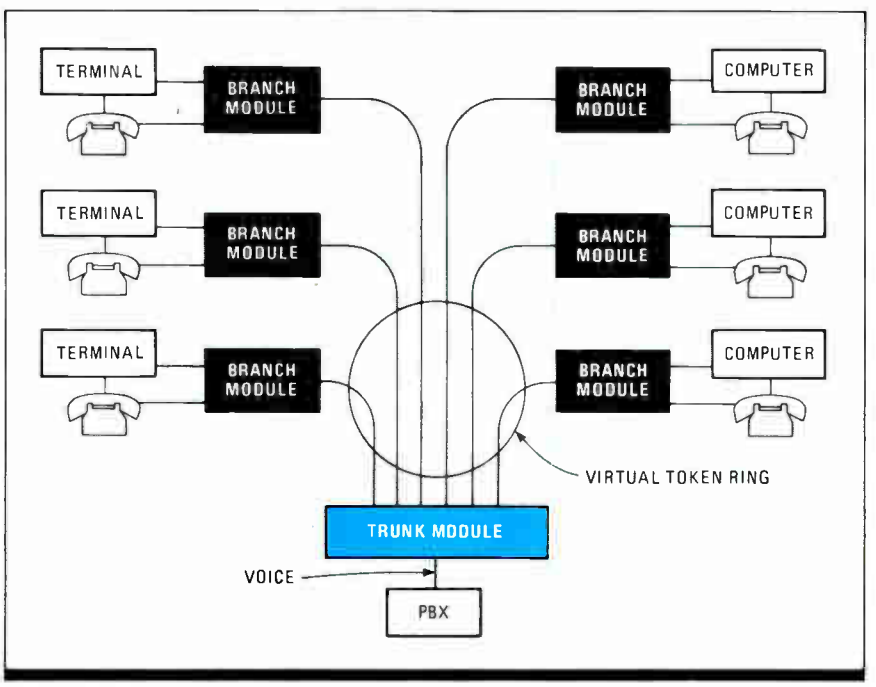
Analyst Will C. Felling, vice president of Dataquest Inc. in San Jose, Calif., says Tokenstar's strongest features are its technology—there is no single point of failure—and its economy, because it offers linear growth with linear cost. Telegence maintains also that the new system could render expensive voice-and-data digital PBXs obsolete, not only because it can easily piggyback on telephone wires, but also because it does not require the PBX's switch for routing. In addition, it costs 25% to 50% less, and it has no effect on voice traffic carried simultaneously on the same lines.

To install Tokenstar, a network interface box about the size of a book is placed under the telephone or near a computer or terminal. The box is plugged into the telephone outlet, and the telephone is plugged into the box. Another connector on the box accepts a standard RS-232-C cable from the computer or terminal.

Connecting work stations to the EasyLAN and GridNet networks is just as easy. The only hardware EasyLAN requires is the RS-232-C cable to connect to the personal computers. When more than two nodes are in the network, one personal computer, a hub machine, must have an RS-232-C port for each of the other computers on the network. With GridNet, a two-box communicator—consisting of a wall-mounted power supply and line interface and one of three types of desktop processors—is hooked up for each station.

The Tokenstar network-interface box adds data-signal packets with their destination headers to the telephone line—without interfering with voice signals, since the signals are at radio frequencies that cannot be heard by voice users. Users can hold telephone conversations without interrupting data traffic, and can place and hold multiple data calls and communicate with devices that operate at different speeds.

The only other equipment needed for a Tokenstar network is a token hub—another box, installed in a telephone closet. The hub separates the voice and data signals, broadcasts the incoming data signals to all lines going out of the closet, and sends the voice signals to the central switch. Tokenstar is physically configured as a star network, with each node directly connected to the hub, but the hub operates the net as a virtual token ring. *–Tom Manuel*



A BIT OF BOTH. Tokenstar is configured as a star network but operates as a virtual token ring.

HOW TO BOOST AN IBM PC TO 4 MIPS

PALO ALTO, CALIF.

A whole new generation of computers based on 32-bit microprocessors promises performance up to 4 million instructions per second. But if it's sheer mips you're interested in, there's no need to invest in a 32-bit machine. A board now available from Silicon Composers, a tiny Palo Alto startup, plugs directly into any 16-bit IBM Corp. Personal Computer or compatible and easily delivers upward of 4 mips.

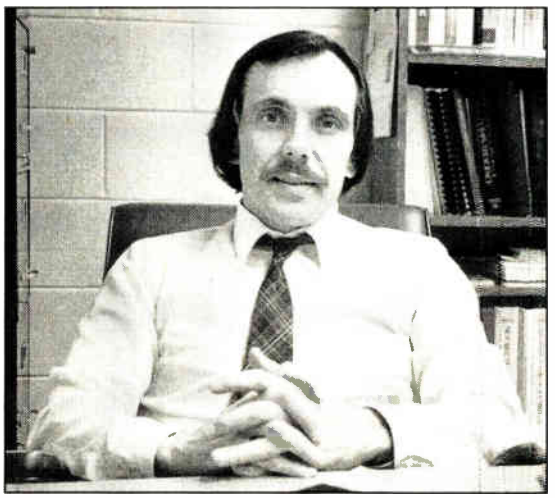
There's one catch: at present, it has to be programmed in Forth, a nonprocedural language used mostly used in real-time control applications that are not normally the business of a PC.

Silicon Composers' PC4000 board incorporates the 16-bit NC4000 chip from Novix Inc., which directly executes Forth instructions. It is the latest and perhaps the most ambitious of a cluster of new offerings based on the chip. And with this increased interest in Forth implementations come efforts to loosen the strictures of the language itself. Interest is growing in applications for the chip that range from graphics to artificial intelligence.

GUARANTEED. Novix, of Cupertino, Calif., claims 10-mips performance for its chip [*Electronics*, Aug. 19, 1985, p. 41]. However, George Nicol, founder of Silicon Composers and designer of the new board, de-rates the chip performance in order to make his own guarantees of board performance.

"The chip is designed to run at 8 MHz," Nicol explains. "Naturally, that's a matter of yield, and not all chips hit that rate. I buy chips guaranteed at 6 MHz, test them at 5 MHz, and guarantee 4 MHz on the board." Because the chip can execute as many as five Forth instructions in a single cycle, Nicol says, the board can easily deliver 4 to 5 mips.

The $995 board is the second Silicon Composers product built around the Novix chip; the first was a standalone computer. And a number of other products are fast emerging from other companies. Last fall VME Inc. of neighboring Milpitas, Calif., mated the Forth processor with 128-K bytes of dual-port static random-access memory, a 68230 input/output chip, and a 24-bit counter/timer. VME sales director Ben Castricone says the company's V4000 board, which plugs into a VMEbus, executes 5 to 20 times faster than the Motorola 68020, the Intel 80386, or the VAX 11/780.



NICOL. Silicon Composers' founder says easy-to-learn Forth will find new jobs in AI and even in the office.

In addition, Harris Semiconductor Corp. of Melbourne, Fla., has put the Novix design into its standard-cell library. Novix itself offers the processor with on-board RAM and read-only memory in a "Tiny Turbo" package similar to Silicon Composers' PC4000. And Charles H. Moore, the inventor of the Forth language, has developed a board that incorporates 50-ns SRAMs for graphics applications. Moore says the chip is so fast that his software can switch from one image to another in a single frame.

"It's all beginning to gather steam," says Novix's ebullient president, John Peers. "We have shipped over a thousand chips, and we have 150 development systems out."

Novix has long maintained that putting a high-level language in silicon offers unprecedented speed advantages. The original Novix chip achieved 10 mips despite being fabricated in 3-μm CMOS (by Mostek Corp., of Carrollton, Texas). An upgrade to 2-μm design rules promises 9-MHz nominal clock speed and 13 or 14 mips, Peers says. And the company hints at an upcoming 32-bit version of the chip, fabricated in 1.2-μm CMOS, that will increase performance further and overcome the memory-address limitations of a 16-bit chip.

Even the Forth restrictions will soon be loosened. Silicon Composers already offers a Delta C compiler for its board, which enables users to write in "Small C," a subset of the C programming language, and then compile the program to run in Forth. A full implementation of C is promised for this year, and Prolog and Basic compilers are in the works.

NO LIMIT. "We are not limited by Forth," Peers says. "Compilers are easy to write and we have people considering implementations in Lisp and Logo. What we really have is a 2-stack, 2-pointer, 4-space machine. We can get at four 16-bit chunks of memory in a single clock." Also, he says, "since the clock is not on chip, it is essentially asynchronous, which means that the chip will run at any speed from dc to the full rate and will execute on whatever data is available when the clock does tick."

But don't underestimate Forth, says Nicol: it's a powerful tool for new applications in AI and even in the office. "Forth is a high-level language with low-level access to the hardware," he says. "It's easy to learn and easy to debug."

Nicol sees real-time expert systems, in which the system actually controls the process it is monitoring instead of simply giving advice, as a prime application for his product. Forth Inc., of Hermosa Beach, Calif., the software company that is the leading supplier of Forth products, has such an expert system that will run on the Silicon Composers board as soon as its PolyForth language can be adapted to the chip. The system makes inferences based on fuzzy logic and is capable of 25,000 logical inferences/second. Besides AI, Nicol says, the Forth board is

SPANNING THE APPLE II–IBM PC GAP

A board under development by a group of ex-Apple Computer designers promises to bridge the gap between Apple II products and the IBM Corp. Personal Computer. The board will plug into an Apple II+, IIe, or IIGS and will run most MS-DOS software. It has already been successfully tested on Lotus 1-2-3, Symphony, Sidekick, and Flight Simulator.

The board is being jointly developed by The Engineering Department Inc., Campbell, Calif., whose designers formerly worked on several Apple computers and software systems, and Applied Engineering, a Carrollton, Texas, company that is the largest supplier of peripherals for Apples. Promised for the second quarter of this year, the board will run 99% of all IBM software and will recognize all of the standard Apple peripherals. A proprietary controller will support both Apple and IBM disk drives. *–Clifford Barney*

ideal for business applications like spreadsheets and spelling checkers.

The only drawback, according to Nicol and VME Inc.'s Castricone, is the lack of a second source for the Novix chip. Novix suggests that the Harris cell offers one escape route for anxious customers. Forth inventor Moore, who has a license from Novix to develop his own chip, notes that customers could buy directly from Mostek—if there were enough demand to justify production.

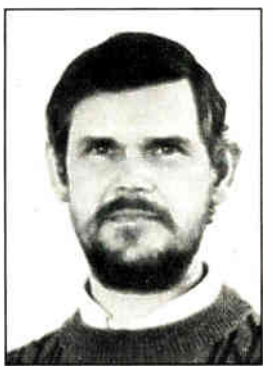
Peers isn't worried. "We are in discussion with major international players," he says. "British Telecom wants to put Forth on the STE bus [the European version of the STD bus], and they are just one example of many. The U. S. Department of Energy has ordered seven systems. There are applications in communications, graphics, and AI. And we still haven't reached the submicron geometries where the chip can be even more powerful." *–Clifford Barney*

ASICS

A QUEST FOR STANDARD ASIC TESTS ON THE WAFER

MARINA DEL REY, CALIF.

A trail-blazing research program will try to develop test tools and procedures for defining the reliability of application-specific integrated circuits. Funded for two years at $2.6 million by the Pentagon's Defense Advanced Research Projects Agency, the program will be run by the University of Southern California's Information Sciences Institute in Marina del Rey, Calif.



TYREE. Out to judge ASIC reliability at the wafer level.

The effort was launched this month by Mosis (for MOS Implementation System), the VLSI prototyping service that is part of the institute [*Electronics*, March 3, 1986, p. 48]. Its task will be complex. The nature of the beast—ASICs have small production runs of diverse designs—makes it impossible to compile the vast statistical base that supports the projections for standard parts. And Mosis researchers and their counterparts in industry know that they can't simply gather facts from accelerated testing and burn-in of sample ASICs. Instead, they must devise a great number of test structures that will be fabricated directly on a semiconductor wafer from which to statistically predict reliability data.

"The use of custom single applications is growing, so reliability can't be based on long-term evaluation of a product. It has to be evaluated at the wafer level, if possible," explains Vance C. Tyree, the Mosis staff member who leads the program. "That's the thrust of our effort."

Tyree notes that most chip fabricators have something like this already, but on a limited scale and tied to a specific process. The Mosis program will use data from 16 manufacturers—among them Harris, Hewlett-Packard, and National Semiconductor—but will pick up where they leave off, greatly expanding their scope and producing test procedures that are vendor independent, along the lines of standard design rules.

The researchers face a daunting schedule in the three-phase program. First, they will spend six months creating the test structures. Industry experts consider this a very tough task in itself, since few chip or research houses have been successful at it so far.

Tyree calls the test structures "wafer-level wear-out mechanisms" that deal with six common causes of failure. These are time-dependent dielectric breakdown; metal and contact electromigration; hot-carrier effects; ion drift; junction and metal-insulator instability; and total-dose radiation hardness of oxides.

The challenge is compounded by the fact that Mosis will use two types of standard tests and correlate the results. One, the so-called classic technique, is used on standard ICs, so it is better documented. But it can require hours or even days to perform. The other, or rapid, technique is more in tune with the ASIC pace, since the tests only need to run for minutes or seconds. The researchers will also come up with a standard cell-based circuit for accelerated burn-in testing of functional parts.

In the second step, which will take a year, Mosis will collect statistics from the test structures with a data-base-management system that can track all the measurements. Most of the measurements will come from nine of Mosis's own wafer runs, three through each of its vendor foundries.

Finally, in phase three, Mosis will apply the findings to real-world applications. "That's the proof of the pudding," Tyree says.

Companies taking part in the Mosis research program agree that it has much to offer. One of the first to sign up was National Semiconductor Corp. of Santa Clara, Calif. W. Joseph Byrne, manager of worldwide failure analysis, says he is an enthusiastic supporter. "From my perspective, we're looking for new tools to get zero defects on each wafer," he says. He agrees that on-wafer assessment of reliability is the key with the new generation of ICs. And he's in a hurry: he says that the only drawback of the Mosis effort is "it's new and takes time to develop."

Tyree says that Mosis has been working toward such a program for some time but made little headway until recently, because manufacturers were reluctant to release data. "Reliability is a very touchy issue," he says, and no supplier wants to be embarrassed.

But by dealing with many device fabricators and customers, Mosis is establishing a reputation as a neutral player. Companies that would be uneasy dealing directly with each other are comfortable with Mosis playing a central role "because we have no axes to grind," says Tyree. *–Larry Waller*

TELEVISION

U.S. BROADCASTERS SEEK AN ENTREE TO HDTV

NEW YORK

The National Association of Broadcasters is demonstrating a high-definition TV system in Washington this month. The NAB sees the demonstration as the first step in a campaign to launch its member TV stations into the HDTV era.

The NAB must convince the Federal Communications Commission to relax its rules and give terrestrial broadcasters the extra bandwidth they'll need to be in the HDTV game. Already, major Japanese TV manufacturers—among them Hitachi, NEC Home Electronics, and Sharp—are gearing up to produce higher-resolution receivers in the next year or two, though HDTV is further away.

As things stand now, HDTV is bad news to the 1,200 U. S. terrestrial broadcasters. Because satellite and cable companies have no bandwidth problems, NAB members are running scared. HDTV has more than double the picture

resolution of conventional NTSC (National Television Standards Committee) standards, and its dimensions are more like those of a wide-screen motion picture. It requires a totally new format using more bandwidth than NAB members can get their hands on—at least 50% more bandwidth than the current standard specifies.

"What's concerning broadcasters is that HDTV is incompatible with our present system," says E. Ben Crutchfield, project director for HDTV at the NAB in Washington. "Because of the limitations imposed by regulation [just 4.2 MHz of transmission bandwidth, plus a 1.8-MHz guard-band to neighboring channels], there's no way we can deliver HDTV," which requires a minimum of about 8 MHz.

USING TWO CHANNELS. The NAB, in conjunction with the Association of Maximum Service Telecasters, is broadcasting the HDTV demonstration on its own WWHD-TV in Washington, using the combined bandwidth on UHF channels 58 and 59 to transmit its signal to a few receivers in the area. Equipment has been borrowed from manufacturers and from NHK (Japan Broadcasting), which developed and has demonstrated the 1,125-line system the NAB will test first. This month's tests will be performed before committees of Congress, the FCC, and others. The dates have not yet been set.

Called MUSE, for Multiple Sub-Nyquist Sampling Encoding, NHK's system was developed for satellite broadcast. NHK's demonstration used frequency modulation; to save bandwidth, the NAB demonstration will use amplitude modulation.

Japan plans two stages of improvements before adopting HDTV

As the NAB investigates HDTV, the Japanese are pursuing their own strategy, one that involves two intermediate stages before final conversion of today's 525-line standard to NHK's HDTV. The first is improved-definition TV—which is what manufacturers are working on now and hope to produce within the next year or two—followed by enhanced-definition TV.

Improved-definition TV, compatible with today's sets, provides picture-quality improvement rather than mainly added functions, such as picture-in-picture or multiwindow displays. It promises improved vertical and oblique resolution, cleaner color, no interline flicker or dot crawl, and enhanced outlines. Vertical resolution is improved by converting the display from an interlaced to a noninterlaced mode. The present NTSC standard has 30 frames a second, each consisting of two interlaced 262.5-line fields that use alternate lines of the full frame. But with improved-definition TV, the lines are interpolated to provide 60 noninterlaced frames, each having the full number of lines.

Enhanced-definition TV is a cooperative project of the Japanese Ministry of Posts and Telecommunications, manufacturers, and broadcasters to develop an upward-compatible standard that would squeeze more information and ghost cancellation into the same channels now used for NTSC broadcasts. Compatible with improved-definition TV, it would enhance reception on specially designed sets and offer standard reception on today's TVs. *–Tobias Naegele*

PACKAGING

NEW LEAD SCHEME SAVES BOARD SPACE

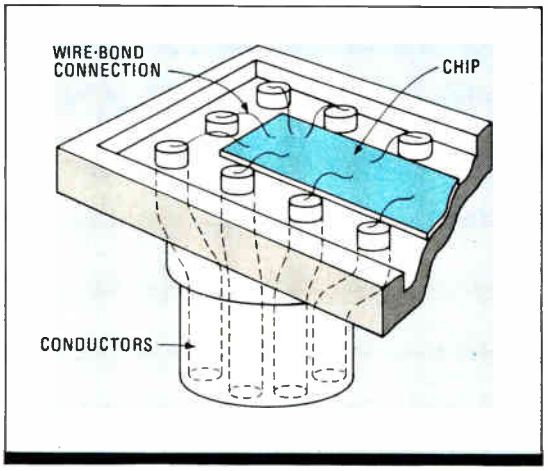
NEW YORK

An innovative mechanical engineer has broken the mold for IC packages and come up with a versatile technique that breathes air into the cramped confines of the printed-circuit board. The difference is in handling leads: in conventional packages, leads protrude from the sides in a square or rectangular pattern; in the new one, called a multiconductive base-form package, they run through columns that extend from the package bottom. Removing the leads from the sides of the package means that packages may be abutted and that there is more room on the pc board for wiring.

The developer of the technique, Sam Goldfarb, president of Mechanical Consulting Co. of Roslyn, N. Y., says his design can be used for plastic or ceramic packages. Goldfarb expects plastic units to be introduced first and adds that they can be produced with standard fabrication processes. He is searching for electronics firms to turn out the first prototypes, though the current slump is not helping his efforts to get financial backing.

On the package, each column, or form, has conductive lead segments, either pins or printed-circuit conductors, running longitudinally through the housing to the upper body. Each lead segment terminates in a post or pad in the upper body that is wire-bonded to a chip's input/output pads.

The butting feature is a key advantage in Goldfarb's package scheme. In a hypothetical situation with this approach, 15 butted packages with 16 leads each, arranged in a five-by-three pattern, would take up only 0.9 in.^{2}. Only two or three DIPs or eight small chip carriers would eat up the same space.



PILLARS. Leads extend through columns rather than from edges, using less room and allowing packages to be butted.

Also, unlike fine-pitch peripheral packages, such as chip carriers and flat packs, there is pc-board space available between the forms for additional wiring. This means a denser wiring interconnection than with peripheral packages and their tightly spaced leads or pads.

One of the first package families, for 16-pin ICs, would be 0.195 in. wide by 0.295 in. long—a footprint of 0.06 in.^{2}. A conventional 16-pin dual in-line package (0.7 by 0.3 in.) requires 0.28 in.^{2} of space. The new package would have two forms 75 mils in diameter, 150 mils apart, each with 8 conductors on a 30-mil pitch.

But Goldfarb isn't stopping with 16 pins. One of his designs measures 0.45 in. by 0.60 in. and has 10 forms—equal to an 80-pin package with a 0.270-in.^{2} footprint. An equivalent leadless ceramic chip carrier with a 50-mil pitch and 84 I/O pads has a 1.32-in.^{2} footprint.

Another of the new package's virtues is its versatility. Forms can be surface-mounted or through-the-board mounted, and wave- or reflow-soldered. Since the forms raise the package above the board, leads and solder joints can be inspected easily. And in its 14- and 16-pin versions, only two holes per package are needed, simplifying the board-making process. *–Jerry Lyman*

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SOLID STATE

WILL SOS CUT A WIDER SWATH IN SPACE?

SOMERVILLE, N. J.

The GE/RCA Solid State Division is showing renewed interest in its jewel, silicon-on-sapphire. The technology was a failure in commercial markets, but it survived in the military arena for the same reason it could now be gaining some luster for new space-based applications: the technology is inherently immune to certain kinds of radiation, making it ideal for use in many aerospace and military systems.

Spurred by rising investment in satellites and other space-based systems, GE/RCA Solid State is planning an ambitious new series of SOS products, beginning with a 16-K-by-1-bit static random-access memory that's going into the Milstar satellite program. One of the densest SOS chips ever, with nearly 100,000 transistors, the 16-K SRAM will be followed in short order by a family of gate arrays, a 64-K SRAM, and, eventually, a family of standard cells.

A confluence of factors has sparked renewed interest in SOS, says Jack Handen, manager of government and high-reliability integrated-circuit marketing at GE/RCA Solid State. Driven by President Reagan's Strategic Defense Initiative, the military is showing increased interest in space-based technology and in SOS in particular. At the same time, satellite makers have shown a willingness to change over from old-fashioned hard-wired logic to more modern computer architectures. "There are more space programs today, and more space programs are using RAM," Handen says.

RAD RESISTANT. SOS is essentially CMOS circuitry implemented on a sapphire substrate. It's the substrate that makes the technology so intriguing to designers of space-based systems.

SOS is no better protected against "total dose" radiation—that is, the gradual breakdown of a component from continued exposure to radiation over an extended period—than any other technology. But it is inherently immune to transient radiation, which can cause latchup in bulk-silicon parts, because there are no transistor wells buried in the dielectrically isolated sapphire substrate.

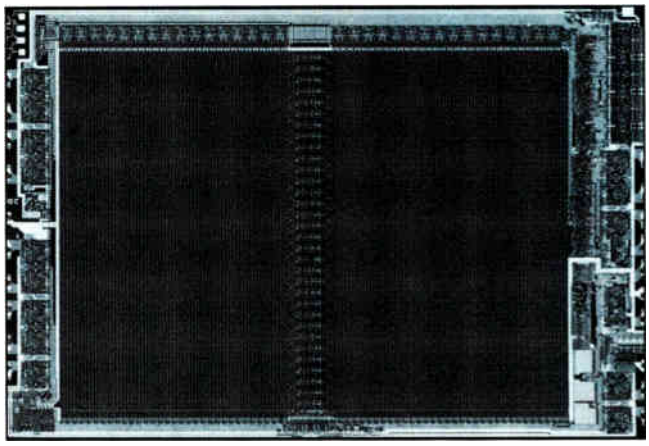
And with its totally isolated silicon junctions, "SOS has a much greater tolerance for single-event upsets that might be caused by ionizing cosmic rays," says Charles Henn, product engineer for the 16-K SRAM.

GE/RCA Solid State has historically kept quiet about its plans, but Handen is eager to describe work going on at the division's Microelectronics Center. The center is already producing test chips of an 8-K-by-8-bit SRAM built with 1.25-μm design rules.

That technology is also the basis for a new family of gate arrays, says Dick Glicksman, marketing manager for the Microelectronics Center. He says the first of the 1.25-μm gate arrays is ready, a 2,700-gate device that uses a single-metal process. Glicksman says the Microelectronics Center has already verified its design of an even denser, 5,000-gate array built in a double-level metal process called SOS-4. Samples will be available late this year. The crowning glory of the family will be a double-level metal, 10,000-gate device, also scheduled for delivery late this year.

Handen acknowledges that double-level metallization at these higher densities is not earth-shattering news on its own. "Silicon-on-sapphire technology would not be able to compete with commercial technologies. On the other hand," he points out, "the commercial technologies aren't radiation-hardened."

–Tobias Naegele



SOS CAN TAKE IT. SOS circuits, like this 16-K CMOS static RAM, are getting a second look because of their immunity to radiation.

AUTOMATIC TESTING

TI TESTER CHASES SPEEDS OF FAST LOGIC

DALLAS

The fledgling advanced CMOS and bipolar logic business could get an important boost from Texas Instruments Inc. The Dallas-based company is moving to fill a gap between the capabilities of most commercial chip-testing equipment and the ever-increasing speed of the latest bipolar and CMOS processes.

Not only is TI deploying its own test system, but it is planning to sell it to chip buyers [*Electronics,* Oct. 2, 1986, p. 23]. Called Impact-1, the new system could be a big help to chip makers, who are finding that commercial chip testers have their hands full with new logic, as the internal gate delays of the new processes drop below the 1-ns level. Most manufacturers are resorting to a mixed bag of software and hardware tricks to get the available testers up to speed.

The development of the Impact-1 is a typical TI response to an urgent need for more testing speed, throughput, and accuracy—the company has always made nearly all its own memory testers. But it has never considered selling any of its testers. TI executives are quick to emphasize that they won't compete with their test-equipment vendors and will, in fact, continue to buy commercial testers for commodity logic families. Nevertheless, the Impact-1 machine is intended to fill a void in ac and dc testing of fast integrated circuits.

So there is hope that the availability of Impact-1 could push the infant advanced CMOS logic business. At Signetics Corp., TI's second-source partner for advanced CMOS logic, the belief is that Impact-1 could help establish markets for the faster, low-power logic.

"If this next generation of CMOS logic is going to get established in the market, there has to be a tester for both customers and sources of the chips," notes Lee Eastly, a manager for product engineering, device characterization, and testing at Signetics' logic-production facility in Orem, Utah. Like most high-speed-logic suppliers, Signetics currently tailors commercially available testers to achieve ac accuracy readings below 500 ps. It is now aiming for 125 ps.

Eastly agrees with other suppliers of high-speed logic who find that, with input-to-output delays diminishing so

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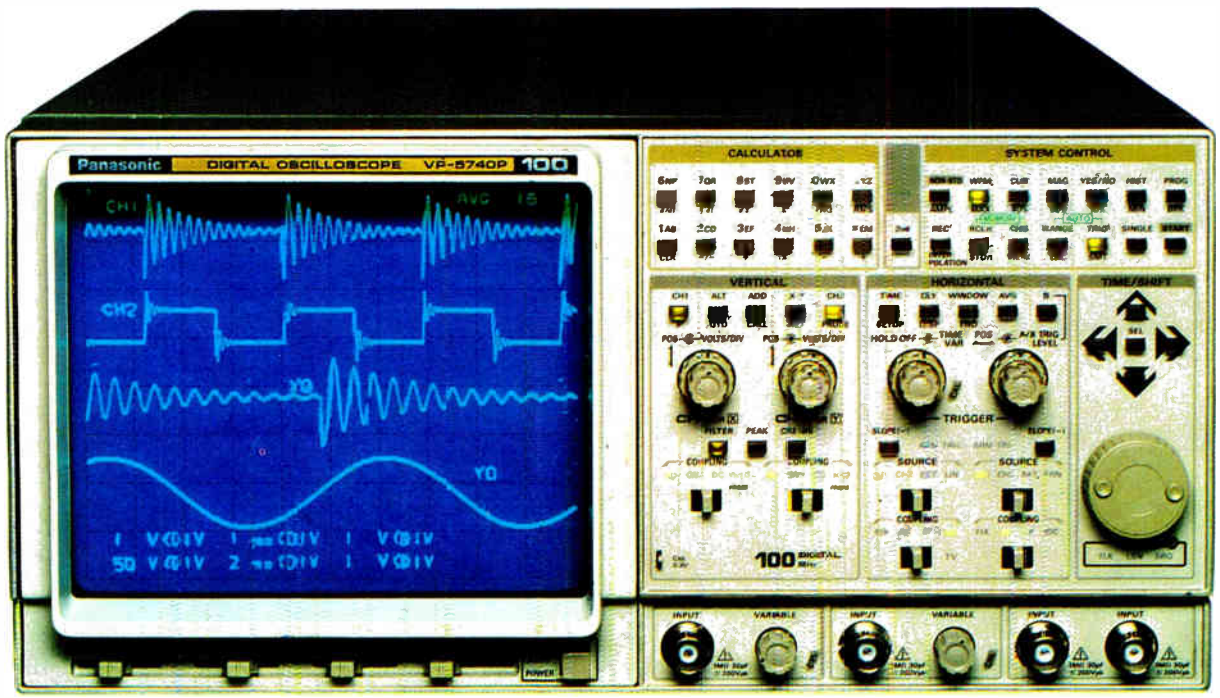

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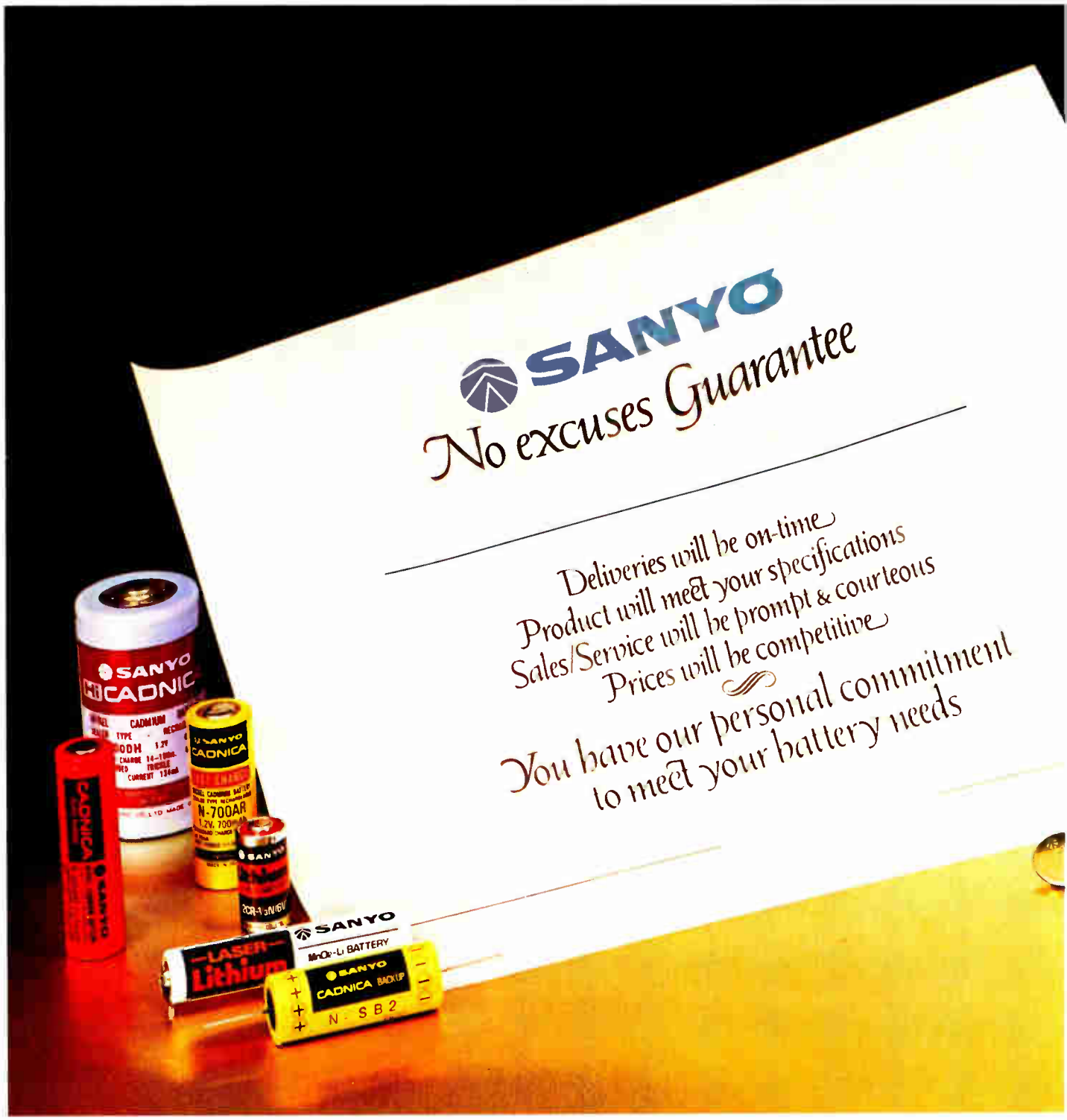

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much, the simplest logic functions are the hardest to measure. And test-equipment vendors have still not gotten the message, he adds. "There is no panic yet [at the chip houses], but we are heading toward a gigantic need as large-scale integrated logic begins to require the same kind of accuracies," he says.

Impact-1 is now handling production volumes at plants in Dallas and Sherman, Texas. And as if to underscore the widespread problem of fast-logic testing, TI is uncharacteristically providing an advance peek at the machine. Initially, it is being used on TI's fastest bipolar and CMOS ICs in the small- and medium-scale-integration range. The unit can have up to four test heads handling 32-pin devices independently, or two 64-pin test heads. The system is capable of testing both wafers and packaged chips.

The TI tester has 250-ns parametric timing accuracies

Impact-1 is modular, enabling test engineers to easily reconfigure the unit for large- or small-volume jobs, says Gollapudi R. Mohan Rao, semiconductor vice president and manager of advanced development in Dallas. Later additions will enable it to handle analog functions, complex processors with up to 300 pins, and other high-speed technologies, such as emitter-coupled logic or even gallium arsenide. Artificial intelligence is also planned for the tester, which will employ expert systems for automatic self-diagnostics and maintenance, Mohan Rao says. "As we learn more about the Impact tester, we are going to increase the pin-count capability and add the ability to program each pin independently up to the VLSI area."

Under the control of a 32-bit microprocessor, the Impact-1 system performs measurements on ac and dc characteristics in a single pass. Changes in test programs can be made in seconds rather than minutes, because the unit uses emulated software from work stations rather than using compiled programs.

Surface-mount chip technology is used throughout to eliminate unwanted high-speed signal noises and to pack test-performing circuitry right at the spot where ICs are plugged into the test head. Impact-1 can measure flip-flop toggle frequency maximums of 150 MHz. Today, it can track clock edges in the 200- to 300-ps range and offers parametric timing accuracies of 250 ps. Still faster systems are being developed.

TI declines to estimate price. However, Mohan Rao says the throughput and cost of the Impact-1, which was developed in little more than a year, compare with advanced commercial systems priced from $300,000 to $400,000.

–J. Robert Lineback

ROBOTICS

ROBOTS GET 'EARS' FOR BETTER DEPTH PERCEPTION

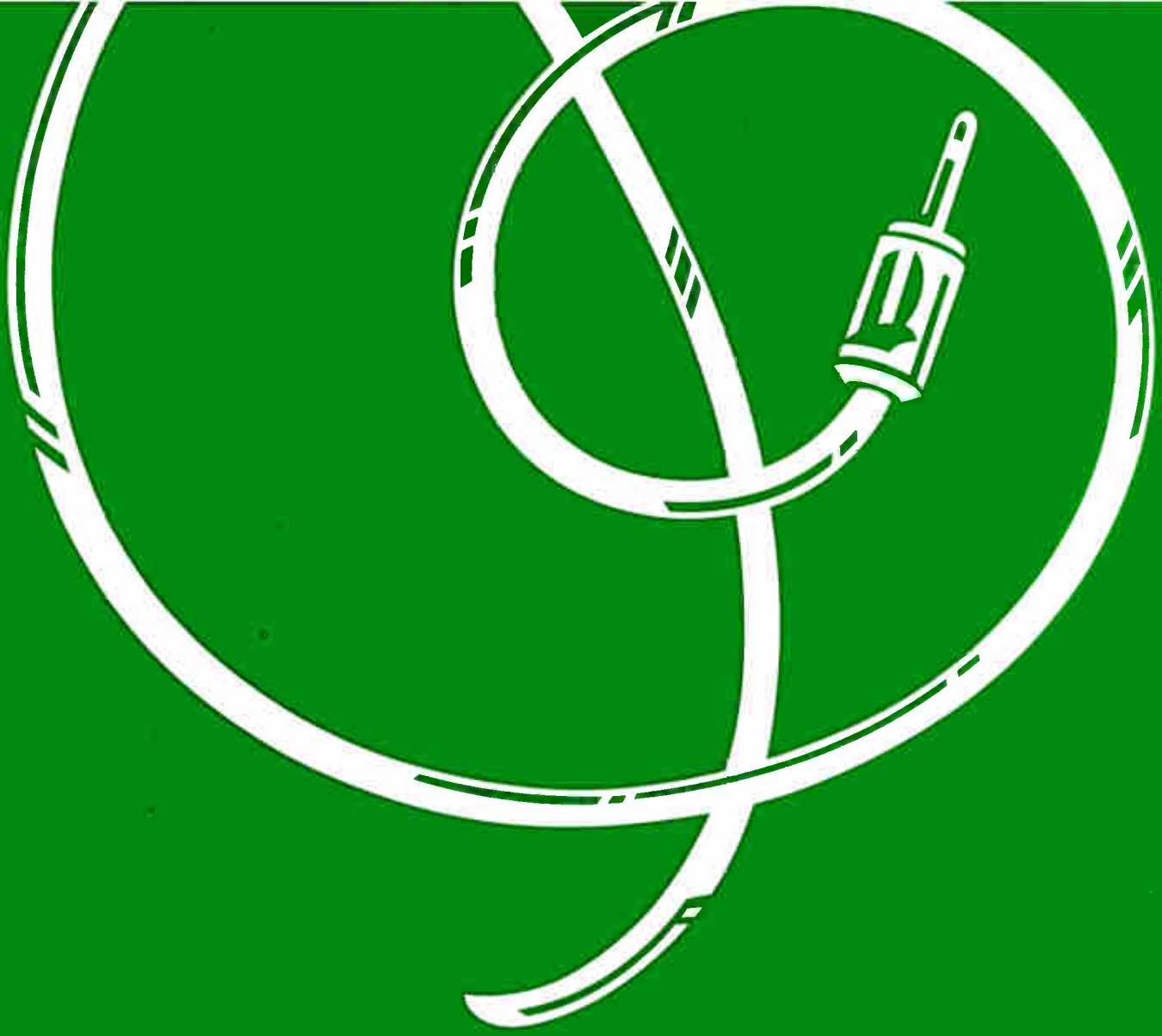
MUNICH

Bats "see" in the dark by sending out sounds at up to 100 KHz that bounce off objects. Borrowing that principle, researchers at Siemens AG have developed a sensor system that can enable a robot to distinguish between objects spaced only 0.1 mm apart in depth at a distance of about half a meter, which is within the working range of a typical robot arm.

Dubbed Echovision by the researchers, the system achieves this resolution with a new type of electro-acoustical transducer. Its piezoelectric foils generate and send out short bursts of broadband sound pulses that are far above the range of human hearing. Reflected by the object and picked up in a similar transducer, the ultrasound pulses are evaluated to determine their propagation delay and hence the distance to the object.

Thus far, the Siemens team has developed a fully functional model of the

ARM'S LENGTH. On a robotic arm, Echovision can pick out objects 0.1 mm apart.



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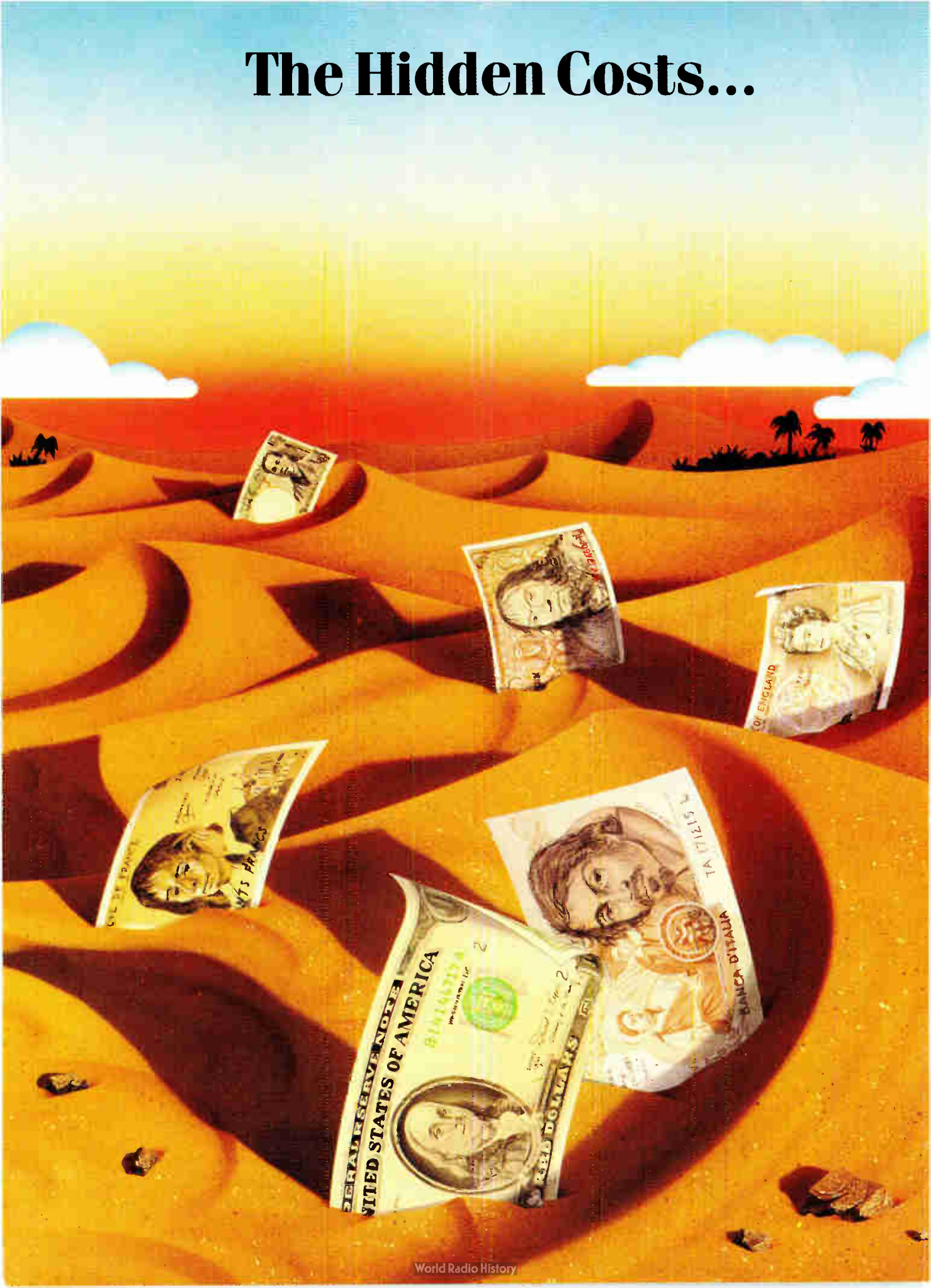

Echovision system. "The Echovision approach could lead to a high-speed, depth-profiling object-recognition system at a cost that is a fraction of that for optical equipment," says Peter Kleinschmidt, who heads the sensor-development team at Siemens's Central Research Laboratories in Munich.

