2012 COMMEMORATIVE ISSUE

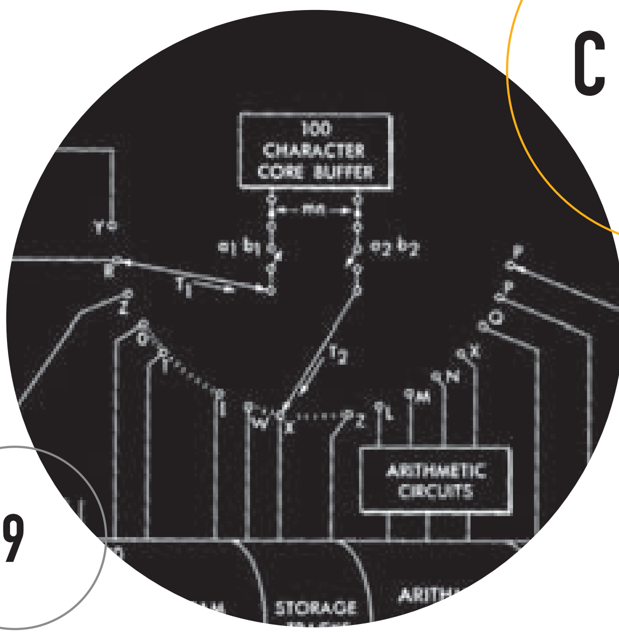
CORE

A Publication of the Computer History Museum

25 Years of the Fellow Awards
The Origins of Timesharing
An Evening with Walter Isaacson

Close up of the Amdahl 470V/6 Computer, 1975. The 470V/6 was the Amdahl Corporation's first product and ran the same software as IBM System/370 computers but cost less and was smaller and faster.

Opposite page: Close-up of IBM 305 RAMAC System Diagram



CORE

2012

SPECIAL SECTION: TWENTY-FIVE YEARS OF FELLOWS

MARK RICHARDS

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DR. KURT W. BEYER

AUTHOR

Kurt, a former naval aviator and professor at the United States Naval Academy, is currently an adjunct professor at Berkeley's Haas School of Business, where he teaches entrepreneurship and innovation. He is the co-founder of a digital media services company and has authored multiple patents (pending) on high-speed digital data processing. His book, *Grace Hopper and the Invention of the Information Age* (MIT Press), was named a top ten science/technology book for 2010 by the American Library Association. Kurt received a master's in economics from Oxford University and his Ph.D. from UC Berkeley. Currently, he advises start-ups and executives in Silicon Valley through Morgan Stanley Smith Barney. He lives in Mill Valley with his wife and two sons.

ALEX BOCHANNEK

CURATOR

Alex Bochannek, curator and senior manager at the Computer History Museum, joined the staff in 2007 following a decade of volunteer work with the Museum. He investigates complex computer-related changes in technology, business, culture, and society. This includes areas as diverse as computing developments outside the United States (especially in Germany and the former Soviet Union); the histories of analog and non-electronic computing; military, financial, and business applications; and theoretical computer science.

JOHN C. HOLLAR

PRESIDENT & CEO

John C. Hollar, President and Chief Executive Officer, directs the Museum's strategic planning and operations. He is responsible for leading the Museum toward its goal of being the world's leading institution exploring the history of computing and its ongoing impact on society. Since joining the Museum in 2008, Hollar has led the development and execution of a new strategic plan that has produced significant growth for the Museum and its mission.

LAUREN SILVER

VP OF EDUCATION

Lauren Silver is Vice President of Education at the Computer History Museum, where she has worked since 2009. Her educational programs incorporate research from the learning sciences into an inquiry-based approach that makes computer history and STEM education principles meaningful for all visitors, from schoolchildren to retired engineers. Her background includes a Ph.D. in developmental psychology, plus more than 20 years' experience teaching, conducting research, and leading education programs in a wide range of settings, including schools; universities; and science, art, and natural history museums.

DAG SPICER

SENIOR CURATOR

Dag Spicer is senior curator at the Computer History Museum, which he joined in 1996. Dag directs the Museum's strategy relating to its collection of computer artifacts, films, documents, software, and ephemera—the largest collection of computers and associated materials in the world. His interests include early electronic computing, computers in medicine, IBM, supercomputers, semiconductors, and computer architecture. He has been interviewed hundreds of times by major news organizations and is internationally recognized as a subject-matter expert in the field of computer history.

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CEO'S LETTER

TO OUR VALUED CORE DONORS

A quarter-century ago, the Computer Museum in Boston established an important tradition that we proudly carry on today: the Fellow Awards. The Computer Museum was our predecessor, as many of you know, and we have carried on several fine traditions begun there. None, however, is more important than the Fellow Awards.

The Awards are important to us, and to the pursuit of history, for at least three reasons. First, the Fellows comprise more than 60 towering figures in the vast field of computing. Every important area is represented. We have honored the greats of early hardware design—Konrad Zuse, Jay Forrester, Gene Amdahl, and others. The Hall includes giants of software—Don Knuth, Ken Thompson, John Backus, Dennis Ritchie, Linus Torvalds, John McCarthy, and more. The architects of the first commercial microprocessor are here—Federico Faggin, Ted Hoff, Stan Mazor, and Masatoshi Shima. We honor individuals whose skills in both technology and business built great commercial enterprises—Gordon Moore, Charles Geschke and John Warnock, Ken Olsen, and Alan Shugart among them. Finally, we honor individuals like Tim Berners-Lee and Vint Cerf, whose very names are synonymous with the stunning development of a globally connected society.

Second, the Fellows represent a category of unsung heroes whose stories are important to tell. They embody the thankless pursuit of technical innovation that triggered enormous human progress. Their work often went on—and in many cases, continues to go on—well out of the limelight of public recognition and acclaim. And yet the diligence, skill, and achievement of our Fellows remain a source of inspiration, especially in those moments when we could stand to feel a bit more inspired. Generations will benefit from the lessons they can teach.

The Fellows are important for a third reason. They represent the essence of computing history—a talented and driven individual, or team, trying to solve a problem. Every great leap forward in computing has involved a focused search for a creative solution to a vexing technical issue. Many of the Fellows were told the problem couldn't be solved at all. Still others were told not to make an attempt—mainly because it wasn't in their job descriptions. From these basic and occasionally rebellious roots, astounding accomplishments grew.

The Museum uses a careful and methodical process to select each year's Fellows. Nominations are open to the public. A select committee from both the private and public sectors reviews each nomination. A weighted balloting process narrows the field through multiple rounds of voting. A Museum committee then makes the final selection.

Only two conditions apply. First, each nominee must be alive at the time of selection, a requirement modeled after the Nobel Prize. Second, we ask that those who are selected also agree to be publicly inducted at the Fellow Awards ceremony. The Fellows Gala is consistently one of the highlights of the Museum's calendar.

We're delighted to present profiles of all of our Fellows in this year's edition of *Core*. And in doing so, we say: here's to the renegades, the geniuses, the rule-breakers, the entrepreneurs, and the problem-solvers. These are our Fellows. I hope you enjoy learning more about them, and celebrating 25 years of the Awards themselves.

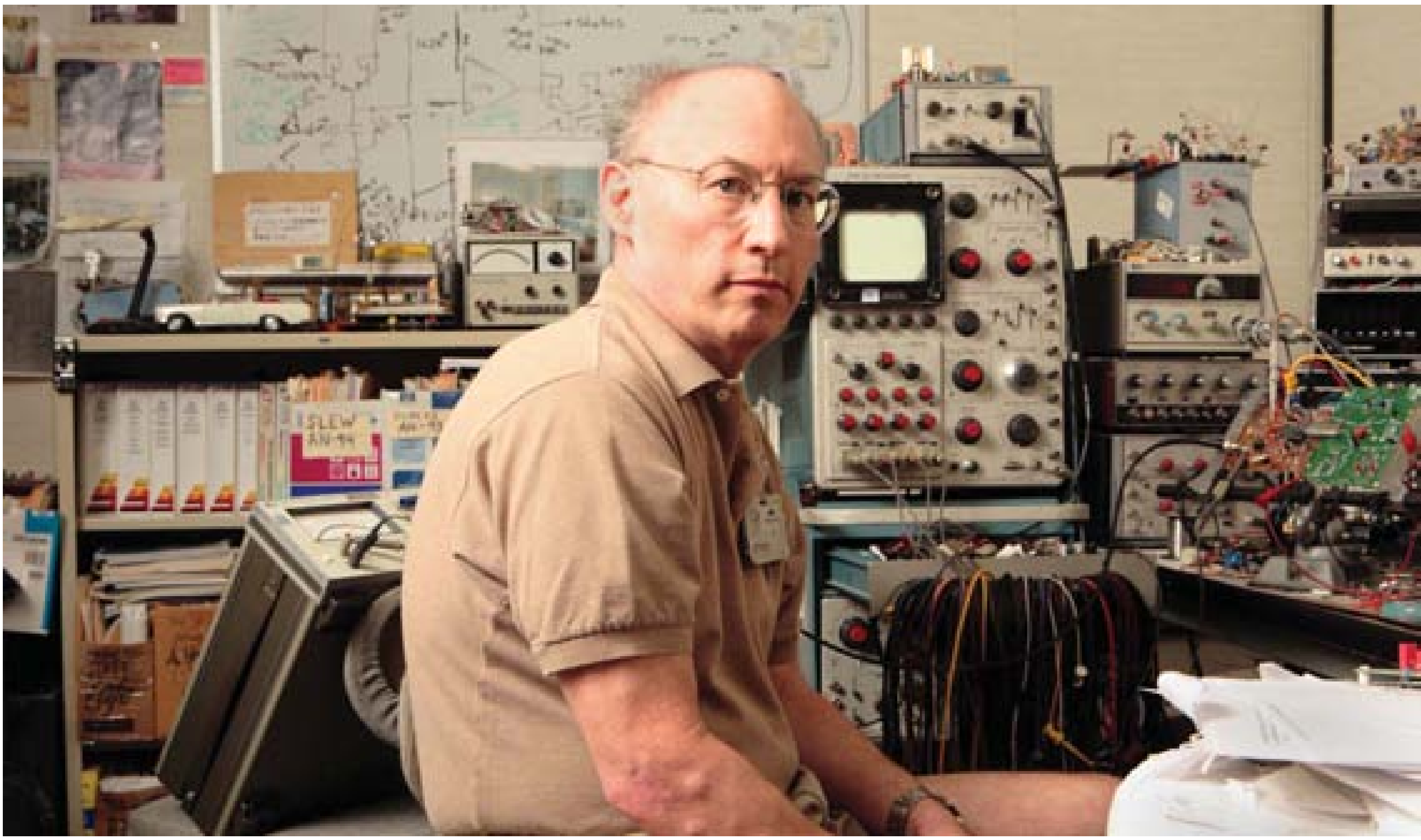
Yours sincerely,

JOHN C. HOLLAR
PRESIDENT & CHIEF EXECUTIVE OFFICER

MUSEUM UPDATES

AN ANALOG LIFE: REMEMBERING JIM WILLIAMS

Analog guru Jim Williams sitting at his famous work bench in 2006



"This exhibit is a memorial to a man but also a monument to his work."

