HOW POLITICS HAS SNARLED A BIG EUROPEAN RADAR DEAL/29

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A VNU BUSINESS PUBLICATION

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JULY 1989

Electronics

TIGHTER AIRPORT SECURITY

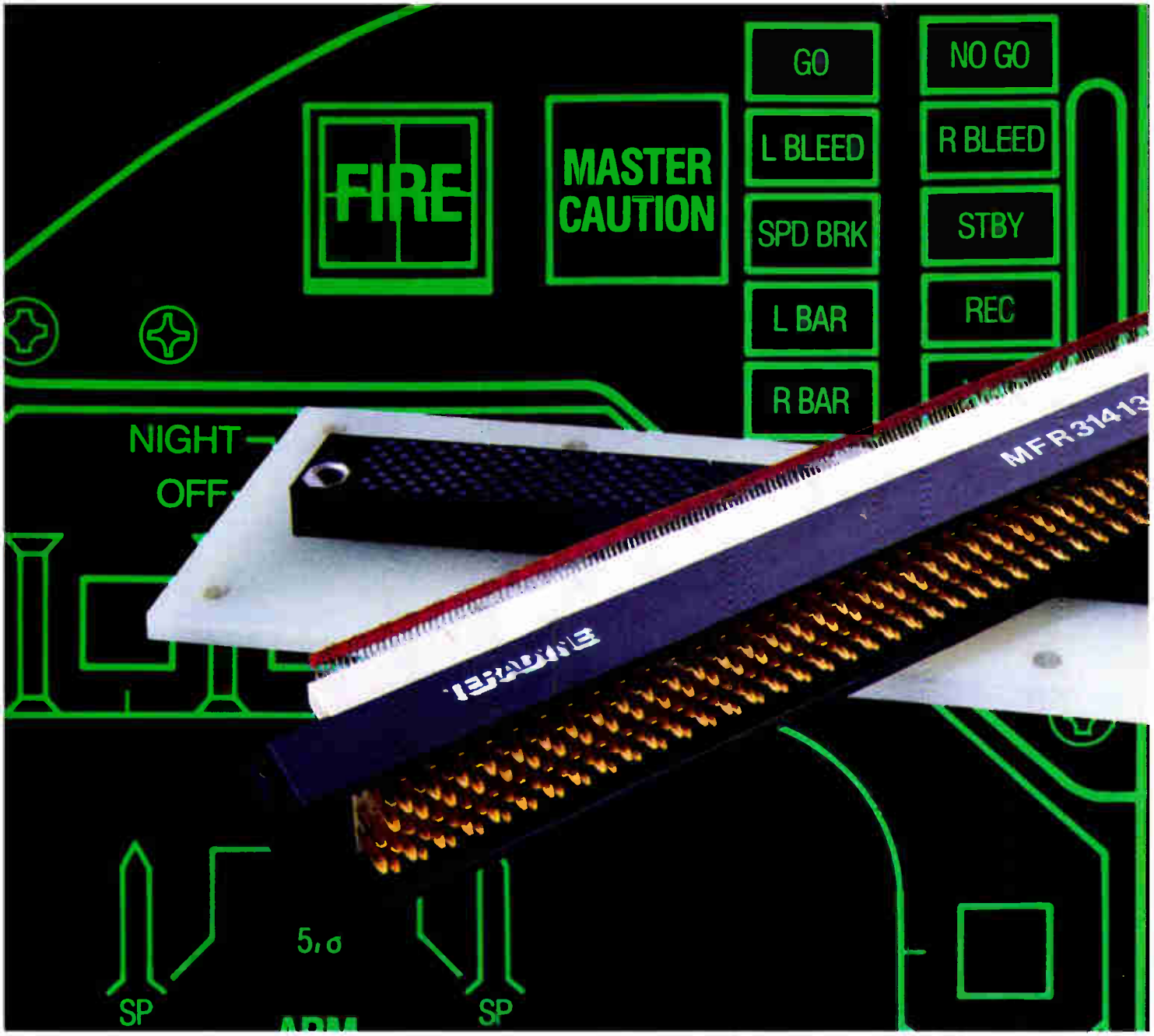
Billion-dollar struggle will pit technology against terror

PAGE 46

HOT SENSORS

Micromachined silicon makes a difference

PAGE 54



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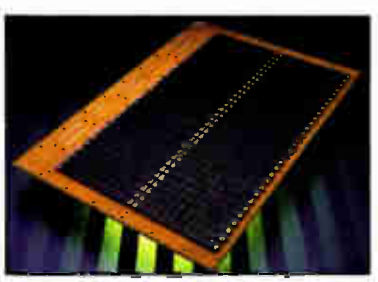

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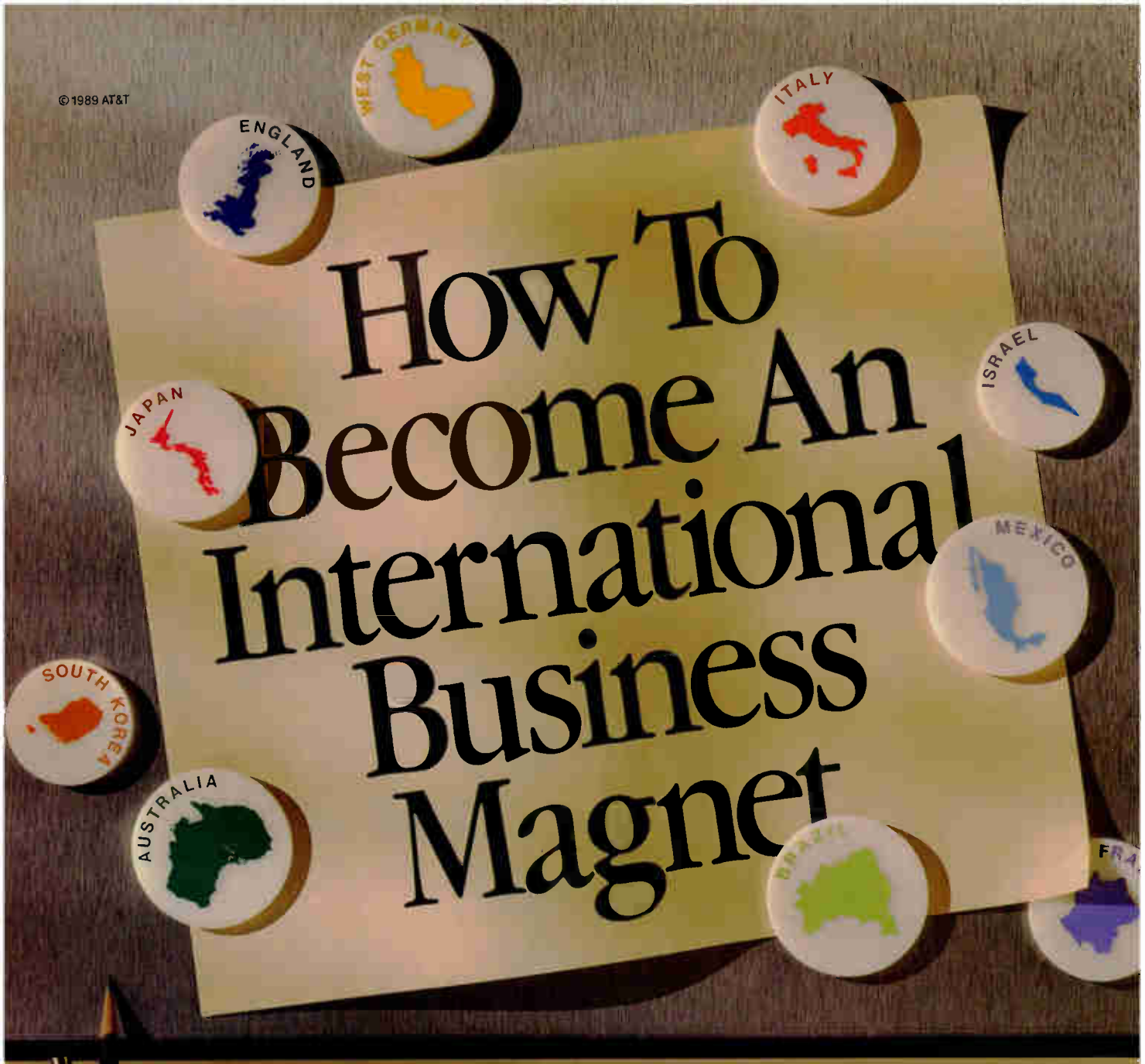

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I GAVE AT THE AIRPORT

Tighter security controls are a modern inevitability. Let's get the best that money can buy.

Anyone with half a brain can spend a futile lifetime pondering the paradoxes of an open society. Let's zoom right into a specific example: on a cost-benefit basis, the convenience we enjoy almost uniquely, here in the U. S., of being able to check baggage onto an airline flight from our cars at curbside is paid for by our knowledge that anybody, for whatever reason, has an excellent chance of planting a bomb on the same plane. Particularly if that person, for whatever reason, is willing to ride with it.

For most people, this stark fact moves into the forebrain only after such chances have been converted into headline-making disasters. However, after looking at our story on airport security in this issue (p. 46), you may come to agree with me—if you don't already—that the current price of curbside check-in is way too steep.

I don't want to hear that the exposure to random terror in all forms, calculated or demented, is some kind of irrevocable dues we pay for living in a modern, civilized, free society. Technology is what shapes the kinds of terror we are exposed to, and technology is certainly what can be applied to bring the costs of living with it into line. Texans say it best: "You got to dance with who brung you." As for the example at hand, I'm quite willing to get to the airport five minutes sooner and pay five bucks more for my ticket in return for the assurance that the bag I check at curbside will get a full zap of thermal neutron analysis. I've still got my freedom, convenience, *and* security, and I paid in full on the spot.

Compare a surcharge on that level to the Israeli paradigm (p. 49). El Al, Israel's national airline, has long since considered its specific odds as a target and simply refused to live with them. In return for defeating the threat manually, as it were, El Al charges passengers from two-and-a-half to three hours of their time on every flight—paid in the form of advance check-in. However willingly El Al's passengers have complied, this seems, again, a steep price. Unless, that is, one doesn't believe there can be alternative solutions.

This is a global business we're in, and many of us tend to live—we hope—on airplanes. The fecklessness of IBM Corp.'s advisory to its overseas-based employees to avoid U. S. carriers, following last December's Pan Am Flight 103 tragedy, is obvious: political terrorists make their own rules; all they have to do is announce that destinations, not national airlines, are their logical and true targets.

Thus, the international electronics community can serve itself, as well as the markets that support it, by aggressively pursuing partnerships that advance security systems worldwide. Today's developing market for detection, surveillance, and access-control systems does not begin and end, of course, at airports. Companies that can package transparent (to the ultimate beneficiary) solutions—the kind that do not affect a given society's perception of its just freedoms—will reap handsome rewards.

ROBIN NELSON

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JULY 1989

Electronics

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FEATURES

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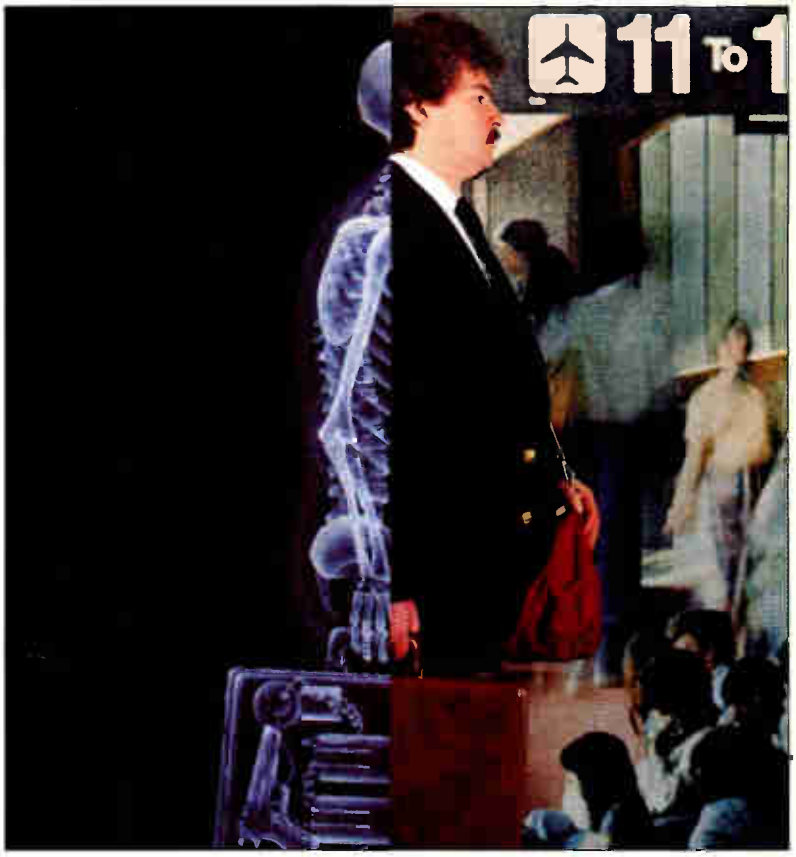

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WORLDWIDE NEWS ANALYSIS

Probing the News

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DEPARTMENTS

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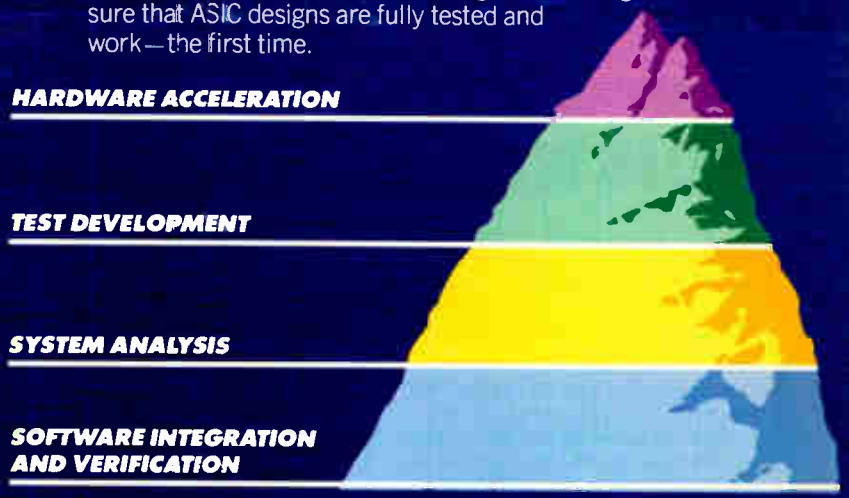

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LETTER FROM LEIPZIG

EAST GERMANS SHOW OFF THEIR HIGH-TECH MUSCLE

LEIPZIG, EAST GERMANY

With its medieval buildings, Leipzig is an archetypal German town, the place where Bach composed his finest choral works and Goethe wrote his early verses. But commerce too has always played a role in Leipzig's history. The famed Leipzig Fair began more than 800 years ago, in 1165. Where once spices, grain, and cloth captured traders' attention, high technology creates the excitement today.

Leipzig, a metropolis with more than 600,000 people, stages its fair twice a year, with the March event emphasizing electronics. The largest fair in Eastern Europe, last spring's week-long event drew some 9,000 exhibitors and a half-million visitors to the city's sprawling fairgrounds. The fair brings together companies, visitors, and products from East and West, and here Western visitors can get a good fix on the output and sophistication of Eastern Europe's electronics industries.

As for host East Germany, the fair reflects the electronics industry's increasingly important role. As in most Western countries, electronics is a pace-setting industry, generally scoring higher growth than the average 4% rise in gross national product in recent years. Though official figures on production are hard to come by, it appears that East German electronics equipment and components output were worth $16 billion to $19 billion last year.

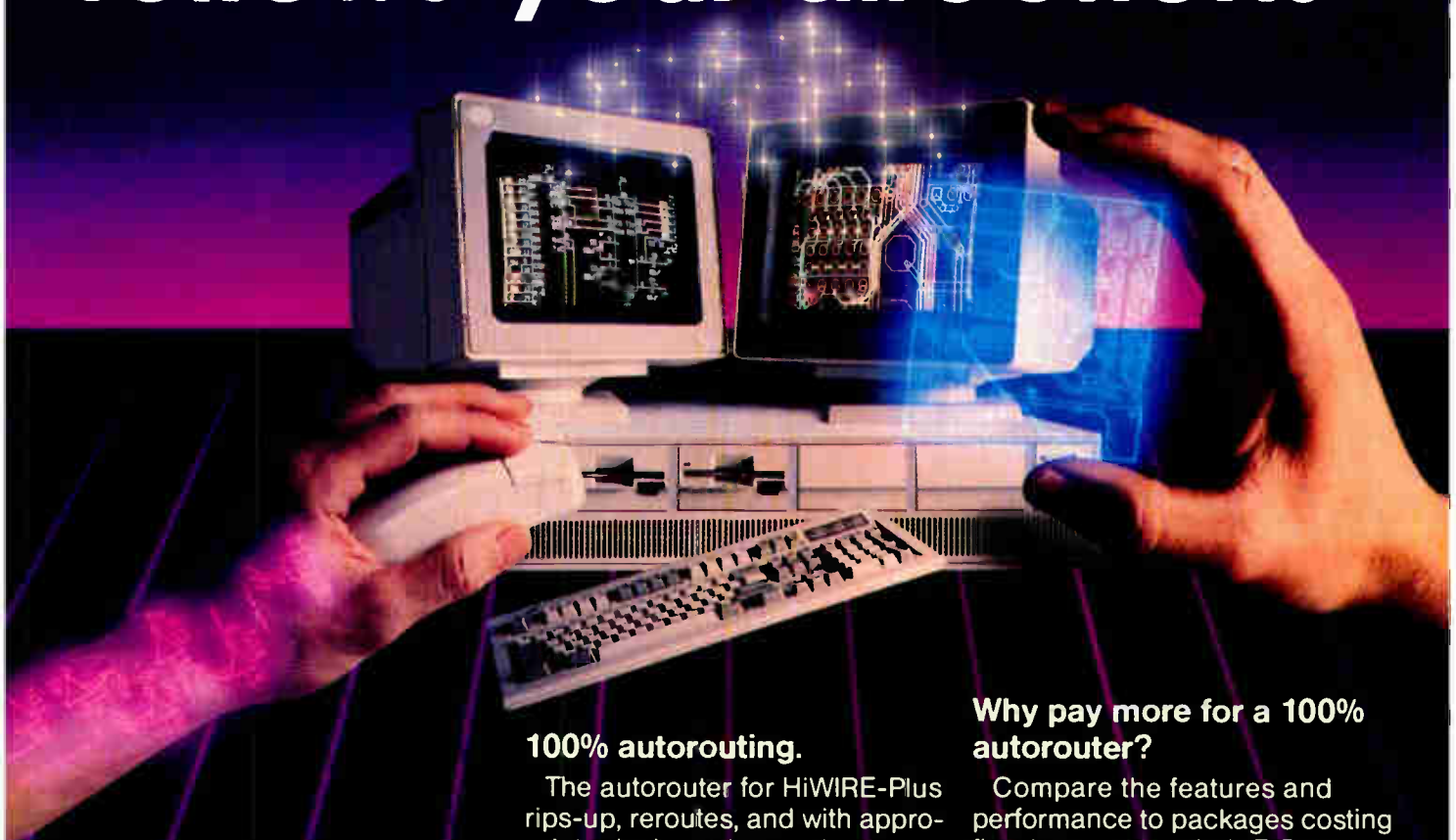
Microelectronics in particular is getting top attention, as witnessed by the East Berlin government earmarking about $7.6 billion for this industry over the past several years. Backing the effort is no less a political figure than Erich Honecker, head of East Germany's Communist Party. Under Honecker's directives, the party's Central Committee decided in 1976 to launch a massive microelectronics research and development program.

Although the results of East Germany's efforts don't match those of the West, they are impressive, particularly because the nation has no access to U. S. or Japanese technology. Testifying to its success are a handful of star products: 1-Mbit dynamic random-access memories using 1.0-μm CMOS, 16-bit microprocessors running 2 million instructions/s, and gate arrays with up to 100,000 transistor functions. Such products demonstrate the industry's engineering know-how and hint at the country's technological standing in the Soviet bloc. East German industry leaders don't like to draw comparisons with their Warsaw Pact partners, but Western analysts believe that in many sectors the nation is ahead of the USSR.

Electronics production in East Germany is done mainly at state-owned enterprises, so-called Kombinate, or combines, each concentrating on a specific sector—communications, production equipment, components, consumer, and so on. A typical example is the Kombinat Nachrichtenelektronik, which lumps virtually all East German activities in communications into

Leipzig's Old Town Hall, built in the fourteenth century, embodies the city's rich past; the tower of the newly built Karl Marx University symbolizes East Germany's hopes for a high-tech future.

At last, an assistant that follows your directions



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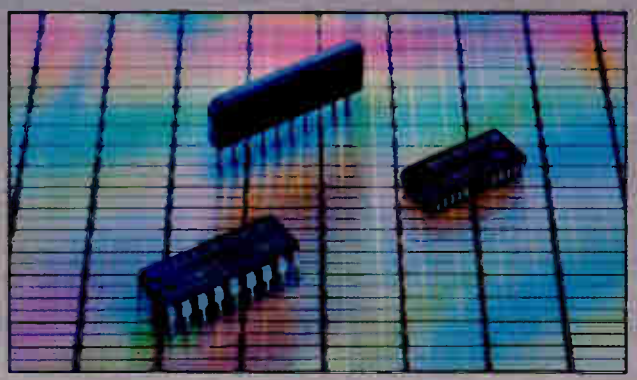

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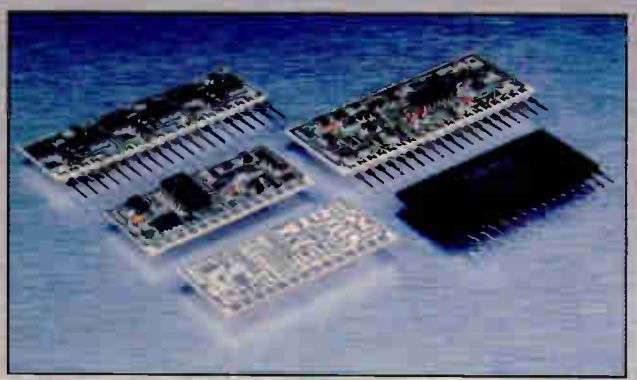

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Circle 4

an organization comprising 18 production centers and one research institute. The Berlin-based combine employs about 37,000 people and scored sales of around $2 billion last year. Roughly 40% of the output goes abroad, with the Soviet Union taking almost two-thirds of that.

Among the heaviest contributors to East Germany's electronics output is the Kombinat Robotron. The Dresden-based combine employs 69,000 workers in 21 production centers, one software institute, an export-import organization, and a number of support facilities. Sales last year came to $6.1 billion.

Among Robotron's top products is a 32-bit engineering work station, the K1840. Representing designs on a monitor in three dimensions, it is intended for computer-aided design and manufacturing, as well as for simulating complex processes and solving scientific and technical problems. For now, the machine is not for export. East Germany's 1986 to 1990 economic plan calls for the production of 85,000 to 90,000 CAD/CAM systems.

Robotron is probably the Eastern bloc's only enterprise with sizable activity in personal computers. Of note are the 8-bit, 256-Kbyte Model 1715 and the 16-bit Model 7150, whose memory can be expanded to 768 Kbytes. Both systems include two slim-line 5.25-in. disk drives. The economic plan for 1986 to 1990 calls for 160,000 to 170,000 office and personal computers. Last year, Robotron turned out 57,000 of these machines. More than two-thirds of Robotron's products and services are sold in over 60 countries, with the Soviet Union taking 70%.

WEAK SPOTS. East Germany still has a way to go before it rates as a weighty contender on world markets. Its weak spots, Western analysts say, are low productivity, slow transfer of products from design to fabrication, and a quality standard that leaves much to be desired. "Long-term supply contracts with Eastern-bloc and Third World countries aren't helping the industry become more competitive," says an executive at a West German firm, noting that such countries put lower demands on equipment performance than do those in the West.

But things are beginning to change as top executives in East German electronics realize that a move to world markets is a must. The first steps have already been taken. The industry has struck cooperative deals with companies in Greece and Belgium and has made first contacts with West Germany's Siemens AG, the Swedish/Swiss Asea Brown Boveri group, and other Western European companies about joint projects in third countries. Says the West German executive, "If East Germany's electronics industry can provide quality and proves to be a reliable and on-time parts supplier, it will be an interesting partner." *–John Gosch*

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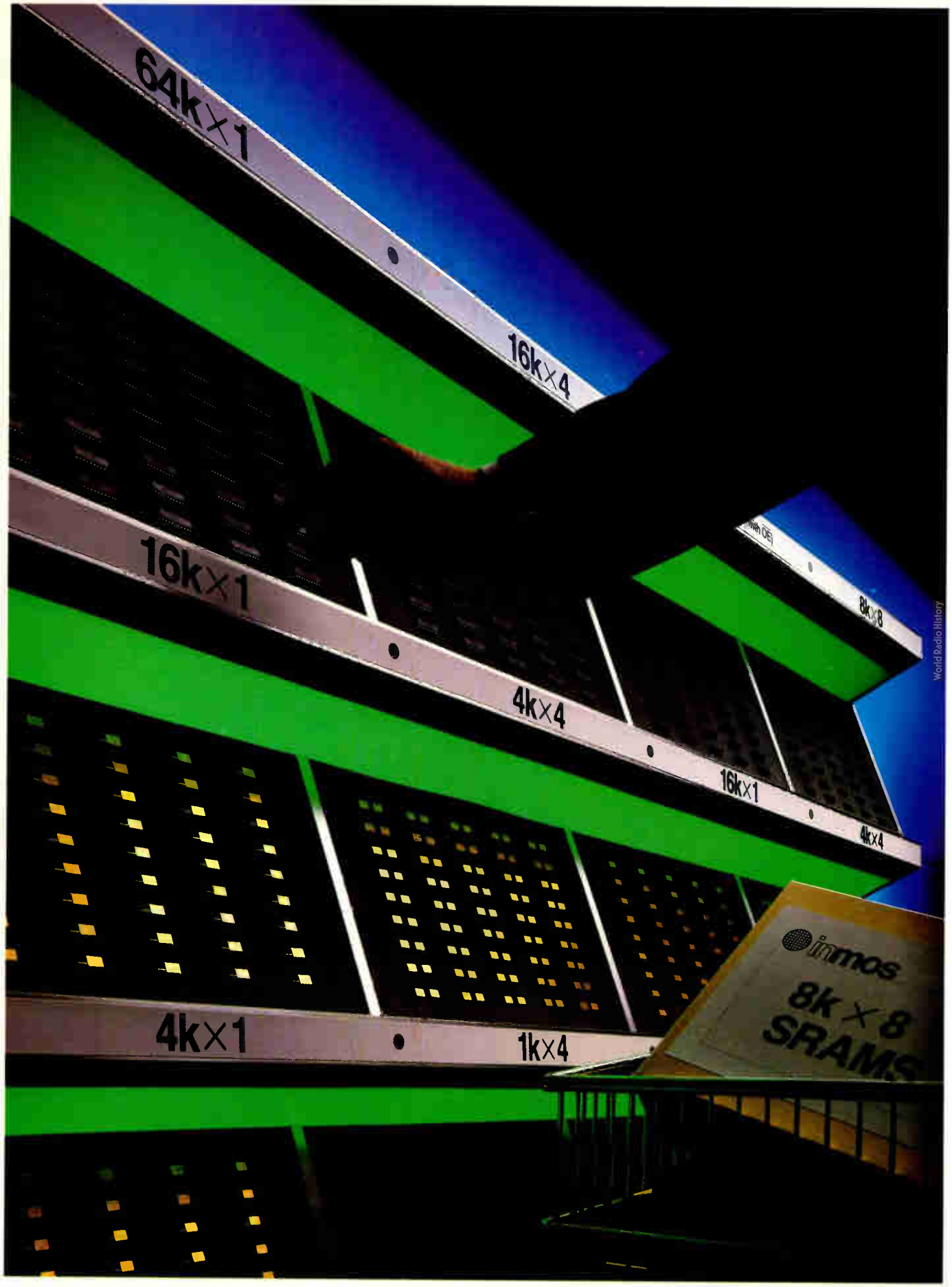

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				IMS 1600M	45,55,70
1K×4	IMS 1223	20,25,35,45		IMS1601LM	45,55,70
	IMS 1223M	25,35,45			
			16K×4	IMS 1620	25,30,35,45,55
16K×1	IMS 1403	25,35,45,55		IMS 1620M	45,55,70
	IMS 1403M	35,45,55		IMS 1620LM	45,55,70
	IMS 1403LM	35,45,55			
	IMS 1400M	45,55,70		IMS 1624	25,30,35,45,55
				IMS 1624M	45,55,70
4K×4	IMS 1423	25,35,45,55		IMS 1624LM	45,55,70
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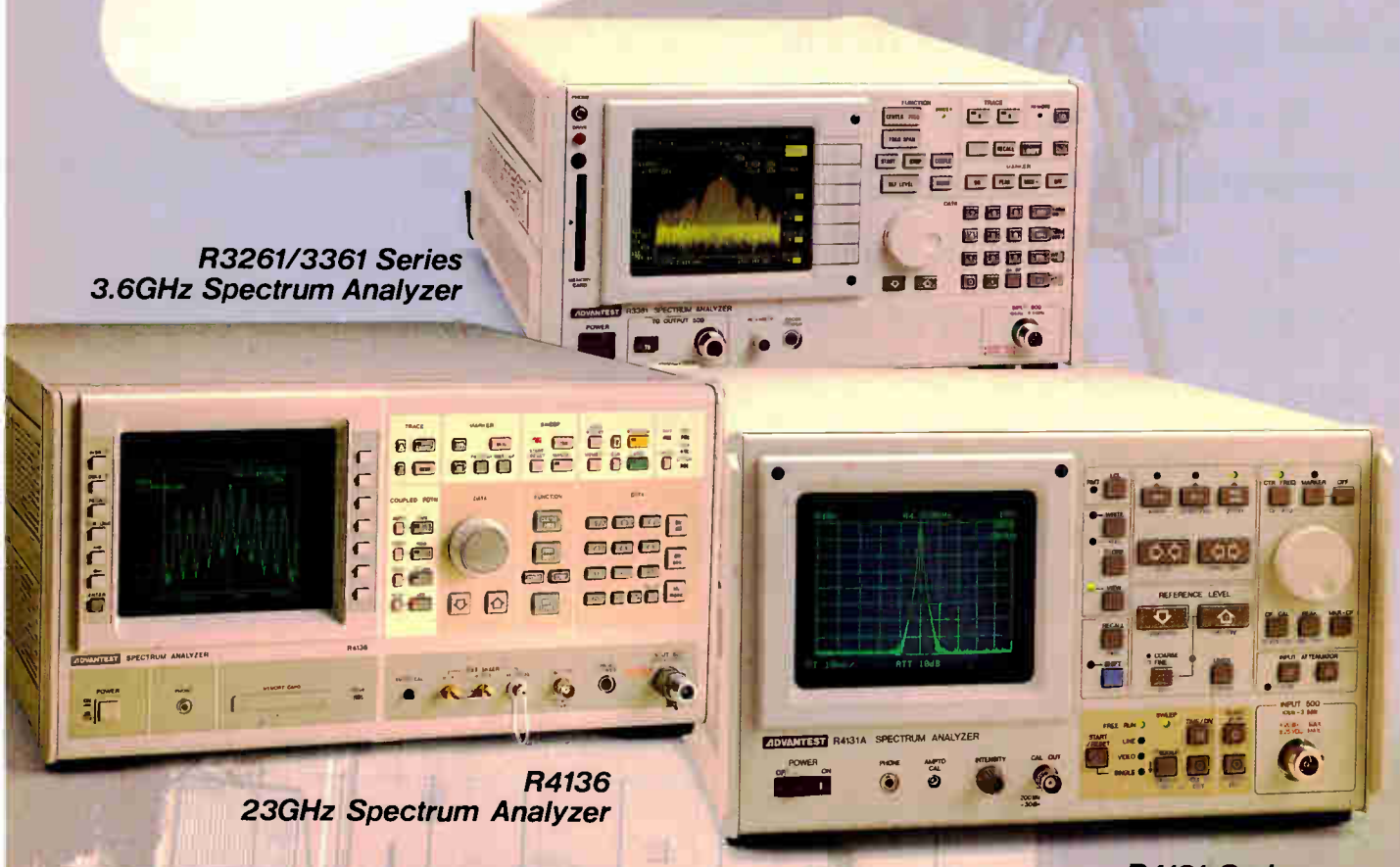

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ELECTRONICS NEWSLETTER

IBM'S 486-BASED ENTRY: SPEED, POWER—AND A FEW QUESTIONS

The price is right and the approach makes sense. That's one conservative assessment of IBM Corp.'s new Power Platform, the Intel 80486-based add-in that can turn the PS/2 Model 70-A21 personal computer into a computing engine, CAD/CAM system, or desktop-publishing system of awesome speed and power—up to twice as fast as a 33-MHz 386 system, says IBM. With the price of the Model 70-A21 pared by $2,300, to $8,995, a power user with $15,000 or so to spend who can wait until deliveries start in the fourth quarter could get the whole multimedia feast—the first 486-based PC with Micro Channel ($3,995 extra for the 486 card) plus the new Audio Visual Connection ($495)—and have about $1,500 left for software. However, that's one of the drawbacks: there isn't much software available for the new system. Also, the Model 70's slow drives leave the user a little strapped for I/O, and it has only three slots available for add-in cards, making it difficult to use as a file server. Then there's another question: will the Power Platform be able to accept IBM's 4-Mbit DRAM when that next-generation dynamic random-access memory is available? □

SEAGATE AND IMPRIMIS: OIL AND WATER THAT COULD MIX

Mixing oil and water—that's how one analyst characterizes the proposed sale of Imprimis Technology Inc. to Seagate Technology Inc. James Porter, president of Disk/Trend Inc. of Mountain View, Calif., notes that the two companies have different corporate cultures: Seagate, based in Scotts Valley, Calif., is primarily a manufacturing-driven company closely controlled by top management, while Imprimis, a subsidiary of Control Data Corp. in Minneapolis, is more marketing driven and technology oriented, and encourages participatory management. Nevertheless, Porter thinks the $450 million deal could work. He notes that there is little or no product overlap, except in one 80-Mbyte 5.25-in. product—which will help when the Justice Department examines the accord for possible antitrust violations. Phil Devin, senior market analyst at Dataquest Inc. of San Jose, Calif., adds that Seagate does 80% of its business in the personal computer aftermarket and needs to regain a presence in the original-equipment-manufacturer market, where Imprimis does 80% of its business. Seagate's expertise in high-volume manufacturing could also help Imprimis, and Imprimis's ability to build drives with high areal storage density could help Seagate gain some presence in the high-performance, high-density 3.5-in. market—where, Devin adds, Seagate has nothing but Imprimis has a complete line. □

IS THE TRADE DEFICIT WITH JAPAN IMPROVING?

The U. S. is chipping away at its electronics trade deficit with Japan, but it still has a long way to go. The deficit declined by 4.4% in the first quarter of 1989, says the American Electronics Association, with U. S. exports to Japan rising 33.5%, to $1.8 billion. That shrunk the deficit to a still substantial $4.58 billion, from the $4.79 billion total in the first quarter of 1988. Though the results are promising, "we would like to see at least three consecutive quarters of improved trade balances . . . before we feel even marginally comfortable," says J. Richard Iverson, AEA president. Japanese exports to the U. S. increased nearly 4% during the same period, to $6.4 billion, the AEA says. On another front, the Semiconductor Industry Association reports that Japanese chip imports have increased only 0.5% over the past year, a rise it considers "not significant." The group is talking with the Electronics Industry Association of Japan about stepping up Japanese IC imports in consumer and automotive electronics and ensuring foreign participation in Japanese high-definition TV. □

ELECTRONICS NEWSLETTER

A SHAKEOUT BEGINS IN THE GaAs MATERIALS BUSINESS...

Gallium arsenide was supposed to have been the hottest technology around by the end of the 1980s. But although there have been a few notable success stories [*Electronics*, June 1989, p. 140], there have also been some failures, and several companies have gone out of business altogether (see p. 102). Now the troubles have spread to the suppliers of raw gallium and GaAs wafers. Alcan Electronic Materials of Montreal was the first to give up: last month it agreed to sell its gallium metal business to French materials giant Rhone-Poulenc Chimie. And Morgan Semiconductor of Garland, Texas, a large producer of GaAs wafers, is shutting down its crystal growth plant, though it will continue to market epitaxially grown GaAs. "The total marketplace just isn't expanding," says Mike Ehmann, Morgan's president. "In 1984–85, the forecasts for 1989–90 were for a GaAs wafer market of 10 million in.^{2}—but today it's barely one-fifth of that." Ehmann says that materials suppliers are likely to go the way of their customers: if the customer stays healthy, so will the supplier. In Morgan's case, all its major customers failed at once: U. S. companies Gain Electronics Inc. and Microwave Semiconductor Corp. both went out of business, and in the UK, Plessey Co. plc closed its GaAs IC foundry and General Electric Co. cut back production. □

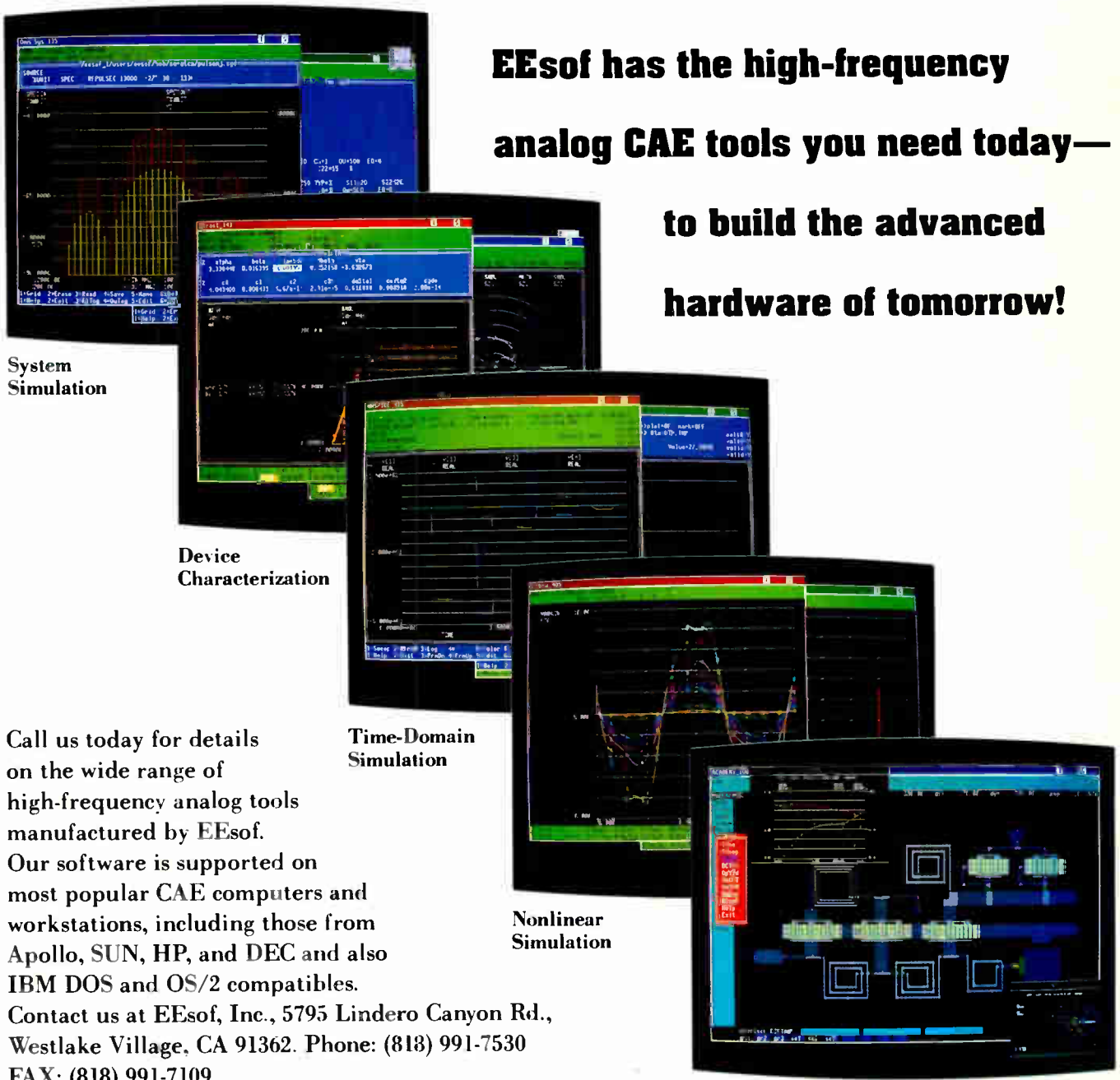
...BUT SOME VENDORS JUST SHRUG IT OFF

The eroding GaAs materials supplier base "is the beginning of the shakeout," says Karl Lifschitz, president of GFI Advanced Technologies Inc., a New York-based supplier of semiconductor-grade gallium. He and other industry insiders say more closings will come, as smaller companies are forced to lower prices to survive. But not everyone is convinced that the shakeout will make a difference to the industry in the long run. "Our business is doing very well," says a spokesman at the New York offices of West Germany's Wacker Siltronic Corp., a top GaAs materials vendor. "No one is going to miss those other guys." GaAs chip makers also say they're not concerned. "That's one part of the business we don't have to worry about," says Ron Rosenzweig, president of Anadigics Inc., a GaAs chip maker in Warren, N. J.; even with the closings, sufficient materials sources remain. □

FOUR PI WORKS A SWEET DISTRIBUTION DEAL

Once upon a time, a brash U. S. startup set out to make a deal with a giant Japanese company without giving away the store: the Americans would get money and the foreign company would get product but no technology. Lo and behold, the Americans made the deal and as a result expect to live happily ever after. If this sounds like a fairy tale, it isn't. It's actually the outline of an agreement between Four Pi Systems Corp. of San Diego and Konematsu Electronics Ltd., a subsidiary of the trading company Konematsu Gosho. Four Pi Systems is the developer of the 3DX Series 2000 inspection and process-control system for solder connections on printed-wiring-board assemblies. The deal provides that for a $2 million fee plus a $2 million stocking order, the Tokyo company gets distribution rights to process-control products based on Four Pi Systems' technology. Konematsu is permitted to use the technology to develop new products—but any resulting patents would belong to Four Pi Systems, and Konematsu would even have to buy the machines from the U. S. company. Why would Konematsu agree to such terms? "Because it wants a leg up in a new product area—automated process inspection," which is replacing automated test equipment, says Michael A. Thiemann, vice president of Four Pi Systems. "In-circuit testers can't isolate components anymore, and functional testers, although they do an adequate job as go/no-go testers, have trouble finding faults." □

Analog CAE Solutions— from picoseconds to GHz



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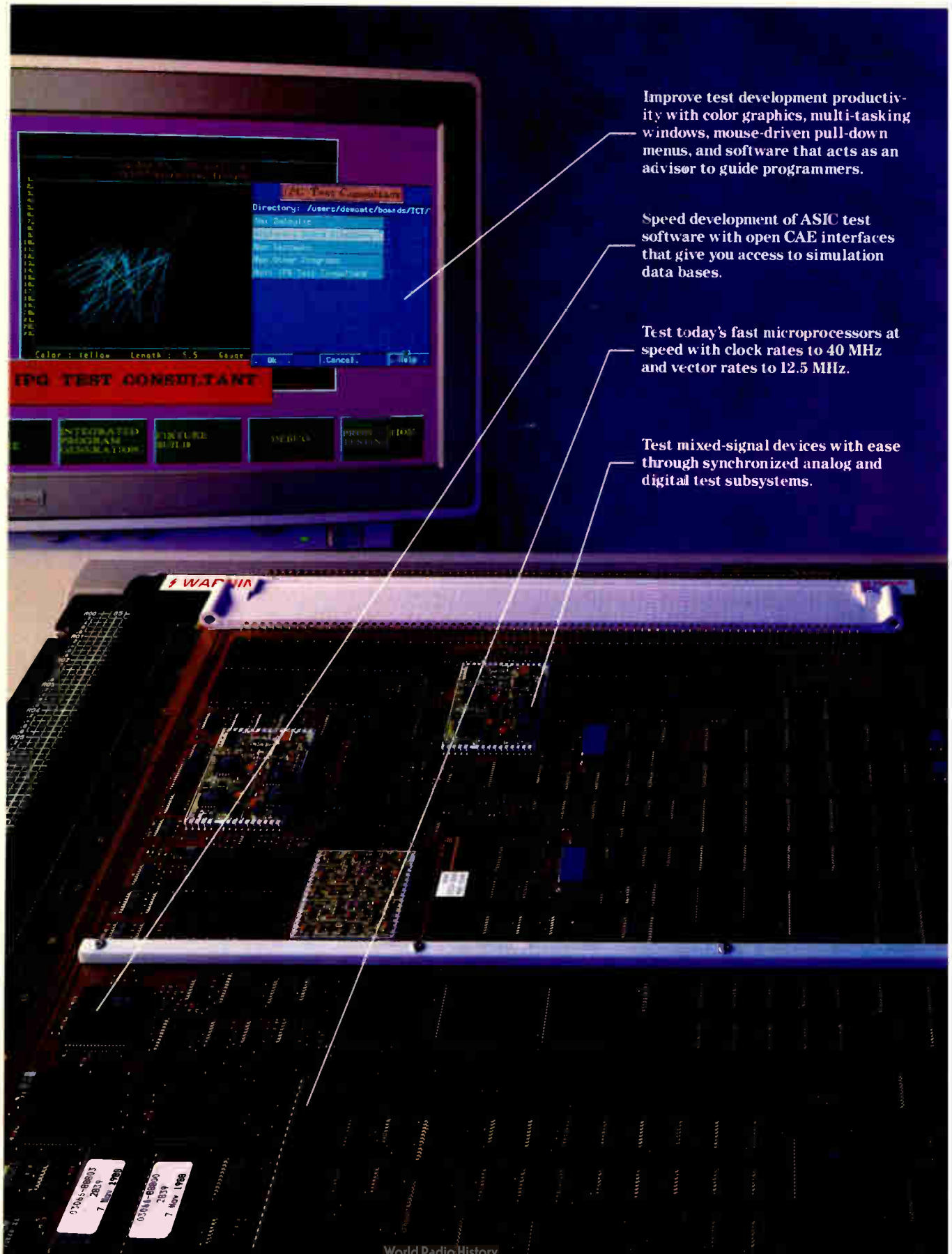
Digital, analog, in-circuit, functional...



