ROUTING AND TRANSMITTAL SLIP

Date

TO: (Name, office symbol, room number, building, Agency/Post)	Initials	Date
1. D/ODP		
2. DD		11 Oct
3. EXO		6 Sep
4.		
5.		

Action	File	Note and Return
Approval	For Clearance	Per Conversation
As Requested	For Correction	Prepare Reply
Circulate	For Your Information	See Me
Comment	Investigate	Signature
Coordination	Justify	

REMARKS

Have sent copies to Processing Application Sop for Circulation

DO NOT use this form as a RECORD of approvals, concurrences, disposals, clearances, and similar actions

FROM: (Name, org. symbol, Agency/Post)	Room No.—Bldg.
Tech Lib	
	Phone No.

5041-102

OPTIONAL FORM 41 (Rev. 7-76)
Prescribed by GSA
FPMR (41 CFR) 101-11.206

Economy & Business

COVER STORY

The Colossus That Works

Big Blue uses salesmanship and innovation to bestride the computer world

IBM. Three of the most famous letters in American business. For years the International Business Machines Corp. towered over the office-equipment industry. Then in the 1970s, besieged by Government antitrust charges and challenged by ambitious new rivals, the giant seemed to be staggering, and those three famous letters lost a bit of their luster. Was IBM's dominance in jeopardy?

Not a chance. Under the direction of John Opel, 58, who became chief executive officer in January 1981, the firm has been acting like its brashest competitors—entering new markets, chasing the latest technology, trimming organizational fat and selling more aggressively than ever. In 1982, IBM had profits of $4.4 bil-

lion on sales of $34.4 billion, making it the most profitable U.S. industrial company. Says Stephen McClellan, author of an upcoming book on the computer industry: "In the 1970s, IBM was a battleship in mothballs. Today it is a fleet of killer submarines."

Nowhere was the company's lean new stance more evident than in the way it plunged into the personal-computer market in August 1981. Tackling the mass market for computers for the first time, the company broke many of the traditions that had made it so successful in the past. Yet its new machine, the Personal Computer, generally known simply as the PC, has done nothing less than trans-

form the industry. IBM has already captured 21% of the $7.5 billion U.S. market for personal computers, a staggering feat in so short a time, and is virtually tied with pacesetter Apple Computer, which had a four-year head start.

Big Blue, as IBM is nicknamed for the corporate color it puts on many products, is a mighty competitor in a range of products from electric typewriters that sell for $800 to data-processing systems that can

HARTMANN—MAGNUM
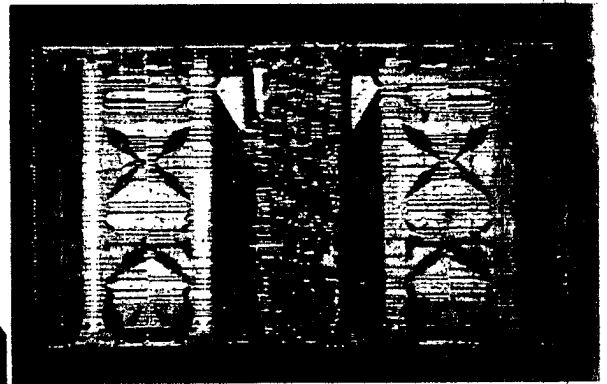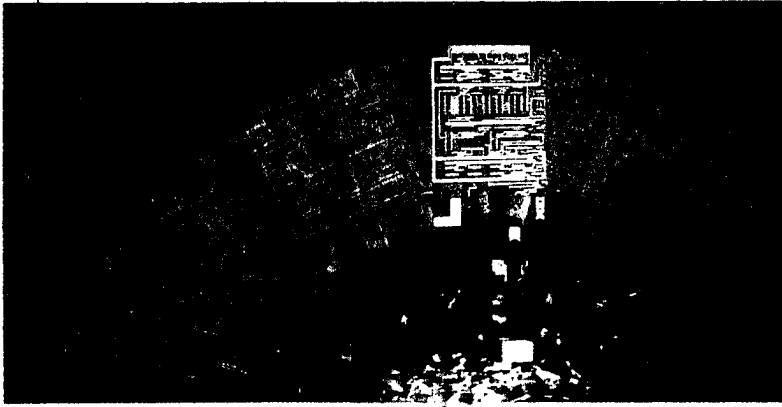
A proud gallery, clockwise from above: multiple-exposure photo of a robotic device; a 288K memory chip; the firm's new 43-story Manhattan building; semiconductor wafers

44
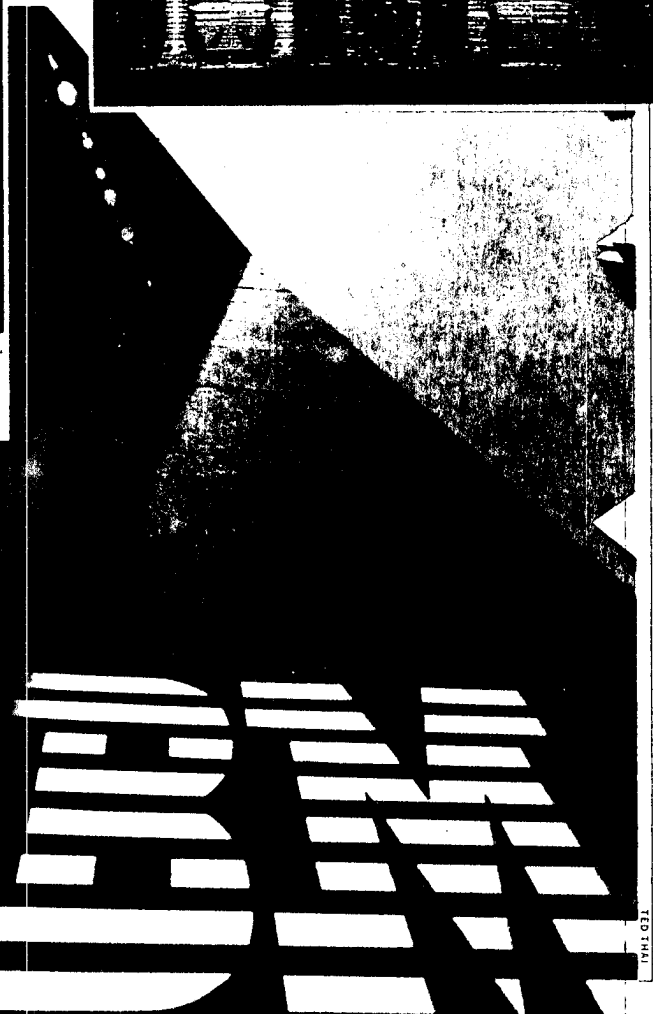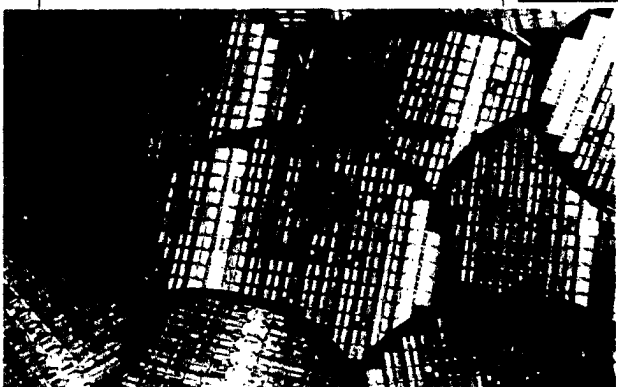
cost more than $100 million. It commands some 40% of the worldwide market for computing equipment and produces some two-thirds of all mainframe computers, which are big and medium-size business machines. So great is IBM's pre-eminence that rivals often seem to be running in a different race. Digital Equipment, the No. 2 computermaker, has less than one-fifth of IBM's sales. Says John Imlay Jr., chairman of MSA, an Atlanta-based software company: "IBM is simply the best-run corporation in American history."

At a time when American business sometimes seems to be slipping, IBM's triumphs have served as a reminder that U.S. industrial prowess and know-how can still be formidable. Struggling U.S. steel and automakers have been severely hurt by Japanese and European imports, but Big Blue's competitiveness is unquestioned. The company is the leading computer firm in virtually every one of the some 130 countries where it does business. "IBM is like your papa," says a Swiss computer-marketing specialist, "because it's so big and it's always there." Even in

Chairman John Opel at his stand-up desk; an instructor during a management training class; staff members eating lunch outside the cafeteria at the Armonk headquarters

HANK MORGAN

Japan, which has six major domestic computermakers and restricts access to its markets, IBM is easily the dominant producer of large computers and is fighting Fujitsu for the overall title. Last year IBM sold $1.9 billion worth of equipment in Japan to Fujitsu's $2.1 billion.