MIKE CASSIDY
SAN JOSE MERCURY NEWS

THIS EXHIBIT IS MADE POSSIBLE THROUGH THE GENEROSITY OF LINEAR TECHNOLOGY

He never tried to impress you with his math or his intellect. He didn't make things complicated so you would think he was smart. He made things look simple. That is why he was brilliant.

PAUL RAKO, TECHNICAL EDITOR, *EDN* REMEMBERS JIM WILLIAMS

The world is a symphony of vibrations. All around us are the sights and sounds of a world alive with continuously varying signals. These real-world sensations are called *analog* signals to distinguish them from *digital* signals, which can only switch between 0 and 1 and which exist only in a computer. Nearly all of our modern technology has both digital and analog components. A smartphone, for example, continuously converts signals between its digital and analog circuits.

The practice of designing analog circuits and systems is as much art as science. Real-world signals vary continuously and can be complex. Analog engineers must combine technical knowledge with a great deal of experience and intuition in order to harness them.

On October 15, 2011, the Museum launched a new exhibit, *An Analog Life*, to showcase the amazing workbench of one of the world's top analog circuit designers, Jim Williams, and to bring the excitement and power of analog technology to a general audience.

In the analog world, Jim Williams was a rock star. His many articles and books encouraged a generation of engineers to pursue intuitive analog design, in which experimentation and testing were emphasized over theory and math. He was entirely self-taught yet set the bar for the entire technical community.

Jim suffered a stroke and passed away on June 12, 2011. Linear Technology, the company Jim worked for, loaned his workbench so that visitors to the Computer History Museum could learn about Jim and the fascinating world of analog circuit design.

On the exhibit's opening night, festivities began with a reception in front of Jim's workbench where people could mingle, think about the exhibit, and tell "Jim stories" (of which there were a lot). Museum CEO John Hollar then led a panel discussion in Hahn Auditorium, focusing on Jim's work and the larger analog world in general. The four panelists were Bob Dobkin, founder and CTO, Linear Technology; Steve Pietkiewicz, VP, Linear Technology; Steve Young, BAM Labs; and Professor Greg Kovacs from the department of electrical engineering at Stanford University.

Jim Williams' unique workbench will be on display at the Computer History Museum from October 15, 2011, to September 15, 2012. Visitors can also learn about Jim Williams online at computerhistory.org/highlights/analoglife

TALKING TO THE FUTURE

FUNDING FOR *TALKING TO THE FUTURE* IS PROVIDED BY THE INTEL CORPORATION

On September 28, the Museum launched a new series for high school students called "Talking to the Future." A collaboration between the Education, Public Programs, and Media departments, "Talking to the Future" brings industry leaders together with high school students to give them an inside look at the world of high tech. Events are being filmed and will be developed into curriculum tools that will be made available to teachers through the Museum website for use in the classroom.

For our first event, Rich Hilleman, Chief Creative Officer at Electronic Arts, joined 19 students from Central County Occupational Center (CCOC), a vocational program for at-risk students in San José; 24 additional students, from the Academia de Informática of the Universidad de Monterrey, Mexico, participated via Skype. We transformed our Computer Graphics gallery into a film studio as Rich presented the students with a challenge: improve EA's popular game, *Plants vs. Zombies*. The students competed in small teams to create proposals, with each person playing a specific role in the development and marketing of their products. At the end of the day, each team presented their ideas; the team with the best proposal—and the best teamwork—got first choice of EA games to take home as prizes.

Feedback after the event indicates that it was a tremendous success. One of the CCOC students characterized it as a confidence-builder and a "huge opportunity." The teacher from Mexico lauded it by saying, "I believe kids…had an experience that will last for years to come…. They were able to do things beyond their imagination, and most important, they really had fun in the process."

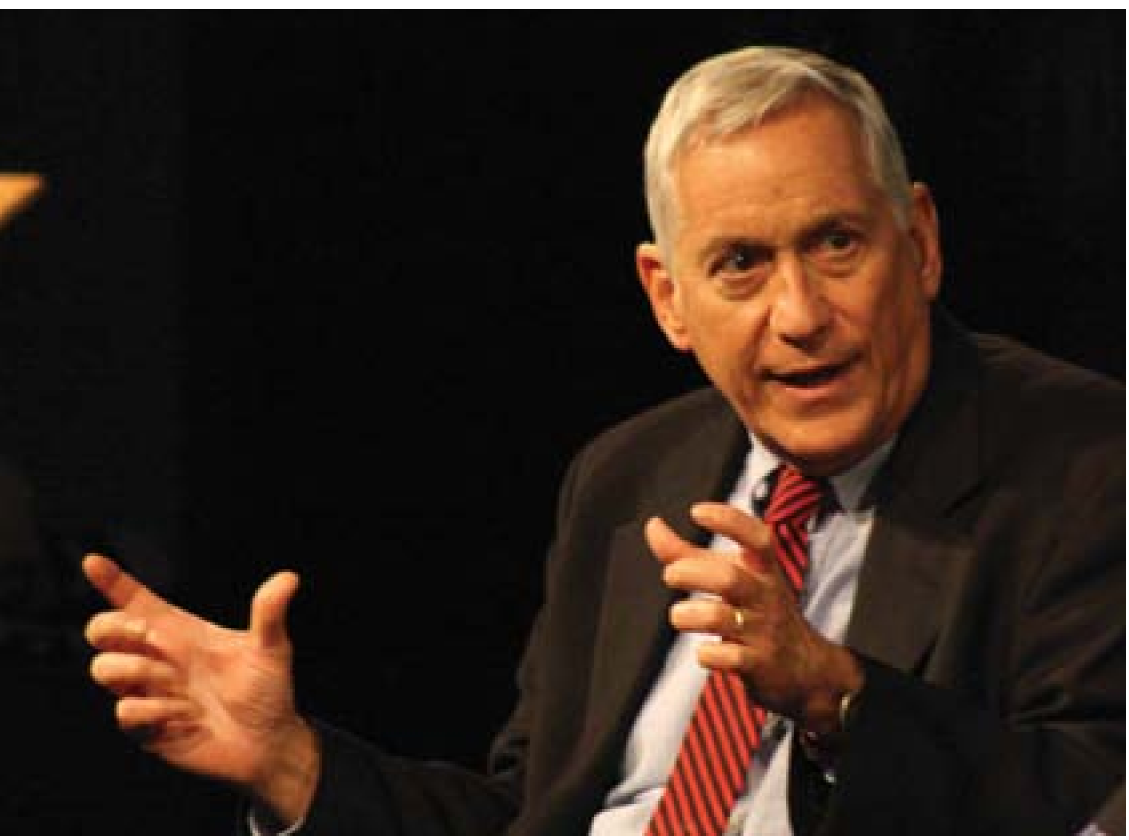
"It was just a wild idea, being able to share 'Talking to the Future' in real time, and you made it possible for us."

ADRIANA HOLGUÍN
INSTRUCTOR AND PROGRAM COORDINATOR, MONTERREY, MEXICO

Electronic Arts' (EA) Chief Creative Officer Rich Hilleman congratulates students for completing his "Talking to the Future" challenge

Q&A: AN EVENING WITH WALTER ISAACSON

In 2011 the Museum launched "Revolutionaries," a year of live events featuring such headliner guests as Mark Zuckerberg, Paul Allen, Pulitzer Prize-winner Jane Smiley, IBM's Sam Palmisano, and Dreamworks Chairman Jeffrey Katzenberg. "Revolutionaries" culminated on December 13, 2011, with a 90-minute conversation between Walter Isaacson, author of the worldwide best-seller *Steve Jobs*, and Museum CEO John Hollar. They began by talking about the process of how the book came to be, and the challenges posed by the famous "Steve Jobs reality distortion field."



Author Walter Isaacson on stage discussing his latest book, *Steve Jobs*, December 2012

Q: Your very first meeting with Steve Jobs was in 1984 when you were an editor at *Time* magazine. He demonstrated the Macintosh. What are your memories of that?

A: You see both sides of Steve. You see the absolutely passionate side with the original Mac. He shows us how small it is, how it looks like a friendly face, not a Neanderthal face, and he shows us all the graphical icons. You can tell he's passionate about every pixel. He's also furious at *Time* magazine. He tells us that we're not nearly as good as *Newsweek*, that somebody—I won't name him, because he lives here—had written a horrible story about him in *Time*. And so I saw the other side of him, the petulant side. That's when I first started to realize that the impatience and petulance that you sometimes saw in Steve Jobs was connected to the passion and the perfectionism.

Q: Did he make a particular impression on you in that meeting?

A: I must admit that I was mesmerized by him. You could tell the first time you met Steve Jobs that there was something compelling about him.

Q: So, flash forward 20 years. It's 2004, and he gets in touch with you.

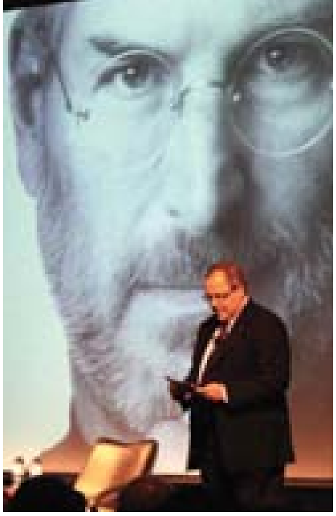
A: I had just joined the Aspen Institute. He called, and we talked a little while. I said, "Do you want to come speak at Aspen?" He said, "No, but I want to come take a walk with you." And after a while, he said, "Why don't you do a biography of me?" I had done Ben Franklin. I was just finishing Albert Einstein. So I thought, okay, you know, Franklin, Einstein, Steve, it's a good progression.

Q: I'm sure that was on his mind.

A: But then I said, "You know, you're a really, really great subject, but let's wait 30 years until you retire." It wasn't until 2009, when he had had his liver transplant and went on medical leave, that it sort of sunk in that he was fighting cancer. By that time we had seen how he had transformed, with his team, a wide variety of industries—first home computing and personal computing, and, by 2009, the music industry, the phone industry, the publishing industry, tablet computing. So I said, all right, this is too good to pass up.

Q: Did you have a theory about him going in?

A: I did have a theory. In his very first phone call, he told me something that [Polaroid founder] Edwin Land had said to him, which is that you always want to stand at the



Museum CEO John Hollar takes the stage during *An Authorized Biography of Steve Jobs* event

MAJOR FUNDING FOR THE REVOLUTIONARIES SERIES IS PROVIDED BY THE INTEL CORPORATION

intersection of the humanities and technology. That's something we lost in the C.P. Snow era, where you either were in the humanities or in the sciences. My theory, among others, was that connecting creativity to wonderful feats of engineering was what made him so magical.

Q: In the book, you wrote this: "His passion for perfection led him to indulge his instinct to control." You must have had to raise and settle the question of editorial control early on. How did you do that?

