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"If you're going to read one history book this decade, **read this one.**"
— John Perry Barlow, co-founder, Electronic Frontier Foundation

Third Edition

Fire in the Valley

The Birth and Death of the Personal Computer

Michael Swaine and Paul Freiberger

Foreword by John Markoff, *The New York Times*

Edited by Brian P. Hogan

Fire in the Valley, Third Edition

The Birth and Death of the Personal Computer

by Michael Swaine, Paul Freiberger

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—Dave & Andy.

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Praise for All Editions of *Fire in the Valley*

Things change over time, even when they don't. When *Fire in the Valley* first came out in 1984, I was just discovering that these clunky little TVs with keyboards were better than Wite-Out, but the idea they might already have a history seemed a Warholian conceit. By the release of the second edition, they certainly had a history—and most who could operate them knew it. By then, I even had a bit part in it. Now…well, now this is a book about events that truly changed history. And it's still pretty much the same book. What's more, most of the millions whose worlds have been utterly transformed by bit-boxes don't know a thing about their origins. But if you're going to read one history book this decade, read this one. You need to know the hilarious saga of the wizards and the wing nuts and the little miracles by which they created everybody's future.

→ John Perry Barlow
Peripheral Visionary executive vice president; Algae Systems cofounder; and rocking chair, Electronic Frontier Foundation

This must-read classic tale of the origins of the personal computer and its role in the evolution of Silicon Valley continues to evolve and inform. In an era when we take the personal computer for granted, we tend to forget the risk-taking and ambition that was required to shift from a hobbyist plaything to a thriving industry. The authors focus on the people and culture that helped to change the world—and continue to change the world through offshoots like smartphones and the Internet. The fire continues to grow.

→ John Hagel
Co-chairman, Center for the Edge, and coauthor, *The Power of Pull*

Fire in the Valley is the seminal story of Silicon Valley. It is the first and only biography of the place that made and continues to make innovation history. Swaine and Freiberger capture the emotions and motivations at the core of this very special place with tenderness and finesse that endure to this day.

→ Andy Cunningham
Founder and president, SeriesC

Fire in the Valley presents the full story: from calculating machines and military computers through the heady days of garage start-ups, the rise of the clones, the initial forays into cyberspace, and on to consolidation, commoditization, and the heightened frenzy of an all-connected world of mobile devices and cloud services that we experience today. Its theme is best summed up by the authors themselves: time and again, crazy dreamers had run up against resistance from accepted wisdom and had prevailed to realize their dreams. Babbage and his Analytical Engine, Turing's test, von Neumann's computer, Shockley's transistor, Noyce's integrated circuit, Kildall’s operating system, Roberts’s microcomputer company, Moore’s law, Gates and software, Woz and hardware, Jobs and the first truly personal computer, Kapor and the spreadsheet, Berners-Lee and the Web, Andreessen and the web browser, and all of the lesser-known and unsung heroes are here.

The authors rightly focused on the human aspects of the story: the hopes, desires, and values of the dreamers. Every student of technological innovation should treat this book as the bible of computer culture and learn its lessons.

→ Tony Bove
Author of *iPod & iTunes for Dummies*, *Just Say No to Microsoft*, and dozens of other technology books

Highly readable and engrossing, *Fire in the Valley* takes the reader behind the scenes, into the creation of the personal-computer industry and how it spawned the technology products we can’t live without today. This updated edition is as fascinating as the original book, piquing the curiosity of the reader as we wonder what new transformative technologies will come next.

→ Barbara Krause
Former vice president of corporate communications, Apple Computer, Inc.

Fire in the Valley is a must-read for entrepreneurs, investors, and anyone involved with technology. The entrepreneurs of the personal-computer industry made every possible mistake. Their story will save you a lot of money, time, and disappointment.

→ Roger McNamee
Cofounder of Elevation Partners, Silver Lake Partners, and Integral Capital Partners

Silicon Valley suffers from an extreme case of historical amnesia. Whatever its virtues, remembering its roots isn’t one. The best remedy—especially for those who treasure understanding the origins of the world’s top innovation cluster—is to read *Fire in the Valley*. Swaine and Freiberger brilliantly capture a bygone time, a forgotten creation story that, when first encountered, greatly enhances your appreciation of the technological marvel that Silicon Valley was, is, and likely shall remain. This is an essential volume in any reading list on the digital age.

→ G. Pascal Zachary
Author of *Showstopper!: The Breakneck Race to Create Windows NT and the Next Generation at Microsoft* and *Endless Frontier: Vannevar Bush, Engineer of the American Century*

Foreword to the Third Edition

Paul Freiberger, Michael Swaine, and I arrived at about the same time in late 1981, at a funky little publication that had recently been renamed *InfoWorld*. Until the summer of 1981, *InfoWorld* had been known as the *Intelligent Machines Journal*, a hobbyist journal written for a small but rapidly growing community of computing enthusiasts. The *Intelligent Machines Journal* had been founded by Jim Warren, an itinerant former schoolteacher who had also created the West Coast Computer Faire. When he decided to sell his then quasi-academic publication, he found an eager buyer in Patrick McGovern, the chairman of the International Data Corporation, whose flagship weekly, *Computerworld*, was the unofficial organ of the mainframe-computer industry.

McGovern had his ear to the ground, and he had realized early on that a new computer industry was emerging that had little in common with the stuffy East Coast–based computer companies. The transformation of *Intelligent Machines Journal* was just one in a series of events between 1977 and 1981 that marked the evolution of a hobbyist subculture into the world's most dynamic industry. The three of us couldn't have arrived at a better time. The PC hobbyist era was ending, but in its place was thriving an equally wild, absolutely out-of-control group of small businesses—populated by remarkable and quirky characters—on their way to becoming major corporations.

Overnight, *InfoWorld* became a perfect perch from which to watch history take place. Everything was moving rapidly, and the publication we had found ourselves working for was attempting to define itself while the world was being turned upside down by the microprocessor. One moment *InfoWorld* tried to be a *Rolling Stone* to the personal-computer industry; the next moment it set out to be a *Sports Illustrated*.

Few of us were trained journalists, but like the fledgling industry we were covering, we made it up as we went along. It was soon obvious that the world was taking notice of the PC. On an almost weekly basis, people from around the country would simply appear at our offices in downtown Palo Alto, having made their way to the Mecca of Silicon Valley looking for jobs or connections.

At *InfoWorld* we were close to history in the making—sometimes too close. One day I walked into Paul Freiberger's office, a small windowless corridor, only to find him in a tense conversation with Steven Jobs. Jobs was yelling at him because Paul was about to break the story of the Lisa and the Macintosh, and Jobs was accusing him of helping the Japanese take over the American computer industry.

This proximity of its authors to the enterprises that birthed the microcomputer industry sets *Fire in the Valley* apart from the dozens of other attempts to tell the story of the computing revolution. Paul and Michael lived through a remarkable period of history, and their book captures the spirit of the personal-computer revolution.

Originally published in 1984, *Fire in the Valley* was the first, and is still the best, account of the people who created what venture capitalist John Doerr has called the "single largest legal accumulation of wealth in the century."

More recent histories of the personal computer have tended to devolve into accounts of the legends of William Gates, Steven Jobs, and the Xerox Palo Alto Research Center. *Fire in the Valley* goes deeper, telling the story of what came before. Freiberger and Swaine's account of the history of the Homebrew Computer Club still stands as the definitive tale of a remarkable anarchist assembly of engineers, hackers, and fellow travelers that began as a genuine counterculture and ended by changing the world.

There is also a trend in computer histories today to reject the impact of culture and politics in the development of the personal computer. But even a casual reading of *Fire in the Valley* clearly demonstrates that the personal-computer industry, and its emergence in Silicon Valley in the 1970s, was a direct outgrowth of a remarkable period in the suburban region that surrounds Stanford University.

It was a particular chemistry—not just greed and not just engineering, but also a strain of passionate political purity best expressed by young people such as Lee Felsenstein, inventor of the Sol and designer of the Osborne 1—that gave rise to the personal-computer industry.

First published three decades ago, this new edition of *Fire in the Valley* has been expanded with both additional reporting and new chapters. This new edition covers the development of the post-PC era and the arrival of mobile devices, $2 apps, and their connection to the original vision of the personal computer.

It covers the return of Steve Jobs to Apple and the impact he had again, including Apple's transition to the mobile, connected world. Paul and Mike also track more recent developments, from the emergence of the Internet to post-Gates Microsoft and Bill's move to the Gates Foundation. Additionally, they chart the rise of the open source software movement and its meaning, impact, and potential, as well as its connection to the ethos of the earlier homebrew era. Finally, they explore the conflict between empowering individuals and loss of privacy, placing us directly in the Snowden Age.

Even Steve Jobs came to admire the first edition of this book, saying, "Reading it made me cry, thinking about those early days.”

Fire in the Valley has stood the test of time well. It remains a great adventure that gives the reader a sense of being close to a historical movement that is still playing itself out.

John Markoff
Senior writer, science section, The New York Times
San Francisco, May 2014

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Preface to the Third Edition

It was a magic, crazy time when cranks and dreamers saw the power they imagined drop into their hands and used it to change the world. It was a technological and business turning point when multinational corporations lost their way and kitchen-table entrepreneurs seized the banner and ran off into a future out of science-fiction stories. It was a brief and heady moment when nerds laughed in bullies' faces, idealism paid off, and you could *feel* the pace of change. Hobbyists became visionaries and visionaries became multimillionaires. It was a bona fide *revolution*, bred of those things that drive people to greatness: greed and idealism, pride and love, the thrill of achieving what nobody else has ever done before, the adrenaline rush of riding a big wave—and yes, throw in Buddhism, *est*, and transcendental meditation, too.

This is the story of the personal computer: its birth, its rise to power and influence, and its eventual decline.

It is also the story of some unusual individuals. The personal computer came into existence because—at a time when the idea seemed far-fetched—these individuals wanted so passionately to have a computer of their own that they just made it happen.

It is also a story of populist values. The personal computer was born in a time of social ferment, when idealism ran high. Many of the people so passionate about making a *personal computer* reality were equally passionate about opening up the arcane technology of the computer to everyone. "Computer power to the people" was their rallying cry, and it truly was one of the forces that shaped the personal-computer era.

For a time, the personal computer—a real computer in the hands of an individual, and usable and even programmable by that individual—became the center of the technological universe. But ultimately the forces of technology and of personal empowerment unleashed in this technological movement passed up the personal computer, as its capabilities were deconstructed and embodied in phones and glasses and watches and other devices of the post-PC era.

But in the early 1980s, we were right in the middle of it: two young and eager reporters for *InfoWorld*, the first news weekly to cover the personal-computer industry—although the word *industry* probably conveys the wrong impression. We were reporting on what comes before an industry. Caught up in the pitch of events, we felt a part of them. It was an exhilarating time, watching and chronicling history in the making.

Like interviewing Bill Gates in the bleachers above the show floor at an early West Coast Computer Faire. Driving the back roads of Georgia to talk with Ed Roberts, the guy who started it all, then in “retirement” as a country doctor. Sitting with Woz on the floor of the apartment he occupied while he attended UC Berkeley under the pseudonym of Rocky Raccoon Clark. Visiting an elementary school and discussing creativity with Alan Kay. Watching night fall in Jim Warren’s aerie in the Santa Cruz Mountains and hearing about his early computer shows and publications and hot-tub parties that *Playboy* covered. Scuba diving with Captain Crunch, the king of the phone phreaks. Dining in the Apple cafeteria with Steve Jobs and finally getting the interview.

We talked shop with them all as part of our work, but we noticed a palpable shift in atmosphere when we put aside the business of the day, laid down our *InfoWorld* notebooks, and said, “Now tell us how you got started.” And tell us they did—often at great length, and frequently with astonishing candor.

The device they gave us, this personal computer, has changed the world as profoundly as the printing press or the Industrial Revolution. And we think it’s all the more amazing when you think about how it got started.

The personal computer still exists, of course, but in an important sense its era is over. We believe the story of that era is worth remembering. This new edition of *Fire in the Valley* is our effort to keep that story—and maybe a little bit of the spirit of that time—alive.

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Acknowledgments

Our indebtedness has grown with each edition of this book. Our primary debt is to the people who lived this story and graciously granted us entry into what is in fact their personal history—through hundreds of hours of interviews and generous access to documents, records, letters, diaries, time lines, telexes, and photographs.

Among others, we are grateful to the following individuals: Scott Adams, Todd Agulnick, David Ahl, Alice Ahlgren, Bob Albrecht, Paul Allen, Dennis Allison, Bill Anderson, Bill Baker, Steve Ballmer, Rob Barnaby, John Barry, Allen Baum, John Bell, Tim Berners-Lee, Tim Berry, Ray Borrill, Stewart Brand, Dan Bricklin, Keith Britton, David Bunnell, Nolan Bushnell, Maggie Canon, David Carlick, Douglas Carlston, Mark Chamberlain, Hal Chamberlin, Roger Chapman, Alan Cooper, Sue Cooper, Ben Cooper, John Craig, Andy Cunningham, Eddie Curry, Steve Dompier, John Draper, John Dvorak, Doug Engelbart, Chris Espinosa, Gordon Eubanks, Ed Faber, Federico Faggin, Lee Felsenstein, Bill Fernandez, Todd Fischer, Richard Frank, Bob Frankston, Paul Franson, Nancy Freitas, Don French, Gordon French, Howard Fulmer, Dan Fylstra, Mark Garetz, Harry Garland, Jean-Louis Gassee, Bill Gates, Bill Godbout, John Goodenough, Chuck Grant, Wayne Green, Dick Heiser, Carl Helmers, Kent Hensheid, Andy Hertzfeld, Ted Hoff, Thom Hogan, Rod Holt, Randy Hyde, Peter Jennings, Steve Jobs, Bill Joy, Philippe Kahn, Mitch Kapor, Vinod Khosla, Guy Kawasaki, Gary Kildall, Joe Killian, Dan Kottke, Barbara Krause, Tom Lafleur, Jaron Lanier, Phil Lemons, Phil Levine, Andrea Lewis, Bill Lohse, Mel Loveland, Scott Mace, Regis McKenna, Marla Markman, Mike Markkula, Bob Marsh, Patty McCracken, Dorothy McEwen, Patrick McGovern, Scott McNealy, Roger Melen, Seymour Merrin, Edward Metro, Vanessa Mickan, Jill Miller, Dick Miller, Michael Miller, Fred Moore, Gordon Moore, Lyall Morrill, George Morrow, Jeanne Morrow, Theodor Holm Nelson, Robert Noyce, Tom and Molly O'Neill, Terry Opdendyk, Adam Osborne, Chuck Peddle, Harvard Pennington, Joel Pitt, Fred "Chip" Poode, Frank and Susan Raab, Jeff Raikes, Janet Ramusack, Jef Raskin, Ed Roberts, Roy Robinson, Tom Rolander, Phil Roybal, Seymour Rubinstein, Sue Runfola, Chris Rutkowski, Paul Saffo, Art Salsberg, Wendell Sanders, Ed Sawicki, Joel Schwartz, John Sculley, Jon Shirley, John Shoch, Richard Shoup, Michael Shrayer, Bill Siler, Les Solomon, Deborah Stapleton, Alan Stein, Barney Stone, Don Tarbell, George Tate, Paul Terrell, Larry Tesler, Glenn Theodore, John Torode, Jack Tramiel, Bruce Van Natta, Jim Warren, Larry Weiss, Randy Wigginton, Margaret Wozniak, Steve Wozniak, Larry Yaeger, Greg Yob, and Pierluigi Zappacosta.

Thanks to Steven Haft, producer of *Pirates of Silicon Valley*, for seeing the movie possibilities in the book.

We also benefited from discussions with and comments from many knowledgeable friends and colleagues. Our friends Eva Langfeldt and John Barry read our initial proposal; Dave Needle provided timely research assistance; Thom Hogan initially prodded us to do the book and offered many useful suggestions; Dan McNeill often found just the right word; Nancy Groth brought grace with a red pencil; Nelda Cassuto offered sweet support in the form of zabaglione and editing; Levi Thomas and Laura Brisbee lent photographic expertise; Amy Hyams provided patient research and friendly conversation; Carol Moran opened secret doors; Scott Kildall gave his trust; John Markoff provided knowledge, insight, and friendship and wrote the foreword; Jason Lewis shared software wizardry; David Reed made corrections from his kitchen on the other coast; Charlie Athanas provided timely and generous insights; former colleagues Judy Canter, Phil Bronstein, and Richard Paoli of the *San Francisco Examiner* opened photo archives; Howard Bailen gave endless and persistent support.

For this third edition we chose to work with The Pragmatic Programmers, and this is the place for a big thank-you to our stalwart editor Brian Hogan, incomparable production manager Janet Furlow, invaluable managing editor Susannah Pfalzer, and keen-eyed copyeditor Candace Cunningham, as well as publishers Dave Thomas and Andy Hunt for creating a great company to work with and for publishing the best technical books today.

On a most personal note, there are some special people who gave their love and support and sacrificed to help make this book possible: Nancy Groth, Jeanne L. Freiberger, Edan Freiberger, and Max Freiberger.

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Your Own Computer

In the late 1960s, just outside Seattle, a group of teenagers met after school each day to go to work. They arrived just as C Cubed closed for the day and its real employees began heading home. The kids thought of themselves as the firm's unofficial night shift. They had unfettered access to the company's DEC minicomputer, and they made full use of it.

The two leaders of the group were obsessed with computers. None of them were getting paid, but Paul, a soft-spoken 15-year-old, would have paid for the chance to get his hands on that computer. Like his friend Bill, who was 13 and looked even younger, Paul desperately wanted a computer of his very own. This after-hours time with the DEC machine was the closest they could come to that for now.

Computer Center Corporation, which the boys called C Cubed, was more than happy to have them hack away on that computer. According to its contract with Digital Equipment Corporation (DEC), as long as C Cubed could show that DEC's programs had bugs, the firm didn't have to start paying for the computer. The kids were finding bugs and postponing the day when C Cubed would have to pay its bill.

DEC's arrangement with C Cubed was a common one at the time for tracking down subtle bugs in complex programs. The DEC software was new and intricate, so everyone knew it would have at least a few errors. But the kids discovered hundreds, and young Bill found more than anyone. The Problem Report Book, as the boys entitled their bug journal, grew and grew and grew, to 300 pages. Finally, DEC called a halt to the proceedings. As Bill later recalled, DEC told C Cubed, "These guys are going to find bugs forever."

Paul Allen and Bill Gates stayed on with C Cubed for months after the other boys lost interest, eventually getting paid for their work. They were privileged—and they knew it. Few teenagers at the time had ever seen, much less programmed, a computer.

Computers in the 1960s were massive. Even the smallest "minicomputers," the kind built by DEC, were refrigerator-sized. And computers were expensive. Only government agencies, universities, and big businesses could afford to own a computer. And they were obscure and sinister, typically operated by a white-coated "priesthood" of specially trained operators and programmers using this mysterious private language. In the 1960s computers were widely regarded as a dehumanizing tool of the bureaucracy, especially by the young.

But not by everyone. There were a few technically minded young people—the nerds, the math majors, the ones who ran the audio-visual equipment for their high schools—who were fascinated by computer technology. Kids like Paul and Bill. Hacking on the C Cubed machine to themselves those evenings, they dreamed of a day when they could actually *own their own computers*. "It's going to happen," Paul would tell Bill.

It did happen, of course. And more has happened than those gifted teenagers, or anyone else back then, could possibly have imagined. Essentially nonexistent before 1974, personal computers quickly became ubiquitous in offices, homes, laboratories, and schools, on airplanes, and at the beach. Computers came to sit on every desktop and ride in every briefcase. They replaced the typewriter, calculator, physical accounting system, spreadsheet, telephone, library, drafting board, theater, tutor, and toy. Connected to the Internet, they opened access to an instant postal system and a dazzling, worldwide array of information, entertainment, and commerce. The personal computer brought about a revolution.

And its very genesis was revolutionary, because the personal computer did not arise from expensive, well-equipped labs staffed by an army of research and development specialists. It began outside the corporate and academic establishment, built by hackers and hobbyists and seat-of-their-pants entrepreneurs like Bill Gates, Paul Allen, Lee Felsenstein, Alan Cooper, Steve Dompier, Gary Kildall, Gordon Eubanks, Steve Jobs, and Steve Wozniak working after hours in garages, basements, and bedrooms.

These revolutionaries fueled the revolution using their own fascination with this technology. Their story is as strange and remarkable as any in modern business. It is a tale of overnight millionaires bewildered by their sudden success, populist engineers holed up in garages soldering together machines that would change lives, manufacturers afflicted with consumerism, consumers who accepted buggy toys of limited capacity for the thrill of being part of a new thing, and a spirit of sharing hard-won technical insights—a spirit rare in any industry but essential for the creation of the personal computer.

Like any story, this one has an end. The fire of the revolution that the personal computer ignited continues to spread, but new technologies and devices are at the center of our new digital world. The personal computer—the box on your desk or lap that can you employ for all the infinite uses of a computer—is just one of many smart devices in your life, and probably not the most important of them. And the particular culture that created the personal computer—that mixture of '60s radicalism, entrepreneurship, and technical nerdiness, and that impossible yearning to own *your own computer*—that's history now.

This is the history of that culture and that revolution.

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Chapter 1

Tinder for the Fire

> *I think there is a world market for maybe five computers.*
>
> *Thomas Watson, chairman of IBM*

The personal computer sprang to life in the mid-1970s, but its historical roots reach back to the giant electronic brains of the 1950s, and well before that to the thinking machines of 19th-century fiction.

Steam

I wish to God these calculations had been executed by steam.

–Charles Babbage, 19th-century inventor

Intrigued by the changes being wrought by science, the poets Lord Byron and Percy Bysshe Shelley idled away one rainy summer day in Switzerland discussing artificial life and artificial thought, wondering whether “the component parts of a creature might be manufactured, brought together, and endued with vital warmth.” On hand to take mental notes of their conversation was Mary Wollstonecraft Shelley, Percy’s wife and author of the novel *Frankenstein*. She expanded on the theme of artificial life in her famous novel.

Mary Shelley’s monster presented a genuinely disturbing allegory to readers of the Steam Age. The early part of the 19th century introduced the age of mechanization, and the main symbol of mechanical power was the steam engine. It was then that the steam engine was first mounted on wheels, and by 1825 the first public railway was in operation. Steam power held the same sort of mystique that electricity and atomic power would have in later generations.

The Steampunk Computer

In 1833, when British mathematician, astronomer, and inventor Charles Babbage spoke of executing calculations by steam and then actually designed machines that he claimed could mechanize calculation, even mechanize thought, many saw him as a real-life Dr. Frankenstein. Although he never implemented his designs, Babbage was no idle dreamer; he worked on what he called his Analytical Engine, drawing on the most advanced thinking in logic and mathematics, until his death in 1871. Babbage intended that the machine would free people from repetitive and boring mental tasks, just as the new machines of that era were freeing people from physical drudgery.

Figure 1. Charles Babbage ***The 19th-century mathematician and inventor designed a machine to "mechanize thought" 100 years before the first computers were successfully built.***
(Courtesy of The Computer Museum History Center, San Jose)

Babbage's colleague, patroness, and scientific chronicler was Augusta Ada Byron, daughter of Lord Byron, pupil of algebraist Augustus De Morgan, and the future Lady Lovelace. A writer herself and an amateur mathematician, Ada was able, through her articles and papers, to explain Babbage's ideas to the more educated members of the public and to potential patrons among the British nobility. She also wrote sets of instructions that told Babbage's Analytical Engine how to solve advanced mathematical problems. Because of this work, many regard Ada as the first computer programmer. The US Department of Defense recognized her role in anticipating the discipline of computer programming by naming its Ada programming language after her in the early 1980s.

No doubt thinking of the public’s fear of technology that Mary Shelley had tapped into with *Frankenstein*, Ada figured she’d better reassure her readers that Babbage’s Analytical Engine did not actually think for itself. She assured them that the machine could only do what people instructed it to do. Nevertheless, the Analytical Engine was very close to being a true computer in the modern sense of the word, and “what people instructed it to do” really amounted to what we today call computer programming.

The Analytical Engine that Babbage designed would have been a huge, loud, outrageously expensive, beautiful, gleaming, steel-and-brass monster. Numbers were to be stored in registers composed of toothed wheels, and the adding and carrying over of numbers was done through cams and ratchets. It was supposed to be capable of storing up to 1,000 numbers with a limit of 50 digits each. This internal storage capacity would be described today in terms of the machine’s memory size. By modern standards, the Analytical Engine would have been absurdly slow—capable of less than one addition operation per second—but it actually had more memory than the first useful computers of the 1940s and 1950s and the early microcomputers of the 1970s.

Figure 2. Ada Byron, Lady Lovelace ***Ada Byron (1815–1852) promoted and programmed Babbage's Analytical Engine, predicting that machines like it would one day do remarkable things such as compose music.*** **(Courtesy of John Murray Publishers Ltd.)**

Although he came up with three separate, highly detailed plans for his Analytical Engine, Babbage never constructed that machine, nor his simpler but also enormously ambitious Difference Engine. For more than a century, it was thought that the machining technology of his time was simply inadequate to produce the thousands of precision parts that the machines required. Then in 1991, Doron Swade, senior curator of computing for the Science Museum of London, succeeded in constructing Babbage's Difference Engine using only the technology, techniques, and materials available to Babbage in his time. Swade's achievement revealed the great irony of Babbage's life. A century before anyone would attempt the task again, he had succeeded in designing a computer. His machines would, in fact, have worked, and could have been built. The reasons for Babbage's failure to carry out his dream all have to do with his inability to get sufficient funding, due largely to his propensity for alienating those in a position to provide it.

If Babbage had been less confrontational or if Lord Byron's daughter had been a wealthier woman, there may have been an enormous steam-engine computer belching clouds of logic over Dickens's London, balancing the books of some real-life Scrooge, or playing chess with Charles Darwin or another of Babbage's celebrated intellectual friends. But—as Mary Shelley had predicted—electricity turned out to be the force that would bring the thinking machine to life.

The computer would marry electricity with logic.

Calculating Machines

Across the Atlantic, the American logician Charles Sanders Peirce was lecturing on the work of George Boole, the fellow who gave his name to Boolean algebra. In doing so, Peirce brought symbolic logic to the United States and radically redefined and expanded Boole's algebra in the process. Boole had brought logic and mathematics together in a particularly cogent way, and Peirce probably knew more about Boolean algebra than anyone else in the mid-19th century.

But Peirce saw more. He saw a connection between logic and electricity.

By the 1880s, Peirce figured out that Boolean algebra could be used as the model for electrical switching circuits. The true/false distinction of Boolean logic mapped exactly to the way current flowed through the on/off switches of complex electrical circuits. Logic, in other words, could be represented by electrical circuitry. Therefore, electrical calculating machines and logic machines could, in principle, be built. They were not merely the fantasy of a novelist. They could—and would—happen.

One of Peirce's students, Allan Marquand, actually designed (but did not build) an electric machine to perform simple logic operations in 1885. The switching circuit that Peirce explained how to use to implement Boolean algebra in electric circuitry is one of the fundamental elements of a computer. The unique feature of such a device is that it manipulates information, as opposed to electrical currents or locomotives.

The substitution of electrical circuitry for mechanical switches made possible smaller computing devices. In fact, the first electric logic machine ever made was a portable device built by Benjamin Burack, which he designed to be carried in a briefcase. Burack's logic machine, built in 1936, could process statements made in the form of syllogisms. For example, given "All men are mortal; Socrates is a man," it would then accept "Socrates is mortal" and reject "Socrates is a woman." Such erroneous deductions closed circuits and lit up the machine's warning lights, indicating the logical error committed.

Burack's device was a special-purpose machine with limited capabilities. Nevertheless, most of the special-purpose computing devices built around that time dealt with only numbers, and not logic. Back when Peirce was working out the connection between logic and electricity, Herman Hollerith was designing a tabulating machine to compute the US census of 1890.

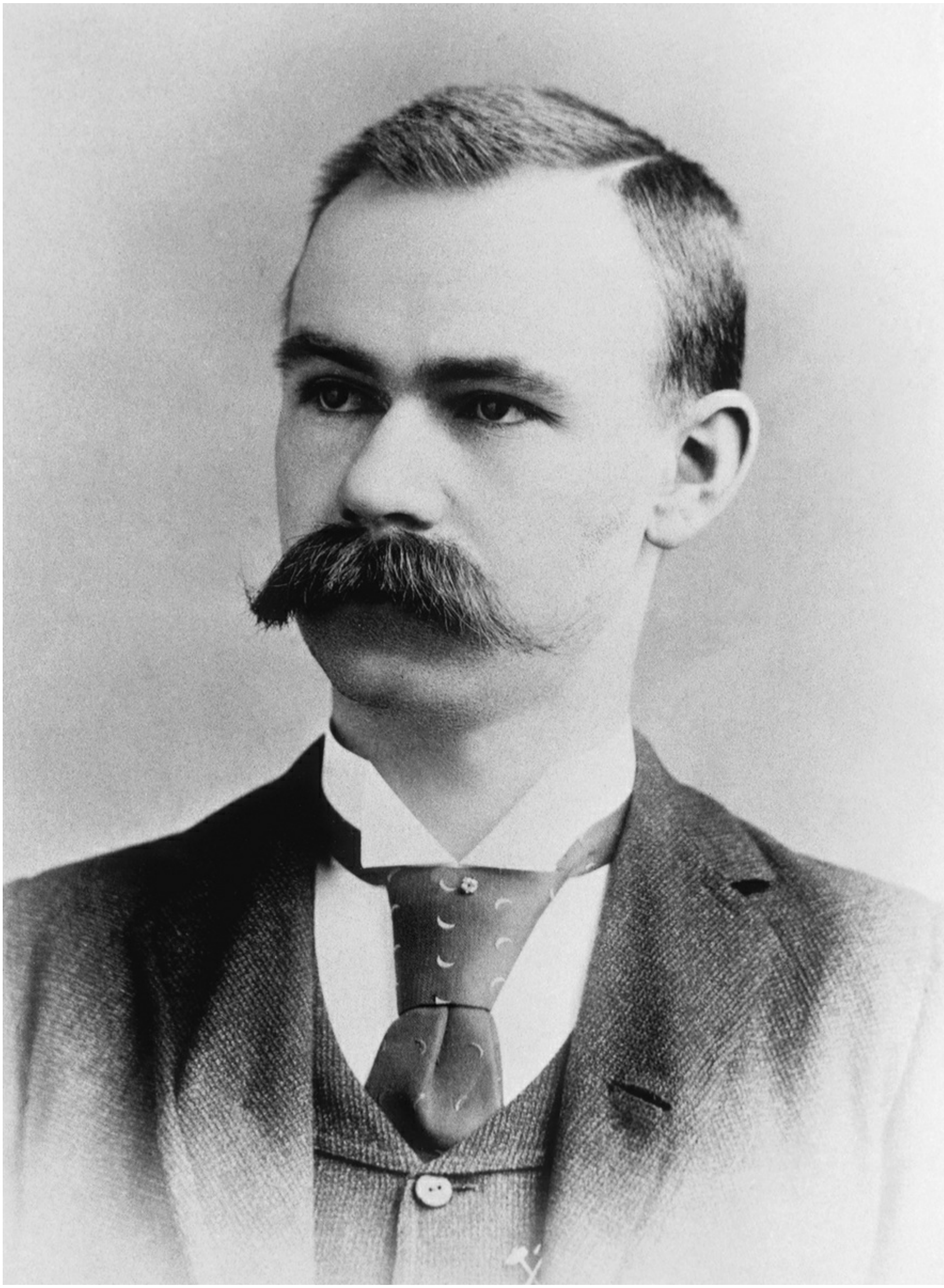

Figure 3. Hermann Hollerith ***Hollerith invented the first large-scale data-processing device, which was successfully used to compute the 1890 census. His work created the data-processing industry.*** **(Courtesy of IBM Archives)**

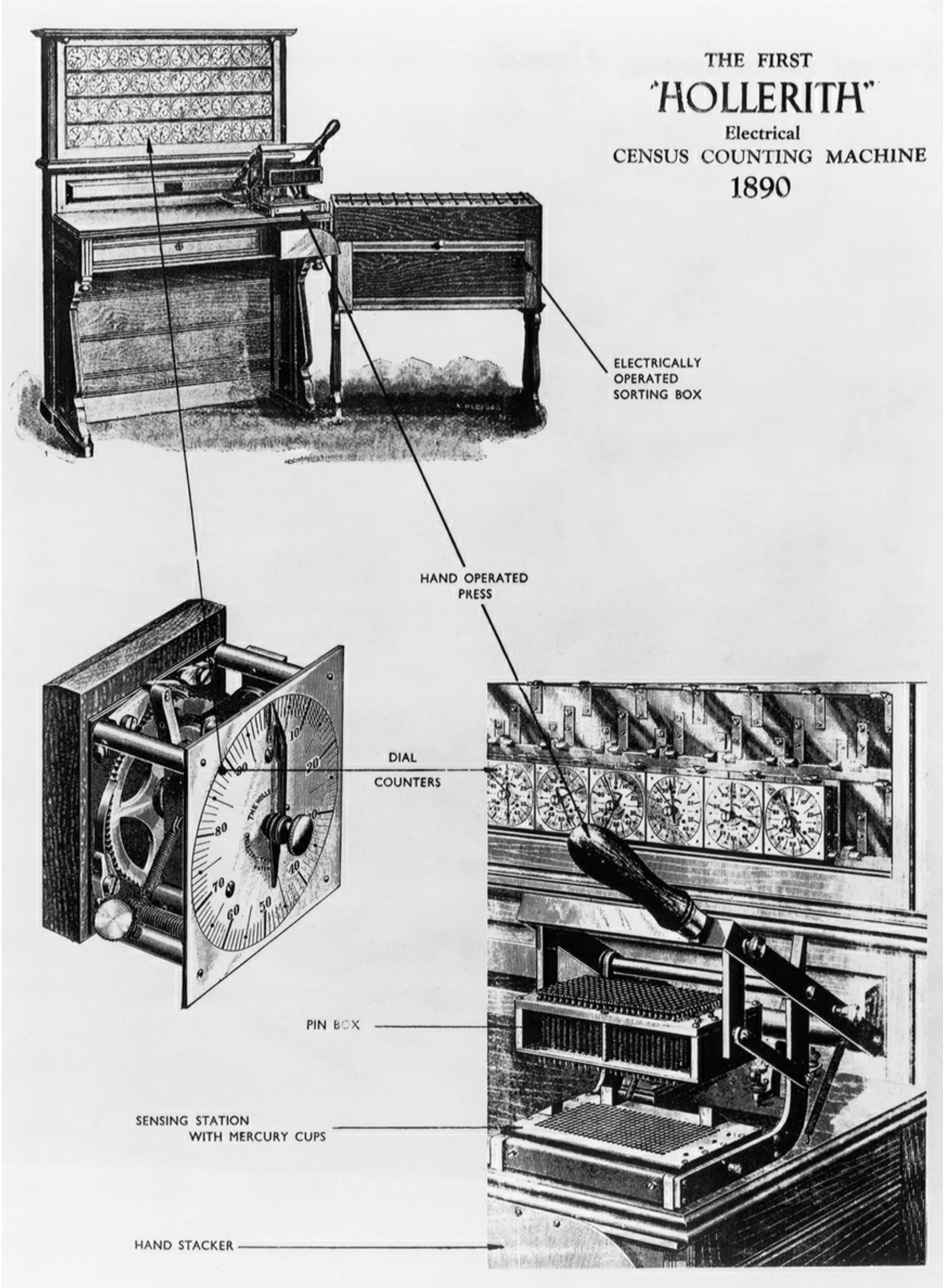
THE FIRST
"HOLLERITH"
Electrical
CENSUS COUNTING MACHINE
1890
ELECTRICALLY
OPERATED
SORTING BOX
HAND OPERATED
PRESS
DIAL
COUNTERS
PIN BOX
SENSING STATION
WITH MERCURY CUPS
HAND STACKER

Figure 4. Hollerith Census Counting Machine ***Hollerith's Census Counting Machine cut the time for computing the 1890 census by an order of magnitude.*** **(Courtesy of IBM Archives)**

Hollerith's company was eventually absorbed by an enterprise that came to be called the International Business Machines Corporation. By the late 1920s, IBM was making money selling special-purpose calculating machines to businesses, enabling those businesses to automate routine numerical tasks. But the IBM machines weren't computers, nor were they logic machines like Burack's. They were just big, glorified calculators.

The Birth of the Computer

Spurred by Claude Shannon's PhD thesis at MIT, which explained how electrical switching circuits could be used to model Boolean logic (as Peirce had foreshadowed 50 years earlier), IBM executives agreed in the 1930s to finance a large computing machine based on electromechanical relays. Although they later regretted it, IBM executives gave Howard Aiken, a Harvard professor, the then-huge sum of $500,000 to develop the Mark I, a calculating device largely inspired by Babbage's Analytical Engine. Babbage, though, had designed a purely mechanical machine. The Mark I, by comparison, was an electromechanical machine with electrical relays serving as the switching units and banks of relays serving as space for number storage. Calculation was a noisy affair; the electrical relays clacked open and shut incessantly. When the Mark I was completed in 1944, it was widely hailed as the electronic brain of science-fiction fame made real. But IBM executives were less than pleased when, as they saw it, Aiken failed to acknowledge IBM's contribution at the unveiling of the Mark I. And IBM had other reasons to regret its investment. Even before work began on the Mark I device, technological developments elsewhere had made it obsolete.

Figure 5. Thomas J. Watson, Sr. ***Watson went to work for Hollerith's pioneering data-processing firm in 1914 and later turned it into IBM.*** **(Courtesy of IBM Archives)**

Electricity was making way for the emergence of electronics. Just as others had earlier replaced Babbage's steam-driven wheels and cogs with electrical relays, John Atanasoff, a professor of mathematics and physics at Iowa State College, saw how electronics could replace the relays. Shortly before the American entry into World War II, Atanasoff, with the help of Clifford Berry, designed the ABC, the Atanasoff-Berry Computer, a device whose switching units were to be vacuum tubes rather than relays.

This substitution was a major technological advance. Vacuum-tube machines could, in principle, do calculations considerably faster and more efficiently than relay machines. The ABC, like Babbage's Analytical Engine, was never completed, probably because Atanasoff got less than $7,000 in grant money to build it. Atanasoff and Berry did assemble a simple prototype, a mass of wires and tubes that resembled a primitive desk calculator. But by using tubes as switching elements, Atanasoff greatly advanced the development of the computer. The added efficiency of vacuum tubes over relay switches would make the computer a reality.

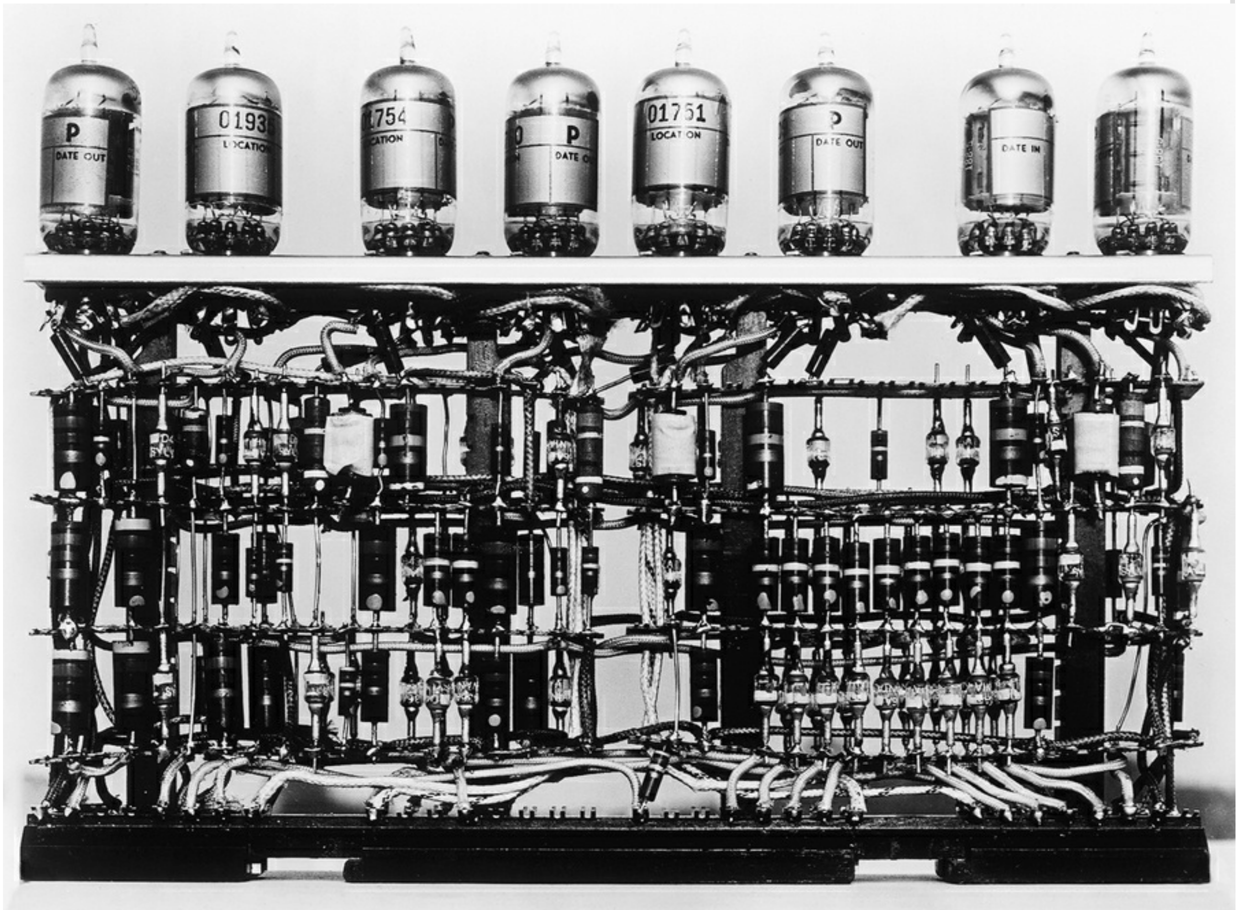

Figure 6. Vacuum tubes ***In the 1950s computers were filled with vacuum tubes, such as these from the IBM 701.*** **(Courtesy of IBM Archives)**

The vacuum tube is a glass tube with the air removed. Thomas Edison discovered that electricity travels through the vacuum under certain conditions, and Lee de Forest turned vacuum tubes into electrical switches using this “Edison effect.” In the 1950s, vacuum tubes were used extensively in electronic devices from televisions to computers. Today you can still see the occasional tube-based computer display or television.

By the 1930s, the advent of computing machines was apparent. It also seemed that computers were destined to be huge and expensive special-purpose devices. It took decades before they became much smaller and cheaper, but they were already on their way to becoming more than special-purpose machines.

It was British mathematician Alan Turing who envisioned a machine designed for no other purpose than to read coded instructions for any describable task and to follow the instructions to complete the task. This was truly something new under the sun. Because it could perform any task described in the instructions, such a machine would be a true general-purpose device.

Perhaps no one before Turing had ever entertained an idea this large. But within a decade, Turing's visionary idea became reality. The instructions became programs, and his concept, in the hands of another mathematician, John von Neumann, became the general-purpose computer.

Most of the work that brought the computer into existence happened in secret laboratories during World War II. That's where Turing was working. In the US in 1943, at the Moore School of Electrical Engineering in Philadelphia, John Mauchly and J. Presper Eckert proposed the idea for a computer. Shortly thereafter they were working with the US military on ENIAC (Electronic Numerical Integrator and Computer), which would be the first all-electronic digital computer. With the exception of the peripheral machinery it needed for information input and output, ENIAC was purely a vacuum-tube machine.

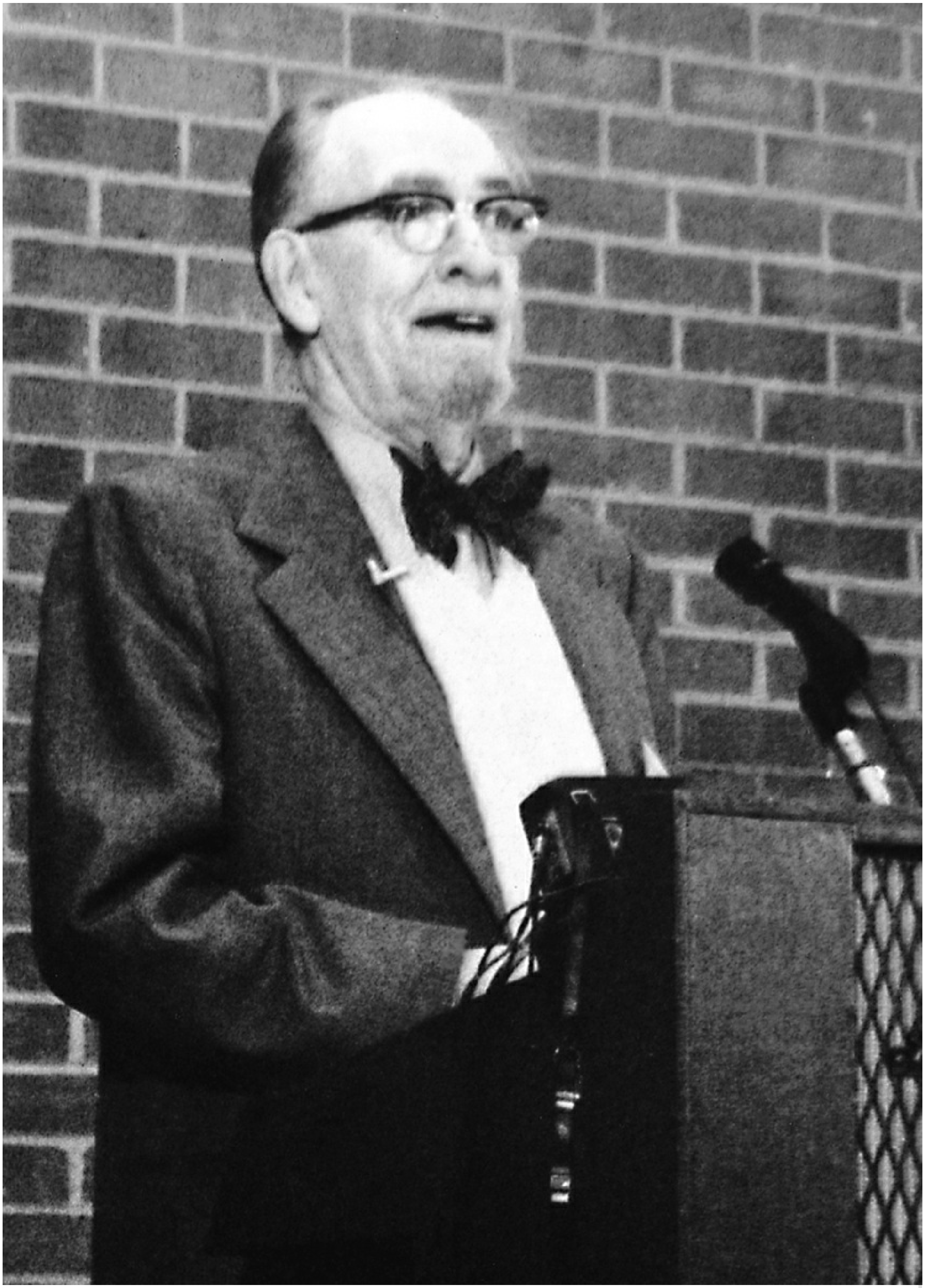

Figure 7. John Mauchly ***Mauchly, cocreator of ENIAC, is seen here speaking to early personal-computer enthusiasts at the 1976 Atlantic City Computer Festival.*** **(Courtesy of David H. Ahl)**

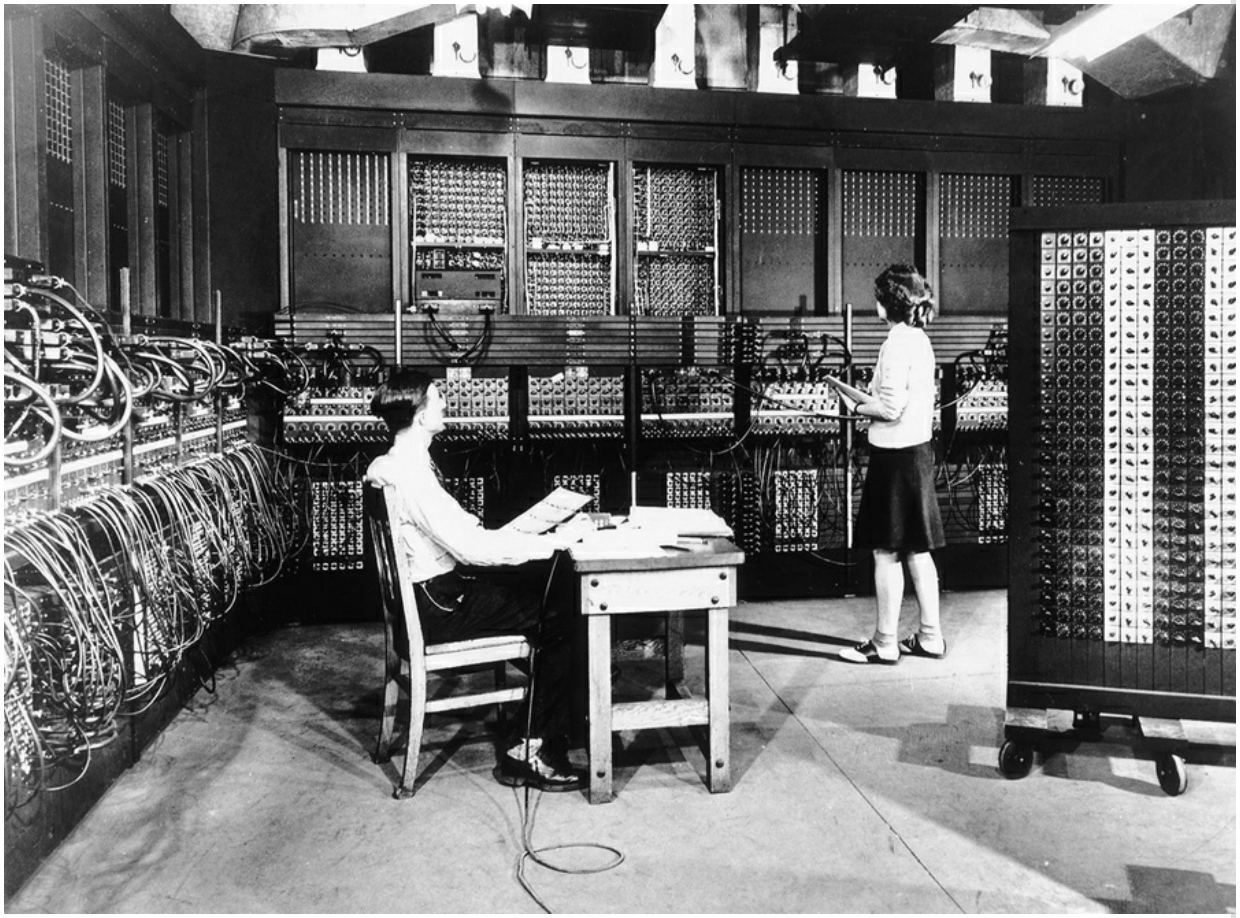

Figure 8. ENIAC ***The first all-electronic digital computer was completed in December 1945.*** **(Courtesy of IBM Archives)**

Credit for inventing the electronic digital computer is disputed, and perhaps ENIAC was based in part on ideas Mauchly hatched during a visit to John Atanasoff. But ENIAC was real. Mauchly and Eckert attracted a number of bright mathematicians to the ENIAC project, including the brilliant John von Neumann. Von Neumann became involved with the project and made various–and variously reported–contributions to building ENIAC, and in addition offered an outline for a more sophisticated machine called EDVAC (Electronic Discrete Variable Automatic Computer).

Because of von Neumann, the emphasis at the Moore School swung from technology to logic. He saw EDVAC as more than a calculating device. He felt that it should be able to perform logical as well as arithmetic operations and be able to operate on coded symbols. Its instructions for operating on—and interpreting—the symbols should themselves be symbols coded into the machine and operated on. This was the last fundamental insight in the conception of the modern computer. By specifying that EDVAC should be programmable by instructions that were themselves fed to the machine as data, von Neumann created the model for the stored-program computer.

After World War II, von Neumann proposed a method for turning ENIAC into a programmable computer like EDVAC, and Adele Goldstine wrote the 55-operation language that made the machine easier to operate. After that, no one ever again used ENIAC in its original mode of operation.

When development on ENIAC was finished in early 1946, it ran 1,000 times faster than its electromechanical counterparts. But electronic or not, it still made noise. ENIAC was a room full of clanking Teletype machines and whirring tape drives, in addition to the walls of relatively silent electronic circuitry. It had 20,000 switching units, weighed 30 tons, and burned 150,000 watts of energy. Despite all that electrical power, at any given time ENIAC could handle only 20 numbers of 10 decimal digits each. But even before construction was completed on ENIAC, it was put to significant use. In 1945, it performed calculations used in the atomic-bomb testing at Los Alamos, New Mexico.

Figure 9. John von Neumann ***Von Neumann was a brilliant polymath who made foundational contributions to programming and the ENIAC and EDVAC computers.*** **(Courtesy of The Computer Museum History Center, San Jose)**

A new industry emerged after World War II when the secret labs began to disclose their discoveries and creations. Building computers immediately became a business, and by the very nature of the equipment, it became a big business. With the help of engineers John Mauchly and J. Presper Eckert, who were fresh from their ENIAC triumph, the Remington Typewriter Company became Sperry Univac. For a few years, the name Univac was synonymous with computers, just as the name Kleenex came to be synonymous with facial tissues. Sperry Univac had some formidable competition. IBM executives recovered from the disappointment of the Mark I and began building general-purpose computers. The two companies developed distinctive operating styles: IBM was the land of blue pinstripe suits, whereas the halls of Sperry Univac were filled with young academics in sneakers. Whether because of its image or its business savvy, before long IBM took the industry-leader position away from Sperry Univac.

Soon most computers were IBM machines, and the company’s share of the market grew with the market itself. Other companies emerged, typically under the guidance of engineers who had been trained at IBM or Sperry Univac. Control Data Corporation (CDC) in Minneapolis spun off from IBM, and soon computers were made by Honeywell, Burroughs, General Electric, RCA, and NCR. Within a decade, eight companies came to dominate the growing computer market, but with IBM so far ahead of the others in revenues, they were often referred to as Snow White (IBM) and the Seven Dwarfs.

But IBM and the other seven were about to be taught a lesson by some brash upstarts. A new kind of computer emerged in the 1960s—smaller, cheaper, and referred to, in imitation of the then-popular miniskirt, as the minicomputer. Among the most significant companies producing smaller computers were Digital Equipment Corporation (DEC) in the Boston area and Hewlett-Packard (HP) in Palo Alto, California. The computers these companies were building were general-purpose machines in the Turing--von Neumann sense, and they were getting more compact, more efficient, and more powerful. Soon, advances in core computer technology would allow even more impressive advances in computer power, efficiency, and miniaturization.

The Breakthrough

Inventing the transistor meant the fulfillment of a dream.

–Ernest Braun and Stuart MacDonald, *Revolution in Miniature*

In the 1940s, the switching units in computers were mechanical relays that constantly opened and closed, clattering away like freight trains. In the 1950s, vacuum tubes replaced mechanical relays. But tubes were a technological dead end. They could be made only just so small, and because they generated heat, they had to be spaced a certain distance apart from one another. As a result, tubes afflicted the early computers with a sort of structural elephantiasis.

But by 1960, physicists working on *solid-state* elements introduced an entirely new component into the mix. The device that consigned the vacuum tube to the back-alley bin was the transistor, a tiny, seemingly inert slice of crystal with interesting electrical properties. The transistor was immediately recognized as a revolutionary development. In fact, John Bardeen, Walter Brattain, and William Shockley shared the 1956 Nobel Prize in physics for their work on the innovation.

The transistor was significant for more than merely making another bit of technology obsolete. Resulting from a series of experiments in the application of quantum physics, transistors changed the computer from a “giant electronic brain” that was the exclusive domain of engineers and scientists to a commodity that could be purchased like a television set. The transistor was the technological breakthrough that made both the minicomputers of the 1960s and the personal-computer revolution of the 1970s possible.

Bardeen and Brattain introduced “the major invention of the century” in 1947, two days before Christmas. But to understand the real significance of the device that came into existence that winter day in Murray Hill, New Jersey, you have to look back to research done years before.

Inventing the Transistor

In the 1940s, Bardeen and Shockley were working in apparently unrelated fields. Experiments in quantum physics resulted in some odd predictions (which were later born out) about the behavior that chemical element crystals, such as germanium and silicon, would display in an electrical field. These crystals could not be classified as either insulators or conductors, so they were simply called *semiconductors*. Semiconductors had one property that particularly fascinated electrical engineers: a semiconductor crystal could be made to conduct electricity in one direction but not in the other. Engineers put this discovery to practical use. Tiny slivers of such crystals were used to “rectify” electrical current; that is, to turn alternating current into direct current. Early radios, called crystal sets, were the first commercial products to use these crystal rectifiers.

The crystal rectifier was a curious item, a slice of mineral material that did useful work but had no moving parts: a solid-state device. But the rectifier knew only one trick. A different device soon replaced it almost entirely: Lee de Forest's triode, the vacuum tube that made radios glow. The triode was more versatile than the crystal rectifier; it could both amplify a current passing through it and use a weak secondary current to alter a strong current passing from one of its poles to the other. It was a step in the marriage of electricity and logic, and this capability to change one current by means of another would be essential to EDVAC-type computer design. At the time, though, researchers saw that the triode's main application lay in telephone switching circuits.

Naturally, people at AT&T, and especially at its research branch Bell Labs, became interested in the triode. William Shockley was working for Bell Labs at the time and looking at the effect impurities had on semiconductor crystals. Trace amounts of other substances could provide the extra electrons needed to carry electrical current in the devices. Shockley convinced Bell Labs to let him put together a team to study this intriguing development. His team consisted of experimental scientist Walter Brattain and theoretician John Bardeen. For some time the group's efforts went nowhere. Similar research was underway at Purdue University in Lafayette, Indiana, and the Bell group kept close tabs on the work going on there.

Then Bardeen discovered that an inhibiting effect on the surface of the crystal was interfering with the flow of current. Brattain conducted the experiment that proved Bardeen right, and on December 23, 1947, the transistor was born. The transistor did everything the vacuum tube did, and it did it better. It was smaller, it didn't generate as much heat, and it didn't burn out.

Integrated Circuits

Most important, the functions performed by several transistors could be incorporated into a single semiconductor device. Researchers quickly set about the task of constructing these sophisticated semiconductors. Because these devices integrated a number of transistors into a more complex circuit, they were called *integrated circuits*, or ICs. Because they essentially were tiny slivers of silicon, they also came to be called chips.

Building ICs was a complicated and expensive process, and an entire industry devoted to making them soon sprang up. The first companies to begin producing chips commercially were the existing electronics companies. One very early start-up company was Shockley Semiconductor, which William Shockley founded in 1955 in his hometown of Palo Alto. Shockley's firm employed many of the world's best semiconductor people. Some of those folks didn't stay with the company for long. Shockley Semiconductor spawned Fairchild Semiconductor, and Silicon Valley grew from this root.

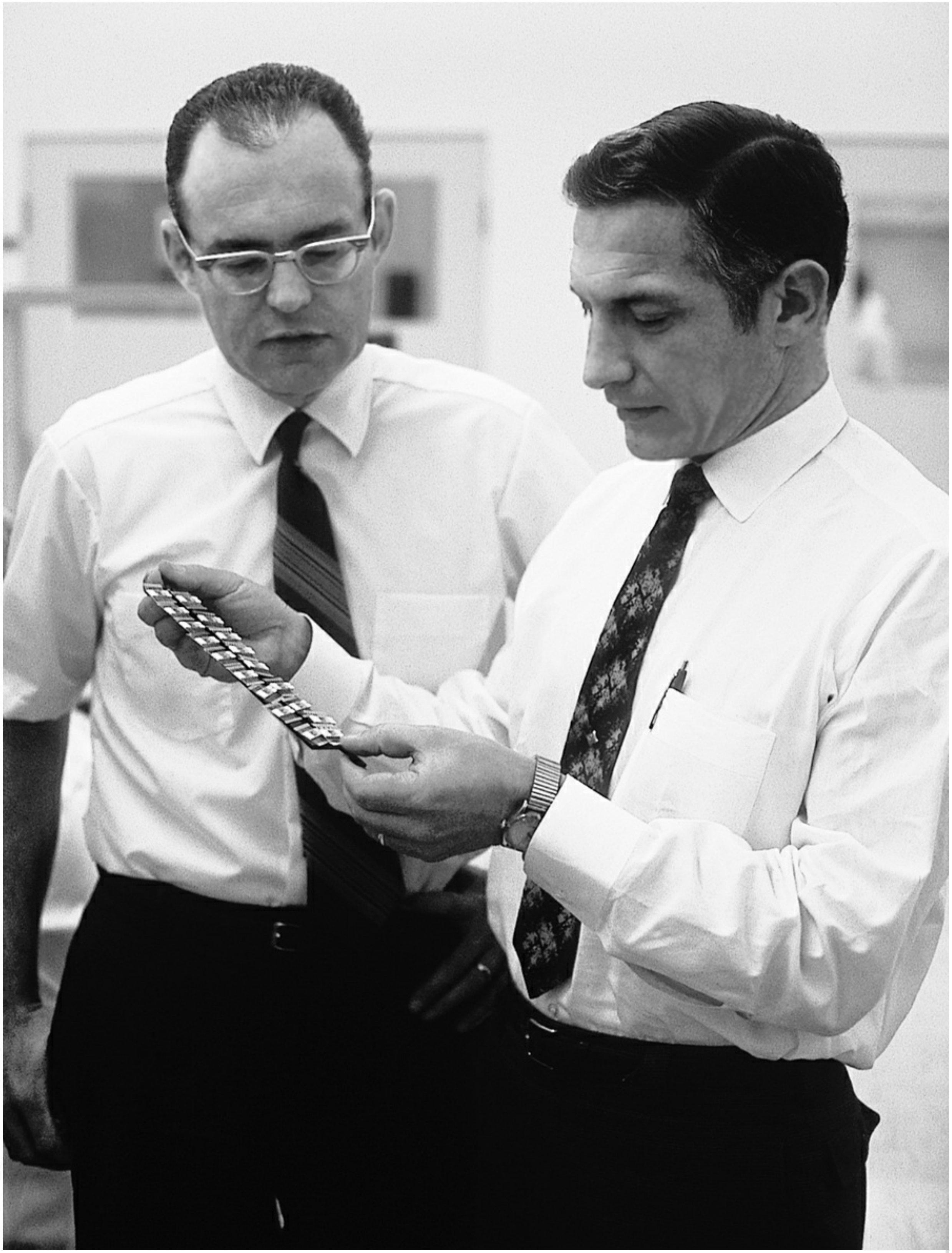

Figure 10. Gordon Moore and Robert Noyce ***Gordon Moore (left) and Robert Noyce***

founded Intel, which became the computer industry's semiconductor powerhouse. **(Courtesy of Intel)**

A decade after Fairchild was formed, virtually every semiconductor company in existence could boast a large number of former Fairchild employees. Even the big electronics companies, such as Motorola, that entered the semiconductor industry in the 1960s employed ex-Fairchild engineers. And except for some notable exceptions—RCA, Motorola, and Texas Instruments—most of the semiconductor companies were located within a few miles of Shockley's operation in Palo Alto in the Santa Clara Valley, soon to be rechristened Silicon Valley. The semiconductor industry grew with amazing speed, and the size and price of its products shrank at the same pace. Competition was fierce.

At first, little demand existed for highly complex ICs outside of the military and aerospace industries. Certain kinds of ICs, though, were in common use in large mainframe computers and minicomputers. Of paramount importance were memory chips—ICs that could store data and retain them as long as they were fed power. Memory chips were the wedge that took semiconductors mainstream.

Memory chips at the time embodied the functions of hundreds of transistors. Other ICs weren't designed to retain the data that flowed through them, but instead were programmed to change the data in certain ways in order to perform simple arithmetic or logic operations on it. Then, in the early 1970s, the runaway demand for electronic calculators led to the creation of a new and considerably more powerful computer chip.

Critical Mass

The microprocessor has brought electronics into a new era. It is altering the structure of our society.

–Robert Noyce and Marcian Hoff, Jr. “History of Microprocessor Development at Intel,” *IEEE Micro*, 1981

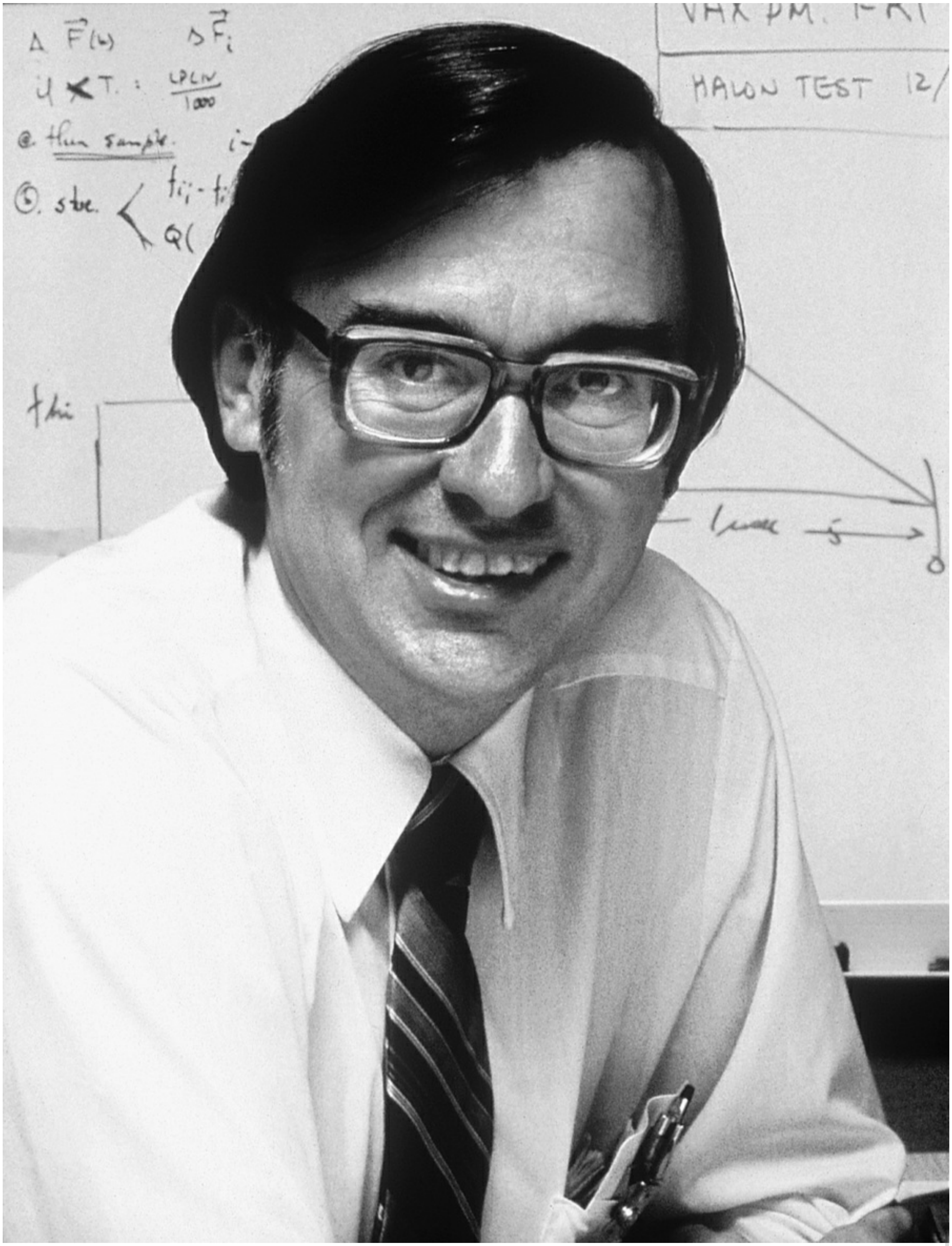

Figure 11. Ted Hoff ***Marcian "Ted" Hoff led the design effort for Intel's first microprocessor.***

(Courtesy of Intel Corp.)

In early 1969, Intel Development Corporation, a Silicon Valley semiconductor manufacturer, received a commission from a Japanese calculator company called Busicom to produce chips for a line of its calculators. Intel had the credentials: it was a Fairchild spinoff, and its president, Robert Noyce, had helped invent the integrated circuit. Although Intel had opened its doors for business only a few months earlier, the company was growing as fast as the semiconductor industry.

An engineer named Marcian “Ted” Hoff had joined Intel a few months earlier as its twelfth employee, and when he began working on the Busicom job, the company already employed 200 people. Hoff was fresh from academia. After earning a PhD, he continued as a researcher at Stanford University’s Electrical Engineering Department, where his research on the design of semiconductor memory chips led to several patents and to the job at Intel. Noyce felt that Intel should produce semiconductor memory chips and nothing else, and he had hired Hoff to dream up applications for these memory chips.

But when Busicom proposed the idea for calculator chips, Noyce allowed that taking a custom job while the company was building up its memory business wouldn’t hurt.

The 4004

Hoff was sent to meet with the Japanese engineers who came to discuss what Busicom had envisioned. Because Hoff had a flight to Tahiti scheduled for that evening, the first meeting with the engineers was brief. Tahiti evidently gave him time for contemplation, because he returned from paradise with some firm ideas about the job.

In particular, he was annoyed that the Busicom calculator would cost almost as much as a minicomputer. Minicomputers had become relatively inexpensive, and research laboratories all over the country were buying them. It was not uncommon to find two or three minicomputers in a university’s psychology or physics department.

Hoff had worked with DEC’s new PDP-8 computer, one of the smallest and cheapest of the lot, and found that it had a very simple internal setup. Hoff knew that the PDP-8, a computer, could do everything the proposed Busicom calculator could do and more, for almost the same price. To Ted Hoff, this was an affront to common sense.

Hoff asked the Intel bosses why people should pay the price of a computer for something that had a fraction of the capacity. The question revealed his academic bias and his naiveté about marketing: he would rather have a computer than a calculator, so he figured surely everyone else would, too.

The marketing people patiently explained that it was a matter of packaging. If someone wanted to do only calculations, they didn't want to have to fire up a computer to run a calculator program. Besides, most people, even scientists, were intimidated by computers. A calculator was just a calculator from the moment you turned it on. A computer was an instrument from the Twilight Zone.

Hoff followed reasoning, but still rankled at the idea of building a special-purpose device when a general-purpose one was just as easy—and no more expensive—to build. Besides, he thought, a general-purpose design would make the project more interesting (to him). He proposed to the Japanese engineers a revised design loosely based on the PDP-8.

The design's comparison to the PDP-8 computer was only partly applicable. Hoff was proposing a set of chips, not an entire computer. But one of those chips would be critically important in several ways. First, it would be dense. Chips at the time contained no more than 1,000 features—the equivalent of 1,000 transistors—but this chip would at least double that number. In addition, this chip would, like any IC, accept input signals and produce output signals. But whereas these signals would represent numbers in a simple arithmetic chip and logical values (true or false) in a logic chip, the signals entering and leaving Hoff's chip would form a set of instructions for the IC.

In short, the chip could run programs. The customers were asking for a calculator chip, but Hoff was designing an IC EDVAC, a true general-purpose computing device on a sliver of silicon. A computer on a chip. Although Hoff's design resembled a very simple computer, it left out some computer essentials, such as memory and peripherals for human input and output. The term that evolved to describe such a device was *microprocessor*, and microprocessors were general-purpose devices specifically because of their programmability.

Because the Intel microprocessor used the stored-program concept, the calculator manufacturers could make the microprocessor act like any kind of calculator they wanted. At any rate, that was what Hoff had in mind. He was sure it was possible, and just as sure that it was the right approach. But the Japanese engineers weren't impressed. Frustrated, Hoff sought out Noyce, who encouraged him to proceed anyway, and when chip designer Stan Mazor left Fairchild to come to Intel, Hoff and Mazor set to work on the design for the chip.

At that point, Hoff and Mazor had not actually produced an IC. A specialist would still have to transform the design into a two-dimensional blueprint, and this pattern would have to be etched into a slice of silicon crystal. These later stages in the chip's development cost money, so Intel did not intend to move beyond the logic-design stage without talking further with its skeptical customer.

In October 1969, Busicom representatives flew in from Japan to discuss the Intel project. The Japanese engineers presented their requirements, and in turn Hoff presented his and Mazor's design. Despite the fact that the requirements and design did not quite match, after some discussion Busicom decided to accept the Intel design for the chip. The deal gave Busicom an exclusive contract for the chips. This was not the best deal for Intel, but at least they were going ahead on the project.

Hoff was relieved to have the go-ahead. They called the chip the 4004, which was the approximate number of transistors the single device replaced and an indication of its complexity. Hoff wasn’t the only person ever to have thought of building a computer on a chip, but he was the first to launch a project that actually got carried out. Along the way, he and Mazor solved a number of design problems and fleshed out the idea of the microprocessor more fully. But there was a big distance between planning and execution.

Leslie Vadasz, the head of a chip-design group at Intel, knew who he wanted to implement the design: Federico Faggin. Faggin was a talented chip designer who had worked with Vadasz at Fairchild and had earlier built a computer for Olivetti in Italy. The problem was, Faggin didn’t work at Intel. Worse, he couldn’t work at Intel, at least not right away: in the United States on a work visa, he was constrained in his ability to change jobs and still retain his visa. The earliest he would be available was the following spring. The clock ticked and the customer grew frustrated.

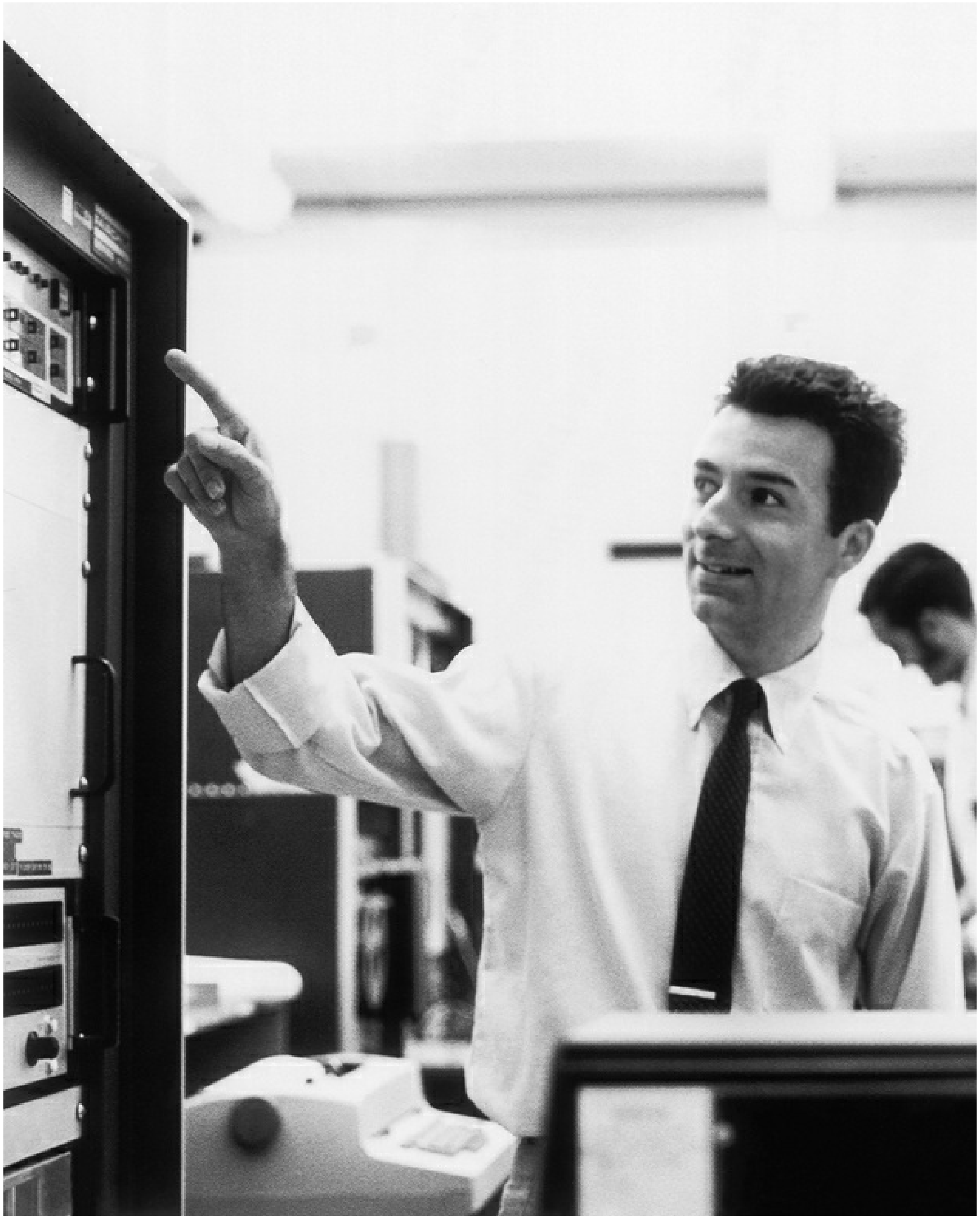

Figure 12. Federico Faggin ***Faggin was one of the inventors of the microprocessor at Intel, and founded Zilog.*** **(Courtesy of Federico Faggin)**

When Faggin finally arrived at Intel in April 1970, he was immediately assigned to implement the 4004 design. Masatoshi Shima, an engineer for Busicom, was due to arrive to examine and approve the final design, and Faggin would set to work turning it into silicon.

Unfortunately, the design was far from complete. Hoff and Mazor had completed the instruction set for the device and an overall design, but the necessary detailed design was nonexistent. Shima understood immediately that the “design” was little more than a collection of ideas. “This is just idea!” he shouted at Faggin. “This is nothing! I came here to check, but there is nothing to check!”

Faggin confessed that he had only arrived recently, and that he was going to have to complete the design before starting the implementation. With help from Mazor and Shima, who extended his stay to six months, he did the job in a remarkably short time, working 12-to-16-hour days. Since he was doing something no one had ever done before, he found himself having to invent techniques to get the job done. In February 1971, Faggin delivered working kits to Busicom, including the 4004 microprocessor and eight other chips necessary to make the calculator work. It was a success.

It was also a breakthrough, but its value was more in what it signified than in what it actually delivered. On one hand, this new thing, the microprocessor, was nothing more than an extension of the IC chips for arithmetic and logic that semiconductor manufacturers had been making for years. The microprocessor merely crammed more functional capability onto one chip. Then again, there were so many functions that the microprocessor could perform, and they were integrated with each other so closely that using the device required learning a new language, albeit a simple one. The instruction set of the 4004, for all intents and purposes, constituted a programming language.

Today’s microprocessors are more complex and powerful than the roomful of circuitry that constituted a computer in 1950. The 4004 chip that Hoff conceived in 1969 was a crude first step toward something that Hoff, Noyce, and Intel management could scarcely anticipate. The 8008 chip that Intel produced two years later was the second crucial step.

The 8008

The 8008 microprocessor was developed for a company then called CTC—Computer Terminal Corporation—and later called Datapoint. CTC had a technically sophisticated computer terminal and wanted some chips designed to give it additional functions.

Once again, Hoff presented a grander vision of how an existing product could be used. He proposed a single-chip implementation of the control circuitry that replaced all of its internal electronics with a single integrated circuit. Hoff and Faggin were interested in the 8008 project partly because the exclusive deal for the 4004 kept that chip tied up. Faggin, who was doing lab work with electronic test equipment, saw the 4004 as an ideal tool for controlling test equipment, but the Busicom deal prevented that.

Because Busicom had exclusive rights to the 4004, Hoff felt that perhaps this new 8008 terminal chip could be marketed and used with testers. The 4004 had drawbacks. It operated on only four binary digits at a time. This significantly limited its computing power because it couldn’t even handle a piece of data the size of a single character in one operation. The new 8008 could. Although another engineer was initially assigned to it, Faggin was soon put in charge of making the 8008 a reality, and by March 1972 Intel was producing working 8008 chips.

Before this happened, though, CTC executives lost interest in the project. Intel now found it had invested a great deal of time and effort in two highly complex and expensive products, the 4004 and 8008, with no mass market for either of them. As competition intensified in the calculator business, Busicom asked Intel to drop the price on the 4004 in order to keep its contract. “For God’s sake,” Hoff urged Noyce, “get us the right to sell these chips to other people.” Noyce did. But possession of that right, it turned out, was no guarantee that Intel would ever exercise it.

Intel’s marketing department was cool to the idea of releasing the chips to the general engineering public. Intel had been formed to produce memory chips, which were easy to use and were sold in volume—like razor blades. Microprocessors, because the customer had to learn how to use them, presented enormous customer-support problems for the young company. Memory chips didn’t.

Hoff countered with ideas for new microprocessor applications that no one had thought of yet. An elevator controller could be built around a chip. Besides, the processor would save money: it could replace a number of simpler chips, as Hoff had shown in his design for the 8008. Engineers would make the effort to design the microprocessor into their products. Hoff knew he himself would.

Hoff’s persistence finally paid off when Intel hired advertising man Regis McKenna to promote the product in a fall 1971 issue of *Electronic News*. “Announcing a new era in integrated electronics: a microprogrammable computer on a chip,” the ad read. A computer on a chip? Technically the claim was puffery, but when visitors to an electronics show that fall read the product specifications for the 4004, they were duly impressed by the chip’s programmability. And in one sense McKenna’s ad was correct: the 4004 (and even more the 8008) incorporated the essential decision-making power of a computer.

Programming the Chips

Meanwhile, Texas Instruments (TI) had picked up the CTC contract and delivered a microprocessor. TI was pursuing the microprocessor market as aggressively as Intel; Gary Boone of TI had, in fact, just filed a patent application for something called a single-chip computer. Three different microprocessors now existed. But Intel’s marketing department had been right about the amount of customer support the microprocessors demanded. For instance, users needed documentation on the operations the chips performed, the language they recognized, the voltage they used, the amount of heat they dissipated, and a host of other things. Someone had to write these information manuals. At Intel the job was given to an engineer named Adam Osborne, who would later play a very different part in making computers personal.

The microprocessor software formed another kind of essential customer support. A disadvantage with a general-purpose computer or processor is that it does nothing without programs. The chips, as general-purpose processors, needed programs, the instructions that would tell them what to do. To create these programs, Intel first assembled an entire computer around each of its two microprocessor chips. These computers were not commercial products but instead were development systems—tools to help write programs for the processor. They were also, although no one used this term at the time, microcomputers.

One of the first people to begin developing these programs was a professor at the Naval Postgraduate School located down the coast from Silicon Valley, in Pacific Grove, California. Like Osborne, Gary Kildall would be an important figure in the development of the personal computer.

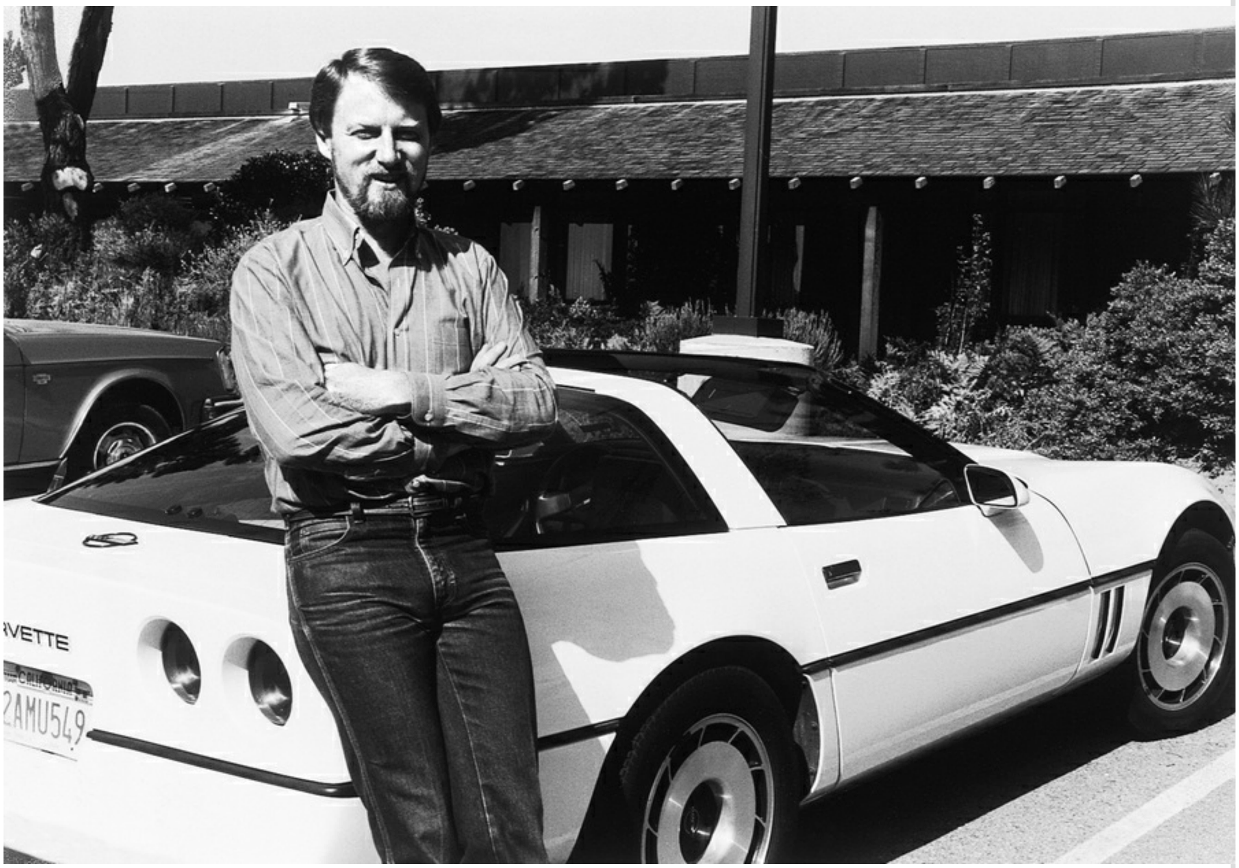

Figure 13. Gary Kildall ***Kildall wrote the first programming language for Intel's 4004 microprocessor, as well as a control program that he would later turn into the personal-computer industry's most popular operating system.*** **(Courtesy of Tom G. O'Neal)**

In late 1972, Kildall already had written a simple language for the 4004—a program that translated cryptic commands into the more cryptic ones and zeroes that formed the internal instruction set of the microprocessor. Although written for the 4004, the program actually ran on a large IBM 360 computer. With this program, one could type commands on an IBM keyboard and generate a file of 4004 instructions that could then be sent to a 4004 if a 4004 were somehow connected to the IBM machine.

Connecting the 4004 to anything at all was hardly a trivial task. The microprocessor had to be plugged into a specially designed circuit board that was equipped with connections to other chips and to devices such as a Teletype machine. The Intel development systems had been created for just this type of problem solving. Naturally, Kildall was drawn to the microcomputer lab at Intel, where the development systems were housed.

Eventually, Kildall contracted with Intel to implement a language for the chip manufacturer. PL/M (Programming Language for Microcomputers) would be a so-called high-level language, in contrast to the low-level machine language that was made up of the instruction set of the microprocessor. With PL/M, one could write a program once and have it run on a 4004 processor, an 8008, or on future processors Intel might produce. This would speed up the programming process.

But writing the language was no simple task. To understand why, you have to think about how computer languages operate.

A computer language is a set of commands a computer can recognize. The computer only responds to that fixed set of commands incorporated into its circuitry or etched into its chips. Implementing a language requires creating a program that will translate the sorts of commands a user can understand into commands the machine can use.

The microprocessors not only were physically tiny, but also had a limited logic to work with. They got by with a minimum amount of smarts, and therefore were beastly hard to program. It was difficult to design any language for them, let alone a high-level language like PL/M. A friend and coworker of Kildall’s later explained the choice, saying that Gary Kildall wrote PL/M largely because it was a difficult task. Like many important programmers and designers before him and since, Kildall was in it primarily for the intellectual challenge.

But the most significant piece of software Kildall developed at that time was much simpler in its design.

CP/M

Intel’s early microcomputers used paper tape to store information. Therefore, programs had to enable a computer to control the paper-tape reader or paper punch automatically, accept the data electronically as the information streamed in from the tape, store and locate the data in memory, and feed the data out to the paper-tape punch. The computer also had to be able to manipulate data in memory and keep track of which spots were available for data storage and which were in use at any given moment. A lot of bookkeeping. Programmers don’t want to have to think about such picayune details every time they write a program. Large computers automatically take care of these tasks through the use of a program called an *operating system*. For programmers writing in a mainframe language, the operating system is a given; it’s a part of the way the machine works and an integral feature of the computing environment.

But Kildall was working with a primordial setup. No operating system. Like a carpenter building his own scaffolding, Kildall wrote the elements of an operating system for the Intel machines. This rudimentary operating system had to be very efficient and compact in order to operate on a microprocessor, and it happened that Kildall had the skills and the motivation to make it so. Eventually, that microprocessor operating system evolved into something Kildall called CP/M (Control Program for Microcomputers). When Kildall asked the Intel executives if they had any objections to his marketing CP/M on his own, they simply shrugged and said to go ahead. They had no plans to sell it themselves.

CP/M made Kildall a fortune and helped to launch an industry.

Intel was in uncharted waters. By building microprocessors, the company had already ventured beyond its charter of building memory chips. Although the company was not about to retreat from that enterprise, there was solid resistance to moving even farther afield. It was true that there’d been talk about designing machines around microprocessors, and even about using a microprocessor as the main component in a small computer. But microprocessor-controlled computers seemed to have marginal sales potential at best.

Wristwatches.

That was where microprocessors would find their chief market, Noyce thought. The Intel executives discussed other possible applications. Microprocessor-controlled ovens. Stereos. Automobiles. But it would be up to the customers to build the ovens, stereos, and cars; Intel would only sell the chips. There was a virtual mandate at Intel against making products that could be seen as competing against its own customers.

It made perfect sense. Intel was an exciting place to work in 1972. To Intel’s executives it felt like Intel was at the center of all things innovative, and that the microprocessor industry was going to change the world. It seemed obvious to Kildall, to Mike Markkula (the marketing manager for memory chips), and to others that the innovative designers of microprocessors should be working at the semiconductor companies. They decided to stick to putting logic on slivers of silicon and to leave the building (and programming) of computers and such devices to the mainframe and minicomputer companies.

But when the minicomputer companies didn’t take up the challenge, Markkula, Kildall, and Osborne each thought better of their decision to stick to the chip business. Within the following decade, each of them would create a multimillion-dollar personal computer or personal-computer-software company of his own.

Breakout

> *We [Digital Equipment Corporation] could have come out with a personal computer in January 1975. If we had taken that prototype, most of which was proven stuff, the PDP-8 A could have been developed and put in production in that seven- or eight-month period.*
>
> –David Ahl, former DEC employee and founder of pioneer computer magazine *Creative Computing*

By 1970, there existed two distinct kinds of computers and two kinds of companies selling them.

The room-sized mainframe computers were built by IBM, CDC, Honeywell, and the other dwarfs. These machines were designed by an entire generation of engineers, cost hundreds of thousands of dollars, and were often custom-built one at a time.

Then you had the minicomputers built by such companies as DEC and Hewlett-Packard. Relatively cheap and compact, these machines were built in larger quantities than the mainframes and sold primarily to scientific laboratories and businesses. The typical minicomputer cost one-tenth as much as a mainframe and took up no more space than a bookshelf.

Minicomputers incorporated semiconductor devices, which reduced the size of the machines. The mainframes also used semiconductor components, but they generally used them to create even more powerful machines that were no smaller in size. Semiconductor tools such as the Intel 4004 were beginning to be used to control peripheral devices, including printers and tape drives, but it was obvious to everyone concerned that the chips could also be used to shrink the computer and make it cheaper. The mainframe computer and minicomputer companies had the money, expertise, and unequaled opportunity to place computers in the hands of nearly everyone. It didn’t take a visionary to see a personal-sized computer that could fit on a desktop or in a briefcase or in a shirt pocket at the end of the path toward increased miniaturization. In the late 1960s and early 1970s, the major players among mainframe and minicomputer companies seemed the most logical candidates for producing a personal computer.

It was obvious that computer development was headed in that direction. Ever since the 1930s when Benjamin Burack was developing his “logic machine,” people had been building desktop- and briefcase-sized machines that performed computerlike functions. Computer-company engineers and designers at semiconductor companies foresaw a continuing trend of components becoming increasingly cheap, fast, and small year after year. The indicators pointed undoubtedly to the development of a small personal computer by, most likely, a minicomputer company.

It was only logical, but it didn’t happen that way. Every one of the existing computer companies passed up the chance to bring computers into the home and to every work desk. The next generation of computers, the microcomputer, was created entirely by individual entrepreneurs working outside the established corporations.

It wasn’t that the idea of a personal computer had never occurred to the decision makers at the major computer companies. Eager engineers at some of those firms offered detailed proposals for building microcomputers and even working prototypes, but the proposals were rejected and the prototypes shelved. In some cases, work actually commenced on personal-computer projects, but eventually they, too, were allowed to wither and die.

The mainframe companies apparently thought that no market existed for low-cost personal computers, and even if there were such a market, they figured it was the minicomputer companies who would exploit it. They were wrong.

Take Hewlett-Packard, a company that grew up in Silicon Valley and was producing everything from mainframe computers to pocket calculators. Senior engineers at HP studied and eventually spurned a design offered by one of their employees, an engineer without a degree named Stephen Wozniak. In rejecting his design, the HP engineers acknowledged that Wozniak’s computer worked and could be built cheaply, but they told him it was not a product for HP. Wozniak eventually gave up on his employers and built his computers out of a garage in a start-up enterprise called Apple.

Likewise, Robert (Bob) Albrecht, who worked for CDC in Minneapolis during the early 1960s, quit in frustration over the company’s unwillingness to even consider looking into the personal-computer market. After leaving CDC, he moved to the San Francisco Bay Area and established himself as a sort of computer guru. Albrecht was interested in exploring ways computers could be used as educational aids. He produced what could be called the first publication on personal computing and spread information on how individuals could learn about and use computers.

DEC

The prime example of an established computer company that failed to explore the new technology was Digital Equipment Corporation. With annual sales close to a billion dollars by 1974, DEC was the first and the largest of the minicomputer companies. DEC made some of the most compact computers available at the time. The PDP-8, which had inspired Ted Hoff to design the 4004, was the closest thing to a personal computer one could find. One version of the PDP-8 was so small that sales reps routinely carried it in the trunks of their cars and set it up at the customer’s site. In that sense, it was one of the first portable computers. DEC could have been the company that created the personal computer. The story of its failure to seize that opportunity gives some indication of the mentality in computer companies’ boardrooms during the early 1970s.

For David Ahl, the story began when he was hired as a DEC marketing consultant in 1969. By that time, he had picked up degrees in electrical engineering and business administration and was finishing up his PhD in educational psychology. Ahl came to DEC to develop its educational product line, the first product line at DEC to be defined in terms of its potential users rather than its hardware.

Figure 14. David Ahl ***Ahl left Digital Equipment Corporation in 1974 to start*** **Creative Computing** ***magazine and popularize personal computers.*** **(Courtesy of David H. Ahl)**

Four years later, responding to the recession of 1973, DEC cut back on educational-product development. When Ahl protested the cuts, he was fired. Rehired into a division of the company dedicated to developing new hardware, he soon became entirely caught up in building a computer that was smaller than any yet built. Ahl's group didn't know what to call the machine, but if it had taken off it certainly would have qualified as a personal computer.

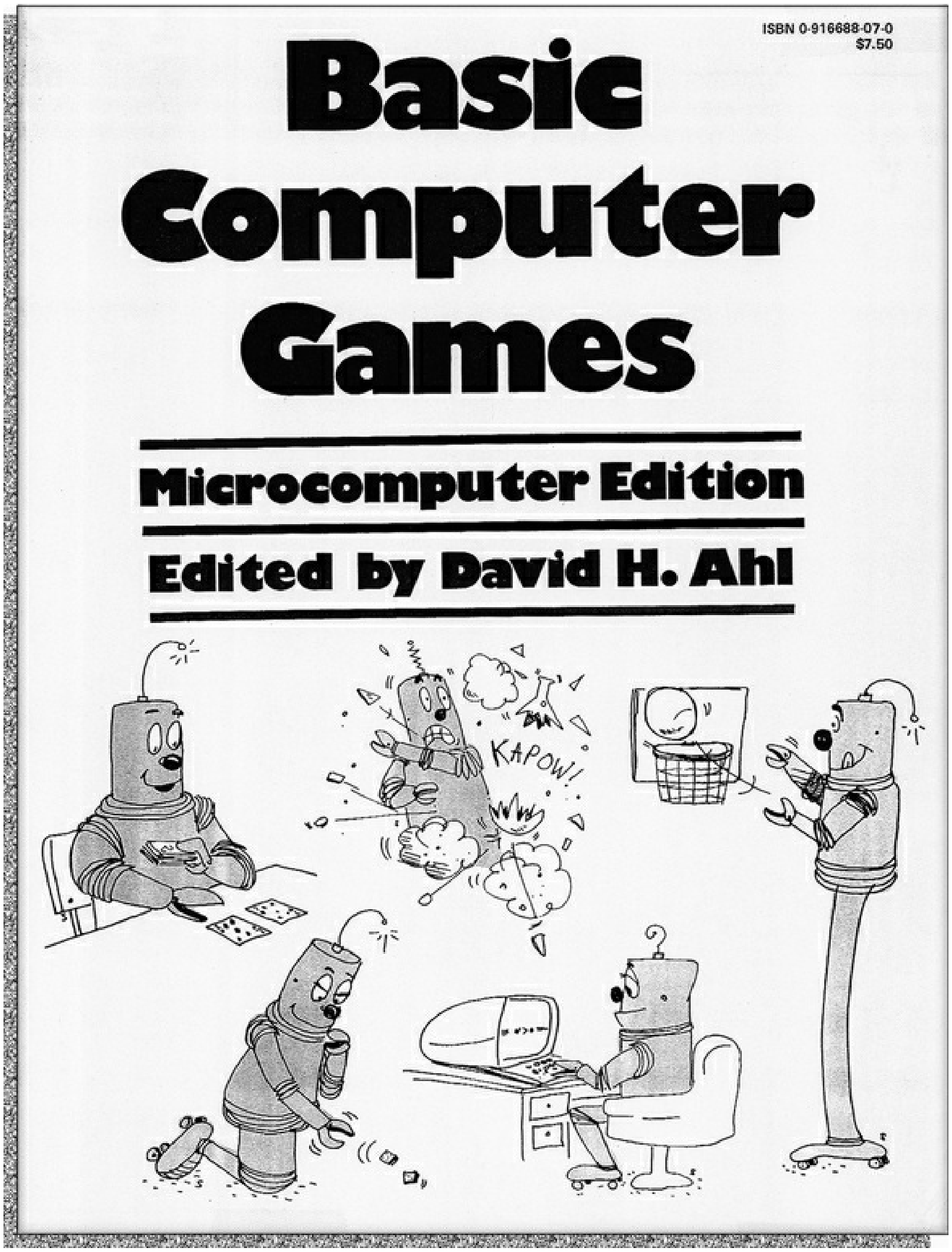

Figure 15. Basic Computer Games ***David Ahl's book*** **Basic Computer Games** ***was translated into eight languages and sold more than a million copies, playing an important role in popularizing personal computers in the late 1970s.*** **(Courtesy of David H. Ahl)**

Ahl's interests had grown somewhat incompatible with the DEC mindset. DEC viewed computers as an industrial product. "Like pig iron. DEC was interested in pushing out iron," Ahl later recalled. When he was working in DEC's educational division, Ahl wrote a newsletter that regularly published instructions for playing computer games. Ahl talked the company into publishing a book he had put together, *Basic Computer Games*. He was beginning to view the computer as an individual educational tool, and games seemed a natural part of that.

DEC wasn’t set up to sell computers to individuals, but Ahl had learned something about the potential market for personal computers while working in DEC’s educational-products division. The division would occasionally receive requests from doctors or engineers or other professionals who wanted a computer to manage their practices. Some of DEC’s machines were actually cheap enough to sell to professionals, but the company wasn’t prepared to handle such requests. A big difference existed between selling to individuals and selling to an organization that could hire engineers and programmers to maintain a computer system and could afford to buy technical support from DEC. The company was not ready to handle customer support for individuals.

The team Ahl was working with intended that this new product bring computers into new markets such as schools. Although its price tag would keep it out of the reach of most households, Ahl saw schools as the wedge to get the machines into the hands of individuals, specifically schoolkids. The machines could be sold in large quantities to schools, to be used individually by students. Ahl figured that Heath, a company specializing in electronics hobby equipment, would be willing to build a kit version of the DEC minicomputer, which would lower the price even more.

The new computer was built into a DEC terminal, inside of which circuit boards thick with semiconductor devices were jammed around the base of the tube. The designers had packed every square inch of the terminal case with electronics. The computer was no larger than a television set, although heavier. Ahl had not designed the device, but he felt as protective of it as if it were his own child. He presented his plan for marketing personal computers at a meeting of DEC’s operations committee.

Kenneth Olsen, the president of the company and regarded throughout the industry as one of its wisest executives, was there along with some vice presidents and a few outside investors. As Ahl later recalled, the board was polite but not enthusiastic about the project, although the engineers seemed interested. After some tense moments, Olsen said that he could see no reason why anyone would want a home computer. Ahl’s heart sank. Although the board had not actually rejected the plan, he knew that without Olsen’s support it would fail.

Ahl was now utterly frustrated. He had been getting calls from executive search firms offering him jobs, and told himself the next time a headhunter called he would accept the offer. Ahl, like Wozniak and Albrecht and many others, had walked out the door and into a revolution.

Hackers

> *I swore off computers for about a year and a half—the end of the ninth grade and all of the tenth. I tried to be normal, the best I could.*
>
> –Bill Gates, cofounder of Microsoft Corporation

Had the personal-computer revolution waited for action from the mainframe-computer and minicomputer companies, the PC might still be a thing of the future. But there were those who would not wait patiently for something to happen, and their very impatience led them to take steps toward creating a revolution of their own. Some of those revolutionaries were incredibly young.

In the late 1960s, before David Ahl lost all patience with DEC, Paul Allen and his school friends at Seattle's private Lakeside School were working at a company called Computer Center Corporation (or "C Cubed" to Allen and his friends). The boys volunteered their time to help find bugs in the work of DEC system programmers. They learned fast and were getting a little cocky. Soon they were adding touches of their own to make the programs run faster. Bill Gates wasn't shy about criticizing certain DEC programmers, and pointed out those who repeatedly made the same mistakes.

Hacking

Perhaps Gates got too cocky. Certainly the sense of power he got from controlling those giant computers exhilarated him. One day he began experimenting with the computer security systems. On time-sharing computer systems, such as the DEC TOPS-10 system that Gates knew well, many users shared the same machine and used it simultaneously, via a terminal connected to a mainframe or minicomputer that was often kept in a locked room. Safeguards had to be built into the systems to prevent one user from invading another user's data files or "crashing" a program—thereby causing it to fail and terminate—or worse yet, crashing the operating system and bringing the whole computer system to a halt.

Gates learned how to invade the DEC TOPS-10 system and, later, other systems. He became a hacker, an expert in the underground art of subverting computer-system security. His baby face and bubbly manner masked a very clever and determined young man who could, by typing just 14 characters on a terminal, bring an entire TOPS-10 operating system to its knees.