For all of its success, IBM has been rethinking some of the ways it does business. In a dramatic departure from its traditional practices, IBM built the PC largely from parts bought from outside suppliers and is selling it through retail outlets like Sears and ComputerLand, as well as its own sales network. The company has begun offering discount prices and introducing new products at an accelerated rate. Last December IBM spent $250 million to acquire 12% of Intel, a leading computer-chip maker based in Santa Clara, Calif. In June IBM paid $228 million for a 15% stake in Rolm, also of Santa Clara, a major produce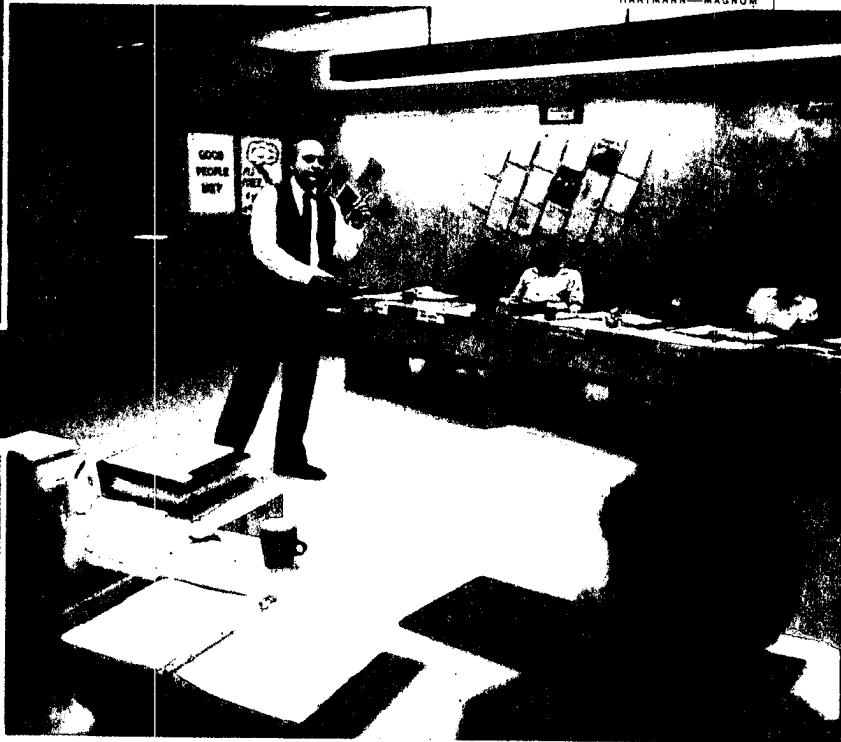r of telecommunications equipment. IBM plans to use Rolm to help create the so-called electronic office. Says Ulric Weil, a top computer analyst for Morgan Stanley & Co.: "We're watching a total transformation of the corporation."

In June IBM Chairman Opel announced that 1983 results were outstripping last year's. That helped push up the price of IBM stock, a leader in the eleven-month-old Wall Street bull rally. After years of hardly moving, IBM shares have nearly doubled in price since the rally started, climbing from 62¼ last August to close last week at 121.

Traditionally, IBM has been so deep in talent that its alumni have gone on to staff laboratories and executive suites throughout the computer industry. "Almost everybody in the business seems to be a former IBMer," observes William Easterbrook, an ex-IBM manager in Copenhagen who now watches the computer industry for Kidder, Peabody, a Wall Street securities firm. Illustrious former employees include Gene Amdahl, founder of Amdahl Corp. (1982 sales: $462 million), which makes large computers; Joe M. Henson, president of Prime Computer (1982 sales: $436 million), a major producer of minicomputers; and David Martin, president of National Advanced Systems, the computer unit of National Semiconductor. Former employees usually speak highly of Big Blue. Says Flavil Van Dyke, president of Genigraphics, a computer-graphics firm: "I still look back fondly at IBM and try to run my company by IBM standards."

Customers of IBM often speak with that same kind of devotion. Some have been known to refuse to see salesmen from rival firms. Says James Marston, vice president for data processing with American Airlines: "You can take any specific piece of hardware or software and perhaps do better than IBM, but across the board IBM offers an unbeatable system." IBM buyers range from Government agencies like the National Aeronautics and Space Administration, which directs space-shuttle missions with Big Blue equipment, to firms as diverse as Bank of America and Coca-Cola.

Longtime industry observers view the loyalty of some customers as a natural outgrowth of the attitudes that IBM drills into its workers from the day they arrive. "IBM creates an environment that is unique because of its strong set of beliefs and principles," says Martin. "It is almost overwhelming how it affects employees and rubs off on customers."

IBM's strong corporate culture is the lengthened shadow of Thomas Watson Sr., a charismatic executive who joined the Computing-Tabulating-Recording Corp. in 1914, renamed it International Business Machines in 1924, and

Economy & Business

An operator monitors automated equipment as tiny wires, inset, are added to the logic circuits

ran it until a month before his death in 1956. Watson was a visionary who believed above all in his company.

Under Watson, IBM had rules for practically everything. Employees were told what to wear (dark business suits, white shirts and striped ties) and what to drink (no alcohol, even when off the job), and were urged in signs posted everywhere to THINK. Aspiring executives usually started out in sales and marketing and were transferred so frequently that they took to joking that IBM stood for "I've Been Moved." Observes Gideon Gartner, chairman of the Gartner Group, a computer-research firm: "If you understand the Marines, you can understand IBM."

Many of the Watson-instilled codes remain in effect today, though in a softened form. All IBMers are subject to a 32-page code of business ethics. Sample warning from the blue-covered rulebook: "If IBM is about to build a new facility, you must not invest in land or business near the new site."

IBM salesmen can now drink at lunch, but if they do they are warned not to make further business calls that day. Male IBMers, who make up 80% of the 8,500-member U.S. sales force, must wear suits and ties when meeting prospective customers, although their shirts no longer must be white. Still, a neat and conservative appearance remains the IBM style. "I don't think I've ever seen an IBMer in a pink shirt or an outlandish tie," says Joseph Levy, a vice president for International Data, a Massachusetts-based computer market-research firm. The THINK signs have largely vanished, but the old admonition remains the title of the company's employee magazine.

IBM has combined Watson's stern

codes with a deep and genuine concern for the welfare of employees, who number 215,000 in the U.S. with an additional 150,000 abroad. The company has often fired workers, but it has never laid anyone off to cut costs; instead it retrains and reassigns them. The company's salaries and perks are widely regarded as among the most attractive in the industry. New employees are expected to spend their working lives with the firm, and regularly go through intensive training programs to upgrade their skills. "We hire with a career in mind," says Edward Krieg, director of management development. Although some overseas IBM plants are

Technicians track silicon-wafer production

Investments in the '70s led to current growth.

unionized, the firm has never had a union vote in any U.S. facility.

The generous fringe benefits extend to recreation. The company provides memberships for less than $5 a year in IBM country clubs in Poughkeepsie and Endicott, N.Y. There, employees can play golf, swim and participate in numerous other sports.

Watson was especially adept at motivating workers and inspiring loyalty. He personally commissioned a company songbook and led employee gatherings in numbers like *Ever Onward.** The song was belted out with gusto during get-togethers of the IBM 100% Club, made up of members who have met 100% of their sales goals for the previous year.

Watson was succeeded by his son Thomas Watson Jr., who served as chief executive officer from 1956 to 1971. A powerful executive in his own right, the younger Watson had helped persuade his father to steer IBM into the computer age. After retirement, Thomas Watson Jr. was U.S. Ambassador to the Soviet Union under President Carter.

More than anything else, it was IBM's awesome sales skills that enabled the company to capture the computer market. Although it now seems hard to believe, IBM did not introduce the first commercial computer. Remington Rand did that in 1951 with a computer called Univac, which became the name of the firm's computer division. But Big Blue knew far more about winning customers than did Univac. IBM, whose major products at the time included calculators and tabulators, recognized that potential buyers might be frightened by the cost and complexity of computers. When the company entered the market in 1952, it set a high priority on dispelling customer fears. Buyers were promised that IBM service engineers would keep a close watch over the machines and quickly fix any glitches. The salesmen were so knowledgeable and thoroughly trained that their very presence inspired confidence. Univac representatives, by contrast, were seen to dwell on technical details that customers could barely follow.

The race was over by 1956. IBM had won a staggering 85% of the U.S. computer market, even though its machines were

*Sample lyric: "Our products are known/ In every zone/ Our reputation sparkles like a gem/ We've fought our way through/ And new fields we're sure to conquer too/ For the ever-onward IBM."

considered to be technically inferi￼ to Univac's. Years later a Univac executive would lament, "It doesn't do much good to build a better mousetrap if the other guy selling mousetraps has five times as many salesmen."

The Univac episode helped give rise to the belief that IBM's real strength is in selling while its technical prowess often lags. Says Kenneth Leavitt, president of CGX Corp., a Massachusetts-based maker of high-performance display terminals: "IBM tends to be a step behind in technology but very good at marketing. There are all sorts of new technologies that IBM doesn't have the expertise to get."

Such claims naturally make IBMers bristle. "This is a shibboleth cultivated by certain Wall Streeters," declares Paul Low, manager of the IBM plant in East Fishkill, N.Y. "Nobody who peeks inside any of our 29 laboratories could fall for that nonsense." Company spokesmen like to point out that IBM spent $3 billion on research, development and engineering last year, an amount that exceeds the total revenues of many of its rivals. The firm has also taken the offensive in a new ad-

detail. "IBM will listen to almost anybody," says Joseph Levy of International Data, which analyzes computer-market trends. "It is one of our best customers." Big Blue subscribes to virtually every major computer market-research service and has a worldwide intelligence-gathering network that includes economists and market analysts.

The company takes equal pains in keeping the skills of its personnel up to date. Last year, for example, IBM invested more than $500 million on employee education and training. Most new IBMers spend much of their first six weeks in company-run classes, and managers are required to take at least 40 hours of additional instruction a year. The classwork often focuses on actual business case studies, in the manner of the Harvard Business School.

The IBM management formula worked so well that the company in the 1960s came to be known as Snow White
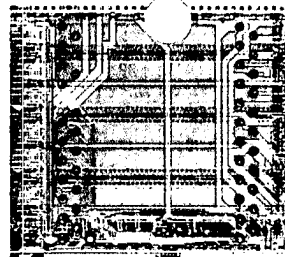
The heart of a new machine

Recalls former IBM Chairman Frank Cary, Opel's predecessor: "The suit was a tremendous cloud that was over the company for 13 years. It couldn't help influencing us in a whole variety of ways. Ending it lifted a huge burden from management's shoulders." Jeffrey Zuckerman, special assistant to Antitrust Division Chief William Baxter, concurs: "We believe IBM must have been deterred from competing as aggressively as it otherwise would have."