A: I was stunned, because it never really came up. All along he kept saying, "Well, it's your book, it's your book, I'm not even going to read it." He said, "I want it to be honest. I want you to interview, you know, people who didn't like me, as well as people who did," because he said that he was brutally honest his whole life. He said he wanted it to feel like an independent book, and therefore he was going to exercise no editorial control.

Q: Did that ever change? Did he ever call you up and say, you know...

A: Well, the one time he did fits into his theory that people don't read books, but they do look at them. Simon & Schuster, about a year ago, put into their catalogue a cover design. It was just a placeholder. And it was a cover with Steve, and with the title *iSteve*. I had just landed in San Francisco, coming to a product launch that he was going to do. I saw the thing you least like to see on your iPhone, which is six or seven missed calls from Steve Jobs. So I'm standing there in the concourse, and I call him, and he just starts yelling at me. He said, "You have no taste," and, "The title is gimmicky, and it's just ugly, and I don't even want you to come to the demonstration." I'm holding the phone away from my ear, and finally he said, "I'm not going to continue to cooperate unless you allow me to have input into the cover art." It took me somewhere between a second and a second and a half to say, "Sure." Here's the greatest design eye for something like that, and he wants input. He spent a lot of time just trying to make it very simple and very clean. So that was the one time I felt his wrath, and also the one time when he had editorial input.

Q: You quote his friends talking about the famous Steve Jobs "reality distortion field." Did you find yourself getting sucked into that from time to time?

A: Well, I think you'd be the last to know. Andy [Hertzfeld] writes about it in *Revolution in the Valley*. It's taken from *Star Trek*. The reality distortion field means that simply by thinking something, and being convinced of something, even if it's impossible, you can convince other people. And the secret is that it sometimes works—that you can convince people they can do the impossible. Woz [Steve Wozniak] talked about that to me. Steve would say, "You'll have to do this in four days." Woz would say, "It can't be done." And Steve would say, "You can do it." Four days later it had been done. So the question of whether I got sucked into it—I found myself deeply emotionally vested with him. I tried very hard to be honest in the book, to put all things and all sides in. But there will be people in this audience who will know more than most, and if they read the book and say, boy, this guy got caught in the reality distortion field, I guess the answer would be yes.

Q: One final question about the process. You had the luxury of a long historical detachment from Einstein, from Benjamin Franklin, perhaps not so much with Kissinger. But here you are, writing a biography of a very compelling living person, up close and personal with him in 40 interviews. How does a biographer maintain the kind of detachment that you can have just by not being able to spend time with Einstein or Franklin?

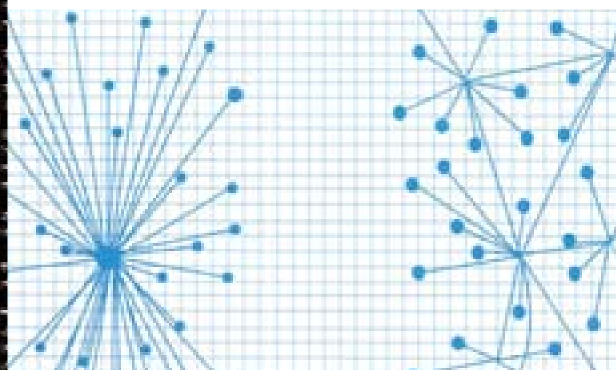
A: Well, a couple of things. First, you become a storyteller. You don't try to preach. I just tried to let the stories tell themselves. The other is—one of the things I discovered by having so much time with him, and so much time with 150 other people who worked with him, was how much more we know or I could know about him than I did about Franklin or Einstein. Benjamin Franklin wrote 40 volumes of papers. They're still compiling Einstein's papers, and in the future we'll know more. But with Steve, I'd hear about everything that happened at great length, and then hear other people's versions. I probably ended up knowing 100 or maybe 1,000 times more about him, and each story in the book, than you would know only know through letters or journals. ○

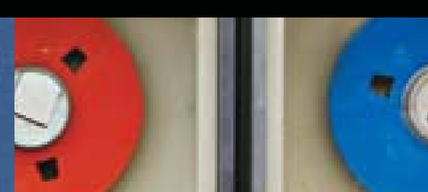
The full interview is available on the Museum's YouTube channel: youtube.com/computerhistory

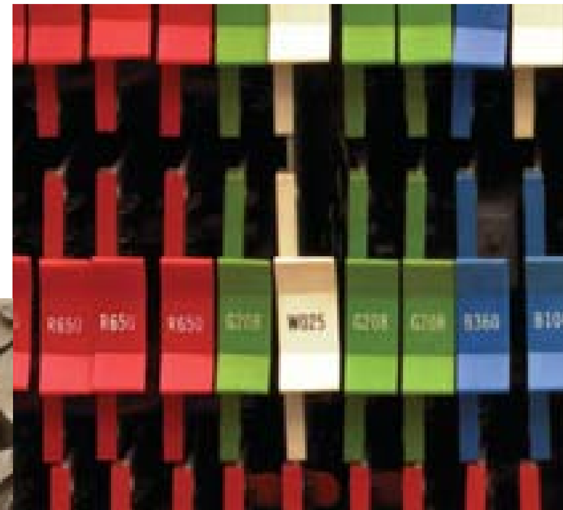
THE PRESIDENT @ CHM

On September 26, 2011, the Museum hosted President Barack Obama's town hall meeting with LinkedIn CEO Jeff Weiner. More than 350 people filled Hahn Auditorium for the nationally broadcast town hall, which covered job creation and economic recovery. LinkedIn members asked questions of the president for 90 minutes, both from the audience and through a global webcast.

For the past twenty-five years, the Computer History Museum Fellow Awards have honored distinguished technology pioneers for their contributions to the evolution of the modern Information Age.

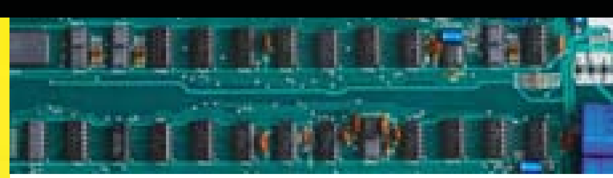






FEATURE

HALL OF FELLOWS



TWENTY-FIFTH ANNIVERSARY

HISTORY

THE FELLOW AWARD

BY DAG SPICER

For the past 25 years, the Computer History Museum has celebrated individuals who have made a difference in the world through computer technology. Known as Museum Fellows, awardees cover the gamut of technologies and eras, from the pioneers who worked in the earliest days of room-sized vacuum-tube behemoths to the creators of today's ubiquitous handheld mobile world.

Fellows have something else too: an extra passion and drive for changing the world around them.

The Fellow Award began at the instigation of Gwen Bell, co-founder of the Boston-based Computer Museum, the predecessor of CHM. Our first Fellow, announced in 1987, was Admiral Grace Murray Hopper, a legendary programmer and spokesperson for computer education. Reflecting on her role in the development of the COBOL programming language, a means for non-technical users to interact with a computer, Hopper notes:

When I started I just went ahead with the idea. I have later learned that it is much easier to apologize than to get permission. In the case of Flowmatic [an earlier language developed by Hopper], we discovered that a lot of people hated symbols, even though the mathematicians and engineers loved them. These people used words. We proposed that we should write programs in English statements providing a compiler that would translate to machine language code. I was told that this couldn't happen because computers don't understand words… So we acted on the motto: "Just go ahead and do it."

Beginning in the 1960s and continuing for the next several decades, COBOL became the most successful programming language in business history, bridging a critical gap between technical and non-technical users and bringing the power of the computer to a rapidly modernizing world coming to grips with an information explosion.

Hopper's experience is not unusual among Fellows. Many, if not most of them, overcame significant obstacles before achieving success. Consider German engineer Konrad Zuse, working in Berlin during WWII in complete isolation to build groundbreaking computers as bombs dropped overhead. Or Jean Bartik, original ENIAC programmer, who struggled for respect in a man's world of engineers and mathematicians. Her secret to success? "Look like a girl, act like a lady, think like a man, and work like a dog." Or Morris Chang, who not only built a new industry (fabless semiconductor design and production) but helped build a new country (Taiwan) while doing so.

CHM Fellows have had an impact on a wide range of disciplines and industries. Reflecting the diversity of computing itself, Fellows have made pioneering contributions to compilers, programming languages, computer architecture, the Internet and World Wide Web, personal computing, mainframes, supercomputers, minicomputers, databases, semiconductors, cryptography, microprocessors, graphics, printing, the theory of computation, artificial intelligence, networking, storage, and operating systems.

Most Fellows are from the United States, though this is changing, and a slightly greater number are known for software rather than hardware innovations. Most have Ph.D.s and come from an American university. Nearly a third of CHM Fellows are also ACM Turing Award winners, the highest professional award in the field and sometimes known as the "Nobel Prize of computing."

As a group, these people have touched our lives by creating the world in which we live. Their impact may at first seem subtle or highly technical but as their ideas take hold, they redefine the realm of the possible in ways we did not imagine. Through a process of creative destruction, old ways of doing things are done away with as new ideas, materials, and technologies—and ways of organizing them—are developed. Being a universal machine, one that has "lifted all boats" societally, it is perhaps not surprising that the computer as a technology attracts such a diverse range of people and problems as CHM Fellows.

How do they do it? Success, it has been said, is the confluence of preparation and opportunity. CHM Fellows, almost without exception, were very well prepared by first-class educations, and the opportunity they shared was to live in a time when something completely new—the stored-program electronic digital computer—came to fruition. Against this technological backdrop, they pursued their work, shaping and being shaped by the computer itself. Sometimes, individuals are given great credit when a team might more accurately represent the relative contributions involved. As Vint Cerf noted in his 2000 Fellow Award acceptance speech, "Many people think they built the cathedral we call technology. But in reality, we are each just adding our own brick to the edifice." Indeed, innovations that are the work of a sole individual are becoming exceedingly rare, and recent CHM Fellow Awards reflect this fact.

Whether sole contributors or team members, however, these are the true heroes of the information age, fulfilling one of the purposes of the Awards, which was to recognize the technologists who have shaped our world but who are rarely acknowledged publically. While our society readily glamorizes highly paid athletes and rock stars, it does little to reward or acknowledge the people who have done a great deal of the work in building our modern civilization. Inspiring others to pursue a career in computing, especially young people, is one of the ways that Museum Fellows have given back to a new generation and sought to make technology an exciting option for them.

Over its 25-year history, the CHM Fellow Awards have showcased many of the leading innovators of our time and brought these accomplishments to the world at large. Museum Fellows are unique, talented, hardworking, and passionate. We hope to continue honoring these unsung revolutionaries who have created our modern world for another 25 years. What will the future bring? ○

Computer History Museum Fellow Award trophy

The best advice I can give a young person starting out today is to not be afraid of doing things that seem crazy.