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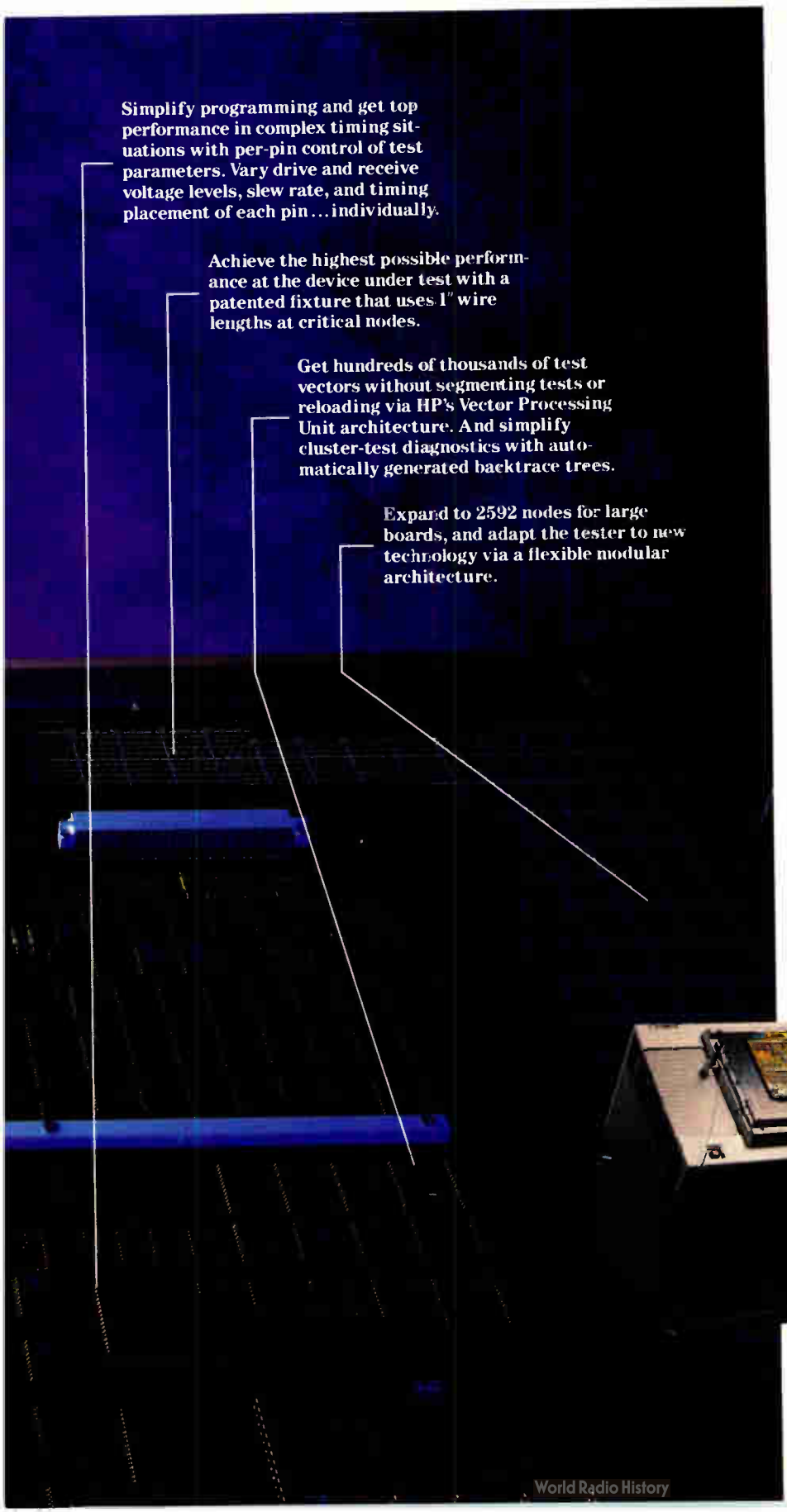

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Equipment summary

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Discharge resister	150Ω ±5%
Charging resister	100MΩ ±10%
Rise time of the discharge current	5ns ±30% at 4kV
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Circle 54

PRODUCTS TO WATCH

TOSHIBA-SIEMENS COMBO ATTACKS ITS GATE-ARRAY COMPETITION ON TWO FRONTS

By using a jointly developed 1.0-μm CMOS process, the team of Toshiba Ltd. and Siemens AG is turning up the heat on both the marketing and technology sides of the hotly contested gate-array business. On the marketing end, Munich-based Siemens has become a worldwide source for Toshiba's family of arrays that offer from 3,000 to 172,000 raw gates and boast unloaded gate delays as fast as 400 ps. Since Siemens is fabricating Toshiba's TC110G, 120G, and 140G double-level-metal arrays using the same CMOS process, both companies can offer identical simulation models. On the technology front, Tokyo-based Toshiba is getting ready to sample its TC150G series, which adds a third level of metal interconnection to the fabrication process and jumps the number of usable gates by 70% compared with the 140G series. Siemens will also market the 150G family of arrays. □

TADPOLE'S 88000-BASED BOARD COMPUTER HITS 120 MIPS

Tadpole Technology Inc.'s VMEbus board-level computer based on the Motorola 88000 microprocessor delivers up to 120 million instructions/s—twice the processing power of Motorola Inc.'s own MVME188 multiboard computer. Design techniques developed by the Waltham, Mass., company allow the TP188V to carry as many as eight 88100 reduced-instruction-set microprocessors per board, which is double the density Motorola obtains. Tadpole gets its 120-mips performance peak for a two-to-four-board Tadpole set, against Motorola's 60 mips for a three-to-six-board implementation. Both firms' boards are the first examples of RISC-based multiprocessor engines for VMEbus computers. Prices for the Tadpole boards will range from about $9,760 to $24,000; the hardware will be available in the fourth quarter. □

SIERRA SEMICONDUCTOR'S MODEM TURNS PCs INTO FAX MACHINES, TOO

Modem manufacturers can now build send-only facsimile capability into their 2,400-bit/s board- and box-level products for about $40 more than they have been paying for the modem chip alone. Sierra Semiconductor Corp.'s SC11046 modem IC integrates the features of a 4,800-bit/s Group 3 fax into a standards-based 2,400-bit/s modem. The San Jose, Calif., company says its CMOS chip is the first to incorporate these capabilities. Used with an external controller, such as Sierra's SC11011, the modem offers Hayes-compatible, full-duplex transmission that meets the CCITT V.22bis standard. The controller performs all modem control functions, including Sendfax call establishment, in accordance with the standard T.30 recommendation for facsimile transmission. The chip set, which includes the controller IC, sells for $84 in a DIP and $85.40 in a PLCC package. Pricing on both is for quantities of 100 or more. □

WANDEL & GOLTERMANN NETWORK SOFTWARE HANDLES REMOTE SITES, IBM'S NETVIEW

Unstaffed remote facilities can now be accessed for monitoring and testing with the DNE-2100 data-network diagnostics system from Wandel & Goltermann GmbH. Besides remote diagnostics, the West German company's SEP-120 network-management software bolsters the system's multivendor connectivity with an interface to IBM Corp.'s NetView network-management system. The IBM interface means that faulty network components can be restored automatically using NetView after alerts are received from DNE-2100 or any data-network diagnostics system. The SEP-120 software also features multiline switching, analog and digital patching facilities, transparency to network protocols, and the ability to store an unlimited number of network configurations. Pricing depends on the importing country. □

PRODUCTS TO WATCH

MICRON TECHNOLOGY'S SRAMs ELIMINATE WAIT STATES IN 386 SYSTEMS

Micron Technology has jumped into the hot market for microprocessor-specific cache memories with a static RAM just for Intel Corp.'s 82385 cache controller and 80386 microprocessor. The Boise, Idaho, company's MT56C0816 sports a 25-ns access time that lets it keep up with 33-MHz processor clock rates without wait states. The cache data RAM can be configured as a single 8K-by-16 or as two 4K-by-16 arrays for use in either direct-mapped or two-way set-associative modes. Micron joins companies such as Chips and Technologies, Cypress Semiconductor, Integrated Device Technology, Mosel, Texas Instruments, and Vitelic in the rush to provide cache RAM chips to designers of high-end personal computers and low-end work stations that are built around the 386. □

WELLFLEET'S NETWORK SOFTWARE TUNES IN TO THE SNMP STANDARD

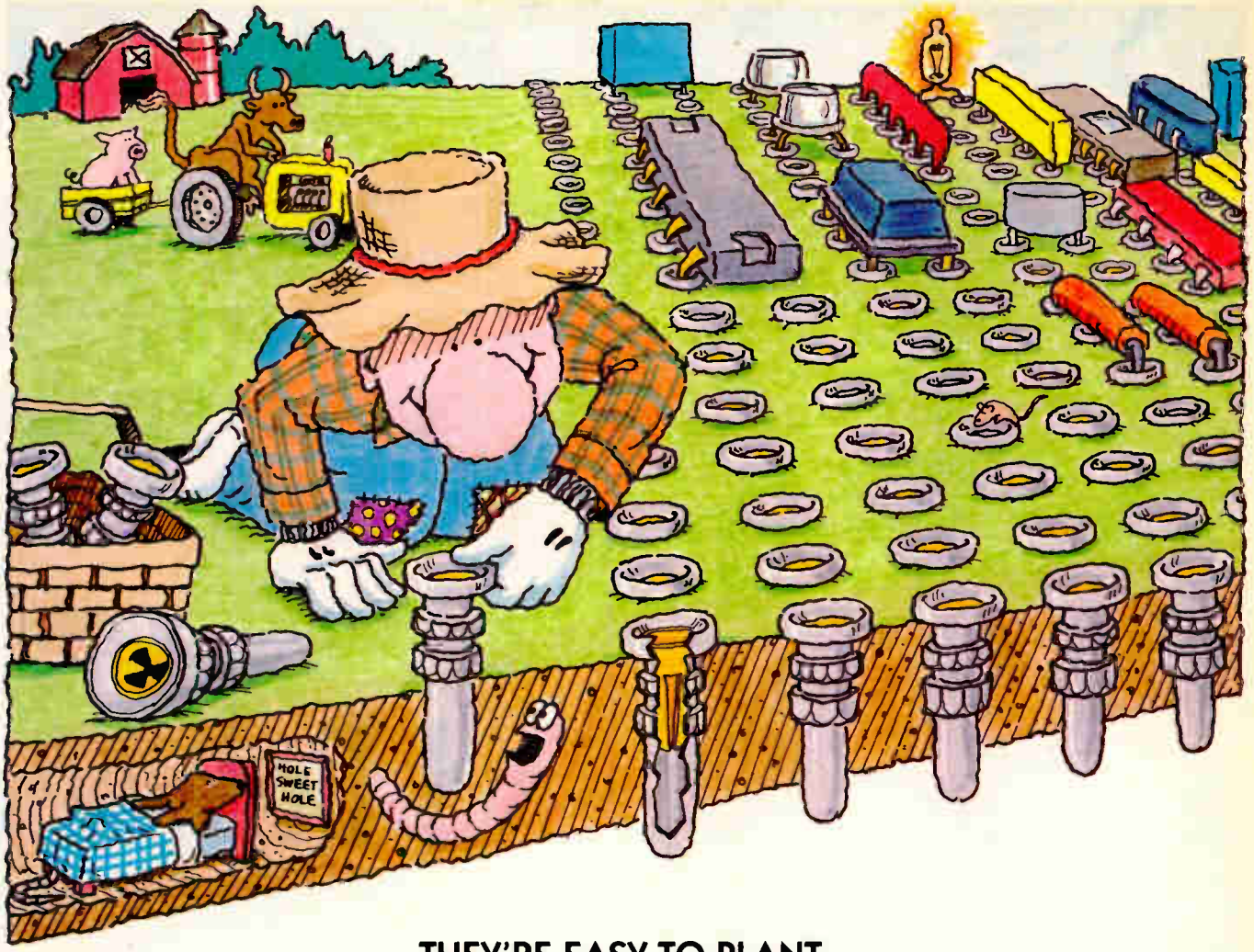
Using the Simple Network Management Protocol, Wellfleet Communications Inc.'s latest network-management software provides real-time diagnostics, fault management, and performance monitoring for linked networks that use such protocols as DECnet, XNS, MAC-Layer Learning Bridge, and X.25. The Bedford, Mass., company's SNMP-NMS runs on Sun Microsystems Inc.'s 3/50 and 3/60 work stations using Sun's OS 3.5 or 4.0 operating system and the X Window System, version 11. It provides instant visibility into internetworks composed of Wellfleet bridges and routers and the local- and wide-area networks they connect. Visible and audible alarms alert network managers to failed nodes. The network-management software sells for $15,000 and is available now. □

RAYTHEON'S ANALOG ARRAYS DELIVER LOW POWER AT BIPOLAR SPEEDS

Look for Raytheon Corp. to field a low-power macrocell array this month that complements its RLA family of bipolar linear arrays by combining the best characteristics of bipolar and CMOS analog arrays. The RFA120 achieves its performance by placing a monolithic array of JFET bipolar input operational amplifier macrocells next to uncommitted thin-film resistor networks and auxiliary bipolar transistors. The array can be configured for FET input amplifier characteristics, for isolated analog switches, or as an eight-channel multiplexer. The company's Mountain View, Calif.-based Semiconductor Division claims that in FET input applications, the macrocells' 200-pA bias currents are a 100-fold improvement over bipolar macrocells. The arrays also boast 18 V/μs slew rates—a threefold to fourfold improvement—and 10-GΩ input impedances, a 10,000-fold improvement. Nonrecurring engineering charges start at $21,000. In quantities of 1,000, the arrays sell for $5.75 each. □

INTEL'S 32-BIT EISA CHIP SET BOLSTERS PC AT ARCHITECTURE

Cloners of MS-DOS personal computers have a powerful weapon to combat market incursions from IBM Corp.'s PS/2 family of 32-bit PCs. Intel Corp. provides the ammunition with the first chip set implementing Extended Industry Standard Architecture (EISA), a 32-bit extension of the PC AT's 16-bit architecture. Available now in sample quantities, the EISA chip set includes the 82352 bus buffer, the 82355 bus-master interface controller, the 82357 integrated system peripheral, and the 82358 bus controller. The combination interfaces the current 8- and 16-bit PC AT bus with the 32-bit EISA bus and the host CPU bus, either a 386 or a 486. The chip set allows direct-memory-access transfer rates of 33 Mbytes/s—eight times faster than the PC AT bus. In 1,000-unit quantities, the 82352 is $18.75 each, the 82355 is $35, the 82357 is $99, and the 82358 is $120. □



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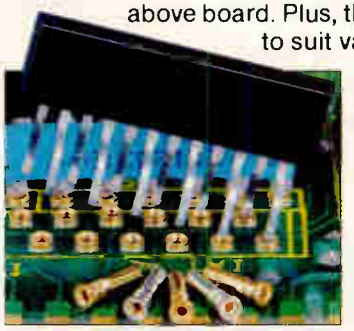

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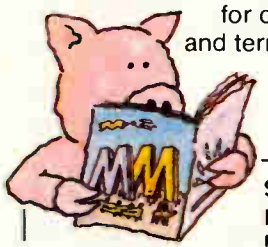

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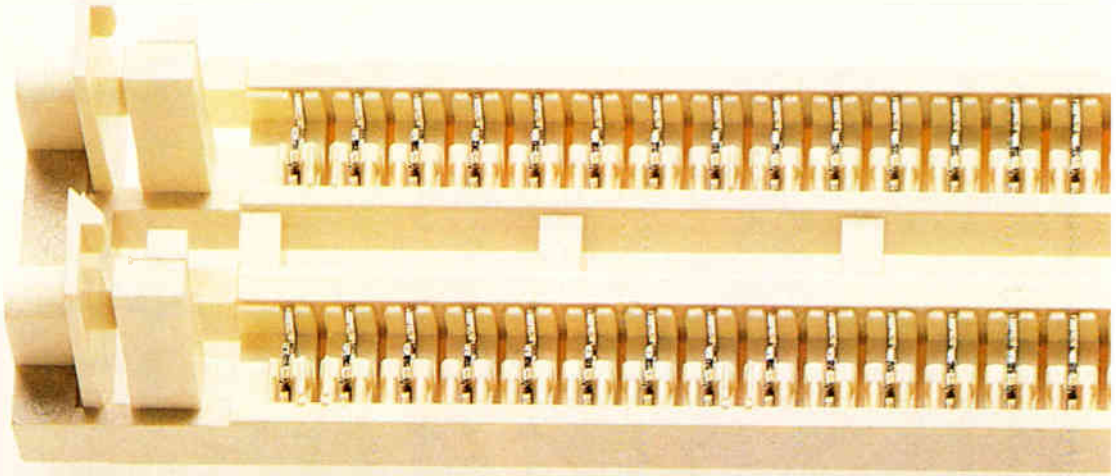

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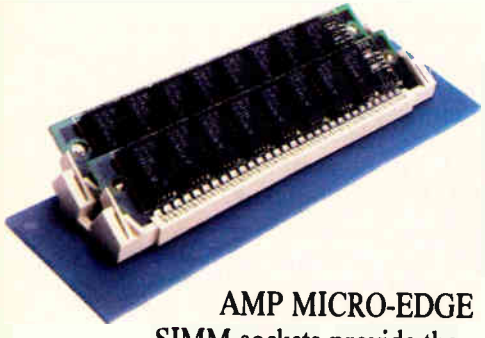

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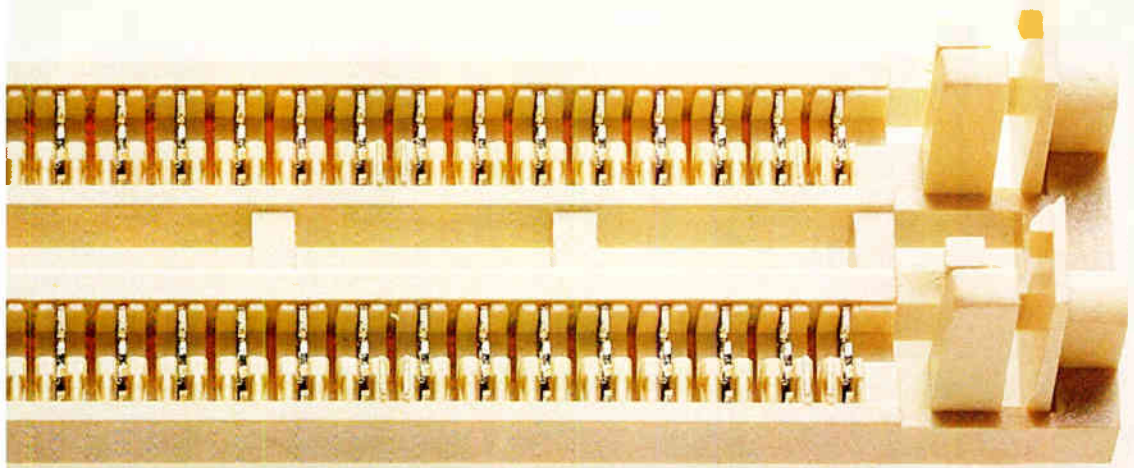

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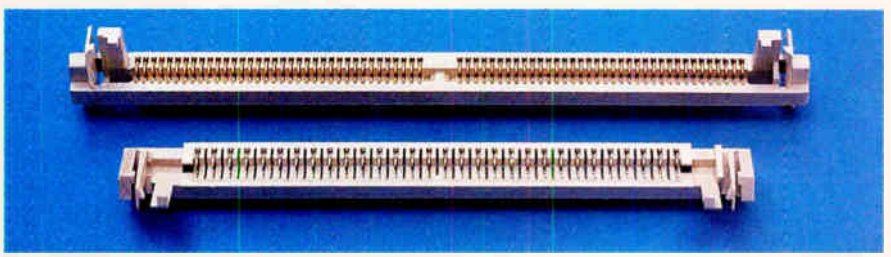

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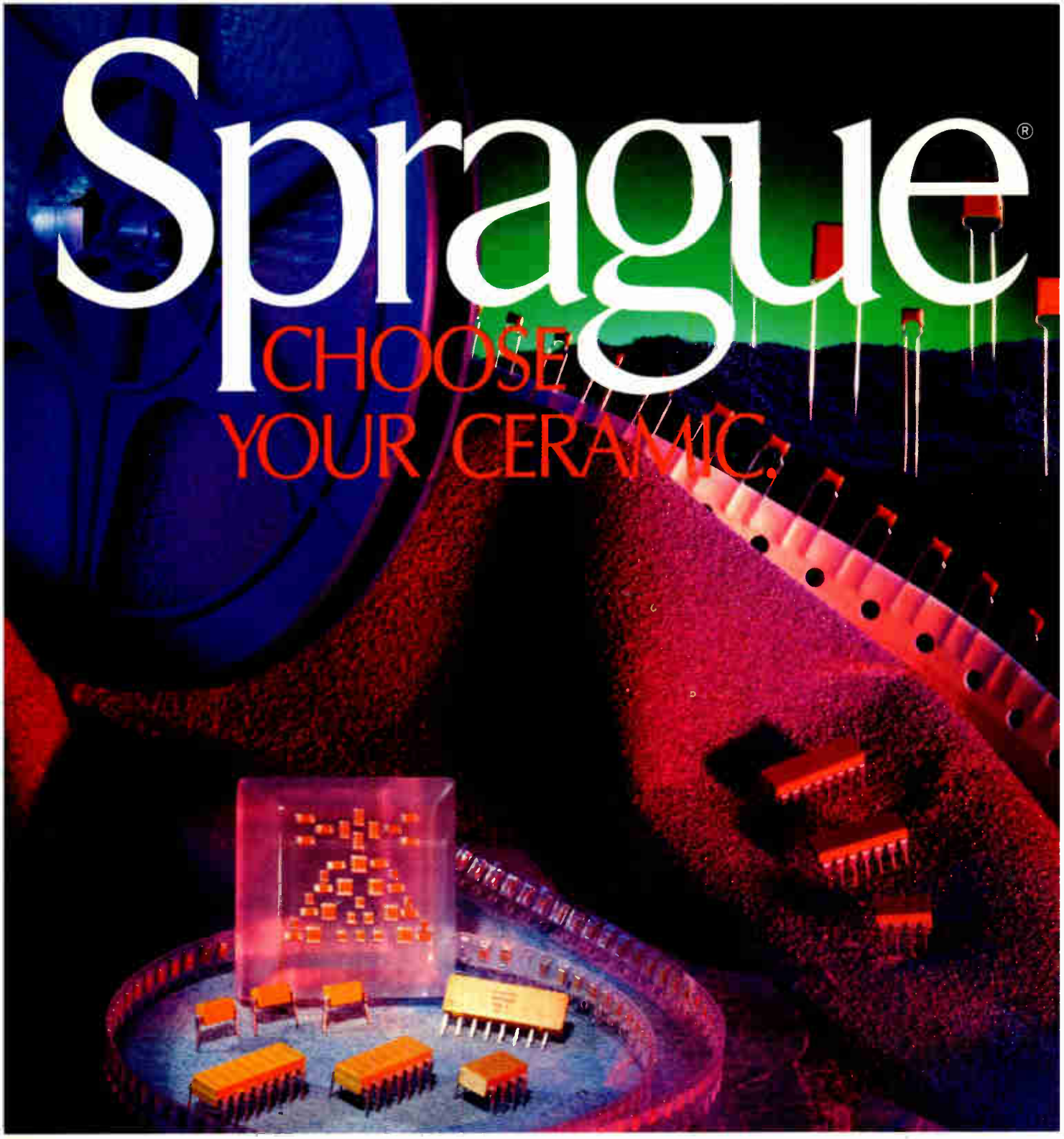

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SPRAGUE

Electronics

UK AND WEST GERMANY LOCK HORNS OVER MULTINATIONAL RADAR PROJECT

Ferranti and AEG are wrangling over a system for the EFA fighter plane

LONDON

It's been a frustrating two years, and the wait still isn't over for two teams of European radar manufacturers bidding to supply the pulse-doppler target-acquisition and tracking system for the advanced European fighter aircraft (EFA). The project continues to be plagued by international wrangling over who will make the radar that will fit in the aircraft's nose, a contract worth billions.

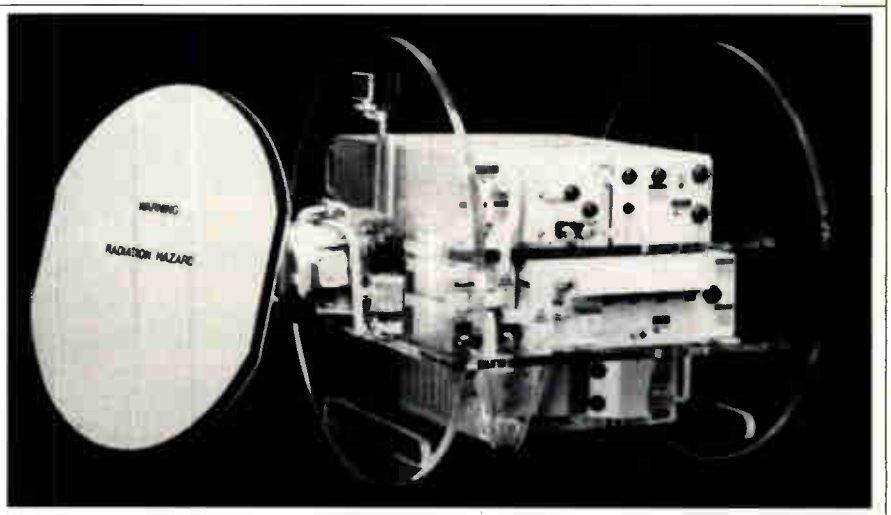
A four-nation effort, the EFA is due to enter service in the mid-1990s to replace aging Phantom interceptors and Jaguar ground-attack planes. The radar-system decision was supposed to have been made early in 1988, but delays kept pushing it back. The choice was finally expected this month, but that now seems unlikely as the two competing teams are cutting prices and evaluating fallback options.

"Two years ago we were on the critical path for the project," says Tony Scott, director of airborne radar for GEC-Marconi Defence Systems Ltd. of Borehamwood, UK, a member of one of the contractor teams. "Now, nearly two years have been lost waiting for the decision."

In contention are two teams thrown together as much by international politics as by industrial logic. In current European fashion, the relationships among the members are convoluted—in fact, two companies are playing on both teams. One side is led by AEG AG's Radar Systems Subdivision of Ulm, West Germany, and includes GEC-Marconi, FIAR's Defense Division in Milan, Italy, and Inisel of Madrid. The opposing consortium is led by Ferranti International Signal plc of the UK and includes Siemens AG of Munich plus FIAR and Inisel.

SCORECARD. Not only are FIAR and Inisel double-dipping, but until a few months ago AEG, in addition to heading its own group, was a member of the Ferranti team. When AEG finally decided to run with only its own ball, Siemens replaced it in the Ferranti group. Take away the common denominators and it turns out that the contest is really between two UK and two West German firms: AEG and GEC on one side, Ferranti and Siemens on the other.

The EFA is being developed for the British, West German, Spanish, and Italian air forces. Each of the four nations is contributing a share of the $1.7 billion development and the estimated $7 billion production costs, and companies from each nation will get work proportional to that share. The West Germans and British are doing 33% each, the Italians 21%, and the Spanish 13%.



The UK's Ferranti is proposing this radar, the ECR-90, but rival AEG of West Germany calls it a technological risk. AEG is pushing an upgrade of the AN/APC-65 from Hughes Aircraft.

When it comes to the heavy metal—engines and airframe—each country really has only one contractor capable of carrying out the work, so there is no competition in forming consortiums. UK-based British Aerospace and Rolls Royce are the leading candidates for the airframe and engines, respectively.

But the main radar system—the biggest single project by value, after the heavy metal—is a different matter. When the British nominated Ferranti as project leader, the West German government balked. Although the West Germans now seem to be favoring the Ferranti scheme, they say they are concerned about technological risks and don't want to pay extra for any budget or time overruns that may result.

But as one insider puts it, "The technical arguments are, in fact, a surrogate for the political battles between the British and West Germans. They have been deadlocked for nearly two years."

The Ferranti team is offering what it calls a brand-new design, the European Collaborative Radar for the '90s (ECR-90), while the AEG group wants to license the AN/APC-65, a 10-year-old system from Hughes Aircraft Co. of Los Angeles. The AN/APC-65 was designed for the U. S. Navy's F/A-18 Hornet fighter and then adapted as the APG-65 for Phantoms belonging to the West German Luftwaffe. If it gets the business, AEG will rename the system MSD-2000.

TOO NEW? The AEG team claims the Ferranti radar is too new and represents a high technology risk. "It will take four years longer to get ready than ours," says Armin Roy, AEG's airborne radar system department manager. "And then there is no guarantee that it will work." The MSD-2000, he notes, is based on a radar that has been in service for nearly six years with the U. S. Navy and has a proven track record.

Ferranti counters that its ECR-90, although "designed with 1990s technology," has much in common with the Blue Vixen radar Ferranti is building for the Royal Navy's Harrier vertical-takeoff fighters. Development models worked straight from the drawing board and have logged several hundred hours on test flights over the last year, Ferranti says. The Blue Vixen radar grew out of the earlier Blue Fox, which saw service

in the 1982 Falkland Islands clash.

A detailed examination of the claims on both sides reveals that the "brand-new" ECR-90 shares 60% to 100% common subsystem components with the Blue Vixen and Blue Fox systems, while only 40% of the modules of the "proven" MSD-2000 can be found in the APG-65. Those estimates come directly from Ferranti and Hughes, respectively.

AEG will need a new antenna for its MSD-2000 because the EFA specification calls for a longer range and more power than the APG-65 supplies. The MSD-2000 will also need a new traveling-wave-tube and transmitter-receiver system. AEG's system will have a new processor designed around the Motorola 68020 microprocessor—the APG-65 uses a proprietary Hughes design. Consequently, its software will have to be recompiled from the Hughes assembler language.

Apart from national pride, there are deeper political and financial interests at play in the dispute. The Luftwaffe wants to refit its fleet of Phantoms with the original Hughes APG-65—so it wants the benefit of common maintenance and spare parts for its EFA planes. The British Ministry of Defence, on the other hand, sees benefits from using the ECR-90 because of its similarity to the Blue Vixen radar.

ECR-90 proponents have also voiced concern that the MSD-2000 will owe too much to its Hughes ancestry. The crux of that concern is the software. Hughes says that the algorithms can be adapted from the originals and that the capabilities of the MSD-2000 processor can be verified by comparison with the APG-65. Negotiations for the release of the code to the Europeans have been going on for a year, but although some progress has been made, they are still not complete.

What's more, existing algorithms cover only 28 of the 31 modes required for the EFA. The remaining three will have to be written from scratch by GEC-Marconi. They relate to self-testing, the verification of a target's identity, and the recognition of "noncooperative targets."

Scott of GEC-Marconi says these new modules, written in Ada, could be relicensed by Hughes. A year ago, Paul Kennard, group vice president of Hughes's Radar Systems Group, said that he had received verbal assurances from the U. S. Navy that the APG-65 algorithms could be used and that a memorandum of understanding was being drafted. But that memorandum is still not complete.

Meanwhile, Ferranti is playing to concerns about AEG's Hughes connection. Ferranti claims it is ensuring that no component in its ECR-90 is single-sourced from outside Europe. *–Peter Fletcher*

DISTRIBUTION

CAN AN UPSTART CHANGE THE WAY CHIPS ARE SOLD?

LOS ANGELES

Of all the things beleaguered electronic-parts distribution firms don't need these days, more competition has to top the list. But there's a good chance that they'll be getting that, and with it a controversial new twist to a business suffering from oversaturation and related profit troubles.

The competition will come from Irvine, Calif.-based Allegiance Distribution Inc. The company, which plans to kick off its national operations by late summer, will be the first distributor dedicated to pure telemarketing—that is, selling commodity semiconductors nationally solely by using telephone sales reps working at a

single location. If plans jell, it will be tied to Japanese chip suppliers by conventional franchise contracts.

There's nothing new about telemarketing itself, since distributors from the beginning more than three decades ago have depended heavily on phone sales augmented by big outside sales forces. Moreover, in recent years several have sold scarce memory chips obtained in the gray market extensively by phone.

COSTS CUT. But the benefit of a pure telemarketing operation wrapped in conventional distribution contracts is apparent, says Michael P. Halloran, president and chief executive of Allegiance. "By getting rid of all the costs associated with outside selling, it ultimately can cut overhead nearly in half from the current industry average of 20%," he claims. Some conventional firms, in fact, are moving heavily toward telemarketing themselves, notably Semispecialists of America Inc. of Melville, N. Y. [*Electronics*, May 1989, p. 122].

The key to making the Allegiance plan work is to lock up a supply of quality commodity parts through agreements with at least three top chip manufacturers, Halloran says. That's important because the contracts provide price protection and other features that distributors need in a fast-changing market. Halloran says he has been negotiating for months with top-tier Japanese companies—he won't name them—and says talks at this time are at "the hammering-out stage," with agreements expected in early summer. Financing for Allegiance, which was organized several years ago to market, on a lesser scale, parts manufactured offshore, will be provided by both U. S. and Asian sources.

Those who follow the distribution business agree that telemarketing will play a bigger role in commodity sales, which account for more than half of total sales. "On the face of it, telemarketing makes a lot of sense," says Clarke Walser, a financial analyst for Chicago Corp. Overhead costs have to come down drastically; overhead in the industry generally matches gross profit margins of about 20%. Allegiance's 11% overhead aim "is not outlandish," Walser says. Distributors need a spread of 4% to 5% between costs and profits to stay healthy, a condition that few now enjoy.

CAUSING UNHAPPINESS. Still, Allegiance seems likely to stir discord. Its success "would put the pressure on the old-line distributors to do the same thing themselves," says Walser. Although many of them are dabbling in telemarketing, most have not pursued it wholeheartedly. Selling by phone with fewer nontechnical employees counters a trend that is contributing to the profit troubles: employing engineers to sell service-intensive microprocessors, programmable devices, and high-price systems. Walser and others see this as something distributors have to work out to get back on the profit track.

Some knowledgeable distributors doubt the Allegiance plan will ever get off the ground. Donald Bell, for one, doubts Japanese chip makers' support, going so far as to state flatly that major Japanese chip makers will not grant distribution rights to anyone taking the Allegiance path. "It's not in their best interests, because it would disrupt their entire franchise system," says the former Kierulff president who now heads his own firm, Bell Microproducts in Milpitas, Calif. Presumably, Allegiance could charge less than existing distributors, thus undercutting service on other components. "Put me in the extreme doubter camp; I say it will never happen," he says.

But Halloran says the Allegiance plan is on track. Operations will start in August or September with a big advertising campaign, he adds. *–Larry Waller*

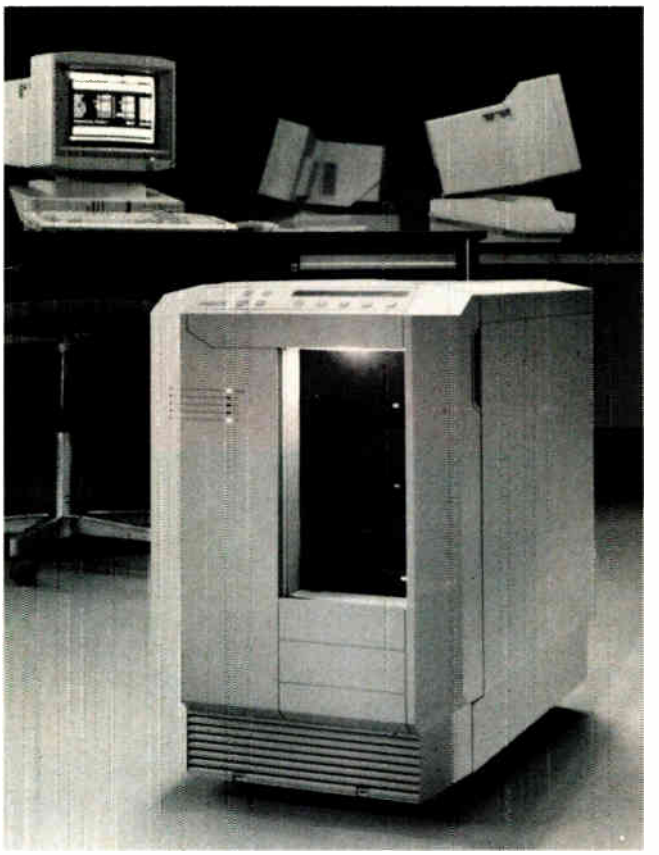
APRICOT BUILDS 80486 INTO FILE SERVERS

LONDON

Even as IBM Corp. is first to use Intel Corp.'s powerful 80486 32-bit microprocessor for a personal computer, an English company is first out of the blocks with a system based on the 486—a pair of big machines designed to quarterback office networks.