Whatever the reason, IBM's momentum slowed markedly in the 1970s, a period Cary called "a time of planning and consolidation." The company entered the decade with a 60% share of the computer market and emerged with a still impressive but slimmed-down 40%.

Though IBM was growing at a respectable annual rate of 13%, the computer industry was expanding even faster. One challenge came from the Route 128 area around Boston, where Digital Equip-

Wonders of the laboratories: a worker aligns televised chips, left; a mixture of neon and argon gases makes the display screen glow

Despite a reputation for being better salesmen than scientists, the firm's employees have been awarded more than 11,000 patents.

vertising campaign that boasts of the more than 11,000 patents IBM inventors have acquired over the past 25 years.

Actually, IBM is skilled at blending both marketing and technical considerations. That goes a long way toward explaining how so huge a company has kept its edge in an industry where key breakthroughs are often made by blue-jeaned engineers working out of their garages.

What IBM seeks, above all, is products that sell. "They have tried to understand what the customer wants," says Stuart Madnick, a professor of management-information systems at M.I.T.'s Sloan School. "Often the customer didn't need or want the more advanced technology that others have produced. In many companies the technology has grown faster than the market can absorb."

IBM evaluates buyers' needs in fine

while its competitors were derisively dubbed the Seven Dwarfs. The dwarfs (Burroughs, Univac, NCR, Control Data, Honeywell, General Electric and RCA) dwindled to five when GE and RCA quit the computer business in the 1970s, and the others are now collectively referred to by their first initials as the BUNCH.

IBM's very success, however, almost backfired against the company. The Johnson Administration on its final working day in office, Jan. 17, 1969, opened a massive antitrust case, accusing the company of monopolistic and anticompetitive practices. The federal suit dragged on endlessly—at a cost to IBM of several hundred million dollars in legal fees—until the Justice Department abruptly dropped it in January 1982, declaring that the case was "without merit."

ment and other firms launched the minicomputer. Such machines were smaller and cheaper than the large ones IBM offered, but still performed a wide range of data-processing functions. Revenues of Digital Equipment, the leading maker of minis, have climbed from $265 million to about $4 billion over the past ten years.

Another challenge came from California's Silicon Valley, where the microprocessor, or computer-on-a-chip, was developed. The tiny devices packed thousands of circuits onto a postage-stamp-size silicon chip and gave rise to the microcomputer. Apple recognized the potentially vast appeal of personal computing, and its sales jumped from less than $1 million to $582 million between 1977 and 1982.

By the start of the 1980s, however, IBM had begun to move in new direc-

Economy & Business

tions, and the dismissal of the lawsuit helped to accelerate the process. The most notable example was in the personal-computer field. Although IBM had been monitoring the market for years, it refused to jump in until it began seeing personal computers appear in offices and became convinced that there was enough demand to make their entry pay off. "There's no particular challenge to building a personal computer other than to build one that someone wants," says Cary.

The task of overseeing the creation of the PC fell to a twelve-member group in Boca Raton, Fla., led by Philip Estridge, a division vice president. The team was first assembled in July 1980 and told to develop a competitive and easy-to-use machine within a year. "Twelve-hour days and six- or 6½-day weeks were commonplace," recalls Estridge. The members made some key moves along the way that help account for the PC's enormous popularity. The planners decided, for example, to build the PC around a 16-bit microprocessor rather than an 8-bit one, which was at that time the industry standard. This move permitted the PC to run faster and handle more complex programs. Says Estridge: "We chose to up the power of the machine so that it could be used without too many changes for the next decade or so."

The group broke with tradition by setting up a so-called open-architecture scheme that makes the PC's technical specifications available to other firms. The idea was to permit outside companies and individuals to write software or build peripheral equipment for the PC and thereby expand its appeal.

The project, however, did not always unfold smoothly and without flaws. Early users discovered that the machine misplaced decimals in certain calculations, but the problem was quickly solved. Also, some owners complained that the keyboard had been poorly designed.

But those problems did not impede sales. "Within just a few months," says Morgan Stanley's Ulric Weil, "the IBM PC was *the* standard for the personal-computer market." Orders for the machine, which has a starting price, with standard accessories, of about $3,200, have been pouring in so fast that some buyers have had to wait several months to get one. Last year IBM sold an estimated 200,000 PCs, and this year sales of 800,000 or more are projected. In June, the Travelers Insurance ordered 10,000 PCs, to be delivered over the next two years. New companies with names like Compaq Computer and Eagle Computer have sprung up making machines that are modeled on the PC.

The explosive growth of the IBM entry has set up a confrontation with Apple Computer. Executives of the California-based company, which introduced a fully assembled personal computer in 1977, profess not to be worried. They even greeted the PC the day after it was announced with ads that read "Welcome IBM. Seriously. Welcome to the most exciting and important marketplace since the computer revolution began 35 years ago." Whatever the intent of the message, some IBMers found it condescending.

Apple Chairman Steven Jobs claims that IBM has expanded the personal-computer market and that his company's share of it has gone on growing at the expense of weaker rivals like Tandy, which owns Radio Shack. Says he: "Apple has a higher market share than IBM, and we intend to keep it." Indicative of how serious Apple considered the challenge was its decision to hire Pepsi-Cola President John Sculley, a marketing expert, to serve as Apple's president and chief executive. "This is not a bruising fight for market share between Apple and IBM," says Sculley. "It's a sorting out of who the major participants will be."

Some observers are far less confident about Apple's prospects. Gene Amdahl knows IBM from the perspective of a rival and a former 13-year employee. Says he: "IBM waits until some brash young companies develop a market to the point where it's interesting, and then they take it over. In Apple's case the shooting isn't over yet, but I think it's clear how the war will come out."

Plain Vanilla, but Very Good

When he was growing up in the 1930s in Jefferson City, Mo., then home to 23,000 people, his schoolmates called him Johnny. Slightly large hands and feet gave him a strong backstroke on the high school swimming team, recalls Boeing Chairman T.A. Wilson, a freestyler on the same squad. Johnny's father "Gump" ran a local hardware store. Years later, when the boy began making it big in business, a reporter for the local newspaper went out to see Gump and asked whether he was surprised by his son's success. "No," said Gump, "I always knew Johnny was a good boy."

Good as gold, almost. As chief executive officer of IBM, John Opel earned a handsome $1.3 million last year. He also owns $4 million worth of his company's stock.

Compared with the Thomas Watsons, father and son, Opel appears almost bland. "Plain vanilla," says one member of the IBM board, "but good plain vanilla." Says a middle-level executive: "With Tom Watson, you knew stories about him. With Opel, there are no vibes. You just know, in a business sense, exactly what his goals and objectives are."

In his simple but elegant office at IBM's headquarters in Armonk, N.Y., the only mildly unusual feature is a stand-up desk that Opel uses in addition to a standard one. He receives visitors with a correctness that is so smooth it can be mistaken for real easiness. But Board Member William Coleman, a Secretary of Transporta-

tion in the Ford Administration and now a Washington lawyer, says Opel is noted more for his strength than for his charm. Says Coleman: "He's tough. You can tell instantly when you're rubbing him the wrong way or when you've stayed beyond your time."

While IBM's stern dress code has been eased, Opel still follows the old one. His shirts are white oxford cloth and as buttoned down as the man. His ties are impeccable and subdued, his shoes standard-issue corporate cordovans: no buckles, tassels or other frills.

John Opel achieved the top post by molding himself to be just what the company wanted, because that is exactly what he too wanted. Opel sees himself as something of an interchangeable part of the firm. "I'm a product of the culture of IBM, of the way we do things," he says.

Starting with the firm straight out of the University of Chicago School of Business in 1949 as a salesman in Jefferson City, Opel was soon being shifted around with dizzying frequency; he has held 19 different jobs. His career picked up fast in 1959, when he was chosen to be an administrative assistant to Thomas Watson Jr., then president, for one year. Following that, Opel began serving in a wide variety of posts, ranging from manufacturing to press relations.

Opel today gives visitors and colleagues a sense of self-containment, but he admits to having had a wicked temper. Once when he could not get a flat tire off his Chrysler because he was turning a lug the wrong way, he became so enraged that he bashed in the side of the car. "I don't get angry the way I used to," Opel says.

WRIGHT STUDIO

The chairman on the 1940 team

Division Vice President Estridge, leader of the group that developed the Personal Computer

The tradition-breaking product has done nothing less than transform the industry.

In fact, IBM's aggressive new posture poses a threat to virtually the entire computer industry. "IBM is creating a dangerous situation for competitors in the marketplace," says computer-industry observer Gideon Gartner. Among those most at risk are makers of so-called plug-compatible computers that run IBM software but sell for less. Such firms thrived during the 1970s, when IBM was slow in delivering equipment. Now, however, a burst of IBM price cuts and new models could badly hurt them.

That has already happened to Mag-nuson Computer Systems (1982 sales: $18.4 million). The San Jose–based maker of medium-size computers prospered in the late 1970s when IBM failed to ship a rival system on time. But IBM fought back in 1981 by slashing prices and introducing a new model. Then, last October, IBM announced two additional computer models and cut prices again. "There was no question. That was the fatal blow," declares Magnuson President Charles Strauch. The company, which has chopped its work force from more than 640 employees to about 100 over the past

months, filed bankruptcy papers in March.

Other firms have also been hit hard. Like Magnuson, Storage Technology enjoyed a big jump in business in 1981 when IBM ran into technical difficulties introducing a new memory device. The Colorado-based company, which makes high-performance memory equipment, gained some 300 customers because of IBM's troubles. However, when Big Blue brought out an improved new line last year, Storage Technology's profits dropped to $64.7 million, from $84.2 million in 1981. Says Jesse Aweida, who co-founded Storage Technology after 13 years with Big Blue: "IBM used to be active in only certain areas of the computer business. Now it wants to be active in the whole business."