Kleinschmidt says that work on making robots hear in order to distinguish between objects is going on at universities and electronics companies around the world. But he believes that no system developed elsewhere sports a resolution near the 0.1-mm value of Siemens's new system.

DEEP AND SIMPLE. Echovision has several advantages over optical sensing devices used in robotics. The most obvious is that it provides a depth of field in a simple way. Optical methods yield a third dimension or a depth profile only by using complex schemes based, for example, on two cameras employed in conjunction with scanning and light-sectioning techniques.

Further, evaluating and processing sound signals requires less hardware and software than does analyzing pictures and handling video signals. With

Echovision is a much simpler setup than optical systems

sound traveling at about 340 meters/s, or roughly a millionth the speed of light, the sound information comes in at a rate that can be handled without the need for elaborate hardware.

What's more, unlike cameras, acoustic transducers are not easily damaged, and they shrug off dirt or dust. So they are well suited for the adverse industrial environments robots often encounter.

Echovision is also much faster than comparable optical systems. The ultrasound pulses contact an object for only 1 ms, including signal processing. This means that the system can recognize 1,000 objects a second. That is 100 to 1,000 times faster than it takes video techniques to identify objects, Kleinschmidt declares.

As for the system's key item, the proprietary transducer, Kleinschmidt says it consists of about 20 piezoceramic foils and polymer layers that are stacked alternately and pressed together to form a solid element. The foils are 0.15 mm thick and the polymer layers 2 mm thick. When electrical pulses are applied to the foils, the element vibrates and produces ultrasound pulses in the air at 80 to 400 KHz. The function of the acoustically optimized polymer layers is to attenuate the ceramic foil's vibrations. *–John Gosch*

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INTERNATIONAL NEWSLETTER

ASAHI CHEMICAL LOOKS TO THE U. S. FOR CHIP TECHNOLOGY

Chemical giant Asahi Chemical Industry is forging ties with two small U. S. chip makers in its bid to diversify into microelectronics. Asahi has acquired a 10% share in Crystal Semiconductor Corp., Austin, Texas, to gain fabrication technology and sales rights for analog-to-digital converters and specialized communications chips. But Asahi isn't stopping there. The company will also jointly develop new products with Crystal, and it has contracted with International CMOS Technology Inc., San Jose, Calif., for technology and sales rights for the U. S. company's electrically erasable programmable read-only memories. Asahi is not being coy about its plans to crack the semiconductor business—earlier this year it bought out Gould Inc.'s stake in Asahi Kasei Microsystem Co., a joint venture between the two. Also, it acquired technology from Hitachi Ltd. to produce static RAMs and mask ROMs. Asahi currently has a laboratory in Atsugi that may be used to make low-volume, high-cost products, and the company says it will build a major chip-making facility as soon as market conditions improve. □

GRUNDIG TV KEEPS FLICKER TO A MINIMUM

West Germany's Grundig AG, determined to stay in the forefront of TV technology, is getting set to introduce what it claims is the world's first color receiver operating with a 100-Hz frame frequency. To suppress flicker on the 27-in. screen, a 4-Mb charge-coupled-device memory is used to double the frame frequency from the standard 50 Hz used in Europe. The memory, provided by Philips International NV, part owner of the Fürth-based company, also allows the set to display still pictures of a quality close to that of a color slide, Grundig says. Grundig, West Germany's top consumer electronics producer, will begin making the set during the second quarter. □

A POWERFUL NEW TELECOM COMBINE COULD REIGN IN SWITZERLAND

Look for Switzerland's biggest communications houses, Hasler AG and Autophon AG, to merge operations next summer in a new company called Ascom. The deal, if completed, would yield a powerhouse that would produce about two thirds of Swiss telecommunications equipment, worth $1.2 billion in annual sales. The merger results from the Swiss government's decision to relax its monopoly on certain equipment and allow companies to sell more switches, telephones, and other gear to the public sector [*Electronics*, July 24, 1986, p. 154]. Both firms make switches, such as PBXs, but Bern-based Hasler specializes in teletype equipment, while Autophon, of Solothurn, concentrates on standard and mobile telephone gear. □

BRITISH AWACS DEAL PAYS OFF FOR PLESSEY, TOO

The British government's decision to opt for the Boeing Co. Awacs airborne early-warning system instead of the British-developed Nimrod Airborne Early Warning System has some pluses for the UK electronics industry. Although the decision could lead to the loss of as many as 1,900 jobs at Nimrod developer General Electric Co. plc, Plessey Co. is already predicting that it will need an additional 2,800 workers by the year 2000 to handle contracts it expects to win as a direct result of the selection. Plessey says the Awacs program will bring it contracts initially worth $216.5 million from Westinghouse Electric Co. and Boeing, and that by the year 2000 these orders will be worth 10 times that much. Plessey has an agreement with Westinghouse to provide parts of the APY-2 radar, the main Awacs surveillance radar that resides in the dome over the aircraft, and to help develop future system enhancements, including systems for the U. S. Air Force. □

INTERNATIONAL NEWSLETTER

JAPANESE APPROVE TWO 130-mm OPTICAL DISK STANDARDS

The Japanese National Committee for optical-disk standardization may be setting the stage for a showdown in formats for 130-mm write-once optical disks. It has given its blessing to two incompatible 130-mm standards. The first, a continuous-servo format with 2-7 modulation similar to that used on magnetic disks, is championed by nine major Japanese computer companies and several U. S. firms; the second is a sampled-servo format, developed by Philips International NV and Sony Corp., that uses 4-15 modulation similar to audio compact disks. Now that standards have been adopted, industry observers expect products to start appearing in the Japanese market as soon as this summer. But opinions differ on whether the standards will coexist, seeking out their own niche applications, or whether the standards will go head-to-head and compete, as did the VHS and Beta video-cassette-recorder formats. □

THE LINE STARTS HERE: $1.5 MILLION REWARD FOR FLAT-SCREEN COLOR TV

The German physicist and author Eduard Rhein is offering a $1.5 million award to the first development team to design a large-format, flat-screen color TV that can be easily mass-produced. Rhein expects the prize winner to build a high-resolution screen, no more than 5 cm deep, with a minimum of 1,200 lines and a 22-in. diagonal measurement. Developers have four years to come up with their designs. Through his Hamburg-based private foundation, Eduard Rhein Stiftung, Rhein awards cash prizes each year for outstanding developments worldwide in entertainment electronics. □

HITACHI IS HELPING AEG'S PUSH INTO GROWING EUROPEAN LCD MARKET

The competition in liquid-crystal displays is heating up in Europe. AEG Aktiengesellschaft, the Frankfurt-based electronics firm, has signed a non-exclusive license agreement with Hitachi Ltd. under which it will manufacture LCDs with Hitachi technology. The two companies are lining up against Philips International NV, which is launching a major effort to corner a large segment of the growing European LCD market [*Electronics*, Dec. 18, 1986, p. 42]. As part of the agreement, Hitachi will sell production and inspection equipment to AEG and will provide instruction to AEG engineers visiting its laboratories in Japan. In addition, Hitachi will send its own engineers to West Germany for technical support under the agreement, which will run through 1993. Hitachi estimates that the European LCD market is worth about $62 million, of which its own sales account for about 25%. □

NIPPON MINING WILL PRODUCE SMALL QUANTITIES OF ULTRA-PURE INDIUM

Nippon Mining is planning to begin making a small quantity of 99.99999% pure indium (called seven nines) for high-speed compound semiconductors. The current state-of-the-art is 99.9999% (six nines). Nippon Mining will make only 20 kg of the seven-nine metal each month at its Isohara plant in Ibaraki prefecture, but at $9,375/kg, that should still be enough to bring in about $187,500/month. □

SONY STARTS MAKING CAMCORDERS IN WEST GERMANY

Moving toward its goal of increased European assembly of its consumer products, Sony Corp. is now assembling 5,000 8-mm camcorders per month at Sony Wega Produktions GmbH in Stuttgart, West Germany. About 41% of the products Sony sells in Europe are manufactured there, but Sony hopes to increase that figure to 50% by 1989. □

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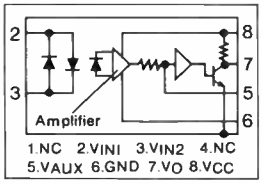

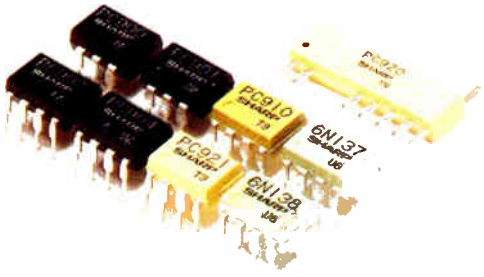

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	PC901	Digital switching, Normal-on operation	Computers, Programmable controllers, Measuring equipment, Numerical control machines
	PC902	AC input, Built-in integration circuit	Programmable controllers, Telephones, Copiers
	PC904	Built-in voltage deviation detection circuit	Switching power supplies
	PC910	Ultra high speed(10Mb/s)	Computers, Programmable controllers, Copiers
	PC920	For inverter control, Single-in-line package	Inverter air conditioners
	PC921	For inverter control, Dual-in-line package	Inverter air conditioners
6N series	6N135	High speed (1Mb/s)	Computers, Telephones, Measuring equipment, Numerical control machines
	6N136	High speed (1Mb/s)	Computers, Telephones, Measuring equipment, Numerical control machines
	6N137	Ultra high speed (10Mb/s)	Computers, Telephones
	6N138	Low input current, High sensitivity (CTR:300 % min.)	Computers, Telephones
	6N139	High sensitivity (CTR:500 % min.)	Computers, Telephones, Measuring equipment, Numerical control machines

OPIC PHOTOCOUPLERS

▶ OPIC is a registered trademark of Sharp and stands for Optical IC.

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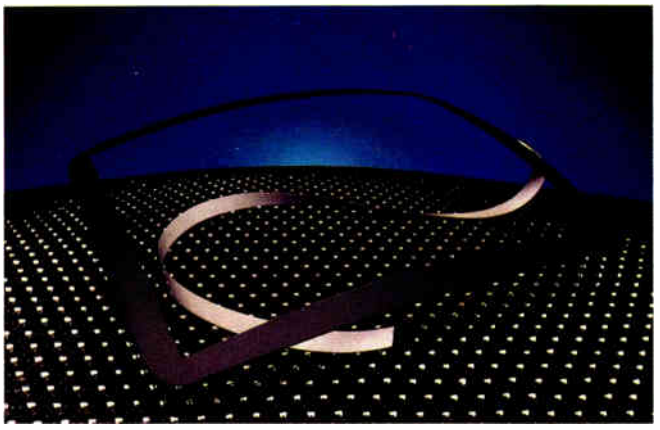

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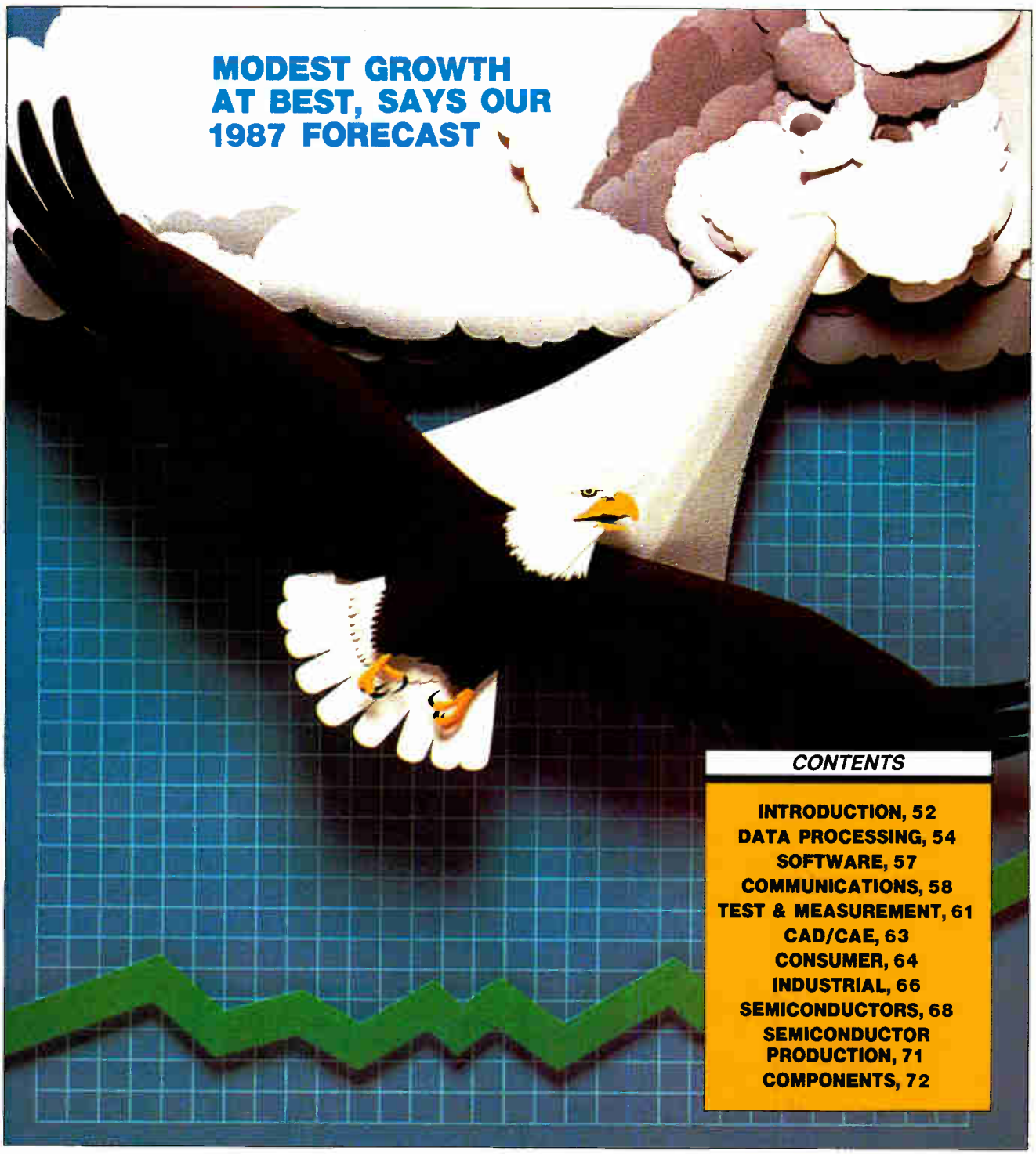
1987 U.S. MARKET REPORT

THE STRUGGLE CONTINUES



CONTENTS

INTRODUCTION

STEADY GROWTH: INDUSTRY SALES WILL CLIMB 10%, THE SAME AS 1986

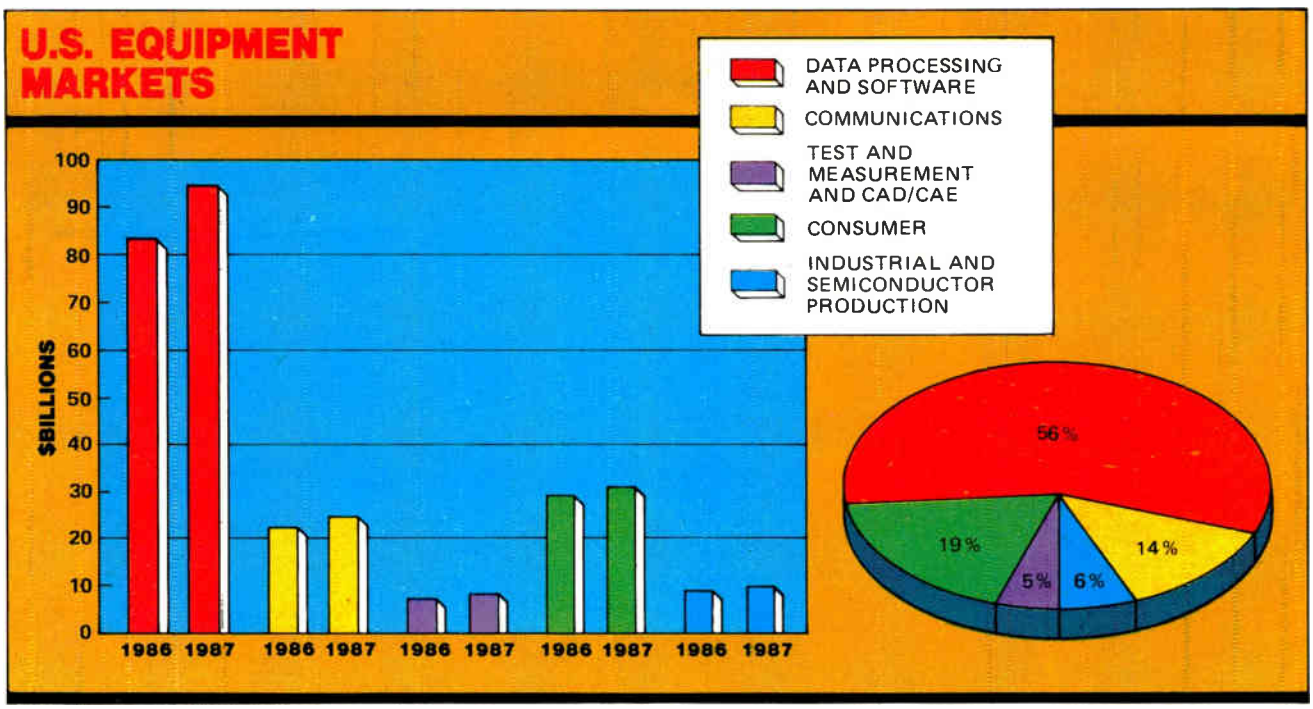
Most competitors fighting for a piece of the U. S. electronics markets will leave 1986 behind with little regret, but they may not like what they find in 1987 much better. The *Electronics* annual U. S. market survey forecasts 10% overall growth in equipment, for total consumption of $166 billion. That's the same growth rate the industry struggled to attain last year. In semiconductors and components, growth will improve only slightly, to 8.5% from last year's 6.2%, for total U. S. consumption of $33.6 billion.

Another factor is the continuing federal deficit, now hovering around the $220 billion mark. According to Data Resources Inc., a division of the McGraw-Hill Financial and Economic Information Co., there is real doubt about the ability of the government to reach the deficit-reduction goals targeted by the Gramm-Rudman law. If so, long-term interest rates will be adversely affected, and this bodes ill for U. S. capital formation and productivity growth.

What's more, 1987 looms as a year in which electronics companies must be prepared to struggle against uncertainty. For one thing, the expansion of the general economy continues to be sluggish. Although no one foresees a recession, most economists expect a growth in the gross national product of less than 3%—not unhealthy, but not terrific, either.

The new tax-reform bill will also affect the industry in ways that cannot be fully anticipated. The retroactive elimination of the investment tax credit and longer depreciation lifetimes, plus new minimum corporate taxes, will add costs to business that will "overwhelm the advantages of a lower statutory tax rate," says DRI's chief economist, Joseph Brinner. These factors all contribute to the 3% drop in real capital spending in the U. S that DRI foresees in its new survey of preliminary 1987 capital-spending plans.

Another uncertain effect is that of the recent semiconductor trade agreement with Japan. It's unclear how successful the pact will be in ameliorating the price erosion in semiconductors and redressing the equipment trade imbalance between the U. S and Japan, which now exceeds $17 billion. There are indications that the agreement has brought some stability and higher prices for dynamic random-access



memories—mostly benefiting the Japanese, however.

On the bright side, the DRI study indicates that the electrical and electronics sectors have the most ambitious capital-spending plans of all the industries surveyed. And the *Electronics* survey shows that manufacturing companies are still willing to invest in automation and productivity-improving equipment: consumption in the industrial-electronics sector will rise 14% this year after dropping 3% in 1986.

Coupled with software, data-processing equipment, which will reach nearly $94 billion in 1987, constitutes more than half the U. S. electronics equipment market. It exerts enormous influence on the demand for semiconductors and other components, and pervades almost every other electronics sector as well. So when the computer industry catches cold, the rest of the business sneezes. This year the *Electronics* forecast is for a modest but heartening 12% uptick in computer consumption after a 10% rise last year. Much of this renewed growth will come from the accelerating demand for personal computers, slated to rise 14% to $13.3 billion, and spectacular gains for the relatively new class of machines called minisupercomputers, which will zoom 54% to $307 million.

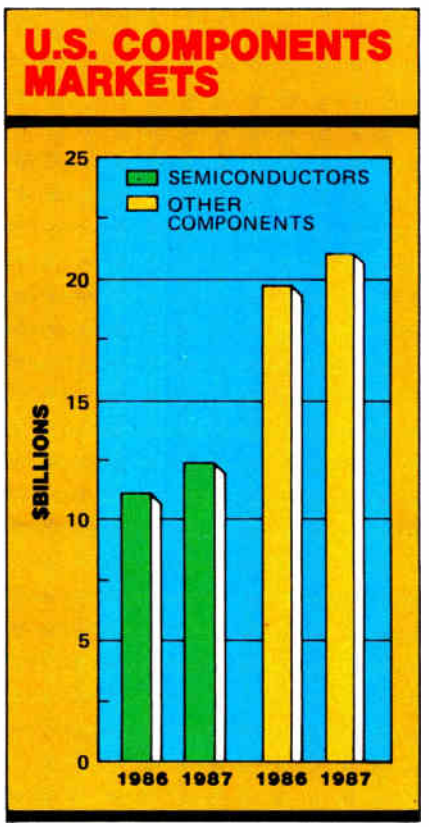
On the other hand, the communications sector is due for a slowdown in 1987 after two consecutive years of growth averaging 14%. In 1987, consumption will increase only 7% to $24.2 billion, perhaps due in part to corporate reluctance to commit to capital spending.

In consumer electronics, too, the outlook is for a slowdown in the growth rate, dropping from 8% in 1986 to 6% this year. Part of the reason: a dip in demand for the newest electronic playthings—compact-disk players and video camcorders, which racked up an unsustainable growth rate of 59% and 87%, respectively, last year. Both will continue to perform well, if less dramatically, this year. Meanwhile, as they inch toward market saturation, color TV sets and video cassette recorders are still registering huge volumes, but at 1% growth.

Reflecting the general sluggishness in equipment markets, the test-instrument sector is forecast to grow only 6% this year, to $6.7 billion, down from the 9% rate of 1986. An exception is automatic test equipment. As ever faster and denser integrated circuits and boards put more demands on test engineers, ATE gear will spurt to $2.2 billion next year, a rise of 12%. Similarly, systems houses are slated to spend liberally in 1987 for computer-aided design and engineering equipment to improve engineering productivity, boosting consumption in this market some 20% to just short of $1 billion.

Because of the seminal nature of semiconductor technology, the state of health of this important industry continues to be pivotal—and controversial. Even as late as December of last year, 1987 forecasts from major market research companies ranged all over the map—from 4% to 22%. *Electronics* pegs semiconductor consumption for 1987 at $12.4 billion, a rise of 12%. This is a modest gain in terms of expectations of the past decade, but welcome nonetheless, considering the dismal showings in this sector in the past two years.

As for other components, aggregate growth remains small, reaching only 7% in 1987, compared with 6% in 1986. Total 1987 component consumption will reach almost $21.2 billion. The largest gains will be in devices required for high-density, high-performance systems.



The major instrument for deriving the information in the 1987 *Electronics* market report was a questionnaire sent to executives of companies that make the equipment or components listed in the survey. Each was asked to supply estimates of the total U. S. consumption—factory shipments minus exports plus imports—of the products his company makes. The questionnaires were mailed early in the fourth quarter of 1986, so the figures for last year reflect conservative estimates of fourth-quarter shipments.

The estimates were then reviewed and analyzed by the *Electronics* staff. Editors made phone calls to supplement the questionnaire results and to resolve ambiguities. We also called on secondary sources such as market research companies and trade associations to corroborate the totals we had developed.

Electronics gratefully acknowledges the cooperation of the following organizations: Bernstein Research, Ceeris International, Dataquest, Disk/Trend, Electronic Industries Association, Electronic Trend Publications, Frost & Sullivan, Future Computing, Gnostic Concepts, In-Stat, Integrated Circuit Engineering, International Data Corp., Link Resources, Needham & Co., Salzer Technology Enterprises, and VLSI Research.

Some product categories have been added in this year's survey, some definitions changed, and other categories deleted, so totals may not be directly comparable with those of previous *Electronics* market reports. Amounts are stated in current U. S. dollars. The year-to-year totals are based on the assumption that respondents have factored in the effects of inflation.

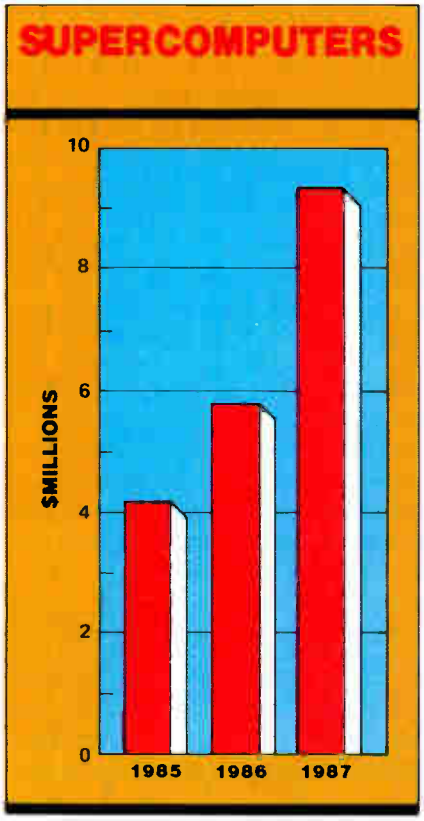
DATA PROCESSING

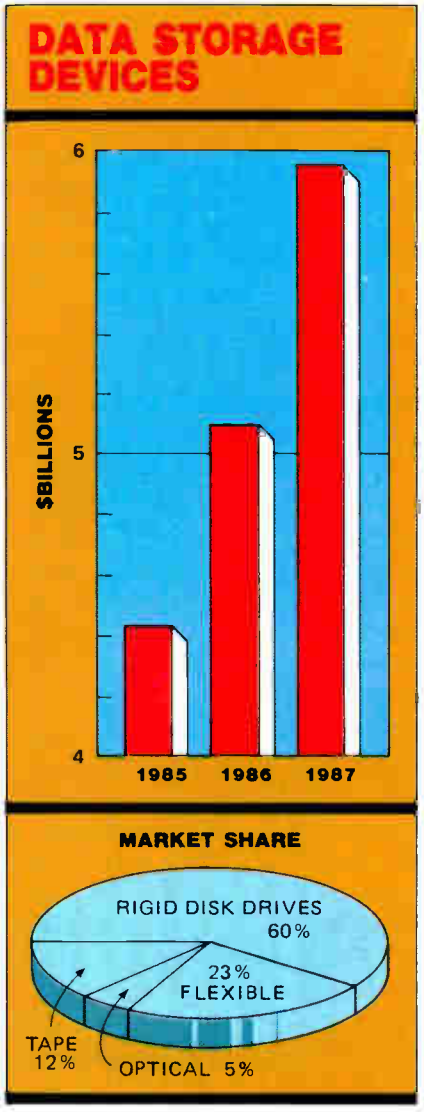
DEMAND WILL HIT 12%, UP A BIT FROM 1986's 10% GROWTH

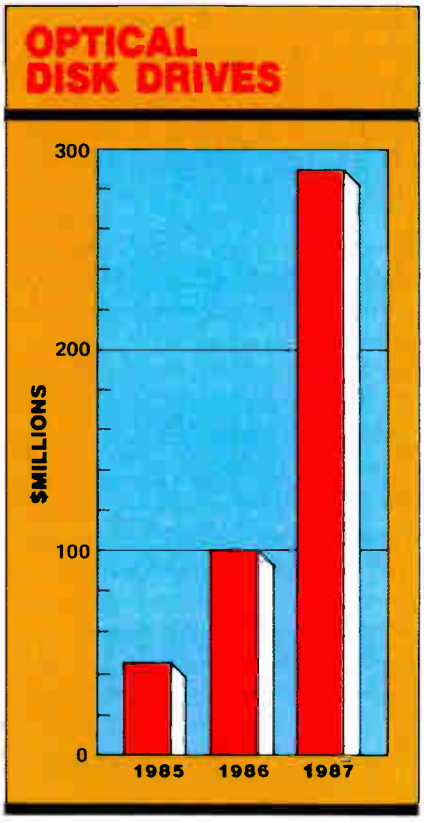
A tiny speedup in growth may be in store for the U. S. data-processing industry in 1987. The *Electronics* market-report survey shows the market for computer systems, peripherals, and office automation advancing at a 12% clip, up from the 10% growth rate of 1986. Although this pace would lag the 18% to 20% growth of the late 1970s and early 1980s, it would be substantially better than the 8% growth in 1985. Data-processing consumption should top $79 billion this year, after almost reaching $71 billion in 1986. The overall total does include some double counting, inasmuch as the computer-systems category bundles in many of the peripherals that also are represented separately in the table.

Although buyers' attitudes will remain conservative, some of the newest computers and peripherals will be star performers, as choosy customers put their dollars into products that offer productivity boosts and more performance for the money. "Consumers of computers are spending a lot of money in 1986 and will continue to do so in 1987," says Robert J. Paluck, president of Convex Computer Corp., Richardson, Texas. "A few companies with the right products, features, and services will grow at phenomenal rates. The more general-purpose companies will be in trouble, with very little or no growth." Indeed, the *Electronics* market report discloses that the newest computers built with the latest, most cost-effective technologies will experience the biggest gains in 1987.

Among the computer systems







in the highest range of price and performance, for example, *Electronics* projects a hefty 60% growth rate for supercomputers, a category marked by many powerful new products. This segment will score $936 million in sales, compared with $584 million last year. But the mainframe market—filled largely by staid, older products—will languish at less than 5% growth and sales of $16.6 billion.

In the middle range, the winners are the minisupercomputers, which offer high performance at very attractive prices. This new market segment will grow 54%, to $307 million in 1987. Although not a category in the *Electronics* survey yet, parallel computers are emerging as another fast-growing segment in the midrange. At least one estimate for 1987 puts their growth as high as 30%.

And among personal computers and technical work stations, which occupy the low end of the market, the scenario is much the same. Some of the new high-end personal computers—such as those using the Intel 80386 processor combined with new, inexpensive but high-performance graphics subsystems—are set for above-average growth. They will lead this segment to a 14% gain overall, with sales of $13.3 billion. Work stations will take off at a 35% spiral, to $2.2 billion in sales.

The *Electronics* forecast looks promising for data-storage devices as well. This category shows a 17% rise overall, to nearly $6 billion, largely the result of robust growth in the market for rigid-disk drives, due for a 25% rise, to $3.6 billion, on top of a 27% rise last year. The flexible-drive market is more problematic, as pricing pressures squeeze profits. A 6% dip is forecast, to $1.3 billion, with the new 3½-in. microfloppy models the only stellar performers. Optical drives are a bright spot and should grow nearly 200%, achieving sales of $289 million.

The reason that supercomputers are taking off so rapidly—60% on top of a strong 39% last year—is because of a big demand for very high-performance computing, nurtured by the steadily increasing price/performance ratio of these machines. The newest and biggest systems—such as the E-Series ETA[10] just being delivered by ETA Systems, and Cray Research's Cray 2—cut the cost of supercomputing dramatically.

In the midrange, the excitement is focused on the new computer category, minisupercomputers. These are smaller, more cost-effective versions of the giant supercomputers. This small market experienced a startup spurt of 60% last year and should grow another 54% this year. And there's no doubt about the machines' popularity. They fill a performance gap between the most powerful superminis and the mainframes or supercomputers, while at the same time offering more attractive prices, sizes, and power requirements than the bigger machines.

Another midrange machine slated for better-than-average growth is the parallel computer. These machines offer a broad spectrum of performance levels, as well as bargains in price/performance and the benefit of incremental growth. At least one executive in this field forecasts a growth rate of 25% to 30% in 1987. "Business is quite good," says Paul A. Castelman, president and chief executive officer of parallel-computer maker BBN Advanced Computers Inc., Cambridge, Mass. "A trend I have noticed is a distinct warming and acceptance of parallel processing as the preferred way to get high performance for a low price. But for the short term, the market size is modest. It will be at least three years before parallel computers hit really high volumes."

On the other hand, traditional minicomputers and many of the superminicomputer offerings will lag behind. Minis will grow at only 3%, to $2.3 billion. Superminis will do better at 13%, with sales of $9.6 billion in 1987, according to the *Electronics* survey. Market watchers believe this growth will be for companies with a broad product range of compatible machines, respectable price/performance ratios,

DATA PROCESSING EQUIPMENT

(millions of dollars)

	1985	1986	1987
Computer systems, total	**40,610**	**44,663**	**49,785**
Personal computers	10,434	11,655	13,280
Technical work stations	1,008	1,627	2,200
Multiuser microcomputers	3,620	4,000	4,472
Minicomputers	2,267	2,282	2,341
Superminicomputers	7,557	8,452	9,593
Minisupercomputers	125	200	307
Mainframes	15,180	15,863	16,656
Supercomputers	419	584	936
Data-storage devices, total	**4,427**	**5,093**	**5,986**
Rigid disk drives, total	2,263	2,882	3,612
14-inch and 10.5-inch	671	735	986
8-inch	607	712	785
5-1/4-inch	885	1,135	1,368
3-1/2-inch	100	300	473
Flexible disk drives, total	1,440	1,411	1,358
8-inch	475	394	225
5-1/4-inch	837	829	850
3-1/2-inch	128	188	283
Optical-disk drives	44	100	289
Cassette and cartridge magnetic-tape drives	160	174	193
Reel-type magnetic-tape drives	520	526	534
Data terminals, total	**4,451**	**4,809**	**5,271**
CRT ASCII terminals	2,391	2,583	2,815
Graphics terminals, total	1,212	1,336	1,508
Monochrome	811	856	922
Color	401	480	586
Remote batch and job-entry terminals	848	890	948
I/O peripherals, total	**5,895**	**6,719**	**7,669**
Computer-output microfilm	507	538	565
Digitizers, graphics tablets, light pens, trackballs, and mice	103	119	141
Optical scanning devices	720	786	880
Plotters	712	897	1,076
Printers, total	3,853	4,379	5,007
High-speed line printers (> 1,000 lpm)	468	487	510
Medium-speed line printers (100 to 1,000 lpm)	1,270	1,429	1,615
Slow serial printers (< 100 lpm)	2,115	2,463	2,882
Office automation, total	**8,920**	**9,627**	**10,394**
Copying equipment	4,525	4,920	5,314
Electronic typewriters	1,210	1,267	1,331
Word-processing systems	3,185	3,440	3,749
DATA-PROCESSING EQUIPMENT, TOTAL	64,303	70,911	79,080

All figures in current U.S. dollars

COMMUNICATIONS

A DECLINING GROWTH RATE: SALES WILL GO UP ONLY 7%

The U. S. communications industry is heading in the wrong direction. The *Electronics* market survey projects a declining growth rate; business in 1987 will increase by only 7%, half the growth rate it achieved in both 1986 and 1985. Overall sales should reach $24.2 billion, compared with $22.5 billion last year.

In some sectors, growth is stabilizing simply because the market is maturing or nearing saturation. This is the case with central-office voice-switching systems, which will grow a scant 1% to $2.8 billion. The much smaller market for data-switching systems, which also will move voice, will grow 15% to $314 million. The slump in voice switchers is enough to depress the overall telecommunications sector, which will show only a 2% rise in 1987, to $5.8 billion. The projections are particularly disheartening after the 18% gain achieved in telecommunications in 1986.

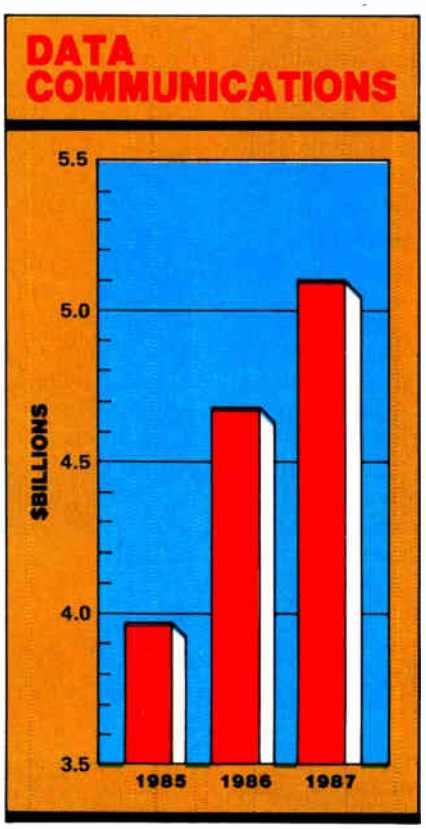
In addition, a slowdown in the large data-communications segment is placing a drag on the overall market profile. After a 17% gain last year, data communications will rise only 8% to $5 billion, the result of a sluggish computer industry and, perhaps, reduced capital spending while U. S. businesses take time to figure out the ramifications of the new tax law. Overall sales should reach $5 billion, compared with $4.7 billion last year.

An example of the slowdown in data communications is the modem market, which will grow to $2.1 billion this year, up only 8%. That rise is disappointing in light of the 18% growth in 1986. The biggest contributor to this slower growth rate is the rapid price declines at the low end of the modem market, rather than a big drop in unit sales. By comparison, the outlook for multiplexers is rosier, even though the rise in demand will moderate to 9%, for $757 million in sales, down from 12% growth last year.

Networks will experience slower but still respectable growth this year, *Electronics* predicts. Consumption of network controllers will rise 16% to $561 million, exactly half the 1986 growth rate.

There are some bright spots in a few market segments, though. Among facsimile terminals, for example, the fast Group 3 products should grow a brisk 23% on top of an 18% rise in 1986. These machines, which produce copies in less than a minute, will achieve sales of $190 million. Overall, the facsimile sector should experience 9% growth to $510 million, against 8% growth to $464 million last year, according to the *Electronics* survey.

In addition, fiber-optic systems are looking good. *Electronics* projects a 21% growth rate and $1.08 billion in sales, on the heels of 18% growth in 1986. The spurt comes as communications companies finish expanding and upgrading the capacity of their long-haul systems and start installing fiber in local loops. Fiber-optic data systems are also growing substantially.



The burst of energy in fiber optics is leading to a downswing in other markets. Microwave systems, for example, will flatten to 2% growth from last year's 9%, as high-capacity, long-haul fiber-optic systems take on more of the communications work. *Electronics* projects microwave sales of $588 million in 1987.

Satellite earth stations, too, will feel the pinch. This segment grew 18% in 1986 but will rise only 7% this year, the result of competition from fiber-optic systems, as well as maturing and some saturation in its own market. Sales of $761 million are forecast.

Radar equipment, one of the biggest communications-market segments, will grow 7% this year to $5.84 billion, somewhat behind the 1986 growth rate of 11%, according to the *Electronics* survey. Some vendors say the slowdown stems from reduced spending by both the U. S. military and the

Federal Aviation Administration.

In the $5.9 billion market for telecommunications gear, voice-switching systems are in for a hard year. Both central-office and private-branch automated exchanges will feel the sting, flattening to a 1% growth rate each. Since it grew 32% last year, voice PABX equipment will be particularly hard-hit, a result of business buyers turning from voice-only to the latest digital PABX gear, which can send both voice and data, or keeping their voice switches and installing local networks for data communications.

Electronics projects that sales should be $2.66 billion for voice PABX units, up slightly from $2.61 billion last year. A 16% growth rate in data-switching PABX systems—from $178 million in 1986 to $208 million this year—is the flip side of this trend. But the voice-and-data market is still too small to offset the losses in the voice-only sector.

Other factors adversely affecting PABX sales include the large number of vendors, says Toby Julian, executive vice president of marketing, sales, and customer support at Mitel Corp. in Kanata, Ontario. "There are too many vendors creating an oversupply in the market," he says. "Price-cutting by industry leaders to obtain market share, and technology improvements that make last year's designs obsolete and force producers to drop prices, are also factors contributing to slow growth."

The big-ticket switches, central-office switches, are also in a state of flux. Voice-only devices grew 9% last year, but will dip this year as telephone companies move to replace voice switches with the voice-and-data variety. Sales should total $2.87 billion, compared with $2.82 billion in 1986. Voice-and-data switches, on the other hand, grew 10% in 1986 and will move forward another 11% in 1987. This category should achieve $106 million in sales, compared with $95 million last year.

One reason for the increase is that equal access can't be done with electromechanical gear. Equal access is a federally mandated move to provide all long-distance carriers with the same kind of access to the local phone companies' networks as AT&T has. The phone companies are changing to electronic central-office switches in order to provide equal access—but this changeover should be nearing completion this year, which could put a drag on the sales of voice-and-data switches.

In the $5.1 billion data-communications equipment market, it appears that the industry is lagging behind the computer slump by a year or two. As a result, says David Woodall, director of new product planning and marketing for Racal-Milgo, Sunrise, Fla., the slowdown in sales of minicomputers and mainframes is retarding sales of such high-end data-communications products as high-speed multiplexers, modems, and network processors. "I think the slump will continue into early 1987, though we may see a modest upturn in the latter half of 1987," he says.

The consensus forecast in the *Electronics* survey is for the weakening to begin in 1987: Growth will slow to 8%, bringing total consumption up to $5 billion, after a surprisingly strong 1986 that was marked by 17% growth and $4.7 billion in sales.