MARTIN HELLMAN, 2011 CHM FELLOW

FELLOWS AT A GLANCE

Key

Alma Mater

Worked at

SOFTWARE

Grace Hopper
1987
Born:
New York, NY
Alma Mater:
Yale
Worked at:
Univac, US Navy
Known for:
Programming, education

Mitch Kapor
1996
Born:
Brooklyn, NY
Alma Mater:
Beacon College
Worked at:
Lotus Development Corp
Known for:
Lotus 1-2-3

John Backus
1997
Born:
Philadelphia, PA
Alma Mater:
Columbia
Worked at:
IBM
Known for:
FORTRAN

Dennis Ritchie
1997
Born:
Bronxville, NY
Alma Mater:
Harvard
Worked at:
Bell Labs
Known for:
UNIX

Ken Thompson
1997
Born:
New Orleans, LA
Alma Mater:
UC Berkeley
Worked at:
Bell Labs
Known for:
UNIX

Don Knuth
1998
Born:
Milwaukee, WI
Alma Mater:
Caltech
Worked at:
Stanford
Known for:
Art of computer programming

John McCarthy
1999
Born:
Boston, MA
Alma Mater:
Princeton
Worked at:
Stanford
Known for:
Artificial Intelligence

Frances Allen
2000
Born:
Plattsburg, NY
Alma Mater:
University of Michigan
Worked at:
IBM
Known for:
Compilers

Vint Cerf
2000
Born:
New Haven, CT
Alma Mater:
UCLA
Worked at:
UCLA, ARPA
Known for:
Networking

Jean Sammet
2001
Born:
New York, NY
Alma Mater:
University of Illinois
Worked at:
IBM
Known for:
History of programming languages

Fred Brooks
2001
Born:
Durham, NC
Alma Mater:
Harvard
Worked at:
IBM, UNC
Known for:
Computer architecture

Maurice Wilkes
2001
Born:
Dudley, UK
Alma Mater:
University of Cambridge
Worked at:
University of Cambridge
Known for:
EDSAC, programming languages

Charles Geschke
2002
Born:
Cleveland, OH
Alma Mater:
Carnegie-Mellon University
Worked at:
Xerox PARC, Adobe
Known for:
Page Desciption Languages (PDF), co-founder Adobe

John Warnock
2002
Born:
Salt Lake City, UT
Alma Mater:
University of Utah
Worked at:
Xerox PARC, Adobe
Known for:
Page Desciption Languages (PDF), co-founder Adobe

John Cocke
2002
Born:
Charlotte, NC
Alma Mater:
Duke
Worked at:
IBM
Known for:
Computer architecture

1987 1995 1996 1997 1998 1999 2000 2001 2002

HARDWARE

Jay Forrester
1995
Born:
Anselmo, NE
Alma Mater:
MIT
Worked at:
MIT
Known for:
Whirlwind, Core memory

Ken Olsen
1996
Born:
Bridgeport, CT
Alma Mater:
MIT
Worked at:
Digital Equipment Corporation (DEC)
Known for:
Co-founder DEC

Steve Wozniak
1997
Born:
San José, CA
Alma Mater:
UC Berkeley
Worked at:
Apple
Known for:
Co-founder, Apple Computer, Inc.

Gene Amdahl
1998
Born:
Flandreau, SD
Alma Mater:
University of Wisconsin
Worked at:
IBM, Amdahl
Known for:
Computer architecture

Gordon Moore
1998
Born:
San Francisco, CA
Alma Mater:
Caltech
Worked at:
Intel
Known for:
Co-founder, Intel

Alan Kay
1999
Born:
Springfield, MA
Alma Mater:
University of Utah
Worked at:
Xerox PARC
Known for:
Alto, Dynabook

Konrad Zuse
1999
Born:
Berlin, Germany
Alma Mater:
TH-Charlottenberg-Berlin
Worked at:
Zuse KG
Known for:
Early computer systems

Tom Kilburn
2000
Born:
Dewsbury, UK
Alma Mater:
University of Manchester
Worked at:
University of Manchester
Known for:
Williams-Kilburn tube

Carver Mead
2002
Born:
Bakersfield, CA
Alma Mater:
Caltech
Worked at:
Caltech
Known for:
VLSI design

Tim Berners-Lee
2003
Born:
London, UK
Alma Mater:
Oxford
Worked at:
CERN, WWWC
Known for:
World Wide Web

David Wheeler
2003
Born:
Birmingham, UK
Alma Mater:
University of Cambridge
Worked at:
University of Cambridge
Known for:
Programming languages

Dan Bricklin
2004
Born:
Philadelphia, PA
Alma Mater:
Harvard
Worked at:
Software Arts
Known for:
VisiCalc

Bob Frankston
2004
Born:
Brooklyn, NY
Alma Mater:
MIT
Worked at:
Software Arts
Known for:
VisiCalc

Niklaus Wirth
2004
Born:
Winterthur, Switzerland
Alma Mater:
UC Berkeley
Worked at:
ETZ - Zurich
Known for:
Pascal, Modula-2, education

Paul Baran
2005
Born:
Grodno, Poland
Alma Mater:
UCLA
Worked at:
SRI
Known for:
Packet swtiching

Doug Engelbart
2005
Born:
Portland, OR
Alma Mater:
UC Berkeley
Worked at:
SRI
Known for:
Human Computer Interfaces

Ivan Sutherland
2005
Born:
Hastings, NE
Alma Mater:
MIT
Worked at:
University of Utah, Caltech, Sun
Known for:
Computer graphics, education

Antony Hoare
2006
Born:
Colombo, Sri Lanka
Alma Mater:
Oxford University
Worked at:
Oxford University
Known for:
Theory of programming languages

Robert Kahn
2006
Born:
New York, NY
Alma Mater:
Princeton
Worked at:
BBN, ARPA
Known for:
ARPANET

Butler Lampson
2006
Born:
Washington, DC
Alma Mater:
UC Berkeley
Worked at:
Xerox PARC
Known for:
Xerox Alto, operating systems

Marvin Minsky
2006
Born:
New York, NY
Alma Mater:
Princeton
Worked at:
MIT
Known for:
Artificial Intelligence

Linus Torvalds
2008
Born:
Helsinki, Finland
Alma Mater:
University of Helsinki
Worked at:
University of Helsinki
Known for:
Linux

Jean Bartik
2008
Born:
Gentry County, MO
Alma Mater:
University of Pennsylvania
Worked at:
Upenn
Known for:
ENIAC

Don Chamberlin
2009
Born:
San José, CA
Alma Mater:
Stanford
Worked at:
IBM
Known for:
Databases

2011
Cryptography Team:

Whitfield Diffie
Born:
Washington, DC
Alma Mater:
MIT
Worked at:
Stanford, Sun
Known for:
Security, cryptography

Martin Hellman
Born:
New York, NY
Alma Mater:
Stanford
Worked at:
Stanford
Known for:
Security, cryptography

Ralph Merkle
Born:
Berkeley, CA
Alma Mater:
Stanford
Worked at:
Stanford
Known for:
Security, cryptography

Edward Feigenbaum
2012
Born:
Weehawken, NJ
Alma Mater:
Carnegie Mellon University
Worked at:
Stanford
Known for:
Artificial Intelligence

Fernando Corbató
2012
Born:
Oakland, CA
Alma Mater:
MIT
Worked at:
MIT
Known for:
Timesharing

2003 2004 2005 2006 2007 2008 2009 2011 2012

Gordon Bell
2003
Born:
Kirksville, MO
Alma Mater:
MIT
Worked at:
DEC
Known for:
Computer architecture

Erich Bloch
2004
Born:
Sulzburg, Germany
Alma Mater:
University of Buffalo
Worked at:
IBM
Known for:
System/360

Bob Evans
2004
Born:
Grand Island, NE
Alma Mater:
Iowa State
Worked at:
IBM
Known for:
System/360

Alan Shugart
2005
Born:
Los Angeles, CA
Alma Mater:
University of Redlands
Worked at:
IBM, Seagate
Known for:
Storage

Morris Chang
2007
Born:
Ningbo, China
Alma Mater:
Stanford
Worked at:
TSMC
Known for:
Fabless semiconductors

John Hennessy
2007
Born:
Long Island, NY
Alma Mater:
SUNY
Worked at:
Stanford, MIPS
Known for:
RISC, CS education

Chuck Thacker
2007
Born:
Pasadena, CA
Alma Mater:
UC Berkeley
Worked at:
Xerox PARC
Known for:
Xerox Alto

David Patterson
2007
Born: Evergreen Park, IL
Alma Mater:
UCLA
Worked at:
UC Berkeley
Known for:
Computer science education

Bob Metcalfe
2008
Born:
Brooklyn, NY
Alma Mater:
Harvard
Worked at:
Xerox PARC
Known for:
Ethernet

Robert Everett
2009
Born:
Yonkers, NY
Alma Mater:
MIT
Worked at:
MIT, MITRE
Known for:
System/360

2009
Intel 4004 Team:

Federico Faggin
Born:
Vicenza, Italy
Alma Mater:
Padua
Worked at:
Intel, Zilog

Ted Hoff
Born:
Rochester, NY
Alma Mater:
Stanford
Worked at:
Intel

Stan Mazor
Born:
Chicago. IL
Alma Mater:
Worked at:
Intel

Masatoshi Shima
Born:
Shizuoka, Japan
Alma Mater:
University of Tsukuba
Worked at:
Busicom, Intel

Bill Joy
2011
Born:
Farmington Hills, MI
Alma Mater:
UC Berkeley
Worked at:
Sun Microsystems
Known for:
Co-founder, Sun Microsystems and UNIX system

Steve Furber
2012
Born:
Manchester, UK
Alma Mater:
University of Cambridgea
Worked at:
Acorn Computers
Known for:
BBC Micro, ARM Processor

Sophie Wilson
2012
Born:
Leeds, UK
Alma Mater:
University of Cambridge
Worked at:
Acorn Computers
Known for:
BBC Micro, ARM Processor

GRACE MURRAY HOPPER

BY KURT BEYER

On the eve of World War I, Field Marshal Ferdinand Foch, a world-renowned military strategist at the French École Supérieure de Guerre, asserted that "Airplanes are interesting toys but of no military value." With similar sincerity, computer pioneer Howard Aiken believed that no more than a handful of computers would be needed to handle the world's computational needs. So often, "experts" have difficulty seeing beyond the borders of their specialty. Education, tradition, and community culture create a mental framework that helps to bring order to a given field or discipline on the one hand, yet on the other also hinders one's ability to see alternative approaches or adjust to ever-changing external circumstances. The rare expert looks beyond "what is" to grasp "what could be." It is even more unusual for the expert to methodically pursue the vision and make it a future reality, often in the face of mounting organizational opposition. Grace Murray Hopper was such a visionary, and her commitment to computer programming helped shape the modern technical milieu.

Along with Howard Aiken, Grace Hopper was present at the birth of the computer age. The events of December 7 at Pearl Harbor inspired the young mathematics professor to radically alter the direction of her life. Within a year of the fateful day, Hopper left her tenured position at Vassar College, separated from her husband Vincent Hopper, and attempted to join the U.S. Navy. Not knowing exactly what to do with a five-foot-three, 105-pound Ph.D., the Navy Bureau of Personnel turned down Hopper's request. With the introduction of the WAVES (Women Accepted for Volunteer Emergency Service) on July 30, 1942, Hopper's persistence paid off, and the newly minted officer found herself in charge of operating one of the world's first computers, the Harvard Mark I.