He grew into a master of electronic mischief. Hacking brought Gates fame in certain circles, but it also brought him grief. After learning how easily he could crash the DEC operating system, Gates cast about for bigger challenges. The DEC system had no human operator and could be breached without anyone noticing and sounding an alarm. On other systems, human operators continually monitored activity.

For instance, Control Data Corporation had a nationwide network of computers called Cybernet, which CDC claimed was completely reliable at all times. For Gates, that claim amounted to a dare.

A CDC computer at the University of Washington had connections to Cybernet. Gates set to work studying the CDC machines and software; he studied the specifications for the network as though he were cramming for a final exam.

“There are these peripheral processors,” he explained to Paul Allen. “The way you fool the system is you get control of one of those peripheral processors and then you use that to get control of the mainframe. You’re slowly invading the system.”

Gates was invading the CDC hive dressed as a worker bee. The mainframe operator observed the activity of the peripheral processor that Gates was controlling, but only electronically in the form of messages sent to the operator’s terminal. Gates then figured out how to gain control of all the messages the peripheral processor sent out. He hoped to trick the operator by maintaining a veneer of normalcy while he cracked the system wide open.

The scheme worked.

Gates gained control of a peripheral processor, electronically insinuated himself into the main computer, bypassed the human operator without arousing suspicion, and planted the same “special” program in all the component computers of the system. His tinkering caused them to all crash simultaneously.

Gates was amused by his exploits, but CDC was not, and he hadn’t covered his tracks as well as he thought he had. CDC caught him and sternly reprimanded him. A humiliated Bill Gates swore off computers for more than a year.

Despite the dangers, hacking was the high art of the technological subculture; all the best talent was hacking. When Gates wanted to establish his credentials a few years later, he didn’t display some clever program he had written. He just said, “I crashed the CDC,” and everyone knew he was good.

BASIC

When Intel’s 8008 microprocessor came out, Paul Allen was ready to build something with it. He lured Gates back into computing by getting an Intel 8008 manual and telling his friend, “We should write a BASIC for the 8008.”

BASIC was a simple yet high-level programming language that had become popular on minicomputers over the previous decade. Allen was proposing that they write a BASIC interpreter—a translator that would convert statements from BASIC input into sequences of 8008 instructions. That way, anyone could control the microprocessor by programming in the BASIC language. It was an appealing idea because controlling the chip directly via its instruction set was, as Allen could see, a painfully laborious process.

Gates was skeptical. The 8008 was the first 8-bit microprocessor, and it had severe limitations.

“It was built for calculators,” Gates told Allen, although he wasn’t quite accurate in his statement. But Gates eventually agreed to lend a hand, and came up with the $360 needed to buy what Gates believed was the first 8008 sold through a distributor. Then, their plan somehow was diverted: they got themselves a third enthusiast, Paul Gilbert, to help with the hardware design, and together the trio built a machine around the 8008.

The machine the youngsters built was not a computer by a long shot, but it was complicated enough to cause them to set aside BASIC for a while. They constructed a machine to generate traffic-flow statistics using data collected by a sensor they had installed in a rubber tube strung across a highway. They figured there would be a sizable market for such a device. Allen wrote the development software, which allowed them to simulate the operation of their machine on a computer, and Gates used the development software to write the actual data-logging software that their machine required.

Traf-O-Data

It took Gates, Allen, and Gilbert almost a year to get the traffic-analysis machine running. When they finally did, in 1972, they started a company called Traf-O-Data—a name that Allen is quick to point out was Gates’s idea—and began pitching their new product to city engineers.

Traf-O-Data was not the brilliant success they had hoped for. Perhaps some of the engineers balked at buying computer equipment from kids. Gates, who did most of the talking, was then 16 and looked younger. At the same time, the state of Washington began to offer no-cost traffic-processing services to all county and city traffic controllers, and Allen and Gates found themselves competing against a free service.

Soon after this early failure, Allen left for college, leaving Gates temporarily at loose ends. TRW, a huge corporation that produced software products in Vancouver, Washington, had heard about the work Gates and Allen did for C Cubed and shortly thereafter offered them jobs in a software-development group.

At something like $30,000 a year, the offer was too good for the two students to pass up. Allen came back from college, Gates got a leave of absence from high school, and they went to work. For a year and a half, Gates and Allen lived a computer nut’s dream. They learned a great deal more than they had by working at C Cubed or as the inventors of Traf-O-Data. Programmers can be protective of their hard-earned knowledge, but Gates knew how to use his youth to win over the older TRW experts. He was, as he put it, “nonthreatening.” After all, he was just a kid.

Gates and Allen also discovered the financial benefits that such work can bring. Gates bought a speedboat, and the two frequently went water-skiing on nearby lakes. But programming offered other rewards that appealed to Gates and Allen far more than their increasingly fat bank accounts. Clearly, they had been bitten by the bug. They had worked late nights at C Cubed for no financial gain, and pushed themselves at TRW harder than anyone had asked them to. Something in the clean precision of computer logic and the sportsmanship in the game of programming was irresistible.

The project they worked on at TRW eventually fizzled out, but it had been a profitable experience for the two hackers. It wasn't until Christmas 1974, after Gates went off to Harvard and Allen took a job with Honeywell, that the bug bit them once more, and this time the disease proved incurable.

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Chapter 2

The Voyage to Altair

> *You can’t deny that Ed Roberts started the industry.*
>
> *Mark Chamberlain, MITS employee*

The personal-computer revolution came from a company started in a garage, but not the company and not the garage that most people know about. By the early 1970s the desire among engineers and electronics hobbyists to own their own computers was like the pressure in a champagne bottle. And when Ed Roberts and his unlikely company, MITS, popped the cork, the party began. MITS launched a personal-computer industry, complete with stores, publications, conferences, user groups, software piracy, and debates over open vs. closed standards. Virtually the whole history of the personal computer appeared in miniature at MITS, where Bill Gates said, “every idea was half executed.”

Uncle Sol’s Boys

> *Ed Roberts? You gotta give him credit for doing the first one. But give the guy [who] published him as much credit: Les Solomon.*
>
> –Chuck Peddle, computer designer

Bill Gates, Paul Allen, and other computer enthusiasts relied on the hobbyist electronics magazines like *Popular Electronics* and *Radio-Electronics* to keep up with the latest technological developments. In the early 1970s, what Gates and Allen were seeing in the pages of those magazines served to frustrate them as much as excite them. Most of the magazines’ readers knew something about computers, and many knew a lot more than that—and every one of them now wanted to own a computer. The computer aficionados who read *Popular Electronics* and *Radio-Electronics* were an opinionated lot; they knew precisely what they did and didn’t want in a computer.

What these enthusiasts wanted most often was more control over the machines they used. They resented having to wait in line to use the very tool of their trade or to engage in their favorite hobby. They wanted immediate access to the files they created on a computer, even if they were off somewhere on a business trip. They wanted to play computer games at their leisure without someone telling them to get back to work. In short, what these enthusiasts wanted was a personal computer. But in the early 1970s, the idea of someone owning his or her own computer was no more than a wild dream.

Your Very Own Computer

A big step toward the realization of the personal-computer dream happened in September 1973, when *Radio-Electronics* published an article by Don Lancaster that described a “TV Typewriter.” A prolific contributor to electronics magazines, Lancaster later published his groundbreaking idea in book form. His proposed uses for the TV Typewriter were nothing short of visionary:

“Obviously, it’s a computer terminal for time-sharing services, schools, and experimental uses. It’s a ham radio Teletype terminal. Coupled to the right services it can…display news, stock quotations, time, and weather. It’s a communications aide for the deaf. It’s a teaching machine, particularly good for helping preschoolers learn the alphabet and words. It also keeps them busy for hours as an educational toy.”

Lancaster’s TV Typewriter, for all its visionary appeal, was nevertheless only a terminal: an I/O (input/output) device that would link to a mainframe computer. It didn’t constitute the personal computer that the electronics hobbyists desperately wanted.

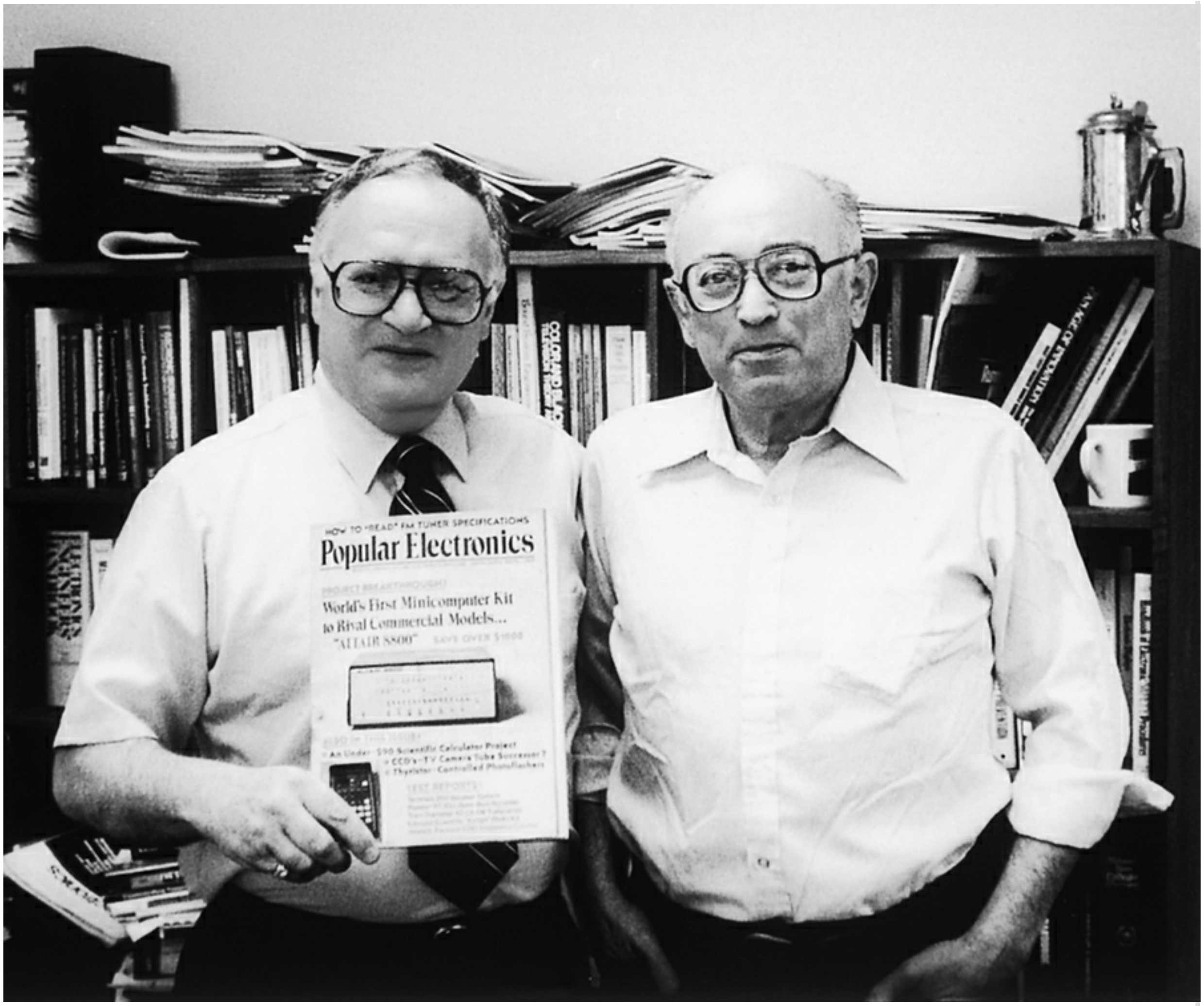

Figure 16. Art Salsberg and Les Solomon ***Salsberg, editorial director of*** **Popular Electronics** ***(left), and Les Solomon, its technical editor, pose with the historic January 1975 Altair cover.***
(Courtesy of Paul Freiberger)

At the time Lancaster's article was published, *Popular Electronics* technical editor Leslie (Les) Solomon was actively seeking a computer story for his magazine. Solomon and editorial director Arthur Salsberg wanted to publish a piece on building a computer at home. Neither of them knew if such a thing was even possible, but in their bones they felt that it should be. They didn't realize that their competitor, *Radio-Electronics*, was already preparing to publish an article on just such a topic.

If a home-built computer design was possible, Solomon figured that it would most likely come from one of his "boys"—those young, technically sharp *Popular Electronics* contributors, like Stanford graduate students Harry Garland and Roger Melen, or Forrest Mims or Ed Roberts.

Designs were being submitted to *Popular Electronics*, but they weren't from these stars, and Solomon and Salsberg found them unimpressive. Solomon described what he was seeing as "a rat's nest of wires," and Salsberg agreed: "They were terrible designs. They were tinker toys. They were kludges." Solomon wanted to feature a really good design that he could develop into a groundbreaking story. So he encouraged his guys to send him their best designs, and they took his request seriously.

A colorful and ebullient editor with a wry New York wit, Les Solomon was known as Uncle Sol to his contributors. He developed a close relationship with them, carrying on lengthy telephone conversations and visiting their labs and workshops whenever he could. Solomon regaled his contributors with far-fetched stories and entertained them with magic tricks, most notably a stunt that involved levitating a stone table. Part of what made Uncle Sol fascinating was in trying to figure out what was for real and what was a complete put-on. But one thing was certain: he was serious about getting the best material for his magazine.

The avuncular Solomon was always willing to give his boys advice. When Garland and Melen submitted one of their designs, Solomon told them that they needed to find a distributor. He put them in touch with Ed Roberts, president of an Albuquerque-based company called MITS.

The Man Who Launched a Revolution

Solomon had met Roberts some time earlier. The *Popular Electronics* editor was vacationing with his wife in Albuquerque and stopped off to visit one of the magazine's contributors, Forrest Mims. Mims took an immediate liking to Uncle Sol and brought him to meet his business partner, Ed Roberts. Solomon and Roberts also hit it off immediately. The meeting would prove to be a significant event in the development of the personal computer.

Roberts, like Solomon, enjoyed tinkering with electronics. He had played with electronics since his childhood in Miami and had managed to build a crude relay computer while still in his teens. Although he had originally wanted to become a doctor, Roberts decided to join the Air Force to get training in electronics. In 1968, while stationed in Albuquerque, Roberts, Mims, and two other Air Force officers started a small electronics company out of Roberts's garage. They called their company Micro Instrumentation Telemetry Systems, or MITS, and sold radio transmitters for model airplanes by mail order.

Roberts soon involved MITS in other types of projects. For a time, MITS was building and selling a digital oscilloscope for engineers, but Roberts pushed to take on something more daring, closer to the technological cutting edge. His three partners objected to some of his wildest ideas, so he bought them out. By 1969 Roberts was alone at the helm, which was how he liked it.

A physically imposing man who became accustomed to giving orders while serving in the Air Force, Roberts ran a tight operation at MITS and would brook no nonsense from his employees.

In every sense, MITS was Roberts's company. By 1970, MITS had moved out of the garage and into a former restaurant whose name, The Enchanted Sandwich Shop, still hung over the door. Roberts began manufacturing calculators.

The calculator market was a dizzying place to be in the early 1970s. In 1969, when Intel got the contract to produce calculator chips for the Japanese firm Busicom, the cost to build and sell a calculator nearly approached the cost to build and sell a low-end minicomputer. By the early 1970s, semiconductor technology had changed the calculator market so radically that Ed Roberts could reasonably consider wrapping some electronics and a case around some chips from Intel and selling the results for a small fraction of the purchase price of a Busicom calculator.

What Roberts really wanted to do, though, was both more and less ambitious than building and selling conventional calculators: he was determined to produce *programmable* calculators and sell them unassembled in kit form. A calculator kit was the ideal product to be featured in the hobby electronics magazines, and Roberts made sure to publicize it there.

The calculator kits sold well for some time among enthusiasts, and Roberts made the fateful decision to invest the bulk of the MITS capital and development efforts in commercial handheld calculators. The decision turned out to be disastrously ill-timed.

Killed in the Calculator Market

Two trends in semiconductor technology reached critical stages in 1974 and helped to create the climate in which the microcomputer was born. The semiconductor companies began to produce and market applications of their technology—in particular, calculators—directly against Intel president Robert Noyce's dictum that the chip manufacturers shouldn't compete with their own customers. In addition, the early, crude microprocessor chips were being refined with better-thought-out designs and more power.

The first trend brought MITS to the brink of bankruptcy; the second yanked it back.

In the early 1970s, the semiconductor houses, racked by fierce technological and price wars, noticed that some of their customers had much healthier profits than they themselves did. One example was Commodore, a Canadian electronics company that had moved into Silicon Valley from Toronto and sold calculators that were assembled around a Texas Instruments (TI) chip. Commodore was raking in money from a product that was little more than a TI chip in a plastic case.

The demand for calculators seemed endless, and great profits were made in meeting the need. By 1972, TI had entered the calculator business, and other semiconductor manufacturers soon followed suit. "They just came in and ripped everybody to shreds," according to semiconductor designer Chuck Peddle. TI's attack on the industry was characteristically aggressive: it burst upon the market and immediately undercut everyone else's prices.

Calculators quickly became smaller and more powerful, prices dropped dramatically, and profits shrank almost as fast. With a nationwide recession hobbling many businesses, 1974 was not a good year for the calculator industry. Peddle, who was working on microprocessor design at Motorola, recalled, “The market went to hell that year. Supply started catching up with demand. Everybody that year lost money in the calculator business.” Calculators went from being a high-end purchase to a sidewalk giveaway. The average price for a consumer calculator in 1974 was $26.25. A year before it had been $150.

One of the firms stricken by the recession and lackluster profits was MITS. In January 1974, MITS was selling a simple eight-function calculator kit for $99.95, and couldn’t bring the price any lower. Texas Instruments was offering a comparable, fully assembled calculator for less than half what MITS was asking. The tiny firm couldn’t swim in those waters. Ed Roberts lay awake nights trying to figure out where he had gone wrong.

The other pivotal development in semiconductors happened in April 1974, when the successor to the Intel 8008 microprocessor was completed.

Intel had really created the brain of a computer in the 8008. However, the 8008 was, in the words of Art Salsberg, “a kludge and a monster.” Everything was there, but not in the right places. It handled vital operations in a slow, roundabout way and demanded a contorted, awkward form of programming and design. Even engineers inside Intel disagreed about whether the 8008 could actually function as the brain of a viable, commercial computer.

The electronics hobbyists weren’t waiting for the semiconductor engineers to make up their minds.

Going for Broke

> *Why don't you call it Altair? That's where the Enterprise is going tonight.*

> –Lauren Solomon, daughter of *Popular Electronics* editor Les Solomon (like other Solomon stories, possibly apocryphal)

Ed Roberts made a decision of his own that spring—he was going to build a kit computer. He had been toying with the idea for some time only to find that by early 1974 the chips, so to speak, were down. MITS's calculator business had blown away like desert sand, leaving the company heavily in debt. Faced with the likelihood of going under, Roberts decided to go for broke. He would build a product that had essentially no precedent or defined market, a product most people considered fanciful at best. But the specter of bankruptcy only gave urgency to his decision. Roberts always cared more about technological challenges than about any business risks they presented. He would have gone ahead with the kit computer under any circumstances.

Les Solomon Flies to Albuquerque

Roberts studied Intel's chips—the early 4004, the 8008, and a third Intel product called the 4040—and rejected the 4004 and 4040 as too crude. He was considering building a machine around the 8008, until a programmer told him that he had tried to implement the BASIC programming language on the 8008 and had found it to be an excruciating process. The 8008 carried out the BASIC instructions far too slowly to be useful.

Then a new product caught Roberts's eye: the Intel 8080. By this time, Motorola also marketed a microprocessor, the 6800, and Texas Instruments and other companies had similar products. But Roberts had studied the chips carefully and concluded that the 8080 was technically superior to the 6800. It had another even more significant advantage.

Intel normally charged $360 for an 8080, but Roberts got the company to knock the price down to $75. It was unheard of: nobody else was getting that price, but for a very good reason. The Intel contract required him to buy in volume, and each computer needed only one processor. He'd be committing to a business model that would require him to sell a lot of computers.

That was fine with Roberts. After the calculator fiasco, which Roberts said was "something you don't want to go through twice in a lifetime," his operation was geared up to sell plenty of product—which he would need to do to salvage the company. He was going to have to think big or give it up entirely.

Meanwhile, *Popular Electronics* was narrowing its search for a computer project it could publicize. "We got in a bunch of computers," Art Salsberg recalled. "We wound up with two models and decided it was going to be a choice of one or the other. One amounted to no more than a promise. The promise was, I can get the chips at a lower price and make this whole thing feasible. That was from Ed Roberts. The other choice was a microcomputer trainer by Jerry Ogdin." The model from Ogdin was actually more a tool for learning about computers than an actual computer.

Roberts offered only a concept, whereas Ogdin's device actually existed and Salsberg and Solomon had seen it. They were both inclined to support a tangible machine over the mere promise of one, even though Ogdin's machine was built around the 8008 chip, which was about to be phased out. "It looked like it was a go with the microcomputer trainer," Salsberg said.

Then the July 1974 *Radio-Electronics* hit the newsstands with an article by Jonathan Titus on building an Intel 8008–based computer called the Mark-8. The article generated a lot of excitement among hobbyists, even if not a lot of orders. The editors at *Popular Electronics* realized immediately that this put a crimp in their plans. On reading the *Radio-Electronics* article, Salsberg announced, "That kills the trainer." Solomon agreed: Ogdin's trainer was just too similar to the Mark-8. *Popular Electronics* had to up the ante. An article on an 8080-based microcomputer would do just that.

Solomon promptly flew to Albuquerque to meet with Roberts and work out the details. Salsberg wanted the computer packaged like a serious commercial product. Roberts spent many late nights hashing out the exact components of a desktop computer that could sell for under $500.

This presented an enormous challenge. The Mark-8 sold for about twice that price, and when you added up the cost of the components that any computer needed, it was hard to get the price much lower. But Roberts did have the advantage of the volume pricing from Intel.

In the end, Roberts promised to meet the price and to deliver the first machine to *Popular Electronics* as soon as it was built, and *Popular Electronics* promised to publish a series of articles on it, including a cover story.

When Salsberg agreed to go with Roberts's machine, he was taking a risk. This was to be the cover story for the issue. If they promoted this computer and it turned out to be a bomb, the magazine would look bad. No one at MITS had ever built a computer before. Roberts had only two engineers on his staff, and one of them had his degree in aeronautical engineering. Roberts had no prototype and no detailed proposal. But Uncle Sol kept assuring Salsberg that Roberts could deliver the goods. Salsberg hoped he was right.

Roberts was just as edgy about *Popular Electronics*'s promises. However much he liked and respected Les Solomon, he was wary of Solomon's cheerful assurances. And the more he realized how crucial a cover story in *Popular Electronics* was for MITS, the more nervous he became. His company's future was in the hands of a man who levitated tables.

The Mark-8 wasn't the first computer built around the Intel 8008, although Roberts had no way of knowing that. That distinction belongs to the Micral computer, built in 1973 by André Truong Trong Thi, a French Vietnamese entrepreneur. Thi sold 500 of the machines, all in France. Later that year, he demonstrated an 8080-based computer at a major computing conference in the United States. Whatever impact the demonstration had on the engineers and computer scientists who saw it apparently didn't extend much beyond that conference. The same fate could easily befall Roberts's machine.

Designing the Personal Computer

Over the summer of 1974, Roberts had sketched out the machine he wanted. As his ideas took shape, he passed them along to the two guys on his engineering team, Jim Bybe and Bill Yates. A quiet and serious man, Yates worked long hours on the layout of the main circuit board for the machine, planning how each electrical signal would get from one point to another in the computer.

Roberts wanted this computer to be expandable, like a minicomputer. He wanted the user to be able to install other circuit boards for particular functions, such as controlling an I/O device or providing extra memory. Roberts wanted the boards designed to plug easily into the computer, a capability that required not just a socket, but also specific, defined data paths. If different elements of the computer were to reside on physically distinct circuit boards, the boards had to be made to communicate with each other. This communication, in turn, required certain engineering conventions. For instance, one board needed to send information when and where it was expected by another board. Almost by default, a *bus structure* for the computer evolved.

A bus is a channel through which computer data or instructions travel. Typically, a bus is a parallel channel with several different signals passing simultaneously. The MITS computer had 100 separate channels, or paths, and each had to have a stated purpose. Added to that were the physical and electrical constraints that sometimes dictated the design of the layouts. For instance, electrical cross-talk—interference between wires—makes it unwise to place channels for certain kinds of signals too close together. But Roberts allowed Yates no time to address such niceties of design, because the creditors had already begun to bay. Wherever the data channels fell, that's where they stayed. The bus design did the job, but it wasn't pretty.

While Yates laid out the boards, another MITS employee, technical writer David Bunnell, was casting about for a name for the computer. His favorite of all the candidates was "Little Brother," but he wasn't altogether comfortable with the name. Bunnell wasn't really comfortable with the whole notion of computers, Roberts recalled. But Bunnell kept his skepticism in check, given Roberts's lack of patience with dissent.

Bunnell had been with MITS since 1972. He and Roberts had coauthored articles for *Popular Electronics*, and they were writing a series of tutorials on digital electronics for the magazine at the same time they were toiling in the MITS workshop developing their computer.

Getting Financing

Despite their efforts, it was beginning to look as if the computer was destined to die in the workshop. MITS owed around $300,000 to its creditors. With Les Solomon’s constant reminders that the article’s deadline was imminent, Roberts made a grim trek to the bank. It was mid-September. He was out of money, needed another loan, and fully expected the bank to turn him down. Given his current credit rating and his depleted assets, he doubted anyone would lend him the $65,000 he needed to keep the company’s doors open.

The officers of the bank listened patiently. He was going to build a kit computer? And what exactly was that? And who, did he think, would buy such a product? Electronics hobbyists, sight unseen, from ads in magazines? And how many of these kit computers did he think he could sell in the next year to these electronics hobbyists through advertisements in magazines?

With a straight face, Roberts told them 800. “You won’t sell 800,” they said, thinking he was being unrealistic. Roberts was indeed fantasizing. Still, the bank officers saw no advantage in bankrupting companies with outstanding loans. The loan officers figured that if Roberts could sell 200 of the things it would help MITS to repay the bank something. They agreed to advance him the $65,000.

Roberts did his best to hide his surprise. He was glad he hadn’t mentioned the informal market survey that he had just conducted. Trying to get some sense of how the machine would be received, Roberts described it to some engineers he knew and asked if any of them would buy it. They all said no.

Although Roberts never considered himself a good businessman, he knew instinctively when to ignore market research. He took his $65,000 and, with Yates and Bybe, worked feverishly to complete the prototype to send to *Popular Electronics*. It was going to appear on the cover, so they made sure it looked especially attractive.

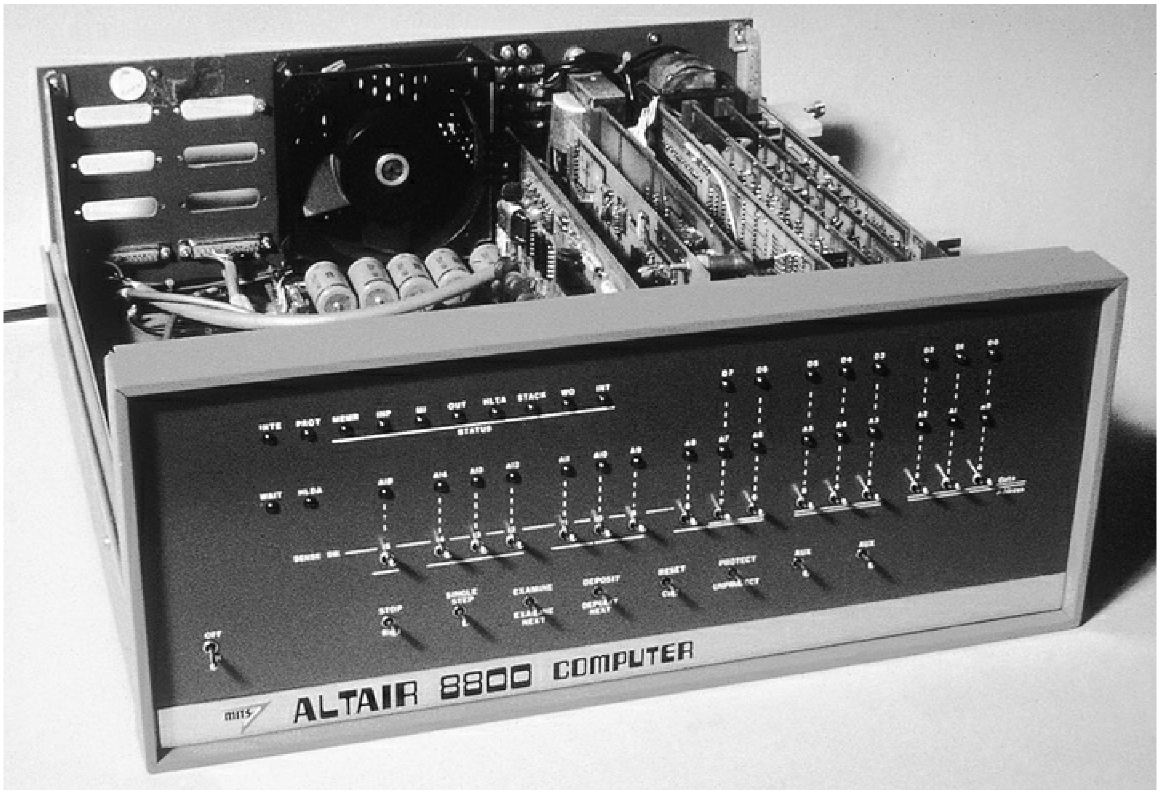

Figure 17. The MITS Altair 8800, assembled ***The default input and output for the Altair computer were the switches and lights on the front panel.*** **(Courtesy of Intel Corp.)**

Because Bill Yates was doing most of the design, he worked with Roberts on the article. While Roberts and Yates were scrambling to finish both the computer and the article, they realized they still didn’t have a name for their machine. They figured Solomon would put a *Popular Electronics* name on it if they didn’t, so they beat him to the punch by calling it the PE-8. It was Roberts’s last small hedge against *Popular Electronics*’s scuttling the project. But that wasn’t the name by which the machine became famous.

According to Les Solomon, his 12-year-old daughter Lauren was the one who came up with the name that stuck. She was watching an episode of *Star Trek* when her father walked into the room and said, “I need a name for a computer. What’s the name of the computer on the *Enterprise*?” Lauren thought for a moment and said, “Computer.” Her father didn’t think much of that name, so Lauren suggested, “Why don’t you call it Altair? That’s where the *Enterprise* is going tonight.”

Some of Solomon’s friends told a different story of the naming, but Altair it was. “I don’t give a damn what you call it,” Roberts told Solomon. “If we don’t sell 200, we’re finished.” Solomon reassured him that things were going well and selling 200 was entirely possible. Solomon wasn’t just being polite and trying to soothe the raw nerves of a man who’d been flayed in the calculator-market crash. He was confident that the Altair had the potential to far outstrip the Mark-8.

The Mark-8 was an experimenter's toy, a way for the engineering hobbyist to learn about computers firsthand. But the Altair was, for all its limitations, a real computer. Its bus structure would make it possible to expand the machine's capabilities by allowing the user to plug in new circuit boards. And the 8080 chip was a far better "brain" than the 8008. The Altair had the potential, at least in miniature, of doing everything a large mainframe computer could do.

Solomon was convinced of it and told Roberts as much. But he didn't voice his concern that the message might not get across to the *Popular Electronics* readers. Art Salsberg told him that *Popular Electronics* had to offer its readers more than just instructions for building the device. To prove that the Altair was a serious computer, *Popular Electronics* had to also offer one solid application, a practical purpose for the Altair that could be demonstrated right away. What that application might be, Solomon had no idea.

Delivering the Goods

The deadline arrived for Roberts to deliver the prototype computer to Solomon. Roberts told him that it was coming by Railway Express, a troubled parcel-shipping service that would cease operations later that year, and to watch for it.

Solomon waited. No computer arrived.

Roberts reassured him that the computer was in the mail and should be arriving any day. Days later, the prototype was still a no-show. Solomon, in turn, tried to reassure Art Salsberg at *Popular Electronics* that the machine was on its way, but now everyone was getting nervous. Roberts flew to New York to demonstrate the prototype, confident that it would arrive by the time he did.

But it didn't. Railway Express had apparently lost their computer. This was a catastrophe, both for MITS and for *Popular Electronics*. The magazine had committed to a cover story, and now it had no computer to put on the cover. For weeks, Roberts had lain awake nights, static buzzing away in his brain. Now he felt that his worrying had been justified. His engineers couldn't possibly assemble another computer in time to meet the deadline. They were sunk.

Unless, of course, they faked it.

Yates could slap together a box, poke little lights through the holes in the front, and ship it to New York. Les Solomon didn't like the idea. Art Salsberg hated it. Ed Roberts was embarrassed. But when the January 1975 issue of *Popular Electronics* went to press, it featured a flashy cover photo of an empty metal box masquerading as a computer.

Between the time the issue was wrapped up and the time it hit the streets, Solomon finally got his hands on an Altair computer. He immediately set it up at his desk, but the noise from the Teletype machine he was using as an I/O device made him instantly unpopular in the *Popular Electronics* offices. So he took the system home and set it up in his basement. It was there that Roger Melen first saw it.

The day after Roberts and Yates's piece on the Altair appeared, an article came across Solomon's desk that caught his attention. Harry Garland and Roger Melen, the two Stanford graduate students Solomon had once hooked up with Ed Roberts, sent in a description of a digital camera they had designed. The Cyclops, as Garland and Melen called it, reduced an image to a rectangular grid of light and dark squares and provided a low-cost visual system for a digital computer.

In December 1974, coincidentally just before *Popular Electronics*'s Altair issue came out, Roger Melen decided to fly to New York. His trip ultimately led him to Les Solomon's basement.

Melen reminded Uncle Sol of Ed Roberts in a way. Both were well over six feet tall and heavyset, and both were inveterate engineers/hobbyists, but the Air Force–trained Roberts was older and tougher. Melen was quiet and soft-spoken, the product of one of the top engineering schools in the world. Nevertheless, the two would see eye-to-eye, Les thought, chuckling to himself at the unintentional joke. Trying to look nonchalant, he led Melen through his basement to a strange-looking apparatus. "What's that?" Melen asked. "That, sir," Solomon told him, "is a computer."

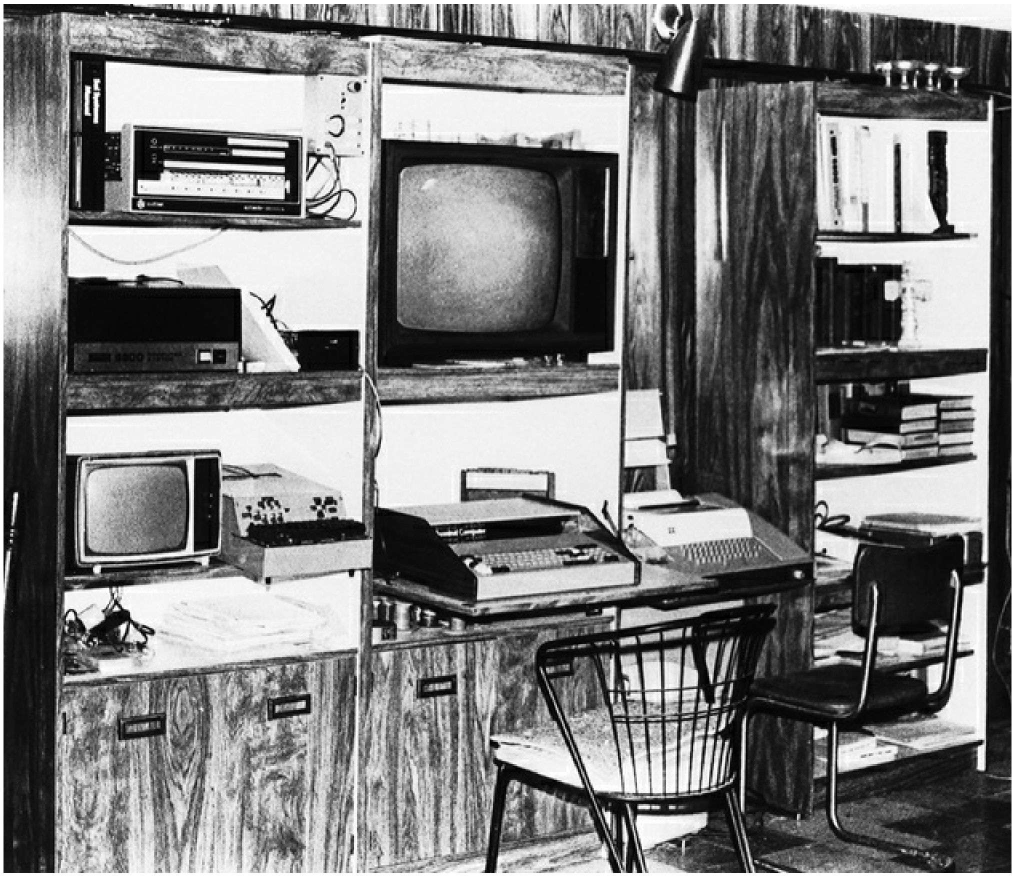

Figure 18. Les Solomon's basement Popular Electronics ***technical editor Les Solomon showed the as-yet-unannounced Altair to an astonished Roger Melen in this basement. Here the basement features a Sol-20 and other historic personal computers.*** **(Courtesy of Les Solomon)**

When Solomon told him what the Altair was and how much it cost, Melen politely demurred. There must have been some mistake. Melen knew for a fact that the microprocessor chip alone cost as much as he claimed this whole computer did. Solomon suppressed a smile and assured him that the price was correct. Roberts was actually going to sell this computer for $397. Delighted at Melen's reaction, Solomon picked up the phone, called Roberts in Albuquerque, and checked the price as Melen stood there. Yep, it was still $397.

Melen was stunned. As he and most hobbyists well knew, Intel was charging $360 for the 8080 chip alone. When Melen left New York that day, instead of flying directly back to San Francisco he took a side trip to New Mexico. Melen sensed that something big was happening, and he wanted to be a part of it.

Roberts greeted Melen enthusiastically at the Albuquerque airport that evening and drove him over to MITS. There Melen was in for another surprise: far from being the large company he had expected to see, the MITS office was in a strip mall, wedged in between a massage parlor and a laundromat. The MITS headquarters must have looked as odd to Melen as it did to the suburban shoppers who strolled past its doors that winter.

“It was obviously the skeleton of what used to be a company, because they had lots of equipment around,” Melen later recalled. “But they only had, I think, 10 employees at that time. They had been very successful in producing calculators, but that was a fad that had passed. He [Roberts] saw this as his big chance for success—his second shot to pull him out of his predicament.”

Melen recognized a mutual opportunity and proposed attaching his Cyclops camera to the Altair. Roberts was interested, and after a brief tour of MITS, the two men sat down to work. Melen studied the Altair schematics, gathering all the information he thought he would need to design an interface between the two devices. He and Roberts talked about computers in general and the Altair-Cyclops interface in particular until dawn, when Melen hurried back to the airport to catch an 8 A.M. flight to San Francisco.

Soon after the meeting between Melen and Roberts, Solomon wrote to Garland and Melen suggesting a television adapter for the Cyclops. They replied that it would be prohibitively expensive, and instead described their plan to link the Cyclops device to the Altair for use as a security camera. Solomon was gleeful. The security camera was the practical application that Art Salsberg had wanted. He incorporated the idea into Garland and Melen’s article on the Cyclops.

The brainstorming session with Melen was not to be Ed Roberts’s last sleepless night. His future, his company, everything hung on this article in *Popular Electronics* and on a positive response from the magazine’s readers. He kept his enthusiasm in check, despite Les Solomon’s cheery encouragement. Roberts felt that Solomon could scrap the project even on the eve of publication. If that happened, MITS was through. Already hundreds of thousands of dollars in debt, Roberts had borrowed heavily to finance this computer venture. He had purchased enough parts to build several hundred machines—and he still had to pay for advertising. At $397 for one machine, he would need to sell the 800 machines he’d glibly mentioned to the bank and a lot more just to break even. He began to suspect that he’d made a terrible mistake.

All Hell Breaks Loose

> *PROJECT BREAKTHROUGH! World’s First Minicomputer Kit to Rival Commercial Models…ALTAIR 8800*
>
> –*Popular Electronics* cover, January 1975

Ed Roberts was still worried about his investment even as the first orders came rolling in. But within a week, it was clear that whatever problems MITS would face in the immediate future, bank foreclosure would not be one of them. In just a two-week period, Roberts’s tiny staff had opened hundreds of envelopes and read with giddy excitement orders for all the computers they had ever hoped to sell. Within a month, MITS had gone from one of their bank’s biggest debtors to a fiscal hero. MITS’s bank balance went from $400,000 in the red to $250,000 in the black in a few weeks. Just processing the orders seemed to be a full-time job for everyone.

They Were Buying a Promise

No one had realized just how primed the market was for a personal computer. The January issue of *Popular Electronics* signaled to thousands of electronics hobbyists, programmers, and other technophiles that the era of the personal computer had finally arrived. Even those who didn’t send in checks saw the Altair article as a sign that they could now have their own computers. The Altair was the fruit of a technological revolution that dropped straight into the hands of a hungry population. They went crazy for it.

Roberts, who had gambled his company’s life on the existence of any market for the machines, was amazed at the magnitude of the response. His experience at selling $99 kit calculators was of little value in predicting the number of buyers for a $397 computer. In addition to the significant price difference, the calculator had a well-defined and obvious function. By comparison, it wasn’t yet clear what the Altair could actually do. Despite Salsberg’s artfully vague promise in *Popular Electronics* of “manifold uses we cannot even think of at this time,” it was not at all obvious what those “manifold uses” were. That didn’t stop Roberts’s phone from ringing almost nonstop.

Electronic hobbyists were happily buying promises.


DOCUMENTATION
ALTAIR
COMPUTER
SYSTEM
ALTAIR 8800 COMPUTER

Figure 19. The MITS Altair 8800, unassembled ***Early purchasers of the MITS Altair received a bag of parts and assembly instructions.*** **(Courtesy of David Bunnell)**

One of the promises customers bought was delivery in 60 days. Faced with an immediate backlog of orders, Roberts determined that he had to establish priorities or they would never make any deliveries. He issued a no-frills edict: initial production would include only the bare machine. All the bells and whistles, such as extra memory, the clock board, and the interface boards to allow the computer to be connected to a Teletype machine, would have to wait. MITS would ship the box and central processing unit (CPU) board with 256 bytes of memory, the front panel, and nothing else until the backlog was cleared. As delivered, the Altair was no more powerful than the Mark-8. Only its possibilities were greater.

A few orders were filled early in 1975. Garland and Melen, working on Cyclops in the guest bedroom of Melen's Mountain View, California, apartment, were MITS's first computer customers. They were not your typical customers. The average order went out only after it inched to the head of the queue, which took time. Garland and Melen received Altair No. 0002 in January. (The first Altair, lost in shipment to New York and never seen again, was unnumbered. Les Solomon got No. 0001.) Garland and Melen immediately set to work on the interface board that would allow the computer to control their Cyclops digital camera.

Despite MITS's promise of 60-day delivery, orders were not filled in any quantity until the summer of 1975. One hobbyist, Michael Shrayer, who went on to write the first personal-computer word-processing program, described his experience with MITS: "I sent away my $397. Many phone calls later, the computer finally came. It took forever. At that time, I received a big, empty box with a CPU card and 256 bytes of memory. No terminal, no keyboard, nothing. To put anything in it, one had to play with the switches on the front panel and put in minor programs. A lot of peripherals were being promised but not delivered."

"Minor programs" was a generous description of what you could feed the early Altair. Programs had to be written in 8080 machine language and entered by flipping switches, with one flip of a switch for every binary digit. And once they were entered, the programs could do little except make the lights on the front of the box blink. One of the first programs written for the Altair was a simple game. It caused the lights to blink in a certain pattern, which the player was supposed to mimic by flipping switches.

Figure 20. Steve Dompier ***He was so eager for a computer of his own that he flew from San Francisco to Albuquerque to check on his Altair order. Here he pays a similar visit to Processor Technology.*** **(Courtesy of Bob Marsh)**

The Altair buyer faced another problem after delivery. The computer was sold as a kit, and assembling it took many hours. The odds of the computer eventually working depended on the skill of the hobbyist and the quality of the parts. Most of the first machines simply didn't work, despite the skill of the user. Steve Dompier, a young building contractor in Berkeley, California, was surprised to find that some of MITS's advertised equipment didn't even exist. He recalled sending in a check for $4,000 with a succinct request for "one of everything." When half his money came back with an apologetic note from a beleaguered MITS secretary saying that they "didn't have all that stuff yet," Dompier boarded a plane for Albuquerque.

Flying from San Francisco to Albuquerque over a delay in filling an order for hobby equipment might seem overzealous to some, but not to Dompier. "I wanted to see if they were really there. I rented a car and drove past the place about five times. I was looking for a big building with the letters MITS on it and a front lawn. It turned out it was in a tiny building next to a laundromat in a shopping center. There were two or three rooms. All they had was a box full of parts." He picked up some of those parts and returned to San Francisco.

On April 16, 1975, Dompier reported on MITS at a meeting of the Homebrew Computer Club, a pioneering microcomputer club in Menlo Park, California. Dompier drew an attentive audience. MITS, he told his listeners, had 4,000 orders and couldn't even begin to fill them. The thousands of orders, more than anything else, sparked people's interest. What they had been waiting for had happened. They were going to have their own computers.

But calling the Altair a computer took some imagination. By mid-1975, when MITS was delivering product on a regular basis, the assembled machine was no more than a metal box containing a power-supply unit bolted next to a large circuit board. This board was called the motherboard because it was the main piece of circuitry in the machine. It contained 100 strands of gold that connected the motherboard to 18 slots into which other circuit boards could be plugged.

Those 18 slots were a symbol of both the Altair's expandability and an owner's frustration at not being able to use most of them. Regardless of whatever a customer may have ordered, what was shipped was a machine with only two of the slots filled. One slot would have a board containing the CPU (basically, the Intel 8080 chip and supporting circuitry), and the other slot would have a board that contained 256 bytes of memory.

The Altair package also included a front-panel board that controlled the lights and switches on the front of the box. These lights and switches were the I/O, the means by which users communicated with the machine. It was up to the customer to attach the front-panel board to the motherboard by hooking up dozens of wires—a task requiring hours of tedious work. But these three boards, comprising a CPU, some memory, and an I/O unit, meant that the early Altair—barely—met the minimal definition of a computer.

Maybe all that the Altair could do was blink its lights, but for the Homebrew members just the fact that it existed was enough for them. They would take it from there.

"They made the business happen," semiconductor designer Chuck Peddle said of these early hobbyists. "They bought computers when they didn't work and when there was no software for them. They created a market, and then they turned around and wrote the programs that brought other people in."

The early purchasers of the Altair had no choice but to write their own programs. MITS initially supplied no significant software with the machine. The typical response of a computer hobbyist to the *Popular Electronics* article was to first send for an Altair, and when it arrived (and had been successfully assembled) begin writing software for it.

Enter Gates and Allen

Two programmers in Boston decided to skip Step One.

Paul Allen was working for Honeywell in Boston. Bill Gates was a freshman at Harvard, where he had customized a curriculum that allowed him to take graduate mathematics courses. On weekends the two would get together to brainstorm about the microcomputers they just knew were coming, and these microprocessors that would surely power them. “We were just trying to figure out something we could do with them,” Allen recalled. Gates and Allen sent out offers on their old Traf-O-Data stationery to write implementations of PL/I (Programming Language One) for $20,000. They also considered selling Traf-O-Data machines to a company in Brazil. In the middle of a Boston winter, they were spinning their wheels.

While walking through Harvard Square one day, Allen spotted the *Popular Electronics* cover that featured the Altair. Like many other computer enthusiasts, he realized at once that the Altair was a tremendous breakthrough. But he also saw it as something of personal interest. Allen ran to tell Bill that he thought their big break had finally come. Bill agreed.

“So we called this guy Ed Roberts,” Gates recalled. “We had a fairly aggressive posture. We said, ‘We have a BASIC. Do you want it?’” In 1975, Allen and Gates were pioneers in the industry practice of preannouncing products that didn’t yet exist. Later, this type of thing would come to be called “vaporware.”

Roberts was justly skeptical. He had heard from many programmers who claimed they could write software for his computer. He told Gates and Allen what he told everyone else: he would buy the first BASIC he saw actually running on an Altair.

Unlike the others, Gates and Allen delivered. About six weeks later Allen flew to Albuquerque to show Roberts their BASIC. The demonstration was a success even though their BASIC initially did little more than announce its presence. The Traf-O-Data company, newly renamed Micro-Soft (later changed to Microsoft) had made its first sale as a microcomputer software house.

In March, Roberts offered Paul Allen the position of director of software at MITS. Frustrated at Honeywell and eager to work in what he saw as a tremendously promising field, Allen accepted immediately and flew to Albuquerque with all the cash he and Gates could lay their hands on. The title of MITS software director, as it turned out, was not quite the illustrious post Allen had imagined. Upon arriving in Albuquerque, he discovered that he *was* the software department.

Figure 21. MITS Altair ad ***David Bunnell wrote the copy for this early Altair ad, which ran in*** **Popular Electronics** ***and*** **Scientific American. (Courtesy of David Bunnell)**

Putting It Together

Every good idea was half-executed at MITS.

–Bill Gates, cofounder of Microsoft

Compared with mainframes and minicomputers, the Altair was seriously deficient. It lacked any means of permanent storage. Users could put information into the machine and manipulate it, but once they shut off the power, the information disappeared. Even temporary storage was extremely limited. Although the Altair had a memory board, its 256 bytes of memory wouldn't have allowed enough space to hold this paragraph.

As an I/O system, the front-panel setup was awkward to use and required a tedious series of steps. To enter information, users had to flip tiny switches on and off; one flip of a switch equaled one bit of information. To read output, a user had to interpret a series of flashing lights. Entering and verifying a paragraph's worth of information might take several minutes, even with practice. Until paper-tape readers and Gates and Allen's BASIC came along, Altair owners had to communicate with their machines in machine language bit-by-bit via this switches-and-lights routine.

Machine language was the native language of the Altair's microprocessor, the Intel 8080. A machine language is a set of commands, in the form of numeric codes, that elicits a response from a computer's CPU. The code causes the CPU to execute one of its elementary functions—for instance, copying the contents of one specified location in memory onto another location or adding the value of 1 to a stored value. Some programmers, the "true hackers," preferred to work in machine language because of the intimate and immediate control the language gives them over a CPU's operation. But all programmers agree that programming in a higher-level language is vastly easier than having to work with machine language. Altair BASIC was a higher-level language. Unfortunately, It took up 4096 bytes of memory. This is remarkably little memory for a high-level language, but it was 16 times the amount of memory that MITS provided in the Altair.

By filling most of the Altair's 18 slots with 256-byte memory boards and entering Gates and Allen's BASIC into the system—a tedious process that involved flipping the front-panel switches more than 30,000 times without an error—users could theoretically get a high-level language running. However, the amount of memory left for their own programs would be minuscule. Moreover, the BASIC would have to be reentered every time the machine was turned back on. Two improvements were needed to make the BASIC, and in fact the Altair, useful: higher-capacity memory boards and a method for entering programs quickly. MITS was at work on developing both of these. But MITS was at work on a lot of things.

Getting It to Work

When Paul Allen arrived in Albuquerque, MITS's biggest hardware project was a 4K memory board that Ed Roberts had designed and technician Pat Godding was attempting to build. In computer jargon, the letter *K*, short for kilo, represents 1,024, the number closest to 1,000 that is a power of two. Therefore, 4K equals 4,096. Because digital computers use a binary number system, in which every number is expressed as a sum of powers of two, exact powers of two are especially easy for a computer to work with. Computer capacities, such as amount of memory or the largest displayable integer, are generally expressed in powers of two. The new MITS memory board could hold more than 4,000 bytes of information, so Altair BASIC could fit comfortably on it.

Because the 4K memory board would make it possible to run Gates and Allen's BASIC on the Altair, Allen was particularly concerned that the board should work reliably. It didn't.

Or rather, it didn't when combined with other boards. The problem wasn't just the board itself, but also the performance of two or more boards together. "It was almost analog circuitry," Allen said. "Things had to be calibrated so exactly." Bill Yates and the other MITS engineers came to dread Allen's visits to their work area. In order to test the enhancements he was adding to his BASIC, Allen had to try them out on a working Altair with functioning 4K memory boards.

Unfortunately, none of the 4K memory boards were working. Allen would bring in his latest modification to a program and key it into the machine, whereupon all the panel lights would turn on, the Altair's way of throwing up its hands in confusion. When technical changes failed to correct the 4K boards, engineers went the redundancy route. At one point, MITS was keeping seven Altairs running constantly just to have three reliable machines at any given time. "That 4K dynamic memory board was atrocious," Roberts later admitted.

At least Allen didn't have to key in all of the BASIC every time he wanted to use the machine. The workshop Altair had some secret capabilities that MITS wasn't yet ready to release to customers. Its programs and data could be stored on paper tape and then loaded back into memory later on. When Allen first demonstrated BASIC to Roberts, he brought it to MITS on paper tape. For a while, paper tape was the major means of distributing the language. Bill Gates would later curse those paper tapes because they provided the medium for widespread illegal copying of their BASIC.

But paper tape had some serious drawbacks as a storage medium for microcomputers. Paper-tape readers and punches were expensive, considerably more expensive than the Altair computer itself. Paper-tape systems were also not terribly fast or efficient.

MITS recognized the need for an inexpensive storage method and was considering using audiocassette recorders. Many computer users already owned cassette-tape recorders, and if a recorder could double as an Altair storage device, all the better. But like paper tape, cassettes were a slow and clumsy way of storing data. By comparison, IBM had long used disk drives for data storage on its large computers. Disks, although expensive, made data storage and retrieval quick and easy.

Roberts was convinced MITS should put disk drives on the Altair. Paul Allen agreed. In 1975, when Bill Gates also made the move to Albuquerque to work on MITS programs, Allen asked him to write the software that would allow the Altair to communicate with a disk drive. But Gates was currently occupied with other tasks, and he put off writing the disk code.

MITS had no shortage of either hardware or software projects. The company was working on interfaces to Teletype machines, printers, and cassette recorders, as well as looking for ways to link a simple terminal to the Altair. MITS was also developing the programs to control these devices, new versions of BASIC and enhancements to the language, and application programs. In addition, all these items needed documentation. On top of all this, MITS undertook PR projects such as a user conference and a newsletter.

Taking It on the Road

One unusual promotional gimmick was the “MITSmobile,” also known as the Blue Goose. An outgrowth of Roberts’s fondness for recreational vehicles, the Blue Goose was an advertising tool designed to spark interest in microcomputing. Gates recalled touring on the Blue Goose: “It was one of those GM motor homes. We’d drive around the nation, and everywhere we’d go, we’d get somebody to start a computer club. I was part of the song-and-dance for one of the tours.” The Blue Goose, like many other MITS innovations, inspired imitators. Utah-based Sphere, one of MITS’s first competitors, soon thereafter sent a Spheremobile roving about the land.

The Blue Goose promotion proved effective. One of the clubs it helped initiate was the Southern California Computer Society, which in turn published an influential early microcomputer magazine, *SCCS Interface*.

There were good reasons for starting computer clubs. The equipment in these early days didn’t always work or work properly, and software was often unusable or nonexistent. Although buyers were typically engineering hobbyists, few of them had all the skills necessary to fully understand a microcomputer. The clubs encouraged a synergistic sharing of knowledge among the sophisticated-but-stymied users of the machines. Without this interaction and mutual aid, the industry would not have blossomed as it did.

MITS no longer depended on local initiative. By April, MITS had its own nationwide computer club that held design contests and published a newsletter called *Computer Notes*. David Bunnell started up the publication and Ed Roberts contributed a semiregular column called “Ramblings.” Throughout much of the newsletter’s publication history, Gates and Allen wrote a sizable portion of its contents.

The Altair club offered free membership to Altair owners or those who could pass as owners while they awaited delivery from MITS. Meanwhile, other clubs were springing up that bore no particular allegiance to MITS. The Southern California Computer Society and the Homebrew Computer Club in Northern California, although filled with actual and prospective Altair owners, were also made up of technically sophisticated hobbyists who soon contemplated building computers of their own.

The Homebrew Computer Club members were especially interested in this challenge, and from the club's ranks there quickly emerged a true competitor to one of MITS's most important products.

The Competition

There was no competition until Processor Tech came out with the memory cards.

–Ed Roberts, founder of MITS

MITS was a catalyst.

Perhaps more by chance than by design, the MITS operation inspired the creation of an entire industry. But that also meant that MITS spawned competitors, and from Roberts's perspective, competitors were poaching on his territory. You could see it in the way he reacted to the memory situation. When MITS began delivering its 4K memory boards, it didn't take long for customers to notice what Paul Allen already knew: the boards didn't work. “I don't think I'd trust an Altair memory board to do anything,” one MITS executive later admitted.

Defective Memory

Although Roberts eventually acknowledged the board's design was awful, at the time he brooked no complaints about it, as Bill Gates soon learned. Gates was using a memory-test program he had written to check the boards as they were completed. “Every one that came off the line wouldn't work,” Gates said, and he told Roberts as much. The resulting confrontation between the slight 18-year-old and the burly Air Force veteran permanently damaged their relationship. Roberts considered Gates a teenage smart aleck and simply ignored him. “I think that was a fundamental failing of Ed's,” another MITS employee said. “If he said the memory boards worked, they worked.” Unfortunately, they didn't.

When Bob Marsh, an out-of-work Homebrew Computer Club hobbyist, started a company called Processor Technology in April 1975 and began selling 4K boards that did work, Roberts took it as a declaration of war. MITS was making little or no profit on the Altair computers and desperately needed the memory-board sales that Processor Technology was cutting in on.

Roberts retaliated by using Gates and Allen's software as a weapon. The BASIC language was a popular item; the MITS 4K board was not. So MITS resorted to a venerable marketing ploy: it tied the price of BASIC to the purchase of the memory board. Customers who bought MITS boards paid $150 for BASIC. Those who didn't buy the boards paid $500 for BASIC—more than the price of the machine.

The tactic backfired, and the effect on the market was dramatic. Hobbyists, seeing the 4K boards as worthless and BASIC as overpriced, bought the Processor Tech memory and made their own paper-tape copies of BASIC, distributing the copies for free. By the end of 1975, most copies of BASIC in use on Altair computers were pirated.

Processor Technology survived the BASIC price ploy and developed more Altair-compatible products. Other companies also began to produce memory boards that could be used in the Altair. Roberts railed at those he regarded as squatters in his territory. The memory-board companies responded by crashing David Bunnell's first World Altair Computer Convention. When Roberts denounced certain memory-board firms in his newsletter, calling them "parasites," two Oakland, California, hobbyists christened their new memory-board company Parasitic Engineering.

The only board company to win approval from MITS was Garland and Melen's Cromemco (named for Crothers Memorial Hall, their graduate dormitory at Stanford). Garland and Melen had gotten sidetracked from their plan to connect the Cyclops digital camera to the Altair. The interface board that was intended to perform this feat had taken on a life of its own, and had become a video interface board for displaying text and pictures generated by the Altair on a color television. The Dazzler, as they called the board, neatly solved the Altair's I/O problem. Roberts saw it as noncompetitive (MITS had nothing like it), and displayed it prominently with his Altair computers at a conference the following spring.

The First World Altair Computer Convention

Figure 22. Harry Garland and Roger Melen ***Garland (left) and Melen were the first customers of MITS and the first to deliver an Altair-compatible third-party product. Later they developed their own line of personal computers under the Cromemco name.*** **(Courtesy of Roger Melen)**

The first World Altair Computer Convention, held in Albuquerque in March 1976, was the first of the microcomputer conventions. Hundreds of people attended this event, but it was intended strictly as a MITS Altair affair. Every one of the dozen or so speakers and presenters was there at MITS's invitation, including one who demonstrated a backgammon game he had written for the Altair. Cromemco was the only hardware company invited. Garland and Melen were there in person, the burly Melen a match for Roberts in size but far more reticent, the diminutive Garland bubbling with enthusiasm.

Figure 23. World Altair Computer Convention ***The sign announcing the first "World" Altair Computer Convention captures the grandiose aspirations and amateurish execution that typified the early days of personal computing.*** **(Courtesy of David H. Ahl)**

A number of uninvited companies sent out representatives to walk the floor and pass out circulars inviting viewers to see competitive equipment on display in hotel rooms upstairs from the conference center. Among that group were reps from Bob Marsh’s Processor Technology, whose memory boards were threatening to eat into Roberts’s profits.

The presence of the show-crashers irked MITS management. David Bunnell was so perturbed by the crashers that he went around tearing down their signs.

MITS had more to worry about than the board companies who were competing against MITS’s components. Other firms were springing up that challenged MITS’s core product, its computer. Don Lancaster’s Southwest Technical Products and Sphere were both working on computers built around Motorola’s recently released MC6800 processor.

Roberts had proposed building a 6800 machine, too. But some of his employees, including Paul Allen, opposed this new venture as a distraction.

“No, Ed,” Allen objected. “We’ll have to rewrite all our software for the 6800. We’ll have two instruction sets to support. That just doubles our headaches.”

Roberts prevailed. MITS did develop a 6800 machine, starting work on it late in 1975. Named the Altair 680b and attractively priced at $293, that computer was substantially different from the original Altair 8800. Components from the 8800 could not be used in the 680b, nor could the original Altair BASIC.

When the new computer magazine *Byte* unveiled Southwest Tech’s 6800 computer in November 1975, the announcement was soon followed by MITS’s announcement of its 680b. Additional engineers were hired to work on the new design, and new employees were added. The struggle to keep up with the orders for the 8800 and the determination to rush out the 680b had swelled the ranks of MITS employees from 12 to more than 100 in just a year.

The Role of Software

One of MITS’s new employees was Mark Chamberlain, a quiet University of New Mexico student with a knack for understatement and a taste for assembly-language programming. Chamberlain had worked on a Digital Equipment Corporation PDP-8 computer, probably the closest thing to a microcomputer that most universities had at the time. “I had done a lot of assembly code…and got so turned on to it that they just couldn’t keep me out.” When a professor mentioned that a small company named MITS was looking for programmers, Chamberlain made an appointment to talk to its software director, Paul Allen.

Allen wasn’t sure where MITS was headed and wanted Chamberlain to know the risks involved. Allen had willingly accepted these risks but wasn’t about to inflict them on the unaware. He hired Chamberlain but warned him, “If it doesn’t work out—well, it doesn’t work out.” Chamberlain appreciated Allen’s candor and commenced writing software for the 680b, a machine that “was not enormously successful,” Chamberlain recalled dryly. They had already encountered serious difficulty with the product. “Lots of [the 680b machines] were ordered, but when I came on board at MITS, the whole project was already in trouble. They had to go through a complete redesign.” Despite the revamping, the 680b never really took off. But Chamberlain found plenty of other work to do at MITS. Roberts had other machines in mind, and each of them required new software.

Meanwhile, Allen and Gates were putting increased effort into their own company, Microsoft. Throughout 1975, Gates, Allen, and Rick Wyland, who was hired to write 6800 BASIC, were branching out with their versions of BASIC, including developing versions for other companies. The relationship between Microsoft and MITS was becoming less clearly defined as the two companies grew.

The fact that Bill Gates had yet to write the disk code for the Altair 8800 didn’t help matters, especially because Gates, on leave from Harvard, was considering returning to school. Paul Allen, in his role as MITS software director, nagged Gates about finishing the code. According to Microsoft legend, in February 1976 Gates checked into a motel with some pens and a stack of yellow legal pads. When he came out, he had finished the disk code.

Figure 24. Bill Gates ***Gates temporarily abandoned his glasses while speaking at the first World Altair Computer Convention in Albuquerque in 1976.*** **(Courtesy of David H. Ahl)**

By 1976, the switch from dynamic memory to static memory (two means of maintaining information in memory) seemed to have solved the vexing problem with the memory board, but MITS still had to either troubleshoot the dynamic boards already in the field or buy them back. Early in that year, MITS revamped its quality-control procedures in an attempt to increase efficiency in manufacturing. MITS was already shipping the 680b and planned to ship the upgraded 8800 by midyear. A rudimentary disk operating system written around Gates's disk code was scheduled to be released in July 1976.

Anyone who owned an Altair had probably written a program for it at one time or another. Mark Chamberlain was now maintaining a library of software submitted by Altair users, thereby setting a precedent for the industry. Chamberlain was distributing such programs as widely as possible throughout the community of users, which was a smart move. Sharing of software vastly increased the value of the machine. In particular, he sought software for the new 680b. When Paul Allen announced the price for the 680b BASIC, customers recognized an already familiar tactic. The BASIC cost nothing with the new 16K memory board, but $200 when purchased without it.

The S-100 Bus

By the middle of that year, the competition that Roberts had long feared was becoming a reality. A new company named IMSAI imitated the Altair design and brought out its own computer, the IMSAI 8080. PolyMorphic Systems introduced what looked like a serious competitor to the Altair, the Poly 88. And, in July 1976, Processor Technology grabbed the front cover of *Popular Electronics* with its Sol computer, named after the magazine's editor. Even MITS's loyal board supplier Cromemco was developing a CPU board designed around the new Zilog Z80 microprocessor as the successor to the Intel 8080 chip that was the heart of the original Altair computer. The Z80 was designed by Federico Faggin, who had left Intel to start his own semiconductor company after his work on the Intel 4004. This new microprocessor was catching a lot of attention among the high-tech hobbyists.

None of the new microcomputer companies represented an immediate threat to MITS's market share for microcomputers. In that arena, MITS reigned uncontested. But all of the machines from these start-ups could, in principle, use the same circuit boards as the Altair. They all had the same 100-line bus structure and, as Roberts viewed things, that bus was the key to compatibility in that it allowed competitive boards to be plugged into the Altair. He typically referred to the system as the "Altair bus" and wanted others to do the same. When some didn't comply, David Bunnell suggested sarcastically that they call it the "Roberts bus." The bus-naming story typifies the curious mix of competitiveness and camaraderie in the nascent computer industry. The bus became a major point of contention between MITS and the rest of the microcomputing world.

Roberts's position was simple: he and Yates had designed the bus just as they had designed the Altair. Therefore, it was the Altair bus. His competitors preferred not to share his view. The advertised name for the device grew to absurd lengths in order to credit just about every manufacturer. It was billed as the “MITS-IMSAI-Processor Tech-PolyMorphic bus.” Garland and Melen talked about the bus-name problem on a flight from San Francisco to Atlantic City, where PC 76, an early microcomputer conference, was held in August 1976. Garland and Melen were about to release a CPU board for the Altair bus and were reluctant to refer to it by a lengthy list of competitors’ names. They agreed about two things: the name of the bus should not favor any one company, and it should suggest an item that’s been engineered. For instance, the name could consist of a letter and some numbers. They liked the name “Standard 100,” and in keeping with their theme, shortened it to “S-100.” That, they thought, sounded sufficiently official.

Their next goal was to secure the approval of other hardware vendors. Melen recalled, “On the same airplane were the people from Processor Technology, specifically Bob Marsh and Lee Felsenstein. I had a can of beer in my hand, and in the course of our discussing the Standard, the airplane hit a little bump, and I spilled my beer on Bob. He agreed [to the new name] very quickly, to get rid of me and my beer can.” The name S-100 became the common coin, although MITS and *Popular Electronics* stubbornly clung to the name “Altair bus” for a long time. Seven years later, Ed Roberts was still adamant about it: “The bus was used by MITS for two years before anybody else was producing a computer. It’s the Altair bus. Calling the Altair bus the S-100 bus is like calling Mona Lisa ‘Tom Boy.’ I’m the only one in the world who’s irritated by that, but I’m irritated.”

In addition to the S-100 companies, MITS was witnessing disturbing signs of competition from other, even more unnerving sources. MOS Technology, a semiconductor company, was doing well with Chuck Peddle’s KIM-1, a low-cost hobbyist computer built around its own bargain-basement 6502 chip. This fact alone may have occasioned no immediate alarm, but two months later, in October 1976, Commodore bought MOS Technology. For the first time, a large and well-established company with extensive channels of distribution for electronics products would be selling a microcomputer.

Roberts was justly worried. He remembered how Texas Instruments had stomped all over the calculator business.

But an even more ominous threat was looming. Tandy Corporation, having “just gotten through killing off Lafayette [Electronics],” as Peddle put it, was casting about for a computer to sell in its hundreds of Radio Shack stores. “What Radio Shack wanted to do was to come up with a packaged machine,” Peddle said, “because they knew their guys couldn’t support, and couldn’t design, this kind of thing.” Radio Shack, with its stores all over the country, could sell thousands of personal computers at rock-bottom prices.

With semiconductor companies and electronics distributors getting into the act, the competition was gearing up.

The Fall

Q: Did you think it was going to go under?

A: All the time, all the time.

–Bill Gates

The troubled MITS had more to worry about than its competition. The company had grown too big too fast. “We had too many irons in the fire,” Roberts admitted later. “We had a lot more things going than a company the size of ours should have had.” The faulty memory boards that were still out there in the field were just one of the problems. Quality control was not particularly effective, and customers were complaining. Projects were often launched despite the reservations of many MITS employees. A number of products failed.

Problems and Changes at MITS

“The high-speed paper-tape reader is a good example,” Mark Chamberlain recalled, “because I know we only sold three of those.” The “spark printer” was another: MITS bought a printer from a manufacturer, rebuilt it and repackaged it, and eventually had to charge considerably more than the supplier’s retail price for the original unimproved item. Naturally, the MITS version didn’t take off. Sometimes an entire major product line was clearly a mistake to everyone at MITS except Roberts. Paul Allen objected strenuously to the 680b.

MITS’s difficulties ran deep. “It really gets into a study of personalities,” Mark Chamberlain said. “I don’t know if it’s possible to understand the situation without understanding all the aspects that were [a result of] people’s different personalities.” One thing is clear in retrospect. The channels of communication between upper-level employees and the president were not always open. “Ed isolated himself,” Gates said. “He didn’t have a good rapport with other people in the company, and didn’t know how to deal with the growth.” Roberts later acknowledged that a problem existed: “I was worried about so many things at the time that I felt like everything was a threat.”

A number of changes occurred at MITS toward the end of 1976. By that time, Roberts had brought in his childhood friend Eddie Curry as executive vice president and Bob Tindley (from the bank that had financed MITS) to help with management. But Roberts was soon to lose an important employee. Paul Allen was restless. Microsoft was becoming a more serious enterprise, and Allen was eager to take control of his own destiny. Convinced that MITS’s best days were past, he and Bill Gates began focusing all their attention on their own company.

Mark Chamberlain moved up to replace Allen as MITS’s software director.

Chamberlain found that the job bore unexpected challenges. He quickly encountered upper-level dissension over which products to build and which projects to undertake first. Chamberlain, along with his hardware counterpart Pat Godding, did not always agree with Roberts on critical decisions. In holding on so tightly to the reins of his company, Roberts may have been trying to shield others from all the uncertainty and vulnerability of the fledgling industry. He took all the responsibility upon himself rather than allowing others to share it. As Gates acknowledged, “Nobody really knew what was going on. So many things would have obviously needed to be done if you’d had the vision back then. Nobody had the view of the market.”

“He did have ideas,” Chamberlain said of Roberts. “But we didn’t fill out the product line; we didn’t provide proper support. I think that the early pioneers who used the Altair in business were up against a hell of a lot of frustration.” Among the most frustrated were Chamberlain and Godding. Too many times, they had proposed projects that they knew would generate significant income with just a small expenditure of time, only to have Roberts say that absolutely no more time would be spent on them. Convinced that their ideas had value and equally certain that Roberts would continue to reject them, they often went ahead on their projects anyway. “He didn’t know we were doing it,” said Chamberlain.

Although MITS grossed $13 million in 1976, the company was losing its edge. Its products were not regarded as anywhere near the best, deliveries were slow, and service was poor. Most other microcomputer companies at the time had similar problems to some degree, but MITS’s position in the industry led people to expect more from the firm. Furthermore, MITS had established an exclusive dealership program early on. Retailers who wished to be the only Altair dealers in their area could sell no other brands. But the knife cut both ways, and MITS began to have trouble finding dealers willing to agree to the company’s terms.

Retailers and customers alike were dissatisfied. It was not that MITS was in imminent danger of going out of business, as it had been in 1974, but its prospects were not good and the competition was getting serious. By now, more than 50 hardware companies had entered the market. At the first West Coast Computer Faire held in San Francisco in the spring of 1977, Chuck Peddle was showing Commodore’s PET, a more serious machine than the MOS/Commodore KIM-1 and a formidable competitor to the Altair machines; also, Apple introduced its Apple II amid fanfare that signaled a change in the market.

Selling the Company

On May 22, 1977, Roberts sold MITS to Pertec, a company then specializing in disk and tape drives for minicomputers and mainframe computers. “It was a stock swap,” Roberts said. “They bought MITS for essentially six million dollars.” Whether Pertec got a bargain or a dud depends on the degree to which Pertec management was responsible for MITS’s ensuing slide into oblivion.

Roberts had talked to other companies, especially semiconductor companies, before deciding on a buyer. Pertec had offered him not only personal stock in the company, but his own private research-and-development lab and the freedom to use it exactly as he pleased. The opportunity to work on new products and to somehow tie his fortunes to MITS undoubtedly meant a lot to Roberts. But he mostly just wanted to climb down off the nose cone. The bust of the calculator venture still haunted him, and he knew a similar disaster could very well happen with personal computers.

“Once you’ve been there,” Roberts said, “staying awake every night wondering whether you’re going to make payroll the following day…you’re pretty gun-shy, and you’re making decisions that aren’t terribly logical.”

The Pertec sale led to acrid fighting over ownership of the software. Gates and Allen had no intention of handing their BASIC over to Pertec. They had written the core of the BASIC before even meeting anyone from MITS, and, unlike Allen, Gates insisted that he had never been a MITS employee. “Pertec thought they were buying the software as part of the whole deal,” Gates recalled. “And they weren’t. We owned the software. It was all under license.”

Suddenly, the whole deal was in jeopardy. Gates later recalled the head of Pertec telling him that if the software were not included in the transaction, Pertec would back out of the deal. If that happened, MITS would fold. The pressure on the boys was tremendous.

“They sent out this big-time lawyer,” Gates recalled, and the matter went into arbitration. When it was all over, Gates and Allen had prevailed. The software belonged to Microsoft. Fortunately for MITS, Pertec went ahead with the purchase anyway.

Ed Roberts always held that the arbitration decision was dead wrong. Years later he felt bitter and betrayed. MITS’s agreement with Gates and Allen, he insisted, stipulated that they would receive royalties on the software up to a maximum of $200,000 and then the software would belong to MITS. His company had paid them that amount and therefore owned the software. Roberts was convinced that the arbitrator misunderstood clear issues of fact. “It was a fluke,” Roberts maintained. “It was just wrong as rain.”

Roberts blamed Gates for the outcome. “Our relationship really went to heck,” Gates said. “Ed really got his feelings hurt.” Having won in the arbitration and with no ties holding them to Albuquerque, Gates and Allen moved Microsoft to their native Washington.

Pertec didn’t back out of the MITS acquisition because of the BASIC ruling, but under Pertec, MITS gradually fell apart. Even before the acquisition, the company was losing its dominant role in the very industry it had created. But MITS didn’t start its dramatic decline until the Pertec management teams walked onto the scene.

The Suits

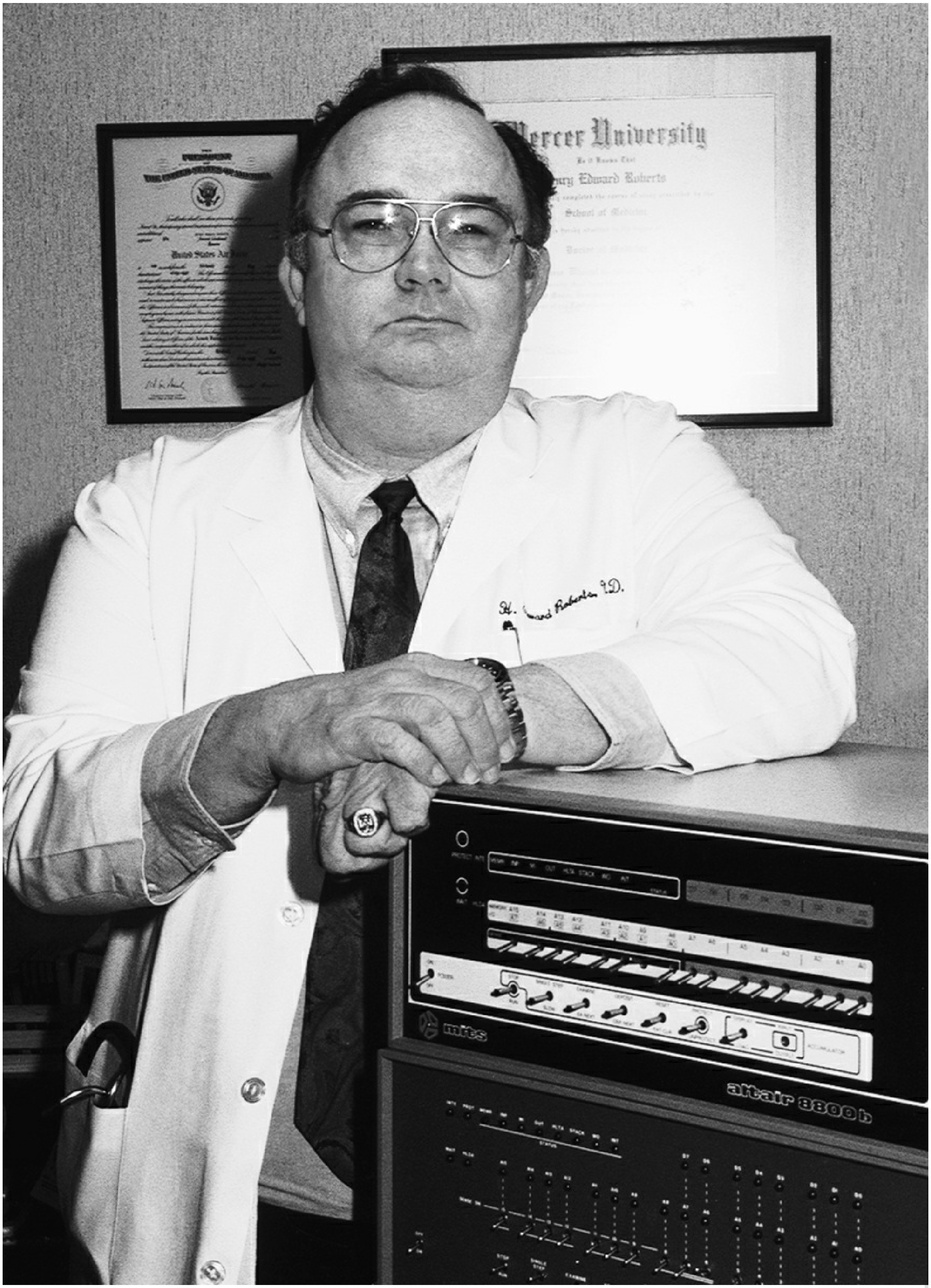
mits
altair 8800b

Figure 25. Ed Roberts ***After launching the personal-computer revolution and riding the roller coaster of entrepreneurship, Roberts sold the company, went back to school, and settled in rural Georgia to live out a second dream as a country doctor.*** **(Courtesy of Ed Roberts)**

The Pertec people managed to alienate virtually all key MITS personnel. “They kept patting us on the head, saying we didn’t understand the business,” Roberts recalled. The MITS regulars didn’t respond well to the Pertec management teams. The standard line on them was that they were “two-bit managers in three-piece suits.” The epithet was used so frequently it was shortened to simply “the suits.”

Pertec treated MITS as if it were a big business in an established industry. Before agreeing to buy MITS, Pertec executives asked Roberts to show them his five-year marketing forecast. At the time, MITS advance planning “consisted of where things would be on Friday,” Roberts said. To please the buyers, Roberts and Eddie Curry invented projections they figured would make the Pertec managers break out the champagne. They told Pertec that sales would double each year and provided a pie-in-the-sky guess of how many machines the company could move. Pertec bought it all. Over the following year, managers came and went at Pertec in extraordinary numbers. “People based their careers on trying to live up to that [forecast],” said Curry.

Mark Chamberlain had no use for the Pertec suits who’d invaded MITS: “They sent in team after team. Each team came in to knock off the previous team. Any given team had about 60 to 90 days to turn the mess into something good, but it wasn’t enough time. It was just long enough for the people to come in and switch from a position of trying to understand the problem to becoming a part of the problem. After 60 to 90 days, you were definitely part of the problem. And they’d send in the next guy to fire you.” Chamberlain left to go to work for Roberts in his lab. “I wanted out of that Pertec thing like right away,” he said. “That thing was crazy.” For a while, Chamberlain worked with Roberts on a low-priced computer based on the Zilog Z80 chip, but he soon left to pursue other opportunities.

Others were defecting from Pertec’s MITS group. Bunnell departed at the end of 1976 to start *Personal Computing*, one of many significant personal-computing magazines he would eventually launch. He published it from Albuquerque throughout 1977 with contributions from Gates and Allen. Andrea Lewis took over as editor of *Computer Notes* and changed it from a company-written newsletter to a slick magazine with outside contributions. Eventually she accepted an invitation from Paul Allen to move to Bellevue and take over Microsoft’s documentation department. Sometime after that, Chamberlain also joined Microsoft.

Several engineering people left Pertec to work for a local electronics company. Even Ed Roberts, after five months, became fed up with Pertec. “They told me I didn’t understand the market. I don’t think they understood it.” Roberts bought a farm in Georgia and told everyone he intended to become a gentleman farmer or go to medical school. Eventually he did both, with the same concentrated energy he had brought to MITS.

Pertec gradually came to regard the MITS operation as a bad venture and eventually abandoned it. According to Eddie Curry, who stayed on longer than any other MITS principal, Pertec continued making Altairs for about a year after the acquisition, but within two years MITS was gone.

It would be hard to overestimate the importance of MITS and the Altair to the existence and form of the personal-computer industry today. The company did more than create an industry. It introduced the first affordable personal computer and pioneered the concept of computer shows, computer retailing, computer-company magazines, users' groups, software exchanges, and many hardware and software products. Without intending to, MITS made software piracy a widespread phenomenon. Started when microcomputers seemed wildly impractical, MITS pioneered what would eventually become a multibillion-dollar industry.

If MITS was, as writer David Bunnell's ads proclaimed, number one in the business, the scramble to be number two was won by one of the most idiosyncratic of the early microcomputer companies.

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Chapter 3

The Miracle Makers

> *Make a miracle.*
>
> *Bill Millard, IMSAI founder*

At MITS, many of the themes that would define the personal-computer industry were already present. But it wasn't much of an industry, and MITS management showed its roots in hobby electronics. Ed Roberts needed to sell computers, but even more, he wanted the fun of designing and building them. At IMSAI, for the first time a company would enter the nascent industry driven by a laserlike focus on business success rather than a passion for technology. It would achieve that success, and would also run afoul of some of the errors that personal-computer companies still struggle with today.

After Altair

Everybody wanted to be second.

–Ted Nelson, computer visionary, philosopher, and critic

During the two and a half years between the January 1975 *Popular Electronics* cover story announcing the Altair 8800 and the May 1977 sale of MITS to Pertec, a new industry was on the rise. The Altair announcement triggered both technological and social change. The hobbyists who read the *Popular Electronics* article may not have envisioned the subsequent proliferation of microcomputers, but they did realize they were witness to the start of a radical change in the way people accessed computers. They had been longing for it.

Programmers, technicians, and engineers who worked with large computers all had the feeling of being locked out of the machine room. They resented the tyranny of the priesthood and dreamed of owning their own machines.

Hobbyist Entrepreneurs

The Altair from MITS breached the machine-room door, and rivals emerged almost all at once from garages all over the country. Ed Roberts's price was hard to undercut, and if it had not been for the long delays in delivering the Altair, MITS's early advantage would have been huge. But none of these hobbyist entrepreneurs was in it primarily for the money. When they failed, and they often did, they failed openly, with their schematics laid on the table for all to see. Mistakes proved instructive, and failures did little to discourage increased innovation. The revolution was running on its own internal drive, and not according to the external pull of profits. As a result, the industry did not take shape according to traditional economic laws.

The MITS competitors were hobbyist enterprises, partly because none of the big corporations wanted to build microcomputers. Only those fanatics who were totally and blindly enthralled by computers and electronics could have endured the tedious detail work required to design and build a computer by hand.

The idea of assembling a computer by hand sounded crazy to most people. It had only recently become possible to attempt such a task at all, and the Altair had yet to prove itself as a computer in anything more than the technical sense. But the hobbyists of 1975 knew that the Altair eventually would make its mark.

Don Lancaster, of TV Typewriter fame, had been providing digital know-how to a generation of computer hobbyists through his freelance articles in electronics magazines. Lancaster became involved with a company called Southwest Technical Products in the mid-1970s. Southwest Tech made high-end audio components kits and in 1975 released an Altair-like microcomputer using a new microprocessor from Motorola, the 6800. Many engineers, including Ed Roberts, thought the 6800 was a better chip than the Altair 8080, and Roberts kept a watchful eye on Southwest Tech.

Don Lancaster exemplified the spirit of information sharing, unthinkable among most other business competitors, that ran throughout the computer-hobbyist field. Special-interest magazines had helped create a nationwide community of hobbyists who regularly wrote to one another, argued at length and with passion, and generously shared their knowledge. As a result, they were technically prepared and emotionally geared up to build their own computers. “They wanted it so bad they could taste it,” said semiconductor designer Chuck Peddle.

Some of the Players

At UC Berkeley, computer-science professor John Torode examined the Intel 4004 and 8008 chips and decided they were less than ideal for use as central processors. When he got one of the first 8080 chips from his old friend Gary Kildall, who was teaching computer science down the coast in Monterey and consulting at Intel, Torode began to think seriously about building his own microcomputer.

By mid-1974, Torode and Kildall had assembled a microcomputer and a disk operating system of sorts. But they were skeptical about the market for such a device and continued to refine the product strictly as a hobby; Kildall created the software and Torode fashioned the hardware. They sold only a handful of machines before the Altair burst on the scene, including the two devices they sold to a San Francisco Bay Area computer-terminal company called Omron. The two then pursued their interests independently; Torode built computers under the name Digital Systems and later Digital Microsystems, and Kildall wrote software under the name Intergalactic Digital Research (later just Digital Research).

Although the Bay Area was recognized as a development hub, the microcomputer phenomenon was spreading nationwide. In Denver, Robert “Dr. Bob” Suding turned his hobby into a business, Digital Group, which soon won the respect of many hobbyist customers. The company initially produced plug-in circuit boards for the Altair and other emerging computer brands. Suding also pioneered an idea that was taken seriously five years later: a machine that could use different types of microprocessors interchangeably. The Altair was an 8080 machine and the Southwest Tech computer a 6800, but either processor would work in a Digital Group computer.

This innovation reflected the thinking of the times. An interchangeable microprocessor was a boon to microcomputer designers (that is, hobbyists), but was of little use to ordinary consumers because of the lack of software for the new processors. The hobbyists were designing computers for themselves. Even the appearance of the machines reflected their hobbyist origins. The typical computer resembled a homemade piece of electronic test equipment—a metal box rigged with toggle switches, blinking lights, and wires running out of its back, front, top, or sides—a real “kludge.”

No one gave much thought to a machine’s visual appeal because designers were creating the computers they wanted, regardless of how the end product looked. When the Southern California–based company Vector Graphic rejected a designer’s pink circuit board with purple rheostats on the grounds that the components clashed with Vector’s green-and-orange computer, the designer was flabbergasted. Color coordination was seldom a consideration in mid-1970s computer design.

One of the first computer companies to consciously consider aesthetic appeal and economical use of desktop space was Sphere, founded by Mike Wise in Bountiful, Utah. This was the company that, like MITS, had promoted its computers with a traveling show run out of a motorhome. The Sphere computer was integrated; that is, the display monitor and keyboard were incorporated into the same case with the microprocessor. The machine was a closed unit, with no mass of wires dangling out of its sides.

The Sphere didn’t last. Although a commercial product on the outside, inside it was all hobby machine. The mechanism under the lid wasn’t pretty—not even to a hobbyist. It was too much of a handmade item, filled with scores of crisscrossing, hand-soldered wires. The Sphere was not engineered for production, nor was it particularly reliable. Plus, as one hobbyist of the time put it, it had “the world’s slowest BASIC.”

The names given to the corporate start-ups reflected the informality and tongue-in-cheek humor of the hobbyist movement. Lee Felsenstein started a company called Loving Grace Cybernetics and later another called Golemics Incorporated. Ted Nelson’s Itty-Bitty Machine Company, a sly play on *IBM*, appeared in Evanston, Illinois. Chicken Delight Computer Consultants cropped up in New Jersey. Kentucky Fried Computers began in Northern California.

A thin line existed between buyers and manufacturers in those early days. Operating a microcomputer took so much expertise and dedication that to say a skilled user could have become a manufacturer was no exaggeration. The “industry” consisted of a conglomerate subculture of technofreaks, hobbyists, and hackers untrained in business practices, entrepreneurs who were more interested in exploring the potential of the microcomputer than in making a fortune.

One exception was IMSAI Manufacturing in San Leandro, California.

IMSAI

IMSAI became the number-two maker of microcomputers and soon thereafter seized the leading sales position from MITS. Started by Bill Millard just months after the January 1975 Altair debut, IMSAI was unique in its origin and philosophy. Practically all the other company presidents were hobbyists who knew each other through club meetings and newsletters. Millard, by comparison, was a former sales representative. He and his associates didn't know the hobbyists and didn't want to know them. They seldom attended the hobbyists' club meetings at which members would swap stories of their experiences with various new (and unreliable) machines, exchange rumors, and share equipment, software, and insights. Millard and company didn't consider themselves part of that crowd.

From the very first, Millard and his team of hard-driving executives saw themselves as serious businesspeople in a field populated by blue-jeaned dilettantes. The IMSAI computer would be the desktop tool of the small business, Millard decreed. It would, among other things, replace the typewriter. In the minds of IMSAI executives, the company was building commercial systems for business customers who wanted to do real work. They weren't in the business of making toys for hobbyists. It was prescient on their part to see such potential in those crude early microcomputers. It may have seemed fanciful to build a company on that vision back in 1975, but Millard and his team were not afraid to be seen as overly ambitious. They were operating outside the envelope, and that was how they liked it.

In 1975, when IMSAI began making its 8080 microcomputer, most of the hobbyists thought that Millard was trying to corner the business market a little early. The hard-core hobbyists didn't know just yet what those machines could do, so how could the business community be expected to embrace them? Microcomputers were still experimental and often didn't work right. So what made Millard and his team think that small businesses would buy the machines?

"Guesswork," according to cofounder Bruce Van Natta. "We guessed that these things were really small business machines, even if the damn things did weight 80 pounds and barely fit on a desk."

Technologically, the IMSAI computer was no breakthrough. It was essentially a copy of the Altair with some enhancements—most notably, a better power supply. The Altair's power-supply unit, which was supposed to distribute the appropriate DC current and voltages to the various parts of the computer, was regarded by hobbyists as dismal. IMSAI, on the other hand, delivered "a power supply you couldn't lift," as Van Natta put it. Although IMSAI eventually solved other stubborn technical problems, perhaps the company's most significant achievements in hardware design were improving the Altair power supply and eliminating the hand-soldered wires that the Altair required. Those two innovations went a long way toward making the machines truly useful.

But IMSAI's most important contribution to the nascent industry was not a technological one; it was the company's pure chutzpah. Millard took a "me-too" design, sold it to a market whose mere existence was dubious, and built a company that became a power to be reckoned with.

Amateurs and Professionals

> *It was an unusual organization in that it really did believe in high-intensity, enthusiastic amateurs.*
>
> –Bruce Van Natta, IMSAI cofounder

Bill Millard was a magnetic role model to the IMSAI executives, and through them he set a singular tone for the company. Millard did not hire hobbyists, but he did hire enthusiastic amateurs. His personality and goals became the corporate personality and the company's goals, so much so that Millard's decision-making style steered IMSAI even when he wasn't around, as happened during some rocky times in the company's history when top-level decisions were critical.

Unlike Ed Roberts at MITS and many others, Millard was not particularly fascinated by hardware. Roberts was a true hobbyist, a computer junkie who really wanted to *see what the thing could do*. Like a number of microcomputer engineers after him, Roberts built the kind of machine that he wanted to use. If MITS managed to sell just a few hundred computers, enough to keep the company in its little shop next to the laundromat, Roberts wouldn't feel that he had failed. He liked money, but for him a larger thrill was always in the possibilities the machine presented.

Bill Millard Assembles His Team

Bill Millard was different from the other company heads. He burned with a much more acquisitive fire, constantly seeking increased market share, increased capital, and more and more attention. "He was a typical entrepreneur," according to one of his protégés, Bill Lohse, "except maybe a little more careless, a little more gutsy." He was a gambler who liked to take chances.

And he knew how to sell. Millard had been a rep for IBM and had done well at it. By the late 1960s, he was manager of data processing for the city and county of San Francisco, where he dealt with mainframe and minicomputer companies into the early 1970s. That experience enabled him to identify the potential players who would join him in the biggest gamble of his life.

Millard was looking for a loyal and dedicated team to follow him onto the competitive industry playing field. He wanted enthusiastic young men and women who weren't necessarily computer experts but who would take the risks he wanted to take. Other microcomputer companies could be run by engineers. Millard created a company run by salespeople.

Millard's people all displayed an intense desire to succeed and an unswerving confidence in their sales abilities. They were an odd bunch for the industry at that time. They wore suits. They talked more about money than machines, and more about goals and “miracles” (Millard’s oft-used expression) than about money. And, almost without exception, they had “done the training.”

“Doing the training” for Millard and many other Californians at the time meant going through Erhard Seminars Training, or *est*, one of a spate of self-help movements that sprang up during the late 1960s. Millard had done the training and encouraged his family and friends to do it, too; it became a condition of employment for upper-level executives at IMSAI. One *est* tenet had particular relevance for IMSAI: failure or the admission of its possibility was viewed as evidence of lack of a desire to succeed. Therefore, many *est* graduates were reluctant to admit a task might be impossible or a goal unattainable. Millard liked that tendency in people and actively sought it in his coworkers.

Initially, Millard had no intention of building computers. He started IMS Associates, the IMSAI parent company, to configure computer systems for businesses, which was the sort of work he had once done for San Francisco’s city and county governments. IMS determined what hardware and programs companies needed to solve their data-processing problems and matched the hardware and software accordingly. His focus began to shift when he met Joe Killian, an *est* graduate and a good programmer who also knew hardware.

The Technical Guy

After dropping out of a graduate physics program, Killian was looking for a job in the Bay Area when a friend introduced him to Bill Millard. Killian had become fascinated with computers in graduate school, and formed an immediate bond with Millard. But Killian was not the model IMSAI executive Millard typically sought. Although he was young and enthusiastic, was open to new ideas, and attacked technical problems with a hobbyist’s zeal, he tended to deliberate before he spoke. He always hesitated a moment before expressing his opinions on a new idea, the moment it took him to reconcile the new idea with his existing knowledge and beliefs.

It took a New Mexico automobile dealer, who was one of Millard and Killian’s customers, to push them into building microcomputers. Early in 1975, a request from the auto dealer presented both a challenge and a maddening problem for Millard. The dealer had commissioned Millard to find a minicomputer to do his accounting, and Millard thought he knew of an inexpensive way to satisfy him. MITS had just announced the Altair, and Millard planned to buy the rudimentary machine and tack on whatever extras the dealer needed. If a microcomputer could do the job, he could cut the cost drastically.

Unfortunately, Millard did not fully grasp the MITS situation and what kind of struggles the company was having. Overwhelmed by orders, Roberts’s little company was not yet ready to deliver finished Altairs, and Roberts had given no thought to quantity discounts. The idea of selling Altairs at a discount to Millard, who would dress them up as business systems with the appropriate software and attachments, didn’t appeal to Roberts. When Millard realized that Roberts couldn’t or wouldn’t supply him with discount-priced machines, he looked elsewhere.

Had Millard been in tune with the hobbyist community, he might have done business with one of the new hobby firms just popping up. Instead, he drew on his contacts in the minicomputer and peripheral-equipment areas. At Omron, a computer-terminal company that had, coincidentally, just bought the first two of John Torode and Gary Kildall’s microcomputer systems, Millard chatted with a fellow named Ed Faber. Faber was, in some ways, a kindred spirit. Like Millard, the softspoken Faber was an ex-IBM salesman in his mid-40s who was intrigued by risks. Despite connecting with Faber, Millard’s immediate goal was to fill the auto dealer’s order, and again nothing acceptable emerged. He was growing frustrated.

Millard realized that a great opportunity had presented itself. It wasn’t just a matter of a single auto dealer in New Mexico. Once Millard’s people had put together a complete system with all the necessary programs and hardware, they could sell it to auto dealers throughout the country. Millard knew they wouldn’t fail. He wasn’t about to let this opportunity evaporate. He took the auto dealer’s money and with it started a company called IMSAI Manufacturing for the express purpose of building microcomputers.

Millard knew what he wanted. He was convinced that the Altair was the machine for the job, and if Roberts wouldn’t sell Altairs to him at a reasonable price, he would build his own. Or Joe Killian would. A friend of Killian’s had bought an Altair, and Killian had carefully studied it, but that wasn’t enough. External examination was fine, Killian said, but he really needed to get inside the thing and dismantle it. His friend liked his Altair as it was, intact. Millard phoned Paul Terrell, whose nearby Byte Shop was one of the few Altair dealerships in the country. Millard ordered some Altairs for dissection. Over the next few months, Killian would tear the computers apart, figure out how they were made, and replicate them.

Figure 26. Paul Terrell ***Terrell supplied Bill Millard with the Altairs that Joe Killian disassembled to learn how to replicate and improve the design.*** **(Courtesy of Paul Terrell)**

The Salesmen

Millard's team was beginning to grow. Killian had worked many late nights on another project, and Millard gave him a much-needed vacation in February 1975. In Killian's absence, Millard advertised for a programmer to take his place. The UC Berkeley computer-science grad school dropout who applied for the job was youthful, brash, and willing to take risks; moreover, he knew how to sell himself. Bruce Van Natta impressed Millard immediately. Van Natta in many ways had the typical appearance and manner of an IMSAI executive. He was tall, thin, bright-eyed, and sharply attired, quick with an opinion, succinct and decisive in his speech, and willing to take outrageous risks.

Van Natta fell naturally into the mold of the aggressive IMSAI exec. When Killian returned from his vacation, the three of them sat around a table at Jake's Lion Restaurant in San Leandro talking late into the night about their plans for microcomputers, their new company (IMSAI), and making miracles happen. If Killian or Van Natta complained that Millard was asking the impossible, Millard would tell them, “Make a miracle.”

While Killian worked on the IMSAI computer, Bruce Van Natta was promoting something called the Hypercube, a product idea he had conceived and hashed out during the Blue Lion talks. The Hypercube device was designed to link together several microprocessors to produce results similar to those you’d get from a large computer. Van Natta was acclaimed for this concept. He was soon giving lectures around the San Francisco Bay Area, at one point speaking before several hundred electrical and electronics engineers. But he was proudest of his invitation to lecture to the UC Berkeley Computer Science Department, which he had just recently left.

The Hypercube caught the attention of the computer-news media, stealing the front page of *Computerworld* and the “Product Spotlight” in *Datamation*, two mainframe-computer publications. A great deal of attention was being paid to a product that never existed except in Bruce Van Natta’s head, but to the computer-press editors who were keeping abreast of all the rapid innovations, the linking scheme that Van Natta proposed may have seemed like the only way tiny microcomputers could be made really useful.

In December 1975, with IMSAI’s computer in its first production stages, Millard once again met with Omron’s Ed Faber. This time he asked Faber to come work for IMSAI. Faber was skeptical. Killian’s computer was a kit, like the Altair. Kits were ridiculous, Faber thought. He had never heard of building your own computer, let alone selling it through mail-order ads run in *Popular Electronics*. But the number of calls coming in when he visited IMSAI changed his mind. He soon got swept up in all the excitement and accepted a position as director of sales in January 1976.

Faber did not exactly fit the IMSAI mold. He was seasoned, experienced, and used to giving orders rather than taking them. Most of the other key people were more malleable. Millard, the gambler, had wanted his eager band of executives to follow him anywhere in his high-risk excursions. Would Faber do the same?

In fact, Faber was willing to take risks. He was a veteran IBM employee who had specialized in two fields: sales and start-up operations. Having started a number of new ventures for IBM, Faber found that he relished the exhilaration of the experience. Millard needed someone to organize a sales force, and Faber was willing to do it. Faber’s post was a critical one; the sales team was the heart of the company.

Bill Lohse, one of the first salesmen Faber hired, was a vitamin peddler with a degree in philosophy. He, too, seemed to have been poured out of the IMSAI mold. He was tall and thin, a recent and enthusiastic *est* graduate, brash, bright, and fond of wearing the kind of top-quality suits that Van Natta and Millard favored. He knew nothing about computers but was convinced he could sell them to anyone.

Many more employees were hired by IMSAI, including a crew to actually produce the machines. And some of the new hires, such as ex–rock band roadie Todd Fischer, were of a different mold than Lohse, Van Natta, and Millard. By the fall of 1976, the production team was turning out Killian’s IMSAI 8080 computer in quantity. MITS, which until then had seen competition only in its circuit-board market, suddenly had a serious rival.

Building One and Building Two

> *Building One was primarily the administrative building. Building Two was the production building. There was always this thing of Building Two versus Building One.*
>
> –Todd Fischer, IMSAI computer repairman and entrepreneur

Todd Fischer liked to fix things.

When high school ended and many of his classmates went to college or engineering school, Fischer headed to the Air Force recruitment center to enlist. The Air Force, in turn, taught him to repair electronic equipment. Fischer valued the training, but didn't want to make the Air Force his career. So, when his hitch was up, Fischer went to work for IBM repairing typewriters and keypunch machines. He quit in 1967 after working there only briefly. It wasn't that Fischer didn't like the job. But it was the late 1960s, and to this Bay Area boy IBM symbolized faceless bureaucracies and soulless corporate power.

After leaving IBM, Fischer discovered that he could make money from music—not by playing it, but by fixing band equipment. In the late 1960s, he drifted into the San Francisco rock-music scene. This was Fischer's milieu and he loved it. From 1968 to 1971, Fischer worked with dozens of local rock groups. He worked as a roadie for legendary drummer Buddy Miles and for the rock band Uriah Heep. He traveled around the world with stage acts repairing electronic equipment. He was in heaven.

Eventually, Fischer returned to Earth. Back in the Bay Area he tried running an electronics-repair shop, but couldn't make a go of it. He was doing repair work in a stereo store when a friend invited him to come to work in the service division of a year-old computer company called IMSAI Manufacturing. "Repair computers? Well, why not?" he thought. After touring with the likes of Buddy Miles the work was a bit of a letdown, but at least Fischer got to fix things.

Fischer would turn out to be a key hire at IMSAI, but his laid-back style was very far from the goal-driven "make a miracle" spirit Millard promoted.

It's the Goal or Nothing

Meanwhile, IMSAI had grown quickly and showed no signs of decelerating. The company already occupied two buildings on Wicks Boulevard in San Leandro; administration, sales, marketing, and engineering were located in one building, and production and support in the other. Millard had assembled a driven organization, a fact nowhere more apparent than among the sales team in Building One. Telephone salespeople like Bill Lohse came in promptly at 8 A.M. and, after a brief meeting, got on the phones and stayed there, logging every call until lunchtime. Lohse would take an hour off, during which time he compared notes with other sales representatives on how many thousands of dollars of equipment they had sold that morning. Then he'd jump back on the phones again, making calls until the end-of-the-day sales meeting. Lohse learned not to talk in terms of "problems," but instead to use the buzzwords "challenges" and "opportunities." Exhortations to "make a miracle" were frequently heard.