Within this market, relatively low growth is expected in such products as modems and multiplexers. Modems should grow 8% to $2.1 billion, against 18% to $2 billion last year. Multiplexers will rise 9% to $757 million, compared with a 12% gain to $690 million last year. Many of the makers of the low-end modems and four- and eight-line multiplexers suffered from severe price pressures in 1986, says Maurice Bailey, vice president of sales and customer service at Racal-Vadic, Milpitas, Calif. "What we saw in the low-speed segment [under 2,400 b/s] was

COMMUNICATIONS EQUIPMENT

(millions of dollars)

	1985	1986	1987
Data communications, total	**3,980**	**4,683**	**5,090**
Concentrators	173	197	209
Front-end communications processors	753	815	845
Message-switching systems	121	135	143
Modems, total	1,651	1,955	2,123
High speed (2,400 b/s and over)	1,297	1,520	1,660
Low speed (less than 2,400 b/s)	327	402	422
Radio frequency	27	33	41
Multiplexers, total	613	690	757
Time division	96	115	130
Statistical	517	575	627
Network controllers, total	364	481	561
SNA	155	202	221
Ethernet	144	184	220
Other	65	95	120
Packet-switching systems	305	410	452
Facsimile terminals (exc. desktop), total	**428**	**464**	**510**
CCITT Group 1 (6 minutes)	135	139	140
CCITT Group 2 (4 to 6 minutes)	163	171	180
CCITT Group 3 (1 minute or less)	130	154	190
Fiber-optic communication systems, total	**750**	**890**	**1,080**
Wide area	713	755	853
Local area	37	135	227
Radar equipment (antennas, data processing, receivers, transmitters), total	**4,872**	**5,408**	**5,840**
Radio, total	**3,209**	**3,685**	**4,060**
Amateur (mobile and base stations)	28	30	32
Aviation mobile (including ground support)	143	156	179
Broadcast equipment	618	694	832
Citizens' band (mobile and base stations)	48	46	48
Land mobile (mobile and base stations)	1,086	1,300	1,438
Marine mobile (ship and shore stations)	164	178	182
Microwave (complete systems)	526	576	588
Satellite earth stations (including transmitters, receivers, antennas, excluding consumer)	596	705	761
Telecommunications systems, total	**4,798**	**5,708**	**5,850**
Data-switching systems, total	248	273	314
Central office	86	95	106
PABX	162	178	208
Voice-switching, total	4,550	5,435	5,536
Central office	2,570	2,820	2,876
PABX	1,980	2,615	2,660
Television equipment, total	**1,600**	**1,684**	**1,769**
Broadcast (studio) equipment	1,120	1,180	1,240
CATV equipment	320	336	353
CCTV equipment	160	168	176
COMMUNICATIONS EQUIPMENT, TOTAL	19,637	22,522	24,199

All figures in current U.S. dollars

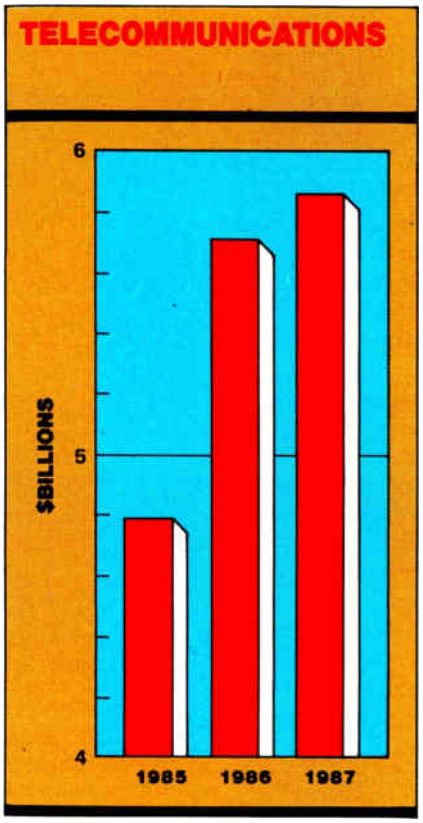
virtual collapse of the market," he says. "Eighteen months ago you could buy a full-duplex modem for about $1,000 to $1,100. Now you can buy a 1,200-b/s modem with more features for about $500—and if you want just a plain data pump, you can get one for $400. This represents a 60% price decline." Bailey notes that "users are still consuming the 1,200-b/s modems. Our volumes are going up. But our profits are declining because we can't add features that would allow us to get our margins up."

One surprise: sales of long-haul fiber-optic systems will rise faster in 1987 than they did last year, growing 12%, to $853 million

Network controllers will maintain reasonable growth—19% for Ethernet, to $220 million, and 26% for all others, to $120 million. However, controllers for systems using IBM Corp.'s Systems Network Architecture will grow only 9% to $221 million, a steep decline from last year's 30% growth rate to $202 million.

But there's debate within the industry about the state of the networking market, and some executives believe the picture is rosier than the *Electronics* forecast indicates. Howard Salwen, chairman and founder of Proteon Inc., a Natick, Mass., LAN manufacturer, says that the computer-industry slump has not affected sales in his market. "I think we are going out [of 1986] stronger than we expected," he says. Salwen is predicting a good year in 1987, with growth perhaps as high as 35%—considerably above the *Electronics* forecast of 16% growth for all network controllers this year.

One communications market segment that is garnering significant sales growth is the fast Group 3 facsimile machines. These units should grow 23%, from sales of $154 million in 1986, to $190 million in 1987. "The Group 3 facsimile market is here, and it's growing like crazy," says Steven Joerg, vice president of sales for Ricoh Corp., West Caldwell, N.J. Lower prices and added features are making fax machines highly attractive to the small-business user, Joerg says. "People are just realizing what you can do with facsimile. It is filtering down to the small businesses with fewer than 20 employees." Joerg adds that facsimile terminals are not a consumer market yet, but they will be if the price of a "plain vanilla" Group 3 device drops much below the current $2,000. Growth rates for the slower Group 1 and 2 products present a much different picture: Group 1 demand should be flat, and Group 2 is slated to rise 5%.



Also marching along at an impressive pace are fiber-optic systems, pegged for a 21% rise to $1 billion in 1987. Long-haul links will grow faster in 1987 than they did in 1986—12% growth compared with 5%. Sales should reach $853 million, against $755 million last year. This forecast comes as a surprise to some industry executives, who expected fiber-optic communications to decline in 1987. "Since 1985 we've seen plenty of fiber sales and a lot of [long-haul] transmission [lines] going into the ground. We should reach a limit to plowing the cable into the ground in 1987 or early 1988," says Richard Snowden, director of service concepts for the Business Markets Group of AT&T Communications, Basking Ridge, N.J. "And since the bulk of the cost is putting cable into the ground, the market should tail off at that time."

But industry observers expect optical fiber for the local loop to pick up the slack, and the *Electronics* survey indicates that this may be beginning. The small market for local-area fiber-optic networks grew by almost a factor of four, from $37 million in 1985 to $135 million in 1986. High growth will continue in 1987 as this market moves up another 68% to $227 million.

Sales of analog and digital microwave systems, which grew 9% in 1986, will flatten to 2% growth this year. William Gibson, president of Digital Microwave Corp., San Jose, Calif., believes that the flattening actually began in 1986. Going after sales of analog microwave for long-haul communications is a losing proposition, he says, because fiber-optic systems are taking over: "I see a shrinking market for analog—except for replacements."

Satellite earth stations, an alternative to ground and underwater transmission lines, grew a rapid 18% in 1986 to $705 million. But because of the burgeoning of fiber optics, this sector will dip to 7% growth in 1987, with sales of $761 million.

Radar systems will be up about 7% to $5.8 billion in 1987, according to the *Electronics* survey. This marks a drop from the 11% growth achieved in 1986. Robert McBride, director of marketing for ITT Gilfilian, Van Nuys, Calif., says that one reason is cutbacks by the U.S. Department of Defense, resulting in fewer new project starts, radar included. Following suit, the FAA is not expected to make any big buys for the civilian air-traffic-control system. "In our opinion, our industry is flat and will remain that way for several years," says McBride.

TEST & MEASUREMENT

GROWTH WILL SLOW TO 6%, DOWN FROM 9% IN 1986

In 1986, a less than buoyant economy made customers of test and measurement and computer-aided design and engineering equipment as tight with a dollar as Scrooge ever was. Many of them will remain as frugal in 1987. *Electronics* has found that the traditional test and measurement market will grow no more than 6% in 1987, down from the 9% achieved in 1986.

But other customers will open their pocketbooks to invest in new types of automated test gear and in sophisticated CAD and CAE systems. As a result, some categories, especially in automated test equipment (ATE), will grow at a double-digit clip. The CAD/CAE market will rack up a 22% growth rate, rising next year to $980 million, which would be remarkable, following a mere 2% rise last year.

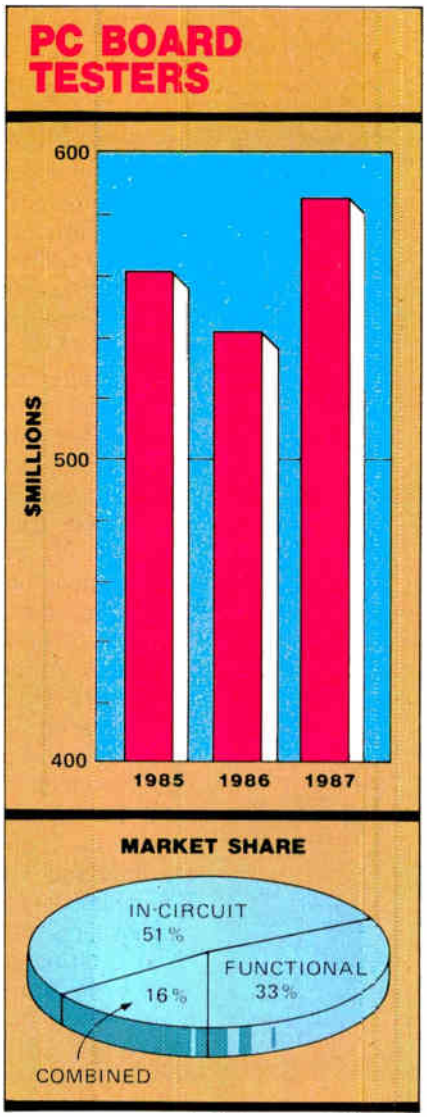
The overall test-gear business will see sales of $6.6 billion, compared with $6.2 billion in 1986. The ATE segment will lead the industry with a 12% growth rate and sales of $2.2 billion. Last year, ATE mustered only a 3% hike and sales of $1.9 billion.

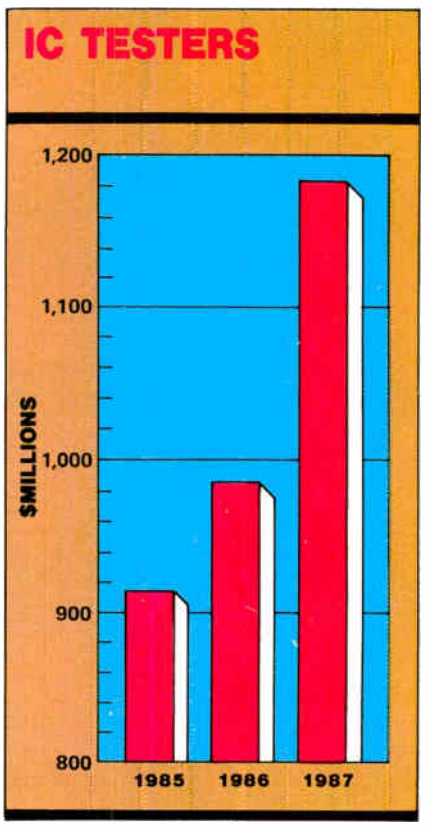
"What buyers in the test and measurement market are looking for are significant improvements in the products on the market," says B. J. Moore, president of Outlook Technology, Campbell, Calif. "They are no longer content to buy equipment offering small incremental improvements in cost and performance. Rather, they are waiting for devices that offer two to three times the improvement in cost or performance—preferably both."

Among the products that offer such advantages are ATE systems able to test very high-speed and application-specific integrated circuits with high pin counts, high clock rates, and mixed analog and digital components. *Electronics* predicts that IC testers will grow at a brisk 20% rate, to $1.1 billion. And printed-circuit-board testers able to perform both in-circuit and functional tests will grow 35% to $95 million, leading the pc-board tester category to 7% growth. Last year, this segment saw a 4% decline.

Among general bench instruments, the new breed of universal counter-timers that can perform 1-ns measurements will see a 26% growth rate in 1987, to $95 million. Thanks to innovative new products that greatly improve productivity, oscilloscopes will grow 10% or more, bringing sales to $1.1 billion. The market for personal-computer-based instruments will grow 15%, to $1 billion.

On the down side, the boom in personal-computer-based gear will depress the market for traditional





test equipment used to develop and debug microprocessor-based systems. Sales will dip 17%, to $780 million, compared with a 23% rise and sales of $933 million in 1986. However, stand-alone in-circuit emulators will show a whopping 74% increase, from $70 million in 1986 to $1.2 billion in 1987.

If the outlook is mixed for test and measurement, it's rosy for CAD and CAE. The *Electronics* survey shows every category in this market marching along at an aggressive pace. Vendors say customers have seen the improvements in productivity that CAD/CAE offers and are coming back for more. Performing particularly well are work stations for pc-board layout, a segment pegged to grow 25%, to $288 million. After a dip of 7% last year, work stations for IC design are bouncing back with a 20% growth rate and sales of $168 million.

While semiconductor manufacturers lamented each quarterly loss in 1986, they continued to buy equipment that would make them competitive when the economy turned around. So ATE systems for testing commodity VLSI chips and random-access memories saw only slight demand, but large ATE systems for testing fast, high-pin-count CMOS VLSI and emitter-coupled-logic gate arrays were being shipped as fast as they could be made. This trend will intensify in 1987, and the 7% growth achieved by IC testers in 1986 will jump 20% to $1.2 billion, as state-of-the-art equipment begins to ship in larger numbers.

Testers for ASICs are also in great demand, since conventional ATE test gear is not well suited for such work; and mixed analog and digital testing is yet another capability ATE customers are willing to loosen their purse strings for. "Mixed analog and digital IC testing is a lucrative business opportunity," says Kuneo Hasebe, product marketing manager at Hewlett-Packard Co.'s semiconductor systems center, Santa Clara, Calif. "Unit shipments of digital-to-analog converters, analog-to-digital converters, and codecs are expected to grow at 24%, 27%, and 38%, respectively, between 1986 and 1988, and there are few testers out there that can handle the test requirements." Such high-performance VLSI and mixed-signal testers will kick the growth of specialized test systems up 22% to $411 million in 1987, compared with only a 6% rise and $336 million in sales in 1986.

Board-test ATE customers are showing a preference for combination in-circuit and functional testers, says Joseph B. Lassiter III, vice president and general manager at Teradyne Inc.'s Manufacturing Systems division, in Boston, Mass. The 35% growth rate forecast for combinational testers compares with 4% for in-circuit and 2% for functional testers. Overall, pc-board testers will realize $585 million, a 7% increase over the $542 million achieved in 1986.

Unlike ATE systems, bench instruments as a class will see little or no growth. *Electronics* shows traditional test gear going up only 3%, to $4.5 billion.

But a few categories will enjoy outstanding performance. Among them are the new universal counter-timers, which offer 1-ns timing resolution. "This higher resolution enables users to make measurements not possible with previous-generation counter-timers, which offered 100-ns resolution," says Malcolm Levy, marketing manager at Racal Dana Instruments Corp., Irvine, Calif. The 26% growth rate for universal counter-timers compares with 12% and $75 million in sales in 1986.

Another growth area is the venerable oscilloscope. "The existing market for scopes is 90% saturated," says Fred Hanson, vice president and general manager of the Tektronix Inc.'s Instruments group in Beaverton, Ore. "To get the customer base to buy new equipment to replace what they have requires functionality and productivity improvements not pos-

TEST & MEASUREMENT EQUIPMENT

(millions of dollars)

	1985	1986	1987
Automated test systems and equipment, total	**1,870**	**1,929**	**2,177**
Active (discrete) component test systems	130	129	120
Automated field-service testers	93	98	100
Integrated-circuit testers, total	915	985	1,182
Benchtop testers	170	185	214
General-purpose systems	430	464	557
Specialized test systems (memory, etc.)	315	336	411
Interconnection and bare pc-board testers	170	175	190
Loaded printed-circuit-board testers, total	562	542	585
In-circuit	312	287	300
Functional	190	185	190
Combined	60	70	95
General test equipment, total	**3,861**	**4,326**	**4,493**
Amplifiers (laboratory)	65	68	71
Analog voltmeters, ammeters, and multimeters	26	28	30
Audio oscillators	26	28	31
Audio waveform analyzers & distortion meters	120	140	152
Calibrators and standards, active and passive	70	72	75
Dedicated IEEE-488 bus controllers	110	120	125
Digital multimeters, total	196	212	226
3-1/2 digits and below	110	120	130
4-1/2 digits and above	86	92	96
Electronic counters, total	131	148	172
Frequency (500 MHz and below)	23	28	30
Microwave (above 500 MHz)	40	45	47
Universal	68	75	95
Frequency synthesizers (below microwave frequencies)	65	73	79
Generators, function	50	54	60
Generators, microwave signal (2 GHz and above)	92	114	116
Generators, pulse	26	27	29
Generators, rf signal (below 2 GHz)	100	101	108
Generators, sweep	85	85	86
Generators, word	16	18	22
Logic analyzers	184	202	207
Microprocessor development systems, total	758	933	780
Dedicated	525	644	530
Universal	233	289	250
Modulation analyzers	9	10	11
Noise-measuring equipment	13	15	19
Oscilloscopes, total	985	1,034	1,140
100 MHz and below	613	614	646
Above 100 MHz	372	420	494
Panel meters	68	66	60
Personal-computer-based instruments	65	90	104
Recorders and plotters	220	250	260
Rf/microwave network analyzers	44	50	57
Rf/microwave power-measuring equipment	30	33	34
Spectrum analyzers	210	250	280
Stand-alone in-circuit emulators	65	70	122
Temperature-measuring instruments	32	35	37
TEST AND MEASURING EQUIPMENT, TOTAL	**5,731**	**6,255**	**6,670**

All figures in current U.S. dollars

sible with the older equipment." Tektronix's new scopes can perform such tasks as a dynamic power measurement in a waveform in a matter of minutes, compared with a day with a conventional scope, says Hanson. By offering this kind of productivity boost, Tektronix believes it can better the 10% growth in scope sales projected by *Electronics*.

In personal-computer-based instrumentation, also, a marked boost in performance means a bright 1987, says John Batton, president and chief executive officer of Wavetek Corp., San Diego. Some suppliers believe their market segment may far outpace the 15% forecast by *Electronics*, soaring to perhaps 50% above the $90 million sales level of 1986. These systems will bite into sales of dedicated IEEE-488 bus controllers, since they can take the place of the controllers driving bench instruments designed for interacting with the personal computer. IEEE-488 controllers, therefore, are expected to grow less than 5% in 1987. Batton sees personal computers acting as IEEE-488 bus controllers driving bench instruments.

One reason for this shift is that the purchase decision for benchtop instruments is changing, Batton says. Before, the design engineer bought instruments for designing the system and specified the same equipment for the manufacturing engineer to test the product. "Now, manufacturing is getting involved earlier in the design cycle and making decisions about what test equipment should be bought," he says. "They are demanding instruments that work well with a personal computer."

Just as the personal computer is having an impact on bench instruments, so, too, is it affecting the microcomputer development system market. "One significant impact the personal computer has had is to force the average unit selling price down from a high of $22,000 a year ago to $9,000 today," says Richard Jansen, vice president of product development at Applied Microsystems Corp., Redmond, Wash. This is the reason for the precipitous 17% dip seen for sales of traditional microprocessor development systems in 1987. Last year this segment grew at a 23% clip, to $933 million. Next year's sales figure of $780 million is just above the 1985 total.

"Instead of buying MDS hardware, software developers will want to use standard platforms, such as the Sun and Apollo work stations and, increasingly, the 80386-based personal computers, for software development," says Jansen. "The code will then be downloaded into a stand-alone in-circuit emulator for the target system." This shift explains the astounding growth rate of such emulators in 1987: 74%, with sales of $1.2 billion, compared with a mere 7% growth rate and $70 million in sales in 1986.

CAE WILL SOAR 20%, AFTER A MILD 2% RISE LAST YEAR

A banner year is in store for CAE and CAD systems, with *Electronics* projecting a 20% growth rate to $980 million, up from a mild 2% growth in 1986. One reason for the strong showing, says Thomas Bruggere, president and CEO of Mentor Graphics Inc., Portland, Ore., is that the productivity gains from early installations of CAE systems are finally being seen. "Where before three to five units were bought for a small number of people in a department, we're beginning to see purchases of five to ten systems as whole departments are getting systems," he says.

Other factors are the availability of networking so that users can pass files from one system to another, and the rapidly declining cost per station for CAD and CAE systems. In 1987, network file systems will allow personal-computer users to access files on a Sun work station or a Digital Equipment Corp. VAX minicomputer transparently. This means whole departments can share data in a common file system, finally achieving the synergy that CAE has long promised its users.

Just as microprocessor development systems are being affected by declining unit prices, so, too, are design work stations. "The average selling price for a CAE work station has fallen from $140,000 down to $30,000," says Bruggere. The fall has been precipitated by the increased use of personal computers in CAE applications. But instead of displacing larger CAE work stations, the personal computer will supplement them. The work stations still offer functionality not available on the personal computer, and they will grow 22% this year to $910 million.

Work stations for the design and layout of printed-circuit boards are the fastest-growing single CAD/CAE category, soaring 25% over last year's sales of $230 million to $288 million. "The growth will come from the installed base, which represents nearly 60% of the total available market converting en masse to newer-technology pc-board layout tools," says Brian Gardner, semiconductor industry manager at Calma Co., Milpitas, Calif.

Most makers bought their current systems in the early 1980s, when pc boards were packed with small- and medium-scale ICs. "Now boards have high-density application-specific ICs and very large-scale chips with large pin counts, as well as surface-mounted devices that can go on either side of a board," Gardner explains. "The number of traces to be run has increased considerably, and spacing between traces has dwindled. You just can't place and route today's boards with yesterday's layout tools."

CAD/CAE EQUIPMENT

(millions of dollars)

	1985	1986	1987
Design work stations, total	730	740	910
Integrated-circuit design	150	140	168
Printed-circuit-board design	210	230	288
Other engineering work stations	370	370	454
Simulation accelerators	50	60	70
CAD/CAE EQUIPMENT, TOTAL	780	800	980

All figures in current U.S. dollars

CONSUMER

DEMAND WILL RISE 6%, DOWN FROM 8% LAST YEAR

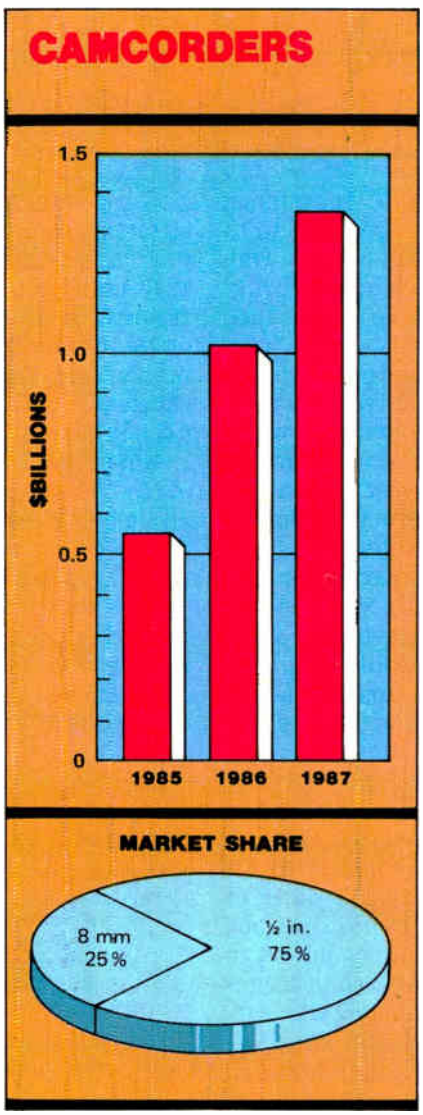
High-volume mainstream products such as color TV sets and video cassette recorders and cameras will send the U. S. consumer-electronics universe into another year of moderate expansion, but at a slightly slower rate than in 1986. *Electronics* projects that total factory sales to the U. S. market will be $31.4 billion, 6% higher than the 1986 total of $29.5 billion. Although this would be a lesser clip than last year's 8%, profits may be higher. The dollar's continuing drop in value against the yen—raising the cost of Japanese imports—may finally help relieve the fierce pricing pressure that has long plagued many consumer-electronics products.

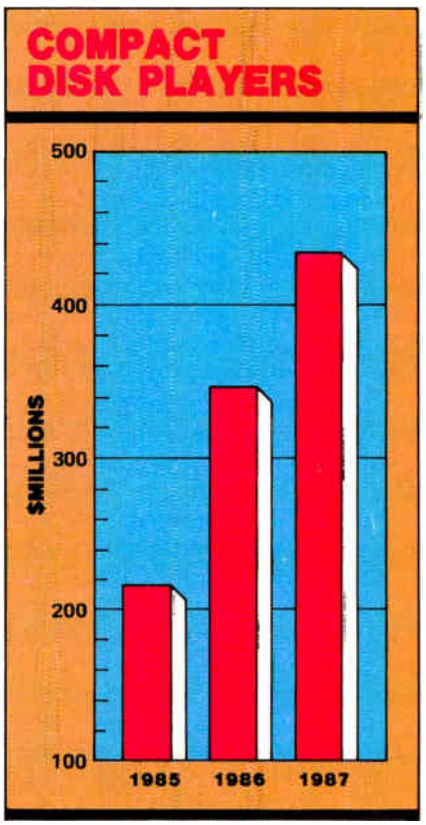
Part of the reason for the slower growth is the leveling off of two categories that skyrocketed in 1986: the video camera/recorder, or camcorder, which soared 87% last year to $1 billion; and the compact-disk player, which took off at a 59% clip to $346 million. Industry watchers note that this is a natural progression as new products settle into the marketplace after an initial growth spurt. The *Electronics* survey forecasts robust, if less dramatic, movement for both next year. The camcorder will show a 32% increase, to $1.3 billion, and the CD player will rise 25%, to $434 million.

In the audio sector, the prosperity in the CD business is spilling over into other, more established components, leading to a 3% growth path overall this year, with $6.2 billion in sales. Another mature product that will show continuing progress is the venerable color TV receiver, for example, which will inch up another 1% to an all-time sales record of $5.8 billion, compared with a 4% rise to $5.7 billion in 1986. The entire video segment—the biggest chunk of the consumer-electronics business at about 43%—should see growth matching the 6% projected for the industry as a whole. Sales will reach $13.6 billion, compared with $12.8 billion in 1986.

Home computers, meanwhile, will grow 13%, to $3 billion. Coming on the heels of a 26% spurt last year, this rise helps take the sting out of 1985's precipitous decline, though it's still far short of the 50% to 60% growth rates seen earlier in the decade. Home-computer peripherals should remain strong at 17%, nearly equalling the 20% hike achieved last year and becoming a $2.8 billion business in 1987.

One video heavyweight, VCRs, will grow by only 1% to $4.5 billion in 1987. In 1986, the growth rate was 5%, to $4.4 billion. By the end of the year, say industry ob-





servers, about half of all U. S. homes will have a VCR. The VHS and Beta units in the conventional ½-in. format will continue to account for the vast majority of sales: better than $4.4 billion of the total, in fact. But the competing 8-mm format will continue to make inroads, with sales more than doubling from $39 million in 1986 to $80 million in 1987.

In the camcorder market, too, the 8-mm format will continue to make headway. Market watchers believe the 8-mm unit's inherently smaller size will help boost sales 54% to $340 million, representing 25% of all U. S. camcorder business. Led by Sony Corp. on the 8-mm side and JVC Co. in the ½-in. VHS camp, manufacturers are expected to push camcorders heavily this year, in part because of the larger profit margins involved. With units priced at $1,000 and up, one camcorder sale can mean profits equal to 20 to 30 VCR sales, given the price competition in VCRs, says John D. Osterhout, planning director at Eastman Kodak Co.'s Consumer Products Division, Rochester, N. Y.

On the audio side, the consumer love affair with digital compact-disk technology, which offers sound far superior to conventional analog hi-fi, should continue. The 1987 market of $434 million is exactly double the market size in 1985. What's more, the rest of the audio business is riding on the CD's coattails. "The advent of CD has put a big boost into hi-fi and audio," says Paul Foschino, a senior product manager for Technics, Matsushita Electric Corp. of America, Secaucus, N. J. "We're selling more one-brand systems with CD players in them, and we're selling more speakers and receivers, because people are looking to upgrade the quality of the other components once they do add a CD player to their system." As a result, stereo equipment overall will grow 1% this year, to $1.74 billion, though the increase is well below the 12% achieved in 1986.

Foschino and others predict an end this year to the severe pricing pressure in CDs, which have dropped at retail to $300 or so per unit, compared with the $800 to $1,200 price tags they carried when they were introduced in 1983. Prices will drop no lower, they believe. And if vendors can stick to their guns against low-end discounters, the same may occur in other product categories, both audio and video, as well. "The dollar/yen situation is going to affect the industry on an overall basis," Foschino says. "The industry has always given you more power, more features, and lower prices every year. But going into 1987, I think a lot of price points are going to be maintained, as opposed to going down. And a lot of the prices on individual components in each category will probably even have to go up."

The big question in audio products is the impact of digital audio tape players. It looks as though the first DAT units will be introduced this year, and some observers think they could eventually drag down CD players. Other industry watchers point out that cassette players didn't sink conventional stereo units.

In terms of sheer sales volume, the color TV receiver—already in 92% of U. S. households—is expected to again take the honors this year. The 1% growth rate is seen as a strong showing for such a mature product. Industry observers credit the widespread adoption of stereo TV broadcasting, the move toward larger screen sizes, and the ongoing revolution in home-video viewing habits as among the reasons for the increase. "People are buying VCRs. They're subscribing to cable. They're joining neighborhood video clubs. And they want the best possible TV sets to anchor their systems," says Allan Schlosser, vice president for communications at the Electronic Industries Association's Consumer Electronics Group in Washington, D. C.

The home-computer market will enjoy another good year. Although the 13% rise forecast is just half of what the business enjoyed last year, some observers believe the market is becoming more stable. Andy Bose, of the New York market research firm Link Resources Corp., says that a transition by vendors from low-end machines to more powerful, versatile computers for the home will produce a more sustainable growth rate for the next several years. "We see the market growing at about 10% a year," Bose says. He puts home-computer penetration of U. S. households at about 18% at the end of 1986, growing to "around 25%" by 1990.

CONSUMER EQUIPMENT

	(millions of dollars) 1985	1986	1987
Consumer audio equipment, total	**5,635**	**6,075**	**6,268**
Car audio	2,100	2,331	2,494
Stereo equipment, total	1,522	1,716	1,745
Compact systems	433	516	520
Components	1,089	1,200	1,225
Phonographs and radio-phonographs	91	78	65
Radios (incl. table, clock, and portable)	555	494	455
Portable audio tape equipment, total	1,150	1,110	1,075
Portable tape recorders and players	210	190	185
Portable radio/tape combinations	940	920	890
Compact-disk players	217	346	434
Consumer video equipment, total	**11,962**	**12,854**	**13,636**
TV receivers, total	5,812	6,025	6,087
Color	5,500	5,730	5,800
Monochrome	312	295	287
Projection TV receivers	490	560	600
Video cassette players and recorders, total	4,215	4,449	4,500
1/2-inch	4,200	4,410	4,420
8-mm	15	39	80
Camcorders, total	545	1,020	1,349
1/2-inch	457	800	1,009
8-mm	88	220	340
Home satellite-receiving stations	900	800	1,100
Personal consumer products, total	**9,653**	**10,605**	**11,480**
Calculators	520	530	555
Electronic games and toys	187	142	160
Electronic musical instruments	472	488	513
Electronic watches	1,275	1,300	1,330
Home computers (under $2,000)	2,100	2,650	3,000
Home-computer peripherals	2,030	2,450	2,870
Microwave ovens	1,650	1,750	1,700
Telephones, total	949	965	985
Corded telephones	689	680	670
Cordless telephones	260	285	315
Telephone-answering devices	270	330	367
CONSUMER ELECTRONICS, TOTAL	**27,250**	**29,534**	**31,384**

All figures in current U.S. dollars

INDUSTRIAL

GROWTH WILL RISE 14%, AFTER DROPPING 5% LAST YEAR

Sharp cutbacks in automation expenditures by the auto industry, a severe downturn in the petrochemical industries, and wariness of the new tax law all combined to undercut *Electronics*' year-ago forecast for 14% growth in 1986. In fact, the industrial electronics sector dropped 5% last year—but this year's survey forecasts a brighter 1987, with an upturn of 14% and sales of $6.4 billion. Most market watchers believe the turnaround will be the result of the country's emergence from an almost three-year slump along with the industry's broadening into more diversified applications.

For all sectors of the business except vision systems, growth was nonexistent in 1986. Robotics was particularly hard hit because of the automaking crunch, taking a 23% nosedive after a flat 1984 and 1985. The 12% rise forecast in this sector for 1987 should produce $520 million in sales, but this total still falls short of the $595 million in 1985.

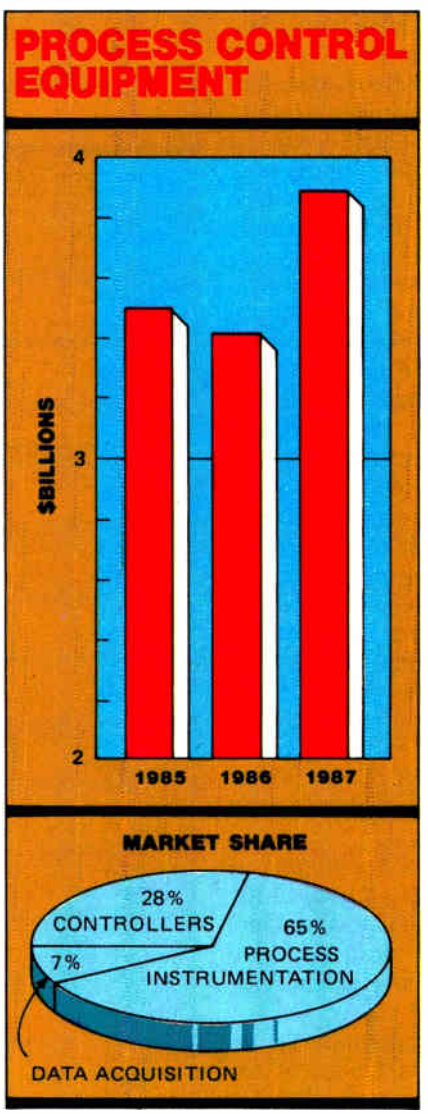
Also caught in the wake of the automakers' cutbacks were motor controls, down 10%, and numerical-control systems and programmable controllers, which dipped 1% each. *Electronics* sees hefty rises in 1987 for all three: 22% in motor control, to $770 million; 26% in numerical control, to $300 million; and 11% in programmable controllers, to $1.1 billion.

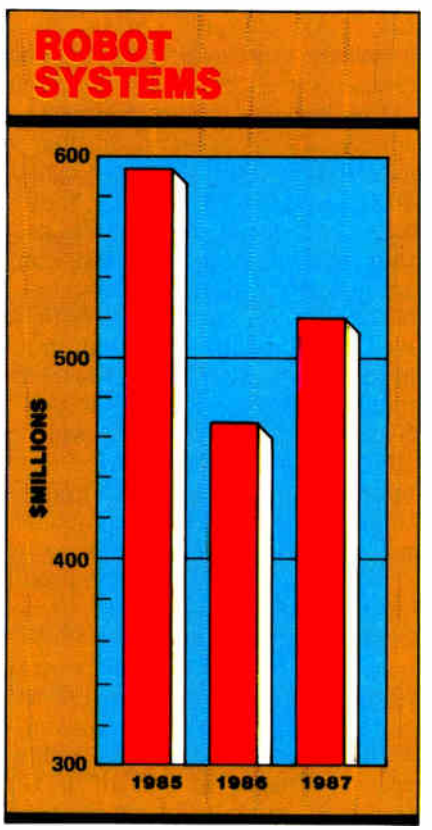
Meanwhile, the problems in the petrochemical industry spelled trouble for process-control makers, who saw sales slip 3% in 1986, to $3.4 billion. An expected increase in demand for oil in 1987 should produce gains of 13%, bringing sales to $3.9 billion.

The single bright spot in 1986 was vision systems, which recorded a sprightly 25% growth rate, to $100 million. *Electronics* predicts that this sector will continue to expand as U. S. industry increases its demand for sophisticated inspection devices employing vision. However, growth will moderate to 10%, for $110 million in sales in 1987.

The robotics industry's troubles are tied to the fact that almost half its business is in auto production, where robots are used for spot welding, material handling, and painting, among other chores. In one extreme example, GMF Robotics Corp.—the Troy, Mich., company set up as a joint venture of General Motors Corp. and the Japanese robot maker Fanuc—gets 85% of its business from the 5% of its customers who are in the auto industry. GMF holds one third of the domestic robot market.

Because of this top-heavy reliance on a single industry, robot





makers were hard hit when carmakers cut back or delayed their automation programs. A case in point is GM's Saturn project, a highly automated line to build an American compact to compete with Japanese imports. Production goals were cut in half and capitalization trimmed by $1.6 billion as part of GM's general retrenchment.

There will be little relief from the fierce setbacks in automotive sales in the immediate future. But two small but promising segments of the robotics market directly related to electronics hold promise for the industry, and in large part account for the rosier picture being painted for 1987. These are special noncontaminating robots for integrated-circuit processing and robots for board assembly. Together they make up less than 10% of the U. S. robotics market, but their excellent yearly growth rates indicate their potential for occupying a larger slot.

With IC processing pushing toward extreme cleanliness for submicron line widths and the concurrent need for higher productivity and yield requirements, noncontaminating robots are beginning to take their place in the clean room. This market currently accounts for only about $12 million in annual sales, but its growth rate in 1986 and 1987 could be as high as 20% a year. And if semiconductor equipment booms in 1988, as some observers predict, clean-room robots could become an even larger force.

Meanwhile, the board-assembly robot is becoming more than a laboratory demonstrator. It's moving out onto the shop floor, says Charles Henri-Mangin, president of Ceeris International, Old Lyme, Conn., a market research firm. U. S. sales were about $34 million in 1985, about $50 million in 1986, and could reach $60 million in 1987, he says.

Robotics makers weren't the only segment of the industrial electronics market hurt by the downturn in automotive automation. The cutbacks also affected makers of motor controls and numerical controls for machine tools and inspection systems. Programmable controllers were also zapped but managed to make up for it elsewhere. This electronic gear is heavily used in carmaking; for example, a spokesman at Allen-Bradley Co., a GM supplier, estimates that 40% to 50% of his company's applications are automotive. But the dip was cushioned by an increased demand in such other applications as food processing, pharmaceuticals, metal refining, paper-making, and electronics, including the burgeoning field of computer-integrated manufacturing. These factors combined to keep the programmable-controller market almost flat. Observers predict a growth rate anywhere from 5% to 15% in 1987 and perhaps an even bigger rise in 1988, keeping pace with the expansion of CIM.

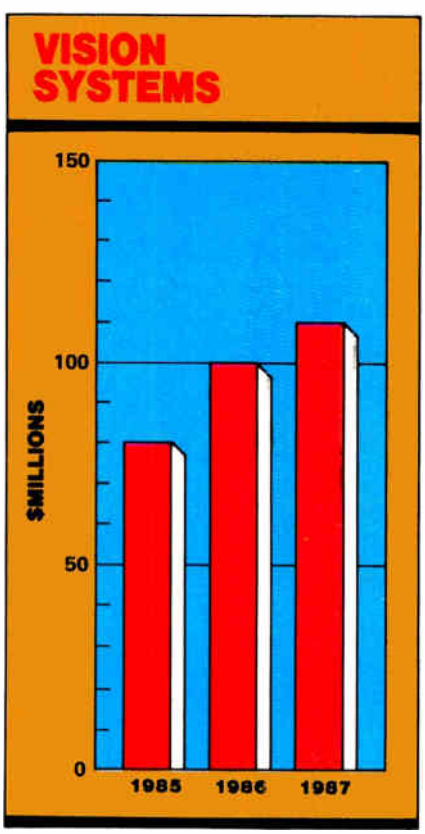
INDUSTRIAL EQUIPMENT

	(millions of dollars) 1985	1986	1987
Energy-management equipment	500	490	510
Inspection systems	340	342	400
Motor controls (speed, torque)	700	630	770
Numerical-control systems	240	238	300
Process-control equipment, total	3,500	3,416	3,874
Data-acquisition systems	240	236	274
Process instrumentation	2,260	2,190	2,500
Programmable controllers	1,000	990	1,100
Robot systems	595	464	520
Vision systems	80	100	110
INDUSTRIAL ELECTRONIC EQUIPMENT, TOTAL	5,955	5,680	6,484

All figures in current U.S. dollars

In process control, sales dipped 3% to $3.4 billion in 1986, with some of the slack created by the precipitous drop in oil-refinery demand taken up by the paper, chemical, plastic, and food industries, which is why the decline in process-control gear was just 3%. A projected rise in oil consumption in the U. S. is the main reason for the anticipated 13% increase in 1987 for process-control equipment.

The outstanding bright spot in industrial electronics is vision systems. With the emphasis on quality and reliability in all forms of manufacturing, the inspection function is becoming more and more critical. Vision systems—which combine optics, electronic sensors, signal processing, microcomputers, and software—are the solution.



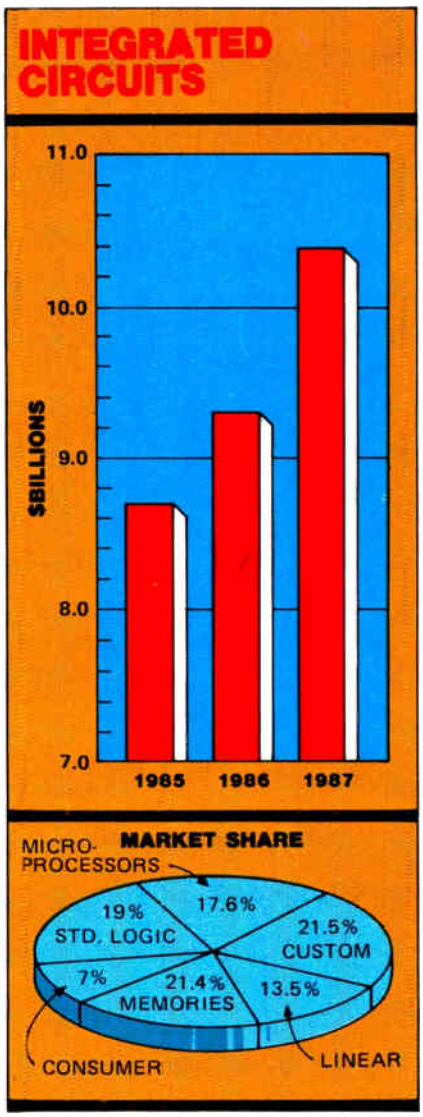
In 1985 the entire vision-system market was only $80 million. Last year it rose to $100 million, and by 1988 the market should grow to about $140 million. However, Ted Chase, manager of marketing at General Electric's Robotics and Vision System Division, Orlando, Fla., points out that this level of growth depends on the industry's developing generic vision systems, rather than the application-oriented types that predominate today.