The Automatic Sequence Controlled Calculator, as the machine was officially called, was the brainchild of Harvard graduate student and navy reserve officer Howard Aiken. The complex machine was 8 feet high, 51 feet long, weighed 9,445 pounds, and contained 520 miles of wiring. When Hopper first set eyes on it in the summer of 1944, she thought it was one of the most beautiful machines she had ever seen, and was astounded at its computational speed of three additions per second. Aiken had designed the machine to generate ballistic tables for the war effort, but Hopper and her crew soon found themselves solving a range of mathematical problems, including the infamous implosion solution for the first atomic bomb. Initially, out of wartime necessity, Hopper developed coding techniques, subroutine principles, debugging practices, and batch processing procedures that served as the early foundation of programming practice. Hopper captured her programming concepts in the Mark I's 560-page *Manual of Operation*, which she wrote and published in 1946.

REMARKABLE PEOPLE

CHM'S FIRST FELLOW

VISIONARY PIONEER

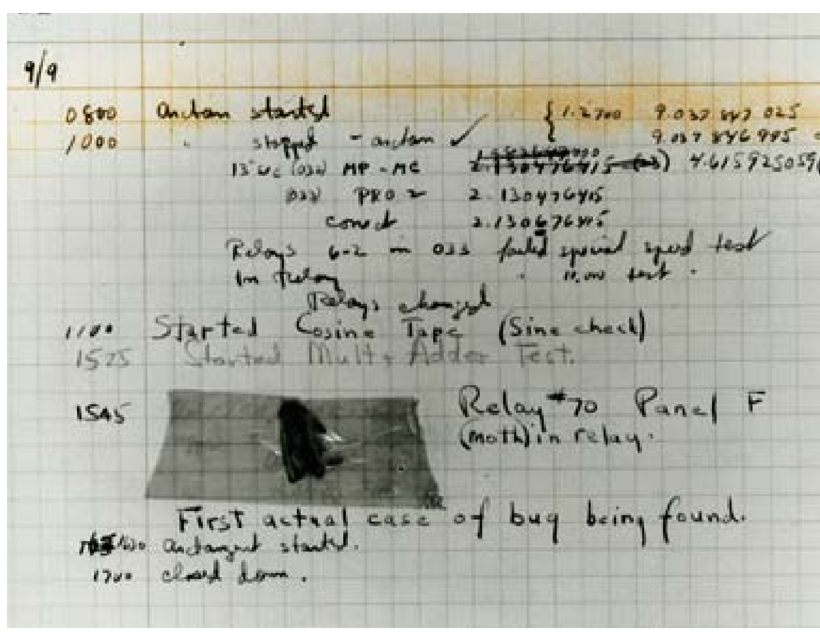
More importantly, she exposed a variety of people to her programming techniques. Hopper's crew went on to seed the nascent computer industry and form the Association of Computing Machinery (ACM), while prominent visitors such as John von Neumann received a hands-on education in how to program and operate a large-scale computer, something that was not lost on him nine months later when he described stored-program architecture in his seminal paper, *First Draft of a Report on the EDVAC*.

As computer technology was transferred from the laboratory to the private sector in the 1950s, programming became the bottleneck that hindered its spread. The costs associated with defining a computer application, along with writing and debugging the associated programs, began to outstrip the cost of hardware itself. Pioneers like Aiken concluded that these technical challenges set the boundaries of the computer's long-term utility and confined the machines to the status of complex scientific instruments. Hopper, who by 1949 had become the senior mathematician at the Eckert-Mauchly Computer Corporation, believed that the technical bottleneck could be overcome by teaching the computers to program themselves. She called her key invention, the one upon which most modern computer languages rest, the compiler. Hopper's compiler allowed the computer to call upon relevant subroutines, manage address and memory allocation, simplify debugging, and, in general, relieve the human programmer from the most difficult and tedious housekeeping tasks.

Compilers, Hopper believed, were the key to "democratizing" computers. The innovation would allow a much wider audience to communicate with the machines. Instead of forcing the human to learn machine language, source code could be written in the language of the mathematician, accountant, or business administrator. During the 1950s, Hopper relentlessly pushed her vision of "automatic programming." As director of programming at Remington Rand UNIVAC, Hopper spearheaded the creation of the first mathematical and business-language compilers. More importantly, she understood that she had to sell her vision to a variety of stakeholders inside and outside of her UNIVAC division. Between 1953 and 1959, Hopper published dozens of articles on the subject, gave hundreds of speeches at conferences and symposiums, and organized a multitude of programming workshops and symposiums.

The most famous conference Hopper orchestrated was held in May 1959. After the war, Hopper remained active in the navy and arranged for the Department of Defense to host the organizational meeting of the Conference on Data Systems Languages (CODASYL). Forty representatives from seven government agencies, eleven companies (users), and ten computer manufacturers attended and were given the task of defining the desired characteristics of a universal business language. Hopper asked Charles Phillips from DOD to chair the two-day meeting, while Hopper served as Phillips' technical advisor.

The ensuing COBOL report, which drew heavily from Hopper's Flowmatic business language, was approved by Hopper and the CODASYL executive committee in January 1960. In the years that followed, scores of people predicted the demise



Left: Grace Hopper in front of a UNIVAC computer, 1961
Right: First computer bug? Harvard Mark II logbook showing a moth found in the machine, 1947

of Hopper's common business language. These forecasts were not the uninformed views of a few but rather, the sound, informed observations of the computer industry's experts, ranging from programmers to computer industry executives. The critique of COBOL included complaints about the language's semantic verbosity, its syntactical redundancy, and its overall lack of linguistic elegance. But COBOL flourished on an unprecedented scale, despite the warnings of the experts. In the 10 years after its introduction, COBOL became the most widely used programming language throughout the world. By the turn of the millennium, it was estimated that 240 billion of the 300 billion lines of computer code (about 80 percent of all code worldwide) had been written in COBOL.

Throughout the 1960s, Hopper understood that no matter how well designed a new technology appears to be, it cannot spread spontaneously. Once again, she led the marketing effort to have COBOL adopted as a standardized language for both the public and private sector. By this time, however, Hopper had become a dominant figure within the maturing computer industry. She had the unique ability to operate in a variety of public, private, and academic subcultures and could translate her computing vision into a language that each of these groups understood, communicating complex technology to technically savvy people and non-technical people alike. Her special gifts and unique position allowed her to democratize the industry and evolve the computer into a far more personal technology than many believed it could be.

As the 1960s came to a close, Grace Murray Hopper stepped down as the director of Automatic Programming, UNIVAC division of Sperry Rand. From all appearances, the 60-year-old Hopper was making the transition to retirement. Showered with numerous accolades, in 1962, the computer pioneer was elected Fellow of the Institute of Electrical and Electronic Engineers (IEEE), and two years later, received the lifetime achievement award from the Society of Women Engineers. The highlight of these tributes came in 1969, when the Data Processing Management Association named Hopper the first-ever Computer Sciences "Man of the Year." Since 1971, the Association of Computing Machinery has bestowed the Grace Hopper Prize in Computer Science to the computer professional who makes the single most significant technical or service contribution.

But to the surprise of everyone—except probably Hopper—"retirement" merely signaled the beginning of a new productive phase in her life. The navy was experiencing difficulties in fully implementing COBOL throughout its growing computer infrastructure, and Hopper was once again called to duty. What began as a six-month contract extended for 20 years of active military duty during which Hopper helped modernize the fleet's tactical data systems. In 1983, by presidential appointment, Hopper was promoted to Rear Admiral, and during her final three years of service she continued to tour and lecture, spreading the word of the information age that she helped to create. The oldest active-duty officer in the U.S. Navy finally retired in 1986 and was hired immediately by the Digital Equipment Corporation, where she worked as a senior consultant until her death in 1992 at the age of 86.

Undeniably, Grace Murray Hopper played a pivotal role in the development of both the computer industry and the modern navy. In 1987, Hopper was rightly named the first Computer History Museum Fellow and received the National Medal of Technology from President Ronald Reagan. What makes Hopper's story even more compelling is the fact that her greatest accomplishments in the field came at a time when many American women were retreating from public life. Ultimately, Hopper's ability to transcend organizational and cultural gender bias in the 1950s and 1960s and elevate her career to uncharted heights may best be explained by her unique character. Hopper's confidence in her abilities, leadership skills, sense of humor, and determined nature allowed her to win over even her toughest critics and push forward her vision of a more democratic and ubiquitous computer industry. Today, Grace Hopper has become a role model for a new generation of women in the computing industry and the U.S. Navy. Each year, women from around the world gather at the Grace Hopper Celebration of Women in Computing Conference, the largest technical conference of its kind to support women in technical careers. Of all her accomplishments, this may be Hopper's greatest legacy. ○

To learn more about Grace Murray Hopper, see Dr. Kurt Beyer's book, *Grace Hopper and the Invention of the Information Age*. Cambridge: The MIT Press, 2009.

>

CHM FELLOWS

Learn more about all of the Computer History Museum Fellows in the following pages

GRACE HOPPER

1987

For her development of programming languages, computer instruction, and lifelong naval service.

Grace Hopper was born in New York, New York, in 1906. She held a B.S. in mathematics and physics from Vassar College (1928) and an M.S. (1930) and Ph.D. in mathematics (1934) from Yale University.

Hopper began her career teaching at Vassar and taught there from 1931 to 1943, when she joined the U.S. Navy Reserve. Her first assignment was to work with Professor Howard Aiken of the Harvard Computation Laboratory on problems of military significance.

Hopper remained at Harvard until 1949, when she joined the Eckert-Mauchly Computer Corporation, led by the designers of the groundbreaking ENIAC computer system. There, she developed one of the world's first compilers and compiler-based programming languages. In 1959, Hopper played an important role in defining a new easy-to-use programming language. The result was COBOL, probably the most successful programming language for business applications in history.

Hopper retired from the U.S. Navy Reserve in 1986 with the rank of Rear Admiral and was then hired as a senior consultant to Digital Equipment Corporation, a position she retained until her death in 1992, at age 86.

Hopper was widely recognized for her achievements and her often humorous lectures on computer science topics. She received many awards, including the U.S. National Medal of Technology (1991).

COBOL Tombstone, 1960

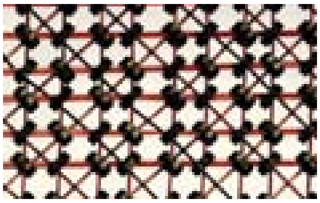
JAY FORRESTER

1995

For his perfecting of core memory technology into a practical computer memory device and for fundamental contributions to early computer systems design and development.

Jay Forrester was born near Anselmo, Nebraska, in 1918. He holds a B.S. in electrical engineering from the University of Nebraska (1939) and an M.S. from MIT (1945).