Under Millard's encouragement—some say insistence—the IMSAI executives and sales staff "did the training," made the miracles happen, and met their goals. IMSAI employees learned to focus on what they wanted to do and then go out and do it. They learned that lesson well, and it intensified their performance in meeting goals and in their relations with coworkers and customers. "Focus on what you want to do and do it" was a powerful message to send to a recent graduate in his or her first serious job. As if things weren't intense enough, the new hires worked for a rapidly expanding company that could apparently either go bankrupt the next week or grow as big as IBM. This message was delivered under the leadership of a charismatic entrepreneur, a high roller who informed each new employee that he or she could perform miracles—and *would* perform miracles.

Millard's exhortations were part of a calculated effort to create an atmosphere that spurred his staff to superhuman achievement. Only those who were driven could thrive in that atmosphere. The intensity created an attitude among IMSAI management of almost manic optimism. They regularly worked well into the night, living and breathing IMSAI and almost losing sight of the sublunary world. Yet from where Bill Lohse stood, eyebrow-deep in work, it was often difficult to focus on anything but what he was already doing. He saw nothing on the horizon but that week's sales goal.

Meeting sales goals became IMSAI's *raison d'etre* and the sales department the company's heart and soul. No one drove this point home more clearly than Bruce Van Natta. He had held a number of jobs at IMSAI, working in purchasing, programming, engineering, and product planning. One day, to everyone's surprise, Van Natta walked into the sales director's office and announced that he himself wanted to be a sales representative. It seemed an odd thing for a cofounder of the company to request, but before long Van Natta was the company's top agent.

Around that time, Bill Millard set a sales goal of $1 million for the month. Two days before the end of that month, Van Natta checked the sales figures. They totaled $680,000, and no potential customers were left to call on. Van Natta would never say that it was impossible to make the goal; one didn't talk that way at IMSAI. But he thought as much when he headed home that night.

Van Natta's wife, Mary, was IMSAI's sales coordinator, and she, too, knew what the sales figures were. Her birthday was approaching, and she wasn't sure she could enjoy it in the wake of the failure to reach their goal. When Van Natta asked his wife what she wanted for her birthday, she could think of only one thing. "I want the goal," she told him. Van Natta reminded her that with just two sales days left in the month, and their having called on everybody they could possibly contact, they would be lucky to ring up another dime that month. And $680,000 was a long way from a million bucks.

Mary Van Natta insisted that she still wanted to make the sales goal her birthday present. Bruce Van Natta said okay and did some mental calculations. He was one of a dozen or so people on the sales team, and he accounted for about 30 to 40 percent of sales. If only he could convince the firm’s biggest customer to place a 90-day order instead of a 30-day order, or if only he could renegotiate a few other sales orders. It all just seemed impossible.

For the next two days, Van Natta and the rest of the sales team labored feverishly to close the $320,000 gap. At ten minutes before 5 P.M. on the last day of the month, Van Natta dragged himself over to Mary’s desk and added his latest sales to the current total. It came to $990,000. It was amazing—virtually a million dollars, and surely a miracle by any reasonable standard. But it was almost five o’clock and time to quit for the day.

What, and fail? No way, Mary said. It’s the goal or nothing. There would be no falling short by even $10,000. Bruce Van Natta went back to the phone and called a dealer he knew. He asked the dealer to take $10,000 worth of equipment that Van Natta knew he didn’t really want as a personal favor. The dealer reluctantly agreed. They made their goal with literally minutes to spare.

A Company with Two Cultures

Building Two was where reality came in. Selling a million dollars’ worth of computers and building a million dollars’ worth of computers are two different things, and the production people had trouble keeping up with the orders. After one spring month when the company actually shipped a million dollars’ worth of machines, the production crew threw a party in Building Two to celebrate. Operations manager Joe Parsialli brought in beer, and pizza was ordered for everyone. Nancy Freitas, a production technician, and Todd Fischer, who by then was supervisor of production testing, both got tipsy on just a beer or two.

Freitas noticed that they weren’t the only ones feeling the effects of the alcohol. After working long hours for weeks on end, getting drunk on just a couple of beers wasn’t surprising. A lot of overtime was expected of everyone. The production team usually arrived to work around 6 A.M. and stayed until at least 8 P.M. They were tired and feeling frazzled, and it wasn’t just the hours that were fatiguing them. It was also the constant push and emotional strain. Fischer recalled that after working 12 to 14 hours straight they would sometimes sit in a bar and drink just to stop their hands from shaking.

When things weren’t so crazed, the group definitely knew how to have fun together, Fischer discovered. There were other musicians on the team, and sometimes they jammed together. Sometimes, when the pressure eased up a bit, a bunch of them would head out back to throw a Frisbee around. They went out for lunch together, sometimes as many as 20 or 30 of them at a time.

Fischer valued the camaraderie, and he noted some other differences between the people in IMSAI's two buildings. Those in Building One were definitely cliquish, whereas those in Building Two were relatively laid back. Building Two employed a few musicians and some dope-smokers, but not many *est* graduates. IMSAI was definitely split into two factions, and it seemed that neither could relate to the other. The people in the production department worked together to get the job done, whereas those in Building One competed aggressively against each other.

Millard believed that competitiveness never handicapped a salesperson. In fact, he did all he could to encourage competition. And probably no one at IMSAI, in Building One or Building Two, was more aggressively competitive than the company's director of marketing, Seymour Rubinstein.

Miracles and Mistakes

> *I personally consummated the CP/M contract. [Gary Kildall] got a good deal, considering that the Navy was supporting him and he didn't have any other expenses.*
>
> –Seymour Rubinstein, software entrepreneur

When he first met Bill Millard, Seymour Rubinstein was a programmer for Sanders Associates, a military-defense-electronics firm in New York. Rubinstein's ambition and self-confidence were obvious to Millard, as was something else that Millard admired—a willingness, born perhaps of supreme self-confidence, to take on tasks that others regarded as impossible.

Taking Software Seriously

Rubinstein was the quintessential self-made man. Born and raised in New York City, he put himself through Brooklyn College taking night classes, including the school's sole computer course. Using his nerve and innate smarts, Rubinstein turned that one course into a job as a technical writer, then a job in programming, and finally a position as chief programmer at Sanders. By the time he left Sanders, he would tell people later with a chuckle, he had a staff of programmers working for him.

In 1971, Millard formed System Dynamics to sell an IBM-compatible telecommunications terminal. He recruited Rubinstein to come work for him in California on the short-lived venture. Rubinstein settled in San Rafael, north of San Francisco. When System Dynamics folded the next spring, driven out of business by IBM, Rubinstein and Millard went their separate ways.

Rubinstein remained enthusiastic about the technology. Ed Faber may have been initially skeptical about selling computer kits, but Seymour Rubinstein was not. After System Dynamics took down its tent, he became a consultant. When Rubinstein returned from a consulting trip in Europe in late 1976, he was unaware that an actual microcomputer industry was in its infancy. So, he was surprised to find that a new store called Byte Shop had opened on a main street of sleepy, suburban San Rafael, selling computer kits. Rubinstein bought a kit, put the device together in a few weeks, and began programming. To his amazement, it was a real computer! Only later did he learn that his computer was manufactured by the same man who had brought him to California, Bill Millard.

Figure 27. Seymour Rubinstein ***At IMSAI, Rubinstein negotiated sweet deals for software from Gary Kildall, Gordon Eubanks, and Bill Gates. Later he launched his own software company, which brought what-you-see-is-what-you-get functionality to word processing with WordStar.*** **(Courtesy of Seymour L. Rubinstein)**

In February 1977, Rubinstein joined IMSAI Manufacturing as a software product marketing manager. After Millard persuaded Rubinstein to "do the training," Millard was even more convinced he had done a smart thing by hiring him. Within a few months, Rubinstein moved up to the position that he would have for the rest of his tenure at IMSAI—director of marketing.

As software product marketing manager, Rubinstein got to know programmer Rob Barnaby, at least as much as one could get to know the angular, taciturn young man who liked to work alone into the early hours of the morning. Both Barnaby and Rubinstein realized that the IMSAI machine needed a greater quantity of software *and* more robust software given that what was originally supplied with the machine was scanty and fairly weak.

Barnaby had proposed to write a version of BASIC for the IMSAI, but Millard vetoed the project when he found out how long the task would take. Until that time, Barnaby had been doing miscellaneous programming and helping to hire other programmers, such as Diane Hajicek and Glen Ewing, plus negotiating software deals from outside sources. Millard wanted fast results, and buying software was quicker than writing it. When Rubinstein arrived at IMSAI, Barnaby was negotiating two software contracts with individuals from the Naval Postgraduate School in Monterey, where Glen Ewing had studied. Rubinstein soon took over those negotiations from Barnaby.

The Negotiator

IMSAI desperately needed a disk operating system. From the start, Millard saw the IMSAI machine as a disk-drive machine; that is, one that would use magnetic disks for permanent information storage, unlike the Altair, which had initially used slower and less-reliable cassette tapes. Disks were essential for the business applications Millard intended for the machine. But a disk drive was useless without a program that would act as a sort of software “reference librarian” to handle storage of the information on the disks.

IMSAI bought a disk operating system called CP/M from Gary Kildall, the professor at the Naval Postgraduate School who had written software for Intel’s 4004 chip and had teamed with John Torode to sell computers to Omron. In 1977, CP/M was brand-new as a product, although it had grown out of his work consulting at Intel. Kildall had given Barnaby the third copy in existence. Rubinstein negotiated with Kildall and his partner and lawyer, Gerry Davis, and closed the deal for a flat $25,000. It was highway robbery, Rubinstein later boasted; if Kildall had had any sense, he would have sold CP/M on a royalty basis, and not for a flat fee. After closing the deal, Rubinstein then chided Kildall that his marketing approach was naive. “If you continue this practice, you are not going to make nearly as much money as you are entitled to,” he told him. Kildall shrugged off the warning. This first deal felt good to him.

One of Kildall’s students had written a version of the programming language BASIC, and IMSAI picked that up, too. The student, Gordon Eubanks, settled for even less than what Kildall got. Eubanks gave IMSAI his BASIC for the promise of a computer and some technical support. IMSAI, in turn, supplied him with a computer, disk drives, and a printer, and encouraged him to develop the language further, with the understanding that IMSAI would have unlimited distribution rights. Eubanks's CBASIC would work with the newly purchased CP/M. It was just what IMSAI wanted. IMSAI got such a good deal on CBASIC that it didn't even consider also buying MBASIC, the BASIC programming language that Bill Gates and Paul Allen were selling under the company name Microsoft.

Later, when IMSAI did begin buying software from Microsoft, Seymour Rubinstein handled the negotiations from start to finish. Rubinstein was a remorseless negotiator and brought all his skills to bear in dealing with Microsoft's young president, Bill Gates. Gates left their meeting thinking that he had done well for Microsoft, but a few days later began to have doubts. Rubinstein, on the other hand, knew at once what kind of deal he had made. "Everything but the kitchen sink," he chuckled, "including the stopper and the faucets." Seymour Rubinstein was making miracles in his own way.

Missing Parts

Meanwhile, Building One's glorification of achieving the impossible dream was creating problems for the production and service people in Building Two. According to Todd Fischer, it was easy to think of the buildings as two conflicting individuals because the departments each had such different personalities. The way that the salespeople dictated the production department's output levels with no concern as to what production could realistically get done was much too disruptive.

For instance, Fischer said, the sales department would set a production quota of 27 units for an item. Production would then set aside the parts for 27 units and build 27 units. Then, someone from Building One would come running across the parking lot yelling, "I've just sold 30 more of those things! We've got to have 30 more by Friday." Sales seemingly didn't care that production lacked the necessary parts and the available people to build the units. At least that's how it looked from Fischer's point of view in Building Two. Sales had to have the items out by Friday, so production would shift gears and get it done. It was "make a miracle" time.

Fischer didn't like the way the unpredictable work schedules jerked people around. Jarring changes in the work hours threw everybody off, taking a psychological toll on the production crew. They never knew when they would have to work overtime hours or hastily salvage an item in order to obtain some needed parts. This constant uncertainty diminished production's pride in their work because machines often had to be rushed out of the shop without proper testing. One time, Fischer got a call from a customer wondering why his computer had a screwdriver inside of it. Apparently, the computer was sealed up and shipped out before the technician had a chance to retrieve the missing tool.

But even the beleaguered production department was better off than customer support. Nancy Freitas's brother Ed, who worked in inventory, could see that the customer-support department got short shrift. When customer support needed a part to repair a customer's machine, supplying that part was low priority. Production got the needed parts first, a practice that failed to charm customers who were waiting for their machines to come back from the repair shop. As a way to fight back, Building Two put an informal (and unauthorized) procedure into effect. If Fischer or Freitas spotted a problem, Freitas would mention it to her brother, who would work his inventory magic. The part that customer support needed would then materialize. Freitas and Fischer often found themselves resorting to this solution. Together they started an underground parts-supply network.

Freitas had worked in both inventory and production, so she was able to diagram an operational flowchart that connected all the departments and detailed the route that parts took through the manufacturing and repair phases. She knew exactly what could be done and how long it would take. All that talk of “making miracles” irritated her. Using her chart as proof, she would explain that a certain goal was physically and materially impossible. Management didn’t want to hear the word “impossible.” Their reply was always the same: make a miracle.

Management’s reluctance to acknowledge production limitations also caused friction within Building One, where the engineering department resided. After the release of the IMSAI 8080, engineering’s big new project was a computer called the VDP 80. The VDP 80 had a novel design featuring a screen built right into the box, and Killian wanted to see the machine thoroughly tested. The order came down that the machine had to be shipped, and it didn’t matter that the whole department, including Joe Killian, said it wasn’t ready to go because it needed to be tested first. The prototype seemed to work, the orders were coming in, and the company needed cash.

Engineering threw up its hands. If you want the computer, Killian’s group told Millard, it’s your baby. Engineering didn’t want responsibility for a machine that would soon be clattering with problems, and Millard didn’t want to hear about potential problems. Sales was getting more and more orders for the VDP 80 every day. The company needed the money to cover current expenses so it could start shipping product. And that was that.

It seemed to many people in the engineering, production, and customer-support departments that the sales group was blindly selling the ground right out from under them. IMSAI cared about success, all right. But management measured success by sales figures first, rather than by the quality of production or level of customer service. IMSAI was a selling machine, and when viewed that way, the company was doing very well.

Selling Computers Like Hamburgers

For Bill Lohse in sales, things were endlessly exciting and challenging. Lohse saw the company as constantly evolving, unafraid to take risks, and scoring some big successes along the way. Millard thrived on change and risky ventures. The sales team was expanding and improving. Salespeople with experience and plenty of IMSAI drive and initiative, like Fred “Chip” Poode, were being recruited. Then there was the franchise idea.

The computer store was emerging as a serious channel of distribution for microcomputers. Ed Roberts limited MITS’s market reach by demanding that the company’s retail outlets sell only Altairs. Bill Millard was not going to make the same mistake, but how could he also ensure loyalty to his product?

Millard liked the notion of an independent but friendly franchise, and the idea also interested Ed Faber. Perhaps Faber was chafing in Millard’s organization and was seeking more autonomy, or perhaps the initial excitement had worn off since the IMSAI start-up. At any rate, in the summer of 1976 Faber told Millard that he wanted to start a franchise operation, like McDonald’s had with hamburgers. Lohse watched this development with special interest, and when Faber left to start the franchise, Lohse replaced Faber as director of sales.

Lohse immediately had two major challenges to overcome. Chip Poode saw Lohse as a kid fresh out of college and resented being passed over for the director’s job, and Seymour Rubinstein, in Lohse’s view, thought that the marketing and sales departments should both report to one person, Seymour Rubinstein. Not surprisingly, Lohse and Rubinstein frequently locked horns.

Nevertheless, Lohse thought IMSAI was a great place to be. He enjoyed working in the sales department for Bill Millard and being around his mentor. IMSAI’s people sold when nobody else thought they could, and hit sales goals that seemed impossible. It was unreal in a way. They did seem to perform miracles.

est and Entrepreneur’s Disease

It was a bunch of people heavily into est.

–Jim Warren, computer publishing pioneer and founder of the West Coast Computer Faire

Millard was busy throughout 1978 creating new companies. IMS Associates, the IMSAI parent company, spawned ComputerLand, Faber’s franchise operation. Millard also went to Luxembourg for several months to set up IMSAI Europe, a separate corporation that would buy computers from the California operation for resale in Europe. As a result of his frequent absences, Millard failed to notice the dramatic tailspin that IMSAI was in.

Overreaching

IMSAI’s high-handed stance regarding customer support was finally starting to hurt the operation, and the company had targeted the wrong market. The prevailing notion was that IMSAI was selling computers to serious business users. However, the quality of the IMSAI machine, like that of every other early microcomputer, was erratic. Someone who bought it for strictly business purposes was likely to be disappointed. The IMSAI 8080 had a distressingly high failure rate, and the instructions that came with the machine, having been written by engineers, were opaque to anyone who tried to use them. Bruce Van Natta’s tongue-in-cheek summation of IMSAI’s attitude toward documentation was, “You got the schematic? Then what’s the problem?”

No software existed for even the simplest business applications when the IMSAI 8080 was first released. The computer was large, unwieldy, and suggestive of nothing so much as a pile of electronic test equipment. It took a huge leap of faith to believe that businesses would rush to install this assemblage in their offices or would entrust their business records to this unproven, unreliable artifact. Therefore, most “business” users were actually hobbyists who only hoped to use the machine in business and tolerated its deficiencies because they were learning how it worked and having fun doing so.

Eventually, IMSAI’s inadequate customer support proved too aggravating even for the most tolerant hobbyists. Word spread fast throughout the hobbyist community, whose opinion IMSAI disdained. Sales soon started falling behind projections, and the gambit of funding current expenses with orders for future products began to wear thin.

When Millard was away, Wes Dean was in charge. Dean was IMSAI’s president, yet he was beginning to feel despair for the company’s future. Looking beyond the day-to-day crises, Dean saw that IMSAI was failing to address critical problems with its support, image, and cash flow that would affect the company in the long term. Dean finally gave up and left and was succeeded by John Carter Scott, who presided over the layoffs that came in early October 1978.

IMSAI's financial problems reached crisis state in the fall of 1978, and it became clear to Scott that drastic steps were necessary. The company had enough orders for machines and repairs to keep everyone busy, but meeting payroll was impossible. In October, Scott initiated the first in a series of layoffs. Building Two suffered the most. When Todd Fischer, who had moved to a key position in the service department, learned that Nancy Freitas would be cut in the layoffs, he resigned, leaving an unanticipated gap in that already struggling department.

The VDP 80 Mess

For IMSAI, Fischer's chivalry could not have been more badly timed. The company had started shipping the new and untested VDP 80, and the VDP 80 machines were coming back almost as fast as production could push them out the door. The downsized service department struggled with a variety of defects in the machines, while the sales team sold more and more of the defective products. Because the repairs were done under warranty and were often extensive, the company was making very little, if any, profits on the VDP 80. IMSAI had two options: send the design back to the drawing board and stop selling the computers until the design problems were solved, or continue selling them and repair them all when they came back.

IMSAI chose the latter option.

Releasing the VDP 80 prematurely was a bad decision, but not inexplicable. Except for Killian and the engineering department, the folks in Building One did not believe that the VDP 80 had really serious problems. Expressing such a belief would have been tantamount to an admission of failure. IMSAI's culture wouldn't allow that. This attitude and the single-minded focus on "The Goal" eventually caused the company to lose track of who its customers were and the very nature of the market. And the relentless positive thinking that had blinded management contributed to the decision to release the VDP 80 too quickly.

Meanwhile, the numbers were heading in the wrong direction. In April 1979, the company took in $20,000 more than it paid out; the following month it took in $12,000 less than it paid out. By June 1979, Millard was looking for investors, but by then it was too late. No one was willing to sink money into his struggling company.

Earlier, when IMSAI was more financially healthy, Millard had turned down several investment offers. He was not alone in his reluctance to take on investment capital. Many early microcomputer executives feared that selling even a part of their companies would cause them to lose control of their organizations. They abhorred the prospect. That thinking came to be called "entrepreneur's disease," a company founder's determination to never release any corporate control to anyone for any price. As he neared the end of his reign at IMSAI, Millard began to have regrets and wished he had accepted a little investment money. The $2 million offered by one would-be investor who hoped to turn a profit would have come in handy in 1978.

Charles Tandy, among others, had made a foray into investing in IMSAI. Tandy was head of the nationwide chain of Radio Shack electronic-equipment stores. He didn't want his company, essentially an electronics-distribution firm, to venture into building microcomputers, but he was interested in carrying them in his stores. Tandy could either buy computers from another company or buy an entire computer company outright. IMSAI was the biggest seller in the field and seemed the logical choice. The day that Bill Lohse observed Tandy walking into Millard's office he knew immediately that the discussion going on inside would be crucial to IMSAI's financial state. It distressed him to learn that Tandy had wasted his time in talking to Millard and that the companies would not do business together.

Millard now thought IMSAI's cash-flow problem was serious enough that it required his presence in San Leandro. Soon, Bill Lohse was packing for Luxembourg to oversee IMSAI Europe.

Death and Rebirth

> *Rod Smith says that he does want one of my VDP80s and sent a 4.6K check and that’s nice. But it feels a little like everything we do is correct and right but nothing produces the result.*
>
> –Bill Lohse, in a telex from IMSAI Europe to IMSAI San Leandro

When Millard arrived in San Leandro, he found IMSAI in terrible financial shape while stuck with a computer on the market that was blackening the company’s reputation. To turn things around, he first authorized the redesign of the VDP 80. Millard and the engineering people agreed that it was basically sound and would sell well if it worked—that is, if its reputation had not already been irreversibly damaged.

Looking for a Miracle

Another project that held some promise for success was Diane Hajicek’s IMNET, a software package that could link several IMSAI machines together. The machines could then share resources, such as disk drives and printers. Together, IMNET and the revised VDP 80 would, Millard hoped, give IMSAI a viable office product to sell. Every step was a gamble now, and time was the opponent. If IMSAI could get the VDP 80 and IMNET earning dollars soon enough, the company could make the miracle it needed. If not, well, Millard didn’t engage in negative thinking.

When Millard thought he could safely return to Europe, he left Kathy Matthews in charge. Matthews was Millard’s sister and had been an executive in the corporation for some time. But the money situation didn’t improve. Finally, in the spring of 1979, the company filed Chapter 11—a provision of federal bankruptcy law that keeps a company’s creditors at bay while the company cuts expenses back in an attempt to dig itself out of its financial hole. Despite filing for bankruptcy, Kathy Matthews still believed IMSAI could recover and prosper.

Now more than ever, IMSAI needed a miracle. Matthews was doing all she could to generate orders. When Diane Hajicek said IMNET was ready, Matthews went on the road for three days straight to show off the product. With the exception of the presentation at one of Ed Faber’s ComputerLand stores that went especially well, many of the demonstrations were embarrassing—IMNET wasn’t really ready to go public. Matthews sent IMNET back to Hajicek for more work while expressing her wish to the Luxembourg group at IMSAI Europe that they could see “how wonderful and exciting IMNET is.”

Layoffs continued, and IMSAI was consolidated into a single building. Company executives who had been living like the big-business officers they dreamed of being now faced seriously reduced circumstances. The interior walls of Building One were rearranged, and the resulting narrow hallways made employees claustrophobic. The functions of the various offices became more generalized, as did those of the company officers. One day, IMSAI vice president Steve Bishop found company president John Carter Scott lying on his back on the floor of the former marketing office assembling machines while chief engineer Joe Killian soldered wires.

IMSAI's European operation wasn't flourishing either. The money just wasn't coming in fast enough. Lohse pronounced the situation grim. Back in San Leandro, at the end of July 1979 Kathy Matthews declared, "We need a great August." Steve Bishop examined the records and found that the company had lost less money than he had feared. IMSAI could at least meet its payroll for another month.

Reading Your Own Obituary

The July issue of *Interface Age* carried a column by industry watchdog Adam Osborne, the former Intel employee who had written the documentation for Intel's first microprocessors, in which Osborne called IMSAI a "financial victim." Matthews felt as if she were reading her own obituary. But they weren't dead yet, she insisted, and wanted "so very much to produce a miracle and create a butterfly from a caterpillar."

Bill Millard decided the San Leandro operation was in need of his personal attention. He booked a flight back and sent telexes on July 31 to Ed Faber, Steve Bishop, and his daughter, Barbara Millard, that said,

> I WOULD LIKE TO MEET WITH YOU WED. 8/2

He named the time and place. Within a week of Millard's return, IMSAI Manufacturing suspended all sales and manufacturing operations. Steve Bishop told Lohse to advise their European dealers of the situation. Meanwhile, Millard was desperately looking for someone with money to keep IMSAI afloat.

On August 7, Steve Bishop telexed Lohse:

> YOU NEED TO CONSIDER YOUR PAY. YOU WERE BEING PAID OUT OF SNLO [IMSAI San Leandro] AND ONLY ONE PERSON IS LEFT ON THE PAYROLL HERE. THE WAY WHM [Bill Millard] IS SAYING IT IS THAT WE CAN STICK AROUND AND MAY GET PAID BUT NO ASSURANCE. ALSO YOU NEED TO CONSIDER YOUR RETURN EXPENSE TO THE US NOT BEING NEGATIVE JUST WANTED YOU TO BE THINKING.

Things weren't working out for Lohse. He had seized the European job in part to escape the problems looming at IMSAI, but there was no avoiding the company's imminent collapse. Lohse had two choices: abandon ship or ride out the storm. Somehow, after all he had experienced, quitting didn't make sense now. But if he stayed, Lohse had to wait for further developments in San Leandro. IMSAI's future was up to Bill Millard. If Millard could find an investor, the sparkle would return to all their lives. Most of the items on Lohse's to-do list said, "Wait for further info." But Lohse wasn't very good at waiting around.

A week later, on August 14, Kathy Matthews and Bill Lohse exchanged terse telex messages.

Lohse:
    ANY NEWS?

Matthews:
    NOT A THING.

Lohse:
    RATS.

Lohse assessed IMSAI Europe's financial position. It was dismal. No matter how he figured it, the European office could not guarantee payment of its September bills. Lohse would have to sell off essential equipment just to keep a legal minimum balance in the company's bank account. Lohse informed his staff that there was no money left to pay them. He had worked closely with these people for six months, and it pained him to give them the news.

Lohse then sent a telex to Matthews:

Lohse:
    WE ARE WAITING.

She replied:
    WELL, WE HAVE ANOTHER DAY.

Lohse waited a bit, then answered,

  WELL, OURS IS ABOUT OVER.

Perhaps he was referring to the time difference, or perhaps to something else.

On August 21, Lohse put in a request to return home. Bill Millard telexed back his permission, and asked Lohse to bring along the Norelco shaver Millard had left behind on a previous trip.

On September 4, 1979, Millard called a meeting in San Leandro. The building where they met, at one time the base for more than 50 people and several divisions of the company, was now vacant except for that small group of people sitting around a table. There wasn't much to say. The VDP 80 redesign was complete and it was solid, but the machine on which the company pinned its hopes came too late. IMSAI had been dying for a long time, and the final miracle hadn't come through. When the meeting ended, everyone got up and walked out in silence. A short while later, a police officer arrived and padlocked the front door.

But strangely enough, IMSAI wasn’t dead yet.

A Surprising Rebirth

Before the lockout, Todd Fischer had arrived to pick up some equipment. He had formed an independent repair company with Nancy Freitas after leaving IMSAI, and they were doing most of the IMSAI repairs when the company filed for Chapter 11 reorganization. Recovery from Chapter 11 almost requires a miracle, and IMSAI hadn’t been able to make one.

It was largely due to Fischer and Freitas that a new company was born out of the ashes of IMSAI. While IMSAI was foundering, Fischer-Freitas was showing a profit. John Carter Scott didn’t want his customers’ equipment tied up in judicial wrangling, so he asked Fischer to take all of it, along with whatever tools Fischer needed to keep his operation going. Plenty of IMSAI computers remained in the field, and they would all need service someday. Scott couldn’t think of a better person to repair them than Todd Fischer.

After a month, Fischer bought most of the remaining IMSAI inventory at a low-key auction. Later, after he found out the company name was also available, Fischer bought that, too. He and Nancy Freitas, now husband and wife, brought in an old music-industry buddy of Fischer’s and incorporated as IMSAI Manufacturing. Operating out of a few hundred square feet in the warehouse district of Oakland, California, they began to build IMSAI computers once more.

The IMSAI that Fischer and Freitas founded was a small company with little resemblance to the frenetic original. The new IMSAI focused more on customer support than on sales and made an effort to get to know its actual customers. Its one brush with fame came when one of its machines was featured in the early computer-cracker movie *War Games* in 1983.

The old IMSAI had been remarkably successful with the IMSAI 8080, selling thousands of units over its three-year existence. Although the success was short-lived, it was a triumph, and a significant accomplishment in an age when corporate executives were still communicating by telex. IMSAI’s brief triumph, and no doubt its ultimate failure, stemmed in large part from the managerial philosophy of Bill Millard. His tenure as IMSAI chief was marked by outsize goals, a complete intolerance of failure, an exceptionally aggressive sales force, a stubborn refusal to acknowledge nagging problems, an unwillingness to relinquish any control, and a perhaps-fatal scorn for the entire hobbyist community. Many wags in the industry used a term to describe such a business style—*est*, after the movement that Millard so thoroughly embraced. Adam Osborne put it simply: “*est* killed IMSAI.” But it might be better just to say that IMSAI’s management failed to take seriously the limitations of the technology of the day and tried to push microcomputers into business markets they were not ready for.

But although the IMSAI decision makers failed to understand the hobbyist culture of their market, they nevertheless fanned the fires of the revolution by giving hobbyists a better Altair. At the same time, IMSAI’s attempt to make the industry into something it wasn’t helped to define what that newborn industry actually was—a grassroots movement of hobbyists fully conscious that they were ushering in not just a technological revolution, but a social one as well.

That revolutionary spirit was nowhere more evident than at the Homebrew Computer Club.

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Chapter 4

Homebrew

> *Are you building your own computer? Terminal? TV Typewriter? I/O device? Or some other digital black box? Or are you buying time on a time-sharing service? If so, you might like to come to a gathering of people with like-minded interests. Exchange information, swap ideas, talk shop, help work on a project.…*
>
> *Flyer for the Homebrew Computer Club, 1975*

Why did the Altair and IMSAI computers generate such excitement among engineers and electronics enthusiasts? Not because they were technological breakthroughs—they weren't. To understand the wild enthusiasm that greeted these computers, you have to get inside the minds of the people who bought them—and who would soon found their own computer companies. And you have to remember the social and political milieu of the time. Although the Altair was released in 1975, it was largely a product of the cultural revolution of the 1960s.

Power to the People

> *It had its genetic coding in the ’60s…antiestablishment, antiwar, profreedom, antidiscipline attitudes.*
>
> –Jim Warren, microcomputer industry pioneer

The San Francisco Bay Area in the late 1960s and early 1970s was a hotbed for political activists, but it also had a large and active community of electrical engineers. The two groups overlapped, and it was where the overlap occurred that the spark ignited.

Radical Politics and Electrical Engineering

Lee Felsenstein had dropped out of engineering school at the end of the 1960s and had gone to work for a company called Ampex as a junior engineer. Ampex didn’t require him to work with computers, and that was fine with Felsenstein, who had been cool toward computers ever since an overly ambitious attempt in high school to build one of his own. But while Felsenstein enjoyed the work, he rebelled at pouring his efforts into projects for the benefit of corporate America. He left Ampex in 1969 to write for the *Berkeley Barb*, a famous and influential counterculture publication, where for a time he was listed on the masthead as “Friday,” as in Robinson Crusoe’s man Friday.

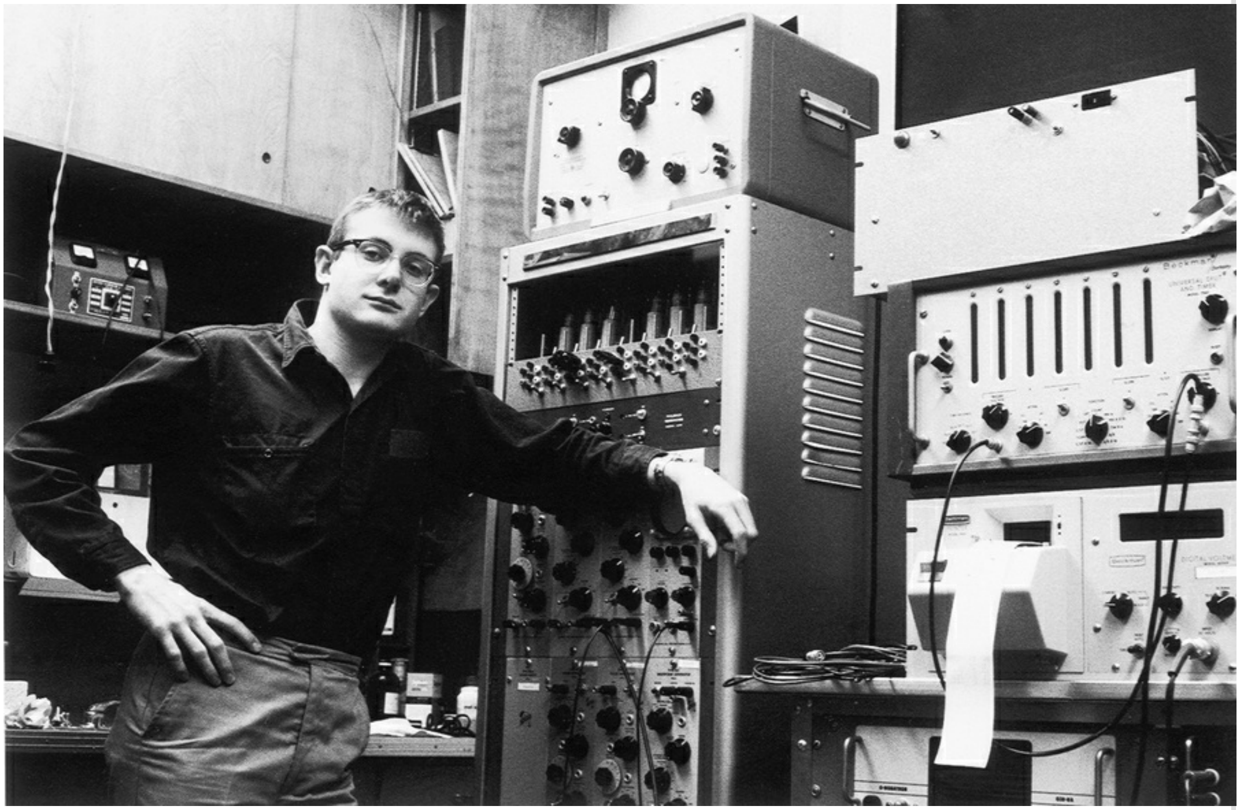

Figure 28. Lee Felsenstein ***Felsenstein embodied all the technical savvy and counterculture spirit of the early days of personal computing. Here he poses with a minicomputer at UC Berkeley in 1971.*** **(Courtesy of Lee Felsenstein)**

Eventually Felsenstein returned to Ampex. There, in 1970, he designed an interface for a Data General Nova computer and began to think that maybe computers weren't so bad after all. Felsenstein saved his money and in 1971 reenrolled at UC Berkeley, where he completed his engineering degree. In 1972, he gathered up his engineering degree and counterculture credentials and went to work for Resource One.

Resource One was an attempt to bring computer networking to nonprofits and radical groups in the San Francisco Bay Area. It was run by people from the San Francisco Switchboard, a volunteer referral agency, along with other computer junkies who had left UC Berkeley in protest of the American invasion of Cambodia. Many of these people lived in an urban commune in a factory building in San Francisco, which was a magnet for counterculture engineers, including Felsenstein.

Amazingly, Resource One had a computer—a large, $120,000 XDS 940. It was a remnant of Xerox Corporation's abortive attempt to enter the mainframe-computer industry. Resource One had inherited it from the Stanford Research Institute, where it ran "Shakey," one of the first computer-controlled robots. Felsenstein moved in as part of the second generation at Resource

One, signing on as chief engineer to run the computer, a job that paid "$350 a month and all the recrimination you can eat." It was a frustrating job, but he believed in the project and would later recall being annoyed when two UC Berkeley graduate students, Chuck Grant and Mark Greenberg, refused to get off the system so he could do maintenance on it.

Resource One put Felsenstein in touch with Cal students and faculty, as well as researchers at other sites. He visited Xerox's Palo Alto Research Center (PARC) and saw innovations that dazzled him. However, Felsenstein's sympathies lay less with technological dazzle than with a growing, grass-roots, computer-power-to-the-people movement.

That movement was developing in the San Francisco Bay Area out of the spirit of the times and the frustration of those who, like Felsenstein, knew something of the power of computers. Resenting that such immense power resided in the hands of a few and was so jealously guarded, these technological revolutionaries were actively working to overthrow the computer-industry hegemony of IBM and other companies, and to defrock the "computer priesthood" of programmers, engineers, and computer operators who controlled access to these machines.

Ironically, many of those technological revolutionaries had themselves been part of the priesthood.

Rebelling Against the Priesthood

Bob Albrecht had left Control Data Corporation in the 1960s because of its reluctance to consider the idea of a personal computer, and had, with friends, started a nonprofit alternative-education organization called the Portola Institute. From Portola sprang *The Whole Earth Catalog*, under the orchestration of Stewart Brand, with its emphasis on access to tools. This, in turn, inspired actress Celeste Holm's son Ted Nelson to write a book similar in spirit but about access to computers. Nelson's *Computer Lib* proclaimed, well before the Altair was announced, "You can and must understand computers NOW!" Nelson was the Tom Paine and his book the *Common Sense* of this revolution.

The other significant publication at the time that brought information about computers to the Bay Area general public was a tabloid called *People's Computer Company* (*PCC*), another of Albrecht's projects. Albrecht said that *PCC* was a company in the same sense that Janis Joplin's band Big Brother and the Holding Company was a company.

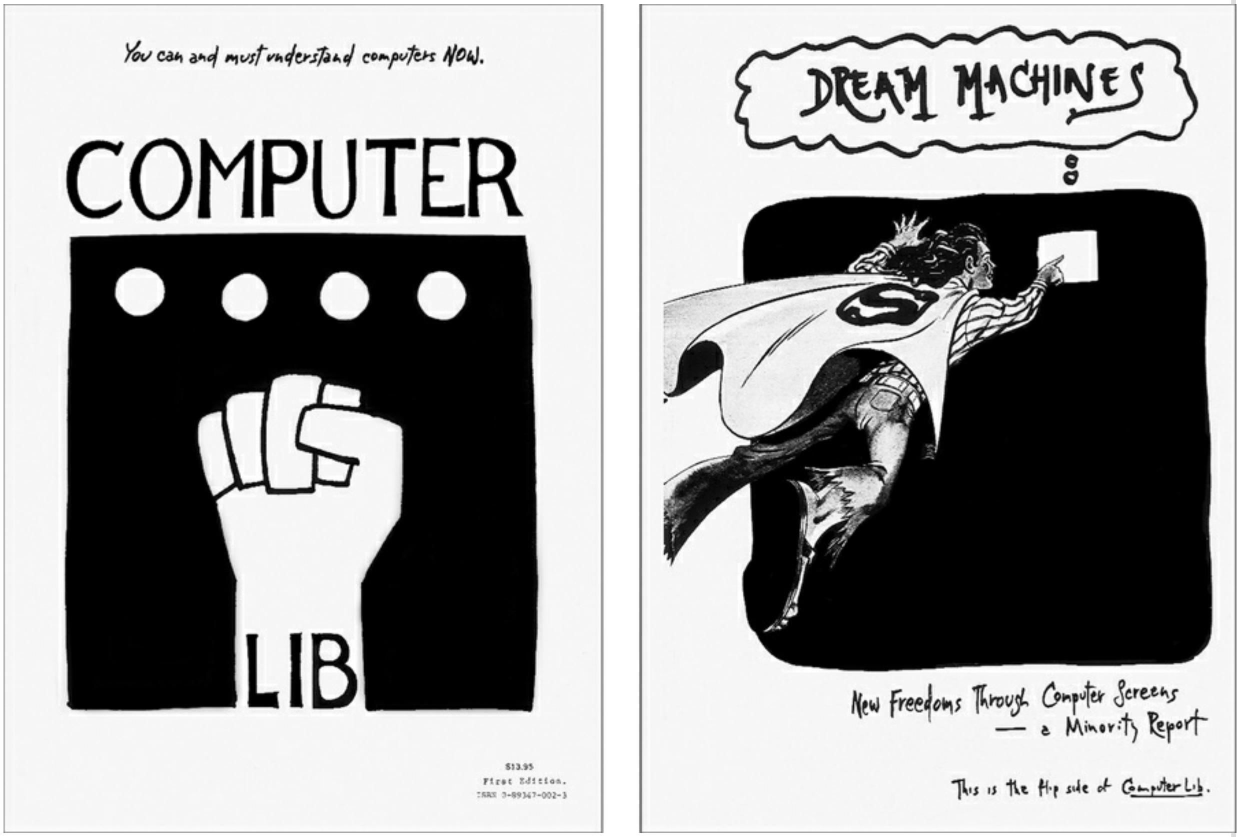

Figure 29. Computer Lib and Dream Machines ***"You can and must understand computers NOW," Ted Nelson's*** **Computer Lib** ***proclaimed. To Homebrewers it was the manifesto of the revolution. The second half of*** **Computer Lib** ***was printed upside down and had its own front cover.***
(Courtesy of Ted Nelson)

Albrecht was a passionate promoter of computer power to the people. He wanted to teach children, in particular, about the machines. So, he split off from the Portola Institute to form Dymax, an organization dedicated to informing the general public about computers. Dymax gave rise to a walk-in computer center in Menlo Park and to the thoroughly irreverent *PCC*.

Computers had been mainly used against people, *PCC* said. Now they were going to be used for people.

Albrecht was never paid, and others worked for little. The 1960s values that pervaded the company exalted accomplishing something worthwhile beyond attaining money, power, or prestige. If *Computer Lib* had the most revolutionary philosophy and the most brilliantly original ideas, *PCC* had solid, practical advice for people who wanted to learn more about computers.

Albrecht and company were not writing about personal computers yet, because personal computers didn't exist. Instead, they wrote about personal *access* to computers. In the early 1970s, users typically gained access to computers via time-sharing.

These big machines were getting smaller, though, and cheaper. DEC sold a PDP-8/F minicomputer that could be programmed in BASIC and that featured a 110 Teletype machine for under $6,000, a remarkably low price for a minicomputer. To the most visionary contemporary observer, this may have been a hint of what was to come, but consumers weren't buying the minicomputer and installing it in their dens. At this point, virtually no individual person owned a computer.

Computers like the DEC minicomputer could, nevertheless, be purchased by schools. David Ahl, editor of *EDU*, DEC's newsletter on educational uses of computers, spent a lot of time writing about small computers such as the $6,000 system. He argued that children learning about computers should be able to get their hands on the real machines, not just terminals connected to a remote, impersonal time-sharing system.

Making Technology Convivial

Lee Felsenstein was working hard to humanize those same time-sharing systems. He helped organize Community Memory, an offshoot of Resource One that installed public terminals in storefronts. The terminals gave anyone who walked in the front door immediate, free access to a public computer network. They were similar to those message boards you see in sandwich shops and other public places. Except that these message boards could be updated electronically, had an unlimited number of responses attached to them, and could be read all over town.

There were problems, though. People didn't know how to use the Community Memory terminals, and they frequently broke down. To really bring the power of the computer to the people, access wasn't enough: it was necessary to make the thing understandable, and to free users from having to depend on a trained repair person.

Felsenstein had a distinct approach to technological problems. Instead of merely fixing the terminals, he began looking for the inherent problem in their design. What was the basic shortcoming of the Community Memory terminals? He decided that they weren't "convivial."

Lee's father had once recommended the book *Tools for Conviviality* by Ivan Illich, author of *Deschooling Society*. Pointing to radio as an example, Illich argued that technologies become useful only when people can teach themselves about those technologies. As a child in Philadelphia, Felsenstein had built his own radio, so he appreciated the comparison. Truly useful tools, Illich said, must be convivial. They have to stand up under the abuse people put them through as they're learning how to use and repair them.

Felsenstein took Illich's message to heart. He wanted computer technology to spread like crystal radio technology had done. He began soliciting ideas for a convivial terminal, and in true 1960s spirit, he sought a communal design. He placed notices in *PCC* and on the Community Memory boards, calling for a meeting to discuss the "Tom Swift Terminal," a computer terminal that would appeal to technology-dazzled teenagers who read the ads in the back of science-fiction magazines. The terminals would be as easy to build and repair as a crystal radio.

Stumbling into a Start-up

One of those responding to the Community Memory message was Bob Marsh. Marsh and Felsenstein discovered they had already met, but this meeting via computer was the important one.

Bob Marsh had been an engineering student at UC Berkeley. Both he and Felsenstein lived in Oxford Hall, the University Students' Cooperative Association building. With his familiar boyish grin and locks of dark hair falling across his forehead, Bob Marsh looked much the same as he did during his days at Berkeley, but Felsenstein could see that his college chum had done some growing up.

While Felsenstein had not been as serious about school as he was about political events, Marsh never seemed to be serious about anything. Pool playing and beer drinking got more of his attention than did classwork, and he had dropped out in 1965 to take a job clerking in a grocery store. Marsh labored there just long enough to save up sufficient cash for a trip to Europe.

When he returned, though, it was with an altered outlook and the motivation to get a degree. He went to a community college to build up a grade-point average that would allow him to return to UC Berkeley. He planned to be a biology teacher—but one visit to a teachers' meeting ended that dream. Marsh didn't care for the way principals and administrators treated teachers, and he switched back to an engineering major.

Marsh began working on a series of engineering projects with his friend Gary Ingram. Marsh and Ingram had known each other since 1971, when they collaborated on their first project together. The project was based on a *Popular Electronics* article by Harry Garland and Roger Melen. Marsh had also read the Don Lancaster TV Typewriter article in *Radio-Electronics* and had tried to devise an improved version of it, with some success.

Ingram was now working at Dictran International, an importer of dictation equipment, and landed his friend Marsh a job there. When Ingram quit Dictran a month later, Marsh suddenly became chief engineer. Somewhat to his surprise, he found that he liked the position. That job eventually disappeared, but Marsh later said that his stint as chief engineer had changed his life. Experiencing life as a Berkeley student in the 1960s, being on his own in Europe, seeing what it was like to be a teacher working under others, and getting a shot at being an engineer and manager at Dictran—these experiences had all contributed to turning Marsh into the prototype for a generation of Silicon Valley entrepreneurs.

But in 1974, Marsh was broke and jobless. As Felsenstein put it, Marsh had worked himself up to the exalted level of an unemployed electronics engineer. With house payments to make, a family to support, and a child on the way, Marsh was looking for a project around which he could build a company.

The Fourth Street Garage

Marsh's meeting with Felsenstein about the Tom Swift Terminal led to a discussion about electronic products and launching a corporation. But unlike Marsh, Felsenstein wasn't interested in starting his own company. He was busy fomenting a revolution.

Marsh decided he needed some work space if he was going to get his company going. He talked Felsenstein into splitting the cost to lease a space. Although Felsenstein still had no plans to start his own venture, he did need to move his home office out of his 276-square-foot apartment. In January 1975, the two rented a 1,100-square-foot garage at 2465 Fourth Street in Berkeley for $170 a month.

Marsh could barely afford his half of the modest rent, but set up shop nevertheless. Felsenstein laid claim to a workbench and took on freelance engineering projects that came his way. He remained involved in Community Memory while the Tom Swift Terminal project was on hold. Marsh then connected with a friend who had access to cheap walnut planks and with an electronics distributor named Bill Godbout. He planned to use these contacts as part of an effort to build and market digital clocks.

Then the January 1975 issue of *Popular Electronics* announced the introduction of the Altair computer. Although they didn't realize it at the time, this would change the lives of Felsenstein, the technological revolutionary, and Marsh, the unemployed engineer. It did so in part because it brought into existence the Homebrew Computer Club, an extraordinary gathering of people with engineering expertise and a revolutionary spirit, from whom would spring dozens of computer companies and eventually a multibillion-dollar industry.

The Homebrew Computer Club

> *There was a strong feeling [at the Homebrew Computer Club] that we were subversives. We were subverting the way the giant corporation had run things. We were upsetting the establishment, forcing our mores into the industry. I was amazed that we could continue to meet without people arriving with bayonets to arrest the lot of us.*
>
> –Keith Britton, Homebrew Computer Club member

Early in 1975, a number of counterculture information exchanges existed in the San Francisco Bay Area for people interested in computers. Community Memory was one, PCC was another, and there was the PCC spin-off, the Community Computer Center. Peace activist Fred Moore was running a noncomputerized information network out of the Whole Earth Truck Store in Menlo Park, matching people with common interests about anything, not just computers.

A Place to Come Together

Moore became interested in computers when he realized he needed computing power. He talked to Bob Albrecht at PCC about getting both a computer and a base of operations. Soon Moore was teaching children about computers while learning about them himself. At the same time, Albrecht was looking for someone to write some assembly-language programs. He found Gordon French, a mechanical engineer and computer hobbyist, who at the time supported himself by building motors for toy slot cars.

After the Altair story appeared in *Popular Electronics*, the need for a more direct information exchange became clear. The PCC people took the Altair seriously from the start. Keith Britton, a demolition consultant and PCC's treasurer, thought its arrival foretold the eventual demise of the computer "priesthood."

"All of us were champing at the bit to get an Altair," French recalls. So Fred Moore pulled out his list of the computer curious, the revolutionaries, the techies, and the educational innovators, and sent out the call: "Are you building your own computer?" Moore's flyer asked. "If so, you might like to come to a gathering of people with like-minded interests."

The announcement referred to the gathering as the Amateur Computer Users Group, and alternately as the Homebrew Computer Club. The group first met on March 5, 1975, in Gordon French's garage. Felsenstein read about the upcoming meeting and resolved not to miss it. He collared Bob Marsh, and they drove Felsenstein's pickup truck through the rain across the Bay Bridge to the peninsula that stretches from San Francisco south to Silicon Valley. French's garage was in suburban Menlo Park, a town jogging distance from Stanford University and perched on the edge of Silicon Valley.

At the club’s first meeting, Steve Dompier reported on his visit to Albuquerque. It was the headquarters of MITS. MITS, he told them, had shipped 1,500 Altairs and expected to ship 1,100 more that month. The company was staggering under the weight of the orders and couldn’t possibly fill all of them. Bob Albrecht displayed the Altair that PCC had just received that week. Immediately in front of PCC on MITS’s waiting list were Harry Garland and Roger Melen, the two Stanford University grad students who had created the Cyclops digital camera and who later founded Cromemco, a company that made computer-interface and CPU boards.

Dompier, like Marsh and Felsenstein, had driven down from Berkeley, but most of the 32 attendees at the first meeting were from nearby communities. Albrecht and Gordon French, who chaired the meeting; Fred Moore, who took notes for the club’s newsletter; and Bob Reiling, who soon took over editing the newsletter, all lived in Menlo Park. Others came from towns farther south, deep in the heart of Silicon Valley—Mountain View, Sunnyvale, Cupertino, and San Jose—people like Allen Baum, Steve Wozniak, and Tom Pittman. Pittman had worked with Intel developing software for the company’s microprocessors and was a self-described microcomputer consultant, perhaps the first in the world.

As the meeting concluded, one Homebrewer held up an Intel 8008 chip, asked who could use it, and then gave it away. Many of those there that night sensed the opportunities presented by this community spirit and Dompier’s revelations that MITS couldn’t build Altairs fast enough to fill its orders.

Homebrew Was an Incubator

One person inspired by the meeting was Bob Marsh, who immediately went to see Gary Ingram about forming a business. “I have a garage,” Marsh told Ingram. That seemed like enough to get started.

They decided to call themselves Processor Technology, immediately shortened to Proc Tech among those in the know. Marsh designed three plug-in circuit boards for the Altair: two I/O boards and a memory board. Both he and Ingram thought they looked pretty good. Marsh designed a flyer announcing Proc Tech’s products, ran off hundreds of copies on a campus photocopying machine, and distributed 300 of them at the third Homebrew meeting.

By this time, the club was flourishing. Fred Moore was exchanging newsletters with Hal Singer, who put out the *Micro-8 Newsletter* in Southern California and had formed a Micro-8 club shortly after Homebrew started. Other publications were passed around at the meetings. *PCC* and Hal Chamberlin’s *Computer Hobbyist* attracted special attention. A Denver organization, The Digital Group, identified itself as a provider of support for Micro-8 and TV Typewriter hobbyists, and offered subscriptions to its newsletter. It was becoming increasingly difficult to keep up with changes in the movement. Intel introduced its 4004, 8008, and 8080 chips, and at least 15 other semiconductor manufacturers had introduced microprocessors into the market. The newly formed club labored to keep its members informed about them all.

The third Homebrew monthly meeting drew several hundred people, too many for Gordon French's garage. The club moved meetings to the Coleman mansion, a Victorian dwelling that later became a schoolhouse. There Marsh gave a brief talk, explaining that he was selling memory and I/O boards for the Altair. He hoped to present Proc Tech as a serious company, not just the whim of an unemployed electronics engineer with access to a copying machine. He offered a 20 percent discount for cash prepayment. To his disappointment, no one approached him during or after the meeting.

But by the following week, the first order arrived. Harry Garland and Roger Melen, the Stanford students and computer entrepreneurs/hobbyists who had created the Cyclops camera for the Altair, were first in line with Proc Tech. Marsh read the order, written on the stationery of Garland and Melen's new company, Cromemco, and saw a request for 30 days net credit. This was hardly what Marsh had expected. Still, he supposed this meant that Proc Tech was now being treated like a serious enterprise. Proc Tech was a serious company, and Cromemco was a serious company—there just wasn't any serious money being exchanged. Oh, well. It was a start.

After the Cromemco order many others followed, and most had cash enclosed. Ingram fronted $360 of his own money for an advertisement in the influential *Byte* magazine, but now with cash streaming in, Marsh and Ingram could afford to advertise in *Popular Electronics*—and they did, spending $1,000 for a one-sixth-page ad. Next they incorporated, and Ingram was named president. For its corporate headquarters and factory, Processor Technology had half of an 1,100-square-foot garage; but it had no products, no schematics for proposed products, no supplies, no employees, and thousands of dollars in cash orders. It was beginning to appear that they had some work ahead of them.

The Toastmaster of Homebrew

Meanwhile, Lee Felsenstein was getting increasingly involved with Homebrew. He took over the master-of-ceremonies role from Gordon French but refused to think of himself as a chairman. The meetings were now held in the auditorium at the Stanford Linear Accelerator Center. Over the years, Felsenstein became intimately associated with the club and fostered its anarchic structure. The group had no official membership, no dues, and was open to anyone. Its newsletter, offered free after a nudge from Felsenstein, became a pointer to information sources and a link between hobbyists.

As group toastmaster, Felsenstein performed with a sort of showmanship that was as curious as it was engaging. As one attendee, Chris Espinosa, said, "People call him the Johnny Carson of Homebrew, but he's more than that. He kept order, he kept things moving, he made it fun to go to the meetings. There were 750 people in that room at one time, and he worked it like a rock concert. It's hard to describe, but to see him work a crowd like a Baptist preacher… He was great.”

With Felsenstein running them, the meetings didn’t follow Robert’s rules of order. He gave meetings their own special twist. First came a Mapping session, during which Felsenstein recognized people who quickly proffered their interests, questions, rumors, or plans. Felsenstein typically had snappy answers to questions and sharp-witted comments on their plans. A formal Presentation session followed, generally on someone’s latest invention. Finally, there was the Random Access session, in which everyone scrambled around the auditorium to meet others they felt had common interests. The formula worked brilliantly, and numerous companies were formed at the Homebrew meetings. A remarkable amount of information was also exchanged at those meetings. Much information needed to be exchanged; they were all in unfamiliar territory.

Around this time, a branch of Homebrew started at the Lawrence Hall of Science at UC Berkeley. Universities were becoming hotbeds of self-taught microcomputer expertise. Professors with grant money now found it cost-effective to buy minicomputers rather than buy time on the university mainframe computer, which was invariably out of date and overworked. DEC was selling PDP-8 and PDP-11 minicomputers to professors as fast as it could build them. The computers were especially popular in psychology labs, where they were used for experimenting on human subjects, automating animal lab processes, and analyzing data. The invasion of the psych lab by minicomputers created a new kind of expert: someone who may know something about research and data analysis but who was actually more of a hacker and computer nut—someone to figure out how to run the computer and make it do what the professors wanted.

Homebrew Spawns More Start-Ups

Howard Fulmer was such a person. Fulmer worked in the Psychology Department at UC Berkeley running PDP-11s, selecting minicomputers for professors to buy, building interfaces, and programming experiments. It all changed in early 1975 when one of Fulmer’s professors bought an Altair and Fulmer taught himself how to use it. Soon after that, Fulmer left his job to devote more time to microcomputers.

Figure 30. George Morrow ***A little older and more outgoing than most of the early personal-computer developers, Morrow was an entertaining showman as well as a technologist.***
(Courtesy of George Morrow)

He was not alone: the fever produced by the announcement of the Altair in *Popular Electronics* spread through UC Berkeley. George Morrow, a graduate student in math, worked with Chuck Grant and Mark Greenberg, two other students at the university's Center for Research in Management Science. They were the same Grant and Greenberg who had refused a few years earlier to get off the Resource One computer to allow Lee Felsenstein to perform maintenance on it. They were attempting to develop a language to use with a microprocessor in computer-controlled research.

Morrow, Grant, and Greenberg found that they worked well together. All three were perfectionists, although in different ways. The thin, prematurely balding Morrow, with the perpetual twinkle in his eye and an irrepressible wit, seemed always to be enjoying himself, and especially so when he was hard at work. Grant and Greenberg, on the other hand, tended to be all business. Although Grant and Greenberg often attended Homebrew meetings and profited from the free, open exchange of information, they never considered themselves part of the hobbyist community. But as far as the technical stuff went, the three formed a good team: Morrow knew hardware, Grant preferred software, and Greenberg was at home with either.

The trio considered making boards for the Altair, or even a computer of their own. They knew that they were a good design team, but they also knew they lacked sophistication when it came to marketing. So Morrow sought the advice of Bill Godbout, a seemingly unlikely choice. Middle-aged, blunt, and opinionated, Godbout freely joked about his expanding paunch and kept an airplane for stunt flying. He was the electronics distributor Bob Marsh had tried, unsuccessfully, to interest in his walnut digital clock when he and Felsenstein first moved into the garage at 2465 Fourth Street.

Figure 31. Bill Godbout ***Godbout sold chips and memory boards by mail and did business***

with developers on a handshake basis. **(Courtesy of Bill Godbout)**

Godbout was at the time selling chips and minicomputer memory boards by mail. Morrow asked him if he intended to sell Altair memory boards. Godbout scoffed. He wouldn't so dignify the product, he said. Morrow wondered if Godbout might be interested in distributing a good computer, one that was the creation of a top-notch design team.

"With you guys?" Godbout sniffed. He gave Morrow the once-over. Godbout felt he was good at sizing people up, and decided Morrow looked all right. They quickly agreed to split the profits equally and shook hands on it. No written contract, Godbout insisted. Written contracts were a sign of mistrust and an invention of lawyers, and if there was anybody Godbout didn't trust, it was a lawyer.

For all their differences, these entrepreneurs were all convinced that they were involved in the birth of something remarkable. The irascible Bill Godbout, who hated lawyers; ex--*Berkeley Barb* technical editor and current Homebrew toastmaster Lee Felsenstein; Bob Albrecht, who left a high-paying career to teach children about computers, smoked cheap cigars, and called himself "The Dragon"; Bob Marsh, who was testing his own abilities by turning his love for electronics into a garage corporation; and Keith Britton, who saw himself and the other Homebrewers as pivotal in "an equivalent of the industrial revolution but profoundly more important to the human race." They all knew that they were revolutionaries.

They weren't necessarily political, although a surprising number of these early movers and shakers held political views that would have shocked the local Rotary Club, and almost all of them had no love for IBM or the rest of the computer establishment. But they and others like them were bringing about a new industrial revolution.

And much of the action took place at Homebrew.

The Homebrew Computer Club was not merely the spawning ground of Silicon Valley microcomputer companies. It was also the intellectual nutrient in which they first swam. Presidents of competing companies and chief engineers would gather there to argue design philosophy and announce new products. Casual remarks made at Homebrew changed the directions of corporations. Homebrew was a respected critic of microcomputer products. The Homebrewers were sharp, and could spot shoddy merchandise and items that were difficult to maintain. They blew the whistle on faulty equipment and meted out praise for solid engineering and convivial technologies. Homebrewers had the power to make or break new companies. Due in part to Lee Felsenstein, Homebrew encouraged the conviction that computers should be used for and not against people. Homebrew thrived in a kind of joyous anarchy, but the club was also an important step in the development of a multibillion-dollar industry.

The seeds of all of this were already present in the spring of 1975.

Wildfire in Silicon Valley

> *Processor Technology was a nexus for hobbyists making a transition, trying to be serious about it all and not always succeeding.*
>
> –Lee Felsenstein, designer of several microcomputer products

The Fourth Street garage in Berkeley was a busy place that spring. Lee Felsenstein was making a meager living from odd jobs, including repairing friends' Altairs, while Bob Marsh was tearing open checks, writing ad copy, and doing his best to convince hobbydom that Processor Technology was a million-dollar company when, in fact, it still existed mostly in his head.

Fixing the Altair

Felsenstein had gotten himself in trouble that spring. In spreading the word about the Altair through an article for *PCC*, he based his description of the machine's workings and capabilities on information he received from Homebrew and from a telephone interview with MITS president Ed Roberts. Irate letters soon poured into the *PCC* office contending that Felsenstein had not been critical enough of the product. The Altair had serious problems, the letters claimed. Steve Dompier, for one, showed Felsenstein the difficulties he'd had with the front panel of his Altair and even got Felsenstein to fix it.

In a *PCC* article he titled "Criticism and Self-Criticism," Felsenstein apologized: "I lied folks; this thing has problems." He detailed the computer's flaws and how to correct them. He also began fixing Altairs for friends and *PCC* readers, working on them in his half of the garage. Loyal to other hobbyists and feeling guilty about misinforming people, Felsenstein did the work cheaply. In the process, he learned a great deal about those early Altairs.

Meanwhile, Marsh and Ingram were using their half of the garage to create the Altair boards they were getting checks for. But they were stalled early on: they needed a sharp engineer to draw up the schematics for the boards that Marsh had conceived. The engineer had to be willing to work in a cramped and messy garage, and he had to work cheap.

Marsh knew just the man.

Felsenstein had made it clear that he did not want to join Processor Technology or any other company. He had better things to do. Although he was working long hours for little pay, he was doing what he wanted and felt beholden to no one. And long hours for little pay was about all Bob Marsh could offer him. Nevertheless, Marsh put forward a new proposal. Would Felsenstein just do the schematic for the first board, as a consultant rather than an employee?

Felsenstein thought it over, agreed, and offered to do the schematic for $50. This price, Marsh thought, was pathetically low. It was a $3,000 job and Felsenstein, the poor goof, was offering to do it for $50. Marsh refused to go below $500. Felsenstein accepted the compromise.

It was fast work, and by June they were shipping boards. One of them was first meant to be a 2K memory board for the Altair, an ambitious project given that MITS was shipping only an eighth as much memory. Then, at the last minute, Marsh changed the design, doubling the capacity to 4K. MITS's first real competition came from those 4K memory boards, which definitely cut into MITS's profits. Ed Roberts wasn't pleased.

But MITS's defective memory boards and delivery backlog had already kicked the door open for some real competition. Bruce Seals, a Tennessee hobbyist, flew to Albuquerque in July to discuss an East Coast dealership, and returned to Tennessee with the entire state as his territory and a promise of three-day delivery. When MITS couldn't move the products fast enough, especially the memory boards, Seals saw the same need—and opportunity—that Marsh had, and he, too, designed and began to sell a 4K memory board. An industry of sorts was developing.

Processor Technology continued to market memory boards while moving on to new designs. The VDM, or video display module, Felsenstein's next contract for Proc Tech, was an interface board that allowed the Altair to display output on a television screen. Chuck Grant and Mark Greenberg, who had left UC Berkeley with George Morrow and were now doing business as G & G Systems, did the software for the module, and Steve Dompier wrote Target, a video game that showed off the VDM. Dompier later asserted that it was the VDM that made video games possible.

In the fall of 1975, a local computer show took place at UC Berkeley's Lawrence Hall of Science, where the East Bay spin-off Homebrew Computer Club first got together. MITS was represented by two area Altair dealers, Paul Terrell and Boyd Wilson, who proudly showed Felsenstein and Marsh the hoops their machine could jump through. Marsh was more impressed by the fact that the Altair was filled with Processor Technology memory boards. Harry Garland and Roger Melen were also present, demonstrating how their Cyclops camera could be used with the Altair.

Sharing Ideas

Before the original Homebrew Computer Club had grown large enough to need the auditorium at the Stanford Linear Accelerator Center (SLAC), *Popular Electronics* technical editor Les Solomon visited the club at the nearby SLAC Orange Room. He was the star of the evening, telling somewhat far-fetched stories of his own experiences. Sometimes he sounded like a counterspy, other times like a vaudeville magician. "It was unclear which country he was working for," joked Lee Felsenstein, who was among Solomon's admirers. At one point, Solomon led the Homebrewers outside, did some hocus-pocus, and instructed them to lift the huge stone table in the yard. They were surprised to find that they could hoist it right up, although Felsenstein noted dryly that the group hadn’t tried lifting it without the hocus-pocus.

Some nights at Homebrew, a tall, dapper, charismatic man could be found at the back of the room selling books out of a cardboard box. He was Adam Osborne, a chemical engineer born in Bangkok of British parents, and the same Adam Osborne who had been doing technical writing for Intel. He had since self-published a book called *An Introduction to Microcomputers*. It was, in fact, an introduction to microprocessors, such as the Intel 8080. In the early days, microprocessors were commonly referred to as microcomputers, especially by the public-relations departments of semiconductor companies.

Although the people from IMSAI, the leading microcomputer company, almost never attended club meetings, IMSAI cofounder Bruce Van Natta was at Homebrew one night when Osborne was hawking his books, and bought a copy. His decision to include a copy of Osborne’s book with every IMSAI allowed Osborne to start a publishing company that would eventually be purchased for millions by McGraw-Hill. Ironically, it would be Osborne who would first announce IMSAI’s demise in a column in a computer magazine.

After Homebrew meetings, its most fanatical members went to a Menlo Park beer-and-burger place named the Oasis but known to the savvy as “the O.” They sat in wooden booths surrounded by the deeply carved initials of generations of Stanford students, drank beer, and argued computer design. They ignored the fact that they were competitors. There were a lot of things to learn in developing this new kind of product, and they weren’t about to let economic issues get in the way. Marsh and Melen regularly traded insights on design, and Grant and Greenberg sometimes joined them at the O.

Wildfire grep -nH -e Beyond the Valley

By the end of 1975, new microcomputer companies were poking up everywhere, with the most furious activity still in the San Francisco Bay Area. IMSAI was located in San Leandro. Bay Area--based Cromemco was designing boards for the Altair. MOS Technology had released its KIM-1 hobby computer, based on its bargain-basement 6502 microprocessor, equipped with a hexadecimal keyboard in place of binary switches. Microcomputer Associates in Los Altos had its Jolt, a 6502 kit.

Southern California was also a center of growing hobbyist activity. In Gardena, Dennis Brown was selling his Wave Mate Jupiter II, a computer based on the Motorola 6800 microprocessor and designed to attract “serious hobbyists,” for less than $1,000. Although the Altair had sold for less than half that, a realistic price for an assembled Altair system, including some sort of I/O device, adequate memory, and a storage device, was well over $1,000. In San Diego, Electronics Products announced another 6800-based computer, the Micro 68.

On December 31, 1975, Rich Peterson, Brian Wilcox, and John Stephensen quit their jobs to form their own company. Peterson and Wilcox had built an Altair, Stephensen had built his own

8080 machine from scratch, and they found themselves designing boards to make the Altair run better. Deciding that their hobby could just as well be their vocation, they formed PolyMorphic Systems and started working on a computer kit. They first called it the Micro-Altair, and later, under duress, changed the name to Poly 88.

Elsewhere in the West, MITS in Albuquerque was offering a 4K static memory board for its 8080 system and was developing a computer based on what was emerging as the “Southwest chip”: Motorola’s 6800. Systems Research in Salt Lake City sold a 6800 microcomputer board. Mike Wise’s Sphere, operating out of a small factory near Salt Lake City, was offering its 6800 computer with a built-in terminal and plastic case. Southwest Technical Products, run by Dan Meyer in San Antonio, also offered a 6800 system. The Digital Group in Denver was selling a variety of boards.

In the Midwest, Martin Research was offering its Mike CPU boards with 8008 or 8080 chips. Ohio Scientific Instruments in Hudson, Ohio, had 6800 and 6502 kits. Heathkit in Benton Harbor, Michigan, had a computer in the works.

In the East, the hobbyist movement grew up around the Amateur Computer Group of New Jersey. Scelbi, in Milford, Connecticut, put out a popular kit based on the 8008, and Technical Design Labs in Trenton, New Jersey, was developing a computer kit around a new chip, the Zilog Z80. Hal Chamberlin in North Carolina, Bruce Seals in Tennessee, and Georgia Tech student Ron Roberts were active hobbyists working on systems, components, or software.

But the fire burned most strongly in Silicon Valley, with its atmosphere of symbiotic information sharing. New companies that created circuit boards for the Altair popped up almost daily. By the end of 1975, one of these, Processor Technology, was on its way to parlaying its substitute for the defective Altair memory board into financial wealth and, within a curiously anticorporate industry, a kind of corporate respectability.

Nostalgia for the Future

> *Bob said he would pay me to design the video section of the Tom Swift Terminal. He knew how to manipulate me.*
>
> –Lee Felsenstein

In June 1975, Bob Marsh and *Popular Electronics* technical editor Les Solomon were contemplating an “intelligent terminal” kit. It would consist of a terminal with semiconductor circuitry that would perform certain display and keyboard decoding functions that another computer attached to it would have otherwise handled. Marsh had some ideas from his own experience and from discussions with Felsenstein about the Tom Swift Terminal. “If you can get me a working model in 30 days, I’ll give you a cover story,” Solomon said.

A Terminal with a Brain

Marsh put the proposition to Felsenstein this way: “Do you think it’s impossible?” Felsenstein appreciated Marsh’s careful phrasing of the question. To dodge the job, he would have to pronounce it impossible, a distasteful act to any self-respecting engineer.

Marsh said he would pay Felsenstein to design the video portion of his dream machine, the convivial terminal that Felsenstein saw as essential to releasing the power of computers to everyone. Felsenstein liked the idea, and agreed to do it. It soon became apparent that Marsh had a different project in mind. What he wanted was a terminal with a brain—the same Intel 8080 chip that was the brain of the Altair. They argued over the details of the design, with Marsh usually getting the better of the arguments. Felsenstein, Marsh, and Les Solomon didn’t realize it then, but the product they were designing would become something more than just a terminal.

Felsenstein had to withdraw from another project when he agreed to design the intelligent terminal. “The roof is falling in again,” he told his ex-customer. Until then, he paid his share of the rent by consulting for various people. But Proc Tech was expanding to take up the whole garage—all 1,100 square feet of it. Felsenstein was gradually being absorbed into Marsh’s enterprise.

Marsh had already developed the terminal’s architecture and continued to change the design requirements as Felsenstein worked. Felsenstein had enjoyed consulting, in part because he could get some distance between him and the person he was working for and concentrate without interruption on a problem. This advantage evaporated when he began to devote most of his time to the Proc Tech terminal. Marsh insisted on design changes on a daily basis and repeatedly forced Felsenstein to junk much of his careful work and start over. “The situation,” Felsenstein later said, “did call heavily on my sense of futility, absurdity, and ultimate irrelevance.”

Despite his complaints, Felsenstein was enjoying himself. His grumbling about being manipulated was more of a jab at himself than it was at Marsh, who, for all his entrepreneurial energy, was involved at least partly for the fun of it. At one point in the project, Felsenstein said, “Let’s advertise it as having ‘the wisdom of Solomon.’” He meant it as a sly reference to Les Solomon, and this whimsical slogan soon inspired them to name the machine “the Sol.”

Figure 32. Bob Marsh and Gary Ingram ***Founders Marsh (chin on fist) and Ingram dressed up to meet customers at Processor Technology’s booth at an early trade show.*** **(Courtesy of Bob Marsh)**

Marsh and Felsenstein argued ceaselessly over the design at Felsenstein’s workbench at one end of their garage and at the makeshift Proc Tech offices housed at the other end. They argued about it over meals and while driving across the San Francisco Bay to Homebrew meetings. Despite their constant wrangling over design, they got the goods out. On one drive to a Homebrew meeting, they redesigned an entire internal bus.

A Real Computer

It eventually dawned on Marsh and Felsenstein that they were designing a real computer. After all, it had an 8080 in it. But clearly it was also a terminal. Until then, computers typically consisted of rectangular boxes with accessory connections to terminals of some kind—Teletypes, cathode-ray tubes, typewriters, or printers. But theirs was a screen, a keyboard, and a computer all in one. Could they really pull this thing off?

The question had both technical and political implications. At this point, the Altair dominated the tiny microcomputer industry, and IMSAI had not yet made its entry. And here they were, developing this terminal under the auspices of the Altair's biggest booster outside of Albuquerque—Leslie "Uncle Sol" Solomon. Would he rescind the cover-story agreement if they told him they were concocting a computer instead of a terminal?

They decided not to tell him.

And they continued to work. Despite all the arguments, Marsh, Ingram, and Felsenstein were enjoying themselves. "This is a company that's going to have fun," Felsenstein said, "no matter how miserable I have to be." He described his partners as "nostalgic for the future," like many computer hobbyists of the day, and their discussions were frequently those of visionaries. But the mundane, day-to-day decisions also had to be made. Marsh's friend still had all that cheap walnut originally slated for the digital-clock business, and it seemed a shame to let it go to waste, so Marsh incorporated walnut side panels into the Sol's design, giving it the appearance of a 1950s station wagon.

Felsenstein had originally expected to hand the finished schematic to a layout artist. As it turned out, he was the chief layout artist. Because they had long since filled all the available floor space in the garage, a light table for the layout work was installed in a loft above the Proc Tech offices. Felsenstein padded the forehead-level conduit, but couldn't keep from bumping his head on the rafters as he worked with the other layout artist 14 to 17 hours a day, seven days a week. The other artist, pumping himself up with cola, dropped out before the end of the project, and Felsenstein had to finish the job alone, on orange juice.

Marsh kept the pressure on, and within 45 days of his initial discussion with Les Solomon, he had a circuit board. But Solomon had given the team a 30-day deadline, so as they neared completion Marsh booked a flight to New York and informed a bleary-eyed Lee Felsenstein that he was going, too. They stuffed the Sol into two brown paper bags and carried it with them on the plane.

The demonstration for Solomon at *Popular Electronics* was an utter disaster. The thing just didn't work. They made what excuses they could and, feeling hopeless at this point, flew to an appointment at *Byte*, where the presentation was even more disastrous. Felsenstein, dead on his feet from the grueling work schedule, fell asleep during the *Byte* demonstration.

Well-rested and back in California at his workbench, he quickly located the problem, a short circuit. Marsh promptly put Felsenstein back on a plane to New York to demonstrate a working Sol with strict instructions to not reveal that it was actually a computer.

Felsenstein kept his mouth shut, but Solomon was no dummy. When Felsenstein showed him the

Sol terminal, he watched it work for a while, and then asked Felsenstein what was to stop him from plugging in a memory board with BASIC on it and running the Sol as a bona fide computer.

“Beats me,” Felsenstein deadpanned.

Who Owns the Software?

Of course the Sol was a computer. And that meant, Marsh and Ingram realized, that it needed software, particularly BASIC. The two contracted with Chuck Grant and Mark Greenberg to write it. One-time partner George Morrow had had a falling out with Grant and Greenberg because he didn’t think they were taking their oral agreement with Bill Godbout seriously enough. Morrow decided to deal with Godbout alone, leaving Grant and Greenberg to go off on their own.

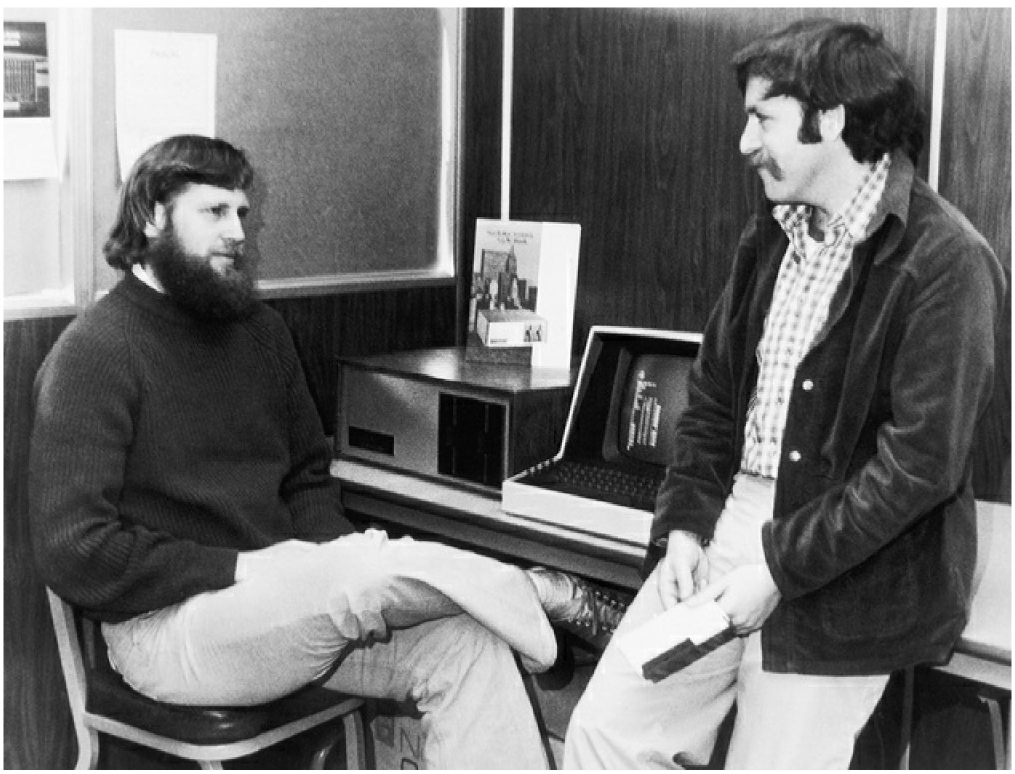

Figure 33. Chuck Grant and Mark Greenberg ***Grant (left) and Greenberg were involved in the personal-computer revolution from the start, and launched several companies, including Kentucky Fried Computers and North Star Computers.*** **(Courtesy of North Star)**

As they worked on the BASIC, Grant and Greenberg found they were having the most trouble with the floating-point routines: arithmetic on real numbers, not integers. They simply couldn’t process the operation as quickly as they wanted to. They finally decided to build the floating-point math into the hardware, and hired George Millard to help design a floating-point board.

Around this time, the issue of proprietary software came up. Conflict arose over ownership of an implementation of the BASIC computer language. Marsh asserted that the software was being developed for Proc Tech, whereas Grant and Greenberg, with growing ambition, insisted that it was theirs and began soliciting other customers for their BASIC. Proc Tech took Grant and Greenberg to court, and the case lumbered through discovery and delay, doing neither company any good.

The Problem of Storage

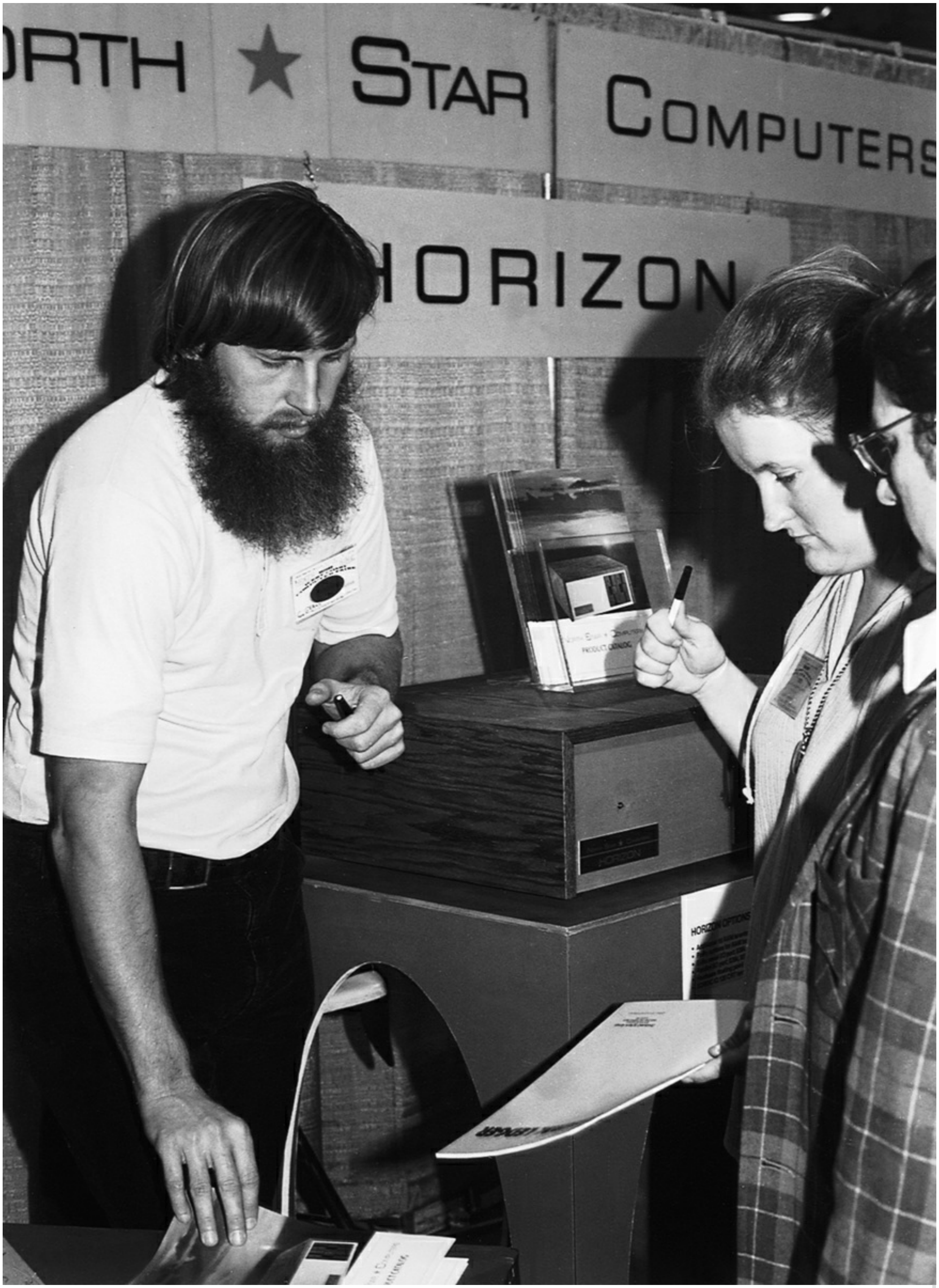
ORTH ★ STAR COMPUTERS
HORIZON

Figure 34. Chuck Grant ***In the early days of the personal-computer era, there was nothing unusual about a computer company's founder demonstrating his product at a show in a T-shirt.***
(Courtesy of David H. Ahl)

Grant and Greenberg had other hot projects going. They developed a cassette-tape interface that would allow microcomputers to save data to tape using cheap audio-tape recorders. But then Shugart, a Silicon Valley minicomputer disk-drive manufacturer, announced the introduction of a drive that used 1 1/4" disks—smaller than the 8" disks commonly used on big computers—that cost less than any other disk drive. Disk drives were the obvious answer for data storage, if they could be made affordable. So Grant and Greenberg dropped their interest in cassette storage and started designing a controller board to make the Shugart disk drive work with microcomputers.

When they had their disk system together, they gave themselves a new name, North Star, perhaps echoing the name Altair, another bright star in the sky. Simultaneously, as Applied Computer Technology, they contracted to sell IMSAIs bundled with their own BASIC and cassette interface to universities. But the market, they discovered, did not want configured systems, but rather raw computers, so they began selling IMSAIs out of Mark Greenberg's garage. This operation, at Grant's suggestion, was called Kentucky Fried Computers.

Meanwhile, their ex-partner, George Morrow, bought an Altair, studied it, and decided not to imitate it. He shared Godbout's estimation of the Altair. The computer that he and Godbout planned to build, and that he began to design, would definitely be better. He would base it on National Semiconductor's PACE, a microprocessor they hoped to get for $50 from National.

Godbout, however, had reservations about the project. He meditated over Altair's sales figures and decided that memory boards for the Altair might do well after all. Morrow, with some reluctance, put aside the PACE machine and commenced designing a 4K memory board with his own name on it, joining Proc Tech and Seals in the memory market. Godbout sold the board for $189, well under Proc Tech's price, and Morrow suddenly found himself making $1,800 a month in royalties.

Godbout now became intensely interested in selling microcomputer boards. But when he vetoed one of Morrow's ideas, Morrow reevaluated their relationship. Couldn't he sell his boards just as well as Godbout, he asked himself. The only difference, he decided, lay in who placed the magazine ads. Thus was born Morrow's Microstuf.

There was no telling who would be successful among these entrepreneurs. Godbout already had a successful electronics business. Morrow was a bit older than some of these players, and with his bald head he came across as more of grown-up and hence more of a serious businessman. Marsh, on the other hand, looked like a kid, and Felsenstein was staunchly anticorporate. But Proc Tech was starting to look really promising. The market was crazy, according to Morrow.

“You could start a company, announce a product, and people would throw money at you.”

Bob Marsh had already learned this lesson with Proc Tech’s memory boards, but was more than willing to take a refresher course. Marsh and Felsenstein took the Sol to the PC Computer show in Atlantic City, New Jersey, in June 1976 to unveil it to the world. It went over big.

When they returned to California, they continued to enhance and modify the Sol. While writing tutorial articles on computer design for *PCC*, Felsenstein added what they called, to use writer Don Lancaster’s term, a “personality module.” This tiny circuit board had a ROM (read-only memory) chip and could be plugged into the back of the machine, enabling its “personality” to be changed in a second. Felsenstein wryly imagined employees popping in game modules for the business modules while the boss was out of the office.

Competition

By late 1976, DEC was selling its LSI-11 bottom-of-the-line minicomputer for slightly over $1,000. In Southern California, Dick Wilcox gave hard thought to a suggestion in *Dr. Dobb’s Journal* about interfacing the LSI-11 with an Altair or IMSAI. What he came up with was the Alpha Micro, an LSI-like multiuser CPU board, which he demonstrated to Homebrew in December 1976.

New microprocessors continued to arrive. Toshiba released the first Japanese chip, the T3444. National Semiconductor issued a new microprocessor plus supplied the development tools hobbyists needed to start building real computers and writing software.

Scores of new microcomputer companies began to appear. Vector Graphic in Thousand Oaks, California, introduced an 8K memory board. Vector consisted of a Stanford engineering-school graduate and two businesswomen. Men had founded almost all the microcomputer companies, although some had recruited wives or girlfriends as business managers. But Vector’s Lore Harp quickly showed she was more than just a business manager as she guided the company with a shrewd sense of the market’s needs and the possibilities for growth.

However, Vector was not doing any better than Proc Tech. During the winter of 1976–1977, Proc Tech moved to a much larger facility, 14,000 square feet, next to a beef-rendering plant in nearby Emeryville. The atmosphere was uninviting, but the new location was far roomier than their former digs.

A month after Proc Tech moved out of the Fourth Street garage, Grant and Greenberg took over two-thirds of the space of the garage, Felsenstein reclaimed the other third, and their three company names were placed on the door: North Star, Applied Computer Technology, and Kentucky Fried Computers. As the last company, they were now marketing IMSAIs, PolyMorphic and Vector Graphic boards, and an Apple I kit that they were persuaded to take on consignment by a scraggly bearded young man named Steve Jobs. But soon, sales of their North

Star disk system soared, and they closed Kentucky Fried Computers to concentrate fully on North Star. A letter from a certain fast-food chain that demanded they cease and desist from using the name Kentucky Fried Computers made the decision easier.

By the end of 1976, Processor Technology, Cromemco, North Star, Vector Graphic, and Godbout Engineering were prominent among the Silicon Valley enterprises, building an entire industry where none had existed two years before. And that industry was growing with amazing speed.

Sixers and Seventy-Sixers

> *I was working on…a military project with $1.5 million to build a display. It occurred to me maybe I could make a few concessions and do it for $99 instead.*
>
> –Don Lancaster, early computer hobbyist and writer

By the mid- to late-1970s, the fire of invention burned brightly in Silicon Valley, fueled by a unique environment of universities and electronics and semiconductor firms, and the legacy of revolutionary fervor left by the Berkeley Free Speech Movement and 1960s counterculture values. But tinder sparks were igniting in scattered places throughout the country. Some of those figurative sparks were fanned by a man who actually spent his days watching for real fires.

The Fire Spotter

Don Lancaster wasn't your typical aerospace engineer. He had gone to work for a defense contractor in the 1960s as a way of avoiding the Vietnam draft, but wasn't too thrilled to find himself working for a company that produced machines designed to kill people. During his tenure there, he began to write articles for *Popular Electronics* and soon found that he could do better on his own. This was before the Altair. He quit the aerospace job, moved to Arizona, and went to work for the forest service as a fire spotter. Stationed in a lonely ten-foot-square fire tower, he had many hours to think up ideas for electronics projects he could write about.

Lancaster's antiwar sentiments may not have found universal approval in Arizona, but his rugged individualism did. And he looked the part. Many of the California Homebrewers, such as Steve Dompier, were longhairs who rebelled against the "straight" look of the typical engineering student. But not Don Lancaster. Picture Lancaster as a computer-era Chuck Yeager—clean-cut, square-jawed, and tight-lipped, with aviator sunglasses and a cowboy hat planted squarely on his head.

Despite his straight-laced appearance, Lancaster was a genuine revolutionary. His do-it-yourself electronics articles were written by one individualist for other individualists. They were written to put the kind of power formerly reserved for aerospace firms and corporate data-processing departments—the computer priesthood—into the hands of the technically savvy everyman.

Lancaster was prolific. In addition to his freelance articles, he wrote books that electronics enthusiasts devoured, with titles like *TTL Cookbook*, *CMOS Cookbook*, and *Cheap Video Cookbook*. An excerpt from the latter provides a sense of Lancaster's style and substance, and a glimpse into the kinds of issues that early microcomputer hobbyists had to deal with:

"Cheap video is a brand new collection of hardware and software ideas that dramatically slash the cost and complexity of both alphanumeric and graphics microprocessor-based video displays.

A typical cheap video system…lets you do things like 12 × 80 scrolling display using only seven ordinary ICs with a total circuit cost as low as $20, transparently run on a microcomputer system that still has as much as 2/3 of its throughput remaining for other programs."

Lancaster was original and generous as well as prolific. *Popular Electronics*'s Les Solomon spoke for all those who had been inspired by Lancaster's books and articles when he said he had been "constantly startled by Don Lancaster's brilliant innovations over the years."

Intel vs. Motorola

Ed Roberts of MITS was one of those who studied Lancaster's books and articles, and he worried because he thought Lancaster had hitched his wagon to a star brighter than Altair. Soon after *Popular Electronics* featured the MITS Altair on its cover, Lancaster joined up with Southwest Technical Products (SWTPC) in San Antonio. SWTPC had been in the audio-component business until late 1975, when it jumped into the business that Ed Roberts regarded as his personal domain: hobby computers. Roberts was convinced that the 6800 microprocessors that SWTPC was getting from Motorola made a better brain for a small computer than the Intel chip that Roberts bought at clearance to put in his Altair.

Roberts's worries foreshadowed the split in the industry between the supporters of processors from Intel and chips from Motorola and other vendors, a split that would continue for decades.

Because the chips in the Intel line usually featured the number 8 prominently in their product names and the Motorola chips usually had a 6 in their names, supporters of the two lines were often called, respectively, "eighters" and "sixers." Roberts was an eighter by default, but wanted to be a sixer. The attendees of the Homebrew Computer Club in Silicon Valley were mostly eighters, with some notable exceptions, such as the young Steve Wozniak, a clearance-sale-shopping sixer who had recently taken a job at Hewlett-Packard. Although the chips weren't all that different in their capabilities, the choice of a computer's microprocessor affected myriad hardware and software compatibility issues. A seemingly small decision, it was nevertheless a fateful one.

Lancaster was a sixer.

The TV Typewriter

Lancaster's best-known contribution to the technological revolution was one of his earliest: the TV Typewriter. Lancaster published his prescient *Radio-Electronics* article that described the groundbreaking TV Typewriter device in 1973, a full two years before Ed Roberts had an Altair up and running. One industry pundit would later crown Lancaster the "father of the personal computer" because of this invention.

The TV Typewriter was just a terminal, but it was a terminal that computer hobbyists could build themselves. The device, and Lancaster's description of its capabilities, got hobbyists thinking about real homebrew computers, and about the kinds of capabilities that the Internet would deliver to a broad market more than two decades later. It is no exaggeration to say that the TV Typewriter inspired a generation of computer hobbyists.

The TV Typewriter impressed Les Solomon. It made it possible for users to enter text on a cheap keyboard and display the characters on a television screen—uniting two inexpensive components that could, in principle, serve as the primary input and output devices for a computer. Bingo. Solomon wanted a way of getting information into and out of the Altair box that was easier and more user-friendly than having to flip switches and read the blinking patterns of the front-panel lights. Inevitably, he thought of Lancaster's TV Typewriter.

The TV Typewriter and the Altair couldn't work together as they were; one or the other would have to be redesigned. But which one? Solomon grabbed the bull by the horns, perhaps a more apt metaphor than he would have liked, and took Lancaster to Albuquerque to meet Ed Roberts. He thought a face-to-face meeting could resolve the issue. No such luck: Arizona faced off against New Mexico, and neither gave an inch.

Figure 35. Bob Marsh ***Marsh had been a teacher and enjoyed showing his computer to children at trade shows.*** **(Courtesy of Bob Marsh)**

The TV Typewriter proved more successful in another context. It was Lancaster's article on the device that got Bob Marsh into computers and had him hook up with Lee Felsenstein, which led to the creation of the Sol. The Sol was the first of the hobby computers to feature a built-in screen and keyboard. So although the design was not Lancaster's, the germ of the idea was his. The built-in screen and keyboard first popularized in the Sol would prove key to turning a hobbyist microcomputer into a true personal computer.

The "Industry" in 1977

By the spring of 1977, the wildfire had spread around the country and beyond. The most visible signs of the phenomenon were the computer clubs springing up all over. The Philadelphia Area Computer Society tracked developments in its newsletter, *The Data Bus*. The Toronto Region Association of Computer Enthusiasts newsletter already had a rating system for products. In Santa Monica, California, a group of hobbyists had formed an influential club, the Southern California Computer Society.

Microcomputer-related companies had already appeared and were doing business—in Tempe, Arizona; Englewood, Colorado; Norcross, Georgia; Skokie, Illinois; Olathe, Kansas; Crofton, Maryland; Cambridge, Massachusetts; Saint Louis, Missouri; Peterborough, New Hampshire; New York City, New York; Cleveland, Ohio; Oklahoma City, Oklahoma; Aloha, Oregon; Malmö, Sweden; Provo, Utah; Issaquah, Washington; and Laramie, Wyoming, to cite a few examples. Newman Computer Exchange in Ann Arbor, Michigan, could already boast of its "giant" catalog of microcomputer equipment, bigger than all the other such catalogs.

Jim Warren, editor of *Dr. Dobb's Journal*, "chairbeing" of the first West Coast Computer Faire and strategically placed observer of the rapid spread of this hobby-computer movement, in August 1977 estimated that there were "50,000 or more general-purpose digital computers in private ownership for personal use." Whether or not that estimate was accurate, or took into account a few rich enthusiasts who could well afford to house a minicomputer in their basements, it stated with certainty that a wild and unstoppable fire was burning across the land.

If Jim Warren had listed all the microcomputer companies, clubs, magazines, and newsletters he knew about in mid-1977, the list would have bulged with Silicon Valley addresses, and not just because it was Warren's home base. California enterprises in general would have occupied a large share of the list. Other states that were home to mainframe and minicomputer companies, semiconductor companies, and high-tech research schools, including Massachusetts, Minnesota, and Texas, would take another big chunk of the list. And then you had the New Jersey hackers.

Sol Libes and the ACGNJ

The Garden State was rich with microcomputer companies, like Technical Design Labs in Princeton and Electronic Control Technology in Union. Roger Amidon and Chris Rutkowski had a "supercomputer," the General, with very good software. There were also the magazines —*Computer Decisions* magazine in Rochelle Park, and the most mainstream, accessible, and entertaining of the lot, David Ahl’s *Creative Computing*.

But the clubs were where the ideas were shared, and they were what kept the fire spreading. The Amateur Computer Group of New Jersey (ACGNJ) was one of the most active computer clubs in the country, and one of its fire-starters was a man named Sol Libes.

Like Don Lancaster, Libes wrote books for electronics enthusiasts. But whereas Lancaster was a loner, Libes was a joiner. Or perhaps it was that he could convince others to join him. Sol was a little older than some of the hackers, and may have seemed avuncular to a number of them. But he was one of the most active ACGNJ members, always getting involved with projects, including a couple of slick computer magazines.

Magazines were important to the spread of the microcomputer movement, but they lacked the immediacy that feeds a fast-moving phenomenon. Clubs like the Homebrew Computer Club and the Amateur Computer Group of New Jersey brought together computer enthusiasts who could share and critique ideas and designs in real time.

The BBS Phenomenon

Although meeting in real time was critical to the movement, meeting in real space wasn’t. It was only a matter of time before some hacker figured out that the best place for computer hobbyists to meet would be on a computer.

Most of the new microcomputers were capable of being hooked up to a modem. That meant with the right software they could be used to allow computer owners to communicate with each other over phone lines, somewhat like ham-radio enthusiasts who typed rather than talked.

Despite this capability, that scenario presented certain problems. Even if you had the right software, and even if the right software that both you and your friend had made all the same assumptions, you could talk only when you were both willing and available at the same time. It would be nice if you could leave an electronic message for your friend, but unless your friend’s computer and modem happened to be turned on when you sent the message, where would you leave it?

A Chicago computer enthusiast solved these nagging problems. He created a way of transmitting data between microcomputers over phone lines, called XMODEM, that became the communications standard. He also created a place to store messages with the first computer bulletin-board system (CBBS or just BBS).

His name was Ward Christensen, and in 1978 he and Randy Seuss wrote the first software that made it possible to set up BBSs, which not only provided a place to store messages for other computer enthusiasts, but also became places where communities of people with common interests—and not just a shared interest in computers—developed.

Over time, communities based not on geography but purely on shared interests developed on BBSs, and later on in Usenet newsgroups, email lists, interactive websites, multiuser domains, and virtual worlds. In 1978, most of those developments were still a thing of the future, but the model for every virtual community to come was present in those BBSs.

The virtual electronic communities on BBSs, the computer clubs popping up all over the country, the companies built more for the excitement than because of a desire for big profits—these were all evidence that something was going on that couldn't be understood in terms of economic self-interest. On the other hand, ignoring economic realities is not a good idea in any business, as some of the Silicon Valley firms soon found out.

Home Rule

> *The first part of the meeting we were involved in open combat with Intel. Intel was out to torpedo any standardization effort on the S-100 bus.*
>
> –George Morrow, founder of Morrow’s Microstuf

Although the spirit of sharing was well established in the early days of the microcomputer industry, its participants had a lot to learn about working together. One thing that accelerated the learning process was fear.

The Big Boys

A continuing concern in the developing microcomputing industry was that “the big boys” would come and spoil all the fun. “The big boys” sometimes meant IBM and the other mainframe-computer and minicomputer companies, but mostly the reference was to such companies as Commodore and other electronics companies that had waged Pyrrhic price-cutting wars in the calculator industry. And, most especially, it meant Texas Instruments, known for its ruthless price slashing. Lee Felsenstein summarized the dread of many hobbyist entrepreneurs: “Anyone but TI!”

Intel and some of the other semiconductor companies, although well situated to produce microcomputers from their own chips, had expressed reluctance to do anything that could be construed as competing with their own customers. By this time, the hobbyist-born microcomputer companies had developed just about enough clout to be taken seriously as semiconductor customers. Or so it seemed.

Then, in December 1976, Commodore International leaked information to *Electronic Engineering Times* about a new product. Commodore, the story went, was ready to release a machine very much like the Sol, but at a lower price and backed by all of Commodore’s marketing muscle. Proc Tech was just shipping the first Sols, and Marsh was thinking about the company’s next product, a new version of the Sol with an integrated keyboard and 64K of memory that would be sold for a cheap $1,000. Unfortunately, it was, in essence, the same as the Commodore machine.

Convinced that Commodore actually had its computer product on the launch pad and that Proc Tech could never compete with it, and worried by the news that National Semiconductor was also planning a microcomputer, Marsh scrapped the new-and-improved Sol project. Five years earlier, the rules of battle in the calculator wars demanded that companies cut prices to the baseline and push the technology relentlessly, even under threat of corporate extinction. Marsh and Ingram had no illusions about being able to compete with Commodore and National in bloody mortal combat. As it turned out, the Commodore machine would not appear for some time, and the National Semiconductor computer never materialized.

Parasitic Engineering

Despite their worries about the big boys, hobbyist-entrepreneurs kept right on launching companies. Many of these new hobbyist-born companies were starting to manufacture microcomputers, but most of them were turning out boards for the Altair or IMSAI, and practically all were small start-up companies like Proc Tech.

Howard Fulmer began such a firm in his Oakland basement. After reading an editorial by Ed Roberts in David Bunnell's *Computer Notes* that attacked the Altair-compatible memory-board companies as "parasites," he considered calling his own company Symbiotic Engineering to emphasize his conception of the proper relationship between MITS's products and his own. But a group called the Symbionese Liberation Army was making a name for itself right about then, and he wanted to avoid confusion with the radical political group. Instead, he called his company Parasitic Engineering, sending a rather pointed message to Roberts.

Meanwhile, Marsh was wondering if Proc Tech shouldn't do a Z80 machine as well. But it seemed irrational to dump a successful design in order to achieve a marginal improvement in performance. The Sol was a hit, and he believed the processor mattered much less than the software. The software made the computer work, and that would distinguish one machine from another. It was the software that really mattered.

And that led to the idea that programs—games, business applications, or anything, really—written specifically for the Sol might help sell the machines. But rather than simply commission software to be written for the Sol, Marsh did something subtler: he commissioned the tools to make it easier to write software for the machine. After all, most of Proc Tech's customers were engineers who could write their own software.

Proc Tech called on two programmers, Jerry Kirk and Paul Greenfield of MicroTech in Sunnyvale, who had produced high-level language compilers for minicomputers. They were asked to create a set of programmer's tools: programs that would make it easier to write, edit, and debug other programs on the Sol. Ingram developed their work into Software Package One, which made the Sol the easiest machine to program, giving it a huge advantage.

Questioning the Culture of Sharing

But software ownership was becoming an inflammatory issue in Silicon Valley and elsewhere. Processor Tech was aggressively pro-sharing, and its hobbyist founders swapped program tapes at Homebrew meetings along with everyone else. Gordon French, who after helping to start Homebrew became Proc Tech's general factotum (his official title), argued for an open system—that is, free dissemination of software code and internal workings to anyone. He wanted outside programmers and peripheral manufacturers to be able to create compatible products and expand the market.

