DEFINING INTEL: 25 YEARS / 25 EVENTS

D E F I N I N G   I N T E L :   2 5   Y E A R S / 2 5   E V E N T S

A Salute to Intel's 25-Year Veterans

Of the almost 100 employees who joined Intel in 1968, only eight remain. These hardy souls bring Intel's history to life; they represent not just the company's past, but also its unique spirit. We congratulate each of Intel's eight original employees on their silver anniversaries with the company. Throughout this publication, they share some of their reflections on Intel's first 25 years.

"*I* was the first engineer doing package development at Intel. I'm still doing basically the same thing and I love it. I can hold a product in my hand and see my contribution to it; my identity's in that package. I was supposed to retire almost 10 years ago, but when there's so much going on here, who wants to retire?"
George Chiu, senior engineer, Package and Assembly Research

"*W*hen I came to Intel, I was scared to death. I left a very secure job where I knew what I was doing and started running R&D for a brand new venture in untried territory. It was terrifying. I literally had nightmares."
Andy Grove, president and CEO

"*I*nternally, things haven't changed much. Now, when we get the first silicon on a new design, the whole design team crowds around the tester to see how it works. Back then, the whole company came and crowded around the tester."
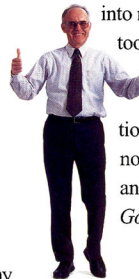*Tom Innes, general manager, Intel Connectivity Division*

"*F*rom the very beginning, Intel has had more advanced technology than any other company. It makes me proud to be part of this company."
Nobuko Clark, tech specialist in California Technology Development, Quality and Reliability

"*M*y 25th anniversary with Intel is on September 23, and my 50th birthday is on September 30. I have spent half my life with Intel!"
Ted Jenkins, vice president and director, Corporate Licensing

"*W*e are currently very successful, but in this industry, fortunes can change rapidly. In 1974, we were as successful in memories as we are now in microprocessors. Then the first oil shock hit and threw the world into recession; the business took a long time to recover. I think we're better braced for such situations now, but still, there's no opportunity to sit back and rest on your laurels."
Gordon Moore, chairman

"*T*here was a unique spirit in our first headquarters in Mountain View. There were many fun-loving, irreverent folks; we became very close. It was hard for me when we moved into the bigger building on Bowers. Then, all of a sudden, we were picking up the phone and calling each other instead of just running over to see people. It's kind of nice in Santa Clara now, to be back under one big roof in RNB!"
Jean Jones, executive secretary

"*T*he biggest change I see is that our industry position has shifted completely. We were an upstart; now we're No. 1 in one of the world's most important businesses. We've transformed from a horizontal supplier of memory and logic silicon products to what is essentially a computer company of a different color."
Les Vadasz, senior vice president and director, Corporate Business Development

Celebrating Intel: A Statement from the Executive Office

When Intel was started in July 1968, we dreamed of building a successful company—but we never imagined that, 25 years later, we'd have over 26,000 employees around the world and annual revenues rapidly approaching $10 billion. In that first year, we developed the processes and first products that would launch us on the road to becoming the world's largest semiconductor company.

We are extraordinarily proud of Intel's accomplishments and contributions in this quarter-century, and of the people who made them possible. Together, we have defined contemporary digital electronics, with the microprocessors, memories and controllers that we have created. We have played a critical role in the PC revolution.

What an exciting time to be celebrating our anniversary. There have been some difficult years—but in 1993, we have record earnings, higher productivity than ever and excellent product lines that support a very strong industry. If we were astrological types, we'd say the planets, the stars and the moon are in alignment. The sun certainly seems to be shining on us. But Intel being Intel, we may not notice, since we tend to be wary of anything that looks like resting on our laurels.

While it's true that we need to stay focused on the future, we do have some real success to celebrate, and the significant milestone of our 25th anniversary reminds us to enjoy it. Whether you've been with us for 25 years or joined us more recently, we thank you for your contributions to Intel's success.

Left to right: executive vice president and chief operating officer Craig Barrett, chairman Gordon Moore and president and CEO Andy Grove.

Craig Barrett,
executive vice president and chief operating officer

Gordon Moore,
chairman

Andy Grove,
president and CEO

In the Beginning: Intel Is Founded

1. One weekend afternoon in the spring of 1968, Gordon Moore dropped by Bob Noyce's home, where Bob was mowing the lawn. The two men stood on the grass and commiserated about the state of affairs at Fairchild Semiconductor, which they had co-founded with six colleagues. Bob, who had co-invented the integrated circuit, was concerned about instability and bureaucracy at the top at Fairchild, and had decided to resign. Gordon suggested that semiconductor memory, an emerging technology, looked promising enough to launch a company and agreed to join Bob in a new start-up. Intel was born.

Bob and Gordon were both well-known and financially successful, yet they gave up their security for the chance to pursue large-scale integrated (LSI) memory. "We were young and arrogant," Bob recalled in 1988. "We wanted the independence to do things our way." Andy Grove joined Bob and Gordon soon after Intel's incorporation and eventually became the third head of the "three-headed monster," as Bob called it, that led Intel.

"We knew we wanted to give this new technology a shot," Gordon recalls. What they didn't know was that their little upstart company would turn the world on its ear, redefining contemporary electronics and changing forever the way the world works.

Like all start-ups, Intel had its share of both stress and celebration. What held the little company through the high tensions and high spirits was the unwavering commitment and vision of its leadership. "We set out to create a whole industry," recalls Intel Connectivity Division general manager Tom Innes, "and Bob and Gordon had the faith in us that made it happen."

Two Found New Firm

MOUNTAIN VIEW — Two founders of Fairchild Semiconductor Division here who resigned last month have established a new integrated circuits electronics company.

The firm, Intel Corp., has leased part of a building at 365 Middlefield Rd. formerly occupied by Union Carbide Corp.'s integrated circuit division. Most of the firm's staff is being moved to San Diego.

Founders of Intel Corp. are Drs. Robert W. Noyce and Gordon Moore. Both were among eight who started Fairchild Semiconductor here more than 10 years ago and helped build it into the world's largest producer of integrated circuits.

They quit last month from Fairchild Camera & Instrument Corp., parent of the Mountain View division.

The firm has experienced slipping profits recently, but Noyce and Moore said they resigned to regain the satisfaction of research and development in a small, growing company.
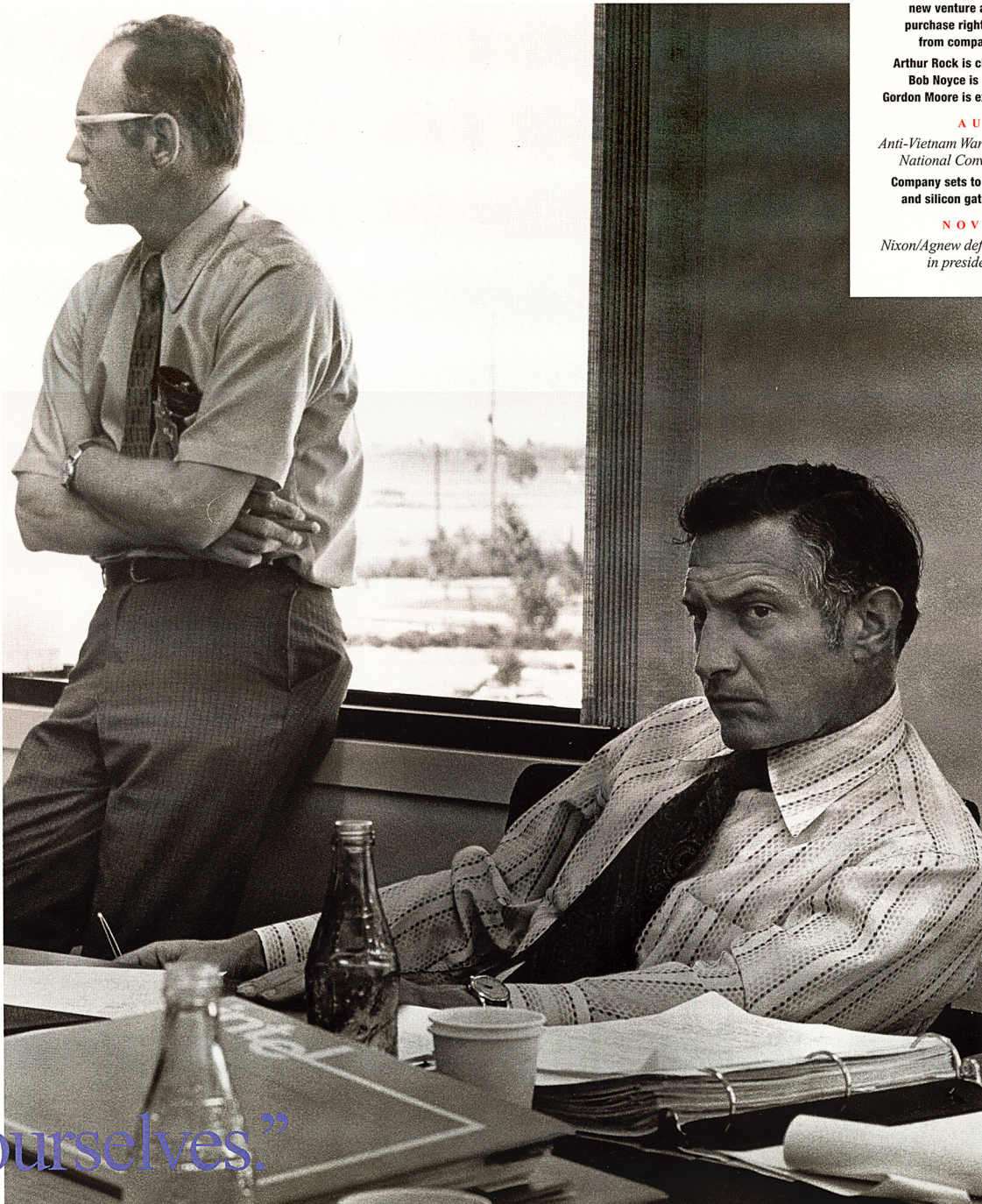
San Jose Mercury,
August 6, 1968

"We're always redeveloping, reinventing

Gordon Moore,
chairman

Outside the original Mountain View facility, Intel's entire workforce gathered for a group photo in 1970.

1968

Memorable Movie:
The Graduate

FEBRUARY

Winter Olympic games held in Grenoble, France; Jean-Claude Killy and Peggy Fleming win gold medals.

APRIL

Martin Luther King, Jr. assassinated in Memphis, Tennessee.

Hair opens on Broadway.

JUNE

Senator Robert F. Kennedy assassinated in Los Angeles, California.

JULY

Bob Noyce and Gordon Moore incorporate new venture as N M Electronics; purchase rights to use Intel name from company using Intelco.

Arthur Rock is chairman of the Board; Bob Noyce is president and CEO; Gordon Moore is executive vice president.

AUGUST

Anti-Vietnam War riots mar Democratic National Convention in Chicago.

Company sets to work on Schottky TTL and silicon gate MOS technologies.

NOVEMBER

Nixon/Agnew defeat Humphrey/Muskie in presidential election.

Like any start-up, Intel had its share of challenges. Founders Gordon Moore (left) and Bob Noyce shared an intense moment in the early 1970s.
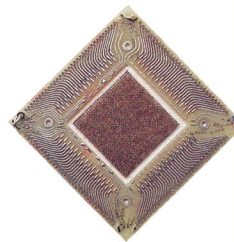
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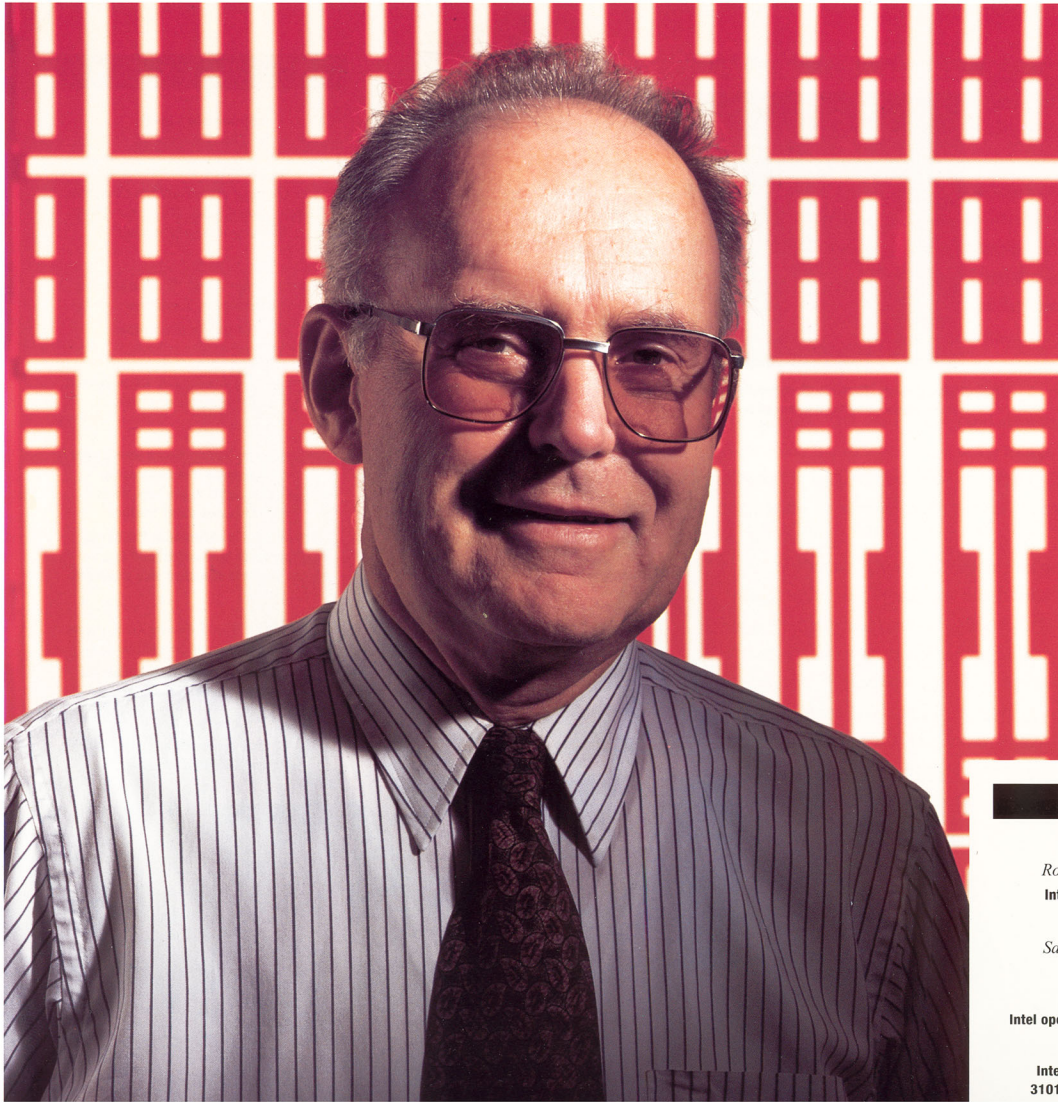
The focus on semiconductor memory set Intel apart from the very beginning. Chairman Gordon Moore stands in front of a rubylith of Intel's first product, the 3101, a bipolar random access memory chip.