One big reason for IBM's clout is the major investments it began making in the late 1970s to upgrade manufacturing facilities. IBM executives point to that drive to cut production costs, launched under Cary, as a foundation of the company's current strength, because it has made the firm extremely cost-competitive. IBM has pumped some $10 billion into capital improvements since 1977. The Boca Raton line that turns out the PC is so highly automated that a personal computer can be assembled in ten minutes of worker time.

The plants use some of IBM's most advanced technology. An engineer in the firm's La Gaude, France, laboratory can

But the old intensity, just barely noticeable beneath the perfect manners, can still be useful. "People know that I mean what I say and that I don't suffer fools," he says.

John Opel is a lot more than just a corporate man, but he guards his privacy as closely as his company protects its secrets. He bridles at revealing much about his background or family, plainly believing that such matters are his own business. He fought with the U.S. Army on Okinawa in World War II and was wounded in the foot by a piece of shrapnel. He and his wife Carole have three daughters and two sons. He drives himself to work in a six-year-old car whose make he will not divulge and lives in a house he will not describe beyond noting that it is "big enough to accommodate five children."

Opel spends much of his non-IBM time with his wife. Three mornings a week they are up at 5:30 and drive 20 miles to do aerobic and exercise-machine workouts "at a place where they don't know me." The Opels fish together, go to the opera together and watch birds together. They also work together to protect their privacy. On the rare occasion when a reporter calls him at home, Carole Opel answers politely and promises to bring her husband to the phone. But then she sets down the receiver without ever telling him. Callers get the message.

Some IBM board members were worried about this almost obsessive penchant for privacy when Opel was being consid-

Says he: "I'm a product of the culture of IBM"

ered for chief executive. They were concerned that he would have trouble handling relations with the board and the public and within the company. Says one board member, former Pennsylvania Governor William Scranton: "He is very possibly the brightest chief executive I've ever dealt with. But he did have some difficulty expressing himself." Yet former Du Pont Chairman Irving Shapiro, another board member, says that this has not turned out to be a problem. Says he: "The beautiful thing is that Opel has come out of his shell."

During his years of rising through the corporate ranks, Opel was often frustrated by IBM's centralized management. "No matter what I had in my jurisdiction, I typically felt I was more competent to deal with it than anyone else. And that wasn't conceit, it was just simple laws of nature," says Opel. That experience left him with a desire for decentralized decision making. He now tries to force corporate policymaking down and out, retaining at headquarters only what is necessary for overall planning and control. "You have to have people free to act, or they become dependent," he says. "They don't have to be told; they have to be allowed." In pursuit of that goal, Opel established seven Independent Business Units, which operate much like small companies within IBM. One of the first products created by Opel's brainchildren: that bountiful beauty, the IBM Personal Computer.   —By John F. Stacks

THINK

The Watsons, father and son: Thomas Sr. in August 1947 addressing a company convention; Thomas Jr. in 1957 with one of the early machines

Rules, principles and intelligent management have built an overwhelming corporate culture that often begins to affect customers as well.

transmit his computerized design information for a new chip via satellite to the IBM facility in East Fishkill, where the chip is actually manufactured. The chip will be floated through tubing on air from one manufacturing station to another and then tested by robotically controlled equipment.

IBM is also the world's largest producer of logic and 64K RAM memory chips, and installs its entire output in its own machines. The company, moreover, can produce at the same plant far denser 256K RAM chips, which Japanese firms are also developing. IBM could start making the chips ahead of the Japanese, perhaps by early next year.

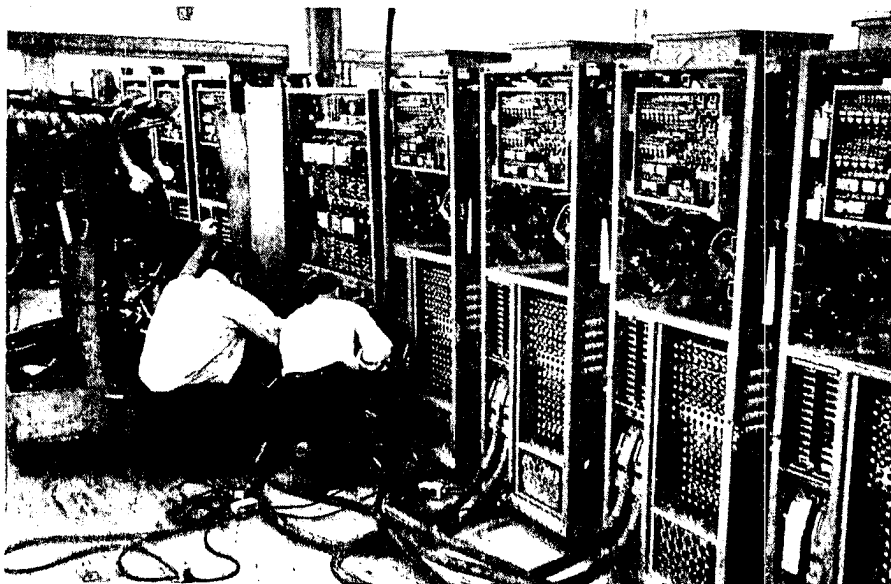In line with its new aggressiveness, IBM has been cracking down hard on those who would steal its secrets. It cooperated with the FBI last year in a sting operation that nabbed employees of Hitachi and Mitsubishi Electric, two Japanese competitors, for trying to buy confidential IBM information. IBM then brought a separate civil suit against Hitachi, which pleaded guilty to conspiracy charges last February and was fined $10,000. The criminal case against Mitsubishi is still pending.

IBMers claim to be unruffled by Japanese competition. "I think I'll be physically ill if I hear one more time that the Japanese are coming," says Paul Low, manager of the East Fishkill plant. "That's not to say that they're not formidable rivals, because they are, but we're ahead." All six of the major Japanese makers of large computers together have less than 2% of the U.S. market for business computers.

Many outsiders believe that IBM is more concerned about the Japanese than it professes. Says Magnuson Computer's Strauch: "I'm sure IBM's basic concern is the Japanese. It is almost certain that what happened to us was a message to the Japanese that if they have any thought of entering the market with a low-to-medium-range mainframe, they had better be prepared to compete at an extremely low cost." Apple's Jobs believes that IBM's investments in Intel and Rolm are at least partially intended to strengthen IBM's ability to compete with Japan.

The struggle between IBM and its Japanese competitors is most intense in Japan, where IBM lost its No. 1 position to Fujitsu in 1979. IBM Japan, the company's wholly owned subsidiary, is fighting back. "They are becoming surprisingly aggressive," says Yuji Ogino, managing director of IDC Japan, a unit of International Data. IBM Japan, which employs 13,000 Japanese workers, has been slashing prices and launching new marketing drives in a bid to win back its overall lead. Admits a spokesman for a rival Japanese firm: "IBM is an enormous competitor."

At the same time that it has been fighting vigorously for market share, IBM has been forming cooperative agreements with the Japanese. In one, IBM and Matsushita Electric Industrial teamed up to produce a personal computer that converts Japanese phonetic symbols into Chinese characters or Kanji. Typewriters have not been widely used in Japan, partly because, with so many different characters, a typical machine must be packed with about 3,000 Kanji. The new machine, which ranges in price from $4,100 to $12,700, has a keyboard of only 45 phonetic symbols plus the Latin alphabet. More than 15,000 of the machines have been ordered, and there is at least a two-month wait for delivery.

If striking similarities exist between

Testing the cables on a bank of early equipment in 1955 at a plant in Poughkeepsie, N.Y.

50

Economy & Business

IBM and Japanese companies. The reason is that Big Blue was the model for some Japanese business techniques. For example, IBM developed "quality circles" some 20 years ago. The circles, small teams of workers that get together to discuss ways to improve output and solve production problems, have been widely adopted in Japan and are often cited as a reason for productivity gains there. Both IBM and Japanese executives stress harmonious employee relations, and both place a high priority on becoming the most modern, cost-efficient manufacturer of the products they turn out.

Foreign operations are vital to IBM. Overseas business accounted for 45% of IBM's gross income in 1982 and 37% of the company's profits. IBM hires mainly local employees at its international locations. There are only 125 Americans among some 1,000 managerial and technical employees in the Paris headquarters of IBM's European, Middle Eastern and African operations. Says Hans-Olaf Henkel, a vice president in the Paris office: "Europeans like IBM not because it is American, but because it is IBM. It promotes from the inside, and the majority of senior positions

are held by nationals of the country.

IBM executives concede that despite its wide-ranging successes, the company has its weaknesses and has made some major mistakes over the years. Despite increased efforts to recruit women and minorities, there are still few of either in management ranks. Only 3,089 of IBM's more than 29,000 managers are women. IBM policies, moreover, can seem high-handed, especially toward women. In December 1981, a California jury awarded $300,000 to an IBM marketing manager who quit after the company objected to her romantic relationship with a former employee who had joined a rival firm. She resigned when her boss, fearing a conflict of interest, tried to transfer her to another division. IBM is appealing the jury verdict.

Some employees find the firm slow to capitalize on opportunities in spite of steps to decentralize decision making. "IBM has more committees than the U.S. Government," complains one insider. To increase its flexibility, IBM has set up 15 small ventures within the company since 1981. These explore new business opportunities in such fields as robotics, specialized medical equipment and analytical instruments. The new units are independently run, but they can draw on IBM resources. This seems to provide IBM with the benefits of both a large company and a small one. Says Robert Burgelman, an assistant professor of management at Stanford University's Graduate School of Business: "If IBM can integrate these new ventures into its culture, the company is going to be an enormously dangerous competitor in most of the emerging areas of high technology."