At the same time, Ed Roberts and the entire mainframe and minicomputer industry held the opposite view, that software should be proprietary. But the hobbyists were bringing their own values to bear in the industry. Most favored openness in hardware and software design. An open architecture—the publicly known, physical design of a machine—was one emerging ideal. An open operating system was another.

At Proc Tech, however, the idea of an open operating system was frowned upon. Marsh and Ingram wanted that particular component to be proprietary. In fact, Proc Tech had its own disk operating system very early on. The company bought PT-DOS from its author, 19-year-old Bill Levy, who developed it at the Lawrence Hall of Science at UC Berkeley. Levy modeled PT-DOS after Unix, a mainframe/minicomputer operating system in use at UC Berkeley. Marsh thought PT-DOS, with its rich set of tools, was much better than the CP/M disk operating system, which did only the bare minimum of what an operating system should do. Unfortunately, PT-DOS was slow to reach the market because of what came to be called "the drive fiasco."

Incompatible Formats

In 1976, when the Sol was released, disk drives posed an alluring challenge. Although they were heavily used on mainframes and minicomputers, mounting disk drives on microcomputers was prohibitively expensive. Drives typically cost $3,500 or more. So Marsh was intrigued when George Comstock, Bob Mullen's partner at Diablo Systems, announced at a Homebrew meeting one night that he wanted to develop a disk drive for microcomputers. Comstock thought that a drive, complete with a controller board and software, could be sold for around $1,000.

But Diablo was not yet involved in the growing microcomputer industry, and Comstock felt that close consultation with microcomputer companies was crucial. He proposed a joint effort to Marsh. Diablo would develop the drives, the physical mechanisms that read and write information from and to disks, and Processor Technology would write the software and develop an S-100 board to control the drives. He also proposed that Proc Tech could market the board on its own.

Disk drives were so clearly destined to be a part of any serious microcomputer system that engineers were already vying to develop a low-cost disk-drive system with software and a controller board. Shugart's 1 1/4" disk drives seemed attractive, but they had one drawback. IBM had been using 8" disk drives and had established certain standards for the devices. No standards existed for small disk drives, and no one could guarantee that disks written on one brand of machine would be readable on another.

North Star, Grant and Greenberg's company that had shared garage space with Proc Tech and Lee Felsenstein, had selected the Shugart disk drive and sold it for under $800. Using an idea borrowed from Eugene Fisher of Lawrence Livermore Labs, both George Morrow and San

Francisco engineer Ben Cooper had begun developing relatively low-cost 8" disk drives. Cooper had perhaps the first commercial 8" disk-drive controller for microcomputers. Morrow, shortly thereafter, had the first one available for the $1,000 price Comstock was aiming for. He then negotiated with Digital Research and Microsoft for an operating system (CP/M) and BASIC to distribute free with the disk-drive system. Both Morrow and Cooper continued to develop disk products, and Cooper created the first hard-disk controller for microcomputers.

Disk storage, including hard-disk storage, was coming to microcomputers, a big step in making them truly useful, but as yet there was no standard for disk storage systems.

Meanwhile at Processor Tech, the disk-drive plans were crumbling. Diablo encountered trouble with the drives and dropped the project, leaving Proc Tech so far into development of the disk-drive controller that it had to continue with the work. Marsh and Ingram raised the price of Proc Tech's disk-drive subsystem for the Sol to $1,700, substituting for the inexpensive Diablo disk drive the more expensive one offered by Persci. The price was too high, and worse, Proc Tech's disk-drive systems didn't always work. Customers could find better deals from Cooper, Morrow, and North Star.

A Room with a View

Despite such problems, Proc Tech still seemed to be thriving. The executives were recycling their profits into the company. (Lee Felsenstein was investing his in the Community Memory project.) The Proc Tech staff in Emeryville now numbered 85, not counting nonemployee/consultant Felsenstein, and the company's headquarters was growing crowded. Proc Tech moved south to the bedroom community of Pleasanton. The new offices boasted a spacious executive suite with large windows looking out over the valley.

But the competition was heavy. As 1977 came to an end, Proc Tech found itself part of a more seriously run industry. The open trading of information, the shirt-sleeve management, the flashes of idealism, and the lack of detailed planning that had characterized the industry from the start still existed. But there was a growing belief that professional management might have its advantages. Still, scarcely anyone outside of IMSAI considered it the time to put such a radical idea into practice. The chief users, designers, and company presidents were still hobbyists at heart, and most of the world knew nothing of the revolution that was afoot.

New companies were sprouting like mushrooms overnight. Among the computer and computer-related companies in business at the end of 1977 were Apple Computer (which some insiders thought had great promise), Exidy, IMSAI, Digital Microsystems, Alpha Micro Systems, Commodore, Midwest Scientific, GNAT, Southwest Technical Products, MITS, Technical Design Labs, Vector Graphic, Ithaca Audio, Heathkit, Cromemco, MOS Technology, RCA, TEI, Ohio Scientific, The Digital Group, Micromation, PolyMorphic Systems, Parasitic Engineering, Godbout Engineering, Radio Shack, Dynabyte, North Star, Morrow's Microstuf, and, of course, Processor Technology.

The Homebrew influence was still strong. Many of these companies were located in the Bay Area and were associated with the Homebrew Computer Club. The club had grown large and by 1977 tended to assemble in fairly predictable clusters. Up front, performing for everyone, was Lee Felsenstein. Bob Marsh and the Proc Tech group usually assembled along one wall. Steve Wozniak and his protégés and the other 6502 processor fans sat in the back. Jim Warren of *Dr. Dobb's Journal* sat on the aisle three seats from the back, stage left, ready to rise during the Mapping session and do his Core Dump, an extemporaneous outpouring of all the news and rumors he had heard. The front row always had Gordon French, who maintained the software library, and Bob Reiling, who wrote the newsletter.

In December 1977, Reiling wrote, "The development of special-interest groups has probably been the biggest change during the past year. At the beginning of the year, the 6800 group was holding regular meetings. At the end of 1977, the groups include not only the 6800 group, but also the P8 Users, North Star Users Group, Sol Users Society, and PET Users." At that time, the Homebrew attendees (the club did not have members) included key people from Apple, Cromemco, Commodore, Computer Faire, *Dr. Dobb's Journal*, IBEX, Itty-Bitty Machine Company, M&R Enterprises, Mountain Hardware, Mullen Computer Boards, North Star, PCC, Proc Tech, and the Bay Area computer stores. The most prominent of them all was Proc Tech. Marsh had, to some extent, realized his dream. The company seemed golden.

Taking Over the Bus

Most of these companies were producing machines or boards that used the S-100 bus, the interface standard developed at MITS for the Altair, the same bus whose naming rights Roger Melen and Bob Marsh usurped from Ed Roberts on a transcontinental plane flight. The bus was becoming a problem, though, because no matter how disorganized and unprofessional the companies may have been, they couldn't compare to the anarchy that prevailed among companies using the S-100 bus. The bus was the channel over which third-party boards communicated with the 8080 microprocessor in the Altair. Without clear specifications for how the bus worked, all such communication with the brain of the machine was unreliable, to say the least. MITS wasn't eager to publish such specifications for the benefit of "parasitic" board makers.

In late 1977, Bob Stewart called a meeting to do something about the S-100 bus problem. A consultant in optics and electronics and a member of the Institute for Electrical and Electronics Engineers (IEEE), Stewart had bought an Altair and was frustrated with it. He called together some microcomputer-company presidents: Harry Garland of Cromemco, Howard Fulmer of Parasitic Engineering, Ben Cooper of Micromation, and George Morrow of what he then called Thinker Toys. *Byte*'s editor, Carl Helmers, was there, too. The idea was to cure the obvious problems of the S-100 bus and to establish common standards so that one company's board could work with another’s.

Garland explained the virtues of his and Melen’s shielded bus, but Morrow thought he had a better approach. No immediate agreement was forthcoming. Stewart suggested petitioning the IEEE to make the group an official standards body charged with creating an IEEE standard for the bus. The petition won approval, and the group was now official.

Ed Roberts was invited to participate in the microcomputer standards subcommittee, but declined to send a representative or even respond directly. He did say in print that he felt MITS had the sole right to define the bus. The subcommittee ignored him. At first the meetings addressed the group’s contention with Intel, which fought standardization. Morrow got the impression that Intel wanted no standards unless Intel could set them. But when the subcommittee decided to formulate standards whether Intel liked them or not, the chip manufacturer acquiesced.

This was bold. A bunch of hobbyists-turned-entrepreneurs had simply ignored the biggest microcomputer company of that time and had faced down the leading chip manufacturer—and not been struck by lightning.

Despite its solidarity, the subcommittee had no guarantee that it could really create standards. It had 15 assertive, opinionated people disputing an issue about which they held legitimate and conceivably irresolvable differences of opinion. Each of the members had a product that would be incompatible with anything likely to be proposed. As the meetings progressed, Roger Melen came in for Cromemco. Alpha Micro was represented. Elwood Douglas appeared for Proc Tech and judged the standard against the memory board he was designing. George Millard spoke for North Star. Someone arrived from IMSAI to read its formal position, which resembled Ed Roberts’s. The subcommittee ignored that position, too. Most of its members had written off IMSAI as a place where training in *est* mattered more than training in engineering.

At times, whatever fondness the subcommittee members had for each other wasn’t apparent. They argued for hours, with no one yielding an inch. They would then return to their respective companies and discuss how they might compromise on their own designs to achieve a single standard. At each meeting, they would find themselves inching closer to an agreement. Little by little, these creative, independent people subordinated their egos and any short-term economic gains for the good of the entire microcomputer field.

The committee was trying a form of “guerrilla” design. In mainframes and minicomputers, the bus was always whatever the bus designer said it was. Independent companies were not about to get together to redesign something as complex as a bus. Timing parameters and other features were dictated by the designers. In fact, IBM and DEC worked this way. But the S-100 committee members dug into the Roberts bus, figured out how it worked, and scrapped it in favor of a new, independent bus that was open to all. This was a populist revolt against the tyranny of big business, with MITS, although hardly in the same league as IBM and DEC, held up as a symbol of the Big Company.

The revolution was here.

Homebrew Legacy

> *That's where the source of this industry has been. It hasn't come out of TI, IBM, or Fairchild. It's come from people who are on the edge, who have an alternative vision.*
>
> –Fred Moore, founder of the Homebrew Computer Club

In 1979, Proc Tech was in deep trouble. Marsh and Ingram, caught off balance by the Commodore and National Semiconductor threats and worried about competition from the promising Apple Computer, had become uncertain about where to go with their product line. Their worries clearly showed. Felsenstein made frequent visits to their offices to talk about new products, but Marsh and Ingram seemed unable to decide on any. At last Felsenstein asked, "Look, what the hell do you guys want?" They replied that they wanted to see what Felsenstein could come up with. He finally understood that they really had no product planning.

Proc Tech also lacked the flexibility that more money would have provided the company, but Marsh and Ingram (being the green executives that they were) suffered, like Bill Millard, from "entrepreneur's disease." Adam Osborne had talked with them about accepting investments, but by now the investors were the ones who were reluctant to talk. Proc Tech was not developing any new products, and the Sol was an aging 8080 machine in a bold new world of computers built around the Z80.

Was the Sol out of date? Not really. But because technology was developing rapidly and Proc Tech had nothing new in the works, it was hard to see a future for the company. When potential investors asked Felsenstein how much work the Sol needed to keep it technologically advanced, he told the truth: quite a bit. That didn't help.

On May 14, 1979, the wolf came to the Pleasanton factory door and found nobody home. The Proc Tech principals had cashed in their chips and gone on to other ventures.

Theories abounded as to why Processor Technology failed: too many revisions of the basic product, too much reliance on one product, failure to develop new products, and failure to keep abreast of new technology. Steve Dompier held that the company looked inward too much and tried to deal with all its problems as though they were simply organizational ones. Proc Tech did shuffle people around, however. According to one story, the company had hired a full-time employee merely to relocate phones in the Pleasanton plant.

Felsenstein has always contended that Proc Tech's boat sank because it was full of small holes and management tended to puncture even more holes in the vessel. Or maybe it was Gary Ingram's desk.

When Proc Tech held its bankruptcy auction, Parasitic Engineering founder Howard Fulmer drove to Pleasanton to check out the defunct enterprise. He walked through the building and passed small, slapped-together cubicles, a sign of a company on the skids. On the top floor of the building, Fulmer found what could only be called the penthouse suite. He'd never been there before and was impressed. There, in the middle of a huge room with large windows, stood Gary Ingram's fine French Provincial desk. Fulmer glanced over his shoulder to check that he was alone in the room, then went over to the desk and sat down behind it. Nice chair, he thought. He settled back, put his feet up on the beautiful desk, looked out across the valley, and sighed contentedly. "I feel rich," he murmured. "Everything must be fine."

Despite its ultimate failure as a company, Proc Tech and companies like it—ones that operated in ways that baffled seasoned executives—were constructing the microcomputer industry. Soon that industry was shifting its orientation from the hobbyist to the consumer. Market niches were being established. By 1979, Cromemco was known for its square steel boxes full of solidly engineered boards that were sold primarily to engineers and scientists. Vector Graphic was selling business machines that started with the turn of a key and immediately ran a business application program. Apple's computer, in its plastic case, was the premier game machine. And encroaching on the territory of the minicomputers was Alpha Microsystems, offering microcomputer systems that could support several users simultaneously.

Over the years to come, the Homebrew legacy continued to influence product designs and marketing principles. Homebrew was both a catalyst in the creation of the microcomputer and an active entity that fed its continued development. But because computers were becoming affordable to large numbers of people, another kind of creative effort was needed to make the hardware useful to the average person. Computer power to the people, the dream of computer revolutionaries like Felsenstein, required software. User-friendly, powerful, and affordable programs and the means for producing them were essential to turn the microcomputer into the personal computer.

The newborn microcomputer industry now needed a software industry. But already differences of opinion were emerging that would shape that industry—such as the question of whether the code should be shared or proprietary.

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Chapter 5

The Genie in the Box

> *I think that most people's real motivation for getting a computer was to learn —they wanted to see what they could do with it.*
>
> *Dan Fylstra, publisher of VisiCalc*

As the buyers of the first Altair computers found out, these new *personal computers* were nothing without software. Even then, it wasn't clear how much they could do or what the programmers would be inspired to make them do. Within a few years there would be a multibillion-dollar market for personal-computer software, but in the 1970s it wasn't immediately obvious that anyone could make money writing programs for these toys.

The Altair’s First Recital

There was nothing he could have said to prepare us for what happened.

–Lee Felsenstein, on Steve Dompier’s Homebrew demo

On the evening of April 16, 1975, during a Homebrew Computer Club meeting, Steve Dompier put on a show to remember. But Dompier was no showman. A slender, quick-moving young man with straight hair down to the middle of his back, he wore jeans and a nondescript sport shirt and “spoke quickly in a young person’s idiom,” Lee Felsenstein remembers, “filling in with ‘stuff’ when he saw no need to be more precise.”

But Dompier had in his possession an actual Altair. Few of the people there had seen one. Because MITS wasn’t delivering Altairs yet, Dompier had to earn his by flying to Albuquerque to pick it up in person. It may have seemed fanatical to travel a thousand miles to get what amounted to a $397 toy, but Dompier made it seem reasonable. This was an actual computer, he told the Homebrewers. It was real and it was here now. And all of them could buy it.

Buy their own computers? they thought. It used to be that only a rare few had the means to own one. Computers were controlled by a priesthood of technicians in white coats, who mediated between the machines and ordinary mortals. The technofreaks in the audience that night got caught up in Dompier’s excitement and began to imagine what they could do if they had computers of their own—or rather, what they would do *when* they had them.

What Dompier showed them that night made them understand how revolutionary that idea was.

Playing the Fool

Lee Felsenstein remembers, “He arrived carrying his Altair and other ‘stuff’ and crouched to set it up in a corner near the door. He unrolled an extension cord out into the hallway where one of the few live electrical outlets could be found, and then hunched over the Altair to enter [his] program through the front panel switches, deflecting all questions with, ‘Wait, you’ll see.’”

The Homebrewers were interested in the machine, but hardly expected it to do much of anything given that it had no display, no keyboard, and only a teaspoonful of memory. But some of them suspected that Dompier would come up with something interesting. He was a likable, down-to-earth fellow around whom the computer universe crackled. Lee Felsenstein was curious to see what Dompier could do with the Altair. If some people are accident-prone, Dompier was serendipity-prone, Felsenstein thought.

He wasn’t accident-immune, apparently. It took several minutes of painstaking switch-flipping for Dompier to enter his program. He knew if he made one mistake, it would all have to be done over. Then, just as he finished, someone tripped over the power cord and erased all his work. He plugged the machine back in and started all over, patiently reentering his program. Finally, he finished it—again.

He straightened up and made a brief announcement to the crowd—little more than an elaboration on “Wait, you’ll see.” “There was nothing he could have said to prepare us for what happened,” Felsenstein recalls. “Noise—sound—music began emitting from the speaker of the portable radio he had placed on the Altair’s cover. We immediately recognized the melody of the Beatles’ ‘The Fool on the Hill.’”

Dompier didn’t wait for applause. “Wait, there’s more,” he told the crowd. “It just started doing this itself.”

And then the tones of “Daisy Bell (A Bicycle Built for Two)” came from the speaker. "We were thrilled,” Felsenstein recalls, “to hear what many of us recognized as the first song ever ‘sung’ by a computer—in 1960, at Bell Labs—coming from this completely amateur setup.”

The music stopped and the applause began. The crowd gave Dompier a standing ovation.

Technically, what Dompier had done was just a clever but not entirely unfamiliar trick. He had exploited a characteristic of small computers that would end up annoying the neighbors of their owners for the next five years. The machines emitted radio-frequency interference, the stuff that makes snow in television pictures and static in radio transmissions. When Dompier realized that the Altair made his radio buzz, he decided to play around with the static. He figured out what he had to do with his program to control the frequency and duration of the noise.

Dompier’s little “radio interface” program, which on paper would have looked nonsensical to any programmer who didn’t know about its accidental side effects, turned the static into recognizable music. Dompier described his accomplishment a year later in an article entitled “Music of a Sort” in *Dr. Dobb’s Journal,* calling the event “the Altair’s first recital.”

Program It Yourself

But the Homebrewers understood the revolutionary implications of Dompier’s act. He understood, too, that by claiming this machine for such a trivial, thoroughly unprofessional use, he was planting a flag on newly conquered ground. *This thing belongs to us,* he was saying, and it was this act of rebellion against the spirit of the computer priesthood, more than his technical prowess, that the Homebrewers applauded that night.

Dompier’s program was short and simple. The machine did not have the memory for useful programs. At the time, hobbyists were more interested in hardware than software. After all, many of them had dreamed of owning a computer for some time, and they couldn’t start programming a machine that did not exist. But with the advent of the Altair, software became not only feasible but essential.

Those early computer enthusiasts had no choice but to write their own software. No one imagined then that anyone would actually buy software from someone else. Hobbyists wrote small programs that were little more than demonstrations of the machine's potential.

Before the microcomputer could begin to change the world, software was needed in order to transform a plaything into a useful tool. A few pioneers worked within the tight memory constraints of the first machines and were still able to create some ingenious programs. As more memory became available, it became possible to write more complex and useful programs. The first of the more complicated programs tended to be frivolous, but soon serious applications and business and accounting software followed.

Programming, which started out as an activity for hobbyists, quickly became an earnest commercial enterprise. The two kinds of programs the new machines would need very quickly if they were going to be truly useful were operating systems and high-level languages. The collection of programs that controls input/output (I/O) devices, such as disk drives, and that shunts information into and out of memory and performs all the other operations that the computer user wants done automatically, is called an operating system. In practice, users typically work with a computer via an operating system. Large mainframe computers had operating systems, and it was clear to many people that microcomputers needed them, too.

Every computer also has what's called a machine language, the set of commands the machine is made to recognize. These commands trigger the machine's basic operations, such as moving data between its internal storage registers, storing data in memory, or performing simple arithmetic on data. A computer becomes widely useful only when it is possible to trigger whole groups of these fundamental operations with a single command. Collections of these more powerful and meaningful commands are embodied in high-level languages. The intricacies of machine language make it a cumbersome and complex language to use. High-level languages enable a computer user to progress beyond having to plod through the minutiae of machine language, thereby making a computer faster and producing more interesting results.

Beyond the programmer's tools lay the application programs, the software that makes a computer actually accomplish something. But this was 1976; operating systems and high-level languages weren't yet available, and application software was even further off. Yet to come were the word-processing programs that would turn a computer into a replacement for the typewriter, accounting programs that would keep track of payroll records and print checks, and educational programs that would introduce computer users to new ways of learning. The hobbyists of the day looked at their new machines and asked themselves what they could do with them.

Play games, they answered.

Pleasure Before Business

Man is a game-playing animal, and a computer is another way to play games.

–Scott Adams, computer-game software pioneer

Long before high-level languages and operating systems simplified programming, computer enthusiasts created games. They drew their inspiration mostly from the arcade games that were then becoming popular. The early microcomputer games were often just simpler versions of Missile Command, Asteroid, and others.

Early PC Games

Games provided the early hobbyists justification for having a computer. When friends questioned the utility of having such a machine, these hobbyists could show off a clever game, perhaps Steve Dompier's Target or Peter Jennings's Microchess, and listen to the oohs and aahs.

Dompier was among the most creative when it came to programming games on the Altair. With no I/O except the front-panel switches, it was a challenge to make the Altair do anything. A number of people, Dompier included, wrote variations on the popular Simon electronic game, in which the player chased the 16 blinking lights up and down the front panel, attempting to press the corresponding buttons to make the lights flash on and off "real pretty."

Creating games also provided a way to learn how to program. As soon as they got their hands on Gates and Allen's BASIC, they had the essential tool needed to create simple games. Several books were soon available that listed the programs for loads of different games. An Altair, KIM-1, IMSAI, or Sol owner could type in the program and start playing the game in no time. The first such book was David Ahl's *101 BASIC Computer Games,* compiled while Ahl was still at DEC and originally intended for use on minicomputers. Often displaying nothing more graphically sophisticated than patterns of asterisks printed out on a Teletype machine, the early games were primitive compared to today's interactive, multimedia extravaganzas.

Many of the first games jumped over to microcomputers from minicomputers and mainframes. (It can be argued that the earliest ancestor of modern computer games, with all their flashy graphics, was a simple tennis-like game played on an oscilloscope.) Games were nothing new to the early hobbyists who had played them on the big computer systems at their jobs, sometimes even loading games into memory on large time-sharing systems. Of course, if they were caught playing, they faced trouble, but the temptation was too much to resist.

One of the most popular games for large machines was Star Trek, which allowed the player to pretend to be Captain Kirk and command the *Enterprise* through a series of missions against Klingon warships. Star Trek was an underground phenomenon, hidden in the recesses of a company or university's computer, to be played surreptitiously when the boss wasn't looking. No one paid for copies of the game, and no royalties were ever paid to the writers or creators of the *Star Trek* television show. Scott Adams, an RCA employee working on satellite-recognition programs at Ascension Island in the South Atlantic, recalls playing Star Trek on the satellite radar screens—an act that did not endear him to government officials.

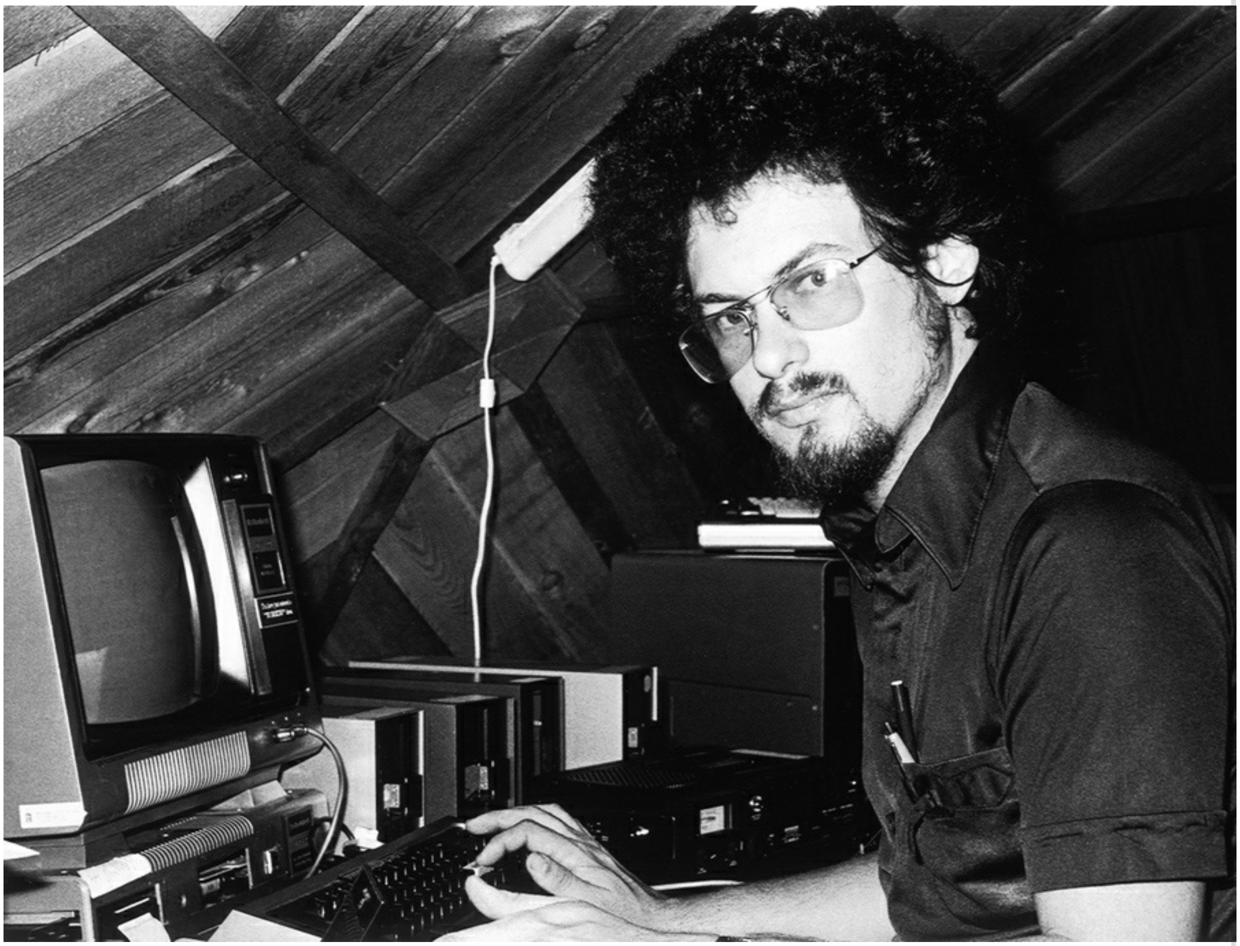

Figure 36. Scott Adams *Adams created some of the first games for personal computers.* (Courtesy of Scott Adams)

Because it was everywhere on larger machines, it was only natural that Star Trek would become one of the first microcomputer games. Many different versions of it already existed, and many more were soon written for microcomputers, including Dompier's Trek for the Sol. When advanced technology made graphics possible on a microcomputer, Star Trek programs added visual simulations of "the final frontier."

By late 1976, having graphics capability in a microcomputer was growing increasingly important. Cromemco, with its Dazzler board, and Processor Technology, with its VDM (Video

Display Module), gave the Altair its first graphics. The VDM, released in 1976, also operated on the IMSAI, Sol, and PolyMorphic computers, and any other machine with an S-100 bus structure.

Frequently, graphics software was designed primarily to test or demonstrate the capabilities of a machine. The kaleidoscopic images and changing patterns of John Horton Conway’s game of Life were popular for that reason. Steve Wozniak’s Breakout and Steve Dompier’s Target were two real games that showcased the computers well. A clever programmer such as Dompier could easily make games to display a computer’s hidden talents. Target, described by its author as a “shoot-down-the-airplane-type game,” became a phenomenon. Employees at Processor Technology regularly played it during lunch, and soon it gained wider exposure.

One evening, Dompier was at home playing Target while occasionally glancing at a color television across the room. Suddenly the television screen lit up with video graphics, and there was his game, blazing away in full color on the set. He jerked his hands off the keyboard in amazement. No physical connection existed between the TV and the computer. Was the computer somehow able to broadcast the game to the TV? Stranger still was that the television screen showed a different stage of the game than what was currently on his terminal, but both screens were certainly displaying Target. Suddenly, the game on the TV screen dissolved into Tom Snyder’s face, and Dompier realized that the talk show host had been playing Target on air, demonstrating the Sol’s capabilities from coast to coast.

Another kind of game was generating a lot of publicity at around that time. It also depended on microelectronics, but it wasn’t played on a computer. A brilliant engineer and entrepreneur named Nolan Bushnell created an electronic game machine that proved to be the successor to pinball machines. He sold it through his start-up company, Atari. That machine, Pong, made Bushnell rich and famous, and eventually spawned millions of arcade and home-video game models. Bushnell sold Atari to Warner Communications in 1976 when Atari was doing $39 million in annual sales. Although the game machines that were Atari’s specialty were not general-purpose computers, the programmers who wrote games for personal computers took much of their inspiration from the Atari devices. (Atari would later make its own personal computers.)

Programs like Dompier’s Target were receiving mass attention and the game machines were enjoying great popularity, but microcomputer programmers in 1976 generally didn’t consider computer software a business, certainly not in the way that computer hardware was a business. At that time, very few programmers sold software to anyone other than a computer company, and in a market that narrow, the software sold cheaply.

Chess

A Toronto chess enthusiast named Peter Jennings (no relation to the TV news anchor) foresaw, earlier than most people involved with microcomputers, that microcomputer owners would gladly buy software from independent companies. Jennings had often toyed with the idea of designing a chess-playing machine. In fact, while still in high school he built a computer that could make the opening moves in a chess match.

After being introduced to microcomputers, Jennings figured he could program a machine to play the ancient board game. Jennings bought a KIM-1 microcomputer with less than 2K of memory at the PC 76 computer show in Atlantic City, brought it home, and boldly declared to his wife, “That’s a computer and I’m going to teach it to play chess.”

Writing a chess program compact enough to take up no more than a few hundred bytes of memory is the sort of challenge most people would just as soon avoid. As intricate as the game of chess is, the task could use up a huge chunk of a mainframe’s memory. Jennings was undeterred: he welcomed the challenge. Within a month he had written most of the code, after a few more months he had perfected it, and before long he was selling his chess program through the mail.

For $10, Jennings sent a stapled 15-page manual that included the source code for Microchess. His notice for it in the *KIM-1 User Notes* newsletter was one of the first advertisements for microcomputer application software. When Chuck Peddle, president of MOS Technology (manufacturer of the KIM-1), offered Jennings $1,000 dollars for all rights to the program, Jennings declined, saying, “I’m going to make a lot more money selling it by myself.”

One day while Jennings waited for the money to roll in, his phone rang and the caller identified himself as Bobby Fischer. The reclusive chess grand master wanted to play a match against Microchess. Jennings knew what the outcome would be, but gladly agreed. Later, after Fischer had trounced the program, he graciously told Jennings that the match had been fun.

The experience was fun for Jennings, too, and lucrative. The orders poured in. Jennings found that people who couldn’t play chess, and who weren’t even interested in learning chess, nevertheless bought the program. With Microchess, computer owners could show their friends that this thing they possessed was powerful and real. It could play chess. In a sense, Microchess legitimized the microcomputer.

One of the first buyers of Microchess was Dan Fylstra, who ordered the program while an associate editor at *Byte* magazine. Later on, after Fylstra started a company called Personal Software, he called on Jennings and the two struck up a partnership. Soon they were investing money from sales of Microchess into the marketing of a business program called VisiCalc, written by Dan Bricklin and Bob Frankston. The pairing of Fylstra and Jennings created one of the most important software companies in the industry. Bricklin and Frankston’s VisiCalc was Personal Software’s biggest hit.


onal Software™
TRS-80
PET
APPLE
PLAY CHESS WITH YOUR COMPUTER!
Commodore
PET
Radio Shack
TRS-80

Figure 37. Personal Software ***In the Personal Software booth at the first West Coast Computer Faire are Peter Jennings (left), creator of Microchess, and Dan Fylstra, who published Microchess and VisiCalc.***
(Courtesy of David H. Ahl)

The transition from games to business software has occurred a number of times in the microcomputer industry. Several early game companies went on to add business-software departments. The games led to profits, and the profits led to business applications.

Adventure

Adventure was another star of the computer-game underground. Originally written by Will Crowther and Don Woods on a mainframe computer at the Massachusetts Institute of Technology, Adventure involved a simple form of role-play: the user explored mazes, fought dragons, and ultimately discovered treasure. The game had no graphics whatsoever. Players would type in terse verb-object commands such as “GET GOLD” or “OPEN DOOR,” and the program would respond by describing whatever was nearby in the imaginary maze.

By storing dictionaries of verbs and nouns and tying them to certain commands, the programmer was able to create the impression that the Adventure program could understand those simple two-word sentences. No one but the programmer knew the program’s vocabulary, and figuring out how to communicate with the program was the best part of the game. Adventure achieved cult status, and San Francisco Bay Area programmer Greg Yob wrote a limited Adventure-type game for microcomputers called Hunt the Wumpus, which was played in a maze of tetrahedral rooms.

By 1978, Scott Adams decided that he could launch a company and sell computer games full time. Well-meaning friends warned him that programming Adventure on a microcomputer was impossible because storing the data for the maze structure and the library of its commands would require an excessive amount of memory. Nevertheless, Adams did the programming in two weeks and started a company, Adventure International. The company became a microcomputer-game empire, and its product attracted huge crowds at computer shows.

Adams became convinced that games like his Adventure Land and Pirate Adventure were serving to introduce computers to the average person. Other software companies also began selling adventure games. Even Bill Gates and Paul Allen at Microsoft, who until then had shown no professional interest in game software, released a version of Adventure. In addition to Star Trek and Adventure, games such as Lunar Lander made the transition from large to small computers.

When customers walked into computer stores in 1979, they saw racks, wall displays, and glass display cases filled with software, and most of it consisted of games. Games with outer-space themes were especially popular—among them Space, Space II, and Star Trek. To this day, games still represent a significant percentage of the software titles released each year.

Many more games were being released, including Programma's emulation of the video game Space Invaders. Software companies such as Muse, Sirius, Brøderbund, and On-Line Systems reaped great profits from games. Programma amassed a huge and diverse supply of software—not a wise policy, as it turned out. Programma sold plenty of programs, mostly games, but not all of them were good, and its reputation suffered. When serious competition arrived, Programma did not survive its reputation for second-rate wares. Nevertheless, many personal-computer programmers got their professional start writing programs for Programma.

Few of those early software companies had the business savvy of the Personal Software people, and fewer still achieved the wide acceptance that Digital Research had earned for its operating system.

The First Operating System

> *CP/M was 5K and it gave you no more and no less than what an operating system should do.*
>
> –Alan Cooper, personal-computer software pioneer

The first operating system to qualify as a standard in the developing microcomputer industry actually appeared before the Altair itself. CP/M was not the result of a carefully planned project involving years of research by dozens of software specialists. Like most of the early significant programs, it originated out of one person's initiative.

Gary Kildall

In mid-1972, Gary Kildall came across an advertisement on a bulletin board that said "MICROCOMPUTER $25." The item advertised, the Intel 4004, was actually a microprocessor, arguably the first in the world, but it still sounded like a real bargain to Kildall. He decided to buy one.

Although many of the microcomputer companies' founders didn't fit the typical image of an industry leader, Gary Kildall didn't even act as if he wanted to be in the game. While wrapping up his PhD at the University of Washington, Kildall had moved to Pacific Grove, California. He loved the scenic coastal town; its laid-back, fog-draped ambiance seemed to suit him. Kildall was soft-spoken, possessed of a disarming wit, and was most at ease in a sport shirt and jeans. He was an incurable diagram drawer. When he wanted to make a point while speaking, he would frequently fish around for chalk or a pencil. In the early 1970s, Kildall was happy in his job at the Naval Postgraduate School. He enjoyed teaching and the job left him time to program. Kildall had no particular business skills and no real desire to leave academia. He was comfortable just where he was.

Gary Kildall also liked to play with computers, and knew a lot about them, in both an academic and a practical, hands-on sense. He had been one of two people responsible for keeping the University of Washington's Burroughs B5500 computer up and running. Later, when the university was acquiring its new CDC 6400 computer, Kildall was so well respected for his knowledge of computers that he served as the technical advisor on the purchase.

The other person responsible for keeping the B5500 running was Dick Hamlet. He and three others started a time-sharing company in Seattle that used DEC's PDP-10 computer and some new DEC software. The idea was to allow people to log onto the PDP-10 remotely in order to tap its capabilities. Hamlet's company was called Computer Center Corporation, or C Cubed, and for a time two teenagers named Bill Gates and Paul Allen worked there after hours searching for bugs in the DEC software.

It turned out that the $25 price on the Intel 4004 applied only to volume purchasers, and besides, a microprocessor was useless by itself; it needed to be incorporated into a computer. Kildall did buy the manual for the Intel 4004, wrote a program on the school's mainframe to simulate the 4004, and began to write and test 4004 code to determine what he might eventually do with the "bargain basement" 4004 chip.

Kildall recalled that his father, who owned a navigation school in Seattle, had always wanted a machine that could compute navigational triangles. Kildall wrote some arithmetic programs to run on the 4004, offhandedly thinking that he might come up with something his father could use. He was just fooling around with the 4004, trying to see how far he could go and with what degree of speed and accuracy. He determined that the processor was pretty limited, but he still loved working with it. Soon thereafter, he traded some 4004 programs to Intel for a development system, a small computer built around the 4004, which was in effect one of the first true microcomputers, albeit not a commercial product.

Hooked on Micros

When Kildall visited the microcomputer division at Intel in 1972, he was surprised to see that the pioneering firm had set aside a space no larger than the average kitchen for the entire division. One of the people he met there was a clever programmer named Tom Pittman, a nonemployee who, like Kildall, had been intrigued by the 4004 and was already writing software for it. Kildall and Pittman got along well with the Intel people, and Kildall began working as a consultant for Intel on his one free day a week. In this new role, he tinkered with the 4004 for a few more months until he "nearly went crazy with it." He then realized that he would never go back to working on large computers.

Soon Kildall was dabbling with Intel's first 8-bit microprocessor, the 8008. He was working in the same two-level mode—that is, developing the software for a microprocessor on a minicomputer—that Gates and Allen used. Like Paul Allen, Kildall wrote programs to simulate the microprocessor on a larger machine and then used the simulated microprocessor with its simulated instruction set to write programs to run on the microcomputer. But unlike Gates and Allen, Kildall had the benefit of a development system so that he could check his work as he went along by trying it out on the system.

CP/M

In just a few months, Kildall created a language called PL/M, inspired by a mainframe language called PL/I that was significantly more elaborate than BASIC. Kildall set up the development system in the back of his classroom, in effect creating the Naval Postgraduate School's first microcomputer lab. Curious students would wander back there after class and tinker with the system for hours. When Intel upgraded the Intellec-8 from an 8008 processor to an 8080 and supplied Kildall with a display monitor and high-speed paper-tape reader, the professor and his students had a system comparable to the early Altair before the Altair was even conceived.

Kildall realized, however, that he was still missing an essential ingredient of a successful computer system—an efficient storage device. Two common storage devices on large computers at the time were paper-tape readers and magnetic disk drives. Considering how slow the microprocessor was, paper-tape storage was simply too cumbersome and expensive. Kildall set out to obtain a disk drive and did a little programming in exchange for a drive from Shugart. There was a catch: in order for the disk drive to work, a special controller was needed—a circuit board to handle the complicated task of making the computer communicate with the disk drive.

Kildall attempted to design such a controller several times. He also tried to create an interface that would allow his system to connect to a cassette recorder. But he found that he needed more than just programming talent to solve the complex engineering problem of interfacing the two machines. The project failed, and Kildall decided he was totally inept at building hardware. Nevertheless, he had demonstrated a lot of vision. It would be years before disk drives came into common use on microcomputers. Finally, at the end of 1973, Kildall approached John Torode, a friend of his from the University of Washington who would later found his own microcomputer company. “We’ve got a really good thing going here if we can just get this drive working,” Kildall told his friend. Torode got the drive to work.

Meanwhile, Kildall polished the software. At one point in late 1973, during his months of frustration with the disk drive, Kildall had taken a few weeks to write a simple operating system in his PL/M language. He called it CP/M, short for Control Program for Microcomputers. CP/M underwent further development, although it already provided the software needed for storing information on disks.

Some of CP/M’s enhancements arose under curious conditions. While he continued teaching, Kildall became involved in a project with Ben Cooper, the hardware designer in San Francisco who had worked with George Morrow on disk systems and had later started his own computer company, Micromation. Cooper thought that he could build a commercially successful machine to chart horoscopes, and he enlisted Kildall’s help in the project. The two had no interest or belief in astrology, and in fact considered it patent nonsense, but Cooper had ideas about the hardware and Kildall wanted to do the math that calculated star positions. They also figured that the result might be a commercial success. So Cooper built and Kildall programmed, and they came up with their “astrology machine,” which would stand in grocery stores eating quarters like an arcade game and printing out horoscopes. Kildall thought the machine was just beautiful.

Commercially, however, the astrology machine was a failure. Its makers placed machines in various locations around San Francisco, but the fancy knobs and dials that excited the two hobbyists irritated users—and with good reason. Customers would drop their quarters in and the paper would jam up. Kildall and Cooper were stumped on how to fix the problem. “It was a total bust,” Kildall later said.

Despite the disappointing results, the astrology machine gave Kildall his first commercial test of portions of his CP/M. In the process of programming the astrology machine, he rewrote the debugger and the assembler, two tools for creating software, and began work on the editor. These constituted the essential tools for developing programs. In addition, he created a BASIC interpreter that allowed him to write programs for the astrology machine. Some of the tricks he learned in developing the BASIC he would later pass on to his pupil, Gordon Eubanks.

As they worked on interfacing the disk drive, Kildall and Torode exchanged their views about the potential applications of microprocessors without saying much about microcomputers. They continued to believe, along with the designers at Intel, that the microprocessor would wind up in things like kitchen blenders and automotive carburetors. They thought of providing a combined hardware- and software-development system to encourage alternative uses of microprocessors. Kildall's belief in the future of such "embedded applications" of microprocessors was undoubtedly fostered by his colleagues at Intel. At one point, Kildall and a few other programmers had written a simple game program using the 4004 microprocessor. When they approached Intel chief Robert Noyce with the suggestion that he market the game, Noyce vetoed it. He was convinced that the future of the microprocessor lay elsewhere. "It's in watches," he told them.

Digital Research

So Torode and Kildall, without forming an actual company, sold their hardware and software together—not as a microcomputer, but as a development system. And when Kildall, encouraged by his wife Dorothy, finally incorporated and began to offer CP/M for sale, he had no idea how valuable a program he had written. But how could he know? There were few microcomputer-software developers around.

At first, the Kildalls called their company Intergalactic Digital Research. The name was quickly shortened to Digital Research, and Dorothy, who was by this time running the company, began using her maiden name McEwen because she didn't want customers thinking of her as "just Gary's wife." Digital Research's earliest customers grabbed some stunning bargains. For instance, Thomas Lafleur, who helped found an early microcomputer company called GNAT Computers, made one of the first corporate purchases of CP/M. For $90 he gained the right to use CP/M as the operating system for any product his company developed. Within a year, a license for CP/M cost tens of thousands of dollars.

Figure 38. Digital Research Staff ***Tom Rolander (front row), Dorothy McEwen, and Gary Kildall (both in front of the sign) pose with the rest of the Digital Research staff in front of their Pacific Grove, CA, headquarters.*** **(Courtesy of Tom G. O'Neal)**

Dorothy later said that a 1977 contract with IMSAI was a turning point. Until then, IMSAI had been purchasing CP/M on a single-copy basis. Its ambitious plans to sell thousands of floppy-disk microcomputer systems prompted marketing director Seymour Rubinstein to negotiate seriously with Gary and Dorothy. He finally purchased CP/M for $25,000.

Rubinstein was convinced that he had virtually stolen the CP/M operating system from Gary, but the Kildalls' perspective was somewhat different; the IMSAI deal made Digital Research a full-time business. After IMSAI bought CP/M, many other firms followed suit. CP/M was such a useful program that it was not until IBM introduced a microcomputer with a different operating system in 1982 that Digital Research faced any serious competition. The programmers who would provide that competition were still working at MITS in Albuquerque.

Getting Down to BASIC

> *If anyone had run over Bill Gates, the microcomputer industry would have been set back a couple of years.*
>
> –Dick Heiser, early computer retailer

While it’s true that the microprocessors and the crude microcomputers built by hobbyists/entrepreneurs gave computing power to the people, it was the BASIC programming language that let them harness that power. Two professors at Dartmouth College, seeking a better way of introducing their students to computers, used their grant from the National Science Foundation to give birth to BASIC in 1964. The language John Kemeney and Thomas Kurtz created was an instant success. Compared with the slow, laborious, and complex process of programming in FORTRAN, the comparable computer language in common use at the time, BASIC was a winged delight.

During the following two years, the National Council of Teachers of Mathematics debated over whether to support FORTRAN or BASIC as the standard educational language. FORTRAN, widely used in scientific computing, was considered better for large computational tasks; however, BASIC was far easier to learn.

Think of the Children

Bob Albrecht was a prominent supporter of BASIC. As a pioneer of computer education for children, he had been frustrated with FORTRAN. The council’s ultimate selection of BASIC was a watershed. The personal computer and the BASIC language would be the two most important products in the effort to convince educators that computers could help students learn. Bob Albrecht wanted to create software for reasons other than personal ambition. Always interested in turning kids on to computers, when the Altair came out, Albrecht asked himself, “Wouldn’t it be nice to have something called Tiny BASIC that resided in 2K and was suitable for kids?” Such a program would fit within the Altair’s limited 4K memory and could be used immediately.

Albrecht pestered his friend, computer-science professor Dennis Allison, to develop Tiny BASIC. Reports of progress on the program appeared in the *People’s Computer Company* (*PCC*) newsletter and its offshoot, *Dr. Dobb’s Journal*. “The Tiny BASIC project at PCC represents our attempt to give the hobbyist a more human-oriented language or notation with which to encode his programs,” wrote Allison. In an early issue of *PCC*, Allison “& Others” (as the cryptic byline read) explained their goal:

> Pretend you are seven years old and don’t care much about floating-point arithmetic (what’s that?), logarithms, sines, matrix inversion, nuclear-reactor calculations, and stuff like that. And your home computer is kind of small, not too much memory. Maybe it’s a Mark-8 or

an Altair 8800 with less than 4K bytes and a TV Typewriter for input and output.

You would like to use it for homework, math recreations, and games like NUMBER, STARS, TRAP, HURKLE, SNARK, BAGELS. Consider, then, Tiny BASIC.

"It's Going to Happen!"

Many of *Dr. Dobb's* and *PCC*'s readers did more than consider Tiny BASIC. They took Allison's program as a starting point and modified it, often creating a more capable language. Some of those early Tiny BASICs allowed large numbers of programmers to start using the microcomputers. Two of the most successful versions came from Tom Pittman and Li-Chen Wang. Pittman knew microprocessors as well as anyone, including the engineers at Intel, because he had written one of the first programs for the 4004. He and Wang were "successful" in terms of the stated goal for Tiny BASIC—to give users a simpler language. The Tiny BASIC authors were not trying to use it as a path to wealth. Another, more ambitious BASIC was also in the works. In the fall of 1974, Bill Gates had left Washington for Harvard University. Gates's parents had always wanted him to go to law school, and now they felt finally he was on the right track.

Figure 39. Paul Allen and Bill Gates ***Allen (left) and Gates founded Microsoft.*** **(Courtesy of Microsoft)**

But as precocious as he may have been, Gates found himself rooming with a math student who was even sharper than he was, and Gates was shocked when his roommate told him he had no intention of majoring in math but planned to study law. Gates thought, “If this guy’s not going to major in math, I’m sure not.” Examining his options, he immersed himself in psychology courses, graduate courses in physics and math, and long, extracurricular nightly poker games.

Then came that fateful January 1975 issue of *Popular Electronics* that Paul Allen would spot in Harvard Square and wave in front of Gates’s face.

“Look, it’s going to happen!” Allen shouted. “I told you this was going to happen! And we’re going to miss it!” Gates had to admit that his friend was right; it sure looked as though the “something” they had been looking for had found them.

Gates phoned MITS immediately, claiming that he and his partner had a BASIC language usable on the Altair. When Ed Roberts, who had heard a lot of such promises, asked Gates when he could come to Albuquerque to demonstrate his BASIC, Gates looked at his childhood friend, took a deep breath, and said, “Oh, in two or three weeks.” Gates put down the phone, turned to Paul Allen, and said, “I guess we should go buy a manual.” They went straight to an electronics shop and purchased Adam Osborne’s manual on the 8080.

For the next few weeks, Gates and Allen worked day and night on the BASIC. As they wrote the program, they tried to determine the minimal features of an acceptable BASIC—the same challenge Albrecht and Allison faced except that Tiny BASIC was to be usable on a variety of machines. Gates and Allen didn’t have this restriction. They were free to make their BASIC whatever they wanted. No industry standard existed for BASIC or for any other software, mostly because there was no industry. By deciding themselves what the BASIC required, Gates and Allen set a pattern for future software development that lasted for about six years. Instead of researching the market, the programmers simply decided, at the outset, what features to put in their software.

Both men threw themselves completely into the project, staying up late every night doing programming. Gates even made the ultimate sacrifice and abandoned some of his nightly poker games. They sometimes worked half-asleep. Paul Allen once observed Gates nod off, head on the keys, wake up suddenly, glance at the screen, and immediately begin typing. Allen decided that his friend must have been programming in his sleep and just kept right on when he woke up.

The two slept at their terminals and talked BASIC between bites of food. One day while in the dining hall at Gates’s Harvard dorm, they were discussing some mathematics routines—subprograms to handle noninteger numbers that they felt their BASIC needed. These floating-point routines were not especially difficult to write, but they weren’t very interesting either. Gates said he didn’t want to write them; neither did Allen. From the other end of the table a voice called out hesitantly, “I’ve written some floating-point routines.” Both of their heads turned in the direction of the strange voice, and that was how Marty Davidoff joined their programming team over lunch in the college cafeteria.

At no time during the project did Gates, Allen, or Davidoff ever see an Altair computer. They wrote their BASIC on a large computer, testing it with a program Allen had written that made the large machine simulate the Altair. At one point when Gates phoned Ed Roberts to ask how the Altair processed characters typed on a keyboard, Roberts must have been surprised that they were actually pursuing the project. He turned the call over to his circuit-board specialist, Bill Yates, who told Gates that he was the first to ask this obviously essential question. “Maybe you guys really have something,” he told Gates.

After six weeks, Paul Allen booked a plane reservation to Albuquerque as he and Gates scrambled to finish up the BASIC. On the night before Allen was scheduled to catch a 6 A.M. flight for Albuquerque, they were still working. At about 1 A.M., Gates told his friend to get a few hours of sleep, and when he awoke, the paper tape with the BASIC would be ready. Allen took him up on the offer, and when he did wake up, Gates handed him the tape and said, “Who knows if it works? Good luck.” Allen crossed his fingers and left for the airport.

Delivering the Code

Allen was sure of his and Gates’s abilities, but as the plane approached Albuquerque he began wondering if they had forgotten something. Halfway into the landing he realized what it was: they had not written a loader program to read the BASIC off the paper tape. Without that program, Allen couldn’t get their BASIC into the Altair. It had never been a problem on their simulated Altair—the simulation had not been that exact. Allen searched for some scrap paper, and as the plane descended, began writing in 8080 machine language. By the time the plane touched down, he had managed to scribble down a loader program. Now when he wasn’t worrying about the BASIC, he could fret about this impromptu loader program.

Not that Allen had much of a chance to worry about anything. Roberts was right there at the appointed time to meet him. Allen was surprised at Ed Roberts’s informality and by the fact he drove a pickup truck. He had expected someone in a business suit driving a fancy car. Equally surprising to him was the dilapidated appearance of the MITS headquarters. Roberts ushered him into the building and said, “Here it is. Here’s the Altair.”

On a bench before them sat the microcomputer with the largest memory in the world. It had 7K of memory, on seven 1K boards, and it was running a program that tested memory by writing random information into the computer’s memory and reading it back. The memory needed testing, but this program was the only one they had. As it ran, all the Altair’s lights were blinking. They had just gotten it working with 7K that day.

Roberts suggested that they postpone testing the BASIC until the next day and took Allen to “the most expensive hotel in Albuquerque,” as Allen recalled. The next day, Roberts had to pay the bill because an embarrassed Paul Allen hadn’t brought along enough cash to cover it.

That morning Allen held his breath as the machine chugged away, loading the tape in about five minutes. He threw the switches on the Altair and entered the starting address that invoked the program. As he flipped the computer’s run switch he thought, “If we made any mistake anywhere, in the assembler or the interpreter, or if there was something we didn’t understand in the 8080, this thing won’t work.” And he waited.

“It printed ‘MEMORY SIZE?’” said Roberts. “What does that mean?”

To Allen, it meant that the program worked. In order to print this message, at least 75 percent of the code had to be accurate. He entered the memory size—7K—and typed “PRINT 2+2.” The machine printed “4.”

Roberts was convinced and told Allen about some additional features he thought a BASIC needed. A few weeks later, Roberts offered, and Allen accepted, the position of MITS software director.

Gates decided that Harvard was less interesting than Albuquerque and moved there to join his friend. Although never a full-time employee of MITS, Gates spent most of his time there after he and Allen were beginning to realize that a large market for software existed beyond Altair users. The two signed a royalty agreement with Ed Roberts for their BASIC and meanwhile began looking for other customers for their language. Gates and Allen began calling their enterprise Microsoft.

The Other BASIC

Studying computer science was the Navy’s idea.

–Gordon Eubanks, software pioneer

One operating system—Kildall’s CP/M—would dominate the early years of the personal-computer industry. By comparison, the relative ease of creating new and different BASIC capabilities led to competition between two higher-level languages. One of those languages was Gates and Allen’s. The other was developed by a student of Kildall’s.

The Nuclear Engineer

In 1976, a young nuclear engineer named Gordon Eubanks had almost finished his US Navy service. As a civilian, he had logged nine months of experience with IBM as a systems engineer. The Navy offered him a scholarship to take a master’s degree in computer science at the Naval Postgraduate School in Pacific Grove, California. *Why not?* he thought. It sounded like a good deal.

Attending class was a tamer experience than most things that initially sounded enticing to Eubanks. His thick glasses and soft-spoken manner belied a real love of adventure. Eubanks thoroughly enjoyed his work on a nuclear-powered, fast-attack Navy submarine. His friend, software designer Alan Cooper, summed it up: “Gordon thrives on tension.”

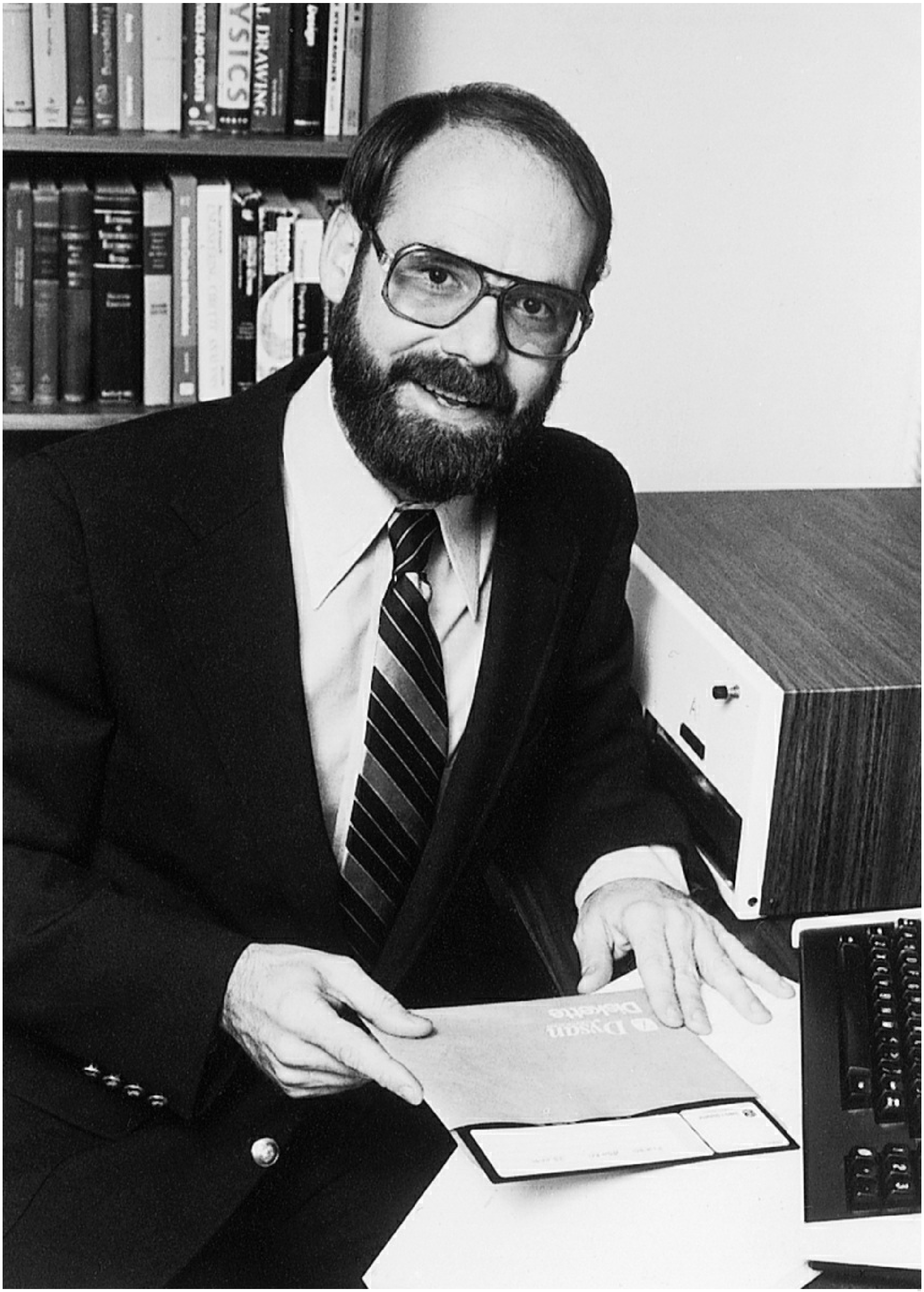

Figure 40. Gordon Eubanks ***Eubanks's master's thesis under Gary Kildall became one of the early industry's standard programming languages.***
(Courtesy of Digital Research)

Gordon also liked to work hard. When he arrived at the Naval Postgraduate School, he soon heard about a professor named Gary Kildall who was teaching compiler theory. Everybody said Kildall was the toughest instructor, so maybe he'd learn something, Eubanks thought. For Eubanks, the hard work in Kildall's class paid off. He became interested in microcomputers and spent a lot of time in the lab at the back of the classroom, working with the computer Kildall received for his work at Intel. When Eubanks approached his professor for a thesis idea, Kildall suggested that he expand and refine a BASIC interpreter Kildall had begun.

The BASIC that emerged from Eubanks's work, called BASIC-E, differed from the Microsoft BASIC in one important way. Whereas the Microsoft version was interpreted—statements were translated directly into machine code—the Eubanks BASIC was a pseudocompiled language. This means that programs written in BASIC-E were translated into an intermediate code, which was then translated by another program into machine code. The same general idea was being tried in a BASIC compiler under development at Ohio State University.

Each approach had its merits, but BASIC-E had one critical advantage. Because its programs could be sold in the intermediate code version, which was not human-readable, the purchaser would be able to use the program but could not modify it or steal the programming ideas it incorporated. Therefore, software developers could write programs in BASIC-E and sell them without fearing that their ideas would be lifted. With a pseudocompiled BASIC, it now made sense to start selling software.

As far as Eubanks was concerned, the BASIC-E was solely an academic project. He placed his BASIC-E in the public domain and returned to the Navy for a new assignment. But before he did, he had two important meetings.

The first was with two young programmers, Alan Cooper and Keith Parsons, who realized there was money to be made writing personal-computer software. They determined to start an application-software company and, as they put it, "make $50,000 a year." They wanted his BASIC-E, so Eubanks gave them a copy of his source code and never expected to see them again.

His second meeting was with IMSAI.

Business Software

Goaded on by Glen Ewing, another ex-student of the Naval Postgraduate School, Eubanks visited IMSAI to find out if the young microcomputer company might be interested in his BASIC. IMSAI wasn't (at least not at first), but Eubanks wasn't particularly disappointed. Sometime later, Eubanks received a telegram from IMSAI software director Rob Barnaby requesting a meeting. Soon after that, in early 1977, Eubanks found himself negotiating a contract with IMSAI's director of marketing, Seymour Rubinstein, to develop a BASIC for the company's 8080 microcomputer. Rubinstein gave the young programmer no quarter in the negotiations. Ultimately, Eubanks agreed to develop the BASIC and give IMSAI unlimited distribution rights to it in exchange for an IMSAI computer and some other equipment. The Navy engineer did retain ownership rights to his program.

The trade seemed more than fair to Eubanks. This was his first software deal and he was very green. As Alan Cooper remarked, "Gordon was saying, 'Oh! They're giving me a printer too!'" Eubanks did aspire to earning something more substantial than a printer—he dreamed of making $10,000 on his BASIC so that he could buy a house in Hawaii.

Figure 41. Alan Cooper ***Seen here in 1970, Cooper was instrumental in bringing business software to personal computers.*** **(Courtesy of Mr. Snoid)**

In April 1977, the first West Coast Computer Faire was taking place in San Francisco. Eubanks demonstrated his BASIC-E in a booth he shared with his former professor, Gary Kildall. Alan Cooper and Keith Parsons also showed up and reintroduced themselves to Eubanks. They explained that they had made some modifications in his BASIC and had begun developing some business-application software. Eubanks asked the young programmers if they had suggestions for his IMSAI project. Soon after that, the three of them decided to work together. As Eubanks refined the BASIC and Rob Barnaby, a demanding and meticulous taskmaster, tested it, Cooper and Parsons began writing General Ledger software under the business name Structured Systems Group, perhaps the first serious business software for a microcomputer.

The development of Eubanks's BASIC was a late-night crash project like the Microsoft BASIC had been. Cooper and Parsons would drive to Cooper's place in Vallejo, California, and sit until 3 A.M. drinking Cokes, poring over listings, and trying to decide which statements to put in the language. Like Gates and Allen had done, Eubanks determined the contents of the BASIC primarily by using his own good judgment. Selections were sometimes less than scientifically based. Sequestered in the Vallejo house, staring at code, Alan Cooper would suddenly suggest, "Why don't you put a WHILE loop in?" referring to a frequently used programming statement. Eubanks would answer, "Sounds good to me," and in the statement would go.

The long nights paid off. The result for Eubanks was CBASIC, which later made it possible for him to found his own company, Compiler Systems. Cooper and Parsons's Structured Systems Group became his first distributor. But Eubanks wasn't sure how much to ask for his BASIC. Cooper and Parsons suggested $150; Kildall suggested $90, the price at which CP/M first sold. Eubanks roughly split the difference and charged $100.

They needed to develop packaging and documentation for the product. Cooper and Eubanks wrote the manual and ordered 500 copies from a printer. They immediately got an order for 400 copies and they had to print another batch. They knew they were on their way. As for Gordon Eubanks, he got his house in Hawaii. In fact, he had underestimated the amount of money he would make on CBASIC, almost to the same degree that he underestimated the cost of houses in Hawaii.

A software industry was just starting to be built, but some of the foundation bricks had already been laid. Another brick was placed independently of either BASIC or CP/M.

Electric Pencil

When I started doing business, I had an unlisted phone number.

–Michael Shrayer, software pioneer and camera operator for *Candid Camera*

In the fall of 1975 at one of the early meetings of the Southern California Computer Society, a guest at the meeting had a special present for the attendees. Bob Marsh offered up a copy of Processor Technology’s public-domain software package called Software Package One. It was a collection of programmers’ programs—tools to make writing and modifying programs easier. Marsh told everyone, “Here you are, guys; enjoy it.”

An Editor for Developers

In the opinion of software developer Michael Shrayer, Software Package One was the most important product then in existence because it effectively enabled people to write software. Shrayer, a self-admitted “laid-back sort,” had moved from New York to California several years earlier. He had tired of his hectic life in the commercial-film world where, among other jobs, he worked as a camera operator for Allen Funt’s *Candid Camera*. In the middle of shooting a soft-drink commercial, Shrayer realized that the rat race was no longer worth it. After moving to California, he hooked up with the Southern California Computer Society, where he discovered Software Package One.

Figure 42. Michael Shrayer ***Shrayer started doing business with an unlisted phone number. Here he shows off his pioneering word-processing program, Electric Pencil.*** **(Courtesy of Paul Freiberger)**

Shrayer was not fully satisfied with the editor portion of the software package and thought he could come up with something better. He created Extended Software Package 1 (ESP-1) and the beginnings of a pioneering software firm. Other computer hobbyists, in numbers that amazed Shrayer, wanted to buy the ESP-1 program. In most cases, he had to reconfigure the program for each customer's particular machine. Almost overnight, the laid-back New Yorker found himself in a brand-new rat race.

Shrayer was soon making enough money to live on. It was a nice hobby, and remunerative, and he found that he liked to program. He gathered with other members of the club and talked endlessly about computers. He filled orders for copies of ESP-1. He was having fun.

Shrayer's next idea proved to have a significant impact on the nascent software industry. Tired of having to type out the documentation for his assembler on a manual typewriter, Shrayer decided to use his Executor software (an upgrade of ESP-1) to get the job done. He asked himself, why not use the computer to type a manual? Nothing close to a word processor was available yet. Without having even heard the term "word processor," Shrayer set about to invent one.

Ahead of His Time

By Christmas 1976, after nearly a year of work, Shrayer's Electric Pencil was ready. Although first written on the Altair, Electric Pencil gained acclaim on Proc Tech's Sol. "The Pencil," as it became known, was soon selling quickly. The former camera jockey called his company Michael Shrayer Software, a decision he later regretted because it publicized his name so widely that it ruined his privacy. Nevertheless, at the outset of his new enterprise, he visited computer clubs to talk about his program and enjoyed the admiration heaped upon him.

The popularity of Electric Pencil was so great that it created a buyer demand that it be on all microcomputers then available. Shrayer spent much of his time rewriting the program for different systems. Not only did each kind of computer require a different version, but so did each kind of printer or terminal. Moreover, Shrayer was constantly upgrading Electric Pencil's capabilities. In all, he wrote about 78 different versions.

Had Shrayer been a more experienced programmer, he might have made the program easier to rework. Had he been a more experienced businessperson, he might have sold it in a more organized fashion. But Shrayer was neither, and the rewriting devoured his time, and sales were often limited to single orders by mail. Shrayer grew tired of Electric Pencil and became irritated that it was growing into a serious business that demanded more of his time. He hired programmers to write some of the new Pencil versions for him.

Shrayer's experience demonstrated that in 1977 hardware manufacturers still didn't recognize the importance of software, perhaps thinking that the marketplace would remain dominated by hobbyists. In any case, no hardware companies were willing to pay Shrayer to adapt The Pencil to their machines, although they certainly wouldn't complain if he did so on his own.

Just as Kildall, Eubanks, Gates, and Allen had done before him, Michael Shrayer proceeded according to his own whims and wishes and wrote programs for whatever machines he wanted to. When he eventually lost his enthusiasm for the whole enterprise, he went back to the quiet life he had found on leaving the film world.

Years later, Electric Pencil seemed to have become the program that would not die. Thousands of personal-computer owners continued to use it on machines such as the North Stars and Radio Shack TRS-80s. Shrayer had broken new ground and empowered nontechnical people to use personal computers to perform practical tasks. The market was expanding.

The Rise of General Software Companies

My unemployment had run out.

–Alan Cooper, software designer, on why he started a software company

After helping Gordon Eubanks write CBASIC, Alan Cooper and Keith Parsons set out to achieve their personal dream of making $50,000 a year. The two had known each other since high school. Parsons was the person who taught Cooper how to tie a necktie, a skill Cooper shelved at college when he became a self-described “long-haired hippie.” Cooper intensely wanted to “get into computers,” and asked the older Parsons for advice. “You’re overtrained,” Parsons told him. “Drop out of school. Get a job.” Cooper took the advice. After work, he and Parsons would get together and talk about starting their own company. Nirvana, they thought, is $50,000 a year.

The Checks Started Rolling In

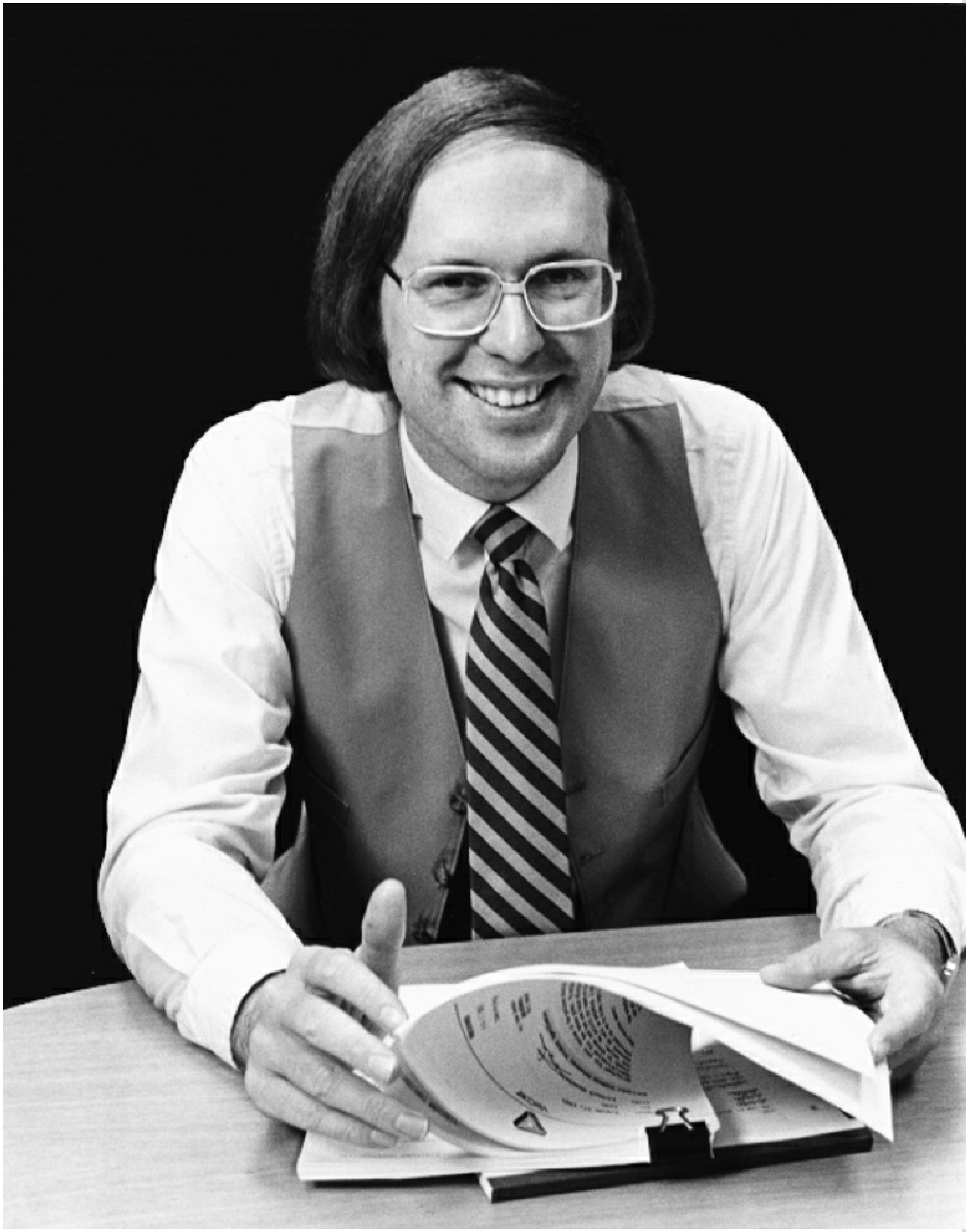

Figure 43. Dan Fylstra ***Fylstra's Personal Software published the first electronic spreadsheet program, VisiCalc.*** **(Courtesy of Liane Enkelis)**

When the Altair came out, Cooper and Parsons drew up their plans. They decided to market business software for microcomputers. They hired a programmer, put him in a tiny room, and told him to write. They were busy writing, too. For a while, the two tried to sell turn-key systems—computers with sophisticated software that jumped into action when the machine was turned on. They got nowhere with that idea. What they really needed was an operating system, of which there were none as far as they knew, and maybe a high-level language. A chat with Peter Hollenbeck at Byte Shop in San Rafael, California, led them to Gary Kildall, CP/M, and Gordon Eubanks.

After months of development on Eubanks's BASIC and their own business software, Cooper and Parsons were ready to start making their $50,000 a year. They placed the first ad for CBASIC in a computer magazine. After much agonizing, they also decided to throw in a mention of their business software. In small print at the bottom of the ad, it read "General Ledger $995." They were prepared for an attack from hobbyists for selling a program that was almost triple the cost of the Altair itself.

It didn't take long to get a response, but it was not the rant they feared. A businessman in the Midwest sent in an order for the General Ledger. Cooper made a copy of the program and inserted it in a zip-lock plastic bag along with a manual, a method of packaging software that became common. Before they knew it, back came a check for $995. Cooper, Parsons, and the whole Structured Systems Group staff went out for pizza.

Meanwhile, they kept working on software. The atmosphere was giddy and the style far from corporate. Parsons paced the office shirtless, while Cooper, hair down to midback, guzzled coffee that "would dissolve steel." The two of them, wired on caffeine and the excitement of the $995 check, wrangled about potential markets and dealer terms. Parsons's girlfriend made phone sales while sunbathing nude in the backyard behind their "office."

Three weeks later, another order came in and the staff had another pizza. The pizza ritual continued for two months. People were sending in checks for thousands of dollars. Soon the Structured Systems Group was eating pizza for breakfast, lunch, and dinner. Yes, there was money to be made writing software for personal computers.

Meanwhile, Back East…

Another early software company started up soon after the Altair announcement. In suburban Atlanta, far from Silicon Valley, several computer enthusiasts opened an Altair dealership called the Computersystem Center in December 1975. The group, including one Ron Roberts, had met as graduate students at Georgia Tech. They quickly realized that, as much as their customers wanted Altairs, they also wanted software to use with the machines. Business was slow at the outset, and they had lots of time on their hands to program.

The group contacted other Altair computer stores throughout the country and discovered that the need for software existed nationwide. In 1976, the group approached Ed Roberts with the idea of using the Altair name for their software distribution. Roberts recognized that software could help sell his machine and vice versa, and he agreed. Ron Roberts (no relation to Ed) became president of the Altair Software Distribution Company (ASDC). The idea was to distribute other people's Altair software and to write a little of their own.

The group from Georgia called a meeting of Altair dealers in October 1976, and almost 20 stores (nearly all that existed) sent representatives. MITS representatives also attended the meeting because the dealers wanted to inform the MITS people about how delays in deliveries and mechanical failures were negatively affecting their business. Ron Roberts found that the Altair dealers had a lot in common. They all suffered from lack of software, hardware-delivery delays, hardware malfunctions, and the general public's meager awareness of microcomputers. Of all those issues, "software was the biggest item on the agenda," according to Ron Roberts.

Several dealers agreed right away at the meeting to purchase ASDC software. The initial software programs from ASDC were simple business packages: accounting, inventory, and, later on, a text editor. The accounting and inventory programs alone retailed for $2,000. Roberts and his colleagues considered the price reasonable; they'd previously worked in the minicomputer and mainframe industry where prices such as that were considered modest. Given the software vacuum at the time, ASDC was able to find buyers even at that hefty price. "We were making quite a bit of money," Roberts recalled.

Ron Roberts later unhitched his wagon from that star after the sale of MITS to Pertec in 1977 and the subsequent fade-out of the Altair. CP/M was gaining popularity, and Roberts decided to convert the programs to enable them to run on Kildall's operating system. This move allowed for sales for more than one brand of computer because many of the new hardware companies started in the wake of the Altair announcement adopted CP/M. Like a later *de facto* standard operating system from Microsoft, CP/M was machine-agnostic.

The word *Altair* now seemed inappropriate as part of the ASDC business name, so the company changed it to Peachtree Software after a downtown Atlanta street. "In the Atlanta area, it's a quality name," Roberts said. Peachtree employees were more businesslike than Cooper, Parsons, and the Structured Systems Group crew. Not only did they wear dress shirts instead of T-shirts, they even wore ties. They called their software product Peachtree Accounting and Peachtree Inventory.

In the fall of 1978, Roberts and one of his partners took the software part of the business and merged with Retail Sciences, a small computer consulting firm in Atlanta run by Ben Dyer, who had previously worked for a hardware-store chain (of the nuts-and-bolts variety). Following the merger, Peachtree released a general-ledger business package. Sales increased rapidly, as did the number of dealers carrying the Peachtree label, and soon it became one of the best-known and -respected names in the software field. Eventually Dyer changed the name of the whole company to Peachtree Software.

With SSG on the West Coast and Peachtree in the eastern part of the country, the software industry was establishing itself as an independent entity.

The Bottom Line

> *If they have a contest as to who is the best negotiator in the industry, I'll withdraw to Seymour's fine abilities. Seymour is a master. And I was just a poor child.*
>
> –Bill Gates

Seymour Rubinstein has said publicly that he left IMSAI to establish a software firm. But with his sharp business sense, Rubinstein must have seen the financial foundation dissolving under the house of IMSAI. More important, however, he chose to bring his business skills to a software industry characterized by haphazard marketing.

Creating a Consumer Market for Software

The lack of business expertise among its executives was holding back the software industry, Rubinstein felt. He decided that his firm would not sell to manufacturers, as Gary Kildall, Gordon Eubanks, and Bill Gates had been doing, nor would it sell by mail to end users, as Michael Shrayer, Alan Cooper, and Keith Parsons did. The number of computer stores wasn't large, but it was growing. Rubinstein decided that his new firm, MicroPro International, would sell only to retailers.

But first he needed some software to sell, and Rubinstein knew where to turn for that. The day he left IMSAI, he visited another ex-employee, Rob Barnaby, who had headed IMSAI's software-development division. Recalling the exhaustive programs Barnaby wrote to test Eubanks's CBASIC and other examples of Barnaby's clever and painstaking programming, Rubinstein knew he wanted Rob Barnaby for his company. So, he went out and got him. By September, Barnaby had completed MicroPro's first two products, SuperSort and WordMaster. The first was a data-sorting program and the second was a text editor that Barnaby had begun working on while still at IMSAI.

Although sales for these two products grew rapidly ($11,000 in September 1978; $14,000 in October; $20,000 in November), Rubinstein felt the market could handle much more; he realized that Shrayer had whetted the appetite of computer owners. MicroPro was inundated with requests for a word processor like Electric Pencil. Not one to shun an opportunity, Rubinstein brought out a similar item. Barnaby's new program, WordStar, was an elaboration of WordMaster into an actual word processor, and it quickly sold more copies than Electric Pencil or any other word-processing rival.

WordStar was also superior to Electric Pencil. Electric Pencil offered word wrap, the feature that allows users to continue typing after the end of a line is reached. But a fast typist could type quickly enough to cause the software to miss one or two characters while the word wrap "carriage" was returning. WordStar overcame that problem and offered another improvement in the form of a what-you-see-is-what-you-get display. In other words, text appeared on the screen in virtually the same form as it did when it was printed.

WordStar soon had rivals. In mid-1979, when MicroPro released WordStar, Bill Radding and Mike Griffin in Houston were almost ready to release their word processor, Magic Wand, a worthy competitor to WordStar.

Rubinstein offered WordStar and his other programs to dealers on a per-copy basis. Michael Shrayer had also investigated that option, but few computer-distribution centers or computer stores existed at the time. By late 1978, when MicroPro International commenced sales, the number of computer stores had grown exponentially. Along with two other companies—Personal Software, with its VisiCalc for the Apple, and Peachtree Software, with its General Ledger program—MicroPro established the standards by which application-software developers did business. By selling its product like any other consumer item, the software industry gained self-respect, credibility, and a financial bonanza.

The Challenge of Software Piracy

Software, these early developers understood, was a product like, say, a wristwatch or a stereo set was a product; however, software was different in one important respect. Software could be appropriated without removing the original item. A thief could copy someone else’s program, easier and faster than making an audio tape of someone’s Pink Floyd album. From the earliest days of the industry, the ubiquitous problem of unauthorized copying outraged many programmers, who saw the fruits of their ingenuity copied and recopied without the slightest monetary gain.

Bill Gates was the first programmer to call attention to the piracy problem. In January 1976, he wrote an “Open Letter to Hobbyists,” which was published, among other places, in the Homebrew Computer Club newsletter. In the letter, Gates lambasted the widespread copying of paper-tape copies of his BASIC and called the hobbyists who copied the program thieves. “The amount of royalties we have received from sales to hobbyists makes the time spent on Altair BASIC worth less than $2 an hour,” Gates wrote. “Why is this? As the majority of hobbyists must be aware, most of you steal your software. Hardware must be paid for, but software is something to share. Who cares if the people who worked on it get paid?”

Gates’s diatribe had no effect on hobbyists except to make them even more angry at the $500 MITS charged for Gates’s BASIC. Hobbyists could see no justification for the price—which was as much as the computer itself—especially because without BASIC the machine was pretty much useless. They felt it should be included with the machine.

From time to time, software developers tried to protect their programs from being copied by using subtle software tricks that either prevented a disk from being copied or that booby-trapped the copied program. Again and again, such schemes failed for one fundamental reason—if a copy-protected program can be written, it can also be cracked. Most companies began to view piracy as a cost of doing business.

The problem was easier to take given that business was good—very good. Soon software became as solid a reason to buy hardware as the computer itself. It was apparent that software was becoming a serious business. In fact, it was an easier business to get started in—and possibly get rich in—than hardware. The only cost of making software, as one wag put it, was printing the serial numbers.

The growing software market soon attracted more aggressive entrepreneurs.

Software Empires

Philippe was frequently absurd and right at the same time.

–Tim Berry, computer consultant who helped write Borland International’s business plan

There’s money to be made in this business. That was the message sent out after the success of the early microcomputer-software ventures such as Microsoft, Digital Research, Structured Systems Group, Peachtree Software, and MicroPro. The message was heard by a group of high-rollers who were willing to risk everything in a growing market that seemed to have enormous potential and no rules or boundaries.

The Frenchman

These new entrepreneurs descended on Silicon Valley from all over the world. Philippe Kahn was visiting from France on a tourist visa. A saxophone-playing mathematics graduate, Kahn was big, flamboyant, exuberant, and had a devilish twinkle in his eye. He had written software for André Truong Trong Thi’s pioneering Micral microcomputer, which had hit the French marketplace more than a year before the Altair made its splash in the United States. Kahn had also worked under computer-science legend Niklaus Wirth on a programming language Wirth had invented called Pascal.

Programming languages were designed for particular audiences. Programs written in FORTRAN looked something like the math notation you’d see on a classroom blackboard or in an engineer’s office; the language had the style and the capabilities that mathematicians and engineers wanted. COBOL programs were verbose and more human-readable, which made them better suited to COBOL’s target audience of business programmers. BASIC was simple and forgiving, a good language for students. Wirth’s new language, Pascal, was formal, rigid, and precise—a language a pure mathematician would love. Philippe Kahn, by education a mathematician, loved it.

When he came to Silicon Valley in 1982, Kahn rented office space in Cupertino and began doing business as a software consultant, using the name MIT (for Market In Time) and lining up clients, including Hewlett-Packard, Apple, and even a company in Ireland. When the Massachusetts Institute of Technology suggested he stop using the name MIT just about the time the Irish company went out of business owing Kahn $15,000, he accepted the defunct company’s name in lieu of payment. MIT became Borland International.

Borland had one marginally interesting software product, called MenuMaster, written by the brilliant Danish programmer Anders Hejlsberg, which worked with the CP/M operating system. By this time, IBM had released its personal computer, and it was obvious that Borland could sell a lot more copies of MenuMaster for the PC than for computers running the CP/M operating system. That, however, would require porting the program—rewriting it to work with the PC’s operating system. Plus, there were the advertising costs. It was clear that Borland needed an infusion of cash, which meant attracting investors, and for that the company needed a business plan.

Tim Berry was working in the same office complex on Stevens Creek Boulevard in Cupertino where Kahn had his office space. Berry agreed to help Kahn develop a business plan in return for a piece of Borland.

Berry was no entrepreneur; he was a cautious analyst with a family to support. But Kahn was bright, charismatic, and motivated. Berry wanted to sign on to see firsthand what Kahn would do. When the company incorporated in May 1983, Berry found himself on the company's board of directors. He also wrote its earliest advertising, which featured a wildly fictitious story of the company's origin along with a picture of a grizzled character named Frank Borland. Berry was a talented writer and the engaging ad copy helped to personalize the young company.

The Hustler

At the time that Philippe Kahn was writing software for André Truong Trong Thi's Micral microcomputer, Lawrence Joseph Ellison, a fast-talking programmer from Chicago, had just landed a job at Ampex, a video- and audio-equipment manufacturer in Silicon Valley. Four years earlier, Lee Felsenstein had left Ampex to write for the counterculture publication *The Berkeley Barb*. But Larry Ellison was no 1960s revolutionary. When Ampex got a contract to develop a tape storage system for the CIA, Ellison was thrilled to be working on the project, which the CIA code-named Oracle.

Ellison was definitely Type-A entrepreneur material: aggressive, bright, fearless, arrogant, and mercenary. In June 1977, Ellison's energy and drive led him to start his own company. Along with two Ampex coworkers, he founded Software Development Laboratories (SDL). With the knowledge they gained on project Oracle and some IBM technology, they figured they could put together a salable product.

The IBM technology they used was the relational model of databases, invented by Edgar F. Codd. An alternative to the usual flat-file model, in which no structure exists that governs the relationship among database entries, the relational model was largely untested. The relational database model required computing horsepower well beyond the capability of the microcomputers of the time. But microcomputers were not yet part of Larry Ellison's world.

Ellison's company, SDL, which soon changed its name to Relational Software Inc. and then again to Oracle, was planning to market a minicomputer database program that would sell "like donuts," Ellison said. He had been telling everyone that he was going to become a billionaire, and to get there he knew he'd have to sell software to everybody. "Everybody" included the CIA, although when he tried to sell agency officials a product called Oracle based on a CIA-financed project by the same name, they told Ellison he "had a lot of nerve."

They had no idea.

Ellison was a thrill seeker. He bodysurfed, flew airplanes, sailed boats, and played basketball, pushing himself hard enough to have suffered a few broken bones in the process. Ellison saw to it that his company reflected his gung-ho attitude and pushed the company to double its sales every year. No one in the company, probably not even Ellison, thought this was a sane business model, but somehow, for the first decade of its existence, the company doubled its sales every year.

Ellison insisted that the Oracle program be portable—“promiscuous” was his word. Like Electric Pencil, Oracle was intended to run on any computer; unlike Electric Pencil, Oracle was engineered to make this task if not easy, at least not extremely difficult.

IBM didn’t bring its relational database technology to market in a timely fashion, thereby opening the door for Oracle to get there first with IBM’s own technology. Meanwhile, other companies, such as Ingres in Berkeley, were soon also producing relational database products. IBM did Oracle another favor when it embraced an approach to writing database queries called SQL, which Oracle used rather than a competing approach used by Ingres. IBM then presented Oracle with its biggest opportunity when it released its microcomputer, the IBM PC, in 1982.

In short order, Oracle ported its database program to the IBM PC. Even though simple arithmetic said that the massive program would be unusable on the tiny machine, Ellison didn’t care. The Oracle database had to be, to use his term, promiscuous.

An Industry Develops

Microcomputers of that time needed a simpler database tool than the massive Oracle relational database program. What they needed was a simple, programmable, flat-file database program—one that fit within the memory capacity of the machines and that allowed users to build meaningfully complicated databases. That product already existed: it was called dBase II.

In 1980, George Tate and Hal Lashlee founded a company called, oddly enough, Ashton-Tate (there was no partner named Ashton). Tate and Lashlee planned to sell a database program for microcomputers, dBase II, which was written by Wayne Ratliff. dBase II was a novelty for the young microcomputer-software industry: it worked well and made computer users more productive. People who were experts in building databases with dBase II, and coding in the simple programming language that it included, were soon making a good living as dBase II specialists. By the early 1980s, when IBM came out with its PC, Ashton-Tate was the database king of microcomputers. When they ported dBase II to the PC, they held onto the title with no problem, untroubled by the existence of Oracle for the PC or any other similar competitor.

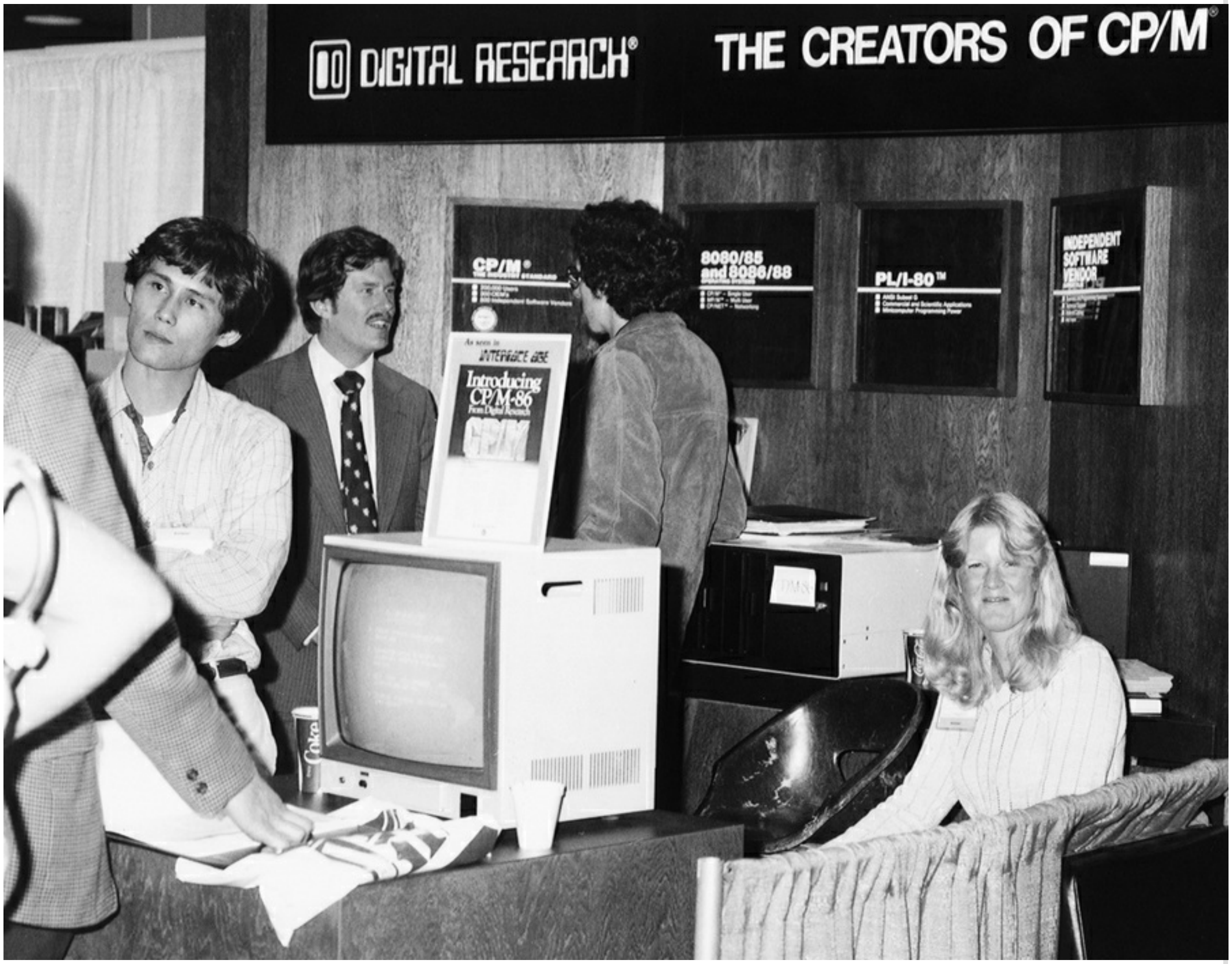

Figure 44. Digital Research at a trade show ***Susan Raab works the Digital Research booth at the West Coast Computer Faire.*** **(Courtesy of Digital Research)**

By 1985, Ashton-Tate had moved to larger headquarters in Torrance and was buying up other companies and fleshing out its product line, with dBase II remaining its bread and butter. Ed Esber had been brought in as CEO, and as Ashton-Tate acquired companies, Esber bragged, “Every software company is up for grabs.” Ashton-Tate’s dBase II virtually owned the database market for microcomputers, but that didn’t stop others from trying to break in with new and innovative approaches to database software.

In the fast-moving microcomputer software industry of the early 1980s, some of the microcomputing pioneers were embarking on their second or even third careers. Gordon Eubanks was one such example. After developing CBASIC with help from Alan Cooper and Keith Parsons, Eubanks sold CBASIC for a few years under the business name Compiler Systems. Then in 1981, he sold the company to Digital Research and went to work for his former professor, Gary Kildall, as a Digital Research vice president.

Inspired by an entrepreneurial urge he hadn't really felt when he started Compiler Systems, in 1982 Eubanks left Digital Research to launch C&E Software. Within months, C&E bought another software start-up, Symantec, and assumed its name. Eubanks had helped to develop a simple and easy-to-use flat-file database program with a built-in word processor. It was called Q&A and became Symantec's first product.

If Q&A represented the ease-of-use strategy in tapping a software market, Framework represented a "Swiss army knife" approach to software marketing. Written by first-class programmer Robert Carr, Framework was a remarkably powerful and advanced product—a word processor, spreadsheet, database program, and programming language all in one—and it ran on a PC. Carr hooked up with Martin Mazner, who had written award-winning ad campaigns before getting into the microcomputer-software business. In 1982, they founded Forefront Corporation with the specific goal of getting Ashton-Tate, one of the leading microcomputer-software companies, to bring Framework to market. Their plan worked when Ashton-Tate bought the company.

But dBase remained Ashton-Tate's cash cow, boasting millions of users. By the late 1980s, dBase II was the third-best-selling program for the IBM PC, and Ashton-Tate was the world's third-largest personal-computer software company, trailing close behind Microsoft (which exploded in size after the release of the IBM PC with its Microsoft-supplied operating system) and Lotus, the spreadsheet king. In 1986, *The Washington Post* called Microsoft, Lotus, and Ashton-Tate "the GM, Ford, and Toyota of the software business." Other successful personal-computer database companies were around at the time, but they survived, like Fox Software and its FoxPro did, by touting their compatibility with dBase II.

Sell It Like a Book

When Philippe Kahn had Tim Berry help him write a business plan for Borland, the initial idea had been to attract some investment capital and port MenuMaster to the PC. But nothing was happening on either front: no investors were lining up and, Berry was alarmed to see, apparently no porting had been developed. Kahn finally admitted that there just wasn't any good development software for PCs for doing the programming the porting job required. So, he put Anders Hejlsberg to the task of writing a Pascal compiler.

Berry was horrified at the thought. Pascal was not a simple language like BASIC. Writing a Pascal compiler was a huge undertaking, a much bigger job than porting MenuMaster. Now the porting of MenuMaster would have to wait until the Pascal compiler was finished. In the meantime, everyone around the world was bringing out products for the PC. Borland would miss that window of opportunity for being the first to market with PC-software products. This strategy was crazy, Berry thought.

In October 1983, Berry got a call from Kahn to come over to his office right away. Borland had relocated to Scotts Valley, on the other side of Northern California’s Santa Cruz mountains, and Berry, an independent consultant, was now working 50 miles away; this was an unexpected two-hour round-trip commute for Berry, but he went.

As Berry and the other Borland directors watched, Kahn demonstrated Turbo Pascal. They were stunned. It was astonishingly fast, and so compact that it easily ran in the limited memory of the PC. This program was better than anything they could remember seeing on a mainframe or minicomputer—a polished, appealing product that was brilliantly coded. Even amateur programmers could use this; one could even learn how to program with it. MenuMaster was never mentioned again.

Kahn dropped another bombshell on the board: they would sell Turbo Pascal for $49.95 by mail order. At the time, Microsoft was selling a Pascal compiler for roughly ten times that price. In theory, the Borland board should have had something to say about these decisions: Kahn was scrapping the business plan, dumping the company’s only proven product, and substituting a new product that he proposed to sell at a ridiculously low price. But at Borland International, Philippe Kahn was running the show, and quite a show it was. He was adamant about the $49.95 price; it would cut through the noise in the market, he said, and help them get their message out loud and clear.

Getting the message out would be a challenge. The company had literally no money for advertising. Nevertheless, a full-page ad for Turbo Pascal, with the $49.95 price and a number to call to place an order, appeared in the November 1985 issue of *Byte* magazine. To have made the November issue’s ad deadline, Berry ruefully observed, Kahn must have placed the ad listing the $49.95 price well before he showed the program to the board. No wonder Kahn was so adamant about the price, Berry thought. He had already committed them to it.

It wasn’t just one ad that ran; Kahn had placed $18,000 worth of ads. When the advertising salesperson came to the Borland offices, Kahn had his friends fill the chairs around the offices to create the impression of a more prosperous business in an attempt to bolster his request for credit. He had no choice; Borland had no money to pay for the ads, and they had no prospects of getting any money unless they got a lot of orders for Turbo Pascal right away.

In November, Borland raked in $43,000 in sales, which Kahn immediately spent on more advertising. “He was betting the company every chance he got,” Berry said. Within four months, the company was bringing in nearly a quarter of a million dollars a month. They were growing too fast to act like a “normal” company, and Kahn’s sales manager understood that. When a major software distributor offered in late 1985 to carry Turbo Pascal, he turned the distributor down even though it could have increased Borland’s sales significantly. It seemed crazy, but the five-month lag in payments the distributor imposed would have killed them.

Microsoft Steps In

Meanwhile, Ashton-Tate and Oracle were on a collision course. In 1988, Ashton-Tate partnered with Microsoft to bring a relational database product to market, edging in on Oracle's technology-industry niche. At the same time, Ashton-Tate filed suit against FoxPro, the competitor in its own backyard, claiming that FoxPro was infringing on Ashton-Tate's copyrights. On the face of it, the claim seemed legitimate: FoxPro's business model basically called for producing something that looked and performed as much like dBase II as possible.

While expanding its market and protecting its flanks, Ashton-Tate was also tending to its current products, bringing out major new versions of dBase and Framework. Then, in late 1988, the boys at Oracle learned that Ashton-Tate was at work on a version of dBase for minicomputers. Now they were moving into Oracle's territory.

Oracle had made a move into Ashton-Tate's territory years earlier with Oracle for the PC, but it wasn't so much a product as a technology demo. Even though nothing much could really be done with Oracle for PCs, given that it was buggy and frequently crashed, one could get an idea of what the software was supposed to do and get a feel for what Oracle on minicomputers was all about. The PC version by and large functioned as advertising for Oracle in a market where it didn't yet have a viable product. When Oracle eventually did have a viable PC version, the company didn't have to educate the market; the demand for the product was already there.

The appeal of the Oracle product was a little difficult to understand. Not only was the PC version inadequate and buggy, but the minicomputer versions were often buggy, too. To make matters worse, Oracle had a reputation for delivering products late. However, relational database technology was appealing, and Oracle's sales efforts were formidable. The ad budget was doubling annually by the mid-1980s, along with the sales figures. The slogan of Oracle's ad agency was "God hates cowards." Oracle's could have been "Take no prisoners."

When Ellison learned that Ashton-Tate was planning a version of dBase for minicomputers, Oracle retaliated by pushing its PC version with a vengeance. Everywhere, ads appeared showing an Oracle fighter jet shooting down an Ashton-Tate biplane. Oracle began selling its PC version at cost. Because it was making large profits on its minicomputer versions, it could afford to do so. Ashton-Tate, with the bulk of its profits coming from dBase for the PC, had no response.

Unfortunately for Ashton-Tate, its newly released version of dBase was full of bugs. On top of that, the judge in the copyright-infringement case Ashton-Tate brought against FoxPro not only decided against Ashton-Tate but also stripped the company of its copyright. The court found that Ashton-Tate had not properly disclosed that its dBase product was based on work done at the government's Jet Propulsion Lab—work that was in the public domain. The company was soon bleeding red ink. CEO Ed Esber was shown the door.

While Ashton-Tate suffered, Borland prospered. It had gone public in 1986, and by the end of the 1980s, with a half-billion dollars in revenues, it was one of the biggest software empires. In 1991, Borland bought Ashton-Tate.

Next, Microsoft launched an assault against Borland's market niche. In 1986, Microsoft put out a major new release of Basic, turning the latest version of the language Microsoft had been rewriting and redefining since 1975 into what it hoped would be a Turbo Pascal killer. This was an important development: Microsoft had built its reputation on programming languages, and Borland's fast, compact, and cheap language had hurt Microsoft's sales in computer languages and made Microsoft look old and stodgy. QuickBASIC was to change that perception, and Microsoft did what it came to do best: it staged a killer press event to promote the product.

Technical journalists were invited to the Microsoft "campus" in Redmond, Washington, to see the latest technology. Those invited were editors and writers for technical magazines, and many of them were programmers in their own right. Microsoft treated the journalists to a fine meal and then issued them a challenge: each would compose a programming task that could be achieved in a few hours of work. A description of one of these tasks would then be pulled at random out of a hat, and from those descriptions the journalists/programmers would begin to write code. Whoever was the first to run a program that successfully completed a task would win a prize. The journalists were free to use their own computers and any programming software they liked. Microsoft's new QuickBasic would be represented, and the programmer using it would be Bill Gates.

It had been nearly four years since Gates had written code. The last time was when he completed the software for the Tandy TRS-80 Model 100, a book-sized portable computer much prized by journalists. Gates was nervous and had stayed up late the night before familiarizing himself with QuickBasic. One of the journalists, a sharp programmer named Jeff Duntemann, would be using Turbo Pascal, and Duntemann knew Turbo Pascal inside and out.

When the contest was over, Bill Gates and QuickBasic had won. It was a crazy thing, an outrageous PR gamble, but it had paid off. The message was clear: Microsoft was run by a sharp, highly competitive businessman who also happened to have helped start the industry. Plus, he was profoundly knowledgeable about the technology, and no slouch as a programmer, either. QuickBasic ended up selling well against Turbo Pascal.

Borland soon found itself in trouble in a now ruthlessly competitive market. But Borland was out for blood, too: when one of its executives left to work for Gordon Eubanks at Symantec, Borland sued the former executive. It wasn't Borland's first major lawsuit. Lawsuits were becoming more and more common. The stakes were high, and competition was getting brutal.

Figure 45. Digital Research headquarters ***As Digital Research grew, it moved to larger headquarters.*** **(Courtesy of Tom G. O'Neal)**

But a market requires a marketplace. Gradually a publishing industry would grow up around the burgeoning personal-computer market, feeding the growing hunger for information, telling computer enthusiasts about the new products that were appearing every day. At the same time the early personal-computer stores were being challenged by well-financed chains. And this would bring a heavyweight player into the market with a bargain-basement computer and a network of stores to sell it. But early on, the marketplace really existed in the clubs and newsletters where hobbyists learned about new products.

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Chapter 6

Retailing the Revolution

> *Computer magazines built the real enthusiast's marketplace.*
>
> *David Bunnell, founder of several computer magazines*

The meanings of words can change over time, complicating the job of the historian.