One factor that slowed sales last year could carry over to 1987: the new federal tax-reform bill, which has caused businesses to put their capital spending on hold. "The impact on business investment has been much greater than either Congress or the administration expected," says Deborah Thresher, program manager at Gnostic Concepts Inc., San Mateo, Calif. "It has contributed to the less-than-optimistic growth prospects for electronic-equipment producers" in 1986.

The semiconductor industry will pick up a little more speed in 1987. The *Electronics* industry survey predicts growth in U.S. demand reaching 12%, with sales reaching $12.4 billion overall. In 1986, the *Electronics* survey shows, the industry grew only 7%, to $11.1 billion. But both years' gains will not move the industry back to the level of sales seen in 1984, the last boom year.

Integrated circuits should see a 12% gain to $10.4 billion, against last year's 8% rise to $9.3 billion. Discrete semiconductors will rise 10% to $1.6 billion, a marked improvement over last year's 3% gain. And optoelectronic devices will increase 14% overall to $348 million. This sector grew 12% last year, with sales of $304 million. In all market sectors, dollar growth will come mainly from higher-volume consumption of such products as CMOS microprocessors and memories, advanced linear ICs, MOS power transistors, and high-resolution optoelectronic arrays. These chips command higher prices than older commodity products, which have suffered severe price erosion.

Within the far larger IC sector, the *Electronics* survey shows microprocessors, microcomputers, and related ICs advancing 12% to $1.8 billion, following a 9% increase and $1.6 billion in sales in 1986. Here, growth will be paced by high-performance CMOS devices that command prices of up to $300, compared with $5 or so for older MOS chips. Doing even better are semicustom chips that replace high-cost subsystem assemblies. Standard cells, for instance, are due to rise 47% to $287 million, and electrically programmable gate arrays should go up 50% to $51 million.



In memories, the overall market should grow 12% to $2.2 billion, following a scant 6% rise in 1986. CMOS static memories, which are replacing cheaper types because of their superior speed-power product and large capacities, are forecast to rise at a brisk 19%, to $273 million. Dynamic random-access memories, which grew only 5% last year, should improve to 9% this year, thanks to the higher prices resulting from the recent U.S.-Japan trade agreement. The fastest-growing DRAM naturally is the newest: *Electronics* shows the 1-Mb chip up almost 200%, to $203 million.

Although most industry watchers agree that 1987 will be better than 1986, there's wide divergence over just how good the recovery will be. On the side of the optimists is Dataquest Inc., the San Jose, Calif., market research house, which sees IC consumption rising 14%, including a 17% rise in microprocessors and microcomputers, and a 12% rise in DRAMs. In contrast, Integrated Circuit Engineering Corp., Scottsdale, Ariz., predicts an up-down cycle in 1987. ICE expects the year to end in a 9% growth rate, but predicts overall U.S. growth of only 4%, compared with 10% worldwide.

In the past three years, original-equipment manufacturers have twice built up inventories to avoid shortages, then cut back on orders while using up the surplus. Now they see little point in refilling their stockrooms, because the semiconductor industry has about twice as much capacity as orders.

On the plus side, the stage is now set for a more orderly U.S. market. Not only was the buying binge in the first half of 1986 smaller and shorter than the one in 1984, but also it produced only a minislump compared with 1985. In December, the Semiconductor

Industry Association reported that book-to-bill ratios, which compare orders and shipments, had risen in October and November to 0.99, indicating slow growth combined with inventory depletion.

Indeed, inventory depletion comes up again and again in conversations with industry executives, along with the hope that U. S. computer and peripheral production—the largest single consumer of semiconductors—will catch fire this year. Michael Graff, vice president of marketing for Harris Corp. Semiconductor Sector, Melbourne, Fla., believes that IC shipments now closely match actual consumption in assembly plants. The same is true of discrete components and linear ICs, says Peter Jenner, director of new product planning for Unitrode Corp., Lexington, Mass. He argues that sales would rise even with no growth in equipment markets because real consumption has overtaken shipments.

In any event, growth needs to hit 15% in order to offset the abnormal price erosions of the past few

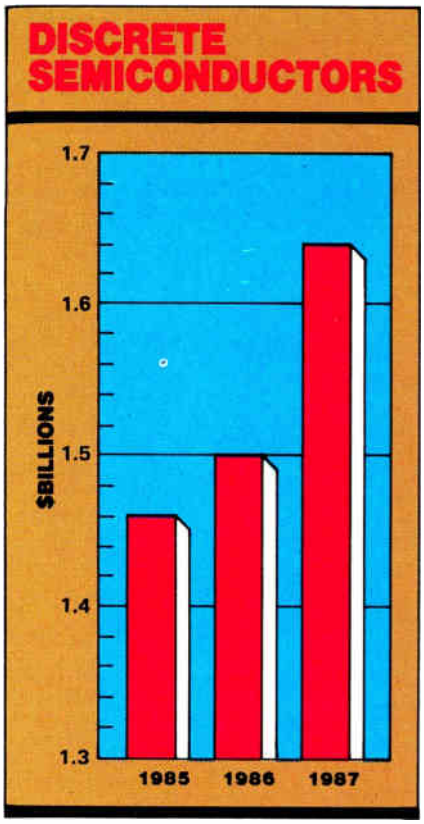
SEMICONDUCTORS

Discrete semiconductors, total	**1,460**	**1,498**	**1,642**
Diodes, total	521	525	582
Arrays (including bridges)	28	26	27
Rectifiers, total	313	310	349
Low power (less than 25 A)	169	173	184
High power	54	55	62
Fast recovery	90	82	103
Signal	75	77	84
Special purpose, total	27	29	31
Microwave (above 1 GHz)	17	18	19
Varactor	10	11	12
Zener	78	83	91
Protection devices (including solid state, excluding fuses and circuit breakers)	19	20	22
Thyristors	125	132	145
Transistors, total	795	821	893
Bipolar, total	585	606	655
Power (1 W or more)	318	331	355
Rf (above 1 GHz), total	72	77	84
Power (1 W or more)	41	45	50
Small signal	31	32	34
Small signal (less than 1 W)	195	198	216
Field effect, total	143	150	168
Power, total	103	108	124
High power (greater than 20 W)	21	22	26
Medium power (1 to 20 W)	82	86	98
Small signal (less than 1 W)	40	42	44
Gallium arsenide	67	65	70
Integrated circuits, total	**8,665**	**9,327**	**10,428**
Consumer-product integrated circuits	618	667	730
Custom ICs, total	1,625	1,858	2,233
Fully custom	773	789	821
Electrically programmable arrays	7	34	51
Fuse programmable arrays	166	187	252
Gate arrays	525	653	822
Standard cells	154	195	287
Linear ICs, total	1,192	1,291	1,410
Analog switches	64	65	68
Communications	122	139	156
Comparators	31	31	32
Data conversion, total	403	449	496
A-D converters	165	186	208
D-A converters	168	188	207
Multiplexers	35	38	41
Sample and holds	35	37	40
Instrumentation amplifiers	15	17	18
Interface	135	144	149
Operational amplifiers	188	200	224
Timers	80	78	82
Voltage regulators	111	116	127
Others (incl. functional ICs)	43	52	58
Memories, total	1,946	2,027	2,241
Magnetic bubble devices (including support circuits)	16	17	19
Random access, total	1,143	1,194	1,324
Dynamic, total	728	763	835
16-K	15	5	5
64-K	291	76	19
256-K	416	613	608
1-Mb	6	69	203
Static, total	415	431	489
Bipolar	113	120	135
Integrated circuits (continued)			
CMOS, total	201	229	273
Fast (less than 70 ns)	31	38	53
Slow	170	191	220
MOS	101	82	81
Read only, total	788	816	898
Ultraviolet-erasable programmable	339	349	387
Electrically erasable, total	83	87	105
EEPROM	67	66	80
Shadow (NVRAM)	16	21	25
Mask type, total	171	189	211
CMOS	60	77	97
MOS	111	112	114
PROM bipolar	195	191	195
Microprocessors and microcomputers, total	1,504	1,644	1,840
LSI peripheral chips, total	526	584	627
Peripheral equipment controllers (disk and CRT controllers etc.)	284	345	395
Processor support devices (DMA, MMU, etc.)	242	239	232
Microprocessors, total	340	388	433
Bipolar	120	154	170
CMOS/MOS, total	220	234	263
8-bit	69	70	71
16-bit	96	95	109
32-bit	55	69	83
One-chip microcomputers, total	429	416	449
4-bit	149	125	107
8-bit	275	283	323
16-bit	5	8	19
Special purpose processors, total	209	256	331
Digital signal processors	42	42	60
Floating-point processors	15	20	27
Multiplier processors	139	169	211
Others	13	25	33
Standard logic families, total	1,780	1,840	1,974
CMOS	712	736	780
ECL	177	184	214
TTL, total	891	920	980
Schottky TTL, total	801	834	892
High speed (AS, ALS, FAST, etc.)	196	206	241
Low power (LS)	551	577	594
Standard (S)	54	51	57
Standard TTL	90	86	88
Optoelectronic devices, total	**271**	**304**	**348**
Imaging arrays, total	51	69	90
CCD	27	46	65
Other	24	23	25
Laser diodes	8	10	11
Light-emitting diodes (discrete), total	70	76	79
Infrared, near infrared	19	24	25
Visible	51	52	54
Optically coupled isolaters	73	89	95
Photoconductive cells (light-dependent resistors)	16	16	17
Photodiodes	6	6	6
Phototransistors	18	19	21
Photovoltaic cells	29	28	29
SEMICONDUCTORS, TOTAL	**10,396**	**11,129**	**12,418**

All figures in current U.S. dollars

years and to restore profitability to the industry, says Thomas Humphrey, director of strategic marketing, Signetics Corp., Sunnyvale, Calif. But since strong growth may not be in the cards for the U. S. market, he notes, the difference must be made up in the now larger and faster-growing Far Eastern market.

The big excitement in the IC market is the strong growth projected for several new products, such as the 32-bit microprocessors. The 32-bitters should soar 20%, to $83 million, on top of a 25% increase and $69 million in sales last year. Intel Corp. expects its new 80386 32-bit microprocessor alone to have a significant impact on the industry, says Ronald Whittier, vice president and director of marketing of the Santa Clara, Calif., company. "We also see continuing pervasiveness of the 16-bit machines and continuation of all the product lines going into CMOS," he adds.



Indeed, advanced CMOS versions of the older MOS processors are also in the forefront of the microprocessor market. Their growth rate will double from 6% to 12%, producing $263 million in sales in 1987 compared with $234 million in 1986. But bipolar microprocessors will slow from 28% growth to just 10%, realizing $170 million in sales.

Although competition is keener than ever in the semicustom IC arena, growth rates are still high. *Electronics* forecasts a 20% growth rate overall in the custom and semicustom market. But the semicustom chips, with their shorter turnaround times and lower design costs, are responsible for virtually the entire spurt. Although the custom market will still be huge, at $821 million, the growth rate will flatten from 4% to 2% because of the continuing swing to semicustom chips.

Especially strong are such startup technologies as electrically programmable arrays, which should grow 50% to $51 million on top of more than 300% growth and $34 million in sales last year. Gate arrays, though, have become commodity products. Also, they're being squeezed out of the low-volume market by programmable arrays and out of the high-volume market by standard-cell circuits, which offer greater flexibility and more functions per chip. Still, with rapidly increasing production volume, this category should post a 26% growth rate to $822 million, on top of 24% to $653 million in 1986.

Standard cells, too, are in for a robust year. This category should catapult 47% to $287 million in 1987, compared with 27% and $195 million last year. This growth largely accounts for the diminishing luster of the traditional, handcrafted custom IC market. "The dividing lines between full-custom and standard-cell circuits are rapidly disappearing, because so many designs are now cell-based with some additional customizing," says Nancy Hartsoch, director of marketing services at Gould AMI Semiconductors, Santa Clara, Calif. "We consider them one market, and together they'll have a compounded annual growth rate of 24% over the next five years."

Electrically erasable programmable read-only memories should post a 21% gain, to $80 million, after a 1% dip in 1986. Much of the gain in EEPROMS comes from the increasing use of parts up to the 64-K size in such applications as updating-instrument-and-control settings. To boost sales, producers are coming out with higher-density, flash-technology devices that cost only about one third more than ultraviolet-erasable EPROMs, instead of 5 to 10 times as much.

But EPROMs are still alive and well, now that predatory pricing has ended, says William De Matteis, director of marketing in the Nonvolatile Memory Division at Advanced Micro Devices Inc., Sunnyvale, Calif. *Electronics* shows this category growing 11% to $387 million, compared with a scant 3% gain, to $349 million, in 1986. One reason: by the end of 1986, U. S. prices for 256-K chips had risen to 10% more than world prices in the wake of antidumping restrictions on Japanese imports. Moreover, says De Matteis, customers have trimmed down excess inventory. "I expect major customers to keep going on working inventory with just-in-time shipments. The computer market is doing quite well; a strong market is building in laser printers, facsimile machines, and so on; and the new 1-Mb EPROMs are going into military systems."

Similarly, dynamic RAM growth of 9% is largely the result of price increases created by the U. S.-Japan trade agreement. However, the foreign market values set in the pact allow Japanese firms to recapture U. S. market share lost during the cutthroat competition of 1985. About 75% of the Japanese manufacturers' U. S. revenues come from DRAMs. Douglas Finlay, market analyst at NEC Electronics Inc., Mountain View, Calif., concurs that the agreement will help the Japanese maintain their U. S. revenue base and market share. But if the computer market does well this year, he says, there will be more revenues for all semiconductor producers at a growth rate around 16%.

In the linear IC market, *Electronics* pegs the growth of data converters—the largest single chunk—at 10%, with sales of $496 million. This segment dropped little in 1985 and has grown steadily since then. Moreover, a high proportion of converters are proprietary designs with fairly stable prices.

But at least one observer believes the growth could be as brisk as 20%. "Digital signal processing is beginning to creep in, and we are seeing a tremendous push toward digitization of controls in what were standard linear markets," says Brian Gillings, director of strategic planning and applications at Maxim Corp., Sunnyvale, Calif. The *Electronics* survey shows analog-to-digital converters growing 12% to $208 million, and digital-to-analog converters rising only 10%, to $207 million. "You can get more functionality now in an ADC by buying it than building your own. So a lot of DACs are going away," says Gillings.

Although discrete components should grow at a lesser clip overall than ICs—10% to $1.6 billion, compared with 12%, respectively—surface mounting is adding some energy to this market. Chris Lister, general manager of Ferranti Electric Inc.'s Semiconductor Group, Commack, N. Y., says sales of surface-mounted diodes and transistor types grew as much as 125% last year, in line with the swing toward automated assembly of automotive electronics and consumer goods. And the popularity of this type of packaging is helping stem the offshore-assembly tide, he says. Up until now, "people have said, 'We're assembling in the Far East, so it's cheap enough,'" he says. "But now they are changing over and finding that they can get better cost control with fully automatic surface-mount equipment."

Also showing good growth in the discrete sector are MOS FETs, which should mark a 12% rise to $168 million this year, following a flat 5% growth rate and $150 million in sales last year. These parts are used for such applications as higher-efficiency power supplies. But they still cost more than bipolar power transistors, so growth has not yet lived up to previous expectations, Lister says.

In optoelectronic components, the forecast is for a 14% rise overall, to $348 billion, and for exceptional growth in imaging arrays, notably charge-coupled-device arrays. CCDs will experience growth of 41% on the heels of a 70% spurt last year, making them a $65 million market. The major impetus is the consumer market for video camera-recorders, according to James Johnson, sales manager of Fairchild's CDD Division, Sunnyvale, Calif.

DRAMATIC TURNAROUND AHEAD FOR SEMICONDUCTOR EQUIPMENT SALES

After a dismal year that saw sales slip 19% overall, the semiconductor equipment industry should experience a boost in 1987 as the recovering IC business begins to lead the equipment makers out of some severe doldrums. The *Electronics* survey pegs the rise at 19%, with sales reaching $2.7 billion. But the increase will serve only to bring the industry back to its 1985 level.

Stronger relief may come in 1988, according to experts like John Salzer, president of Salzer Technology Enterprises Inc., Santa Monica, Calif., and Dan Hutcheson, president of VLSI Research Inc., San Jose, Calif. The two market watchers predict a surge of 27% to 40% that year.

Many factors have contributed to the poor state of this industry, notably the excess capacity built up by U. S. chip makers during the boom year of 1984. Until this is dissipated—perhaps in 1988—semiconductor firms will be hesitant to invest in new equipment. Two additional complications are the new tax reform bill, which is inhibiting capital investments in new processing lines, and the U. S.-Japan semiconductor trade agreement, which may help the Japanese to solidify their recent market gains in the U. S.

The large lithography segment of the industry has been additionally hard-hit by the increasing Japanese presence in the step-and-repeat optical-lithography-systems market. Canon and Nikon have nabbed as much as 40% of this business, and U. S. lithography sales tumbled to $517 million in 1986. This was a 22% decline from an already depressed 1985 figure. *Electronics* projects growth of 16% in this sector in 1987, bringing sales to $601 million, still shy of the $657 million realized in 1985.

Perhaps the only steady spot in lithography is electron-beam systems. Sales of these units for direct writing on wafers for very high-speed integrated circuits and very large-scale chips and gallium arsenide devices underwent just a 6% decline in 1986, to $85 million. *Electronics* expects a slight upturn of 4% for 1987, with sales of $89 million, near the 1985 level. With added growth in VHSICs, some observers expect almost 20% growth in 1988.

Etching, deposition, and ion implantation—all parts of wafer processing—dove about 22% in 1986, and should almost make up that dip in 1987 as part of the general economic recovery, according to the *Electronics* survey. A particularly volatile segment was plasma-etching equipment, which went from a 64% growth rate in 1984 to 5% in 1985 and then dipped 9% last year. Salzer Technology Enterprises expects growth to begin again in 1987, with sales rising 25% to about $600 million.

SEMICONDUCTOR PRODUCTION EQUIPMENT

	(millions of dollars) 1985	1986	1987
Assembly (wire bonders, etc.)	350	350	350
Lithography, total	657	517	601
Aligners, total	570	437	501
Contact (proximity)	37	32	32
Direct wafer stepping	247	200	260
Electron beam	90	85	89
Projection	196	120	120
In-line handling (scrubbers, etc.)	87	80	100
Mask generation (digitizers, etc.)	52	47	56
Wafer preparation (crystal growers, etc.)	48	40	52
Wafer processing (furnaces, etc.)	1,650	1,300	1,642
SEMICONDUCTOR PRODUCTION EQUIPMENT, TOTAL	2,757	2,254	2,701

All figures in current U.S. dollars

LACKLUSTER GROWTH OF 7.7% WILL FOLLOW A 6% RISE IN 1986

U.S. component sales are in a slow-growth rut. This year they will rise only 7.7%, chalking up $21.2 billion in sales. This performance is about the same as the 6% gain to $19.8 billion seen in 1986, according to the *Electronics* market forecast. Industry executives, faced with lackluster growth, generally agree on one fundamental problem causing the meager growth in today's U.S. components industry: too much inventory chasing too few sockets.

"There are two reasons why this [low growth] is happening," says Peter B. Cherry, president of Cherry Electrical Products Corp. of Waukegan, Ill. "First, the world market is healthier than the U.S. market; and second, there are an increasing number of [components-laden] products that are not being made in this country." As a result, he says, U.S. companies will have to look toward foreign markets in order to boost growth. "We have to look for growth in worldwide markets—and those of us who don't, won't be around," he adds.

While developing a base in the international marketplace may be a partial solution, the problem of slow growth is rooted in a number of factors in the U.S. The Reagan Administration's new tax-reform initiative, which takes effect this year, has hit the business community full force. Sketchy about how the law will affect corporate profits, businesses

Capacitors, total	**1,263**	**1,303**	**1,432**
Ceramic (except chips)	420	437	460
Chips	89	104	145
Electrolytic, total	447	448	488
Aluminum	137	143	165
Tantalum	310	305	323
Film	133	137	156
Glass and vitreous enamel	15	15	16
Mica	25	23	23
Paper	119	123	125
Variable	15	16	19
Character displays, total	**305**	**338**	**374**
Gas discharge	80	83	85
Light-emitting diode	45	45	45
Liquid crystal	150	172	198
Vacuum fluorescent	30	38	46
Connectors, total	**3,389**	**3,595**	**3,843**
Coaxial (excluding assemblies)	318	330	349
Cylindrical, total	543	590	636
Miniature	218	238	257
Standard	150	159	169
Subminiature	175	193	210
Fiber-optic	40	46	58
Flat-cable	318	350	389
Insulation displacement	258	273	290
Printed-circuit edge connectors	720	763	805
Rack and panel	580	603	633
Special purpose	612	640	683
Crystals, total	**196**	**210**	**225**
Assemblies (including mounts and ovens)	136	150	165
Discrete crystals	60	60	60

Electron tubes, total	**2,239**	**2,334**	**2,390**
Cathode ray (excluding TV)	120	131	144
Power and special purpose, total	927	971	981
Gas and vapor	39	41	42
Klystrons	95	100	101
Light and image sensing	263	275	277
Magnetrons	84	88	89
TWTs (including backward wave)	312	327	330
Vacuum	134	140	142
Receiving	34	36	37
TV picture, total	1,158	1,196	1,228
Color	1,118	1,163	1,198
Monochrome	40	33	30
Hybrid and modular components, total	**344**	**370**	**410**
Active filters	20	21	22
Analog I/O (data-acquisition) boards	4	5	6
Custom hybrids and modules	250	265	294
Data conversion, total	40	44	48
ADCs	14	14	15
DACs	20	24	26
Converter subsystems	4	4	5
Sample-and-holds	2	2	2
Instrumentation and isolation amplifiers	8	10	12
Operational amplifiers	22	25	28
Magnetic, total	**885**	**943**	**1,027**
Af and rf transformers, coils, and chokes	200	207	228
Ferrite components (coil forms, etc.)	85	93	107
Power transformers	350	375	408
TV magnetic components (incl. yokes and flyback)	250	268	284

have become more conservative in their spending. "When businesses are uncertain about how policy might affect them, they generally choose to do nothing new and wait to see how the new policy takes shape in the ensuing months," says Deborah Thresher of Gnostic Concepts Inc., a San Mateo, Calif., market research firm.

Another factor slowing U. S. growth is a weakening in military expenditures, long a bulwark in the components industry. The Gramm-Rudman law, which essentially dictates that Congress must produce a budget within $10 billion of a $144 billion deficit goal for 1987, is causing governmental belt-tightening. The No. 1 victim here is military electronics: analysts predict zero growth in defense-budget outlays during 1987.

The effects are already being seen in such market segments as microwave components and special-purpose electron tubes, which depend heavily on military funds. *Electronics* shows microwave components growing 11% to $417 million in 1987, compared with 14% growth to $375 million last year. Similarly, power and special-purpose electron tubes are expected to grow a scant 1% this year, a significant drop from the 5% growth registered in 1986. Sales of these tubes should be $981 million, against $971 million last year.

Some market sectors are declining largely because of the increasing number of component imports finding their way into U. S. equipment. While the *Electronics* consumption figures report U. S. factory shipments minus exports plus imports, they do not reflect an important market indicator:

Microwave components, total	**329**	**375**	**417**
Amplifiers	120	142	163
Detectors	25	30	33
Ferrite devices	50	55	58
Mixers	40	45	49
Passive components, total	52	57	62
Coaxial and strip-line	40	45	49
Waveguide	12	12	13
Power limiters	20	22	25
Switches, total	22	24	27
Coaxial and strip-line	15	18	22
Waveguide	7	6	5
Passive filters and networks, total	**229**	**250**	**264**
Delay lines	28	30	32
Electromechanical filters	35	36	37
RC networks	30	32	35
Rfi and emi filters	136	152	160
Power supplies, noncaptive (switching and nonswitching), total	**1,516**	**1,664**	**1,837**
Switching, total	583	627	674
Pc-board mountable (encapsulated)	36	43	49
Open-frame and card	297	312	328
Rack mountable	74	78	83
Industrial (0.1% or worse regulation and over 1 kW)	111	128	147
Programmable	65	66	67
Linear, total	383	367	358
Benchtop	86	84	81
Rack mountable	150	136	130
Industrial (0.1% or worse regulation and over 1 kW)	84	86	89
Programmable	63	61	58
Uninterruptible	550	670	805
Printed circuits and interconnection systems, total	**2,986**	**3,115**	**3,352**
Chip carriers	19	27	40
Interconnections, total	445	506	548
Backplanes	185	210	218
Socket and socket panels for DIPs	260	296	330
Printed circuits, total	2,522	2,582	2,764
Flexible circuits	205	216	233
Rigid boards, total	2,317	2,386	2,531
Double sided	1,270	1,285	1,375
Multilayer	867	900	972
Single sided	180	181	184
Relays, total	**707**	**692**	**711**
Crystal can	123	122	123
General purpose	243	230	239
Reed	70	72	76
Rf	131	130	132
Solid state	58	61	63
Stepping and impulse	12	11	12
Telephone-type	45	44	46
Time delay	25	22	20
Resistors, total	**846**	**866**	**885**
Chip resistors	26	29	34
Fixed, total	234	239	240
Composition	43	41	40
Deposited carbon film	25	23	21
Metal film	85	90	94
Wirewound	81	85	85
Resistive networks, total	183	195	209
Thick film	163	174	186
Thin film	20	21	23
Thermistors	69	73	80
Variable, total	334	330	322
Potentiometers	200	198	190
Trimmers	134	132	132
Switches and keyboards, total	**1,101**	**1,136**	**1,176**
Dual-in-line	61	63	65
Keyboards	440	462	486
Lighted	123	125	129
Push-button	145	147	150
Rotary	73	74	76
Slide	41	43	44
Small-movement snap action	93	90	88
Thumbwheel	31	32	33
Toggle	94	100	105
Transducers (electronic), total	**950**	**1,060**	**1,180**
Flow	150	159	168
Fluid-level	108	121	135
Motion, linear and angular	130	143	154
Pressure (including air, liquid, and mechanical)	400	460	529
Temperature (excluding thermocouples and thermistors)	115	129	144
Vibration	47	48	50
Wire and cable, total	**1,477**	**1,593**	**1,653**
Coaxial cable	305	303	306
Fiber-optic cable	440	488	489
Flat-cable	112	124	136
Hook-up-wire	215	220	225
Multiconductor	405	458	497
COMPONENTS, TOTAL	18,762	19,844	21,175

All figures in current U.S. dollars

the balance of trade, which is exports minus imports. For example, in 1985, the electron-tube market recorded its first-ever balance-of-trade deficit, reports the Department of Commerce. Imports outweighed exports by close to 8%, an indication of stiff competition from foreign sources. Other areas with high trade deficits were capacitors at $71 million in 1985, and resistors at $87 million in 1985.

Ironically, today's fast-paced technological advances also are playing a part in the meager growth rates. Increased density in integrated circuits, for example, translates into a need for fewer connectors. More powerful and sophisticated active components produce a need for more complex and expensive printed-circuit boards and passive components—but they also reduce the need for many older devices considered to be industry standards.

Thanks to surface-mount technology, sales of double-sided printed circuit boards will grow 7%, to $1.37 billion, in 1987

But at least one new technology should help the growth of the components market. Surface-mount technology is the catalyst that will turn the business around, many industry watchers believe. Besides being 30% to 60% smaller than traditional leaded components, surface-mount devices are faster, more reliable, and cheaper to produce. As surface mounting becomes more widespread, it will make big inroads in the communications, computer, and auto industries, where it will allow high-volume production of electronic functions that were previously impractical with through-hole leaded components.

Gnostic Concepts predicts that by 1988, 27% of all passive and active components will be SMDs. Furthermore, it believes that as the technique is adopted by more manufacturers, the passive-components market in the U. S. will balloon from $13 billion in 1985 to almost $30 billion in 1993.

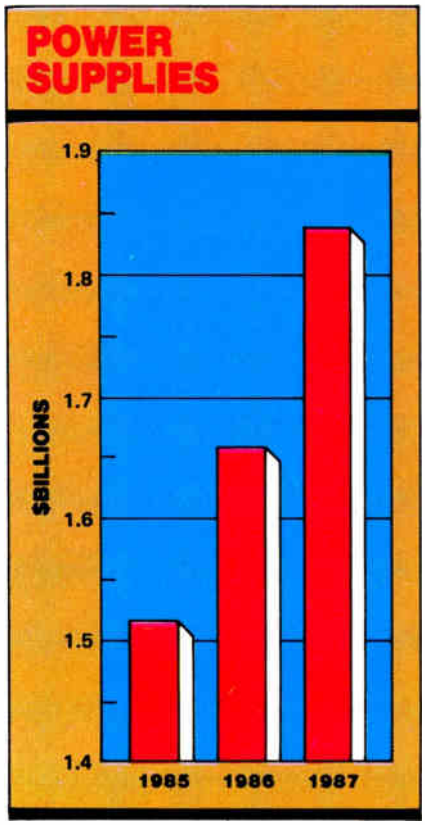
Still, Gnostic Concepts is the first to admit that surface mounting has been slow to catch on. So far, only large manufacturers have been able to afford the high cost of converting. A lack of standards, poor availability, and technical kinks in the surface-mount process itself have also contributed to the slow start.

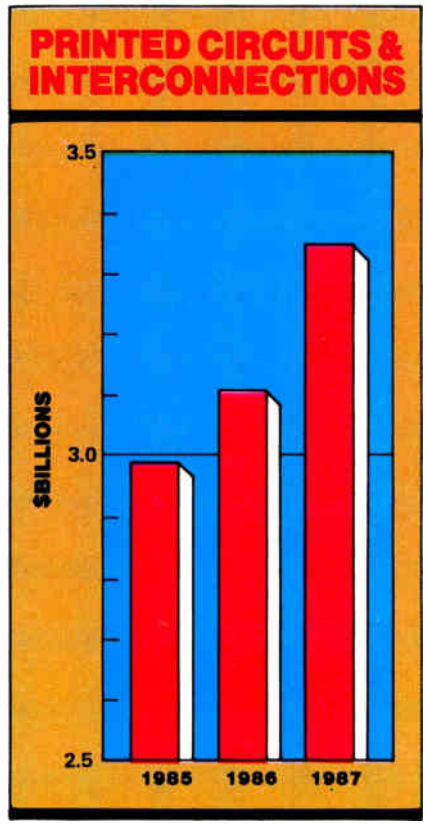
But growth is definitely occurring, and 1987 will show it. The *Electronics* survey shows chip capacitors soaring a strong 39% in 1987 to $145 million, compared with 17% growth to $104 million in 1986. Chip carriers will escalate 48% to $40 million, on top of 42% growth to $27 million last year. Similarly, chip resistors will move up 17% to $34 million, compared with a 12% gain and $29 million in sales in 1986.

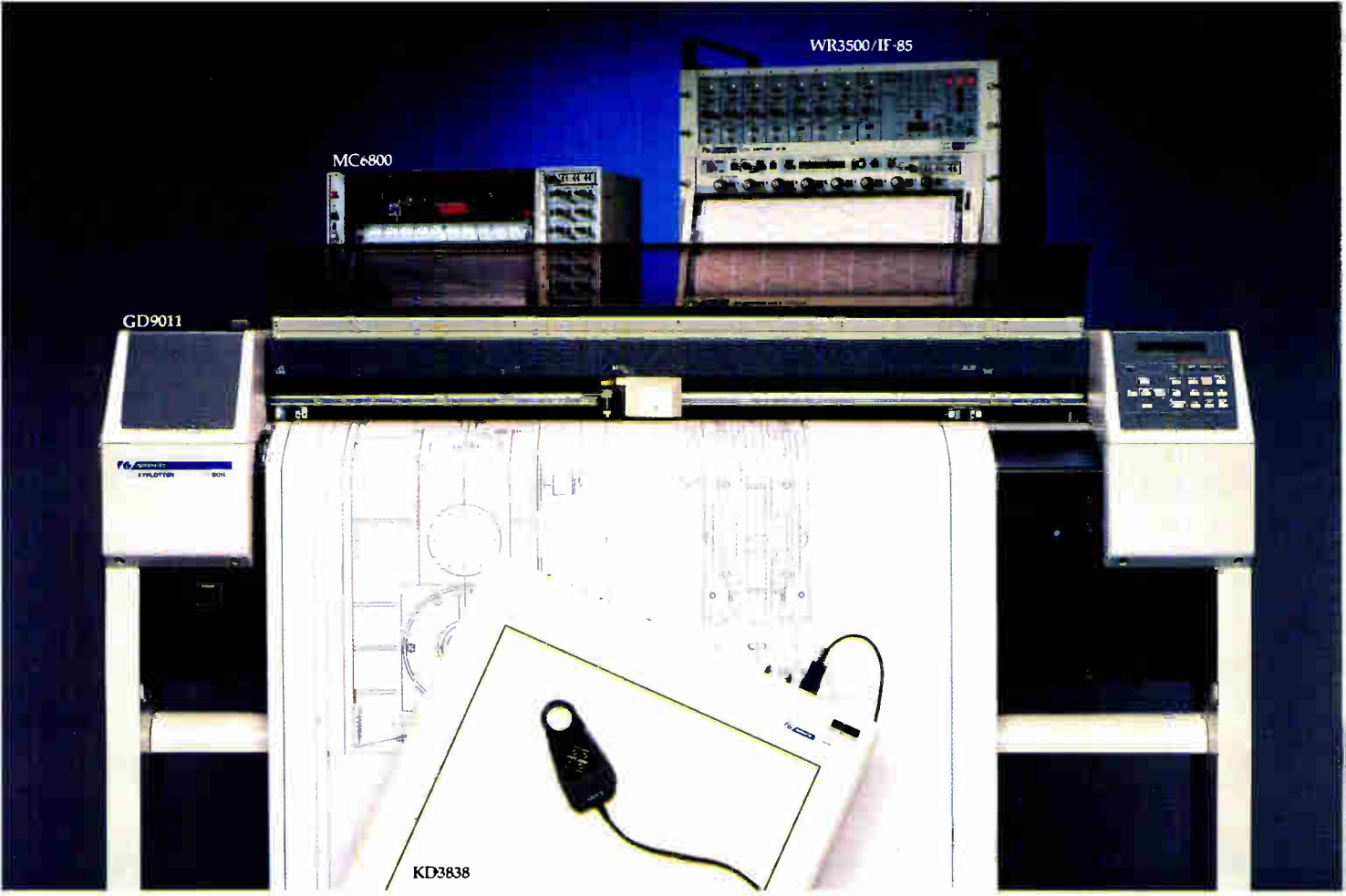
Moreover, a significant side effect of surface mounting is the growth in double-sided printed-circuit boards. Because surface-mounting technology eliminates the need for through-holes in boards and for bent leads on devices, components can be soldered to both sides of a pc board. *Electronics* predicts a 7% growth rate to $1.37 billion for double-sided pc boards this year, compared with a meager 1% growth rate in 1986.

Another component exhibiting strong growth is uninterruptible power supplies. *Electronics* predicts a hike of 20% in this category to $805 million, on top of a 22% rise to $670 million last year. Representing 44% of the power-supply market, these devices are finding more and more applications in such industry sectors as data processing, communications, medical electronics, and the military, where continuous electrical power is required. Sales should continue to increase as technological innovations make them smaller, less bulky, and easier to use. □

A reprint of both the U. S. and the overseas market report costs $6 or the equivalent in local currency. Quantity discounts are available. Send a check or money order to Electronics *Reprints at 1221 Ave. of the Americas, New York, N.Y. 10020, or at McGraw-Hill House, Maidenhead, Berks., SL6-2QL UK.*







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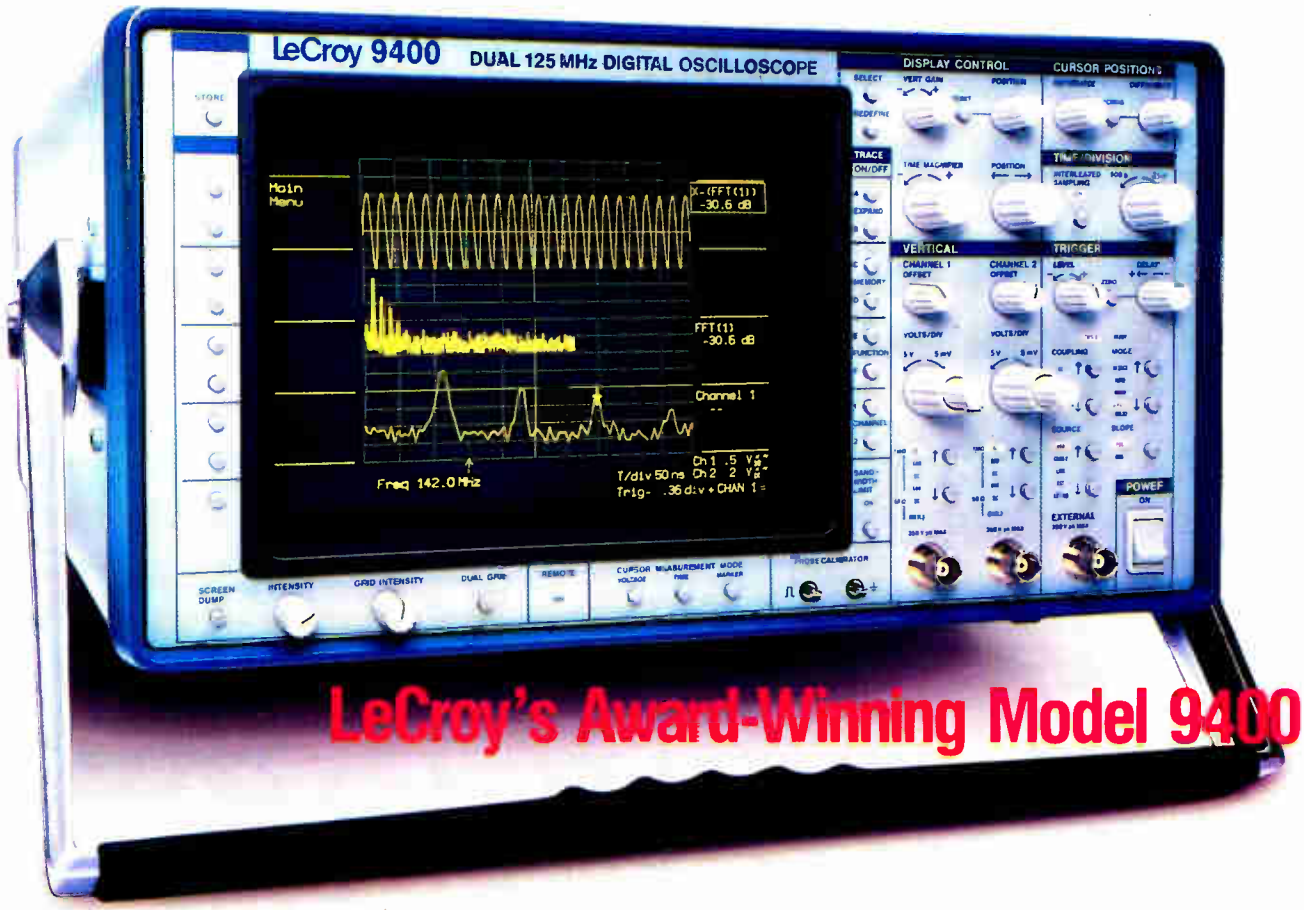

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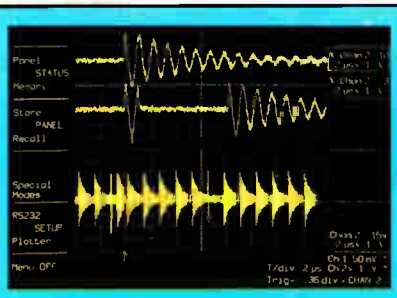
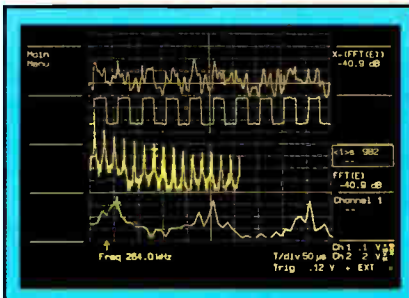
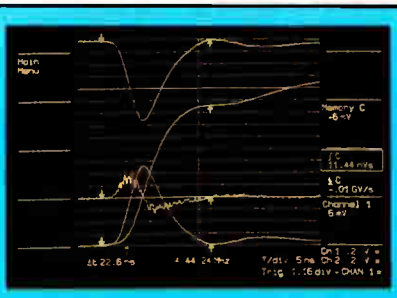


Switching transients recorded in segmented memories show contact bounce in segment number 3. Cursors can measure bounce-time-interval precisely.



Noisy R.F. Transmission Signal is averaged in time domain. Spectral content of cleaned-up signal is analyzed by FFT.



Inverted photo-diode signal is normalized then integrated for energy measurement (area under curve =11.44 nVs). Differential dC/dt is shown as well.

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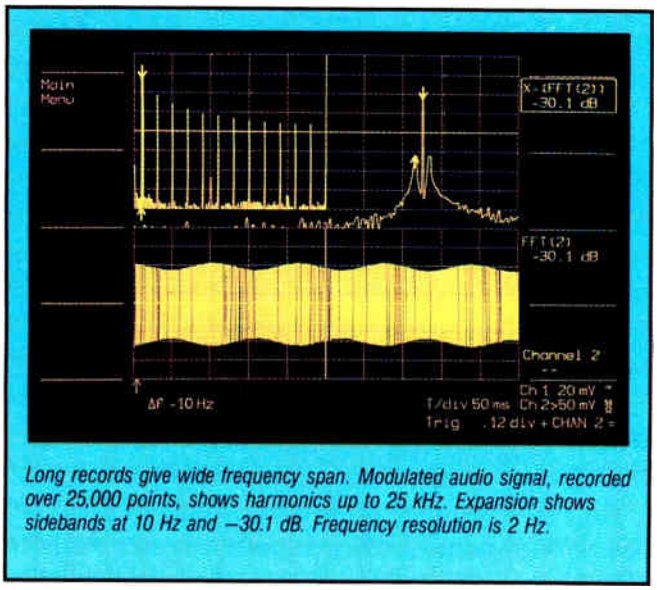

Long records give wide frequency span. Modulated audio signal, recorded over 25,000 points, shows harmonics up to 25 kHz. Expansion shows sidebands at 10 Hz and −30.1 dB. Frequency resolution is 2 Hz.