1969

Favorite TV Program:
Rowan & Martin's Laugh-In
Intel's 1968 revenues: $2,672.

FEBRUARY
*Saturday Evening Post folds
after 147 years.*

MARCH
Intel opens office in Geneva, Switzerland.

APRIL
**Intel introduces its first product,
3101 64-bit Schottky bipolar RAM.**

JULY
*During Apollo 11 mission,
Neil Armstrong becomes first man
to set foot on the moon.*
**Intel introduces the 1101, world's first
MOS static RAM.**

NOVEMBER
Brussels, Belgium office opens.

1970

Hit Song:
Bridge Over Troubled Water

JANUARY
Intel's 1969 revenues: $565,874.
**Intel buys 26 acres in Santa Clara
for first site purchase.**
Beatles disband.
Millions celebrate first Earth Day.

MAY
*Anti-war protest at Kent State University
in Ohio; four students killed.*
Intel opens sales and marketing in Japan.

JUNE
**Recession forces company to lay off
employees for first time.**

OCTOBER
**1103, world's first commercially
successful DRAM, introduced.**

The Defining Challenge: Semiconductor Memory

2. Intel started out with a precise focus: to bring semiconductor computer memory to the market. The large-scale integration of transistors onto silicon was still an emerging business. Intel had to develop the process technologies and the products at the same time, and also convince a skeptical world that the day of the semiconductor memory was at hand.

It was an ambitious goal: the cheapest semiconductor memory element cost 100 times more than magnetic core memory, the dominant computer memory at the time. The fledgling company had to make some significant breakthroughs in density as well as cost to drive up unit volumes.

"We figured we had about five years to get established before the big semiconductor companies would follow in this market and become direct competitors," Gordon Moore remembers. "And we figured we needed to get to $25 million in those five years, so we could meet that competition. In fact, we more than doubled that goal, with revenues of $66 million in our fifth full year of operation. And it took the other companies seven years to change directions. That early success propelled us on our way."

Setting an ambitious goal: semiconductor memory such as the 1103 (lower image) cost 100 times as much per bit as core memory (upper image), the dominant computer memory device at the time. But it was tiny, more powerful and used less energy—advantages that led to success.

Making MOS Work

3. When Intel started, three different approaches to semiconductor memory offered promise; Intel pursued all three. Gordon Moore refers to this as the "Goldilocks technology strategy." "Multichip memory modules proved too hard and the technology was abandoned without a successful product. Schottky bipolar worked just fine but was so easy that other companies copied it immediately and we lost our advantage. But the silicon gate metal-oxide semiconductor [MOS] process proved to be just right."
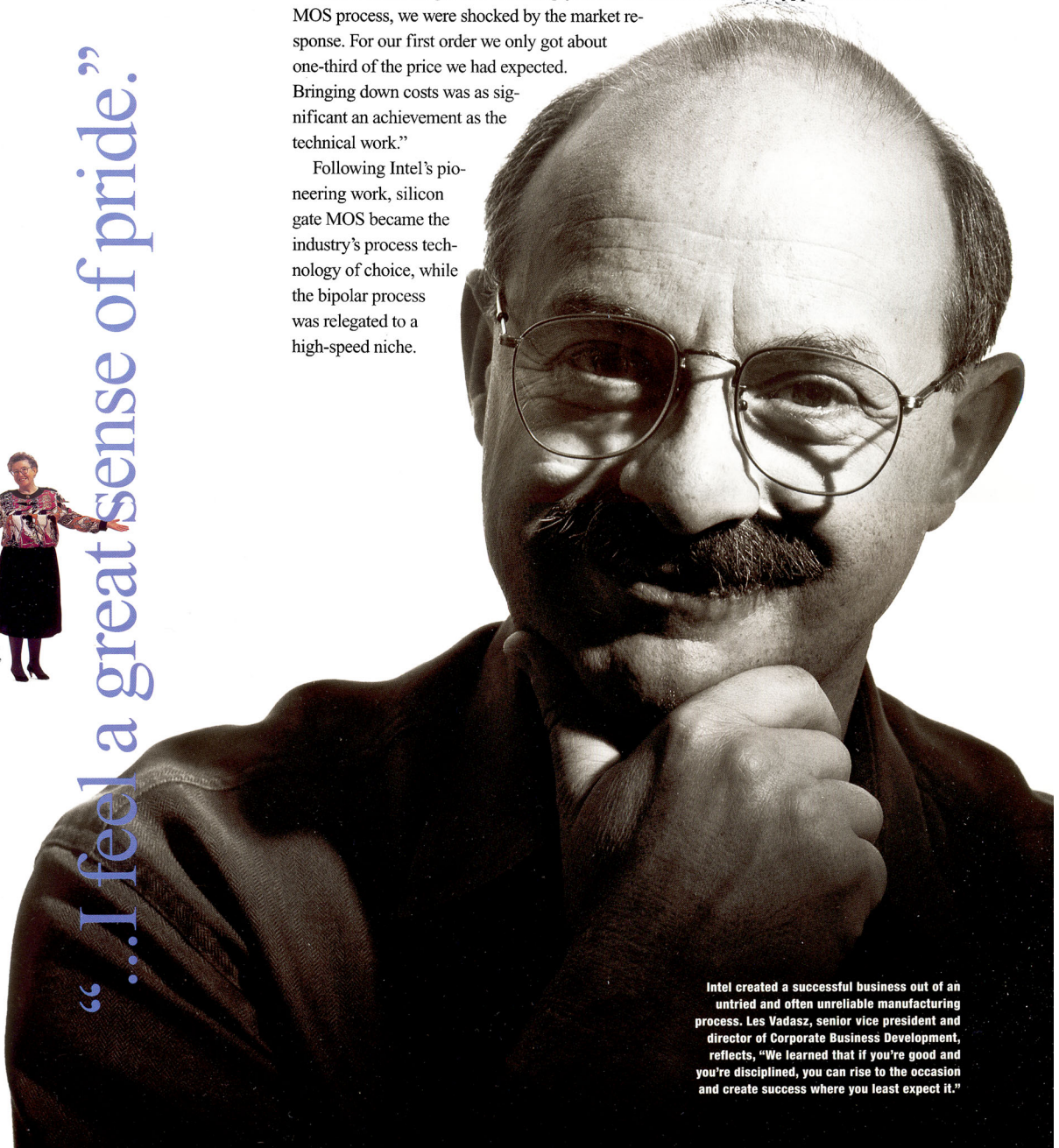
Even though MOS was "just right," making memories proved difficult. Andy Grove recalls, "The fab area looked like Willy Wonka's factory, with hoses and wires and contraptions chugging along—the semiconductor equivalent of the Wright Brothers' jury-rigged airplane. It was state-of-the-art manufacturing at the time, but by today's standards, it was unbelievably crude."

Les Vadasz, now senior vice president and director of Corporate Business Development, remembers the first MOS product. "We worked around the clock," he says. "Joel Karp and I redesigned a good portion of the product while the first moon landing was going on. We listened to 'One small step for man' on the radio while we scrambled to rework the chip.

"Then, when we got into DRAM [dynamic random access memory] production on the MOS process, we were shocked by the market response. For our first order we only got about one-third of the price we had expected. Bringing down costs was as significant an achievement as the technical work."

Following Intel's pioneering work, silicon gate MOS became the industry's process technology of choice, while the bipolar process was relegated to a high-speed niche.

There were many technical obstacles to making the MOS process work. Chairman Gordon Moore developed one ingenious innovation, the reflow glass process, which rounded the rough edges of the chip's metal layer and prevented cracking. The original reflow glass patent still hangs in Gordon's office.

Jean Jones, executive secretary

" …I feel a great sense of pride."

Intel created a successful business out of an untried and often unreliable manufacturing process. Les Vadasz, senior vice president and director of Corporate Business Development, reflects, "We learned that if you're good and you're disciplined, you can rise to the occasion and create success where you least expect it."
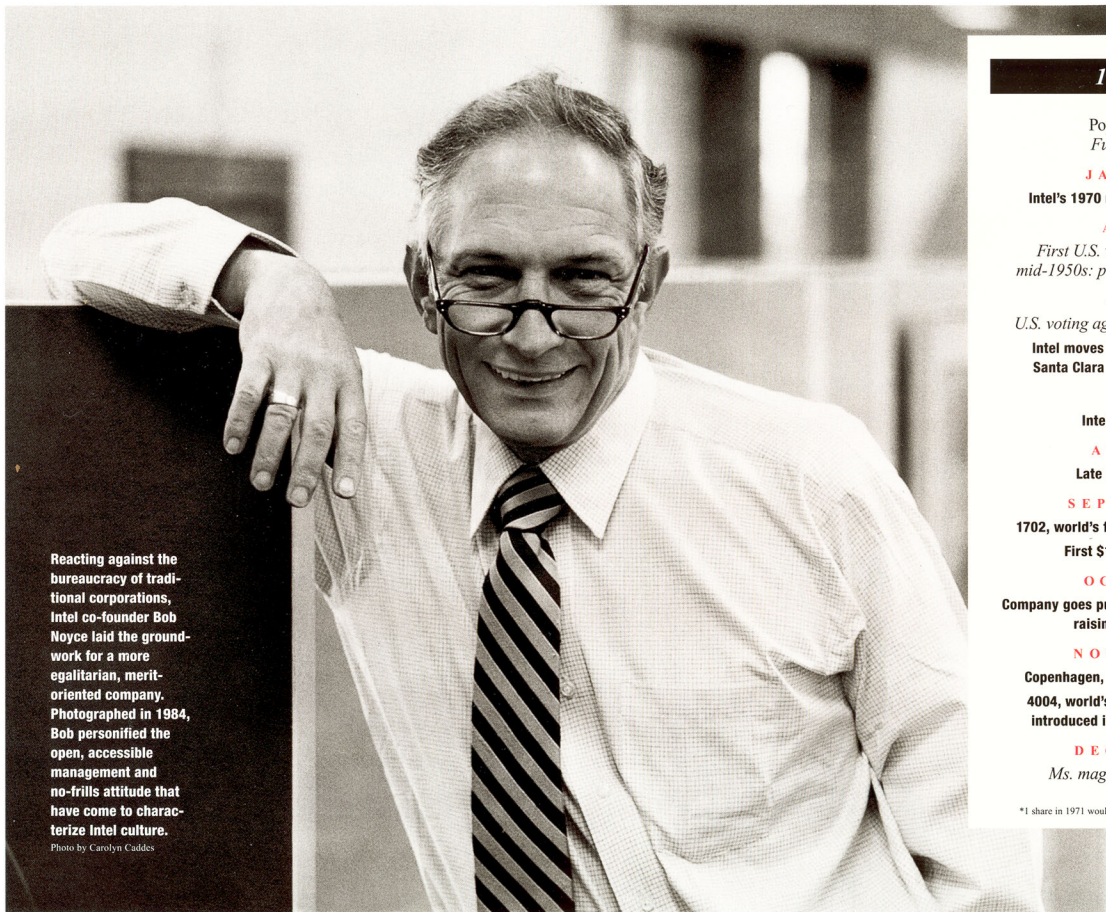
Reacting against the bureaucracy of traditional corporations, Intel co-founder Bob Noyce laid the groundwork for a more egalitarian, merit-oriented company. Photographed in 1984, Bob personified the open, accessible management and no-frills attitude that have come to characterize Intel culture.
Photo by Carolyn Caddes

A Unique Place to Work: Intel Culture

4. The egalitarian, open culture that characterizes Intel was built into the company from the very beginning. Bob Noyce's experience at Fairchild Semiconductor laid the groundwork. "Fairchild was steeped in an East Coast, old-fashioned, hierarchical business structure," he stated in a 1988 interview. "I never wanted to be part of a company like that. When we started Intel, I saw it as a community of common interests. It was much more a cooperative venture than an authoritarian structure—a community rather than an army. People came here because of their abilities, and we knew we would all prosper or fail together."