To the hobbyists who made up the early core market for personal computers, this personal-computer phenomenon was less an industry than a movement. This showed clearly in the style and atmosphere of the magazines, shows, and stores. Initially, these were primarily about community building. Around the magazines and stores and shows there blossomed a culture in which computers for individuals could be imagined, built, understood, and, almost incidentally, bought and sold.

Spreading the Word: The Magazines

The magazines basically defined a nationwide small town.

–Carl Helmers, the first editor of *Byte* magazine

Buying microcomputers by mail required a healthy measure of blind faith. Customers mailed checks to companies they had never heard of to acquire products they couldn't be sure existed. All they knew was that they wanted a computer, so they mailed their money and waited. And waited. Fortunately for the manufacturers, the earliest buyers of microcomputers rarely demanded customer service. They were hobbyists who would tolerate almost anything—including the mirage world of mail order—to get their own computers.

Soon magazines were coming on the scene to alert the hobbyists to the new machines. But this would prove to be a mixed blessing.

Products were being announced before they were even designed, let alone built, and the magazines supported the practice. *Popular Electronics* had passed off an empty box as the original Altair and a mock-up as the Processor Technology Sol in a couple of its cover stories. The journalistic excesses were probably harmless, but ads used the same technique. *Byte*'s Carl Helmers said, "I'm not saying [the technique was] legitimate, but it's certainly one that's used all over the place in technology. A product may be there to show in so-called functional simulation form, and that functional simulation is one step toward making the thing actually happen."

The "functional simulation" was the least misleading of the ads because it at least gave the buyer some idea of what the machine could do. Other ads were more fantastic than factual. "A guy who is in love with writing copy about computers can dream up any kind of system," said Helmers. "And there were people who did that."

The computer magazines of the time played dual, almost schizoid roles in this frenzy. Editors encouraged the frenzy by reporting advances, printing ads, and sometimes failing to alert readers to substandard items. Carl Helmers, for instance, rationalized his refusal to assess product quality on the grounds that "products that don't fulfill [their promises] over the long haul will sort themselves out and die." But some publications did actively sift the good from the bad. Adam Osborne, who had been selling books out of a cardboard box at Homebrew meetings, started a muckraking column that appeared in *Interface Age*, and later in *InfoWorld*, that alerted buyers to the shortcomings of certain products. *Dr. Dobb's Journal*, the offshoot of the *People's Computer Company* (*PCC*) newsletter, took a strong consumerist stance, steering readers away from purchases that they'd later regret.

Byte

Byte was one of the great success stories among microcomputer magazines, but the success grew out of conflict and perceived betrayal. *Byte* was launched in mid-1975, the brainchild of Wayne Green, who had published *73*, a magazine for ham-radio enthusiasts. The Peterborough, New Hampshire, resident was part hobbyist and part huckster. Green enjoyed promoting those things he believed in: ham radio, microcomputers, and himself. Some viewed Green as a front-porch philosopher who was fond of contemplative argument and prone to thinking out loud. But others saw a complex individual who could be difficult to work for. His busy, impatient mind would flit from the latest software developments to psychic phenomena, but it always came back to the bottom line. Wayne liked to make money.

By 1975, Green was looking to computerize *73*'s circulation department. He called the major minicomputer firms, each of which sent a representative. Every rep warned him of the dangers inherent in buying a rival's machine. Green found all their warnings convincing. The computer investment was beginning to feel like a leap into darkness. Before paying $100,000 for a computer, Green decided he should learn something about the players in the field.

Green discovered that the computer books and magazines that were available seemed to be written in a foreign language. Only computer-club newsletters were understandable. They also were the only good sources of information about these new microcomputers. The more Green thought about it, the more he realized that he was not alone. The country was full of people who needed an introduction to computers written in plain English.

Green saw his opportunity and decided to create a magazine to ease beginners into *microcomputing*. He needed a name for his publication, one that was short, catchy, and evocative of the machines themselves. He decided on *Byte*.

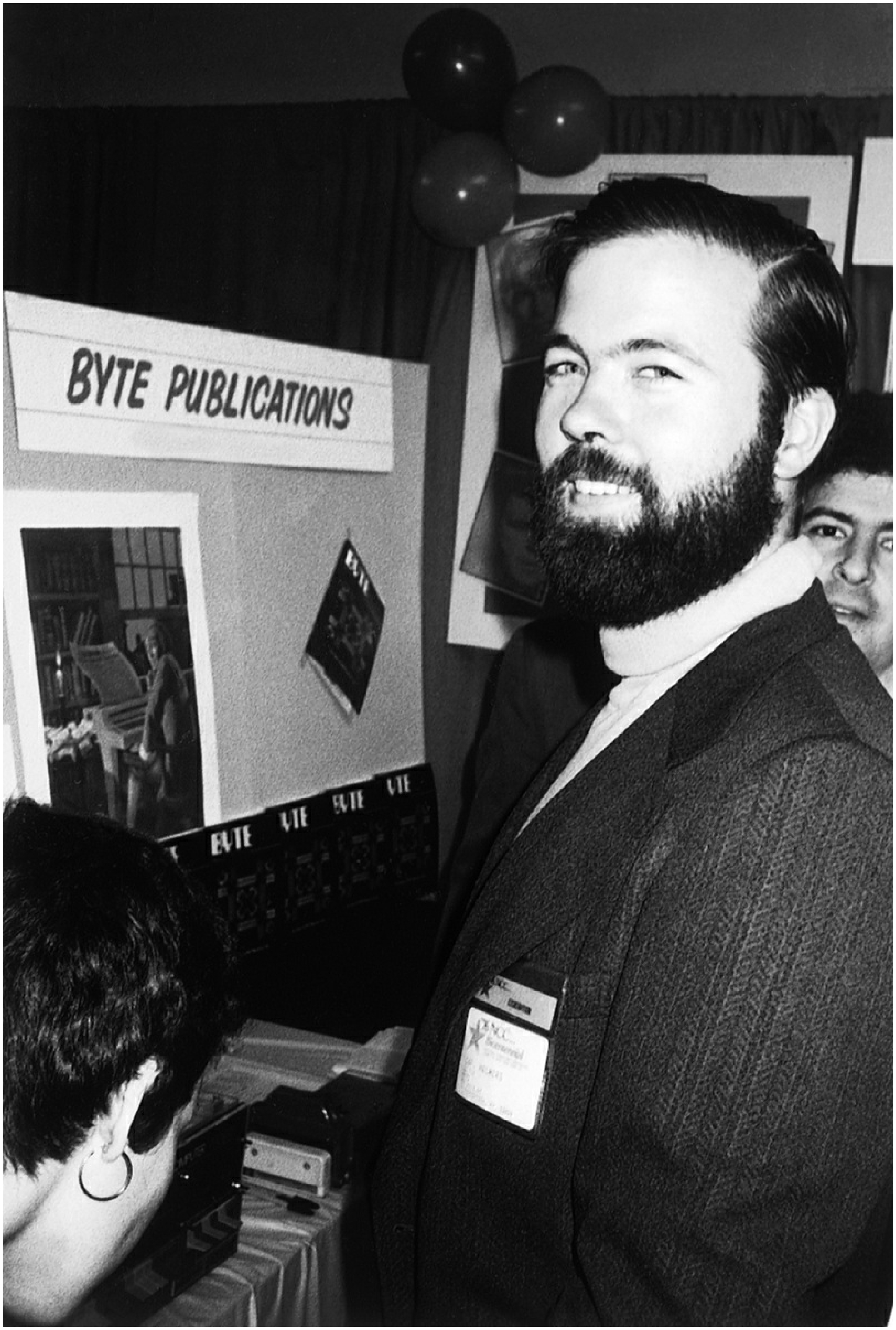
BYTE PUBLICATIONS

Figure 46. Carl Helmers ***Helmers, the first editor of*** **Byte** ***magazine, is seen here at the National Computer Conference in the 1970s.***
(Courtesy of David H. Ahl)

Green recruited Carl Helmers as editor. Helmers had been issuing a periodical called *ECS* (*Experimenter's Computer Systems*) solo in Boston. Since January 1975, just after the *Popular Electronics* announcement of the Altair, Helmers had been writing 20 to 25 pages each month on his ideas for building and programming microcomputers. He then shepherded the pages through editing and photo-offset printing and had them distributed to some 300 readers. Helmers accepted Green's offer and moved to New Hampshire. Green drew his *Byte* contributors and readership from the early newsletters such as *ECS* and from his own ham-radio-enthusiast subscribers, believing the latter to be a natural audience for *Byte*. When the first edition of *Byte* appeared on August 1, 1975, its 15,000 copies sold out immediately. This was the beginning of a new magazine genre, the personal-computer magazine.

Within a decade, the personal-computer magazine market would support scores of magazines competing for millions of dollars of advertising revenue. At the height of the PC-magazine boom, the leading magazines swelled to 400+ pages and hosted gala awards ceremonies with tuxedo-wearing journalists and CEOs arriving in stretch limos to hand out and receive gold statuettes.

But in the early days, it was considerably less pretentious.

With Wayne's ex-wife, Virginia Green, as office manager, Helmers as editor, and much of the *73* staff filling in the personnel ranks, Green set about compiling a second issue. He estimated that 20 percent of *Byte*'s readership came from the *73* mailing list. To beef up the subscription list, Green took the first issue around to manufacturers, including MITS in Albuquerque, Sphere in Salt Lake City, and Southwest Tech in San Antonio. Green was greeted with enthusiasm, and the manufacturers supplied him with customer address lists. Those lists, he guessed, gave *Byte* another 20 to 25 percent of its subscriptions.

Byte was immediate, chatty, and enthusiastic. It caught the flavor of the computer and electronics hobbyist newsletters, and spoke directly to the people building and buying and lusting for their own microcomputers. It was the right formula, and it was wildly successful.

Wayne Green had struck a mother lode and was exhilarated. But he had one problem. He didn't own the company. It belonged to Virginia, from whom he had been divorced for 10 years. This unusual arrangement was a result of Green's legal difficulties: he had been convicted of tax evasion and had other pending legal issues. "The lawyers said we should set up the new magazine as a different corporation and have somebody keep the stock separate from other assets until the suits were resolved," Green explained. He entrusted *Byte* to Virginia.

The trouble started almost immediately. Helmers had a good sense of what the computer hobbyists wanted, but Green had been publishing successful magazines for years and was convinced that he had the formula. Anyone should be able to pick up two or three issues and get up to speed, he was convinced. Helmers had put together something far more technical, a kind of bulletin board for a highly technical community.

Green was pushing Helmers to simplify the content to reach a broader audience, and Helmers pushed back. After the first issue hit the stands, he and Virginia forced Wayne out and took over the publication. By January 1977, *Byte* had a readership of 50,000 and was the premier magazine in the subject area. In its field it had the stature of *Scientific American*, the in-crowd feel of *The Village Voice* in the beat era, and the style of a Homebrew Computer Club meeting. Helmers remained as editor and part owner of the company, which he and Virginia eventually sold to publishing giant McGraw-Hill in April 1979. Helmers stayed with the publication until September 1980.

Kilobaud

Wayne Green did not sit still for long. In August 1976, he circulated among the computer manufacturers to find out if they would support a new magazine with him at the helm. The response, he said, was unequivocally positive. Green wanted to call the publication *Kilobyte*, but *Byte* claimed it would infringe on its name. Because Green was telling people that the publication's mission would be to "kill *Byte*," that was probably not an unreasonable claim; so Green christened his magazine *Kilobaud*.

Kilobaud was an expansion of a regular feature on computers called "I/O" that Green had run in the pages of *73*. The new publication strove to achieve the Wayne Green ideal: anyone should be able to pick up the publication and after reading two or three issues understand its contents. Green lamented that *Kilobaud* never overtook *Byte* in circulation or advertising, but it was clearly a success nonetheless.

Green kept an eye on how his market developed. When he started *Kilobaud*, almost all his readers were hobbyists, people who had no qualms about building their own accessories or using a soldering iron to modify the apparatus. Around 1980, Green recognized a new kind of hobbyist, one who liked to use the equipment but shunned all that tinkering. Responding to this change, Green renamed the magazine to give it broader appeal. He called it *Microcomputing*. Around the same time, he started another journal, *80 Microcomputing* (later called *80 Micro*), aimed at users of the Radio Shack TRS-80 computer line. Green later launched other, even more consumer-oriented publications. Helmers and his successors at *Byte* held *Byte* to a high technical level for years.

Carl Helmers saw the early periodicals as having a threefold purpose: economic, educational, and social. The magazines defined a market, spread important news, and helped bring hobbyists together. These publications created a nationwide community of computer users. “Peterborough, where I live, is a small town, but it’s geographically constrained,” Helmers said. Like a small town where everyone knows everyone else and news of events is spread almost as soon as they happen, everyone and every event was known among the small village of microcomputer hobbyists, wherever they really lived. And, no publication had more of a small-town flavor than Wayne Green’s early *Kilobaud*, with its chatty editorials, industry gossip, and calendar of events.

Dr. Dobb’s Journal

To Carl Helmers’s threefold statement of purpose, Jim Warren would have added two more elements: social consciousness and a cheerful antiestablishment attitude straight out of the 1960s.

Warren was chair of the Math Department at the College of Notre Dame, a Catholic women’s academy just north of Silicon Valley. At the time, Warren liked to throw huge get-togethers at his home, with most of the revelers partying in the nude. “The parties were rather sedate by any common standards, except that people didn’t have any clothes on,” he recalled.

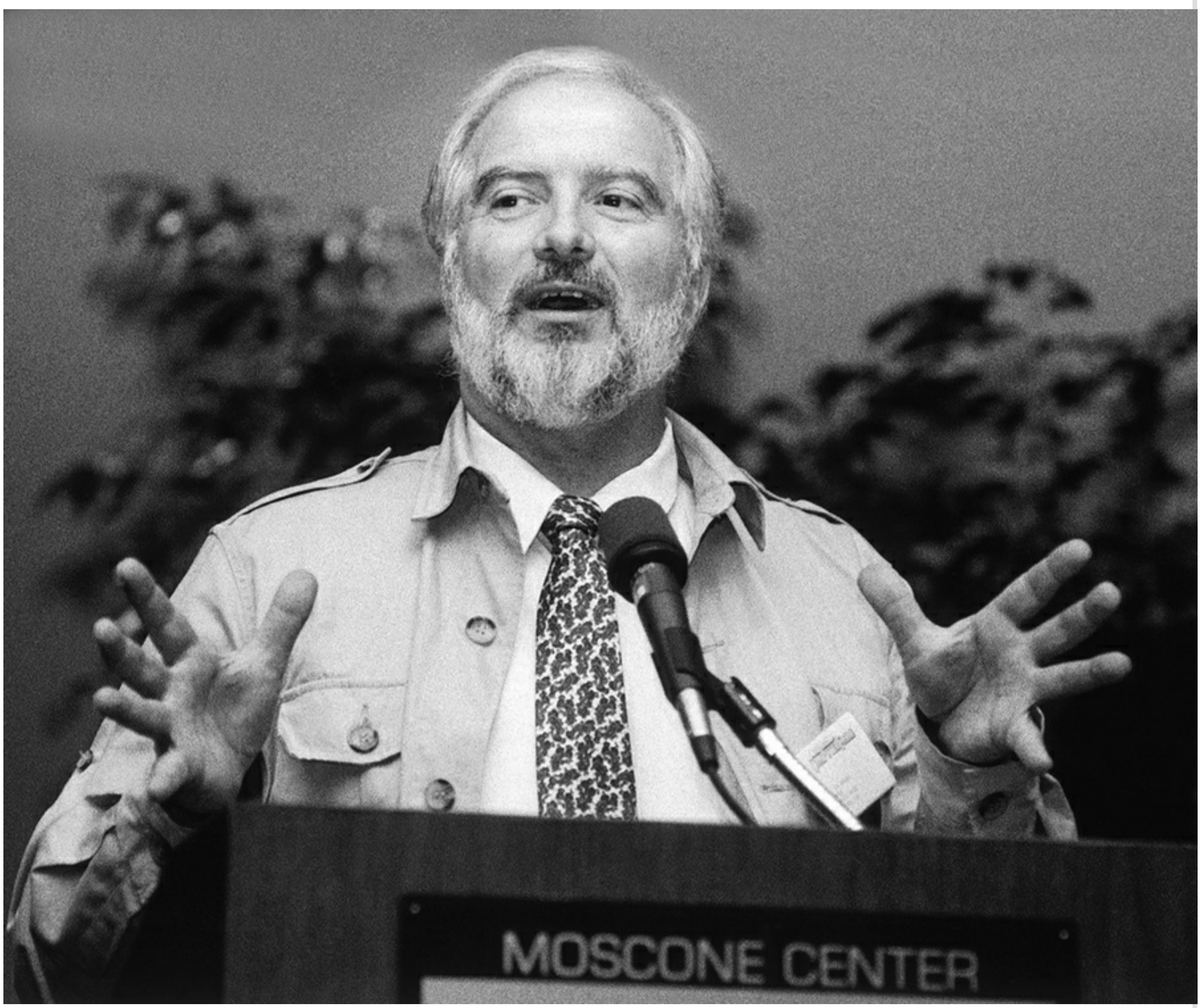

Figure 47. Jim Warren ***Warren was the first editor of*** **Dr. Dobb's Journal** ***and launched the West Coast Computer Faire.*** **(Courtesy of Jim Warren)**

The media descended on Warren's home. *Playboy* photographed these affairs; the BBC filmed them; and *Time* did an article on them. All the publicity forced the hand of the college officials, who told Warren that his conduct struck a sour note at the Catholic school and asked him to leave. Warren shrugged it off. In this enormous world, there had to be more interesting jobs than this one, he thought.

Warren was looking for something new when a friend suggested that he go into programming. "You'll pick it up," the friend assured him. So Warren went to work doing programming at the Stanford University Medical Center and ended up loving it. Just for the sheer fun of it, he became an avid follower of state-of-the-art developments in the field. He had become an enthusiast.

In the early 1970s, the Stanford University Medical Center was also home to the Stanford Free University, which offered an alternative, noninstitutional approach to higher education that was much to Warren's liking. He soon became the Free University's executive secretary and newsletter editor, while taking on a variety of consulting jobs. And it was there that he met Bob Albrecht and Dennis Allison.

Albrecht was a transplant from the Midwest who had parted ways with Control Data Corporation and was looking for ways to get kids connected with computers. Allison was a Stanford computer-science professor who was as interested in the network of hackers he was building up as he was in computer science. When the Altair appeared, followed by Gates and Allen's BASIC, Albrecht and Allison began seeking ways to bring their expertise to the cause of spreading the word about computers. Like, say, a magazine.

Byte had debuted in September 1975 and was publishing information on hardware design, but no software magazine existed yet. Hobbyists turned to Albrecht and Allison's *People's Computer Company* newsletter to provide one. Dick Whipple and John Arnold of Tyler, Texas, sent PCC a long list of code that constituted a "Tiny BASIC," a 2K version of the full-blown BASIC, designed for machines with limited memory. Allison decided to publish a limited-edition, three-issue magazine to get this code into hobbyists' hands.

The response to the magazine was overwhelming. In January 1976, the publication became an ongoing project called *Dr. Dobb's Journal of Tiny BASIC Calisthenics and Orthodontia*. "Dobb's" was a contraction of "Dennis" and "Bob," Allison and Albrecht's first names. The rest of the title was an in-joke about "running light without overbyte." Jim Warren was hired to run the publication. Warren thought the name was too specific and soon changed it to *Dr. Dobb's Journal of Computer Calisthenics and Orthodontia*.

The magazine published, among other material, classic Tiny BASIC implementations by Li-Chen Wang, Tom Pittman (the consultant who had programmed Intel chips before Gary Kildall), and others, along with all the micro news, rumors, and scuttlebutt Warren could unearth. *Dr. Dobb's* adopted an irreverent, folksy tone that reflected the influence that the 1960s had on its editor. Warren believed in contributing one's efforts to the good of all humanity; in fact, in the early 1970s he wondered whether he should continue working with computers at all. He thought of the machines as mostly gadgets; they were playthings as stimulating as chess but by and large devoid of social utility. As he later put it, "Somewhere back there I'd been raised with a Puritan work ethic (if not all the Puritan values), a make-a-contribution-to-society ethic, which was certainly illustrated in my 10 years of teaching at destitute wages, over which I have no regrets at all."

Nor did he have any regrets about editing *Dr. Dobb's* at $350 a month when he could have been earning far more consulting. Money wasn't of paramount importance as long as he was making a contribution to society. He liked to quote Dennis Allison's slogan: "Let's stand on each other's shoulders and not on each other's toes."

Warren was enjoying himself and believed that others should, too. He infused *Dr. Dobb's* with a sense of merriment that became one of the publication's hallmarks. Idleness might ultimately ruffle his conscience, but pleasure was still one of the great rewards of existence. "Let's not worry about conformity and tradition. Let's just do whatever works and let's have fun doing it," he said. He was attracted to *PCC* partly because it was the first periodical to treat computers as objects suited to intellectual forms of recreation.

A Publishing Industry Develops

A large variety of other computer-enthusiast magazines quickly appeared, some of which spun off from existing publications. For instance, *PCC* spun off *Recreational Computing*, which addressed a broader and less technically inclined audience. Corporations produced other publications. *Computer Notes* came straight from MITS and focused on the company's Altair line. Its editor, David Bunnell, later quit to run the slick-looking *Personal Computing* magazine, with articles geared to beginners.

Still other magazines grew out of informal newsletters exchanged by hobbyists, while many others seemed to appear spontaneously. Hal Singer and John Craig started the *Mark-8 Newsletter* to provide information for fellow users of the Mark-8. (Craig later became the editor of *Kilobaud*.) The Southern California Computer Society produced a newsletter called *Interface*. After David Ahl left DEC, he started *Creative Computing*, which had the bright and mirthful air of its somewhat rumpled and clever editor. *ROM* offered regular contributions from iconoclasts such as Lee Felsenstein and Ted Nelson, and a "chipcake" centerfold of the droid R2D2.

This crop of magazines spread the word about microcomputing and enabled hobbyists in the most far-flung parts of the country to stay current on personal-computing trends. As personal computers matured into a big business in the 1980s, explaining them became a great satellite industry. The demand for information about computers seemed to grow faster than the demand for the equipment itself.

Computer books were now hot. Computer-technology sections appeared in both the chain stores and mom-and-pop bookstores, and began to eat up shelf space. At least a few writers and several publishing houses were making a lot of money on books that explained how to use software, the very same task that a user manual was designed to accomplish. In one legendary deal, a publisher paid a $1.1 million advance for *The Whole Earth Software Catalog*, a book that offered reviews of software products. The huge advance was thought fair even though many of the reviews would already be out of date before the book was published, recalled Stewart Brand, who coordinated the project.

Industry magazines were evolving right along with the products they featured. The more technically geared magazines, like *Byte*, spanned platforms (such as computers running the CP/M operating system, IBM PCs, and Macintosh computers) in their coverage and addressed readers interested in all kinds of computers. As the computer became more of a consumer product and the computer market settled into one of two camps, IBM-compatible or Macintosh, magazines became more platform-specific in their coverage. The change was inevitable, because an IBM owner had no use for an article about Macintosh software, and vice versa. These new publications offered elaborate product reviews that helped customers to assess the relative merits of hardware and software. Good reviews were invaluable to vendors. “Product reviews made all the difference,” said Seymour Rubinstein, founder of MicroPro International, which sold the popular WordStar software.

Among the more prolific computer publishers was David Bunnell of MITS, who launched an array of successful computer magazines, including *PC Magazine*, *PC World*, *MacWorld*, *Publish*, and *New Media*, and in 1996 became publisher of the computer-business magazine *Upside*. Bunnell had founded *PC Magazine* right after the IBM PC debuted, and he published it out of his San Francisco home.

The first issue in January 1982 included a review of John Draper’s EasyWriter word processor that was entitled “Not So Easy Writer.” The product never fully recovered from the review. The first issue of *PC Magazine* was 100 pages and chock-full of ads, including one from IBM. The second issue went to 400 pages. A year later Bunnell was looking for an outside investor or even a buyer. Both publishing giants Bill Ziff of Ziff-Davis and Pat McGovern of IDG coveted the magazine. Bunnell thought he had an agreement with McGovern, but his initial investor struck a separate deal with Ziff. Bunnell and his staff were furious and resigned en masse to start the rival *PC World* for IDG. Bunnell thus has the distinction of having started both of the leading magazines for PC users.

Despite its staff's departure, *PC Magazine* became a fabulous success. Ziff, too, had a formula. He invested a large initial sum to stake out his territory, then let the paid circulation, product-oriented text, and flashy look and feel do the rest. The formula usually worked well, although he had some conspicuous failures, such as *Corporate Computing* in 1992. Eventually, Ziff grew tired of managing the company and in 1994 sold it to an investment bank that turned it over two years later to a Japanese entrepreneur for $2.1 billion.

Bunnell's *PC World* also thrived, and by the late 1990s both *PC World* and *PC Magazine* boasted million-plus circulations that brought in a great tide of ad revenues. Both magazines routinely published issues as thick as phone books. "Getting ads was so easy," said Bunnell. "All you had to do was answer the phone."

The computer magazines single-handedly resurrected mail-order computer sales. As customers became more product savvy, they no longer shied away from buying products sight unseen, especially if a magazine had covered the gear in one of its articles. "Mail-order advertising occurred overnight," said Bunnell. This trend contributed to the rise of Dell Computer and other firms whose businesses were based on direct sales to customers. Mail order also contributed to the downfall of some retail chains. In retrospect, mail order was a harbinger of events to come with the explosive growth of the Internet.

Computer magazines were changing, but remained an important vehicle for promoting and communicating new products and ideas. Another effective method over the years for getting the message across was the computer show.

Word of Mouth: The Clubs and Shows

> *The First Computer Faire was definitely a torn-T-shirt, computer-junkie crowd. It was a gas. We didn't know what the hell we were doing. The exhibitors didn't know what they were doing. The attendees didn't know what to expect. But we pulled it off.*
>
> –Jim Warren, computer-industry pioneer

Computer clubs and shows were the public forums of the early micro world. They not only offered hobbyists an entree into an interesting social club, but also supplied otherwise-unobtainable news about product releases and industry innovations. The clubs provided ongoing support for hobbyists and featured free and wide-ranging discussions about products, which often led to the publication of another newsletter. The fairs were technology spectacles, and their carnival atmosphere ignited each attendee's enthusiasm for the growing field. They also gave hobbyists the opportunity to try out the latest novelties with their own hands.

Clubs

Homebrew Computer Club, with Lee Felsenstein presiding and other microcomputer pioneers in attendance, served as the prototype of the computer-enthusiast club. The group's candid assessments of market offerings had an impact that reached far beyond the four walls of the club's meeting room. Its influence reached user groups all over the country. When the magazines emerged, they sent reporters to cover the Homebrew meetings, spreading the club's influence even farther. The Homebrew Computer Club's opinion could be critical to a company's success. Processor Technology, Apple, and Cromemco all profited from Homebrew endorsements. Many other corporations received less flattering appraisals, which were felt in their sales figures.

The first Homebrewers realized early on that they could affect the image and the future of the computer industry itself. Prior to 1975, computers were associated with technicians in lab coats—the "high priests" of the big machines—who would retire to an air-conditioned environment with a problem to solve and emerge sometime later with a printout. The Homebrew Computer Club helped replace that vision with one of rugged, if not ragged, individualism in which solo mental efforts could lead to multimillion-dollar companies. The Homebrewers felt that they had a duty to chart a road map of the future. The first edition of the club's newsletter, issued in March 1975, predicted that home computers would perform tasks ranging from editing text and storing information to controlling household appliances and doing the housework (robotically) to instructing users and providing pleasant diversions.

Like Homebrew, the Amateur Computer Group of New Jersey (ACGNJ) became an arbiter and conduit for the new technology. For instance, the founders of Technical Design Labs of Trenton, New Jersey, started their company by selling used computer terminals at the ACGNJ meetings.

One early club that was run more like a professional organization than an informal group of hobbyists was the Boston Computer Society (BCS), even though its founder, Jonathan Rotenberg, was 13 when he started it. Rotenberg eventually developed BCS into a 7,000-member organization with 22 different committees, a resource center, and a lengthy list of industry and corporate sponsors. Rotenberg would later insist that BCS was a “users’ group, not a club.” BCS and the other users’ groups were computer clubs that had developed into something more. They served as informal think tanks, social groups, and arenas for the exchange of information. The clubs fostered a spirit of voluntarism and adherence to consumer advocacy that was carried over into the users’ groups. These groups worked to protect computer buyers to an extent that was unprecedented for any American industry. Committees worked diligently against shoddiness in manufacturing and deception in advertising. The clubs were responsible for directing the efforts of the free-spirited microcomputer manufacturers of the day. Without the feedback from the clubs, the early hobbyist-oriented microcomputers might never have developed into useful personal computers.

Shows

For the hobbyist shopping for hardware, nothing substituted for a hands-on demonstration of a new product. For that reason, and for that taste of “the future is now” that sends the imagination into orbit, hobbyists flocked to the computer shows.

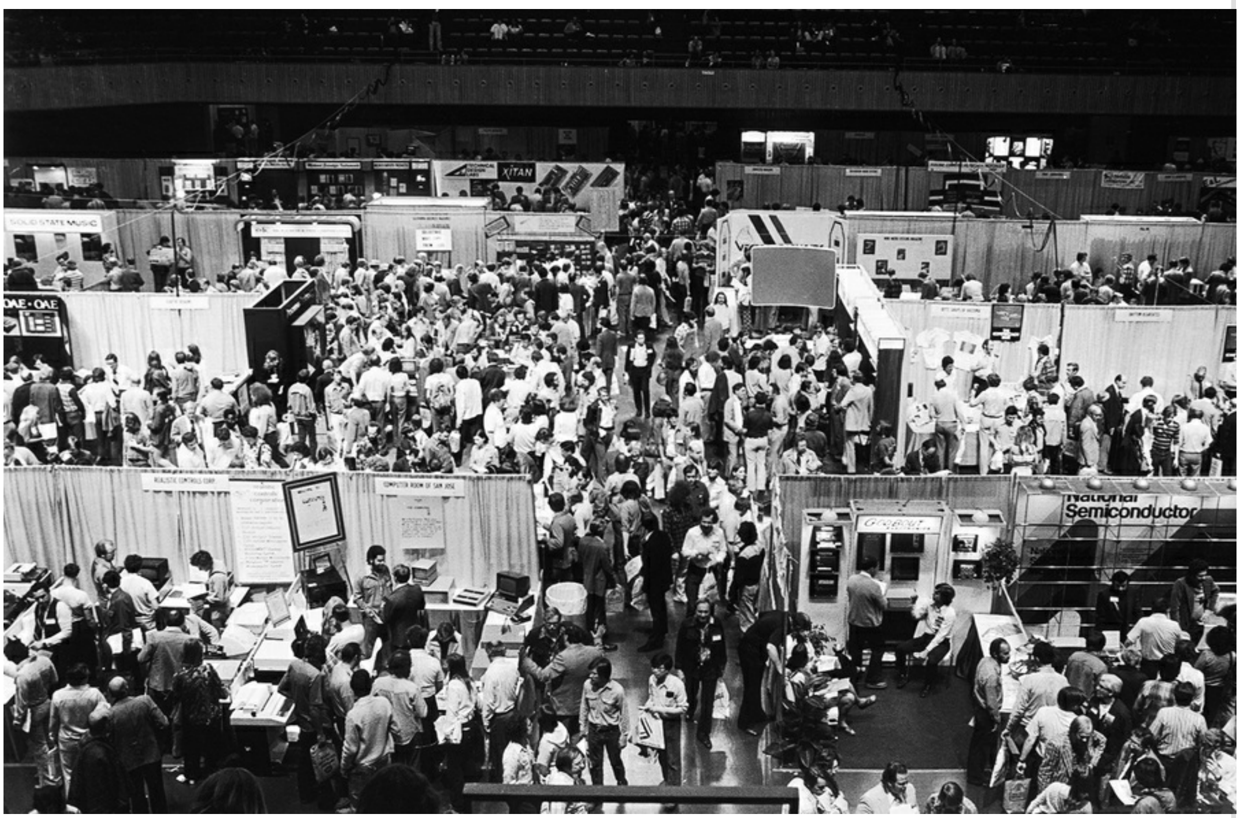

Figure 48. West Coast Computer Faire ***Right from the start, the computer shows tapped the pent-up demand for personal computers and information about them.*** **(Courtesy of David H. Ahl)**

The first microcomputer fair to attract a sizable crowd was a single-company event. Early in 1976, David Bunnell of MITS began promoting the World Altair Computer Convention in Albuquerque in the MITS news organ *Computer Notes*. By the time the event took place in March, several hundred people turned out.

Among the speakers was *Computer Lib* author Ted Nelson, who delivered a scandalous and wildly entertaining speech on what he called “psycho-acoustic dildonics.” Lee Felsenstein (of Homebrew Computer Club, Community Memory project, and Processor Technology fame) was surprised some audience members didn’t drag Nelson off the stage during his carefully detailed explication of computer technology’s potential contribution to sex toys. After this off-the-wall presentation, Nelson talked to several people about setting up a computer store in the Chicago area. Nelson was a provocateur, but he understood that these computers were going to be big business.

MITS chief Ed Roberts planned the conference as a showcase for MITS and only MITS. He refused to give booth space to competitors such as Processor Technology. Proc Tech’s Lee Felsenstein and Bob Marsh were undaunted. Felsenstein suggested to Marsh that the two of them set up shop in a hotel room during the conference. "Great idea,” Marsh answered. They nabbed the penthouse suite and posted signs around the conference floor inviting people to drop by. They demonstrated Steve Dompier’s Target using the television set as their video display monitor. Because the Sol wasn’t ready, they had an Altair on hand. When Ed Roberts stopped by, it was the first time that he and Felsenstein had spoken since Lee criticized the Altair in *Dr. Dobb’s Journal*.

More shows soon followed in other places around the country. In May 1976, Sol Libes of ACGNJ put together the Trenton (New Jersey) Computer Festival, something of a hardware swap meet and discussion session. The fair pioneered the idea of an open computer conference that wasn’t tied to a single manufacturer. It also showed Californians that the microcomputer revolution was not confined to the West Coast. Featured speakers included premier hobbyist Hal Chamberlin from North Carolina, and David Ahl and Dr. Bob Suding of Denver. Ahl and Suding’s Digital Group had just received advance copies of the Z80 chip from Federico Faggin’s new semiconductor company, Zilog, and were raving about what could be done with this hot chip.

What started on the coasts soon spread across the country. In June 1976, a loosely organized group of hobbyists staged the first Midwest Area Computer Club conference. The inaugural event drew nearly 4,000 people. Midwest dealer Ray Borrill shared a booth with Processor Technology, which displayed its new Sol-20 computer. Borrill and Proc Tech sold thousands of dollars’ worth of parts and supplies, and because they hadn’t thought to bring along a cash box, money was stacked in piles on the table. By the end of the show, people were snapping up whatever was left in the booth, just to buy something. The computer-hobbyist fever was running high.

Then in August 1976, in Atlantic City, New Jersey, hobbyist John Dilks staged the Personal Computing Festival. This show was significant for being the first national computer show. This event helped popularize the term *personal computing*. Before that festival most people spoke in terms of hobby computing or microcomputing. Wayne Green’s *Kilobaud* magazine booth at the festival took in more than a thousand subscriptions. Peter Jennings bought the KIM-1 computer that he would later use to write Microchess. Other such shows were held in 1976, including events in Denver and Detroit.

But not in California. *Dr. Dobb’s Journal* editor Jim Warren had both an appreciation of these festive get-togethers and a gnawing sense that something was out of whack. “My myopic contention was that all of this good stuff was happening on the wrong coast,” he said. A week or two before the Atlantic City show, Warren commenced planning a show for the San Francisco Bay Area. He decided to call it a computer faire after the medieval summer spectacles in Elizabethan England. It was an apt name, he thought. A Renaissance faire celebrates the past; the computer faire would celebrate the future. In April 1977, Jim Warren staged the first West Coast Computer Faire.

When David Bunnell got wind of Warren’s plans, he contacted him on behalf of MITS. Bunnell said MITS was also planning a West Coast show, and suggested that the two merge their efforts and stage a conference sponsored by *Personal Computing* magazine. Warren would get 10 percent of the gate and profit further from his partner’s greater experience and professional acumen. Warren wasn’t at all comfortable with this proposal. He didn’t consider it appropriate that he, as editor of *Dr. Dobb’s*, be involved in a show sponsored by *Personal Computing* or any other magazine. He was also uneasy about the emphasis on money. “I wasn’t thinking about doing a big-bucks thing at all,” he recalled. “I just wanted to stage this event. I’d done the be-ins in the ’60s. I just wanted this [computer fair] stuff happening out here.”

Warren tried to reserve some space at Stanford University for his event but couldn’t get the dates he wanted. He then looked into the San Francisco Civic Auditorium. It would be a great spot for the event, he thought. It had excellent conference facilities and a splendid exhibition room. He asked how much it would cost. Rental was $1,200 per day. He was stunned.

Later that day, Warren got a bite to eat with Bob Albrecht at a restaurant called Pete’s Harbor. They did some figuring on a table napkin. If they could get at least 60 exhibitors, charge them around $300 each, and draw maybe six or seven thousand people, they could break even. What the hell, Warren thought, they could actually make money on the event. That’s the precise moment when he founded his company Computer Faire.

Figure 49. West Coast Computer Faire exhibitor ***An exhibitor getting ready for the first West Coast Computer Faire in 1977*** **(Courtesy of David H. Ahl)**

As it turned out, Warren greatly underestimated the attendance figures. He had hoped to draw 7,000 to 10,000 people between Saturday and Sunday. Instead, almost 13,000 showed up. For several hours on Saturday morning, two lines of attendees stretched around one side of the auditorium and three lines stretched around the other side to the back of the building. It was a clear and windy day, and fairgoers stood in line chatting with each other. It took an hour to get through the door, but no one seemed to care. The fair had begun outside during the discussions among individuals who were equally rabid about computers.

Once inside, attendees found themselves in computer heaven. Rows and rows of festively decorated booths touted the latest advances in personal computing. An inquiring hobbyist could find him- or herself chatting up the very person who had designed some innovative product. Company presidents in T-shirts and blue jeans staffed a number of booths. The Apple II was unveiled in a large and rather attractive booth staffed by Steve Jobs, Mike Scott, and other Apple executives. Gordon Eubanks demonstrated his BASIC-E in a booth he shared with Gary Kildall. The Commodore PET was also introduced at the event.

Sphere had failed to rent booth space, but still made its presence known. The Sphere folks parked the Spheremobile, a 20-foot motor home modeled after MITS’s Blue Goose, out front and sent an employee to walk through the fair wearing a placard saying, “Come see the Sphere.” The excitement could be felt everywhere. “It was like a toy store at Christmas. It was mobbed,” said attendee Lyall Morrill. Among the many cosponsors were the Homebrew Computer Club, the Southern California Computer Society, PCC, and the Stanford Electrical Engineering Department. Science-fiction writer Frederick Pohl spoke, as did Ted Nelson, Lee Felsenstein, Carl Helmers, and David Ahl. Everyone agreed it was a gas.

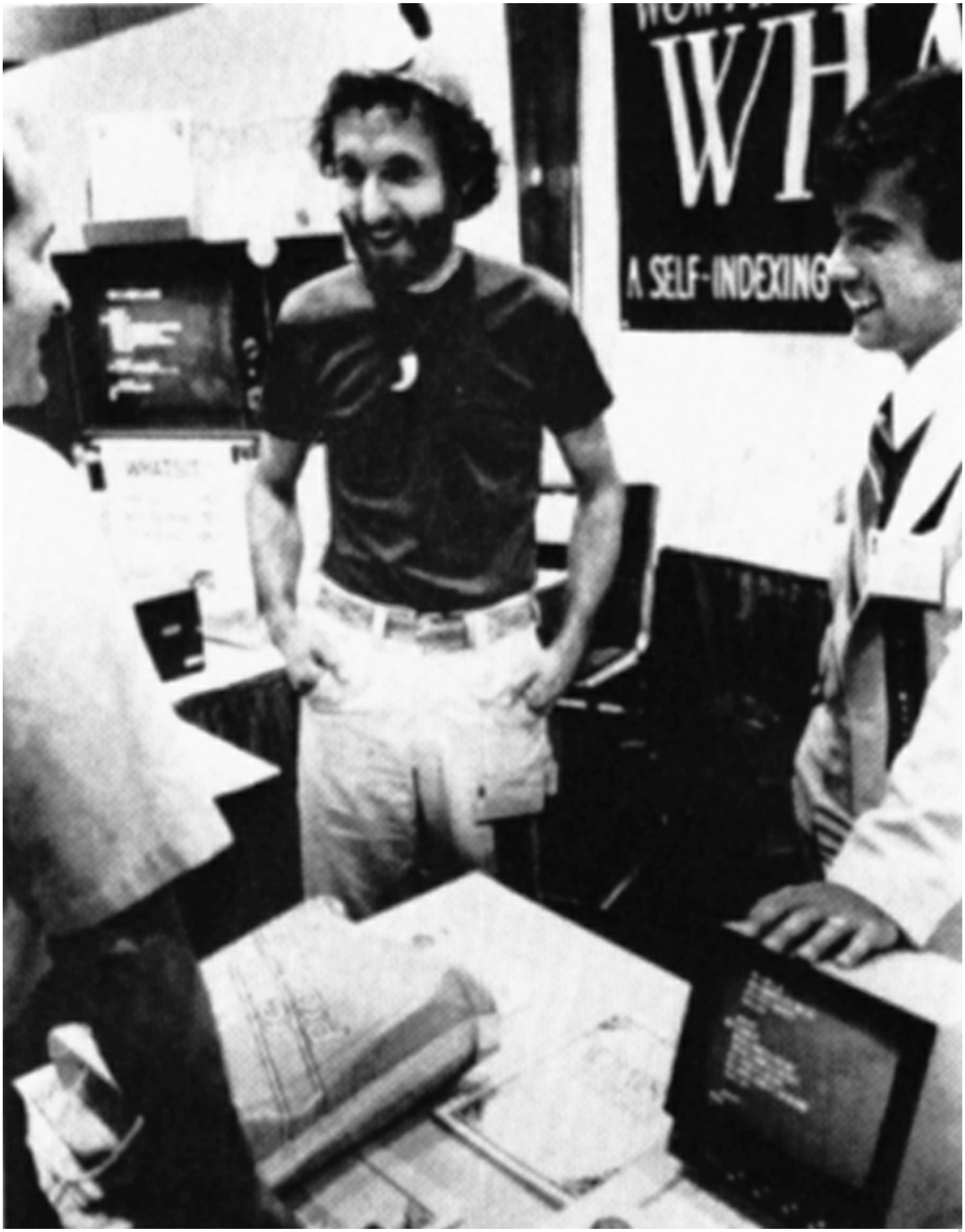

Figure 50. Lyall Morrill and Bill Baker *Early software entrepreneurs Lyall Morrill (left) and Bill Baker talk with a customer at the second West Coast Computer Faire.* **(Courtesy of Paul Terrell)**

Jim Warren spent most of the weekend in a whirlwind, racing around to smooth out little snafus. At subsequent faires, he saved time by dashing around the convention halls on roller skates. Even while attending to the administrative duties, Warren was as thrilled to be there as everyone else. “It was the excitement of turning all those people on,” he recalled. He felt proud of his accomplishment. The first West Coast Computer Faire was three to four times larger than any previous computer show. It also led to the first published proceedings of a personal-computer conference. Warren had made his contribution to the industry by staging this watershed event.

Before the first West Coast Computer Faire even opened, Warren had decided to stage a second one. It took place in March 1978, in San Jose, California. Exhibit space was sold out a month in advance. Lyall Morrill once again was on hand, but this time he represented his own software company, Computer Headware. “Either by the luck of the draw or the strange humor of Jim Warren, my booth was positioned next to the IBM booth,” he noted. The contrast between the two booths was striking. IBM had mounted a slick chrome booth staffed by men in business suits and polished dress shoes. The booth featured the IBM 5110, a relatively expensive desktop minicomputer that didn’t particularly impress the attendees.

Morrill, wearing a propeller-topped beanie, was showing off his software package, a simple database-management program called WHATSIT, a loose acronym for Wow! How’d All That Stuff Get In There? He had created his signs the night before with a felt-tip pen. Jim Warren enjoyed the IBM–Computer Headware juxtaposition so much that he had photos taken of Morrill socializing with the IBM staff.

IBM and Computer Headware’s sales results by the close of the faire were as far apart as their corporate style. IBM got just a few orders, whereas Morrill was besieged with them. Customers queued up at his booth, credit cards in hand, to buy his program.

The second West Coast Computer Faire was such a great success that Warren decided to do one every year. If, as Carl Helmers said, the magazines defined the microcomputer community, shows such as Warren’s gave the community a meeting place.

Hand-Holding: The First Retailers

We didn’t want to sell Altairs. We wanted to solve problems.

–Dick Heiser, computer retailer

The first personal-computer store appeared not long after the Altair announcement. Its origin had very little to do with the usual motives or starting a retail business.

The First Personal-Computer Store

On June 15, 1975, 125 hobbyists and computer novices gathered in the recreation room of the Laurel Tree Apartments in Miraleste, California. Digital engineer Don Tarbell and computer neophyte Judge Pearce Young had brought them together to form the Southern California Computer Society. The participants engaged in a lively debate over the structure and purpose of the club. At one point, someone asked for a showing of hands of those who either owned or had ordered an Altair. A forest of hands popped up from the crowd.

Dick Heiser, a systems analyst who was among the assembled, was struck by the response. He realized that these Altair customers were going to have a lot of questions about assembling their kits. He thought that maybe he could be of help. Heiser had recently spent $14,000 building a video word processor for a low-cost minicomputer. With the introduction of the Altair, he realized that he could write a similar program for it for about $4,000. He was familiar with the innards of a computer and was eager to work on an Altair.

Heiser then had a brainstorm: why not set up a small storefront to market the Altair kits and provide advice and support for buyers? Heiser had little business experience and never imagined working as a salesman, but he knew that he’d have fun putting his technical skills to use. He wondered whether it could be profitable. He sat down and devised a cash-flow plan. If he paid $200 in rent per month and sold around 10 to 20 assembled computers at $439 each, he could stay in the black. It seemed to be worth a try.

In June 1975, Heiser flew to Albuquerque to talk to the people at MITS. The MITS execs weren’t sure what to make of Dick Heiser. Ed Roberts thought he was a “nice guy” but lacked the aggressiveness that marked a born entrepreneur. Roberts also worried about Heiser’s profit margin. MITS was selling the Altair kits for $395 ($439 assembled), which left skimpy profits. MITS couldn’t afford to discount its prices for anyone. Roberts hadn’t built any room for discounts into the Altair’s asking price. Heiser could buy the kits, assemble them, and sell them at the assembled price, for a pitiful 10 percent margin. Despite all this, Roberts took Heiser seriously. Others had approached MITS with the retailing idea, but Heiser was the first to come with a spreadsheet. “They thought I was a little weird,” Heiser recalled, “but they told me it sounded like a good idea, and we signed a contract.”

Heiser leased a small space for $225 a month in a low-rent area of West Los Angeles and launched the world's first computer store. In mid-July, he opened for business. In large letters across the front of his store he advertised the outlet's official name, Arrow Head Computer Company. In smaller letters, below the name, he added the tag line "The Computer Store" because he thought it sounded "funky" and interesting. Soon everyone was calling the outlet The Computer Store.

It was a strange kind of store. Heiser, an imposing figure with his beard and cowboy hat, would be engaged in a serious technical discussion with a hobbyist one minute, and the next minute be assuring a skeptic that the Altair, despite its low price, was truly a computer. When not attending to customers, he'd hole up in the back room where he repaired equipment and worked on his own computer, which he was still in the process of soldering together.

Heiser quickly discovered that his spreadsheet was seriously in error. He had anticipated getting a small but steady stream of individual computer purchases at $439 each, the price of an assembled Altair. Instead, he found that someone who was buying a computer could easily spend another $4,000 on accessories—extra memory, video terminals, disk drives, and such. It was his first small excursion into retailing and Heiser was amazed that so many people were willing to spend real money on these machines. In his first month, he took in between $5,000 and $10,000, and in his first five months in excess of $100,000. By the end of 1975, he was ringing up more than $30,000 in sales per month.

Heiser did little advertising other than posting flyers at large engineering firms such as System Development Corporation, Rand, and TRW. As a result, most of his early customers were engineers, who were typically computer enthusiasts who had moved to California to work in high technology. This being Southern California, he also got his share of celebrities: Herbie Hancock, Bob Newhart, and Carl Sagan visited The Computer Store. But the clientele consisted mainly of hobbyists.

Heiser's Challenges

A customer base consisting exclusively of hobbyists was probably just as well, because the process of assembling an Altair generated each and every problem Heiser anticipated. "It was really tough in those days," he recalled. "You had to know electronics as well as software. You had to bring up the raw machine, and you had to use the toggle switches to put in the bootstrap loader," he said, describing the various steps required to get an Altair up and working. Buyers who stumbled at various points en route to setting up their Altairs came running back to Heiser, who patiently instructed them about careful assembly, repaired any malfunctions, and lent a sympathetic ear to complaints about the MITS memory boards.

Although Heiser was selling enough computers to make a healthy profit, a careful accounting of his and his employees' time would have shown that most of their time was spent explaining the technology, repairing machines, setting up systems, and reassuring customers. Hand-holding, community building, proselytizing. It worked, but it sure wasn't the business-school model of retail sales.

The Computer Store was not without some local competition. In late November 1975, John French opened his Computer Mart in a small rented office suite. French offered the IMSAI, which was simply a better piece of computer hardware than the Altair. On the other hand, Heiser, with Gates and Allen's BASIC computer language, had the superior software offering. Software was the more important ingredient of the two, but because BASIC could run on French's machines, French thrived along with Heiser. Eventually, French sold his interest in Computer Mart and invested in his friend Dick Wilcox's computer company Alpha Micro.

Heiser also faced competition from a group of devout Indian Sikhs in Pasadena. Although American by birth and upbringing, they embraced the culture of their Indian ancestors. They also embraced cutting-edge technology. "For them, it wasn't, 'Let's sit by the river and meditate,'" Heiser observed. Dressed in their turbans and white coats, the Sikhs sold computers manufactured by Processor Technology, and later sold Apple products. Heiser respected them immensely. Like him, they cared more about solving a customer's problems than moving more inventory.

In May 1976, Heiser moved The Computer Store to Santa Monica to a facility four times the size of the one in West Los Angeles. He now had several employees and was making $50,000 to $60,000 a month. He installed carpets and desks that made the store look like the offices of a bank executive. Customers would sit across the desk from a salesperson to discuss system requirements and how best to meet them. Heiser saw himself as more of a counselor than an entrepreneur. The problem-solving approach also gave him personal satisfaction. "I'm a computer enthusiast and a compulsive explainer," he said.

One problem that he simply couldn't solve nagged at Heiser. MITS was pressuring him into making questionable deals with his customers. MITS bound the purchase of Gates and Allen's BASIC to the purchase of the notoriously defective MITS memory boards. Heiser understood the value of the BASIC, but he realized that no one wanted to buy memory boards that didn't work and he simply didn't want to carry them.

"We went through a lot of grief trying to make a viable computer system and a viable computer business when we didn't have any memory devices," he said. Then MITS decreed that Altair outlets would sell only its products and no one else's. MITS was worried that if its retailers also offered competitors' wares, customers would buy the MITS software but reject its hardware. As it turned out, the company's worries were unfounded given that most of the early computer stores quickly sold out of whatever they got their hands on. Heiser complained to Ed Roberts, but Roberts was adamant and, according to Heiser, threatened to shut down dealers who disobeyed his edict. This policy of exclusivity cost MITS many dealers, but Heiser remained loyal and reluctantly abided by the rules until Roberts sold MITS to Pertec.

Heiser concluded that if MITS was out of touch, Pertec must be roaming the ether. Thinking it could inject MITS with much-needed capital and a proper business orientation, Pertec called a meeting of MITS's 40 dealers. Heiser listened to the Pertec representatives' marketing ideas but didn't think much of them. Pertec figured that if it could sell one computer to General Motors, for instance, the automotive giant would return to Pertec for its next 600 computers. Retailers would soon be filling 600-item orders left and right. The company would rocket into the Fortune 500.

Heiser was amazed at Pertec's naivete. It was clear to him that the company was oblivious to the problems it had acquired with MITS. At the end of the meeting, Heiser stood up and said that Pertec would have to deal with the immediate problems if it ever hoped to succeed financially with MITS. At that point, Heiser began making plans to go his own way and started stocking other computers, including the Apple II and the PET.

Dick Heiser watched the computer retailing scene change dramatically over the coming years. Discounters entered the market. They employed salespeople with no technical backgrounds who sold machines "with the staples still in the box," Heiser said. "They may as well have been selling canned peaches." It was becoming increasingly difficult for Heiser to maintain his standards of excellence. In March 1982, he left the store for good.

Like many of the personal-computer pioneers, Heiser had broken new ground through his unflagging enthusiasm for the technology. Even in retailing, the hobbyist ideal led the way. But unlike computer design, which can be done for love or for money, retailing is necessarily a commercial venture. Computer retailing quickly attracted individuals more aggressive than Heiser, including Paul Terrell.

Byte Shop

Paul Terrell's friends warned him that retailing computers would never work. Some people, Terrell mused, also said it never snowed in Silicon Valley. Terrell recalled his friends' warnings as he watched snow drifting down on December 8, 1975—the day he opened his Mountain View Altair dealership, Byte Shop, in the heart of Silicon Valley. Like all the other Altair dealers, Terrell soon ran headlong into the MITS exclusivity policy, except that Terrell chose to ignore it. He was selling all the Altairs he could get, between 10 and 50 a month, plus anything else he could get from IMSAI and Proc Tech. The MITS edict, Terrell concluded, was not only pointless but, if he followed it, financially harmful as well.

Figure 51. Byte Shop *The original Mountain View Byte Shop* (Courtesy of Paul Terrell)

It wasn't long before David Bunnell, then MITS vice president of marketing, called to cancel Byte Shop's Altair dealership. Terrell argued that MITS should regard Byte Shop as something like a stereo store that carried many different brands and could turn a profit for them all. Bunnell waffled. It was Roberts's decision, he said. At the World Altair Computer Convention in March 1976, Terrell approached Roberts directly about his being dropped from the roster of MITS dealers. Roberts stood firm. Terrell was out.

Figure 52. Inside Byte Shop ***Paul Terrell opened Byte Shop in 1975 in Mountain View, CA.*** **(Courtesy of Paul Terrell)**

At the time, Terrell was selling twice as many IMSAIs as Altairs, and he consoled himself with the fact that MITS's policy of excommunicating the unfaithful would ultimately hurt Roberts more than his dealers. Terrell was still selling whatever he could stock. As Terrell saw it, he and John French, Dick Heiser's Computer Mart competitor in Orange County, were responsible for most of IMSAI's early business. They used to do battle for the product. Terrell would rent a van and drive to the loading dock at IMSAI's manufacturing site in Hayward to collect his and French's orders. Check in hand, Terrell would ask, "You want cash on the barrelhead, boys?" It was hardware war.

Terrell had opened Byte Shop in December 1975. By January, people who wanted to open their own stores were approaching him. He signed dealership agreements with them in which he would take a percentage of their profits in exchange for the name and business guidance. Other

Byte Shops soon appeared in Santa Clara, San Jose, Palo Alto, and Portland. In March 1976, Terrell incorporated as Byte, Inc.

Terrell was part of the hobbyist community. He named his store after the leading hobbyist magazine, and he insisted that Byte Shop managers in the Northern California area attend meetings of the Homebrew Computer Club.

A single Homebrew meeting might have a half-dozen Byte Shop managers in attendance. “If I had a store manager that didn’t attend the club meetings, he wasn’t going to be my store manager for long. It was that important,” Terrell said. At one Homebrew meeting, a longhaired youth approached him and asked Terrell if he might be interested in a computer that a friend named Steve Wozniak had designed while working out of a garage. Steve Jobs was trying to convince Terrell to carry the Apple I. Terrell told Steve Jobs he had a deal.

Terrell discovered, as Dick Heiser had before him, that customers needed help assembling the machines and obtaining the proper accessories. He got the idea to offer his customers “kit insurance.” For an extra $50, he would guarantee to solve any problems that arose in the course of putting the computers together. Terrell understood that he was doing true specialty retailing and so he had to provide essential information and a certain amount of hand-holding. Terrell likened computer stores to the stereo stores of a decade or two earlier, when clerks routinely had to explain woofers, tweeters, and watts of power to puzzled customers.

Byte Shop’s cachet soared after the July 1976 issue of *Business Week* described the chain of stores and suggested that it offered significant opportunity to investors. “We had something like five thousand inquiries come in,” Terrell said. He found himself talking to people such as the president of the Federal Reserve Bank. The chairman of Telex Corporation called to ask if Oklahoma was available for franchising. “The credentials [of the callers] were staggering,” Terrell said.

The chain was adding eight stores a month, and Terrell had negotiated a price for an 8080 chip below what IBM was paying. (IBM was not yet building a microcomputer.) By the time Terrell sold Byte Shop operation in November 1977, he had 74 stores operating in 15 states and Japan. He valued the chain at $4 million.

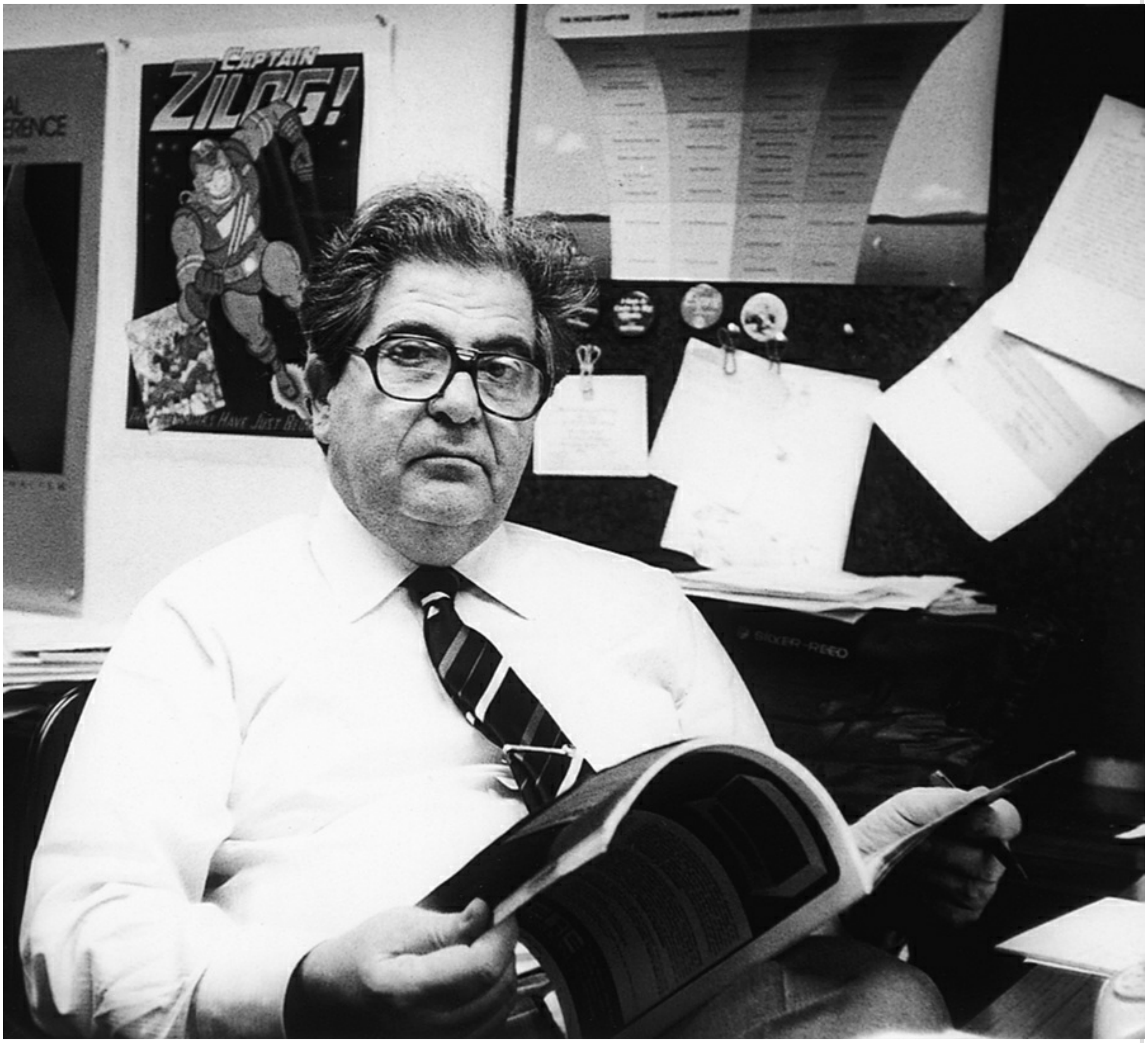

Figure 53. Stan Veit ***Veit founded Computer Mart in New York, one of the first computer stores.***
(Courtesy of Paul Freiberger)

Other computer stores were popping up in many parts of the country, many starting out as Altair dealers then defecting to carry other brands. Dick Brown opened a shop also called The Computer Store on Route 128 in Burlington, Massachusetts. On Long Island, Stan Veit didn't like the MITS deal from the start and launched his store selling anything he could get his hands on.

In the Midwest, Ray Borrill opened Data Domain in early 1976, with the aim of "out-Terrelling" Paul Terrell. Borrill quickly spun off nearly a dozen affiliated stores from his first outlet in

Bloomington, Indiana. He also helped start the Chicago-based Itty-Bitty Machine Company, an ill-fated venture that was conceived during conversations with Ted Nelson at the World Altair Computer Convention.

With computer stores opening across the country, countertop sales had clearly started to elbow aside mail order. At computer-club meetings, Terrell reminded the assembled over and over again, “You don’t have to buy through mail order any more.” Relief from the potential hazards of buying through mail order was one of the best selling points the new retailers could offer.

While running Byte Shop, Terrell began marketing his own brand of computer. Called the Byte 8, it was a private-label product with a profit margin close to 50 percent, twice the average retailer’s 25 percent margin. It proved to be an easy commercial success. “All of a sudden, I realized the power of distribution that Tandy/Radio Shack had. Guaranteed sales.” Tandy, a huge electronics distributor, much bigger than Terrell’s chain, had not yet ventured into computers, although some microcomputer retailers feared Tandy in the way that microcomputer makers feared Texas Instruments. Neither group had cause to worry—for the moment.

Franchising

IMSAI was a manufacturing company run by a sales force. The San Leandro, California, manufacturer of the 80 Micro computer cared little if its products featured the latest technological breakthroughs. IMSAI thrived for a time on its vigorous sales effort and ultimately failed through sheer neglect of its production and customer-service side. It is fitting that IMSAI’s most lasting contribution to the personal-computer field was a sales enterprise—a chain of retail stores, a computer franchise—ComputerLand, started by Ed Faber in 1976.

Faber was an old hand at start-up operations. In 1957, he joined IBM as a sales representative. In 1966, IBM tapped Faber to help develop a department called New Business Marketing, which was designed to ease IBM into the small-business area. Faber helped create a business plan that would include a newly assembled sales force and a fresh marketing concept for the company. This was his first start-up operation, and he relished the challenge. He identified problems, devised solutions for them, and then, as corporate start-up strategies inevitably go, he had to deal with a set of new problems created by the solutions. By 1967, Faber decided he wanted his career to revolve around start-ups, an unusual choice at IBM at the time.

In 1969, after 12 years with IBM, Faber left to join Memorex. At Memorex, and later at a minicomputer company, Faber was hired to build the internal marketing organization. A pattern was developing. After he had created and launched a program, he wanted to move on.

In 1975, Bill Millard invited Faber to join him at start-up IMSAI. Millard described the IMSAI opportunity in lavish terms, which Faber automatically suspected was overstatement. The idea of selling kit computers through the mail for buyers to assemble at home seemed preposterous to Faber, the IBM man. But Faber couldn’t argue with the market’s response to kit computers.

IMSAI was knee-deep in orders. At the end of December 1975, he joined IMSAI as its director of sales.

Almost immediately, Faber was in contact with John French, Dick Heiser’s competitor in Southern California. French had approached IMSAI with the idea of buying kits in quantity and retailing them through a computer store. Again, Faber was dumbfounded. Sell computers to customers right off the street? The idea was ludicrous, he thought. On the other hand, Heiser’s retail operation was more than solvent, and IMSAI had little to lose. Faber sold French 10 computer kits at a 10 percent discount, not much for a retailer to work with. French quickly moved the 10 units out the door and was asking for another 15. More orders followed. Other retailers were contacting Faber seeking similar deals. By March 1976, IMSAI had raised its price in order to give retailers a 25 percent margin.

Faber had an excellent reason for courting the dealers. Selling computers to retailers in batches of 10 or 15 was much easier than selling single units to individuals over the telephone. Furthermore, the retail market was wide open. The MITS exclusivity policy was forcing dealers over to IMSAI. Not only were Altair dealers required to carry the MITS line and nothing else, but late arrivals were geographically subservient to early ones, who had established “territory.” Enterprising dealers such as Paul Terrell chafed at the restrictions and ended up bolting to freedom.

The MITS retailing strategy amazed Faber. Ed Roberts sought to dominate his dealers and compel their loyalty. Given the entrepreneurial spirit of the time, Faber predicted that dealers would eventually balk at attempts to control them, and Roberts’s marketing tactics would backfire on him. Defiantly, Faber took a stance in complete opposition to Roberts’s. He encouraged nonexclusivity in the kinds of products dealers could sell, and the freedom to open outlets wherever they pleased. If two dealers wanted to open stores a block away from each other, it was fine with Faber if they competed for sales. IMSAI products would vie with any others on the dealers’ shelves.

By the end of June 1976, some 235 independent stores in the United States and Canada were carrying IMSAI products.

Faber kept an eye on the competing dealers, making note of their relative strengths and weaknesses. Most of them, he realized, were hobbyists with scant experience running a business. Their inexperience was reason enough to fail, he thought; however, they weren’t failing. They were buying more and more merchandise from IMSAI and selling it almost as soon as it came in. In addition, the number of retailers was growing steadily.

Bill Millard got together with Ed Faber to discuss the phenomenon. They wondered what would happen if someone with a well-recognized name started providing comprehensive services, including product purchasing, continuing education, and accounting systems for a network of small, retail storeowners. They were both thinking franchise. They couldn't find one reason not to start a franchise operation. Faber talked to John Martin, a former associate of Dick Brown's who was knowledgeable about that kind of business, and Faber attended a seminar on franchising offered through Pepperdine University. When Faber sat down with Millard to talk about launching the operation, Millard asked Faber what he would choose to do. Faber sensed the *est* in this question and replied that he wanted to be in charge of the franchising operation.

ComputerLand incorporated on September 21, 1976, with Faber as president and Millard as board chairman, and opened its pilot store in Hayward, California, on November 10 of that year. This store served not only as a retail outlet, but also as a training facility for franchise owners. Gordon French, who had helped start the Homebrew Computer Club, worked for ComputerLand early on, helping to evaluate products and establish the pilot store before moving on to do consulting work. ComputerLand eventually sold the flagship outlet and became a pure franchise operation owning no stores at all. The first ComputerLand franchise store opened on February 18, 1977, in Morristown, New Jersey. The second store appeared soon thereafter in West Los Angeles. The stores initially offered products manufactured by IMSAI, Proc Tech, PolyMorphic, Southwest Tech, and Cromemco, the last being one of the first manufacturers to support the new enterprise. Cromemco's Roger Melen and Harry Garland told Faber they thought the franchise was a terrific idea and gave him one of the best discounts then available.

ComputerLand went on to achieve spectacular success as the nation's largest chain of computer stores. At the close of 1977, it had 24 stores; by June 1983, 458 ComputerLand stores were operating. ComputerLand outdistanced the Byte Shop chain, and its fiercely competitive practices helped bury the Data Domain chain in the Midwest. In the early 1980s, Faber could reasonably claim that, as far as the general public was concerned, the place to buy computers was ComputerLand.

In 1982, the chain launched plans for a string of software stores called ComputerLand Satellites. ComputerLand intended to license the new software stores to existing franchise owners in its chain. By 1983, Ed Faber conceived a five-year plan that had him semiretired and living in some bucolic setting. He loved to fish and hunt game fowl and was looking forward to a little relaxation. But for the moment, he was busy squelching the competition. To spur the performance of his franchise, whenever he could he opened a ComputerLand outlet near a store belonging to his biggest rival, the new Radio Shack Computer Centers chain.

The Big Players

Not a kit, the TRS-80 comes completely wired and tested, ready to plug in and use.

–A Tandy Corporation press release

Ed Roberts had seen the well-heeled established electronics companies come crashing into the calculator business, cutting margins to the bone and driving out the little guys. He and the other “little guys” who had created this nascent microcomputer industry dreaded the day when the big guys would enter their world.

In 1977, it looked like it was about to happen, and the company that was going to change the nature of the game was a retailer, the leading electronics distributor, with stores in nearly every town in the country. Tandy/Radio Shack was going to make and sell its own microcomputer.

Tandy

Computer retailing at the time, even when it was profitable, was still more about building community than pushing products. Ray Borrill’s store in Bloomington, Indiana, was typical: in 1977 the store employed repair technicians and programmers, but no salespeople. Borrill himself was the closest thing the store had to a salesperson, but his conversations with customers ranged from broad discussions of the power of microcomputers to risky promises of what Borrill’s team could put together for the customer, promises based mostly on how much “fun” Borrill thought the project would be: that is, how challenging it was.

The specter of Radio Shack loomed over Borrill and the other retailers as much as over the computer companies. None of them could compete with this powerhouse. Or so it seemed.

The Tandy Corporation began as a wholesale leather business. In 1927, Dave Tandy and his friend Norton Hinckley founded the Hinckley-Tandy Leather Company, which soon established a solid reputation around Fort Worth. In 1950, Tandy’s son Charles, a graduate of Harvard Business School, conceived of expanding the business into a chain of leathercraft stores that would sell goods partly by retail and partly by mail order. Cofounder Hinckley balked at the idea and left the Tandy Leather Company.

Charles Tandy had an engaging, magnetic personality and a dry sense of humor, and he seemed to have an influence on everyone around him. He was an inveterate instructor who was engrossed in the daily operations of the company. When he had nothing else to do on a Friday afternoon, he would phone his retail outlets to ask how business was doing.

Tandy quickly set about building a national retail chain. By 1961, he had 125 stores in 105 cities in the United States and Canada. In 1962, Tandy bought a company that fundamentally changed the nature of the corporation. Tandy got wind of a small, nearly bankrupt chain of nine mail-order electronics stores called Radio Shack. He took control of the Boston-based company in 1963 and at once began reconstructing it, adding hundreds of retail stores throughout the country. Before Tandy took over, Radio Shack had been losing $4 million annually. Within two years after Tandy bought the chain, it was turning a profit. By 1973, when Radio Shack purchased its closest competitor, Allied Radio of Chicago, Radio Shack so dominated the market that the Justice Department brought an antitrust suit against it and compelled Tandy to divest itself of the corporation.

Tandy had begun manufacturing some of its own wares in 1966, but resisted making microcomputers when they arrived on the scene, even though some Tandy employees were caught up in the computer hobbyist movement. The behemoth chain was pushed into microcomputer manufacturing chiefly by one man: Don French.

French was a buyer for Radio Shack in 1975 when the Altair was released. He bought one as soon as he could and thoroughly studied it. Concluding that microcomputing had potential, French began to concoct his own machine. Although forbidden to develop his computer on company time, French eventually managed to convince John Roach, then vice president of marketing at Radio Shack, to take a look at his project. As French recalls, Roach was not particularly impressed with French's efforts. Nonetheless, Radio Shack offered Steve Leininger of National Semiconductor payment to examine French's design. Leininger needed no arm-twisting, and by June 1976 he and French were working together on the project, using equipment and software of their own design.

The TRS-80

French and Leininger received the official go-ahead to develop a Radio Shack computer in December 1976, even though the firm was only casually committed to their project. Radio Shack told French to "get it done as cheaply as possible." This was a more encouraging statement than the one he had heard a few months earlier when a Radio Shack executive had telexed French saying, "Don't waste my time. We can't sell computers."

Tandy was, however, protecting its turf. When Bill Millard and Ed Faber launched ComputerLand in 1976, it was under the name Computer Shack. That was too close for Tandy's comfort, and the company notified Faber that it intended to protect its trademark. Faber stood firm, seeking a court judgment in California. Tandy immediately sued in New Jersey. Faber got the message: Tandy was going to sue him state-by-state, keeping him tied up in court forever. He quietly changed the name of his franchise to ComputerLand.

In January 1977, just a month after they began work on the project, French and Leininger had a working model. They demonstrated their new machine for Charles Tandy in the Radio Shack conference room. The keyboard and display sat on the table, but the computer itself lay hidden beneath it. The two engineers had devised a simple tax-accounting program, H & R Shack, and asked the magnate to try it out. Tandy typed in a salary of $150,000 for himself and promptly crashed the program. After French and Leininger explained the limits of integer arithmetic in BASIC, Tandy gracefully entered a much smaller figure, but French made a mental note that the machine needed better math capabilities.

Serious work began on the machine a few months later. The company projected a retail price of $199 and sales of 1,000 units per year. French thought that the 1,000-unit figure was absurd. MITS had sold more than 10,000 Altairs in a year without the overwhelming advantage of Radio Shack's retail network. French wasn't too sure the $199 price was right, either.

Soon after that, Tandy and Roach met with computer-division personnel to discuss what to do with the little computer if it failed to sell. Could they at least use it for internal Radio Shack accounting? After all, French was doing some simple record keeping on his handmade version. If nothing else, the company's own stores could serve as a backup customer base and absorb the first year's projected production.

Radio Shack announced its new TRS-80 in August at New York City's Warwick Hotel. The $199 price hadn't survived; the machine would retail for $399 and come complete and ready to use in a black-and-gray plastic case. By September 1977, with projected sales at 3,000 units annually, Radio Shack stores had already sold 10,000 TRS-80s.

Back in June 1977, Radio Shack gave French the task of establishing retail outlets for the TRS-80. The computer was the orphan of the Radio Shack family. The company wasn't sure how successful it would be, and didn't take it that seriously. When the TRS-80 was introduced, Radio Shack outlets didn't even stock it—customers needed to special-order the company's own product.

Tandy management's hesitation about selling computers was in part based on the accurate assessment that computer sales weren't like calculator or answering machine sales. There was a reason why existing computer stores operated as they did: customers needed a lot of support and hand-holding. Computer retailing really was still about community building and support more than about moving products. This was not the Radio Shack model.

Tandy/Radio Shack ventured out a bit into the computer retailing business when it opened its first all-computer store in Fort Worth in October 1977. The outlet carried not only the TRS-80, but also IMSAIs and other companies' products. It was regarded as an experiment. But that venture succeeded, too, and resistance to microcomputers began fading away within the Tandy Corporation ranks. Radio Shack outlets began stocking the TRS-80s, and Radio Shack Computer Centers were appearing all over the country, staffed by individuals who knew more about computers than the average electronics salesperson. The backlog of orders was tremendous: in June 1978, Radio Shack president Lewis Kornfeld admitted that only about one-third of the stores had TRS-80s in stock, though over half had sold some.

Charles Tandy celebrated his sixtieth birthday in style, making an entrance to his birthday party astride an elephant. A few months later, on a Saturday afternoon in November 1978, Tandy died in his sleep. The following Monday, the value of the Tandy Corporation stock dropped 10 percent on Wall Street. But the Tandy Corporation was not a one-man show. Charles Tandy had surrounded himself with capable executives, and after his death the company retained a solid financial footing.

The original TRS-80 was fairly limited in what it could do. It had only 4K of memory, a Z80 processor running at slightly under half its rated speed, a sketchy BASIC, and very slow tape cassettes for data storage. Most of these limitations stemmed from the company's cut-rate approach to manufacturing. The first TRS-80 lacked the capability to type lowercase letters. This was not an oversight. French and Leininger had deliberately omitted them to save $1.50 on parts, which translated to $5 on the purchase price.

Tandy quickly supplemented the TRS-80 with a better BASIC and add-on memory kits, and soon after that offered a combination disk drive and printer. These enhancements were a prelude to Tandy's announcement, on May 30, 1979, of the TRS-80 Model II, a respectable business system that overcame many of the drawbacks of the original model. The Model II showed that Tandy had learned from its mistakes with the first TRS-80 and was capable of creating a state-of-the-art business machine. This surprised some, given Tandy's underpowered entry into the personal-computer field.

Between 1978 and 1980, personal computers and related equipment rose from 1.8 to 12.7 percent of Radio Shack's North American sales. In 1980, Radio Shack introduced a spate of new machines. Its Pocket Computer, slightly larger than an advanced calculator with four times the memory of the original Altair, sold for $229. Its Color Computer, at $399, offered graphics in eight colors and up to 16K of memory. And the TRS-80 Model II was an upgrade of the Model I.

The TRS-80 Model I was a price breakthrough, and people who knew nothing about computers began buying Model Is. Far from driving the little guys out, this actually expanded the market and helped to legitimize microcomputers in the eyes of the general public. Tandy's toylike machines and reputation as a hobbyist's company didn't do much for the idea of the microcomputer as a business tool, although some businesses did experiment with TRS-80s. But the home/hobby computer market began to expand rapidly.

Commodore

Tandy was not the only company driving prices down, thereby opening the market for home computers. Nolan Bushnell's Atari, which initially produced only video-game machines, began putting out low-priced devices that could legitimately be called computers. Texas Instruments, the company that so many microcomputer manufacturers feared would announce a bargain-basement computer, did just that with its TI-99/4. And in Britain, a daring and brilliant entrepreneur named Clive Sinclair introduced a tiny computer called the ZX80, which was distributed by Timex and sold for under $50.

But Commodore, with its strong distribution channels for its electronics equipment and its own semiconductor design capabilities, was perceived as the greatest threat.

Commodore International was a Canadian electronics-products firm founded and run by Jack Tramiel, an Auschwitz survivor and a hard-driving businessman. In the early 1970s it had been heavily focused on selling pocket calculators using TI chips. When TI jumped into the industry itself, Commodore went from $60 million in annual sales to a $5 million loss.

Tramiel’s reaction was to move the company to Palo Alto, purchase chip company MOS Technology, and hire its lead designer, Chuck Peddle. Peddle had shaken up the market with his 6502 microprocessor, a chip that could sell for $25, about a sixth the going price for such chips.

Peddle had also designed a computer of his own, and had tried unsuccessfully to sell it to Tandy. When the Commodore PET debuted in early 1977, it was a worthy competitor to Radio Shack’s TRS-80 and another new computer that was getting a lot of attention, the Apple II. Tramiel immediately took it worldwide, dominating the early European market.

But Peddle was just getting warmed up. After a brief move to Apple, Peddle returned to Commodore and developed a line of computers that led to the spectacularly successful Commodore 64. By 1983, it was the best-selling computer in the world, and Tramiel had made it difficult for competitors to gain any ground against Commodore by cutting its price to $200.

But while Commodore, TI, and other well-financed companies were getting into the game, in the early 1980s the toughest competition Tandy faced came from a Silicon Valley firm financed by the sale of two calculators and a Volkswagen bus.

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Chapter 7

Apple

> *I try to get people to see what I see. When you run a company, you have to get people to buy into your dreams.*
>
> *Steve Jobs*

It was the prototypical Silicon Valley start-up story: two smart boys with a driving passion and an angel investor, all three of them willing to risk it all for a chance at the gold ring. Conceived at a Homebrew meeting and launched on April Fool's Day, Apple would grow to be the most valuable company in the world. But it started with two bored teenagers playing with scavenged electronics.

Jobs and Woz

Woz was fortunate to hook up with an evangelist.

—Regis McKenna, high-tech marketing guru

There were still orchards in Santa Clara Valley.

But by the 1960s it was no longer the largest fruit-producing area in the world. It was starting to transition to urban sprawl as the electronics and semiconductor companies began taking over, and for the son of an engineer in Sunnyvale it was easier to pick up a spare transistor than to find somewhere to pick an apple.

The Prankster

In 1962, an eighth-grade boy in Sunnyvale built an addition-subtraction machine out of a few transistors and some parts. He did all the work himself, soldering wires in the backyard of his suburban home in the heart of what became Silicon Valley. And when he entered the machine in a local science fair, no one who knew him was surprised that he won the top award for electronics. He had designed a tic-tac-toe machine two years earlier and, with a little help from his engineer dad, had assembled a crystal radio in the second grade.

The boy, born Stephen Gary Wozniak, but called Woz by his friends, was brilliant, and when a problem caught his interest, he worked relentlessly to solve it. When he enrolled in Homestead High School in 1964, Woz quickly became one of the top math students there, although electronics remained his true passion. Unfortunately for the teachers and administrators of Homestead High, that wasn’t his only passion.

Woz was a prankster, and he applied the same ingenuity and determination to carrying out his practical jokes as he did to building electronics. He spent hours at school concocting the perfect prank. His jokes were clever and well executed, and he usually emerged from them unscathed.

But not always. Once, Woz got the bright idea to wire up an electronic metronome and plant it inside a friend’s locker, its bomblike ticking audible to anyone standing nearby. “Just the ticking would have sufficed,” Woz said, “but I taped together some battery cylinders with the labeling removed. I also had a switch that sped up the ticking when the locker was opened.” But it was the high-school principal who fell for the trick. Bravely snatching the “bomb” from the locker, he ran out of the building with it. Wozniak thought the whole incident was hilarious. Post-9/11 he would probably have been expelled. At the time, the principal showed his appreciation of the joke by suspending Woz for two days.

The Cream Soda Computer

Soon after that, Steve Wozniak's electronics teacher, John McCullum, decided to take him in tow. Woz clearly found high school less than stimulating, and McCullum saw that his pupil needed a genuine challenge. Although Woz loved electronics, the class McCullum taught was nowhere near demanding enough. McCullum worked out an arrangement with Sylvania Electronics whereby Wozniak could visit the company's nearby facilities during school hours to use their computers.

Woz was enthralled. For the first time, he saw the capabilities of a real computer. One of the machines he played with was a Digital Equipment Corporation PDP-8 minicomputer. "Play" for Woz was an intense and engrossing activity. He read the PDP-8 manual from cover to cover, soaking up the information about instruction sets, registers, bits, and Boolean algebra. He studied the manuals for the chips inside the PDP-8. Confident of his newfound expertise, within weeks Woz began drawing up plans for his own version of the PDP-8.

"I designed most of the PDP-8 on paper just for the heck of it. Then I started looking for other computer manuals. I would redesign each [computer] over and over, trying to reduce my chip count, and using newer and newer TTL chips in my designs. I never had a way to get the chips to build one of these designs as my own."

He knew that he was going to build computers himself one day—he hadn't the slightest doubt of that. But he wanted to build them *now*.

During the years Steve Wozniak attended Homestead High, semiconductor technology advances made possible the creation of minicomputers like the PDP-8. The PDP-8 was one of the most popular, while the Nova, produced by Data General in 1969, was one of the most elegant. Woz was enchanted by the Nova. He loved the way its programmers had packed so much power into a few simple instructions. The Data General software was not just powerful; it was beautiful. The computer's chassis also appealed to him. While his buddies were plastering posters of rock stars on their bedroom walls, Woz covered his with photos of the Nova and brochures from Data General. He then decided—and it became the biggest goal in his life—that he would one day own his own computer.

Woz was not the only student in Silicon Valley with electronics dreams. Many of his fellow students at Homestead High had parents in the electronics industry. Having grown up with new technology around them, these kids were accustomed to watching their parents play around with oscilloscopes and soldering irons in the garage. And Homestead High had teachers who encouraged their students' interests in technology. Woz may have followed his dream more single-mindedly than the others, but the dream was not his alone.

The dream was, however, highly unrealistic. In 1969, it was almost unthinkable that individuals could own their own computers. Even minicomputers like the Nova and the PDP-8 were priced to sell to research laboratories. Nevertheless, Woz went on dreaming. He did well on his college entrance exams but hadn't given much thought to which college to attend. When he eventually made his choice, it had nothing to do with academics. On a visit to the University of Colorado with some friends, the California boy saw snow for the first time and was enchanted. He concluded that Colorado would suffice. His father agreed he could go there for a year, at least.

At the University of Colorado, Woz played bridge intensely, designed more computers on paper, and engineered pranks. After creating a device to jam the television in his college dorm, he told trusting hallmates that the television was badly grounded, and they would have to move the outside antenna around until they got a clear picture. When he had one of them on the roof in a sufficiently awkward position, he quietly turned off his jammer and restored the television reception. His hallmate remained contorted on the roof, for the public good, until the prank was revealed.

Woz took a graduate computer class and got an A+. But the computer center allocated the computer's time jealously and Woz wrote so many programs that he ran his class over its computer-time budget by a large multiple. His professor instructed the computer center to bill him. Woz was afraid to tell his parents and he never went back to school there. After his first year, he came home and attended a local college. For a summer job in 1971, he worked at a small computer company called Tenet Incorporated that built a medium-scale computer. He enjoyed it enough to stay on into the fall rather than returning to school.

The same summer he started work, Woz and his old high school friend Bill Fernandez actually built a computer out of parts rejected by local manufacturers because of cosmetic defects. Woz and Fernandez stayed up late cataloging the parts on the Fernandez family's living-room carpet. Within a week, Woz showed up at his friend's house with a cryptic penciled diagram. "This is a computer," Woz told Fernandez. "Let's build it." They worked far into the night, soldering connections and drinking cream soda. When they finished, they named their creation the Cream Soda Computer; it had the same sort of lights and switches as the Altair would more than three years later.

Woz and Fernandez telephoned the local newspaper to boast about their computer. A reporter and a photographer arrived at the Fernandez house, sniffing out a possible "local prodigy" cover story. But when Woz and Fernandez plugged in the Cream Soda Computer and began to run a program, the power supply overheated. The computer literally went up in smoke, and with it Woz's chance for fame, at least for the moment. Woz laughed the incident off and went back to his paper designs.

The Two Steves Meet

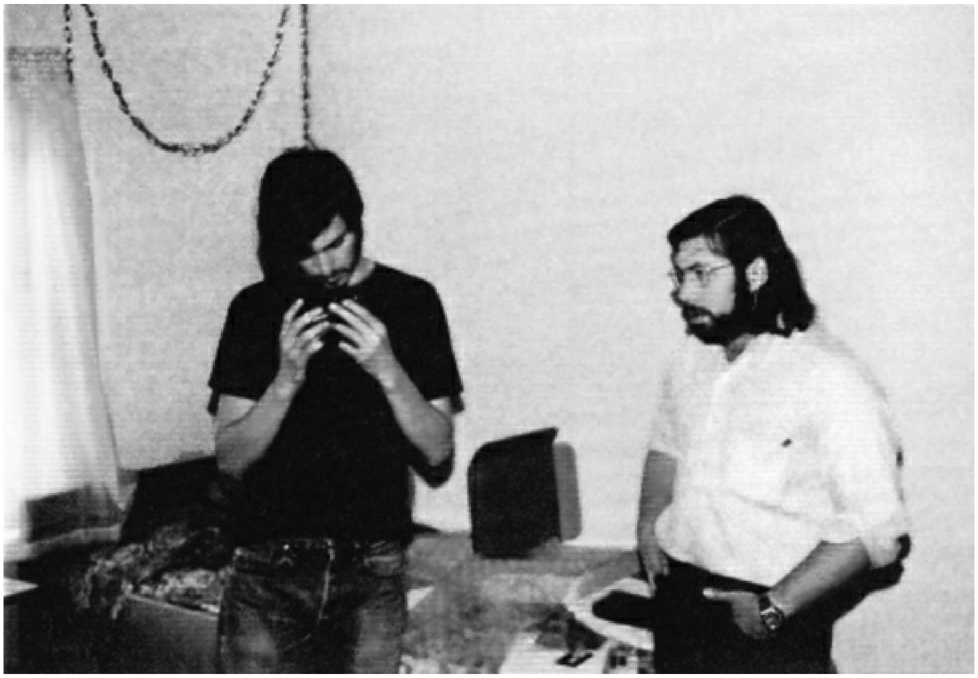


Figure 54. Steve Jobs and Steve Wozniak ***Jobs and Woz look over an early Apple I circuit board.*** **(Courtesy of Margaret Kern Wozniak)**

Besides assisting with the Cream Soda Computer, Bill Fernandez did something that would profoundly change the life of his friend. He introduced Woz to another electronics hobbyist, an old friend of his from junior high school. Although a good number of Silicon Valley students were interested in electronics because their parents were engineers, this friend, a couple of years behind Fernandez in school, was an anomaly in that respect. His parents were blue-collar workers, unconnected to the computer industry. This friend, a quiet, intense, long-haired boy, was named Steven Paul Jobs.

Although Jobs was five years younger than Woz, the two hit it off immediately. Both were fascinated with electronics. In Woz’s case, this led to the concentrated study of schematics and manuals and lengthy sessions designing electronic gadgets. Jobs was as intense as Woz, but his passion showed itself in different ways, and it sometimes got him into trouble.

Jobs confessed to being a terror as a child. He claimed that he would have “ended up in jail” if it hadn’t been for a teacher, Mrs. Hill, who moved him ahead a year to separate him from a boisterous buddy. Mrs. Hill also bribed Jobs to study. “In just two weeks, she had figured me out,” Jobs recalled. “She told me she’d give me five dollars to finish a workbook.” Later, she bought him a camera kit. He learned a lot that year.

As an adolescent, Jobs had an unshakable self-confidence. When he ran out of parts for an electronics project he was working on, he simply picked up the phone and called William

Hewlett, cofounder of Hewlett-Packard. “I’m Steve Jobs,” he told Hewlett, “and I was wondering if you had any spare parts I could use to build a frequency counter.” Hewlett was understandably taken aback by the call, but Jobs got his parts. The 12-year-old was not only very convincing but also surprisingly enterprising. He made money at Homestead High by buying a broken stereo or other piece of electronic equipment, fixing it, and selling it at a profit.

But it was a mutual love of practical jokes that cemented the relationship. Jobs, Woz discovered, was another born prankster. This led the two to engage in a rather shady early business enterprise.

Blue Boxes

Woz returned to school, this time to the University of California at Berkeley, to study engineering. He had resolved to take school more seriously and even enrolled in several graduate courses. He did well, even though by the end of the school year he was spending most of his time with Steve Jobs building blue boxes.

Woz first learned about these sneaky devices for tricking the phone network and making free long-distance phone calls in a piece in *Esquire* magazine. The story described a colorful character who used such a device as he crisscrossed the country in his van, the FBI panting in pursuit. Although the story was a blend of fiction and truth, the descriptions of the blue box sounded very plausible to the budding engineer. Before Woz even finished the piece, he was on the phone to Steve Jobs, reading him the juicy parts.

The *Esquire* story was drawn from the extraordinary real-life experiences of John Draper, a.k.a. Captain Crunch. Draper had discovered that a whistle included in boxes of Cap’n Crunch cereal had an interesting ability. Blow the whistle directly into a telephone receiver and it would exactly mimic the tones that caused the central telephone circuitry to release a long-distance trunk line. With it, you could make long-distance calls for free.

Draper expanded on this trick with electronics, essentially inventing phone phreaking and becoming its prime practitioner, traveling around the country showing people how to build and operate these blue boxes. True phreaking, purists said, was motivated solely by the intellectual challenge of getting past a complex network of circuits and switches. The telephone company, however, took a dim view of the enterprise and prosecuted the phreaks whenever it could catch them.

With his customary thoroughness, Wozniak collected articles on phone-phreaking devices of all kinds. In a few months, he had become a phone-phreaking expert himself, known to insiders by the nickname Berkeley Blue. Perhaps it was inevitable that Woz’s newfound infamy would get back to the man who had inspired him. One night a van pulled up outside Woz’s dorm.

Wozniak was thrilled to meet John Draper. The two quickly became good friends, and together they used phone-phreak techniques to tap information from computers all over the United States. At least once they listened in on an FBI phone conversation, according to Wozniak.

It was Jobs, however, who made this pastime turn a profit. Jobs got into phone phreaking, too, later claiming that he and Woz had called around the world several times and once woke the Pope with a blue-box call. Soon Wozniak and Jobs had a neat little business marketing phone-phreaking boxes. “We sold a ton of ’em,” Woz would later confess. When Jobs was still in high school, Woz made most of the sales to students in the Berkeley dorms. In the fall of 1972, when Jobs entered Reed College in Oregon, they were able to broaden their market.


COMPUTER
MARTIN

Figure 55. Dan Kottke and Steve Jobs ***Kottke traveled to India with Jobs and later worked for Apple. Here he and Jobs are manning the booth at an early computer show.*** **(Courtesy of Dan Kottke)**

Buddhism

Jobs had considered going to Stanford, where he had attended some classes during high school. "But everyone there knew what they wanted to do with their lives," he said. "And I didn't know what I wanted to do with my life at all." On a trip to Reed, he had fallen in love with the school, seeing it as a place where "nobody knew what they were going to do. They were trying to find out about life." When Reed accepted him, he was ecstatic.

But once at Reed, Jobs lived as a recluse. As the son of working-class parents, he may have felt out of place in a school populated largely by upper-class youths. He began investigating Eastern religions, staying up late at night with his friend Dan Kottke to discuss Buddhism. They devoured dozens of books on philosophy and religion, and at one point Jobs became interested in primal therapy.

In the year Jobs spent at Reed, he seldom attended class. After six months, he dropped out but managed to remain in the dorm. "The school sort of gave me an unofficial scholarship. They let me live on campus and looked the other way." He remained for over a year, attending classes when he felt like it, spending much of his time studying philosophy and meditating. He converted to vegetarianism and lived on Roman Meal cereal, a box of which cost less than 50 cents and would feed him for a week. At parties he tended to sit quietly in a corner. Jobs seemed to be clearing things out of his life, searching for some utter simplicity.

Although Woz had little interest in Jobs's nontechnical pursuits, his friendship with Jobs remained strong. Woz frequently drove up to Oregon on weekends to visit Jobs.

Breakout

Woz took a summer job in 1973 at Hewlett-Packard, joining Bill Fernandez, who was already working there. Woz had only just finished his junior year, but the lure of Silicon Valley's most prestigious electronics company was hard to resist. College would have to wait once again as Woz continued his education in the firm's calculator division. This was the pre-Altair era when calculators were a hot commodity, and HP was manufacturing the HP-35 programmable calculator. Wozniak realized just how much the device resembled a computer. "It had this little chip, serial registers, and an instruction set," he thought. "Except for its I/O, it's a computer." He studied the calculator design with the same energy that he had applied to the minicomputers of his high-school days.

After his year at Reed College, Jobs returned to Silicon Valley and took a job with a young video-game company called Atari. He stayed until he had saved enough money for a trip to India that he and Dan Kottke had planned. The two had long discussions about the Kainchi Ashram and its famous inhabitant, Neem Karoli Baba, a holy man described in the popular book *Be Here Now*. Jobs rendezvoused with Kottke in India, and together they searched for the ashram. When they learned that Neem Karoli Baba had died, they drifted around India, reading and talking about philosophy.

When Kottke ran out of money, Jobs gave him several hundred dollars. Kottke went on a meditation retreat for a month. Jobs didn't go with him, but instead wandered the subcontinent for a few months before returning to California. On his return, Jobs went back to work for Atari and reconnected with his friend Woz, who was still at HP. Jobs himself had worked at Hewlett-Packard years before, on the strength of that brazen phone call to Bill Hewlett asking for spare parts. Now he was at Atari, and though he was still just as brash and just as convinced that he could get anything he wanted, he had been changed in subtle ways by his year at Reed and his experiences in India.

Woz was still a jokester at heart. Every morning before he left for work he would change the outgoing message on his telephone answering machine. In a gravelly voice and thick accent, he would recite his Polish joke for the day. Woz's Dial-A-Joke phone number became the most frequently called phone number in the San Francisco Bay Area, and he had to argue more than once with the telephone company to keep it going. The Polish American Congress sent him a letter asking him to cease and desist with the jokes, even though Woz himself was of Polish extraction. So Wozniak simply made Italians the butt of his jokes instead. When the attention faded, he went back to Polish jokes.

In the early 1970s, computer arcade games were becoming popular. When Woz spotted one of those games, Pong, in a bowling alley, he was inspired. "I can make one of those," he thought, and immediately went home and designed a video game. Even though its marketability was questionable (when a player missed the moving blip, "OH SHIT" flashed on the screen), the programming on the game was first-rate. When Woz demonstrated his game for Atari, the company offered him a job on the spot. Being comfortable with his position at HP, Woz turned them down.

But he was devoting much of his time to Atari technology. Woz had already dropped a small fortune in quarters into arcade games when Jobs, who often worked nights, began sneaking him into the Atari factory. Woz could play the games for free, sometimes for eight hours at a stretch. It worked out well for Jobs, too. "If I had a problem, I'd say, 'Hey, Woz,' and he'd come and help me."

At the time, Atari wanted to produce a new game, and company founder Nolan Bushnell gave Jobs his ideas for what came to be called Breakout, a fast-paced game in which the player controls a paddle to hit a ball that breaks through a wall, piece by piece. Jobs boasted he could design the game in four days, secretly planning to enlist Woz’s help.

Jobs was always very persuasive, but in this case he didn’t have to bring out the thumbscrews to get his friend to help him. Woz stayed up for four straight nights designing the game, and still managed to put in his regular hours at Hewlett-Packard. In the daytime, Jobs would work at putting the device together, and at night Woz would examine what he’d done and perfect the design. They finished it in four days.

The experience taught them something: they could work well together on a tough project with a tight deadline and succeed.

Woz also learned something else, but not until much later. The $350 Jobs gave Woz as his share for the work was considerably less than the $6,650 cut that Jobs kept for himself. With Jobs, friendship only went so far.

Starting Apple

I met the two Steves. They showed me the Apple I. I thought they were really right on.

—Mike Markkula

Jobs and Woz had discovered that they were a good team. Jobs, inspired by the blue box and Breakout experiences, was eager to find a way to make this pay off. But the inspiration would have to come from Woz, and it was Homebrew that gave him that inspiration.

Woz Discovers Homebrew

Breakout wasn’t Woz’s only extracurricular project while at HP. He also designed and built a computer terminal. Jobs had heard that a local company that rented computer time needed an inexpensive home terminal to access the company’s large computer. Jobs told Woz about it, and Woz designed a small device that used a television set for a display, much like Don Lancaster’s TV Typewriter. More significantly, around this same time Woz began attending the Homebrew Computer Club meetings.

Homebrew was a revelation for Woz. For the first time, he found himself surrounded by people who shared his love for computers, and who were more knowledgeable about computers than any of his friends, or sometimes even himself. He attended his first Homebrew meeting only because a friend of his at HP told him a new club was forming for people interested in computer terminals. When he first arrived at Gordon French’s suburban garage, he felt a little out of place. Club members were talking about the latest chips, the 8008 and the 8080, and Woz was unfamiliar with them. There, too, he learned about this new computer an individual could actually buy, called the Altair. Club members were interested in the video terminal he designed, however, and that encouraged Woz. He went home and studied up on the latest microprocessor chips. He bought the first issue of *Byte* and made it a point to attend the biweekly Homebrew Computer Club meetings.

Woz was inspired by Jim Warren’s and Lee Felsenstein’s visions that these devices could and should be used for social good. These things could help stop wars, he thought as he listened to Felsenstein talk about using computers for the antiwar movement.

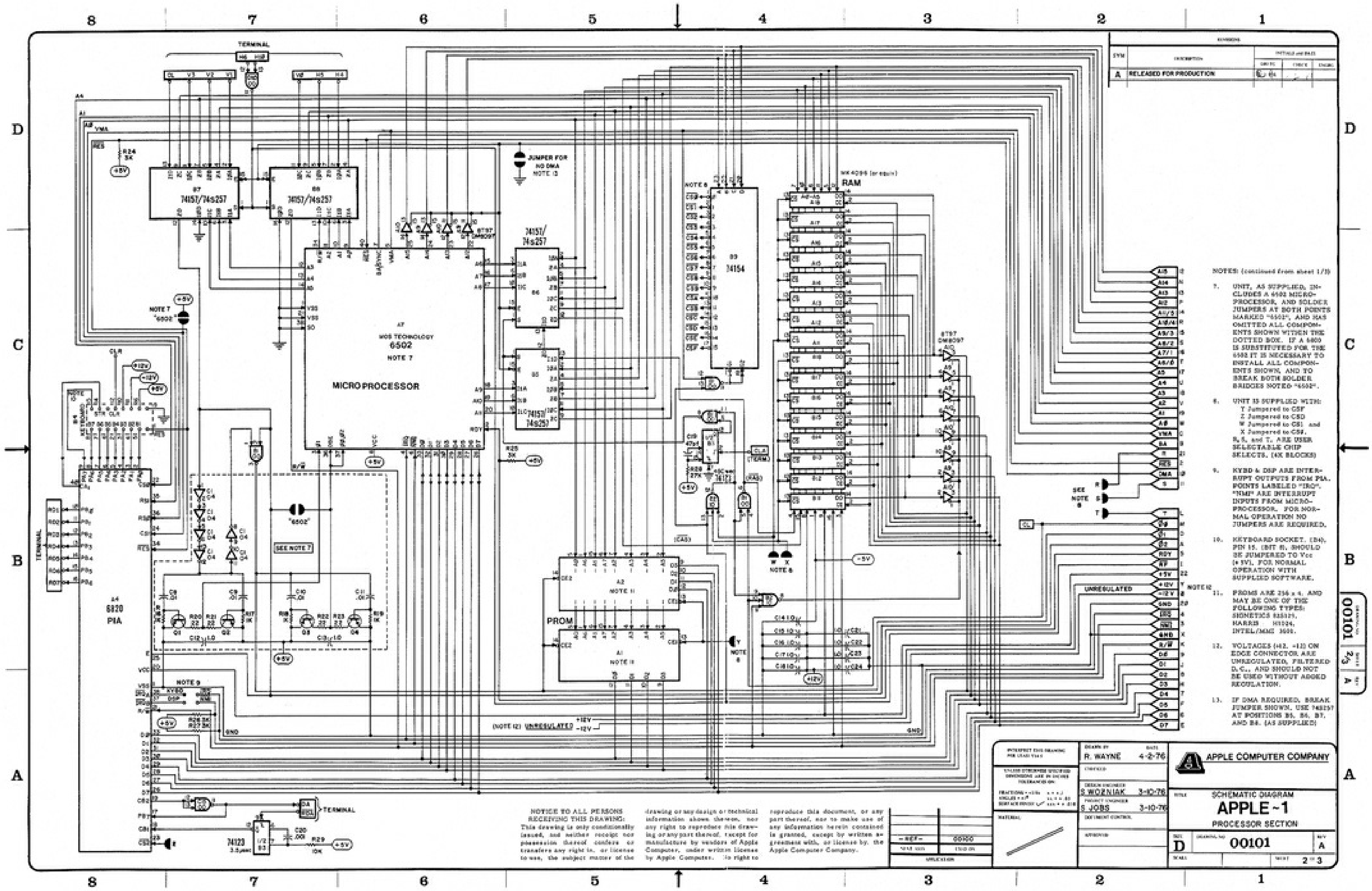
“It changed my life,” Woz recalled. “My interest in computers was renewed. Every two weeks the club meeting was the biggest thing in my life.” And Woz’s enthusiasm, in turn, invigorated the club. His technical expertise and innocent, friendly manner attracted people to him. He quickly developed a following. For two younger club members—Randy Wigginton and Chris Espinosa—Woz became the prime source of technical information, as well as their ride to meetings. (They didn’t have their driver’s licenses yet.)

Woz couldn’t afford an Altair, but he watched with fascination as others brought theirs to the gatherings. He was impressed by the way Lee Felsenstein chaired the meetings. He realized that many of the home-built machines shown at the club resembled his Cream Soda Computer, and he began to feel that he could improve on their basic designs. But the 8080 was out of his price range. What he needed was a low-cost chip.