While leading the MIT Whirlwind computer project (1947–1953), Forrester developed the "coincident-current" magnetic core memory system, the first reliable, high-speed random access memory for digital computers. This invention was of monumental importance to the further advancement of digital computers and was used for main computer memory in most computers into the 1970s.



MIT Whirlwind magnetic core memory, ca. 1953

Whirlwind itself was groundbreaking. Under Forrester's strong leadership, the project, which employed 175 people and took three years to complete, was the first electronic, stored-program digital computer to operate in real-time. Whirlwind's innovations led directly to the multi-billion-dollar U.S. continental air defense system known as SAGE, and to practical memory systems and high-speed digital design techniques for all computers.

In 1956, Forrester left engineering to join the MIT Sloan School of Management, where he led the development of the field of system dynamics in which computational techniques are used to analyze the social and economic behavior of corporations, cities, and countries.

Forrester's contributions have been widely recognized and include the U.S. National Medal of Technology (1989).

1996

KEN OLSEN

For his introduction of the minicomputer; co-founder, Digital Equipment Corporation (DEC).

Ken Olsen was born in Bridgeport, Connecticut, in 1926. He received a B.S. (1950) and M.S. (1952) from MIT in electrical engineering.

Olsen began working at MIT's digital computer laboratory after graduation and mastered high-speed transistor circuit design from the TX-2 computer project there. He also contributed to the practical implementation and testing of magnetic core memory, a key enabling technology for digital computers.

In 1957, Olsen left MIT and, with funding from America's first venture capital firm, founded Digital Equipment Corporation (DEC) with colleague Harlan Anderson. Although it grew slowly at first, DEC was known as a creative and technically oriented employer that attracted some of the country's best engineers. By the mid-1980s, DEC was the second-largest computer company in the world.

DEC enjoyed a steady rise in growth under Olsen and produced genuinely innovative computer systems until the personal computer revolution occurred and DEC had no clear strategy. Olsen left in 1992 and DEC was acquired by Compaq in 1998.

Olsen received many awards, including the U.S. National Medal of Technology (1993).

With Gwen and Gordon Bell, Ken Olsen was a founder of The Computer Museum. He passed away in 2011.

Ken Olsen on cover of FORTUNE

1996

MITCH KAPOR

For his development of Lotus 1-2-3, the first major software application for the IBM PC.

Mitch Kapor was born in Brooklyn, New York, in 1950. He received a B.A. in psychology from Yale University (1971) and an M.A. in psychology from Beacon College (1978).

Kapor founded Lotus Development Corporation in 1982 with Jonathan Sachs, co-creator of Lotus 1-2-3. Released in January 1983, Lotus 1-2-3 was the first "killer app" for the IBM personal computer (PC). It combined a spreadsheet, charting and graphing, and rudimentary database operations into one application. Used primarily for its spreadsheet function, it was the leading program of its type for DOS-based personal computers for several years, outselling VisiCalc by a significant margin.

Lotus 1-2-3 also became a benchmark, along with Microsoft Flight Simulator, for checking that an IBM "clone" was 100 percent hardware-compatible. Lotus 1-2-3 was eventually surpassed by Excel, the Microsoft Windows-based program.

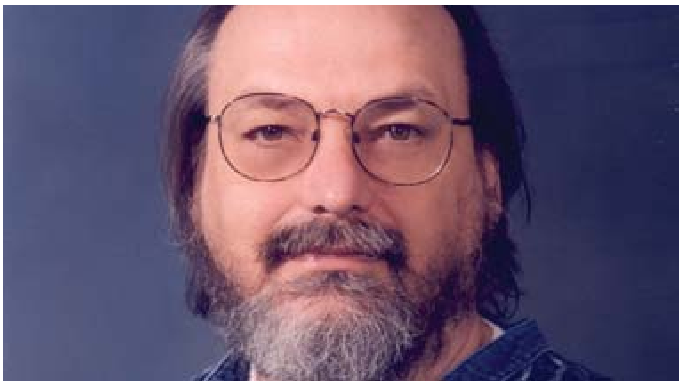
In 1990, with fellow digital rights activists John Perry Barlow and John Gilmore, he co-founded the Electronic Frontier Foundation and served as its chairman until 1994. Kapor has been involved in a number of successful start-ups and was the first chairman of the Mozilla Foundation. He has also served as an adjunct/visiting professor at MIT and has written and lectured widely on technology and society.

Lotus Notes advertisement

1997

KEN THOMPSON

For his co-creation, with Dennis Ritchie, of the UNIX operating system, and for development of the C programming language.



Ken Thompson was born in New Orleans, Louisiana, in 1943. He received a B.S. (1965) and M.S. (1966) in electrical engineering and computer science from UC Berkeley.

In 1969, Thompson and colleague Dennis Ritchie created the UNIX operating system at Bell Telephone Laboratories. UNIX was a scaled-down version of the MIT MULTICS operating system, one meant to run on the new smaller minicomputers becoming available at the end of the 1960s. When re-written in the C programming language by Dennis Ritchie, UNIX became a truly portable operating system capable of running on many different hardware platforms. The C language itself was widely adopted and is in wide use today.

UNIX, which has had numerous incarnations since its inception, has become the backbone of the computerized technical infrastructure of the modern world. UNIX or its variants run on devices as different as supercomputers and smartphones and as enormous as global banking networks and military systems.

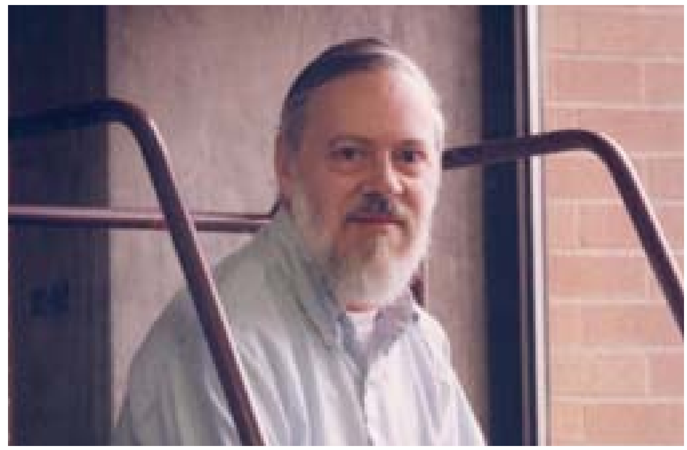
The longevity, reliability, and security of UNIX reflect the excellence of its design as it has been adapted to modern use. Thompson won the ACM Turing Award (1983), the U.S. National Medal of Technology (1999), and the Japan Prize (2011), all with Dennis Ritchie.

Ken Thompson and Dennis Ritchie (standing) at Bell Labs, 1972

1997

DENNIS RITCHIE

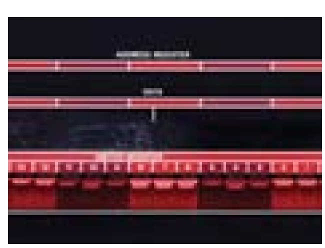
For his co-creation, with Ken Thompson, of the UNIX operating system, and for development of the C programming language.



Dennis Ritchie was born in Bronxville, New York, in 1941. He graduated from Harvard University with degrees in physics and applied mathematics and with a PH.D. in mathematics (1968). His contributions to computing span four decades and have had global impact. While at Bell Labs' Computing Sciences Research Center in the early 1970s, he created the C programming language and co-developed (with Ken Thompson) the UNIX operating system—both of which are foundations of our modern digital world.

The C programming language and its descendants continue to be used to write the software that makes digital devices and networks work, while UNIX and UNIX-like operating systems run on a vast range of computing systems.

Ritchie's early work laid the foundations for much of the technical infrastructure of our modern digital world. He enjoyed traveling and reading, but his main passion was his work, and he stayed with Bell Labs until his retirement in 2007. With Ken Thompson, he was awarded the ACM Turing Award (1983), the U.S. National Medal of Technology (1999), and the Japan Prize (2011). He passed away in 2011.



DEC PDP-11, 1970

1997

STEVE WOZNIAK

For his invention of the Apple I and Apple II computers and co-founding of Apple Computer.

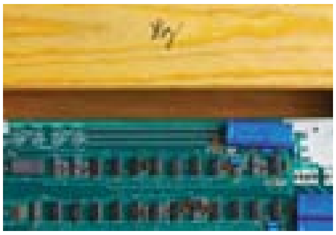
Steve Wozniak was born in San José, California, in 1950. He received a B.S. in electrical engineering and computer science from UC Berkeley (1986).

Wozniak ("Woz") built his first computer when he was 13 years old, and was an electronics prodigy in high school. At 19, he met 14-year-old Steve Jobs and the two teenagers built an electronic "blue box" enabling them to hack the public telephone network and make toll-free calls.

Their next collaboration was a kit computer, designed by Wozniak, first shown at the Homebrew Computer Club in Menlo Park, California, in 1976. Called the Apple I, it was meant for hobbyists, but the two Steves received an order for 50 assembled kits from a local store, suggesting to the business-savvy Jobs that there might be a market for personal computers.

The answer was the Apple II, another Wozniak design, which offered color graphics and came in a consumer-friendly case with a built-in keyboard. Sales of the Apple II were brisk and the newly formed Apple Computer became a large company.

Wozniak remains an Apple employee and has enjoyed a diverse career in teaching and entrepreneurship as well. In 1985, he was awarded the U.S. National Medal of Technology (with Steve Jobs).

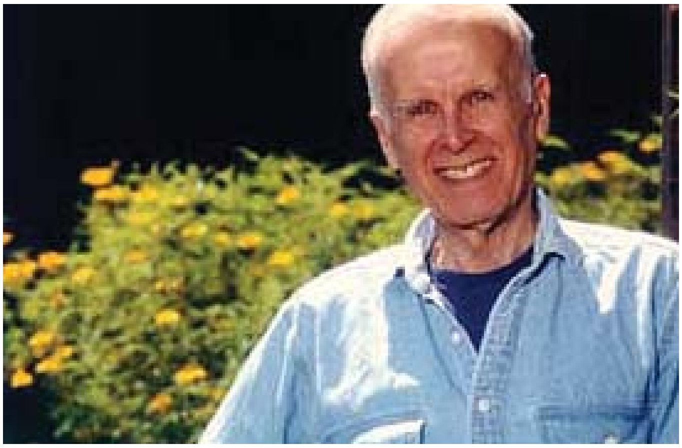


Apple-1, Apple Computer, Inc., 1976

1997

JOHN BACKUS

For his development of FORTRAN, contributions to computer systems theory, and software project management.



John Backus was born in Philadelphia, Pennsylvania, in 1924. He received an M.S. in mathematics from Columbia University (1950).

Shortly before he graduated, Backus interviewed at IBM and was hired to work on programming their new computer systems. By 1953, he was leading a small team to create an easy-to-use programming language for scientific users. At the time, programming was exceedingly difficult—Backus once described it as "doing hand-to-hand combat with the machine." After four years of intense effort, Backus' team produced the FORTRAN programming language. FORTRAN became a global standard for science and engineering and is still in use for certain applications, a testament to its good design.