IBM is introducing the 486 as an add-in for its Personal System/2 (see p. 17). But Apricot Computers plc, a Birmingham, UK, company, has designed its 486-based computers to work as file servers or Unix hosts. And like the new IBM offerings, they are scheduled to be delivered beginning in the fourth quarter.

Production will be at the company's factories in Scotland. At Intel headquarters in Santa Clara, Calif., a spokesperson confirms that "we are optimistic about meeting customer commitments for the fourth quarter."



Apricot's new offering, the VX FTserver, is a series of network and Unix servers built around Intel's 80486 microprocessor.

Apricot's new machines, the VX FTserver 400 and 800 series, firmly snap shut the gap between minicomputers and personal computers, says Tim Taylor, Apricot's marketing director. The 400 series is designed to run as a network server and the 800 series as a Unix host. Both can handle 15 million to 20 million instructions/s.

What's more, they boast low initial and running costs, says Taylor. At about $40,000 for the top-of-the-line model, he says, the Apricot machines are less than half the price of comparable systems from Bull Information Systems, Digital Equipment, Hewlett-Packard, and IBM.

Peter Horne, director of research and development, and his team took just three months to design the new machines. They got a head start by basing them on Intel's 80386 32-bit processor, using an open-architecture concept that Apricot had first applied to its Xen series of PCs.

WINNING GAMBIT. Those machines were based on the Intel 80286 chip, but users could simply unplug the 286 processor and replace it with the speedier 386SX. This gambit allowed Apricot to get to market first with its 386-based computer, which is compatible with the IBM PS/2, since 90% of the engineering work had been carried out beforehand.

The new models are similarly designed. The 486 chip is mounted on a daughterboard that plugs into the motherboard's pin-grid-array sockets—which could be occupied by a 25- or 33-MHz 80386. In fact, existing 386-based models can be field-upgraded the same way the Xen machines were.

This interchangeability depends on a few designer's tricks, Horne says. Some adjustments had to be made for the different ways the two chips use their clocks. The 386 uses a double-edge clock, which means that although the clock runs at 25 MHz, it needs to generate pulses at twice that speed. The 486 uses a single clock pulse, so its clock runs at the same speed as the processor. "Once we had full 486 timing information from Intel, a few programmable logic arrays solved that problem," Horne says.

More difficult was arranging for extra cache memory to allow for maximum use of the 486's power. The 486 has 8 Kbytes of on-chip cache; Apricot's designers added a second tier—128 Kbytes—of Hypercache memory.

The hardest problem to solve was what Horne calls cache coherency. Each time the system's memory is accessed for data, he explains, the system has to check whether a later version is held in the Hypercache or on-chip cache memory. This is no mean feat: the machines are designed to operate at the hubs of large networks and to access large amounts of disk storage—a fully configured machine can drive up to 256 Ethernet ports and access 5 Gbytes of disk storage—and each port and drive has direct memory access.

The solution is a circuit that "snoops" around the data buses, sensing the addresses appearing there and comparing them with those in the cache memories.

Apricot's machines boast a number of minicomputer-like features. The 800 series Unix hosts come with 16 Mbytes of random-access memory, 32 or 64 serial ports, and up to 5 Gbytes of disk storage. Serial input/output capability can be expanded by adding 32-channel communications cards based on IBM's Micro Channel Architecture—and there are six free slots.

Other features include fault tolerance, integrated disk shadowing, full system-environment control, an uninterruptible power supply, and backup storage based on Hewlett-Packard Co.'s new digital-audio-tape system.

Despite the minilike features, Apricot's machines are firmly rooted in the company's experience with PCs, and they are fully compatible with the IBM PS/2 specification. "Traditional mini-makers base their systems around proprietary architectures," says Taylor, "so they are expensive and are compatible with each other only at the highest level of the Open Systems Interconnection seven-layer-model definition."

With their open-hardware architecture, the Apricot machines can run Unix, OS/2, and MS-DOS operating systems, providing users with access to the vast volume of existing applications software. The six free Micro Channel-compatible expansion slots allow feature cards designed for the IBM PS/2 to be used as is.

Apricot says that within 24 hours of its announcement of the new machines, "20 or 30" deals had been made for evaluation models, mainly from large corporate users. Taylor has not revealed the company's strategy for overseas marketing yet, but he says he is seeking original-equipment-manufacturer deals from North America. *–Peter Fletcher*

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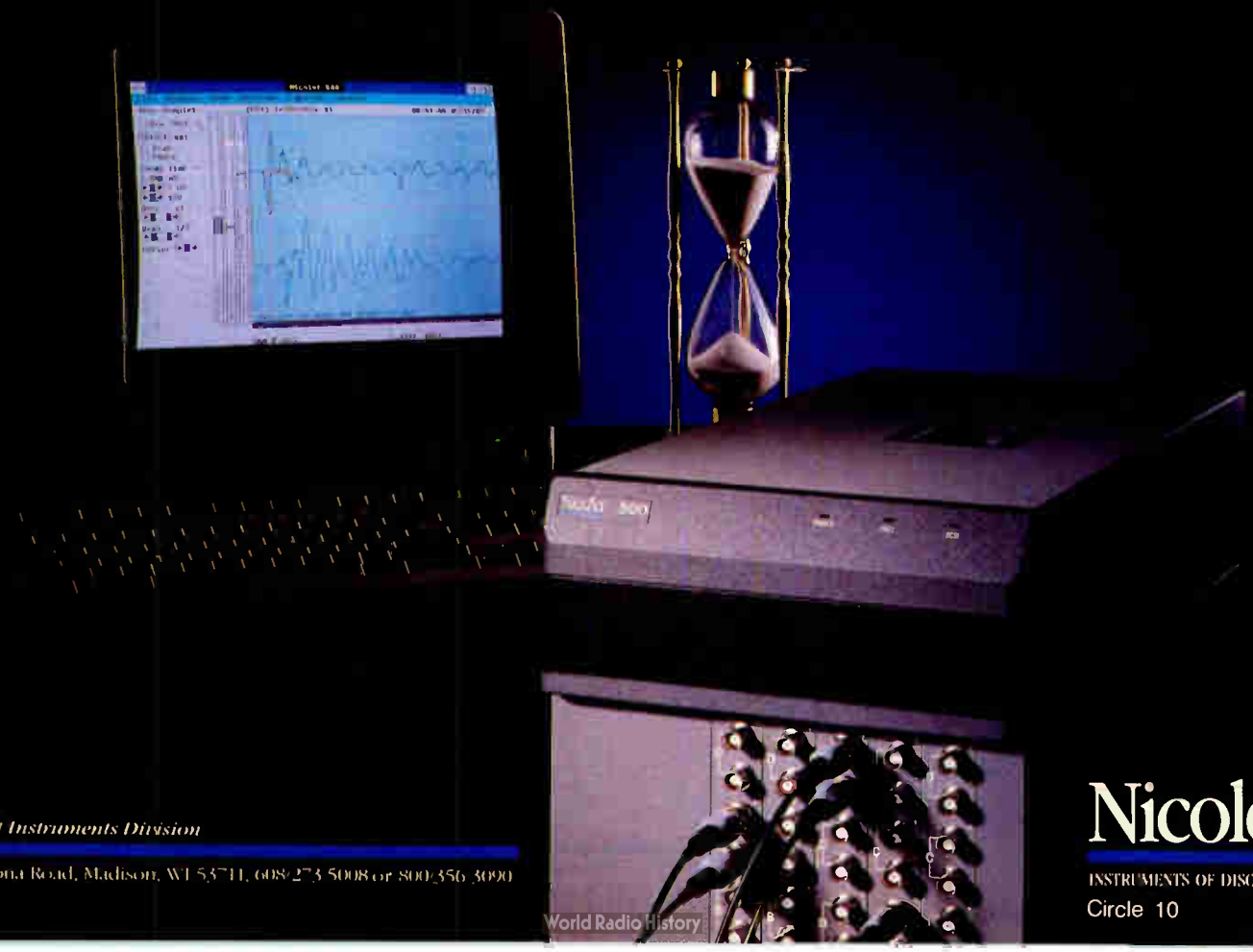

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DARPA BACKS BIG GaAs INSERTION EFFORT

WASHINGTON

Despite pressure to pull back on gallium arsenide research spending in favor of more mature technologies, the Defense Advanced Research Projects Agency is forging ahead with a new GaAs technology-insertion program. Darpa plans to support at least 11 projects over the next four years to get currently available GaAs technology into systems that are in the field or soon will be—including digital radios, radar processors, digital map systems, and frequency jammers.

The projects will take from 18 to 42 months to complete and represent a range of challenges. But each can be handled with today's technology, Darpa officials say. So although semicustom chip designs may be required, the gate arrays themselves are already available. "This is off-the-shelf, existing technology," says Daniel Butler, director of studies and analysis at Booz, Allen & Hamilton Inc. of Rosslyn, Va., a consultancy that is helping Darpa manage the program. "There will be custom chips, but they will be 10,000-gate devices or equivalents."

The long-awaited insertion program still faces a few hurdles before it really gets going. Darpa is launching the effort with $9 million in research funds set aside for the project by Congress late last year—the Defense Department had eliminated such a program from its own budget proposal. The Pentagon has done the same thing for fiscal 1990, leaving it up to Congress to keep the program alive.

FUNDS SOUGHT. Although Darpa publicly supports the current DOD budget, it is quietly seeking about $40 million for next year to fund the 11 insertion efforts and a GaAs pilot line at AT&T Co. It wants another $19 million to keep its other ongoing GaAs research programs on track. These include development of a 32-bit microprocessor and 16- and 64-Kbit random-access memories, both funded in recent years by the Strategic Defense Initiative Organization and managed by Darpa.

GaAs R&D has been pared considerably over the last several years, as the SDIO has emphasized short-term technology solutions over less mature technologies. SDIO's support for GaAs research declined from a high of $35 million in 1987 to $16 million in 1988 and $14.7 million in 1989. But SDIO has spent much of this year trying to cut $4 million to $10 million out of that $14.7 million, and although the budget proposal now before Congress seeks $19 million in fiscal 1990, SDIO has since cut that back to $10 million, says Arati Prabhakar, Darpa's program manager for the GaAs insertion effort. "It could drop to zero," she says. "It's unreasonable to expect anything from SDIO when they're making a mad dash to get something deployed."

Such dwindling support is threatening the GaAs technology base in the U. S., says Sven Roosild, Darpa's assistant director for electronic sciences. "The only reason that GaAs is surviving in this country is the fact that Cray had the guts to say the Cray-4 will use GaAs," he says, referring to supercomputer dean Seymour Cray's upcoming megamachine.

The worry that the U. S. might lose its investment in such a potentially important technology led Congress last year to come up with $18 million to keep active a GaAs pilot it had helped build at AT&T and to start funding a series of technology insertions. But now Darpa faces the ax again. Darpa officials had sought $39 million to keep the pilot line and the insertion efforts on track in 1990, but were unable to convince the Pentagon hierarchy.

Nevertheless, Butler of Booz, Allen expresses confidence. "There's nothing in the budget for 1990, but there wasn't anything for 1989, either," he says. "I would guess [Darpa will] get $20 million to $30 million in 1990."

Darpa's hopes could ride heavily on the success of an amendment to the Defense Appropriations Act of 1990 submitted by Rep. Robert K. Dornan. The California Republican's measure not only provides $40 million for Darpa to continue its pilot-line support and GaAs insertion projects but also gives Darpa full control of the $19 million for GaAs research that's now in the SDIO's budget.

If Darpa does get the money to continue the program, it will have an array of projects to work on, ranging from the comparatively simple to the complex. On the simple side is an 18-month contract with KOR Electronics Inc. The Huntington Beach, Calif., company is designing a GaAs digital radio-frequency memory for the Navy's ULQ-21 Threat Jamming Simulator. The unit will be flown on manned aircraft as well as on unmanned aerial

WHERE DARPA FAVORS DIGITAL GaAs

Company	Military program office	Insertion project
E-Systems Inc. Greenville, Texas	Air Force Logistics Command	Distributed array processor for special-mission aircraft will process six times the simultaneous inputs of current silicon processor and reduce subsystem weight by 300 lbs.
E-Systems St. Petersburg, Fl.	Army Communications Electronics Command	Modem and synthesizer for AN/PRC-126 Small Unit Radio will provide antijam frequency-hopping capability and compatibility with the Single-Channel Ground-Air Radio System.
Grumman Corp. Bethpage, N. Y.	Naval Air Systems Command	Radar Signal Processor for Navy's E-2C Airborne Early Warning Aircraft will boost radar's range by 45%, cut false target rate by 40%, and help it detect smaller targets in clutter.
Honeywell Inc. Albuquerque, N. M.	Naval Air Systems Command	Digital GaAs components for the Digital Map aboard the V-22 Osprey and other aircraft will replace current CMOS components to boost performance fourfold.
KOR Electronics Huntington Beach, Calif.	Navy Pacific Missile Test Center	Digital radio-frequency memory for AN/ALQ-167 pod used to simulate enemy jamming capability will be significantly cheaper than conventional ones.
Martin Marietta Denver	(Classified)	Digital GaAs replacements for existing CMOS devices in an on-board spacecraft signal processor will boost speed from 75 to 560 million operations/s without altering the current system architecture or software.

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targets and will simulate the jamming capability of enemy aircraft.

Far more ambitious is a Martin Marietta Corp. project that will replace a CMOS chip set aboard a classified spacecraft with a set of GaAs integrated circuits. Martin Marietta's Space Systems Division in Denver says the new chip set will boost performance from 75 million operations/s to 560 mops—without architectural or software changes. More than any other of the 11 projects, this one comes closest to being a can't-miss proposition, says Darpa's Prabhakar. "The customer is very high on it," she says. Martin Marietta is also working on a digital GaAs signal processor for the Army's Hellfire Anti-Tank Missile.

Among other GaAs contractors, ITT's Avionics Division, Nutley, N. J., is developing a digital rf memory for an Army frequency jammer. McDonnell Douglas Electronic Systems, McLean, Va., is adapting its high-speed GaAs microprocessor for use in a mast-mounted sight for the Army's OH-58 Scout helicopter. And Texas Instruments' Defense Systems and Electronics Group in Dallas is working on a high-resolution upgrade of the Surface Search Radar system aboard the Navy's P-3C planes. *–Tobias Naegele*

SALES

THORN FACES THE MUSIC ON DEFENSE UNIT

LONDON

England's big entertainment conglomerate has decided to bring down the curtain on its high-tech fling. Thorn EMI plc, which once had visions of becoming a world-class technology company, is shopping for a buyer for its defense-electronics business, Thorn EMI Electronics Ltd.

According to chief executive Colin Southgate, Thorn wants to concentrate on the three sectors it perceives as its core businesses: appliance rental, music, and lighting. Earlier this year, the company sold chip-maker Inmos Ltd. plc to French-Italian conglomerate SGS-Thomson. Two other technology businesses, concerned with the manufacture of meters and domestic appliances, are also up for sale. Southgate says the three businesses on the block account for no more than $630 million of Thorn's $5.2 billion in annual revenue.

A PLUM. There's no question that of the three, Thorn EMI Electronics is the plum. Analysts peg its annual revenue at about $470 million, most of it from advanced military technology, including battlefield sensors, radar and communications, sonar, airborne-surveillance and missile-guidance systems, and bomb fuses. Ironically, analysts say, the company's successes in these fields have caused problems for Thorn—many of the group's top-rank recording artists are unhappy to be associated with a weapons maker.

Southgate says funds raised from the sales will be used "to support expansion in the group's chosen markets." But so far, no buyer is in sight. One possible bidder is defense-electronics heavyweight Plessey Co. plc, now in limbo pending a renewed hostile-takeover bid by Britain's General Electric Co. and West Germany's Siemens AG. Although a bid from Plessey would make commercial sense, it would also be interpreted as a tactical move in the cat-and-mouse game Plessey is playing with GEC and Siemens.

One other British electronics giant, Racal Electronics plc, wants to shed some of its defense businesses, including radar, but has been waiting for the right time. Chief executive Sir Ernest Harrison has made no secret of the fact that negotiations for Racal's defense holdings have been iced pending the outcome of the GEC-Siemens play for Plessey.

The most likely contenders for Thorn EMI Electronics are STC plc of the UK and Thomson CSF, the French defense company. STC is eager to expand its depleted defense-electronics business, analysts say, while state-owned Thomson CSF has a number of collaborative projects with Thorn EMI Electronics and is known to be looking for inclusion in pan-European defense partnerships. Thomson CSF's director general, Henri Starck, has said that European defense-electronics companies should regroup to form transcontinental conglomerates.

Indeed, embryonic Euro-defense groups are now forming as major UK, French, Italian, and West German defense-electronics contractors forge partnerships. So far, however, Thomson CSF has not been involved in any of the alliances. The major players that have emerged are GEC, Matra of France, and Daimler Benz of West Germany. Daimler Benz is seeking to gain control of Deutsche Aerospace, and through it Dornier, Turbo Union, and Messerschmitt Bolkow Blohm. It has already acquired AEG and owns Mercedes Benz. Matra has reorganized along similar lines, with Matra Defense et Aerospace, Matra Transport, and Matra Communications.

Meanwhile, Matra Aerospace and Deutsche Aerospace have exchanged equity shares believed to be in the 20% range. Daimler holds a 5% stake in Matra. And GEC, which grabbed a 5% piece of Matra when the company went private in 1987, is reported to have discussed gaining a further 20% stake in Matra in exchange for a similar equity in GEC's Marconi subsidiary in the UK. Malcolm Bates, GEC's deputy managing director, has denied those reports.

The "for sale" sign going up outside Thorn EMI Electronics headquarters at Hayes, West London, may provide the opening Thomson's Starck needs to practice the across-the-border ownership he has preached. *–Peter Fletcher*

NETWORKS

WIRELESS LANs EASE NETWORK CONNECTIONS

NEW YORK

Just when bridges, routers, and brouters are becoming known outside local-area-networking circles, that fast-evolving arena has added another hardware niche: wireless LANs that pass messages by radio using spread-spectrum techniques. Two companies, Agilis Corp. of Mountain View, Calif., and O'Neill Communications of Princeton, N. J., opened the market last month.

Agilis made its system compatible with Apple Computer Inc.'s 230.4-Kbit/s AppleTalk. For the IBM Corp. Personal Computer market, Agilis will license its radio technology to third-party developers and let them build plug-in products.

For its part, O'Neill is positioning its 9.6-Kbit/s network primarily for low-data-rate file transfers among PCs. Printers, modems, and any other devices with a serial or parallel communications port can also be attached to the network.

Although radio-based LANs will not challenge conventional wired networks in numbers of installed nodes, they can be potent problem solvers in tricky situations, says Peter Cripps, vice president and director of Agilis's Digital Radio Division. Some applications include terminals that are frequently moved or too distant from the wired LAN for easy connection. Because the radios that implement wireless LAN nodes are compact, inexpensive, and resistant to electromagnetic noise, vendors are also salivating over the fast-growing market for point-of-sale terminals, hand-held computers, and laptops.

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HPC16064	8	Yes	52	16K	512	4 ICRs
HPC16083*	8	Yes	52	8K	256	4 ICRs
HPC16104	8	Yes	32	0	512	8 CH A/D
HPC16164	8	Yes	52	16K	512	8 CH A/D
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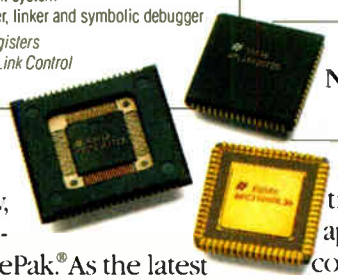

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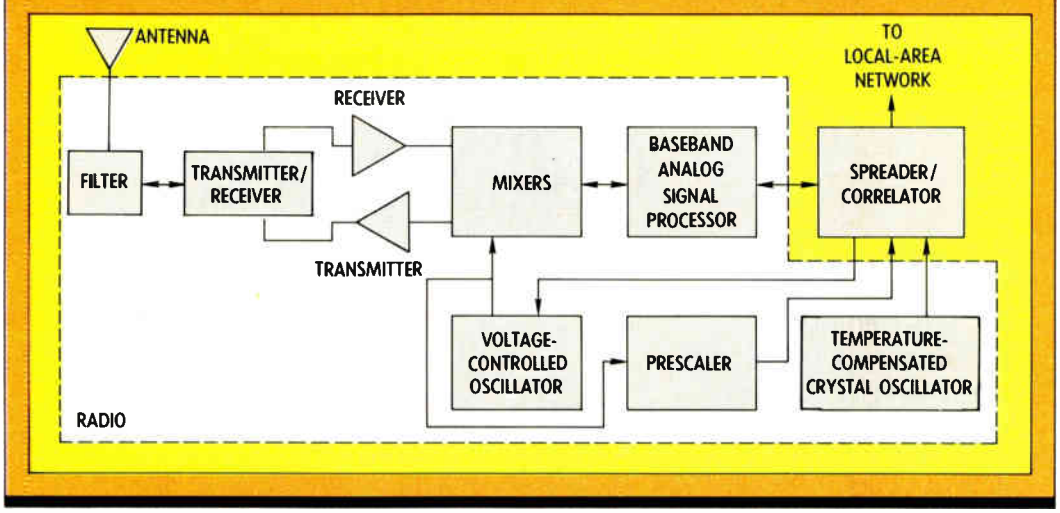
National Semiconductor

Circle 13

gy worthy of investment in 1985, when the Federal Communications Commission allocated three bandwidths for unlicensed broadcasting with spread-spectrum radio. Before that, anyone who wanted to use a broadcast signal to link computers into a LAN had to get an FCC license, and that put a damper on the wireless LAN concept, says Cripps.

The FCC ruling limits total radio-frequency power to 1 W. Moreover, spread-spectrum technology reduces power density—and the potential for interference—by spreading the signal over many frequencies in the allocated band. The signals are then correlated back into a baseband signal at the receiver.

AGILIS DE-WIRES THE LAN



The transceiver architecture will eventually include three ASICs: a CMOS spreader-correlator, a bipolar baseband analog signal processor, and a high-speed bipolar mixer circuit.

Implementing an advanced spreader-correlator technology was the major challenge in wireless LANs, says Cripps, and accounts for much of the lag time between the appearance of products and the FCC's 1985 action. The three spread-spectrum bands are 902 to 928 MHz, 2.4 to 2.483 GHz, and 2.725 to 5.85 GHz.

PATENTS PENDING. Both Agilis and O'Neill have applied for patents on their spread-spectrum technology, and both have implemented their spreader-correlator schemes in application-specific integrated circuits. The similarities pretty much end there.

O'Neill's local-area wireless network (LAWN) offers a data rate of 9.6 Kbits/s. It transmits at 20 mW over a range of 100 ft inside buildings and 500 ft outside. Users select from four channels using MS-DOS software supplied with the LAWN, which costs $495 and will be available in the third quarter of this year.

The Agilis radio runs at 230.4 Kbits/s and transmits at 1 W. Its range is 100 m indoors and 1 km outdoors. Users select from 16 channels by setting DIP switches. The AppleTalk module that plugs users into a wired—or unwired—Macintosh network will cost $300 when it becomes available early in 1990. The system is compatible with any networking software, including the popular TOPS software for the Macintosh.

Agilis developed its spread-spectrum radio to be the primary communications link for the rugged hand-held computers it introduced last month. Plug-and-play compatibility with Macintoshes and AppleTalk is the first follow-on product, according to Cripps. "It will be a boon for nontechnical people such as lawyers who don't want to be bothered with wires and network connections," he says. "They can buy a small box, plug it into the back of a Mac, and do anything they could do on a wired network."

The company is eager to enter other markets through the third-party-developer route by licensing the radio technology to original-equipment manufacturers. OEMs will probably be able to build plug-in LAN cards that integrate the radio and the IBM PCs for about $500, says Cripps. Special-purpose portable terminals, such as those used in inventory-management systems, are another prime OEM opportunity for the technology, he says.

> OEMs can build plug-in LAN cards integrating the radio and IBM PCs for about $500

Agilis selected the 902-to-928-MHz band for its initial technology implementation because operating in the 2-GHz bandwidths introduces a few new design problems. Besides achieving a 230-Kbit/s data rate in the 900-MHz band, the technology can be pushed to about 1 Mbit/s, says Cripps, with the key limiting factor being the clock speed of the ASIC spreader-correlator.

Using the two higher bandwidths could boost the data rate to 10 Mbits/s, which is compatible with Ethernet speeds. In the meantime, a store-and-forward scheme can be used to match the data rates of conventional wired LANs.

The spreader-corrrelator technology that is the key to spread-spectrum radio involves coding each bit of the baseband signal into a sequence of bits called chips and embedding the chips in a random signal. The chips are transmitted using the spread-spectrum radio and then reconstituted into the original baseband signal by the correlator.

COST CHALLENGE. The challenge is to accomplish this at relatively high bit rates and keep the cost down, says Cripps. Conventional methods turn out either to have a slow data rate or require complex circuitry that pushes the price above acceptable limits. Agilis won't reveal details about its design except to say that it has been executed in a 5,000-gate dedicated digital signal processor ASIC.

Agilis has also applied for a patent on its radio design, which abandons conventional superheterodyne radio technology. The radio requires virtually none of the adjustments needed by superheterodyne radio, and it is comparatively inexpensive to build because it offers much higher integration onto ASICs.

The Agilis transceiver architecture will eventually be implemented primarily in three ASICs: the CMOS spreader-correlator, a bipolar baseband analog signal processor, which is due in the first quarter of 1990, and a high-speed bipolar mixer circuit, which is even further off, says Cripps. Intermediate products will use discrete components.

Agilis has ambitious plans to trim the 7-by-5-in. board in its current design to 5 by 3 in. in 1990, and it plans to integrate all major functions into a four-chip set by 1992. The price of the transceivers for end users will fall from an initial $500 per unit at low-volume production of the 7-by-5-in. board to about $300 per unit when the 5-by-3-in. board is being produced at a rate of 10,000 per year. The price may drop to $100 per unit for the smaller board when production ramps up to 100,000 units, the company says. *–Jack Shandle*

TEXAS INSTRUMENTS

A PERSPECTIVE ON DESIGN ISSUES:

New ways to link digital brains to advanced analog worlds

IN THE ERA OF

MegaChip TECHNOLOGIES

Next-generation analog: Advanced Linear ICs

A new breed of linear chips, born of leadership processing at Texas Instruments, can help you design superperformance systems.

Sophisticated design and simulation tools shorten development cycles of TI's Advanced Linear ICs, helping you get to market faster. By using these tools, TI can offer as standard circuits many designs that previously would have had to have been customized.

The human brain has separate but dependent left and right sides. Similarly, an electronic "brain" or system has separate but dependent parts, one digital, one analog. Designers accustomed to the spectacular performance gains made in digital chips are now demanding comparable improvements in analog devices so that both parts of their systems can function to full potential. Leading the analog evolution: Advanced Linear circuits from Texas Instruments.

These new chips are called *advanced* for one or more reasons. They are more highly integrated than ever before, often combining digital and analog functions on a single chip. They offer higher performance and greater flexibility. They are often the result of advanced processing that may merge two or more technologies.

Better parameters from better processing

Because advanced analog system requirements for performance and flexibility vary greatly, a single workhorse technology typically can't do the job any longer. Nor can creative circuit designs alone. We at TI are convinced the key to driving the linear evolution lies in the excellence of our processing technologies.

TI is committed to developing and implementing a range of leadership wafer-fabrication processes (*see descriptions on back page*). The result: TI's Advanced Linear devices are already helping system designers link digital brains to advanced analog worlds more efficiently and with greater ease in many applications. Here are a few examples.

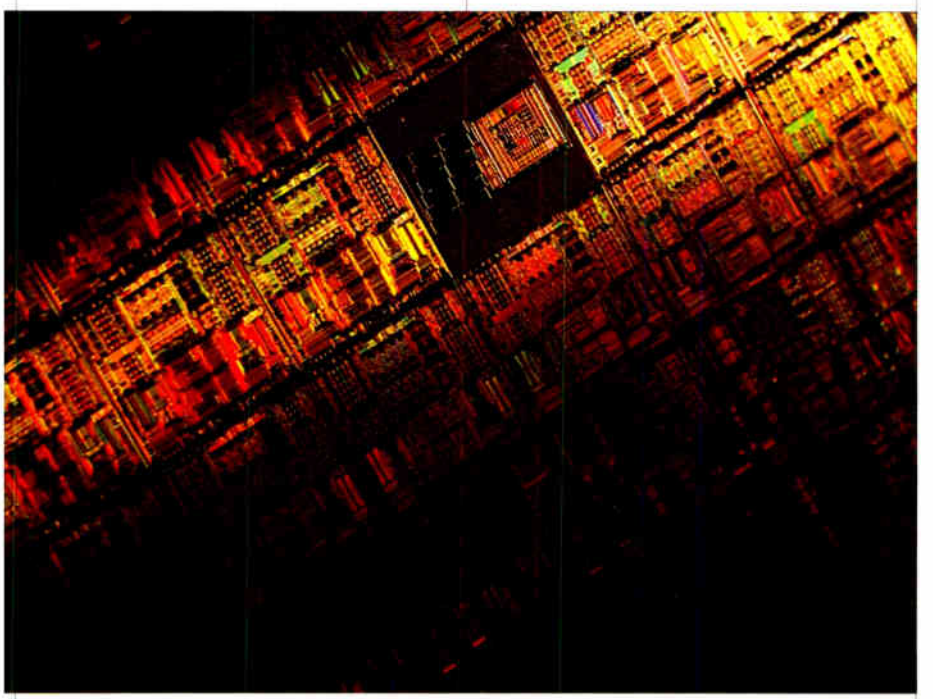
Advanced Linear: Displaying greater brilliance

Out of our pacesetting LinEPIC™ processing comes our high-performance Color Video Palette, operating at 125 MHz with a very high-resolution 1024 x 1024 pixel count. Because of one-micron CMOS processing, power consumption is reduced more than 40% compared to other CMOS implementations. Additionally, the device is pack-

...the key to driving the linear evolution lies in the excellence of processing technologies.

aged in reliable, economical plastic.

LinEPIC has also produced such high-speed, high-density interface chips as our Flash A/D and our Video DAC for use in graphics displays, imaging systems, monitors, and cameras. Both devices require about five times less power than bipolar equivalents.



High-density Analog Interface Circuit chips demonstrate the greater integration achieved by TI's innovative linear processing technologies. These DSP interfaces allow you to alter circuit configuration under software control without external adjustments.

Advanced Linear: Intelligent power for every car

Chips fabricated with our Power DMOS-based BIDFET™ processing are replacing electromechanical relays in many automotive applications, such as driving headlamps and motors. Power BIDFET allows us to minimize power loss in the switch and add high-complexity logic functions.

Multi-EPI bipolar processing, a very cost-effective technology, is used to produce chips having inherent reverse battery protection and high operating voltages. Such chips are ideal for use in automotive antilock braking systems, electronic transmissions, and active suspension systems.

Either technology can produce devices with low-side drive, high-side drive, or H-bridge configurations.

In the future, these developments may lead to multiplexed systems for cars, replacing bulky wiring harnesses.

Advanced Linear: Enhancing modems and facsimiles

TI's dual driver/receiver is a good example of the integration achieved with advanced processing technologies. LinBiCMOS™ processing has enabled us to put the drivers and receivers needed for RS-232 voltage levels on the same chip with the charge pump required to generate the necessary split rails from a single 5-V supply. You eliminate external power supplies and get a device that's easier to design with—it is available in our LinASIC™ cell library for integration with digital ASICs.

A new family of Analog Interface Circuits (AICs) is emerging from our Advanced LinCMOS™ processing. The voice-band AICs, designed for modems and fax equipment, combine high-performance analog functions—14-bit A/D and D/A converters and switched capacitor filters—with digital functions such as control circuitry, program registers, and DSP interface. The usual clutter of resistors, capacitors, and pots is eliminated.

High-speed AICs are available for use in servo controllers and hard-disk-drive applications.

These AICs are also high-performance members of our LinASIC standard-cell library. Based on TI's proven digital ASIC methodologies, the LinASIC library has allowed us to develop complex, semicustom chips in as little as 16 weeks.

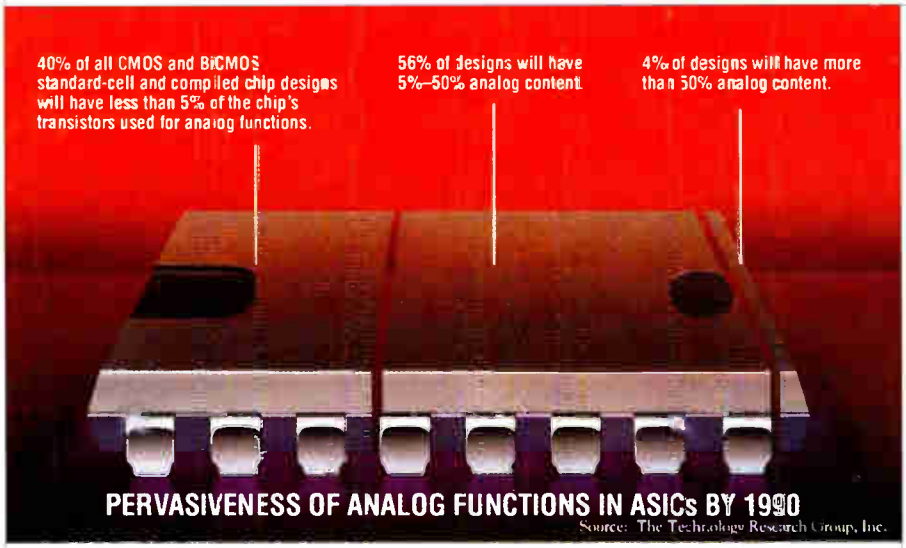
Advanced Linear: Boosting instrumentation accuracy

Even one of the most basic analog building blocks, the operational amplifier, is benefiting from TI's Advanced Linear technologies. Our Excalibur op amp family combines low power consumption with a 5X speed improvement while retaining low offset voltages. Offset-voltage drift has been cut from 300 µV to 60 µV to reduce your calibration, test, and measurement expenses.

For high-accuracy applications, Advanced LinCMOS is making possible Chopper Stabilized Op Amps with chopping frequencies 10 times higher than previously available (10 kHz). Noise levels are the lowest on the market.

The evolution in analog devices has only begun. Dramatic progress lies ahead throughout the 1990s. As the Advanced Linear leader, Texas Instruments is pledged to remain at the forefront, supplying you with new ways to link digital brains to advanced analog worlds.

For suggestions on choosing a linear supplier, turn the page.



Circuits combining analog functions with digital logic will soon be widespread in ASIC chip designs. TI is taking a leadership role with the development of its LinASIC methodology.

Checkpoints for choosing an analog supplier in the 1990s.

Questions and answers with Tom Engibous, Vice President, Semiconductor Group, and Manager, Linear Products, Texas Instruments Incorporated.

Q. What is the first thing to look for in choosing a linear supplier?

A. Product performance is definitely the first priority. Our customers are asking for ever-increasing linear device performance. At TI, we believe creative circuit designs alone won't meet the challenge. Advanced process technologies—note the plural—are becoming the keys to success in linear device performance of the '90s.

Q. What else should a designer look for?

A. Whether or not the supplier has experience with digital as well as analog devices. These two worlds are merging (*see chart above*). Functions once performed by analog are now done digitally, and a growing percentage of our Advanced Linear devices combines analog and digital circuitry on one chip.

At TI, we've leveraged our 30 years of digital expertise into the development of our Advanced Linear products and processing with highly satisfactory success. This has been especially noticeable with our LinASIC methodology.

Q. Do you expect ASICs to play a major role in your linear future?

A. Very definitely, as they already do today. Cell-based designs will be the rule in both user-specified functions and highly integrated standard products. Digital ASIC methodologies are also the key to cutting system design cycles. As our digital experience proves, suppliers who have advanced process technologies and fast, accurate design-automation tools will be the best equipped to deliver single-chip solutions.

Today, we have customers doing their own LinASIC designs using our advanced processes and design-automation tools.

Q. What role does manufacturing capability play in picking a supplier?

A. It is always a factor, and the need for efficient worldwide manufacturing facilities such as TI has in place will become even more important. Today's semiconductor market is global in nature. You can't serve worldwide customers from a single plant—you have to be "multilocal." This is particularly true with ASICs.

Q. Any other important factors?

A. Yes, I'd suggest that, in choosing a linear supplier, the designer find one he can live with for a long time. Close supplier-customer relationships are essential to the development of products that will provide the highest performance and lowest cost systems.

TI's Leadership Linear Processing Technologies

LinBiCMOS—Combines Advanced LinCMOS, digital ASIC CMOS, and up to 30-V bipolar technologies to allow the integration of digital and analog standard cells and handcrafted analog components on a monolithic chip.

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Advanced LinCMOS—An N-well, silicon-gate, double-level polysilicon process featuring improved resistor and capacitor structures and having three-micron minimum feature sizes.

Power BIDFET—Merges standard linear bipolar, CMOS, and DMOS processes and allows integration of digital control circuitry and high-power outputs on one chip. Primarily used for circuits handling more than 100 V at currents up to 10 A.

Multi-EPI Bipolar—A very cost-effective technology that utilizes multiple epitaxial layers instead of multiple diffusion steps to reduce mask steps by more than 40%. Used to produce intelligent power devices that can handle loads as high as 20 A and voltages in excess of 100 V.

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Our just-published *Advanced Linear Circuits* brochure examines more fully the changes taking place in analog system design and their impact on linear devices. The brochure also describes TI's leadership processing technologies and explains the performance improvements that result. **For your copy, call 1-800-232-3200, ext. 3407, today.**

TEXAS INSTRUMENTS

WASHINGTON INSIDER

SEMATECH PUTS ITS MONEY IN OPTICAL MASK-WRITING . . .

Sematech's first joint development contracts display a daring look into the future by the Austin, Texas, chip consortium and strong support for small, innovative equipment makers. "Sematech's really trying to experiment," says Dan Hutcheson, an analyst with VLSI Research Inc. in San Jose, Calif. Adds Bill McLean of Integrated Circuit Engineering Corp. in Scottsdale, Ariz.: "They're reaching a little bit, going away from the mainstream and looking ahead to the next wave of capital equipment." That was clearly the motivation behind Sematech's development deal with Ateq Corp., which uses a unique laser technology—instead of an electron beam—to produce the masks used in stepper systems to print circuit designs on silicon wafers. Sematech is helping the Beaverton, Ore., company complete an 18-month-old project to upgrade its Core-2000 reticle writer with new modules in the optical column and improved electronics and software. The resulting system should be ready for demonstrations by Christmas. □

. . . AS IT PROPS UP THE U. S. CHIP-MAKING EQUIPMENT INDUSTRY

The shared-cost development contracts Sematech is signing with U. S. equipment makers are rooted in a shrewd assessment of the state of the American industry. The chip-making consortium can't save the whole 150-company industry, analysts say, so it must pick and choose with the goal of preserving at least one viable U. S. source for every critical area in the equipment business. That's left some firms disgruntled, says Mark Reagan, an industry analyst at market researcher Dataquest Inc. in San Jose, Calif. But there aren't many alternatives. "They aren't a bank," he says. "They can't finance everyone." Sematech's deal to help GCA Inc. of Andover, Mass., make evolutionary improvements to its current I-line and excimer stepper systems represents a clear move to strengthen the strongest stepper supplier in the U. S., Reagan says. GCA has been overwhelmed by Japan's Nikon, which now dominates the wafer-stepper market, supplying systems to the likes of Intel, Motorola, and Texas Instruments. More joint development contracts will be awarded over the next several months to fund dry etching, multichamber vacuum cluster tools, metalization, and thermal processing. □

IS THE U. S. 'INSTITUTIONALIZING' TRADE FRICTION WITH JAPAN?