Then he learned that MOS Technology was going to sell samples of its new 6502 microprocessor chip at the upcoming Wescon electronics show in San Francisco for only $20. At the time, microprocessors were generally sold only to companies that had established accounts with the semiconductor houses, and they cost hundreds of dollars apiece. The Wescon show did not permit sales on the exhibit floor, so Chuck Peddle, the designer of the 6502, rented a hotel room to make the sales. Woz walked in, gave his 20 bucks to Chuck Peddle’s wife, who was handling the transactions, and went to work.

Designing the Apple I

Before designing the computer, Woz wrote a programming language for it. BASIC was the hit of the Homebrew Computer Club, and he knew he could impress his friends if he could get BASIC to work on his machine. “I’m going to be the first one to have BASIC for the 6502,” he thought. “I can whip it out in a few weeks and I’ll zap the world with it.” He did wrap it up in a few weeks, and when he finished, he set to work making something for it to run on. He considered that the easy part: he already had experience building a computer.



NOTES: (continued from sheet 1/3)
7. UNIT, AS SUPPLIED, INCLUDES A 6502 MICROPROCESSOR, AND SOLDER JUMPERS AT BOTH POINTS MARKED "6502", AND HAS OMITTED ALL COMPONENTS SHOWN WITHIN THE DOTTED BOX. IF A 6800 IS SUBSTITUTED FOR THE 6502 IT IS NECESSARY TO INSTALL ALL COMPONENTS SHOWN, AND TO BREAK BOTH SOLDER BRIDGES NOTED "6502".
8. UNIT IS SUPPLIED WITH: Y Jumpered to CSF, Z Jumpered to CSD, W Jumpered to CS1 and X Jumpered to CSØ. R, S, and T, ARE USER SELECTABLE CHIP SELECTS. (4K BLOCKS)
9. KYBD & DSP ARE INTERRUPT OUTPUTS FROM PIA. POINTS LABELED "IRQ", "NMI" ARE INTERRUPT INPUTS FROM MICROPROCESSOR. FOR NORMAL OPERATION NO JUMPERS ARE REQUIRED.
10. KEYBOARD SOCKET, (B4), PIN 15, (BIT 8), SHOULD BE JUMPERED TO Vcc (+5V), FOR NORMAL OPERATION WITH SUPPLIED SOFTWARE.
11. PROMS ARE 256 x 4, AND MAY BE ONE OF THE FOLLOWING TYPES: SIGNETICS 82S129, HARRIS H1024, INTEL/MMI 3601.
12. VOLTAGES (+12, -12) ON EDGE CONNECTOR ARE UNREGULATED, FILTERED D.C., AND SHOULD NOT BE USED WITHOUT ADDED REGULATION.
13. IF DMA REQUIRED, BREAK JUMPER SHOWN, USE 74S257 AT POSITIONS B5, B6, B7, AND B8. (AS SUPPLIED)
NOTICE TO ALL PERSONS RECEIVING THIS DRAWING:
This drawing is only conditionally issued, and neither receipt nor possession thereof confers or transfers any right in, or license to use, the subject matter of the drawing or any design or technical information shown thereon, nor any right to reproduce this drawing or any part thereof, except for manufacture by vendors of Apple Computer, under written license by Apple Computer. No right to reproduce this document, or any part thereof, nor to make use of any information herein contained is granted, except by written agreement with, or license by, the Apple Computer Company.
REVISIONS
A RELEASED FOR PRODUCTION
APPLE COMPUTER COMPANY
DRAWN BY R. WAYNE 4-2-76
DESIGN ENGINEER S WOZNIAK 3-10-76
PROJECT ENGINEER S JOBS 3-10-76
SCHEMATIC DIAGRAM
APPLE -1
PROCESSOR SECTION
D 00101 A
SHEET 2 OF 3
MICROPROCESSOR
A7 MOS TECHNOLOGY 6502 NOTE 7
A4 6820 PIA
B9 74154
RAM MK4096 (or equiv)
PROM
B7 74157/74S257
B6 74157/74S257
8T97 DM8097
74123
JUMPER FOR NO DMA NOTE 13
SEE NOTE 7
TERMINAL
UNREGULATED

Figure 56. The Apple I schematic ***Many engineers consider this design by Wozniak a work of art.*** **(Courtesy of Apple Computer Inc.)**

Woz designed a board that included the 6502 processor and interfaces connecting the processor to a keyboard and video monitor. This was no mean feat. The Intel 8008, which *Popular Electronics* had ignored in publishing the groundbreaking Altair story, was arguably far more suited to be used as the brain of a computer than the 6502 processor. Nevertheless, Woz finished the computer within a few weeks. Woz took his computer to Homebrew and passed out photocopies of his design. The design was so simple that he could describe it in just one page and anyone who read the description could duplicate his design. The consummate hobbyist, Woz believed in sharing information. The other hobbyists were duly impressed. Some questioned his choice of processor, but no one argued with the processor's $20 price tag. He called his machine an Apple.

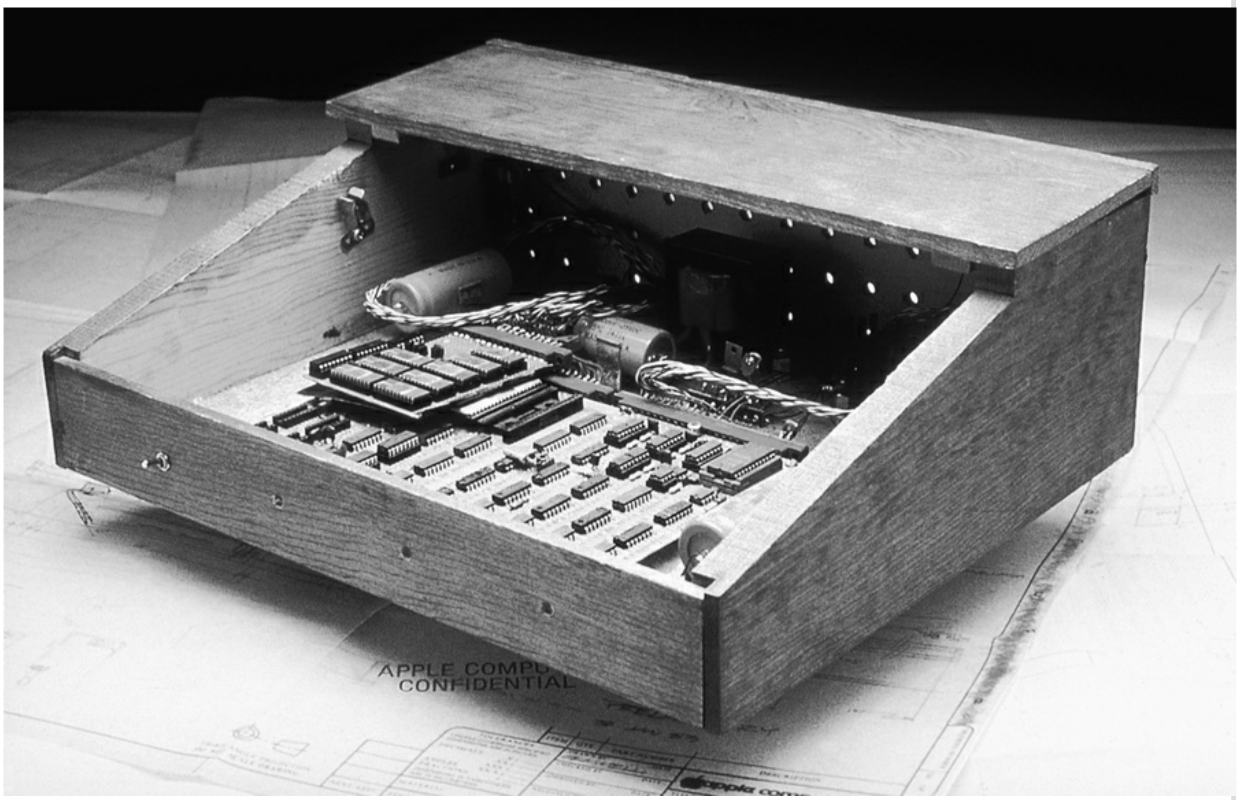


Figure 57. The Apple I ***Steve Wozniak's original Apple I was a circuit board.*** **(Courtesy of Apple Computer Inc.)**

The Apple I had only the bare essentials. It lacked a case, a keyboard, and a power supply. The hobbyist owner had to connect a transformer to it in order to get it to work. The Apple I also required laborious assembly by hand. Woz spent a lot of time helping friends implement his design.

Steve Jobs saw a great financial opportunity in this skeletal machine, and urged Woz to start a company with him. Woz reluctantly agreed. The idea of turning his hobby into a business bothered him, but Jobs, as usual, was persistent. “Look, there’s a lot of interest at the club in what you’ve done,” he insisted. Woz conceded the point with the understanding that he wouldn’t have to leave his job at Hewlett-Packard, which he loved.

Starting a Company


APPLE
COMPUTER
CO.
NEWTON ----"A MIND FOREVER
VOYAGING THROUGH
STRANGE
SEAS
OF THOUGHT --- ALONE."

Figure 58. Apple's original logo ***The 1976 logo, designed by Apple cofounder Ron Wayne, features Isaac Newton under an apple tree.*** **(Courtesy of Apple Computer Inc.)**

They founded the company on April Fool's Day, 1976 (an appropriate date for two pranksters), together with a third partner, Ron Wayne. An Atari field service engineer, Wayne agreed to help found the company for a 10 percent stake. Wayne immediately started work on a company logo, a drawing of Isaac Newton seated under an apple tree.

Jobs sold his Volkswagen microbus and Wozniak sold his two prized HP calculators to pay for the creation of a printed circuit board. The PC board would save them the trouble of assembling and wiring each computer—a task that was forcing them to clock 60-hour work weeks. Jobs figured they would be able to sell the boards at Homebrew.

But Jobs wasn't content to sell boards merely to hobbyists. He also began trying to interest retailers in the Apple. At a Homebrew meeting in July 1976, Woz gave a demonstration of the Apple I. Paul Terrell, one of the industry's earliest retailers, was in attendance. Jobs gave Terrell a personal demonstration of the machine. "Take a look at this," Jobs told Terrell. "You're going to like what you see."

Jobs was right. Terrell did like the machine, but he didn't immediately place an order. When Terrell told Jobs the machine showed promise and that Jobs should keep in touch, Terrell meant what he said. The machine was interesting, but there were a lot of sharp engineers at Homebrew. This computer could be a winner, or some other machine might be better. If Jobs and Wozniak really had something, Terrell figured they'd keep in touch with him.

The next day, Jobs appeared, barefoot, at Byte Shop. "I'm keeping in touch," he said. Terrell, impressed by his confidence and perseverance, ordered 50 Apple I computers. Visions of instant wealth flashed before Jobs's eyes. But Terrell added a condition: he wanted the computers fully assembled. Woz and Jobs were back to their 60-hour work weeks.

The two Steves had no parts and no money to buy them, but with a purchase order from Terrell for 50 Apple I computers, they were able to obtain net 30 credit from suppliers. Jobs didn't even know what net 30 meant. Terrell later received several calls from parts suppliers who wondered whether Jobs and Woz really had the guarantee from Terrell that they claimed they did.

Jobs and Woz were now in business. But even though they had successfully worked together under time pressure in the past, they knew they couldn't do this task alone. The parts had to be paid for in 30 days, and that meant they had to build 50 computers and deliver them to Paul Terrell within the same time period. Jobs paid his stepsister to plug chips into the Apple I board. He also hired Dan Kottke, who was on summer break from college. "You've got to come out here this summer," Jobs told Kottke. "I'll give you a job. We've got this amazing thing called 30 days net."

Terrell got his 50 Apple I machines on the 29th day, and Apple Computer was off and running. Jobs ran the business. All of the 200 or so Apple I computers eventually built were sold either through a handful of computer stores in the Bay Area or by a parcel service out of Jobs's "home office" (initially his bedroom, and later his parents' garage). The Apple I was priced at $666, the so-called Number of the Beast from the Book of Revelation, evidence that the prankster spirit was alive and well at Apple.

A Partner Bows Out

Unfortunately, the Apple Computer partnership wasn't faring as well. Ron Wayne, overwhelmed by Jobs's intensity and ambition, wanted out, and submitted his formal resignation. Jobs bought him out for $500.

By the end of the summer, Wozniak had begun work on another computer. The Apple II would have several advantages over the Apple I. Like Processor Technology's Sol, which had not yet appeared, the Apple II would be an integrated computer, featuring a keyboard and power supply and BASIC, all within an attractive case. For output, the user could hook the computer up to a television set. Jobs and Woz made provisions to sell just the circuit board to hobbyists who wanted to customize the machine. They were both sure the Apple II would be the hit of Homebrew, but Jobs hoped it would have a much broader appeal.

After deciding on the features to include in the Apple II, Woz and Jobs argued over its price. Jobs wanted to sell the board alone for $1,200. Woz said that if the price were that high, he wanted nothing to do with it. They finally decided to charge $1,200 for the board and the case.

Now they had at least the outline of a real commercial product, and Jobs's ambition flowered. "Steve was the hustler, the entrepreneurial type," said Woz. Jobs wanted to build a large company, and once again he went straight to the top for help, seeking advice from Atari founder Nolan Bushnell. Bushnell, figuring that Apple needed a money guy in their corner, introduced Jobs to Don Valentine, a Silicon Valley venture capitalist. Valentine suggested that Jobs talk to a friend of his named Mike Markkula.

A Partner Signs On

In the busy two years after the introduction of the Altair, the microcomputer industry had reached a critical turning point. Dozens of companies had come and gone. MITS, the industry pioneer, was foundering; IMSAI, Processor Technology, and a few other companies were jockeying for control of the market even as they faltered. Before long, all these companies failed.

In some cases, the failure of these early companies stemmed from technical problems with the computers, but more often it was a lack of expertise in management and in marketing, distributing, and selling the products that did in these companies. Their corporate leaders were primarily engineers, not managers; they weren't versed in the ways of business, and often alienated their customers and dealers. MITS drove retailers away by forbidding them to sell other companies' products; IMSAI ignored dealer and customer complaints about defects in its machines; and Processor Technology responded to design problems with a bewildering series of slightly different versions, failed to keep pace with advances in the technology, and boxed itself in by refusing the venture capital needed for growth. Computer dealers eventually grew tired of these practices.

At the same time, the market was changing. Hobbyists had organized into clubs and users' groups that met regularly in garages, basements, and school auditoriums around the country. The number of people who wanted to own computers was growing, as were the ranks of knowledgeable hobbyists who wanted "a better computer." Unfortunately, would-be manufacturers of that "better computer" all faced one seemingly insurmountable problem: they didn't have the money to develop such a device.

The manufacturers, usually garage enterprises, needed investment capital, but there were strong arguments against giving it to them: the high failure rate among microcomputer companies, the lack of managerial experience among their leaders, and—the ultimate puzzle—the absence of IBM from the field. Investors had to wonder, if this area of computer technology had any promise, why hadn't IBM preempted it? In addition, some of the founders of the early companies looked unfavorably on the notion of taking money from an outside source, as that could mean losing some control of their companies.

For the microcomputer industry to continue advancing, an individual with a special perspective was needed—someone who could see beyond the basic risks to the potential rewards, right the bad management and poor dealer relations, and address the sometimes-slipshod workmanship in order to capitalize on the enormous potential of these garage entrepreneurships.

In 1976, Armas Clifford "Mike" Markkula, Jr., had been out of work for more than a year. His unemployment was self-imposed. Markkula had done well for himself during his tenure with two of the most successful chip manufacturers in the country, Fairchild and Intel, largely because he was uniquely suited to the work. Although a trained electrical engineer who understood the possibilities of the microprocessor, at Intel he worked in the marketing department, where he was considered a wizard. Beyond the excitement of being around emerging technology, Markkula enjoyed forging ahead with a large company in a competitive environment.

Outside the hobbyist community, few people understood the potential of microprocessor-based technology as well as Mike Markkula did. With his rare combination of business savvy and engineering background, Markkula was just the person microcomputer companies needed to promote their technology, if any could afford him.

Markkula had retired from Intel in his early thirties with stock options that made him a millionaire. He planned a leisurely existence, and he convinced himself that after the breakneck pace of life in the semiconductor industry, he could be happy learning to play the guitar and going skiing at his cabin near Lake Tahoe. Friends may have observed that his investments in wildcat oil wells did not bespeak a full commitment to the idle life, but Markkula was adamant about being out of the rat race for good.

Nevertheless, in October 1976, at Don Valentine's suggestion, Markkula visited Jobs's garage. He liked what he saw. It made sense to provide computing power to individuals in the home and workplace, and these boys had a good product. When Markkula offered to help them draw up a business plan, he told himself he wasn't violating his resolve to stay retired—he was just giving advice to two sharp kids. He was doing it more for pleasure than business, he rationalized, as Jobs and Woz couldn't afford to pay him what a consultant with his experience would normally get.

But within a few months, Markkula decided to throw in with these two kids. He assessed Jobs and Woz's equity in the company at about $5,000. He put up a considerably larger chunk of money himself, promising Apple up to $250,000 of his own money, and then investing $92,000 to buy himself a one-third interest in the company. Jobs and Woz were stunned by Markkula's assurance that they each owned a third of a nearly $300,000 company.

Why did this 34-year-old retired executive throw in his lot with two long-haired novices who had no collateral except their ingenuity, ambition, and creative ideas? Even Markkula couldn't answer the question satisfactorily, but he had become convinced—and hooked on the idea—that he could take Apple to the Fortune 500 in five years.

The first decision Markkula made was to keep the name Apple. From a marketing standpoint, he recognized the simple advantage of being first in the phone book. He also believed that the word *apple*, unlike the word *computer*, had a positive connotation. "Very few people don't like apples," he said. Furthermore, he liked the incongruous pairing of the words apple and computer, and believed it would be good for name recognition.

Then he set out to turn Apple into a real company. He helped Jobs with the business plan and obtained a line of credit for Apple at the Bank of America. He told Woz and Jobs that neither of them had the experience to run a company and hired a president: Michael Scott, nicknamed Scotty, a seasoned executive who had worked for him at Fairchild.

Designing the Apple II

By the fall of 1976, Woz had already made progress on the design of his new computer. The Apple II would embody all the engineering savvy he could bring to it. It would be the embodiment of Steve Wozniak's dream computer, one he would like to own himself. He had made it considerably faster than the Apple I. There was a clever trick he wanted to try that would give the machine a color display, too.

Wozniak was skittish about forming a company from the start, and now he was worried about working full time for it. He had always enjoyed his job at Hewlett-Packard. HP was legendary among engineers for its commitment to quality design. It seemed crazy to give up a job at HP. Still…

Woz had shown his Apple I design to the managers at Hewlett-Packard with the hope that he could convince the company to build it. But they told him that the Apple was not a viable product for HP, and gave him a release to build the machine on his own. He'd also attempted, twice, to join computer-development projects at HP—the project that eventually developed into the HP 75 computer and a handheld BASIC machine—and, lacking the experience and the academic credentials HP expected, was turned down for both.

Wozniak was unarguably an outstanding engineer, but he really wanted to work on projects that interested him, and then only for as long as they interested him. Jobs understood his friend's restless genius better than anyone. He constantly urged Woz on, and the pressure sometimes led to arguments.

Woz had no interest in designing the connector for hooking the computer up to the television set, nor did he want to design the power supply. Both tasks required skill in *analog* electronics. The digital circuitry of a computer basically comes down to power on or off, a 1 or a 0. To design a power supply or send a signal to a television set, an engineer has to consider voltage levels and interference effects, things Woz didn't know or care about.

The Everything-Else Guy

Figure 59. Rod Holt ***Holt, an early hire at Apple, wore many hats.*** **(Courtesy of Apple**

Computer Inc.)

Jobs turned to Al Alcorn, his boss at Atari, for help, and Alcorn suggested that Jobs talk to Rod Holt, a sharp analog engineer at Atari. When Jobs phoned Holt in the fall of 1976, Holt was feeling dissatisfied with his position at Atari. “I was a second-string quarterback,” he said. Holt suspected he had been hired just in case his manager, whose hobby was racing motorcycles, got hurt. But Holt was skeptical of Jobs. He had a daughter older than Steve Jobs. And he had trouble understanding the West Coast culture that shaped Apple’s founders.

Holt told Jobs that as an Atari engineer, his helping Apple represented a conflict of interest. Besides, he added, he was expensive. His services ran at least $200 a day. That didn’t faze Jobs. “We can afford you,” he said. “Absolutely.” Holt liked the brashness. Regarding the conflict of interest, Jobs told him to check with his boss. Alcorn told Holt, “Help the kids out.”

Holt started working after hours at Atari on Apple’s television interface and power supply, concentrating especially on the latter. He persuaded Jobs not to challenge FCC regulations by trying to build an interface for a television set. Holt knew that the FCC would hassle them over interference. Jobs was frustrated at first, but then hit on a clever way out of the problem: just make it easy for someone else to design the modulators to link the computer to a television set. If regulations got bent, the culprit wouldn’t be Apple.

Soon Holt was on board full time. Wherever no one else had the technical or managerial expertise to solve a problem, Holt took care of it. “I was the everything-else guy,” he said. As the company began growing faster than even Markkula had hoped, Holt found that he was overseeing the quality-control department, the service department, the production engineering department, and the documentation department. Things got so stressful that Holt threatened to resign several times. But he couldn’t do it. Apple was just too interesting to leave.

Rod Holt was one of the first employees of Apple once Markkula came aboard, but the real first employees date back to the Apple I era. Bill Fernandez, the friend who had introduced the Steves to each other several years earlier, was the first hire. As a formality, Jobs tested Fernandez with a series of questions about digital electronics before officially hiring him to manufacture Apple I computers. Fernandez practiced the Bahai faith and he and Jobs spent many hours discussing religion in Jobs’s garage that doubled as their workshop.

Other early employees included high-school students Chris Espinosa and Randy Wigginton, Woz’s friends from the Homebrew meetings. After the meetings, the trio routinely headed to Woz’s house to continue discussing ways to improve the capabilities of the Apple I to turn it into something more powerful.

Espinosa and Wigginton were software hackers. They had no special expertise in designing machines. Instead, they loved writing programs. Whenever Woz brought the Apple I to the

Homebrew meetings, Espinosa and Wigginton would knock off some programs on the spot to demonstrate the machine to club members. Woz had built a working prototype of the Apple II by August of 1976, and loaned one to Espinosa, who began developing games and demonstration software for the computer. By actually using the new computer, the self-confident teenager was able to suggest ways to better its design.

Before he went to work for Apple, Espinosa spent a lot of time at Paul Terrell's Byte Shop. He recalled that a "tall, scraggly looking guy would come in every day and say, 'We got a new version of the BASIC!'" That was how Espinosa met Steve Jobs. Later, at Homebrew, Jobs noticed a demo program running on the Apple I. He asked Espinosa, "Did you do that?" Shortly thereafter, Espinosa was working for Apple.

Espinosa spent Christmas vacation of his sophomore year of high school in Jobs's garage, helping debug the BASIC that would be sold with the Apple II. Jobs took him under his wing, although Espinosa's early impression of Jobs was as something other than a paternal figure. "I thought he seemed dangerous," Espinosa said about Jobs. "Quiet, enigmatic, almost sullen, a fierce look in his eyes. His powers of persuasion are something to be reckoned with. I always had this feeling that he was shaping me."

Woz Waffles

Jobs then faced the biggest obstacle thus far to his legendary powers of persuasion. By this time, Markkula had agreed to join Jobs and Woz. The final hurdle was convincing Woz to leave his job at Hewlett-Packard to work full time for Apple. Markkula would have it no other way.

Woz wasn't sure he wanted to make the move. Jobs was panicking. All of his carefully wrought plans depended on Woz. Then, one day in October 1976, Woz said that he would not leave his great job at HP, and that his decision was final. "Steve went into fits and started crying," Woz recalled. Soon Jobs began lobbying Woz's friends, having them call Woz to persuade him to change his mind.

Woz was afraid that designing computers full time would be drudgery, unlike the efforts he put into designing the Apple I and II. Somehow his friends convinced him otherwise, and he finally agreed to leave his job at HP and join Apple full time. It was a brave move given that Woz imagined that they would, at best, sell no more than a thousand Apple II computers.

But Jobs had an entirely different vision and aggressively set out to get people who could help him achieve it—people like Regis McKenna, owner of one of the most successful public-relations and advertising firms in Silicon Valley.

Creating an Image

Jobs had placed an ad in the computer magazine *Interface Age*. He'd also seen the Intel ads in various electronics magazines and was impressed enough to call the semiconductor company and ask who had done them, and got McKenna's name. Jobs wanted the best for Apple and, deciding that McKenna was the best, set about getting his firm to handle Apple's PR.

Figure 60. Regis McKenna and Andy Grove ***McKenna talks with Intel cofounder Andy Grove.***
(Courtesy of Regis McKenna)

McKenna's ads had been very good for Intel, as well as for McKenna himself, whose office decor spelled success. Customarily dressed in a natty suit, McKenna sat behind a large desk backed by photographs of his favorite Intel ads. He spoke softly and reflectively, in sharp contrast to the unkempt and pushy kid who walked into his office one afternoon in cutoffs, sandals, and what McKenna called a "Ho Chi Minh beard." McKenna was accustomed to taking start-up companies as clients, so Jobs's garb didn't put him off. "Inventions come from individuals,” he reminded himself, “not from companies,” and this Jobs was certainly an individual.

At first McKenna said no, but that didn’t stop Jobs. “I don’t deny that Woz designed a good machine,” said McKenna. “But that machine would be sitting in hobby shops today were it not for Steve Jobs.”

McKenna eventually succumbed to Jobs’s persistence, and his agency became Apple’s PR firm. The agency immediately made two major moves.

The first was a new logo to replace Ron Wayne’s overly busy Newton under the apple tree: a rainbow-striped apple with a bite taken out of it. The logo was designed by Rob Janoff and, with variation, served as the company’s trademark ever since. From a printing standpoint, there was some initial fear that the multiple colors would run together. Jobs vetoed the addition of lines to separate the colors, making the cost of printing the logo very high. Apple president Michael Scott called it “the most expensive bloody logo ever designed.” But when the first foil labels arrived for the Apple II, everyone loved the look of the design. Jobs made one change: he rearranged the order of the colors to put the darker shades at the bottom. A later president of Apple products, Jean-Louis Gassée, would say that the logo was perfect for Apple: “It is the symbol of lust and knowledge, bitten into, all crossed with the colors of the rainbow in the wrong order…lust, knowledge, hope, and anarchy.”

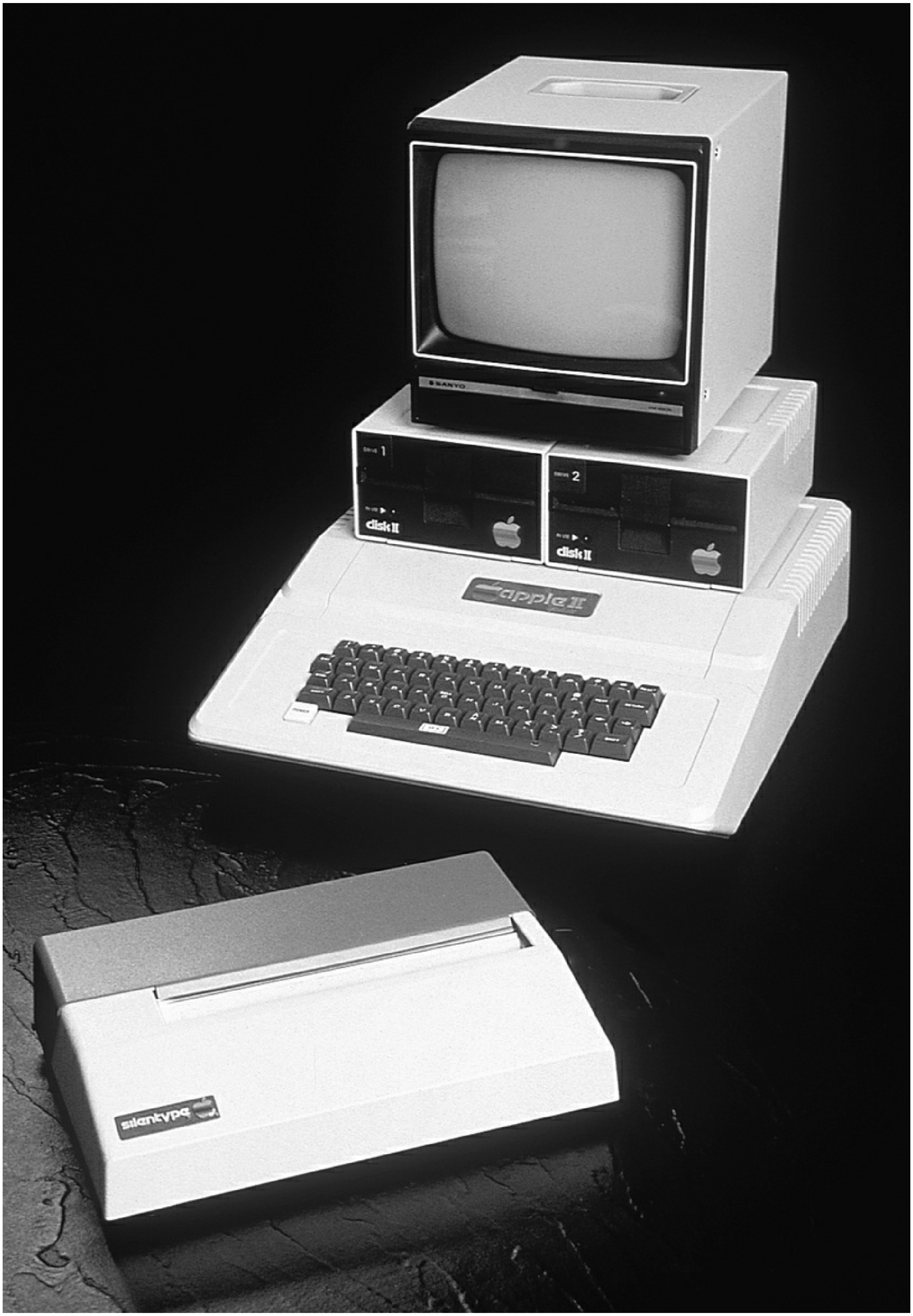

SANYO
1
2
disk II
disk II
apple II
silentype

Figure 61. The Apple II ***This is the product that launched Apple as a serious business.*** **(Courtesy of Apple Computer Inc.)**

McKenna also decided to run a full-color ad in *Playboy* magazine. It was a bold, expensive grab for publicity. A cheaper ad in *Byte* would have reached virtually all the microcomputer buyers of that time, and *Playboy* seemed an off-the-wall choice given that there were no demographic studies to support it. “It was done to get national attention,” said McKenna, “and to popularize the idea of low-cost computers.” Other companies had been selling microcomputers for two years, but no one had yet tried to capture the public’s imagination in this way. Apple’s publicity campaign resulted in follow-up articles in national magazines, and not just about Apple, but about small computers in general.

Apple was bringing the idea of a *personal computer* into the mainstream consciousness.

Jobs’s persistence persuaded McKenna to buy into the Apple dream, as it had with Woz, Markkula, and Holt. Woz invented the machine, Markkula had the business sense, McKenna provided the marketing talent, Scotty ran the shop, and Holt was the everything-else guy, but the pushy kid with the scraggly beard was the driving force behind it all.

By February 1977, Apple Computer had established its first office in two large rooms a few miles from Homestead High School in Cupertino. Desks were hauled in and work benches were trundled over from Jobs’s garage. The night before they were to begin working in their new suite, Woz, Jobs, Wigginton, and Espinosa scattered around the 2,000-square-foot office playing telephone games, with each trying to buzz one of the other extensions first. The whole thing felt like play. It was hard to imagine that they were starting a real business. “We never thought that we’d grow up to be battling one-on-one with IBM,” said Espinosa.

The Debut

The young company faced a more modest challenge than tackling the company that had defined *computer* for generations: they had to finish the Apple II design in time for Jim Warren’s first West Coast Computer Faire in April and get it ready for production shortly thereafter. Markkula was already signing up distributors nationwide, many of whom were eager to work with a company that would give them greater freedom than microcomputer manufacturer MITS had, as well as provide a product that actually did something.

Figure 62. Steve Wozniak ***Woz scrambles for a phone in one of Apple's early offices.*** **(Courtesy of Margaret Kern Wozniak)**

Steve Wozniak is justly credited with the technical design of the Apple I and Apple II. Nevertheless, an essential contribution to making the Apple II a commercial success came from Jobs. Early microcomputers were typically drab and ugly metal boxes. Steve Jobs decided to spruce up the look of the product. He would encase the device in a lightweight beige plastic shell that melded the keyboard and computer together in a modular design. Woz could design an efficient computer, but he cheerfully admitted that he didn't care whether or not wires were left dangling out of it. Jobs realized that the Apple had to look presentable to better the competition.

It took a gargantuan effort to ready the Apple II for the West Coast Computer Faire. Woz worked day and night, as was his modus operandi, until it was done. Jobs made sure that nobody would miss it. He arranged to have the biggest and most elegant booth at the show. He brought in a large projection screen to demonstrate programs and placed Apple II computers on either side of the booth. Jobs, Mike Scott, Chris Espinosa, and Randy Wigginton manned the booth while Mike Markkula toured the auditorium signing up dealers for the company. Woz walked around checking out other machines. All in all, the Computer Faire was a big success for Apple. Everyone seemed to like the Apple II, although *Computer Lib* author Ted Nelson complained that it displayed only uppercase letters.

Woz couldn’t resist playing one of his practical jokes. MITS was absent from the show, and with the help of Randy Wigginton, Woz whipped up a brochure on the “Zaltair,” supposedly an enhanced Altair computer.

“Imagine a dream machine. Imagine the computer surprise of the century, here today. Imagine BAZIC in ROM, the most complete and powerful language ever developed,” the fake advertisement purred. Woz was satirizing the marketing hype that he’d learned from Jobs. The brochure gushed on, “A computer engineer’s dream, all electronics are on a single PC card, even the 18-slot motherboard. And what a motherboard.…” On the back of the brochure was a mock performance chart comparing the Zaltair to other microcomputers—including the Apple.

from altair™ to zaltair™

Predictable refinement of computer equipment should suggest online reliability. The elite computer hobbiest needs one logical optionless guarantee, yet.

Ed Roberts
President, MITS, Inc.

Imagine a dream machine. **Imagine** the computer surprise of the century, here today. **Imagine** Z80 performance plus. **Imagine BAZIC** in ROM, the most complete and powerful language ever developed. **Imagine** raw video, plenty of it. **Imagine** autoscroll text, a full 16 lines of 64 characters. **Imagine** eye-dazzling color graphics. **Imagine** a blitz fast 1200 baud cassette port. **Imagine** an unparalleled I/O system with full **ALTAIR-100** and **ZALTAIR-150** bus compatibility. **Imagine** an exquisitely designed cabinet that will add to the decor of any living room. **Imagine** the fun you'll have. **Imagine ZALTAIR,** available now from MITS, the company where microcomputer technology was born.

bazic™

Without software a computer is no more than a racing car without wheels, a turntable without records, or a banjo without strings. BAZIC is the language that puts ZALTAIR's powerful hardware at your fingertips. For example, you can test the entire memory with the MEMTEST statement. Or read the keyboard directly with the KBD function. If you like to keep time the CLCK function will really please you. And in case you're in a hurry, you'll be glad to know that BAZIC runs twice as fast as any BASIC around. The best thing of all about BAZIC is the ability to define your own language . . . a feature we call perZonality.™ And ZALTAIR's BAZIC language comes standard in ROM, to insure 'rip-off' security.

hardware

We really thought this baby out before we built it. Two years of dedicated research and development at the number ONE microcomputer company had to pay off, and it did. A computer engineer's dream, all electronics are on a single pc card, **EVEN THE 18-SLOT MOTHERBOARD.** And what a motherboard. The ZALTAIR-150 bus is fully ALTAIR-100 compatible with 50 extra connectors. In addition, with ZALTAIR's advanced I/O structure called verZatility,™ access to peripherals is easier than ever before. And of course, our complete line of ALTAIR peripherals is directly compatible with the ZALTAIR 8800.

don't miss out

Weighing just 16 pounds, the ZALTAIR 8800 is a **portable** computer. The highly attractive enclosure was designed by an award winning team, and is fabricated from high-impact, durable ABS Cycolac® plastic. In the MITS tradition, nothing is compromised. Because of its superior design we were able to price the ZALTAIR 8800 far below the competition for this special introductory offer only. **You will not find the ZALTAIR in any store.** We want to bring this incredible offer to you directly, and avoid the retail mark-up of a middle man. Already, over 100 ZALTAIR's have been delivered to 75 satisfied customers. Don't miss out, order your ZALTAIR before April 30, 1977, and get immediate delivery.

Figure 63. From Altair to Zaltair ***One of Wozniak’s practical jokes; this one fooled Jobs.*** **(Courtesy of Steve Wozniak)**

Jobs, knowing nothing of the joke, picked up one of the brochures and read it in dismay. He took a quick, nervous scan of the performance chart, and a look of relief came over his face. “Hey,” he said, “We came out okay on this.”

Magic Times

After the West Coast Computer Faire, we had a sense of exhilaration for having pulled off something so well, not just for Apple, but for the whole computer movement.

—Chris Espinosa

In 1977, Apple could do no wrong. It was an enchanted time for the tiny company, whose principals radiated an innocent confidence. Hobbyists praised Woz's design, dealers clamored for the new computer, and investors were itching to sink money into the company.

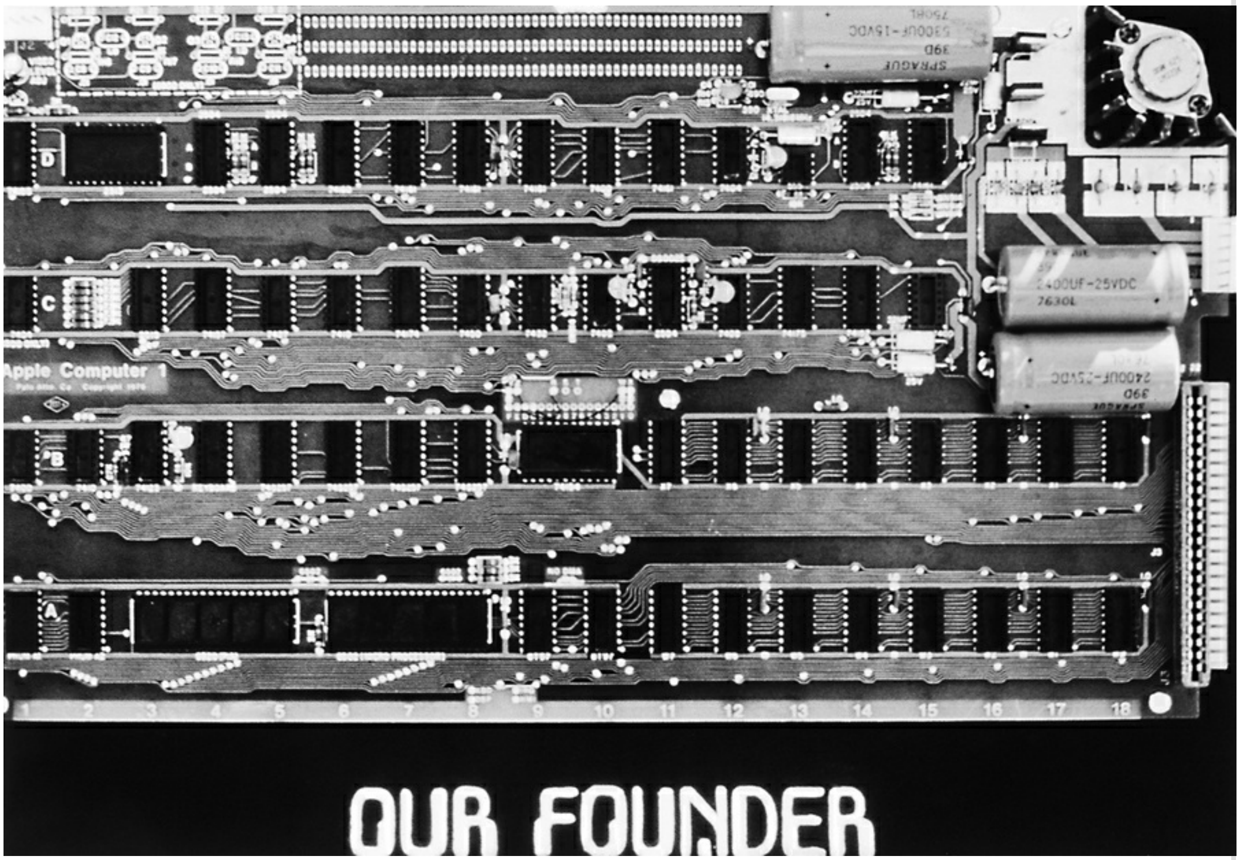


Figure 64. Apple I circuit board ***The original Apple I circuit board was framed and hung in the Apple offices, with the legend "Our Founder."*** **(Courtesy of Apple Computer Inc.)**

Assembling the Team

In May, Woz reviewed Wigginton's performance to see if he deserved a raise. His work was fine, but Woz demanded more. He found it unacceptably inefficient that he had to walk around the block to get to the next-door 7-Eleven. If Wigginton would remove a board from a fence, Woz could slip under it and Wigginton could have his raise. The next day Woz found the board on his desk, and Wigginton started earning $3.50 an hour.

Apple employee Chris Espinosa was in his first semester at Homestead High. Every Tuesday and Thursday he drove to the Apple offices on his moped, purchased with Apple earnings, because he wasn't old enough to drive a car. There he supervised the twice-weekly public demonstrations of the Apple II. Once when representatives of Bank of America dropped by, Espinosa had to quicky replace "OH SHIT" in Woz's implementation of the Breakout game with "THAT'S TERRIBLE." Espinosa had a precocious air of responsibility. Jobs and Markkula were thankful that he kept the visitors engaged so that they could attend to the more important task of signing up new dealers. "For about six months, I was the sole means by which people off the street in the Bay Area would learn about Apple Computer," Espinosa said.

It wasn't the most professional environment, and Mike Scott was tiring of the crowd that frequently dropped in to check out Woz's progress. Sometimes they did more than watch: Allen Baum, a close friend of Wozniak's from Hewlett-Packard, contributed important design ideas. But if they could contribute ideas, they could just as easily swipe them. Mike Scott finally decreed that some confidentiality was necessary. He felt it was his job to instill a professional environment in Apple. Under pressure from Scotty, Baum visited less and less frequently. Scotty recognized some young talent, however, and he convinced Randy Wigginton to stay involved by offering to have Apple pay for his college education.

Mike Scott was a complex individual who was vital to Apple's success. Unlike the dapper Mike Markkula, he was down-to-earth, boisterous, frank, and not one to hide his feelings, positive or negative. He liked to stroll through the office and chat with employees, often using maritime metaphors. He saw himself as a captain of a ship, wheel in hand at the helm. "Welcome aboard," he would say to a new employee. When Scotty was happy, those around him were happy. According to Rod Holt, Scotty had a slush fund for special expenses, part of which paid for an enormous hot-air balloon and a sail for Holt's yacht, each sporting the Apple logo. One Christmas, he walked around dressed in a Santa Claus suit, handing out presents to employees. But if Scotty was displeased with your performance, he let you know it.

Scott quickly grew impatient when projects were delayed. He couldn't understand Wozniak's irregular work habits, which swung from total dedication to headstrong avoidance, depending on his interest in the task at hand. Scotty also objected to some of Woz's friends—like John Draper, a.k.a. Captain Crunch.

Peripheral Issues

In the fall of 1977, Draper was visiting Woz at Apple and expressed interest in helping design a digital telephone card for the Apple II. No one understood telephone technology better than Captain Crunch. Scott had granted Woz a separate office in which to work, hoping that it might encourage his creativity, and soon John Draper was working there, too.

Figure 65. Steve Wozniak and Steve Jobs ***Wozniak at the keyboard of his creation as Jobs looks on*** **(Courtesy of Apple Computer Inc.)**

Draper and Woz constructed a device that could, among other things, dial numbers automatically and function much like a telephone answering machine. But Draper also built a blue-box capability into the card. According to Espinosa, a network of a dozen Apples equipped with Draper's cards could bring down the nation's entire phone system. When Scott learned that the device could be used illegally, he stalked the Apple offices in a rage.

The phone card didn't last long after that, although, without Draper's knowledge, modifications were being designed into the card by other engineers to nullify most of its phone-phreak capabilities. According to one Apple board member, Scott considered firing Woz after that. It wasn't inconceivable that Scott would have made one of the company's founders walk the plank. "Scotty is the only guy that would dare fire me," said Woz. "That guy could do anything." Rod Holt agreed: "Scotty could fire anybody." All he needed was a single excuse. When John Draper was later arrested for phone phreaking, he had an Apple computer with him. The machine was confiscated, and Scotty again cursed Woz.

At the same time Woz hired Draper, Scotty recruited two other key employees. In August 1977, Gene Carter became Apple’s sales manager and Wendell Sander came on board to work under Rod Holt. An electrical engineer with a PhD from Iowa State University, Sander had years of experience in the semiconductor field. But it wasn’t his high-technology experience that convinced Apple to hire him.

Sander had bought an Apple I a year earlier and was working on a version of a Star Trek game for his teenage children to play. In the course of writing the program, he had met Steve Jobs while chasing down updated versions of the integer BASIC programming language. Jobs supplied him with the updates and in the process learned about the Star Trek program. When Jobs was getting ready to ship the first Apple IIs, he invited Sander to the company’s office and asked him to rework the program to run on the new machine. Sander met with Mike Markkula and decided that he wanted to work for the young company. After he was hired, he took a loan on his San Jose home in order to buy Apple stock. Woz, Rod Holt, and Sander made up the core of Apple’s engineering department for the remainder of 1977.

During 1977 and 1978, Woz worked on a number of accessory products that were necessary to keep Apple on stable ground during its formative years. To make the Apple II appealing to customers outside the hobbyist realm, add-on peripherals were needed. These devices enabled the machine to work with different kinds of printers and connect with modems used to transfer information from one machine to another over a telephone line.

Thanks to its small size and well-oiled internal mechanism, the company could choose and build new products more easily than many other firms. Among the most important of these items were peripheral cards: printer cards, serial cards, communications cards, and ROM cards. Woz worked on developing most of these, with Wendell Sander and Rod Holt contributing their share of the development duties.

Business was building. More and more dealers signed on, and Apple began manufacturing the Apple II. By the end of 1977, the company was making a profit and doubling production every three months. An article in *Byte* helped to further popularize the Apple II. Mike Markkula had also attracted investment capital from the successful New York—based firm of Venrock Associates, which was formed by the Rockefeller family to invest in high-tech enterprises. Venrock’s Arthur Rock became a member of Apple’s board of directors.

Figure 66. Regis McKenna and Arthur Rock ***McKenna talks here with venture capitalist Arthur Rock, one of Apple's first investors.***
(Courtesy of Regis McKenna)

By year's end, the company moved into a larger office on nearby Bandley Drive in Cupertino. The structure felt huge, and gave the Apple employees a feeling that the firm was going to become something big. They were right. Apple soon outgrew the building and added another on the same street. Perhaps the most significant accomplishment of this period occurred during Woz's 1977 Christmas vacation.

Beautiful Circuitry

Before the end of 1977, Woz had started working on his next big project. The idea arose from a December executive board meeting attended by Markkula, Scott, Holt, Jobs, and Woz. At the meeting, Markkula stepped forward and wrote on a board a list of goals for the company. At the top of the list, Woz saw the words “floppy disk.” “I don’t know how floppy disks work,” Woz thought.

But Woz knew Markkula was right in his priorities. Cassette-tape storage of data was slow and unreliable compared to disks, and dealers were constantly complaining about it. Markkula had decided that disk drives were essential about the time he and Randy Wigginton were writing a checkbook program that Markkula thought the Apple needed. Markkula was fed up with the laborious task of reading data off cassette tapes and realized how much a floppy-disk drive would help. He told Woz that he wanted the disk drive ready for the Consumer Electronics Show that Apple was scheduled to attend in January.

Markkula knew that by issuing the edict he was in essence taking away Woz’s Christmas vacation. It was unreasonable to expect anyone to devise a functioning disk drive in a month. But this was the kind of challenge Woz thrived on. No one had to tell him to work long hours over the vacation. Woz wasn’t entirely ignorant about disk drives: while at Hewlett-Packard, he had perused a manual from Shugart, the Silicon Valley disk-drive manufacturer. Just for fun, Woz designed a circuit that would do much of what the Shugart manual said was needed to control a disk drive. Woz didn’t know how computers actually controlled drives, but his method seemed to him to be reasonably simple and clever.

When Markkula challenged Woz to put a disk drive on the Apple, Woz remembered that disk-drive circuit and began seriously considering its feasibility. He examined how other computers—including those from IBM—controlled drives. He also dissected disk drives—particularly the ones produced by North Star. After reading the North Star manual, Woz knew just how clever his design was—his circuit could do what theirs did, and more.

But Wozniak’s coming up with a circuit solved only part of the disk-control problem. The puzzle had other pieces—like how to handle synchronization. A disk drive presents tricky problems with timing. Somehow the software has to keep track of where the data is while the disk is spinning. IBM’s technique for dealing with timing involved complex circuitry, which Woz studied until he fully understood it.

All that circuitry was unnecessary, he realized, if he could alter the way in which the data were written to the disk. For the Apple disk drive, he figured out how to make the drive synchronize itself automatically with no hardware circuitry at all.

This “self-sync” technique scored a point against IBM: Woz gloated over the fact that the mammoth corporation lacked the flexibility to come up with such an unlikely solution. He also knew that no matter what economies of scale IBM brought to its product, *no* circuitry is less expensive than *some* circuitry.

Wozniak could now write the software to read from and write to the floppy disk. At this point, he called in Randy Wigginton to help. Woz needed a formatter, a program that could write a form of “nondata” to the disk, essentially wiping it clean to set it up for reuse. Woz gave Wigginton just the essential instructions, like how to make the drive motor move via software. Wigginton took it from there.

Woz and Wigginton worked day and night throughout December, including a 10-hour day on Christmas. They knew they couldn’t get a complete disk operating system running for the show, so they spent time developing a demo operating system that would let them type in single-letter filenames and read files stored in fixed locations on the disk. But when they left for the Consumer Electronics Show in Las Vegas, they weren’t even able to do that.

The Consumer Electronics Show was not a hobby computer show. Many of the exhibitors were established consumer-electronics firms that manufactured stereo equipment and calculators. The buyers of such items were general consumers, not electronics hobbyists. But Markkula wanted Apple to pursue a broader market, and he regarded this show as vital for Apple’s growth. For Woz and Wigginton, it was an adventure outside time.

Wigginton and Woz arrived in Las Vegas the evening before the event. They helped set up the booth that night and went back to work on the drive and the demo program. They planned to have it done when the show opened in the morning even if they had to go without sleep. Staying up all night is no novelty in Las Vegas, and that’s what they did, taking periodic breaks from programming to inspect the craps tables. Wigginton, 17, was elated when he won $35 at craps, but a little later back in the room, his spirits were dashed when he accidentally erased a disk they had been working on. Woz patiently helped him reconstruct all the information. They tried to take a nap at 7:30 that morning, but both were too keyed up.


disk II™
$495.
INTRODUCTORY PRICE
IN USE
disk II
apple computer, inc.

Figure 67. The disk drive *Apple's first ad as a company.*
(Courtesy of Apple Computer Inc.)

Despite the snafus, the demo went well. After the show, Woz, together with Rod Holt, completed work on the disk drive so that it met Woz's expectations as to what it could realistically accomplish. Normally the layout work was sent to a contracting firm, but the contractor was busy and Woz wasn't. So, Woz himself laid out the circuit board that was to control the drive. He worked on it every night until 2 A.M. for two weeks.

When Woz was finished, he saw a way to cut down on feedthroughs—signal lines crossing on the board—by moving a connector. The improvement meant redoing the entire layout, but this time he completed the task in less than 24 hours. He then saw a way to eliminate one more feed-through by reversing the order of the bits of data transmitted by the board. So he laid out the board again. The final design was generally recognized as brilliant by computer engineers, and beautiful in terms of engineering aesthetics. Woz later said, "It's something you can only do if you're the engineer and the PC board layout person yourself. That was an artistic layout. The board has virtually no feedthroughs."

The disk drive, which Apple began shipping in June 1978, was vital to the company's success, second only to the computer itself in importance. The drive made possible the development of robust software like word processors and database packages. Like most early successes at Apple, it represented an enormous amount of unconstrained individual effort, as did the early achievements of the Altair and the Sol. But at Apple, the hobbyist spirit was being channeled by a few sharp executives who understood how to build a company.

The Red Book

The Apple II desperately needed a good technical reference manual. When the company started shipping the computer in 1977, the instruction manual wasn't much better than any other documentation in the industry; that is, it was unspeakably bad. Documentation was the last thing a microcomputer company worried about in 1977. Customers were still mostly hobbyists and would tolerate abominable documentation because they welcomed the challenge of assembling and troubleshooting their machines. But Apple couldn't afford to neglect documentation if it wanted to bring a broader spectrum of consumers into personal computing.

Apple lured Jef Raskin from a writing job at *Dr. Dobb's Journal* to run the company's documentation effort. Raskin encouraged Chris Espinosa, who had planned on attending college full time in the fall, to write something that would explain the Apple computer to its users.

The manual's genesis is a true hobbyist's story. Espinosa had left his high-school job at Apple to go to college and was a freshman living in the dorms at Cal Berkeley—Lee Felsenstein and Bob

Marsh's alma mater—when he began work on a manual that would explain, in a clear and organized fashion, the technical details of the Apple II. Espinosa wasn't quite finished with it when he had to leave his dorm at the end of the term. For a week, he slept in parks and in the campus computer rooms, living out of his backpack and working 18-hour days to complete the manual. He typeset it on university equipment and turned it in to Apple.

The Red Book, as the manual came to be known, provided the kind of information that mattered to people who wanted to develop software or add-on products for the Apple II; it was a great success and unquestionably aided in Apple's growth. It would be hard to overestimate the contribution made to Apple by outsiders and such third-party developers as Espinosa, who wasn't employed by Apple when he wrote the Red Book.

Apple was definitely on to something, but if it was going to continue to grow, it had to get beyond enthusiasts and create a perceived need for personal computers within a broader buying public. People had to believe that the machines served a practical purpose. Gary Kildall's CP/M operating system and the subsequent development of business-application software helped some companies sell machines in quantity. But Apple's operating system was different from CP/M, and the Apple machines needed their own software.

Several programmers started writing games and business applications for the Apple. And although some of them were impressive, none were important enough to induce people to buy the computer just to use the program. Not until VisiCalc.

The Killer App

Back on the East Coast, Dan Bricklin, a quiet and unassuming Harvard MBA candidate, conceived an idea for a computer program to do financial forecasting. He thought it would be especially useful in real-estate transactions. Bricklin had been a software engineer with DEC and had worked on its first word-processing system. He thought he could sell his program to users of DEC minicomputers, or perhaps even sell it in the new microcomputer market.

Bricklin approached a Harvard finance professor with the idea. The professor laughed at him, but said that he might want to talk to an ex-student of his, Dan Fylstra, who had researched the market for personal-computer software. The professor also gave Bricklin the same warning he'd once given to Fylstra: because of the availability of time-sharing systems, personal-computer software would never sell.

Daniel Fylstra was a Californian who had gone east to study computers and electronics at MIT. As an associate editor for *Byte* magazine in its early days, he had been impressed with the chess program designed by Peter Jennings. While pursuing an MBA degree from Harvard Business School, he started a small software-marketing company, Personal Software, whose chief product was Jennings's Microchess. By this time, Tandy Corporation had entered the microcomputer field, and the first version of the program Fylstra sold ran on the TRS-80 Model I. Fylstra liked the way graphics programming worked on the Apple II, and soon he was also offering Microchess for the Apple II.

Fylstra ended up liking Bricklin's idea for the financial-forecasting program. The only personal computer he had available at the time was an Apple II. He lent it to Bricklin, who began designing the program with a friend of his, Bob Frankston. Something of a mathematics genius, Frankston had been involved with computers since he was 13. And he had done some programming for Fylstra's company, converting a bridge game program to run on the Apple II.

Shortly thereafter, Bricklin and Frankston founded a company, Software Arts, and started coding the financial-analysis program. Throughout the winter, Frankston worked on the program at night in an attic office, and during the day he consulted with his partner on his progress. Occasionally the two would get together with Dan Fylstra to dream of the lucrative future that would soon be theirs.

Figure 68. Bob Frankston and Dan Bricklin ***They invented VisiCalc, the first electronic spreadsheet program, in 1979.*** **(Courtesy of Dan Bricklin)**

A prototype of the program was ready by the spring of 1979. Bricklin and Frankston called it VisiCalc, short for “visible calculations.” VisiCalc was a novelty in computer software. Nothing like it existed on any computer, large or small. In many ways, VisiCalc was a purely personal computer program. It kept track of tabular data, such as financial spreadsheets, using the computer’s screen like a window through which a large table of data was viewed. The “window” could slide across a table, displaying different parts of it.

The VisiCalc program simulated paper-and-pencil operations very well, but also went dramatically beyond that. Data entered in rows and columns in a table could be interrelated so that changing one value in the table caused other values to change correspondingly. This “what-if” capability made VisiCalc very appealing: one could enter budget figures, for instance, and see at once what would happen to the other values if one particular value were changed by a certain amount.

When Bricklin and Fylstra began showing the product around, not everyone responded as enthusiastically as they had expected. Fylstra recalls demonstrating VisiCalc to Apple chairman Mike Markkula, who was unimpressed and proceeded to show Fylstra his own checkbook-balancing program. But when VisiCalc was released through Personal Software in October of 1979, it was an immediate success. By this time, Fylstra had moved his company to Silicon Valley.

Another early application program for the Apple was a simple word processor called EasyWriter, a program similar to Electric Pencil, written by John Draper. Eventually Draper marketed his program through Information Unlimited Software of Berkeley, California, the same company that was selling the early database-management program WHATSIT.

But VisiCalc was far more significant.

Fylstra asked his dealers to estimate a competitive price for VisiCalc, and he was told between $35 and $100. Initially Fylstra offered the package for $100, but it sold so fast that he quickly raised the price to $150. Serious business software for personal computers was rare, and no one was sure how to price it. Plus, VisiCalc had capabilities other business software didn’t. Year after year, even as VisiCalc increased in price, the volume of sales rose dramatically. In its first release in 1979, Personal Software shipped 500 copies of VisiCalc per month. By 1981, the company was shipping 12,000 copies per month.

Not only did VisiCalc sell, but the popularity of the program also helped to sell Apple computers. It was the “killer app,” the application program that people bought the computer to get. During its first year, VisiCalc was available only for the Apple, and it provided a compelling reason to buy an Apple computer. In fact, the Apple II and VisiCalc had an impressive symbiotic relationship, and it’s difficult to say which contributed more to the other. Together they did much to legitimize both the hardware and the software industries.

Trouble in Paradise

Committee marketing decisions—that was the major source of all the problems.

—Dan Kottke

During Apple's third fiscal year, which ended on September 30, 1979, sales of the Apple II increased to 35,100 units, more than quadruple the number of the previous year. But the company felt the need to develop another product soon. No one believed that the Apple II could remain a best-seller for much longer.

Looking for the Next Thing

In 1978, Apple took several steps to gear up for the challenge. They hired Chuck Peddle that summer, with undefined responsibilities. As the designer of both the 6502 microprocessor and the Commodore PET computer (which competed with the Apple II), he just seemed like a good person to have around. Peddle had seen possibilities in Apple even before it had emerged from the garage, and had tried unsuccessfully to get Commodore to purchase the company.

Peddle's PET computer (said to stand for either Personal Electronic Transactor or Peddle's Ego Trip, but actually named after the pet-rock fad of the day) was introduced at the first West Coast Computer Faire in 1977, as was the Apple II. As it turned out, the PET did not greatly influence the development of the American personal-computer industry, largely because Commodore president Jack Tramiel opted to concentrate on European sales and Commodore delayed in providing a disk drive for its computer.

Peddle and the Apple executives ultimately failed to agree on what role he would play at the company, and he returned to Commodore at the end of the year.

By that time, Tom Whitney, Woz's old boss at Hewlett-Packard, had been hired to supervise and enlarge the engineering department in order to begin designing new products.

In late 1978, several new computer projects were started. The first, an enhanced version of the Apple II with custom chips, was code-named Annie. Woz worked with another engineer on it but didn't complete the project. Moreover, he didn't pursue it with the intensity he had given to his previous computer designs or to the disk-drive project. But Wozniak wasn't twiddling his thumbs, either.

Apple executives discussed having Woz design a supercomputer that utilized something called bit-sliced architecture, which would spread the capabilities of the microprocessor over several identical chips. The chief advantages of such an architecture were speed and variable-precision arithmetic. An engineering staff was put together to create this computer, code-named Lisa. The

Lisa project started slowly and passed through many incarnations over several years. Eventually John Couch, a former Hewlett-Packard engineer hired by Tom Whitney, took over as project director.

The Third Apple

Meanwhile, Wendell Sander took charge of designing the next Apple computer, the Apple III. Sander, one of Apple's most trusted employees, was asked to design a machine that would equal the success of all the other Apple products. When he commenced work on the Apple III, company executives told him that they hoped he could finish it within a year.

When Wozniak had designed the Apple II, he was free to create the machine he wanted. Sander, on the other hand, had constraints from the outset that stemmed from a meeting of the executive staff, which at that point still included Chuck Peddle. The executive staff compiled a general and somewhat vague list of guidelines, mentioning such desired items as enhanced graphics and additional memory. The few detailed concepts added to the list seemed cosmetic by comparison. For instance, executives wanted the machine to be capable of displaying 80 columns rather than 40, and upper- and lowercase characters onscreen.

Sander was told that the new machine should be able to run software designed for the Apple II. Although this compatibility was desirable considering the large pool of software being developed for the Apple II by outside programmers, it posed a problem. Designing a computer with such "backward-compatible" capabilities ties a designer's hands.

When hardware differs between two computers, those computers can be made to run the same application software through an intermediate layer of software built into one of the machines. This added layer intercepts commands from the application program and translates them into corresponding commands or sequences of commands for the underlying hardware. The process is inherently inefficient, and the inefficiency is most evident in programs where timing is vital. The most critical hardware feature for such emulation is the microprocessor, and Apple decided to simplify this aspect of the emulation problem by using the same processor found in the Apple II, the venerable and underpowered 6502.

The emulation-layer edict that came down from the Apple executive offices was not without controversy. Apple engineers and programmers felt that emulation would limit the capabilities of the breakthrough machine they were supposed to create. They themselves wouldn't want this kind of machine. But the marketing staff saw emulation as a stimulus to sales: an existing body of software could run on the Apple III immediately, and Apple could claim it was designing a family of computers. The edict was not rescinded.

Emulation and the choice of the 6502 processor boxed Sander in and limited his creative options. The most important decision in the design of a computer—selection of a microprocessor—had been made by others. When Chuck Peddle designed the 6502, he hadn't even intended it to be used as the central processor in a computer. Apple considered adding an additional processor, with some capacity to switch from one to the other, but a dual-processor machine would have been too expensive. Sander wasn't one to protest. He liked designing computers, and he uncomplainingly set out to implement the guidelines given to him.

Dan Kottke worked as Sander's technician on the project. Each day, Sander would hand Kottke a drawing of a new part of the computer. Kottke would then copy over the schematic to make it more legible, slap on his stereo headphones, and wire-wrap the computer to music. Within a few months, they had a working prototype of the main board.

Around that time, Apple assembled a software team to design an operating system and a few applications for the new computer. Management wanted the Apple III to have a better operating system than the simple one Woz had created for the Apple II. Indeed, the Apple III required a more complex system to handle its extra memory.

Although the 6502 microprocessor could normally handle only 64 kilobytes (K) of memory, Sander was sidestepping that limitation by a technique known as bank switching. The computer would have multiple banks of 64K, and the operating system would keep track of which bank was currently active and what information was in each bank. The operating system could then move from bank to bank as necessary. The microprocessor would behave as though the machine had only 64K, but the application software would run as though the machine were handling 128K or 256K directly.

Sander labored on the Apple III throughout 1979, and discovered that the emulation requirement also limited the extent to which he could improve the new computer's graphics. In the Apple II, a chunk of memory was reserved for the bits and bytes representing the colors of pixels on the screen. Apple II software accessed this graphics screen map whenever it needed to update the screen with new colored lines and pictures. The Apple III needed to have the same map, in the same size, at the same location in memory, and with the same means of access. This need precluded many possibilities for enhancing graphics on the Apple III.

Woz occasionally checked in with Sander on the project, but he trusted his colleague, whom he called "an incredible engineer," to get the job done without his interference. Nevertheless, Woz later complained about the emulation software. It didn't adequately emulate the II, he felt. "Apple claims they've got it and they don't," he said. Woz was disengaged, even bored. One day he sneaked into a programmer's cubicle and placed a mouse inside his computer. When the programmer returned, it took him more than a few minutes to figure out why his Apple was squeaking. Meanwhile, without the singular vision of a Steve Wozniak, the Apple III project was floundering.

Delays in the Apple III were soon causing concern in the marketing department. The young company was beginning to feel growing pains at last. When Apple was formed, the Apple II was already near completion. The Apple III was the first computer that Apple—as a company—had designed and built from scratch. The Apple III was also the first Apple not conceived by Steve Wozniak in pursuit of his personal dream machine. Instead the Apple III was a bit of a hodgepodge, pasted together by many hands and designed by committee. And, as is typical of anything created by committee, the various members weren't completely happy with the results.

Ironically, the pressure put on the Apple III project group for a swift completion wasn't even necessary. The market loved the Apple II. Although new companies were entering the personal-computer market, Apple had overtaken Radio Shack to become the leading personal-computer company. In 1980, Apple II sales doubled to more than 78,000 units. Nevertheless, the marketing people were worried and pushed for the release of the III.

Although he felt the curtain was being raised on the Apple III a bit prematurely, Sander consented to introduce the new machine at the National Computer Conference in Anaheim, California, in May 1980. For all Mike Scott's efforts to make Apple a serious professional company, these were still the wild and wooly days of hobby computing, and product-quality testing was primitive at best. With a few functioning prototypes and the operating-system software somewhat in working order, Sander thought they should be able to pull off the introduction.

Success and Failure

At the computer conference, the Apple III was well received by both the industry and the press. In addition to unveiling its new computer, Apple announced the new software it intended to have ready by the time the machine shipped a few months later—a word processor, a spreadsheet program, an enhanced BASIC, and a sophisticated operating system. The marketing plan called for the Apple III to be portrayed as a serious computer that could be used in professional offices. The machine seemed likely to succeed.

A few months later, continuing to ride the tide of acclaim, Apple announced its first public stock offering. *The Wall Street Journal* wrote, "Not since Eve has an apple posed such temptation."

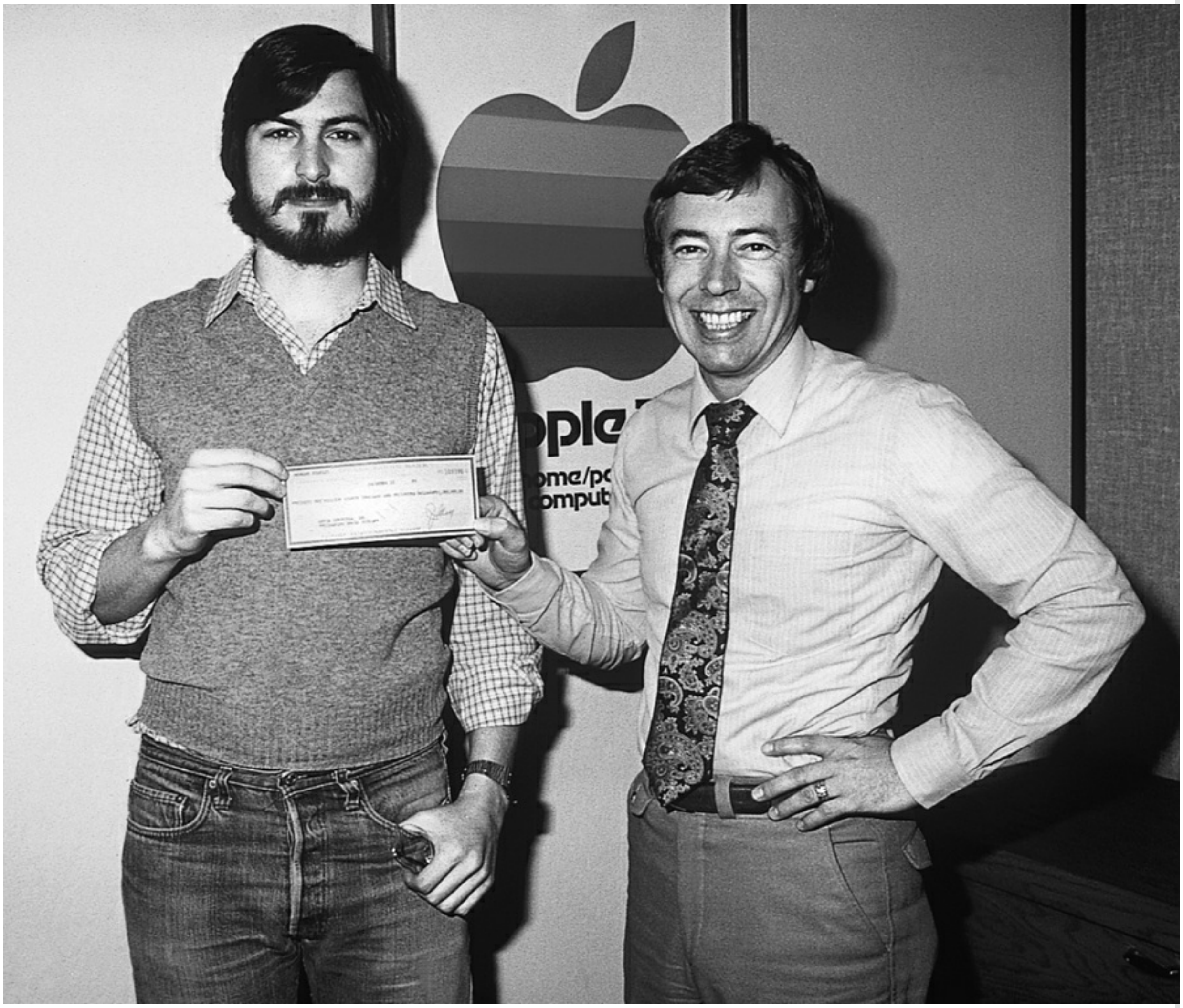


Figure 69. Apple goes public ***Mike Markkula presents Steve Jobs with a check for $92 million from his stock offering in Apple.***
(Courtesy of Apple Computer Inc.)

When Apple was first formed, Mike Markkula dreamed of building the largest privately held company in the nation, a company fully owned by its employees. What he didn't foresee at the time was the explosive growth of the personal-computer industry. To keep pace with advances in personal computing, investment in research and development, as well as advertising and marketing, was essential. Apple had to go public. On November 7, 1980, when the company registered with the Securities and Exchange Commission for an initial public stock offering, Apple revealed that its advertising budget alone for the year had doubled to $4.5 million.

Jobs and Woz were now millionaires many times over. But the young moguls and their cohorts at Apple were about to pay for rushing a product to market.

After shipments of the Apple III commenced in the fall of 1980, it quickly became apparent that the machine had defects. Users brought the computers back to their dealers in droves, complaining that programs were crashing inexplicably. The dealers, in turn, started complaining to Apple.

The Apple staff now attempted to isolate the problem, carrying out the diagnostic tests they should have done before the computer was announced, or at least before it was released. As problems with the Apple III became public knowledge, Apple slowed its promotion of the new computer and called a temporary halt to production. The staff isolated one problem: a loose connector. While working on the Apple III, Dan Kottke had noticed that on occasion the machine would die. When he lifted it a half inch off the table and let it drop, it would turn back on. Kottke suspected a faulty connector, but he had hesitated, as a lowly technician, to voice his doubts to his superiors. Wendell Sander, the engineer, was not involved with mechanical details like connectors. It was a problem that had fallen through the cracks.

Another shortcoming owed to a bad break rather than faulty design. Sander had counted on having a special National Semiconductor chip to use as an internal electronic clock. National informed him late in the project that the chip would not be available. Apple considered other chips, but finally scrapped the entire idea. However, because the Apple III had been advertised as having an internal electronic clock, the price of the computer had to be lowered due to its lacking a promised feature.

The problems were identified by January 1981, but selling a defective computer for several months had hurt Apple's reputation. Until then, the company could do no wrong, and a certain amount of overconfidence led Jobs, Markkula, and Scott to release the Apple III without properly testing it.

Woz Crashes His Plane

On February 7, 1981, Woz crashed his four-seat, single-engine airplane at the Scotts Valley Airport, just a short drive from Apple. He had been practicing touch-and-go landings with two friends and his fiancée Candi onboard. Woz and his sweetheart were injured; his friends escaped unscathed. Fortunately, he didn't smash into a crowded skating rink that was just 200 feet away.

Candi recovered quickly. Woz had cuts on his face, but was otherwise thought to be in remarkably good condition. No one realized, not even Woz, what the accident had actually done to him. At the time, Woz's family and friends thought he seemed a bit slow, mentally. They didn't know that while he could remember everything up to the day before the accident, his memory of events just prior to the crash, and for a period afterward, had been wiped out.

"I didn't know I had been in a plane crash," said Woz. "I didn't know I had been in the hospital. I didn't know I had played games on my computer in the hospital. I thought I was just resting on a weekend and after the weekend I would go back to work at Apple." He had what doctors call anterograde amnesia, a condition not uncommon in plane-crash survivors.

A month passed, during which time Woz still had no knowledge of his condition. After watching the movie *Ordinary People*, he became troubled by the idea of being in a plane crash. “Was I in a plane crash,” he asked his fiancée, “or did I dream it?”

“Oh, you dreamed it,” Candi said, thinking he must be kidding.

But the thought continued to nag at Wozniak, and he began to dwell on it. He brought back the events leading up to the flight, every detail he could force himself to remember, right up to putting his hand on the throttle. Then—nothing.

This was exciting. The explanation was amnesia! He had a gap in his memory. He found hundreds of get-well cards next to the bed, some dated weeks before, which he couldn’t remember ever seeing. Now he knew the gap was weeks long.

It took Woz more than a month to “talk himself” out of his amnesia, as he put it. Even after his memory returned, Woz didn’t want to go back to Apple right away. He had already phased himself out of the major decision making there. He simply wasn’t interested in the business end of the company. He was an engineer, and he had continued to work on the engineering projects assigned to him. “I’m not a manager type. I just love instruction sets,” he said.

One of Wozniak’s last projects before the crash involved writing the math routines for a program that Randy Wigginton was developing. The program was Mike Scott’s idea. Frustrated with the long project delays at Apple, Scott had ignored the company bureaucracy and assigned the young Wigginton a major role in developing a spreadsheet program similar to VisiCalc.

Wigginton worked faster than Woz had anticipated and was ready for the routines almost before Woz had begun creating them. Mike Scott, angered by Woz’s inconsistent work habits and by delays in shipping the Apple III, began pressuring him. Woz worked night and day, suffering Scotty’s daily complaints about his slow progress.

At one point, in order to get Scott off his back, Woz dreamed up yet another practical joke. Woz knew that Scotty was a fan of movie director George Lucas, and Scotty had told Woz that he hoped the director might join Apple’s board of directors. So Woz had a friend phone Scott’s secretary saying that he was George Lucas and that he would call again. Scott, anxiously anticipating Lucas’s call, left Woz alone for the next few days.

Woz wasn’t sure even a year later, but he believed that he may have had the final spreadsheet routines with him when he crashed the plane. However, subsequent events at Apple had a more devastating effect on the company than the loss of that code.

Black Wednesday

Just three weeks after Woz's accident, Mike Scott decided that Apple needed a healthy shakeup. The ship he was steering had listed a bit, in his estimation, and he decided it was time to jettison some of the dead weight. On a day referred to by the staff as Black Wednesday, Scott fired 40 Apple employees and terminated several hardware projects that he believed were taking too long to complete. The move stunned the company at every level.

Mike Scott had never hidden his volatile personality. He had had a number of arguments with both Woz and Jobs. "I've never yelled at anybody more in my life," Jobs recalled. Sometimes Jobs would leave the president's office in tears after a long altercation. Scott was also known for his flamboyant behavior. He was a familiar figure around the company, visiting employees regularly to keep in touch with what was happening. Scott also knew how to boost the company's morale, as evidenced by his suggestion that the company pay for a trip to Hawaii for the entire staff. But the Apple III exhausted Scotty's limited patience.

Because the necessity of the firings was questionable, the young company was shocked. At first, remaining employees wondered who would be next. Simultaneously, they mounted an effort to hire back some of the people Scotty had fired. Even those who agreed that a shakeup was necessary felt that Scott had fired some good employees unfairly.

Chris Espinosa visited Jobs in his office the day after the firings and told him, "This is a hell of a way to run a company." Although Jobs defended the mass ejection, he seemed to be as demoralized as everyone else. Scotty had acted too arbitrarily for the taste of either Jobs or Markkula.

A month later, Jobs and Markkula demoted Scotty. No longer at the helm, Scotty decided the current state of affairs was intolerable. In a bitter letter of resignation dated July 17, he announced that he was fed up with "hypocrisy, yes-men, foolhardy plans, a 'cover your ass' attitude, and empire builders." Perhaps his most significant allegation, one that epitomized his approach to management, was that "a company's quality of life is not and cannot be set by a committee." The next day he flew to Germany to attend the Bayreuth opera festival, something he had wanted to do all his life.

Despite the problems with the Apple III, Woz's amnesia, Black Wednesday and its aftermath, and Scotty's resignation, Apple continued to prosper. As always, Woz's labor of love, the Apple II, carried the company. Net sales of Apple IIs had more than doubled during fiscal 1980 and continued to climb through the first half of 1981. By April 1981, Apple employed more than 1,500 people. The company had opened domestic manufacturing facilities in San Jose, Los Angeles, and Dallas, in addition to Cupertino. To meet the growing demand in Europe, a facility was opened in Cork, Ireland. Worldwide sales of Apple products were increasing at a pace of 186 percent above the previous year, and now totaled more than $300 million. The number of Apple dealers had risen to 3,000. Mike Markkula took over for Scotty as president of Apple, a position he believed to be a temporary one, and at age 26 Steve Jobs became chairman of the board.

Apple was now investing millions of dollars in research and development to create a product that would stun the world. It wanted to prove that it had learned the lessons of the Apple III, that Apple could indeed introduce a new product successfully. By the fall of 1981, rumors abounded in the trade journals about new products Apple was developing.

The rumors were wrong, though not even Apple realized it at the time. Apple would indeed unveil a computer that stunned the world, but its roots lay elsewhere, with the work of a brilliant engineer a few miles up the road and a technology over a decade old and still unknown to most of the world.

Shooting for the Moon

> *When you have nothing to lose, you can shoot for the moon. So we shot for the moon, and we always knew if we were successful that it would come down to Apple and IBM.*
>
> —Steve Jobs

The Apple II had taken the nascent personal-computer industry to a new level of product marketing and design. Designed by one genius engineer, it was also technically impressive. But the whole notion of how people interacted with computers was about to undergo a fundamental change. And it would be Apple that would introduce this new vision of the personal computer to the world.

The Mother of All Demos

It was, by all accounts, one of the most impressive technology demonstrations since the atomic-bomb test at Alamogordo, New Mexico.

In December 1968, the Fall Joint Computer Conference (FJCC) took place in San Francisco, and it included a presentation by Douglas Engelbart and his colleagues from what was then called the Stanford Research Institute, later SRI, in Menlo Park, a few miles up the peninsula from Cupertino.

Engelbart, an angular man who spoke quietly and efficiently, took the stage decked out in microphone and headphones, and seated himself in front of a bizarre device that featured a keyboard and other odd implements. Behind him was a screen, on which much of the demonstration would play out.

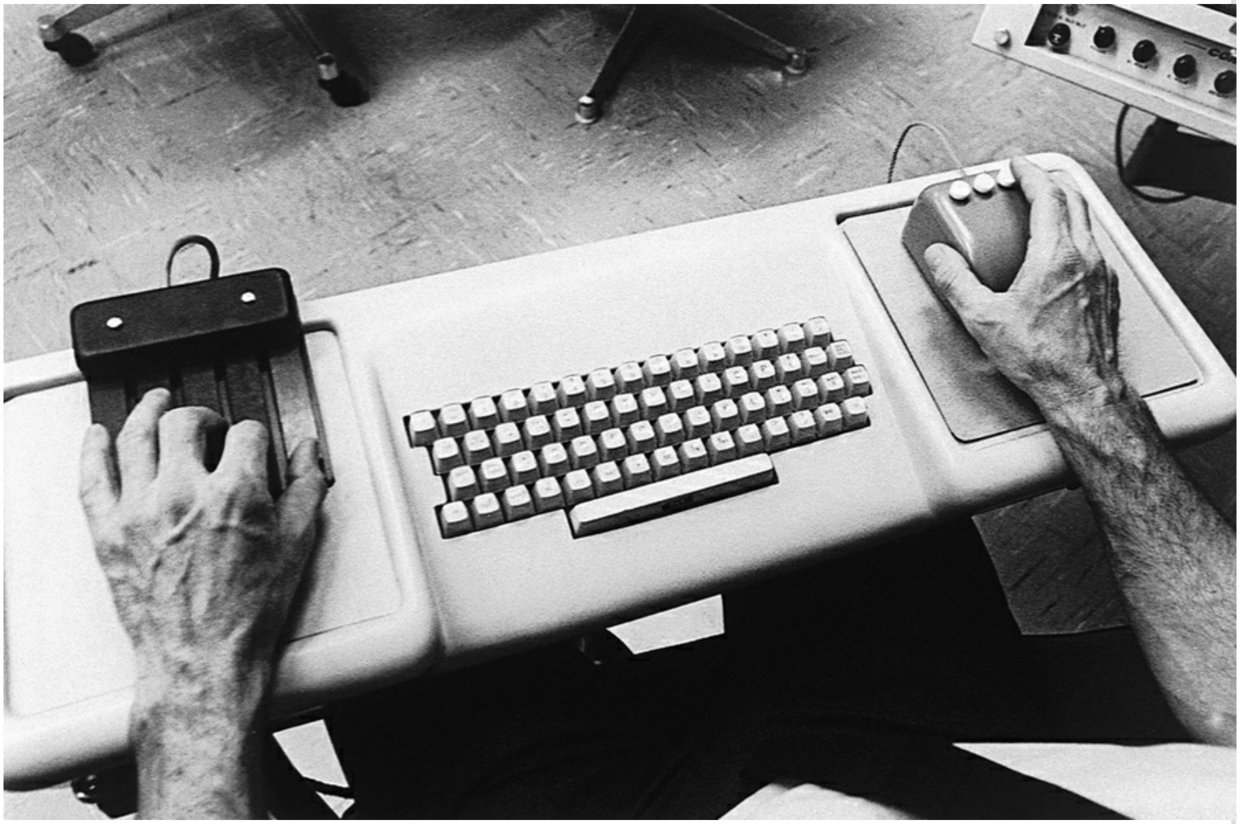


Figure 70. The mother of all demos ***The input devices used by Douglas Engelbart at the 1968 Fall Joint Computer Conference when he put on "the mother of all demos"*** **(Courtesy of Doug Engelbart)**

The demo was like opening a window into the future. It showed how a computer could deal with common chores like planning one's tasks for the day. Engelbart kept all this information in an electronic document he could organize and examine in many different ways. At a time when a clanking Teletype was a common way of getting information out of a computer, Engelbart took the FJCC audience into a new world. He showed them lines of text that expanded into hierarchical lists and then collapsed back down, text that could be "frozen" at the top of the screen while the prose below changed, and the mixing of text, graphics, and video on a split-screen display.

And Engelbart controlled it all with an extraordinary device called a mouse that had an apparently telepathic link with a dot (they called it a "bug") that moved around the screen, specifying where instructions would take effect. By using the "mouse," Engelbart could click on a word and jump to another location in the document or to another document.

Figure 71. The first mouse ***Douglas Engelbart invented the mouse in 1964 as an input device. This first one was carved from a block of wood.*** **(Courtesy of Doug Engelbart)**

The demonstration got even more interesting when Engelbart introduced one of his team members via a video/audio link. This man also sat in front of a device like Engelbart's, and wore a microphone and headphones. Both he and Engelbart were in front of television cameras so they could speak to each other. And both, it soon became clear, could also work on the documents on Engelbart's screen, taking turns controlling that telepathic bug, manipulating the document collaboratively in real time while talking and seeing one another in half of the split-screen display.

This was unlike anything anybody had ever seen computers do.

The demo anticipated many breakthroughs that wouldn't reach computers for a generation. It included collapsible and expandable outline lists, text with embedded links to other documents as in web browsers today, a mouse, a one-handed chording keyboard that left one hand free for the mouse, and live video and audio conferencing with a user in another city. And this was in 1968.

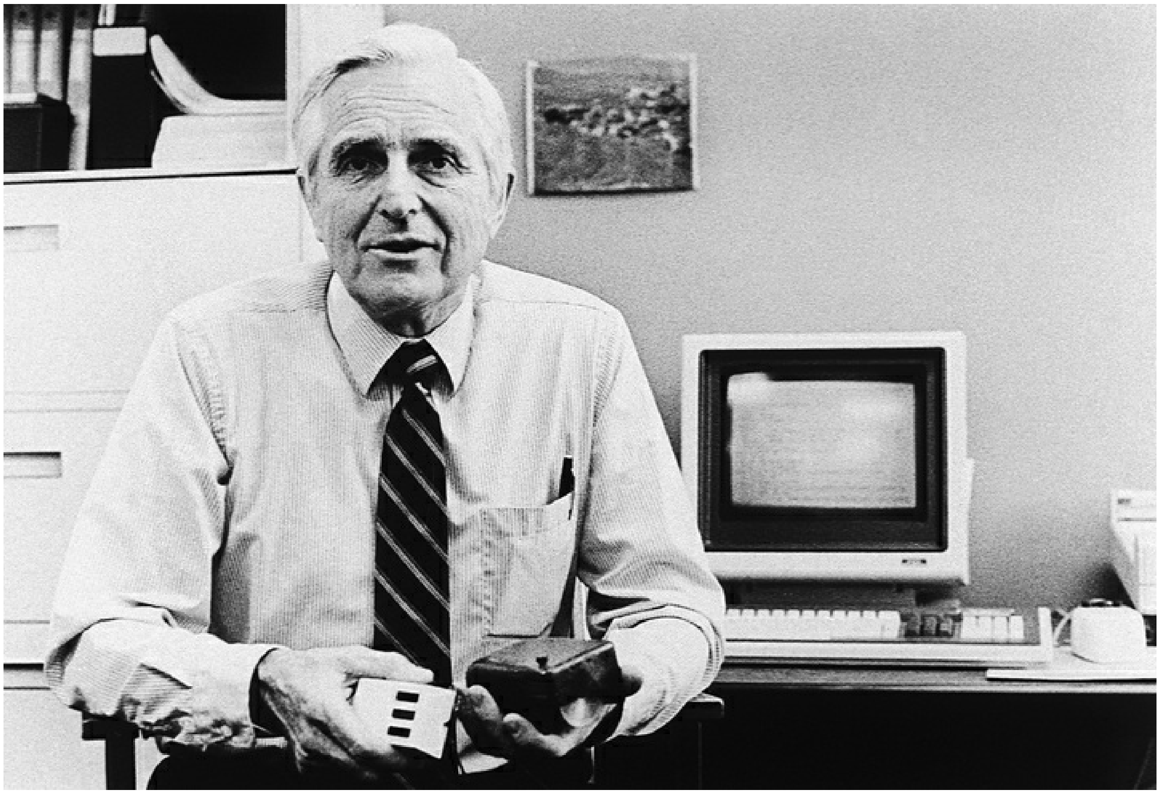


Figure 72. Douglas Engelbart ***Tech visionary Engelbart holds his original wood-block mouse alongside a more modern descendant.*** **(Courtesy of Doug Engelbart)**

Engelbart presented more innovation that day than most acknowledged greats of the field achieved in a lifetime, and he was still a young man. When he finished, the audience gave him a standing ovation. It was later called "the mother of all demos," and the National Museum of American History (at the Smithsonian) has preserved elements of it. That's appropriate. It was historic.

Computer scientist Alan Kay had seen Engelbart's technology before the demo. "I knew everything that they were going to show. I had seen it. And yet it was one of the greatest experiences of my life. It was the totality of the vision, the breadth of the vision, the depth of the vision. The standing ovation there came from that instant recognition that something important had happened and we didn't have to be the same thereafter. That happens in Texas tent meetings when you get converted, and most Baptist preachers will tell you it doesn't last long. But for the few who realized what Doug was trying to do, it made an enormous difference."

Technology futurist Paul Saffo later said, "This demo set a brush fire burning that swept across the computing landscape that inspired one researcher after another to head off in their own direction. It quite literally branched the course of computing off the course it had been going for the previous 10 years, and things have never quite been the same again."

Xerox PARC Opens the Kimono

The demo should have opened all the doors. In another era, investors would have been throwing money at Engelbart. But in 1968, few of them recognized high tech as a promising area for funds. Years went by. Engelbart went to a company called Tymshare, and many of his former staff ended up at a new research center in Palo Alto called Xerox PARC.

Figure 73. Early workstation ***This 1965 workstation embodies many of Engelbart's innovations, including the mouse.*** **(Courtesy of Doug Engelbart)**

Xerox opened PARC, its Palo Alto Research Center, in 1970. Xerox had separated research from development, and PARC was strictly a cutting-edge research institute with no commitment to develop commercial products. PARC was chartered to explore technological frontiers, which it did. One Silicon Valley observer called PARC a national resource because of its relatively open sharing of technical knowledge with the outside world, an openness more akin to an academic institution or to the computer hobbyist movement than to the research wing of a large corporation. With both the freedom of a university and the financial backing of a large corporation, PARC was an exciting place for any computer engineer or programmer to work.

Among PARC's achievements was Smalltalk, a computer language that was more than a language, really a new way of thinking about how to map real problems to computer solutions. PARC also developed key technology for connecting an office full of computers in a local network. With the addition of Engelbart's innovations, PARC held the greatest treasure trove in the history of computing. It was the future, yet the only parts of that future that ever seemed to dribble out of the PARC lab were those that meshed well with Xerox's copier business.

Meanwhile, Apple was taking the final steps to correct the damage from the Apple III snafu. In late 1981, Apple officially reintroduced the Apple III. Now the machine included increased memory storage in the form of a hard disk and improved software. But two other important computer projects were also underway at the time.

Figure 74. Lisa ***The Mac's big sister was not a commercial success.*** **(Courtesy of Apple Computer Inc.)**

The Lisa was originally conceived as a multi-CPU computer, and Woz was going to design it. That plan had changed over time, and now the Lisa was going to use a single very powerful CPU, the Motorola 68000. And programming whiz Bill Atkinson, instrumental in getting the Pascal language on the Apple II, was spearheading the software-development team. Lisa was to be a potent machine with novel features. Atkinson envisioned a "paper" paradigm—the screen background would be white, and text and graphics would mix freely, as on a printed page. The Lisa would address the market the Apple III failed to reach. It would be a wedge in the corporate door, a personal computer for business.

If the Lisa was the high-end, costly business machine, the Apple Macintosh was to be in many ways the opposite: small, inexpensive, easy to use, and simple. That was the plan of Jef Raskin, who led the Macintosh project. It was Raskin who, as head of documentation for Apple, had induced Chris Espinosa to write the Red Book, which helped popularize the Apple II. Now Raskin was making better use of his computer-science degree running an actual computer project. The Macintosh Raskin foresaw would be a low-cost, portable device, with none of the dazzle of the Lisa.

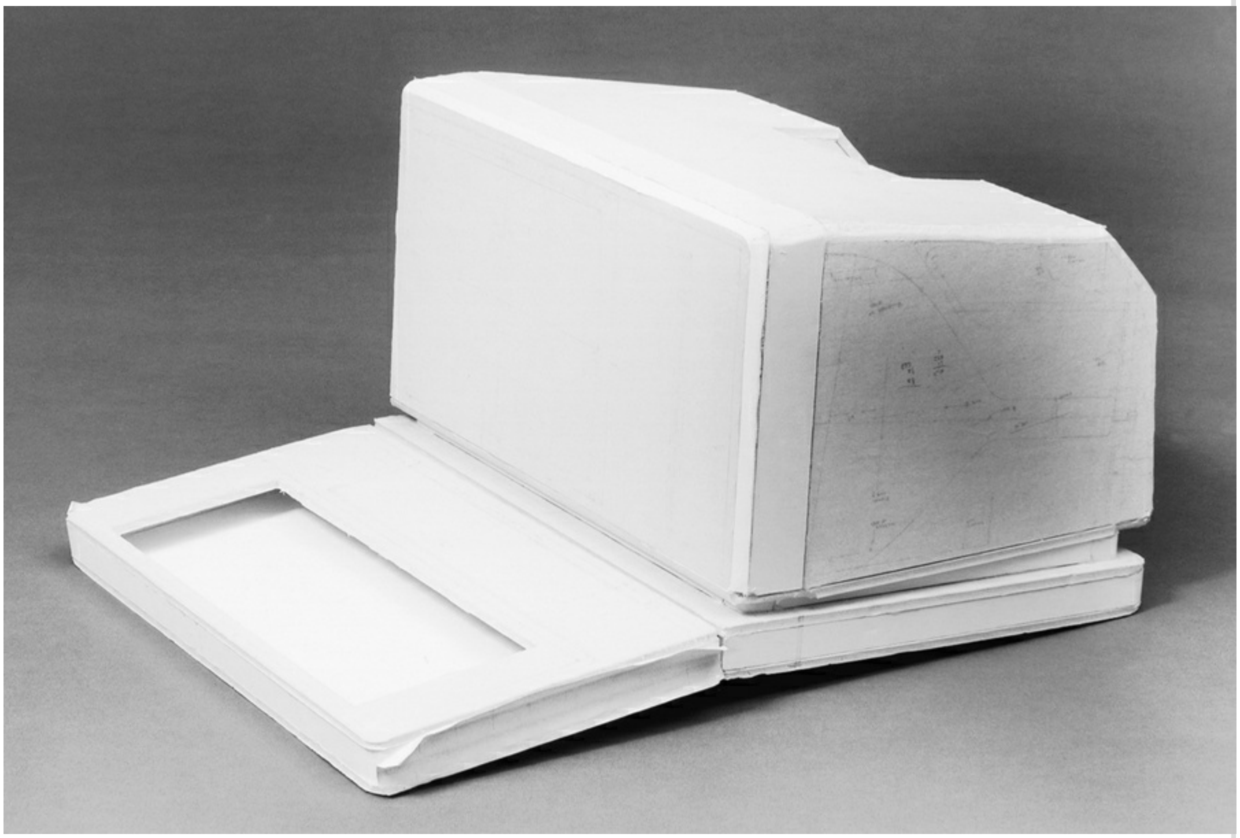


Figure 75. Macintosh prototype *The Mac concept evolved during development.* (Courtesy of Apple Computer Inc.)

At the time, few personal-computer entrepreneurs were aware of the work at PARC. It was primarily a research facility, and a different world. PARC was closer to the world of academia than to the industrial sector.

Jef Raskin was the rare individual with a foot in both worlds. He was an academic computer scientist who was working for the hottest personal-computer company. He knew what was up at

PARC and was convinced that Steve Jobs should know about it, too.

But Raskin had no illusions about his relationship with Jobs. Jobs was quick to judge people, and was binary about it. Individuals were either ones or zeros—on his good list or his bad list. Raskin didn't believe he was on Jobs's list of ones, although he didn't particularly care.

Still, Raskin knew he was not the man to convince Jobs to look at the wonderland at PARC. Bill Atkinson, whom Raskin had hired, had Jobs's respect, so Raskin encouraged Atkinson to get Jobs to take a tour of PARC. It was Atkinson, then, who brought PARC to Jobs's attention and piqued his interest.

The ploy worked. According to Jobs, he also negotiated a better-than-average demo with Xerox.

"I went down to Xerox Development Corporation," Jobs said, "which made all of Xerox's venture investments, and I said, 'Look. I will let you invest a million dollars in Apple if you will sort of open the kimono at Xerox PARC.'"

PARC researcher Adele Goldberg was furious. She felt that Xerox would be giving away all its secrets. Others had gotten tours of PARC and seen demonstrations of the technology, but now for the first time Xerox was opening its doors to a computer-company executive in a position to bring the technology to market. But Xerox Development Corporation overruled her.

Jobs made trips to PARC in November and December of 1979, with Bill Atkinson, Mike Scott, and others. There, Larry Tesler showed them around and gave them "look-but-don't-touch" demos of the innovations. For the first time they saw a graphical user interface: documents appeared in overlapping frames on a white screen, and software programs were made tangible through icons and direct manipulation of onscreen elements. Supplementing the keyboard was Engelbart's mouse, now part of a fully functioning system, which let one click on items and drag them around the screen. It all astounded Jobs.

The Genesis of the Macintosh

Although he and his colleagues paid close heed to the demos, they really learned nothing about how the PARC engineers had done their magic; they saw only the results. PARC didn't really give Apple folks the technology so much as the vision. But that was enough to alter Apple's plans fundamentally, and the change took place right then and there when Steve Jobs decided that Apple would implement these marvels.

Figure 76. Larry Tesler ***Tesler joined Apple from Xerox PARC, where he had worked on Smalltalk.*** **(Courtesy of Larry Tesler)**

Some time later, Apple took more from PARC when it hired Larry Tesler to work on the Lisa. Soon, several more PARC engineers moved over to Apple, recognizing that it offered them their chance to bring to market their vision of a graphical user interface.

Jobs insisted that the Lisa project was to change direction and embody the PARC revelations. Jobs was fired up and was driving everyone hard, insinuating himself into the project at many levels. He was, by many accounts, driving everyone nuts. If this had happened only a few months later, he might have gone unchallenged, but at the time Apple still had a president who had no qualms about managing a company founder. Scotty pulled Jobs off the Lisa project. Former Hewlett-Packard engineer John Couch, who had been hired in 1978, was placed in charge of Lisa.

Unwilling either to accept the decision or to challenge it, Jobs reacted by moving in on the Macintosh project. He had Raskin pushed aside, and he completely redefined the Macintosh to be something very similar to the Lisa—the major difference being that Jobs wanted his team to make the Mac better than the Lisa. He moved the Mac team offsite, pulled in top-notch engineers and programmers, drove them to work long hours, criticized them as much as he praised them, and told them that they were the future of the company and everyone else at Apple was the past.

In 1981, Apple spent $21 million on new product research and development, three times what it had spent the year before. Jobs toured the world's leading automated factories and then commissioned a new factory for Apple in Fremont, California, to build the Macintosh. "We have designed the machine to build the machine," Jobs said. "The manufacturing of the Macintosh has been designed from day one to be highly automated."

Jobs and others at Apple wanted to see the company's rapid growth continue and establish Apple as the technology leader, for a number of reasons—the main one being the likelihood of a late-1981 entry into the personal-computer market by a company called International Business Machines Corporation (IBM).

Figure 77. Steve Jobs and Mike Markkula ***Jobs soon learned how to upgrade his image to better match his ambitions.***
(Courtesy of Apple Computer Inc.)

Apple was not surprised by rumors that IBM planned to produce a personal computer. The company had considered the possibility for several years. Jobs described the situation as being like a gate that’s been inching down slowly, and Apple had been running at top speed for four years to get through the gate before it finally shut. Apple made this concern public knowledge in December 1980 in the prospectus for its initial stock offering. Apple also expected competition soon from Hewlett-Packard and various Japanese firms. But the greatest challenge by far was IBM, the chrome colossus whose name meant “real” computers to most people, a multinational corporation richer than many small countries. Whatever IBM had to offer, Apple would be meeting it with its Lisa and Macintosh. There was no looking back.

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Chapter 8

The Gate Comes Down

We got creamed.

Don Massaro, president of Xerox's office-products division

In the years since they had left Albuquerque for their native Bellevue, Washington, Bill Gates and Paul Allen had established a successful software business specializing in programming languages for personal computers. The BASIC they had originally written for the MITS Altair was still their most popular product, a standard in an industry with few standards. In addition, Gates and Allen had introduced other programming languages, like mainframe-originated FORTRAN and COBOL, to personal computers. They even had a hardware product, a card for the Apple that would let it run Microsoft's 8080 and Z80 software. Tim Paterson of Seattle Computer Products, located across Lake Washington, had been instrumental in developing that.

Gates, 24, and Allen, 27, were pleased with their accomplishments. Microsoft was racking up $8 million in annual sales and it employed 32 people, most of them programmers. But in July 1980 they became involved in a project that would jolt and transform their company and the entire personal-computer industry.

By 1980, dozens of personal-computer hardware and software companies were running businesses that were fundamentally sound, if not earth-shattering success stories. It was the success of Apple Computer that notified the world that personal computers were serious business. The growth of this garage operation into a large company, Apple's enormous annual sales increases, and the proliferation of smaller companies writing software and making add-on hardware for the Apple II convinced skeptics that the personal computer was not another hula hoop.

Figure 78. Bill Gates and David Bunnell ***Just a few years after working together at MITS, they meet here as the software entrepreneur demonstrates a program to the magazine entrepreneur.***
(Courtesy of David Bunnell)

The biggest skeptics had been the large minicomputer and mainframe corporations. Some of them, like Digital Equipment Corporation and Hewlett-Packard, had even rejected employee proposals to build personal computers in the early 1970s.

There were many reasons why the established computer companies were slow to embrace this new market. Prior to Apple’s success, they could still question the very existence of a market for personal computers. Besides, for non-IBM companies, the established markets already offered sufficient risks. Launching an unproven product is perilous, and while a start-up company has relatively little to lose, an established firm can damage its reputation badly by plunging into untested waters. The expense was higher for the established companies, too. Their engineers’ salaries for assessing the feasibility of a personal computer alone could cost a big company more than MITS and Proc Tech ever spent on research and development. The company would also need prototypes and market research, which cost more money.

Finally, there was the seemingly intractable problem of the sales force. Engineers who understood their inner workings sold large computers one at a time. The transaction often involved several visits, long phone calls, and many hours of a highly trained professional's time. In this system, the cost to a company of selling a mainframe would easily exceed the total price of a personal computer. This method was clearly inappropriate for personal computers, but no large computer company was eager to explore new approaches and perhaps alienate its own sales force in pursuit of a chimerical market.

But Apple proved that the "niche" personal-computer market was very real indeed. It no longer took much vision to see that a company with a well-designed machine, some marketing savvy, and the funds for promotion could reasonably expect to sell personal computers at a profit. It was inevitable that the big boys would jump in.

The Luggable Computer

> *Early personal computer companies were managed by amateurs who deluded themselves into believing that their transient success had something to do with good management or foresight.*
>
> –Adam Osborne, personal-computer pioneer

This situation was not lost on Adam Osborne. In 1980, Osborne, who had been involved with microcomputers from the start, from writing microprocessor manuals for Intel to launching a line of computer books and writing a popular industry-watching column in a computer magazine, decided to get much more deeply involved.

From the Fountainhead

As one of the most quotable figures in microcomputing, Osborne had a tongue as glib as his pen. His commanding, distinctive voice, highlighted by a precise British accent, seemed to find the right word at all times, and his delivery convinced his listeners that he had stated the matter in its finality. Osborne had gained a good deal of notoriety in the field from his writing—first books on microprocessors and then columns in *Interface Age* and *InfoWorld*.