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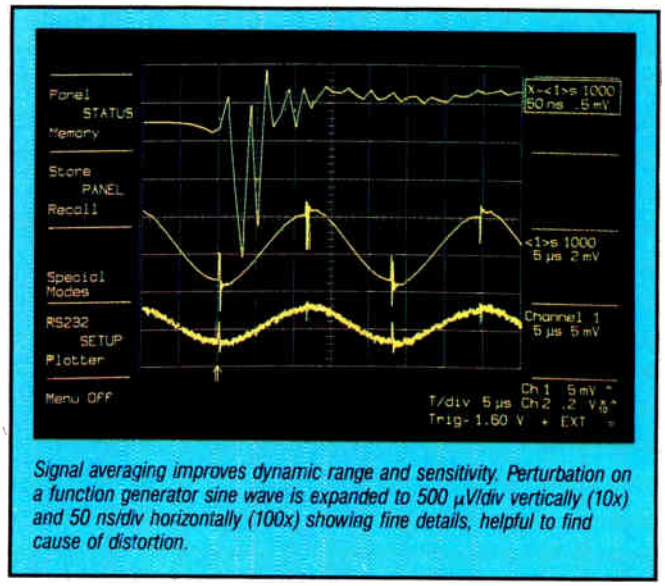

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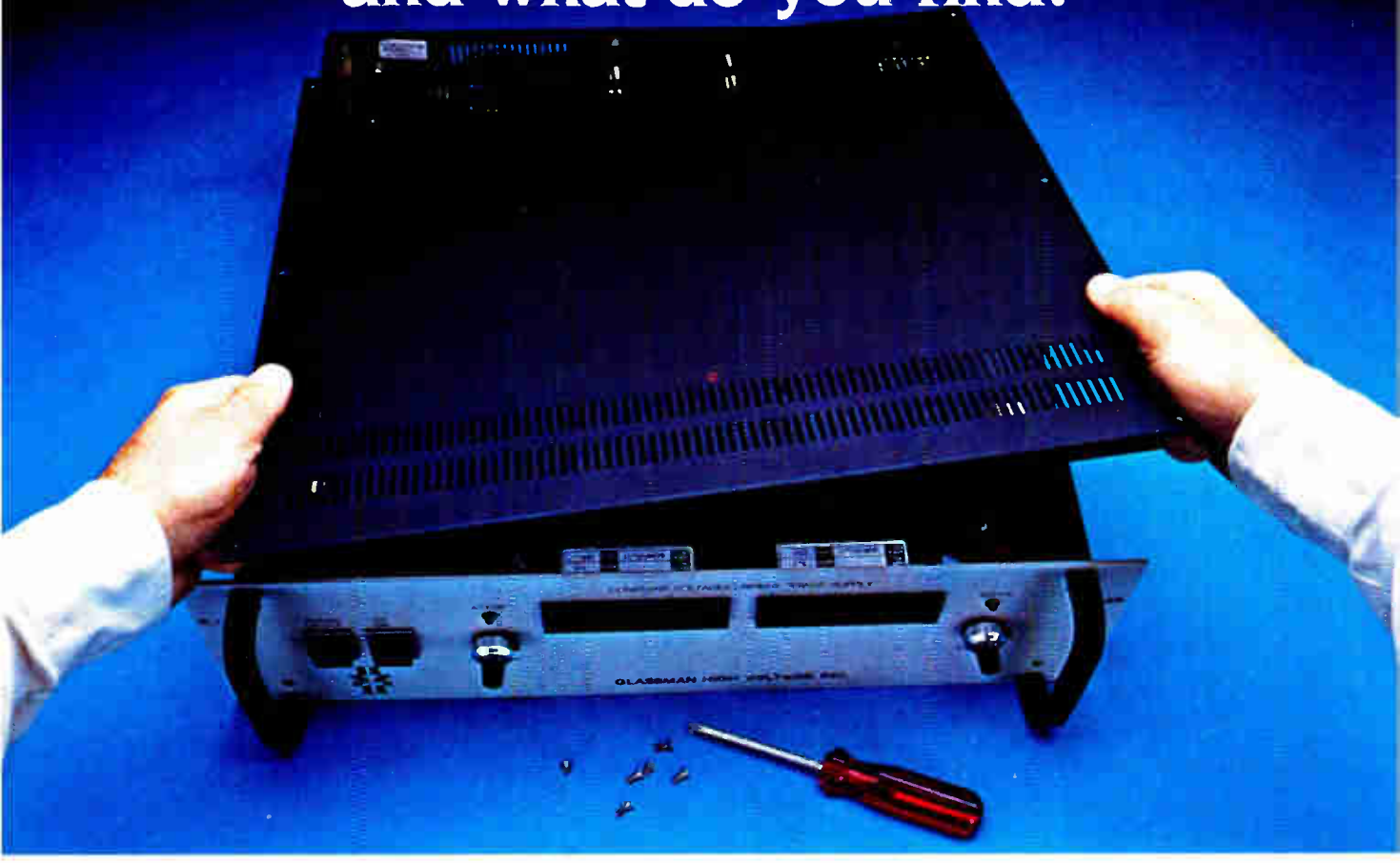

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INSIDE TECHNOLOGY

A MODEM CHIP THAT NEEDS ONLY ONE 5-V POWER SUPPLY

Silicon Systems' single-chip modem draws one-tenth as much power yet still has a dynamic range 15 dB greater than competitive chips

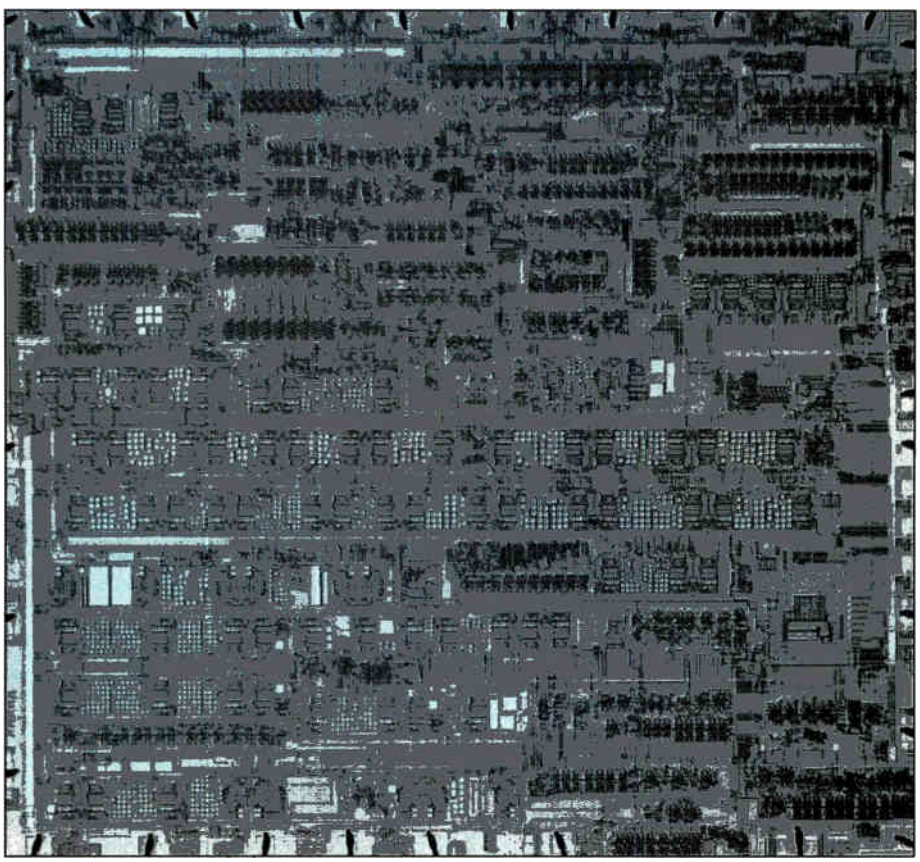
Low-power, single-chip modems usually suffer from serious drawbacks—they require multiple-voltage power sources, and they are prone to signal interference from line noise. These drawbacks create serious problems in applications such as laptop computers, where simplicity of design and accuracy of transmission are crucial. But now Silicon Systems Inc. has come up with a family of modems that uses a single 5-V power supply or telephone-line power—drawing less power, by an order of magnitude, than comparable modem chips—while maintaining a dynamic range up to 15 dB greater than competitive devices.

The Tustin, Calif., company's L-Series of modem chips typically draws just 35 mW, lower by as much as a factor of 10 than most other chip modems in the 300-to-1,200 bits/s class, says Gary Kelson, Silicon Systems' chief technical officer and senior vice president. By using a software-selectable power-down technique, the power can be further reduced in the standby mode to about 12 mW.

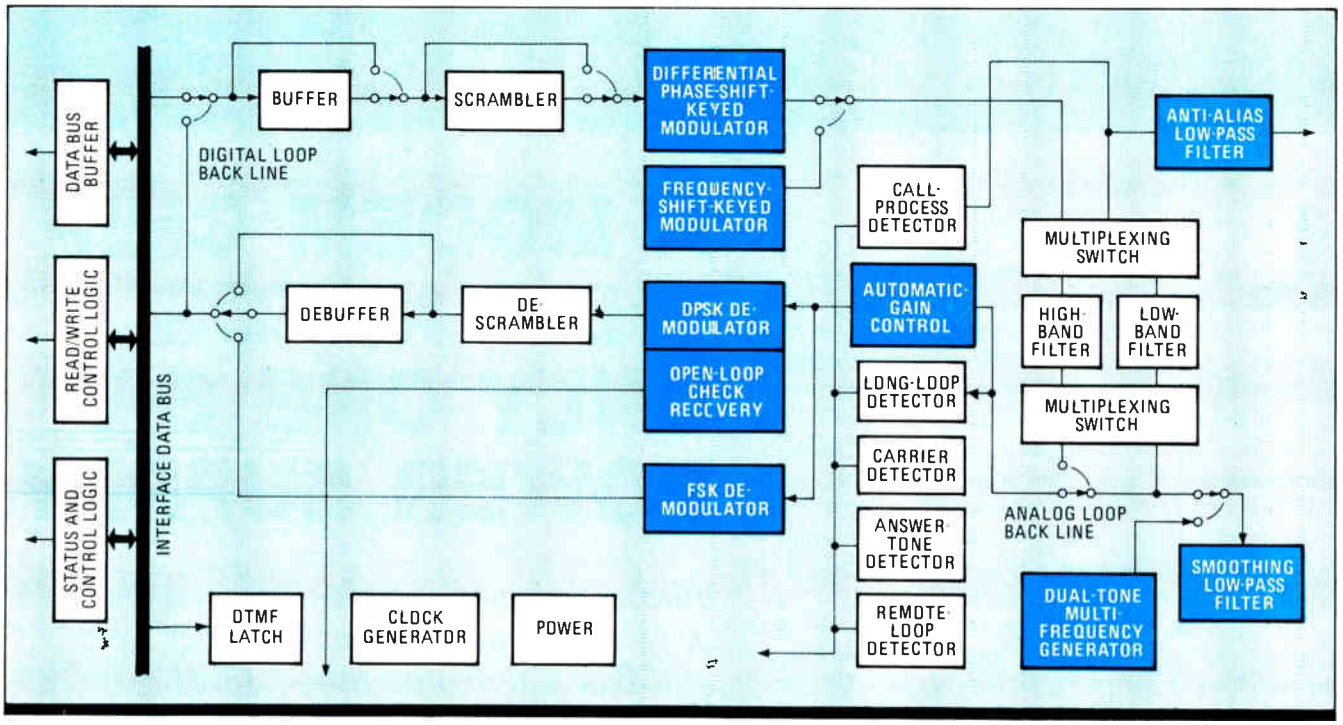
Building in the single-source low-power capabilities caused no sacrifice of transmission quality. Dynamic range is the widest in the industry for single-chip modems in the L-Series' class, the company claims. In addition, the careful placement of automatic-gain-control circuitry, along with the design of the modems' operational amplifiers, minimize noise, as did the use of analog technology to produce the chips.

Production itself was simplified by the use of emulation software, developed by the company, in the design of the chips. What emerged was a family of modem chips with speeds ranging from 300 to 2400 bits/s that meet a variety of operational requirements. All have the same architecture, which includes a standard bus interface and programmable control of the modems' features, simplifying their integration into larger systems (Fig. 1).

The family, which is being produced now in sample quantities,



1. LOW-POWER MODEM. The new Silicon Systems modems use an order of magnitude less power than comparable chips.



2. QUIET ANALOG. Silicon Systems' analog approach to modem chips relies on the noise-supression characteristics of its operational amplifier, which uses a 5-V power supply and measures 65 square m, but performs as well as units twice as large.

includes the 28-pin K224L. It features full duplex operation at 300, 600, 1,200, and 2,400 bits/s while providing all of the functions needed to construct a modem satisfying the CCITT V.22, V.21, Bell 212A, and Bell 103 requirements for operation over dial-up telephone lines. It provides both phase-shift- and frequency-shift-keyed modem functions, as well as such functions as carrier, call progress, precise answer-tone and long-range detection, and handshake monitoring. It also incorporates circuitry for producing the dual-tone-multifrequency answer, and guard tones required for use with European phone systems. In addition, it allows both synchronous and asynchronous communications and incorporates a wide array of test functions—analog loop, digital loop, and internal remote digital loop-back. Other members of the family include the 300-to-1,200-bps K222L, the V.22/V.21-compatible K221L, and the Bell 103/212A compatible K212l.

The biggest challenge in creating the chips was insuring a wide dynamic range—the measure of signal strength in the face of poor line quality. The range of the L-Series, measured at 45 dB, is the broadest in the industry for single-chip, 300-to-2,400-b/s modems, says John M. Huggins, vice president of design engineering—up to 15 dB better than competitive devices. And with a signal-to-noise ratio of 10 dB to 12 dB, the L series operating at 1,200 bits/s has an error rate of only 1 bit in 100,000, an order of magnitude better than competing devices.

To achieve its 45-dB range, Silcon Systems decided to forego the digital signal-processing approach favored in other low-voltage modem designs, in favor of a CMOS process developed specifically for analog functions. The 3-μm, double-polysilicon, single-metal p-well process produced chips featuring polysilicon-to-polysilicon capacitors. They also incorporate special diffusion and ion implant steps to keep noise down.

"DSP has a lot of advantages, but not for this application," says Paul Laity, director of marketing for the company's telecommunications products division. "The DSP approach requires a much larger die to accommodate all the transistors necessary to do the signal processing, so there are higher power requirements. You don't need the accuracy and speed that DSP delivers in this application. DSP is better for applications beyond the 2,400-bits/s range."

Also important in maximizing dynamic range was the placement and type of automatic gain control. In other single-chip modem designs, the AGC sits downstream of the equalizer and all pass filters. In the Silicon Systems design, it is put as far forward as possible. With the AGC between the compromise amplitude and the phase equalizers, the usually noisy phase equalizer makes less noise. In other designs, the AGC is typically implemented as part of the amplifier, using MOS transistor technology, which means it exhibits a linear response. Silicon Systems built a switched-capacitor AGC that exhibits discrete values of gain. These values can be adjusted by selection of the capacitor ratios, so the gain size can be adjusted to the application. The gain values can be adjusted in 1-dB steps for a total transmittable gain of 15 dB.

The analog approach relies heavily on the

characteristics of the operational amplifiers used to condition the signal and perform filtering (Fig. 2). "We spent a lot of time on the op amp design. Smaller power supplies mean smaller signal swings, so you tend to be more sensitive to noise, layout, offset voltages, and other things that can destroy the signal," Kelson says.

Silicon Systems had to come up with an operational amplifier design that could accommodate a 5-V power requirement, yet not be overwhelmed by circuit-induced noise. Although only 65 m^2, the op amp rivals the performance of units twice as big. They have a gain of 100,000 and a unity-gain bandwidth of 500 KHz, and consume no more than 25 μA each.

They are fast enough to settle within 13 μA when working with a 38.4-KHz sampling clock, yet are limited enough in bandwidth to prevent the production of spurious low-frequency signals, or aliases, in the signal passband that cannot be distinguished from the legitimate signal.

To help design the chips, Silicon Systems created a modem emulator—a set of software routines written in the C language that ran on the company's automated-design system. The emulator allowed designers to simulate the performance of the modems in the presence of typical line impairments, by plugging in filter descriptions and matching them against the impairments. Most modem designers build a breadboard of the circuit and connect it to a test instrument, and then they adjust poles of filtering until the right performance curves are achieved.

One quality uppermost in the designers' minds was ease of system integration. To make integration simpler, the designers incorporated in all of the modems an interface to Intel's family of 8-bit microprocessors. Available as an option are 22-pin versions with a serial command bus for interfacing with other microprocessors. The modems look like peripherals to a microprocessor when they communicate across an 8-bit multiplexed address and data bus.

To provide an easy migration path between 300-, 600-, and 1,200-bits/s parts, Silicon Systems adopted a programmable modem design, using an addressable register stack in which 3 bits of address information are used to define eight registers. Silicon Systems is using only seven registers now; the eighth is being reserved for use in future products—to hold control data for new functions that may be added. "This is going to let the designer go from 300 to 2,400 b/s without modifying his hardware, just swap out the chip," says Huggins. "We will have four ICs he can plug into the socket and he won't have to change his software. The same board with different chips can serve niche or European markets."

One register at the front end of the chip was used to further ease the work of systems integrators. That register controls the modems' features (Fig. 2). "What we attempted to do with this bus architecture was to make a modem look like a memory device," Kelson says. "If an engineer has written microcode to read and write data into a RAM, then he can design with this modem."

Silicon Systems also implemented a parallel-bus command set to control the bus interface. "Customers have gone toward the parallel bus because that's the kind of hardware design that they are used to," says Laity. "Software engineers like it much better because it's easier to use." □

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

A ROUNDABOUT ROUTE TO A MODEM CHIP

John Huggins believes in planning ahead. And his work on Silicon Systems Inc.'s CMOS modems, which use only 5-V single-source power, is no exception. "When we started thinking about building a family of modems several years ago, our ultimate aim was the 5-V-only products," says Huggins, the Grass Valley, Calif., company's vice president of design engineering. He was responsible for the overall product definition and architectural features.

However, the company took a roundabout route: it first built a family of 12-V chips. "The 12-V family at the time was more compatible with the existing multi-supply parts. Achieving 5-V-only operation in a modem without losing bandwidth was not an easy job."

MODEM MAKERS. Designers Eric Davies, John Huggins, and Kiyoshi Fukahori (from left).

It was clear at the outset that the best way to go, in terms of process technology, was linear CMOS rather than the CMOS digital signal-processing approach adopted by many other companies, says Huggins, an electrical engineering graduate with an MS from the University of Minnesota.

"The problem is that, unlike digital implementations, much more attention must be paid to noise at the 5-V level," he says. "For example, a ½-V spike on a 5-V part is much more significant than a similar noise signal on a 12-V part."

With project engineer Kiyoshi Fukahori and Eric Davies, who designed the digital portions of the chip, Huggins determined that the best strategy was to budget the noise floor of the 12-V modem part as if it were a 5-V part.

"Noise budgeting is one of the most demanding parts of a linear design," says Huggins. "Mostly it is just a matter of back-breaking and mind-numbing attention to detail, particularly in the design of the filters, the sizing of the key components, and balancing of performance against noise and bandwidth."

THE FURIOUS RACE TO DEVELOP 2,400-b/s MODEM CHIP SETS

Many believe the chips will dominate low-end computer applications

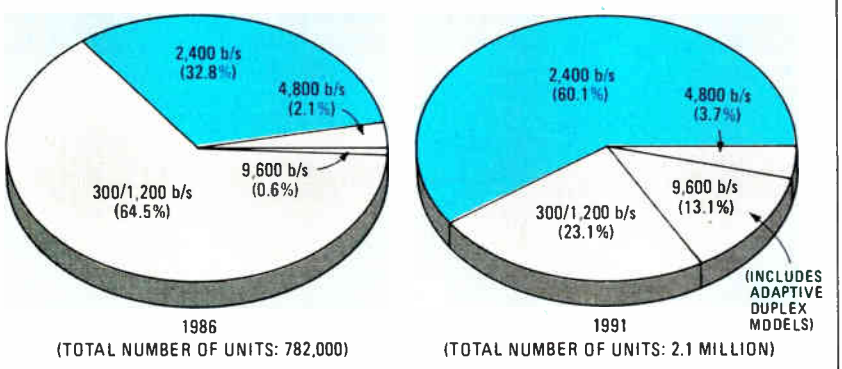
By J. Robert Lineback

Chip makers are working furiously to field entries in the potentially huge market for integrated circuits for full-duplex 2,400-b/s modems. Driving their efforts is the growing conviction that 2,400-b/s modems are the next large and stable market for modem chip sets.

Behind this flurry of activity is the conviction by researchers that major technological barriers—among them limits in signal-processing chip power, the expense of echo cancellation, and inadequate telephony standards—will stop the bulk of low-end computer applications from migrating to anything faster, at least in the immediate future. That means that 2,400-b/s units will dominate the modem market.

The number of major IC makers getting into the 2,400-b/s game is growing. New chip sets are due soon from at least nine chip houses. All of them are trying to get a piece of a market that one research firm projects will grow from a little more than $60 million last year to more than $600 million in 1990, and the competition is expected to get fierce as that market heats up (see chart). "Competitive pressures will be huge, even greater than they were in the 1,200-b/s generation, and we were stunned by that round of competition," says Garry Shapiro, technical marketing manager for data communications at Fairchild Semiconductor Corp.

2,400-b/s MODEMS WILL DOMINATE THE ASYNCHRONOUS DIAL-UP MARKET



FIGURES REPRESENT U.S. MARKET PLUS EXPORTS OF U.S. MANUFACTURERS

SOURCE VENTURE DEVELOPMENT CORP.

The new year is starting off with a bang. Silicon Systems Inc., for example, is unveiling a new family of low-power modem chips that includes a 2,400-b/s version (see p. 81). The entire line consists of modem chips controlled by standard microprocessors or controllers.

And next week, Intel Corp. will become the newest major entry, with the debut of its 89024 two-chip set. Product managers at Intel's Telecommunications Operation in Chandler, Ariz., decline to provide details, but industry sources say the CMOS set will include a digital signal processor, the 89026, with an integrated controller to handle modem features. The second chip, the 89027, will be an analog front end.

Not everyone thinks the fight will be worth the effort. At least one major supplier, Motorola Inc., has already decided against building commodity 2,400-b/s modem chips. Other suppliers are waiting to see whether the market will develop as projected. They question whether 2,400-b/s modems can maintain transmission quality, and they want to find out what will happen in the ongoing efforts to set error-correction and other standards for modems before they commit themselves. A few say that the 2,400-b/s mark is by no means the high end for low-cost modems—so they're setting their sights on modems rated 4,800 b/s and above. And, finally, hanging over the entire modem industry is the prospect of the integrated services digital network, which will render modems unnecessary for sending data over phone lines.

Other chip entries into the emerging 2,400-b/s modem-chip market will be coming from Fairchild Semiconductor, Texas Instruments, Thomson Components-Mostek, Gould, Sierra Semiconductor, Exar, and Plessey. And established 2,400-b/s modem supplier Rockwell International Corp. expects to introduce this year a CMOS chip that replaces two n-MOS DSP parts in its current three-chip 2,400-b/s set.

Fairchild, of Cupertino, Calif., plans to show samples of a 2,400-b/

IC this summer. The CMOS product will be shipped in volume by the end of 1987.

Product managers for DSP at TI in Houston are already claiming that 2,400-b/s modems built on half-size PC expansion cards can be had for the same cost as a 1,200-b/s system. TI says that with its new DSP2400 chip set a 2,400-b/s modem can be made for $50. The set is made up of its general-purpose TMS32011 digital signal processor and a read-only-memory-coded 8-bit TMS7042 microcontroller [*Electronics*, Nov. 13, 1986, p. 25]. Prototyping kits, which include an example of a working 2,400-b/s modem for personal computers (see photograph), are now available for $995. "We see 2,400 b/s replacing 1,200-b/s modems simply because customers will be getting the extra speed free," says Mike Hames, DSP marketing manager at TI.

Sierra Semiconductor Corp., San Jose, Calif., is preparing to introduce this winter a two-chip product for 2,400-b/s modems. The chips will include an SC11006 modem device and one of two interface ICs—the SC11009 for microprocessor-bus attachment or the SC11010 for serial RS-232-C connections to computers.

The Gould Semiconductor Division (formerly AMI) in Santa Clara, Calif., plans to introduce a 2½-chip 2,400-b/s modem chip set in March. Included in the implementation will be a 3550 analog front-end IC, a 3551 signal processor, and a standard microcontroller, which will spend half its time processing high-level modem protocols.

"To show how chip makers feel about the modem market potential, just look at the number of companies developing chips," says Jim Lange, applications engineering manager for modem products at Exar Corp. The Sunnyvale, Calif., company, an early pioneer in modem ICs, is planning a first-quarter introduction of a two-chip CMOS chip set for the 2,400-b/s market. Like many other 2,400-b/s chip sets, the Exar ICs will team a DSP-based device with an analog-interface chip performing band-split filtering.

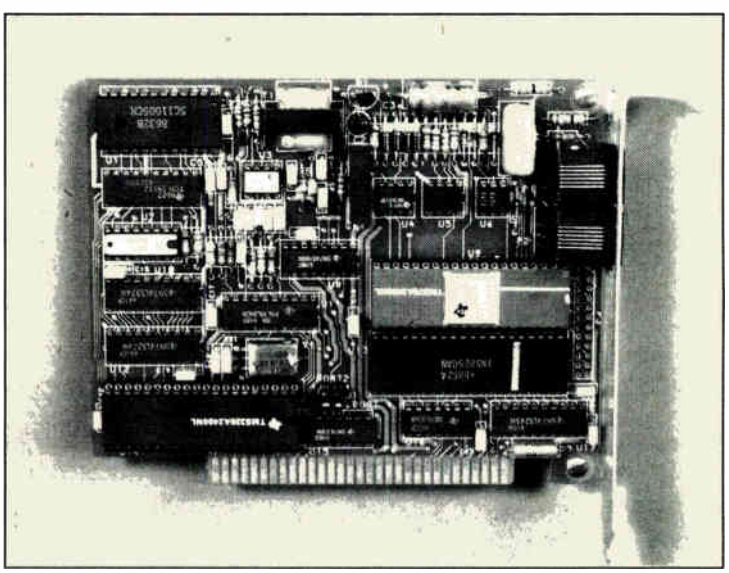
What's fueling all this activity is the expectation of rocketing sales growth for 2,400-b/s modems in the U. S. personal-computer market. Jack Musgrove of Dataquest Inc. says sales of 2,400-b/s modems will jump from $64 million in 1986 to $642 million in 1990. Venture Development Corp., Natick, Mass., says asynchronous dial-up modem sales in North America and those of U. S.-based suppliers selling abroad will grow at a healthy 21.9% clip during the next five years. Between now and 1991, 2,400-b/s modems will move from just a third of that market to more than a majority of sales.

Besides the obvious market considerations, there's another reason IC makers are being drawn into the modem arena: they're the ones with DSP experience. The 2,400-b/s speed is the point at which DSP replaces analog switched-capacitor modem designs, providing adaptive equalization that automatically adjusts for phone-line quality. Without DSP-based chip sets, going from 1,200 to 2,400 b/s means incurring high error rates, as signal-to-noise margins drop with the additional splitting of signals into the multiple bands used to boost transmission speeds. Hames says TI's approach, for one, is based on taking advantage of the economies of scale it can derive from its overall production of DSPs to offer a low-cost modem chip set. He also argues that general-purpose, programmable DSP chips—as opposed to tailored modem signal processors—will enable designers to cope with the uncertainties of future telephony standards.

Such flexibility could well be necessary. Error-detection and correction techniques are in a state of flux, with various industry standards groups attempting to define protocols. The International Telegraph and Telephone Consultative Committee, having already established its V.22 bis standard defining 2,400-b/s modems, now has working committees considering a number of error-correction techniques, including the Microcom Network Protocol, which has been available under license from Microcom Inc. of Norwood, Mass., for several years.

One reason for the standards activity is the growing awareness on the part of system designers that, as modem speed increases, actual data throughput will suffer with each transmission glitch. "We are finding more and more of our customers looking at the performance side of transmission—not merely the speed but the effective throughput," says Dave Hall, product manager for 1,200- and 2,400-b/s modems at Rockwell in Newport Beach, Calif. "More and more customers are putting chip sets through rigorous performance evaluations to determine how well they can handle not only error correction but also a wide variety of phone-line conditions."

As system integrators increasingly demand



MORE FOR LESS. A TI prototyping kit that includes a 2,400-b/s modem made up of a digital signal processor and a microcontroller costs less than $1,000.

higher-quality transmission, a debate is growing among modem makers as to whether or not V.22 bis standards—without error-correction—can achieve effective data throughputs in the existing telephone network. Pessimistic projections indicate that the actual data throughput, using 2,400-b/s modems, could be as little as 40% better than 1,200-b/s transmissions. Others disagree, believing the network quality will not significantly degrade throughput. "The jury is still out," says Fairchild's Shapiro, adding that "most manufacturers of V.22 bis modem products will end up including an error-correction scheme, which means Microcom stands to license a lot of MNP [its network protocol] out there."

Until such questions are resolved, some suppliers are approaching the 2,400-b/s modem market with caution. Motorola has no plans to introduce commodity modem chips aimed at the 1,200- or 2,400-b/s segments. Instead, the company will serve the medium- to high-speed modem market with custom designs, according to Al Mouton, MOS telecom marketing manager.

Advanced Micro Devices Inc. of Sunnyvale, Calif. has shelved its Am79C14—the 2,400-b/s cousin of its new 1,200-b/s 79C12 fell victim to cost cutting. AMD telecom product managers in Austin, Texas, still plan to enter the 2,400-b/s market, perhaps with a new design. National Semiconductor Corp., which is readying a new TP3330 1,200-b/s modem, is considering a move into 2,400-b/s markets.

While some suppliers are racing to field 2,400-b/s entries and others are still considering whether to join them, however, Thomson Components and its U. S. subsidiary, Mostek, want to blow the lid off high-speed modems. They are aiming their three-chip TS68950 set at a combined speed range of 2,400, 4,800, and 9,600 b/s. The DSP-based modem interface for signal processing contains an analog transmit interface, an analog receive interface, and a clock generator. The three perform the modem front-end function for a DSP, providing band-splitting and echo-cancelling for medium- and high-speed ranges. A single-chip implementation of the three-chip set could be on the way as early as 1988.

"If we and other competitors can provide 9,600-b/s chip-set solutions, the 2,400-b/s market could end up being short-lived," says Jim Garrett, Mostek director of communications products in Carrollton, Texas. Mostek is now ramping up volume production of the chip set.

The prospect of faster modems bypassing the less expensive 2,400-b/s versions seems unlikely to many suppliers, though. One reason is the extra processing power needed to remove signals that echo back to a transmitting station. The time to recover each incoming bit is also compressed, requiring fast correction techniques.

Because of the cost of added signal-processing power and the lack of error-checking-and-correction standards, many chip suppliers believe applications will pile up at the 2,400-b/s range as the industry grapples with new 4,800- and 9,600-b/s specifications. TI's Hames estimates the jump from 2,400 to 4,800 and 9,600 b/s will hike costs by a factor of four to eight. "The current standards do not allow very cost-effective solutions in the 4,800- and 9,600-b/s full-duplex range," he says.

At some point, however, the entire question of which speed works best will become moot. Eventually, the need for computer interfaces to analog twisted-pair transmission lines will drop drastically, with the arrival of the integrated services digital network. "Right now, modem manufacturers are taking the attitude that ISDN is something that will inevitably come up, but it's a matter of when. It is now discussed in every product planning session," says Dataquest's Musgrove, who sees ISDN impact in 1993. □

JUST WHAT IS A ONE-CHIP MODEM?

Integrated circuits simplify the design of modem systems, but they also lead to confusion—specifically, confusion about what, if anything, the term "single-chip modem" means. The problem, according to IC makers, is that the traditional definition of a modem is evolving as the function moves from a strictly analog design to an intelligent digital subsystem often integrated into a computer system.

One basic rule: no single chip constitutes a working modem. And most modem-chip makers predict that it is unlikely one die will ever hold a fully functional modem, because of the need for high-voltage circuitry to handle ringing voltages and lightning surges.

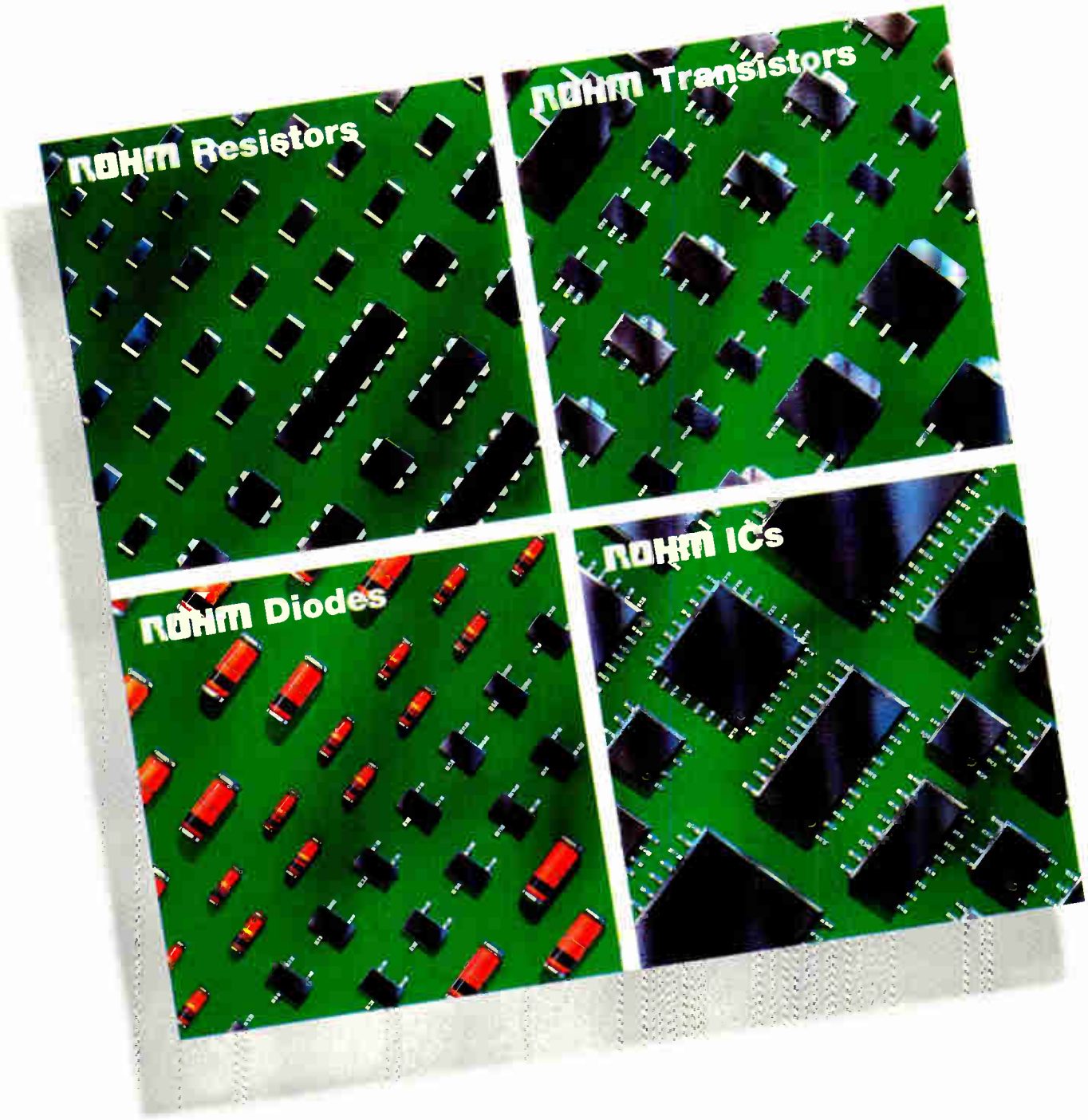
In addition to the modem chip or chip set, working systems need phone-line interfaces and network-protection circuitry known as the direct-access arrangement. External resistors and capacitors are also usually required. Additional microcontrollers or microprocessors are needed to run handshake protocols and error-correction, if used. In many, chips are needed to connect a modem to a microprocessor bus. Occasionally, a circuit is also needed to implement such features as dual-tone-multifrequency generation or call-progress monitoring.

"There are no single-chip modems on the market. People can be misled so easily in this discussion," says Bill Nicholson, marketing director at Sierra Semiconductor Corp.

Terminology has become a problem as modems take on intelligent features. "It is a floating definition," says Garry Shapiro, technical marketing manager for data communications at Fairchild Semiconductor Corp. Shapiro argues modems can be defined as monolithic ICs in the strictest traditional terms.

"Modem stands for 'modulator/demodulator.' So the name implies all of the signal-processing functions. Everything else that's been added to the signal-processing function has got to be called features, and whether or not they apply to a single-chip modem is in the eye of the marketeer," he says. Definitions have also blurred as modems move from being the handiwork of analog equipment engineers toward becoming an integrated block inside digital systems, notes Robert Gammon, modem marketing manager in the Microprocessor and Microcontroller Products Division at Texas Instruments Inc. in Houston.

—J. R. L.



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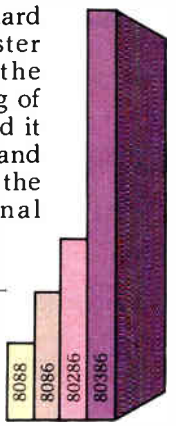

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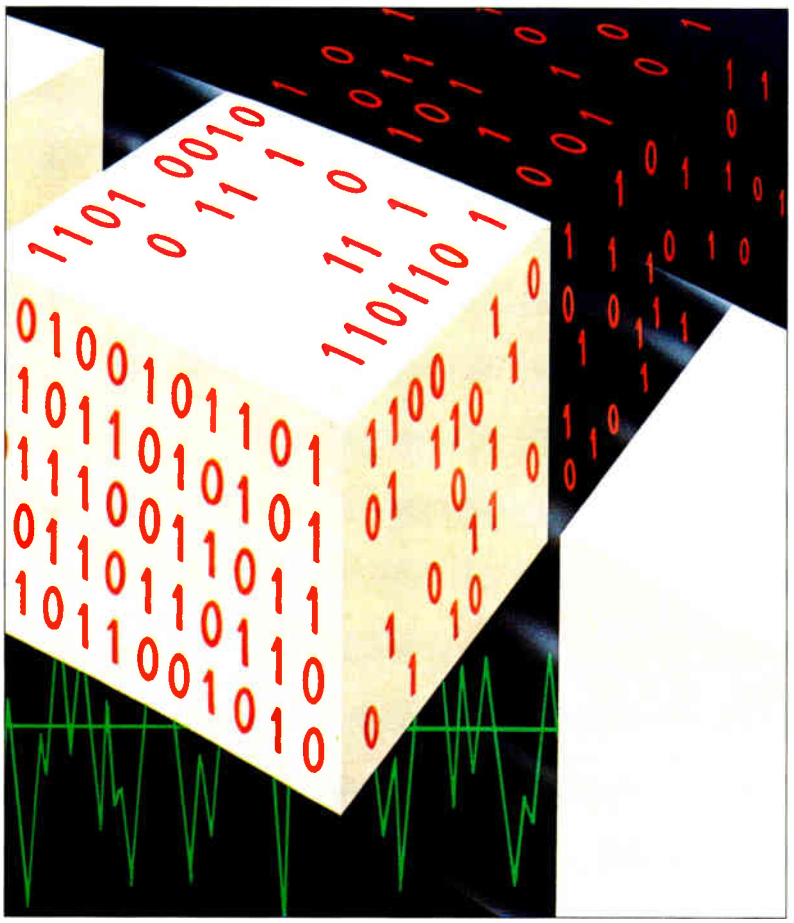


Zoran's vector digital-signal-processing chip with 70,000 transistors requires only three instructions to do a 1,024-point fast Fourier transform in 2.4 ms.

"A speedy new single-chip contender is getting set to make a splash in digital signal processing. Zoran Corp.'s ZR34161 uses vector-handling techniques to gulp down blocks of data, rather than picking off a single data input at a time as scalar processors do. Vector processing alone is a big speed booster, and Zoran enhances it with embedded signal-processing algorithms that radically pare down system overhead.

The Santa Clara, Calif., company's 16-bit CMOS VSP is the first monolithic signal processor to utilize the powerful vector-handling techniques employed for scientific data processing in large vector computers and minicomputer array processors..."

Excerpted from an exclusive article in the July 24, 1986 issue.

Electronics

THE LEADER IN NEW TECHNOLOGY COVERAGE

INOVA BRINGS WAFER-SCALE INTEGRATION TO MARKET

Inova Microelectronics Corp. is set to debut a commercial 256-K SRAM made by linking usable dice via fuse-programmable logic—and without custom metallization

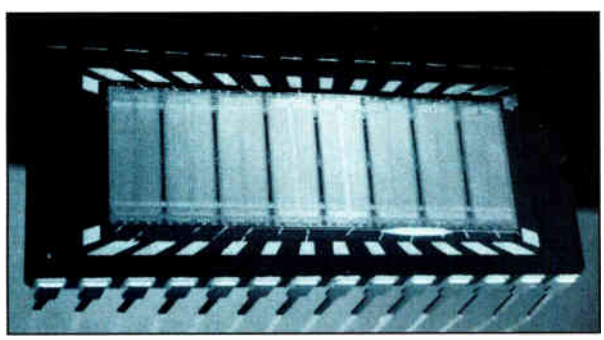
by Bernard C. Cole

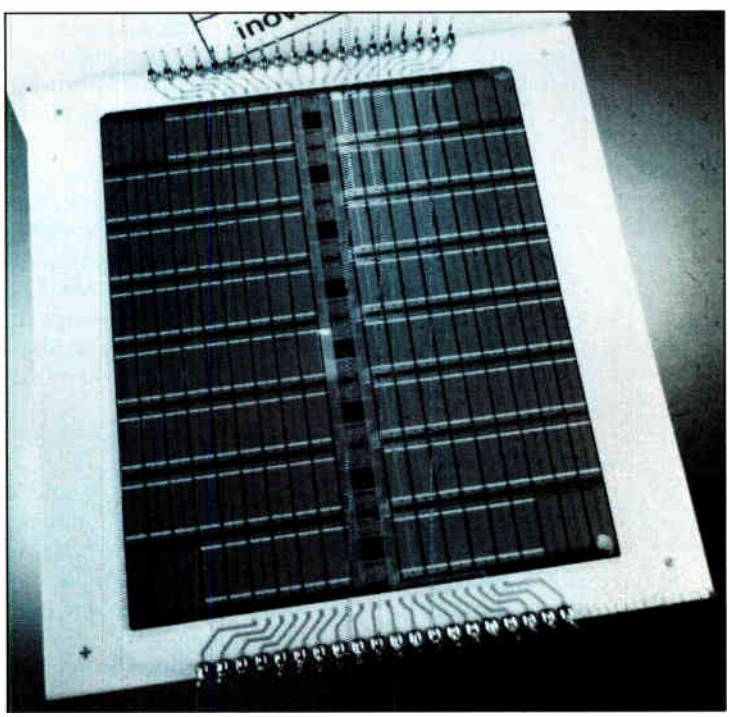
In the next couple of months or so, Inova Microelectronics Corp. will start marketing a 256-K static random-access memory chip. That in itself is no earth-shattering announcement—this size SRAM has been available in sample quantities for a year or more. What makes Inova's new part a big deal is that it represents the first commercial entry of a product using wafer-scale integrated-circuit technology.