Culture is defined as the collective norms, values and standards that determine behavior in an organization. Forming the backbone of Intel's culture are the values that guide the company. They were first expressed in their current form by senior vice president and general manager of the Semiconductor Products Group Bob Reed (then director of Administration), who drafted an Intel values statement during the half-time of a Sunday football game. "The only reason I could do it so easily is because the values were already in our blood," Bob notes. "I was just articulating what was already there."

"Overall, I think we've stuck pretty well to a merit-based system and have avoided political entanglements," Bob Noyce reflected in 1988. "People get respect or get ahead because of their abilities, not their positions. You can always tell the boss he's wrong."

"It's sometimes difficult to blend Intel culture with Asian tradition

Intel culture is

Carlene Ellis was Intel's first female vice president. Now director of Information Technology, she spearheaded the refinement and re-communication of Intel's culture over the past several years as director of Human Resources. Says Carlene, "One of the biggest challenges for managers at Intel is that we've given permission for people to say to the CEO or anyone, 'What you just did was not good role-modeling of this value.' And when you're in a position of high visibility, you may get called on the carpet quite often for not living up to the values. You have to be able to hear that without getting defensive, or it destroys your credibility."

at Intel. In the early days, we played as hard as we worked. One year during the World Series, we smuggled radios into work. Les Vadasz blew up at us about how irresponsible that was. Then he was back five minutes later to ask what the score was." *Paul Metrovitch, R&D Lab manager, Folsom, California; 24-year veteran.*

"People are motivated by the atmosphere of freedom and trust here.

No one is telling you what to do; you're expected to use your head." *Beth Hernandez, secretary in Assembly Technology Development, Chandler, Arizona; five-year veteran.*

"I love the way we laugh at ourselves

"In the mid-1980s, there was a lot of bureaucracy. But by 1988, I think the company had been humbled a bit.

# Now we accept creativity better; we're more tolerant of diversity."

Eric Murphree, Fab 9 Organizational Development manager, Rio Rancho, New Mexico; seven-year veteran.

We tend to focus on saving face and respecting our elders; we are more reserved.

focused on being aggressive and direct.

We've had to encourage people to speak up with ideas and criticisms.... The U.S. is very individual-oriented, but we in Asia fall naturally into teamwork. When the rest of the company is trying to promote teamwork, we're a bit ahead of the game." *P.Y. Lai, vice president of the Technology and Manufacturing Group, general manager of Penang Operations; 22-year veteran.*

Left to right: 1103 designer and now Microprocessor Division program manager Bob Abbott, DRAM production supervising engineer Ron Whittier, Les Vadasz and DRAM development engineering manager Bill Regitz struggled to get the first DRAM into production. Ron, now senior vice president and general manager of Intel Architecture Labs, recalls, "In 1969, the word on DRAMs was, 'Nice theory, but in practice there's no way to make them.' A year later, I was at Intel, responsible for producing these impossible-to-manufacture products."
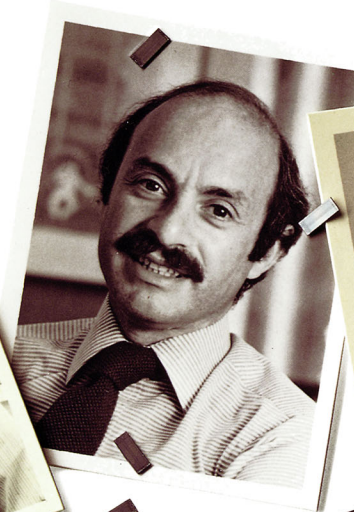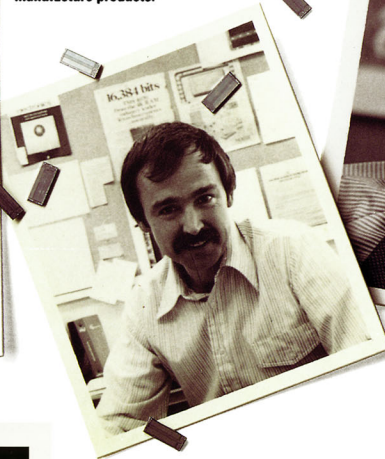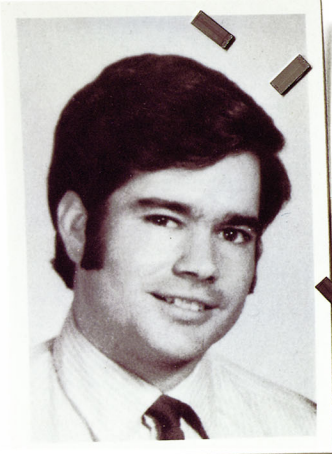
1972

Favorite TV Program:
All in the Family

JANUARY

Intel's 1971 revenues: $9,431,921.

IN-10 system-level standard memory system introduced.

APRIL

Intel opens in Munich, West Germany.

MAY

President Nixon becomes first U.S. president ever to visit Moscow.

SIM-4, SIM-8 development systems are introduced.

JUNE

Five men arrested for breaking into Democratic National Committee offices in Watergate office complex.

Intel converts from 2- to 3-inch wafers.

JULY

2102 1Kb static RAM, company's first NMOS and first 5-volt product, introduced.

Company enters digital watch business, acquiring Microma.

Stock Participation Plan introduced. Intel hires 1,000th employee.

AUGUST

Summer Olympic games held in Munich, West Germany. Terrorists massacre 11 Israeli Olympians.

8008, first 8-bit microprocessor, introduced. Intel U.K. opens in Oxford.

NOVEMBER

Nixon/Agnew defeat McGovern/Shriver in presidential election.

Making Memories Better: First Intel DRAM

5. In its first 18 months, Intel produced two static random access memory (SRAM) products. They were moderately successful, but "no great shakes," Andy Grove notes. "We were a little nervous."

The nerves calmed a bit in 1970 with the introduction of the 1103 dynamic random access memory (DRAM)—the world's first merchant market LSI (large-scale integrated) DRAM and Intel's first really successful product. "The DRAM, used to store a computer's instructions and data, was smaller, more powerful and used less energy than the magnetic core memories that were popular at the time," recalls Bill Regitz, Folsom Engineering Service Operation manager, who took part in the DRAM engineering development effort. "However, DRAMs don't offer permanent storage the way cores do, so we had to do a bit of selling. Customers had to be helped to overcome the short-term technical obstacles and see the long-term possibilities of the product."

Attracted by the DRAM's superior performance and smaller size, customers soon caught on. It wasn't long before the DRAM started to bury magnetic cores. By the end of 1971, the 1103 was the world's largest-selling semiconductor device. Its success provided vital capital with which to fund Intel's early growth.

Tom Innes, general manager, Intel Connectivity Division

"We focused on understanding

A Fortuitous Discovery: The First EPROM

6. Few of Intel's breakthroughs were more significant—and more unanticipated—than the EPROM. Invented by Dov Frohman (now Microprocessor Products Group vice president and general manager of Intel Israel) and introduced in 1971, the erasable, programmable read-only memory was at first conceived of as a prototyping device.

The original technical paper presented by Dov at the International Solid State Circuits Conference, the premier technical conference for this field, was the hit of the show. Gordon Moore recalls, "Dov projected a film that displayed the bit pattern in the EPROM memory cells. As the cells were exposed to ultraviolet light, the bits dropped out one-by-one until all that was left was the familiar Intel logo, dropped 'e' and all. The bits fell and, when the final one disappeared, the entire audience broke into applause. Dov's paper was voted the best at the conference."

It wasn't until the blossoming of the microprocessor that the full potential of the EPROM was realized. As an alterable storage medium, the EPROM gave OEMs a flexible, low-cost way to store microprocessor programs—thereby rapidly increasing the market for both the microprocessor and the EPROM. The unexpected synergy between the two chips is legendary; Gordon refers to them as "unrelated but happily concurrent developments." The prototyping device became a high-volume memory.

For many years, Intel was the only company that could make EPROMs in high volume. As a result, the EPROM was a significant product family for Intel through the mid-1980s.

As the first easily erasable storage medium, Intel's 1702 EPROM gave OEMs a flexible, low-cost way to store microprocessor programs.

Dov Frohman, now Microprocessor Products Group vice president and general manager of Intel Israel, invented the world's first EPROM in 1971. "We weren't geniuses," he reflects. "Invention is just a process of dreaming a lot and then asking, 'Why not?'"

results and acting on them."
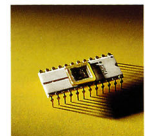
Intel "blue boxes," such as the Intellec 4 development system, made it easy for engineers to develop software to go into their microcomputer systems. The success of these products, which were essentially early engineering workstations, spurred internal debate about whether Intel should enter the retail computer business itself.

Intel Fellow Ted Hoff invented the world's first general-purpose microprocessor.

Democratizing the Computer: The First Microprocessor

7. The development of what Gordon Moore calls "one of the most revolutionary products in the history of mankind" began modestly in 1969. Japanese calculator manufacturer Busicom asked Intel to design a set of chips for a family of programmable calculators.
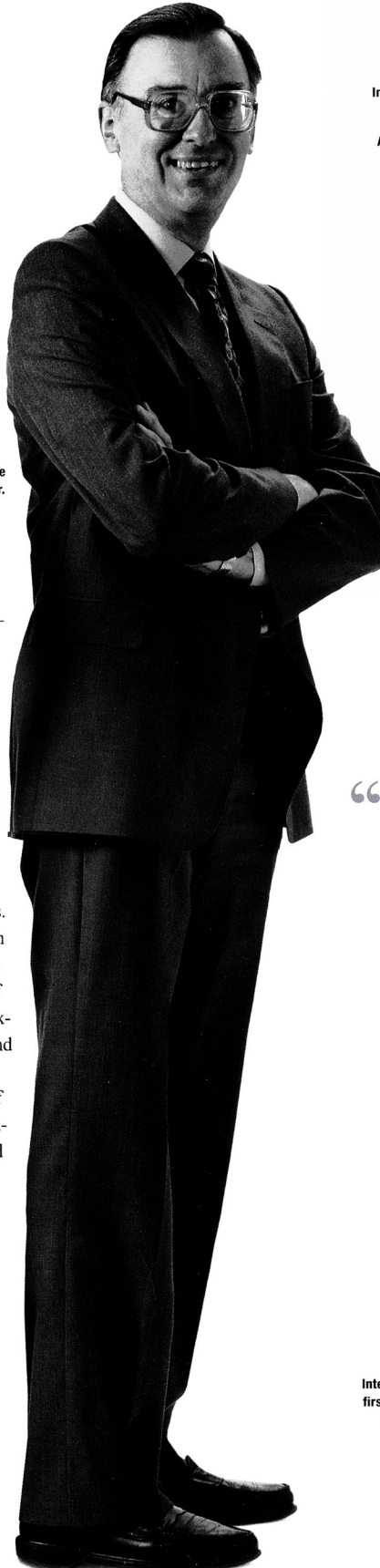
Intel engineer Ted Hoff thought he could do better than the unwieldy 12 custom chips called for in the Japanese company's original designs. His solution: develop a four-chip set, centered around one general-purpose logic device that would access its application instructions from semiconductor memory. Ted saw that the same set of chips with different programs could be used for a wide range of applications. Federico Faggin joined Intel to turn Hoff's vision into silicon reality. In nine months, Faggin and his team delivered the 4004, ready to market.

But Busicom owned the rights to it. Sensing the market potential of the chip set, Intel offered to return Busicom's $60,000 investment in exchange for the rights to the microprocessor design. Busicom agreed and Intel introduced the 4004 in November 1971, under the modest headline, "Announcing a New Era of Integrated Electronics." Consisting of 2,300 MOS transistors, the 4004 microprocessor packed as much computing power as the first electronic computer, the ENIAC, which filled a room when it was built in 1946.

"Part of the fun was changing the way people thought about computers," Ted says. "Computing used to be accessible only to a very privileged group—those with access to a mainframe. Today, a typical high school student with an Intel486™ CPU-based PC on his or her desk has more power than most mainframes had in the early 1980s.

Information is power. I like the way the microprocessor has spread that power around."

"What we
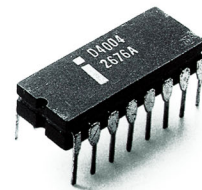
Intel's 4004 microprocessor, the world's first "computer on a chip," ushered in a new era of integrated electronics.

To PC or Not to PC?

8. When the 4004 came out in 1971, engineers at other companies were intrigued, but they weren't sure how to put the microprocessor to work. Ted Hoff and other Intel design engineers devised a simulator board to demonstrate how customers could develop 4004 products. When it became clear how eager OEMs were for them, Intel sold the boards and was launched into the development tools business. A similar device, designed to help engineers use the first DRAMs, had gotten Intel's systems business on its way the previous year.

"In retrospect, I think of those development tools as the first 'benchtop' computers, because engineers used them in the labs to write their applications and do programming," recalls senior vice president and director of Corporate Strategy Dave House. "The systems had a CPU and an operating system that was basically the precursor to DOS; they had just about everything in them that the first IBM* PC had in it. For a long time, we made more money selling those systems to design engineers than we made selling the chips themselves."