The Bush Administration is winning praise in industry circles for its hardball actions in naming Japan an "unfair trading partner" in both telecommunications and supercomputers, and for having the strongest fair-trade policy of any White House since World War II. But some industry watchers fear that turning up the heat on Japan too high and too fast could backfire. "I'm a little worried that with all of the ongoing investigations of unfair trading practices—on telecommunications, computers, semiconductors, and intellectual property rights—we may have institutionalized trade friction," says William Maxwell, vice president for international affairs at the Computer and Business Equipment Manufacturers Association. "It's created considerable uncertainty in the business community." But that's a risk that must be taken, says Bill Krist, vice president for international trade at the American Electronics Association. "The thing is, we do have a trade problem with Japan—there's no getting around it," he says. "In electronics alone, we have a $20 billion trade deficit that's growing." In telecommunications, the trade imbalance is worse still, says Pat Williams, director of government relations at the Telecommunications Industry Association. "The U. S. is the biggest market in the world, and it's the most open," he says. "Japan's is the second biggest and it's one of the most restrictive." Of the total U. S. telecommunications trade deficit, which is now $2.6 billion, $2.3 billion is with Japan. □

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EUROPEAN OBSERVER

INMOS TRANSPUTER TO BE BUILT IN TEXAS

The hunt for a second source for the Inmos Transputer has ended—in Texas. Production of the 32-bit parallel-computer chip that can churn away at 1.5 million floating-point operations/s is to start before year's end at the Carrollton, Texas, plant of SGS-Thomson Microelectronics. The Franco-Italian group took over from the chip's English designer, Inmos Ltd., earlier this year. Transfer of the Inmos 1.0-μm CMOS process will begin this summer, according to Graham Trickey, micro marketing manager. He says that the move will ensure that there is a second source for the Transputer, which he says is now designed into more than 1,000 projects. Other Inmos products, including its line of static random-access memories and graphics controller chips, are also likely to be made in the Texas plant. □

PAN-EUROPEAN ISDN TRIALS TO START, AT LAST

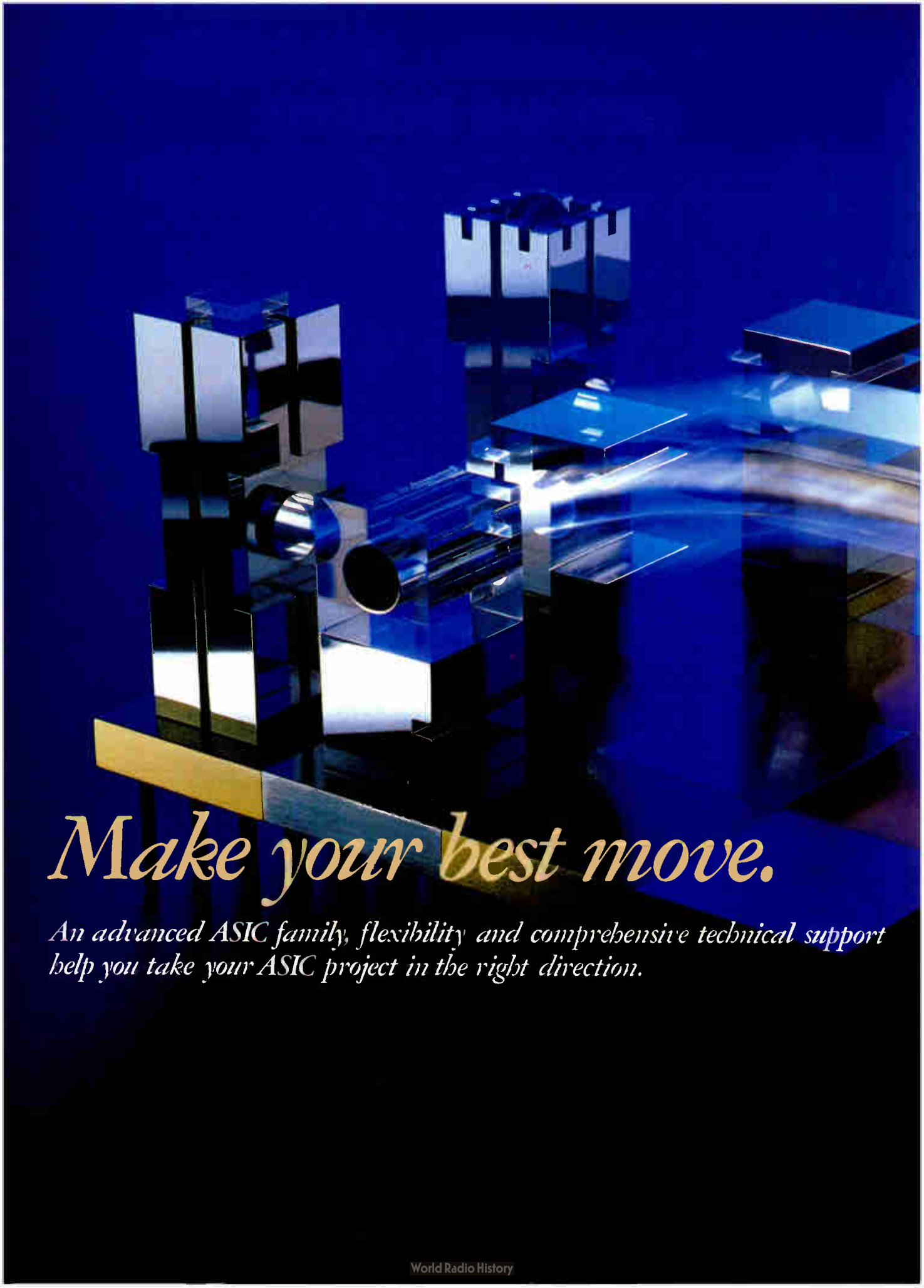
Look for pan-European trials of 2-Mbit/s switched digital telecommunications service to begin now that a memorandum of understanding has been signed by 14 countries and 17 telecommunications operators belonging to the European Postal and Telecommunications Conference. The European Broadband Interconnection Trial will form a backbone network that will support pilot application services developed under the Commission of the European Communities' RACE (Research into Advanced Communications for Europe) program. Still, work on a pan-European integrated services digital network is three years behind schedule. Although full-scale ISDNs have been launched in West Germany and France, and trials are in progress in Britain, Belgium, Italy, and Holland, there are no standards that allow direct connections between networks. Plans set out by the Commission of the European Communities in 1986 called for the setting up of transcontinental ISDNs in time for the Single European Market by 1992. To reach that goal, standards have to be in place by the end of this year—a target that is unlikely to be met. □

CAD PROGRAM AIMS TO AVERT VLSI ENGINEER SHORTAGE

To combat a potential shortage of engineers and scientists skilled in the design and manufacture of VLSI circuits, the Commission of the European Communities is going to issue computer-aided-design work stations, test equipment, and software to a "kernel group" of 58 universities and polytechnic colleges in 14 European nations. In addition to the equipment, which will be procured centrally, members of the kernel group will receive funding for teaching posts and for advanced training for lecturers. Another 60 institutions, designated as associate members, will get equipment at reduced prices, and all 118 participants will be given access to silicon foundry services. The program, projected to cost about $12.5 million, is expected to double the number of VLSI researchers and engineers trained during the next three years. □

U. S., CANADIAN MOBILE NETS TO USE ERICSSON'S MOBITEX

A unit of the Swedish telecommunications giant L M Ericsson is going to provide the equipment to build nationwide mobile data-communications networks in Canada and the U. S. that may be interconnected. The work will be done by Ericsson Radio Systems AB of Stockholm, using technology based on the company's Mobitex system. American Mobile Data Communications Inc., a subsidiary of RAM Broadcasting Corp., plans to spend $55 million on the U. S. network; the Canadian version will be built by Cantel Inc. Mobitex is a cellular data network that uses digital packet-switching technology. It was developed in Sweden by Eritel, a joint-venture research-and-development firm owned by Ericsson and Swedish Telekom. □



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■Telex:J27662 OKIDENED

Oki Electric Europe GmbH
Hellersbergstr. 2, D-4040 Neuss 1,
West Germany
■Tel:2101-15960 ■Fax:2101-103539
■Telex:8517427 OKI D

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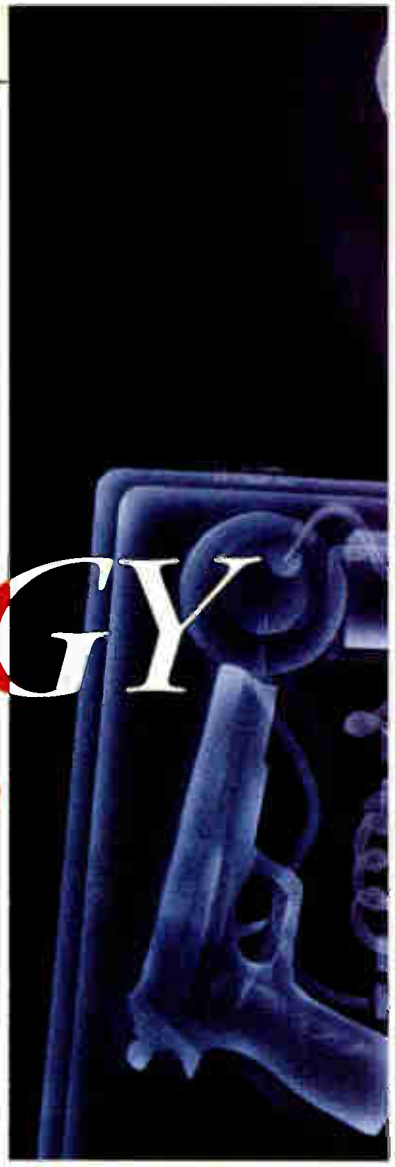
Circle 31

TECHNOLOGY VS. TERROR



The price tag for keeping bombs out of our airplanes: over a billion dollars in detection and access-control systems

BY PATRICK FLANAGAN

The horror of Pan Am Flight 103's explosion over Lockerbie persists. It is now known that about 11 ounces of plastic explosive, molded inside a cassette recorder, were deliberately detonated last December 21, killing 259 passengers and crew on board and 11 people in the Scottish village below. Airline officials, government leaders worldwide, grieving relatives, and airline passengers all say it cannot—must not—happen again.

However compelling the sentiment, that's a tall order. With possibly one exception (see p. 49), no airports or airlines have a security system in place that could have thwarted the terrorist methodology or detected the materials (see p. 51) that caused the Lockerbie tragedy. "X-ray detection of explosives has not been effective since terrorists stopped using little round bombs with smoking fuses," says Ronald Armstrong, chief of security for Qantas, the Australian airline. "We badly need new technology for use in baggage checking and contents identification."

New technology is indeed on its way. The emphasis today is on detecting explosives in checked and carry-on baggage. The newest systems fall into two categories: vapor detection devices that "sniff" the air, setting off an alarm when a chemical element found in explosives is detected; and thermal neutron-activation (TNA) devices that sense characteristic gamma radiation from chemical elements, such as the nitrogen that is common to high explosives.

The advantage of vapor detection and TNA is that both technologies require minimal human interpretation. Although conventional X-ray detection equipment is also being greatly improved, it still depends upon the alertness, training, and competence of the person monitoring the X-ray picture.

However, the greater security provided by vapor detection and TNA will come at a steep price. Vapor detection units are projected to sell for $100,000 when produced in quantity, and none is yet in everyday operation, while TNA units will cost $750,000 once production begins. In comparison, the enhanced X-ray machines, which are coming into use in airports worldwide, cost only $35,000 to $50,000.

Despite their high cost, six TNA units already have been purchased by the Federal Aviation Administration in Washington. The first is going into operation this summer at the Pan Am terminal in New York's John F. Kennedy International Airport. The locations for the five other units are still being determined, with one likely to be London's Gatwick Airport, where on-site trials are about to begin.

Which of the world's airports pose the highest security risk? Security experts name 45 in Europe and the Middle East as prime targets for terrorism or likely entry points for explosives. None of the high-risk airports is in the U. S., but included are the capital cities of almost all other major industrialized nations, as well as Bombay, Cairo, Riyadh (Saudi Arabia), Istanbul, and Manila. Second-tier high-risk entry points include Nice, Basel, and Vienna.

Other than airports in Athens, Frankfurt, London, Paris, and Rome, airports on the high-risk list aren't likely to receive the latest in explosives-detection devices soon because of the cost. In the 45 high-risk airports outside the U. S. that are served by U. S. carriers, the Air Transport Association estimates that 66 TNA units and 171 vapor detection devices would be required to adequately cover U. S. carriers—at a total cost of $66.6 million. If airlines pay the total cost of security equipment, the carriers that service the most high-risk airports would be hardest hit—Pan Am, for instance, flies to 32 of the 45 airports that occupy spots on the risk list. In contrast, United Airlines and Piedmont fly to only one high-risk airport. Add to that what overseas airlines would have to spend, along with the cost of equipping the biggest domestic airports with the same protection, and the total nears $200 million.

The total market for equipment to detect explosives could be worth more than $1 billion, estimates Tina Rizopoulos, an analyst with Paine-Webber Inc. in New York. That figure includes 260 U. S. State Department embassies and consulates abroad and 1,400 airport concourses in the U. S.

The main line of defense against bombs concealed in checked baggage for the foreseeable future will be TNA systems similar to those marketed now by Science Applications International Corp. in Santa Clara, Calif. Snoope, or system for nuclear observation of possible explosives, was developed with the support of an $8.4 million contract from the FAA for six TNA units. Company officials say they've been in high gear since 1985, when a wave of terrorist incidents spurred the FAA to move up its timetable for developing advanced detection equipment.

With Snoope, a piece of luggage or a parcel—up to 16 in. wide, 26 in. deep, and of any length—enters the 13-ft-long device on a conveyor belt. If the system detects the possibility of explosives, an alarm sounds. Ten pieces of luggage can be inspected per minute, meaning that one Snoope unit can screen the luggage for a jumbo jet in about an hour, which is considered workable. About 4% to 5% of baggage triggers the alarm, based on tests in two California airports. At that rate, 20 to 30 hand searches per jumbo jet are required.

In a TNA system, unopened luggage is bombarded with neutrons generated by 300 μg of Californium-252 sealed in a steel container that can withstand government-standard underground blast tests. Neutrons, which have greater penetration power than X rays, cause elements in baggage to emit characteristic, high-energy gamma rays. These in turn are sensed by detectors linked to a digital computer programmed with a decision-making algorithm. The computer triggers an alarm when elements found in explosives, or explosive-masking metals such as cadmium, are detected. Luggage that triggers an alarm is diverted by a conveyor to a secure inspection area, and information as to why the bag was routed to the inspection area is displayed on a computer screen.

Snoope operators are exposed to less than 200 millirems of radiation per year, about the equivalent dosage of working in a conventional nuclear facility—a level that according to government standards is not hazardous. Snoope has met the licensing requirements of the Nuclear Regulatory Commission and the California Department of Health Sciences.

TNA will be employed to screen-checked baggage only. Speed is not so much of a concern when this function is separated from waiting passengers; questionable luggage can be diverted to secure areas for searches. Some sort of baggage-matching technology will also be incorporated into this system, ensuring that when passengers pass through the boarding gate, computers can verify that all are present and accounted for without cabin personnel having to count heads—possibly the one aspect of more rigid security that will actually accelerate departures.

A primary reason that TNA is not planned for passenger screening is concern about radiation exposure. Stories have appeared in the press raising concerns about radioactive baggage; by keeping the public away from TNA screening, officials hope that such concern can be minimized. In actual tests involving 40,000 pieces of luggage, a radiation alarm was triggered twice:

in both instances, the radiation was caused by legally transportable objects emitting low-level radiation.

"TNA is not dangerous," insists Tsahi Gozani, vice president and chief scientist at Science Applications International, "but we aren't even suggesting that TNA be used on people. It's the public perception that's the problem." Thus far, U. S. nuclear regulatory and testing agencies agree with this assessment.

This leaves an important role for vapor detection and enhanced X-ray equipment. If portable sniffers continue to prove their effectiveness, as many as 50 could be produced this year, at a cost of $125,000 per unit. If, as some estimates project, the number of units produced reaches 250 or more next year, the per-unit cost could drop below $100,000.

The first portable device based on vapor detection technology was shown at the Paris Air Show in June, after having undergone testing in the U. S. The underlying technology came out of medical research for determining the amount of nitroglycerin, a drug commonly used to treat chest pains by dilating blood vessels, in a person's bloodstream. Since nitroglycerin is a key component in explosives, there was a clear opportunity for technology transfer.

Currently, the leading vendor of vapor detection equipment, Thermedics Inc. of Woburn, Mass., offers two types of devices. The Egis explosives-detection system is a hand-held device that, when run around the sides of luggage or a parcel, draws an air sample into a chamber, where a classified number and type of chemical and electronic analyzing instruments determine if explosives are present. The analysis takes about 30 seconds and is sensitive to the presence of vapors on the order of one part per 100 trillion.

The same device, marketed as Sentor and armed with a different set of analytical instruments, can detect controlled substances and drugs in small quantities. About one reading per hundred is a false alarm.

A walk-through version of the Egis system, called SecurScan, has also been tested. The detector, a 6-by-8-ft closed booth, swirls air around each passenger who steps inside. Then the air is sampled using the same technology found in the Egis portable unit.

The main drawback to using SecurScan is that it takes 30 seconds to get a result. Passengers are inside the unit for only a few seconds and must enter a holding area until the results are analyzed. This means that at least six people have to maintain their place in the "post-sniff" queue. Thermedics has SecurScan on hold for now while it works on trimming processing time to under 10 seconds, or about what it takes travelers to pass through a metal detector and reclaim their X-rayed hand baggage.

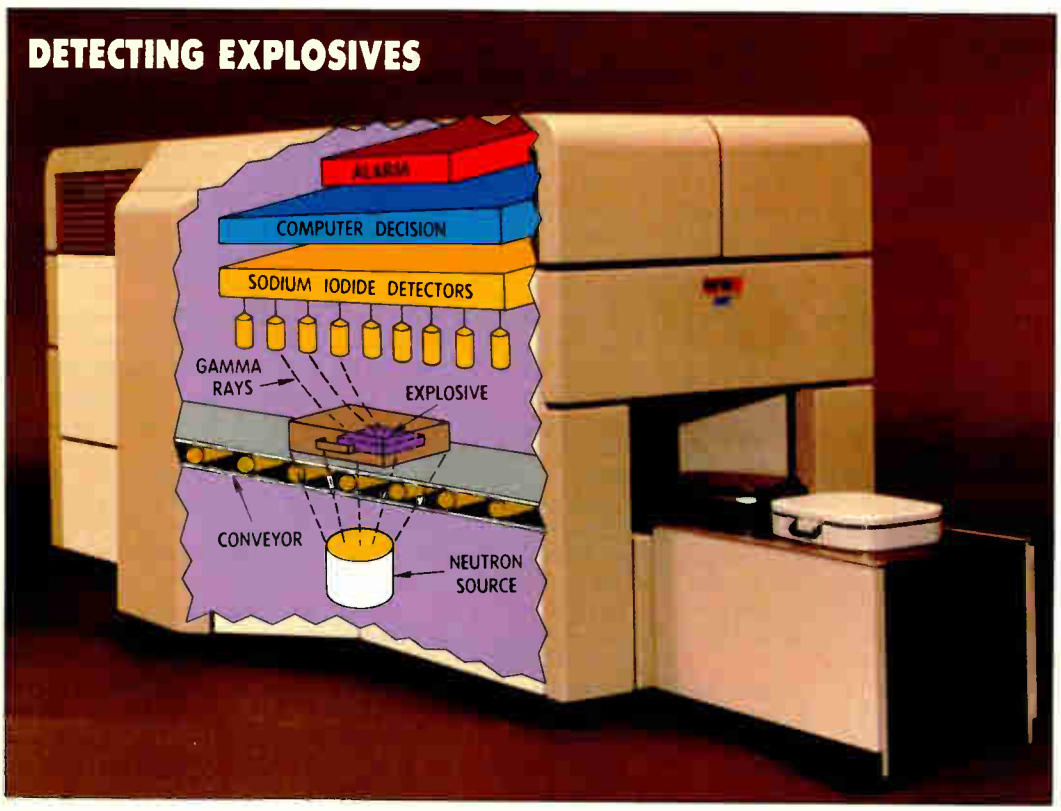
The impact is that passengers would spend two or three minutes gaining access to the secure area that leads to their flight. Their baggage would be sniffed at the earliest possible moment in the security check. The results would be given to security personnel 30 seconds later while they are X-raying carry-on baggage and profiling passengers. Checked luggage could also be sniffed, using a second unit, in airports where TNA devices are not available.

The entire screening process would take about two minutes per passenger, compared with a few seconds under current procedures, once the screening process began. When many passengers arrive at the same time, delays would be inevitable, particularly when only a limited number of vapor detection devices are in place at an airport.

Advanced X-ray technology that differentiates between organic and inorganic matter is a boon to security workers who peer for hours on end at video images of baggage and parcels passing through airport X-ray machines. Two systems, E-Scan from Astrophysics Research Corp. in Long Beach, Calif., and Hi-Mat from Heimann Systems Co. of Iselin, N. J., classify items based on the average atomic number of the materials in the item being X-rayed.

Colored displays show organic materials in orange and inorganic items in blue. Very dense objects are displayed in green. The systems permit easier identification of potential problems: weapons show up in a bright green, plastic explosives are displayed in orange, and homemade bombs containing chloride and sugar appear in green.

Most organic materials consist mainly of hydrogen (atomic number 1), carbon (6), nitrogen (7), and oxygen (8). Common metals, as well as silicon (14) and calcium (20) found in glass, have atomic numbers from 13 (aluminum) to 30 (zinc). Materials with low atomic numbers attenuate X-rays differently than



In Snoope from Science Applications International Corp., baggage passes through a cloud of thermal neutrons and the resulting gamma rays are analyzed by computer.

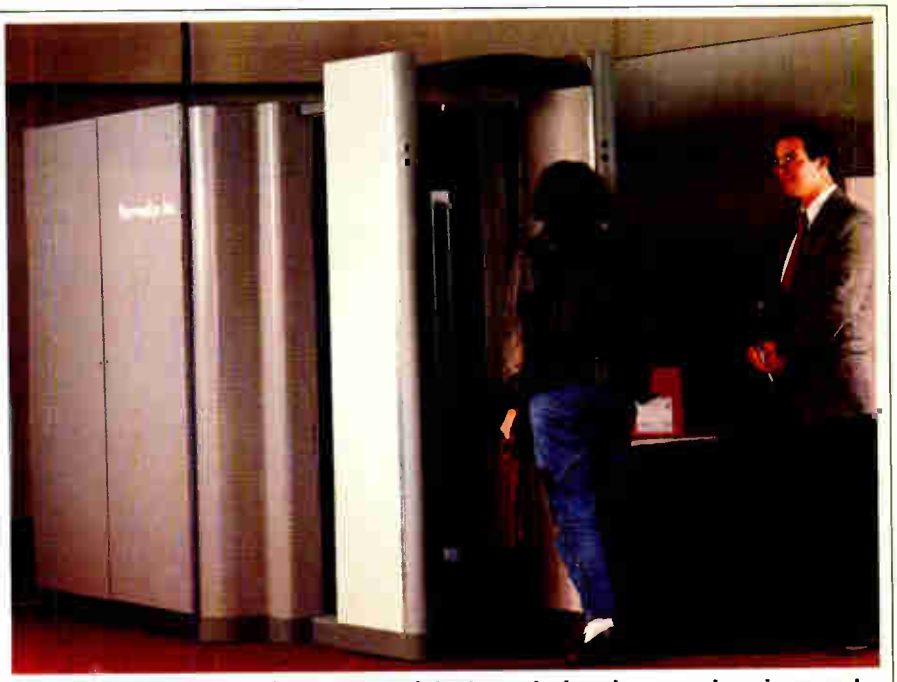
materials with higher atomic numbers. By taking X-ray images at several kV levels simultaneously, the machine calculates the amount of attenuation, permitting organic and inorganic materials to be segregated and displayed through orange and blue filters in varying degrees of density. When overlapping organic and inorganic materials are present in the same object, or density does not permit penetration, the blue and orange filters are both used, producing green.

E-Scan and Hi-Mat vary slightly in terms of proprietary technology but appear to work equally well for weapons. To increase accuracy, a black-and-white display is used beside a color one. Comparing the two images helps security personnel differentiate between the harmless and the potentially dangerous. If a plastic explosive, which can be rolled out like pie dough, were used to line a suitcase, it would immediately be spotted. The systems are also useful in detecting narcotics hidden inside objects.

The U. S. government is underwriting much of the development costs for explosives-detection technology, largely through the FAA. In addition, classified amounts have been spent by the State Department, the Federal Bureau of Investigation, and the Secret Service.

The airline industry thinks the government should pay more, however. "Terrorism is not an act against an individual airline or group of passengers, but an act to influence the policies of governments," says Richard F. Lally, a former FAA official who is now vice president of security for the Air Transport Association. "The target is the U. S. flag, not a specific carrier, and individual airlines and passengers are not responsible for protecting themselves against acts of government-sanctioned terrorists," he says.

The sense among U. S. legislators is that tax funds will continue to be spent on airport security, but taxpayers will not bear a large burden because most are occasional fliers and many never fly. Rep. Joseph Kennedy (D., Mass.) has proposed that a $5 to $10 surcharge be placed on plane tickets to cover the cost of installing explosives-detection equipment worldwide, placing the primary financial burden on passengers.



The Thermedics SecurScan system detects explosives by sweeping air around passengers and performing a chemical analysis.

Much conflict and confusion remains as to who will set new rules and standards for air-travel security. In the U. S., the FAA is top dog; it issues rulings, funds technology research, and is generally responsible for the flying public's safety. Individual airports are operated by governmental bodies in all but rare instances, and the operator, in conjunction with its tenants—the airlines and vendors supplying food, fuel, and maintenance—are responsible for carrying out FAA mandates. Each airline pays for its own security equipment outside the U. S., which often is shared with other carriers.

Internationally, the United Nations-affiliated International Civil Aviation Organization, headquartered in Montreal, sets standards worldwide under what is known as Annex 17. Compliance is voluntary among the 160 member nations, and because the ICAO has no enforcement powers, it's not unusual for countries to modify or ignore its provisions. Some nations, such as the U. S. and the UK, have reasonably effective security systems. Others can often be easy entry points for terrorists; in February, the ICAO passed a resolution urging its members to increase aid to countries that need more financial or technical assistance.

The FAA has issued a ruling that all foreign airlines flying to and from the U. S. submit security plans for FAA approval. In just one example of how difficult it is to get international cooperation on airport security, other governments immediately saw this as an attempt to impose U. S. security guidelines worldwide, and France, for one, has issued a formal protest. This is expected to blow over with some diplomatic face-saving.

When it comes to worldwide airport security, says FAA security chief Raymond Salazar, "we must all basically strengthen together if we are going to fight a common enemy." In Europe, few really disagree. "The problem of terrorism has done a lot to break down bureaucratic barriers," says Aurelio Cozzani, police director for the Italian Interior Ministry.

International air travelers are obviously at the greatest risk from terrorists; while hijackings have occurred inside the U. S., no terrorist-linked aircraft bombings have—yet. U. S. airport security rates fairly high, except for the vulnera-

EL AL—A LOW-TECH SOLUTION

El Al, the Israeli national airline, employs a preflight security system as highly efficient as it is low tech. Passengers arrive two and a half to three hours ahead of departure and are "profiled" at check-in, answering such questions as: Why are you taking the flight? Do you know anyone at your destination? Are you carrying any gifts as a favor to others?

Phrased to preclude simple yes or no answers, questioning can take minutes or hours, as El Al agents go back over points, trying to trip up anyone who is lying. Any suspicion results in more interviews. Also, all baggage is searched by hand or X-rayed, and no one without a ticket gets past the reception area. Luggage left unattended for more than a few seconds is carted away.

Though El Al has never had a terrorist incident on any of its flights, experts say the airline's solution is limited in scale because it is so labor-intensive and requires the extraordinary cooperation of passengers. "Major U. S. airlines are 200 times or more the size of El Al," says Raymond Salazar, FAA head of security. FAA rules do require profiling all U. S. passengers at check-in, but the typical exchange has no bearing on security. □

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bility posed by allowing curbside baggage check-in. According to Rome's airport police chief, Mario Esposito, "Most scrupulous after the Israelis are the Americans." But much more remains to be done in Europe, the Middle East, and Latin America.

U. S. experts view the total airport-security solution as grounded in technology, not people. "We want the human being out of the loop," says Fred Farrar, an FAA spokesman. "People get tired, people get distracted. Instead, we want to find a way to automatically set off an alarm any time a bomb is headed for a plane." This requirement seems to give the nod to systems like TNA and vapor detectors.

With color-enhanced X rays, plastic explosives appear orange while weapons are bright green.

Yet neither of these technologies can detect guns and other weapons, so some form of conventional or advanced X-raying must be maintained to scan carry-on baggage and passengers. FAA inspectors regularly attempt to smuggle phony weapons aboard aircraft; last year, they succeeded in doing so 12% of the time—hardly a reassuring figure.

Lyle Malotki, program manager for security research at the FAA, points to areas where existing technology remains to be applied. "The use of embedded microchip processors is progressing rapidly for access security systems," he says. Opportunities exist for electronics vendors as well in baggage-matching systems—even though bar-code scanners can now be found in small-town supermarkets, airports haven't put anything together. "No one system has emerged as both feasible and economical," says Malotki.

Art Kosatka, director of technical services for the Airport Operators Council International, sees big market opportunities in complying with the FAA ruling on controlled access to secure areas of airports. "Potential vendors need to work together, rather than approaching airport operators with bits and pieces of an overall system," he suggests. The FAA issued a ruling in February that requires operators at 269 U. S. airports to install systems that guard against access to secure areas by unauthorized personnel. The systems must be installed within 18 to 30 months, depending on the number of passengers using the airport.

The technology for such systems already exists and is used by many corporations where limited access is required, but the procedures for implementing it at airports are not as cut and dried.

The major difference is in the number of employees who work for different vendors who require access and the number of access points. JFK airport in New York has 1,500 access points in 50 passenger-terminal buildings that are used by 18,000 people—the cost per door for electronic access control at JFK is estimated at $18,000, or a total of $27 million.

No one knows for sure exactly what airport operators will have to spend to beef up security around perimeters to comply with the February FAA ruling. The FAA estimates it will cost $169.9 million in 1987 dollars, but Wilfred Jackson, director of airport operations at the Baltimore-Washington International Airport and chairman of the Airport Operators Council International Safety and Security Committee, says that the overall cost may be 10 times that amount, given the ambiguities of the rule and the lack of clear guidance as to what will be actually required and how extensive these systems must be.

Not any company can walk in and sell security systems, warns Kosatka. "The bureaucratic nature of airport purchasing is cumbersome and unfamiliar," he says; what is needed are vendors that have the ability to integrate computer, telecommunications, and access-point terminals.

Overall, the bottom line for the flying public everywhere will be increased scrutiny before boarding an airplane. Checked baggage will be carried to the airline counter and undergo some form of bomb detection behind the scenes. This means earlier arrival, but it should not be perceived as a major inconvenience since most international airlines have been gradually creeping check-ins forward for years on international flights.

Stricter enforcement of predeparture arrival times is definitely in the offing as airlines centralize security screening to get passengers through the process as soon as possible once they enter the terminal. When leaving the public area of the airport, carry-on baggage will go through an X-ray screening for weapons and an anti-bomb detection device, most likely a vapor detector. Passengers will pass through a number of walk-through devices. Conventional metal detectors will continue in service, but they may be augmented by infrared sensors that can detect plastic guns. These sensors detect spots on the body where the density of the plastic weapon blocks heat from the skin.

Clearly, more partnerships can be formed between the international electronics industry and those responsible for ensuring airport security. With 6.5 million flights a year on U. S. carriers alone and 700 million pieces of luggage, much cooperation is needed to find potentially lethal needles in an immense haystack.

Additional reporting by Tobias Naegele

THE ENDURING TERROR OF 'PLASTIQUE'

The most deadly trademark of terrorism is nothing new: the explosive was developed during World War II by the British, who called it "plastique" because it could be molded into any shape at any temperature. Its basic ingredient is cyclonite, a nitrogen-oxygen compound.

Besides its versatility and imperviousness to X-ray detection, plastique is the most destructive explosive, one-third more powerful than TNT. Just 11 ounces of plastique caused the crash of Pan Am Flight 103, and two pounds could blow any airplane out of the sky, say experts. The destructiveness comes from the power to eject debris as projectiles at more than 25,000 feet per second. By comparison, the slug from an M16 infantry rifle travels at 3,000 feet per second.

Moreover, the march of technology applied to detonating it has made plastique even more fearsome. The detonators themselves are now no larger than the eraser on a pencil. Miniaturization has made bomb timers and barometric—altitude-sensitive—triggers easy to disguise as well. The detonator for the bomb aboard Flight 103 may have been hidden in the lock of a suitcase, making detection by X ray difficult. □

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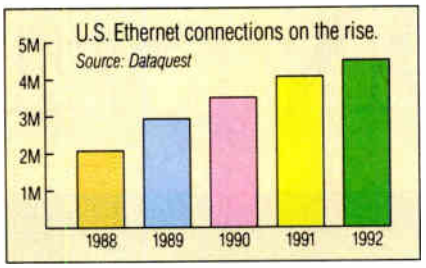

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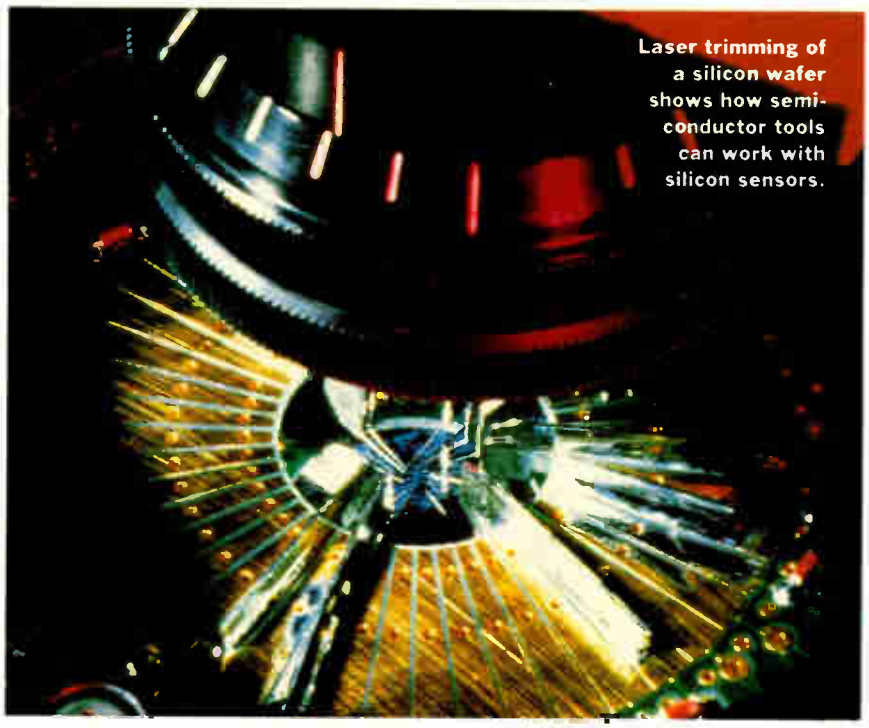
Circle 14

THE VENDORS ARE BETTING THEIR CHIPS ON SILICON SENSORS



Laser trimming of a silicon wafer shows how semiconductor tools can work with silicon sensors.

Since the early 1980s, the advocates of silicon micromachining have been touting the technology's potential to revolutionize the field of sensors and carve out vast new commercial markets. Now there are signs that silicon micromachined sensors may finally be primed to live up to that billing. Indeed, some market watchers are predicting explosive growth for the technology across a broad range of applications.

The new optimism stems from converging trends. New techniques such as silicon fusion bonding and the use of electrochemical etch stops are producing a new generation of commercial micromachined silicon sensors that are more complex and offer higher sensitivity and performance than their predecessors—all at a lower cost.

Research advances in the field are also coming rapidly, promising a wider range of even more sophisticated silicon sensors by the early 1990s.

For example, one of the latest laboratory techniques is called surface micromachining. It involves building up structures in polysilicon or other materials on a silicon surface, as opposed to conventional commercial approaches that rely on carving out structures in the silicon by selectively etching down into a wafer.

Fueling all of the activity is the continuing proliferation of microproces-

BY WESLEY R. IVERSEN

sors. As computing power gets cheaper, the sensors needed to link a central processor to the outside world are becoming a larger portion of overall system cost. In many cases, the availability of reliable low-cost sensors can make or break a development project. And as system designers rely increasingly on distributed computing solutions, there's an ever growing need for so-called smart sensors that incorporate more intelligence at the sensing site, either in the package or integrated onto the sensor die itself.

It's a trend that's spurring an intense effort in low-cost sensor development. And many vendors—ranging from traditional broad-based sensor suppliers to Silicon Valley startups—are betting their chips on micromachined silicon devices.

"Probably no other sensor technology under development today will have as much impact in as many markets over the next 20 years as microminiature silicon sensor technology," declares Paul Chapman, director of technology at sensor-industry leader Micro Switch, a division of Honeywell Inc. in Freeport, Ill.

RAMPING UP. "We see a definite ramp-up," says Joseph R. Mallon Jr., chief operating officer at NovaSensor, a Fremont, Calif., startup that is betting its future on micromachined silicon. The company says it is already shipping silicon sensors at a rate of 6 million units annually and has capacity in place to support production of more than 200 million devices per year. NovaSensor projects 1989 revenues at $12.5 million, but expects to become a $100 million company within the next five years.

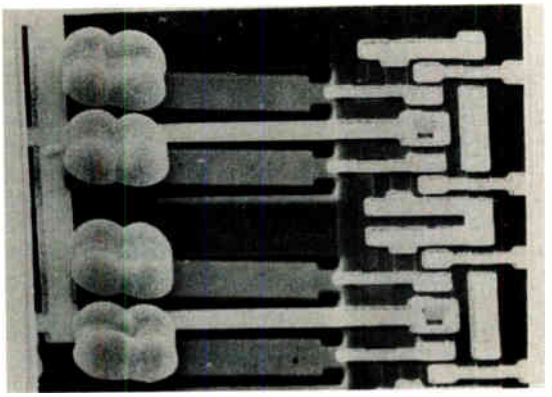
The growing excitement over micromachined silicon stems from a variety of factors. For one thing, besides its well-known properties as an electrical material, silicon is an almost perfect mechanical material for building sensors. Though brittle, silicon has an elasticity greater than stainless steel's and a low mass equal to that of aluminum. Unlike most metals, it can be repeatedly stressed without weakening or deforming. Silicon is also piezoresistive, exhibiting a large change in resistance when subjected to stress.

These and other attributes make possible a variety of sensor types based on tiny, three-dimensional moving mechanical structures that are literally sculpted in silicon by the micromachinist, to provide quick and accurate sensing of real-world phenomena.

And because many of the processes used for micromachining—such as masking, etching, and selective doping—are common to integrated-circuit processing, it means that silicon sensors can be made in high volume using semiconductor-style batch-manufacturing techniques.

Silicon micromachined sensors have already shown startling success in some market categories. Today, low-cost silicon pressure sensors have all but replaced conventional strain-gage sensing devices in high-volume, cost-sensitive jobs in automotive manifold pressure sensing. General Motors Corp.'s auto-electronics unit, Delco Electronics Corp., builds 6 million micromachined silicon pressure sensors a year. Motorola Inc. likewise supplies Ford, Chrysler, European carmakers, and others with about 7 million silicon pressure sensors annually.

What's more, silicon micromachined parts have opened up brand-new high-volume markets in applications such as disposable blood-pressure sensors, a business that topped 6 million units last year.



In a tiny accelerometer, a silicon sensing element is integrated with the driving electronics.

Automotive silicon pressure sensors currently sell in the $10 range in volume, while blood-pressure sensor chips can be priced as low as $2 to $4 each. Both types are rapidly displacing earlier sensor solutions that were bulkier and typically three to four times more expensive. According to NovaSensor, micromachined silicon devices already account for about 60% of the total $600 million U. S. pressure sensor market, with prospects for capturing more than 80% by the mid-1990s.

But micromachined-silicon vendors are now setting their sights on new targets. "Pressure sensors are still the highest-volume business. But the two fastest-growing segments are in accelerometers and in custom microstructure sensors," says James Knutti, president of IC Sensors in Milpitas, Calif.

Knutti is just one of the industry players who believes that silicon accelerometers could be the next big commercial volume runner for the fledgling micromachining industry. "Accelerometors are catching up to pressure sensors very quickly," he says. "The curves are going to slam at each other after some period of time."

As with pressure sensors, the major market driver here is the automotive industry, which needs accelerometers in high volume at low cost for sensing jobs in air-bag and smart-suspension systems. Because of long automotive design cycles, volume applications are still two to three years away. But the prospect of this lucrative new market segment has got silicon sensor makers watering at the mouth.

For smart suspension alone, the new automobiles will use from one to ten accelerometers apiece, says Janusz Bryzek, NovaSensor's chief executive officer. "Even if we get only 10% of the new car market, as many as 28 million acceleration sensors could be needed per year," he says. At a price of $5 to $15 per sensor, "this is a $200 million to $300 million market."

Bryzek, like others, also sees momentum in a multitude of new applications. These include jobs in heating, ventilation, and air conditioning; industrial applications for automated factory control; and aerospace. That's not to mention a variety of consumer applications ranging from appliances to wrist-worn computers for scuba diving and new classes of home gadgetry.

The market watchers agree with the industry executives. Most forecasters expect gains for silicon micromachined devices for sensing a variety of parameters beyond pressure. For example, UK-based McIntosh Consultants Inc. sees the world market for micromachined silicon sensors other than pressure sensors growing from $21.3 million in 1987 to $204 million in 1990.

The firm sees the biggest growth for flow and acceleration sensors, which will each top $50 million by 1990, according to McIntosh. But the British consultants also see growth elsewhere, notably in silicon devices for sensing temperature, force, and chemicals.