IBM stumbled badly when it set out to produce an office copier in the 1970s. Executives first turned down a chance to buy a process that Xerox later used with great success, and then introduced a balky model. Admits Cary: "If you're asking was it a mistake to ship so many copiers before they were really reliable to sell, yes it was a mistake." The company was forced to suspend deliveries until the problems were solved.

IBM, in addition, has not broken into the market for so-called supercomputers, which are used mainly for scientific research. The company launched supercomputer projects in the 1950s and 1960s, but could not produce a design that executives believed would be profitable. IBM has since abandoned the specialized field to Control Data and Cray Research.

Opel is bullish about the future of IBM, and he is very optimistic about the outlook for the whole industry. He notes that while people have limited demands for commodities like shoes and automobiles, they seem to have an insatiable appetite for information. Says he: "I have yet to hear somebody say they could not use more information. Hence the demand

for information processing, though perhaps not infinite, is enormous."

What will be coming next out of the IBM laboratories to satisfy that demand? Opel is clearly not ready to sit back and relax despite his company's achievements. Says he: "We've got an enormously successful operation. Therefore you could be complacent; you could play it safe and not change. All the natural forces in the business pressure you in that direction." But one sign that the pace of the past two years will continue will be the arrival of a home computer, which IBM originally code-named "peanut." This will sell for about $700 and could reach stores in late fall. The machine, fully compatible with the PC, will come with a built-in disc drive and cartridge slot for software. "It will offer the best performance on the market for its price," asserts Clive Smith, a computer watcher with the Yankee Group, a Cambridge, Mass., research firm.

IBM is also developing a raft of exotic technologies. These include Josephson Junction and quiteron switching devices that operate in trillionths of a second at temperatures that approach absolute zero (–459.67° F). Says one IBMer: "There's
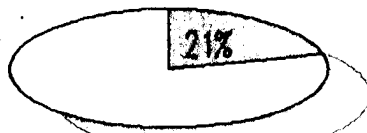
BIG BLUE'S MARKET SHARE
Percent of units installed
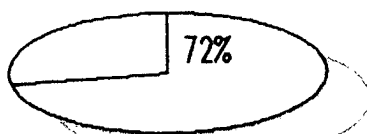
72% □ Mainframe Computers
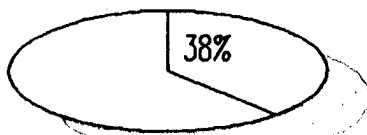
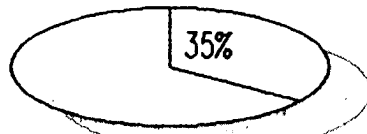38% □ Small Business Computers

21% □ Personal Computers

4% ▮ Minicomputers

35% □ Typewriters

Source: International Data Corp.

SOURCE OF INCOME

8%
2.5%
5%
29%
11.5%
25%
19%
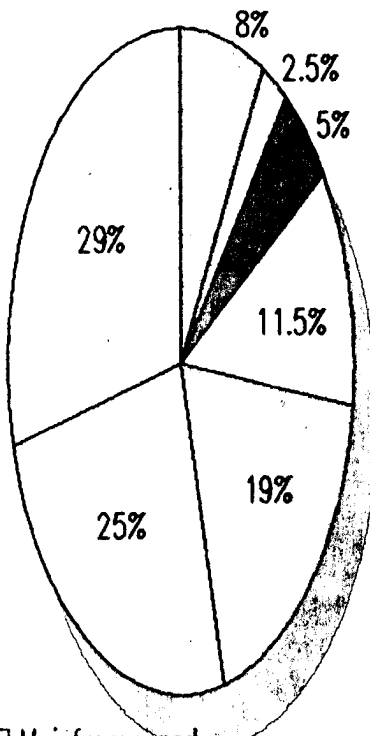
□ Mainframe and Personal Computers
□ Printers, Copiers, etc.
□ Office Systems and Typewriters
□ Maintenance   □ Other
□ Federal Contracts ▨ Software

TIME Charts produced on an IBM Personal Computer by Joe Lertola

Economy & Busine(

nothing, literally nothing, noteworthy in the field that IBM doesn't have its fingers into."

The biggest future payoff for IBM is likely to come in the field of office automation. The key to the so-called paperless office will be computerized networks that shuttle messages between computer terminals, telephones and other office equipment. All can then be consolidated into a "work station" atop a desk. "The world of the future is centered on powerful work stations," says Lewis Branscomb, IBM's chief scientist.

Last month IBM showed that it was determined to become a leader in developing the automated office by agreeing to acquire 15% of Rolm. That company's advanced PBX system, a type of computerized switchboard, can be used to direct the flow of voice and data traffic between work stations. The investment will enable the two firms to work out ways to link IBM computers with the Rolm PBX.

In fact, IBM has long been deeply involved in telecommunications. In 1975, the company bought a one-third interest in Satellite Business Systems, which transmits voice and computer data. IBM is seeking partners for communications ventures in Europe. In March 1982, it won an $18 million contract to upgrade the British telephone system, and it is installing a computer-driven telephone information service in West Germany.

IBM's moves into telecommunications will put it squarely in competition with American Telephone & Telegraph, now the world's biggest company. An extended battle between the two giants seems inevitable in the area where computers and communications overlap to create the Information Age. Once the separation of A T & T from its regulated telephone units goes into effect next January, the company will be able to use its Bell Laboratories and Western Electric facili-

ties to develop products to compete directly with IBM. A T & T through the new American Bell is expected to introduce computers next year, and it already has the capability of offering a wide range of data-processing services similar to those IBM provides.

In that upcoming clash of the titans and the continuing fight for the world computer market, IBM will be tough to beat. Its resources—human, technological and financial—are enormous. Its ability to combine salesmanship and service with research and innovation is unmatched in the U.S., perhaps anywhere. At a time when the rallying cry "Small is beautiful" can be heard even in business circles and when some critics charge that large corporations are inherently inflexible, IBM has shown how to be a successful colossus.   —*By John Greenwald. Reported by Bruce van Voorst/New York, with other bureaus*

Softening a Starchy Image

A mustachioed little clown with an undersize jacket and oversize trousers to symbolize IBM's first computer aimed at the mass market? That hardly fits IBM's stuffy old image, but when the company needed an advertising campaign for its new personal computer 2½ years ago, it turned to one of the 20th century's most enduring and endearing characters: Charlie Chaplin's Tramp. Says Charles Pankenier, director of communications for the PC: "We were dealing with a whole new audience that never thought of IBM as a part of their lives." Industry insiders estimate that the firm has spent $36 million in one of the largest ad campaigns ever mounted for a personal computer.

Manufacturers of personal computers have been using readily recognizable people for some time to make the slightly intimidating machines seem warmer and more empathetic. Apple has Dick Cavett for its commercials, Texas Instruments recruited Bill Cosby, Commodore has William Shatner, and Atari just hired Alan Alda. None of these living celebrities, however, has had the impact of the Tramp. The character has starred in three widely seen television commercials, plus more than 20 print ads. He has won numerous advertising-industry awards.

Chaplin once explained that he created the character in 1915, after an accidental meeting with a hobo in San Francisco. The Tramp's resurrection was only slightly less serendipitous. IBM's advertising agency, the Madison Avenue firm Lord, Geller, Federico, Einstein, was looking for someone, or something, that would attack the problem of computer fright head on. The agency was talking about using the Muppets or Marcel Marceau, the

Chaplin's enduring, endearing Tramp

mime, when, according to Creative Director Thomas Mabley, the idea for the Tramp "sort of walked in and sat down."

Some officials at both the company and the agency were afraid that the floppy character was not in keeping with IBM's starched white-collar image. The question of whether the Tramp represented antitechnology sentiment, as epitomized in the most famous scene from one of Chaplin's best-known movies, *Modern Times*, was also raised. In the scene, Chaplin gets caught in the giant gears of a factory. But both the agency and IBM eventually concluded that the character, in Pankenier's words, "stands fear of technology on its head and would help the PC open up a new technological world for the non-technician."

The company obtained rights from Bubbles, the Chaplin family company that licenses use of the actor's image, to use the Tramp. To cast the part, the agency interviewed some 40 candidates in New York City and 20 on the West Coast. The winner was 5-ft. 6-in. Billy Scudder, 43, who has been doing Tramp impersonations since 1971. Says he: "Nobody tires of the little Tramp. He creates instant sympathy."

The commercials are elaborate Madison Avenue extravaganzas. In one 60-second spot, which symbolizes the problems of inventory control in a small business, the Tramp stands at the intersection of two assembly lines in a bakery. He comes a cropper when the fast-moving line spews cakes onto the floor after he tries to jam a giant-size one into an economy-size box. Taping the sequence required 30 takes—and 150 layer cakes.

The Tramp campaign has been so successful that it has created a new image for IBM. The firm has always been seen as efficient and reliable, but it has also been regarded as somewhat cold and aloof. The Tramp, with his ever present red rose, has given IBM a human face.

BUSINESS

The Giant Takes Command

IBM begins an offensive to capture world markets in the coming information age

The meeting was a closely guarded secret. In July 1980 a research team from IBM's Boca Raton, Fla., operations flew to Seattle to meet with Bill Gates, the head of a tiny, $8 million-a-year software company in Bellevue, Wash. After Gates signed a strict nondisclosure pact, the IBM team made a startling proposal: the company was about to develop a small personal computer to challenge Apple and Radio Shack head-on—and IBM wanted Gates, who was then only 24, to write the vital operating-system software for the new machine, code-named "Chess." The offer was unprecedented: never before had the giant $26 billion corporation deigned to let an outsider play such a critical role in designing one of its computers.