The success of the microcomputer development systems, or "blue boxes," as they were known at Intel, spurred some people to consider the possibility of Intel entering the retail systems business itself. "We recognized the trend toward a computer on every engineer's desk," says Gordon Moore, "but we were very busy growing in our existing businesses. We missed the chance to lead the engineering workstation revolution."

In one particularly ironic example, Gordon remembers, "In the mid-1970s, someone came to me with an idea for what was basically the PC. The idea was that we could outfit an 8080 processor with a keyboard and a monitor and sell it in the home market. I asked, 'What's it good for?' And the only answer was that a housewife could keep her recipes on it. I personally didn't see anything useful in it, so we never gave it another thought."

Ed Gelbach, who was director of Marketing at the time, recognized the need to teach engineers how to put this new thing called a microprocessor to use.
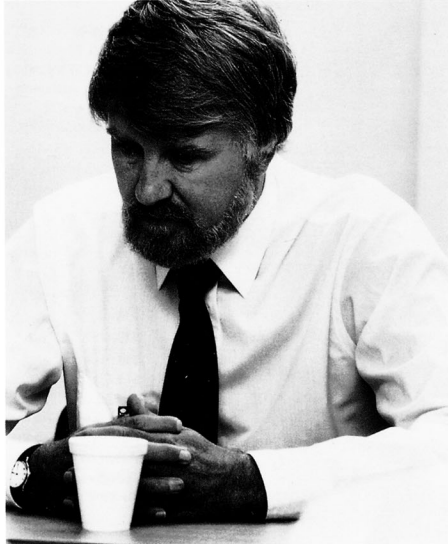
do is different, not how we do it."

Andy Grove, president and CEO

This calculator from Japanese manufacturer Busicom was the first microprocessor application.

1834
McCormick's reaper ushers in farm mechanization.
1844
Telegraph brings instant long-range communication.
1852
Otis's elevator allows high-rise buildings.
1876
Telephone binds America by voice.
1879
Edison's bulb harnesses electric energy.
1885
First adding machine is grandfather of computer.
1903
Wright brothers fly and begin the air age.
1913
Ford starts first moving assembly line.
1946
Dedication of first general-purpose computer.
1948
Bell Laboratories unveils the transistor.
1971
First microprocessor developed by Intel Corporation.
1973
Production of DNA is boon to biotechnology.

From *U.S. News & World Report,* 1982

1975

Memorable Movie:
One Flew Over the Cuckoo's Nest

Popular Book:
Shogun

JANUARY
Intel's 1974 revenues: $134,456,000.

FEBRUARY
Intel's Stockholm, Sweden office opens.

MARCH
Intel introduces 8255 programmable peripheral interface.
ICE™-80, world's first in-circuit emulator, introduced.

APRIL
Bob Noyce elected chairman of the Board.
Gordon Moore elected president and CEO.

MAY
Junko Tabei of Japan becomes first woman to reach summit of Mt. Everest.
140,000 South Vietnam refugees flown to U.S., following fall of Saigon.
Intel's original A1 building in Penang burns to the ground.

OCTOBER
MULTIBUS I specification introduced.

1 9 7 6

Memorable Movie:
Rocky

J A N U A R Y

Intel's 1975 revenues: $136,788,000.

**Intel decides to proceed with development
of the 8086 in addition to the iAPX 432.**

F E B R U A R Y

*Winter Olympic games held
in Innsbruck, Austria.
Dorothy Hamill wins gold
in figure skating for the U.S.*

A P R I L

Intel Japan K.K. established.

M A Y

**iSBC® 80/10, first single-board
computer, introduced.**

J U N E

Company converts to 4-inch wafers.

J U L Y

U.S. celebrates bicentennial.

A U G U S T

**2147 static RAM,
first HMOS product, introduced.**

S E P T E M B E R

Company opens facility in Santa Cruz.

O C T O B E R

Aloha, Oregon site opens.

N O V E M B E R

*Carter/Mondale defeat Ford/Dole
in presidential election.*

8085 8-bit microprocessor introduced.

D E C E M B E R

**8748/8048, world's first 8-bit
microcontrollers, introduced.**

1 9 7 7

Favorite TV Program:
Happy Days

J A N U A R Y

Intel's 1976 revenues: $225,979,000.

A P R I L

*Apple Computer introduces Apple II,
a personal computer.*

J U N E

Silver Jubilee for Queen Elizabeth II.

**Intel opens Rotterdam,
The Netherlands office.**

*Leonid Brezhnev becomes
President of the Soviet Union.*

Intel starts Penang, Malaysia's T3.

A U G U S T

Volkswagen phases out "Bug" in U.S.

Intel hires 10,000th employee.

S E P T E M B E R

First *Inteleads* published.

Intel's Oslo, Norway office opens.

2910, first single-chip codec, introduced.

Intel enters bubble memory business.

O C T O B E R

Barbados, West Indies site opens.

N O V E M B E R

*Egypt's Anwar Sadat makes
historic first visit to Israel.*

Top Photo: Bill Lattin, pictured here
in 1982, managed the iAPX 432
project. The team started from
scratch to design the optimal chip.
Film Strip: Justin Rattner, now Intel
Fellow and Supercomputer Systems
Division director of Technology, led
the iAPX 432 engineering team.

An Architecture Ahead of Its Time: The iAPX 432

9. In 1975, after the 8-bit 8080 processor was established in the market, work began on the next-generation microprocessor. Gordon Moore recalls, "We figured we had one last opportunity to do it right, before the growing installed base led us irrevocably into maintaining the 8080 architecture path."

Out of this impulse, the Intel Advanced Processor Architecture (iAPX) 432 project was born: an attempt to embrace the best theory of the time at every level of design—not just a new microprocessor architecture, but a new system architecture and new operating system software as well.

Intel Fellow and Supercomputer Systems Division director of Technology Justin Rattner led the iAPX 432 engineering team. Justin recalls, "At the time, most Intel microprocessors were going into things like gas pumps and traffic lights. With the iAPX 432, we were aiming to replace minicomputers."

The iAPX 432 contributed to Intel's microprocessor bag of tricks with features such as fault tolerance and self-checking hardware—later incorporated directly into the Pentium processor. More importantly, many new CAD tools and Intel's whole hierarchical CAD methodology were pioneered by the iAPX 432 component team.

In the end, the iAPX 432 architecture proved too complex and unwieldy for customers and was phased out in the early 1980s. But it remains a classic example of Intel's willingness to go out on a limb and learn from all experiences.

The iAPX 432 was an
incredibly advanced
32-bit microprocessor
architecture that never
came down to earth.

Some of the brains behind the Intel architecture (left to right): John Crawford, Intel Fellow and chief architect of the Intel386™ and Intel486™ microprocessors; Vinod Dham, Microprocessor Products Group vice president and general manager of Microprocessor Divisions 5 and 7; and Avtar Saini, Pentium™ processor design manager.

8086 (1978): Intel's new 16-bit architecture, originally designed to fill the gap while waiting for completion of the 32-bit iAPX 432 CPU, set the standard for Intel's most famous product line.

8088 (1979): The first 16-bit microprocessor with an 8-bit internal architecture was selected to become the brains of the ubiquitous IBM PC.

286 (1982): At its introduction, the 80286 provided about three times the performance of any 16-bit processor on the market. Aimed at the high end of the 16-bit market, it featured on-chip memory management, enabling users to conduct several different tasks at the same time.
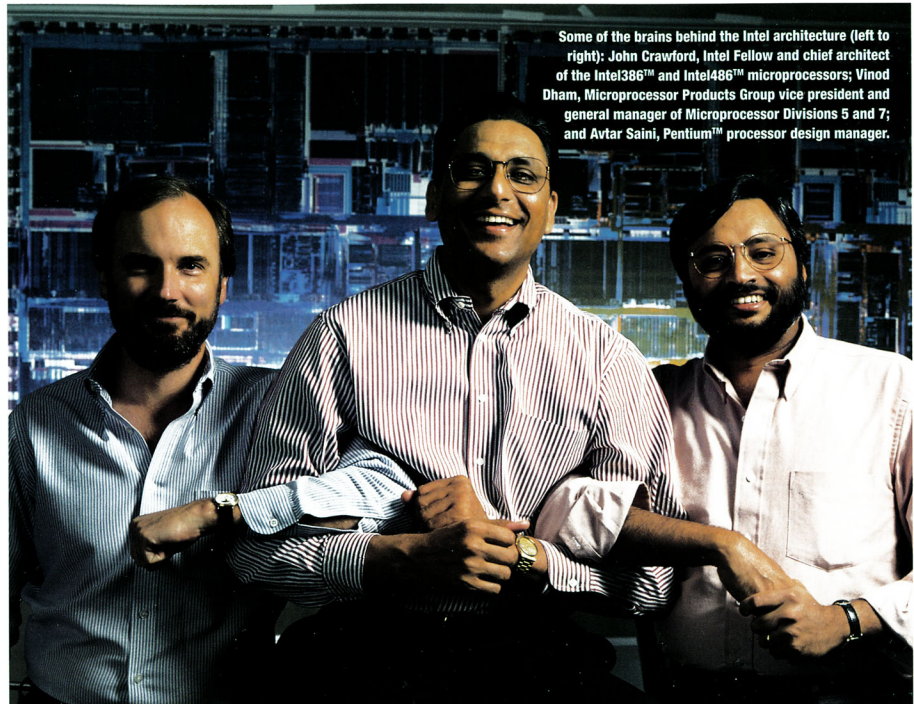
Intel386™ CPU (1985): The first microprocessor to extend the binary compatibility of the Intel architecture family to 32 bits, the Intel386 CPU had 275,000 transistors—over 100 times as many as the 4004 microprocessor. Its top operating speed of 5 million instructions per second (MIPS) won it the designation as "the highest-performance commercial microprocessor ever introduced."
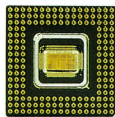
Intel486™ CPU (1989): At its introduction, the Intel486 CPU weighed in at 1.2 million transistors and offered the performance of a mainframe computer on a single chip. By 1992, the Intel486 processor had become the chip of choice for mainstream business computing.
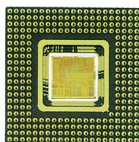
Pentium™ processor (1993): With over 3 million transistors and up to five times the performance of the 33-MHz Intel486 DX CPU, the Pentium processor powers high-end PCs, network servers and workstations—and can still run every piece of software ever written for an Intel architecture CPU-based system.

The Chips That Built a Revolution

10. Early in the history of the microprocessor, few people could have predicted how significant the Intel microprocessor family would become. In December 1975, the company decided to create the 8086 as its first 16-bit microprocessor. "We knew that a new architecture required new software development—a significant investment on the part of customers and developers," recalls Jean-Claude Cornet, vice president and general manager of the Personal Computer Enhancement Division (PCED) Mobile Unit and director of engineering for the 8086. "We heavily supported customers' transition to the 8086. A few years later, IBM's selection of the 8088 CPU for its first PC created a large installed base that cemented our commitment to compatibility for future generations."

Jean-Claude Cornet, vice president and general manager of the PCED Mobile Unit, led the engineering team in the design of the 8086 chip, the architecture that is the basis for Intel's major microprocessors.
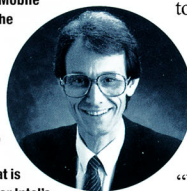
Since then, Intel has been unwavering in its dedication to its microprocessor family tree. Each new generation proves Moore's Law by radically increasing the number of transistors packed onto the chip. "When Intel introduced the 286, the world said we'd never be able to take this design to a 32-bit format, and yet we did it, and we keep doing it," notes Vinod Dham, Microprocessor Products Group vice president and general manager of the Microprocessor Divisions 5 and 7. "Making chips this complex takes a tremendous conviction in your heart."

Compatibility remains the key to Intel's strategy. The Pentium™ processor, the latest powerhouse chip in the family, still can run every piece of software ever written for any microprocessor based on the Intel architecture. As Jean-Claude notes, "In a mature marketplace, the best way to bring about revolution is through evolution."

The Intel486™ CPU design team gathered to celebrate its success in March 1989.

The Crush Is On

11.

In 1979, the success of Intel's chief microprocessor family was by no means secure. The 16-bit 8086 and the 8-bit 8088 were winning orders steadily, but the competition was hot. Of particular concern was Motorola's 68000, which beat out the 8086 for a number of key design wins.

In response, Intel launched a campaign in 1980 to make the 8086/8088 architecture the industry standard. The plan was code-named "Operation Crush"; its objective was to generate 2,000 design wins within a year.

The campaign worked, and Intel raked in 2,500 new design wins that year. "We fought a lot of gear-head arguments about why the other guy's chip was better," admits Dave House, director of Marketing at the time. "But in the end, we got every one of those wins because we had the product that solved the customer's problem first."

The most significant Crush result was IBM's selection of Intel's 8088 as the microprocessor for its first PC. Intel had to go to great lengths to win IBM's confidence, since "Big Blue" had never used an outside vendor for a key microprocessor before. "Everything was very secretive," recalls Earl Whetstone, vice president of the Worldwide Sales Group and director of Americas Sales and Marketing. As a field sales engineer at the time, Earl won the IBM design for Intel. "When we went in to provide technical support, they'd have our technical people on one side of a black curtain and theirs on the other side, with their prototype product. We'd ask questions; they'd tell us what was happening and we'd have to try to solve the problem literally in the dark. If we were lucky, they'd let us reach a hand through the curtain and grope around a bit to try to figure out what the problem was."