Figure 79. Adam Osborne ***Osborne wrote manuals for Intel, created a computer-book publishing company, wrote an influential column for computer magazines, and founded the first company to produce a portable personal computer.*** **(Courtesy of David Carlick)**

His column began with straightforward analyses of Silicon Valley chip technology. But Osborne quickly gravitated to other issues, and soon wrote muckraking indictments of computer companies. He was particularly critical of the common practice of preannouncing items and then bankrolling their development with money from the ensuing orders. Silicon Valley was the source of his information, and he called his column “From the Fountainhead.” Osborne had never been accused of toe-scraping humility, and many readers plausibly assumed he meant the title to refer to himself.

Osborne felt comfortable writing exposés about the industry because he was not directly involved in it. But the Berkeley-based computer-book publishing company he founded as an offshoot of his microprocessor consulting business attracted the attention of McGraw-Hill. After he sold the book company, now called Osborne/McGraw-Hill, he began looking for something else to do.

For a long time, Osborne believed that computers should be portable—a pipe dream in those days. Portability would be the next product innovation, he felt, a fact that companies did not yet understand. During visits to computer shows, Osborne met industry pioneers like Bill Gates and Seymour Rubinstein and sought their reaction to this idea. “At first he was saying, ‘Why doesn’t someone do this?’” recalled Gates. “And the next thing I knew it was, ‘It’ll be called the Osborne 1.’”

Lee Felsenstein’s Next Project

On a hot day in June 1979, Lee Felsenstein was on the auditorium floor of the National Computer Conference in New York City. No one had told him that Processor Technology, the company for which he was consulting, had folded. He waited, patient but sweating, with the prototype of his latest Proc Tech board in hand until it sank in that Bob Marsh and Gary Ingram were never going to show up.

Felsenstein returned to Berkeley, where he tried to drum up business to offset his lost Proc Tech royalties. He tried selling the design of the last Proc Tech board, an enhanced version of his VDM video board, to other companies, but had no luck. He undertook various freelance projects. The jobs offered him a bare subsistence—he was particular about the kinds of work he would accept. “I was running into the ground,” he said. “I was just waiting for the opportunity to do what I wanted to do and closing my eyes to the monetary considerations.”

Felsenstein recalled an evening later that year when he sat wire-wrapping video boards late into the night while listening to the Berkeley alternative radio station KPFA. The disc jockey played the romantic ballad “The Very Thought of You” six times in a row. As it ended the first time, Felsenstein continued his work and wondered what song would be next. Up it came again and again and again.

“That was the low point,” he says. “It was as if I was trapped; the sun was never going to rise; I was just going to have to keep going and going and going. The rest of the world didn’t exist, and all I would do was listen to this song and keep working.”

Things didn’t improve much for Felsenstein in 1980. In February, he moved into the Berkeley barn that housed the Community Memory project he had helped start before hooking up with Marsh. The “barn” was a big room with a black ceiling, white walls, and many sandblasted wood beams, evidence of the “earthquake proof” architecture of the early 1900s. As Community Memory’s founder, he expected that he wouldn’t have to pay rent. Unfortunately, Community Memory was teetering financially and Felsenstein found his living situation growing more and more precarious.

His luck finally took a turn for the better at the West Coast Computer Faire in March, when Adam Osborne approached him with a bold assertion: he was going to start a hardware company and he was "going to do it right." Felsenstein told Osborne, "You took the words right out of my mouth."

Osborne and Felsenstein knew each other through Osborne's publishing company, for which Felsenstein reviewed books and consulted on technical projects. Felsenstein showed Osborne a batch of his unsold designs, including a controller that "would have been able to control a room full of joysticks and run a group space war game."

Osborne summarily rejected those ideas. He knew what he wanted. He was going to sell a personal computer and offer bundled software—that is, application software included with the machine. Until then, hardware and software companies served the same consumers but did not work together on purchases. Osborne knew that novice computer buyers often were confused about what software they needed. By offering the most common applications—word-processing and spreadsheet programs—packaged with the computer, Osborne thought he could attract buyers.

Oh, yes. And the computer would be portable.

Assembling the Pieces

Osborne's plan to produce a portable personal computer at this early stage was ambitious but he approached it pragmatically. He didn't want state-of-the-art hardware for its own sake; he wanted only those innovations necessary to make the computer easy to carry. Thinking portable, he asked for a 40-column display. The Sol had 64. Felsenstein split the difference and gave him 52. Osborne wanted the computer to fit under an airplane seat. Felsenstein obliged by minimizing the number of lines of characters on the screen so that the screen would be tiny enough—only five inches—to leave room inside for cushioning the CRT. Because people would tote the machine around, they would inevitably drop it. Felsenstein designed it to survive a drop test, and that meant adding cushions.

He also came up with a display innovation that would be rediscovered decades later when designers tried to figure out how to display a web page on a smartphone screen. He stored a larger screen's worth of information in memory and gave the user a way to scroll the information on that screen across the tiny display. The user saw what seemed to be a sheet of paper sliding behind the glass.

Figure 80. Lee Felsenstein ***Here Felsenstein is surrounded by some of his inventions, including the Sol and Osborne computers.*** **(Courtesy of Levi Thomas)**

Serious microcomputers at that time had two disk drives, so Felsenstein put two in the Osborne 1 as well. Not confident that high-density drives could tolerate rough handling, he used relatively primitive drives that gave the machine adequate but unimpressive storage.

“Adequacy,” Osborne pronounced, “is sufficient.”

The machine had a Z80 microprocessor, 64K of memory, and standard interfaces to devices—typical fare for the time. But it was designed, from its overall dimensions down to the disk pockets Osborne insisted on, for portability. Compared to the thin notebook computers in years to come, “luggabality” might be a better term, but there was a handle and you could fit it under an airplane seat.

Osborne then set out to get the software that he would bundle with his computer. He needed some simple programs, tools that would facilitate software development. He called Richard “The Surfer” Frank, a sandy-haired Silicon Valley software developer. Frank made a variety of contributions to the company and even provided space to work early on.

For the operating system, Osborne turned to the industry leader: Gary Kildall’s CP/M. For the programming language, BASIC was the obvious choice. Osborne had two widely used versions to choose from. Because the two BASICs had complementary virtues, he decided to offer them both and made deals with Gordon Eubanks for CBASIC and Bill Gates for Microsoft BASIC. Osborne also needed a word processor.

In 1980, the man with the leading word processor was Seymour Rubinstein, president of MicroPro. Osborne gave Rubinstein a part of his company in exchange for WordStar at a bargain price. Osborne had also offered Gates, Kildall, and Eubanks stock in the company. Only Kildall refused, on principle, to avoid the appearance of favoring one customer over another. Gates turned down a position on Osborne Computer Corporation’s board of directors but accepted the stock in exchange for a special deal on Microsoft BASIC. Osborne offered Rubinstein more—the presidency of the new company. Rubinstein turned it down and instead took the position of board chair. He thought Osborne’s idea was so good, though, that he invested $20,000 of his own money in the company.

Unable to make an acceptable deal with Personal Software for the spreadsheet program he needed, Osborne turned to Richard Frank and his company Sorcim to develop a spreadsheet program, which Frank called SuperCalc. The per-copy market value of Osborne’s software now totaled almost $2,000, and he planned to include it all in the basic price of the machine.

Up to now, most of the design work was done in the Community Memory building, but in January 1981 Osborne Computer Corporation filed for incorporation and obtained office space in Hayward, California.

Skyrocket to Success

Osborne introduced his Osborne 1 at the West Coast Computer Faire in April, where it was the hit of the show. People jammed his booth. Osborne towered over the others and seemed to be gloating. The machine was no technological marvel, but it was a bold step forward. Not only would it prove to be the first commercially successful portable computer; it was the first personal computer to come with all the software an average buyer needed. This made the purchase a much easier decision, a fact that would help to open the market to more people. And then there was the price. At $1,795, it was said that Osborne was selling software and had thrown the computer in for free.

True, there were snide comments from those—including the irascible Bill Godbout—who remembered Osborne’s tirades against manufacturers who took customers’ money before making the products, and who now saw Osborne doing the same thing himself. But in September 1981, Osborne Computer Corporation (OCC) had its first million-dollar-sales month. New companies quickly sprang up trying to duplicate or improve on his design, and others seized on his ideas of portability and of including software in their system packages.

The $1,795 price became a target. The Kaypro portable contained software similar to that of the

Osborne 1 and had the same look and the identical price. George Morrow’s Morrow Designs also brought out a machine for $1,795, and Harry Garland and Roger Melen of Cromemco introduced one for $5 less.

But whatever their merits, none of the portables, none of the machines with software included, and none of the other $1,795 wonders had the impact of Adam Osborne’s first venture into computer manufacturing. One of the industry’s early participants had further advanced the development of the personal computer, and the Osborne 1 quickly became one of the new industry’s top-selling personal computers, reaching a peak sales rate of about 10,000 a month.

Since Osborne’s initial business plan called for selling 10,000 total, OCC had certainly skyrocketed to success. Staying there was another matter.

The HP Way and the Xerox Worm

> *One of the things [Hewlett-Packard] learned is that closed architectures aren't going to work, that you really have to depend on third-party suppliers.*
>
> –Nelson Mills, project manager, Hewlett-Packard

Osborne was among the last pioneers to open new territory before civilization arrived. After the Osborne 1 appeared in 1981, the big companies really did begin to enter and transform the market. Soon IBM, DEC, NEC, Xerox, AT&T, and even Exxon and Montgomery Ward were thinking about producing a personal computer. Some companies, like Hewlett-Packard, had started much earlier, though.

Project Capricorn

Hewlett-Packard hadn't rejected Steve Wozniak's Apple I design because it didn't believe in the idea of a personal computer. It did. HP built large computers as well as calculators, so it understood how to sell relatively inexpensive, personal technology products. There are many reasons why HP may have turned Wozniak down. One is that his machine did not lend itself to mass production. As Jobs later acknowledged, "it was designed to be built in a garage." It was also true that the Apple I was not a machine for the engineers and scientists who made up HP's primary market. Woz was clearly told that the Apple I was more appropriate for a start-up company than for HP. He may also have even been turned down because he had no university degree, which would not have been surprising at any established computer company at that time. Those reasons aside, HP had another reason to reject a personal-computer design in 1976: it was already working on one of its own.

In early 1976, a crew of engineers at HP's Cupertino, California, facility began to coalesce around a project with roots in its calculator technology. Chung Tung, the engineer in charge of Project Capricorn, brought in engineer Ernst Ernie along with Kent Stockwell to direct the hardware design and George Fichter to oversee software. There was no shortage of talent at HP, and Capricorn was a significant project.

Initially, Capricorn was intended to be a computerlike calculator but more elaborate than any of HP's small machines. HP already made highly specialized calculators. The calculator-market war that had driven Ed Roberts to create the Altair had not hurt HP as much as it had other calculator manufacturers because HP had concentrated on scientific calculators that did more and sold for more than the less expensive commercial versions. Capricorn was at first intended to have a liquid crystal display, like a calculator, but with several lines instead of one. It would be a desktop BASIC-language calculator. By summer the project had redefined itself, and Capricorn was ornamented with a cathode-ray tube, a significant change both in terms of manufacturing costs and the potential market for the machine. Capricorn was gradually turning into a computer.

HP was perhaps better suited to develop a personal computer than any other established computer company—with the possible exception of Xerox. HP was headquartered in Silicon Valley, near most of the semiconductor companies and in the midst of the growing micro mania. Some of the Capricorn engineers were actually hobbyists like Woz, working on their own homebrewed systems. HP also had far more resources to devote to creating such computers than the garage start-ups. By the time they finally designed a machine, the Capricorn staff had grown to more than a dozen engineers and programmers.

This computer was becoming quite distinctive. It was to have a small built-in printer, a cassette-tape recorder for data storage, a keyboard, and a display, all in one desktop package that was smaller than the Sol (which had not appeared yet and would not include an integrated display or data storage—let alone a built-in printer—when it did). Its chip was also ahead of its time—but this was not necessarily an advantage. In 1976, the only microprocessor that looked feasible was the Intel 8080, the Altair's chip, but the Capricorn team wanted one better adapted to its purposes, and turned the problem over to another HP division. Hence, Capricorn got its own HP-designed proprietary microprocessor. It was a decision some members of the team later regretted.

Another problem soon emerged. In the fall of 1976, in a corporate-level decision, the project was moved out of Silicon Valley to HP's offices in sleepy Corvallis, Oregon, a shift that played havoc with the schedule and damaged morale. Woz, who more than anything else wanted to design computers at HP, seriously considered joining the Capricorn team and moving to Corvallis. He thought he would like living in Oregon, and he wanted to get in on the project. But HP turned him down.

Then in October, Mike Markkula made his first visit to Steve Jobs's garage, and Woz began being pulled into Jobs's plan to start a company. Unlike Woz, many other Capricorn engineers felt that Corvallis was exile, that they were being asked to leave the center of the universe and move into the void. Some elected not to move and dropped out of the project. When others did make the move, they found the plant wasn't ready for them. At first, programmers had to commute 70 miles to do software development on the nearest mainframe computer.

Missing the Window

For all the delay, however, the Capricorn team was progressing. By November they had developed a prototype. It had no tape drive, printer, or display yet, and the CPU chip and certain other microprocessors the engineers wanted for controlling peripherals were still in the layout stage. In 1977 they solved the tricky problems of mixed technologies that were posed by building a printer into the computer. Finally, the chips began to appear. During a visit of the corporate brass, one executive vice president told the engineers that the machine needed more I/O ports on the back to connect it with other HP devices or to allow future capabilities to be added. It was a little late to suggest significant design modifications, but the changes were made. Together, the move and the modifications helped Capricorn slip a full year behind schedule.

When project became product in January 1980, it was an attractive, solidly engineered machine, but relatively expensive—even given its capabilities—at $3,250. It was called the HP-85 and had a 32-character display, almost as wide as the 40 characters on Wozniak's Apple II.

Although the HP-85 sold well enough for HP's purposes and led to a series of related machines, it did not set cash registers ringing as the Apple II did. Then again, it wasn't designed to—HP sold it not as a business machine but as a scientific and professional one. Nevertheless, HP's sluggish pace in completing and marketing the product unquestionably hurt sales. By the time this machine with its built-in cassette-tape drive came out, the field was moving toward using floppy disks, which were more reliable than tape cassettes and stored much more information. Moreover, the HP-85 cost more than some of these floppy disk–based systems.

In the long run, though, the HP-85's greatest flaw may have been its closed system design that required HP software and HP peripherals. When the Apple II was released in 1977, the Capricorn team believed their machine would compete well with it. But by the time the HP-85 appeared three years later, some Capricorn programmers were privately conceding the general and business market to Apple. There was real irony here because the Apple II's 40-column, lowercase display was clearly inappropriate for basic applications like word processing and report generation, and its 6502 processor was no number cruncher. Apple machines eventually got 80-column upper- and lowercase display capabilities, but only because Wozniak left the architecture open and others created the necessary boards and software. Third parties were continually improving the Apple II, whereas they were shut out of the HP-85. HP soon concluded that the closed architecture had been a mistake.

Still, HP had beaten the other established computer companies into the market by more than a year, and the HP-85 and its successors carved out a solid market niche for themselves. The next big manufacturer to introduce a personal computer fared less well.

The Alto

Xerox had made its name in photocopying machines, but the company had flirted with computers as well, and maintained close ties with Silicon Valley. After acquiring Scientific Data Systems, a computer company in El Segundo, California, and renaming it Xerox Data Systems (XDS), Xerox became one of the dwarfs—the seven mainframe computer companies living in IBM's shadow. XDS, however, was a financial millstone, and Xerox finally sold it, although it retained the El Segundo facility itself for some integrated circuit and electronics design and systems programming.

Xerox purchased Shugart, the disk-drive manufacturer, in the winter of 1977—1978. Don Massaro, president of Shugart through the early 1970s, recalled that in the days before Apple soared to its zenith, young Steve Jobs was in his office nearly every week nagging him to devise a disk drive that personal-computer users could afford. Massaro and his colleague James Atkinson did just that, helping make Apple and Shugart leaders in their fields. When Xerox bought Shugart, it acquired that wedge in the personal-computer market, and it also got Massaro, who proved instrumental in Xerox's foray into the market some years later.

At PARC, its research center in Palo Alto, Xerox had attracted some talented people. Hungarian-born Charles Simonyi, who had learned programming on a Russian vacuum-tube computer and had degrees from Berkeley and Stanford, worked there. Also working at PARC was John Shoch, who finished his PhD at Stanford while helping get PARC started, and the fiercely independent but farsighted Alan Kay, who adorned his desk with a cardboard model of his dream computer—a machine that Kay called Dynabook, powerful and yet small enough to fit in a book bag. Larry Tesler brought the newest programming techniques to his PARC software. Bob Metcalfe was involved in a technique for networking computers.

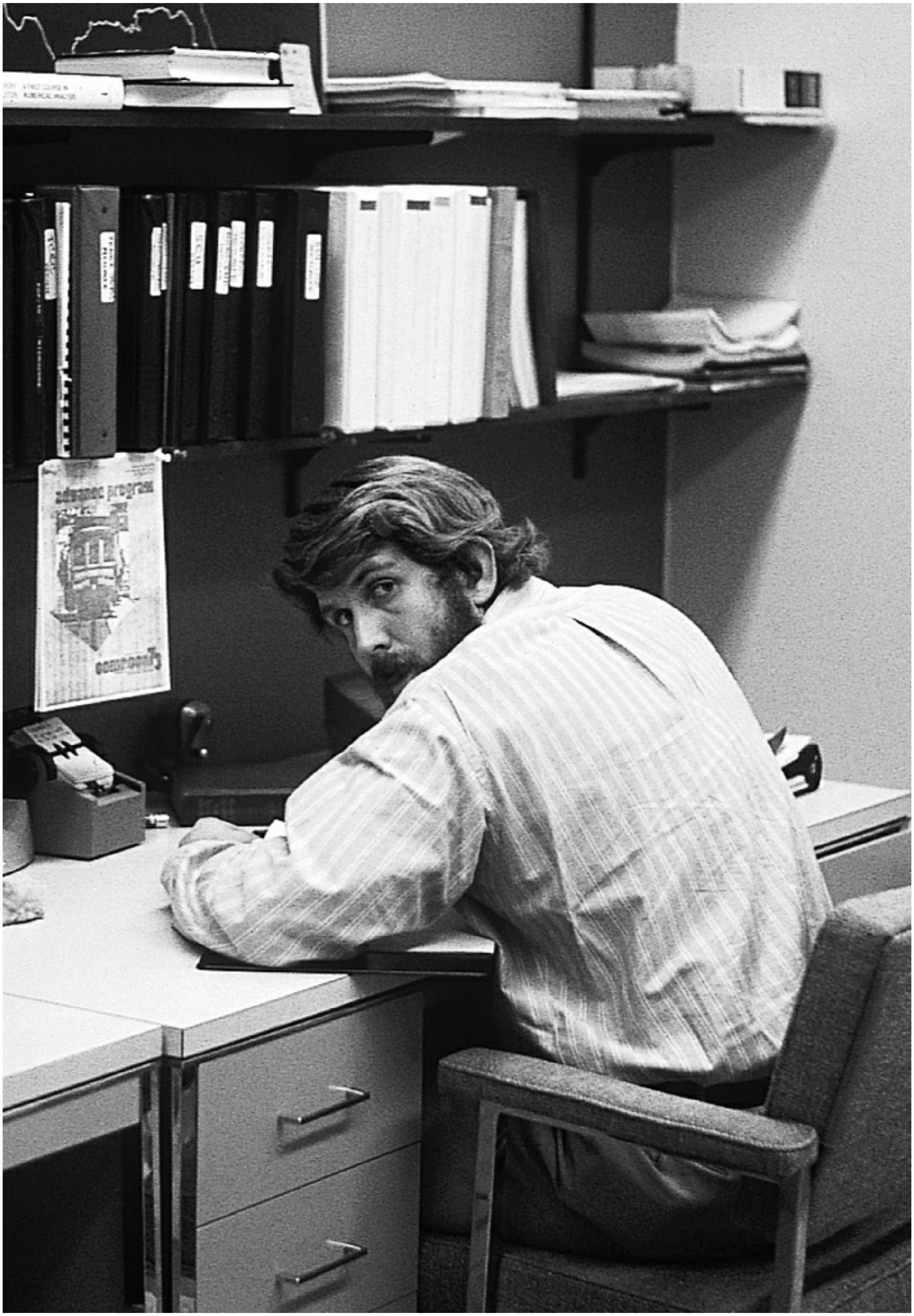

advance program

Figure 81. Bob Metcalfe ***While working at Xerox PARC, Metcalfe cocreated Ethernet, which became the standard for networking computers.***
(Courtesy of Richard Shoup)

Over several years these engineers and programmers, building in part on the revolutionary work of Douglas Engelbart, created an impressive workstation computer called the Alto. The Alto boasted an advanced language called Smalltalk, an input device borrowed from SRI called the mouse, and that networking technique of Bob Metcalfe's called Ethernet for connecting individual Altos for communication and cumulation of effort, as if they were one big computer. Xerox referred to the whole arrangement as the "office of the future," and it was both visionary and technically sound. Xerox marketed Altos to government agencies, placing them in the White House, the Executive Office Building, the National Bureau of Standards, the Senate, and the House of Representatives, where they were used to print the Congressional Record.

The Alto was 20 times more computer than the original Altair. Not only did it have impressive speed and display graphics, but the Smalltalk language was a generational leap beyond BASIC. Because work on it was completed in 1974, some people, particularly those at Xerox, claim it as the first personal computer ever. But the Alto was never a commercial product. No more than 2,000 were ever built, and its cost removed it from the category of a personal computer, even if it was a self-contained machine for one individual's use. It was priced as a minicomputer.

Figure 82. Charles Simonyi and Bill Gates ***Simonyi came from Xerox PARC to oversee development of Microsoft's most profitable products. He became a billionaire and was the first space tourist.*** **(Courtesy of Microsoft)**

The Alto took two years to develop—from 1972 to 1974—and was used for three more years before Xerox decided to develop it further into a marketable product. In January 1977, David Liddle was put in charge of this task, and Charles Simonyi came to work for him. Liddle had joined PARC in 1972 after having worked on computer display systems in a project funded by the Defense Advanced Research Projects Agency. But the project proceeded slowly. Many researchers at PARC, attracted by the freedom to design technologically dazzling innovations, were growing frustrated that their creations remained sequestered in the lab. They could see things happening in quickstep around them, particularly at Apple, while Xerox dawdled. Before Xerox got a personal-computer product to market, several key people left, with others departing soon afterward. Tesler went to Apple, Kay to Atari, and Simonyi to Microsoft.

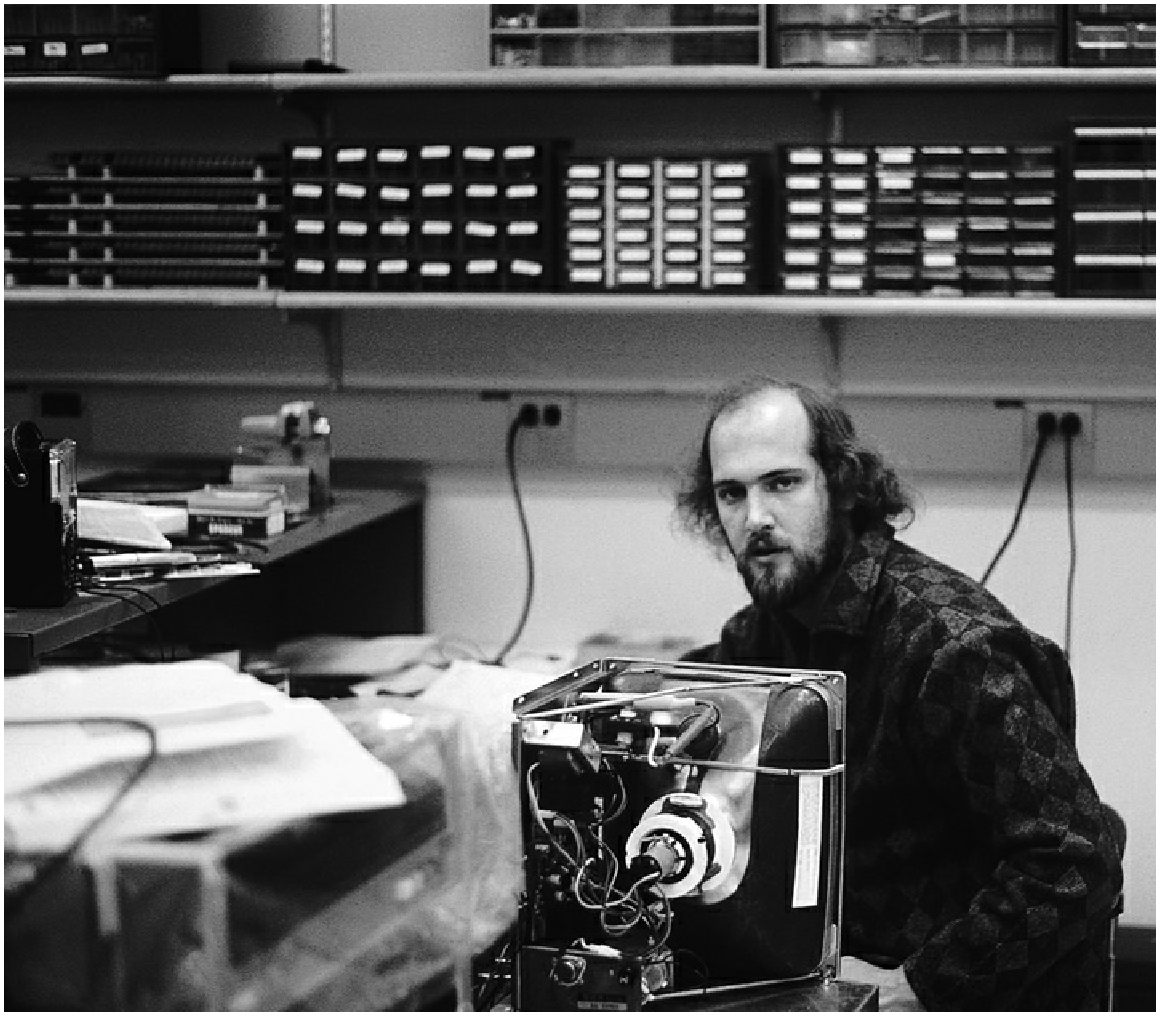
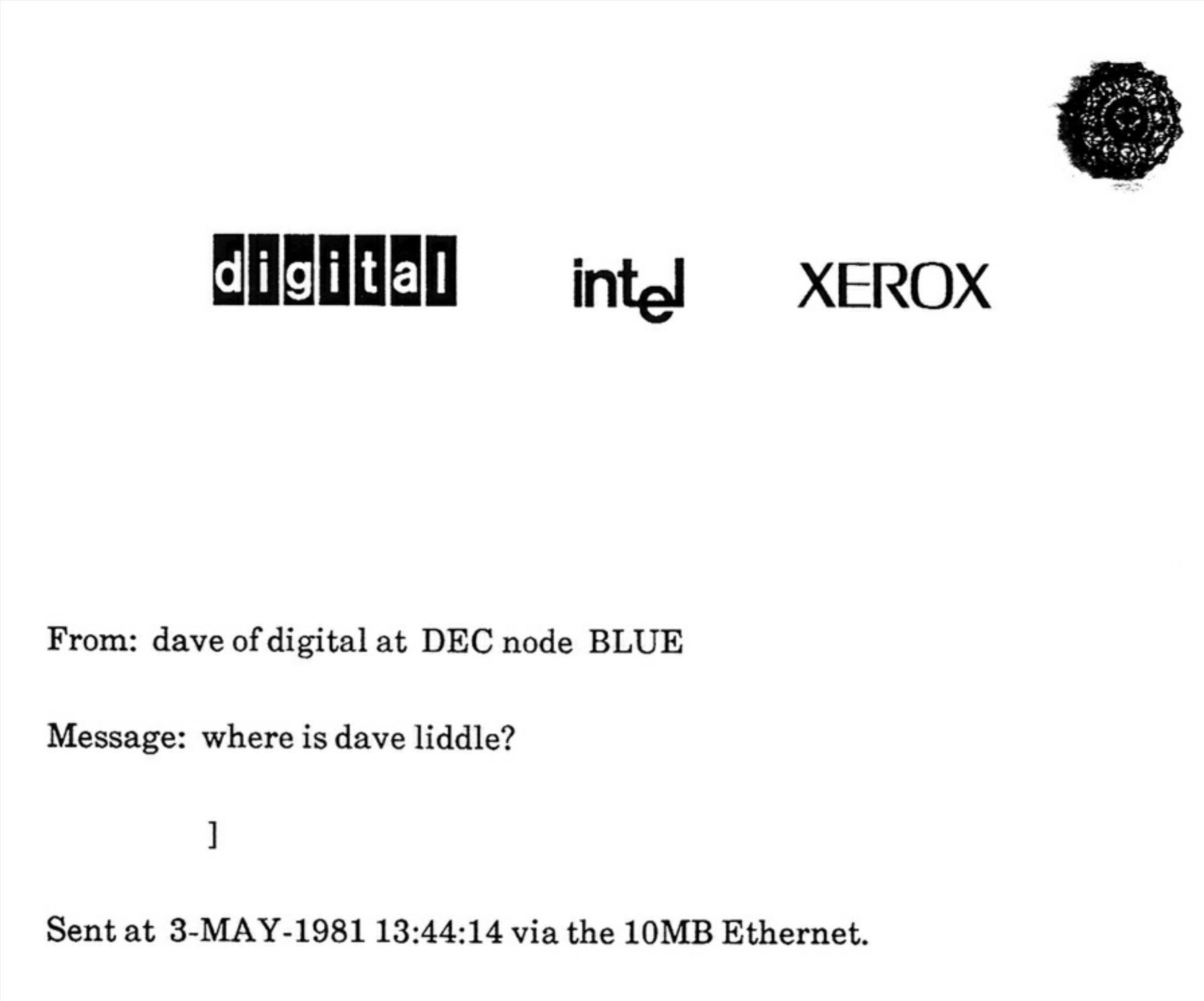


Figure 83. David Liddle ***Liddle headed up the Star computer project at Xerox, which attempted to turn the revolutionary Alto into a marketable product.*** **(Courtesy of Richard Shoup)**

The Worm

Meanwhile, Xerox released its Ethernet network and began linking personal computers. In 1981, four years after it started, Xerox announced the 8010 Information System (nicknamed Star). It was an impressive machine, using much of the advanced Alto technology that Jobs had seen in 1979. But at $16,595 the Star was not really a personal computer either. Nor did Xerox try to convince people it was. For example, the company did not try to sell the machine in computer stores. If HP's laggardly development of the HP-85 had caused it to miss its commercial window by offering a tape-based machine in a disk-based world, the Xerox Star missed the market altogether.



digital intel XEROX

From: dave of digital at DEC node BLUE

Message: where is dave liddle?

]

Sent at 3-MAY-1981 13:44:14 via the 10MB Ethernet.

Figure 84. Ethernet ***This is a printout of the first message, other than some within Xerox PARC, ever sent via Ethernet.*** **(Courtesy of David Liddle)**

A month later, though, Xerox introduced a true personal computer. The Xerox 820, announced in July 1981, was code-named The Worm during development, perhaps because Xerox had dreamed it would eat into Apple's market. Like many existing personal computers, the Xerox 820 used the Z80 chip. Xerox also offered Kildall's CP/M and the two BASIC languages, one written by Gates and Allen and one by Eubanks.

Don Massaro led the 820 project. The 820s would be inexpensive, individual workstations on Ethernet systems in Fortune 500 corporations, the same market the Star sought. Development took only four months, and the machine quickly went into manufacture. "All we wanted to do was reserve those desks for Stars later on," Massaro said. Given that target market, Xerox's next move didn't make much sense.

"It was designed to go after the end-user market through our direct sales organization," Massaro explained. “Xerox has always sold through its own sales organization. Xerox had 15,000 salespeople worldwide, and that was one of the real strengths of Xerox.” But ComputerLand waved huge purchase orders before Xerox corporate eyes, and “in a moment of weakness, we went to that channel.”

Mass marketing was a mistake. Xerox fared poorly in the developing shelf-space war in ComputerLand stores. Perhaps it was the paucity of technological innovation in the 820, or Xerox’s failure to learn from the lesson of open architecture. Or perhaps the competition was simply getting too heavy even for Xerox by that point. In Bill Gates’s view, the company misunderstood the market. “Xerox was aiming a little too high and trying to do something very difficult and didn’t see the opportunity,” said Gates. “When they did, they threw something together in a couple of months, and it was too little too late.”

“We got creamed,” Massaro admits. And it was IBM that did it.

IBM

IBM is a pretty big company.

–Bill Gates

Hewlett-Packard and Xerox had made less-than-impressive entries into the personal-computer market, and there was intense curiosity within that industry about how IBM would fare. The megafirm was considered successful in almost everything it had tried. Its reputation had held up at least since the mid-1960s, when IBM owned two-thirds of the computer market. And when IBM chief Thomas J. Watson, Jr., bet the company on a new semiconductor-based computer line that instantly made IBM's most profitable machines obsolete—and the bet paid off—IBM only appeared all the more infallible.

In 1980 a new CEO, Frank Cary, proved willing to risk if not the company, at least some of its pristine reputation on a very un-IBM venture.

Taking a Meeting with IBM

In July of 1980, Bill Gates, busily developing a BASIC for Atari, received a phone call from a representative of IBM. He was surprised, but not greatly so. IBM had called once before about buying a Microsoft product, but the deal had fallen through. However, this communication was more tantalizing. IBM wanted to send some researchers from its Boca Raton, Florida, facility to chat with Gates about Microsoft. Gates agreed without hesitation. "How about next week?" he asked. "We'll be on a plane in two hours," said the IBM man.

Gates proceeded to cancel his next day's appointment with Atari chairman Ray Kassar. "IBM is a pretty big company," he explained sheepishly.

Because IBM was indeed a pretty big company, he decided to turn to Steve Ballmer, his advisor in business matters and a former assistant product manager at Procter & Gamble. Gates had known Ballmer when he attended Harvard in 1974. In 1979, when Gates decided that Microsoft was getting difficult to manage, he hired Ballmer. Ballmer was brash and ambitious. After Harvard, he had entered Stanford University's MBA program but had dropped out to start making money sooner.

Ballmer had been glad to join Microsoft. He was enthusiastic about the little software company, and he liked Bill Gates. At Harvard, he had convinced Gates to join his men's club. As an initiation rite, he dressed his friend in a tuxedo, blindfolded him, brought him to the student cafeteria, and made him talk to other students about computers. Gates's dealings with IBM would remind him of this experience.

Gates liked Ballmer, too. Gates had played poker during the evenings in the Harvard dorms, and after being cleaned out, he often went to Ballmer to describe the game. As they started working together at Microsoft in 1980, Gates found he still enjoyed discussing things with his friend, who quickly became one of his closest business confidants, and he naturally turned to him after IBM's call.

Figure 85. Steve Ballmer and Bill Gates *Gates's ebullient college buddy would go on to replace him as Microsoft CEO.* (Courtesy of Sarah Hinman, Microsoft Museum)

"Look, Steve," Gates said, "IBM is coming tomorrow. We better show those guys a little depth. Why don't we both sit in on the meeting?"

Neither of them could be sure that the call was anything special, but Gates couldn't help getting worked up over it. "Bill was superexcited," Allen later recalled. "He hoped they'd use our BASIC." Thus, Ballmer said, he and Gates "did the thing up right," meaning suit and tie, which was unusual attire at Microsoft.

Before the meeting began, IBM asked Gates and Ballmer to sign an agreement promising not to tell IBM anything confidential. Big Blue used this device to protect itself from future lawsuits. Hence, if Gates revealed a valuable idea to the company, he could not sue later on if IBM exploited the concept. IBM was familiar with lawsuits; adroit use of the legal system had played an important part in its long control of the mainframe-computer business. It all seemed rather pointless to Gates, but he agreed.

The meeting seemed to be little more than an introductory social session. Two of the IBM representatives asked Gates and Ballmer "a lot of crazy questions," Gates recalls, about what Microsoft did and about what features mattered in a home computer. The next day Ballmer typed up a letter to the IBM visitors thanking them for the visit and had Gates sign it.

Nothing happened for a month. In late August, IBM phoned again to schedule a second meeting. "What you said was really interesting," the IBM representative told Gates. This time IBM would send five people, including a lawyer. Not to be outdone, Gates and Ballmer decided to front five people themselves. They asked their own counsel—a Seattle attorney whose services Microsoft had used before—to attend the meeting, along with two other Microsoft employees. Allen, as usual, stayed in the background. "We got five people in the room," said Ballmer. "That was a key thing."

At the outset, IBM's head of corporate relations explained why he had come along. It was because "this is the most unusual thing the corporation has ever done." Gates thought it was about the weirdest thing Microsoft had ever been through, too. Once again, Gates, Ballmer, and the other Microsoft attendees had to sign a legal document, this time stipulating that they would protect in confidence anything they viewed at the meeting. Then they saw the plans for Project Chess. IBM was going to build a personal computer.

Gates looked at the design and questioned the IBM people across the table. It bothered him that the plans made no mention of using a 16-bit processor. He explained that a 16-bit design would enable him to give them superior software—assuming they wanted Microsoft's. He was emphatic and enthusiastic and probably didn't express himself with the reserve they were used to. But IBM listened.

IBM did want Microsoft's languages. On that August day in 1980, Gates signed a consulting agreement with IBM to write a report explaining how Microsoft could work with IBM. The report was also to suggest hardware and Gates's proposed use of it.

The IBM representatives added that they had heard about a popular operating system called

CP/M. Could Gates sell that to them as well? Gates patiently explained that he didn't own CP/M, but that he would be happy to phone Gary Kildall and help arrange a meeting. Gates later said that he called Kildall and told him that these were "important customers" and to "treat them right." He handed the phone over to the IBM representative, who made an appointment to visit Digital Research that week.

When Gary Went Flying

What ensued has become the material of personal-computer legend. Instead of landing a contract with IBM, "Gary went flying," Gates recounted, a story that became well known in the industry. Kildall disputed Gates's recollection. He denied that he was out flying for fun while the IBM representatives cooled their heels. "I was out doing business. I used to fly a lot for pleasure, but after a while you get tired of boring holes in the sky." He was back in time for his scheduled meeting with IBM.

That morning, however, while Kildall was airborne, IBM met with Kildall's wife Dorothy McEwen. Dorothy handled Digital Research's accounts with hardware distributors. The nondisclosure agreement that the IBM visitors asked her to sign troubled her. She felt that it jeopardized Digital Research's control of its software. According to Gary, she stalled until she could get hold of Gerry Davis, the company's lawyer. That afternoon Gary arrived on schedule, and along with Dorothy and Gerry Davis, he met with IBM's representatives. Kildall signed the nondisclosure agreement and heard IBM's plans. When it came to the operating system, though, they had an impasse. IBM wanted to buy CP/M outright for $250,000; Kildall was willing to license it to them at the usual $10 per-copy rate. IBM left with promises to talk further, but without having signed an agreement for CP/M.

They immediately turned to Microsoft. Gates required no prodding. Once IBM agreed to use a 16-bit processor, Gates realized that CP/M was not critical for their new machine because applications written for CP/M were not designed to take advantage of the power of 16 bits. Kildall had seen the new Intel processors, too, and was planning to enhance CP/M to do just that. But it made just as much sense, Gates told IBM, to use a different operating system instead.

Where that operating system would come from was a good question, until Paul Allen thought of Tim Paterson at Seattle Computer Products. Paterson's company had already developed an operating system, 86-DOS, for the 8086, and Allen told him that Microsoft wanted it.

Three Months Behind Schedule Before We Started

At the end of September, Gates, Ballmer, and a colleague took a redeye flight to deliver a report. They assumed it would determine whether they got the IBM personal-computer project. They nervously finished collating, proofreading, and revising the document on the plane. Kay Nishi, a globetrotting Japanese entrepreneur and computer-magazine publisher who also worked for

Microsoft, had written part of the report in “Nishi English,” which, according to Ballmer, “always needs editing.” The report proposed that Microsoft convert 86-DOS to run on IBM’s machine. After the sleepless flight, Gates and Ballmer were running on adrenaline and ambition alone. As they drove from the Miami airport to Boca Raton, Gates suddenly panicked. He had forgotten a tie. Already late, they swung their rental car into the parking lot of a department store and waited for it to open. Gates rushed in and bought a tie.

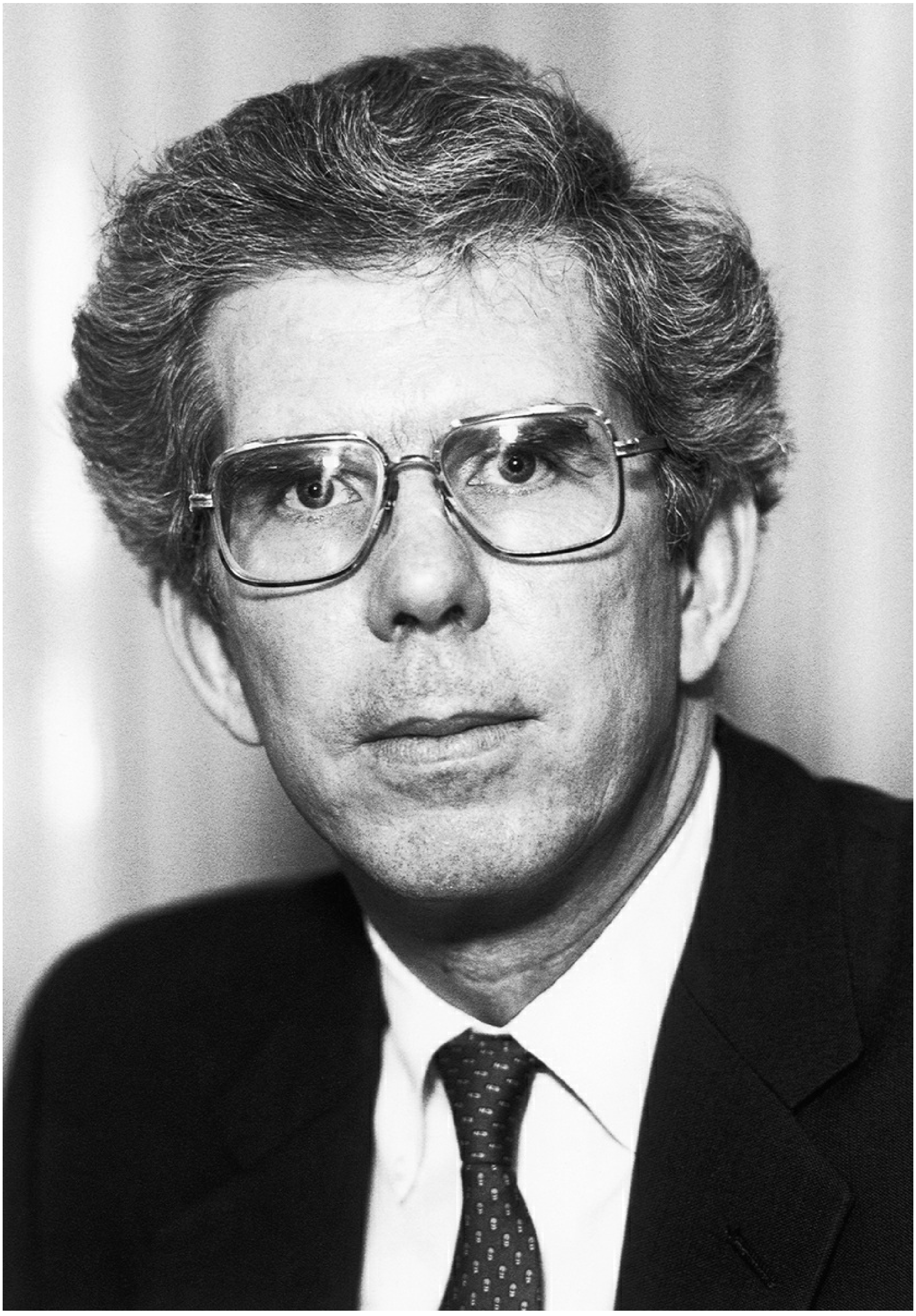


Figure 86. Phil Estridge *Estridge headed the IBM PC project in the 1980s.* (Courtesy of IBM Archives)

When they finally met with the IBM representatives, they learned that IBM wanted to finish the personal-computer project in a hurry—within a year. It had created a team of 12 to avoid the kind of corporate bottlenecks that can drag a project on for years—three and one-half for the Xerox Star, four for the HP-85. IBM president Frank Cary dealt roughly with all internal politics that could cause delays. Throughout the morning, Gates answered dozens of queries from members of IBM's project team. "They pelted us with questions," said Ballmer. "Bill was on the firing line."

By lunchtime, Gates was fairly confident Microsoft would get the contract. Philip Estridge, who was the project head, an IBM vice president, and an owner of an Apple II, told Gates that when John Opel, IBM's new chairperson, heard that Microsoft might be involved in the effort he said, "Oh, is that Mary Gates's boy's company?" Opel had served with Gates's mother on the board of directors of the United Way. Gates believed that connection helped him get the contract with IBM, which was finally signed in November 1980.

Microsoft first had to set up a workplace for the project, a more difficult task than might be imagined. IBM wasn't just any company. It treasured secrecy and imposed the strictest security requirements. Gates and Ballmer decided on a small room in the middle of their offices in the old National Bank building in downtown Seattle. IBM sent its own file locks, and when Gates had trouble installing them, IBM sent its own locksmith. The room had no windows and no ventilation, and IBM required that the door be kept constantly closed. Sometimes the temperature inside exceeded 100 degrees. IBM conducted several security checks to make sure Microsoft followed orders. Once the IBM operative found the secret room wide open and a chassis from a prototype machine standing outside it. Microsoft wasn't used to dealing with this kind of strictness.

But Microsoft learned. To speed communication between Microsoft and IBM, a sophisticated (for those times) electronic mail system was set up, which sent messages instantly back and forth between a computer in Boca Raton and one in Seattle. Gates also made frequent trips to Boca Raton.

The schedule was grueling. The software had to be completed by March 1981. IBM's project managers showed Gates timetables and more timetables, all of which "basically proved we were three months behind schedule before we started," Gates said.

The first order of business was the operating system. Paterson's 86-DOS operating system was a close but crude imitation of CP/M. It needed a lot of work to make it fit the bill for the IBM job. Gates brought Paterson in to work on adapting his operating system. The operating-system APIs, in particular, had to be completed as soon as possible.

APIs are application programming interfaces. They specify how application programs, like word processors, interface with the operating system. Despite the generally tight security surrounding the PC, developers writing application programs for the IBM machine had to have the APIs to do their work. That provided a crack in the security through which Gary Kildall managed to see, before the machine was released, what Microsoft's operating system was like.

When he saw the APIs, Kildall realized just how close to his CP/M the new IBM/Microsoft operating system was. He threatened to sue IBM. "I told them that they wouldn't have proceeded down that path if they knew [the IBM operating system] was that closely patterned after mine. They didn't realize that CP/M was something owned by people." IBM met with him and agreed to offer the 16-bit version of CP/M as well as Microsoft's operating system for their PC. Kildall, in return, agreed not to sue. IBM said that it couldn't set a price, though, because that would be a violation of antitrust laws.

When Gates heard about IBM's dealing with Digital Research, he complained, but IBM reassured him that Microsoft's DOS was its "strategic operating system." It would turn out that Gates had nothing to worry about. Kildall's operating system would never be given a chance to compete with Microsoft's.

Meanwhile Gates took charge of converting Microsoft BASIC, the warhorse originally written for the old Altair, to the IBM computer. He worked on it with Paul Allen and Neil Konzen, another Microsoft employee. Six years before, Allen, as MITS software director, had nagged Gates to do the Altair disk code and the teenaged Gates had procrastinated. Now Gates was doing the nagging and Allen did most of the work. Other Microsoft programmers labored on the various language-conversion projects.

Gates was feeling the pressure from IBM, and he passed it on to his employees. Some of them were used to spending winter weekends as ski instructors—but not that winter. "Nobody went skiing," said Gates. When some of them wanted to fly to Florida to watch the launch of the space shuttle, Gates was unsympathetic. But when they insisted, he said that they could go if they completed a set amount of work beforehand. The programmers spent five days straight at Microsoft, even sleeping there, in order to meet his demands. Allen remembers programming until 4 A.M. when Charles Simonyi, formerly of Xerox PARC, walked in and declared that they were flying down to Florida for the launch that morning. Allen protested. He wanted to continue his work. Simonyi dissuaded the exhausted programmer, and they were on the plane a few hours later.

Open Architecture

Gates discussed the design of the new machine with IBM continually, usually with Estridge. He pointed out that the open architecture of the Apple computer had contributed immeasurably to its success. Gates had reason to appreciate openness because the SoftCard, Microsoft's only hardware product, was a cornerstone of the corporation. Because Estridge owned an Apple II, he had leaned toward an open architecture at the outset. With Gates's encouragement, IBM defied its tradition of secret design specifications and turned its first personal computer into an open system.

This was an extraordinary move for IBM, the most aloof and proprietary of all computer companies. It was deliberately inviting the "parasites" that Ed Roberts had condemned. IBM would use standard parts and design patterns created by kids in garages, and it would encourage more contributions from them. It was shrugging off the tailored tux to don the ready-to-wear clothes of the hobbyists and hackers.

Gates especially understood the open-system issue from MITS's experience. Ed Roberts had accidentally created an open system in 1974 by making the Altair a bus-based machine. Other manufacturers could, and did, produce circuit boards for the Altair's S-100 bus, and an entire S-100 industry developed, to Roberts's dismay. When Roberts tried to hide the bus's details, the industry effectively took the bus away from him, redefining it to standard specifications.

Gates was intent on making Microsoft's operating system, now called MS-DOS (really PC-DOS for IBM but MS-DOS for every other customer), the industry's standard operating system. He abandoned the symbiotic relationship he had once enjoyed with Digital Research whereby Digital Research was the operating system firm and Microsoft did languages. Gates made a strong and convincing case to IBM for an open operating system, too. The IBM people in charge of the PC were receptive, but openness was not an IBM hallmark. The benefits took some explaining. If people knew the details of the operating system, they could develop software for it more easily, and VisiCalc had shown that good third-party software can help sell a machine. He may have had more practical considerations in mind, however. Having broken into mainframe operating systems when he was 14, having seen his original Altair BASIC become an industry standard through theft, Gates may simply have found it wiser to give away what would otherwise be preempted.

The operating system was also open in another way. Gates managed to get IBM to agree to let Microsoft sell its operating system to other hardware manufacturers. IBM didn't understand what a wealth-creation machine they were handing to Bill Gates.

Although pressure to finish the software was extreme, Gates was confident in his ability and the capability of his company, which was glittering with programming talent. But he had one fear that he could not overcome. It concerned him even more than the deadline, and it haunted him right up to the announcement of the IBM computer: would IBM cancel the project?

They were not really working with IBM, after all. They were working with a division of IBM, a maverick division on a short tether. There was no telling when IBM might pull in the rope. IBM was a Goliath with many, many projects. Only a small percentage of the research and development work done at IBM ever appeared as finished projects. What other secret IBM personal-computer projects might be proceeding in parallel with Chess he didn't know and would probably never know. "They seriously talked about canceling the project up until the last minute," said Gates, "and we had put so many of the company's resources into the thing."

Gates was under strain, and any talk of cancellation upset him. He worried about the speculative stories increasingly appearing in the press about an IBM personal computer. Some were quite precise. Would IBM question his company's compliance with its security requirements? When an article in the June 8, 1981, issue of *InfoWorld* accurately described four months early the details of the IBM machine, including the decision to develop a new operating system, Gates panicked. He called the magazine's editor to protest the publication of "rumors."

When IBM came out with its personal computer, fortunes would be won and lost. Bill Gates wanted to be sure nothing prevented Microsoft from being among the winners.

The IBM Personal Computer

When, on August 12, 1981, IBM announced its first personal computer, it radically and irrevocably changed the world for microcomputer makers, software developers, retailers, and the rapidly growing market of microcomputer buyers.

Figure 87. The original IBM PC ***In 1981 IBM's entry into the field of personal computers legitimized the field and changed it fundamentally.*** **(Courtesy of IBM Archives)**

In the 1960s, there was a saying among mainframe-computer companies that IBM was not the competition; it was The Environment. Whole segments of the industry, known collectively as the plug-compatibles, grew up around IBM products, and their prosperity depended on IBM's prosperity. To the plug-compatibles, the cryptic numbers by which IBM identified its products, like the 1401 or the legendary 360, were not the trademarks of a competitor, but familiar features of the terrain, like mountains and seas. When IBM brought out a personal computer, it too had one of those product numbers. But the IBM marketing people knew that they were dealing with a new kind of customer and that a number might not convey the right message. It isn't hard to guess what IBM thought the right message was. By naming its machine the Personal Computer, it suggested this device was the only personal computer. The machine quickly became called the IBM PC, or simply the PC.

The IBM PC itself was almost conventional from the standpoint of the industry at the time. Sol and Osborne inventor Lee Felsenstein got his hands on one of the first delivered IBM PCs and opened it up at a Homebrew Computer Club meeting.

“I was surprised to find chips in there that I recognized,” he said. “There weren’t any chips that I *didn’t* recognize. My experience with IBM so far was that when you find IBM parts in a junk box, you forget about them because they’re all little custom jobs and you can’t find any data about them. IBM is off in a world of its own. But, in this case, they were building with parts that mortals could get.”

The machine used an 8088 processor, which, although it was not the premier chip then available, put the IBM PC a notch above any other machine then sold. The PC impressed Felsenstein—not technologically, but politically. He liked to see IBM admitting that it needed other people. The open bus structure and thorough, readable documentation said as much. “But the major surprise was that they were using chips from Earth and not from IBM. I thought, ‘They’re doing things our way.’”

In addition to operating systems and languages, IBM offered a number of applications for the PC that were sold separately. Surprisingly, IBM had developed none of them. Showing that it had learned from Apple, IBM offered the ubiquitous VisiCalc spreadsheet (Lotus 1-2-3 would come later and would become must-have software for business), the well-known series of business programs from Peachtree Software, and a word processor called EasyWriter from Information Unlimited Software (IUS).

WordStar, from Seymour Rubinstein’s MicroPro, was the leading word-processing program, and IBM had wanted it. But Rubinstein, like the Kildalls, balked at accepting IBM’s terms. They wanted MicroPro to convert WordStar to run on the IBM PC and then turn the product over to IBM, Rubinstein said. “They said I could build my own program after that, but I’d have to not do it the same way. They were setting themselves up to sue me later. They were going to grab control of my product. I had something to protect, so I didn’t do the deal. I tried to negotiate a different deal, but they wouldn’t.” IBM turned to IUS.

Captain Crunch and EasyWriter

The IUS deal may have been the ultimate culture shock for the IBM people. They had designed their machine with non-IBM components. They had released to the general public the sort of information they had always kept secret. They had bought an operating system instead of writing it; they had done and dealt with things that had always been utterly beyond IBM’s pale. But they hadn’t bargained for John Draper.

IUS was a small Marin County software firm with a word processor called EasyWriter. IBM had approached IUS about EasyWriter, and Larry Weiss of IUS contacted EasyWriter’s author, John Draper, alias the notorious phone phreak Captain Crunch, from whom Woz and Jobs had learned how to build blue boxes.

Draper recalled, “Eaglebeak [Weiss] comes to me and he says, ‘John, I got this deal that you’re not going to believe, but I can’t tell you anything about it.’ And then we had this meeting at IUS. There were these people in pinstripes and me looking like me. This was the time that I realized we were dealing with IBM. I had to sign these things saying that I wasn’t going to be discussing any technical information. I wasn’t even supposed to disclose that I was dealing with IBM. They were coming out with a home computer and Eaglebeak said something to me about putting EasyWriter on it.”

Draper had written EasyWriter years before out of frustration because the Apple had no satisfactory word processor and he couldn’t afford an S-100 system on which he could run Michael Shrayer’s Electric Pencil. Draper liked Electric Pencil, the only word processor he’d seen, so he fashioned his own after it. Demonstrating it at the fourth West Coast Computer Faire, he ran into Bill Baker, a transplanted Midwesterner who had started IUS, and Baker agreed to sell EasyWriter for him. All that had led to this: Captain Crunch sitting down with IBM.

IBM gave IUS and Draper six months to convert EasyWriter to run on the PC, and Draper went right to work. “In order to keep from slipping and talking about IBM, we called it Project Commodore,” Draper recalled. Soon, Baker was irritating Draper. “Baker comes down on me for not working 8 to 5, and that’s bullshit. Look, man, I don’t operate in that style. I operate in a creative environment. I don’t go by the clock. I go by the way my mind works.” Then IBM made changes in the hardware that Draper had to incorporate. The six months passed and the release program wasn’t done. Draper found himself pressured to say that an earlier but completed version was adequate and that it could be released with the machine. With grave reservations he finally did so, and IBM’s machine was sold with Captain Crunch’s word processor. The program did not receive rave reviews. IBM later offered free updates to the program.

A word processor was sober software, no matter who wrote it, but at the last minute IBM decided to add a computer game to its series of optional programs. Toward the end of the press release announcing the PC, the company declared, “Microsoft Adventure brings players into a fantasy world of caves and treasures.” Corporate data-processing managers around the country read the ad and thought, “This is IBM?”

Welcome, IBM

The PC’s unveiling received wide play in the national press. It was by far the least expensive machine IBM had ever sold. IBM realized that the personal computer was a retail item that consumers would buy in retail computer stores and could not, therefore, be marketed by its sales force. The company again departed from tradition and arranged to sell its PC through the largest and most popular computer retail chain at the time, the IMSAI spin-off ComputerLand. This was a much bigger departure for IBM than it had been for Xerox, but it was a no-brainer for ComputerLand. They knew the value of the IBM logo. IBM didn’t stop there; it also announced plans to sell the PC in department stores, just like any appliance.

Wherever it was sold, the purchaser had a choice of operating systems: PC-DOS for $40 or CP/M-86 for $240. If it was a joke, Gary Kildall wasn't laughing.

Software companies quickly began writing programs for PC-DOS. Hardware firms also developed products for the PC. Because PC sales started fast and continued to increase, these companies were easily convinced that PC-based products would find a market. In turn, the add-on products themselves spurred PC sales because they increased the utility of the machine. IBM's open-system decision was now paying dividends, for IBM and a new generation of plug-compatible companies.

Apple Computer was not surprised by the IBM announcement, as it had predicted an IBM microcomputer several years earlier. Steve Jobs claimed that Apple's only worry was that IBM might offer a machine with highly advanced technology. Like Felsenstein, he was relieved that IBM was using a nonproprietary processor and an accessible architecture. Apple responded publicly to the PC announcement by asserting that this would actually help Apple because IBM publicity would cause more people to buy personal computers.

The world's largest computer company had endorsed the personal computer as a viable commercial product. Although innovative hobbyists and small companies had founded the industry, only IBM could bring the product fully into the public eye. "Welcome, IBM. Seriously," Apple said in a full-page advertisement in *The Wall Street Journal*. "Welcome to the most exciting and important marketplace since the computer revolution began 35 years ago.… We look forward to responsible competition in the massive effort to distribute this American technology to the world."

IBM's endorsement certainly did increase demand for personal computers. Many businesses, small and large, balked at the idea of buying a personal computer. Many seriously wondered why IBM wasn't working in that area. Now IBM had said it was all right. They could buy a personal computer. Between August and December 1981, IBM shipped 13,000 PCs. Over the next two years, it would sell 40 times that number.

The early microcomputers had been designed in the absence of software. When CP/M and its overlayer of application software became popular, hardware designers built machines that would run those programs. Similarly, the success of the IBM Personal Computer caused programmers to write an array of software for its PC-DOS operating system—which, when licensing it to companies other than IBM, Microsoft called MS-DOS. New hardware manufacturers sprang up to introduce computers that could run the same programs as the IBM PC: "clones." Some offered different capabilities than those of the IBM machine, like portability, additional memory, or superior graphics, and many were less expensive than the PC. But all served to ratify the PC operating system. And MS-DOS quickly became the standard operating system for 16-bit machines.

Microsoft benefited more than any other player, including IBM. Gates had encouraged IBM to use an open design and had managed to get a nonexclusive license for the operating system. The former ensured that there would be clones if other companies could get their hands on the operating system. The latter ensured that they could, and that they would pay Microsoft for it. And IBM's pricing strategy ensured that Microsoft's operating system would be the only one that mattered.

Even DEC entered the fray a year later with a dual-processor computer called the Rainbow that could run both 8-bit software under CP/M and 16-bit software under CP/M-86 or MS-DOS.

All the companies in the industry had to cope with the imposing presence of IBM. ComputerLand was dropping the smaller manufacturers for IBM, and even Apple found that it had to respond to IBM's incursion into the ComputerLand stores. Apple terminated its contract with ComputerLand's central office where IBM was influential, and started dealing directly with the outlet franchise stores.

The Shakeout

It was the end of the beginning. A shakeout that had been only foreshadowed in the failures of MITS, IMSAI, and Processor Technology began to loom real in the eyes of the pioneering companies, and with more than 300 personal-computer companies in existence, many hobbyist-originated companies began to wonder if they would still be in business two years hence. IBM had forced even the big companies in the market to reappraise their situations.

Xerox, Don Massaro said, had carefully considered that IBM might produce a personal computer. "We did a worst-case scenario in getting approval for the [Xerox 820] program. We said, 'What could IBM do? How could we not be successful in this marketplace?' The scenario was that IBM would enter with a product that would make ours technically obsolete, they would sell it through dealers, and it would have an open operating system." It seemed an unlikely prospect. "IBM had never done that, had never sold through dealers, and had certainly never had an open operating system. I thought IBM would have their own proprietary operating system for which they would write their own software, and that they would sell through their own stores." Instead, Xerox's worst fear came to life in painful detail, and "the whole world ran off in that direction. IBM just killed everybody."

Not everybody. But the circle of attention had narrowed. There were now two personal-computer companies that everyone was watching: Apple and an IBM nobody knew; an IBM that had, in John Draper's words, "discovered the Woz Principle" of the open system.

The presence of IBM and the other big companies shook the industry to its hobbyist roots. Tandy, with its own distribution channels, was only modestly affected. Commodore was doing all right concentrating on European sales and sales of low-cost home computers.

But the companies that had pioneered the personal computer began dropping out of the picture. The shakeout was in earnest. The resurrected IMSAI was one of the first companies to go. Todd Fischer and Nancy Freitas supplied the IMSAI computer that figured prominently in the popular movie *War Games*, and it was effectively the company's last act. Shortly thereafter, Fischer and Freitas gave the pioneering microcomputer company a decent burial. (But not permanently: Fischer and Freitas would be selling IMSAI computers again in 1999, feeding a retrocomputing craze.)

By late 1983, even some of the most successful of the personal-computer and software companies to spring up out of the hobbyist movement were hurt. North Star, Vector Graphic, and Cromemco all felt the pinch. There were massive layoffs, and some companies turned to offshore manufacturing to stop leaking profits. Chuck Peddle, who had been responsible for the PET computer and had been active throughout the industry in semiconductor design at MOS Technologies and in computers at Commodore and briefly at Apple, was now running his own company, Victor, with a computer similar to IBM's. In the face of the IBM challenge, Victor soon had to severely cut back its work force, hurt by softening sales. George Morrow's company Microstuf considered a stock offering, but then withdrew the idea in response to IBM's growing influence in the market.

On September 13, 1983, Osborne Computer Corporation declared bankruptcy amid a mountain of debt accumulated when it tried to catch up with Apple and IBM. Of all the company failures in the history of the personal-computer industry, none was more thoroughly analyzed. OCC had flown high and fast, and its fall was startling. At the height of their success, Osborne executives appeared on the television program *60 Minutes*, predicting that they would soon be millionaires. They were on paper, but the company's financial controls were so lax that the figures were meaningless. The media coverage of the company's failure was intense, but the analyses were conflicting. Certainly there were problems with the hardware, but most companies have them and Osborne dealt with them. Osborne executives made serious mistakes in the timing of product announcements and the pricing of new products.

In May, Osborne had announced its Executive computer. Its improvements included a larger screen, but the company's new "professional" management priced it at $2,495 and stopped selling the original product. Sales immediately declined. "If we had left the Osborne 1 on the market, management would have seen the mistake because it would have kept on selling," said Michael McCarthy, a documentation writer at the firm. Instead, first-time buyers who liked the Osborne 1 for its packaging and price now looked elsewhere.

What seems clear is that Osborne grew so fast in its attempt to be one of the three major companies that Adam Osborne had predicted would dominate personal computing in a year or so, that its managers were unable to control it. As industry analyst John Dvorak put it, "The company grew from zilch to $100 million in less than two years. Who do you hire who has experience with growth like that? Nobody exists." Osborne was just too successful for its own good.

The last chapter of the Osborne story had a bittersweet irony for the employees. Coming to work one day, they were instructed to leave the premises. Money owed them was not paid. Security guards were posted at the doors to ensure that they took no Osborne property with them. But someone had failed to inform the guards that the company made portable computers, and the employees walked out carrying Osborne's inventory with them.

Others fell under IBM's shadow. Small software companies like EduWare and Lightning Software allowed themselves to be bought by larger ones, and all software companies learned to think of first doing "the IBM version" of any new software product. Even major corporations adjusted their behavior. Atari and Texas Instruments swallowed millions in losses in their attempts to win their way into the personal-computer market through low-cost home machines. Atari suffered deep wounds. And although TI had more of its low-cost TI-99/4 computers in homes than almost any other computer, it announced in the fall of 1983 that it was cutting its losses and getting out of personal-computer manufacturing.

IBM's entry also affected the magazines, shows, and stores. David Bunnell, who had left MITS to start *Personal Computing* magazine, responded to IBM's arrival by coming out with *PC Magazine*, a thick publication directed at users of the IBM machine. Soon major publishers were fighting over Bunnell's magazine. Wayne Green, having built *Kilobaud* into an empire of computer magazines by 1983, sold the lot to an East Coast conglomerate. Art Salsberg and Les Solomon rode out *Popular Electronics*'s transformation into *Computers and Electronics*. Jim Warren started an IBM PC Faire in late 1983 and then sold his show-sponsoring company, Computer Faire, to publishing house Prentice Hall, claiming that the business was too big for him to manage. ComputerLand and the independent computer stores found themselves competing with Sears and Macy's as IBM opened new channels of distribution for personal computers.

Late in 1983, IBM announced its second personal computer. Dubbed the PCjr, the machine offered little technological innovation. Perhaps to prevent business users from buying the new and less expensive machine in place of the PC, IBM equipped the PCjr with a poor-quality "Chicklet" keyboard, a style of keyboard unsuited to serious, prolonged use. Despite the PCjr's unimpressive technological design and chilly reception, by announcing a second personal computer, IBM demonstrated that it recognized a broad, largely untapped market for home computers. IBM intended to be a dominant force in that market, too.

Apple, in preparation for its inevitable toe-to-toe battle with IBM, made several significant moves. In 1983, the firm hired a new president, former Pepsi-Cola executive John Sculley, to manage its underdog campaign against IBM.

That Apple, no longer the dominant company in an industry still in its infancy, could attract the heir apparent to the presidency of huge PepsiCo was a tribute to the persuasive powers of its cofounder, Steve Jobs. “You can stay and sell sugar water,” he told a vacillating Sculley, “or you can come with me and change the world.” Sculley came.

Then, in January 1984, Apple introduced its Macintosh computer.

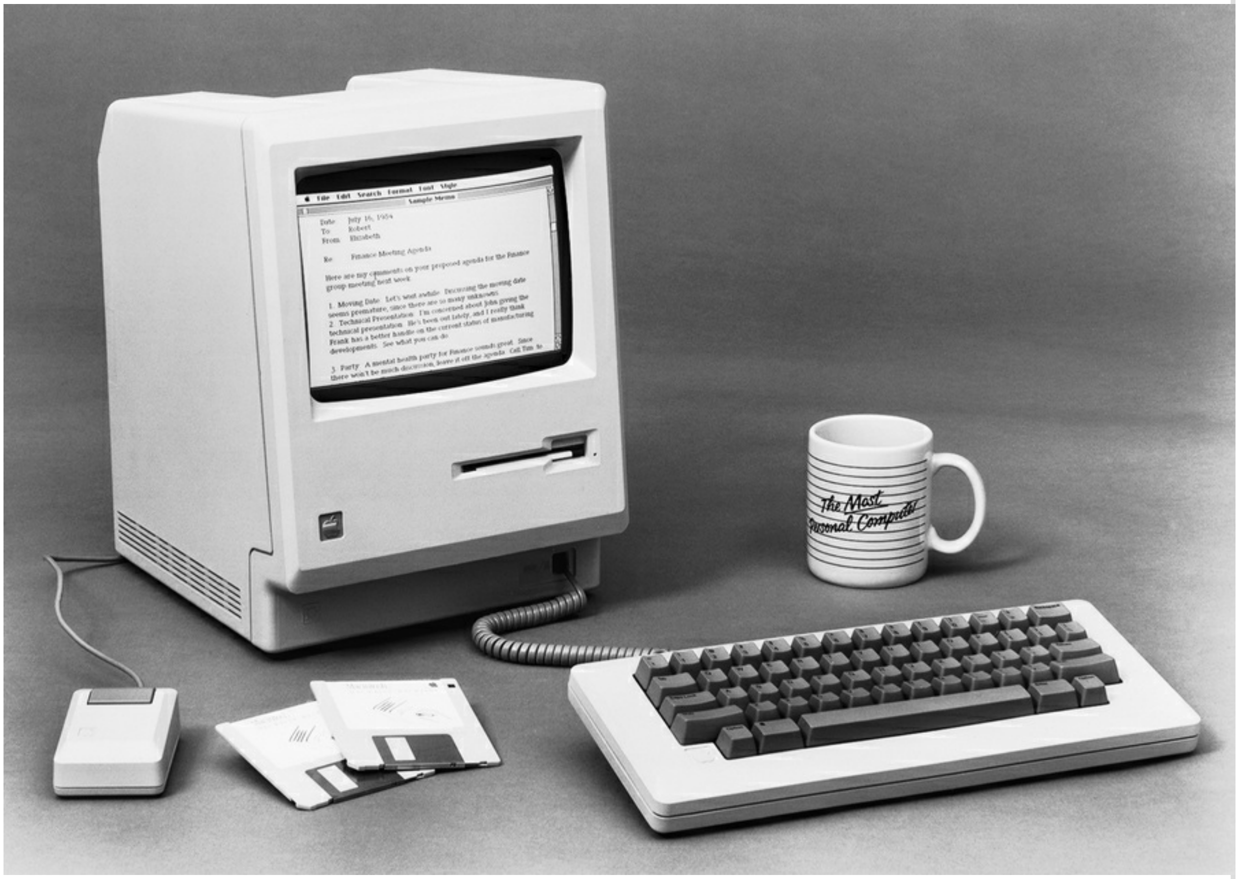


Figure 88. The original Apple Macintosh *It had 128K of memory.* (Courtesy of Apple Computer Inc.)

IBM had chosen to emphasize its name—the best-known three letters in the computer industry. Apple decided to provide state-of-the-art technology. The Macintosh immediately received accolades for its impressive design, including highly developed software technology that used a mouse, an advanced graphical user interface, and a powerful 32-bit microprocessor in a lightweight package.

But while Apple delighted in portraying this situation as a confrontation between Big Brother and the unruly upstarts, Apple was no longer some hippie garage shop financed by pocket change and float. The computer industry was now big business, and Apple was a serious, well-funded company.

The money dealers had come to where the money was, and the financial success of the industry rooted in hobbydom severed the industry from its roots. But the computer-power-to-the-people spirit Lee Felsenstein and others had sought to foster had by no means disappeared. Even staunchly conservative IBM had bent to it in adopting an open architecture and an open operating system. IBM’s corporate policy in the 1950s and 1960s had often been to lease computers and to discourage sales. For the room-sized computers made then, this method was appropriate. With proprietary architectures and software, the power of the machines really belonged not to the people who used them, but to the companies that had built them.

But something had changed in this first personal-computer decade, and in 1984 it looked like the personal computer and all the growing power it harnessed belonged to the people.

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Chapter 9

The PC Industry

> *You were dealing with entrepreneurs mostly. Egos, a lot of egos.*
>
> *Ed Faber*

By 1985, IBM had entered the fledgling personal-computer field and transformed it into an industry, while Apple’s Macintosh had changed expectations about how people interacted with personal computers. But now the hobbyist days were fading and personal computing was entering a new phase. This new era would be a long and impressive period of growth with no direct parallel in any other industry. There was no question any longer that this *was* an industry, yet the indications of its hobbyist beginnings were still visible. People who came out of that culture still wielded great influence, people like Bill Gates and Steve Jobs. In fact, this era would be bracketed at the beginning and end by two eerily parallel events: the ignominious departure of Jobs from the company he cofounded, and his triumphant return.

Losing Their Religion

> *We found ourselves a big company, glutted from years of overspending. Then the money supply dried up, and that caused the first of a series of convulsions.*
>
> –Chris Espinosa, employee no. 8 at Apple Computer

In the 1980s Steve Jobs’s dream machine became reality. And market reality can be brutal.

The Mac’s Shortcomings

After the release of the Macintosh in 1984, Steve Jobs felt vindicated. Plaudits from the press and an immediate cult following assured him that the machine was, as he had proclaimed it, “insanely great.” He had every right to take pride in the accomplishment. The Macintosh would never have existed if it hadn’t been for Jobs. He had seen the light on a visit to Xerox PARC in 1979. Inspired by the innovations presented by the PARC researchers, he longed to get those ideas implemented in the Lisa computer. When Jobs was nudged out of the Lisa project, he hijacked a team of Apple developers working on an interesting idea for an appliance computer and turned them into the Macintosh skunk works.

Jobs hounded the people on the Macintosh project to do more than they thought possible. He sang their praises, bullied them mercilessly, and told them they weren’t making a computer; they were making history. He promoted the Mac passionately, making people believe that he was talking about much more than just a piece of office equipment.

His methods all worked, or so it seemed. Early Mac purchasers bought the Jobs message along with the machine, and forced themselves to overlook the little Mac’s serious shortcomings. For about three months, Mac sales more or less measured up to Jobs’s ambitious projections. For a while, reality matched the image in Steve Jobs’s head.

Then Apple ran out of zealots.

Figure 89. Andy Hertzfeld ***After Jobs pulled him off Apple II development, Hertzfeld wrote the key software for the Macintosh.***
(Courtesy of Andy Hertzfeld)

Figure 90. The Mac design team ***Left to right: Andy Hertzfeld, Chris Espinosa, Joanna Hoffman, George Crow, Bill Atkinson, Burrell Smith, Jerry Manock*** **(Courtesy of Apple Computer Inc.)**

The first Macintosh purchasers were early adopters—technophiles willing to accept the inevitable quirks of new technologies for the thrill of being the first to use them. Those early adopters all bought Mac machines in the first three months of sales, and then the well dried up. In 1984 and 1985, the first two years of the Mac's life, sales routinely failed to reach the magnitude of Jobs's expectations—sales projections that the company was counting on. For those two years, it was the old reliable Apple II that kept the company afloat. If Apple had depended on Mac sales alone, it would have folded before the 1980s were over.

All the while, the Mac team still got the perks, the money, and the recognition, and the Apple II staff got the clear message that they were part of the past. Jobs told the Lisa team outright that they were failures and "C players." He called the Apple II crew "the dull and boring division."

Chris Espinosa came to the Mac division from the Apple II group. He had family and friends still on the Apple II side. The 20-year-old Espinosa had worked at Apple since he was 14. The us-versus-them syndrome he witnessed saddened him.

Customers, third-party developers, and Apple stockholders weren't all that happy, either. The Mac wasn't selling slowly for lack of an advertising budget. It deservedly failed in the market. It lacked some essential features that users had every reason to demand. Initially, it had no hard-disk drive, and a second floppy-disk drive was an extra-price option. With only a single disk drive, making backup copies of files was a nightmare of disk-swapping.

At 128K RAM, it seemed that the Mac's memory should have been more than adequate; 64K was the standard in the industry. But the system and application software ate up most of the 128K, and it was clear that more memory was needed. *Dr. Dobb's Journal* ran an article showing how anyone brave enough to attack the innards of their new Mac machine with a soldering iron could "fatten" their Mac to 512K, six months before Apple got around to delivering a machine with that much RAM.

But the memory limitations weren't a problem unless you had the software that used the RAM, and therein was the real problem. The Mac shipped with a collection of Apple-developed applications that allowed users to do word processing and draw bitmapped pictures. Beyond that, the application choices were slim because the Mac proved to be a difficult machine to develop software for.

The Departure of Steve Jobs

Jobs was entirely committed to his vision of the Macintosh, to the point that he continued to use the 10-times-too-large sales projections as though they were realistic. To some of the other executives, it began to look like Jobs was living in a dream world of his own. The Mac's drawbacks, such as the lack of a hard-disk drive, were actually advantages, he argued, and the force of his personality was such that no one dared to challenge him.

Even his boss found it difficult to stand up to Jobs. John Sculley, whom Jobs had hired from Pepsi to run Apple, concluded that the company couldn't afford to have its most important division headed up by someone so out of touch with reality. But could Sculley bring himself to demote the founder of the company? The situation was getting critical: early in 1985, the company posted its first-ever quarterly loss. Losses simply weren't in the plan for Apple, which stood as an emblem of the personal-computer revolution, a modern-day legend, and a company that had risen to the Fortune 500 in record time.

Sculley decided to take drastic action. In a marathon board meeting that began on the morning of April 19, 1985, and continued into the next day, he told the Apple board that he was going to strip Jobs of his leadership over the Mac division and any management role in the company. Sculley added that if he didn't get full backing from the board on his decision, he couldn't stay on as president. The board promised to back him up.

But Sculley failed to act on his decision immediately. Jobs heard about what was coming, and in a plot to get Sculley out, began calling up board members to rally their support. When Sculley heard about this, he called an emergency executive board meeting on May 24. At the meeting he confronted Jobs, saying, "It has come to my attention that you'd like to throw me out of the company."

Jobs didn't back down. "I think you're bad for Apple," he told Sculley, "and I think you're the wrong person to run the company." The two men left the board no room for hedging. The individuals in that room were going to have to decide, then and there, between Sculley and Jobs.

They all got behind Sculley. It was a painful experience for everyone involved. Apple II operations manager Del Yocam, for one, was torn between his deep feelings of loyalty toward Jobs and what he felt was best for the future of the company. Yocam recognized the need for the grown-up leadership at Apple that Sculley could supply and that Jobs hadn't, and he cast his vote for maturity over vision.

Jobs was understandably bitter. In September, he sold off his Apple stock and quit the company he had cofounded, announcing his resignation to the press. The charismatic young evangelist who had conceived the very idea of Apple Computer, had been the driving force behind getting both the Apple II and the Macintosh to market, had appeared on the cover of every major newsmagazine, and was viewed as one of the most influential people in American business was now out the door.

Clones

> *Had Compaq or IBM changed in ’88 or ’89, Dell would not have been a factor. Now Dell is driving the industry.*
>
> –Seymour Merrin, computer-industry consultant

Apple was struggling with the new realities of the rapidly growing computer industry, but every company found itself challenged to adapt. The fear in the fledgling personal-computer industry had been that IBM would enter the market and transform everything. That fear came true in the 1980s. But the personal-computer industry transformed IBM as well.

Imitating IBM

While Apple was losing its way in the wake of IBM’s entry into the market, IBM’s own fortunes followed a strange path. When IBM released its Personal Computer, very little about the machine was proprietary. IBM had embraced the Woz principle of open systems, not at all an IBM-like move. One crucial part of the system was proprietary, though, and that part was, ironically, the invention of Gary Kildall.

Like Michael Shrayer, who had written different versions of his pioneering word processing program for over 80 brands of computers, Kildall had to come up with versions of his CP/M operating system for all the different machines in the market. Unlike Shrayer, however, Kildall found a solution to the problem. With the help of IMSAI’s Glen Ewing, he isolated all the machine-specific code that was required for a particular computer in a piece of software that he called the basic input-output system, or BIOS.

Everything else in CP/M was generic, and didn’t need to be rewritten when Kildall wanted to put the operating system on a new machine from a new manufacturer. Only the very small BIOS had to be rewritten for each machine, and that was relatively easy.

Tim Paterson realized the value of the BIOS technique and implemented it in 86-DOS, from which it found its way into PC-DOS.

The BIOS for the IBM PC defined the machine. There was essentially nothing else proprietary in the PC, so IBM guarded this BIOS code and would have sued anyone who copied it.

Not that IBM thought it could prevent others from making money in “its” market. That was a given. In the mainframe market, people spoke of IBM as The Environment, and many companies existed solely to provide equipment that worked with IBM machines. When IBM moved into the personal-computer market, many companies found ways to work with the instant standard that the IBM PC represented.

Employees of Tecmar were among the first in the doors of Chicago's Sears Business Center the morning the IBM PC first went on sale. They took their PC back to headquarters and ran it through a battery of tests to determine just how it worked. As a result, they were among the first companies to supply hard-disk drives and circuit boards to work with the PC. These businesses took advantage of the opportunity to compete in this market with price, quality, or features. Ed Roberts's pioneering company, MITS, had encountered a similar situation in 1976 and Roberts had labeled these companies "parasites."

And just as IMSAI had produced an Altair-like machine to compete with MITS, many microcomputer companies came out with "IBM workalikes," computers that used MS-DOS (essentially PC-DOS but licensed from Microsoft) and tried to compete with IBM by offering a different set of capabilities, perhaps along with different marketing or pricing. Without exception, the market resoundingly rejected these IBM workalikes. Consumers might buy a computer that made no pretense of IBM compatibility—Apple certainly hoped so—but they weren't going to put up with any almost-compatible machine. Any computer claiming IBM compatibility would have to run all the software that ran on the IBM PC, support all the PC hardware devices, and accept circuit boards designed for the IBM PC, including boards not yet designed. But IBM's proprietary BIOS made it very hard for other manufacturers to guarantee total compatibility.

The Perfect Imitation

Yet the potential reward of creating a 100 percent IBM PC–compatible computer was so great that it was to be assumed that someone would find a way. In the summer of 1981, three Texas Instruments employees were brainstorming in a Houston, Texas, House of Pies restaurant about starting a business. Two options they considered were a Mexican restaurant and a computer company. By the end of the meal, Rod Canion, Jim Harris, and Bill Murto had deep-sixed the Mexican restaurant and sketched out, on the back of a House of Pies placemat, a business plan for a computer company, detailing what the ideal IBM-compatible computer would be like. With venture capital supplied by Ben Rosen, the same investor who had backed Lotus, they launched Compaq Computer and built their IBM-compatible. It was a portable or, at 28 pounds, more of a "luggable," had a nine-inch screen and a handle, and looked something like an Osborne 1.

Unlike the workalikes, the key to their machine was that it was 100 percent IBM compatible. Compaq had performed a so-called "clean-room" re-creation of the IBM BIOS, meaning that engineers reconstructed what the BIOS code had to be, based solely on the IBM PC's behavior and on published specifications, without ever having seen the IBM code. This gave Compaq the legal defense it needed for the lawsuit that they knew they would face from IBM.

Compaq marketed aggressively. It hired away the man who had set up IBM's dealer network, sold directly against IBM through dealers that IBM had approved to sell its PC, and offered those dealers better margins than IBM did. The plan worked. In the first year, Compaq's sales totaled

$111 million. There were soon thousands of offices where a 28-pound “portable” from Compaq was the worker’s only computer.

The idea of a clean-room implementation of the IBM PC BIOS was vindicated. In theory, any other company could do what Compaq had done.

Few companies had the kind of financial backing that Compaq could call on to compete head-to-head with IBM, even if they had their own clean-room re-creations of the IBM BIOS. However, one did have enough savvy to leverage the technology. After Phoenix Technology performed its clean-room implementation of the BIOS, it licensed its technology to others rather than build its own machine. Now anyone who wanted to build fully IBM-compatible machines without risk of incompatibility or lawsuit could license the BIOS from Phoenix. Consumers and computer magazines tested the “100 percent compatibility” claim, often using the extremely popular Lotus 1-2-3: if a new computer couldn’t run the IBM PC version of 1-2-3, it was history. If it could, it usually could run other programs, also. The claims, generally, held up.

Soon there were dozens of companies making IBM-compatible personal computers. Tandy and Zenith jumped in early, as did Sperry, one of the pioneering mainframe companies. Osborne built an IBM-compatible just before going broke. ITT, Eagle, Leading Edge, and Corona were some of the less familiar names that became very familiar as they bit off large chunks of this growing IBM-compatibles market.

Suddenly, IBM had no distinction but its name. Until now, that had always been enough. IBM had been The Environment, but now it had leaped into a business environment that it apparently didn’t control. The clone market had arrived.

Imitating Apple

Apple stood virtually alone in not embracing the new IBM standard, initially with its Apple II and Apple III, and soon thereafter with the Macintosh. Although user loyalty and an established base of software kept the Apple II alive for years, it was not really competitive with the PC and compatibles, particularly when IBM began introducing new models based on successive generations of Intel processors and the Apple II was locked into the archaic 6502. But the Macintosh graphical user interface, or GUI, gave Apple the edge in innovation and ease of use, and kept it among the top personal-computer companies in terms of machines sold. Jobs’s prediction that it would come down to Apple and IBM was initially borne out, although the clones were not to be overlooked.

Software was growing increasingly important, too. With the advent of the clone market, the choice of a personal computer was becoming a matter of price and company reputation, not technological innovation. And since people bought machines specifically to run certain programs, such as Lotus 1-2-3, Apple’s appeal was diminished. Even if Apple was selling as many machines as IBM or Compaq, its platform was a minority player, while computers using the magic combination of IBM’s architecture, Intel’s microprocessor, and Microsoft’s operating system increasingly became the dominant platform.

Why didn’t anyone clone the Mac? There simply was no Mac equivalent of Kildall’s BIOS—what made the Mac unique was incorporated in many thousands of lines of code. It was, in short, much harder to clone the Macintosh. It couldn’t be done without Apple’s approval, which the company invariably withheld.

Consolidation

You have to think it's a fun industry. You've got to go home at night and open your mail and find computer magazines or else you're not going to be on the same wavelength as the people [at Microsoft].

–Bill Gates, 1983

Microsoft became the dominant company in the personal-computer industry in the 1980s, surpassing IBM in influence, and its founders became billionaires. But as the 1980s began, Microsoft and Bill Gates were known only within the tight community of personal-computer companies.

In 1981 the company's business focused on programming languages, with some application software and a lone hardware product thrown in—Paul Allen's brainchild, the SoftCard, which let people run CP/M programs on an Apple computer. DOS, which would begin the company's rise to prominence, was under development, but did not come out until months later, when the IBM PC was released.

Although Gates had insisted that Microsoft should not sell directly to end users, an aggressive salesman named Vern Raburn convinced him otherwise, using the now-standard method of impressing Bill: he challenged him, had his facts straight, and didn't back down. After winning his argument with Gates, Raburn became president of a new Microsoft subsidiary, Microsoft Consumer Products, which began selling both Microsoft-developed products and other licensed products, including some applications, in computer stores and anywhere else Raburn could find shelf space. But in 1981 this operation was just beginning, and the company wasn't a major player, even in the young computer industry.

Microsoft's total revenues for 1981 were about $15 million. It seemed like a lot of money to Gates, but by way of contrast, Apple's annual gross revenues were running just about 20 times as high, and IBM was in another league altogether.

Microsoft converted from a partnership to a corporation in June 1981. Much of the stock was held by three people: founders Gates and Allen and Bill's friend from Harvard and increasingly powerful executive at Microsoft, Steve Ballmer. A clear majority of the stock was in the hands of the unkempt, squeaky-voiced president, who new employees sometimes mistook for some teenaged hacker trespassing in the president's office.

Such new employees soon learned that the 26-year-old president, who looked 18, was a force to be reckoned with. And they learned that the company they had come to work for was, in many ways, as unusual as its young president. The company was, in fact, a lot like Bill Gates.

This was not surprising because Gates made it a point to hire people who were like himself—bright, driven, competitive, and able to argue effectively for what they believed in. A small but influential number of the new employees came from fabled Xerox PARC, the research lab where Steve Jobs saw the vision that would become the Macintosh.

Gates invited employees to argue with him about important technical issues. He hardly gave what could be called positive feedback; he frequently characterized work or ideas as “brain damaged” or “the stupidest thing I ever heard.” But he prided himself on being open to good ideas from any source, and even when he delivered one of his devastating denouncements, it was always the idea he attacked, not the individual. Because Gates was such a demanding critic, employees who impressed him gained credibility and influence. It was the key to the executive washroom, the prime parking place in a company that had no executive washroom and no reserved parking places.

The easy access to the president and his willingness to listen to good arguments from any employee gave the appearance of democracy to the company culture. Even if you couldn’t nail him down in the hall, anyone could send an email message directly to *billg* and know that Bill G. himself would read it. But Microsoft was far from a democracy. The flattened communication structure was a double-edged sword. Although displeasing Bill Gates was death, getting positive feedback from *billg* on your work or ideas was money in the bank. Those who were most favored tended to see Microsoft as a meritocracy.

In a meritocracy, the real power resides in the authority to judge merit. At Microsoft, Bill’s judgment was the final word.

One competent employee who just didn’t fit the Bill mold was Jim Towne. Towne was hired from Tektronix in July 1982 to serve as president of Microsoft. Gates was conscious that a lot of early microcomputer companies had failed because they didn’t know when to bring in more-experienced managers. Entrepreneur’s disease was at least part of what had killed MITS, IMSAI, and Proc Tech. Bill was juggling a lot of balls, and he brought Towne in to lighten his load and take the official title of president. Towne served about a year, but Gates never thought he had the right feel for the company. There was no real problem with his management; ultimately, Towne failed to “take” at Microsoft because he wasn’t Bill. It began to appear that what Bill wanted was not a president but a way to clone himself.

Through the early 1980s, the IBM deal and its aftermath gave the company a huge boost, particularly when Compaq and Phoenix Technologies created a clone market for Microsoft to sell MS-DOS to.

By the end of 1981, Microsoft had grown to 100 employees and had moved to new offices in Bellevue, Washington. The stresses of the IBM deal and the company’s growing pains were getting to some employees. Soon some long-timers left, including Bob Wallace, who had been a mainstay since the Albuquerque days. But Wallace’s leaving was a blip compared to the departure of Paul Allen, Bill’s lifelong friend and partner. Although Allen’s departure was due to a health issue (he had Hodgkin’s disease) and not stress, it increased Gates’s own level of stress. Now the company was totally his to run.

Pam Edstrom, Microsoft’s PR chief, was pushing an image of Bill as the nerd who made good. Another story was equally true, however: the privileged child of comfortable affluence, weaned on competition and the importance of winning, who read *Fortune* magazine in high school and became a ruthless cutthroat businessman determined to dominate markets and crush the competition. But the general press could handle only one image of Gates, and Edstrom made sure they got the “right” one—right for Microsoft, that is. Journalists certainly had no trouble believing the official tale; a few minutes with Gates would convince anyone that he was a nerd, and the balance sheet made the case for his having done well.

Gates, meanwhile, was presenting an image of Microsoft that stuck in the craw of industry insiders. He insisted that Microsoft produced quality products, whereas the reality was that the general run of stuff was less than top-notch work. Microsoft’s software was of varying quality, sometimes buggy, sometimes slow. And within the company the image of quality and professionalism was a joke. Internal systems were a disaster. There were not enough computers. The huge plastic boxes in which Microsoft was packaging its products were a warehouse nightmare and one more indication that all was not rosy inside Bill’s empire. If Microsoft reflected Bill Gates’s personality and values, its organization could have been modeled on Bill’s personal life. He ate fast food, neglected to shower, and had trouble remembering to pay his bills. Microsoft paid its bills, but otherwise its internal systems looked a lot like Bill. The second try at getting somebody in to clean up the mess made Radio Shack’s Jon Shirley the new president of Microsoft.

Playing Rough

There was another way in which the image of Microsoft didn’t match the reality. Microsoft would have people believe that its OEM customers bought its products solely for their quality, not because of Microsoft’s aggressive business dealings. (OEM, or original equipment manufacturer, refers to the computer companies who licensed software from Microsoft to include with their machines.) Microsoft’s cutthroat tactics with its OEMs were most evident in Microsoft’s efforts to win the GUI market.

Microsoft was one of the first companies to develop software for the Mac, and had been briefed on Apple’s project for months before the release. So closely did Microsoft work with Apple that its programmers were making suggestions about the operating system as it was being refined. Microsoft Windows was based on what Microsoft learned during that process.

On November 10, 1983, Microsoft staged an impressive media blitz for its upcoming Windows product that trumpeted to the industry the scores of vendors who had signed on to develop application software that would be Windows-compatible. Some of these had also signed on with VisiCorp's pioneering GUI product, Visi On, and were wavering in their commitment to Microsoft, so the message was a little disingenuous—plus Windows wasn't anywhere to be seen.

According to one OEM customer, Microsoft agreed to give its OEMs an early beta version of Windows—absolutely necessary if the OEMs wanted to have a Windows-compatible application out when Windows itself came out—but only if the OEMs agreed not to develop for a competing product such as Visi On. The Justice Department might have considered such tactics—and other tactics Microsoft was engaging in at the time—as restraint of trade or unfair business practices, but nobody was talking about these backroom deals. Later there would be charges of "undocumented system calls"—code in Windows or DOS that Microsoft reserved for its own use to give its application software an advantage over any competitor's. Microsoft was engaging regularly in behavior that would eventually lead the Justice Department to its door.

Windows was finally released in 1985. After an initial burst of good press, the actual reviews began to come in—and they were not kind.

Given the wide variety of hardware configurations that MS-DOS had to support, cloning the Mac GUI to run snappily on top of it was a tough problem, and Microsoft hadn't adequately solved it. And yet Windows did have to run on top of MS-DOS. The MS-DOS operating system was installed in all the IBM and clone machines, which made up most of the market. Microsoft had to maintain compatibility with all those machines when it released this Mac-like user interface, and the only way to do that was to make Windows merely an interface between the user and the real operating system. Underneath, it had to be MS-DOS, dealing with application programs, data files, printers, and disk drives, just as MS-DOS always had.

But Microsoft continued to prosper, with MS-DOS making up a larger and larger share of revenues. The company's March 1985 initial public offering of stock was eagerly anticipated in the financial community. When the numbers were tallied after the IPO, Bill's 45 percent of the company was worth $311 million. Microsoft had grown to over 700 employees, and it had moved to larger headquarters.

By 1987, Microsoft passed Lotus as the top software vendor. This remarkable ascendancy came about in large part due to its control over the MS-DOS operating system used on nearly all non-Apple PCs. But Microsoft had increasingly developed ambitions to offer products for most software categories, including spreadsheets, word processors, presentation programs, and educational tools. There were now some 1,800 Microsoft employees worldwide.

Microsoft Supplants IBM

Meanwhile, IBM, beginning to face real competition from the clone manufacturers, decided to replace DOS (and its unsuccessful GUI product, TopView) with a new, powerful operating system with a graphical user interface. The new operating system would be called OS/2.

Microsoft was commissioned once again to work on the operating system, but the arrangement was rocky from the start. By 1990, the final split with IBM was imminent.

Microsoft had committed a lot of resources to OS/2, as had IBM. But it appeared that neither party was entirely faithful in this software-development marriage.

Microsoft was alarmed when IBM seemed to be hedging its bets by leading an industry effort to standardize the Unix operating system and by licensing NeXTSTEP, the operating system from Steve Jobs's NeXT Inc. This was normal behavior; IBM typically had a number of alternate plans in the works, with different divisions of the company competing with one another to see whose project would actually be chosen to ship. But that was hardly a comfortable position for Microsoft, which would be in trouble if OS/2 were scrapped in favor of Unix or NeXTSTEP while Microsoft had spent years developing an operating system that IBM decided it didn't want to support.

And, of course, at the same time Microsoft was developing Windows. Windows wasn't actually an operating system, but Windows plus DOS was, so Microsoft had its own hedge. At first, the plan was to make Windows and the graphical interface of OS/2 work alike. Microsoft started telling programmers that if they developed software for Windows they would be ready for OS/2 when it came out. This grew less plausible as time went on.

Before long, Microsoft programmers working on OS/2 weren't talking to IBM OS/2 programmers and vice versa. The companies officially denied the friction, but the marriage was on the rocks. IBM was convinced that Microsoft had shifted its efforts to Windows, that Microsoft was only pretending to be concentrating on OS/2, and that Microsoft was claiming Windows would not compete with OS/2 when competition was exactly the plan. That was all true, eventually.

IBM announced that OS/2 would be released in two versions, the more sophisticated of which would be sold exclusively by IBM. That wasn't news Bill Gates wanted to hear.

Finally, Gates told Steve Ballmer that they were going to go for broke on Windows and that he wasn't worrying about what IBM thought about it. Then a Gates memo that called OS/2 "a poor product" was made public. The arrangement fell apart, IBM took over OS/2, and Microsoft indeed went for broke on Windows.

Windows 3.0 rolled out in 1990, which was the first adequate release of the GUI product. Jon Shirley also departed from Microsoft in 1990. Although things had worked out all right, the Texan just figured it was time to move on. In six weeks, Gates had hired ex-IBMer Mike Hallman as the new president. Although he lasted only into 1992, it hardly mattered to the direction and atmosphere of the company. Microsoft was Bill Gates's baby.

As Gates approached 40, neither he nor Microsoft seemed to lose any vitality. The break with IBM invigorated Microsoft and left IBM floundering. Windows was finally getting positive reviews while IBM's OS/2 and its GUI product, Presentation Manager, were not. Computer companies and software developers believed that Microsoft was in charge and followed its lead.

Sculley Saves Apple

With Jobs gone, Sculley set to work saving the company from ruin. Under his direction, Apple dropped the Lisa computer, and brought out a high-end Macintosh—the Macintosh II—along with new models of the original Mac, in particular a model called the Mac Plus that was introduced in January 1986.

The Mac Plus addressed most of the shortcomings of the original Mac and got the money flowing in the right direction. Sculley had stopped the financial bleeding and put the company back on its feet. For the next few years Apple was golden.

Sculley had turned around the demoralization that followed Jobs's departure, got the Mac line moving, and made the company profitable again. Eventually he retired the Apple II line, but not without first giving the Apple II employees a measure of the credit they had been denied during the latter part of Jobs's tenure. As a sign of his support of the Apple II team, he promoted Del Yocam to chief operating officer.

Sculley began relying on two Europeans more than ever before. German Michael Spindler, savvy about technology and the European market, headed Apple's European efforts, while Jean-Louis Gassée, a charismatic and witty Frenchman, got the job of inspiring and motivating the engineering troops.

Gassée, who had made Apple France the company's most successful subsidiary, quickly became the second most visible executive in one of the world's great corporate fishbowls. He had a penchant for metaphor and bold pronouncements; he once gave a speech called "How We Can Prevent the Japanese from Eating Our Sushi." Unlike Sculley, he was technical, and he won the respect and affection of Apple's engineers.

When alumni of Xerox PARC came up with a language for controlling printers and a program for designing publications, Apple released a laser printer, and a lucrative desktop publishing (DTP) market was born. The Macintosh, with the artful typography that Jobs had insisted on, was a natural DTP machine. Apple dominated the DTP market for years after that.

"We were in the catbird seat," Chris Espinosa recalled, with a product that was such a favorite among consumers that Apple could raise prices and get away with it. "We were making 55 percent gross margins, on our way to becoming a $10 billion corporation. We were in fat city."

One portentous event went unnoticed by the outside world: on October 24, 1985, Microsoft was threatening to stop development on crucial applications for the Mac unless Apple granted Microsoft a license for the Mac operating-system software. Microsoft was developing its graphical user interface (the items and options a user sees and selects onscreen) for DOS, which it was calling Windows, and didn't want Apple to sue over the similarity between the Windows GUI and the Mac interface. Although Microsoft might not have followed through on its threat to stop development of the applications, Sculley decided not to take the chance. He granted Microsoft its license, a move that he would later regret, and try, unsuccessfully, to undo.

But the company was prospering. Investors, customers, and employees were happy. On the horizon, though, new and disturbing problems were developing for Apple.

Other companies had entered the personal-computer market and were making machines that worked like the IBM PC and that ran all the same software. Prices for these IBM-compatibles or clones were dropping, and Apple's machines, already premium-priced, were getting too far out of line. Throughout the late '80s, the Windows user interface was getting better and better and was taking increasingly more market share from Apple.

Microsoft's Windows wasn't the only alternative GUI. IBM had its TopView; Digital Research its GEM; DSR, a small company run by a programmer named Nathan Myhrvold, had something called Mondrian; and VisiCorp (née Personal Software) had Visi On.

The graphical user interface was beginning to be taken for granted, undermining the most apparent advantage of the Mac. Personal computers were becoming more standardized, with the particular hardware mattering less to consumers than the software. Third-party software (software developed by companies other than the computer maker) was being written first for Windows and then maybe for the Mac. The early perception in the corporate world that the Mac was a toy, not a serious business machine, was never really refuted. The walls were closing in on Apple.

It seemed clear as the '80s wound down that Apple couldn't go it alone indefinitely against the whole IBM-clone market. Apple appeared to have just two options. One was to rediscover the Woz principle—open the architecture so that other companies could clone the Mac, but do it under license so that Apple would make money on every clone sold. The other option was to join forces with another company.

The licensing idea had been around since at least 1985, when Sculley got a letter from Bill Gates, of all people, detailing the reasons why Apple should license the Mac technology. At Apple, Dan Eilers, the director of investor relations, was a persistent proponent of licensing, both at that time and then for years after. Jean-Louis Gassée fought the idea, questioning whether Apple could really protect the company's precious intellectual property after its release. The question in Gassée's mind was, "How do you ensure that another company will only sell into a market that complements your own?"

A deal that may have worked to the benefit of Apple was close to completion in 1987. Apple would license its operating system to Apollo, the first workstation company, for use in high-end workstations, a market that seemed to nicely complement Apple's. But Sculley nixed the deal at the last moment.

Apple's waffling over the partnership may have helped to sink Apollo. Its workstation competitor, Sun, was pursuing an open systems model, licensing its operating system and swallowing up more and more of the workstation market.

Another option for Apple was a merger or acquisition. Early on, Commodore had tried to buy Apple and came very close to a deal. Other merger or acquisition discussions were held over the years, and they grew more and more compelling as the PC-clone market grew. In the late 1980s, Sculley had Dan Eilers exploring the possibility of Apple buying Sun. A decade later, the relative fortunes of the two companies would be such that Sun would explore the possibility of buying Apple.

In 1988, Del Yocam got squeezed out as chief operating officer (COO) in a management reshuffling. Gassée and Spindler were immediate beneficiaries of the restructuring. "Reorgs" were routine at Apple by now. In a 1990 reorganization, Spindler was anointed COO, Sculley named himself chief technology officer (CTO), and Gassée was sidelined. Gassée soon resigned and left the company.

It was becoming an open question whether Apple could survive in this new market created by the entry of IBM.

Commoditization

> *We were going to change the world. I really felt that. Today we're creating jobs, benefiting customers. I talk in terms of customer benefits, adding value. Back then, it was like pioneering.*
>
> –Gordon Eubanks, software pioneer

By the end of the 1980s, the personal-computer industry was big business, making billionaires and creating tremors in the stock market.

A Snapshot

On October 17, 1989, the 7.1-magnitude Loma Prieta earthquake that hit the San Francisco Bay Area also rocked Silicon Valley. When systems came back online, this was the state of the industry:

There was a renewed rivalry between the sixers, users of microprocessors from the Motorola/MOS Technology camp, and the eighters, users of Intel microprocessors. Intel had released several generations of processors that upgraded the venerable 8088 in the original IBM PC, and IBM and the clone makers had rolled out newer, more powerful computers based on them. Motorola, in the meantime, had come out with newer versions of the 68000 chip it had released a decade earlier. This 68000 was a marvel, and the chief reason why the Macintosh could do processor-intensive things such as display dark letters on a white background and maintain multiple overlapping windows on the screen without grinding to a halt. Intel's 80386 and Motorola's 68030 were the chips that most new computers were using, although Intel had recently introduced its 80486 and Motorola was about to release its 68040. The two lines of processors battled for the lead in capability.