The gamble paid off. In the next 10 months, Gates's Microsoft Corp. designed the entire operating system and key language programs for IBM's Personal Computer, and influenced the choice of other vital features. The machine debuted in August 1981 and has taken the computer market by storm. Sales are expected to top 600,000 this year and more than a million in 1984. The success of the PC has also created a vast new market for independent software

firms and smaller hardware companies; they are racing to turn out new products for the PC and a host of "IBM compatible computers." Meanwhile Apple and Radio Shack, which two years ago commanded the lion's share of the personal-computer market, are rapidly losing ground (chart).

Attack: IBM's roaring success in personal computers is only one thrust in its aggressive attack on the global marketplace. Over the past two years, IBM has reorganized its gigantic sales and marketing force and overhauled its production, research and pricing strategies for a head-on battle with American, Japanese and European competitors in nearly every computer-related market. Since 1976, IBM has poured $25 billion into new plant and equipment, upgrading its facilities and, as one IBM executive puts it, "roofing over America with new factories and warehouses." Says IBM chairman John R. Opel, "The reorganization has the same goals as the extensive capital investments IBM has been making over the past several years—to put IBM in a position to take advantage of the tremendous growth opportunities in our business."
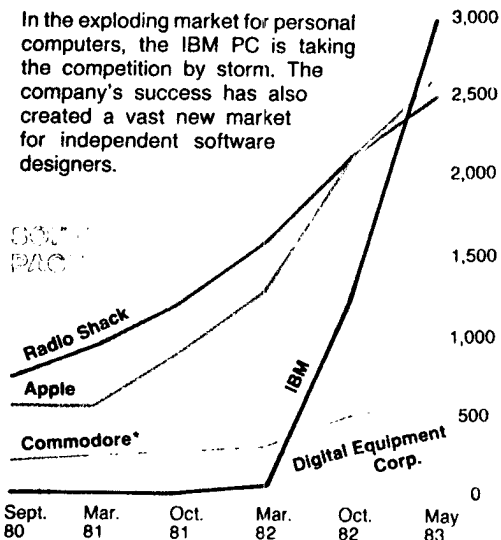
The evidence is already in: IBM's worldwide gross income jumped to a record $34

billion last year, profits surged 20 percent—and analysts expect a similar 20 percent profit growth this year and next. "In the past year or so," says analyst Frank Gens of Boston's Yankee Group, "the industry has seen the birth of a new IBM, and the competition is kicking and screaming." But there are few complaints on Wall Street. IBM stock closed at 121¼ last week. During the past 11 months, the tremendous surge in IBM stock—up 60 points from 62½ last August—has helped power the Dow Jones industrial average to record levels, accounting for 10 percent of its total rise. "No other stock has had anywhere near that effect on the Dow," says Jane Staunton, vice president at Salomon Brothers.
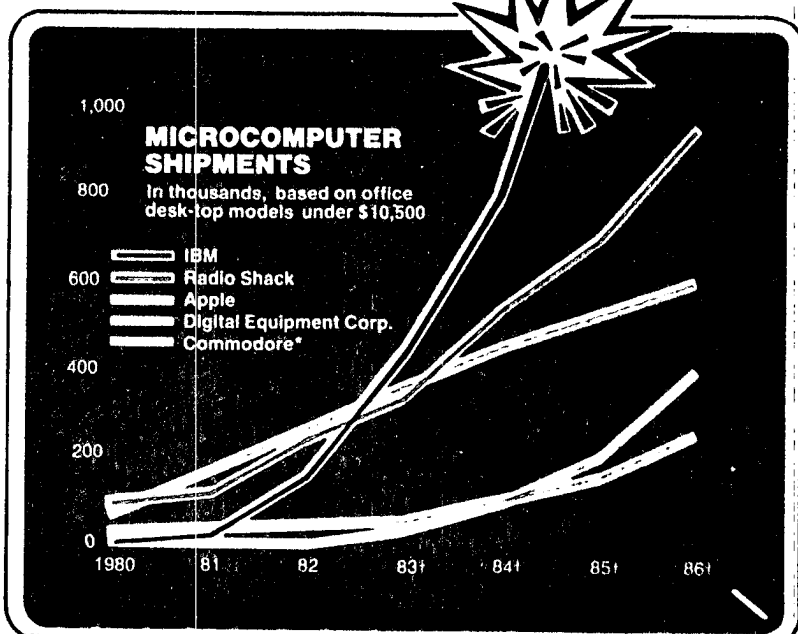
Much of IBM's aggressive new strategy stems from January 1982, when the Justice

A BONANZA IN PERSONAL COMPUTERS

In the exploding market for personal computers, the IBM PC is taking the competition by storm. The company's success has also created a vast new market for independent software designers.

Radio Shack
Apple
Commodore*
IBM
Digital Equipment Corp.

3,000
2,500
2,000
1,500
1,000
500
0

Sept. 80 | Mar. 81 | Oct. 81 | Mar. 82 | Oct. 82 | May 83

*Does not include packages for home computers.
Source: P C Clearinghouse, Inc.

MICROCOMPUTER SHIPMENTS
In thousands, based on office desk-top models under $10,500

IBM
Radio Shack
Apple
Digital Equipment Corp.
Commodore*

1,000
800
600
400
200
0

1980 | 81 | 82 | 83† | 84† | 85† | 86†

2,000
1,500

*Does not include home computers   †Projections.   Source: Yankee Group
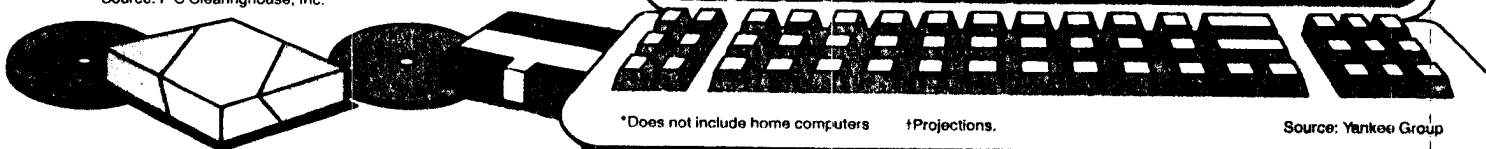
IM chairman John Opel, a Personal Computer demonstration in New York: A big gamble turned out to be a roaring success

=partment dropped a massive 13-year-ng antitrust suit against the computer ant. "The antitrust suit had a huge im-ict on IBM," says analyst Ulric Weil, of Iorgan Stanley. "The very life of the com-iny was at stake." Under the threat of court-ordered dismemberment, IBM ived cautiously, and profits slipped in '9. But once the threat was lifted, the npany began an unabashed drive to iint the world IBM blue. "IBM was giv-; some price discounts before the Jan. 8 :ision, but they were secretive. The sys-n was word-of-mouth," says Weil. "The gressive pricing strategy erupted in its .l splendor after the antitrust victory." he price-cutting strategy was a stinging ow to competitors. Last year Amdahl orp., a manufacturer of IBM-compatible iainframe computers, reported an operat-g loss; Magnuson Computer Systems ent bankrupt, and National Advanced ystems turned to the Japanese, agreeing i sell Hitachi computers rather than com-te directly with IBM.

Relentless: Along with the more aggres-ve pricing strategy, there has been a sea :ange in some of IBM's cherished ways of ;ing business. IBM had always prided it-lf on developing, building and marketing ; own products. Yet the IBM PC is built most entirely of components made by oth-manufacturers. Like the PC, the brain of 3M's Displaywriter word processor is a icroprocessor from Intel Corp., a leading miconductor firm. And IBM's Instru-ients Computer Systems uses a Motorola orp. 68000 microprocessor, the same chip sed in Apple's new Lisa computer. "IBM as made a psychological jump," says ana-yst Peter Wright of the Gartner Group. "If

the markets are moving fast, IBM is going to move fast even if it needs a little help." And IBM is going even further: recently it has announced three joint ventures with Japa-nese companies and a marketing venture with Artificial Intelligence Corp. of Wal-tham, Mass. IBM bought a 12 percent inter-est in Intel and 15 percent of Rolm Corp., a top manufacturer of advanced telephone-switching networks.

Most analysts expect IBM to keep driving relentlessly into new markets. "IBM wants to be the leading force in every communica-tions and data-processing-related market," says Gens of the Yankee Group. The com-pany has demonstrated the PC as a factory automation tool for controlling robots; it is readying a new, less expensive personal computer (code-named "Peanut") aimed at the educational and home markets. It is gearing up for an assault on scientific and engineering markets, and IBM is certain to be a major force in the looming telecom-munications war, battling for newly deregu-lated markets against AT&T. The company is pushing development of a broad array of new technologies, including plasma-display screeens that may replace cathode-ray tubes (CRT's), and an important advance in pack-aging circuits for mainframes—the "ther-mal conduction module." Industry sources say IBM has also quietly formed a team of 25 scientists to plan a counterattack against Japan's Fifth Generation computer project (NEWSWEEK, July 4).

Even before the antitrust victory, IBM was beginning to make profound changes in order to adapt to faster-moving markets. When IBM decided to develop a personal computer in July 1980, the company set up what it calls an Independent Business Unit

(IBU) to handle the project. The group was given unusual freedom to bypass IBM's corporate bureaucracy; the PC team had its own independent sales, marketing and de-velopment staff. The IBU, says retired chairman Frank T. Cary, is "IBM's answer to the question, 'How do you make an ele-phant tap-dance?'"

The PC development team in Boca Raton studied Apple's success (in fact, it used Ap-ple II computers during the project) and decided to emulate Apple's strategy of en-couraging independent software companies to boost the success of its personal comput-er. "They've seen that it is to their advantage not to get in the way of a healthy, creative software market," says Mitch Kapor, presi-dent of Lotus Development Corp. of Cam-bridge, Mass., developer of the Lotus 1, 2, 3 financial-analysis program, which runs on IBM's PC. "They let us go our own way."