What finally clinched the deal for Intel was the company's long-range commitment to the 8086/8088 line, Earl surmises. "IBM was interested in the business issues, such as our plans for future products and our ability to manufacture in volume," he says.

IBM's decision proved a terrific coup for Intel, but no one understood the true significance of it at first. Earl remembers, "A great account was one that generated 10,000 units a year; nobody comprehended the scale the PC business would grow to—tens of millions of units a year."

"There's a certain rigor associated with this place."

Les Vadasz, senior vice president and director, Corporate Business Development

Simple answers to your questions about
IBM Personal Computers.

Little Tramp character licensed by Bubbles Inc., s.a.

"The Tramp" became a familiar figure in IBM's PC ads.

CHARLIE CHAPLIN ™ used by permission of Bubbles Inc. SA, represented by Bliss House Inc. 01103.

1 9 7 8

Hit Song:
Stayin' Alive

JANUARY

Intel's 1977 revenues: $282,549,000.

8041/8741 universal peripheral interface introduced.

MARCH

Intel opens Helsinki, Finland office.

APRIL

Intel phases out of the Microma digital watch business.

Intel's Hannover, Stuttgart and Wiesbaden, West Germany offices open.

JUNE

8086 industry-standard 16-bit microprocessor introduced.

Preview **magazine debuts; renamed** *Solutions* **in 1981,** *Microcomputer Solutions* **in 1987,** *Intel Solutions* **in 1993.**

JULY

Louise Brown, world's first test-tube baby, born in London.

iRMX® 80 operating system introduced.

Intel's Hawthorn Farms, Oregon opens.

AUGUST

Intel marks 10th anniversary with celebration at Cow Palace in San Francisco, California.

OCTOBER

Poland's John Paul II named Pope.

Fab 5, Aloha, Oregon opens.

DECEMBER

Israel's Begin and Egypt's Sadat jointly win Nobel Peace Prize.

Senior vice president and director of Corporate Strategy Dave House, who was director of Marketing at the time, remembers the sweet victory of beating out Motorola for several key design wins in the 1980 Crush campaign.

Earl Whetstone, Worldwide Sales Group vice president and Americas Sales and Marketing director, was the field sales engineer who won the IBM PC account for Intel.

intel

AL PREZZO DI UN 386 POTETE ORA ACQUISTARE Intel486.™

CUSTOMER 'YES'

President of Intel Japan K.K. Bill Howe and IJKK executive vice president Norm Denda project a customer-oriented message for the 1990s in this poster from Intel Japan.

intel

Fly through the 90's **1990**

インテル ジャパン 株式会社

Microprocessore Intel486.™
Più di 40 Milioni di Istruzioni al Secondo.

Memorable Movie:
Apocalypse Now

JANUARY

Intel's 1978 revenues: $399,390,000.

Intel opens office in Milan, Italy.

FEBRUARY

Intel's Zurich, Switzerland office opens.

MARCH

Bob Noyce receives IEEE Faraday Medal.

APRIL

Gordon Moore elected chairman of the Board;
Bob Noyce elected vice chairman;
Andy Grove elected president and COO.

MAY

Margaret Thatcher selected Great Britain's first woman Prime Minister.

8088 industry-standard 8-bit microprocessor introduced.

Intel makes Fortune 500 list: No. 486.

Intel introduces the FAST-3805 Semiconductor Disk Unit.

JUNE

Intel Magnetics introduces first product:
1-megabit bubble memory.

Hillsboro, Oregon site opens.

OCTOBER

Intel opens office in Sydney, Australia.

NOVEMBER

Bob Noyce awarded National Medal of Science by President Jimmy Carter.

1980

Favorite TV Program:
Dallas

JANUARY

Intel's 1979 revenues: $660,984,000.

Intel Semiconductor, Ltd., Hong Kong opens its doors.

FEBRUARY

STAR order processing system installed.

JUNE

Intel introduces the first math coprocessor, the 8087.

APRIL

Bob Noyce elected to the National Academy of Sciences.

MAY

Intel, DEC and Xerox join forces to develop Ethernet.

Solidarity Union formed in Gdansk; Lech Walesa, leader.

Intel and Ford Motor Corporation complete development of 8061 and 8361 two-chip electronic engine control system.

P2 opens in Las Piedras, Puerto Rico.

NOVEMBER

Reagan/Bush defeat Carter/Mondale in presidential election.

DECEMBER

Dun's Review names Intel one of America's five best-managed companies.

Intel closes first fab in Mountain View.

Now there's an easier way
to find out whether it's Intel inside.

Just look out for this sign.

intel

Intel ads from around the world reflect the company's global sales presence.

Selling Intel to the World

12. Intel has been aware of an international market for its products from its inception. Intel Europe opened its doors in Geneva in March 1969 and moved to Brussels in November. That first sales office employed two Danes, two Brits, a Belgian and a Dutchman. "We were just a tiny offshoot," recalls Keith Chapple, now managing director of Intel's site in Swindon, U.K. "Intel was virtually unknown. It took me three months to get my first meeting with the buyer from Philips [the Dutch electronics firm]."

Things began to turn around with the introduction of the first DRAM, and in 1971 the group branched out to offices in France and the U.K. (The German office opened a year later.)

Meanwhile, on the other side of the world, Intel opened a sales office in Tokyo in 1971 to serve the growing Japanese computer market. In the early days, the company was as little known in Japan as in Europe. "We were often mistaken for an interior design firm," recalls Norm Denda, IJKK executive vice president.

"Our customers used to hate the fact that we didn't have a factory in Japan, because they didn't trust the reliability of products from the U.S.," Norm notes. "We adopted special product quality specifications for product shipped to Japan. Now, incoming products are far beyond our customers' expectations. We have proven ourselves."

Today, Intel spans the globe with 92 sales offices in 25 countries.

Chip Making, International Style

13. Intel opened its first international assembly plant on the small Malaysian island of Penang in 1973. A 1975 fire burned the plant to the ground, but the site was shipping product from rented quarters within two weeks. With P.Y. Lai as vice president of the Technology and Manufacturing Group and general manager of Penang Operations, the site has received major regional quality awards, such as the Malaysian Prime Minister's Quality Award in 1990.

In 1974, Intel was the first American semiconductor company to set up an assembly facility in the Philippines. A test facility followed in 1982, and the site has survived natural disasters and political upheavals, remaining a solid contributor to Intel's success.

In Israel, Dov Frohman's persistent badgering of Andy Grove led to the establishment of the Haifa design and development center in 1974 and the Jerusalem fab in 1983. "Throughout the 1970s, the group at the design center worked very hard to prove to Intel management that the benefits of a highly educated work force outweighed the political concerns about having a fab in the Middle East," Dov notes. The site has since proven its worth many times over.

Other sites outside the United States include the Intel systems plants in Puerto Rico and in Leixlip, Ireland. The latter is being joined by the new Fab 10, scheduled to begin production soon.

Intel's international sites have faced special difficulties: typhoons in Penang, volcanic eruptions and a government overthrow in the Philippines, the Gulf War in Israel, Hurricane Hugo and devastating floods in Puerto Rico. Through it all, output has stayed high. "We have overcome enormous obstacles through the sheer dedication of our employees," says Manila operations general manager Jake Pena.

Jake Pena is general manager of operations at the Manila site.

Intel's Penang site won the Malaysian Prime Minister's Quality Award in 1990, the first time the award was ever given to an organization in the private sector.
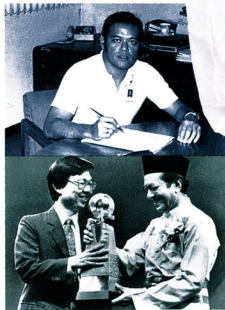
To ensure a smooth start-up of Fab 10 in Leixlip, Ireland, employees have trained in existing fabs for almost two years. From left to right, integration engineer Duncan Cresswell, integration technician Paula Donovan and manufacturing supervisor Clem Hussey look forward to taking the high-tech training on 8-inch wafers they've received at D2 back to the Emerald Isle.

Craig Barrett, now executive vice president and chief operating officer, gave Intel the kick it needed to get its manufacturing quality back on track in the mid-1980s.
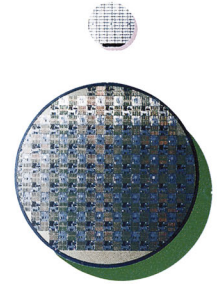
Over the years, Intel's manufacturing processes have been refined to allow for chips with smaller circuit sizes, fabricated on larger wafers. The company's first products were made on 2-inch wafers; today, Intel's most advanced products are made on the new 0.6-micron technology process using 8-inch wafers.

1982

Memorable Movie:
E.T. The Extra-Terrestrial

JANUARY
Intel's 1981 revenues: $788,676,000.

FEBRUARY
Intel and AMD enter microprocessor peripheral exchange agreement.

MARCH
AT&T break-up announced.

80186/188 high-integration 16-bit embedded processors introduced.

80286 high-performance 16-bit microprocessor introduced.

First LAN coprocessor, the 82586, introduced.

2914, first combo codec/filter chip, introduced.

APRIL
Argentina invades Falkland Islands.

P3, Puerto Rico, opens.

MAY
U.S. Equal Rights Amendment defeated.

AUGUST
8096, first 16-bit microcontroller, introduced.

SEPTEMBER
Wall Street Transcript names Gordon Moore the outstanding CEO for the semiconductor industry the second year in a row.

OCTOBER
7114 4-Mbit bubble memory introduced.

NOVEMBER
CEAMS (Component Engineering Analysis and Manufacturing System) tracking system for wafer fabrication introduced.

DECEMBER
Dr. Barney Clark receives first permanent artificial heart.

IBM announces plans to purchase 12% of Intel for $250 million.
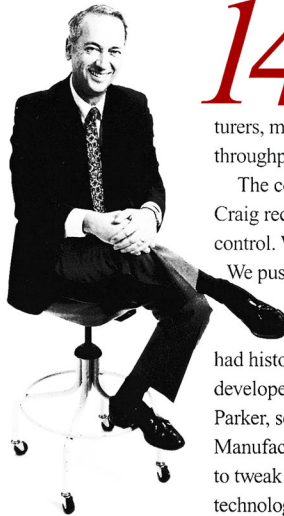
Senior vice president and Technology and Manufacturing Group general manager Gerry Parker directs Intel's technology development and worldwide manufacturing facilities.

Turning On to Quality: Intel Manufacturing

14. The industry downturn of the mid-1980s gave Intel a rude shock about its manufacturing processes. As Craig Barrett puts it, "We suddenly realized we weren't so hot." Intel compared its key indicators with those of world-class manufacturers, many of whom were competitors. "Basically, all our results—yields, throughput time, capital utilization—were pretty abysmal," Craig notes.

The company went back to basics. "We set our expectations higher," Craig recalls. "We trained our engineering staff in statistical process control. We gave more attention to equipment selection and management. We pushed our technology development."

This last solution involved changing the relationship between process technology development and manufacturing, which had historic significance for Intel. "We had always been proud that we developed our manufacturing processes in the factory," recalls Gerry Parker, senior vice president and general manager of the Technology and Manufacturing Group. "However, it was clear that interrupting production to tweak our processes was too disruptive. So we turned Fab 5 over to technology development [it became D1]. When they got the yields up on a new process, the manufacturing teams had to replicate the process exactly."

The results were astounding. Says Craig, "We've made several quantum leaps. For example, in the mid-1980s, fewer than 50 percent of our chips were functional at the end of the line. Today, we regularly have yields of more than 80 percent. Equipment utilization has risen from below 20 percent to as high as 60 percent today.

"People who were in manufacturing 10 years ago think the yields we have today should be impossible. It's a great example of how you can always do better."

Fab 9 in Rio Rancho, New Mexico has Intel's largest clean room.

IDO: Intel's Hothouse for New Ventures

15. "One of Intel's strengths is its ability to focus precisely on a defined technology direction," Les Vadasz reflects. "However, when you are so focused, it's harder to tap other business opportunities that are relevant and worthwhile but don't happen to fit the current corporate blueprint."

With an eye to developing new business opportunities, the company started the Intel Development Operation (IDO) in 1984. "The idea was to fund good ideas, build a fire wall around them and see what developed—a kind of internal venture capital operation," Les says. This "*in*trepreneurial" focus helped keep many good employees and their ideas inside the company.

Justin Rattner, now an Intel Fellow and director of Technology for the Supercomputer Systems Division (SSD), thought Intel should develop a line of parallel processing supercomputers based on its Intel386 microprocessors. In 1984, the IDO board gave him the funding to give it a shot. Recalls Justin, "Parallel processing was a very risky idea; it required both seed capital and a significant incubation period to develop a business."

Also under the wing of IDO, today's Personal Computer Enhancement Division (PCED) got its start in 1984, selling math coprocessors and add-in memory boards to PC users through retail channels. "Marketing to PC consumers is in Intel's blood now, but at the time it was almost unthinkable," says Intel Products Group vice president and assistant general manager Jim Johnson, who co-founded PCED with Rich Bader.

The combined 1992 sales of PCED and SSD approached a quarter of a billion dollars. Other IDO projects were not successful financially—but, says Les, "There is more to the technology business than accounting for the money. You nurture a sense of what's possible: it's never what *is* that drives you; it's what *could be*."