Several companies have tried for years to achieve wafer-scale integration with monolithic techniques, but they failed miserably. As a result, they either abandoned the concept or opted for the more easily achievable hybrid silicon-on-silicon process (see p. 94). Going it alone with a monolithic approach is Inova, which this month achieved the second milestone with its 256-K SRAM on a carefully planned path toward commercial wafer-scale products: it interconnected multiple 64-K prime (good or partially good unscribed) dice based on 1.8-μm design rules on a partial wafer. This follows by six months the company's first milestone: fabrication of a 1-Mb full-wafer SRAM and a 64-K partial-wafer SRAM, both based on 16-K prime dice fabricated with 3-μm design rules.

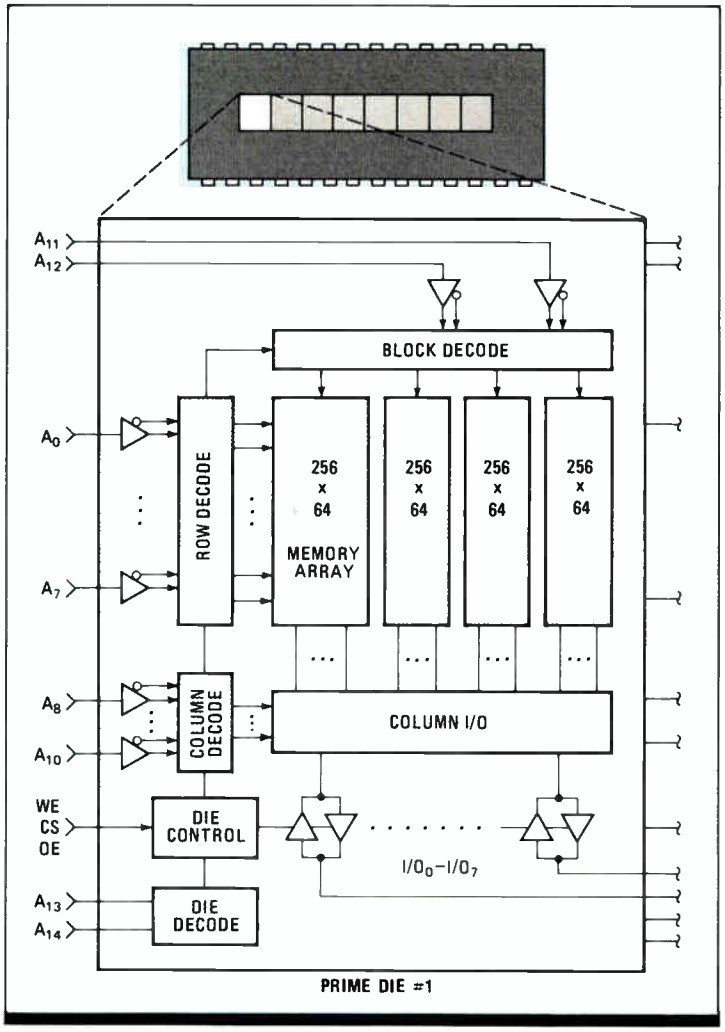
Inova executives are now so optimistic about their monolithic process that rather than continue on to a full-wafer implementation at the 1.8-μm level, they have moved ahead to the fabrication of partial- and full-wafer SRAMs using 1.25-μm design rules. The company expects to offer samples of a 1-Mb partial-wafer SRAM late this year, followed by devices ranging through the full 32-Mb SRAM capacity of a 4-in. wafer, says Kirk MacKenzie, Inova vice president.

One reason for the Campbell, Calif., startup's success lies in its Inroute method of interconnecting usable dice on a wafer, says founder, chief technical officer, and vice chairman Ramesh Varshney. After prime dice are identified





1. SECOND LEVEL. Using second-level global interconnect, Inova has linked unscribed dice into the S32K8 partial-wafer 256-K SRAM modules (above) and a 1-Mb full-wafer prototype (right).



2. HOOKED UP. 256-K out of 512-K available are linked by fuse-programmable logic on eight 64-K SRAMs in a Jedec package.

on a wafer at the probe stage, the addresses of good quadrants are established by means of fuse-programmable logic; then the interconnections are hard-wired by a universal second-layer metal pattern.

Another reason for Inova's success is the fact that it hasn't bitten off more than monolithic wafer-scale technology can chew. The company recognizes that repeatable structures with identical dice lend themselves best to the monolithic approach. Companies that have tried to mix device types on the same wafer have either abandoned the concept or opted for silicon-on-silicon approaches.

The 1-Mb full-wafer device that was developed six months ago measures 2.5 in. by 3 in. (Fig. 1). It is cut from the center of a 4-in. wafer and is then partitioned into eight rows of 18 devices each, for a total of 144 devices, or 2.359 Mb of SRAM, giving 100% redundancy. The memory array is broken up into two blocks, one on each side of a central array containing custom logic for memory support and I/O buffers. When the second-level metal is laid down, each prime die is connected to the central array with horizontal busing. The central area, in turn, is connected to the bonding pads at the top and bottom of the wafer by vertical busing.

The 256-K S32K8, which Inova is demonstrating this month, contains eight identical single-metal CMOS 8-K-by-8-bit prime dice interconnected by a second level of metal and packaged in a Jedec standard 28-pin package (Fig. 2). From the 512-K available on the partial wafer slice, 256-K good circuits and partially good devices are identified and connected, and the remaining elements are disconnected, says MacKenzie.

With an access time ranging from 70 to 120 ns, the S32K8 compares with the midrange of other commercially available 256-K SRAMs. Yet Inova achieves this density and performance level with a standard 1.8-μm process, while competitors must go to the much more difficult-to-control 1.25-μm processes, or to exotic circuit techniques. Thus, with a proven set of conservative design rules, Inova believes that it can leapfrog a generation ahead in both system density and reliability, rather than pushing the state of the art of lithography. These conservative design rules should result in higher reliability for the new Inova SRAM.

Using a design approach similar to that of the 256-K chip, the third generation of Inova wafer-scale products will include devices ranging from partial-wafer 1-Mb SRAMs in Jedec standard packages to full-wafer 24-to-32-Mb SRAMs fitting into a 50-pin package 4 in. on a side, says MacKenzie. "To achieve the same memory sizes at the board level with existing approaches would require from 4 to 96 separately packaged 256-K SRAMs and a total of 112 to 2,688 leads," he says. "The significantly increased density and improved reliability are key benefits of wafer-scale integration and are particularly important in military applications."

For full wafer-scale devices at the 1.25-μm level, the company is exploring various speed and density alternatives. For example, if speed is the primary consideration, small but fast 32-K or 64-K prime dice can be used to produce up to 16-to-24-Mb devices, MacKenzie says. If the lowest cost and the highest density possible are what's needed, he says, then larger but more dense 256-K prime dice can be interconnected to obtain up to 32 Mb per device.

Inroute, invented by Varshney, is used to interconnect the simple, repetitive SRAM memory structures. The CMOS process keeps power requirements low. A reliance on redundancy techniques and supporting equipment helps increase yields. And the large-diameter wafers allow for efficient use of large rectangular devices.

With the Inroute approach, each prime die is tested separately during the wafer-probe stage, and the good portions are interconnected; any extra or bad portions remain electrically isolated. An internal coding scheme is used to determine

which prime die and which block within that die is accessed for a given input address. The decoding scheme then becomes hard-wired when the second level of interconnect is processed. "Unlike prior wafer-scale efforts, we do not use customized metallization to isolate bad dice and interconnect good dice," says Varshney. "The Inroute approach uses the same metal pattern for each wafer, regardless of the location and type of defects."

A small amount of fuse-programmable logic is built into each die to establish the addresses for each quadrant in the SRAM arrays. "We test for good dice, bad dice, and partial dice," says Varshney. "The good quadrants are assigned addresses, and the bad quadrants are not. Furthermore, bad dice are electrically disconnected."

Design of the prime dice, support logic, and interconnect is performed in-house, and fabrication and assembly are contracted out. The only variations required from a standard basic SRAM design are the modifications that allow Inova to disconnect nonfunctional dice and interconnect fully and partially good dice, says Ben Warren, vice president of engineering.

Because there is no need to push the limits of lithography in order to cram more circuitry into a single die, Inova can also work with more relaxed interconnect line widths. Unlike current devices that use a metal pitch of 5 μm or less, Inova is currently working with a 25-μm pitch, which produces an interconnect density of slightly more than 1,000 traces per square inch, compared with about 20 per square inch for the average printed-circuit board. Although denser circuits are planned, the company believes it will be a long time before wafer-scale devices will require the 5-μm metal pitch commonly used now. "That is more than 5,000 traces to the inch," says MacKenzie—far more than is necessary for even the most complex system-level implementations.

Balancing the relaxed pitch rules, though, are a new set of constraints at the second interconnection level. "For one thing, it must be contamination-free," says Varshney. "For another, both the metal and intermetal dielectric used to connect dice on the wafer must be thickened to minimize noise, resistance, and capacitance."

The Inroute approach offers advantages in terms of access time, size, and reliability, says MacKenzie. As far as access time is concerned, the cost of the additional logic and interconnect is no more than 10 to 20 ns of delay—about the same amount posed by the discrete system logic that would otherwise be required to interconnect as many devices, says Warren. And in terms of size, Varshney expects a full-wafer, 4-in.-square by 0.2-in. 24-to-32-Mb SRAM to require only 16 in.^{2} of board space and 3.2 in.^{3} of volume.

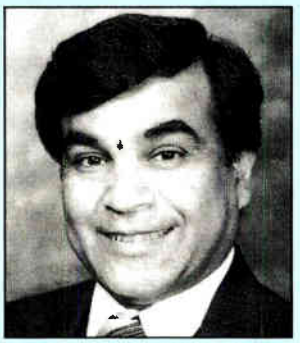
MacKenzie says that the reliability of wafer-scale devices should interest military and aerospace customers. "In many applications, what they are worried about more than the reliability of the actual silicon is the reliability of the mechanical accoutrements, such as the pins and interconnects between packages," he says. A 32-Mb SRAM wafer-scale device uses only 50 pins and 50 bonding wires, compared with up to 3,000 pins and 3,000 bonding wires for 32 Mb worth of interconnected discrete devices. The difference in pin reliability amounts to a factor of 635, calculated according to MIL-HDBK-217D.

What customers may find most exciting about the Inroute approach is its transportability to other fabrication technologies, MacKenzie says. "The Inroute method is a synergistic technology, enhancing the process vehicle on which it is riding," adds Varshney. "Applied to SRAMs in current products, Inroute can be applied to EEPROMs, EPROMs, DRAMs, and processors. It can also be used across different technologies, including most CMOS processes, CMOS/bipolar processes, certain Very High-Speed Integrated Circuit processes, and even bipolar processes with appropriate package-cooling technology." □

CHOOSING SIMPLE STRUCTURES IS THE KEY

Simplicity is the secret to success in solving technical problems, says Ramesh Varshney. "If a proposed solution to a technological problem has too many steps, or requires complex methodologies to work, it is not the right one," he maintains. The founder, chief technical officer, and vice chairman of Inova Microelectronics Corp. applied this philosophy to wafer-scale integration and decided that while other companies were trying to put complex, mixed-device systems on a chip, he would work with simple, repetitive structures instead.

His instincts have paid off. Later in this quarter, Varshney's Campbell, Calif., company will begin to market its first commercial wafer-scale device, a 256-K static random-access memory. The companies that went after complex wafer-scale systems-on-a-chip, though, have either abandoned the concept or turned to easier hybrid silicon-on-silicon approaches.



RAMESH VARSHNEY

Varshney has had a tough time convincing potential customers and investors of the viability of Inova's approach. "Wafer-scale technology has a black eye due to the overambitious plans and ultimate commercial failure of Trilogy," he says, referring to the Cupertino, Calif., company that threw in the towel on monolithic wafer-scale integration in 1984. Nevertheless, Inova has raised $6.3 million from venture capitalists.

Varshney holds degrees in physics, electrical engineering, and economics from universities in his native India, and a Ph.D. in electrical engineering from the University of Waterloo, in Waterloo, Ontario. He went to work at Fairchild Semiconductor Corp. in 1974, where, except for a brief stint at IBM, he remained until 1983, when he left to start up Inova. He has been responsible for 26 inventions and patents in semiconductor memory and programmable logic.

DON'T WRITE OFF WAFER-SCALE WORK: IT'S STILL GOING STRONG

Despite costly failures, many see it as a way to meet circuit-density demands

by Bernard C. Cole

Wafer-scale integration refuses to die. A few stalwarts are still hot on the trail—and they are beginning to report some successes. This comes as welcome news to many in the semiconductor industry who believe that WSI is necessary to get the yearly increase of system-level circuit densities back on a healthy growth path.

For a while it looked as though WSI was an impossible dream, one that had eaten up millions of dollars and frustrated leading semiconductor companies and researchers. What has saved WSI is a turn away from the ambitious goal of integrating onto a single wafer all the different ICs needed for a system. Now companies are working along two more cautious routes: wafers that integrate repeated structures, such as memory cells, connected by multiple levels of interconnection, and hybrid-like silicon-on-silicon assemblies in which the wafer constitutes a substrate of interconnections onto which ICs are bonded.

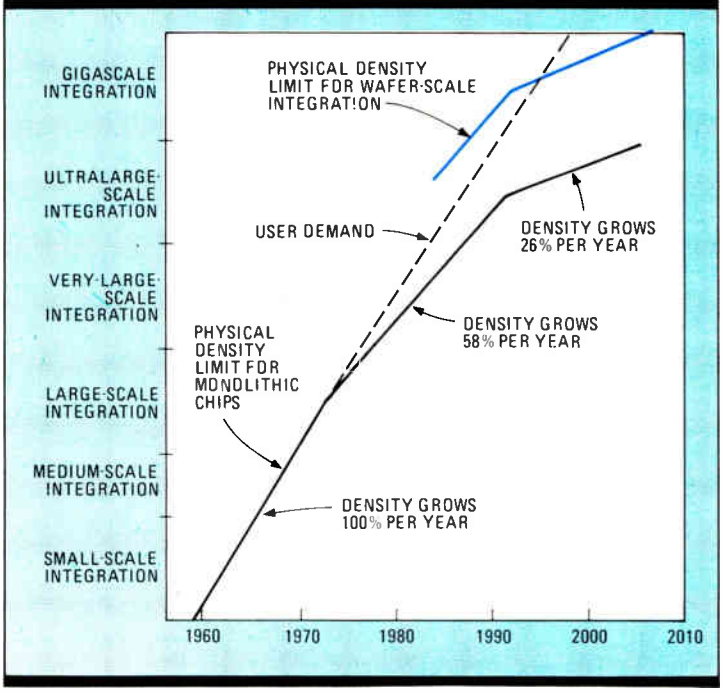
Among the companies taking the first approach are Inova Microelectronics (see p. 91) and British companies such as Plessey and Sinclair Research. The hybrid camp includes Mosaic Systems and GE. Also, TRW, GTE, and Honeywell are pushing slowly toward WSI by building ever-larger chips; in Honeywell's case, hybrid-circuit techniques are being used as a part of the interim solution. GM/Hughes Aircraft Co., meanwhile, is working on an ambitious project that not only involves building monolithic WSI, but stacking a number of wafers together as well.

One attraction of WSI is that it reduces the number of pin connections that can fail in a system. But the main reason so many keep plugging along is that semiconductor density improvements are slowing down, just as systems-level users in the military/aerospace industry and others are calling for a leap forward, says Ramesh Varshney, chief technical officer at Inova Microelectronics Corp., Campbell, Calif.

"During the 1960s and early 1970s, the number of components per chip doubled each year as the result of both design and process innovations," Varshney says. But by the mid-1970s, when most of the innovations had been made, the annual increase in density dropped from 100% to under 60% (figure). Around 1990, the rate should plunge to about 25% a year when second- and third-order effects in semiconductor physics, such as hot-carrier injection, become major practical issues. "The skyrocketing costs of semiconductor capital equipment required by each new generation may force a practical roll-off [from the 60% annual increase] even earlier," Varshney says. He thinks WSI is the only way to keep increasing system-level density.

A fundamental problem with many past attempts at WSI, Varshney says, was their focus on mixing device types on a single wafer substrate. "This use of WSI has never been economically viable," he says. "No one universal process has been found that is optimal for every device type." Also, busing can be complex, as is testing; and yields can be very low. For example, he says, the yield of a monolithic WSI device with 20 types of circuits is about 1%, given individual circuit yields of 80%. This can be improved with redundant circuitry, but only at the cost of de-

WAFER-SCALE INTEGRATION WILL SATISFY DENSITY DEMAND



creased density and increased complexity.

The silicon-on-silicon hybrid approach solves the yield problem for wafer-sized subsystems with a mix of IC types; individual chips can be tested prior to mounting on the substrate. A leading proponent of the hybrid approach is Mosaic Systems Inc., Troy, Mich. [*Electronics*, Nov. 27, 1986, p. 39], which is selling its electrically programmable Unipro substrates in two sizes—either a 4-in. wafer (photograph) or a 1-by-1-in. segment. But Robert R. Johnson, chairman and chief technical officer, says that without exception, customers are more interested in the 1-by-1-in. segments than they are in the 4-in. wafers, because of "engineering reasons that start with the packaging." One, two, or three of the 1-by-1-in. segments can be put into existing commercial and military-qualified packages, whereas the wafer-size Unipro substrates cannot.

Also going the hybrid route is General Electric Corp., Schenectady, N. Y., working in conjunction with the Center for Integrated Electronics at Rensselaer Polytechnic Institute in nearby Troy. GE's director of semiconductor packaging, Constantine E. Neugebauer, says the advantage of building a silicon substrate is that "it's an easy substrate to put through photolithography." It's not much different from a printed-circuit board, he says, "but you can have a grid on a 2-mil pitch as opposed to the 20-mil pitch on a pc board. You have 10 times the density."

The more traditional monolithic wafer-scale approach still has a raft of proponents, such as Inova. Its Inroute methodology is a test-before-connect scheme, using deletive hard-wired connections and a common second-metal mask. Two key benefits, says Varshney, are individual die testing and standard, low-cost processing. Inroute does not depend on error-checking or majority-voting schemes to boost yield, but it can be used to build such circuits if necessary.

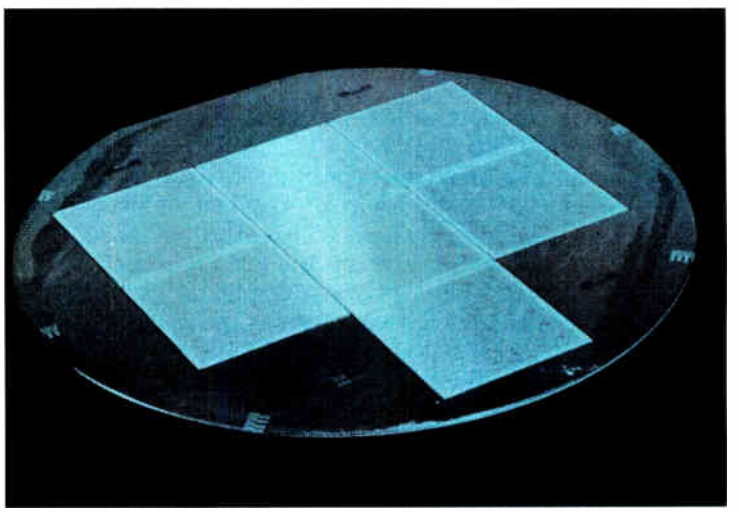
Another member of the monolithic camp is the Massachusetts Institute of Technology, where until recently researchers were using a laser to form additive links after wafer processing is done. This technology requires complex new techniques, so the goal at the MIT Lincoln Laboratory has been to develop a more practical link technology that uses standard CMOS processes. The lab is now demonstrating a WSI dynamic time-warping circuit for speech memory.

The British are also pursuing monolithic WSI. Among the aims of the UK's Alvey fifth-generation computer project is the study of fault-tolerant WSI—in which yield is enhanced by switching in redundant circuit elements to replace faulty ones—in an attempt to gain an edge in what the project's principals consider to be the technology of the 1990s. Managing the project is the Plessey Co., working in conjunction with General Electric Co. plc's Hirst Research Center, International Computers Ltd., and several British universities. Test cells incorporating such regular circuit structures as random-access memory and multipliers will be combined in demonstration circuits and at least one full 4-in. WSI part by 1990.

Commercial WSI parts could emerge within the next year from Anamartic Ltd., Cambridge, UK, a company set up earlier this year by Sinclair Research Ltd. The first product, a 160-megabyte RAM using 1.25-μm n-MOS, is due in early 1988.

In the U. S., TRW Inc.'s Electronic Systems Group in Redondo Beach, Calif., is building what it calls "superchips"—parts larger than standard ICs by a factor of 3 to 10, using WSI methodologies [*Electronics*, July 10, 1986, p. 49]. GTE Laboratories, in Waltham, Mass., is also taking an evolutionary approach. Rather than leaping directly into WSI, it is moving slowly to larger ICs.

Straddling the boundary between monolithic and hybrid approaches is Honeywell's Corporate Solid State Laboratory in Plymouth, Minn. Honeywell is fabricating very large CMOS chips, typically 0.7 to 1.0 in. on a side and containing several functional cells. These chips can then be put down in a hybrid-type package.

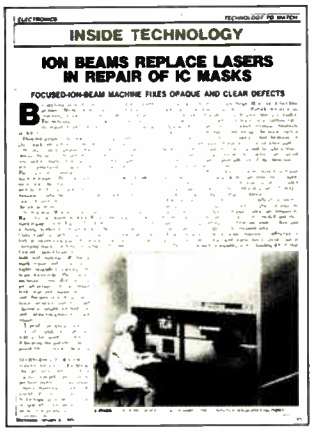


SILICON ON SILICON. Customers mount chips on Mosaic Systems' wafer substrates after programming interconnections.

The most impressive system-level effort to date in monolithic WSI is the 3-D Computer Project of the Exploratory Studies Department at Hughes Research Laboratories, Malibu, Calif. The Hughes team is building an image-processing cellular array of stacked CMOS wafers that has one processor for each pixel. The team believes that by stacking wafers and fabricating feedthroughs and interconnections, it can create massively parallel communications channels on, between, and passing through wafers. Funded under a Defense Department contract to build a feasibility demonstration machine, the machine currently being developed will be a 32-by-32-processor array in a five-wafer stack. □

Reporting for this story was contributed by Wesley R. Iversen, Steve Rogerson, Craig D. Rose, and Larry Waller

UPDATE: A THRIVING MASK REPAIRER GETS EVEN BETTER


INSIDE TECHNOLOGY

ION BEAMS REPLACE LASERS IN REPAIR OF IC MASKS

FOCUSED-ION-BEAM MACHINE FIXES OPAQUE AND CLEAR DEFECTS

It might have been a slow year for most semiconductor-equipment makers, but for Micrion Corp., 1986 was a boomer. It sold eight of its KLA/Micrion 808 focused ion-beam mask-repair systems for more than $1 million each. And the Beverly, Mass., company hopes to do even better next year with enhanced versions of the system: it has expanded the 808's software, refined two of its etching techniques, and introduced a faster mask-repair technique.

Some of Micrion's customers, in fact, have placed orders for additional machines—not bad for a product introduced just a year ago [*Electronics*, Jan. 6, 1986, p. 65]. Already the company has multiple orders for 1987, at a cost of $1.05 million for the basic system and $1.095 million with its new ion-deposition feature, says John Doherty, Micrion's vice president of marketing.

The newer system will feature enhanced software that can turn on the 808 from a cold start with just one software command. It performs functions such as powering up the high voltage, turning on the ion gun, establishing beam focus, and correcting beam astigmatism; before, these functions were done manually.

Originally in the 808, the ion beam milled out opaque defects and removed clear defects from masks by etching opaque optical microstructures. During the ensuing year, however, Micrion has refined its existing opaque- and clear-mask techniques and developed a new clear-defect repair technique.

In the improved opaque-repair technique, called adaptive blanking, the beam is blanked when it is over clear areas of the mask, reducing unwanted etching of the photomask glass. The resulting repairs are still nearly undetectable.

The other refinement, a microstructure clear-repair technique called Phase II, can be milled into the substrate about twice as fast as the prism structures of the original repair system.

To repair clear defects 10 to 15 times faster than the original method on the 808, Micrion came up with a new ion-deposition technique. Hydrocarbon gas is supplied to the defect site, which is then automatically scanned by the system's ion beam. As the beam strikes the gas, a carbon deposit forms on the surface of the glass, resulting in an opaque patch. Since the patch is formed only over the area scanned by the ion beam, and beam placement on the mask is precisely controlled by a computer, the entire repair process is exceptionally accurate.

The new repair technique is also 5 to 10 times faster than the methods on Seiko and IBS's competing ion-beam mask-repair machines. For example, ion deposition creates opaque patches at the rate of almost 1 $\mu m^2/s$, compared with 15 to 20 $\mu m^2/s$ for fabricating microstructures. The new throughput milestone has been achieved with no loss in accuracy, because the 808's ± 0.1 μm edge-reconstruction specification is maintained.

–Jerry Lyman

UPDATE: LASERS SLOW TO CATCH ON IN CHIP MAKING


HOW LASERS WILL GIVE CHIP MAKING A BIG BOOST

NEW SYSTEMS ELIMINATE PHOTOMASKS IN SUBMICRON CHIPS AND ASICs

A year ago, it appeared that a wide range of new laser-based systems were about to be put to work on IC fabrication [*Electronics*, Jan. 6, 1986, p. 70]. Now the future for lasers looks brightest in applications that take place after fabrication. More ambitious uses will have to wait until the semiconductor industry picks up steam.

XMR Inc. says its excimer laser system for micromachining silicon circuits, LMMC, is doing well at the end of its second year of production. But the Santa Clara, Calif., company hasn't been as fortunate with another system—this one based on an excimer laser-assisted doping technique that promises precise, ultrashallow diffusions on large memory chips. The company is still looking for a major partner to invest in its system.

Two other companies—LaserPath Corp. and Dallas Semiconductor Corp.—report that their techniques for producing semicustom chips are working out even better than they had hoped. Both companies were early users of lasers for direct chip programming.

For XMR, though, last year had both gains and setbacks. "The industry has not been overwhelmingly receptive to new procedures, since there is overcapacity in existing production equipment," says XMR president Robert J. Pressley "We had thought the doping system was going to be a production component in the 4-megabit DRAM programs. Generally, those pro-

grams have slipped by about a year."

In the XMR process, ultraviolet energy from the laser is absorbed by semiconductor materials, forming a thin molten layer. A chamber is filled with dopant gas. The excimer laser dissociates the gas and causes boron to diffuse into the molten material, which then recrystallizes, forming a doped diffusion region.

XMR's plan for 1986 was to find IC makers who would act as development partners for its $450,000 system, giving XMR a chance to build a production-class system from its prototype. The company has signed deals in both the U. S. and Japan, and it is also getting some funding from the Semiconductor Research Corp. consortium. But for the most part, seven-year-old XMR is bearing the costs of refinements alone.

Meanwhile, Pressley says, the company's LMMC excimer-laser micromachining system is finding extensive work in the chip industry. The system can punch 1-μm holes for either round or square vias into silicon or gallium arsenide. Because UV energy is absorbed in a shallow region near the surface, the beam is less likely to crack the brittle bulk compound. New U. S. military efforts to advance GaAs circuits has kindled interest in excimer laser machining tools for direct programming of chips, Pressley says.

Already, other laser-based semicustom-chip programming techniques are moving into volume production at Dallas Semiconductor in Dallas and Laserpath in Sunnyvale, Calif. At Dallas Semiconductor, lasers based on neodymium yttrium-aluminum-garnet are being used on more than a half dozen IC products to customize timing and to program in unique security codes, says Michael Bolan, a company founder and vice president of marketing. A telecom T1 product should be coming soon. Initially, the company used its technique to tailor timing-calibration constants of a silicon delay-line IC.

At Laserpath, laser beams are programming 2-μm double-metal CMOS gate arrays in a single day by selectively cutting away interconnections from fabricated dice. The company is now producing 880- to 4,200-gate arrays. This month, Laserpath will begin—six months ahead of schedule—production-quantity shipments of laser-programmed arrays, says Larry Jordan, vice president of sales and marketing. *–J. Robert Lineback*

TECHNOLOGY TO WATCH

UPDATE: TOLERANT GAINS TOEHOLD WITH COMPUTER

In the year following the introduction of its Eternity system, Tolerant Systems Inc. has managed to gain a toehold in the on-line transaction-processing computer market, with systems installed at about 10 different sites. Progress has been slow, however.

When the P100, the first model of Eternity, was introduced, the San Jose, Calif., company's strategy was to establish itself at the low end of the on-line transaction-processing market. The key to this strategy was a system that could be enlarged in increments, by adding system building blocks, with a price of $190,000 for a typical two-block configuration [*Electronics*, Jan. 13, 1986, p.55].

Sales of the Eternity did not take off right away, however. The P100, which was built around National Semiconductor Corp.'s 32016 microprocessor, could execute only four transactions per second and could be expanded up to only 15 system modules. But last June, Tolerant introduced the P200, a machine that uses National's more powerful 32032 chip. The new microprocessor helped to increase the number of transactions per second the P200 can handle to eight per second. In addition, the number of modules that could be used in the system was increased to 40. That's when customers sat up and took notice. "The latter half of the year turned out to be a very significant piece of the business for us," says director of marketing Tom Banks. All told, some 60 system building blocks were installed by the end of the year.


INSIDE TECHNOLOGY

HOW TECHNOLOGY IS CUTTING FAULT-TOLERANCE COSTS

2:1 GAIN IN PRICE/PERFORMANCE CLAIMED FOR TRANSACTION SYSTEM

A typical installation is the setup at the Communications Satellite Corp. in Washington, D.C. Comsat will soon begin using a two-module system at its Southbury, Conn., earth station to control ship-to-shore telephone communications. "Our Tolerant machines . . . [will] control communications equipment: a voice switch, a telex switch, various types of satellite modems, [and] access to the terrestrial AT&T long-lines network," says Gary Kudis, Comsat's director of control systems. The system must handle up to 384 calls per second.

Whatever their size, Tolerant's users seem pleased with their systems. "Overall, I'm quite impressed with the job that [Tolerant's] done," says Jeff Canin, an analyst at Hambrecht & Quist Inc., San Francisco, Calif. "I have contacted a number of the users and found that, almost universally, companies have been very satisfied with the progress. *–Alexander Wolfe*

APPLE GOES AFTER A BIGGER BITE OF THE MICROCOMPUTER MARKET

Three versions of the Open Mac will spearhead the all-out effort

by Alexander Wolfe

With sales booming and its year-old Macintosh Plus making inroads into corporate markets, Apple Computer Inc. is taking on its toughest challenge yet. The Cupertino, Calif., microcomputer maker is gunning not only for the IBM Corp. Personal Computer in the business world, but Sun Microsystems and others in the work-station market. During 1987, a large number of new Apple products is expected, led by the introduction of the long-awaited Open Mac, whose open architecture will let third-party vendors and users tailor systems to their needs.

That machine is key to the assault that Apple is mapping out to conquer the business, desktop-publishing, and engineering/scientific microcomputer markets. But how well Apple succeeds in those markets may be influenced by the next generation of IBM Corp. personal computers. DOS 5.0, the operating system from Microsoft that will run the IBM machines, is late [*Electronics*, Sept. 18, 1986, p. 91]. This may slow the PC's momentum, giving Apple an added boost.

"I think the critical question for Apple is not 'do we know what we need to accomplish'—that's pretty clear to all of us—but whether we can implement it, and in what kind of time frame. The challenge for us in 1987 will be taking all of these new products and new markets and delivering on the promise. Our approach [in 1986] has been to underpromise and overdeliver. That'll be our intention in the coming months as well," says John Zeisler, Apple's manager of business marketing.

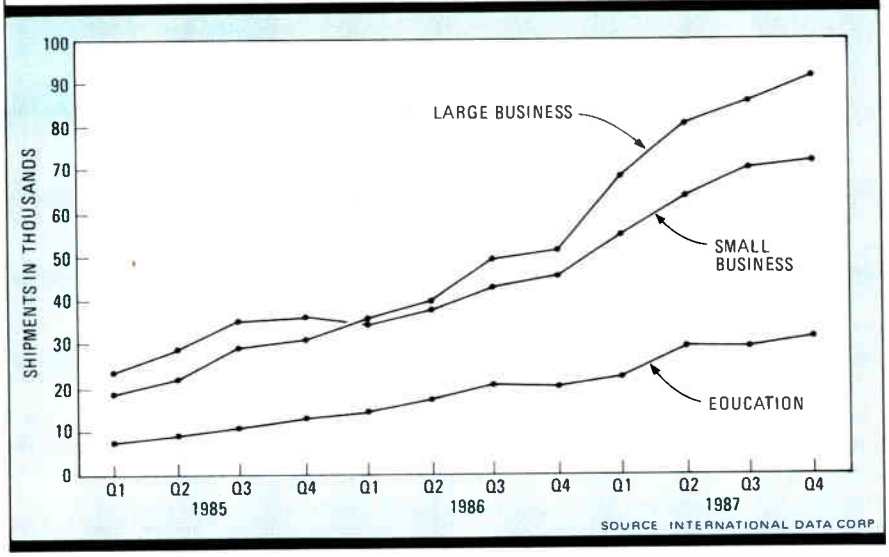
Apple has spent much of the three years since the introduction of the original Macintosh trying to convince business users that its ease of use and its graphics capabilities make it an attractive alternative to IBM's PC line. Initially, business buyers were reluctant to adopt the machine, but it has slowly gained ground. Apple chairman and chief executive officer John Sculley points to the January 1986 introduction of the Macintosh Plus, a machine with ample memory and power to tackle heavy-duty business applications such as spreadsheets, as a big factor in those gains. "We've made a lot of progress [since last year], and Macintosh today is really a serious business computer," Sculley recently told executives of Businessland, a major Apple retailer.

Indeed, the Macintosh is now capturing 13% of the retail personal-computer market, according to the market research company Infocorp. During 1986, shipments of Macintoshes to businesses bounded to 415,000 units, according to Infocorp. It estimates that figure will rise to 585,000 units in 1987. Those sales have helped Apple earn $154 million after taxes on sales of $1.9 billion in its 1986 fiscal year.

Products like the Open Mac are vital if Apple is to continue as a serious participant in the business market, some observers say. "If they just kept trying to ride Mac Plus, they'd lose the edge they've got in the markets [such as desktop publishing] that they're really starting to have some success in," says Tom Roberts, an analyst at International Data Corp., Framingham, Mass.

That's why the rush of new products is expected. On the way, say industry insiders, are three versions of the Open Mac and the introduction of a new Macintosh.

MACINTOSH SHIPMENTS WILL SHOW STRONG BUSINESS-SECTOR GROWTH



Leading industry observers say the Open Mac, code-named Paris, will be a three-piece unit and will come in three different versions. Built around Motorola's 32-bit 68020 microprocessor running at 16 MHz, the first and most basic Paris system will consist of separate keyboard, monitor, and central processing units. Replacing the Mac's small 9-in. screen will be a monitor measuring 13 in. and providing 80 dots/in. of resolution.

But it is the new CPU that opens up the Open Mac. It is expected to have eight slots for users to plug in optional hardware cards. Such expandability, a key factor in the success of both the original Apple II line and the IBM PC, means that buyers can customize their units for graphics, telecommunications, and disk storage. The basic Paris is expected to cost $3,995.

SCULLEY: Recent progress has made Macintosh a serious business computer.

The second Open Mac, the Paris work station, will be distinguished by its monitor. While keyboard and CPU are identical to the basic system, the new screen provides a full-page 8½-by-11-in. display aimed at the desktop publishing market. There, displays that allow users to view complete text pages on screen without scrolling are becoming mandatory. The work station will also come with a 40-megabyte hard disk. This Mac incarnation is likely to sell for about $5,500.

The third and most potent of the Open Macs, the so-called Color Mac, is aimed at the users of powerful 32-bit work stations. That's probably why it's been informally dubbed the "Sun Killer," a reference to the Unix-based work stations from Sun Microsystems Inc., Mountain View, Calif. The 68020-based Color Mac will feature a 17-in. color screen and will sell for about $6,500.

The Open Mac is expected to lead a revamping of the entire Macintosh line. The 512-K-byte Mac will be discontinued, making the Mac Plus the base machine in the line. Above the Mac Plus will be a new machine, code-named Aladdin, with a 16-MHz 68020, two 800-K-byte 3.5-in. disk drives, two expansion slots, an 80-dot/in. display, and a keyboard similar to the Apple II GS. An optional math coprocessor and a hard-disk drive will be available. The Aladdin is expected to sell for about $2,800, or $3,500 with the hard disk. Mac Plus owners will be able to purchase upgrades for $1,000 to convert their units into Aladdins. Also on the list of new introductions for 1987 is a 1.6-megabyte 3.5-in. disk drive.

Apple hopes the new product lineup will pave the way to fortune in the scientific/engineering, desktop-publishing, and general business markets. Although the company says the Macintosh has already achieved a high degree of success in the scientific/engineering market, it admits it is more likely to run support functions rather than tackle the heavy-duty CAD/CAM applications that are the province of high-powered 32-bit work stations.

Taking on more of the CAD/CAM job may well require a move to Unix, the operating system popular on hardware from Sun Microsystems. Rumors have abounded that Apple intends to offer Unix for the Mac in 1987, and Apple tacitly confirms this.

In the desktop-publishing arena, Apple is the company to beat. To date, it has all but blown IBM out of the water, garnering more than 70% of the market. Zeisler admits that it will be difficult to maintain this share. But the graphics capabilities of the 68000-series chips at the heart of the Macintosh give the machine an advantage in flexibility and cost over the PC, he believes.

What do IBM-based publishing systems need to challenge Apple? "A new MS-DOS standard, more memory space, a high-resolution screen, a good user interface, a document description language, and open fonts," says Paul Brainerd, president of Aldus Corp., the Seattle, Wash., software house whose PageMaker software thrust the Macintosh into the forefront of desktop publishing.

But Apple's future may rest most of all on its efforts in the general business arena. "That's the bellwether for all the markets, [where a product must] provide the basic capabilities that people have come to expect in the PC environment," says Zeisler. "We have the equivalent functionality" with the Macintosh, he argues.

Delays in readying the operating system for IBM's 386-based personal computer may provide a crucial opportunity for a market incursion by Apple

Until recently, end users have not had access to all the business software required to check out that claim for themselves. That's why the impending release of DBase Mac from Ashton-Tate, Culver City, Calif., is so significant.

Successfully integrating the Macintosh into a workplace full of IBM PCs also means Apple must nurture networking products. "Products allowing PCs and Macs to exchange data will become more important for Apple," says Roberts. The capability is already available in such third-party products as Maclink from Dataviz, Norwalk, Conn., and 3Com Corp.'s PC Network. □

Additional reporting by Clifford Barney

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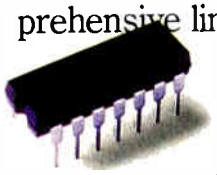

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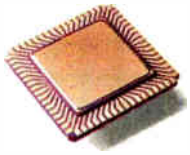

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Circle 101 on reader service card

TWO STARTUPS ARE THE ONLY U.S. PLAYERS IN BUBBLE MEMORIES

With Intel bowing out, just MemTech and Magnesys face Hitachi and Fujitsu

by Jonah McLeod

The announcement by Intel Corp. last month that it had signed a letter of intent to sell its bubble-memory operation marked the end of an era. Intel's decision meant the last major U.S. semiconductor manufacturer involved in bubble memories was abandoning the field to the Japanese and two U.S. startups, MemTech Inc. and Magnesys Inc.

MemTech and Magnesys don't intend to abdicate the market to the Japanese without a fight. MemTech is being formed to take over the Intel Magnetics operation in Folsom, Calif., and will gain access to the considerable research and development Intel put into bubbles. Magnesys, San Jose, Calif., is emphasizing subsystem-level memories, and it has developed its own wafer-level functional tester and circuits for its subsystem products that help improve yields from bubble wafers.

But with Intel gone, Hitachi Ltd. and Fujitsu Ltd. of Tokyo are the only giants left in the bubble business. Both are working on the next generations of bubbles—16-Mb devices, which are due toward the end of this year, and 64-Mb devices, expected in 1990 (the arrows in the chart represent the expected life spans). They, along with NEC Corp., a relative newcomer, are also exploring advanced Bloch-line technology for future parts [*Electronics*, Oct. 14, 1985, p. 16].

The question for the U.S. companies is whether they can catch up. Each is confident it can. Although the companies themselves are young, both stand to benefit from the accumulated experience of U.S. bubble-memory pioneers.

"The technology and production capability MemTech will be getting is state-of-the-art," says Jack Belove, general manager at Intel Magnetics. Intel has been shipping 4-Mb components throughout 1986. In addition, the five integrated circuits needed to support its 4-Mb bubble in a subsystem are being shipped as interchangeable parts. Previously, the bubble and support chips were sold as a kit, because the chips had to be selected to operate with an individual bubble part. Intel's technology has improved sufficiently that the chips and bubbles no longer have to be matched, and so they cost less.

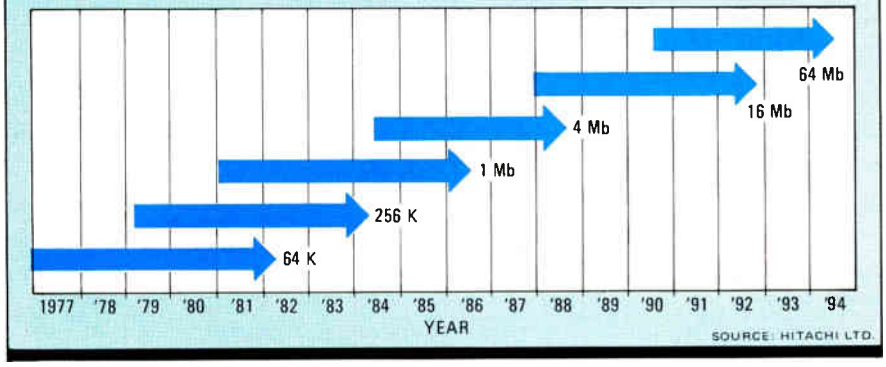
"We expect to continue the R&D effort Intel had begun to develop the 16-Mb chip," says William Almond, president and chief operating officer of MemTech. Intel received a contract from the U.S. Air Force worth several million dollars to develop 16-Mb devices. MemTech should therefore be well along in the development of a 16-Mb bubble, although the disposition of the contract obligations has not yet been determined.