Backus made many other important contributions to computer science, particularly in the area of functional programming languages and systems. He served on the international committees developing the ALGOL system of programming languages and, with Danish computer scientist Peter Naur, developed a common notation for describing the structure of programming languages, a method known as the Backus-Naur Form (BNF).

Backus won the National Medal of Science (1975) and the ACM Turing Award (1977), and was a fellow of the American Academy of Arts and Sciences (1985). He passed away in 2007.

Fortran for Precedent button

WOZNIAK, BACKUS ARTIFACTS: ©MARK RICHARDS / WOZNIAK PORTRAIT: ©ROGER RESSMEYER / CORBIS

1998

GENE AMDAHL

For his fundamental and continuing work in computer architecture and design, project management, and entrepreneurship.

Gene Amdahl was born in Flandreau, South Dakota, in 1922. He holds a B.S. in engineering physics (1948) from South Dakota State University and M.S. and Ph.D. (1952) degrees in theoretical physics from the University of Wisconsin.

Amdahl joined IBM directly upon graduation and made an immediate impact as chief architect of IBM's 704 scientific mainframe computer. This far outsold initial predictions, cementing Amdahl's reputation as a rising star. Amdahl left IBM in 1956 but returned in 1960 to become chief architect of their System/360 family of computers, a daring business and technical gamble that became one of the greatest success stories in the history of computing.

IBM System/360 Model 65, 1965

In 1970, Amdahl left IBM for the second and final time to pursue his dream of building his own computers, founding Amdahl Corporation. His new company made mainframe computers that ran IBM software, but at lower cost. At its peak, it captured nearly one-fifth of the market. The Amdahl company prospered and was eventually purchased by Fujitsu when costs made further development difficult without a well-funded partner. Amdahl founded several other companies in the 1980s, developing advanced computer systems and technologies.

Amdahl is a Fellow of the U.S. National Academy of Engineering (1967).

1998

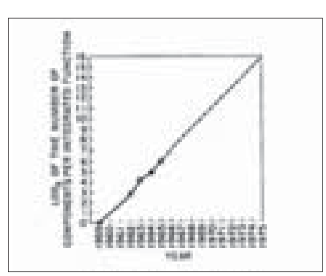
GORDON MOORE

For his fundamental early work in the design and production of semiconductor devices; co-founder, Fairchild and Intel.

Gordon Moore was born in San Francisco, California, in 1929. He holds a B.S. (1950) in chemistry from UC Berkeley and a Ph.D. (1954) in chemistry and physics from Caltech.

Moore is a key figure in the development of semiconductor electronics, making major contributions to the origin and perfection of the integrated circuit (IC) as a viable technology. With Robert Noyce and others, he founded Fairchild Semiconductor Corporation in 1957, where he implemented Noyce's concepts to create "wireless clusters" of transistors, the basic idea of the IC, or "chip."

As head of R&D at Fairchild, in 1965 he published a widely read article that first proposed what would become known as "Moore's Law," in which he predicted that the number of transistors the industry would be able to place on a computer chip would double every year. This observation has proven to be basically correct for more than four decades.



Original Moore's Law diagram, 1965

In 1968, Moore co-founded Intel Corporation with Robert Noyce. Intel has become a world leader in the design and manufacturing of semiconductors and is the largest semiconductor company in the world. Among other awards, Moore holds the IEEE Medal of Honor (2008) and the U.S. National Medal of Technology (1990).

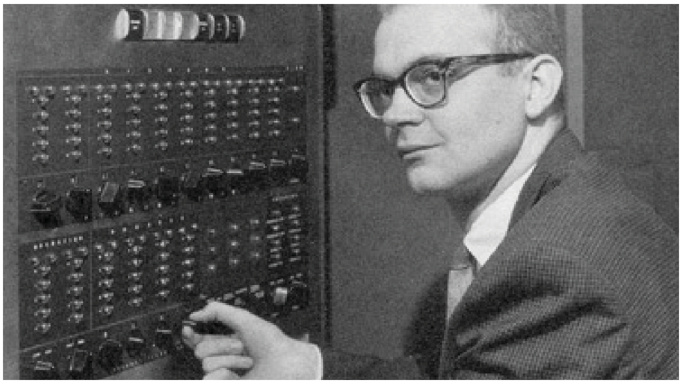
"THERE IS SUCH A THING AS A NATURAL-BORN ENTREPRENEUR. BUT THE ACCIDENTAL ENTREPRENEUR LIKE ME HAS TO FALL INTO THE OPPORTUNITY OR BE PUSHED INTO IT."

GORDON MOORE

1998

DONALD KNUTH

For his fundamental early work in the history of computing algorithms, development of the TeX typesetting language, and major contributions to mathematics and computer science.



Donald Knuth was born in 1938 in Milwaukee, Wisconsin, and holds a B.S. and M.S. in mathematics from the Case Institute of Technology (1960) and a Ph.D. in mathematics (1963) from Caltech. Over a prolific publishing career, Knuth is best known for having written the classic, multi-volume series, *The Art of Computer Programming*, the "Bible" of computer science pedagogy. Through his writing and teaching at Stanford University, where he was a long-time professor (beginning in 1968), Knuth has influenced the thinking of countless computer science students and professionals.

Cover, *The Art of Computer Programming*, 1968

Knuth's lifelong love affair with computers began as an undergraduate when he discovered the IBM 650 computer system at Case. He quickly mastered the inner workings of the machine and developed a novel program to automate coaching of the school's basketball team, earning him an appearance on the *CBS Evening News* with Walter Cronkite.

In 1976, Knuth invented the typesetting language TeX when he grew frustrated with the poor quality of typography proposed for an upcoming new volume of *The Art of Computer Programming*. TeX remains a worldwide standard for technical publishing.

Knuth has won dozens of awards, including the ACM Turing Award (1974), the National Medal of Science (1979), and the Kyoto Prize (1996).

1999

KONRAD ZUSE

For his invention of the first program-controlled, electromechanical, digital computer and the first high-level programming language, Plankalkül.

Konrad Zuse was born in Berlin, Germany, in 1910. In 1935, he graduated from the Technische Hochschule Berlin-Charlottenburg in civil engineering.

After graduating, he went to work for the Henschel Aircraft Company, but spent his weekends building a computer (the Z1) in his parents' living room. He completed the Z1, for which instructions were punched on used movie film, in 1938.

Zuse worked throughout WWII on other designs, culminating in his Z3 computer, the world's first fully operational stored-program electromechanical computer. He was able to sell one to the German aircraft bureau, which needed it to solve aerodynamic problems. Z1–Z3 were ultimately destroyed in an Allied bomb attack on Berlin in 1945, but Zuse persisted and completed a relay-based version, the Z4. He sold this to the Swiss Federal Institute of Technology (ETH-Zurich)—it was at the time the only working computer in continental Europe.

Zuse's reputation grew, and he founded Zuse KG to build his machines as well as developing one of the earliest high-level programming languages, *Plankalkül*.

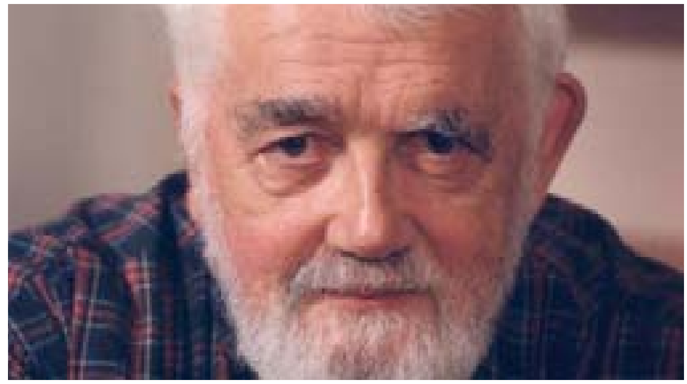
Zuse's story is one of success over adversity, as he independently conceived and implemented the principles of modern digital computers in complete isolation. He passed away in 1995.

Zuse Z1 in living room, Germany, 1938

1999

JOHN MCCARTHY

For his co-founding of the fields of Artificial Intelligence (AI) and timesharing systems and for major contributions to mathematics and computer science.



John McCarthy was born in Boston, Massachusetts, in 1927. He received a B.S. in mathematics from Caltech (1948) and a Ph.D., also in mathematics, from Princeton University (1951).

McCarthy was a pioneer in the fields of artificial intelligence (AI), computer science, and interactive computing systems.

McCarthy coined the term "AI" in 1955 in connection with a proposed summer workshop at Dartmouth College, which many of the world's leading thinkers in computing attended. As part of refining his ideas about AI, he also invented the programming language LISP in 1958.

John McCarthy at Stanford's IBM 7090, ca. 1967

While at MIT, McCarthy proposed a method of distributing computer resources known as timesharing, in which many individual users could appear to have sole access to an expensive mainframe computer system. Timesharing became a dominant computing paradigm in the 1960s and 1970s, and MIT led much of the early work, influenced by McCarthy's ideas.

In 1965, McCarthy became the founding director of the Stanford Artificial Intelligence Laboratory (SAIL), where research was conducted into machine intelligence, graphical interactive computing, and autonomous vehicles.

McCarthy was chosen as the 1971 winner of the ACM Turing Award, and was awarded the Kyoto Prize (1988) and the National Medal of Science (1990). He passed away in 2011.

ALAN KAY

1999

For his fundamental contributions to personal computing and human interface development; co-founder, Xerox PARC.

Alan Kay was born in Spring-field, Massachusetts, in 1940. He received a B.S. in mathematics and molecular biology from the University of Colorado at Boulder (1966) and an M.S. (1968) and Ph.D. (1969) from the University of Utah in computer science.

Kay is best known for the idea of personal computing, the concept of the laptop computer, and the inventions of the now ubiquitous overlapping-window interface and modern object-oriented programming.

His deep interest in children was the catalyst for these ideas, and it continues to inspire him.

Children using proposed Dynabook, 1968

Kay was one of the founders of the Xerox Palo Alto Research Center (PARC), in Palo Alto, California, where he led one of the groups that developed ideas into modern workstations (and the forerunner of the Macintosh), the Smalltalk computer language, the overlapping-window interface, desktop publishing, the Ethernet, laser printing, and network "client servers." His "Dynabook" concept prefigured the modern laptop computer by several decades.

Kay has received many awards, including ACM's Software Systems Award and the J-D Warnier Prix d'Informatique. He is a Fellow of the American Academy of Arts and Sciences, the National Academy of Engineering, and the Royal Society of Arts. He has won the ACM Turing Award (2003) and the Kyoto Prize (2004).

"THE BEST WAY TO PREDICT THE FUTURE IS TO INVENT IT."

ALAN KAY

KAY ARTIFACT: COURTESY OF ALAN KAY / KAY PORTRAIT: ©LOUIS FABIAN BACHRACH

2000

TOM KILBURN

For his contributions to early computer design, including random access digital storage, virtual memory, and multiprogramming.