Intel Fellow and Supercomputer Systems Division (SSD) director of Technology Justin Rattner has guided SSD to its current position as a leader in massively parallel supercomputing.

Jim Johnson (left), now Intel Products Group vice president and assistant general manager, and Rich Bader formed the PC Enhancement Operation in 1984.

As godfather of IDO, Les Vadasz gave fledgling groups a protected start.

Almost ten years later, PCED has blossomed into a major strategic business for Intel, with branded products offering new capabilities of all kinds to PC users.

"Intel is a different company now."

Nobuko Clark, tech specialist in California Technology Development, Quality and Reliability

Challenges From Japan

16.

In the late 1970s, Japanese manufacturers emerged as a major force in the semiconductor industry. Heavy Japanese investment contributed to overcapacity in the semiconductor industry, precipitating the industry crash of 1985-86.
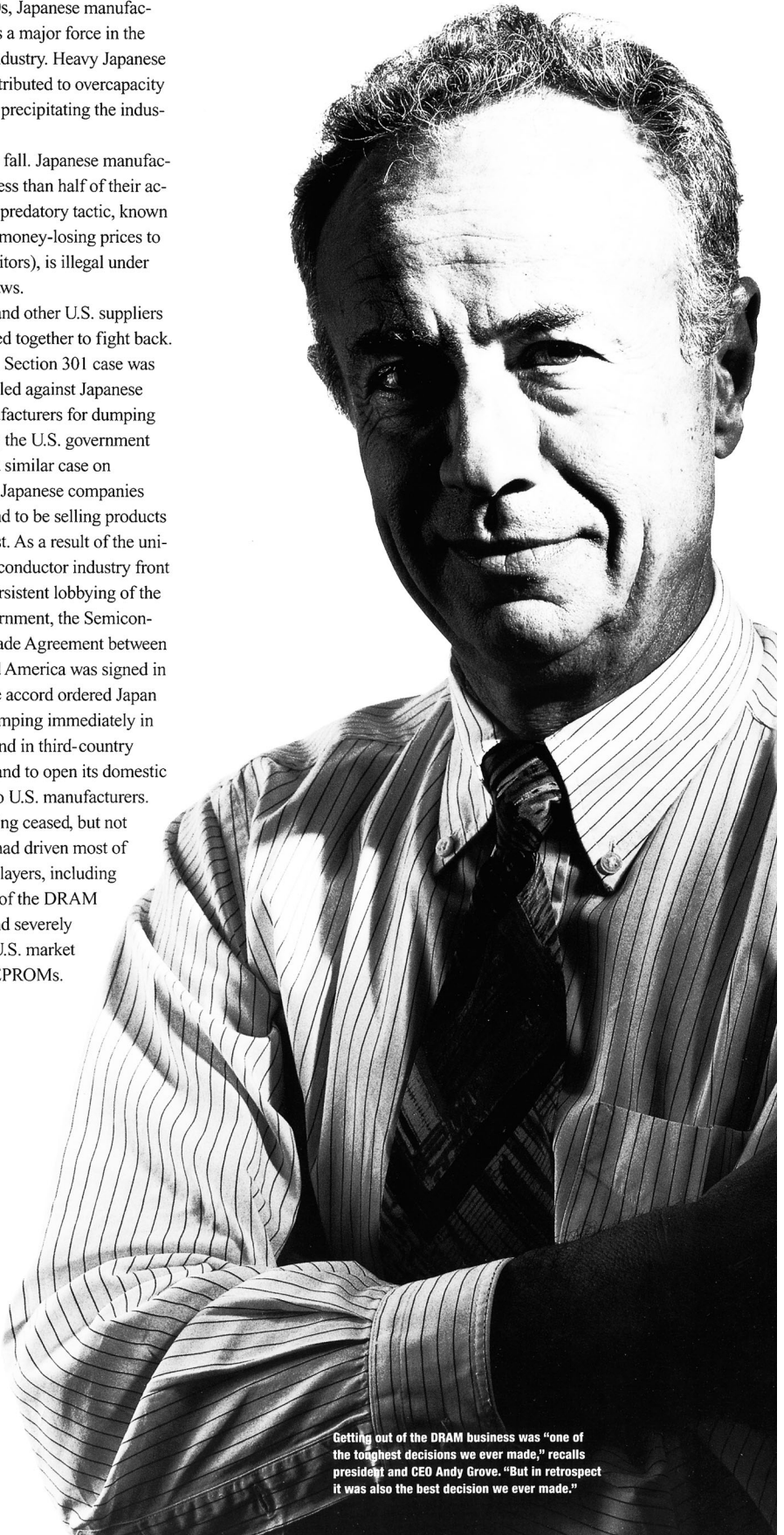
EPROM prices were in free fall. Japanese manufacturers were slashing prices to less than half of their actual manufacturing costs. This predatory tactic, known as "dumping" (selling parts at money-losing prices to destroy competitors), is illegal under U.S. trade laws.

Intel and other U.S. suppliers banded together to fight back. A Section 301 case was filed against Japanese manufacturers for dumping EPROMs; the U.S. government initiated a similar case on DRAMs. Japanese companies were found to be selling products below cost. As a result of the unified semiconductor industry front and its persistent lobbying of the U.S. government, the Semiconductor Trade Agreement between Japan and America was signed in 1986. The accord ordered Japan to halt dumping immediately in the U.S. and in third-country markets, and to open its domestic markets to U.S. manufacturers.

Dumping ceased, but not before it had driven most of the U.S. players, including Intel, out of the DRAM market and severely reduced U.S. market share in EPROMs.

1984

Memorable Movie:
Ghostbusters

JANUARY

Apple introduces the Macintosh personal computer.

Intel passes the $1-billion annual revenue mark, announcing 1983 revenues of $1,121,943,000.

FEBRUARY

Winter Olympic games held in Sarajevo, Yugoslavia.

MARCH

Gordon Moore and Bob Noyce named to IEEE Hall of Fame.

MAY

Intel chosen one of "100 Best Companies to Work For" in book of same name.

JUNE

Intel Singapore opens.

JULY

Geraldine Ferraro becomes first woman to run for U.S. vice president on a major party ticket.

AUGUST

IBM announces PC AT,* based on Intel's 80286 microprocessor.

OCTOBER

U.S. Congress passes landmark Semiconductor Chip Protection Act.

Fortune magazine highlights Intel as one of eight masters of innovation.

NOVEMBER

Vietnam Memorial unveiled in Washington, D.C.

Reagan/Bush defeat Mondale/Ferraro in presidential election.

DECEMBER

South Africa's Bishop Desmond Tutu awarded Nobel Peace Prize.

Intel announces closing of operations in Austin, Texas.

PCEO (Personal Computer Enhancement Operation) starts Intel PC retail sales.

NEC sues Intel, seeking to show microcode is not copyrightable.

Getting out of the DRAM business was "one of the toughest decisions we ever made," recalls president and CEO Andy Grove. "But in retrospect it was also the best decision we ever made."

Getting Out of DRAMs

17. By 1985, falling prices and a glut in the market prompted Intel to jettison its DRAM business. "In retrospect, it's fascinating to see how long we held on, basically deluding ourselves," Andy Grove muses. "By 1985, DRAMs accounted for only 5 percent of our revenue, yet we were spending one-third of our development dollars on the product.

"Finally, I said to Gordon [Moore], 'What would someone do with this business if they came into Intel from the outside?' The answer was clear: 'Get out immediately.'

"It was an emotional decision. We had been the first to introduce the product and build the business. Even as we were losing market share hand over fist, we clung to the idea that we'd come back. It was hard to admit that it was a battle we had lost.

"In retrospect, getting out of DRAMs when we did was the best business decision we've ever made, both for us and for the industry. We'd have been of no value to the industry as one of many limping memory suppliers. As it was, we were freed to put those resources into microprocessor development and production, which enabled us to become the technology powerhouse for the PC industry. We didn't act a moment too early."

Downsizing Intel

18. The cyclical nature of the semiconductor industry was never more evident than in 1984. Seemingly insatiable demand for the company's products led Intel to add capacity and people at a dramatic rate. Then, in the second half of the year, without warning, demand plummeted.

In response, Intel instituted temporary pay cuts of 10 percent and mandatory days off without pay. "People understood the urgency of the situation, and they rose to the occasion," recalls vice president and director of Corporate Programs Dick Boucher, who was the director of Human Resources at the time. "They gave extra effort without a lot of gritted teeth."

Finally, however, left with an unaffordably large production capability and no growth in sight, Intel resorted to drastic measures. From 1985 to 1986, the company closed seven factories, abandoned several businesses and cut head count by one-third.

What didn't get cut were investments in the future. Intel stuck to its long-term orientation, with combined R&D and capital expenditures totaling 30 percent of revenues in 1986. This difficult period set the stage for the dramatic growth that began in 1987.

Dick describes the layoffs as "a truly awful process. We were not laying off people who were incompetent—many were long-tenured and had successful careers."

Bob Reed, who became director of Administration in 1987, reflects on what Intel learned from the downsizing process: "It made us realize that in a business that will change forever, you need to move people constantly from areas of lesser return to areas of higher return. Redeployment is like always watching what you eat, rather than bingeing and going on crash diets."

Bob Reed (left), senior vice president and general manager of the Semiconductor Products Group, and Dick Boucher, vice president and director of Corporate Programs, remember the painful lessons Intel learned from the 1985-86 layoffs.

1985

Favorite TV Program:
The Cosby Show

JANUARY

Intel's 1984 revenues: $1,629,332,000.

Intel Technology Asia Ltd. opens office in Seoul, Korea.

FEBRUARY

U.S./Japan agree to eliminate tariffs on importation of semiconductors.

iPSC° Supercomputer unveiled.

Intel announces first layoffs in 10 years and plans to close T2 in Santa Cruz and A0 in Santa Clara.

MARCH

OpenNET local area network introduced.

APRIL

Intel ranked 226th in Fortune 500.

ABOVE™ board products introduced.

Intel Taipei, Taiwan office opens.

MAY

Intel's French headquarters open in Saint-Quentin-en-Yvelines.

AUGUST

Intel opens Folsom, California site.

SEPTEMBER

Huge earthquake kills thousands in Mexico City.

Divers find wreck of the Titanic— 73 years after it sank in Atlantic Ocean.

Intel/AMD/National Semiconductor file joint anti-dumping petition with U.S. Government against Japanese EPROM manufacturers.
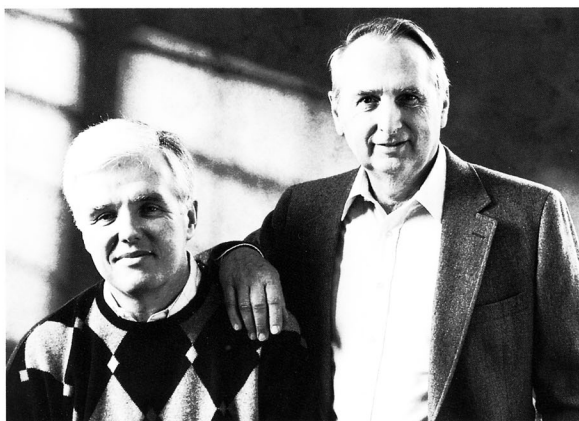
OCTOBER

Intel decides to quit the DRAM business.

Intel386™ CPU introduced in San Francisco, London, Paris, Munich and Tokyo.

DECEMBER

Bob Noyce inducted into National Inventors Hall of Fame.

Intel opens Beijing office in China.

An 'Awesome' Intel Corners Its Market

It has turned its key computer chip into Silicon Valley's latest cash cow.

By ANDREW POLLACK

SANTA CLARA, Calif.
IN company presentations, the Intel Corporation's president, Andrew S. Grove, displays a cartoon that depicts Intel as a castle. Attackers are coming from all directions brandishing a variety of weapons — lawsuits, competitive products and imitations of Intel's product — all after the jewel of the kingdom that is hidden inside.

The jewel is a piece of silicon smaller than a postage stamp that contains 275,000 microscopic transistors. And so far, Intel has protected its prize well, perhaps too well for the comfort of some of its customers. The personal computer industry and Wall Street are waking up to the fact that Intel has one of the most lucrative monopolies in America. It is the designer and sole supplier of its silicon jewel — the 80386 microprocessor, a com-

puter chip that is the central component of the latest and most advanced personal computers made by the International Business Machines Corporation and most other manufacturers.

There are other microprocessors on the market, but they do not easily run the industry's standard software. And while Intel licensed previous generations of its chips to other companies, it has kept control over the 386, as the chip is popularly known, except for giving permission to I.B.M. to produce some for its own needs. Other makers of personal computers have no choice but to go to Intel. As a result, Intel not only has the jewel, it now rules the kingdom.

"It's got a lock on the market," said Adam Cuhney, semiconductor analyst with Kidder, Peabody & Company. Rajiv Chaudhri of Goldman, Sachs & Company agreed: "It's awesome how well they are positioned."

Indeed, with the 386 in short supply for two years, just how Intel allocates the chip among its customers can determine who will prosper and who will fade in the computer industry.