At Magnesys, Ted Wuerthner, president and chief executive officer, points out that "the founders of the company are all ex-employees of Intel, Rockwell International, and Texas Instruments. Their experience in the bubble-memory operations of these companies convinced them that bubble memory had to be made and sold as subsystems, and not components."

By building subsystems, the bubble maker addresses the great nemesis of bubble technology: low yield. Magnesys is attacking the yield problem by designing its subsystem to operate with bubble components that vary in operating characteristics, rather than struggling to build bubble chips that hew to the operating requirements of system components.

The wide variability in output signals from the bubble memory stems from the operation of the detector stack in the bubble. The stack detects the presence or absence of a bubble and produces a millivolt-level analog signal to indicate the presence of a bit.

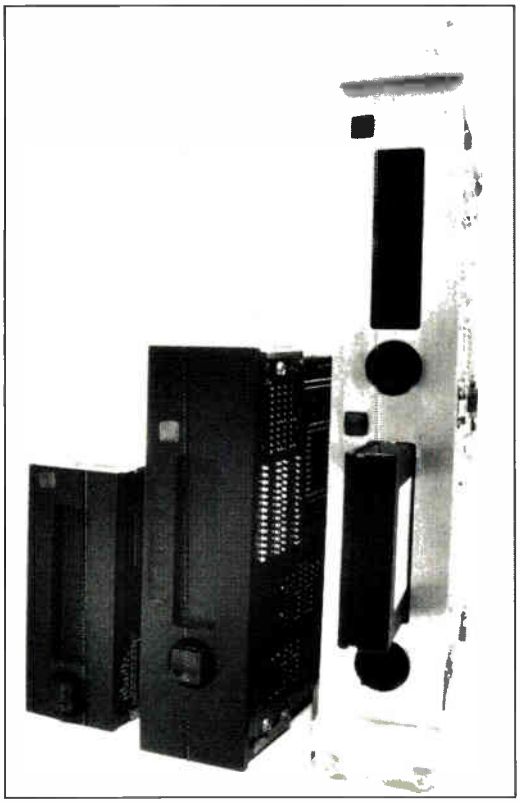
THE FIRST 16-Mb BUBBLE MEMORIES ARE DUE NEXT YEAR



So far, no bubble-device maker has found a way to achieve high levels of consistency in detector-output phase and amplitude. To solve this problem and increase the number of usable bubble chips per wafer, Magnesys builds subsystems that interrogate each bubble component to determine what its operating characteristics are.

Another Magnesys technique aimed at improving the yield of packaged parts is a new wafer-level functional tester. "With bubbles, packaging is 50% of the total cost," says Wuerthner. "It is imperative to package as few bad parts as possible."

With its low-cost functional tester, Magnesys can test 100% of the dice on each wafer to determine which parts are worth packaging. Increased packaged yield and lower testing costs help Magnesys cut the price of subsystems. "Up until now, bubble subsystems were $2,500 answers to $500 problems," says Wuerthner. "Our solution brings the price of the subsystem more in line with expectations." Magnesys sells subsystems for $750 in volume.



BUBBLE DRIVES. Selling bubble memory at the subsystem level lets Magnesys attack yield problems.

Magnesys subsystems are read/write units built with form factors identical to 5¼- and 3½-in. floppy-disk drives (photograph). Each subsystem comes with an integral Small Computer System Interface, which makes it a plug-compatible replacement for a disk drive with that interface. It has a slot for removable bubble cartridges offering 360- or 720-K bytes of storage.

The innovations of Magnesys and the cache of technology MemTech gets from Intel will help make the two companies worthy bubble competitors for the immediate future. But they face formidable opponents.

Hitachi is already moving away from an early-generation technology based on bubble-propagation patterns formed of permalloy and toward a new ion-implantation technology for its 16-Mb devices. Ion implantation of the garnet film affords the same capacity in one-third the chip area required by the permalloy approach.

Current bubble memories use permalloy patterns shaped like chevrons. Hitachi's new devices, by contrast, propagate bubbles along patterns of contiguous disks created by implanting large doses of ions. A 1-bit cell measures 3.5 μm^2, compared with a 6-μm^2 cell for permalloy technology; ion-implanted parts due in 1989 will have 2-μm^2 cells. Smaller chips built with improving implantation techniques will cost less. Hitachi expects to make 16-Mb parts that "will sell for less than current 4-Mb devices," says Edward Klink, Hitachi America's bubble-memory marketing development manager.

"Hitachi is already perfecting technology that will enable it to make a 256-Mb device by the mid-1990s, and eventually a gigabit device," says Klink. At these capacities, bubbles become competition for low-end Winchester drives.

Fujitsu also is developing its 16-Mb bubble components with ion-implantation techniques. To improve area efficiency, the 16-Mb parts will be built as two stacked 8-Mb chips, with both chips controlled by the same rotating magnetic field. Each 8-Mb chip will be about the same size as Fujitsu's current 4-Mb chips. The company says it will be offering samples of the 16-Mb part sometime during the next fiscal year, which begins in April. Development of 64-Mb parts has begun but is still in its earlier stages.

Beyond 64 Mb, Bloch-line technology may turn out to be the way to go. In Bloch-line devices, a single bubble carries more than 1 bit of data—perhaps as many as 100 bits in a single stripe-shaped bubble about 0.5 μm wide. The individual bits are represented by changes in polarization within the wall of the bubble domain.

Innovation and a leg up from Intel may make small U. S. players competitive over the short term, but the Japanese have long-term research clout

Fujitsu and Hitachi are researching this technology, as is NEC Corp., which does not currently have a commercial bubble-memory line. Both Hitachi and NEC say they have working versions of experimental Bloch-line devices that store a handful of bits each, but practical chips appear to be a long way off. □

Additional reporting by Charles L. Cohen

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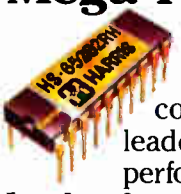

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64K Module 8K x 8 16K x 4	HS-6564RH	250 ns
Asynchronous		
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*Samples available Quarter 2, 1987

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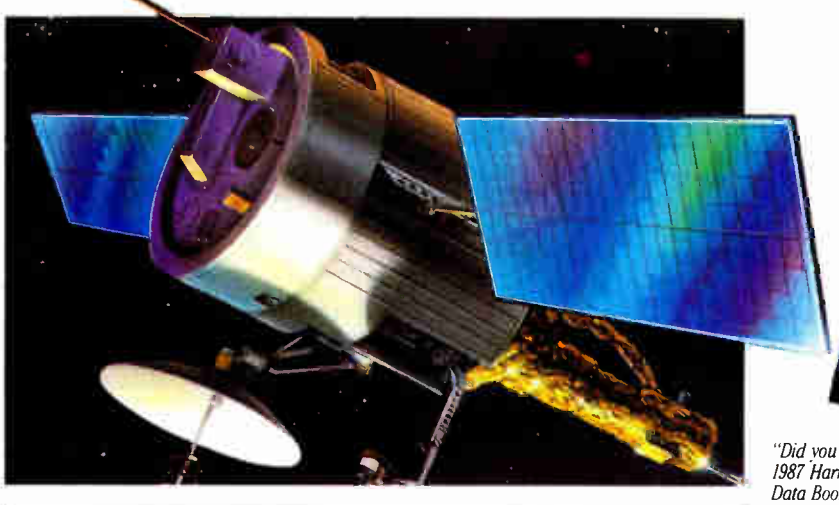

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MILITARY/AEROSPACE NEWSLETTER

A NEW TWIST IN THE DEBATE OVER OWNERSHIP OF TECHNICAL DATA

The great debate between defense contractors and the Pentagon over who owns what technical data could come to a head later this month when contractors get their first look at a new, 20-page regulation on data-ownership rights. The document, written by the interservice Joint Logistics Commanders Group on Data Rights, is aimed at standardizing procedures for all three military services, each of which had its own policy on data ownership. According to Seaman Nachemson, the Army's representative for the group, data whose ownership is claimed by the manufacturer "must be on paper and demonstrated" to have been "developed at private expense . . . exclusive of government cost" for it to pass muster under the new regulation. Under consideration, also, is a separate regulation for software data rights. □

LAUNCH DATE NEARS FOR CDI, A MAJOR PUSH FOR CONVENTIONAL WEAPONS

Defense contractors will get a new line on Pentagon funding priorities for conventional weapons technology in mid-month, when a special Defense Department committee is expected to present to Congress its plan for the so-called Conventional Defense Initiative. A total of about $350 million in fiscal year 1987 funds has been allocated for CDI, a five-year effort aimed at enhancing conventional weaponry. Congress passed CDI last year, with backing by critics of the Pentagon's Strategic Defense Initiative. For CDI, Congress wants emphasis on programs like defenses against armed helicopters; hypervelocity missiles for ground combat use; defense against antiship missiles; "smart" mines; air-transportable vehicles; improved conventional anti-submarine warfare munitions; and "smart" standoff munitions. Initial CDI contracts could be awarded around mid-year. □

THE NAVY MAY NAME A SECOND SOURCE FOR AEGIS RADARS

Pressed by Congress to increase competition for military contracts, the Navy has begun to evaluate second-source proposals for future Aegis radar contracts. At stake is more than $9 billion in Aegis systems work. So far, RCA Corp. has received more than $1 billion in contracts as the sole producer of the phased-array radar. Recently, however, the Navy began talking to the Sperry Corp. about producing the radar system. One problem: RCA operates the only test production facility for Aegis in Moorestown, N. J., and doesn't want anyone else to use it. However, the Navy jointly owns the facility with RCA. The radar units are scheduled to be placed on 27 Ticonderoga-class cruisers and 29 Burke-class destroyers. Aegis system installation costs are pegged by the Navy at $210 million on a cruiser and $150 million for a destroyer. The Navy said it expects to make a decision on a second-source contract within two months. □

AUTOMATED INSPECTION OF PC-BOARD SOLDER JOINTS IS THE ARMY'S GOAL

The Army wants improved production quality in its electronics gear, and one goal is better solder joints. So it is seeking proposals from defense contractors on ways to implement new automatic solder-joint inspection technologies for printed-circuit boards. As part of a three-year plan to incorporate new technologies into the DOD-STD-2000 soldering-workmanship standards, the Army's Harry Diamond Laboratories in Adelphi, Md., will let contractors recover the cost of solder-joint inspection equipment and other manufacturing equipment needed to achieve correct levels of soldering process control. The Diamond labs will host the semiannual meeting of the Association of Laser Inspection Technologies, Jan. 21-22, to further discuss proposals for updating DOD-STD-2000. □

MILITARY/AEROSPACE NEWSLETTER

CDC AND BOEING JOIN FORCES TO DEVELOP SPACE COMPUTERS

Control Data Corp., Minneapolis, and Boeing Electronics Co., Seattle, are hooking up in a long-term cooperative effort to develop and market a new family of high-performance, radiation-hardened space computers for the Defense Department's Strategic Defense Initiative and other advanced satellite programs. The joint effort will continue the thrust begun by CDC's Government Systems Group with its Spacecraft Control Processor, a new MIL-STD-1750A chip set based on CMOS silicon-on-sapphire technology [*Electronics*, July 10, 1986, p. 27]. Engineering units of the chip set are expected to be demonstrated by this year's third quarter. Under terms of the initial 33-month pact, Boeing will work with CDC to develop additional space processors that are compatible with the chip set, as well as a programmable interconnect scheme to tie them together. Initial hardware development efforts will focus on 1.25-μm CMOS/SOS. □

ONLY TWO COMPANIES MEET THE DOD'S NEW CUSTOM HYBRID STANDARD

Some 300 companies have asked the Defense Electronics Supply Center for information on the new requirements for custom hybrid microcircuits, but only two so far have actually obtained DESC certification and qualification. ILC Data Device Corp. of Bohemia, N. Y., and Teledyne Microelectronics, Los Angeles, have fully satisfied the MIL-STD-1772 requirements for auditing of their processing and testing facilities, according to DESC officials. Another 16 companies have certified their processes and materials only. Contractors who don't use parts that fully meet MIL-STD-1772 may have their hybrid devices disapproved or may be forced to run costly qualification testing on their systems. Makers of custom hybrid circuits must also comply with MIL-STD-883 on test methods and procedures for microelectronics and MIL-M-38510 covering general specifications for microcircuits. □

RADAR SPENDING BY THE DOD WILL DROP NEXT YEAR

Radar is the only key category of military hardware in which 1987 spending will be less than in 1986, according to the latest Henderson Ventures' Electronic Market Forecast. "Its decline can be traced to a leveling of production for radar platforms, including ships and airplanes," said the Los Altos, Calif., market research organization. Spending will be $6.6 billion, a 2.1% drop from 1986. Command, control, communication, and intelligence remain a priority item, and will see relatively good growth in 1987, reaching almost $11 billion. That's a 5.8% hike over 1986's spending—but 1986 was up 13.2% over 1985. The need to update both strategic and tactical communication networks is a major DOD goal, but it will be tough to achieve, Henderson notes. The outlook for sonar is less promising, Henderson adds. Flat submarine production and a slowdown in retrofits will result in essentially zero growth for sonar systems, with $2 billion in outlays this year. □

INFRARED DEVICE DETECTS PILOT BLACKOUTS

An eye-blink detector is one of several systems that the Aerospace Medical Research Laboratory, Wright-Patterson AFB, Ohio, is investigating to sense pilot blackouts under high-g acceleration during stunt flying or combat maneuvers. Designed and built by Energy Optics Inc., Albuquerque, N. M., under a $130,000 contract, the detector senses a pilot's fixed stare just before he blacks out. Mounted on the pilot's oxygen mask, the device uses infrared light to monitor changes in reflection of light off the cornea of the eye. Such devices could lead to systems that take control of the aircraft until the pilot regains consciousness. □

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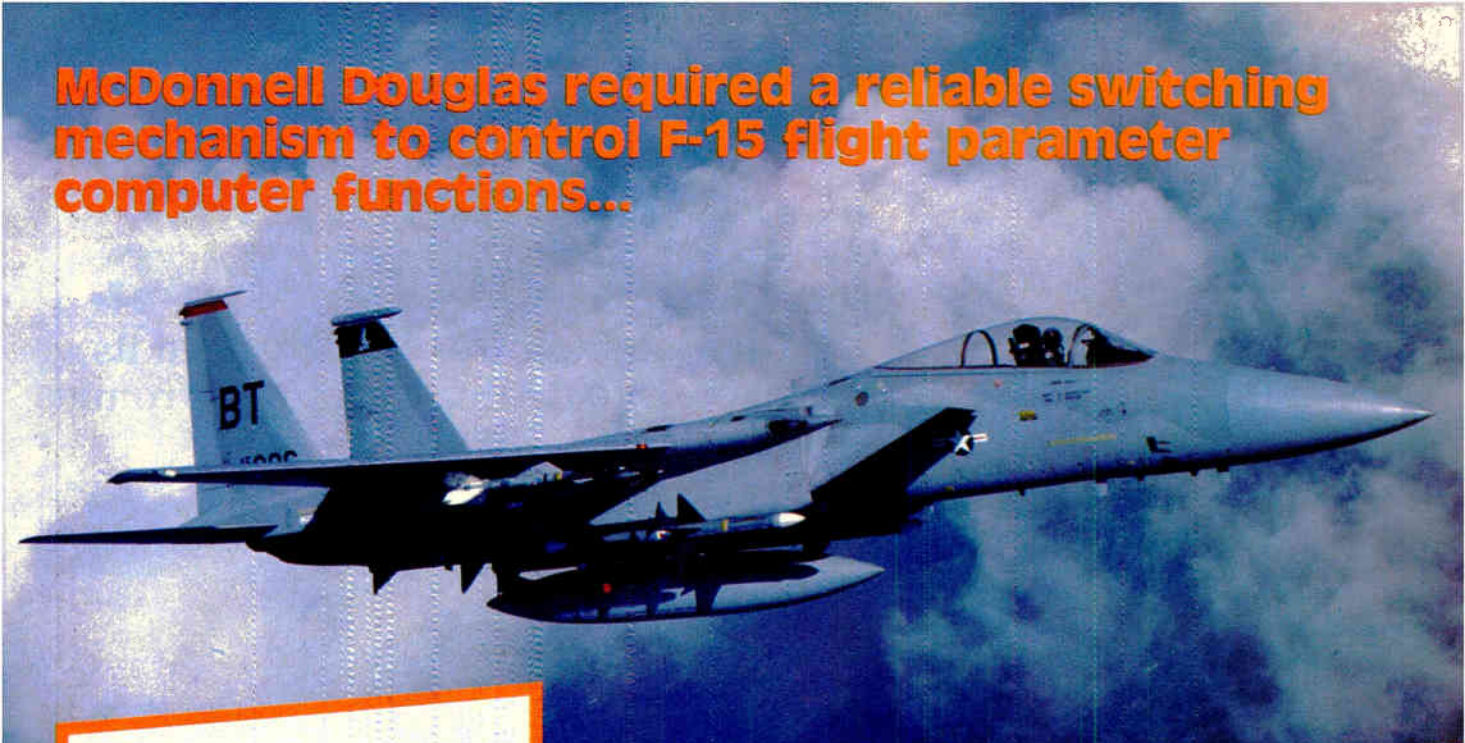

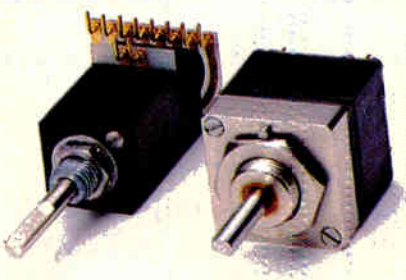

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FOR SEMICONDUCTORS THE NAME IS AMSC.

Maruei Shoji Co., Ltd. changed its name into AMSC Co., Ltd. as from January 1, 1987.

AMSC

AMSC is an abbreviation of Alps Maruei Semiconductor Components. Note that it contains the letter "A" on the consent of Alps Electric Co., Ltd., a shareholder of AMSC.
Taking an advantage of this opportunity, AMSC has determined to open a new business office in Osaka, thereby to further strengthen its business system in Japan. Underlying this determination are AMSC's resources and experiences enough to merely grow as a semiconductor trading firm but to benefit all the areas of the world.
If you're in the market for high quality semiconductors and need advice on semiconductor products, consult us. AMSC is always at your service.

President: Shigeru Kurihara

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Head Office: Asahi-Seimei Mitaka Bldg.
1-6-7 Nakamachi, Musashino-shi, Tokyo, Japan
Phone: 0422-54-6800 Fax: 0422-54-6179

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Phone: 06-222-1031 Fax: 06-222-1033

NEW PRODUCTS

PACKAGE MOLDER ADAPTS EASILY TO ASIC AND PROTOTYPE JOBS

ASM USES MICROPROCESSORS TO REPROGRAM MOLDING PARAMETERS

The special requirements involved in stamping out molded plastic packages for low-volume integrated circuits are addressed by two molders from ASM America Inc. Chips produced in limited volumes—such as application-specific ICs and laboratory prototypes—need molding equipment that can be easily adapted to design changes and can achieve high yields at low speeds.

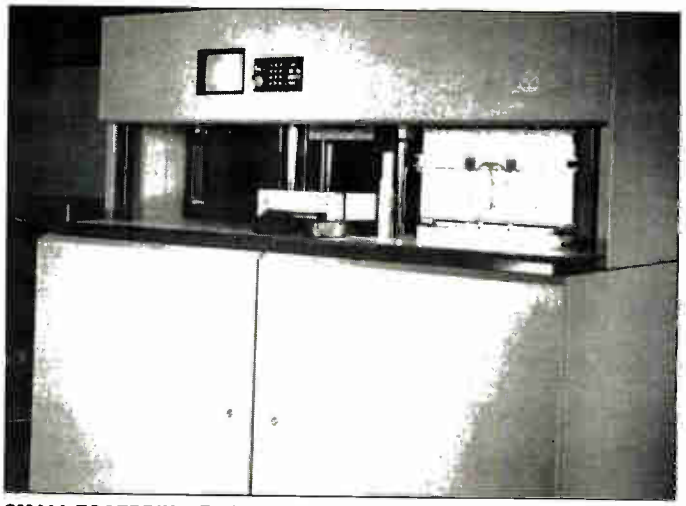
ASM America's MS 100 and AMS 140 are both microprocessor-controlled systems for encapsulating epoxy into a package in the configuration of a leadframe strip. They are among the first such machines designed for low-production applications, the company claims.

"The units are designed to meet industry demand for greater flexibility, interchangeability, and changeover among different package types," says Jeffrey Clifford, ASM's director of operations. Microprocessors in both systems allow thousands of molding parameters to be preprogrammed and reset easily when different packages are run. Parameter adjustments including sequencing, clamping pressure, molding time, and temperature.

Conventional molding units can turn out up to a million units a day, but their yield suffers as a result. The new ASM systems "have proved themselves to improve encapsulation yield from 15% to 20%," Clifford claims.

Most of the gain in yield derives from a multiple-plunger mechanism that forces pellets down to form the package. Molders with single plungers use larger pellets, resulting in irregularities, says Clifford.

The MS 100 is aimed at very low-volume applications. With a maximum throughput of about 100 strips per hour, it is designed primarily for the prototype-development environment. Although the process is controlled by a microprocessor, the MS 100 requires an operator to load the epoxy pellets and unload the continuous strips of leadframes. It can reach a cycle time of 70 s per unit.



SMALL FOOTPRINT. Both the MS 100 and the AMS 140 can fit into small areas in laboratories and prototyping facilities.

For medium-volume production of approximately 140 strips, the AMS 140 incorporates automatic loading features. Depending on the type of molding compound used, its cycle time can be as short as 50 s.

Both the MS 100 and AMS 140 can fit into most laboratory or prototyping production facilities. Their footprint measures 73 in. by 44 in. by 69 in. They also incorporate sensor-controlled keyboards and display screens that reduce problems associated with operator diagnostics, and provide complete control over molding parameters, Clifford says.

The prices, including mold sets, press, and controller, are about $125,000 for the MS 100 and about $215,000 for the AMS 140. Conventional molding systems cost upwards of $500,000. Delivery is six months after order. *–Ellie Aguilar*

[Circle 421]

EMCORE CUTS GaAs PRODUCTION TIME

Emcore Inc.'s production-oriented metal-organic chemical-vapor-deposition systems boost wafer throughput by incorporating a load-lock chamber that allows the reactor to be held at constant pressure and insulated from atmospheric contaminants.

The South Plainfield, N.J., company is targeting the gallium-arsenide chip industry with the GS/5200-M system, which handles 2-in. wafers, and the GS/5300-M, designed for 3-in. wafers. The machines mark Emcore's first products for use outside the research laboratory.

"These are the largest systems that we now make," says director of marketing Les Polgar. The 5200 can process sixty-three 2-in. wafers, 21 at a time, while the 5300 can load twenty-seven 3-in. wafers, nine at a time. Both capacities are comparable to other machines on the market, but, depending on a user's needs, processing time is generally between 60 and 90 minutes. Other production machines take from 2½ to 5 hours.

Speed is not the sole advantage of these new systems. "The load-lock chamber enables you to load wafers while you're running the reaction chamber," says Polgar. The load-lock chamber can be depressurized as soon as it is loaded with raw wafers. The wafers can then be preheated—making possible an exchange from one chamber to another without cooling or drastically increasing pressure in the reaction chamber. Once a batch of wafers has been processed, an operator can transfer more raw wafers to the reaction chamber while removing the finished wafers to the load-lock chamber.

"The load-lock is a feature that brings GaAs processing in league with silicon," Polgar says. "Up to now, people had to expose the reaction chamber after every single run." Since the chamber in the new machines is not exposed to the atmosphere during processing, contamination is minimized, which reduces defect levels to boost yield while also cutting down on the frequency of chamber cleanings. These factors improve throughput—a matter of key importance to chip makers.

Wafers are handled by a robotic system controlled by the operator, who uses joysticks for horizontal and vertical motion. Polgar says a fully automated handling system is under development.

The systems range in price from $450,000 to $800,000 or higher, depending on the complexity of the substrate. Delivery takes three to six months.

–Tobias Naegele
[Circle 420]

SEMIX PUTS MOTORS UNDER PC CONTROL

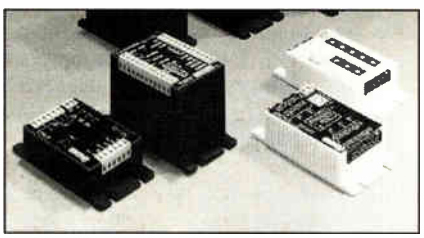
The RD/RC series of step-motor master drive controllers from Semix Inc. includes a model that facilitates personal-computer control of up to 40 step motors. All models resist vibration, humidity, and dust so they can be mounted directly on the motor.

The RC-201 and RC-203 are stand-alone devices with rotary switches. The RC-202 is a microprocessor-based module that can be linked to a computer through a three-wire connection and Semix's RS-232-C interface, model RC-002. The device accommodates step-motor drive needs for 2- to 5-phase motors with outputs up to 6 A per phase, and it runs off a common power supply from 18 to 40 V dc.

The RC-002 interface lets the personal computer control up to 20 RC-202s through the same port—each one capable of controlling two step-motor drivers, or up to 20 inputs and outputs when addressed as a general-purpose controller. Currently there are nine bipolar models and one unipolar model.

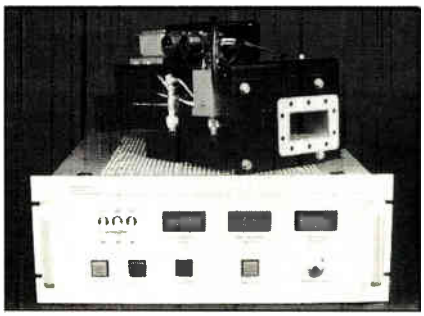
Available now, the RC-201 costs $250, and the RC-202 costs $270. Pricing is not available for the RC-203. The RC-002 interface sells for $270.

Semix Inc., 4160 Technology Dr., Fremont, Calif. 94538.
Phone (415) 659-8800 [Circle 425]



MICROWAVE SOURCE HAS HIGH PRECISION

Applied Science and Technology Inc.'s S-1000 series of microwave power sources delivers continuous-wave power of up to 1 kW at 2.45 GHz. Output power is regulated to 0.1%, with less than 1% deviation from dc. The series is designed for use in plasma-production applications, such as ion sources for ion implantation, ion-beam milling, and ion-assisted deposition.



The units sense reflected power and automatically adjust output to minimize it. They also include digital metering of auxiliary signals. Some of the available options available are: remote control with power-level programming; regulation of power from an auxiliary process-feedback signal; and alternate power levels and frequencies.

For OEM-quantity purchases, the S-1000 series power supply costs $9,800 each. The power supply fitted with a 0.5-kW head costs $11,700, and the power supply with a 1-kW head costs $16,000. Delivery takes 12 weeks.

Applied Science and Technology Inc., 37 Cedar St., Newton, Mass. 02159. Phone (617) 253-8154 [Circle 426]

CHIP PLACER HANDLES SURFACE MOUNTING

Cambridge Automatic, a division of Eyelet Tool Company Inc., offers a single-head placement machine for surface-mounted devices that is intended for use by research, repair stations, and low- to moderate-volume production facilities.

The SMD425 bench-mounted machine transfers chips from 8- or 12-mm EIA tape and reel carriers to pc boards or substrates at up to 30 chips a minute.

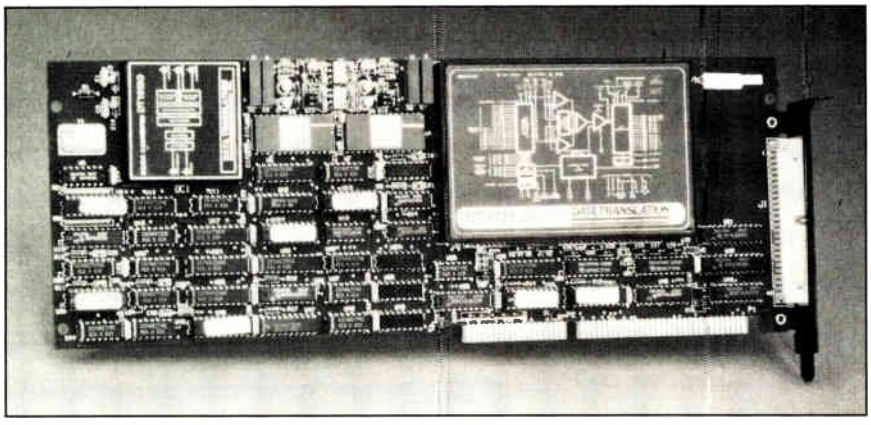
Reels of parts on tape are fed into the machine by positive-indexing drives. A vacuum system removes the chip from its carrier and deposits the chip onto solder paste by reversing the vacuum with an air blast. The SMD425 has quick-change and reload features and operates at 60 lb/in.^{2} at 110 V. Measuring 2 in. by 12 in., the device costs less than $3,000.

Cambridge Automatic, 15 Erie Dr., Natick, Mass. 02161.
Phone (617) 653-9002 [Circle 428]

1	Exxon	25	Standard Oil (Ohio)	49	Consolidated Foods	73	American Home Prod	97	North American Philips
2	General Motors	26	AT&T Technologies	50	Lockheed	74	Litton Industries	98	Agway
3	Mobil	27	Boeing	51	Georgia-Pacific	75	Hewlett-Packard	99	Pfizer
4	Ford Motor	28	Dow Chemical	52	Monsanto	76	Control Data	100	H.J. Heinz
5	IBM	29	Allied	53	W.R. Grace	77	Texas Instruments	101	NCR
6	Texaco	30	Eastman Kodak	54	Signal Companies	78	LTV	102	Pillsbury
7	E.I. du Pont	31	Unocal	55	Anheuser-Busch	79	American Brands	103	PPG Industries
8	Standard Oil (Ind.)	32	Goodyear	56	Nabisco Brands	80	International Paper	104	Int. Harvester
9	Standard Oil of Cal.	33	Dart & Kraft	57	Johnson & Johnson	81	Motorola	105	American Motors
10	General Electric	34	Westinghouse Elec.	58	Coastal	82	Burroughs	106	Borg-Warner
11	Gulf Oil	35	Philip Morris	59	Raytheon	83	Archer-Daniels-Midland	107	American Cyanamid
12	Atlantic Richfield	36	Beatrice Foods	60	Honeywell	84	Digital Equipment	108	Kerr McGee
13	Shell Oil	37	Union Carbide	61	Charter	85	Borden	109	United Brands
14	Occidental Petroleum	38	Xerox	62	General Mills	86	Champion International	110	FMC
15	U.S. Steel	39	Amerada Hess	63	TRW	87	Armco	111	Emerson Electric
16	Phillips Petroleum	40	Union Pacific	64	Caterpillar Tractor	88	Esmark	112	Dresser Industries
17	Sun	41	General Foods	65	Aluminum Co. of Amer.	89	Diamond Shamrock	113	Boise Cascade
18	United Technologies	42	McDonnell Douglas	66	Sperry	90	CPC International	114	Warner Comm.
19	Tenneco	43	Rockwell Int.	67	Gulf & Western Ind.	91	Time Inc.	115	Owens-Illinois
20	ITT	44	PepsiCo	68	Continental Group	92	Deere	116	Carnation
21	Chrysler	45	Ashland Oil	69	Bethlehem Steel	93	Bristol-Myers	117	American Can
22	Procter & Gamble	46	General Dynamics	70	Weyerhaeuser	94	Martin Marietta	118	Reynolds Metals
23	R.J. Reynolds Ind.	47	3M	71	Ralston Purina	95	Firestone Tire & Rubber	119	Campbell Soup
24	Getty Oil	48	Coca-Cola	72	Colgate-Palmolive	96	IC Industries	120	Kimberly-Clark

DATA ACQUISITION CARD SUITS THE FAST NEW PCs

DATA TRANSLATION'S BOARD GIVES 250-KHz THROUGHPUT FOR THE COMPAQ 386, 180 TO 235 KHz FOR THE IBM PC AT



HIGH RESOLUTION. The DT2821-G offers 12-bit accuracy for 16 single or eight differential inputs.

Fast new personal computers now can be harnessed to a data-acquisition board that matches their speed. Data Translation Inc.'s DT2821-G board can run at 250 KHz with the Compaq 386 PC personal computer. Throughput for the IBM Corp. PC AT and compatibles is in the range of 180 to 235 KHz, depending on clock speed.

The 250-KHz throughput rate is about twice the speed of Data Translation's other high-end products, which were themselves industry leaders, says the company.

Data Translation is marketing the board for applications requiring very high-speed data acquisition or very high-speed sampling of many channels. The DT2821-G offers 12-bit resolution for 16 single-ended or eight differential analog inputs.

When the Marlboro, Mass., company developed the board, it targeted Digital Equipment Corp.'s Q-bus products. But Data Translation decided to extend the new board to cover the latest generation of microprocessors, such as Intel Corp.'s 80386 microprocessor.

Then, the company decided there was a market for the DT2821-G in AT-class personal computers. "We took all those things that people wanted on the Q-bus and moved them over to the AT bus," says Dick Pleau, product marketing manager.

To control analog and digital sampling on the board, the DT2821-G keeps track of each channel's gain by means of a list implemented in random-access memory. The 16-location RAM allows the sampling of input channels in any sequence and at any gain.

The board makes use of a proprietary direct-memory-access technique that provides gap-free acquisition. Switching between the two DMA channels, the DT2821-G can collect continuous samples at maximum throughput rates.

Two 12-bit, independent, deglitched digital-to-analog converters, each with a throughput of 130 KHz, control the analog output. The board also includes 16 lines of digital I/O, a programmable clock, and support for interrupts and DMA.

Data Translation's ATLab software package fully supports the DT2821-G. ATLab includes high-level interface calls to Pascal, C, and Fortran. The software package also supports uninterrupted data transfer to memory and disk.

Available now, the DT2821-G costs $2,995 in single-unit purchases. Quantity discounts are available. *–Craig D. Rose*

[Circle 340]

BOARD COMPUTER RUNS AT 3 TO 4 MIPS

Force Computers Inc.'s VMEbus single-board computer based on Intel Corp.'s 32-bit 80386 microprocessor pipelines the 16-MHz microprocessor to 2 Mb of high-speed dynamic RAM.

The CPU-386 runs at 3 to 4 million instructions/s. Equipped with an Intel Corp. 80387 math coprocessor, it can achieve 1.8 million Whetstones/s.

Its architectural interface is compatible with VMEbus. With four 28-pin sockets, the board accommodates up to 256-K of electrically programmable ROM or electrically erasable PROM, and it supports device speeds between 100 ns and 250 ns. The CPU-386 runs operating systems and applications software programs developed for Intel's iAPX 8086 family, and it offers a virtual 8086 mode. The Forcebug/386, a debugging package included with the board, contains a single line assembler/disassembler and features test and macro facilities.

The product is in beta test and samples are now in production for delivery this month at the introductory price of $5,775 for between one and nine units. Volume discounts are available.

Force Computers Inc., 727 University Ave., Los Gatos, Calif. 95030.
Phone (408) 354-3410 [Circle 346]

CALCULATOR CAN DO SYMBOLIC MATH

Hewlett-Packard's HP-28C hand-held calculator, which can handle problems in symbolic notation, is the first in the company's new generation of professional scientific calculators.

The HP-28C's symbolic-function set includes a large set of algebra and calculus operations, such as expanding expressions, collecting terms, substitution, differentiation, integration, and rewriting expressions according to standard mathematical rules. Its equation-solving

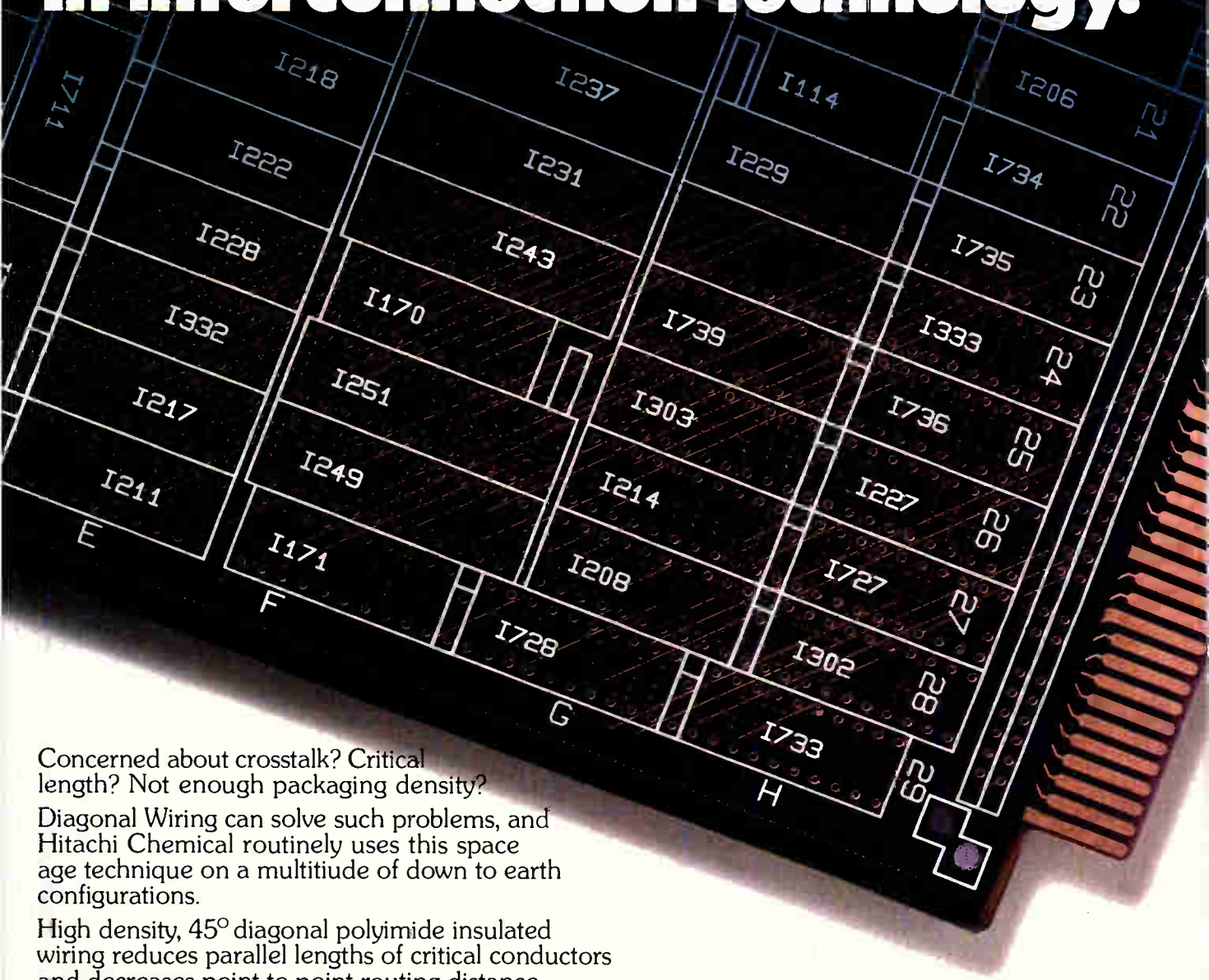
capability allows the user to enter and store unevaluated equations for evaluation later.

With 250 built-in programmable commands and 60 keyboard commands in addition to its symbolic processing capability, the calculator is one of the most versatile on the market, according to the company.

The HP-28C is equipped with 30 commands that allow a wide spectrum of matrix operations on real or complex-valued matrices and vectors. It has a 2-K random-access memory and 128-K bytes of ROM—about three times the built-in ROM available with HP's other models. An enhanced operating system allows the user to mix direct entry of algebraic expressions with reverse-Polish-notation logic operations.

Among the HP-28C's other features are a four-line, 23-character liquid-crystal display and separate alphabetic and

A new direction in interconnection technology.



Concerned about crosstalk? Critical length? Not enough packaging density?

Diagonal Wiring can solve such problems, and Hitachi Chemical routinely uses this space age technique on a multitiude of down to earth configurations.

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Circle 113 on reader service card

numeric keyboards. Measuring 7.5 in. by 6.25 in. by 0.5 in., the calculator weighs 8 oz and is powered by three alkaline batteries. It lists for $235, and the companion HP-82240A infrared-linked printer costs $135. Both are available now.

Hewlett-Packard Co., 1820 Embarcadero Rd., Palo Alto, Calif. 94303.
Phone (800) 367-4772 [Circle 345]

PARALLEL PROCESSOR HANDLES 255 USERS

BNN Advanced Computers Inc.'s enhanced Butterfly parallel processor features a multiuser capability permitting up to 255 programmers to use the system simultaneously.

The processor also offers X Windows, which allows an unlimited number of windows and subwindows and dynamic allocation of node sets of varying sizes for different application needs. A remote shell permits the execution of programs from the AT&T Bell Laboratories Unix operating system.

The enhanced Butterfly is compatible with Sun Microsystems' Sun Workstation and Digital Equipment Corp.'s VAX minicomputer and functions as a user-transparent computational server on an Ethernet local-area network.

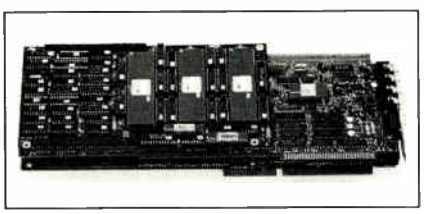
Prices start at $37,000 for a three-processor starter system and go to $375,000 for a 32-processor system. Additional processor nodes are priced between $6,700 and $9,500. The systems are available now.

BNN Advanced Computers Inc., 10 Fawcett St., Cambridge, Mass. 02238.
Phone (617) 497-3700 [Circle 347]

GRAPHICS BOARDS TARGET CAD SYSTEMS

Matrox Vision Processor-AT, a two-board graphics set with a 1-Mb frame buffer from Matrox Electronics Systems Ltd., offers drawing rates as high as 40,000 vectors/s to accommodate the fast imaging requirements of computer-aided design systems.

Proprietary hardware boosts copy rates to as high as 13 million pixels/s. The boards support display resolutions from 640 by 480 pixels to 1,280 by 1,024 pixels, as well as three different flicker-free display formats. They are plug-in-compatible with IBM Corp.'s PC/XT, PC AT, and RT PC computers. The system's arithmetic-logic-unit processor performs convolutions, dilation, and line-thinning approximately five times faster than the company's previous graphics processor boards.



A 24-bit system, the MVP-AT displays up to 16.7 million colors and 256 gray levels.

Two separate pan, scroll, and zoom windows allow viewing of one part of the frame buffer while another part is being digitized. A $\times 2$ and $\times 4$ hardware zoom allows expansion of 1/4 or 1/16 of an image to fill the entire screen. In addition to CAD systems, the MVP-AT has applications in machine vision and electron microscopy, where it can enhance original images.