Another market watcher, Frost & Sullivan Inc. in New York, concurs, projecting the U. S. market for all types of semiconductor sensors growing from $340 million in 1986 to $534 million in 1990. And that's above and beyond micromachined mechanical parts such as miniature nozzles, channel and flow restrictors, and valves, all of which are also expected to see major-league growth.

Other prognosticators vary widely in their predictions and categorize the sensor and microactuator markets in different ways. For its part, NovaSen-

sor projects that emerging markets for silicon sensors and microstructures of all types could amount to $3.6 billion worldwide by the year 2000.

Micromachining traces its roots to 1954, when a Bell Laboratories research team discovered a piezoresistive effect in silicon. But, says NovaSensor's Mallon, "the real basis for micromachining is at the universities—particularly Berkeley, Stanford, and Case Western Reserve—and at places like IBM Research in San Jose." It was at laboratories such as these, he says, that "a whole bunch of tools for machining of silicon first became available in the late 1970s."

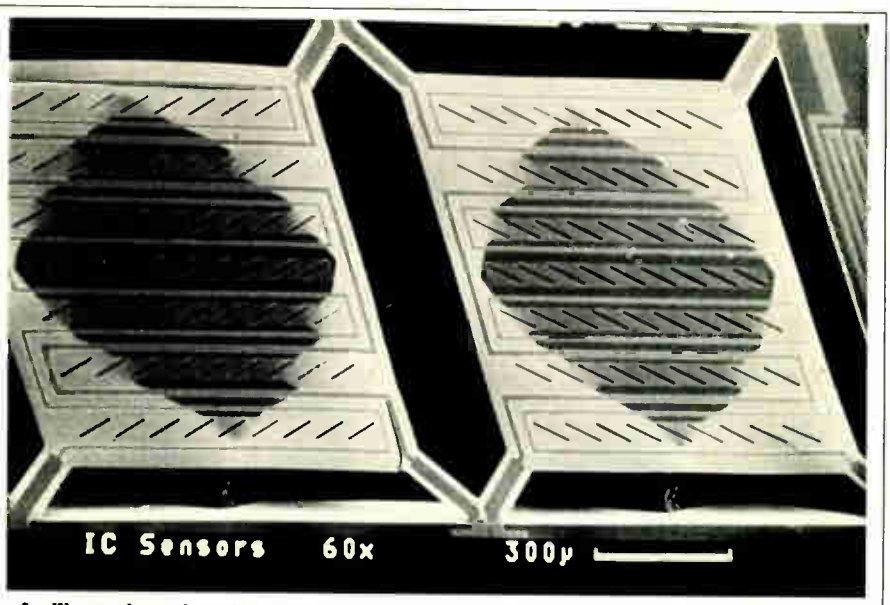
Today's commercial silicon micromachined sensors are based on a variety of mechanical structures. For example, a piezoresistive silicon pressure sensor typically relies on an ultrathin silicon diaphragm or membrane that can vary in advanced devices down to only 1.0 or 2.0 μm in thickness. Most commercially available pressure sensors, however, still rely on diaphragms typically around 50-μm thick, says Robert L. Tucker, a product device engineer at Motorola's Small Signal and Sensor Division in Phoenix.

The pressure sensor's diaphragm typically spans a cavity that is anisotropically etched from the back side of a bulk silicon wafer. Strain-gage resistors are put down on the surface of the membrane, often in a Wheatstone bridge configuration, using techniques such as diffusion, film deposition, or ion implantation.

PREDICTABLE CHANGE. In operation, when pressure is applied, the membrane flexes, and stress induced on the resistors causes a corresponding and predictable change in the sensor's output voltage. Capacitive silicon pressure sensors can also be fabricated using similar diaphragm structures that serve as one capacitive plate. In this scheme, the other plate is formed on a solid mechanical platform such as glass, which is bonded to the silicon to make the sensor.

A variety of other mechanical structures are employed in other sensor device types. Piezoresistive accelerometers, for example, frequently rely on tiny, diving-board-like bending beams attached to a seismic mass that moves under the influence of acceleration. These devices are read from the output of strain-sensitive resistors, which are placed at points of maximum stress on the beam. Still other micromachined sensors take advantage of silicon's high thermal conductivity for sensing parameters like temperature, flow, power, and thermal radiation.

For example, commercially available mass air-flow sensors from Micro Switch rely on a tiny heater flanked by two temperature-sensitive resistors, all made with thin-film metal, all thermally isolated by deposited insulators, and all suspended over a silicon trench. Flow rates are read when a gas moving through the channel transfers heat to the central element, causing temperature differences in the two resistors. The resulting change in resistance between the two is directly proportional to the flow.



A silicon piezoelectric pressure sensor relies on a diaphragm or membrane that may be just 1.0 or 2.0 μm thick in more advanced devices.

Besides the innate suitability of silicon for many sensing tasks, silicon micromachining practitioners also have another big element going for them: they are riding the coattails of mainstream IC technology.

This brings with it the advantages of available high-quality ultrapure starting materials, along with advanced processing, batch-manufacturing, and packaging techniques—all of which can be borrowed by the micromachinist. It means too that in high volume, silicon sensor learning-curve yields and cost reductions can mimic those seen with electronic circuits. Compatibility with IC materials and processes also means that micromachined silicon sensors can be integrated on the same chip with electronic support circuitry.

Based on some economic lessons learned in the marketplace, however, some silicon sensor makers are now backing off on the once ballyhooed concept of the monolithic "smart sensor." This device was to integrate vast amounts of intelligence along with all of the sensor suport circuitry on the same die with the micromachined sensing element.

As Chapman at Micro Switch puts it, "What we're trying to do is not make such a big deal any more about whether or not the associated electronic circuitry is on the same piece of silicon [with the sensor], but rather on whether it resides in the same package." Indeed, sensor makers say that in most applications, it is still not economically justifiable to integrate large amounts of circuitry on-chip with a sensor. "The industry is still well away from putting much smarts on the sensor chip for most applications," agrees Mallon at NovaSensor. "The products you can buy today basically have the intelligence in the package."

"We do build smart parts for people, but they're in a definite minority," says IC Sensors' Knutti. In most cases, it is cheaper to house even simple support circuitry for signal conditioning and signal amplification on a separate chip, he says.

At Delco Electronics, engineers reached a similar conclusion when they set out a few years ago to design a next-generation silicon pressure sensor to meet the needs of the European automotive market.

"Like most people in this business, we had been searching for the Holy Grail," says Robert M. Burton, manager of sales and program management at Delco, in Kokomo, Ind. "And to most people, that means a single-chip, all-silicon approach." But Delco determined that "the technology step was too far down the road for us to wait on," he says. "What we were looking for was a reduction in size and cost and some improvement in reliability. And a couple of years ago we decided we could meet most of those objectives by taking a two-chip approach."

The result is the new two-chip, all-silicon automotive pressure sensor that Delco is introducing this month. "It

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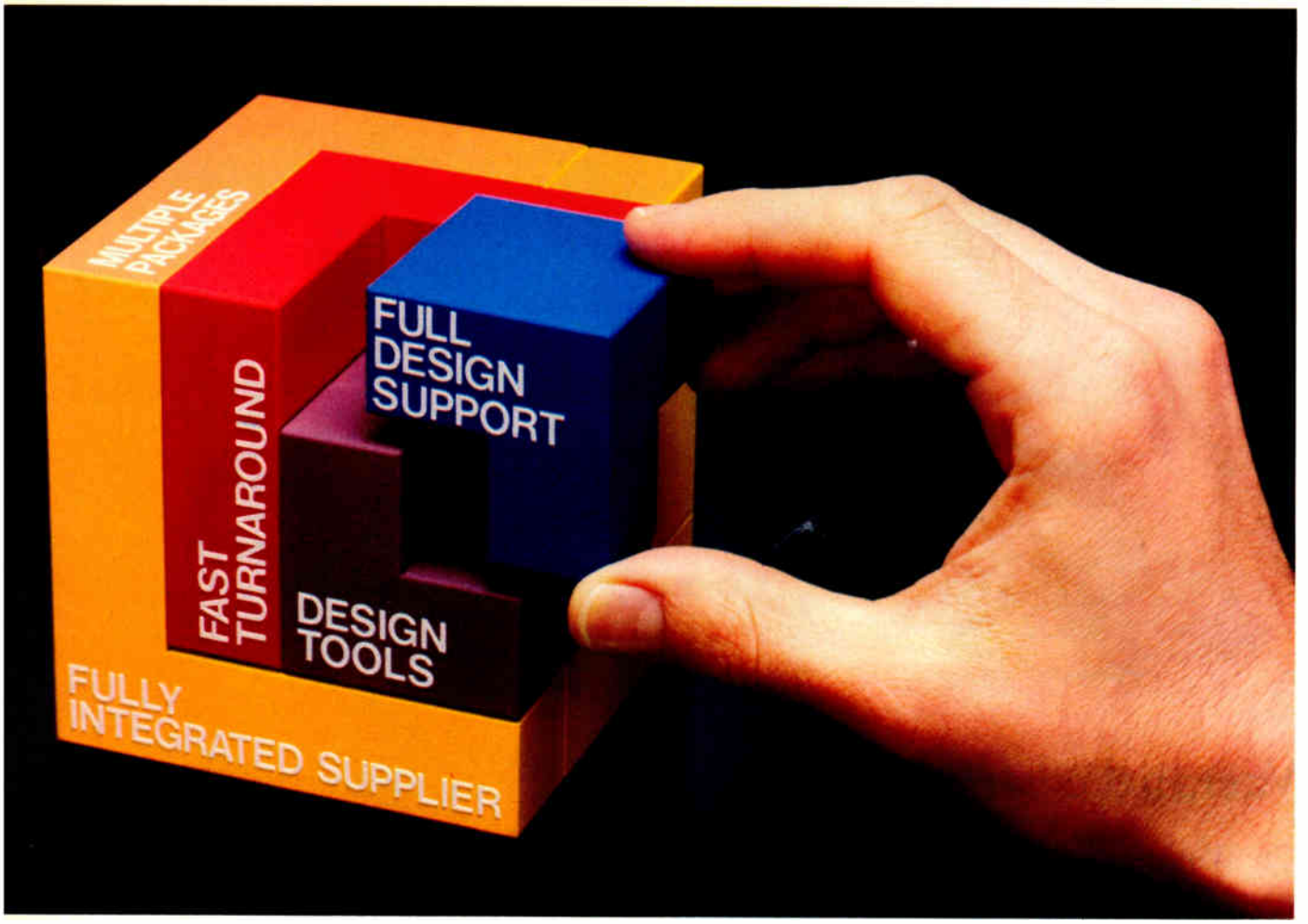

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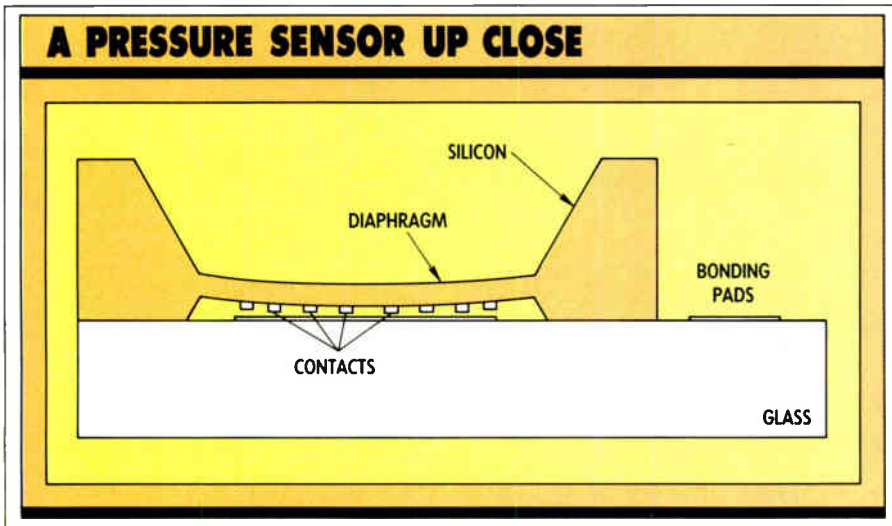
A PRESSURE SENSOR UP CLOSE



When pressure is applied the membrane flexes, and stress induced on the resistors causes a corresponding change in the sensor's output voltage.

performs the same function as our high-volume pressure sensor today," Burton says. "But that one is in a big heavy rugged package that is placed under the hood, on a bulkhead or a wheel well." The new one, by contrast, "is small enough that it will be mounted right inside the engine controller on a circuit that is not much bigger than an 18- or 20-pin dual-in-line package." Compared with the 3-by-2-by-1-in. thick-film hybrid assembly of the earlier design, the new all-silicon sensor package measures about 1 by ½ by ⅜ in.

Delco got to the smaller size not by integrating the electronics on the sensor die, but through innovative packaging that does away with the hybrid. "We have put some temperature compensation on the sensor chip," Burton allows. But signal-conditioning circuitry for gain, offset, slope, and amplification is housed on a companion silicon chip, which is wire-bonded directly to a lead frame. The sensor chip itself is quartz-isolated and is mounted on an aluminum backplate.

Compared with the $10 volume-quantity selling price for Delco's current hybrid silicon pressure-sensor product, the new two-chip silicon unit will be priced initially about $7.50, a drop of 25%, says Burton. He expects the price to be further reduced as manufacturing volume grows. The new unit will show up first in model year 1990 cars from one or more European manufacturer. But the unit will catch on more slowly in the U. S., Burton predicts, where automakers are less inclined to mount a manifold pressure sensor directly in the engine controller.

Although Delco chose a two-chip approach, some automotive-sensor suppliers see benefits from integrating more circuitry on the sensor die itself. One such supplier is Motorola. The company's next-generation MPX4100 automotive pressure sensor is "the industry's first fully signal-conditioned monolithic integrated solution," according to Tucker at the Phoenix Small-Signal and Sensor Division. The MPX4100 is scheduled for formal introduction in late summer. Unlike the new Delco pressure sensor, the Motorola offering integrates all signal-conditioning and amplification circuitry with the micromachined sensor element itself. "Everything we've done says we can make a one-chip [solution] cheaper than a two-chip," Tucker says.

No matter how much or how little electronic circuitry is integrated on the die, makers of micromachined silicon sensors agree on one thing: prices are coming down rapidly.

There is a high end, of course. Micromachined sensors sold by NovaSensor can typically cost up to $100 each in fully packaged configurations. Pricing for high-performance sensor chips alone can range from $10 to $50. But many lower-performance sensors sold into the consumer market go in volume at prices "well below $1," according to the company.

The trend is evident even on the newly emerging silicon accelerometers. IC Sensors, for example, is currently offering accelerometer chips priced at $5 each in high volume. "We're moving down the learning curve very, very rapidly on accelerometers," Knutti says. "We're finding a tremendous number of ways to keep reducing our cost and increasing our yields. Only a couple of years ago, a $5 price tag would have been unheard of."

Most industry executives cite the emergence of new micromachining tools within the past two to three years as a major factor enabling both lower prices and higher performance.

One such technique is silicon fusion bonding, a method borrowed from the semiconductor industry that allows the bonding of two silicon wafers without using intermediate adhesives and without the use of applied electric fields, as in glass-to-silicon anodic bonding.

"What this means is that we can preetch structures on both pieces of material, line the two pieces up, and end up with cavities and structures that are more or less encapsulated between the two pieces," says Knutti at IC Sensors.

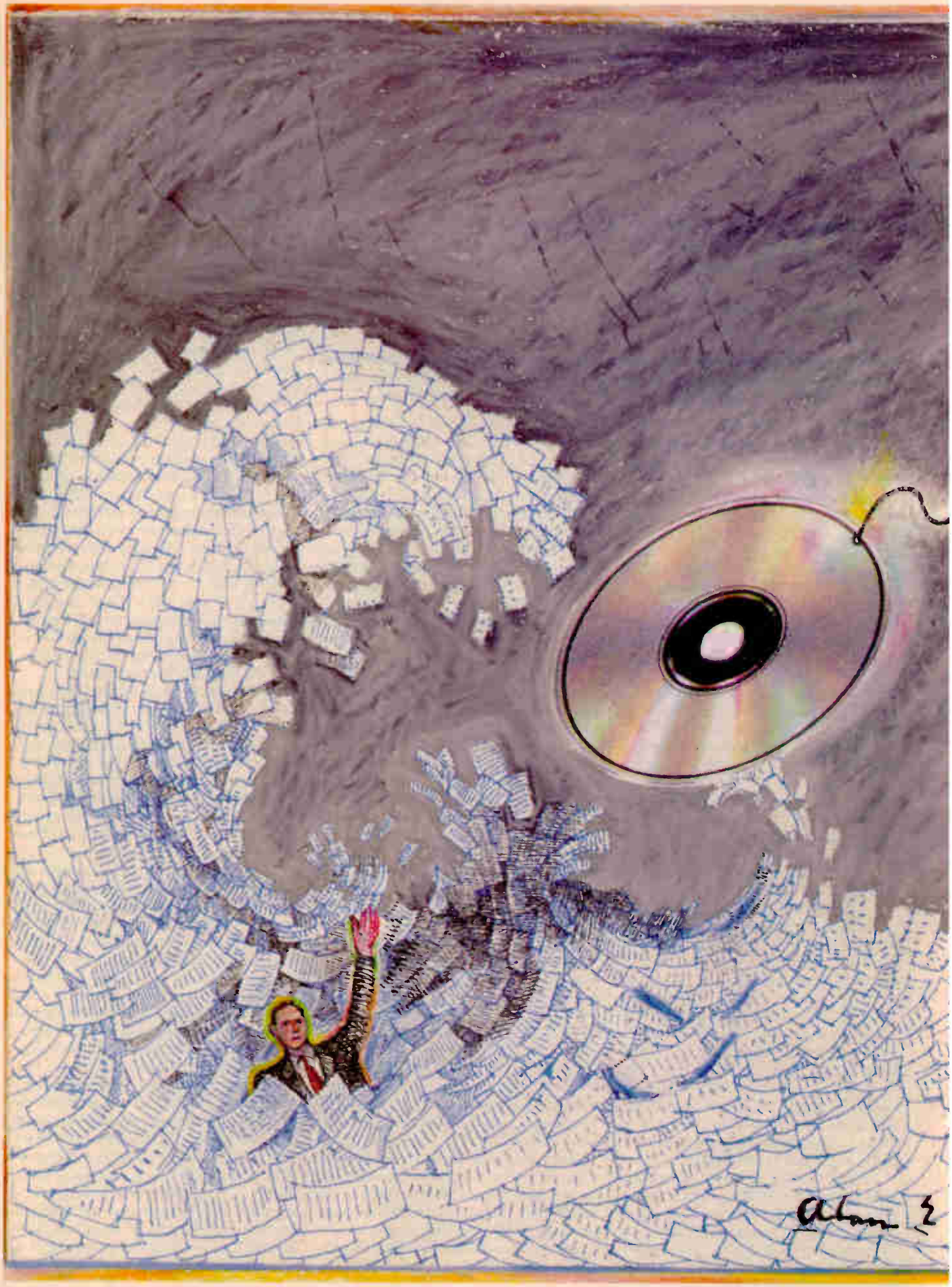
Another new tool involves the use of electrochemical etch stops. This technique provides for more precise etching of cavities and thin structures than is possible with older micromachining methods, which rely on timing an etch. Electrochemical etch stops have made feasible the micromachining of silicon diaphragms down to 1.0 or 2.0 μm in thickness, compared with about 5.0 to 15 μm in the past, according to NovaSensor's Mallon.

The combination of silicon fusion bonding and electrochemical etch-stop micromachining techniques is producing a range of benefits, vendors say. These include improved structure complexity and higher-performance sensor products at continuously lower prices. "We get better precision, the dice are smaller, and we get more of them per wafer," Knutti says. Over the last three years, the introduction of electrochemical etch-stop techniques alone has reduced processing costs at IC Sensors by about 25%, he estimates.

AT THE LABS. What's more, there are further advances percolating at an ever quickening pace in a number of university laboratories around the country. Researchers at the University of California at Berkeley, the Massachusetts Institute of Technology, and the University of Wisconsin, for example, are working on so-called surface micromachining techniques.

This method uses a combination of structural and sacrificial materials that can later be dissolved to build new kinds of structures on top of a silicon wafer. These techniques look promising for the fabrication of micromachined actuators and purely mechanical moving structures. They should also have applications in building higher-performance and lower-cost micromachined sensors, the researchers say.

Surface micromachining is so far used only sparsely in the commercial sector. But at least one school, the University of Wisconsin, has already sold licenses to several unnamed commercial vendors for an advanced high-volume polysilicon pressure sensor built using surface micromachining techniques. Initial commercial parts based on the technology could be on the market within two to three years, says a university official. □



Imaging

As U. S. businesses and government agencies groan under an avalanche of paperwork, electronic-imaging systems are offering solutions: ways of converting documents into digitized form

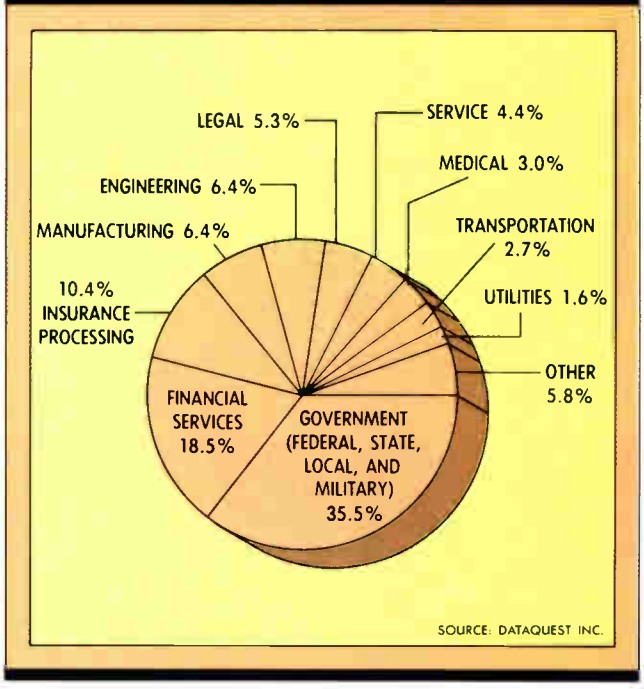
A growing mountain of paper is threatening to bury the corporate world. Arrayed against this threat are the tools of electronic imaging, poised to convert all these paper documents to digitized images and store them on magnetic and optical disks. And at the foot of that paper mountain are a host of companies in the burgeoning image-management industry, about to mine for gold.

Even a cursory look at statistics on the document glut boggles the mind. A recent study by Big Eight accountancy Coopers & Lybrand for the Association for Information and Image Management (AIIM), an industry group, found that each day, U. S. companies produce 600 million pieces of computer printouts, 234 million photocopies, 76 million letters, and 21 million other paper documents; 45 sheets of file-folder contents are generated per office worker. Despite the growing amount of data being kept on electronic and optical storage media, 95% of the nation's information still resides on paper. And demand for paper as a storage medium is still growing to the tune of 5% to 7% a year.

A basic burden is storing all these documents, in sizes ranging from credit slips and checks to E-size engineering drawings. Beyond that lie the more complex problems of indexing, retrieving, distributing, and, if required, editing or changing these documents in a timely manner. Companies—particularly in paper-intensive businesses like insurance or banking—are feeling the effects of clogged paper pipelines

BY SAMUEL WEBER

WHO USES ELECTRONIC IMAGING?



that slow throughput, reduce productivity, and pile up huge overhead costs. All this is driving an explosion in the marketplace for electronic imaging equipment: this market will be worth $2 billion to $12 billion a year by the mid-1990s, compared with about $500 million a year in 1989.

Although market figures vary, governments and the military are easily the biggest customers, according to Dataquest Inc., the San Jose, Calif., market research firm, which pegs the world market at $2.16 billion by 1993. Next in line are financial services and insurance processing.

The startling growth numbers have attracted a crowd of competitors. At least 45 companies in the U. S. alone are now participating in the electronic image-management systems market, Dataquest says. Once the purview of a handful of companies producing stand-alone image-processing systems—including Eastman Kodak and some relatively small specialist firms like FileNet and Plexus—the potential is so huge and customer interest so great that the big, traditional systems houses are getting into the game. Among them: Digital Equipment, IBM, Unisys, and Wang.

"The big guys have all discovered there's a lot of interest," says Pamela Stone Bliss, who follows the industry for Dataquest. "The customers are becoming more and more familiar with imaging, mainly through the rise of scanning and fax technology, and with the concept of a document being more than just ASCII text, but containing words and pictures and numbers and drawings." The major players, she says, have "all introduced compound document architectures. They're going to be stepping on the toes of the FileNets."

The rise of the IBM PC as an imaging platform is another important market trend, says Bliss. "These are low-volume, small-scale systems being used for archival storing and viewing of documents. These systems are selling well, and I expect that they will drive imaging from the desktop up, in much the same way that we saw electronic publishing rise from the desktop."

Happily supplying the imaging demand are companies that produce scanners, optical-disk drives, software, and peripherals such as monitors, printers, and plotters. The Japanese have been in the imaging business for a long time as a logical outgrowth of their pictorially written language, but very few Japanese systems are exported.

"We're moving to broad acceptance, but we're not there yet," says Dave Liddell, IBM Corp.'s marketing manager for imaging in White Plains, N. Y. One major impetus in that direction will be the Defense Department's CALS, for Computer-aided Acquisition and Logistics Support, aimed at converting all paper documentation associated with weapons and aerospace procurement into electronic form [*Electronics*, April 1989, p. 46].

Many industry players see image processing not as a stand-alone function but destined to be merged with conventional data processing, a marriage that would yield total control over information flow in a corporate or government office environment. As Harry C. Andrews, vice president of 3M Information Systems Group in St. Paul, Minn., pointed out at the AIIM show in San Francisco last month, there has been a split between the document and the alphanumeric data it contains. "On the one hand," he says, "data-processing people argue that the value of any document is derived from the information it contains. If this information could be stored as alphanumeric data, it could be accessed more quickly, manipulated in hundreds of useful ways, and transmitted quickly and easily to remote locations." On the other hand, Andrews says, document images contain more than alphanumeric data: they also have photos, graphics, and signatures.

The advent of electronic imaging promises to overcome this dichotomy. "As image-management applications are refined," says Dataquest's Bliss, "it will make imaging part of a larger information-processing solution, rather than simply an electronic archiving tool used to replace paper storage."

Although electronic image processing relies on many proprietary products, much of its hardware was developed in other contexts. Scanners, for example, evolved from facsimile equipment; high-resolution monitors originally served work stations, optical and magnetic storage devices, networking, and laser printers. In other words, imaging isn't a technology-driven market—it's an application. The real key to success is developing an architecture that permits easy customization and adherence to open standards, as well as software that ties all these disparate elements together. The emergence of open-system standards is making that easier.

A basic image-based document-management system consists of a scanner and a controlling computer. The scanner converts the document page into digital form; the computer controls the peripherals, provides an indexing function to permit retrieval of input documents, and compresses and decompresses the digital data or bit map representing the converted image. Such compression is required because an 8½-by-11-in. document page, scanned at a resolution of 300 dots/in., consumes a megabyte of a data file. Without compression, the memory requirements would be prohibitive.

Once digitized and indexed, the document can be processed further, or called up on a monitor and viewed, passed on to other work stations over a network for further editing or processing, or stored for later retrieval. And at any point, copies can be made on a laser printer or high-speed plotter.

The simplest setups are single-user document-storage and -retrieval systems. Larger systems can be enhanced for distributed multiuser operation, controlled by a host mainframe or minicomputer. The larger systems combine magnetic memory for temporary storage of digitized images and optical multiple-disk drives in "jukeboxes" for more permanent, large-capacity storage.

Dataquest's Bliss sees a three-part market for electronic imaging: high-, mid-, and low-volume systems. High-volume systems, based on mainframes, are highly customized and transaction-oriented. They serve from 10 to 100 users, store more than 1 million pages on line, read

from and write to 12-in. optical disks, and access them through jukeboxes. Prices range from $300,000 to several million dollars. Some of the major players here are FileNet, Integrated Automation, Plexus, and Wang.

Mid-volume systems, which usually serve corporate departments, are based on 32-bit work stations or 386-based PC servers. They handle from 20,000 to 1 million pages of on-line storage with up to 10 users, and storage is on 5.25-in. or 12-in. optical disks. Prices range from $100,000 to $300,000. Competing here are Micro-Dynamics, Eastman Kodak, FileNet, ViewStar, Wang, and newcomer Imix.

At the low end, systems are generally for one or two users and based on high-performance work stations or 286/386 PCs. They have from 20,000 to 50,000 pages stored on line, using either 5.25-in. optical disks or magnetic media. Prices range from $35,000 to $100,000. Besides LaserData and Summit Software, vendors include Bell & Howell, Eastman Kodak, Imnet, and Tab Products.

Among the imaging pioneers is FileNet Corp. of Costa Mesa, Calif., which now has almost a quarter of the U.S. high-volume market, according to Dataquest. FileNet systems are based on a distributed client-server architecture using the Unix operating system and multiple windows. At the low end, the Series 1000 consists of two low-cost, 5.25-in. optical-disk systems: the single-server 1100 and the 1500, which has multiple servers to handle scanning, storage, retrieval, and printing.

At the midrange is the Series 3000. The 3100 system has centralized image-management servers cabled to a document scanner, printer, and image terminal. Users can also attach multiple optical-disk units, each containing one or two optical-disk drives, or optical storage and retrieval (OSAR) libraries containing up to 288 optical disks. The 3100 accommodates up to four cluster work stations, each with up to four image displays for a total of 16 users.

The market is huge and the competition heated as the big systems houses take aim at the specialty firms that founded the imaging industry

At the high end, the 3500 system is designed for high-volume, paper-intensive customers that scan tens of thousands of documents per day and maintain very large archives. Each function—document entry, printing, and so forth—has its own server. With the addition of networked work stations and PCs, the 3500 system can handle more than 1,000 users. Besides its own work station, FileNet supports the IBM PC AT and compatibles, the PS/2, Sun Microsystems' work stations running Sun OS, and DEC VAX work stations and systems.

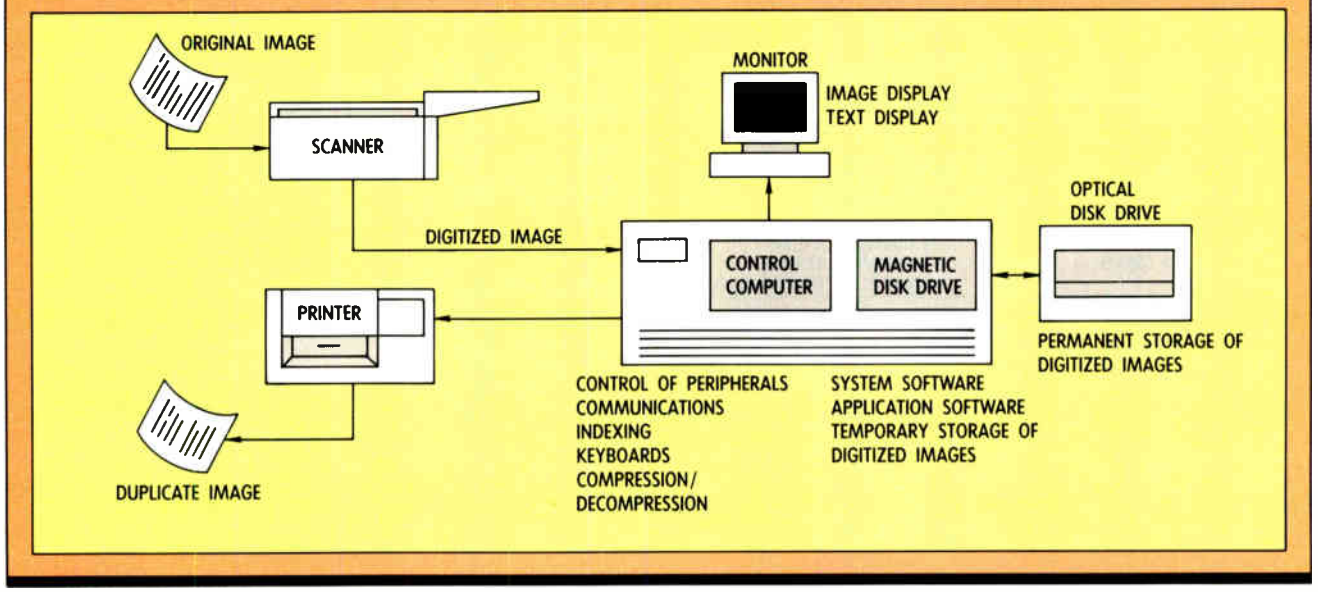
Robert L. Castle, FileNet's marketing vice president, says the company isn't perturbed by the entry of the big systems houses into the imaging market. "An important difference between us and those vendors is that we built our system from the bottom up," he says. "We didn't have to cobble together different pieces that weren't really designed to address this problem, and try to force the use of images into our system." The result, he says, is that "we have a much better-tuned system and a much more complete set of software."

Castle's confidence comes in the face of a major market thrust by players like DEC, IBM, Unisys, and Wang. Wang has already established a solid installed base in FileNet's high- and mid-volume playing field. For its part, IBM a year ago introduced ImagePlus, a document-management system aimed at high-volume users.

Like other large-system vendors, IBM doesn't intend to sell image processing as a stand-alone function. "We're approaching the market as an integrator providing complete solutions—not as a component supplier," says Liddell. "We'll use third-party vendors and components from other manufacturers," and even form business partnerships to develop imaging applications in the more complex fields.

IBM's ImagePlus is available for two different system environments. One, for large enterprises and high-volume opera-

CONVERTING DOCUMENTS TO IMAGES



In a typical imaging system, a scanner converts a document page into digital form. The computer compresses the digital data for storage on an optical disk The file is then decompressed when it is to be displayed on-screen.

tions, is ImagePlus System MVS/ESA for IBM's ESA/370 processors, which power the 3090 and 4381 mainframes; the system can support hundreds to thousands of work stations. The other is ImagePlus System AS/400 for midsize businesses or large departments depending on the AS/400 and System/36 midrange processors. Pilot systems are installed at about 10 beta sites. Prices range from $200,000 to $15 million.

Meanwhile, Wang Laboratories Inc. of Lowell, Mass., one of the first data-processing system vendors to offer imaging capability, has established a beachhead in the midrange and high-end markets with its proprietary VS-based Wang Integrated Imaging System, which was introduced just over two years ago. Dataquest pegs Wang's share of the U. S. midrange installed base at 10.6% and the high-end, 12.9%.

WIIS can be integrated with other Wang applications such as E-mail, Wang Office, and Wang's PACE relational data base. The company recently announced that the WIIS applications library has doubled to 62 imaging software applications, most developed through third parties. While WIIS is widely perceived as a proprietary system that must run on Wang processors, the company points out that it can be linked to other vendors' systems.

Digital Equipment Corp. is a relative newcomer in the imaging field, having announced VAXimage earlier this year. Its Digital Image System Architecture allows imaging to be integrated with current applications running on VAX processors. And Unisys Corp. has no products yet—only an announced intention to move into imaging with an integration strategy similar to IBM's.

At the low end of the imaging hierarchy, competition is crowded and keen. Primarily PC-based single-user or networked systems, much of this relatively low-cost segment is aimed at straightforward archiving and retrieval functions. But these systems, too, can be customized for particular applications.

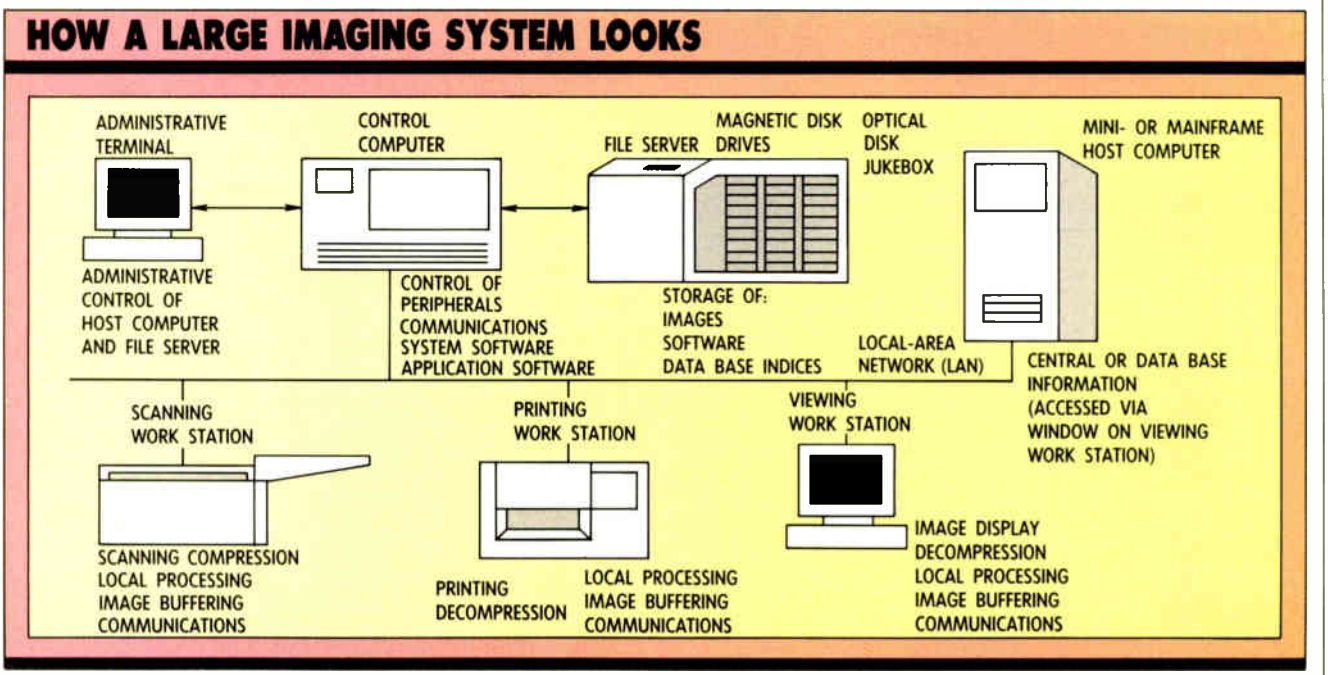
LaserData Inc. of Tyngsboro, Mass., was one of the first companies to reach the market with a PC-based document image-management system. Dataquest estimates that LaserData is the leader in the low-volume arena, with a market share of 17.4%. The firm also may have as much as 41.7% of the market in networked PCs and 28% of the stand-alone installations. The company's LaserView work-station line is sold primarily through value-added resellers. LaserData designs and manufactures the controller boards for its systems, which integrate a variety of monitors, scanners, printers, write-once-read-many (WORM) optical-disk drives, and jukeboxes. A stand-alone system for small single-user applications sells for about $50,000; a typical network configuration—one scanner and three retrieval stations—sells for about $150,000.

The networked configuration can be connected with DEC VAX/VMS minicomputers or IBM mainframes over HostLink, LaserData's document image-management networking software. At the AIIM show last month, LaserData introduced the second-generation components of the LaserView family. These include the high-performance CorVette ScanStation, CorVette ViewStation, and Add+-Image, a software utility that adds imaging to standard EGA-, VGA-, and Hercules-compatible PCs. ViewStation displays images in less than half a second—four times faster than LaserView.

The PC-based segment is providing a growing opportunity for manufacturers of components and board-level products. A specialist in IBM PC-compatible board products for image management is KoFax Image Products of Irvine, Calif. The company's line includes compressor/decompressor boards, a document processor that combines scanner and printer interfaces with compression/decompression, a graphics-display adapter tailored to high-resolution display monitors, and a document-display adapter that eases document retrieval from a shared data base.

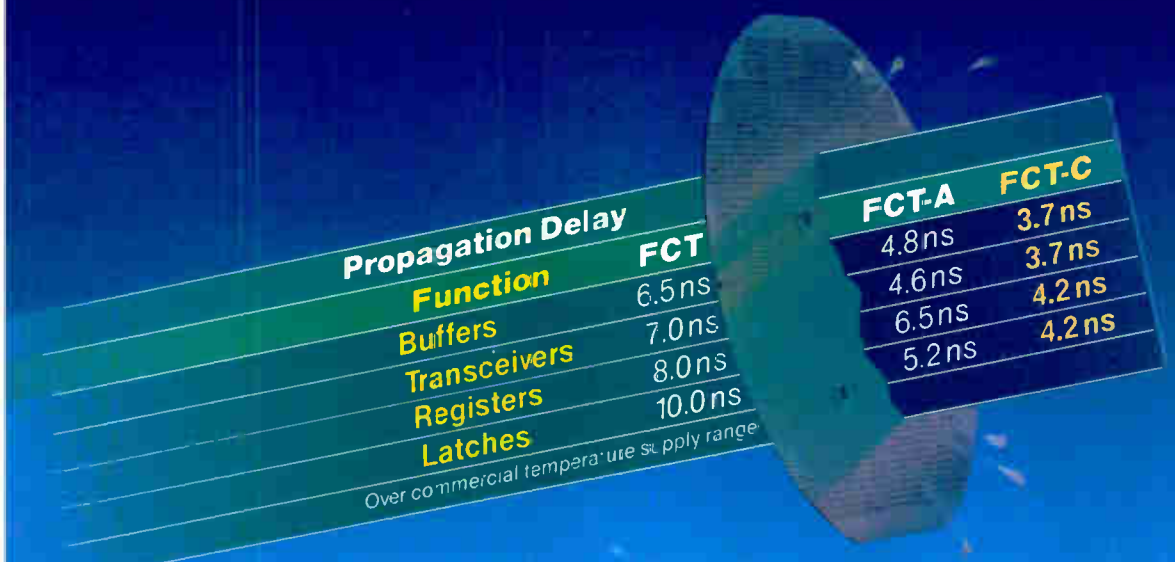
Recognition Equipment Inc. of Dallas, a leader in scanning technology, is parlaying that skill into a full-fledged entry into the document-management arena. Recognition introduced two new high-performance systems at the AIIM show. System 1000 is a high-volume, image-capture and management system for large financial organizations that operates in an IBM MVS environment and can provide a variety of scanning options. To be built by Recognition and FileNet, the System 100 is Unix- and PC-based and aimed at time-critical documents such as insurance claims, charge-card applications, and transportation waybills. □

HOW A LARGE IMAGING SYSTEM LOOKS



Controlled by a mini- or mainframe computer, large imaging systems are equipped with multiple-drive "jukeboxes," some containing hundreds of optical disks, to provide permanent, large-capacity storage.