Intel insists it has been fair in its allocation practices. "We are very meticulous about all of that," said Dr. Grove, who said Intel's supply will catch up to demand in a few months. Still, some custom-
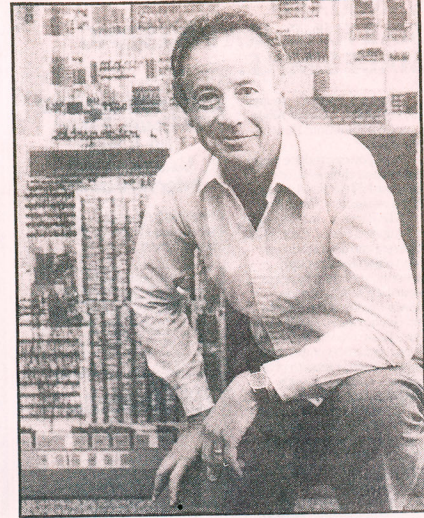
Andrew Grove and blowup of an 80386 microprocessor.

1986

Hit Song:
That's What Friends Are For

Favorite TV Program:
Miami Vice

JANUARY

Space shuttle Challenger explodes moments after lift-off, killing 7 aboard.

Intel's 1985 revenues: $1,364,982,000.

Asia Pacific Operation formed.

FEBRUARY

20-year rule of Philippines President Ferdinand Marcos ends.

Flexible Workforce Program introduced.

APRIL

Major accident at Chernobyl nuclear reactor power plant in Ukraine.

Fab 6 introduces GORE-TEX* bunny suits.

MAY

82786 graphics coprocessor unveiled.

JULY

U.S. and Japan sign historic semiconductor accord designed to increase U.S. market share in Japan.

Martina Navratilova wins 5th straight women's Wimbledon tennis title.

Intel System 310s track information in Operation Sail 1986 at the 100th anniversary Salute to Liberty in New York.

AUGUST

Intel announces plans to shut down Barbados facility.

29C53 transceiver chip and 29C48 codec filter combo chip, Intel's first ISDN products, introduced.

As part of Intel/NEC dispute, court rules that microcode can be copyrighted and that Intel's copyright is valid.

Compaq is first major computer maker to introduce an Intel386™ CPU-based PC.

OCTOBER

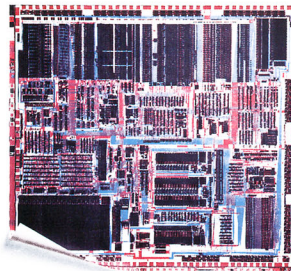**Intel announces entry into ASIC market.**

NOVEMBER

Iran-Contra affair becomes full-fledged scandal for Reagan administration.

DECEMBER

Experimental U.S. aircraft, Voyager, circles the earth nonstop on one tank of gas.

Electronic Engineering Times readers select the Intel386™ CPU as the most significant IC product of the year.

Going It Alone with the Intel386 Chip

19. Today Intel is the sole open market supplier of the genuine Intel architecture line of microprocessors. But that wasn't always the case. Until the mid-1980s, the pattern of the industry was to second-source most products, meaning other companies were licensed to make and sell Intel products, in exchange for royalties and/or the rights to other products.

That pattern began to turn sour as Intel's microprocessor line increased in value and candidates for exchange did not keep pace. When the Intel386 chip was introduced, the company wanted fair compensation. "We just didn't want to put the chip on a silver platter and ship it off to other companies," Andy says. "We wanted to be sure we would get something of value in return."

From this concern was born the decision to remain the only manufacturer of the Intel386 chip—at least until other companies demonstrated they had equally valuable technology to offer in exchange. "I think AMD, especially, thought we were bluffing. They did not meet their commitments, thinking we'd need their help eventually to meet demand," Andy notes. "It was like a game of chicken, and we didn't swerve."

The sole-source policy pushed Intel to new heights in manufacturing. "We had to commit to supplying the entire needs of the industry," Andy says. "That motivated us to get our manufacturing performance up to snuff. We developed multiple internal sources, so several factories and several processes were making the chips simultaneously. We made major commitments to production ramps, and we didn't hedge."

The plot of the Intel386™ CPU inspired an exhibition of chip plots. The show was developed by the Museum of Modern Art in New York, funded by the Intel Corporation Foundation.

"Consider the changes we have helped to bring about."

SEMATECH Brings the Industry Together

20. Heartened by their experience in banding together to get the U.S./Japan Semiconductor Trade Agreement passed, U.S. chip makers found another way to exercise their strength in numbers. SEMATECH (for SEmiconductor MAnufacturing TECHnology) was founded in 1987 by 12 semiconductor companies, including Intel, to recover key manufacturing capabilities.

Intel's commitment to the project was illustrated by Bob Noyce's 1988 decision to take on the role to lead the consortium as president and CEO. In a 1988 interview, Bob said, "The country had made a commitment to this concept. I felt that if I didn't follow up with personal involvement when it was needed, it was betraying a trust to the people of America." Bob's leadership and influence in Washington were critical to SEMATECH's early survival.

What held the effort together was the organization's focus on two clear goals: to regain predominance in the worldwide semiconductor market and to increase the proportion of domestic manufacturing equipment bought by U.S. chip makers. "Five years later, we've achieved both goals, although there's clearly more improvement to be made," says Craig Barrett, who has served on SEMATECH's board for several years.

To Bob, SEMATECH represented more than just the sum of its parts. "This is a model for how government and industry can

those who help themselves; that's a model that's endorsed by many Americans."

Photo by Ziggy Kaluzny

In 1988, Bob Noyce took on construction of his third "start-up" as president and CEO of SEMATECH.

George Chiu, senior engineer, Package and Assembly Research

Memorable Movie:
Fatal Attraction

Hit Song:
Didn't We Almost Have It All?

J A N U A R Y

Dow Jones Industrial Average tops the 2,000 mark for first time.

Intel's 1986 revenues: $1,265,011,000.

A P R I L

After 1986 net loss, Intel celebrates first-quarter net income of $25,511,000. Employees worldwide celebrate with "Back in the Black" parties.

Andy Grove elected CEO.

M A Y

SIA Board of Directors approves business plan for SEMATECH.

Intel's Systems Group World Headquarters opens at Hawthorn Farms, Oregon.

J U N E

Bob Noyce receives National Medal of Technology from President Reagan.

Andy Grove receives 1987 Engineering Leadership Recognition award from IEEE.

Intel repurchases the shares of Intel stock sold to IBM in 1983.

Intel Brazil opens in Sao Paulo.

J U L Y

Intel386™ CPU-based System 301 introduced.

A U G U S T

National Semiconductor announces plans to buy Fairchild Semiconductor.

S E P T E M B E R

Intel launches Knockout campaign.

Dow Jones Industrial Average plummets 508 points, or 22.6 percent, in one day.

D1 development fab for microprocessors opens in Aloha, Oregon.

D E C E M B E R

IBM sells the last of its shares of Intel stock, closing out its stake in the company.

July 28, 1988

Living

A trivia quiz: Politics in the movies, on TV
PAGE 1C

...18th, Angels top A's
SPORTS, PAGE 1G

Thursday morning, July 28, 1988

San Jose Mercury News

Serving Northern California Since 1851

25 cents

Morning Final

Intel founder Noyce to lead Sematech

Choice is widely hailed by industry

By David Willman and Michael Feibus
Mercury News Staff Writers

WASHINGTON — Robert N. Noyce, the Silicon Valley pioneer who co-founded Intel Corp. and helped invent the integrated circuit, announced Wednesday that he will head Sematech, the semiconductor research cooperative.

Noyce's selection was widely praised in the industry and in

Washington. In landing one of the most celebrated and respected leaders in the semiconductor industry, Sematech countered fears that the project had stalled.

The consortium in Austin, Texas, had been criticized recently because its yearlong search for a chief executive had dragged three months behind schedule. Earlier, another executive had turned down an offer to run Sematech.

That helped persuade Noyce — one of three Silicon Valley executives leading the search team — to step forward.

Noyce, 60, said he had been "approached" about a year ago about taking the job of CEO. But he had "disqualified" himself because of personal considerations and because of management changes in

See SEMATECH, Page 10A

Robert Noyce
... 'Industry seer'

Consortium backers were sure they wanted Noyce all along

By Michael Feibus
Mercury News Business Writer

A year ago, Sematech officials had a lot of questions to answer.

They didn't know what kind of chips to make. They didn't know where to locate the project. And they didn't know where the money would come from.

But they did know one thing. Robert N.

Noyce should run the project.

That's because he had the rare mix that Sematech needed: a capable leader who was as effective on Capitol Hill as he was in engineering labs.

"I imagine it was tough when your criterion is to find somebody like Bob Noyce," said Gordon Moore, Intel's

See NOYCE, Page 10A

Taking the Lead in Flash Memory

21. In 1988, Intel seized the opportunity for a new technology known as flash memory. Toshiba, a Japanese company, invented flash technology, but in an ironic role reversal, Intel, an American company, took the leadership position by improving the technology and making it more manufacturable and affordable. The worldwide flash market has reached $500 million, and industry forecasters predict 100 percent annual growth for the foreseeable future.

Flash offers the non-volatility of EPROMs with the added bonus of electrical erasability. Flash was originally introduced as an EPROM replacement for embedded systems because manufacturers could change or upgrade machine software without having to open the system or replace components.

Intel has increased the density of flash while reducing the cost to help put flash within reach of the new class of portable systems. Flash offers these systems the combination of high storage density plus compact size, light weight, extreme ruggedness and low power. Notes Dick Pashley, vice president of the Semiconductor Products Group and general manager of the Memory Components Division, "It looks as if solid-state technology will eventually render conventional disk drives obsolete in mobile systems.

"Most memory technologies invented in the past 20 years have become low-margin commodities," says Pashley. "Disk drive replacement was a radical idea five years ago, and people were naturally skeptical. A very dedicated and immensely creative team clung to the vision, and today people are believers."

The potential for flash is so significant that Intel has phased out its EPROM design and production efforts in favor of flash.

Flashing with conviction, the flash memory development team has seen their vision become reality. Clockwise from upper left: Product Marketing manager Bruce McCormick; design manager Mark Winston; engineering manager Stefan Lai; and Semiconductor Products Group vice president and Memory Components general manager Dick Pashley.
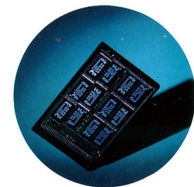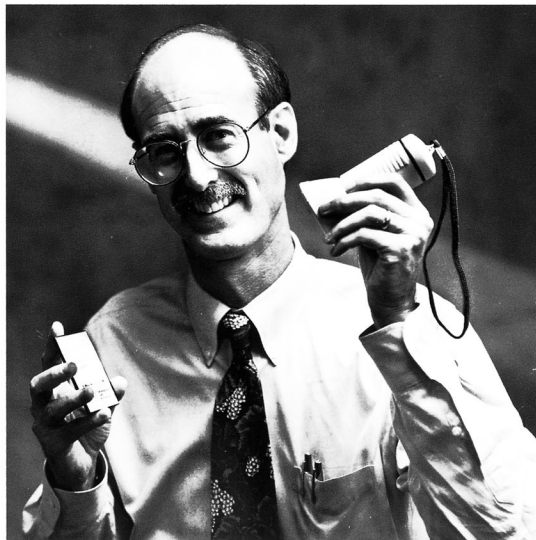
Flash memory may replace disk drives in mobile computers as well as provide high performance in traditional embedded memory applications.

The innovative two-part ad campaign made the message clear: the Intel386™ SX CPU aimed to displace the 286 as the entry-level processor of choice.

The Red X Ad Campaign

22. In 1989, Intel burst upon the advertising world with a bold new ad campaign. The so-called "Red X" ad raised eyebrows wherever it appeared. Dennis Carter, vice president and director of the Corporate Marketing Group, led the group that developed the campaign. "The Intel386 chip was a successful product, but it was mired in the high end of the market. The market was stagnant, and people perceived that the Intel 286 CPU was all that they would ever need. The Windows operating system was coming, giving people a compelling reason to move to 32-bit processors, but that message wasn't getting across. We wanted a dramatic way to convey that the Intel386 SX CPU was an affordable way to enter the 32-bit world."

Before it hit the billboards, the Red X campaign stirred up controversy, Dennis recalls. "We were speaking directly to PC consumers for the first time, rather than marketing only to OEMs. We weren't sure how our OEM customers would react.

"Also, we were concerned that we could actually damage ourselves if people failed to understand the campaign. The red X slashing through the 286 was calculated to grab attention, to cut through the clutter of other advertising. But it could have killed the 286, without moving people to the Intel386 CPU. Dave House called it the 'Eating Our Own Baby' campaign."

Intel previewed the Red X ads in a test market in Denver, Colorado, and they were wildly successful. "We saw significant changes in the buying patterns of PC buyers; they were switching from 286-based machines to Intel386 SX CPU-based PCs," Dennis says. Among PC buyers, there were very few negative perceptions of Intel as a result of the campaign. OEMs were pleased as well with the movement to 32-bit machines.

Making Intel a household name are (clockwise from upper left): Architecture Manager Team manager Pat Perry; Reseller Support Programs manager Charlene Hama; Creative manager Kevin Teixeira; Processor Brand Marketing manager Sally Fundakowski; Intel Inside® Program manager Janice Wilkins; and Trademarks and Brands managing attorney Ric Giardina. Proud godfather, vice president and director of the Corporate Marketing Group Dennis Carter (facing page), watches over the branding efforts.

Ted Jenkins, vice president and director of Corporate Licensing

"The drive to get at issues of substance

29

Making a Name for Intel

23.

The Red X campaign was Intel's first corporate-wide experience with marketing to the PC-buying public. It spawned several programs that continue today, all focused on building the perceptions of quality and compatibility associated with the Intel name.