'Brown Suit': That may be true, but IBM's blue-suited legions have had a marked im-pact on the freewheeling entrepreneurs who are chasing the $300 million software mar-ket for IBM PC software: "Whenever we talk to IBM we get dressed up in colors that we know will please them," says George Lechter of Alpha Software in Burlington, Mass. "I once saw an IBM executive in a brown suit—but it was a classy brown suit." IBM's influence extends well beyond the sartorial. "Working with IBM has changed us," says Lechter. "They've taught us to have more of a commitment to our business, to tie up more money in our future." At Mi-crosoft, Gates has instituted IBM-style re-views of performance. "We've changed how we measure quality, how we schedule proj-ects, our security requirements and a lot of other things," says Gates, whose link with

BUSINESS

Bernard Gotfryd—NEWSWEEK

IBM's Poughkeepsie, N.Y., plant: 'The competition is kicking and screaming'

IBM has proved lucrative: Microsoft has grown from 35 to 350 employees, and this year sales should reach $64 million. MS DOS, the operating system he designed for the IBM PC, is now a standard operating system on more than 60 computers.

While the independent companies writing software for IBM's PC are cashing in on the exploding market, IBM's competitors in hardware are feeling the heat. "If the world were fair," says Charles I. Peddle, the founder and president of Victor Technologies, Inc., of Scotts Valley, Calif., "IBM would give me about one-third of their money, let me steal a few more of their salesmen and let me borrow their name every three days. Then we could have a more even game." Even so, Victor's sales are growing rapidly—from $65 million last year to $55 million for the first quarter of this year. IBM is unable to keep up with demand for the PC, and its august presence in the personal-computer field has given the entire industry a new respectability. Apple's sales are running at a record $1 billion-a-year pace. Tandy, Hewlett-Packard and DEC are surging. For the time being, at least, it's the latecomers who may face the most trouble: "I would hate to be the 170th microcomputer company right now," says E. Floyd Kvamme, executive vice president of sales at Apple. "There are a lot of them out there."

'Trojan Horse': For IBM, the PC's success may soon lead to even greater rewards. "They're following the Trojan-horse strategy," says Gens of the Yankee Group. By selling large numbers of desktop Personal Computers to big corporations, IBM is, in effect, creating a new market. "The executive sits down at his well-contained PC, but pretty soon he discovers he has to plug into the company's mainframe. Suddenly 300

executives want to tie into the mainframe—and the corporation has to buy more mainframe capacity," says Gens.

Although Apple hopes to carve out a market of its own with the introduction of its Lisa computer (NEWSWEEK, Jan. 31), it recognizes that IBM's strength is simply too great to ignore. In April, Apple announced a joint program with Cullinet Corp. of Westwood, Mass., that will enable Apple computers to link up, using Cullinet software, to large IBM mainframes. Apple has also announced two local-area networks that will tie office computers together, allowing them to exchange information and communicate with mainframes. "In the large office where we are competing heavily with IBM, what we are saying is, 'We understand networking and data communica-

Gates of Microsoft: A helpful outsider

Jim Wilson—NEWSWEEK

tions'," says Kvamme. "Our products have that capability today."

Some competitors, however, are greeting IBM's growing strength in the personal computer market with undisguised alarm. "IBM wants everything. It's their policy wait until a market gets big enough so they can deal with it in their own *modus operandi*," says Gene M. Amdahl, one of IBM's top computer designers who left the company in 1970 to start Amdahl Corp. and more recently Trilogy Systems Corp. "Now they are helping themselves to the fruit that Apple grew."

But as both companies realize, the rules of the game have changed dramatically from the days when Apple was starting out in a Palo Alto garage. IBM and Apple are now producing personal computers on streamlined, highly automated assembly lines. Keeping the cost of production down is essential, a strategy IBM is pursuing throughout its worldwide operations. "We are aggressive in the pursuit of the goals we have established for ourselves, especially our goal of being the low-cost producers," says Allen J. Krowe, IBM senior vice president for finance and planning staffs. Following the same logic, IBM has streamlined its sales and marketing staff, so that corporate customers need only deal with a single IBM sales team instead of having to contend with competing fiefdoms within the company.

Forays: The success of the PC has been so great that IBM is now attempting to apply the strategy to other explosive markets. It has set up new Independent Business Units to handle IBM's forays into biomedical systems, analytical instruments, factory automation, educational materials, a new computer time-sharing service and telecommunications products. And the company has increased its spending on research and development to $2.6 billion last year.

The need for huge outlays is clear: to sustain a growth rate of 20 percent a year in profits, IBM will have to become even more aggressive and diversified. And as product cycles grow shorter and the pace of technology accelerates, the company will have to continue introducing new technologies and products at a rapid rate. IBM is expected to introduce an interoffice computer-communications network in the next few months, and it will undoubtedly work with Rolm in bringing out a sophisticated new telephone and computer-data exchange, a move that will put IBM directly in competition with AT&T.

In the next decade IBM's global drive for supremacy in the Information Age will be a formidable challenge to AT&T, Japan Inc. and thousands of competitors large and small. "It's difficult to stop a charging elephant," says Peter Wright of the Gartner Group. Perhaps even more difficult than teaching an elephant to tap dance.

WILLIAM D. MARBACH with RICHARD SANDZA and KIM FOLTZ and JENNIFER CONANT in New York and GEORGE RAINE in San Francisco

Inside the Supercomputer

In the last 35 years, as computers have grown immensely more powerful, the basic scheme of their operation—their "architecture," as engineers call it—has never changed. In the late 1940s, John von Neumann, a Hungarian-born mathematician, conceived what was first called the stored-program computer: a central-processing unit—the brain of the computer—that executed its calculations one step at a time, storing each result in its memory before moving on to the next calculation. The primitive vacuum-tube models worked that way, as did the next generation of transistorized computers. With its almost unimaginable speed, the Cray-1 supercomputer still depends on serial processing, its signals shuttling back and forth through the dense mass of 350,000 silicon chips. Even as computer designers use faster and faster microelectronic circuits in the quest to build ever-faster machines, however, the von Neumann architecture has become the "von Neumann bottleneck," a traffic jam that limits the speeds existing computers can attain.

In the race to build the next generation of supercomputers, scientists are experimenting with a variety of designs that will break the von Neumann bottleneck between the processor and memory. These "non-von Neumann architectures" range from machines that will have two or more processors and shared memories to extensive parallel architectures with hundreds of local memories and processors, all executing instructions simultaneously. "Given the state of the art today and the way the physics are formulated, we think parallel processing is clearly the wave of the future," says John A. Rollwagen, chairman of Cray Research of Minneapolis, one of the world's leading supercomputer manufacturers. "We and Control Data and everyone else who wants to play the game will have to have a completely different architecture." Where the Cray-1 had only one processor, the Cray X-MP now coming onto the market has two processors and the Cray-2 due in late 1984 will have four processors. The next machine, the Cray-3, will probably have 16 processors; Seymour Cray, the master designer of supercomputers, is working out final designs for it now. One machine already in use, the HEP supercomputer built by Denelcor, Inc. of Aurora, Colo., uses four processors to reach speeds up to 40 million instructions per second.

Road Map: The more radical solutions to the von Neumann bottleneck involve networks of many more processors and their liberation from the tyranny of a central memory. At the University of Texas at Austin, James Browne has built a small prototype of a parallel-processing machine. The Texas Reconfigurable Array Computer (TRAC), as it is called, has four processors and nine memories and works more like a telephone network than a traditional von Neumann computer. "Instead of processing in a straight line, it looks like a road map where the cities are processors and the roads are the communications links between them,"

says Browne. "If one processor wants to talk to a certain memory, it can, in effect, dial it up." The scheme allows for much faster speeds, just as the phone network could handle more traffic when direct dial replaced human operators. The trick is to organize and synchronize the communications between the processors and memories.

For their Fifth Generation Computer project, the Japanese are considering a radical departure from the von Neumann architecture, the so-called "dataflow" computer championed for the past 15 years by Jack Dennis at MIT. (Dennis and MIT Professor Arvind spent two days lecturing on dataflow computers to an audience of 200 scientists in Japan in 1980.) Dataflow computers will have huge numbers of processors, each with its own memory, and, as in simpler parallel schemes, the computer will have a routing network so that the processors and memories can communicate with each other.

But the dataflow computer will go even further: "The rules about when instructions are executed are different," says Dennis. Conv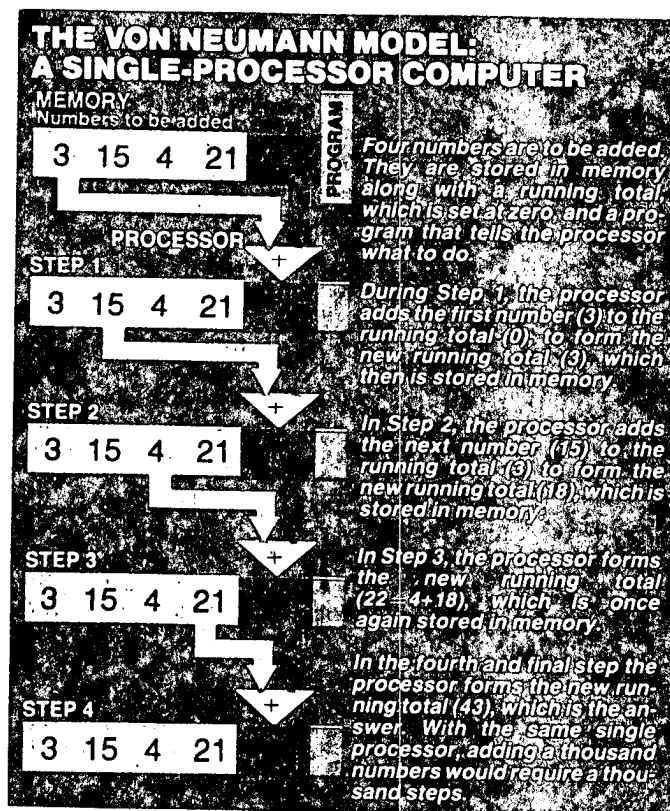entional computers process a stream of instructions, one after another, in the order the program tells the computer to follow. In dataflow machines, on the other hand, the processing units don't have to go looking for data in memory; they simply do whatever calculation is necessary when a "data packet" arrives (chart). Dennis is now planning to build a dataflow computer with 256 processors and memories, and scientists at the University of Manchester in England are working on a similar machine.