Breaking the TTL Speed Barrier



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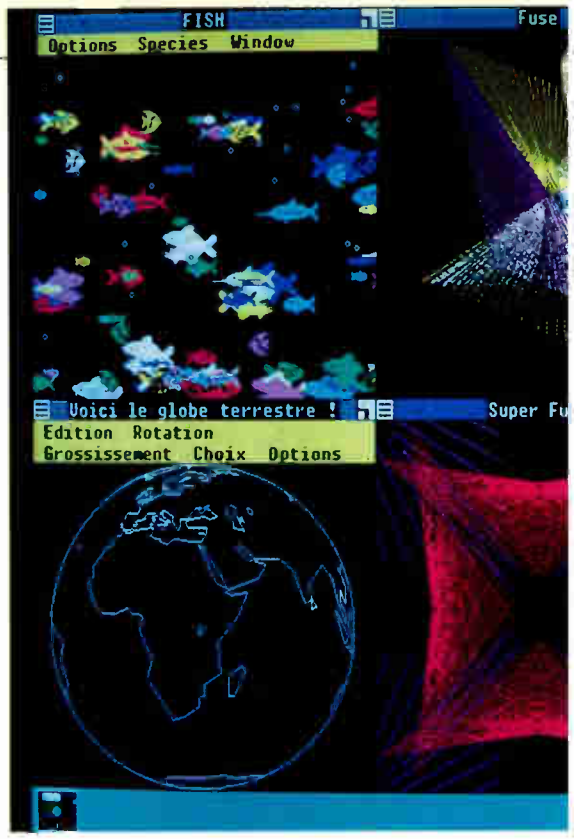
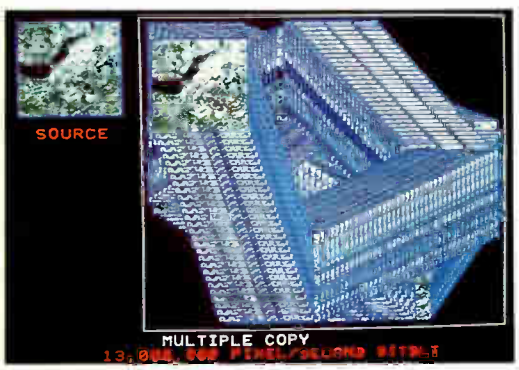


The PC community is groping toward standards for high-resolution graphics



The Matrox Electronic Systems Ltd. PG-1281 graphics board brings work-station-level color display to personal computers; it boasts resolution of 1,280 by 1,024 pixels.

MOVING

Just as it's getting firmly entrenched as an industry standard, IBM Corp.'s Video Graphics Array personal computer graphics technology is already becoming passé. Manufacturers and users alike are eager to push displays past VGA in terms of resolution and number of available colors. The higher-performance technology is here, in the form of graphics boards and monitors that go way beyond VGA's resolution of 640 by 480 pixels and 16-color simultaneous display. But up until now, each piece of hardware has had a different software interface, necessitating special drivers for every board.

Out of this hodgepodge, several efforts are under way to standardize personal computer graphics beyond VGA, with four main alternatives emerging. Since VGA is quite adequate for many applications and is not about be replaced, these higher-performance alternatives will complement VGA and coexist with it.

One approach moves a little beyond VGA by adding extended-resolution modes to VGA-type video controllers. A brand-new organization—the Video Electronics Standards Association—was formally established in April by a number of PC-graphics hardware and software vendors to set standards in this arena. A second route is to make IBM's advanced 8514/A graphics-processor-based system an industry standard. Several independent chip and board vendors are going down this track.

Rapidly emerging as a third high-performance contender is Texas Instruments Inc.'s graphics architecture interface specification for its extremely popular TMS340 graphics-system processor family. TI's specification, the TIGA-340 interface, is gaining widespread support among graphics-board, PC-system, and software manufacturers.

A fourth alternative is to standardize an interface for one of the many graphics processors now on

The Genoa Systems Corp. high-resolution 6400 graphics board displays many windows.

BEYOND VGA

from its superior performance on both text and graphics—and also because it represented a standard in an arena that sorely needed one. All three components of a graphics subsystem are compatible in VGA—controllers, monitors, and software. If VGA's 16 colors and 640-by-480-pixel resolution are acceptable—and for many applications, they are—then life is easy for users. They can buy standard hardware and select from a wide variety of applications that work with it.

However, there are quite a few applications, such as computer-aided design, high-end presentation graphics, desktop publishing, and computer art, that will be improved by higher resolution and more colors. Here the user does not have a clear choice. If his needs revolve around one major application—CAD, for example—he can select a popular program such as AutoCAD or VersaCAD and find many high-resolution controllers and monitors that these packages support. But if he plans to run a variety of applications, he will have to stitch together his own solution—or wait until the industry settles on a standard (or two).

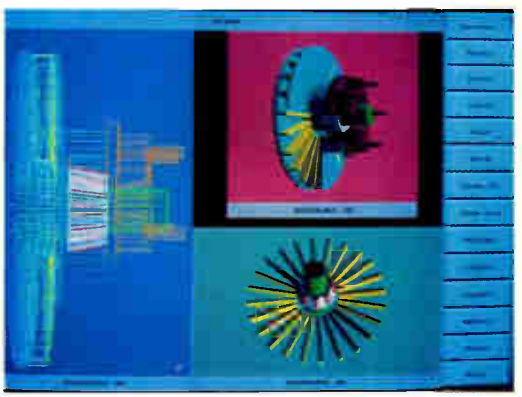
One of the main thrusts in standardizing higher-resolution PC graphics is in extending the modes of VGA. The initial members of the new VESA organization are starting the ball rolling by agreeing on a standard BIOS interface for what they are calling a "Super VGA" mode boasting resolution of 800 by 600 pixels and 16 colors. "This was an easy one," says Greg Reznick, vice president of systems marketing at Headland Technology Inc. in Fremont, Calif., and the newly appointed chairman of VESA. "We were all able to agree quickly on standardizing this mode." The fledgling VESA group is quickly gaining the support of a major segment of the PC-graphics industry: its 25 members represent a good cross-section of chip, board, system, and software players. Along with its Super VGA effort, VESA has also formed a subcommittee on 8514/A.

The details of the VESA VGA BIOS Extension have been published, and VESA members are starting to use the standard. It will allow software developers to write one driver for all Super VGA cards that conform to the standard. The VESA group plans similar standards for modes supporting other resolutions and color depths. Two such modes—for 640-by-480-pixel resolution with 256 colors and for 800-by-600-pixel resolution with 256 colors—have been proposed so far.

A couple of companies have jumped on the VESA bandwagon right away by introducing products. On the graphics-board side, the first was the market, such as Hitachi's ACRTC 63484, National Semiconductor's DP8500 Raster Graphics Processor, or NEC's graphics processors. There are no big independent standards activities under way around these architectures, although National has announced a joint effort with Graphic Software Systems of Beaverton, Ore., to standardize on the Direct Graphics Interface Standard (DGIS).

In one way or another, all this activity piggybacks on IBM's own efforts, which date back to April 1987, when Big Blue introduced enhanced graphics as an integral part of its Personal System/2 line of PCs. This was VGA, and it quickly became a de facto industry standard. IBM also introduced VGA capability on an adapter card for its older PC XT and AT machines, and the rest of the industry soon followed suit with built-in VGA-compatible graphics and VGA board products.

VGA's quick rise to the top came



Another example of PC graphics beyond VGA is Nth Graphics Inc.'s three-dimensional engine, which can render computer-aided design images in seconds.

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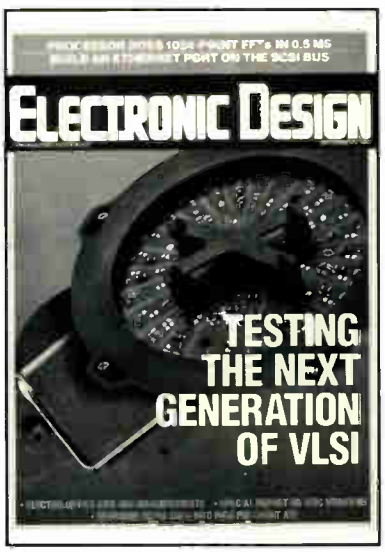

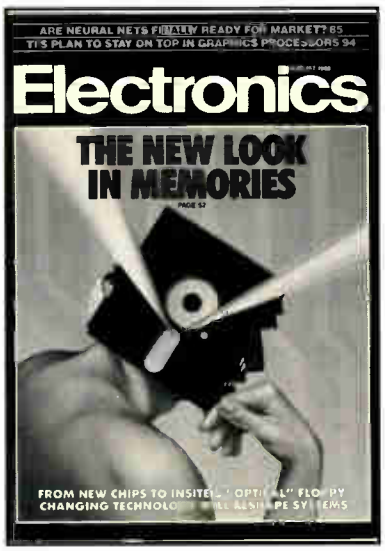

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Headland Technology, formerly known as Video 7, which announced support of the VESA BIOS interface for the initial version of the Super VGA mode. Headland's entire line of VEGA VGA, FastWrite VGA, and V-RAM VGA products will support the VESA standard when upgraded with a new BIOS electrically programmable read-only memory. In reducing the software development effort by letting programmers write one driver for all VESA-compatible boards, Headland and other vendors hope to up the number of applications that use 800-by-600-pixel resolution.

Another Super VGA player is Genoa Systems Corp., which unveiled at the Spring Comdex show in Chicago last April an application-specific integrated circuit that will provide high-resolution graphics across all PC operating environments. Called the GVGA, the chip offers both noninterlaced and interlaced monitor support at resolutions up to 1,024 by 768 pixels for computers running MS-DOS, OS/2, Unix, and Xenix. The San Jose, Calif., company says the chip conforms to the VESA standard.

Meanwhile, IBM itself has been trying to push beyond VGA. At the same time that VGA made its debut, IBM also took the wraps off its 8514 monitor and the companion 8514/A graphics-processor-based controller for higher graphics performance on PS/2 systems. The 8514/A, as the whole subsystem is usually called, offers 1,024-by-768-pixel resolution with 16 colors. The 8514/A adapter card for PS/2 systems contains two proprietary IBM chips that form the heart of a powerful graphics coprocessor. IBM has yet to release any technical details on this duo.

But far from garnering the status of a de facto industry standard, 8514/A has not caught on in a big way. The main reasons for this seem to be the lack of published specifications for the register set, the performance loss that occurs when using the IBM-supplied software interface, and the flicker in the interlaced display. Also, a number of key functions, especially those involved with text handling, are missing.

IBM chose not to publish the hardware-register specifications in an attempt to encourage software developers to use the Adapter Interface, an application programming interface Big Blue supplies. If everyone followed this procedure, it would leave IBM some flexibility to change the 8514/A while keeping the interface consistent. However, to get maximum performance from 8514/A, some software developers have bypassed the application interface altogether and addressed the hardware registers directly. Microsoft Corp. did this with Windows and the Presentation Manager.

One major thrust is to extend the modes of VGA; VESA's choice is 'Super VGA,' with 800-by-600-pixel resolution

But now, enter a couple of independent hardware vendors that are willing to champion 8514/A and push it as a standard: Headland and Western Digital Imaging of Mountain View, Calif. The VESA organization, too, is contemplating supporting 8514/A as another standard.

Western Digital, a strategic business unit of Western Digital Corp., has released a specification for an 8514/A-equivalent chip set. The so-called PWGA-1 spec contains the first public release of the 8514/A register information, critical data for ensuring hardware and software compatibility if 8514/A is to become a standard. The company figured out the specs during its reverse engineering of the 8514/A controller and decided to share them as a way of making 8514/A a standard in much the same way that VGA is. If everyone making an 8514/A product uses the register specs, all the products will be compatible. And as the PC industry has so amply demonstrated, compatibility sells more products.

Western Digital's motivation, of course, is not a desire to enrich IBM. By announcing specifications for a chip set, the firm is showing its intention to offer 8514/A circuits and boards of its own. Headland Technology will also be offering an 8514/A chip set.

But 8514/A has some competition in the 1,024-by-786-resolution league. For example, Metheus Corp. of Beaverton offers a family of VGA graphics controllers, the models 1104, 1124, and 1128, that provide a resolution of 1,024 by 768 pixels with 16 to 256 colors. And Miro Datensysteme GmbH of Braunsweig, West Germany, offers PC/AT and PS/2 boards at the same level—the MiroGraph 511 VGA and MiroGraph 515 VGA, respectively.

In the midst of all this activity, Compaq Computer Corp. has come out with its own 1,024-by-768 Advanced Graphics System—the 1,024 graphics board and a monitor to go with it. As it is wont to do, the Houston PC company went beyond IBM's

At the high end of the resolution scale is the Lundy 1612 Personal Graphics Workstation, which offers 1,600 by 1,200 pixels with 16 colors. It's based on the Texas Instruments 34010 processor.

high-resolution offering, supplying 256 colors rather than 16. The Compaq 1,024 board uses the TI 34010 graphics processor, which is the object of a standardization effort of its own. The processor, which TI brought to market two years ago, is now the chip most used for high-performance PC graphics—the Dallas-based company lists 51 PC add-in graphics boards using the 34010. And TI has just launched an all-out effort to make the 340 family an industry standard.

Last April at the National Computer Graphics Association show in Philadelphia, TI announced the completion and publication of its TIGA-340 (Texas Instruments Graphics Architecture) interface specification. Among the 28 supporters that TI says intend to provide compatible hardware and software products are some industry heavyweights, including Compaq, Hewlett-Packard, Intergraph, Microsoft, and Number Nine Computer.

As for the 340 hardware itself, TI continues to enhance it. Early this year it started offering a 60-MHz version, and now comes an upgrade, the 34020, which the company says boasts 20 times the performance of the workhorse 34010. Samples of the 34020 became available in April, and production will begin in the second half of this year.

The first products using the 60-MHz 34010 were introduced by Number Nine Computer Corp. at the NCGA. Two of the Cambridge, Mass., company's Pepper family of graphics boards use the souped-up processor, a zero-wait-state machine. These Pepper Pro1024 boards for the IBM Micro Channel Architecture and the industry-standard bus offer 1,024-by-768 resolution with 256 colors.

The multitude of other graphics chips and processors that can be used to provide resolutions beyond VGA are taking a back seat in the standardization movement. National Semiconductor Corp.'s DP8500 Raster Graphics Processor and Genoa's GVGA Super VGA ASIC at its highest levels of resolution are just two examples out of many—no major standardization efforts appear to be under way for any of them.

However, National, based in Santa Clara, Calif., is working with Graphic Software Systems to provide a standard graphics protocol for the DP8500 that uses DGIS, which is National's choice for a standard DOS graphics interface. This firmware will make the DP8500 compatible with more than 600 DGIS software packages. On another front, Graphic Software Systems recently announced a faster DGIS for the Texas Instruments TMS340 architecture.

All the standardization efforts for high-resolution PC graphics fall in the range of resolution between VGA at the low end and 1,024 by 768 pixels at the top. But 1,024 by 768 is not where graphics resolution stops. Engineering and graphics work stations have been offering resolutions of 1,024 or even 1,280 by 1,024 for many years now. A few boards and monitors boasting these resolutions have been available for PCs, too. And some graphics subsystems beyond 1,280 by 1,024 are showing up as well.

There is, for example, a board-and-monitor product offering 1,280-by-1,024 resolution and four shades of gray from Relisys of Milpitas, Calif. The company, a wholly owned subsidiary of Taiwan's TECO Electric & Machinery Co., unveiled the product at Spring Comdex. It uses an ASIC produced by Gemini Technology Inc. of Richmond, B. C., Canada. Also offering 1,280-by-1,024-resolution color graphics is the TIGA-based TI-1210 board from IMAgraph of Woburn, Mass., the PG-1281 and PG2-1281 boards from Matrox Electronic Systems of Dorral, Quebec, Canada, and the MiroGraph 530 and 534 VGA boards from Miro Datensysteme. The West German boards use Hitachi Ltd.'s ACRTC 63484 processor.

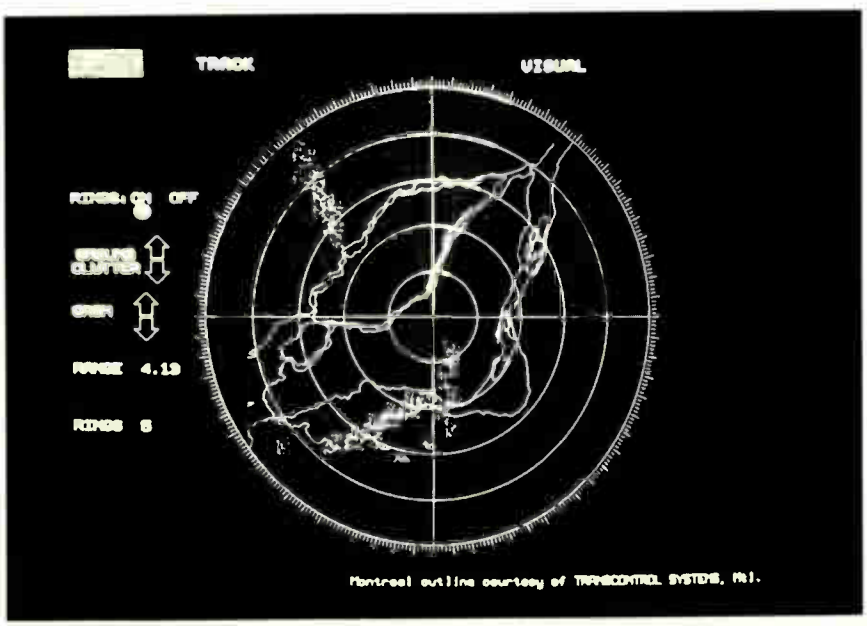
Even in the heady resolution realm beyond 1,280 by 1,024 there are a few products for PCs. For example, Lundy Electronics of Glen Head, N. Y., offers both a 1,600-by-1,200 color monitor and a 386-based graphics work station with a graphics controller powered by a TMS 34010. Another player is Aura System Inc. of Carlsbad, Calif., with graphics controllers for 1,664-by-1,280-pixel resolution and up to 256 colors. The products are based on the TMS 34010 at 40, 50, and 60 MHz.

Topping off the resolution climb are ultrahigh-resolution gray-scale monochrome monitors aimed primarily at publishing applications. MegaScan Technology Inc. of Gibsonia, Pa., makes a 200-dot/in. monitor subsystem with 8 bits of gray scale and 2,560-by-2,048-pixel resolution. And Flanders Research Inc. in Flanders, N. J., supplies the Exact-8000M series of two monitors reaching for the resolution sky at 3,300 by 2,560 pixels. But one-upping them all is MegaScan's UHR-3000, a 1-bit monochrome monitor with resolution of 4,096 by 3,300 pixels.

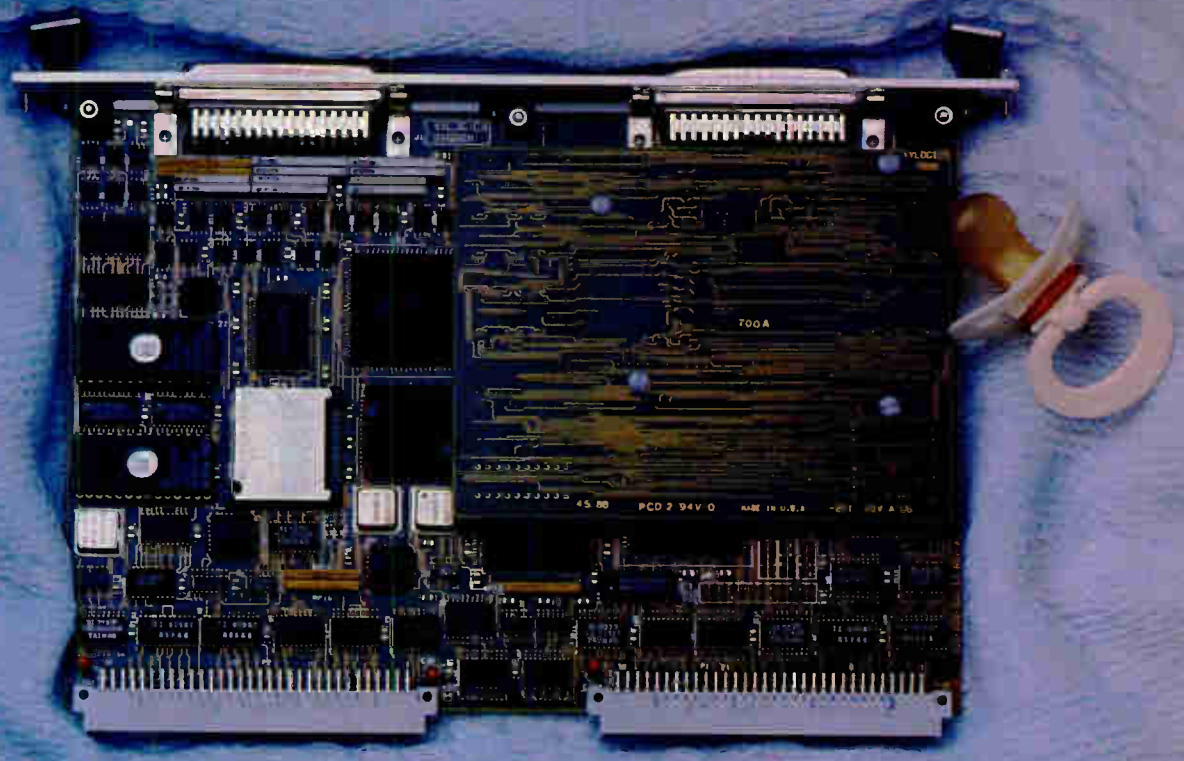
It is unlikely that very many PCs will need a display with this much resolution. However, there are applications in page display, medical imaging, some CAD work, and military imaging that justify this level of display quality. □

PUSHING BEYOND VGA

Graphics Type	Resolution	Number of Colors
IBM VGA	640 × 480	16
Enhonced VGA	640 × 480	256
VESA	800 × 600	16
Further enhonced VGA	800 × 600	256
IBM 8514/A	1,024 × 786	16
Unnomed	1,024 × 786	256



The Matrox PG2-1281 board for PS/2 systems delivers the resolution necessary for displaying detailed information such as that seen on this radar image.



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BY JACK SHANDLE

LIGHTS, CAMERA, COMPUTE!

Get ready for multimedia PCs, with high-fidelity audio and full-motion color video

The stage is being set for audiovisual computing. When the curtain rises in the 1990s, the multimedia show will be running on personal computers with interfaces enriched and enlivened by high-fidelity audio and full-motion color video. IBM Corp. and Apple Computer Inc. have already let it be known that they crave starring roles. Microsoft Corp. showed its faith in the technology's potential last month by forming a separate Multimedia Division. But dozens of lesser names are auditioning too, such companies as Comsell, Digital F/X, MacroMind, and Owl.

If the future is up for grabs, there's plenty of action right now in business and government organizations eager to try out the nascent technologies. PC-based interactive video is proving itself an effective teacher in training applications. Sev-

A Digital F/X work station lets artists do special effects formerly possible only in video postproduction studios.

eral software companies have fielded packages for the Apple Macintosh and the IBM family of PCs that weave audio, graphics, and video into flashy desktop presentations for sales or in-house corporate meetings. At the very high end, PC-based systems are penetrating video postproduction studios, where special effects and graphics are merged with video shot on location.

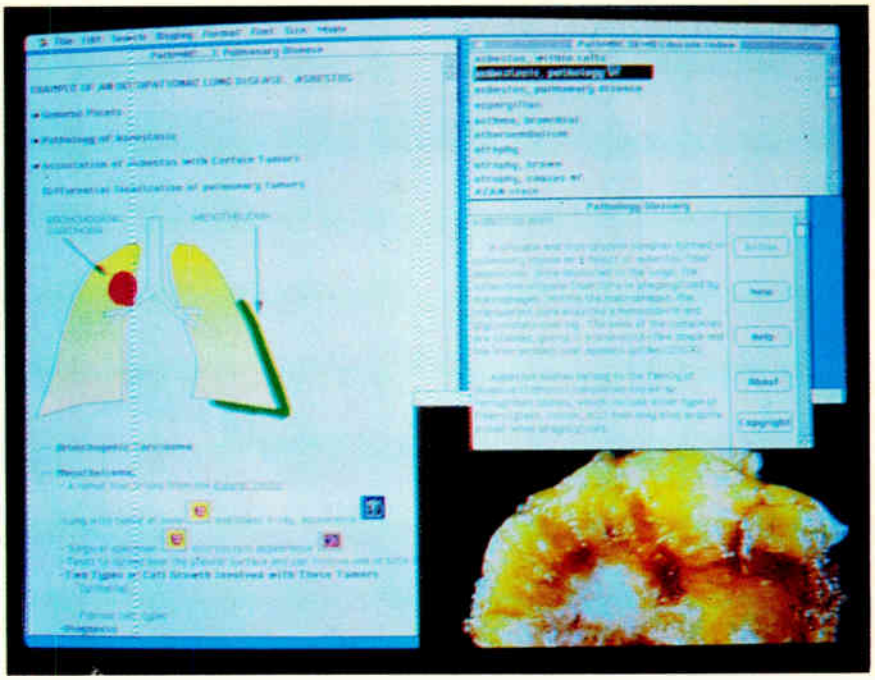
The leading multimedia platforms for interactive training are IBM's PC and Personal System/2, with more than 50,000 in use, according to *Multi-Media Computing and Presentations*, a Santa Clara, Calif., newsletter. Training stations include the PC, an IBM InfoWindows touch screen and software, and an analog videodisc player.

VALUE ADDED. In training applications, custom software is the value-added ingredient. For example, Comsell Inc. of Atlanta has an interactive-video product line that helps users learn the fundamentals of PCs and applications programs such as Lotus 1,2,3, says Glenn Crews, director of marketing and product development. Its ToggleWare software "returns the user directly to Lotus 1,2,3 after he learns a specific skill, such as gritting a macro," he says. Toggling back and forth in this way gives students hands-on experience that reinforces the lesson.

Comsell, which also markets interactive training products for law enforcement and the financial industry, scored a coup in May for its Financial Flashfax courseware, which trains bank and security personnel. That's when the firm signed on Nynex Computer Services as a system integrator.

But Nynex's audio-video computing interests go beyond shrink-wrapped software, says Mark Maltz, marketing manager for Nynex's Video Information Services Unit in Pearl River, N. Y. Nynex's strategy is to develop applications that use the parent company's telecommunications network, he says. For the time being, that means retail point-of-sale terminals, information kiosks, and catalog sales. Nynex has developed two IBM-PC-based platforms, one capable of linking hundreds of kiosks over phone lines and the other for stand-alone applications.

Nynex will install more than 200 information kiosks in Atlanta to help visitors find their way around town. It also has installed 14 kiosks for New York Telephone, where customers can pay bills and have an interactive session concerning products and services. In the market for catalog sales terminals, Nynex has signed on to build an interactive device for Call Center Services Corp., the national leader in 800-number order fulfillment for department stores, says Maltz.



Pathology students at Cornell University use Owl International's Guide to master more than 40,000 facts with the aid of multimedia interactivity.

The enormous market potential for multiple media linked via phone service has not been overlooked by IBM and Apple. Universal phone service that handles audio/video updates will arrive in the mid-1990s, in the form of the integrated services digital network. That falls in the same time slot that IBM and Intel Corp.—which supplies video-compression technology through its Digital Video Interactive board set—have set for interactive video in the home. "Intel and IBM are trying to make DVI the [multimedia] standard early," says Nick Arnett, editor of the *Multi-Media Computing* newsletter. "If they succeed, they could have a standard for video on ISDN."

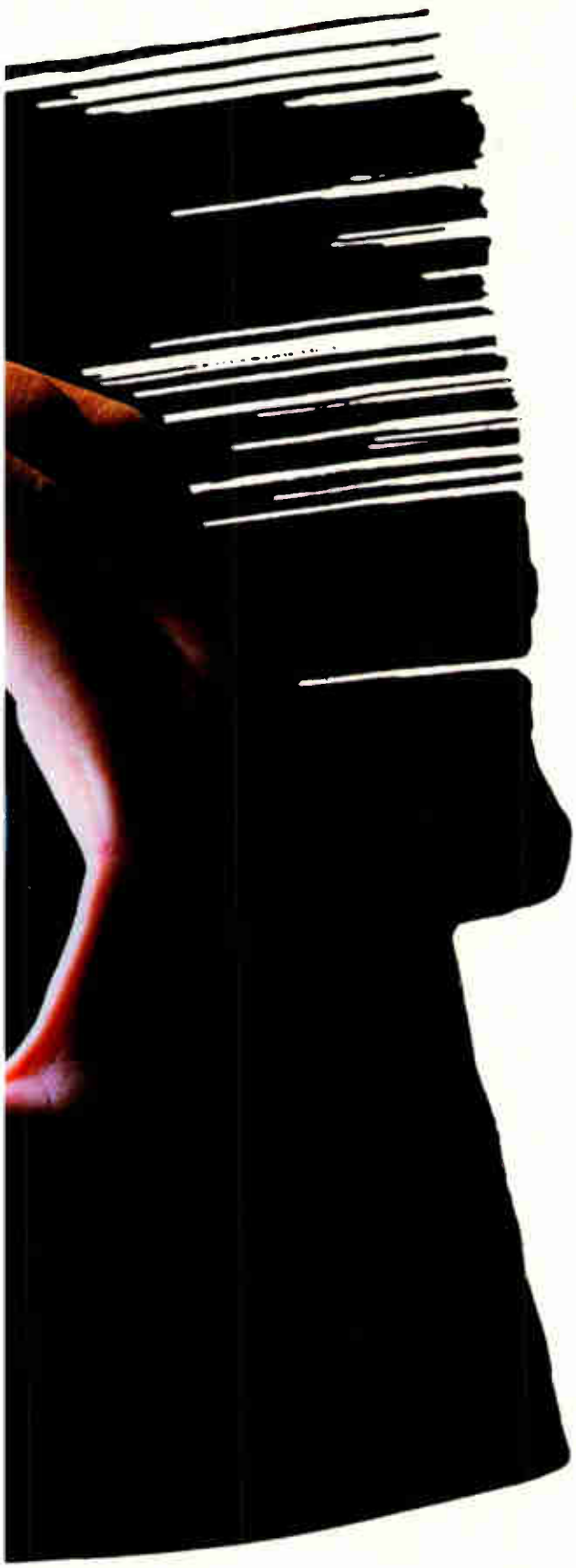
Meanwhile, Apple has signed up First Pacific Networks Inc. of Sunnyvale, Calif., to supply its broadband local-area network product transmitting video, voice, and data in forms compatible with most private branch exchanges. It will use Macintoshes initially as the front end for government command-and-control integration projects.

For the time being, IBM and Apple are concentrating on short-range targets. IBM will have little difficulty adapting Intel's DVI from its original PC AT platform to the PS/2 Micro Channel architecture, says Satish Gupta, manager of IBM's Mixed Media Products Division in White Plains, N. Y. The challenge, says Gupta, lies in software development, where radically different data bases—audio, video, and graphics—must be synchronized. IBM will bring a Micro Channel multimedia product line featuring DVI data compression to market by the first quarter of 1990, he says.

Most multimedia products running on the Macintosh are the work of third-party developers. One of the earliest is MacroMind Director, from San Francisco-based MacroMind Inc. It synchronizes text, graphics, and video with music and sound effects. Aimed at corporate users, the software started shipping in April.

Owl International Inc.'s Guide has similar capabilities, but does not interleave audio with graphics and text. On the other hand, Owl offers versions that run on IBM PCs as well as the Macintosh. Applications include education, on-line reference, and electronic publishing. Built around Hypertext—a more comprehensive implementation than Hypercard—the Bellevue, Wash., company's Guide has been used to tutor pathology students at Cornell Medical School and tame 600,000 pages of technical documentation for the F-16 Fighter.

Although low-end applications—audio-visual presentations, data retrieval, and the like—dominate today's multimedia product offerings, a few high-performance systems are also PC-AT-based. Occupying the top of the hill is a video postproduction system from Digital F/X Inc. that costs $129,000 but competes handily with proprietary systems priced at $1 million or more. The DF/X 200 replaces systems consisting of special-purpose boxes developed for broadcast postproduction studios, says Steve Mayer, chief executive officer of the Mountain View, Calif., company. The system integrates high-end paint and video typography with real-time digital effects. And it's finding customers in nonbroadcast markets. Aerospace companies use it to combine video with high-resolution graphics, says Mayer, and interactive-video producers have also expressed interest. □



Sizing Up the Earth in 200 B.C.

Eratosthenes believed the earth was round. As director of the great library at Alexandria in Egypt, he decided to go beyond abstract argument and actually measure it to back up the argument.


Eratosthenes

Knowing that the midsummer noon sun shone straight down a vertical well in Syene far to the south, he measured the slight angle of the sun's shadow in Alexandria on the same day. He figured the distance between the two cities by how long it took a camel to walk there. Then, with a little simple geometry, Eratosthenes came up with fairly accurate figures for the earth's circumference and radius. His pioneering measurement made a significant impact on history.

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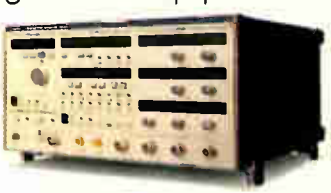
Anritsu continues the pioneering tradition in measurement.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Circle 55

BY TOBIAS NAEGELE

THE ELUSIVE TECHNOLOGY AT THE HEART OF STAR WARS:

FOCAL-PLANE ARRAYS

These tiny, highly sensitive infrared detectors are the objects of a massive development effort by government and industry. They hold great promise—but difficulties with materials have made for manufacturing headaches and sky-high prices

Somewhere in the frozen Siberian tundra, a nuclear missile blasts off from its launching pad and rockets into the sky. Instantly, a 3-ft-long U. S. rocket orbiting the Earth spots the superheated missile, determines its speed and trajectory, takes aim, and launches after it. The tiny U. S. rocket blasts through space, first tracking and then intercepting and destroying the Soviet missile—long before any warheads are deployed. This is Brilliant Pebbles, the cornerstone of the Strategic Defense Initiative.

A soldier, sitting on a rise near enemy lines on a dark winter night, peers through a missile sight and spies an enemy tank several miles away. Lining up the tank with the cross hairs in the sight, he locks on the target, pulls a trigger, and launches a missile that is guided by its own infrared detector to destroy the tank. This is the Advanced Anti-Armor Weapons System (Medium).

What both weapons have in common is a tiny infrared focal-plane array, a highly sensitive imaging system that provides detailed pictures at night, in heavy smoke, or through clouds from orbit. Direct descendants of the night-vision systems developed in the late 1960s and '70s, focal-plane arrays offer wider fields of view, increased sensitivity, and improved resolution over their predecessors—all in a much smaller package. What's more, the arrays are based on a passive sensing technology: unlike radar, IR detection doesn't emit a signal that an enemy can use to aim return fire. Focal-plane arrays obtain imaging data simply by absorbing light from the IR spectrum; they are invisible to the enemy.

These attributes have designers falling all over themselves trying to incorporate the arrays into weapons systems. Indeed, in addition to Brilliant Pebbles and the AAWS-M, such high-profile weapons as the Air Force's Advanced Tactical Fighter and the Army's LHX attack helicopter and M-1 Tank will all have focal-plane arrays on board, as will a revamped version of the Navy's F-14.

"We're beginning to see dramatic increases in the programs that are interested in focal-plane arrays," says one Defense Department source. As a result, demand for arrays in the 1990s could total 300,000 units or more, presenting a financial bonanza worth at least $6 billion, and probably much more.

But although several companies, including Hughes Aircraft, Rockwell International, and Texas Instruments, can produce focal-plane arrays, output is limited, yields pitiful, and prices out of this world. A single 128-by-128 array—which has 16,384 detectors integrated on a single chip—can cost upward of $60,000. That's far too much for any tactical application. "There's still a lot of witchcraft in detectors," says a branch chief at the Strategic Defense Command.

So defense electronics companies and the Pentagon are sinking millions into a series of efforts aimed at slashing those costs to $2,000 or less. For example, Texas Instruments Inc. has already invested $35 million in capital and facilities for manufacturing focal-plane arrays, says Jesse C. Wilson, vice president of TI's Defense Systems and Electronics Group in Dallas. Other firms have done likewise.

But the big money is coming from the Pentagon, which is spending $50 million or more a year to fund a series of efforts aimed at cutting production costs. That's in addition to the hundreds of mil-

lions it's spending to develop detectors for individual applications. One of these is D-Star—the Defense Strategic and Tactical Array Reproducibility program. Managed by the Defense Advanced Research Projects Agency, D-Star will cost the Pentagon around $200 million over the next five years.

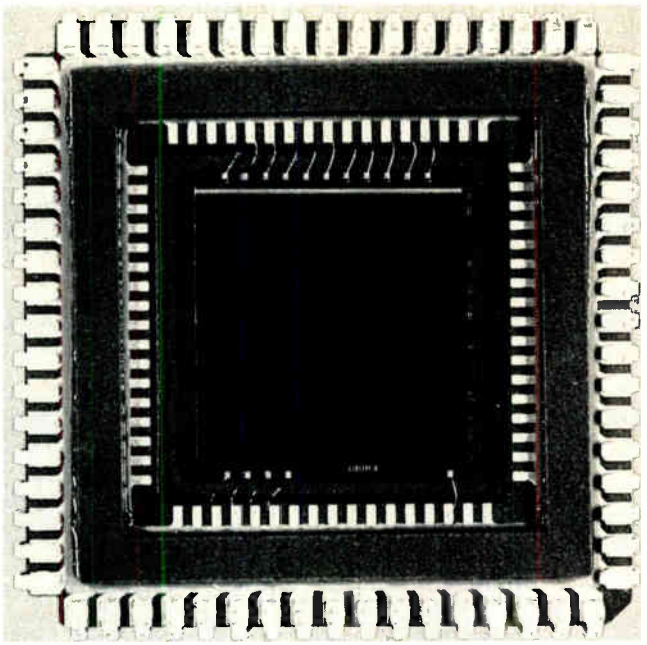
The first-phase D-Star awards, announced last month, provide $30 million over two years for manufacturing and process development work at Hughes, Rockwell, and Fairchild Weston CCD Imaging Division of Milpitas, Calif. TI, at first considered a leading contender for a D-Star contract, was knocked out early on a technicality. Darpa said the company didn't precisely address its requirements, a point TI disputes.

However, D-Star isn't the only game in town. The Air Force's Wright Research and Development Center at Wright-Patterson Air Force Base in Dayton, Ohio, is funding Hughes Aircraft Co. and Rockwell International Corp. to the tune of $30 million over a four-year period to refine their materials-processing capabilities. And the Army's Strategic Defense Command in Huntsville, Ala., is spending $15 million a year to improve the ability of focal-plane arrays to withstand radiation.

Focal-plane arrays are difficult to make because the materials involved are not easy to work with. The most common material used is mercury cadmium telluride (MCT), because it offers the greatest flexibility: it can handle both short- and long-wave IR detection and can operate at room temperature or, for improved sensitivity, at a supercooled 77 degrees K.

Other options include extrinsic silicon, which offers excellent long-wavelength performance but operates only at 10 to 15 degrees K, and platinum silicide, which is easier to process but is not as efficient as MCT.

It's not surprising, then, that the majority of the Pentagon's investments are aimed at MCT, even though it may be the most difficult of the materials to use. "MCT is comparable to talc," says TI's Wilson. "It's soft and brittle." Engineers have concocted a number of techniques to get around this problem. The oldest and most problematic is to simply build the arrays on an ultrathin layer of MCT grown on a cadmium telluride substrate. But because both materials are so delicate, wafers are limited to about 1-in. squares, so only a very few arrays can be built at once. With a complex, multistep process, few if any of the arrays produced with this method will ever operate to spec.



Rockwell's 256-by-256 array, of MCT on a sapphire substrate, is the largest of its type ever built.

Rockwell and others have begun to look at growing MCT epitaxially on other materials, notably synthetic sapphire and gallium arsenide. "We felt that if we were going to improve MCT, we had to make it more silicon-like," says Mike Andrews, director of Rockwell's Electro-Optical Center in Anaheim, Calif. Rockwell needed larger substrates to produce more arrays at once, round substrates that matched what was called for by standard silicon manufacturing equipment, and harder substrates that wouldn't break so easily. Growing MCT on silicon posed basic physical problems, so Rockwell settled on sapphire and GaAs.