"What we learned from the Red X campaign was that we *could* communicate arcane technical ideas—that, in fact, people wanted to hear them," Dennis Carter says. The Architecture Manager (AM) program grew out of this recognition. AMs help information technology managers, dealers and user groups around the world understand the capabilities and benefits of the Intel architecture.

The Intel Inside® program also taps the value of the Intel name by encouraging PC buyers to look for systems with a genuine 32-bit Intel processor inside. In OEMs' advertising and on their PCs in the stores, the Intel Inside logo helps PC shoppers tell a genuine Intel CPU-based PC from an imitation.
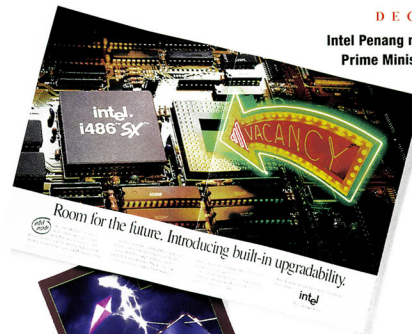
Ads such as the "Vacancy" campaign have been key in making PC users aware of the benefits of genuine Intel technology. Here also, Intel's latest ad for the Pentium™ processor.

has kept us sharp over the years."

Vice president and treasurer Arvind Sodhani (left) and vice president and chief financial officer Harold Hughes are responsible for keeping Intel's coffers filled with cash for key strategic investments.

Cashing In on Success

24. Over the years, in good times and bad, Intel continues to invest in manufacturing and R&D. Not all companies have this luxury. Vice president and chief financial officer Harold Hughes comments, "The semiconductor business has truly awful cash flows. There are constant, large outlays for R&D and manufacturing, but the income is very cyclical. So, Intel has put a priority on building a buffer of cash for the times when income is constrained."

Intel's Initial Offer Sold Out

NEW YORK — Investors oversubscribed Intel Corp.'s initial public offering of 350,000 capital shares ($8,225,000) at a price of $23.50 apiece, sponsoring underwriters said.
Underwriters led by C. E. Unterberg, Towbin Co. handled the offering. There are 2,551,233 Intel capital shares outstanding.
* * *
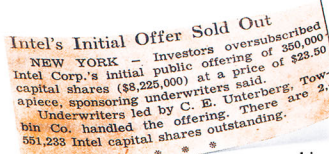
Wall Street Journal,
October 14, 1971

Working as an internal investment bank, the Intel Treasury department provides the cash for Intel's strategic programs. The group invests millions of dollars, searching for the best possible return, while also minimizing risk. "Intel's Treasury has beaten all expectations for returns," Harold notes. "They are creative and innovative; they can smell a good deal."

The Treasury minimizes Intel's financial risk through investing only in secure financial institutions with high credit ratings and high-quality returns. "Our goal is to beat market returns while taking minimum risks," vice president and treasurer Arvind Sodhani notes.

In September 1992, with nearly $2.5 billion in cash and short-term investments on hand, Intel's Board decided to share its success directly with stockholders, in the form of a dividend. "I never thought we'd pay a dividend, because we didn't want to give up any of the cash we might need for the next lean period," Harold says. "It's a statement that our financial position is very secure, and it's important for stockholders to understand that confidence."
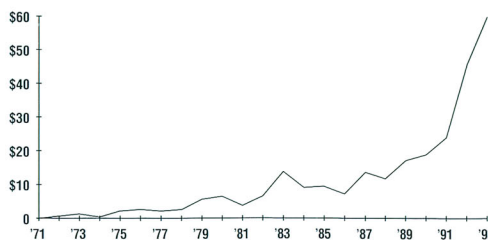
Intel's stock price shown at fiscal year end, 1971 through 1992, and as of June 1, 1993. A 100-share purchase at the offering price has grown from a $2,350 value to 7,594 shares with a value of $438,554 at end of trading on June 1, 1993 (adjusted for May 1993 stock split).

Victories on the Legal Front

25. Since the early 1980s, Intel has become more aggressive in its efforts to protect its intellectual property rights. "Intel's engineers have made many great innovations, and other companies naturally want to imitate our successful products," notes vice president and general counsel Tom Dunlap. "But when we're spending so much on research and development to create those products, we're not about to sit by and let other people piggyback on our efforts."

Legal protection for intellectual property was strengthened when computer software programs became expressly protectable under the 1980 Copyright Law. The 1984 Semiconductor Protection Act prohibited copying of the complex patterns printed on the wafers. The formation of the Court of Appeals for the Federal Circuit (CAFC) has generally strengthened patent rights and made patent rulings more consistent. (Intel has increased the number of patents filed each year from 105 in 1990 to an estimated 420 in 1993.)

"We've gained a certain notoriety, because we've had to resort to litigation with freeloading companies who try to infringe our rights," Tom notes. Among Intel's most significant legal victories is the NEC case of the mid-1980s, in which it was established that microcode is a computer program and therefore protectable under copyright law. On the patent side, the International Trade Commission (ITC) issued an exclusion order in March 1989 because several companies were infringing on Intel's EPROM patents. The precedent set in that case has allowed Intel to collect licensing fees from other memory manufacturers, rather than having to go to court with each one individually.

"One of our greatest frustrations has been the painfully slow court process," Tom notes. "Consequently, we support the rapid implementation of the Court Reform Act that Congress passed in 1990, which should help speed cases to trial. In this environment of just-in-time business, it's time for a little just-in-time justice."

And as for Intel's most notorious imitator? "AMD has developed a strategy of being the world's No.1 imitator of successful Intel products," Tom observes. "They refer to their imitations as 'genuine copies.' Beginning with the Intel386 CPU, we have enforced our intellectual property rights to limit AMD's ability to leech off Intel's innovation."
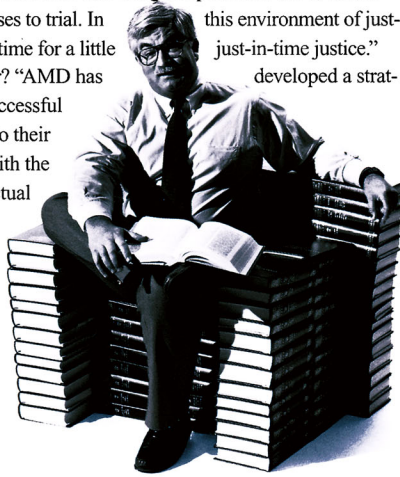
Working as a kind of internal law firm, Intel's Legal Department throws the book at companies that try to infringe on Intel's intellectual property rights. Clockwise from upper right: managing attorney of Components Operations Dennis O'Reilly; Group counsel Ted Vian; vice president and director of Corporate Licensing Ted Jenkins; vice president and general counsel Tom Dunlap; Intellectual Property chief counsel Carl Silverman.
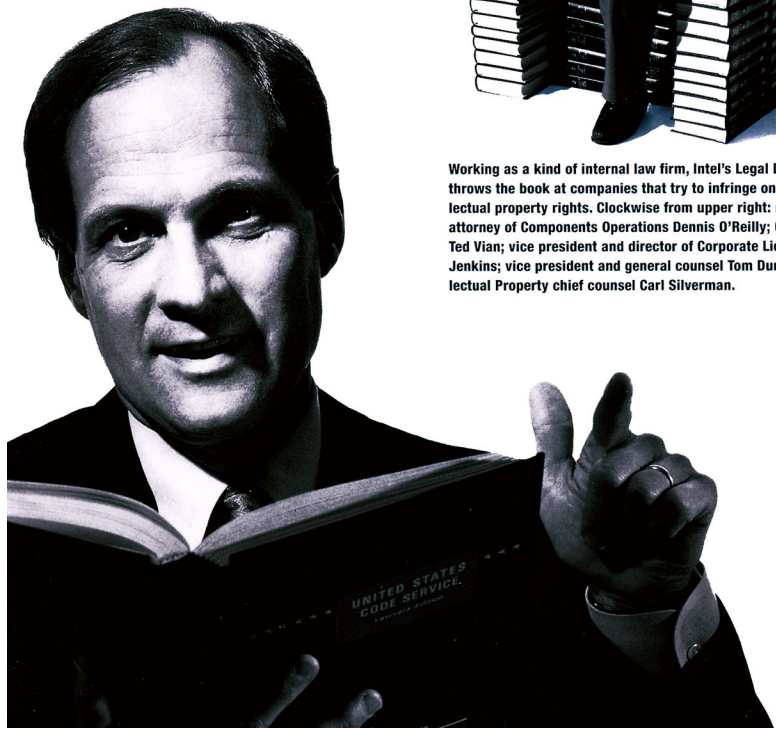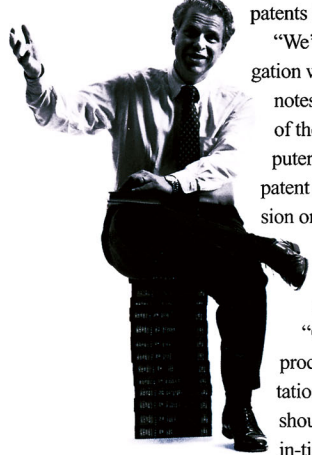
1992

Favorite TV Program:
Murphy Brown

JANUARY
Intel's 1991 revenues: $4,778,616,000.

FEBRUARY
In arbitration, Judge rules AMD is not entitled to the Intel386™ microprocessor under an earlier second-source agreement, but he awards the right to sell its copy of the Intel386 CPU.

MARCH
Intel announces OverDrive™ processors.

APRIL
Intel's D2 Fab in Santa Clara produces first 8-inch wafers.
In-Stat names Intel world's largest maker of ICs, passing NEC.

JUNE
Jury rules that AMD has no rights to copy the Intel287™ math coprocessor microcode.

SEPTEMBER
Intel announces 10-cents-per-share payout (before effect of May 1993 stock split), first cash dividend in the company's history.
Intel opens D1A in Aloha, Oregon.

OCTOBER
Intel announces a $400 million expansion of D2 manufacturing plant.
Clinton/Gore defeat Bush/Quayle in the presidential election.
Intel introduces Indeo™ video technology.
Intel opens office in Guadalajara, Mexico.
Intel establishes Penang Design Center.

DECEMBER
European Community becomes a reality as trade borders disappear.
Court rules that AMD does not have the right to copy any Intel microcode.

1993

Popular Song:
A Whole New World

JANUARY
Intel's 1992 revenues: $5,843,984,000.
Dataquest ranks Intel as the world's largest producer of semiconductors, first time a U.S. firm has held that position since 1984.
Craig Barrett named Intel COO.

FEBRUARY
World Trade Center in New York bombed.

MARCH
Intel introduces Pentium™ processor.
Intel announces its first $2 billion quarter.

APRIL
Judge Ingram grants AMD a new trial in the Intel287™ chip case but denies AMD a license for the second time.

JUNE
California Appeals Court reverses arbitrator: throws out 1992 AMD 386 license.
Fortune magazine features Intel Pentium™ processor on cover. Intel plays leading role in "The New Computer Revolution."

JULY
Intel sites celebrate 25th anniversary worldwide.

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The PCED-Business Communications team leads Intel into the cutting edge of the future. Left to right, back row: Tad Hetu, Group Strategy manager; Frank Jones, Business Communications Manufacturing manager; Scott Darling, Strategic Marketing manager. Middle row: Dick Gough, Internal Communications Business Area manager; Chris Hughes, Software Business Area manager; Pat Gelsinger, Intel Products Group vice president and general manager of PCED-Business Communications. Front row: Sudhir Bhagwan, Communications Business Area manager; Laura Finney, Finance manager; Michael Bruck, Video Business Area manager.

Looking to the Future

*A*s Intel enters its second quarter-century, the company is once again leading the computing industry into a revolution. "We see incredible opportunities in the area of business communications—making the PC a truly full-functional, real-time communications tool," says Andy Grove. "The PC has the ability to obliterate time and space barriers in dealing with information."

Business communication is defined as the discipline of using computers and software for new levels of interpersonal communication and information sharing. Intel's "biz-comm" vision includes such advanced technology as digital video conferencing; electronic meetings, in which all participants can manipulate a shared display of text or data; and enhanced telephone management and messaging capabilities—all on the PC. The Business Communications unit of the Personal Computer Enhancement Division (PCED) expects to introduce more than 20 add-in video and communications hardware and software products this year.

"The time is ripe," says Intel Products Group vice president and PCED-Business Communications general manager Pat Gelsinger. "The PC is powerful enough, the installed base of PCs is high enough, and the telecommunications industry is making the necessary high-bandwidth networks available. The $300 billion computing industry is destined to merge with the $500 billion communications industry. And we're going to be part of that merger.

"For Intel, business communications is a triple win. It will increase the utility of the PC, expand the total market of the PC industry and use a lot of MIPS, which our processors will provide. When a new technology hits on three of our four key strategic areas in this way, we want to be part of it."

Intel has thrived on pursuing new business opportunities. Andy remembers the surprise in 1971 when the company introduced the 4004, a generic processor appropriate for a multitude of applications. "One of our board members asked me, 'You're a semiconductor memory company. What business is it of yours to do CPU development for other people?'

"Today, some people have asked me essentially the same question: 'Where do you get off making end-user-ready telecommunications products?' It has the same flavor to me as our venture into microprocessors—it's a risk, but it's enormously exciting. We have no guarantees that it will work, but it seems like something people will want. It just feels right.

"Once again, we're leading with our chin into a brand new arena," Andy says with a grin. "Historically, it's our best mode." Intel's first 25 years prove it—and so will the next 25.

intel