Tree Leaves: There is another way to break the von Neumann bottleneck, one that doesn't depend on dataflow concepts. At the University of North Carolina at Chapel Hill, a team of scientists led by Gyula Magó has designed a "binary tree" computer, multiple processors arranged like leaves on a tree with the branches carrying information to and from the processors. IBM scientist John Backus, who invented Fortran, the most widely used programming language 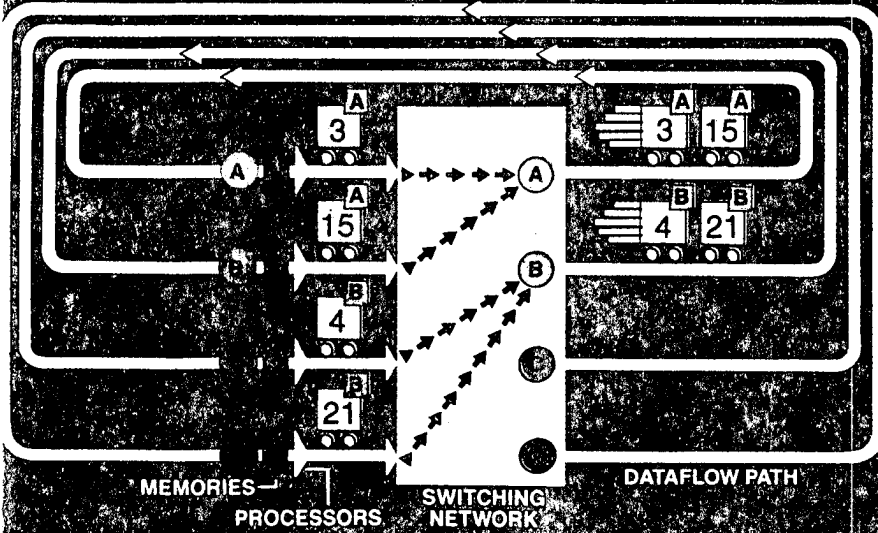on mainframe computers, is now working on "function-level programming" languages that can run on computers like Magó's machine. One advantage of Backus's is that the programming instructions and the data are intermingled, making programming easier and providing the mathematical tools that will enable the program to run more quickly.

Before computer manufacturers abandon von Neumann architecture in favor of these more radical designs, however, many problems will have to be solved. Designers must prove that the prototype machines will indeed outperform conventional computers. "People are now dazzled by the prospect that they can have 1,000 chips, 10,000 chips or 1 million chips," says IBM scientist Herbert Schorr. "But the question of how to organize 1 million chips to do anything effectively is still very open." Despite the promise of the radical designs, von Neumann's imprint on the computer world has yet to be erased.

WILLIAM D. MARBACH with WILLIAM J. COOK in Washington and JENNET R. CONANT in New York


THE VON NEUMANN MODEL: A SINGLE-PROCESSOR COMPUTER

MEMORY
Numbers to be added

3 15 4 21

PROCESSOR

STEP 1
3 15 4 21

STEP 2
3 15 4 21

STEP 3
3 15 4 21

STEP 4
3 15 4 21

Four numbers are to be added. They are stored in memory along with a running total, which is set at zero, and a program that tells the processor what to do.

During Step 1, the processor adds the first number (3) to the running total (0) to form the new running total (3), which then is stored in memory.

In Step 2, the processor adds the next number (15) to the running total (3) to form the new running total (18), which is stored in memory.

In Step 3, the processor forms the new running total (22=4+18), which is once again stored in memory.

In the fourth and final step the processor forms the new running total (43), which is the answer. With the same single processor, adding a thousand numbers would require a thousand steps.

Ib Ohlsson—Newsweek

A DATAFLOW SYSTEM: ONE VERSION OF A SUPERCOMPUTER

MEMORIES → PROCESSORS. SWITCHING NETWORK. DATAFLOW PATH

In this dataflow computer every one of the four processor-memory combinations produces both a number (shown inside the boxcar) and a destination (shown on the label on the boxcar's corner). The boxcars move through a switching network that, like a railroad switchyard, switches each car to the destination of its flag. The network begins the operations by routing 3 and 15 to A and 4 and 21 to B, where they move on to memories A and B.
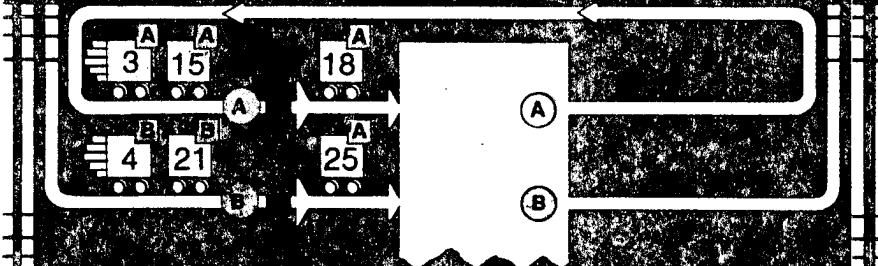
The programs in memories A and B then tell their respective processors to add the numbers that have just arrived, producing two new numbers, 18 and 25. (Processors C and D and dataflow paths C and D are no longer needed.)
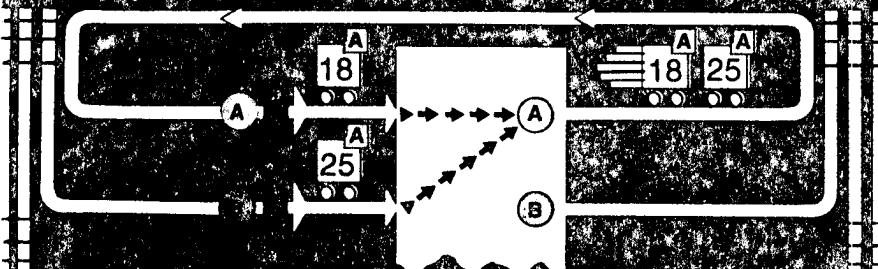
The numbers 18 and 25 are now routed via the switching network to destination A.
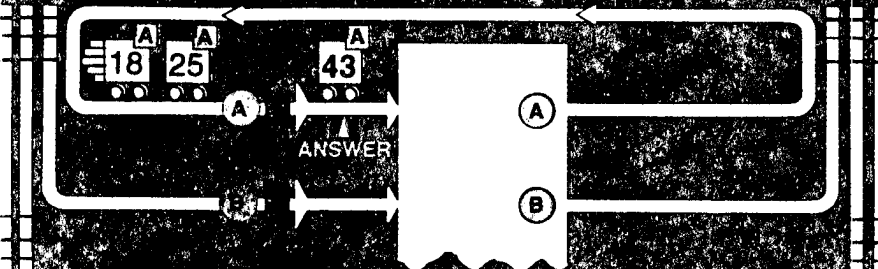
ANSWER

Arriving back at processor A, 18 and 25 are added to produce the answer: 43.

Source for charts: Prof. M. L. Dertouzos, director, MIT Laboratory for Computer Science

Ib Ohlsson—NEWSWEEK

TECHNOLOGY

also put up the money to fund MCC's research, in return for the rights to use the results. Whether the scheme will work is an open question. The 12 companies in MCC are competitors in fast-moving, high-technology markets, and ordinarily they jealously guard any technological edge they gain. In fact, many top U.S. firms—Cray Research, Texas Instruments, Intel and others—chose to stay out of MCC. "That's not our style," says John A. Rollwagen, chairman of Cray Research, an 11-year-old company proud of its entrepreneurial creed. "We don't want to participate." The biggest market force of all—IBM—reportedly stayed out of MCC because it feared antitrust action against it if it joined.

So far, however, the creation of MCC has not provoked any such suits. In January San Francisco antitrust lawyer Joseph M. Alioto did write to the chief executives of the companies that were about to form MCC: "In my opinion, your contemplated conduct is an unequivocal combination in violation of the antitrust laws of the United States." But the threat did not deter MCC's co-owners and, for the time being at least, the Justice Department has allowed the MCC plan to stand.

To run the new corporation, MCC's directors chose retired Adm. Bobby Ray Inman, former director of the National Security Agency and former deputy director of the CIA. Inman is widely respected for his managerial abilities and is an adept politician besides (page 63). "The day they picked Bob Inman to head MCC," says George W. Keyworth II, Ronald Reagan's top science adviser, "any concern about its success diminished in my mind."

Over the past five months, Inman orchestrated a competition among 57 cities for the MCC headquarters; the winner was Austin, Texas, after private donors, the state and universities put together a generous package of incentives.

The consortium will have a budget of about $75 million a year and a staff of 250. Its first projects include programs in semiconductor packaging and interconnect technology, advanced software engineering and computer-aided design and manufacturing (CAD/CAM) for the electronics and computer industries. Most ambitious is a 10-year program aimed at breakthroughs in computer architecture (page 60), software and artificial intelligence. MCC will own the licenses and patents to the technologies; the manufacturing and marketing will be left to the companies that sponsor the projects. MCC will give them a competitive edge on the market—they will have exclusive rights for three years before the research is published and other firms are allowed to buy licenses.

■ **The Semiconductor Research Corp.** Over the past three years Japan has captured a vital segment of the world semiconductor