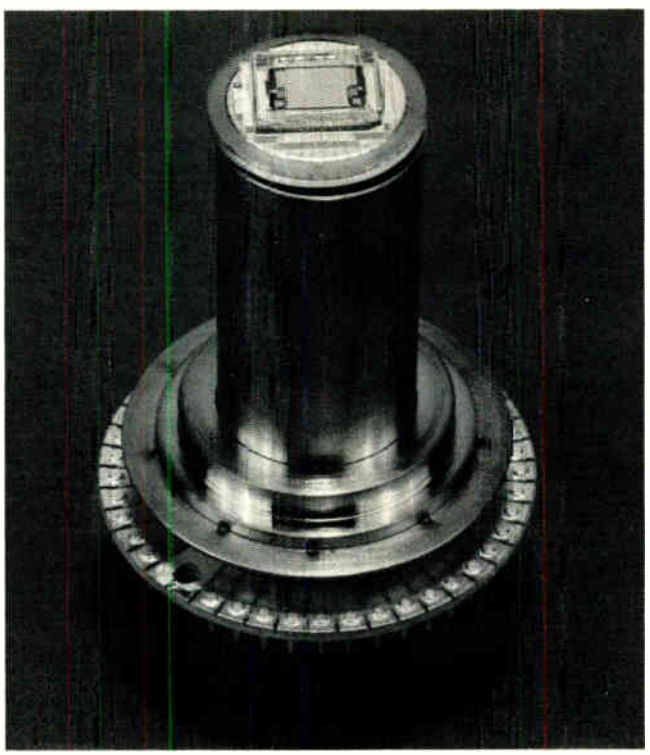
Although neither sapphire nor GaAs is considered ideal in the IC world compared with silicon—designers complain that these materials are defect-ridden and too soft and brittle—both are more robust than cadmium telluride. "Everything in life is relative," Andrews says.

But even on sapphire, MCT yields are mired at the 1%-to-3% level. Rockwell is now under contract with the Wright Research and Development Center to improve the MCT-on-sapphire process yield to around 10% or more by 1991. That improvement should help drop costs down to about $1,500 to $3,000 per unit from $30,000 to $60,000 per unit.

The MCT-on-GaAs process is less mature but should get a major boost from D-Star funding. "GaAs probably has the highest payoff potential," says Ray Balcerak, D-Star program manager at Darpa. "You might eventually be able to integrate data processing on the GaAs substrate."

Rockwell is investigating both technologies because neither substrate alternative offers the same flexibility that made MCT the focal-plane material of choice in the first place. In building any array, designers must arrange for output data to reach a readout circuit. That chip, which is generally bonded to the back end of the array, typically includes an amplifier for each detector and a multiplexer to pare down the number of connections between the array and its signal processor.

However, when the array is built on material grown epitaxially on a foreign sub-



TI's arrays, like this 64-by-64 long-wavelength model, are mounted directly on a silicon readout circuit.

strate, the challenge increases. No one has yet come up with a method for either building the readout circuit on the substrate itself or for wiring through the substrate to the array. That leaves only one alternative: bonding the readout circuit to the exposed MCT. This means the array must be built to look at the world through the substrate. Sapphire is transparent to IR light in the 3-to-5-μm band; GaAs is transparent at 8 to 14 μm.

Critics of this process point out that illuminating through the substrate causes problems for the optical system and makes it more vulnerable. It also adds processing steps that can have a severe effect on yield. After the detector is built, there are two process steps that can destroy the MCT layer: indium bump pads must be deposited, and the readout circuit must be bonded to those pads. Improper handling can ruin an array.

There is one approach, however, that does not require the array to look through its substrate. TI builds its detectors right on top of its silicon readout chip, a technique that has helped the vendor win more focal-plane-array development contracts for specific weapons systems than any of its competitors.

"We've got a factor-of-two more programs under way than any other competitor," says TI's Wilson. TI is now developing individual arrays for at least 13 military systems, among them the M-1 Tank, the LHX, and two SDI programs, including a Brilliant Pebbles prototype.

In the TI scheme, the readout circuit is built first, using standard silicon processing techniques. The finished wafer is probed and the bad dice marked. But rather than dicing the wafer at this stage, it is kept whole. A pick-and-place machine then bonds individual pieces of comparatively thick MCT—about 30 mils—with epoxy over each working readout circuit.

Focal-plane-array systems like this one, from Hughes Aircraft, let a foot soldier spot and track an enemy vehicle from several miles away.

TI uses the thick MCT slab so that it won't break during the bonding process. But, Wilson says, the piece is too chunky to use for an array. So the slab is thinned down to less than 1 mil before the focal-plane array is finally built. A final metalization step bonds the array's output circuits to the silicon chip beneath. TI won't disclose yields, but Wilson claims that they are the highest now available.

The prime advantage of TI's process is that operator handling is held to a minimum. From the time the MCT is inserted into the pick-and-place machine, through the warm and cold probe tests that are performed just before final dicing and packaging, no hands touch the material at all. That's precisely the goal for D-Star's second phase, which should begin around 1991—in time to meet heavy demand for focal-plane arrays in the mid-1990s, when weapons systems now under development move into production.

In that phase, D-Star will seek to establish a full-fledged, diversified manufacturing base for focal-plane arrays, says Darpa's Balcerak. "We plan on building an entire manufacturing system." □

HOW AN ARRAY WORKS: IT'S 'LIKE AN EYEBALL'

Infrared focal-plane arrays are a close relative of the charge-coupled-device cameras that make consumer video camcorders possible. But they are far more complex, more sensitive, more expensive, and more difficult to manufacture than their monolithic silicon cousins.

A typical focal-plane array includes thousands of tiny infrared detectors on a single chip. The detectors "look" through a complex set of optics, absorb infrared light, and then download the incoming data to a silicon readout circuit bonded to the back of the array.

This readout circuit multiplexes the data, converts it to digital form, and sends it on to a signal processor.

"It's like an eyeball," says Mike Andrews, director of Rockwell International Corp.'s Electro-Optical Center in Anaheim, Calif. "Focal planes see thermal information and convert it into information that can be displayed on a screen and understood by a viewer." IR light, in the form of photon emissions from a target, hit the focal plane and are processed into an image.

The result is a detailed temperature map that, when properly analyzed, can yield all the data necessary to identify and track a target—everything from the size and shape of an object to its speed and location.

Focal-plane arrays come in a wide variety of configurations. They can range from systems boasting very broad fields of view to systems with an extremely narrow focus. Depending on the application, arrays can be built in formations ranging from squares—128 by 128 detectors, for example—to very long and narrow—960 by 4 detectors. They can also be designed to operate in either of two modes: scanning or staring.

Scanning arrays, which are based on more mature technology, are used in applications that require a wider field of view, such as night-vision systems or targeting systems for the new breed of sophisticated missiles, such as the Advanced Anti-Armor Weapons System (Medium). These systems typically scan across each of their detectors 30 times/s, providing an image that's adequate for long-range sensing.

But once a missile is launched and is closing in on its target, it needs a more continuous update. That's where the newer staring arrays come in.

"Staring arrays are for seeker applications, where you have a relatively small field of view—just a few degrees—but you need a very detailed, continuously updated picture," says an official at the Army's Strategic Defense Command in Huntsville, Ala. *–T. N.*

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Next act: network norms

The Network Management Forum is accelerating product cycles for OSI-based solutions to pressing problems

BY JACK SHANDLE

Don't look now, but network-management standards are just around the corner. In its first year of work, the OSI/Network Management Forum has laid a solid foundation for implementing standards to manage multivendor networks. Network-management products conforming to the seven-layer Open Systems Interconnection model may be available by late 1990—two to three years ahead of what reasonably could have been expected a year ago.

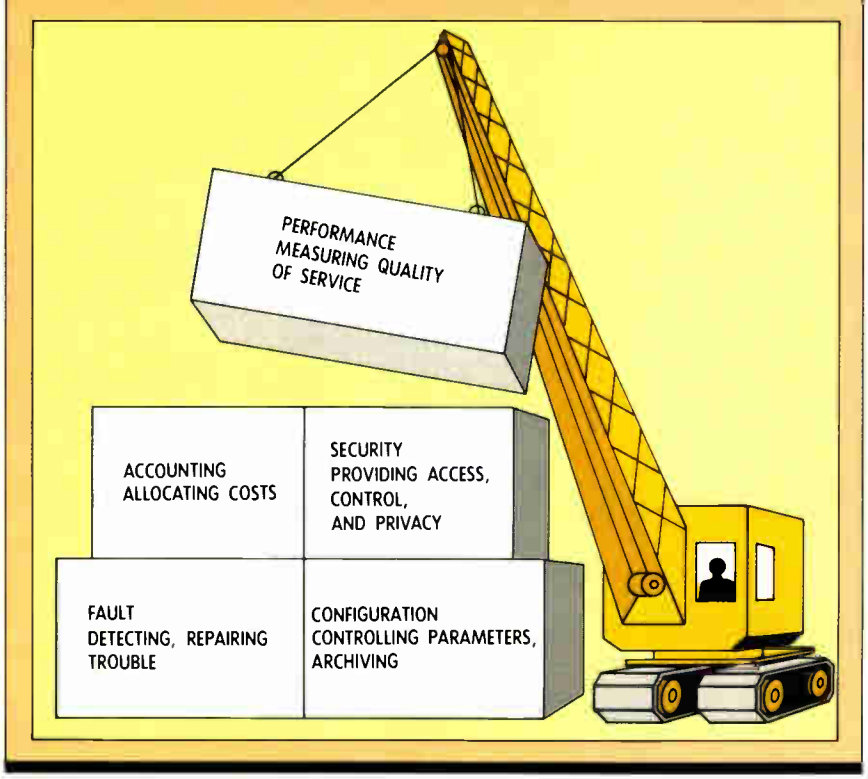
That's not a bad piece of work for an organization that started out last July with eight members and the comparatively modest goal of accelerating the product-development cycle of OSI-compliant network-management hardware and software. The forum now boasts more than 60 members in 11 countries.

For network managers struggling to keep tabs on dozens of local-area and wide-area networks, the Network Management Forum arrived not a moment too soon. In essence, the forum is an implementers' group that stands between the International Standards Organization—the developer of the OSI model—and conformance testing groups, says John Miller, president of the Bernardsville, N. J.-based group.

"People have been through a decade of plugging boxes together," says Jim Warner, senior marketing manager for the Open Network Management System Division of Digital Communications Associates Inc. in Alpharetta, Ga. "Now they want to turn their networks into tools that will give them a competitive advantage by optimizing the networks' capabilities."

International standards may ultimately provide the communications highway of the future, but so far that road has been tortuous indeed. Standards-making organizations like ISO tend to move slowly, if only because they must cover all technological bases before they issue a standard. In fact, OSI's network-management standards have yet to be finalized. Ironically, the very completeness of the OSI protocol set hinders implementation. In general, the ISO provides several options for each major segment of a standard. If different companies choose

BUILDING A SOLID FOUNDATION



different options for their products, there's no guarantee their equipment will be compatible.

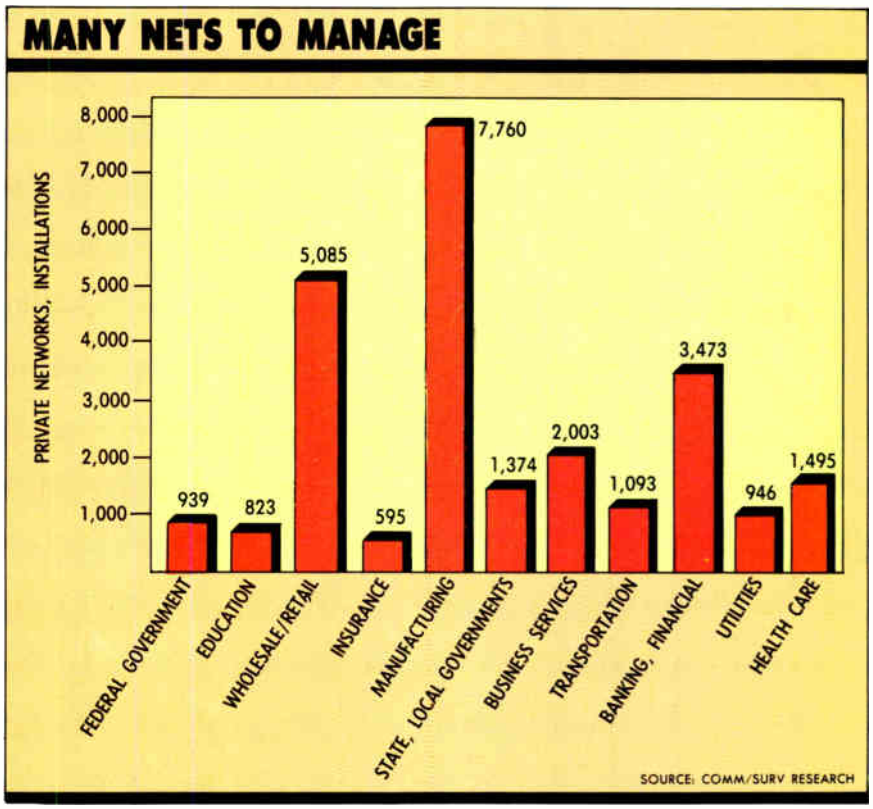
The forum's self-defined role is to ensure compatibility by identifying a subset of standards options on which all members will base at least their first round of equipment. That guarantees the boxes—and software—will play together. The organization has already agreed on a subset of OSI network-management protocols and formed a partnership with two conformance testing organizations, the Corporation for Open Systems in McLean, Va., and the Standards Promotion and Applications Group in Brussels, Belgium. Remaining work—specifically, the publication of documents describing a common management language and defining the objects to be managed—is due by the third quarter of this year, says Dave Mahler, product marketing manager for Hewlett-Packard Co.'s Open View Network Management System Division in Roseville, Calif.

THREE STAGES. The forum is pursuing a three-stage strategy: endorse a subset of networking standards from among those that seem most likely to be in the final OSI protocol set; agree to build products conforming to that subset; and secure conformance testing for the subset. With the likes of computer and communications giants Amdahl, AT&T, HP, Nippon Telegraph and Telephone, Northern Telecom, and Unisys as members, the forum has enough muscle to push for early standards that overwhelm competing efforts.

Of course, the forum can't bring standards into existence on its own. "The ISO documents we rely on are not all that complete," says Ian Sugarbroad, vice president of Northern Telecom Inc.'s Network Systems Division in Austin, Texas. The forum, he says, is in the peculiar situation of speeding implementation without being sure what the ultimate OSI standards will be. "We don't want to lead the pack by too much," Sugarbroad says. "We don't want to revise the document two or three times."

The forum's protocol document, published in January, describes the list of protocols that will be forum-compliant—as opposed to the much longer, albeit still incomplete, list of OSI-compliant protocols. "We decided that mechanisms for two transports—wide-area networks and local-area networks—were of particular importance," says HP's Mahler.

"In WANs, the forum's protocol committee settled on X.25, and in LANs, it chose IEEE 802.3," he says. (The IEEE 802.3 protocol is similar to the Ethernet standard.) Moreover, Mahler says, the committee chose to make X.25 mandatory for any company that wants to field a forum-compliant product.



Next in line for publication are the so-called FCAPS messages. FCAPS stands for the five types of management message sets—fault, configuration, accounting, performance, and security—that create a language for the transmissions. In fault management, they specify how alarms are to be set up and filtered to keep the network from being flooded. Configuration management lets network managers define their network hierarchy and archive information. Accounting message sets help keep track of services being used. Security message sets provide network access, network control, and privacy for users. The performance sets keep track of the quality of service, recording data concerning system availability and utilization.

The forum's third set of documents will define the objects—modems, multiplexers, and the like—to be managed in terms of the attributes that network managers consider important. Attributes go beyond such characteristics as serial number or baud rate to include, for example, whether a particular modem can be turned on and off.

Besides the internally generated protocol, message, and objects standards, the forum is also addressing the issue of conformance testing, a critical component in the standards-making process. Users typically are skeptical of manufacturers' claims that their products conform to a standard; tests by third parties can significantly speed the acceptance of a new standard.

The organization took a big step in that direction in May, when it agreed to set up a decision-making executive council with two independent conformance testing groups, COS and SPAG. The cooperation will "ensure a common technical focus and maximize the use of resources," says Patrice d'Outremont, SPAG's managing director.

The forum has been so successful in meeting its deadlines to date that few observers doubt that its Showcase '90—a presentation of forum-compliant products—will go off as scheduled in October 1990.

As the forum winds down its first year of activity, its key goal remains interoperability. There are more than 25,000 private networks operating worldwide, most of which include more than one vendor's product line. That's because no one anticipated that LANs could be linked, so enterprise-wide compatibility rules were not developed. Also, the recent wave of mergers has left most corporations with a variety of vendors' solutions.

"We're making the transition from a single-vendor world to heterogeneous vendors and standards," says Lou Krieg, director of network architecture for Unisys. "The old days are over. We're entering a time when no one will look for a complete solution from one vendor." □

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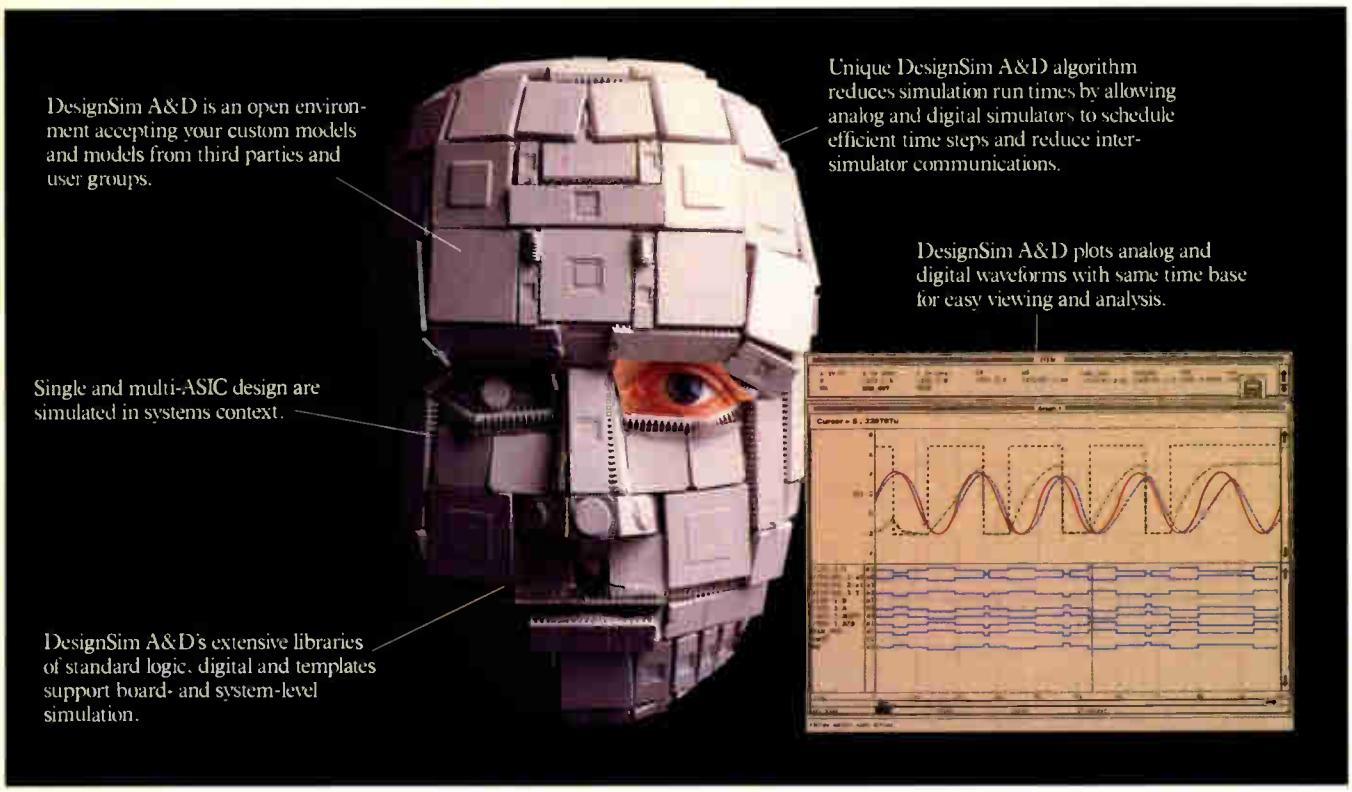

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BY BERNARD C. COLE

BREAKING THE POWER FACTOR BOTTLENECK

THERE'S A NEW BARRIER IN THE BATtle to improve computer performance: the wall socket. Even as high-power processors emerge to boost the performance of work stations, minicomputers, and high-end personal computers, the new deterrent to higher throughput is the dc power supply that converts the ac supplied by utilities into the dc needed by the system.

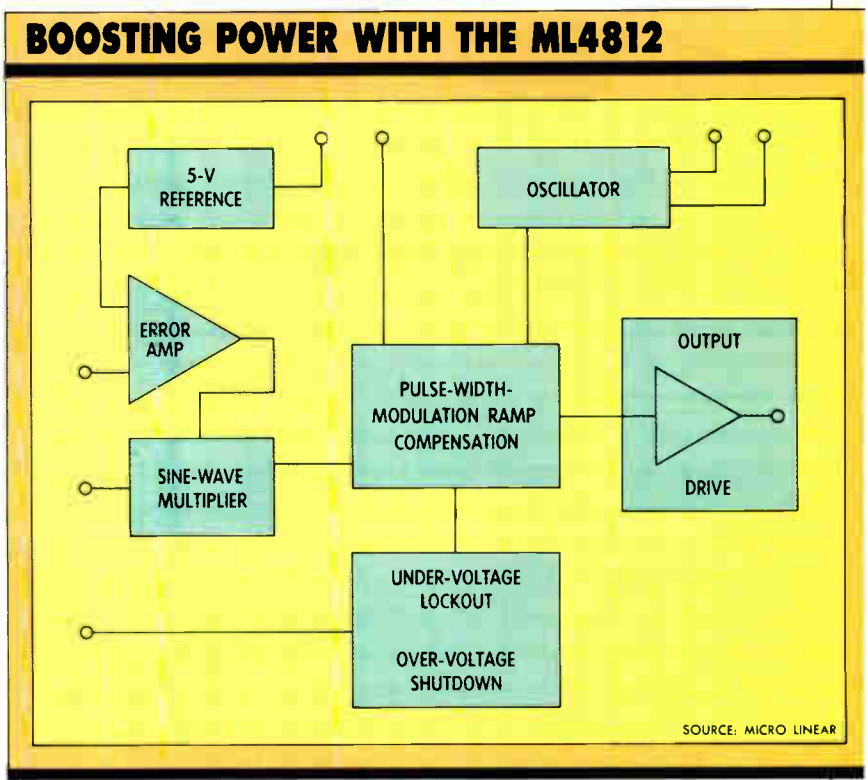
Currently, only designers of larger computer systems are hitting the wall. But in the longer run, designs of personal computers and any appliances using microcomputers or microprocessors will have to deal with the power factor, mostly for problems of power-line noise and distortion. Already, in Europe, the International Electrotechnical Commission has drawn up standards to control the harmonics, voltage fluctuations, and noise in all household appliances. And although they're still only in the beginning stages, restrictions on power-line distortion and noise may be imposed by U. S. utility companies.

To address the problem, a number of manufacturers of computer systems and work stations—such as Apollo Computer Inc. and Digital Equipment Corp.—are beginning to consider incorporating so-called power-factor correction circuitry to gain efficiency and allow more power to be used. Also incorporating such circuitry into their switching power-supply modules are subsystem manufacturers, such as ACDC, Acopian, Aztec, Boschert, Cherokee, Elpac, HC Power, Jeta Power, Power One, Pioneer Magnetics, RTE Power-Mate, and Sorenson. Joining them, a number of semiconductor firms are also assessing the need for such circuitry.

The first to offer products in this new application area are Micro Linear Corp. of San Jose, Calif., which introduced its monolithic solution, the ML4812, last month, and Unitrode Corp.'s IC Division in Santa Ana, Calif., which will introduce its UC1854 later this summer. A third player is Siemens AG of West Germany, which is on the market with a power-factor correction controller originally designed for fluorescent tubes. The Munich-based company is developing a circuit geared more directly toward computer makers.

So just what is a power factor? Simply stated, it is the percentage of usable power derived from the power grid; in other words, the apparent power divided by the true power. Poor power factor is an inherent problem with typical dc supplies in computer systems; it ranges from 60% to 80% efficiency. Thus, in order to get 800 W of apparent power from the line, the grid must deliver in the range of 1,000 to 1,200 W. This inef-

BOOSTING POWER WITH THE ML4812



Micro Linear's bipolar ML4812 can supply up to 25% more power from a standard 120-V wall outlet. It also improves noise immunity.

ficiency stems from the high peak-input current developed when charging the power supply's input capacitor. These peaks have high harmonic control, which is effectively out of phase with the input ac voltage and thus degrades the power factor. Only in-phase current produces usable power.

The ac input current of these systems is often significantly higher than the calculated current, quite often causing the 15-A circuit breakers on the line voltage to trip. Without some form of power-factor correction, this limits system design in terms of the functional load it places on a standard line. In addition, the harmonics produced by the excessive peak current develop substantial amounts of power-line noise and distortion. And since a large amount of the current is lost to these harmonics, a considerable amount of apparent (or unusable) power is produced, lowering the available "true power" of the supply to as little as 600 or 700 W.

System designers have long been aware of the power-factor problem but have been unwilling to deal with it for one simple reason: cost. "Adding power-factor correction circuitry into a design costs anywhere from 2 cents to 10 cents per watt using current technology," says Robert White, principal engineer in DEC's corporate power-conversion group in Maynard, Mass. "The extra $70 to $150 that it adds to the cost of a system can be the difference between making or not making a sale."

But the prospect of IEC555, the IEC's regulation in Europe, is forcing a shift in thinking. Right now still primarily voluntary on a country-by-country basis, it is expected to take on the force of law throughout Europe by 1992, when the 12 countries in the European Community combine to form a single market. IEC555 places absolute limits and scaled limits by

The new deterrent to higher throughput is the power supply that converts the ac furnished by utilities into the dc needed by computer systems

power level on the harmonic content for all power supplies, says Charles Gopen, vice president of marketing at Micro Linear. "This will make necessary some form of power-factor correction for all supplies rated higher than 300 W," he says. That encompasses not only high-performance minicomputers, superminis, and work stations, but PCs and a wide range of consumer products as well.

Initially, many power-factor circuit designs being implemented by system houses such as Apollo and by many switching power-supply makers use the simplest and lowest-cost option: a passive approach based on simple choke filters. This produces about 90% efficiency, says White. The disadvantage is that such an approach requires bulky capacitors and is limited in range. By comparison, active power-factor correction designs, such as those being considered by companies such as DEC, boost the efficiency to 95% to 99%. But in discrete designs, the added cost is greater complexity and circuit count—at least six or seven ICs, including a pulse-width-modulated switching converter controller plus a dozen or so resistors and capacitors for a typical 1-kW design.

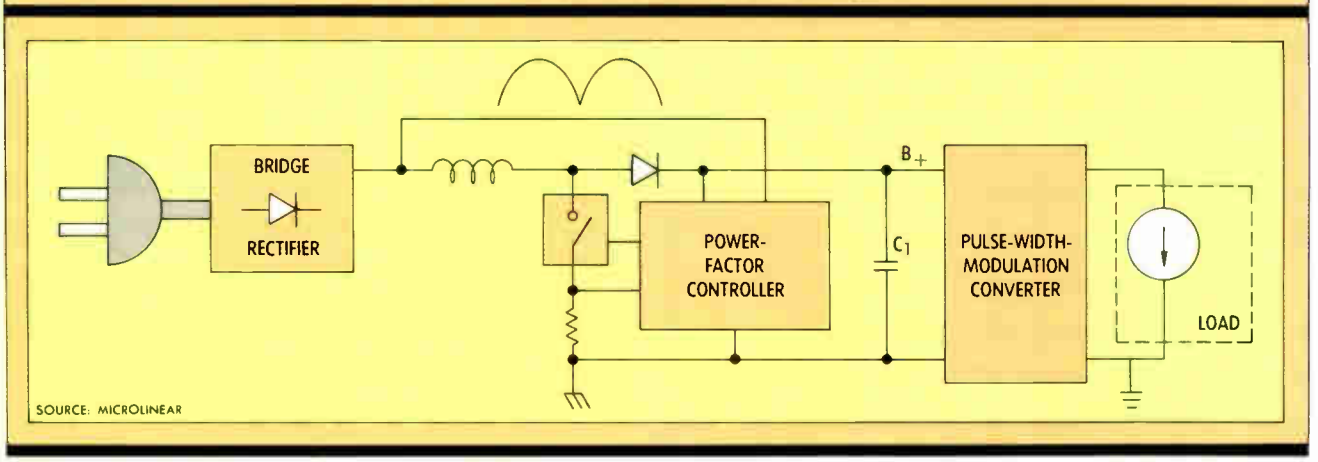
But the trade-off is simpler and less expensive overall system design, says White. "Among other things, it allows you to use smaller bulk capacitors throughout your design and allows you to run the switching power supply at a much higher duty cycle—but with considerably lower peak current." It also simplifies greatly the problem of distributing power to such systems.

With the introduction of monolithic active ICs to correct the power factor, such as Micro Linear's ML4812, much of the cost differential between the active and passive approaches can be eliminated, says Gopen. The bipolar controller circuit, made with 3.0-μm, 40-V, double-metal-layer techniques, can supply up to 25% more power from a standard 120-V ac, 15-A wall outlet. It acts as a preregulator for a conventional PWM converter to achieve efficiencies beyond 99.5%.

Incorporating at its core a current-mode boost regulator, the circuit also contains a precision reference, an error amplifier, overvoltage protection circuitry, programmable ramp compensation circuitry, and a 500-mA totem-pole output. A unique current-input multiplier improves noise immunity, and an undervoltage lockout circuit simplifies startup.

To achieve its high power-factor rating, the ML4812 employs a form of waveform synthesis in which the input current waveform—normally a narrow pulse—is modified to closely follow the phase and shape of the input voltage waveform at the output of a system's bridge rectifier, says Jon Klein, Micro Linear's bipolar standard-product marketing manager. The current supplied to the PWM, he says, is actually the product of the sinusoidal line voltage and the output of the error amplifier. "By reducing the peak current in this fashion," says Klein, "the harmonics produced by the high current spikes are minimized, effectively eliminating the apparent power while significantly reducing noise." □

HOW A POWER-FACTOR CORRECTION CIRCUIT WORKS



As the first monolithic active IC to correct the power factor, the ML4812 incorporates a pulse-width-modulation converter. This is a greatly simplified design compared with discrete solutions, which typically require six or seven ICs.

FOR EEs, LIFE IS ROSY IN SAN FRANCISCO

That's where salaries are highest, says an IEEE report

The Institute of Electrical and Electronics Engineers is talking money again—that is, how much of it EEs are earning these days, and where and how they are earning it. The organization has just published the results of its biennial "U. S. Membership Salary and Fringe Benefit Survey," and for the electronics manager, the report can be enlightening.

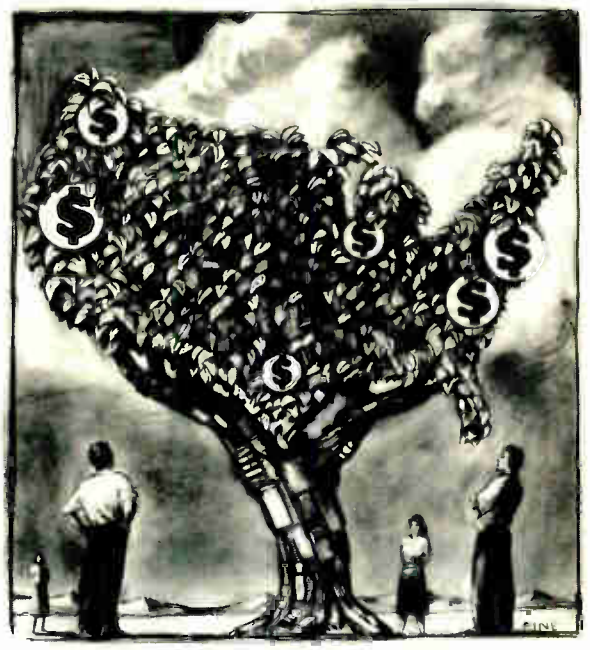
Not only does the survey deal with salaries, but it also examines pay in relation to location, specialty, and position; looks at the distribution of fringe benefits; assesses changes over the years; and delves into a host of other ancillary questions.

Among the facts turned up by the IEEE's detailed six-page questionnaire:

- The 1988 mean pretax income of nonstudent IEEE members was $54,700. That's a slight increase over the 1986 survey's figure of $53,400.
- In areas with the highest concentration of engineers, the three top-paying cities are San Francisco ($59,000), New York ($58,000), and Washington ($56,100). At $60,000, the overall leader is Poughkeepsie, N. Y., where IBM Corp. holds sway—but the low number of respondents in the area may have skewed the findings, says James H. Beall, chairman of the survey committee. Ranking No. 47 and last is New London, Conn., where EEs averaged $40,000 in 1988.
- Nearly a quarter of the engineers in the sample are job hunting.
- EE salaries tend to stay even with inflation. "There is a net growth in nominal income equal to inflation," says Beall, but not in purchasing power.
- A salary drop-off occurs after age 60.

The survey forms went to 10%—or every 10th name—of the IEEE's nonstudent, U. S. members at the associate level and higher. Of those, 7,141, or 36%, returned surveys.

When it comes to salary, "We're about in the same spot we were in about 20 years ago," says Beall, who retired from the Bell System five years ago and lives in New Port Richey, Fla. "We had been behind, then we got ahead, and now we're staying even." Taking inflation into account, he says, "the purchasing power of the EE is about the same now as with the $19,000 [income] of 1971." Reflecting that, the survey shows that although nominal income increased 3.9% between the 1987 and 1989 studies, purchasing power has remained essentially static.



On the other hand, there is a positive change from a decade or more ago, says Beall. "In 1975, unemployment was double what it is now," he says. But even that is subject to geographic vagaries. "As I get around to various IEEE functions," he says, "I get the impression that in some parts of the country they are saying that things aren't bad, but in others they're not that good. For example, it's not too good in the Northeast."

Looking at the pay picture from the angle of particular industries rather than locations, the big winners are EEs in communications ($61,600), independent research ($60,300), and electronic equipment ($59,000). Engineers in the electrical machinery industry—which includes numerical control—topped those three categories at $64,000, but here again, says Beall, there were only 29 respondents, too few to accord this segment first place.

Even as salaries remain more or less in place, there are more EEs looking for a job change today than two years ago. According to the survey, 24% of the respondents are job hunting; the figure in the last survey was only 20%.

On the fringe-benefits side of the compensation equation, the extent of coverage and the number of survey respondents covered have dwindled. More than 90% of the respondents reported that their employers offer coverage in standard areas of health and life insurance. Major medical, dental, and disability are available for 80% to 90% of employees, though only 45% get eye care. But these numbers are lower than those reported in 1987, when health care was available for 99%, versus 95% in the most recent study. By the same token, life-insurance coverage was reported by 97% in 1987 and just 91% last year. And the percentage reporting dependent health care dropped to 92% from 97%.

Retirement vesting and portability of benefits, long a sore point with the traditionally mobile EE, come in for their share of attention. Some 92% of the engineers who returned their questionnaires report that they are not vested or vested in only one company, while 7% say they are vested in two companies. And about half the respondents say they have portable benefits, with 25% reporting that they do not. (However, there is some question about the way the query was worded, says the survey committee in its report, because a high percentage—25%—replied "not sure.")

Of those who reported participating in a portable retirement-benefits plan, 34% had a 401(k) or variant, 31% a so-called SEP (for Special Employee Plan, usually favored by smaller companies), and 21% were in other plans.

The report may be obtained from Publication Sales, IEEE Service Center, 445 Hoes Lane, P. O. Box 1331, Piscataway, N. J. 08855-1331. Ask for Publication No. UH0183-4. The price is $59.95 for IEEE members, $79.95 for others. □

by Howard Wolff

PEOPLE TO WATCH

HOW AN ENGINEER 'GONE WRONG' GOT TO HEAD A SOFTWARE FIRM

Silc's Steadman figures it took experience, knowledge—and availability

BURLINGTON, MASS.

David R. A. Steadman gives three reasons why he was selected as chief executive officer at Silc Technologies Inc.: his previous experience with a company whose business has a substantial software component, his intimate knowledge of the world of venture capital, and the fact that he was available.

Based in Burlington, Silc leads the market for design synthesis with its SilcSyn family of tools, which automatically generate structural representations of application-specific integrated circuits from high-level behavioral descriptions. SilcSyn runs on Apollo, Digital Equipment VAX and MicroVAX, and Sun Microsystems platforms. The company spun out of GTE Laboratories Inc. of Waltham, Mass., in 1986, got its first venture funding in February 1987, and began delivering SilcSyn last year.

As a startup software firm, Silc can make good use of Steadman's experience with software and venture capital. A self-described "engineer gone wrong," the British-born Steadman has degrees in electrical and mechanical engineering from London University. The software savvy springs from his position as president of Raytheon Data Systems, which Raytheon Co. sold in 1984 to Telex Corp.

Steadman then delved into seed financing by setting up and running Raytheon's corporate venture-capital division until his departure in mid-1987 to become chairman and CEO of GCA Corp., the Andover, Mass., manufacturer of semiconductor production equipment. Steadman's charter there was to help restructure the company and bring it back to profitability after financial hard times—a task made difficult after the stock market crash of October 1987.

After GCA got back into the black, Steadman was instrumental in finding a corporate parent for the company, overseeing its sale to in General Signal Corp. of Stamford, Conn. That sale is what made him "available"—after a little more than a year at GCA—when some Silc investors approached him to run the company. He signed on last December, convinced that SilcSyn, which was already shipping to customers, was a unique product, "but the marketing game wasn't fully together."

As an open system, SilcSyn can be integrated with existing computer-aided engineering systems and ASIC design techniques. It generates designs in familiar gate-array and standard-cell libraries, including those from Fujitsu, LSI Logic, NCR, Standard Microsystems, and Toshiba. The product can link to CAE systems from Mentor Graphics, Valid Logic Systems, and Viewlogic. Support for other interfaces and cell libraries is coming.

Steadman believes design synthesis will play an increasingly important role in design automation. This market should grow to some $200 million by 1992, says The Technology Research Group, a Boston-based market research firm. Design synthesis using SilcSyn drastically reduces the time now required for schematic capture and test-vector generation.

The task now for Steadman and Silc is to solidify the company's market position and broaden SilcSyn's sales reach through additional OEM relationships with CAE houses and deals with distributors. Another goal is to move into design tools beyond the ASIC arena.

Toward those ends, Silc has secured Marubeni Hytech Co. Ltd. as a distributor in Japan and is working with European Marketing and Sales Ltd. to establish a European distributor network. Steadman says both firms have good track records in marketing CAD/CAM products for U. S. companies.

"Last year was one of rolling out the product, testing what customers thought about it, and getting revenues rolling," Steadman says. "Now we have to move from a low level of revenues to a point at the end of the year somewhere between $2.5 million and $6 million." Silc is now developing a VHSIC Hardware Design Language (VHDL) strategy, with release of a VHDL tool set slated for the first quarter of 1990. *–Lawrence Curran*

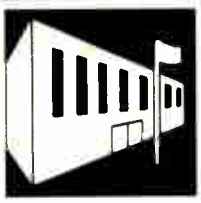
Silc Technologies' CEO David Steadman believes that design synthesis is playing an increasingly important role in design automation.

COMPANIES TO WATCH

WHAT'S THE NEXT STEP FOR SILICON COMPILER SYSTEMS?

The goal: to become a broad-line supplier of CAD/CAE tools for IC and system designers

SAN JOSE, CALIF.



Building a better mousetrap has paid off for Silicon Compiler Systems Inc. Targeting a niche for complete silicon compilation systems, the company's computer-aided design and engineering tools for chip designers have chalked up a 40% increase in software revenue since the third quarter of 1987. But silicon compilation hasn't become a mainstream design method, as company executives had hoped. So now Silicon Compiler has decided to go after broader markets.

Last month James T. Hammond, president and chief executive officer, announced that the San Jose company was being repositioned as a broad-line supplier of CAD/CAE tools to serve designers of systems and integrated circuits alike. The company is unbundling its software tool set and is at the same time offering tools that allow for the use of more conventional design methods.

Of the company's three new packaged systems, one is for custom-IC designers, another is for system designers performing IC layout, and the third is for system designers building application-specific ICs. Silicon Compiler already offers systems in each area, but the new packages add layout capability.

Another bold move on Silicon Compiler's part was to open up its tool offerings to accept CAD/CAE tools from vendors that offer so-called point solutions—individual tools, rather than complete tool sets—such as Gateway Design Automation Corp. in Lowell, Mass., and Synopsys Inc. in Mountain View, Calif. In addition, Silicon Compiler has begun offering its own point solutions as well as a design framework to tie the tools together, a strategy that could strike fear in the heart of the only other framework vendor, Cadence Design Systems Inc. of San Jose [*Electronics*, June 1989, p. 121].