The MVP-AT costs $4,995, and the MVP-AT/NP costs $8,995. Delivery is in 60 days.

Matrox Electronics Systems Ltd., 1055 St. Regis, Dorval, Quebec, Canada, H9P 2T4.
Phone (514) 685-2630 [Circle 348]

SYSTEM RECOGNIZES CIRCUIT SYMBOLS

The GTX 5000 Drawing Processor System from GTX Corp. is an automatic drawing-recognition system that is capable of automatically scanning and storing all types of engineering drawings on a standard IBM Corp. PC/AT floppy disk.

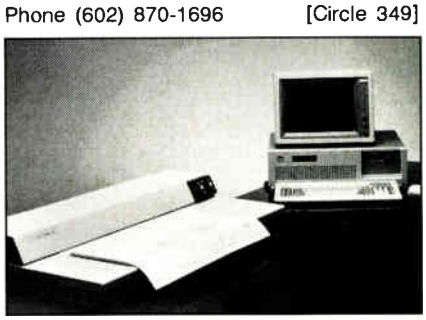
The system's text editor can be programmed to recognize engineering icons, from circuit elements to company logos. By doing this, it eliminates the time-consuming process of entering the diagrams manually.

Using an IBM PC/AT or compatible machine as a work station, the system can scan a standard-size drawing in 18 s, and then recognize each discrete element and store the information on disk in an average time of 1 to 15 minutes. This is less than one fourth the time required to redo a drawing using computer-aided design.

The unit is compact enough fit on a desk and can convert drawing data to major CAD-vendor formats.

The GTX 5000 will be introduced in February. The complete system, including scanner, PC/AT, and editor will cost $70,000. Purchased unbundled, the editing software will cost $3,900.

GTX Corp., 2501 West Dunlap, Phoenix, Ariz. 85021.
Phone (602) 870-1696 [Circle 349]



ENCRYPTION CHIP SET GIVES LOW-COST SECURITY

AT&T's $88 DUAL-CHIP SET OFFERS MULTILAYER CODING ON FOUR DATA LINES, PLUS PROGRAMMABLE MODES

A new data-encryption chip set from AT&T Co. provides a low-cost means of attaining highly secure communications. The two-chip set can cost as little as $88 in quantity, and it offers several layers of encryption on each transmission. Also, the devices can be used with a multiplexer to encrypt as many as four data lines simultaneously.

The T7000A Digital Encryption Processor provides the master key for encrypted transmissions, and the T7001 Random Number Generator gives the T7000A a starting point for the encryption.

The T7000A can be programmed to perform any of the four operating modes of DES, the National Bureau of Standards' Data Encryption Standard, says Thomas V. Gates, product manager for communications devices at AT&T Technologies. The chip has a user-defined mode that allows it to run less than the full DES algorithm in those instances where speedy transmission is more important than maximum security.

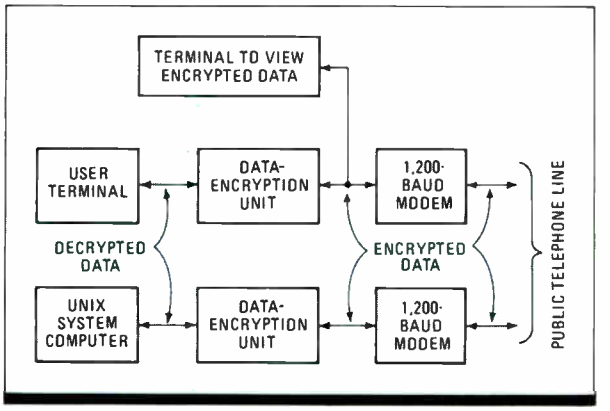
The chips can encrypt multiple data lines with no degradation in service and can provide for multiple layers of security. "You can actually encrypt using electronic codebook [the most common, single-pass mode of DES] and then re-encrypt using cipher-block chaining," a more complex DES mode, Gates says.

Another security layer derives from the random-number generator, which AT&T says provides a system with a "truly random" number as opposed to a pseudo-random number. The device consists of two oscillators; one is finely tuned to give a clear, predictable output, and the other generates a noisy and unpredictable output. The chip delivers a random number on request by measuring the phase difference between the waveforms of each oscillator.

The random numbers become session keys, which are used on the receiving end of a transmission to crack the code. According to Gates, most encryption systems use either a mathematical algorithm or a simple method—such as asking the host computer how long it has been since the system was last powered up—in order to determine a random number for the session key.

"But these can be deciphered," he says. Schemes that use a standard question always provide a positive number, and subsequent session keys will always be larger than the last transmission, says Gates, making it much easier for someone to break the code and intercept a transmission than could be done with the AT&T random-number set.

A typical application designed for complex encryption would require a microprocessor, a universal synchronous/asynchronous receiver/transmitter as an interface between the microprocessor and the host system, clock circuitry, and receive and transmit buffers, as well as the two AT&T chips.



SAFE PASSAGE. Secure transmissions are achieved over public telephone lines by using two encryption units.

Gates says the random-number generator could be used in certain simulation applications, and it also could find use in a lottery or gambling system. The parts cost $65 each in small quantities, but the price falls to $45 for the random-number generator and $43 for the processor in orders of more than 1,000. The set is available for delivery from stock in small orders, or in 16 weeks for volume purchases. *–Tobias Naegele*

[Circle 440]

PORTABLE ANALYZER HAS 32-K BUFFER

An RS-232-C analyzer, monitor, and patch panel from Standard Logic Inc. permits viewing of real-time data transfer in different formats and the recording of data in its 32-K buffer memory.

Designed for real-time testing of all RS-232-C networks, the portable Datamon analyzer is compatible with most data-terminal equipment. It provides breakout-box capability, LED status monitoring, baud-rate conversion, and data-pattern triggering through its on-screen, menu-driven firmware.

The analyzer costs $795, including a carrying case and accessory pack, in single-unit purchases. Discounts are available for volume purchases.

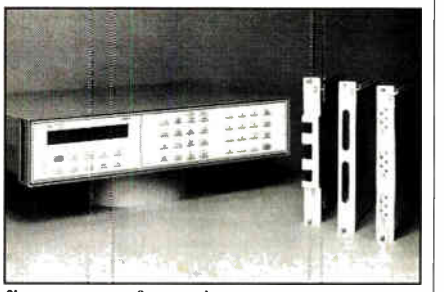
Standard Logic Inc., 132 Business Center Dr., P.O. Box 2319, Corona, Calif. 91720. Phone (714) 735-8610 [Circle 447]

HP ADDS MICROWAVE TO SWITCHING UNIT

Hewlett-Packard Co.'s plug-in modules provide microwave switching capability to the company's HP 3488A IEEE-488 programmable switch-control unit.

The 44476A targets applications requiring a wide dynamic range and a low standing-wave ratio. It has three channels, each with an isolation greater than 90 dB at 18 GHz.

The 44476B facilitates multiport microwave switching in HP's IB series test systems. It comes in three-, four-, and



five-port configurations.

Although both the 44476A and 44476B have normal maximum operating frequencies of 18 GHz, their range can be extended to 26.5 GHz when used in conjunction with the optional HP 33311C frequency-extension unit.

The HP 44477A Form-C relay module has seven channels. The unit, which requires an external power supply, can drive programmable step attenuators, such as HP's 33300 series, as well as

non-HP microwave relays.

In applications where signal integrity is important, the 44477A can be used to drive relays at the test setup instead of extending the test-signal cables to the switch driver, which is normal practice. It offers a maximum switching range of from dc to 18 GHz.

The 44476A module costs $2,200; the 44476B, $400; and the 44477A, $400. The HP 3488A switch/control unit costs $1,400. All are available now. Delivery takes four weeks.

Hewlett-Packard Co., 1820 Embarcadero Rd., Palo Alto, Calif. 94303.
Phone (800) 367-4772 [Circle 448]

SIEMENS FIELDS FIBER-OPTIC LAN

Siemens Information Systems Inc.'s fiber-optic star-configuration local-area network meets the IEEE 802.3 standard and can be linked with a wide variety of coaxial and optical-based Ethernet-type LANs.

Fiber-optic technology permits a LAN to operate over greater distances than cable and eliminates ground-loop and electromagnetic interference problems.

Siemens' fiber-optic Active Star LAN consists of three components—couplers, modules, and transceivers—and features a highly modular approach to building networks, the company says.

Couplers come in a rack-mount chassis and provide for 16 dual-channel, plug-in communications modules. Each coupler connects to as many as 32 nodes. Nodes and repeaters in the network interface the optical cable through the transceivers. Light-emitting diodes on each module alert operators to broken cables or fibers.

The product will be available for test in the first quarter of 1987. Prices have not been set.

Siemens Information Systems Inc., 5500 Broken Sound Blvd., Boca Raton, Fla. 33413. Phone (305) 994-8800 [Circle 445]

9,600-BAUD MODEM RUNS FULL DUPLEX

Cermetek Microelectronics Inc.'s 9600/V32 Trellis modem conforms to international CCITT V.32 specifications, permitting it to operate in full-duplex mode at 9,600 baud over a wide range of telephone lines.

The modem also conforms to the CCITT V.25 standard governing international dialing. During dialing, the modem can monitor call progress (dial tone, ring, busy signal, voice, and answer tone) electronically or audibly through a built-in speaker.

Other dialing enhancements include resident nonvolatile memory for ten 40-character telephone numbers that can be used to route a call when a primary number is inaccessible.

The modem uses trellis coding, an error-correction scheme that transmits redundant bit information simultaneously with the data bits to limit errors caused by noise in the line. It also uses an echo-cancellation scheme to minimize echoes caused by a powerful transmitter feeding back to the sensitive receiver.

Available this month, the 9600/V32 Trellis modem costs $2,995.

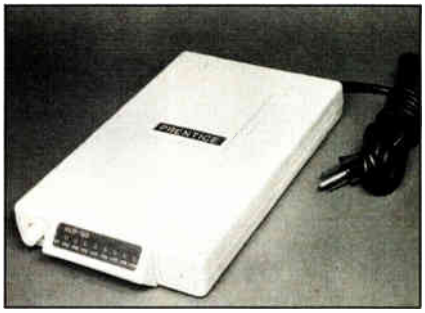
Cermetek Microelectronics Inc., 1308 Borregas Ave., Sunnyvale, Calif. 94088.
Phone (408) 752-5000 [Circle 446]

MODEM EMBRACES MULTIPLE STANDARDS

Prentice Corp.'s 2,400-baud modem offers an open-architecture interface to provide users with a flexible growth path to multiple standards compatibility.

Because the P-2424 is compatible with Bell 103, 212, and international CCITT V.22bis modem specifications, users can choose to expand in several directions. It also supports Hayes Microcomputer Products Inc.'s AT command set and offers full-duplex asynchronous or synchronous transmission.

Other features of the modem include a switch that allows switching between



data and voice during the same phone call, plus manual or auto-answer and auto-dial operation. The modem can be interchanged between stand-alone and rack enclosures and intermixed with other Prentice modems.

The modem has diagnostic indicators for analog and digital loopback, as well as power status.

The P-2424 in a rack-mountable version with power supply costs $695. The T-2424 modem-only model costs $595.

Prentice Corp., 266 Caspian Dr., P.O. Box 3544, Sunnyvale, Calif. 94088.
Phone (408) 734-9810 [Circle 449]

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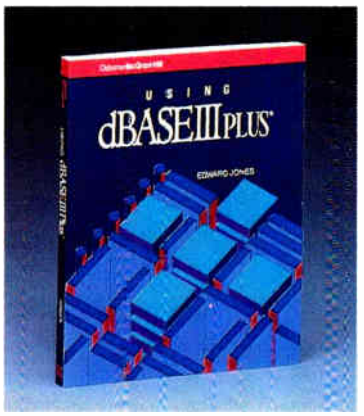

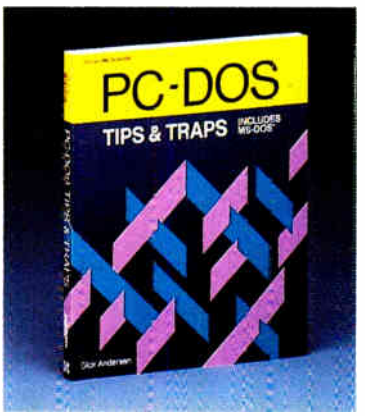

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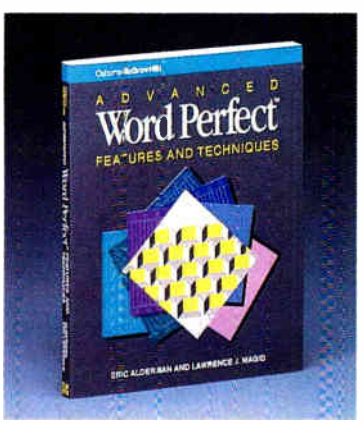

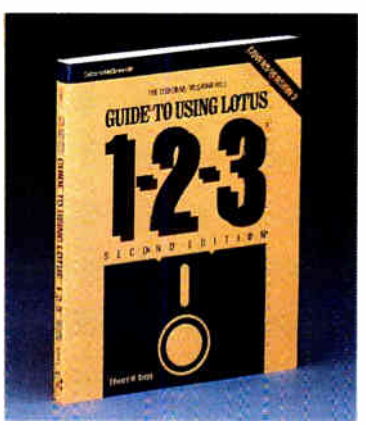

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Computer-Aided Engineering
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March 5
Online Transaction Systems
ISSCC Wrap-Up

March 19
Optical Storage
Single-Board Computers

April 2
Electro Preview
Semiconductors

April 16
VHSIC
Networking

April 30
Personal Computers
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Pan Am World Service to expand Florida activities

Pan American World Services Inc. has undertaken a major modernization program at the Eastern Test Range at Patrick Air Force Base, Florida, where it is the prime contractor to the U.S. Air Force for the range's planning, engineering and operations. As part of the program, the Pan American Corp. subsidiary is recruiting several communications, radar and optical engineers, and other technical specialists.

Since 1953, when Pan Am became prime contractor for the operation of the test range, it has been active in every missile and space effort at the range—from the early air-breathing missiles to the present day launches of the Navy's Trident C-4 missile and the Air Force's Titan III launch vehicle, plus NASA's scientific and communications satellites, and the space shuttle.

Currently, more than 2,500 people work for the Pan Am company (Pan American World Airways Inc. is another Pan Am Corp. subsidiary), according to D.K. Mosby, superintendent of employment of the Eastern Test Range Project. Mosby said Pan Am is also the prime contractor at Cape Canaveral, Fla., and manages NASA facilities at the Johnson Space Center in Houston, Texas; the Army's Fort Gordon, Ga.; and the Navy's Trident base in Washington State, among other operations.

Pan Am's engineering tasks at the Eastern Test Range involve analysis and design, fabrication, installation, evaluation and maintenance of range systems as well as the reduction and analysis of the data produced by range instrumentation. Pan Am is engaged in all tasks that support target acquisition, tracking, and post-flight data analysis for flights of missiles, space vehicles, and aircraft.

Mosby said that Pan Am World Service also has engineering responsibility for the range instrumentation ships that obtain data from broad ocean area coverage of missile and space launches.

Engineers at these facilities specialize in telemetry systems, data systems, radar, communications systems, optical systems, and related technologies.

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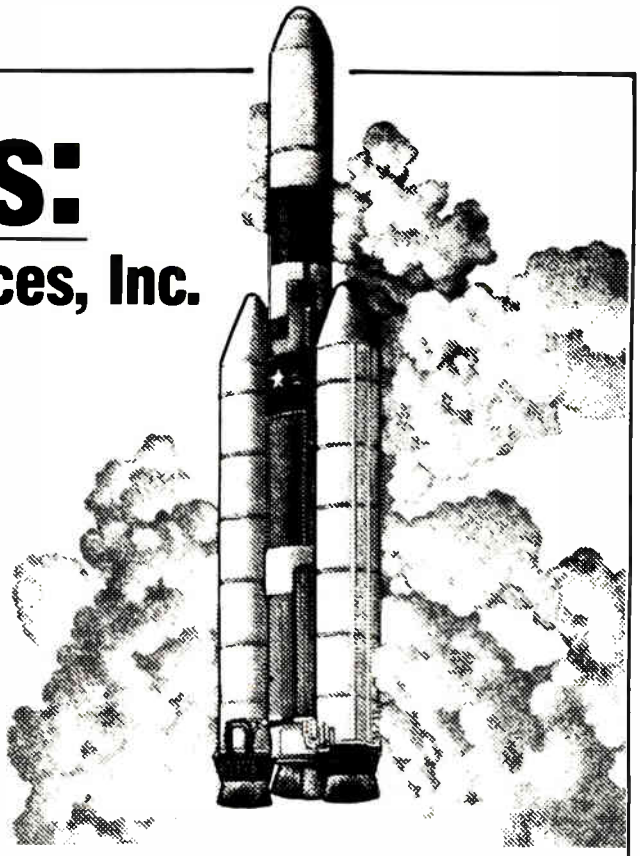

One range is geographical

World Services is prime contractor to the U.S. Air Force for the planning, engineering and operation of the Eastern Test Range. It stretches 10,000 miles from Cape Canaveral to Pretoria, South Africa, and includes some 1,800 ship and land based tracking units.

Another is professional

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DATA SYSTEMS ENGINEER
Will accomplish design, acquisition, installation and evaluation of data acquisition, transmission, processing and display systems for distributed instrumentation complexes. Must have substantial experience in system/subsystem design, test and evaluation.

RADAR SYSTEMS ENGINEER
Will perform design, acquisition, installation and evaluation of high power transmitters, solid-state receivers, and digital range machines, and preparation of specifications for new land and shipboard radar used in tracking and signature data collection. Must be experienced in system/subsystem design, test and evaluation.

OPTICAL SYSTEMS ENGINEER
Will perform system design, installation, modification and evaluation of manned and unmanned optical tracker and camera systems.

COMMUNICATIONS SYSTEMS ENGINEER
Will accomplish design, acquisition, installation and evaluation of subsystem equipment and systems to support communications and timing requirements. ETR Communications Systems include analog and digital communications systems, red and black switching systems, long and short haul data transmission over HF, Microwave, Satellite and Cable (copper and fiber optics) Systems and Electronic Security Systems. Timing includes state-of-the-art PTTI systems.

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Issue Date	Feature	Closing Date
January 8	U.S. Market Forecast	December 22
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March 5	Online Transaction Systems ISSCC Wrap-Up	February 16
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October 29	Artificial Intelligence Materials	October 12
November 12	Wescon Preview Minisupercomputer Workstations Digital Signal Processing Paris Components Show Preview	October 26
November 26	Military Electronics Parallel Processing ISDN IEDM Preview	November 9
December 17	Year-End Double Issue Executive Outlook ISSCC Preview GaAs Technology	November 30

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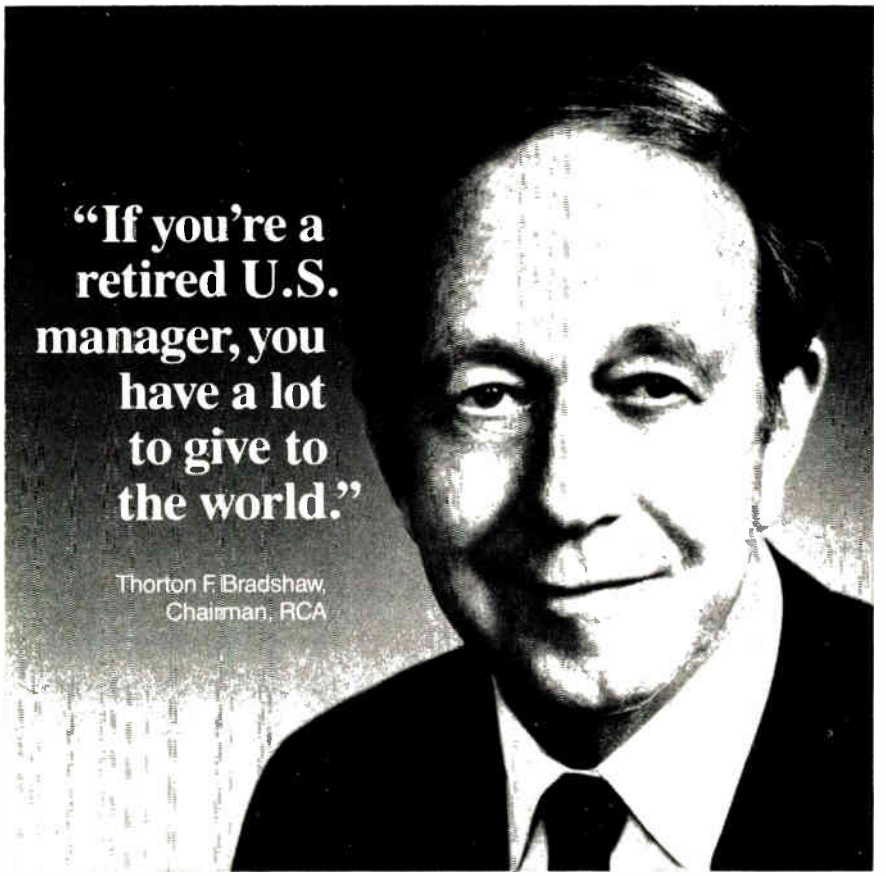

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Apply to: Employment Office, University of Colorado Health Sciences Center, 4200 E. Ninth Avenue, Denver, CO 80262. AA/EOE. Applications deadline is February 28, 1987.

MEETINGS

Hybrid Microtech '87: Conference for Electronic Interconnection Technology, International Society for Hybrid Microelectronics (Hybrid Microtech Secretariat, 13 Firlands, Bracknell, Berkshire RG12 3SB, UK), Heathrow Penta Hotel, Heathrow, UK, Jan. 19-21.

International Symposium on Modeling and Simulation Methodology, University of Arizona, *et al.* (Special Professional Education, Harvill Building/Box 9, Tucson, Ariz. 85721), Hotel Park Tucson, Tucson, Ariz., Jan. 19-23.

Advanced Semiconductor Equipment Exposition & Conference, Cartlidge & Associates Inc. (1101 S. Winchester Blvd., Suite M259, San Jose, Calif. 95128), Santa Clara Convention Center, Santa Clara, Calif., Jan. 27-29.

Wincon '87, Aerospace and Electronic Systems Society (P.O. Box 6876, Burbank, Calif. 91510), South Coast Plaza Hotel, Costa Mesa, Calif., Jan. 27-29.

1987 Annual Reliability and Maintainability Symposium, IEEE, *et al.*, (Gen Pettee, Lockheed Missiles and Space Co., P.O. Box 1269, Cocoa Beach, Fla. 32931), Dunfey City Line Hotel, Philadelphia, Jan. 27-29.

Computer Graphics New York '87, Exhibition Marketing & Management Inc. (8300 Greensboro Dr., Suite 690, McLean, Va. 22102), The Jacob Javits Convention Center, New York, Jan. 28-30.

Measurement Science Conference, MSC (John Van de Houten, program chairman, TRW S/937, One Space Park, Redondo Beach, Calif. 90278), Irvine Marriott, Irvine, Calif., Jan. 29-30.

International Symposium on Pattern Recognition and Acoustical Imaging, International Society for Optical Engineering (P.O. Box 10, Bellingham, Wash. 98227), Newport Beach, Calif., Feb. 1-6.

International Conference on Data Engineering, IEEE Computer Society (1730 Massachusetts Ave., N.W., Washington, D.C. 20036), Pacifica Hotel, Los Angeles, Feb. 2-6.

Manufacturing Productivity Conference & Exposition, Society of Manufacturing Engineers (One SME Dr., P.O. Box 930, Dearborn, Mich. 48121), Expo Centre, Orlando, Fla., Feb. 2-5.

Aerospace Applications Conference, IEEE South Bay Harbor Section (Fausto Pasqualucci, Hughes Aircraft, 3100 Fujita St., Torrance, Calif. 90509), Vail, Colo., Feb. 8-13.

Communication Networks '87, CW/Conference Management Group (375 Cochituate Rd., Box 9171, Framingham, Mass. 01701), Washington Convention Center, Washington, D.C., Feb. 9-12.

Systems Design & Integration Conference, IEEE, *et al.* (Electronic Convention Management, 8110 Airport Boulevard, Los Angeles, Calif. 90045), Santa Clara Convention Center, Santa Clara, Calif., Feb. 10-12.

Southwest Optics '87, IEEE Lasers and Electro-Optics Society, *et al.* (Optical Society of America, 1816 Jefferson Place, N.W., Washington, D.C. 20036), Albuquerque Convention Center, Albuquerque, N.M., Feb. 9-13.

Smartex '87, Surface Mount Exhibition and Conference, Smart Group (30 Calderwood St., Woolwich, London SE18 6QH, UK) Barbican Centre, London, UK, Feb. 10-12.

Which Computer? Show, Cahners Exhibitions Ltd. (Chatsworth House, 59 London Rd., Twickenham TW1 3SZ, UK), National Exhibition Centre, Birmingham, UK, Feb. 17-20.

Interfinances Expobanques '87, International Association for Microcircuit Cards, *et al.* (26 Rue Mogador, 75009 Paris, France), Palais des Congres, Paris, Feb. 17-19.

ACM Computer Science Conference, Association for Computing Machinery (11 W. 42nd St., New York, N.Y. 10036), Adams Mark and Clarion Hotels, St. Louis, Feb. 17-19.

NEPCON West, Cahners Exposition Group (1350 E. Touhy Ave., P.O. Box 5060, White Plains, Ill. 60017), Convention Center, Anaheim, Calif., Feb. 24-26.

Computer-Aided-Software Engineering Symposium, Digital Consulting Associates Inc. (6 Windsor St., Andover, Mass. 01810), Hyatt Regency Ravinia, Atlanta, Feb. 24-26.

International Solid-State Circuits Conference, IEEE Solid-State Circuits Council (345 E. 47th St., New York, N.Y. 10017), Hilton Hotel, New York, Feb. 25-27.

Automated Manufacturing Computers, Communications & Controls, Frost & Sullivan Inc. (106 Fulton St., New York, N.Y. 10038), Don Cesar Beach Resort, St. Petersburg, Fla., March 9-10.

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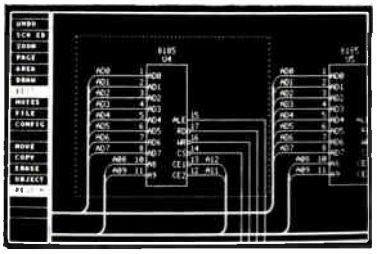

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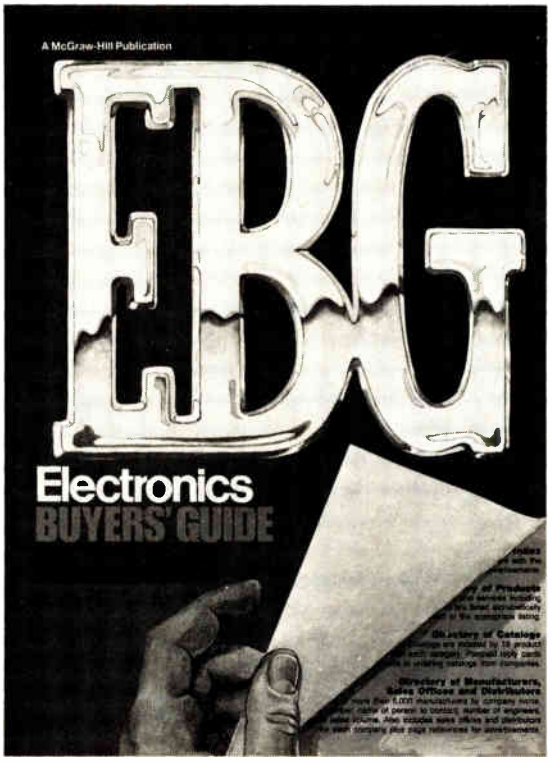

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DISTRIBUTION WEEK

LEAN TIMES CONTINUE FOR DISTRIBUTORS: NEDA FORESEES 12% GROWTH IN 1987

The lackluster growth and weak market conditions in the U.S. distribution business last year show little sign of abating in 1987. "We're still muddling along with very slow, long-term secular growth rates," laments Toby Mack, executive vice president of the National Electronic Distributors Association in Chicago. NEDA recently scaled down its 1987 forecast for growth from 20% to 12%. And Mack says even that looks optimistic.

One reason for Mack's caution is 1986's record. NEDA's book-to-bill ratio was lower in November than it was in January (see figure). The book-to-book and bill-to-bill ratios, which compare each month with the same month in 1985, followed the same path.

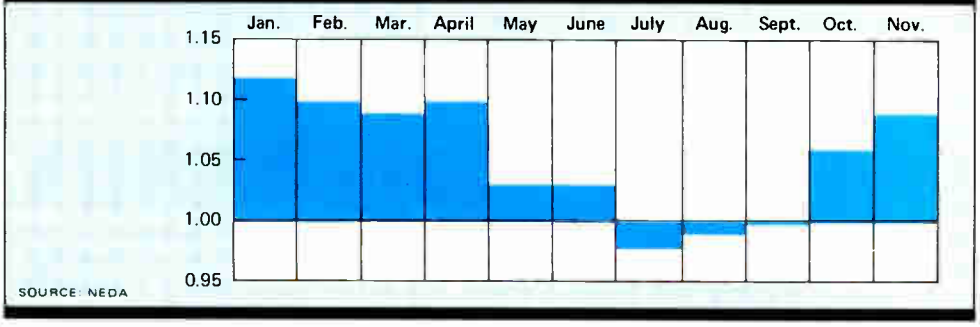
NEDA does see some cause for hope in 1987. Lean end-user inventories could help, and a fourth-quarter 1986 surge in computers could fuel component consumption.

But Mack remains cautious. A trend toward offshore manufacturing by end users is a "big negative," he says. Also worrisome are the sluggish U.S. economy and prospective capital-spending constraints caused by the elimination of the investment tax credit. "We've thought we were on the verge of better business for such a long time now, that I think everybody is in an 'I'll believe it when I see it' mode," he says. *–Wesley R. Iversen*

DISTRIBUTION BOOKINGS AND BILLINGS: JANUARY TO NOVEMBER 1986

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
Book-to-bill ratio	1.12	1.10	1.09	1.10	1.03	1.03	0.98	0.99	1.00	1.06	1.09
Book-to-book ratio	1.11	1.00	1.03	0.96	0.97	1.03	0.90	1.02	1.06	1.01	1.07
Bill-to-bill ratio	1.05	1.02	1.04	0.95	1.04	1.03	0.94	1.01	1.05	0.95	1.04

BOOK-TO-BILL RATIO: JANUARY TO NOVEMBER 1986



SOURCE: NEDA

WILL TOP PLAYERS HANDLE JAPAN ICs?

One of the biggest headaches for distributors is the problem of selling Japanese components side by side with U.S. devices. But new strategic alliances between U.S. and Japanese firms may finally settle the matter.

Except for Texas Instruments Inc., the largest U.S. chip makers refuse to share distribution outlets with Japanese competitors. Since the manufacturers carry a lot of clout, distributors have upheld this barrier, leaving the door open for smaller outfits: Marshall Industries Inc. of El Monte, Calif., for example, has used Japanese lines to catapult into the top 10 of U.S. distributers, with about $285 million in sales in 1986.

But now the rules are changing. The two most important reasons are the proposed acquisition of Fairchild Semiconductor Corp. by Fujitsu Ltd. and the sweeping semiconductor alliance between Motorola Corp. and Toshiba Corp. [*Electronics*, Dec. 18, 1986, p. 33].

One school, albeit a minority, holds that Fairchild's parts could be considered Japanese and subject to exclusion. But top distributors almost certainly would balk at dropping a popular line. Also, Motorola, one of the staunchest proponents of the lockout, might find it difficult to remain hard-nosed in light of its ties to Toshiba.

More likely, the barriers will gradually melt away. George T. Tarnawsky, senior vice president at Marshall, predicts that "changes are definitely in the making. Some [U.S. chip] manufacturers have to do lots of soul-searching."

No one has exact figures on Japanese chip sales through distribution, but NEDA estimates it could be as high as 20% of the semiconductor distribution total. U.S. distribution sales were about $6 billion in 1986, with about 80% of this in semiconductors. *–Larry Waller*

TWO IC MAKERS PICK KIERULFF

In separate marketing agreements, SGS Semiconductor Corp. and Gould AMI Semiconductors Inc. have signed with the Kierulff Electronics Division of Ducommun Inc.

Kierulff will distribute and support Gould's new family of electrically erasable programmable logic devices, as well as its communications and memory ICs.

SGS fabricates a wide range of components, including power transistors, bipolar and CMOS logic, and memory chips and will market them all through Kierulff.

WYLE TO MARKET ASIC TOOLS

FutureNet, a division of Data I/O Corp., has signed a distribution deal with Wyle Laboratories to distribute its Dash line of computer-aided-design products in the U.S. The agreement couples FutureNet's CAD tools for designing application-specific integrated circuits on IBM Corp. personal computers with Wyle's network of ASIC and standard-cell design centers, the companies say.

MOTOROLA TO DROP SOME DISCRETES

Motorola Corp.'s Discrete Semiconductor Group has asked customers to assess their future needs and stock up on a large number of small-signal discrete devices before it shuts down production lines for the devices. The company has recommended replacements for most of the devices, although the package in some cases may not be identical to that of the discontinued device. Among the items to be taken out of production are TO-92 plastic, metal, SOT-23, FETs, multiples, Micro-T, and tuning diodes. The devices must be ordered by May 1987, with shipment taking place by May 1988.

ELECTRONICS WEEK

MCC NAMES INTERIM CHAIRMAN

Microelectronics and Computer Technology Corp., still searching for a successor to former chairman B. R. (Bobby) Inman, has taken the precautionary move of naming Harris Corp. chairman Joseph A. Boyd as interim chairman. As he promised in the fall, Inman completed a three-year stint as MCC's chief last month. The MCC board had hoped to replace Inman by the end of 1986.

AT&T TAKES A $3.2 BILLION WRITEOFF

AT&T Co. is making a major move to cut costs and strengthen its competitive position. On Dec. 18 the company's New York headquarters announced that the telecommunications giant will take a $3.2 billion charge against fourth-quarter profits in 1986—including the elimination of more than 27,000 jobs at a cost of $1 billion, $1.2 billion for streamlining and consolidating operations, and the rest for write-downs of assets and inventories and changes in depreciation.

GaAs CHIP BREAKS SPEED RECORD

Engineers at Bell-Northern Research in Ottawa, Ontario, report that they have run a gallium arsenide multiplier chip at the fastest speed ever achieved in such a device: it can multiply two 4-digit numbers in a nanosecond. The chip, which is built with 1-μm design rules, is aimed at replacing slower silicon circuits used in digital signal processing. It was designed so that it could easily be put into production.

McDONALD'S GETS COOKING WITH ISDN

McDonald's Corp. is adding some sizzle to its corporate communications system. The Oak Brook, Ill.-based fast-food firm last month began pilot use of an integrated services digital network. Illinois Bell is providing the service, which McDonald's will use initially for digital phones, integrated voice and data terminals, facsimile, voice mail, message desk systems, and modem pooling. About 25 user locations in two McDonald's buildings are currently equipped for ISDN, but the company plans to have about 400 work locations on the system by 1988. Following the 18-month trial, Illinois Bell says, it may offer the service to other companies.

TAMKE MOVES FROM IBM TO CULLINET

Cullinet Software Inc. chief executive officer David Chapman has signed on George W. Tamke, a 17-year hardware and software veteran from IBM Corp., as the company's new president. Chapman himself moved to Cullinet just nine months ago from Data General Corp. The two will split the job of managing the Westwood, Mass., software company, which reported a loss of $5.9 million in the last quarter. Squeezed by competition and a general downturn in mainframe software, Cullinet will enter the minicomputer software market next September.

JAPANESE BUY U. S. SILICON PLANTS

Nippon Kokan KK (Nikon) is joining the parade of Japanese companies moving into the silicon manufacturing business. Nikon is buying land in Millersburg, Ore., for an $11.1 million polycrystalline silicon plant and hopes to go into production by mid-1988. In 1985, Nikon bought Great Western Silicon Corp. from General Electric. Other companies snapping up U. S. plants are Osaka Titanium, a major Japanese silicon-wafer producer that just took control of U. S. Semiconductor Corp. in Fremont, Calif.; Mitsubishi Metal Corp., which bought Siltec Corp. of Menlo Park, Calif., a manufacturer of silicon wafers and wafer-production equipment; and Kawasaki Steel, which took over NBK Corp.

GTE TAKES TO THE SKY WITH AIRFONE

GTE, of Stamford, Conn., has acquired Airfone Inc., a commercial-airline telephone link, from Western Union Corp. and A. F. Holding Inc. John D. Goeken, president of A. F. Holding and the developer of the service, will remain as president of the unit, which is joining GTE's Business Services Group. Airfone service is now aboard more than 300 aircraft.

RACAL-REDAC BUYS 1,000 APOLLOS

Apollo Computer Inc., continuing its rebound from tough times a year ago, will supply Racal-Redac Inc. of Westford, Mass., with more than 1,000 work stations in the next 18 months. Under the $25 million deal, Racal-Redac will integrate its Visula software with Apollo's low-end Series 3000 work stations, selling the units as turnkey design automation systems. Apollo, of Chelmsford, Mass., has shipped more than 7,000 Series 3000s since introducing them last February.

MICROCODE IS BACK IN COURT

A U. S. District Court decision placing microcode under the copyright protection laws will get its first test this month. National Semiconductor Corp. of Santa Clara, Calif., has amended its trade-secrets case against United Microelectronics Corp. of Taiwan to include a charge that UMC copied microcode in National's INS8250A universal asynchronous receiver/transmitter. Previously, National had sued to prevent UMC, a former second source for the UART, from marketing its own device. The case is being heard by District Judge William A. Ingram, who made the original ruling in a case brought by Intel Corp., also of Santa Clara, against NEC Corp. of Tokyo.

U. S. R&D SPENDING RISING STEADILY

Expenditures for research and development in the U. S. are expected to rise 7.42% to $127.4 billion in 1987, up from $118.6 billion in 1986, according to the Battelle Memorial Institute in Columbus, Ohio. Adjusted for inflation, this year's spending will amount to a real increase of 4.33%, slightly higher than the 4.26% average rate seen over the last decade. Battelle says federal R&D support will rise 7.6% to $59.5 billion this year, amounting to 46.7% of the total. Industry maintains its position as the largest source of R&D funding, with expenditures rising 7.2% to $63.8 billion.

RIDGE ADDS RISC TO PACT WITH BULL

Ridge Computers of Santa Clara, Calif., is extending its cooperative development agreement with Groupe Bull of Paris. Bull will offer Ridge's new R3200 RISC processor. In return, Ridge is getting rights to Bull's Unix-based operating system and its graphics and communications products.

SIGNETICS CUTS ITS WORK FORCE

Signs of a semiconductor turnaround have yet to reach Signetics Corp., which has begun laying off some 300 of its 9,000 employees. Signetics, a subsidiary of the Dutch electronics giant Philips NV, is rated as the sixth largest U. S. chipmaker by Integrated Circuit Engineering Corp. ICE pegs Signetics' 1986 sales at $500 million.

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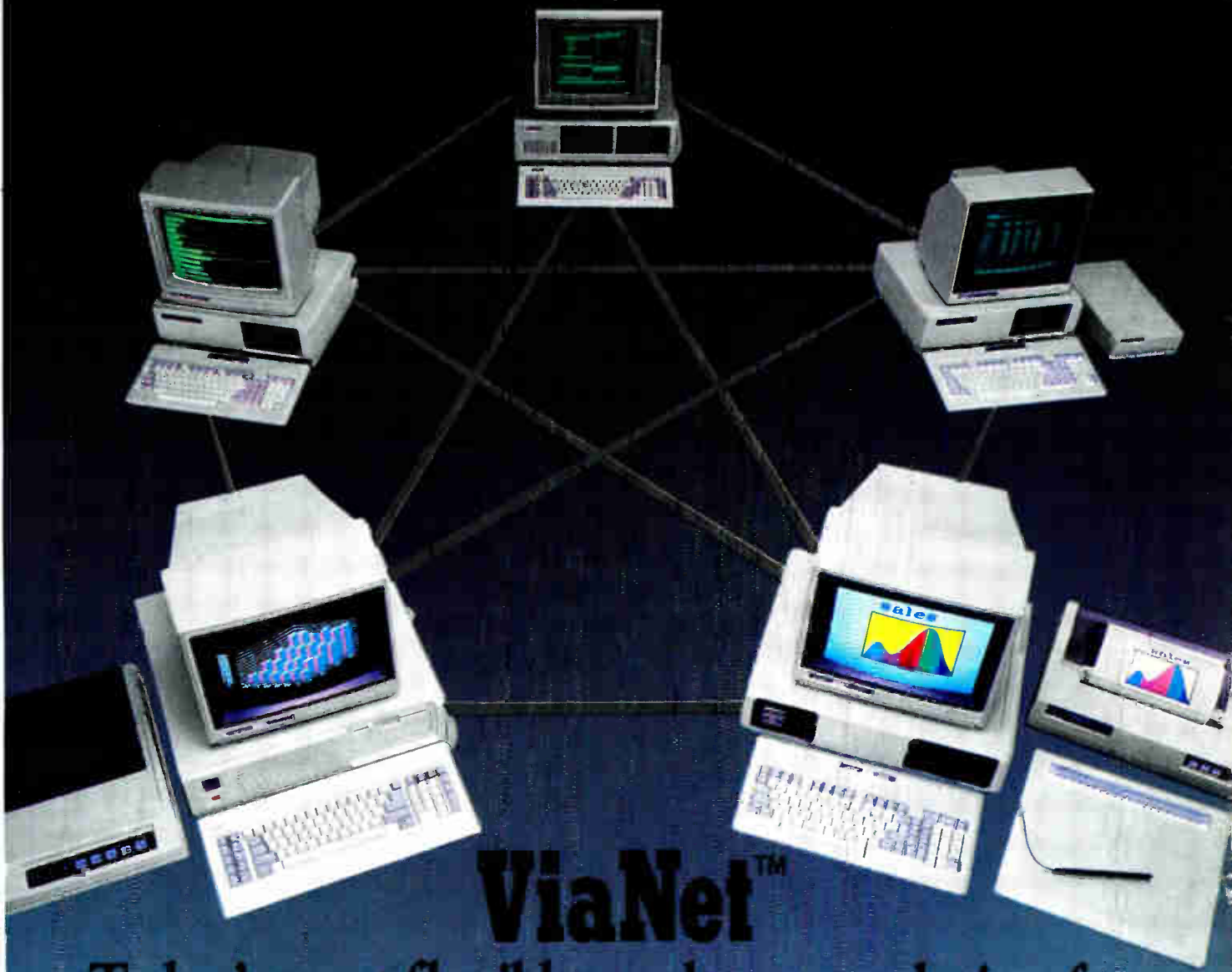

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