Intel, though, held the lead in sales quite comfortably. Its microprocessors powered most of the IBM computers and clones, whereas Motorola had one primary customer for its processors—Apple. (Atari and Commodore, with their 680x0-based ST and Amiga computers, had to wait in line for chips behind Apple, foreshadowing Apple supply-chain strategies that would be solidified under Tim Cook as COO.)

In 1989 "Moore's law," Intel cofounder Gordon Moore's two-decade-old formulation that memory-chip capacity would double every 18 months, was proving to still roughly predict growth in many key aspects of the technology, including memory capacity and processor speed. The industry seemed to be on an exponential-growth path, just as Moore had predicted.

The best-selling software package in 1989 was Lotus 1-2-3; its sales were ahead of WordPerfect's, the leading word processor, and MS-DOS. The top 10 best-selling personal computers were all various models of IBM, Apple Macintosh, and Compaq machines. Compaq was no mere clone maker; it was innovating, pushing beyond IBM in many areas. It introduced a book-sized IBM-compatible computer in 1989 that changed the definition of portability. Compaq also introduced a new, open, nonproprietary bus design called EISA, which was accepted by the industry, demonstrating the strength of Compaq's leadership position. IBM had unsuccessfully attempted to introduce a new, proprietary bus called MicroChannel two years earlier. IBM was fast losing control of the market, and it was losing something else: money.

By the end of 1989 IBM would announce a plan to cut 10,000 employees from its payroll, and within another year Compaq and Dell would each be taking more profits out of the personal-computer market than IBM. In another three years, IBM would cut 35,000 employees and suffer the biggest one-year loss of any company in history.

ComputerLand's dominance of the early computer retail scene was short-lived. During ComputerLand's heyday, consumers wanting to buy a particular brand had to visit one of the major franchises and distribution was restricted to a few chosen chains, the largest of which was ComputerLand. But in the late 1980s, the market changed. Price consciousness took precedence over brand name, and manufacturers had to sell through any and all potential distributors. The cost of running a chain store such as ComputerLand was higher than competitive operations, which could now sell hardware and software for less.

Another line of computer stores, called Businessland, gained a foothold and became the nation's leading computer dealer in the late 1980s by concentrating on the corporate market and promising sophisticated training and service agreements. But consumers were more comfortable with computers and no longer willing to pay a premium for hand-holding. Electronics superstores such as CompUSA, Best Buy, and Fry's, which offered a wide range of products and brands at the lowest possible prices, eclipsed both ComputerLand and Businessland. Computers were becoming commodities, and low prices mattered most.

Bill Gates and Paul Allen were billionaires by 1989; Gates was the richest executive in computer industry. In the industry, only Ross Perot and the cofounders of another high-tech firm, Hewlett-Packard, had reached billionaire status, but most of the leaders of the industry had net worths in the tens of millions, including Compaq's Rod Canion and Dell Computers' Michael Dell. In 1989, *Computer Reseller News* named Canion the second-most-influential executive in the industry, deferentially placing him behind IBM's John Akers. But perspective matters: in the same year, *Personal Computing* asked its readers to pick the most influential people in computing from a list that included Bill Gates, Steve Jobs, Steve Wozniak, Adam Osborne, and the historical Charles Babbage. Only billionaire Bill made everyone's list.

There was a lot of money being made, and that meant lawsuits. Like much of American society, the computer industry was becoming increasingly litigious. In 1988, Apple sued Microsoft over Windows 2.01, and extended the suit in 1991 after Microsoft released Windows 3.0. Meanwhile

Xerox sued Apple, claiming that the graphical user interface was really its invention, which Apple had misappropriated. Xerox lost, and so, eventually, did Apple in the Microsoft suit, although it was able to pressure Digital Research into changing its GEM graphical user interface cosmetically, making it look less Mac-like.

GUIs weren't the only contentious issue. A number of lawsuits over the "look and feel" of spreadsheets were bitterly fought at great expense to all and questionable benefit to anyone. The inventors of VisiCalc fought it out in court with their distributor, Personal Software. Lotus sued Adam Osborne's software company, Paperback Software, as well as Silicon Graphics, Mosaic, and Borland, over the order of commands in a menu. Lotus prevailed over all but Borland, where the facts of the case were the most complex, but the Borland suit dragged on until after Borland had sold the program in question.

Borland was also involved in two noisy lawsuits over personnel. Microsoft sued Borland when one of its key employees, Rob Dickerson, went to Borland with a lot of Microsoft secrets in his head. Borland didn't sue in return when its key employee, Brad Silverberg, defected to Microsoft, but it did when Gene Wang left for Symantec. After Wang left, Borland executives found email in its system between Wang and Symantec CEO Gordon Eubanks—email that they claimed contained company secrets. Borland brought criminal charges, threatening not just financial pain but also jail time for Wang and Eubanks. The charges were eventually dismissed.

Through essentially the whole of the 1980s, Intel and semiconductor competitor Advanced Micro Devices (AMD) were in litigation over what technology Intel had licensed to AMD.

Meanwhile, in the lucrative video-game industry, everyone seemed to be suing everyone else. Macronix, Atari, and Samsung sued Nintendo; Nintendo sued Samsung; Atari sued Sega; and Sega sued Accolade.

By 1989 the pattern was clear, and it persisted into the next decade—personal computers were becoming commodities, increasingly powerful but essentially identical. They became obsolete every three years by advances in semiconductor technology and software, where innovation proceeded unchecked. Personal computers were becoming accepted and spreading throughout society; the personal-computer industry had become big business, with ceaseless litigation and the focused attention of Wall Street; and this technology, pioneered in garages and on kitchen tables, was driving the strongest, most sustained economic growth in memory.

During the 1990s, Moore's law and its corollaries continued to describe the growth of the industry. IBM had become just one of the players in what originally had been called the "IBM-compatible market," then was called the "clone market," and later was called just the "PC market."

Within two decades the personal-computer market launched in 1975 with the *Popular Electronics* cover story on the Altair surpassed the combined market for mainframes and minicomputers. As if to underscore this, in the late 1990s Compaq bought Digital Equipment Corporation, the company that had created the minicomputer market. Those still working on mainframe computers demanded Lotus 1-2-3 and other personal-computer software for these big machines. Personal computers had ceased to be a niche in the computer industry. They had become the mainstream.

Sun

As the center of the computing universe shifted toward PCs, other computer-industry sectors suffered. In particular, it was becoming a tough haul for the traditional minicomputer companies. *Forbes* magazine proclaimed, “1989 may be remembered as the beginning of the end of the minicomputer. [M]inicomputer makers Wang Laboratories, Data General, and Prime Computer incurred staggering losses.”

However, minicomputers were being squeezed out not by mainstream PCs but rather by their close cousins, workstations. These workstations were, in effect, the new top of the line in personal computers, equipped with one or more powerful, possibly custom-designed processors, running the Unix minicomputer operating system developed at AT&T’s Bell Labs, and targeted at scientists and engineers, software and chip designers, graphic artists, movie makers, and others needing high performance. Although they sold in much smaller quantities than ordinary personal computers, they sold at significantly higher prices.

The Apollo, which used a Motorola 68000 chip, had been the first such workstation in the early 1980s, but by 1989 the most successful of the workstation manufacturers was Sun Microsystems, one of whose founders, Bill Joy, had been much involved in developing and popularizing the Unix operating system.

Figure 91. Sun Microsystems founders ***From left to right: Vinod Khosla, Bill Joy, Andreas "Andy" Bechtolsheim, and Scott McNealy*** **(Courtesy of Sun Microsystems)**

Riding the general PC-industry wave, Sun had gone public in 1986, exceeded $1 billion in sales in six years, and became a Fortune 500 company by 1992. In the process, it displaced minicomputers and mainframes, and made *workstation* an everyday term in the business world.

But Sun now cast its eye on the general PC market, at the same time that Microsoft was taking steps to threaten Sun on its own turf.

Gates's firm had a new operating system called Windows NT, which was intended to give business PCs all the power of workstations. McNealy decided to wage not only a technical war but also a public-relations war. In public talks and interviews, he ridiculed Microsoft and its products. Along with Oracle CEO Larry Ellison, he tried to promote a new kind of device, called a network computer, which would get its information and instructions from servers on the Internet. This device did not immediately catch on.

But Sun had a hidden advantage in the consumer market—its early, foursquare advocacy of networks. People were repeating its slogan, "the network is the computer," and it seemed prescient as the Internet emerged.

Sun was a magnet for talented programmers who enjoyed the smart, free-spirited atmosphere of the Silicon Valley firm. In 1991, McNealy gave one of its star programmers, James Gosling, carte blanche to create a new programming language. Gosling realized that almost all home-electronics products were now computerized. But a different remote device controlled each, and few worked in the same way. The user grappled with a handful of remotes. Gosling sought to reduce it to one. Patrick Naughton and Mike Sheridan joined him, and they soon designed an innovative handheld device that let people control electronics products by touching a screen instead of pressing a keyboard or buttons.

The project, code-named Green, continued to evolve as the Internet and World Wide Web began their spectacular bloom. But more than the features evolved; the whole purpose of the product changed. The team focused on allowing programs in the new language to run on many platforms with diverse central processors. They devised a technical Esperanto, universally and instantly understood by many types of hardware. With the Web, this capacity became a bonanza.

Although the project took several years to reach market, Sun used the cross-platform programming concepts from Green, which became known as Java, to outmaneuver its competition. Sun promoted Java as “a new way of computing, based on the power of networks.” Many programmers began to use Java to create the early, innovative, interactive programs that became part of the appeal of websites, such as animated characters and interactive puzzles.

Java was the first major programming language to have been written with the Web in mind. It had built-in security features that would prove crucial for protecting computers from invasion now that this electronic doorway—the web connection—had opened them up to the world. It could be used to write programs that didn’t require the programmer to know what operating system the user was running, which was typically the case for applications running over the Web.

Java surprised the industry, and especially Microsoft. The software titan was slow to grasp the importance of the Internet, and opened the door for others to get ahead. But once in the fray, Gates made the Internet a top priority.

At the same time, Gates was initially skeptical about Java. But as the language caught on, he licensed it from Sun, purchased a company called Dimension × that possessed Java expertise, and assigned hundreds of programmers to develop Java products. Microsoft tried to slip around its licensing agreement by adding to its version of Java capabilities that would work only on Microsoft operating systems. Sun brought suit. Gates saw Sun and its new language as a serious threat. Why, if Java was a programming language, and not an operating system? Because the ability to write platform-independent programs significantly advanced the possibility for a browser to supplant the operating system. It didn’t matter if you had a Sun workstation, a PC, a Macintosh, or what have you; you could run a Java program through your browser.

And Sun was serious about pursuing its “the network is the computer” mantra to challenge Microsoft’s hegemony. In 1998, Sun agreed to work with Oracle on a line of network server computers that would use Sun’s Solaris operating system and Oracle’s database so that desktop-computer users could scuttle Windows. Moreover, Sun began to sell an extension to Java, called Jini, which let people connect a variety of home-electronics devices over a network. Bill Joy called Jini “the first software architecture designed for the age of the network.” Although Jini didn’t take the world by storm, something like Sun’s notion of network computing and remotely connected devices would re-emerge in the post-PC era in cloud computing and mobile devices.

The NeXT Thing

As Apple Computer struggled to survive in a Microsoft Windows—dominated market, Steve Jobs was learning to live without Apple. When he left, he gathered together some key Apple employees and started a new company.

That company was NeXT Inc., and its purpose was to produce a new computer with the most technically sophisticated, intuitive user interface based on windows, icons, and menus, equipped with a mouse, running on the Motorola 68000 family of processors. In other words, its purpose was to show them all—to show Apple and the world how it should be done. To show everyone that Steve was right.

NeXT and Steve Jobs were quiet for three years while the NeXT machine was being developed. Then, at a gala event at the beautiful Davies Symphony Hall in San Francisco, Steve took the stage, dressed all in black, and demonstrated what his team had been working on all those years. It was a striking, elegant black cube, 12 inches on a side. It featured state-of-the art hardware and a user interface that was, in some ways, more Mac-like than the Mac. It came packaged with all the necessary software and the complete works of Shakespeare on disc, and it sold for less than the top-of-the-line Mac. It played music for the audience and talked to them. It was a dazzling performance, by the machine and by the man.

Technologically, the NeXT system did show the world. While the Mac had done an excellent job of implementing the graphical user interface that Steve had seen at PARC, the NeXT machine implemented much deeper PARC technologies. Its operating system, built on the Mach Unix kernel from Carnegie-Mellon, made it possible for NeXT engineers to create an extremely powerful development environment called NeXTSTEP for corporate custom software development. NeXTSTEP was regarded by many as the best development environment that had ever been seen on a computer.

Jobs had put a lot of his own money into NeXT, and he got others to invest, too. Canon made a significant investment, as did computer executive and occasional presidential candidate Ross Perot. In April 1989, *Inc* magazine selected Steve Jobs as its “entrepreneur of the decade” for his achievements in bringing the Apple II and Macintosh computers to market, and for the promise of NeXT.

NeXT targeted higher education as its first market, because Jobs realized that the machines and software that graduate students use are the machines that they will ask the boss to buy them when they leave school. NeXT made some tentative inroads into this target market. It made sense to academics to buy machines for which graduate students, academia's free labor force, could write the software. NeXTSTEP meant that you could buy the machine and not have to buy a ton of application software. Good for academic budgets, but not so good for building a strong base of third-party software suppliers.

The company had some success in this small market, and a few significant wins. But after its proverbial “15 minutes' worth,” the black box was ultimately a commercial failure. In 1993, NeXT finally acknowledged the obvious and killed off its hardware line, transforming itself into a software company. It immediately ported NeXTSTEP to other hardware, starting with Intel's. By this time, all five of the Apple employees that Jobs had brought along to NeXT had left. Ross Perot resigned from the board, saying it was the biggest mistake he'd ever made.

The reception given to the NeXT software was initially heartening. Even conservative chief information officers who perpetually worry about installed bases and vendor financial statements were announcing their intention to buy NeXTSTEP. It got top ratings from reviewers, and custom developers were citing spectacular reductions in development time from using NeXTSTEP, which ran “like a Swiss watch,” according to one software reviewer.

But for all the praise, NeXTSTEP did not take the world by storm. Not having to produce the hardware its software ran on made NeXT's balance sheet look less depressing, but NeXTSTEP was really no more of a success than the NeXT hardware. While custom development may have been made easy, commercial applications of the “killer app” kind, which could independently make a company's fortune, didn't materialize. NeXT struggled along, continuing to improve the operating system and serve its small, loyal customer base well, but it never broke through to a market share that could sustain the company in the long run without Jobs's deep pockets.

The Birth of the Web

What one user of a NeXT computer did on his machine, though, changed the world.

Electronics enthusiasts in Albuquerque and Silicon Valley didn't invent the World Wide Web, but its origin owes much to that same spirit of sharing information that fueled the first decade of the personal-computer revolution. In fact, it could be argued that the Web is the realization of that spirit in software.

The genesis of the Web goes back to the earliest days of computing, to a visionary essay by Franklin Delano Roosevelt's science advisor, Vannevar Bush, in 1945. Bush's essay, which envisioned information-processing technology as an extension of human intellect, inspired two of the most influential thinkers in computing, Ted Nelson and Douglas Engelbart, who each labored in his own way to articulate Bush's sketchy vision of an interconnected world of knowledge. Key to both Engelbart's and Nelson's visions was the idea of a link; both saw a need to connect a word here with a document there in a way that allowed the reader to follow the link naturally and effortlessly. Nelson gave the capability its name: hypertext.

Hypertext was merely an interesting theoretical concept, glimpsed by Bush and conceptualized by Nelson and Engelbart, without a global, universal network on which to implement it. Such a network was not developed until the 1970s, at the Defense Advanced Research Projects Agency (DARPA) and at several universities. The DARPA network (DARPAnet) didn't just link individual computers; it linked whole networks together. As the DARPAnet expanded, it came to be called the Internet, a vast global network of networks of computers. The Internet finally brought hypertext to life. And by the DARPA programmers having developed a method for passing data around the Internet, and the personal-computer revolution having put the means of accessing the Internet in the hands of ordinary people, the pieces of the puzzle were all on the table.

Tim Berners-Lee, a researcher at CERN, a high-energy research laboratory on the French-Swiss border, created the World Wide Web in 1989 by writing the first web server, a program for putting hypertext information online, and by writing the first web browser, a program for accessing that information. The information was displayed in manageable chunks called pages.

It was a fairly stunning achievement, and it impressed the relatively small circle of academics who could use it. That circle would soon expand, thanks to two young men at the University of Illinois. But the NeXT machine on which Berners-Lee had created the Web was no more.

Nevertheless, the NeXT saga was not over.

Cyberspace

> *There was no particular reason why it took two guys at the University of Illinois to do it, any more than it should have taken two guys in Sunnyvale to do the Apple I. It's just that sometimes the establishment needs a kick in the pants.*
>
> –Marc Andreessen, cofounder of Netscape

In 1994, Microsoft was riding high and Bill Gates was a billionaire. But that didn't mean he wasn't still driven by fear.

No matter that he was the richest person in America, viewed by most people as the symbol, and possibly the inventor, of the personal-computer revolution. Nor did it matter that he was the founder and leader of the company whose products dominated most of the industry. Gates truly believed that he and Microsoft held their position only by virtue of constant vigilance, aggressive competition, and tirelessly applied intelligence. He was convinced that some bright young hacker somewhere could knock out a few thousand lines of clever code in a couple of months that would change the rules of the game, marginalizing Microsoft overnight.

Gates knew about these hackers because he had been one. He had known the thrill of proving your mettle by outsmarting a giant corporation. Now he was on the other side, and somewhere out there he could picture the bright young hacker who would one day succeed in outsmarting him.

Microsoft's Muscle

Microsoft continued to push into new areas. When the OS/2 deal fell apart, an operating-system project that had been quietly in development since 1988 was pulled to center stage, given serious funding, and dubbed "Windows NT." NT would be sold into "corporate mission-critical environments"—chiefly the server market, which was then dominated by the venerable Unix operating system.

Server computers provided resources to—or "served"—computers connected to them on a network. File servers were like libraries, holding shared files; application servers held application programs used by many machines; mail servers managed electronic mail for offices. Servers were increasingly being used in business and academia, tended to be more expensive than individual users' computers, and, because many users depended on them, were typically maintained by technically sophisticated personnel. And they typically ran the Unix operating system.

Unix came on the scene in 1969. Invented by two Bell Labs programmers, Ken Thompson and Dennis Ritchie, it was the first easily portable operating system, meaning that it could be run on many different types of computers without too many modifications. As Unix was stable, powerful, and widely distributed, it quickly became the operating system of choice in academia, with two results: lots of people wrote utility programs for it, which they distributed free of charge, and virtually all graduating computer scientists knew Unix inside and out. On the job, they typically had control of a server, and on it they preferred to run the familiar Unix, with its large, loose collection of utility programs.

Microsoft hoped to supplant Unix and take over the server market.

In addition to its NT project, Microsoft continued to exert a powerful influence over its MS-DOS and Windows OEMs. The control extended to dictating what icons representing third-party programs could appear on the user's desktop when the computer first started up.

In 1994, Compaq, by then the leading personal-computer maker, decided to install a program on all its machines that would run "in front of" Microsoft Windows. This small "shell" program would display icons that let the user start selected programs. Although this shell program was very simple and wouldn't supplant Windows, it would have undermined the gatekeeper role that Windows was coming to play, and thus undermined Windows's control of the user's desktop.

"We've got to stop this," Gates said.

And he did. What was said, what was intimated, may never be known, but Compaq removed the program.

Compaq also backed down two years later, when Microsoft threatened to stop selling it Windows unless Compaq included Microsoft's Internet browser on its machines.

Microsoft had become a powerhouse and Bill Gates was not reluctant to use that power.

The Internet Threat

In the 1980s, online systems had become a big thing. These were an outgrowth of the early computer bulletin-board systems (which offer a public area for posting messages to other users, much like a typical "corkboard" bulletin board found in an office), or BBSs. BBSs provided content, such as news services, discussion groups, stock quotes, and electronic mail, to their subscribers. CompuServe, Prodigy, America Online, and others maintained their own proprietary systems, which users could access with a local phone call.

When the Internet blossomed in popularity with the invention of the World Wide Web in 1994, the online systems began having trouble justifying their existence independent of the Internet, and all began offering Internet access. The sudden popularity of the Internet and the World Wide Web began changing the whole nature of computing, shifting the emphasis away from the operating system and the individual desktop to the network.

Every company struggled to forge an Internet strategy. New companies emerged to take advantage of this shift in the market. Amazon and others exploited radical new forms of electronic commerce. Cisco Systems provided the networking infrastructure for this new market.

Microsoft responded promptly, trying several approaches to carve out its profits from the phenomenon, and just as promptly cutting these attempts short when the market moved in a different direction. The company hadn't settled on an Internet strategy, but it responded quickly to the rapidly changing landscape, more easily than most large companies could.

Perhaps it was because of the structure Gates installed when Hallman left.

In 1992, Gates set up an organizational arrangement that he could live with: the Office of the President. It was also known as BOOP—Bill and the Office of the President. It consisted of Bill and three close friends: Steve Ballmer, Mike Maples, and Frank Gaudette. By this time these friends had been influenced by Gates, and had arguably influenced him to the extent that he could trust them to make decisions he'd approve of.

He had succeeded in spreading himself thinner.

For so large a company as Microsoft to be able to change directions so quickly was impressive. The biggest fish in the pond and maneuverable, too: Microsoft in the mid-1990s dominated the personal-computer industry and seemed utterly invincible.

Until that bright young hacker came along.

Creating Cyberspace

One of the places where Tim Berners-Lee's achievement in creating the Web was fully appreciated was at the National Center for Supercomputing Applications (NCSA) at the University of Illinois's Urbana-Champaign campus. NCSA had a large budget, a lot of hot technology, and a large staff with "frankly, not enough to do," according to one of the young programmers privileged to work there.

Even at $6.85 an hour, Marc Andreessen saw it as a privilege to work at NCSA. He was a sharp undergraduate programmer who loved being in an environment where he could talk about Unix code. Andreessen looked at what Berners-Lee had done and saw the potential of the Web, but he also saw that potential being restricted to a few academics, accessed on expensive hardware through archaic, arcane software. The opportunity to open up the Web to everyone looked to him like "a giant hole in the middle of the world."

Riding in friend Eric Bina's car one night late in 1992, Andreessen put the challenge to Bina: "Let's go for it," he said. Let's fill that hole.

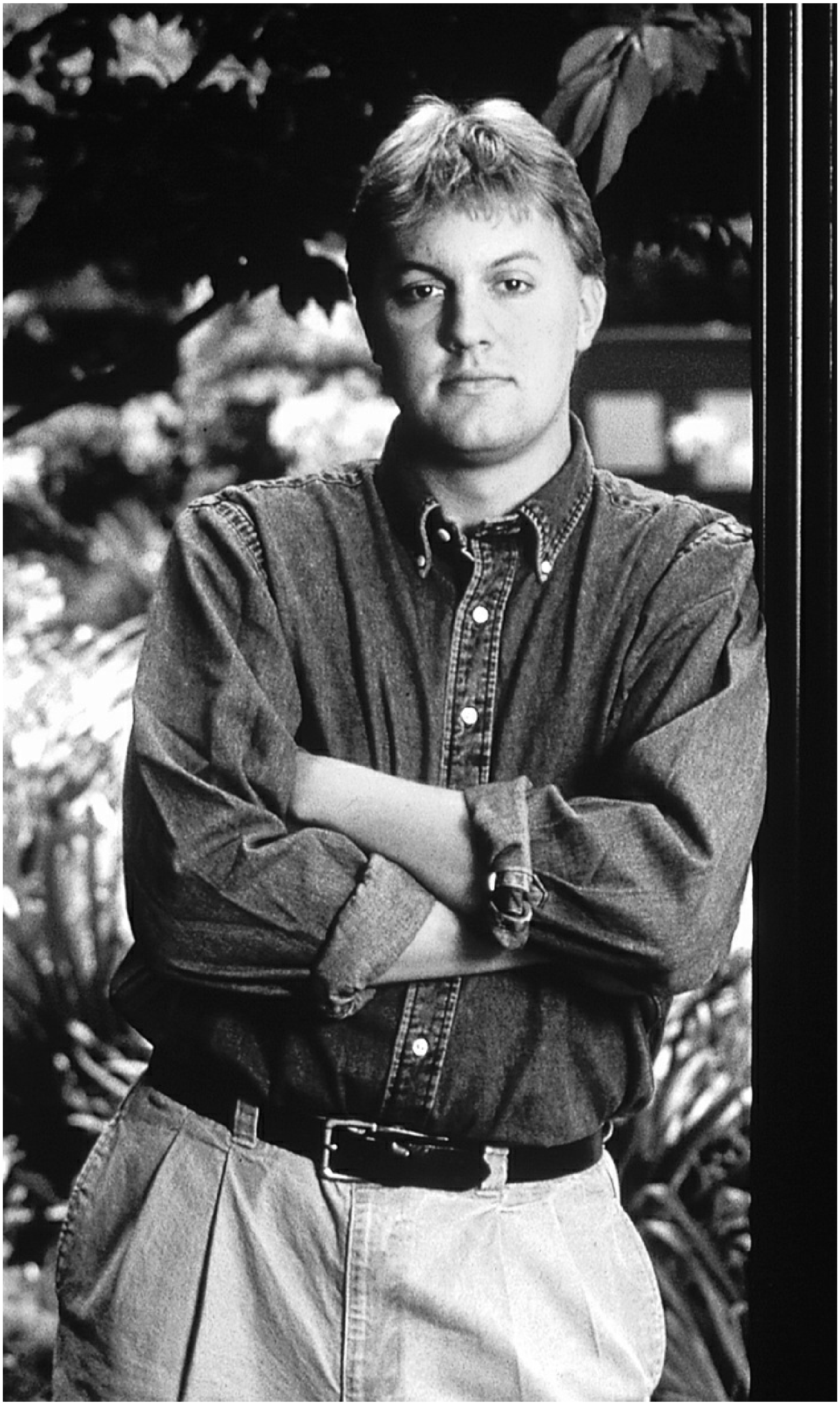

Figure 92. Marc Andreessen ***After cocreating the first visual web browser while a student at the University of Illinois, Andreessen cofounded Netscape.***
(Courtesy of Netscape Communications Corp.)

They coded like mad. Between January and March of 1993, they wrote a 9,000-line program called Mosaic. It was a web browser, but not like Berners-Lee's. Mosaic was a browser for the GUI generation, a web browser for everyone. It displayed graphics, it let you use a mouse and click on buttons to do things—no, to go places. Mosaic completed the process of turning abstract connection into place; using Mosaic, one had a compelling sense of going from one location to another in some sort of space. Some called it cyberspace.

This was exactly what Bill Gates had feared: some bright young hacker—well, two—had knocked out a few thousand lines of clever code in a couple of months that would change the rules of the game forever, putting the biggest software company in the world on the defensive, and threatening everything Gates had built.

Andreessen and Bina released Mosaic on the Internet. They signed on other NCSA kids to port Mosaic from the Unix operating system to other platforms, and released those on the Internet, too. Millions of people downloaded it. No piece of software had ever got into so many hands so quickly.

This thing let you travel the planet, virtually. It was amazing. It let you read about Shakespeare on a computer in a New York library, click once to zip across the ocean to England to look at a picture of the Globe Theater, click again to return to the stacks to read Hamlet—except that they're different stacks. This copy of Hamlet happens to be on a website in Uzbekistan. Doesn't matter; terrestrial geography isn't relevant in cyberspace. You can browse a world of information without leaving your chair. None of this could happen until people had created the websites, but this took place in tandem with the spread of Mosaic. Everyone who tried it "got it"; Mosaic was a hit and Andreessen was a hero.

In December 1993, Andreessen graduated from college, wondering what to do for an encore. Gravitating to Silicon Valley, he met Jim Clark, founder of Silicon Graphics. Clark was impressed by Mosaic and by Andreessen's grasp of the potential of the Web. By April 1994, the two had founded a company, first called Electric Media, then Mosaic Communications, and finally Netscape Communications. They were going to produce software in support of this new thing, this World Wide Web.

The Browser Boom

They were not alone. By midyear there were dozens of web browsers: some free, some commercial; some available for Windows and the Macintosh and Unix, some platform-specific;

some stripped-down, some festooned with bells and whistles. In addition to Mosaic, there were MacWeb, WinWeb, Internetworks, SlipKnot, Cello, NetCruiser, Lynx, Air Mosaic, GWHIS, WinTapestry, WebExplorer, and others.

Personal web pages became a fad. So did new uses of the Web, such as ordering pizza. Webcams were another fad—digital cameras feeding a continuous stream of pictures to a website. You could visit a website and watch coffee perk at MIT, check the commute traffic on Highway 17 coming up from the Santa Cruz beaches into Silicon Valley, or monitor the waves along the California coast. Steve Wozniak set up a Wozcam so friends could watch him work. The Web was a wave and Clark and Andreessen were riding it.

They hired Eric Bina and other NCSA kids from Mosaic, wrote a new browser from scratch, and made it as bulletproof and nifty as they knew how. By October 1994, they had a beta version out on the Internet. By December, they were shipping the release version of Netscape Navigator, along with other web software products. By the end of 1996, 45 million copies of Navigator were in people's hands. The company was growing at a delirious rate, and Clark brought in industry veteran Jim Barksdale, who was widely respected for his management of McCaw Cellular Communications, as president.

Netscape was perceived in the industry, and on Wall Street, as a hot property. One admirer was Steve Case of America Online (AOL), the premier online service. He offered to put up money for Netscape's first round of financing, but Clark turned him down, concerned that AOL's involvement might put off potential customers who considered AOL to be competition. On August 9, 1995, Netscape filed its IPO of five million shares at $28 each. Its stock doubled by the end of the day, and Netscape was suddenly worth billions.

That year, Microsoft responded.

In May 1995, Gates had already described the Internet to his staff as "the most important single development to come along since the IBM PC in 1981." In December, he announced publicly that the Internet would be pervasive in all that Microsoft did. Netscape's stock dropped 17 percent and never recovered. Microsoft was going to enter the browser market. It did, rapidly and impressively, licensing some browser technology and developing its own browser, Internet Explorer, to compete with Netscape's browser. The company launched by the young coder and the industry veteran was, in Gates's opinion, a threat to Microsoft's existence, and it needed to be snuffed out.

Gates was not alone in seeing the Internet as a threat to Microsoft's dominance in the PC market. Bob Metcalfe, the networking guru who had developed the Ethernet protocol, wrote a weekly column for the industry magazine *InfoWorld*. In February 1995, he predicted that the browser would in effect become the dominant operating system for the next era. The dominant operating system for the current era was, of course, Microsoft's Windows. Metcalfe was predicting that

Windows's dominance was on the verge of ending.

How, exactly, could a browser replace an operating system? Partly by providing the same capabilities; Netscape Navigator could launch application programs, display directories of files, and do most of the things an operating system did. Partly by making the choice of operating system invisible and irrelevant—Navigator ran on Macs and PCs and workstations and looked and acted the same on all of them—and partly by moving the center of the computing universe. Sun Microsystems had a slogan, "the network is the computer." With Navigator, it didn't matter if an application program or a data file was on your hard disk, on a server in the next office, or on a computer in another country. It didn't matter what computer—Mac, PC, or Amiga—it was on; it just mattered whether you could get to it with your browser.

If the network was the computer, the browser was the operating system, and single-computer-based operating systems were irrelevant. Gates wasn't going to let Windows become irrelevant.

Over the next few years, Microsoft, Netscape, and other companies whose interests intersected at the Internet crossroads performed a complex dance. Mostly it was Microsoft against everybody else, but there were complications.

Browser Wars

One of the most significant of those other companies was Sun Microsystems.

AOL was continuing a courtship with Netscape and a battle with Microsoft.

When Jim Clark rebuffed AOL's offer to buy into Netscape, AOL purchased a browser from another source—grabbing the other browser just before Microsoft could—but Steve Case was still interested in both Netscape and its browser. The browser was regarded as the best available, and the company was a hot property. But there was another reason for his interest in Netscape: most AOL executives viewed Netscape's team as people they could relate to. At AOL, Netscape was viewed as a natural ally in the war against Microsoft.

Microsoft had been steadily moving into AOL's territory, online systems, for years. Although AOL was enabling people to get on the Internet with its web browser, its business was primarily as an online service. Since the 1980s, online services provided Internet connections, hosted electronic discussion groups, and provided email services. All these were also available on the Internet, but online services were a lot easier to work with—and familiar. Microsoft had entered this market with its Microsoft Network, MSN. AOL was still the unchallenged leader of the online companies, but it was worried.

The future of online companies was becoming cloudy as browsers made the Internet easier to navigate. That was why AOL needed a browser and why it was interested in Netscape, and it was why Microsoft was willing to undercut its own MSN in order to beat Netscape.

In 1995, Microsoft committed itself publicly to the Internet. What that meant was soon evident. After licensing browser technology from a small company and then developing its own browser, Internet Explorer, Microsoft approached AOL. Getting AOL's browser replaced by Microsoft's would be a huge blow to the stellar public image of Netscape. By this time, AOL had millions of subscribers; if every one of them began using Microsoft's browser, Netscape would be well on its way to second place behind Microsoft in the browser wars.

To get its browser on AOL subscribers' screens, Microsoft was willing to make a very sweet deal. In exchange for AOL's licensing Internet Explorer, Microsoft would put an icon for AOL on the Windows desktop. This amounted to free advertising and an endorsement from Microsoft on every Windows user's computer screen each time the user started up the machine. This was a major sellout of Microsoft's own online service, MSN, but that didn't matter. What mattered to Microsoft was crushing Netscape. And the price made the sweet deal even harder for AOL to turn down—AOL could have the browser for free.

Incredibly, AOL still considered turning down the offer. Microsoft was the enemy. In the end, AOL cut deals with both Netscape and Microsoft, but Microsoft's browser was promoted as the preferred browser. Netscape got the short end of the stick.

During the negotiations with Netscape, Case emphasized the importance of Netscape's website. This was an immensely popular area on the Web, and Netscape could easily sell advertising on it. Millions of people were visiting Netscape's site on a daily basis. Case pointed out that it was analogous to the presence that the online services were able to have with their subscribers. Microsoft understood this and was already evolving its MSN into its own website. Case didn't think Netscape understood what a treasure it had.

At the same time, AOL was negotiating with Sun regarding Java, and Netscape was working with Sun on a simple language, unrelated to Java but called JavaScript. Written by Brendan Eich, JavaScript would let people add interactive features to web pages without the need to learn a full programming language like Java. All three companies saw Microsoft as the enemy and had reason to work together.

Now everyone was threatening Microsoft. At least that was the view from Microsoft's headquarters. Sun had ideas about a Java-based operating system. Netscape was developing the browser as an alternative to an operating system, in a sense. And Oracle jumped into the fray by pushing stripped-down machines that wouldn't run Windows.

In October 1996, Oracle and Netscape announced that they would be working together on an NC, a network computer. This announcement showed how fear of Microsoft could drive companies together; two months earlier, Marc Andreessen had ridiculed the NC and Larry Ellison had derided Netscape's technology as "very, very thin."

The anti-Microsoft contingent got a heavy hitter in the late 1990s when IBM made a big commitment to Java. But Microsoft continued to make inroads into the Internet and online spaces. By the end of 1997 Internet Explorer had passed Netscape's browser in popularity, and by the end of 1998 MSN had passed Netscape's Netcenter site in the number of visitors and had become a major portal, a place that millions of people used as a sort of home base from which to conduct their explorations of the Web. Netscape was rapidly losing ground. It wasn't clear what its future would be.

Open Source

Early in 1998, fighting for survival in the market Andreessen had launched just five years earlier, Netscape did something that made jaws drop in corporate boardrooms and cheers rise from programmers. It freed the source code for its browser.

The source code for its products is the equivalent of a software company's crown jewels, to be protected against prying eyes and thieving hands. Legal wars had been fought over such intellectual property, so bitterly that in some cases the warring companies were damaged beyond recovery. Borland was deeply wounded by the cost of such litigation; Digital Research had lost its chance to recover from the IBM disaster when Apple threatened to sue over GEM; and Software Arts was driven out of business by protracted litigation with Personal Software.

But Netscape was proposing to put its source code on the Internet for all to see. And not just see. Programmers would be free to use the code to develop new products. But what they developed would also have to remain open to other developers. This meant that Netscape could use enhancements written by other programmers in its browser. The company was inviting the entire software community to help develop its software. The project and its website were called Mozilla, the original code name for Netscape's browser.

Andreessen and Clark knew that there were risks in doing this, but they also knew the benefits of open systems. The personal-computer industry had been built on the free sharing of information. Where progress was rapid, it made sense to share, they believed. In fast-growing areas like the Internet, it didn't make sense to protect technology that was growing rapidly obsolete anyway. It was a bold plan.

But not without precedent. Most of the software underlying the Internet had been developed in this open way. In particular, the Unix operating system had advanced in this open manner.

In 1991 a young programmer in Finland named Linus Torvalds began work on a new variant of the Unix kernel (the part of an operating system that handles basic operations such as memory, files, and peripheral interfaces). Torvalds called his operating system Linux, and he made the source code public, inviting the programming community to contribute to its enhancement.

Linux was itself built on a tradition of open development. Torvalds even toyed with naming it Freax, for Free Unix. Torvalds did all of his development work using another freely available

Unix variant called MINIX, written by Andrew Tanenbaum in the Netherlands. At the same time, Richard Stallman and Bill Joy had variants of Unix (called GNU for “GNU’s Not Unix,” and BSD for "Berkeley Software Distribution," respectively) in advanced states of development. All were in some fashion or other open software. Linux was soon covered by the GNU General Public License, written originally by Stallman, which guarantees users the right to use, study, share, and modify the licensed software. The name Linux refers most properly to the kernel, and the operating system as a whole is sometimes called GNU/Linux.

The response to Linux was electrifying: in six years, Linux went from a hobby project at the University of Helsinki to become the dominant version of Unix. It was ported to Intel PCs and the Mac and spread like a virus through the software-development community. Before long, competition from Linux was getting to Microsoft. In an internal document revealed by Eric S. Raymond, Microsoft laid out the threats that Linux and free software posed to Microsoft and the strategies for countering them. The popularity of Linux in the server market was forcing Microsoft to rethink NT, the high-end operating system that it had hoped would supplant Unix in that market. With apparently thousands of talented programmers contributing to the development of Linux, it was questionable that even Microsoft could keep up.

Web professionals, in particular, understood and appreciated the open source model. Apache, the leading web-server program, was a free, open source product, as were many other must-have Internet tools. The Internet and the Web had emerged in academic environments where this was the natural model. It may not have been the most obvious commercial model, but that was deceiving. Linux companies were making money, attracting investors. And open is not the same as free.

Meanwhile, on May 18, 1998, the US Justice Department and the attorneys general of some 20 states filed an antitrust suit against Microsoft that would drag on interminably, alleging, among other things, that Microsoft abused its monopoly position in operating systems to thwart competition, particularly in the case of Netscape.

Netscape was thwarted, all right. The company was thrashing about, trying to decide whether its future, if it had one, was in browsers, in other web software, in services, or in promoting its website as a source of advertising revenue. The fate of Mozilla was uncertain.

Then, on November 24, 1998, AOL announced that it had agreed to buy Netscape Communications in a stock swap valued at some $4.2 billion. Case finally got the company he thought would complement AOL. Sun Microsystems figured in the deal, too, with Sun promising to market the Netscape software that AOL didn’t need in return for a cut of its earnings on the products and some Sun-developed technology. Netscape’s assets were carved up and served to the parties most likely to be capable of exploiting them. Microsoft pointed to the deal as evidence that the playing field had been leveled and that the lawsuit should be dropped. The court didn’t see it that way.

At the same time, the Mozilla project, by enlisting the help of hundreds of programmers outside the company, finished a new version of the browser. Although AOL announced continued support for Mozilla, it hardly mattered. Now that it was an open source product, the browser had, as one journalist put it, “gone directly from the Internet’s endangered species list to virtual immortality.” No longer tied to one company, it would be around as long as programmers saw value in maintaining it. But immortal or not, it had been marginalized by Microsoft.

Apple Without Jobs

> *Without Jobs, Apple is just another Silicon Valley company, and without Apple, Jobs is just another Silicon Valley millionaire.*
>
> –Nick Arnett, *Accidental Millionaire*

Meanwhile, Steve Jobs found a use for some of the millions that he hadn’t put into NeXT, and at his former company, the engineers were getting restless.

Sculley Moves On

When Scully squeezed out Del Yocam and bypassed Jean-Louis Gassée, the Apple engineers were outraged. It wasn’t just that this former sugar-water salesman Sculley had the gall to name himself CTO of Apple, but Gassée, whom they would have picked as CEO had they been asked, was being shown the door.

Apple employees exhibited a lot of so-called attitude about their status within the industry. They were paid extremely well—at least the engineers were—and they felt as if they were artists. They generally believed that Apple made forward progress only by innovative leaps. This meant that everyone wanted to work on the hot projects; nobody wanted to be in an equivalent of the Apple II division when an equivalent of the Mac was in the works.

Figure 93. John Sculley ***Hand-picked by Jobs to be CEO, Sculley would eventually get Jobs stripped of all management power at Apple.*** **(Courtesy of Rick Smolan)**

One promising project for Apple during this era was something called Pink. Pink was the internal Apple code name for the next-generation replacement operating system that could run on different machines, including IBM compatibles. The significant talent was placed on the Jaguar project, a new machine using all-new hardware technology, and Pink, a next-generation operating system.

On April 12, 1991, Sculley demonstrated Pink to IBM. The IBM executives were impressed by what looked like the Mac operating system running on IBM hardware. By October, Apple and IBM had agreed to work together on the operating system, now to be called Taligent, and on a new microprocessor for a new generation of computers to be developed by each company.

This wasn't a merger, or an acquisition, or a licensing deal—it was a collaboration with another company that had the potential to grab back a bigger chunk of the market for Apple. It was also evidence of the changing power structure of the industry: Apple could afford to work with its old nemesis IBM because IBM wasn't the competition any more. Intel, which made the CPU for IBM and compatible computers, and Microsoft were the competition.

The deal with IBM was a bold move, and it may have been Sculley's last significant contribution to the company. Apple's longest-tenured CEO was getting burned out. He had already handed the presidency to Spindler, and now he was becoming distracted, ready to move on to something else.

That something else might have been a very different kind of job from running a personal-computer company. Sculley was spending a lot of time with his new friends, Arkansas governor Bill Clinton and Hillary Rodham Clinton. It was 1992, and the Arkansas governor was running hard for president. There was talk of a cabinet position for Sculley, even talk that he was on Clinton's short list for the vice presidency. (He didn't get it, of course, but he did get to sit next to Hillary at the inauguration.) Little wonder he seemed a bit disconnected at marketing planning meetings.

He could always move to IBM. Not only were they recruiting him, but it looked as though he was going to be offered the top spot. IBM might not be as dynamic as Apple, but it was a lot bigger, and it would mean a move back to the East Coast, which appealed to Sculley.

That year he told Apple's board that he wanted to leave. April 1993 would be his tenth anniversary, and that was long enough, he said. When they asked his advice for the company, he was blunt: sell Apple to a larger company such as Kodak or AT&T. The board asked him to stay until the sale happened.

But the sale didn't happen, and Apple's earnings dropped from a peak of $4.33 per share in 1992 to $0.73 per share in 1993 as competition mounted. On June 18, 1993, John Sculley was out the door and Michael Spindler was now the CEO of Apple.

Spindler's first act as CEO was to cut 16 percent of the staff. It was necessary. Apple was running an aging operating system on a dead-end microprocessor line. The Motorola 68000 line was nearing the end of its life, and Apple was committed to move to a new processor, the PowerPC chip being codeveloped with IBM and Motorola.

Spindler presided over the PowerPC transition, which was itself an impressive technical achievement. Apple had produced some 70 models of Macs on the 68000 family, and its operating system was written for the 68000 chip. Moving to the PowerPC meant rethinking both hardware and software, basically rebuilding everything the company was doing, plus asking all third-party developers who wrote programs for Macintosh to rewrite their software, too. It was like rebuilding a car while driving it in the passing lane on the freeway.

Apple pulled it off, but not without some help. A company named Metrowerks came through at the last minute with the development software that third-party developers needed to convert their software to the PowerPC. Apple hadn't managed to get a decent development system together in time. In March 1994, Apple began selling PowerPC machines, and they were immediately successful.

The other part of the formula for getting Apple back in shape—the new operating system—was in trouble. The Taligent effort (Apple's joint venture with IBM) was failing; it was a $300 million casualty of committee design and lack of focus. Moreover, Apple was still pursuing all the visionary research and development projects that had been launched in Sculley's golden years, but only allocating two or three programmers when there had been dozens before. Those projects ate resources with little chance of ever producing results.

Merger talks took place, including discussions of joining Compaq, but they went nowhere.

The ever-contentious push to license the Mac operating system finally bore fruit in 1995. The first licensee was Power Computing, a company started by Steve Kahng, who had designed a top-selling PC clone—the Leading Edge PC—10 years before. Unfortunately, it was too late. Apple's fruit had dried up. The Mac-clone market didn't take off as it might have earlier. The Mac operating system appeared to be on its last legs. Power Computing did all right for itself, but it wasn't helping Apple's bottom line.

Christmas was a sales disaster. Fujitsu edged in on the Japanese market, formerly a reliable income source for Apple. By January 1996, it was time for more layoffs.

Apple had been aggressively pursuing a buyer since 1992; now Sun Microsystems stepped in with an offer. At two-thirds the stock valuation, it was a slap in the face, symbolic of how badly Apple's reputation had deteriorated. It was becoming conventional wisdom among even the best business analysts to doubt whether a viable business plan for Apple would emerge.

A lot had gone out of the company. Jobs was gone. Woz was technically an employee but hadn't been involved in years. Jean-Louis Gassée, passed up for promotion, had moved on and, like Jobs, had started his own computer company, Be Labs. Chris Espinosa, who had been there virtually from the beginning, riding his moped to the Apple offices at age 14 and writing the first user manual for the Apple II while in college, was in his thirties now, married, with children. He remembered an Apple no one else in the company had known, and it pained him to see it dying. He had never had another job, and wasn't eager to go looking for one. He decided just to hang on for the end game. "I might as well stick around to turn out the lights," he told himself.

The end game was about to begin, apparently. Spindler was fired on January 30, and Apple board member and reputed turnaround artist Gilbert Amelio was named CEO. Apple needed a turnaround artist, all right. The company was on life support.

Pixar

For the next chapter in Apple's life, it helps to flash back to 1975, the year that the Altair was announced. When Paul Allen was spotting that *Popular Electronics* cover in Harvard Square and rushing to tell Bill Gates that they had better do something or they would be left out, two computer-graphics experts at the New York Institute of Technology were getting together to try to do something innovative in computer animation. They were bright and creative and they worked hard, and by 1979, Edmund Catmull, Alvy Ray Smith, and the team they assembled had come up with some nifty tricks. They moved to Marin County, California, to work for George Lucas at Industrial Light & Magic, which became the premiere special-effects house and changed the way movies are made.

Seven years later, frustrated that Lucas's game plan did not match theirs, they began looking for a way out. Lucas gave it to them when he sold their division to Steve Jobs, who had recently sold his Apple stock and had a spare $10 million to invest. The resulting company was called Pixar.

Pixar was not a personal-computer company, but it was a company that would not have existed without the technology of the personal-computer revolution. It was a precursor to other businesses that would expand personal-computer technology into new areas, and is worth a look for that reason. But Pixar is also significant for the clues it gives to the growth of Steve Jobs in his years away from Apple.

Pixar ate another $50 million of Jobs's money over the next five years, as Jobs encouraged the Pixar employees to push the state of the art as far as possible. That was exactly what Catmull and his team had in mind; during these years, Pixar employees published seminal articles on computer animation, won awards, and invented most of the cutting-edge techniques that made it possible to do computer-animated feature films.

Jobs had once again placed himself among bright people working on innovative technologies. If building computers had become a boring commodity business, computer animation was a field hot with creative fire. Jobs was, of course, encouraging the crew at Pixar to do their absolute best. But that was a subtle change for Steve, and showed that he had learned something from his experience at Apple. The Pixar people were already driven to push the state of the art, so he didn't need to drive them. His role at Pixar was more that of an enabler.

Pixar was a collection of technological artists, and Steve Jobs, an artist at heart, was their rich patron. But the artists were about to start paying the rent.

Pixar discovered that its strength lay in content development more than in building devices or writing software, although it did game-changing work in both those areas. In 1988, Pixar's *Tin Toy* became the first computer-animated film to win an Academy Award. Jobs took notice. Then, in 1991, Disney signed a three-picture deal with Pixar, including a movie called *Toy Story*.

The Pixar team put everything they had into *Toy Story*. By the time the box-office receipts had been counted in 1995, *Toy Story* was a major success, Pixar was a force in the movie industry, and Jobs himself had become a billionaire. He promptly went to Hollywood and, over lunch with Disney head Michael Eisner, negotiated a new contract that was much more favorable to Pixar.

Although he never succumbed to the lures of Hollywood life, Steve Jobs was now a player in that world, the newest movie-industry billionaire, dealing with the biggest names in Hollywood. Compared to that, NeXT was small change. And Apple, his first company—well, it was on the ropes.

The Return of Steve Jobs

Turnaround artist Gilbert Amelio had been named the new CEO at Apple, as well as chair of the board; Mike Markkula accepted a demotion to vice chair.

The operating system was the biggest problem Apple had to solve. Taligent, the joint venture with IBM, had fallen apart and Copland, the in-house operating-system project, was going nowhere fast. Amelio's chief technologist, Ellen Hancock, recommended that Apple buy or license an operating system from someone else.

There were at least three options on the table: license Sun's operating system and put a Mac face on it; do the same with Microsoft's NT operating system; or purchase Jean-Louis Gassée's BeOS outright. Gassée, Apple's ex–head of engineering, had formed Be Labs when he left Apple, taking key employee Steve Sakoman with him, and Sakoman had come up with both a computer, the BeBox, and a highly regarded, multimedia-savvy (albeit not yet fully polished) operating system, BeOS.

The press was having fun guessing which way Apple would turn. BeOS looked like the best fit. Gassée was a former top manager at Apple and was popular with Apple's engineers, the Be operating system had a friendly feel that seemed very Mac-like, and the technology was state of the art. It was easy to imagine BeOS as the future of the Mac and Gassée back in charge of (at least) engineering. But Hancock told the press cryptically, "Not everyone who is talking to us is talking to you."

Meanwhile, Oracle's unpredictable founder Larry Ellison, now a member of the Silicon Valley billionaire boys' club, was stirring things up by hinting that he would buy Apple and let his good friend Steve Jobs run it. Jobs gave no credence to Ellison's hints, and no one took Ellison too seriously, but Jobs did at one point call Del Yocam, Apple's COO from the company's best days and now CEO of a restructured and renamed Borland (to Inprise), to bend Yocam's ear about their running Apple together.

But no one really took Ellison seriously. So when Apple's decision was announced hours after it was made, it caught the industry completely by surprise. Apple would acquire NeXT Inc., lock, stock, and barrel, and use its technology to build a next-generation operating system for its computers. Apparently when Hancock had said that not everyone talking to Apple was talking to the press, she was talking about Steve Jobs. And while his staff had made the initial contact with Apple, it was predictably Jobs himself who shut out Be Labs and closed the deal.

One detail of the announcement overshadowed the rest for sheer drama: Steve Jobs was coming back to Apple.

The deal made Jobs a part-time consultant, who reported to CEO Gilbert Amelio and who was charged with helping to articulate Apple's next-generation operating strategy, but with no one reporting to him, no clearly articulated responsibilities, no seat on the board, and no power.

No power? Amelio didn't know Steve Jobs.

Apple unquestionably needed saving. After four profitable quarters in fiscal 1995, it had lost money quarter after quarter, gone through major restructuring and layoffs, and was losing market share rapidly. Third-party software developers were choosing almost routinely to develop for Windows first, and then, maybe, to port their products to the Mac. Apple stock was falling and brokerage firms were recommending not to buy Apple. The press was sounding its death knell.

People weren't buying Apple's computers, either, at least not enough to maintain Apple's already tiny market share, because they didn't see any advantage in the Macintosh over Windows machines. This was partly because of the aggressive marketing of the Windows 95 release by Microsoft, which included purchasing the rights to the Rolling Stones' "Start Me Up" for $10 million, but mostly because of Apple's demonstrated inability to deliver a long-delayed overhaul of the Mac operating system.

By the end of 1996 Apple's future was in question, but some observers thought the company could be turned around if it got three things: focused management, a better public image, and a next-generation operating system. And it needed all of them right away.

Some thought that Amelio and the team he had put together were that focused management. And NeXTSTEP really was a next-generation operating system, not an implausible idea. Even though it was more than half the age of the doddering Macintosh operating system, it had everything a modern operating system should have—things like true multitasking. The NeXT team had designed well, and NeXTSTEP was field-tested. As for the change in Apple's public image…

Three weeks after the announcement, Amelio took the stage for his keynote address at the Macworld Expo in San Francisco, the biggest Macintosh event of the year, the place where Apple often laid out its plans for the coming year. The room was jammed, and attendees had to find sitting or standing room in the aisles. The word was out that Apple had bought NeXT and that Steve Jobs was back, but little more was known. The news was dramatic, but the unknowns were even more of a draw.

Amelio laid out the essence of the plan plainly: Apple would produce a new operating system, based very closely on NeXTSTEP, to run on its PowerPC hardware. NeXTSTEP, the operating system of Steve Jobs's company, was Apple's future.

Then he introduced Steve Jobs.

The crowd jumped to its feet and applauded wildly. When things finally quieted down, Jobs described NeXTSTEP and his view of the challenges facing Apple. He could have said anything. He had the crowd in his hand.

Later, Amelio called Jobs back to the stage, along with cofounder Steve Wozniak. The packed house rose to its feet again, and again there was thunderous applause.

It was a moment.

For Steve Jobs it was also a symbol of some kind of a homecoming, and like all homecomings, this one was remarkable for what had changed as well as for what had not. A great deal was now different for Steve Jobs than it was when he left Apple more than a decade earlier. He was married now and had a family. The lack of success at NeXT would have been humbling to anyone else, and probably was even to Jobs. But by selling NeXT he had finally paid his debt to its long-suffering employees (and had stock options that were now worth real money). And both Jobs and Apple were simply older; the company was now as old as the man was when he and Steve Wozniak founded it.

What followed was not quite what Amelio expected. The correct word for it is *coup*. Within weeks, Jobs had his chosen managers in place. NeXT veterans Jon Rubenstein and Avi Tevanian were now totally in charge of Apple's hardware and software divisions. By midyear, Jobs had eased Amelio out of the company entirely, had engineered a new board of directors loyal to Jobs, and was appointed interim CEO with unchallenged authority over every aspect of the company's business. Months later, Amelio was still trying to put a favorable spin on the coup.

Steve Jobs was back. But could even its charismatic cofounder rescue Apple?

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Chapter 10

The Post-PC Era

> *The introduction of the iPad was a huge moment. As soon as I saw Steve take that thing and sit down in a comfy brown leather armchair and kick back and start flicking his finger across the screen, I tweeted, "Goodbye, personal computer." Because I recognized that moment as the beginning of the end.*
>
> *Chris Espinosa*

When Steve Jobs returned to Apple in 1997, both he and the company had changed. But the industry itself was changing, and computer companies that wanted to survive were going to have to deal with the new realities.

The Big Turnaround

> *When Steve came back to Apple, he told me that Microsoft had won the PC battle and that was irreversible, over and done with. But he thought that if he could get Apple healthy enough to persist until the next major tech dislocation, Apple could win at that.*
>
> –Andy Hertzfeld

Apple was a company in dire trouble, struggling very publicly for survival. Its already small market share was eroding, developers were building applications for Macs second if at all, the stock was dropping, and nobody seemed to have a plan for changing any of that. In 1996 *Business Week* headlined Apple's troubles as "The Fall of an American Icon."

But Apple wasn't simply short of cash. It was in an existential struggle to rediscover its identity and to find relevance in the market.

Even before the Mac, Apple had distinguished itself from the rest of the market by virtue of a greater emphasis on design and graphics and top-to-bottom control of the computer's hardware and software. But Apple's "thinking different" was a double-edged sword. The design sense and the coherence of a single-source model were advantages. But the proprietary approach frustrated third-party developers and premium pricing kept Apple's market relatively small. Apple had defined itself as a niche player in a market that was increasingly nicheless. Microsoft had kept improving Windows, to the point where most consumers couldn't see much difference between a Mac and a PC—except for the price. Windows was undermining Apple's positives, and the negatives were looming larger.

Retaining its identity and relevance were *both* critical because while an Apple that tried to be a me-too company would fail, so would an Apple that remained marginalized by its increasingly undesirable differences.

Apple also suffered from internal problems, including lack of focus. "[John Sculley] never really did any technology transitions," Chris Espinosa recalls, "and Michael Spindler had so many long, flat gestation periods, investing in everything, that he starved everything and nothing ever really took off. I think…that they thought too strategically and too abstractly about technologies and markets, and they took their eye off the ball of 'real artists ship.' That what matters is the product that you put into people's hands." Jean-Louis Gassée concurs: "They had the wrong leadership in software. And also the culture had become…for a while it had been soft."

But leaders can lead only in a receptive environment. "John Sculley did a lot of great things," Espinosa explains. "He came into a company that was headed south fast, and he got it on a firm bearing. One of the problems with Apple from 1985 through 1997 when Steve came back is not that we had poor leaders. It's that we had extremely crappy followers…the culture of Apple had been designed to follow Steve, and Sculley wasn't Steve."

But Jobs, too, had changed in the intervening years.

Espinosa was leery of Jobs when he returned: "I remembered my experience on the Mac team fairly vividly, and frankly, I didn't really want to create it again. So I hid out in developer tools."

But Espinosa soon found that he, at least, needn't fear Jobs's outbursts. "He was extremely congenial [to me]. I kept hearing the terror stories of the elevator interviews and the screaming fits, which were the good old Steve. But I got the general feeling that those were kind of for show—that it was him exercising reputation maintenance. You know, that used to be an uncontrollable part of his character, and I got the feeling, in later years, that it was an act that he could put on when he needed to. I saw much, much more of the gentle, appreciative, wistful Steve in his later years."

Most crucially, Jobs had become more effective. The Pixar success, and his role in supporting the Pixar crew and then in negotiating deals for their work, had impressed observers. And there was the money: billionaires tend to be taken seriously. "He was," Espinosa points out, "the most successful studio CEO since Samuel Goldwyn."

Legitimacy

But as much as Apple and Jobs had changed, the industry had changed even more.

When Jobs left Apple in 1985, the personal-computer market was less than a tenth the size it would be by 1997, when he returned.

Remember that Apple ad welcoming IBM? It was the one that began, "Welcome, IBM. Seriously." It got some attention when it ran in 1981, acknowledging that IBM's entry brought legitimacy to the personal-computer industry. What wasn't widely recognized even at the time was that the ad channeled an edgier ad from an earlier era. When IBM entered the minicomputer industry a generation earlier, Data General CEO Edson de Castro commissioned an ad that read, "They Say IBM's Entry into Minicomputers Will Legitimize the Market. The Bastards Say, Welcome."

That ad never ran, but the sentiment was clear. De Castro was saying that Data General didn't want to be legitimate. It didn't want to be IBM. That's akin to what Jobs was conveying in 1984, when he told the Mac team, "It's more fun to be a pirate than to join the Navy."

But legitimacy had won out. There were no more bastards, no more pirates. At least not making personal computers. As a consequence, the computers themselves were becoming commodities.

It seems rapid in retrospect but felt slow as it happened. The GUI—created at PARC, brought to market by Apple, and made essential by Microsoft—made computers easy enough for anyone to use. The electronic spreadsheet, created by Dan Bricklin and Bob Frankston and made essential by Lotus, became the killer app that got personal computers into every business. The IBM name, as it had before, made the purchase of personal computers justifiable to the corporate numbers people. Personal computers had achieved legitimacy.

And what was legitimized was specifically *personal* computers. Putting a computer on an employee's desk required new thinking about job requirements, budgeting, internal tech support, maybe even new desks. It challenged entrenched company thinking.

But by 1997 that battle was won. The legitimization of the personal computer, ironically, even drove IBM out of the market. Although IBM had legitimized the business by entering it, "then the dragon's tail flopped," as Jean-Louis Gassée puts it, "and IBM got maimed." IBM had more experience selling computers than anyone else, but it was experience in selling computers one at a time, experience with premium pricing and with strong support. None of that matched well with selling generic boxes off the shelves at Walmart.

In the interim, while the market was expanding by a factor of ten, Apple's market only tripled. Apple executives could do the math. They were trying to keep the company relevant. Chris Espinosa was there through it all, and reflected on it later:

"I remember [John Sculley] talking about 'technology S-curves'.… The idea was that a technology would have a long, flat gestation period and then a sudden period of hypergrowth, and then it would top out as the market got saturated or the technology got mature. And at that point the technology in the market would really cease to be interesting, and if you were a company that had bet everything on that technology…you were eventually going to get picked to death by the clones.

"So in order to be a constantly innovative company, you needed to stack up those S-curves. While you had one product that was in a vertical growth period, you had to be developing other products in that long, slow, flat gestation stage that would take off on the next S-curve.

"That was his theory," Espinosa concludes. "He couldn't implement it."

The iCEO

In this environment began the turnaround year for Apple. Most of the changes Jobs implemented had been planned on Gilbert Amelio's watch, and many had been the ideas of chief financial officer Joseph Graziano, but Jobs made them happen. He shut down the licensing program, which had come too late and had allowed clone makers to cut into Apple's own sales, as Gassée had feared. Jobs laid off employees, dropped 70 percent of the projects, radically simplified the product line, instituted direct sales on the Web, and stripped down the sales channel.

Most of the decisions ruffled at least some feathers, but one move shocked the Apple faithful and drew boos from the crowd when it was announced at Macworld Expo in January 1997. As Jobs stood on stage, the face of Bill Gates appeared on the enormous screen behind him, looking down like Big Brother in the movie version of George Orwell's *1984*. Jobs announced that Microsoft was investing $150 million in Apple. Jobs recovered by assuring the crowd that it was a nonvoting stake. The investment gave Apple an infusion of needed capital and the good public relations of the endorsement of Microsoft, but Microsoft exacted a heavy price: the rights to many Apple patents and the agreement that Apple would make Microsoft's web browser its browser of choice. Microsoft was enlisting Apple in its war to control the key software used to browse the Internet.

In the same year that his image was looming ominously over the Macworld show, Bill Gates started the William H. Gates Foundation with an initial investment of $94 million. Later renamed the Bill & Melinda Gates Foundation, Gates's further investments soon grew it into one of the largest private foundations in the world, focused on enhancing healthcare and reducing extreme poverty internationally, as well as expanding educational opportunities and access to information technology in the United States.

Within three years Gates would step down as CEO of Microsoft, turning over the reins to his old friend Steve Ballmer. In the ensuing years he would ease himself out of any role at Microsoft to devote himself full time to the foundation. But in 1997, Gates still seemed like the enemy to the Apple faithful.

Despite the plan laid out in the earlier Macworld keynote address, Jobs didn't retire the Mac operating system. Instead he folded the NeXT technology into an improved OS that was still Macintosh. It would be easy to think, knowing Jobs, that the whole NeXT acquisition had been a Machiavellian scheme, but it wasn't that simple. Jobs was not at all convinced that Apple could be saved when he sold NeXT. He unloaded the 1.5 million Apple shares he got in the NeXT deal cheaply, convinced that the stock wasn't going up. "Apple is toast," he said to a friend in an unguarded moment. But within months Apple had gone from a zero to a one in Jobs's mind, and he threw himself into saving it. The board was willing to give him anything he wanted, repeatedly offering him the CEO job and chairmanship. He turned them down but still ran the company dictatorially, inserting himself into any department at any level he thought necessary, under the title of interim CEO. He wasn't getting any significant compensation and, having sold his Apple stock almost at its lowest point, wasn't getting any financial benefit from Apple's success, either.

Merging the NeXT operating system with Apple's was an extremely complicated and chancy endeavor, like fixing an airplane engine while flying. And it took time: it was three years before what was called OS X finally came out.

Meanwhile the hardware line was also being revamped. Conceding that personal computers had become commodities, Jobs embraced that model and used commodity features to sell computers. The iMac and the new desktop Mac computers that came out in 1998 and 1999, designed by Jony Ive, brought color and a sense of style to computers to a degree that had never been attempted before. The market ate them up. The iMac not only sold well; it became the best-selling computer on the market for several months running. Apple began making consistent profits again, and analysts pronounced that the slide had been halted and Apple was a good investment once more.

Jobs was remaking Apple into a company that had at least a chance of surviving in a market hemmed in by consolidation and cloning, heavily commoditized, being reshaped by cyberspace, and dominated by Microsoft and Windows.

Getting Really Personal

> *Today the computer is not a bag of parts being shipped to us; it is integrated into our telephone and automobile and refrigerator and we don't need to think about the software because it has become so intuitive and embedded in the product that all we have is life itself.*
>
> —Paul Terrell

If the war for control of the PC industry was over, Apple's hope, Jobs believed, was to stay alive long enough to be a player in the next big movement.

Some significant change was coming, it was clear; but guessing just what its form would be was the challenge. What happened was that the core of the computing universe began to move away from the desktop and onto mobile devices and the Internet. In the first of these shifts, Jobs and Apple played well and delivered a series of category-defining products. It was one of the most remarkable recoveries in corporate history, and was to be one of the most impressive instances of market domination. Starting in 2001, Apple began to set the mark that the rest of the industry had to hit in one new device category after another.

But as the 1990s came to a close, the world of mobile devices was looking very different.

Windows was not just the operating system of the great majority of personal computers. It was also behind the scenes in everything from point-of-sale terminals and automobiles to early smartphones.

These phones, which came on the scene at the end of the 1990s, were a niche product, the top end of the cell-phone market. They featured extra capabilities like a camera, media player, GPS, and to-do lists and other personal-productivity tools. BlackBerry smartphones from RIM set the bar with email, messaging, and web browsing, and they were the phone of choice for government workers. These phones weren't full-fledged computers, but they delivered some of the same functionality.

Another popular device category was the digital music player, almost always called an MP3 player (after the widely popular digital music format). There were already analog cassette players, the category-defining example being Nobutoshi Kihara's Sony Walkman. But British inventor Kane Kramer came up with a design for a *digital* audio player, along with the means to download music, plus digital-rights-management (DRM) technology, clear back in 1979. He lost the rights to his inventions when he couldn't afford to renew patents, but his ideas were not lost. By late 1997 the first production-volume commercial digital music player from Audible.com went on sale. Through the end of the millennium the MP3 player market blossomed with many new players, including the Diamond Rio and the Compaq HanGo Personal Jukebox.

The recording industry was terrified. Its trade association, the Recording Industry Association of America (RIAA), regarded these devices as tools for music piracy. The RIAA sued Rio but lost. Although Rio prevailed, other companies didn't fare as well in the clash between the music industry and Internet culture. Napster was a peer-to-peer file-sharing service primarily used for sharing music MP3s. Founded by Shawn Fanning, John Fanning, and Sean Parker, it prospered from June 1999 to July 2001, peaking at 80 million registered users. Then Metallica and Dr. Dre and several record labels sued, and Napster was shut down by court order.

Napster doubtless hurt some musicians, but it was arguably instrumental in making others, such as Radiohead and Dispatch. These new services and devices challenged traditional thinking in many ways, and they were creating new market niches. Again, the devices were not computers—but they had microprocessors in them and, like the BlackBerry, they could do some of what a computer could do.

The idea of such smart devices predates personal computers. As semiconductor designers had understood back in the 1970s, the chips *were* the computers. All the other bulky stuff was just there to communicate with humans. For many applications, the level of human interaction expected was relatively minimal. If it didn't have to do all that a computer did, a device could deliver a lot of capability in a very small package. And significant new markets were finally developing around certain kinds of devices.

Apple was not a player in any of these markets. But in the MP3 devices, Jobs saw an opportunity.

The Player

Technologically, music players were a solved problem. And the market for them was well established. The problem was, it wasn't exactly a *legal* market. Jobs had sung the virtues of being a pirate, but getting shut down for music piracy wasn't what he had in mind.

But Jobs had clout now. As the CEO of Pixar, he was a player in the entertainment industry. Under contract to Disney, Pixar had released *Toy Story* in 1995 and had gone public the same year. Jobs became an instant billionaire and someone to pay attention to in Hollywood. But it remained to be seen whether his newly minted Hollywood cred would buy him any time with music-industry executives.

And he needed face time with those executives for what he had in mind. There were several pieces to the plan: a music player, a new model for selling music, and buy-in from the music industry.

Somehow, he got it. Somehow he convinced the big players in the industry to license music to Apple under terms never before considered.

But first came the device. The original iPod introduced a scroll wheel as its primary input device, and it had a monochrome LCD display and earbuds. It was marketed with the slogan “1,000 songs in your pocket.” It was basically Kane Kramer’s (now public domain) digital player.

For the selling model, Apple purchased Bill Kinkaid’s SoundJam MP from Casady & Greene in 2000, renamed it iTunes, and released it in 2001. By 2003 iTunes had developed into the first fully legitimate digital music store. DRM software within the store protected the industry from piracy, and a radical pricing model made piracy elsewhere far less appealing. The pricing model made music sales a meritocracy, leveled the playing fields for indies, and destroyed the album. Everything would now be a single, Jobs dictated, and the new price for every song was the same: 99 cents.

The streamlined processing of the iTunes store meant that labels and artists got paid faster than in the past. Much of technology was inherent in Napster and the MP3 format, but Apple put it all together. In the first week the store was open, it sold a million song files.

Sales for the iPod took off more slowly, but by the end of 2004 Apple and its iPod owned some two-thirds of the growing market for digital music players. Margins were big and the profits huge. By 2007 iPod sales were making up roughly half of Apple’s revenue. Apple had, as Jobs knew it must, identified an emerging market and dominated it.

But Apple was not resting on its laurels.

The Phone

As far back as 1983 Jobs knew what he wanted the next product after the desktop or portable personal computer to be. At an offsite meeting for the Mac team, the one where he told them that “real artists ship” and “it’s more fun to be a pirate than to join the Navy,” he also challenged the Mac team to do a “Mac in a book by 1985.”

In a book? Apple would later produce portables called MacBooks, but Jobs wasn’t talking about a portable computer. What he was really talking about was Alan Kay’s Dynabook.

Kay, a Xerox PARC legend, had conceived of the Dynabook years earlier. It was in effect the prototype for every tablet device since created. It was a thin, flat display. Viewing it, you felt like you were reading from a piece of paper rather than a screen. It had no physical keyboard. It was a ubiquitous information and communication device that wasn’t necessarily a computer.

Jobs wanted the Mac team to wrap up the Macintosh quickly and get started on this next big (or little, really) thing, this tablet. But it didn’t happen then or in all the time he was gone, really. In the early 2000s, on the heels of iTunes and the iPod, he was ready to make it Apple’s next product.

It didn’t play out that way, though.

At the January 2007 Macworld show, Jobs announced “three revolutionary products…a wide-screen iPod with touch controls…a revolutionary mobile phone…[and] a breakthrough Internet communications device.” After getting cheers for each of these “devices,” he confided that they were all one product: the iPhone. The iPhone was essentially the tablet device shrunk to handheld size and with a phone packed into it.

It wasn’t the Dynabook, but neither was it a traditional smartphone. One of the things that set it apart from smartphones was the groundbreaking user interface. Another was that it ran Apple’s OS X, a full computer operating system. That didn’t make it a full computer, but it was impressive for the capability it promised.

Jean-Louis Gassée understood how impressive and powerful that was. “I thought Steve was lying. He was saying that OS X was inside the phone. I thought, He’s going to get caught. This time, he’s going to get caught. Well, no. When the geeks had their way with the first iPhones and looked at it…it was genuinely OS X.”

To really make use of a computer operating system in a phone, you had to figure out how to let the user do most of what could be done with a keyboard and a mouse on a device that had neither. The user-interface team, led by Greg Christie, had to invent a whole language of finger gestures. From there, the potential of the device was far beyond what had ever been delivered in a phone.

At the time of the demo, much of that was still potential. The iPhone was nowhere near ready to release when Jobs demoed it. But when it was released a few months later, somewhere around half a million iPhones were sold in the first weekend.

But Apple wasn’t alone in the new market for extra-smart phones. Microsoft had been probing this market with its Windows CE and later its Pocket PC platforms for over a decade. And back in 2003, four entrepreneurs—Andy Rubin, Rich Miner, Nick Sears, and Chris White—started a company named Android to create a new operating system based on the Linux kernel and emphasizing a touch-based interface for tablets, smartphones, and the like. Two years later, the company was acquired by Google, which had been investing its huge income from its search business in various enterprises. The Android project remained in stealth mode, with no hint of any intent to produce a new operating system to compete with Windows Mobile and Symbian—which were the players to beat.

When Apple released the iPhone, the developers recognized that Windows Mobile and Symbian were not the target; Apple’s iOS mobile operating system was. They regeared and, within months, unveiled Android. But arguably more interesting than the technology was the fact that Google announced Android as the first product of a consortium of companies committed to developing open standards for mobile devices. Apple’s iOS was Apple’s own proprietary platform. Two different models for mobile devices were now in competition: the open Android model and the closed iOS model.

Delivering the Tablets

Jobs hadn’t forgotten the Mac-in-a-book dream, though. And he wasn’t alone. Technology companies had been exploring the Dynabook concept for 20 years, since well before Jobs said anything to the Mac team about a Mac in a book. The concept required several innovations: flat-panel displays, the display as input device, and advances to get the machines small enough to carry.

Back in January 1979, inspired by the Dynabook, Xerox PARC researcher John Ellenby left to start a company with friends Glenn Edens, Dave Paulsen, and Bill Moggridge. Working without publicity, they delivered a computer, the GRiD Compass, in 1981—the same year IBM introduced its PC. It was an impressive machine, the first laptop computer, the first with the later ubiquitous foldable “clamshell” design, featuring a novel bit-mapped flat-panel display and a rugged magnesium case. It was a product driven by technological challenge, not budget constraints, and it was priced at $9,000. *Fortune* magazine named it a product of the year and it found a ready market in the military. It was reputed to be the first piece of consumer equipment (except for the powdered drink Tang) used on the space shuttle.

Although the GRiD Compass inspired an entire industry of laptop computers and its magnesium case was an idea that Steve Jobs picked up on at NeXT, the GRiD machine was no Dynabook. In particular, it used a keyboard for input. But if you could use the screen for input as well as output, you could immediately eliminate half the bulk of the device. A number of companies moved the idea forward over the years.

But while these companies pushed the technology for Dynabook-like devices, many of them were designed to be computers. Part of the genius of the Dynabook, though, was that it didn’t necessarily aspire to that. It was something new—something that didn’t yet exist.

Jerry Kaplan (Symantec Q&A and Lotus Agenda developer), Robert Carr (Ashton-Tate Framework developer), and Kevin Doren (music synthesizers) started Go Corp in 1987 to build on the flat-screen idea by producing a portable computer that used a stylus for input. Their product, the EO Personal Communicator, didn’t take the world by storm, but it did solve a lot of technical problems, and to those in the industry it was at least a proof of concept.

Another personal-computer pioneer who believed in the possibility of these no-keyboard devices was VisiCalc designer Dan Bricklin. In 1990 he and some colleagues founded Slate Corporation with a mission of developing software for pen-based computers.

Then Jeff Hawkins, who had worked at GRiD, started Palm Computing in 1992 to develop handheld devices that were not necessarily computers. He and his team had varying degrees of success with personal digital assistants, smartphones, handwriting-recognition software called Graffiti, and a mobile operating system called WebOS.

Apple, under the leadership of John Sculley, embraced the idea and fielded a whole line of pen-based products under the Newton label. Newton was a handheld computer with its own operating system and some groundbreaking technology. After bad publicity for its iffy handwriting recognition, Apple replaced it with a highly regarded handwriting-recognition system developed in-house by Apple researcher Larry Yaeger and others.

As a demonstration of the achievements of Apple research and development it was wonderful, but it fell somewhat short as a successful consumer product. Consumers were not clamoring to enter data via handwriting. Neither Newton nor any of the other tablet devices from the 1990s succeeded. It would be a decade before the tablet market would truly catch fire.

When Apple finally returned to the tablet market in 2010, its iPad was another category-defining product, like the iPod and iPhone. Skeptics pointed out that it did less than a personal computer, and questioned what the market was for such a device. But that was the point. It was something else, and if it found a market it would be plowing fresh soil. Jobs would again have succeeded in opening a new market.

And the market was there. By mid-2010 Apple had sold a million iPads, and a year later the total was 25 million. The tablet market was booming for other companies as well. Amazon had released a handheld reader called the Kindle in 2007, and it staked out a somewhat different market, being specifically a book-reading device. Google’s mobile operating system, Android, was in use in phones and tablets from many companies, and the Android slice of the tablet market soon surpassed Apple’s. With Android, developers saw the re-emergence of an open platform.

The idea of browser as operating system came to fruition when Google released its Chrome OS in 2009. Built on top of a Linux kernel, its user interface was initially little more than the Google Chrome web browser. Chrome OS was the commercial version of an open source project, Chromium, which opened the source code for others to build on. Laptop computers were soon being built to run Chrome OS natively.

Although Apple was setting the bar in each of these new product categories and profiting greatly from them, it wasn’t necessarily leading in sales. By 2011 Android devices were outselling all others. By 2013 they were outselling all other mobile devices *and personal computers* combined. Nearly three-quarters of mobile developers were developing for Android. Google’s open model had been a highly successful play.

Meanwhile, sales for personal computers were flat or declining. The center of the computing universe had shifted to these new mobile devices. To be sure, the market for some of these mobile devices may already have been reaching saturation by 2014, as evidenced by a general decline in iPod sales and the hint of a decline in iPad sales. But the trend toward new specialized devices was not dependent on any particular device. New ones were being planned and launched. The personal computer was being deconstructed, its capabilities allocated to more specialized products.

The other major trend away from the desktop wasn't about physical products, though, and it wasn't led by Apple.

Into the Cloud

> *I was always clear, from like 1970, that networked computers were going to be necessary for sustainability of communities. So, then it was a matter of figuring out how to implement that. And it's not like I suddenly woke up and said, Oh, this is important stuff. No, it was always important stuff for me.*
>
> —Lee Felsenstein

By 2000 the Internet was an integral part of life for millions of people. Indeed, 350 million or more people were online, the majority of them in the United States. That figure would grow by an order of magnitude over the next decade and a half, and more closely match the relative populations of countries. By 2014, China was home to the most Internet users.

Robert Metcalfe's 1995 prediction that the web browser would become the operating system for the next era had largely come true. If, as Sun Microsystems had famously claimed, the network was the computer, then the browser was the operating system, and single-computer-based operating systems were irrelevant. It wasn't quite that simple, but websites were becoming more like applications, powered by JavaScript. But even if the network was (sort of) the computer, that didn't mean the actual computer could be turned into a glorified terminal, as Larry Ellison had discovered back in 1996 (when Oracle and Netscape were unsuccessful with what they called a network computer, or NC). A new model of computing was emerging, but the NC model wasn't it.

In the 21st century, that new model revealed itself in the ubiquity of e-commerce and social media, and it grew on top of new algorithms and technologies designed to process data in new ways. Beneath all that was the data—data being collected and stored and processed on a scale far beyond anything human beings had ever experienced.

E-commerce as presently known didn't happen until 1991, when the National Science Foundation lifted its restrictions on commercial use of the Internet. But with the launch of Amazon and eBay in 1995 and PayPal in 1998, online shopping was soon threatening the viability of brick-and-mortar stores.

The easiest product to sell online was software. Gone were the shrink-wrapped boxes on shelves in computer stores. And with the dominance of portable devices, the programs got smaller. Even the name got smaller: the biggest category of computer software used to be called application software, but now it was just *apps*. The average price dropped even more, from tens, hundreds, or even thousands of dollars to a couple of bucks.

What made it possible to write and sell two-dollar apps was the shift of processing to the Internet. Mobile apps often functioned simply as interfaces to web-based applications. And in that online market there were huge opportunities, with venture capitalists throwing money at every new instance of Gates's bright young hacker. And while e-commerce was booming, the biggest opportunity to make your first billion was in the emerging market of social media.

Since the earliest days of personal computing, the online element of it had been at least in part about community. This online community, which Ted Nelson had called "the future intellectual home of mankind" in *Computer Lib*, Lee Felsenstein was working to build through projects like Community Memory. Later, online systems such as CompuServe and AOL succeeded because they provided that sense of a community. With its eWorld, Apple went so far as to build an online service around a cartoon town.

The World Wide Web put an end to these isolated services and opened up the world, but it was not a single community. New web-based services emerged, like MySpace and Friendster, each acutely aware of the huge opportunity there was for those who could successfully create that sense of community.

The most successful of these was Facebook, started by a bright young hacker at Harvard in 2004. Within ten years its community would have more members than there were people on the Internet in 2000.

A spate of new companies started by recent grads with major backing were all defining themselves against Facebook, with many of them successfully identifying communities of professionals, photographers, videographers, and devotees of various crafts. These overnight successes did not produce products in the sense that the iPod was a product. But just as Apple succeeded by designing products that people would want, these social-media companies succeeded by understanding key facts about how people connected. Their sites were highly personal.

The booming e-commerce and social-media sites had a serious problem, though: they made demands on storage and processing that existing hardware and software couldn't deliver. In 2014 Amazon required some half a million servers to process its orders. Facebook had about half that many. The services had grown far beyond the point where a single computer of any size could do the job. But connecting any two individuals in a massive network or keeping inventory current across so many orders required new tools. The established ones simply did not scale. The work had to be distributed. New programming tools came on board, better suited to the parallelization of work to allocate it among many widely distributed processors.

Big as Facebook and Amazon were, their needs were dwarfed by those of the biggest dot-com company. This was neither an e-commerce site nor a social-media site; it was a search engine. The Web was huge, and just searching it was an even bigger job than the task facing an Amazon or a Facebook. Many search engines had been developed, but one was dominant in the 21st century: Google. Its processing and storage needs were massive, requiring huge warehouses with hundreds of thousands of servers at each one of these “server farms.”

A new term began to gain popularity: *cloud computing*. It was an old idea, but the technology to make it work was now in place. The distributed computing technology worked. It scaled. And soon you didn’t have to be an Amazon or a Facebook or a Google to benefit from these innovations. Google, HP, IBM, and Amazon turned this in-house technology into a marketable service. They made it possible for any business to distribute processing and storage with maximum efficiency. Amazon Web Services, or AWS, began renting Amazon’s distributed computing capability. You could rent computers, storage, the processing power of computers—virtually any definable capability of computers—on an as-needed basis. If your business grew rapidly and you needed ten times the capability tomorrow as today, you just bought more.

By 2014, seven out of eight new applications were being written for the cloud.

Meanwhile, the increases in computers’ storage capacity were continuing to redefine what computer technology was capable of. “Big data” is the term applied to the new collections of data emerging from the data-gathering of search engines—from online transactions with humans and from Internet-connected sensors gathering data like temperatures—collections so large that no traditional database tool could process them.

Computing had changed. People were now interacting with a growing variety of devices, only a fraction of which were personal computers as traditionally understood—devices that more often than not simply mediated interaction with an e-commerce or social-media site elsewhere, which in turn stored its data and executed its code in a virtual cloud, the physical location of which was not only shifting and hard to pin down but, in practice, unimportant. The model of a personal computer on your desk or lap had become quaint. The personal-computer era was giving way to something else: a post-PC era.

Paralleling this shift away from the personal computer has been a general changing of the guard among the players.

Leaving the Stage

In 2011, at the age of 56, Steve Jobs died due to complications from pancreatic cancer. A few months earlier he had stepped down as CEO, telling the board, “I have always said if there ever came a day when I could no longer meet my duties and expectations as Apple’s CEO, I would be the first to let you know. Unfortunately, that day has come.” COO Tim Cook was named CEO.

In 2013, Steve Ballmer retired as CEO of Microsoft. The company had been struggling to find its way in recent years, failing to secure a significant market share in the new product categories. Satya Nadella, a 22-year Microsoft veteran, would become only the third CEO in Microsoft’s history. Tellingly, Microsoft turned to cloud computing to lead it into the future.

In 2014, Oracle’s Larry Ellison stepped down as CEO of the company he founded. Many of the companies that had helped to define the personal-computer era were gone now, including Sun Microsystems, which Oracle acquired. In Silicon Valley there was a pervading sense that the old guard was gone and that the industry was in the hands of a freshman class of bright young hackers. And in terms of products, those bright young hackers were driving the vehicle of technology to a new era.

In this new era, handheld devices have become wearable, and are moving past wearable to embedded. We’re in that era now. From a device that you can put down when you’re done with it to a device that you take off like jewelry to a device that would require outpatient surgery to disconnect, smart devices are going beyond the personal, to the intra-personal. At the same time, these devices are deeply entwined with the Internet, talking to other devices in a new “Internet of things,” bypassing their slow fleshy hosts.

The two trends of smaller and more intimate devices and of an increasingly ubiquitous network are coming together to produce something that transcends either individual technology. The results will be interesting.

Looking Back

> *It’s a brave new world we are embarking on with all of our embedded personal computers that have been programmed by others who hopefully have our well being in mind.*
>
> —Paul Terrell

What is a personal computer?

To those who first built them, a personal computer meant a computer of your own. It meant a lot. That was the promise of the microprocessor: that you could have a computer of your own.

And that, to some—the time in question being the tail end of the idealistic ’60s—implied empowering others as well. "Computer power to the people" was not just a slogan heard in those days; it was a motivating force for many personal-computer pioneers. They wanted to build computers to be used for the betterment of mankind. They wanted to bring the power of computers to everyone.

This humanitarian motive existed alongside other, more self-centered motives. Having your own computer meant having control over the device, with the sense of power that brought. If you were an engineer, if you were a programmer, it specifically meant control over this necessary tool of your trade.

But control over the box was just the start; what you really needed was control over the software. Software is the ultimate example of building on the shoulders of others. Every program written was either pointlessly reinventing the wheel or building on existing software. And nothing was more natural than to build on other programs. A program was an intellectual product. When you saw it and understood it, you had it; it was a part of you. It was madness to suggest that you couldn’t use knowledge in your own head—and only slightly less mad to try to prevent you from acquiring knowledge that would help you do your job.

The idea of owning your own computer, paradoxically, fed the idea of *not* owning software, the idea that software should be open to be observed and analyzed, independently tested, borrowed, and built on. It supported the ideas of open source software and nonproprietary architectures, a collaborative perspective that John “Captain Crunch” Draper had called “the Woz principle” (for Steve Wozniak).

How have these ideas—the Woz principle and computer power for the people—fared with the deconstruction of the personal computer?

The Woz Principle

There was once an ongoing debate about the merits of proprietary versus open source software. Supporters of open source argued that it was better than the commercial kind because everyone was invited to find and fix bugs. They claimed that in an open source world, a kind of natural selection would ensure that only the best software survived. Eric S. Raymond, an author and open source proponent, contended that in open source we were seeing the emergence of a new nonmarket economy, with similarities to medieval guilds.

The debate is effectively over. Open source software didn’t drive out proprietary software, but neither is open source going away. This open source idea, what John Draper had called the Woz principle, is really just an elaboration of the sharing of ideas that many of the pioneers of the industry had enjoyed in college, and that scientifically trained people understood was the key to scientific advance. It was older than Netscape, older than Apple, older than the personal-computer revolution. As an approach to developing software, it began with the first computers in the 1940s and has been part of the advance of computer-software technology ever since. It was important in the spread of the personal-computer revolution, and now it powers the Internet.

The market for post-PC devices is different from the market for personal computers. The personal computer started as a hobbyist product designed by tech enthusiasts for people like themselves. Commoditization began in just a few years, but the unique nature of the computer—a device whose purpose is left to the user to define—allowed it to resist commoditization for decades. In the post-PC era, even though the devices are still really computers they are designed around specific functions. So the forces of commoditization that had been held at bay are now rushing in. The mainstream market for these devices doesn’t want flexibility and moddability and choices to make once they’ve purchased a device. They want it all to be simple, clear, consistent, and attractive. They don’t care about open source, but they like free. They want security but they don’t want to have to do anything about it. Their values are not the values of the people making the devices or the apps. They’re normal consumers, something the companies in the early personal-computer industry never really had to acknowledge.

If you look only at commercial apps, you will conclude that proprietary software, locked-down distribution channels, and closed architectures have won. If you look at the Internet and the Web and at the underlying code and practices of web developers, on the other hand, it is clear that open source and open architecture and standards are deeply entrenched.

And even in the device space, the differing models of Android and Apple suggest that things may shift further in the direction of the Woz principle. In this revolution, the workers have often succeeded in controlling the tools of their trade.

The implications go beyond the interests of software developers. Google’s Android model has allowed the development of lower-priced platforms that benefit the developing world, where personal computers and iPhones are out of the price range of many people.

As for the developers, a change has occurred in the makeup of that community. Hobbyists, who comprised the bulk of early personal-computer purchasers and developers, are harder to find in the post-PC era. When new phones and tablets hit the market now, they don't come with BASIC installed, as the Apple II did. The exceptions are in programmable microcomputers used to program devices. The low-budget Arduino and Raspberry Pi being used by electronics hobbyists of today are rare examples of computers that are still intended to be programmed by their users. Perhaps the shift away from hobbyist programming is balanced by the growth in website development, which has a very low barrier to entry.

The industry has changed, but for one player the change had come much earlier, and he decided he didn't want to be a part of it any longer.

The Electronic Frontier

At the height of his power and influence at Lotus Development Corporation, Mitch Kapor walked away from it all.

Lotus had grown large very quickly. The first venture capital arrived in 1982, Lotus 1-2-3 shipped in January 1983, and that year the company made $53 million in sales. By early 1986 some 1,300 people were working for Lotus. Working for Mitch Kapor.

The growth was out of control, and it was overwhelming. Rather than feeling empowered by success, Kapor felt trapped by it. It occurred to him that he didn't really like big companies, even when he was the boss.

Then came a day when a major customer complained that Lotus was making changes in its software too often: that it was, in effect, innovating too rapidly. So what was Lotus supposed to do, slow down the pace of innovation? Exactly. That's what the company did. It was perfectly logical. Kapor didn't really fault it as a business decision. But what satisfaction was there in dumbing down your company?

Figure 94. Mitch Kapor ***Kapor went from teaching transcendental meditation to founding one of the most successful companies in personal computing's boom days to defending individual rights in the information age.***
(Courtesy of Mitch Kapor)

Lotus just wasn't fun anymore. So Kapor resigned. He walked out the door and never looked back.

This act left him with a question: what now? After having helped launch a revolution, what should he do with the rest of his life? He didn't get away from Lotus cleanly. He had spent a year completing work on a Lotus product called Agenda while serving as a visiting scientist at MIT.

After that he jumped back in and started another firm, the significantly smaller On Technology, a company focusing on software for workgroups.

And in 1989 he began to log on to an online service called The Well. The Well, which stood for Whole Earth 'Lectronic Link, was the brainchild of Stewart Brand, who had also been behind *The Whole Earth Catalog*. The Well was an online community of bright, techno-savvy people.

"I fell in love with it," Kapor said later, because "I met a bunch of people online with similar interests who were smart that I wanted to talk to." He plunged headlong into this virtual community.

One day in the summer of 1990, he even found himself on a cattle ranch in Wyoming talking computers with John Perry Barlow, a former lyricist of the Grateful Dead.

What led to that unlikely meeting was a series of events that bode ill for civil liberties in the new wired world. A few months earlier, some anonymous individual, for whatever motive, had "liberated" a piece of the proprietary, secret operating-system code for the Apple Macintosh and had mailed it on floppy disks to influential people in the computer industry. Kapor was one of these people; John Perry Barlow—the former Grateful Dead lyricist, current cattle rancher, and computer gadfly—was not. But apparently because Barlow had attended something called The Hacker's Conference, the FBI concluded that Barlow might know the perpetrator.

The Hacker's Conference was a gathering of gifted programmers, industry pioneers, and legends, organized by the same Stewart Brand who had launched The Well. *Hacker* in this context was a term of praise, but in society at large it was coming to mean "cybercriminal"—that is, one who illegally breaks into others' computer systems.

An exceptionally clueless G-man showed up at Barlow's ranch. The agent demonstrated his ignorance of computers and software, and Barlow attempted to educate him. Their conversation became the subject of an entertaining online essay by Barlow that appeared on The Well.

Soon afterward, Barlow got another visitor at the ranch. But this one, being the founder of Lotus Development Corporation, knew a lot about computers and software. Kapor had received the fateful disk, had had a similar experience with a couple of clueless FBI agents, had read Barlow's essay, and now wanted to brainstorm with him about the situation.

"The situation" transcended one ignorant FBI investigator or a piece of purloined Apple software. The Secret Service, in what they called "Operation Sun Devil," had been waging a campaign against computer crime, chiefly by storming into the homes of teenaged computer users at night, waving guns, frightening the families, and confiscating anything that looked like it had to do with computers.

"The situation" involved various levels of law enforcement responding, often with grotesquely excessive force, to acts they scarcely understood. It involved young pranksters being hauled into court on very serious charges in an area where the law was murky and the judges were as uninformed as the police.

It did not escape the notice of Barlow and Kapor that they were planning to take on the government, to take on guys with guns.

What should they do? At the very least, they decided, these kids needed competent legal defense. They decided to put together an organization to provide it. As Kapor explained it, “There was uninformed and panicky government response, treating situations like they were threats to national security. They were in the process of trying to put some of these kids away for a long time and throw away the key, and it just felt like there were injustices being done out of sheer lack of understanding. I felt a moral outrage. Barlow and I felt something had to be done.”

In 1990 they cofounded the Electronic Frontier Foundation (EFF). They put out the word to a few high-profile computer-industry figures who they thought would understand what they were up to. Steve Wozniak kicked in a six-figure contribution immediately, as did Internet pioneer John Gilmore.

Merely fighting the defensive battles in the courts was a passive strategy. EFF, they decided, should play an active role. It should take on proposed and existing legislation, guard civil liberties in cyberspace, help open this new online realm to more people, and try to narrow the gulf between the “info haves” and the “info have-nots.”

The pace picked up when they hired Mike Godwin to head their legal efforts. “Godwin was online a lot as he was finishing law school at the University of Texas,” Kapor remembers. “I was impressed by him.”

EFF evolved quickly from a legal defense fund for some kid hackers to an influential lobbying organization. “In a way it was an ACLU of cyberspace,” Kapor now says. “We quickly found that we were doing a lot of good raising issues, raising consciousness [about] the whole idea of how the Bill of Rights ought to apply to cyberspace and online activity. I got very passionate about it.”

By 1993, EFF had an office in Washington and the ear of the Clinton administration, especially Vice President Al Gore, who dreamed of an information superhighway analogous to his father’s (Senator Albert Gore, Sr.) favorite project, the interstate highway system. Also addressing the issues were organizations such as Computer Professionals for Social Responsibility, which EFF was partly funding.

To a personal-computer pioneer intent on using the power of computers to benefit people and exorcising the shibboleth of the computer as an impersonal tool of power over the masses, this looked promising. It looked like dumb, slow, old power structures on one side and clever, agile, new techno-savvy revolutionaries on the other.

And since those heady days? It is easy to conclude that the problems EFF was created to address are growing faster than the efforts of such organizations can handle. Revelations that the US government is, with the help of huge cloud corporations, tapping into the massive stores of data they collect on citizens of the United States, on foreign countries, and on foreign heads of state, have undermined confidence not just in government but in technology. Once again, as before the personal-computer revolution, computer technology is starting to be seen as power that can be used by the powerful against regular people.

Ironically, the social networks built by the cloud-based companies have become the means of circulating both facts and wild rumors about these surveillance horrors. As the industry rushes gleefully into a networked world of embedded devices and lives lived in public, the public is increasingly convinced that we are being sucked into some nightmare science-fiction future of mind control, tracking devices embedded in newborns, and a Big Brother who sees your every act and knows your every thought. Mary Shelley could do a lot with that material.

But the fears are not groundless. Computers actually have given great power to individuals, and they will continue to do so. But this question cannot be avoided: can we keep them from taking away our privacy, our autonomy, and our freedom?

Looking Forward

The revolution that produced the personal computer is over. It grew out of a unique mixture of technological developments and cultural forces and burst forth with the announcement of the Altair computer in 1975. It reached critical mass in 1984, with the release of the Apple Macintosh, the first computer truly *designed* for nontechnical people and delivered to a broad consumer market. By the 2000s the revolutionaries had seized the palace.

The technology carried in on this revolutionary movement is now the driving force of the economies of most developed countries and is contributing to the development of the rest. It has changed the world.

Changing the world. By 1975, time and again crazy dreamers had run up against resistance from accepted wisdom and had prevailed to realize their dreams. David Ahl trying to convince Digital Equipment Corporation management that people would actually use computers in the home; Lee Felsenstein working in post-1965 Berkeley to turn technology to populist ends; Ed Roberts looking for a loan to keep MITS afloat so it could build kit computers; Bill Gates dropping out of Harvard to get a piece of the dream; Steve Dompier flying to Albuquerque to check up on his Altair order; Dick Heiser and Paul Terrell opening stores to sell a product for which their friends told them there was no market; Mike Markkula backing two kids in a garage—dreamers all. And then there was Ted Nelson, the ultimate crazy dreamer, envisioning a new world and spending a lifetime trying to bring it to life. In one way or another, they were all dreaming of one thing: the personal computer, the packaging of the awesome power of computer technology into a little box that anyone could own.

Changing the world. It’s happening all the time.

Today that little box is taken for granted at best, and just as often supplanted by new devices, services, and ideas that will, in turn, be supplanted by newer, possibly better ones. Technological innovation on a scale never seen in human history is simply a fact of life today.

Perhaps the lesson of the personal-computer revolution is that technological innovations are never value-neutral. They are motivated by human hopes and desires, and they reflect the values of those who create them and of those who embrace them. Perhaps they are a reflection of who and what we are. If so, are we happy with what they show us?

In any case, we seem to be in an era of unbridled technological innovation. You can’t guess what new technological idea will shake the world, but you can be sure it is coming. Some bright young hacker is probably working on it today.

She may even be reading this book right now.

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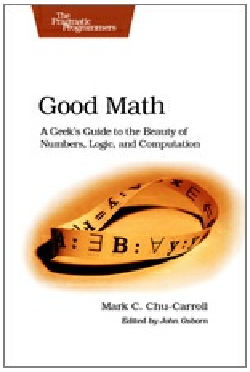

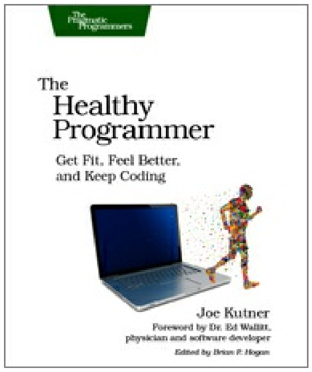

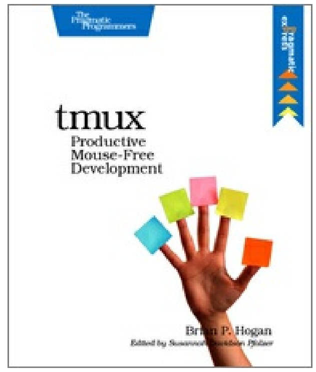

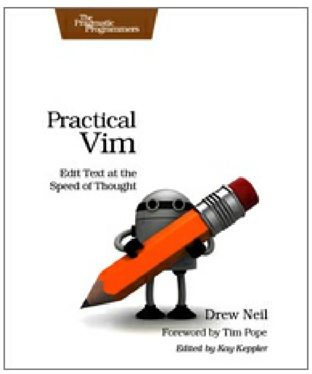

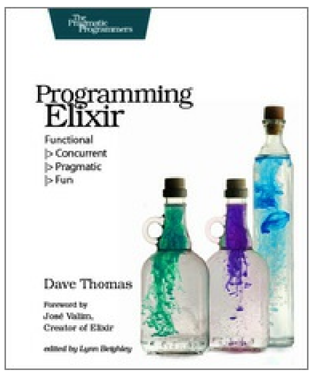

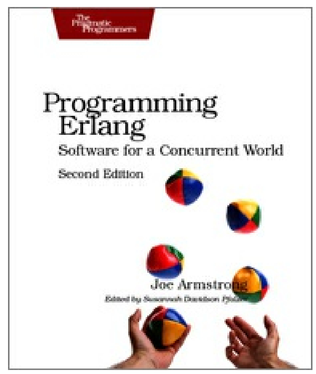

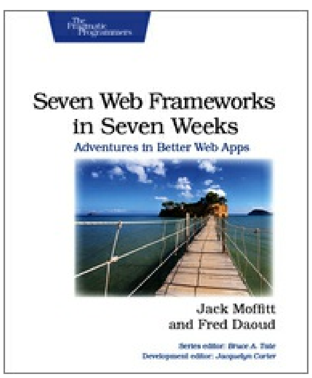

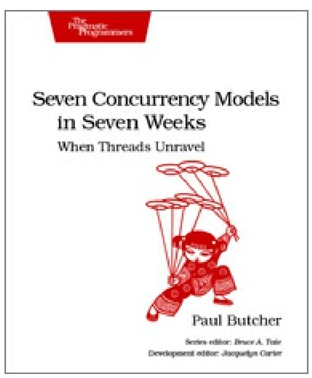

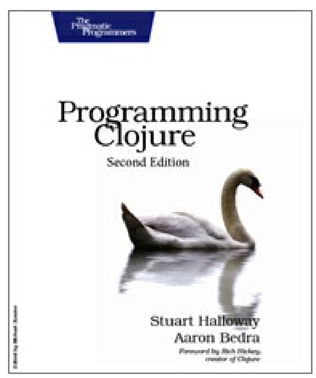

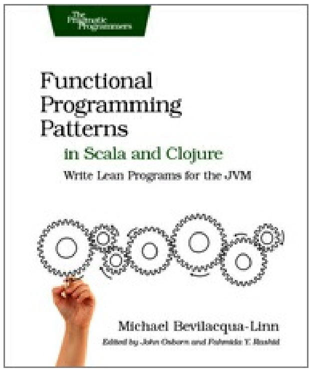
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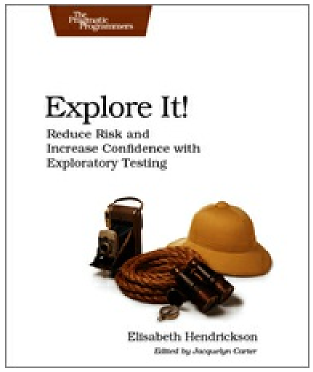
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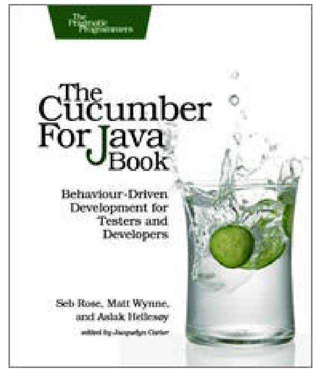
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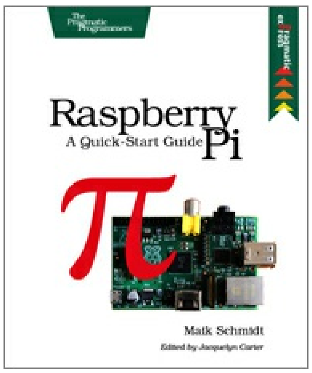
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