Until recently, Silicon Compiler took aim at IC designers at major semiconductor houses, such as Intel, Motorola, and National Semiconductor, or at captive foundries inside large system manufacturers such as Digital Equipment, Hewlett-Packard, and IBM, says Robert Herwick, senior analyst at Hambrecht & Quist Inc. in San Francisco. The company has done well by this market. In 1988, Silicon Compiler had profits of about $3.9 million on revenue of $33 million, and it anticipates chalking up approximately $50 million in revenue this year.

In fact, the company has turned a profit every quarter since its 1987 merger with Silicon Design Labs Inc. of Liberty Corner, N. J. Revenue grew from a few hundred thousand in the third quarter of 1987 to more than a million in the fourth quarter of 1988. In this period, software orders rose 43%.

But Silicon Compiler has had to revamp its strategies to keep up with IC designs that grow ever more complex; chips are hitting the 12-million-transistor mark. Because laying out such a densely packed chip one transistor at a time is impractical, designers of custom ICs are turning to reusable designs, says Andrew Rappaport, president of the Technology Research Group, a Boston market research firm.

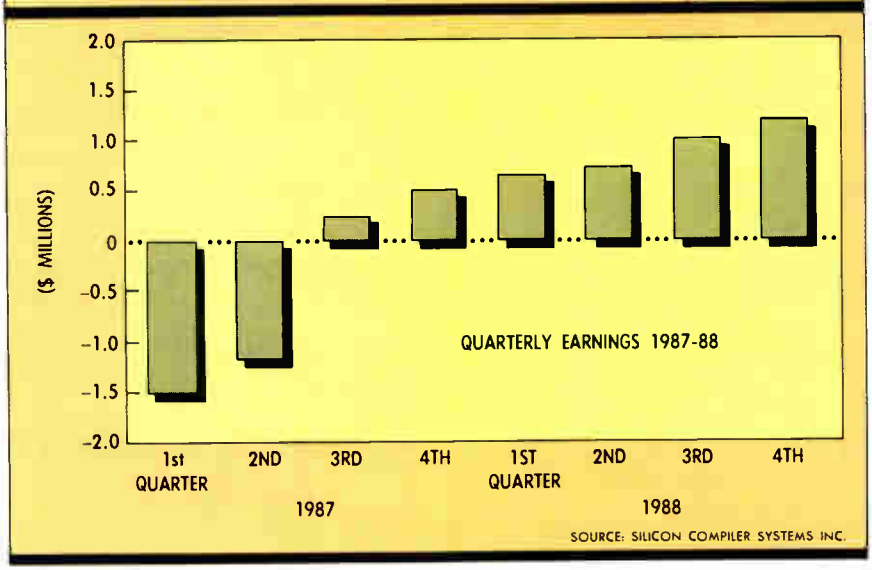
Reusing the layout of existing designs rather than re-creating the function in a new design saves time and money. The 68040 and 80486 microprocessors from Motorola Inc. and Intel Corp., respectively, were designed this way, for example.

"Designers are no longer designing using a Calma, polygon layout, and editing system," says Hammond. "They are moving toward reconfigurable design tools." Reconfigurable designs are made possible by advanced tools, with which designers capture a design in a reusable language. Later, they can quickly reconfigure the design to get a new, higher-performance part.

To beef up its software-tool offering for this market, Silicon Compiler purchased Sunnyvale, Calif.-based Caeco Inc. in January. "Caeco brought us a sophisticated layout editor," says Hal Allis, vice president of engineering. The Caeco tools, with other Silicon Compiler tools, make up the new Composite Designer, one of three turnkey systems in the Explorer series.

A second offering, called the IC Designer, combines the Caeco tool with Silicon Compiler's block-cell and route tools for what is called composite design capability. For example, says Hammond, chips such as the Motorola 68030 are composite designs made up of blocks of handcrafted layouts mixed with compiled cells—read-only and random-access mem-

SILICON COMPILER CLIMBS OUT OF A HOLE



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2V ±5% ADJ.	30.00	27.00	24.00	100.0 × 65.1 × 171.0	$270.00	$243.00	$185.00	**LI5-9-2**
	30.00	27.00	24.00	128.4 × 70.8 × 176.5	300.00	270.00	210.00	**LI5-9I-2**
5V ±5% ADJ.	3.00	2.40	1.80	100.0 × 41.7 × 171.0	147.00	129.00	94.00	**LI5-3-5**
	3.00	2.40	1.80	128.4 × 50.5 × 176.5	173.00	152.00	115.00	**LI5-3I-5**
	6.00	4.20	3.20	100.0 × 41.7 × 171.0	157.00	136.00	100.00	**LI5-5-5**
	6.00	4.20	3.20	128.4 × 50.5 × 176.5	184.00	160.00	121.00	**LI5-5I-5**
	10.00	7.50	5.70	100.0 × 43.9 × 171.0	189.00	164.00	121.00	**LI5-6-5**
	10.00	7.50	5.70	128.4 × 50.5 × 176.5	215.00	187.00	142.00	**LI5-6I-5**
	15.00	12.00	8.00	100.0 × 54.0 × 171.0	210.00	182.00	134.00	**LI5-7-5**
	15.00	12.00	8.00	128.4 × 60.7 × 176.5	236.00	205.00	155.00	**LI5-7I-5**
	20.00	17.50	15.00	100.0 × 65.1 × 171.0	236.00	205.00	152.00	**LI5-8-5**
	20.00	17.50	15.00	128.4 × 70.8 × 176.5	262.00	228.00	173.00	**LI5-8I-5**
	30.00	27.00	24.00	100.0 × 65.1 × 171.0	270.00	243.00	185.00	**LI5-9-5**
	30.00	27.00	24.00	128.4 × 70.8 × 176.5	300.00	270.00	210.00	**LI5-9I-5**
6V ±5% ADJ.	2.50	2.00	1.50	100.0 × 41.7 × 171.0	147.00	129.00	94.00	**LI5-3-6**
	2.50	2.00	1.50	128.4 × 50.5 × 176.5	176.00	152.00	115.00	**LI5-3I-6**
	5.00	3.50	2.60	100.0 × 41.7 × 171.0	157.00	136.00	100.00	**LI5-5-6**
	5.00	3.50	2.60	128.4 × 50.5 × 176.5	184.00	160.00	121.00	**LI5-5I-6**
	8.50	6.40	4.80	100.0 × 43.9 × 171.0	189.00	164.00	121.00	**LI5-6-6**
	8.50	6.40	4.80	128.4 × 50.5 × 176.5	215.00	187.00	142.00	**LI5-6I-6**
	12.50	10.00	6.70	100.0 × 54.0 × 171.0	210.00	182.00	134.00	**LI5-7-6**
	12.50	10.00	6.70	128.4 × 60.7 × 176.5	236.00	205.00	155.00	**LI5-7I-6**
	16.70	14.70	12.60	100.0 × 65.1 × 171.0	236.00	205.00	152.00	**LI5-8-6**
	16.70	14.70	12.60	128.4 × 10.8 × 176.5	262.00	228.00	173.00	**LI5-8I-6**
	26.00	23.00	21.00	100.0 × 65.1 × 171.0	270.00	243.00	185.00	**LI5-9-6**
	26.00	23.00	21.00	128.4 × 70.8 × 176.5	300.00	270.00	210.00	**LI5-9I-6**
12V ±5% ADJ.	1.25	1.00	0.75	100.0 × 41.7 × 171.0	147.00	129.00	94.00	**LI5-3-12**
	1.25	1.00	0.75	128.4 × 50.5 × 176.5	173.00	152.00	115.00	**LI5-3I-12**
	2.50	2.00	1.50	100.0 × 41.7 × 171.0	157.00	136.00	100.00	**LI5-5-12**
	2.50	2.00	1.50	128.4 × 50.5 × 176.5	184.00	160.00	121.00	**LI5-5I-12**
	4.20	3.80	3.40	100.0 × 43.9 × 171.0	189.00	164.00	121.00	**LI5-6-12**
	4.20	3.80	3.40	128.4 × 50.5 × 176.5	215.00	187.00	142.00	**LI5-6I-12**
	6.30	5.70	4.40	100.0 × 54.0 × 171.0	210.00	182.00	134.00	**LI5-7-12**
	6.30	5.70	4.40	128.4 × 60.7 × 176.5	236.00	205.00	155.00	**LI5-7I-12**
	8.40	7.40	6.30	100.0 × 65.1 × 171.0	236.00	205.00	152.00	**LI5-8-12**
	8.40	7.40	6.30	128.4 × 70.8 × 176.5	262.00	228.00	173.00	**LI5-8I-12**
	13.00	12.00	10.00	100.0 × 65.1 × 171.0	270.00	243.00	185.00	**LI5-9-12**
	13.00	12.00	10.00	128.4 × 70.8 × 176.5	300.00	270.00	210.00	**LI5-9I-2**
15V ±5% ADJ.	1.00	0.80	0.60	100.0 × 41.7 × 171.0	147.00	129.00	94.00	**LI5-3-15**
	1.00	0.80	0.60	128.4 × 50.5 × 176.5	173.00	152.00	115.00	**LI5-3I-15**
	2.00	1.60	1.20	100.0 × 41.7 × 171.0	157.00	136.00	100.00	**LI5-5-15**
	2.00	1.60	1.20	128.4 × 50.5 × 176.5	184.00	160.00	121.00	**LI5-5I-15**
	3.40	3.10	2.70	100.0 × 43.9 × 171.0	189.00	164.00	121.00	**LI5-6-15**
	3.40	3.10	2.70	128.4 × 50.5 × 176.5	215.00	187.00	142.00	**LI5-6I-15**
	5.00	4.50	3.50	100.0 × 54.0 × 171.0	210.00	182.00	134.00	**LI5-7-15**
	5.00	4.50	3.50	128.4 × 60.7 × 176.5	236.00	205.00	155.00	**LI5-7I-15**
	6.70	5.90	5.10	100.0 × 65.1 × 171.0	236.00	205.00	152.00	**LI5-8-15**
	6.70	5.90	5.10	128.4 × 70.8 × 176.5	262.00	228.00	173.00	**LI5-8I-15**
	11.00	10.00	8.80	100.0 × 65.1 × 171.0	270.00	243.00	185.00	**LI5-9-15**
	11.00	10.00	8.80	128.4 × 70.8 × 176.5	300.00	270.00	210.00	**LI5-9I-15**

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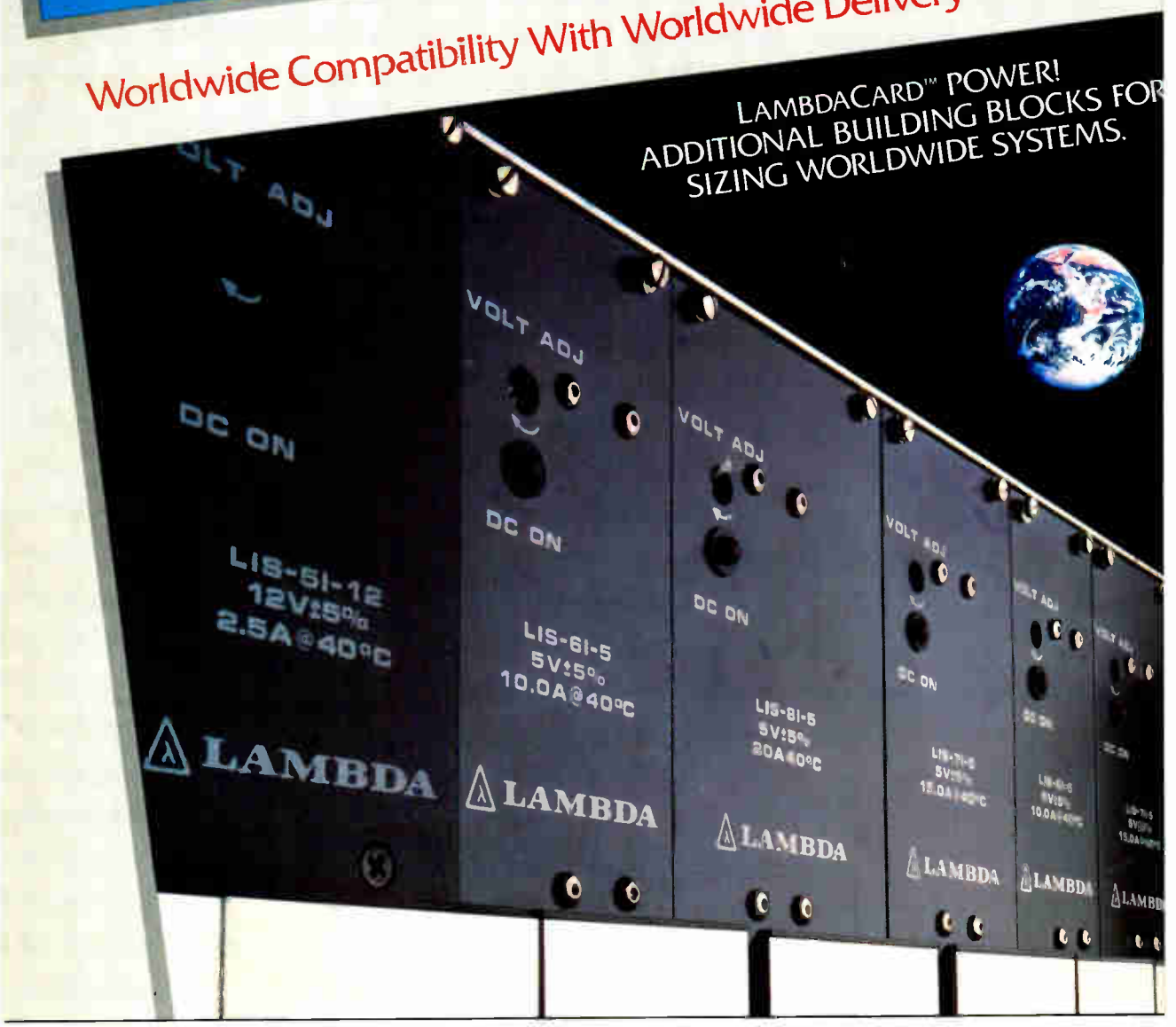

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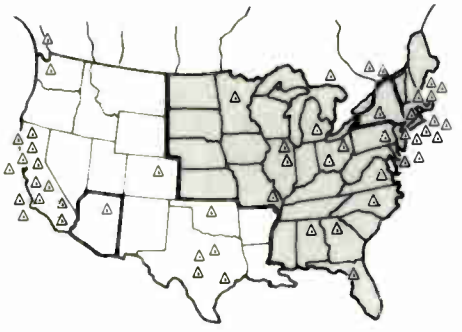

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20V ±5% ADJ.	0.75	0.60	0.45	100.0 × 41.7 × 171.0	147.00	129.00	94.00	**LIS-3-20**
	0.75	0.60	0.45	128.4 × 50.5 × 176.5	173.00	152.00	115.00	**LIS-3I-20**
	1.50	1.20	0.90	100.0 × 41.7 × 171.0	157.00	136.00	100.00	**LIS-5-20**
	1.50	1.20	0.90	128.4 × 50.5 × 176.5	184.00	160.00	120.00	**LIS-5I-20**
	2.50	2.20	2.00	100.0 × 43.9 × 171.0	189.00	164.00	121.00	**LIS-6-20**
	2.50	2.20	2.00	128.4 × 50.5 × 176.5	215.00	187.00	142.00	**LIS-6I-20**
	3.80	3.40	2.60	100.0 × 54.0 × 171.0	210.00	182.00	134.00	**LIS-7-20**
	3.80	3.40	2.60	128.4 × 60.7 × 176.5	236.00	205.00	155.00	**LIS-7I-20**
	5.00	4.40	3.80	100.0 × 65.1 × 171.0	236.00	205.00	152.00	**LIS-8-20**
	5.00	4.40	3.80	128.4 × 70.8 × 176.5	262.00	228.00	173.00	**LIS-8I-20**
	8.20	7.40	6.60	100.0 × 65.1 × 171.0	270.00	243.00	185.00	**LIS-9-20**
	8.20	7.40	6.60	128.4 × 70.8 × 176.5	300.00	270.00	210.00	**LIS-9I-20**
24V ±5% ADJ.	0.65	0.55	0.40	100.0 × 41.7 × 171.0	147.00	129.00	94.00	**LIS-3-24**
	0.65	0.55	0.40	128.4 × 50.5 × 176.5	173.00	152.00	115.00	**LIS-3I-24**
	1.30	1.05	0.80	100.0 × 41.7 × 171.0	157.00	136.00	100.00	**LIS-5-24**
	1.30	1.05	0.80	128.4 × 50.5 × 176.5	184.00	160.00	121.00	**LIS-5I-24**
	2.10	1.90	1.70	100.0 × 43.9 × 171.0	189.00	164.00	121.00	**LIS-6-24**
	2.10	1.90	1.70	128.4 × 50.5 × 176.5	215.00	187.00	142.00	**LIS-6I-24**
	3.20	2.90	2.20	100.0 × 54.0 × 171.0	210.00	182.00	134.00	**LIS-7-24**
	3.20	2.90	2.20	128.4 × 60.7 × 176.5	236.00	205.00	155.00	**LIS-7I-24**
	4.20	3.70	3.20	100.0 × 65.1 × 171.0	236.00	205.00	152.00	**LIS-8-24**
	4.20	3.70	3.20	128.4 × 70.8 × 176.5	262.00	228.00	173.00	**LIS-8I-24**
	6.90	6.20	5.50	100.0 × 65.1 × 171.0	270.00	243.00	185.00	**LIS-9-24**
	6.90	6.20	5.50	128.4 × 70.8 × 176.5	300.00	270.00	210.00	**LIS-9I-24**
28V ±5% ADJ.	0.55	0.45	0.35	100.0 × 41.7 × 171.0	147.00	129.00	94.00	**LIS-3-28**
	0.55	0.45	0.35	128.4 × 50.5 × 176.5	173.00	152.00	115.00	**LIS-3I-28**
	1.10	0.90	0.65	100.0 × 41.7 × 171.0	157.00	136.00	100.00	**LIS-5-28**
	1.10	0.90	0.65	128.4 × 50.5 × 176.5	184.00	160.00	121.00	**LIS-5I-28**
	1.80	1.60	1.40	100.0 × 43.9 × 171.0	189.00	164.00	121.00	**LIS-6-28**
	1.80	1.60	1.40	128.4 × 50.5 × 176.5	215.00	187.00	142.00	**LIS-6I-28**
	2.70	2.40	1.90	100.0 × 54.0 × 171.0	210.00	182.00	134.00	**LIS-7-28**
	2.70	2.40	1.90	128.4 × 60.7 × 176.5	236.00	205.00	155.00	**LIS-7I-28**
	3.60	3.20	2.70	100.0 × 65.1 × 171.0	236.00	205.00	152.00	**LIS-8-28**
	3.60	3.20	2.70	128.4 × 70.8 × 176.5	262.00	228.00	173.00	**LIS-8I-28**
	6.20	5.50	5.00	100.0 × 65.1 × 171.0	270.00	243.00	185.00	**LIS-9-28**
	6.20	5.50	5.00	128.4 × 70.8 × 176.5	300.00	270.00	210.00	**LIS-9I-28**
48V ±5% ADJ.	1.10	1.00	0.90	100.0 × 43.9 × 171.0	189.00	164.00	121.00	**LIS-6-48**
	1.10	1.00	0.90	128.4 × 50.5 × 176.5	215.00	187.00	142.00	**LIS-6I-48**
	1.60	1.50	1.10	100.0 × 54.0 × 171.0	210.00	182.00	134.00	**LIS-7-48**
	1.60	1.50	1.10	128.4 × 60.7 × 176.5	236.00	205.00	155.00	**LIS-7I-48**
	2.10	1.90	1.60	100.0 × 65.1 × 171.0	236.00	205.00	152.00	**LIS-8-48**
	2.10	1.90	1.60	128.4 × 70.8 × 176.5	262.00	228.00	173.00	**LIS-8I-48**
	3.60	3.20	2.30	100.0 × 65.1 × 171.0	270.00	243.00	185.00	**LIS-9-48**
	3.60	3.20	2.30	128.4 × 70.8 × 176.5	300.00	270.00	210.00	**LIS-9I-48**

TRIPLE OUTPUT.

OUTPUT NUMBER	ADJUSTABLE VOLTAGE RANGE (VDC)	MAX CURRENT AT AMBIENT OF (AMPS) 40°C	50°C	60°C	DIMENSIONS (millimeters)	PRICE QTY. 1	QTY. 100	QTY. 250	MODEL
1	5V ± 5%	5.00	4.50	2.50	128.40 × 40.64 × 176.5	$235.00	$209.00	$197.00	**LIT-6I-5152**
2	11.4-15.75	1.20	0.85	0.50					
3	11.4-15.75	1.20	0.85	0.50					
1	5V ± 5%	10.00	7.50	5.00	128.40 × 60.70 × 176.5	350.00	309.00	290.00	**LIT-8I-5152**
2	11.4-15.75	2.00	1.50	1.00					
3	11.4-15.75	2.00	1.50	1.00					

LI SERIES

Specifications

The LIS-3I, 5I, 6I, 7I, 8I, 9I and LIT-6I, 8I are standard enclosed units. These models include a front panel with handle, LED V_O indicator, and shields on both sides of the PC board to eliminate shock hazard. The LIS-3, 5, 6, 7, 8 and 9 models are PC LAMBDACARDS only.

DC OUTPUT
Voltage range shown in tables.

REGULATED VOLTAGE

regulation, line	0.1% from 95 to 132VAC or 187 to 265VAC on LIS-3, 5, 6, 7 and 8 models. 85 to 132 VAC or 170 to 265VAC on LIS-9, 9I and LIT models.
regulation, load	0.2% from 0 to full load. (0.1% on LIS-9, 9I and on all outputs of LIT models. All LIT outputs are independently isolated from each other and from the chassis.)
ripple and noise	20mV RMS, 120mV pk-pk on 2V, 5V and 6V single output models and 5V outputs of LIT-6I, 8I. 20mV RMS, 150mV pk-pk on 12V through 48V models of LIS Series and on secondary outputs of LIT-6I, 8I.
temperature coefficient	0.03%/°C.
remote programming resistance	1000 Ω/V nominal (LIS Series only).
remote programming voltage	volt per volt (LIS Series only).

AC INPUT
(User selectable at connector without changing internal jumper.)

line	95 to 132VAC, 187 to 265VAC, 47-440Hz (85 to 132VAC/170 to 265VAC on LIS-9, 9I and LIT models).
power	LIS-3, LIS-3I: 26.0 watts max. LIS-5, LIS-5I: 52.5 watts max. LIS-6, LIS-6I: 77 watts max. LIT-6I: 92 watts max. LIS-7, LIS-7I: 113 watts max. LIS-8, LIS-8I: 150 watts max. LIT-8I: 165 watts max. LIS-9, 9I: 240 watts max.

DC INPUT
290V ± 10%. 240 to 370 VDC at 220V input on LIS-9, 9I.

EFFICIENCY
55% minimum on 2V models. 70% minimum on 5V models of LIS Series and on LIT-6I, 8I. 75% minimum on 12V through 48V models. 60% minimum on all LIS-3, 3I, 5, 5I models.

OVERSHOOT
No overshoot at turn-on, turn-off or power failure.

OPERATING TEMPERATURE RANGE
Continuous duty 0°C to 60°C with suitable derating above 40°C.

STORAGE TEMPERATURE RANGE
−55°C to +85°C.

OVERLOAD PROTECTION
ELECTRICAL
External overload protection. Automatic electronic current limiting circuit limits the output current to a preset value, thereby providing protection for the load as well as the power supply.

HOLD UP TIME
All models will remain within regulation limits for at least 20msec after loss of AC power when operating at full load, V_O max, and 105VAC (210VAC) at 60Hz (50Hz).

OVERVOLTAGE PROTECTION
Non-crowbar, inverter shutdown type OV protection is standard on all LIS models and on main output of LIT models.

COOLING
Convection cooled. No fans or blowers required.

IN-RUSH CURRENT LIMIT
An in-rush current limiting device limits the peak in-rush current from a cold turn on, to 25A on LIS-3, 3I, 5 and 5I; 45A on LIS-6, 6I, 7, 7I and LIT-6I, 8I; 80A on LIS-9, 9I; 90A on LIS-8, 8I.

DC OUTPUT CONTROLS
Single turn output voltage adjust pot located on front edge of PC board. Access hole is provided on front panel of LIS-3I, LIS-5I, LIS-6I, LIS-7I, LIS-8I, and LIS-9I. Three single turn pots on LIT-6I, 8I.

INPUT AND OUTPUT CONNECTIONS
All connections to the unit are made via a DIN type H15 connector.

MOUNTING
Mounting is compatible with standard 3U-high Eurocard subracks. Depth is standard 160mm (pc board only). Unit width is: 8Te (HP) for the LIT-6I; 9Te (HP) for the LIS-3, 5, 6; 10Te (HP) for the LIS-3I, 5I, 6I; 11Te (HP) for the LIS-7; 12Te (HP) for the LIS-7I, LIT-8I; 13Te (HP) for the LIS-8, 9; 14Te (HP) for the LIS-8I, 9I.

REMOTE SENSING
Provision is made for remote sensing to eliminate the effects of power output lead resistance on DC regulation on all LIS models.

OUTPUT STATUS INDICATOR
LED indicates presence of voltage on all LIS models and on 5V output of LIT-6I, 8I.

ISOLATION RATING
1250VAC input to ground. 3750VAC input to output (1250VAC on LIS-9, 9I and LIT models). 500VAC output to ground.

PHYSICAL DATA

Package Model	Weight Lbs. Net	Weight Lbs. Ship	Size Millimeters
LIS-3	0.69	1.00	100.0 × 41.7 × 171.0
LIS-3I	1.50	1.75	128.4 × 50.5 × 176.5
LIS-5	0.69	1.00	100.0 × 41.7 × 171.0
LIS-5I	1.50	1.75	128.4 × 50.5 × 176.5
LIS-6	1.31	1.63	100.0 × 43.9 × 171.0
LIS-6I	1.69	2.00	128.4 × 50.5 × 176.5
LIT-6I	1.80	2.20	128.4 × 40.64 × 176.5
LIS-7	1.44	1.75	100.0 × 54.0 × 171.0
LIS-7I	1.81	2.13	128.4 × 60.7 × 176.5
LIS-8	1.50	1.81	100.0 × 65.1 × 171.0
LIS-8I	2.06	2.38	128.4 × 70.8 × 176.5
LIT-8I	2.20	2.50	128.4 × 60.7 × 176.5
LIS-9	1.50	1.81	100.0 × 65.1 × 171.0
LIS-9I	2.06	2.38	128.4 × 70.8 × 176.5

FINISH
All units have tan covers. Enclosed units have tan shields, brown front panels with black handles, and brushed aluminum handle inserts.

GUARANTEE
One year guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end of one year.

UL/CSA/TUV
All LIS models are UL recognized, CSA certified and are all under evaluation for TUV. LIT models and LIS-9, 9I are under evaluation for UL, CSA and TUV.

ories, programmable logic arrays, standard cells, and macro cells.

Although composite design is attractive to custom-IC designers, analyst Herwick says, in recent months system designers have begun taking on IC layout to achieve a competitive advantage in their market.

Serving system designs is creating new market opportunities for companies like Silcon Compiler and Cadence, which leads a field that includes Mentor Graphics and Valid Logic. But system designers performing layout represent no more than 10% of all system designers, warns Rappaport. That proportion is growing, he concedes, but it isn't expected to surpass 15% of all system designers.

NONE TOO SOON. For the most part, system designers are performing gate-array and standard-cell designs. As a result, Silicon Compiler has rolled out the ASIC Designer, the third offering in the Explorer series. The move came none too soon, since rival Cadence earlier this year purchased Santa Clara, Calif.-based Tangent Systems Corp. for its well-regarded set of gate-array and standard-cell design tools.

Though Silicon Compiler has come up with a series of products to address the major CAD/CAE markets, to some customers the company name suggests a closed-system, niche-tool supplier.

The company may have been slow to reposition itself in the market, but it is on steady ground now. Helping to put it there is Foundation, the company's open, user-extendable design framework, along with several new modular point-solution tools that plug into Foundation. This object-oriented design data base is the bedrock of the Silicon Compiler approach, Hammond says, since it eases reusable design and rapid iteration of design changes. Foundation maintains design data while also providing design management, a human interface, and a simulation infrastructure, he says. Changes are handled easily because Foundation contains every representation of a design.

To become more competitive, the company has opened up its tool environment to more easily accommodate outside tools and to provide tools within their environments, such as its enhanced logic-synthesis tool, Autologic, to be used in other design systems.

Other new tools included in the Explorer series are packages for schematic capture; circuit simulation (Lsim-C) and system simulation (Lsim-S); logic libraries; RAM, ROM, PLA, and data-path compilers; block route and cell place and route; and a plotter tool called Hotplot.

Silicon Compiler seems ready to take on all comers in the competitive market for CAD/CAE IC design. But it remains to be seen whether the company's marketing ability will prove as sharp as its technical acumen. *–Jonah McLeod*

A NEW ENTITY, 'DAZIX,' ARISES AFTER TAKEOVER

MOUNTAIN VIEW, CALIF.

Like a challenger preparing for a championship fight, Daisy/Cadnetix Inc.—or Dazix, as the Mountain View company has nicknamed itself—believes it has a good shot at the title. The firm's confidence is up now that the merger of Daisy Systems Inc. and Cadnetix Inc. is about to be completed. But some industry watchers think the company has a way to go before it can trade blows toe to toe with the heavyweights in the design automation market.

For the past few months, Dazix's most formidable opponent has been itself. The hostile takeover of Cadnetix by Daisy Systems caused some initial hard feelings between the two. But internal rifts have been mended, company executives say. Norman E. Friedmann, chairman and chief executive officer of the merged company, says the merger has created a leaner, more efficient competitor.

The fact that Daisy borrowed heavily to fund its acquisition—including a $50 million nine-month bridge loan—and sold

HHB Systems Inc. has made the company vulnerable in the eyes of some analysts. But Ron Collette, senior industry analyst for Dataquest Inc., a market research firm in San Jose, Calif., says the merger was the best thing Daisy could have done given its market status. "It had lost ground in the printed-circuit-board computer-aided-design market," he says. Robert Herwick, senior technology analyst at Hambrecht & Quist Inc. in San Francisco, adds that Daisy's decline would have accelerated and says Friedmann had to take action.

The fact that the merger was the first successful hostile takeover of a high-tech company, whose primary assets are its employees, also fueled skepticism. If Cadnetix staffers jumped ship, the merger could have been disastrous. Friedmann contends that the dispute between Daisy and Cadnetix was over money. That issue has been resolved, he says. Cadnetix employees who traded their stock for Dazix debentures cannot easily cash out, Herwick points out, because the securities are currently heavily discounted. Those employees have a financial stake in making Dazix profitable.

Friedmann took another step toward mollifying the Cadnetix crew by making Bruce M. Holland, president of Cadnetix, the new president and chief operating officer of Dazix. In addition, Dazix is keeping Cadnetix's offices in Boulder, Colo.

With the hostility apparently behind it, Dazix still faces the tough task of merging two disparate product lines. Friedmann says the company will begin shipping an integrated product—"not two products tied together"—by year's end.

Analyst Herwick notes that Cadnetix had already begun some integration work with Daisy's front-end tools at the request of Pittsburgh-based Rockwell International Corp., which uses both Daisy and Cadnetix work stations. "Integration is a short-term weakness for the company," he says, adding that Dazix's main competitors—Cadence Design Systems, Mentor Graphics, and Valid Logic Systems—are still integrating their tools.

Herwick believes that by year's end Dazix will have all its software running on the Sparc-, 680X0-, and 80X86-based platforms from Sun Microsystems Inc. of Mountain View. Indeed, Friedmann asserts that a strong relationship with Sun is critical to Dazix's success.

MOVING UP? If Dazix succeeds in integrating its product lines, it could move up from its No. 2 position in the design automation market, behind Mentor. The merger has already provided one big advantage: Daisy and Cadnetix both had been spending big money on research, development, and sales in their battle against each other. Dazix is in the process of consolidating its branch offices and it has trimmed its sales staff significantly. "There were more people in sales than we needed to penetrate the markets we are going after," Friedmann says. "We kept the best-performing salesmen."

The company is building on a strong product base, analysts note. "Cadnetix had set the standard in pc-board layout," says Charles Foundyller of Daratech, a market research firm in Cambridge, Mass. Friedmann believes that Dazix is now in shape to weather any blows that the competition may dish out. Most analysts, however, are reserving judgment—they're waiting for Dazix to score some points in the ring. *–Jonah McLeod*

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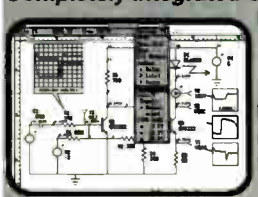

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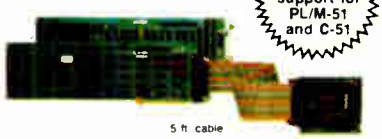

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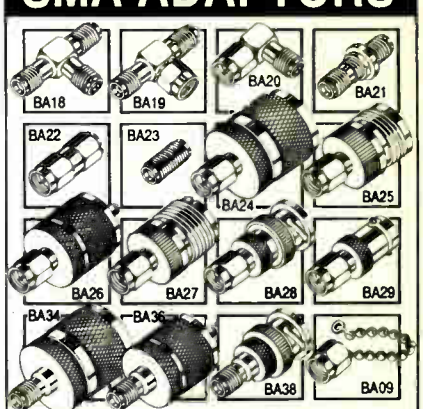

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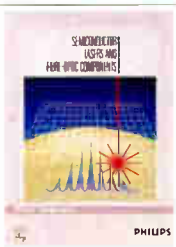

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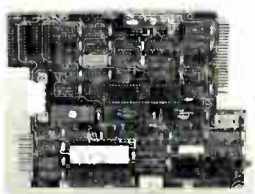

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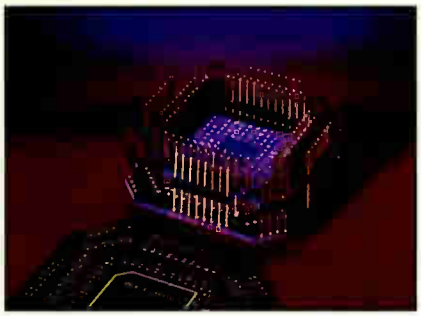

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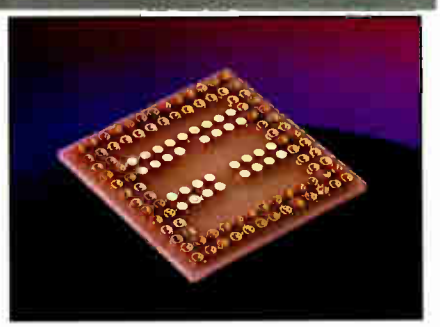

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UPDATE: IN NEW JERSEY, THE GARDEN IS WILTING

In the months following the breakup of the Bell System, refugees from AT&T Co.'s Bell Laboratories led a rush by New Jersey entrepreneurs into what was to be the boom market of the late 1980s: gallium arsenide integrated circuits. Central New Jersey was dubbed Gallium Gardens, in honor of the state's Garden State moniker [*Electronics*, Jan. 13, 1986, p. 62]. If market researchers' projections of a booming trade in GaAs ICs by the late 1980s had come to pass, it would now be summer in Gallium Gardens. Instead, it is winter.

"Over the last couple of years, you've seen a pruning out of some of the merchants [GaAs chip makers], and a refining and focusing of others' strategies," says Ron Rosenzweig, president of Anadigics Inc., a Warren, N. J., company that makes GaAs ICs for high-volume applications in the communications field. "The weak ones have left."

GaAs technology has come a long way in the last half decade, and as researchers-turned-entrepreneurs tuned their processes for production runs, yields have improved dramatically. Chip densities have increased to the point where arrays of 30,000 gates are no longer the stuff of hyperactive imaginations, as West Coast chip makers move ahead with technological advances [*Electronics*, June 1989, p. 140].


PROBING THE NEWS

SURPRISE! GaAs STARTUPS THRIVE IN NEW JERSEY

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The state's GaAs startups have fallen on hard times as the market is slow to develop

But the GaAs IC market remains minuscule compared with that of silicon. Nowhere are the effects of the sluggish market more evident than in New Jersey. Two of the most highly funded GaAs startups—Microwave Semiconductor Corp. of Somerset and Gain Electronics Corp. of nearby Somerville—were shut down in the past year after their parents decided further investment would be fruitless. Gain closed its doors altogether, leaving its founders some $25 million in the hole, and all that remains of Microwave Semiconductor is a modest silicon-components business. A third company, Tachonics Inc. of Plainsboro, has been struggling in its efforts to secure new financing.

Microwave Semiconductor was the oldest of the Gallium Gardens companies. It was founded in 1968 by Anadigics' Rosenzweig and two other RCA Corp. veterans as a GaAs discrete-circuit house. Siemens AG of Munich bought the company in 1979, and the three founders left in 1983. That's when Siemens decided to use its sizable capital to turn the small operation into the giant of the GaAs chip market. The move failed. "Siemens spent way too much and greatly oversized the company," says Rosenzweig. After investing up to $100 million, Siemens decided to give up last October.

At about the same time, Gain Electronics also bit the dust. Company founder Ray Dingle, a Bell Labs alumnus, left just over a year ago after a disagreement with his board over how much influence he was to wield. His departure prompted several other key executives to follow suit. Six months later, Gain was dead. Not that Gain hadn't had its troubles all along. Despite a top-rated staff of technologists, Gain was plagued by delays. Its fab was completed nearly a year late, and it took longer than expected to install equipment and start churning out working chips. But Gain was among the first of the GaAs IC houses to offer gate arrays, and it took dead aim at high-speed silicon emitter-coupled-logic application-specific ICs.

Nevertheless, the holdups unnerved Gain investor Mitsui, a giant Japanese trading company that had no experience in the chip business. After putting up $25 million—$10 million less than Dingle said was the minimum the company would need to become self-sustaining—Mitsui closed the plant. "I don't think the investors had a clear understanding of what we were doing," Dingle says. "The plug was pulled too fast."

Dingle wasn't the only Bell Labs veteran to lose a GaAs startup in New Jersey. Fellow Bell Labs veteran Gene Gordon, who founded Lytel Inc. just down the street from Gain in the same industrial park near Somerville, was forced out of his company only a few months before Dingle and Gain parted ways. Lytel was taken over by its primary financial backer, Amp Inc., a Harrisburg, Pa., component producer that wanted to install its own management team.

Meanwhile, Tachonics has had different troubles. With parent Grumman Corp. of Bethpage, N. Y., squeezed by the loss of several key military contracts, the firm has had to look elsewhere for its second round of financing. Tachonics president Chuni Ghosh denies rumors that Grumman is trying to sell its portion of the business and adds that Tachonics is just a year away from breaking even. He says new financing should be completed soon.

Overall, "it's fair to say that nobody is out of the woods," says Rosenzweig of Anadigics. "It's only so long that anybody will fund the losses—and everybody's got losses. Fundamentally, what went wrong was that we got too many companies all at once. It was a proliferation." So now the industry—and Gallium Gardens—are being cut down to size. *–Tobias Naegele*

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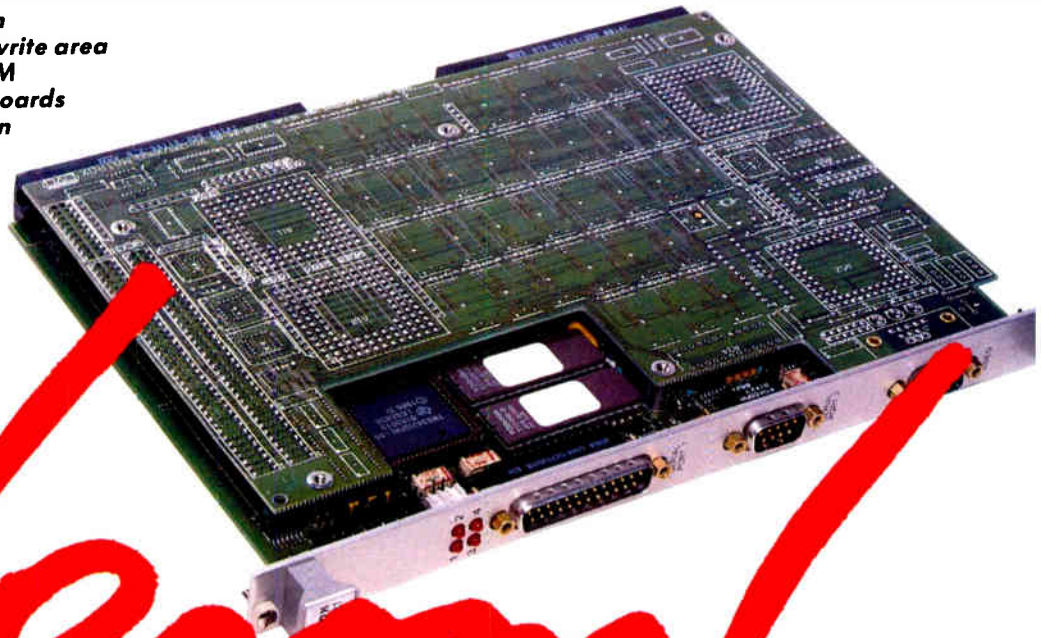

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