Tom Kilburn was born in Dewsbury, England, in 1921. He received a Ph.D. from the University of Manchester (1948).

Kilburn's early work with Frederic Williams at the University of Manchester in 1947 concentrated on the digital storage of information on a cathode-ray tube and resulted in the first random access electronic storage device for computers, the Williams-Kilburn Tube.

To test it, in 1948 Kilburn led the work on designing and building "the Baby," a small-scale experimental computer. The Baby was the first stored-program computer—the first computer in the world that could hold both user program and data in electronic storage and process it at electronic speeds.

Tom Kilburn (standing) at Ferranti Mark I computer, ca. 1950

In the early 1950s, Kilburn led the development of two new pioneering computers that were turned into commercial machines by U.K. manufacturers.

Kilburn then led the development of the Atlas computer system, which pioneered such modern concepts as paging, virtual memory, and multiprogramming, influencing the development of computer systems for generations. In 1962, it was considered the most powerful computer in the world.

Tom Kilburn was professor of computer engineering (1960), then computer science (1964) at the University Manchester, retiring in 1981. He was a Fellow of the Royal Society. He passed away in 2001.

2000

VINTON CERF

For his contributions to computer architecture, operating systems, and software engineering.

Vinton Cerf was born in New Haven, Connecticut, in 1943. He received his B.A. in mathematics from Stanford University (1965) and his M.S. (1970) and Ph.D. (1972) from UCLA.

After graduation, Cerf became an assistant professor at Stanford University, where he co-developed the TCP/IP protocol suite with colleague Bob Kahn. This set of communication standards for data would become the backbone of the Internet.

From 1976 to 1982, Cerf was a program manager with the U.S. Department of Defense's Advanced Research Projects Agency (DARPA), where he fostered development of Internet-related packet data and security technologies based on TCP/IP. In the late 1980s, when the Internet began a transition to the commercial sector, Cerf moved to MCI Communications, where he led development of the first commercial email system (MCI Mail) connected to the Internet.

BBN Interface Message Processor (IMP), ca. 1965

In 1992, Cerf founded the Internet Society and served as its president for three years. He also served on the board of ICANN from 1999 to 2007. In 2005, Cerf became a vice president and chief Internet evangelist at Google.

Among many awards, Cerf has won the U.S. National Medal of Technology (1997) and the ACM Turing Award (2004).

"ALL THE THINGS I DO ARE OF A PIECE. I'M EXPLORING THE EDGES, FINDING NEW WAYS OF DOING THINGS. IT KEEPS ME VERY, VERY ENGAGED."

FRANCES ALLEN

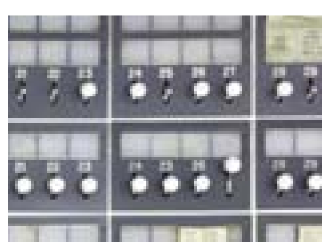
2000

FRANCES ALLEN

For her contributions to program optimization and compiling for parallel computers.

Frances Allen was born in Plattsburg, New York, in 1932. She holds a B.S. in mathematics (1954) from Albany State Teacher's College, and an M.S., also in mathematics (1957), from the University of Michigan. She holds several honorary doctorates in science.

Allen is a pioneer in the field of optimizing compilers, programs that translate source code written in a programming language into machine code for direct use by a computer. Her specialty is the development of advanced compilers for making such computers work faster and more efficiently.



Close-up of IBM 7030 ("Stretch") operator console, 1961

Allen began her career at a small rural high school in Peru, New York, teaching practical math to farm kids, then took a job at IBM in order to earn the money she needed to pay off her college loans. She had planned to work there for a couple of years and then return to her first love—teaching—but at IBM, she found something she loved even more, "great people." She would stay at IBM for the next 45 years, making dozens of important and original contributions to computer science.

In 1989, she became the first woman to be named an IBM Fellow and, in 2006, received the ACM Turing Award.

ALLEN ARTIFACT: ©MARK RICHARDS / ALLEN PORTRAIT: ©LOUIS FABIAN BACHRACH

2001

SIR MAURICE V. WILKES

For his contributions to computer technology, including early computer design, microprogramming, and the Cambridge Ring network.

Maurice V. Wilkes was born in Dudley, England, in 1913. He received a Ph.D. in physics (1936) from the University of Cambridge.

Wilkes began experimental research on the atmosphere, complex calculations that led him to an interest in computing methods. In 1945, he became the first head of the computer laboratory at Cambridge and the following year, began working on the groundbreaking EDSAC computer, which became functional in 1949. In 1951, along with two colleagues, he published the first book on computer programming and then proposed microprogramming, a system that was ultimately adopted throughout the computer industry.

In 1974, Wilkes concluded that local area networks could be more effective if based on computers rather than telecommunications technology. His design study for what became known as the Cambridge Ring was a landmark in the field of networking.

After 1980, Wilkes worked in industry, first with Digital Equipment Corporation (DEC) and then with AT&T Research Laboratories. He was a Distinguished Fellow of the British Computer Society, and a Fellow of the Royal Society and the Royal Academy of Engineering. He held the Turing Award (1967) and the Kyoto Prize (1997), and was knighted in 2000. He passed away in 2010.

Maurice Wilkes (center) with EDSAC, 1949

"IT WAS ON ONE OF MY JOURNEYS BETWEEN THE EDSAC ROOM AND THE PUNCHING EQUIPMENT THAT THE REALIZATION CAME OVER ME THAT A GOOD PART OF THE REMAINDER OF MY LIFE WAS GOING TO BE SPENT IN FINDING ERRORS IN MY OWN PROGRAMS."

MAURICE V. WILKES

WILKES ARTIFACT: COURTESY OF THE UNIVERSITY OF CAMBRIDGE COMPUTER LABORATORY

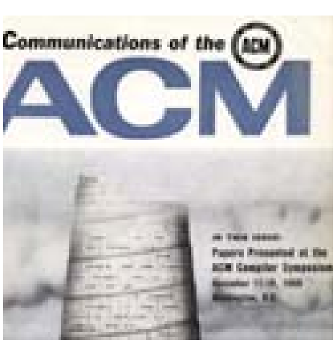
2001

JEAN SAMMET

For her contributions to the field of programming languages and its history.

Jean Sammet was born in New York, New York, in 1928. She holds a B.A. in mathematics from Mount Holyoke College (1948), an M.A., also in mathematics, from the University of Illinois (1949), and an honorary doctorate from Mount Holyoke College (1978).

Sammet started work in the computer field at Sperry Gyroscope in 1955 and supervised the company's first scientific programming group. She also taught graduate courses in programming at Adelphi College from 1956 to 1958.



Communications of the Association for Computing Machinery (ACM) cover, 1961-01

From 1958 to 1961, she worked at Sylvania Electric Products and managed the basic software development for MOBIDIC, a computer built for the Army Signal Corps. From 1959 to 1961, she served as a key member of the committee that developed COBOL, which became the standard programming language for business applications around the world.

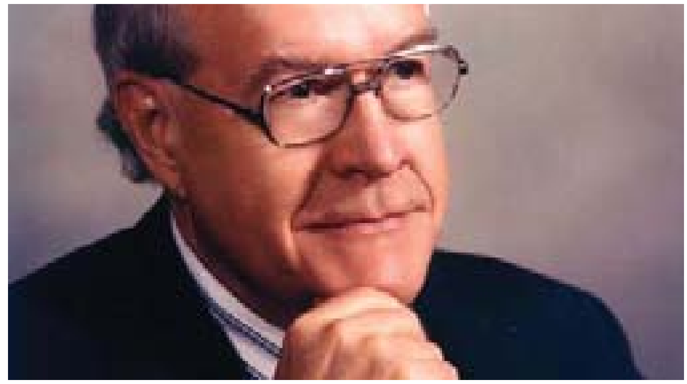
Sammet joined IBM in 1961 and directed the development of FORMAC, a widely used programming language and system for symbolic mathematics. In 1965, she became programming language technology manager in the IBM systems development division and later led IBM's work on the Ada programming language.

She was president of the ACM from 1972 to 1974 and is a world authority on the history of programming languages. Among other honors, she is a member of the U.S. National Academy of Engineering (1977).

2001

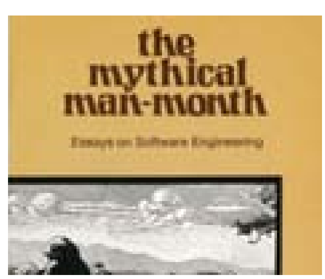
FREDERICK P. BROOKS

For his contributions to computer architecture, operating systems, and software engineering.



Frederick P. Brooks was born in Durham, North Carolina, in 1931. He holds an A.B. in physics from Duke University (1953), and an S.M. in applied mathematics (1955) and a Ph.D. in computer science (1956), both from Harvard University. His dissertation was supervised by legendary computer pioneer Howard Aiken.

Upon graduation, Brooks joined IBM and served as one of the architects of IBM's groundbreaking Stretch and Harvest supercomputers, making several early and important contributions. From 1961 to 1965, he was corporate project manager for the IBM System/360, the most important product in company history at that time, developing both hardware and software.



Cover, *The Mythical Man-Month*, 1975

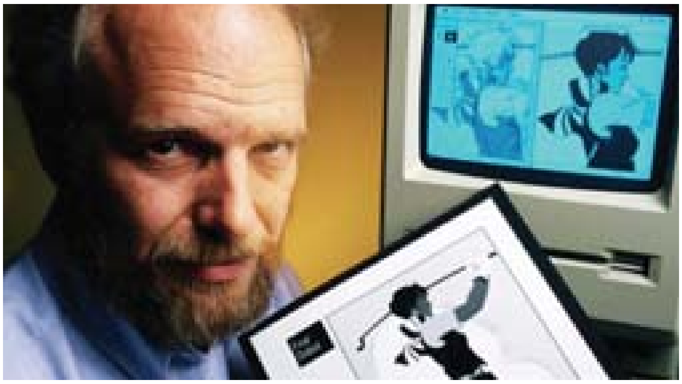
Brooks joined the University of North Carolina in 1964, where he founded the department of computer science and served as chairman for its first 20 years. His research has included computer architecture, software engineering, and interactive 3-D computer graphics, or "virtual reality." His book, *The Mythical Man-Month: Essays on Software Engineering*, is a classic in the field of computer project management.

Brooks holds dozens of awards, including the ACM Turing Award (1999). He shares the U.S. National Medal of Technology (1985) with IBM's Bob Evans and Erich Bloch for his work on System/360.

2002

JOHN WARNOCK

For his accomplishments in the commercialization of desktop publishing with Charles Geschke, and for innovations in scalable type, computer graphics, and printing.



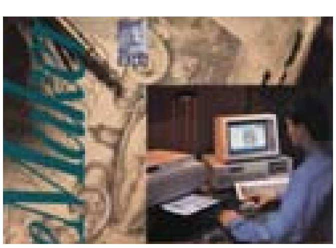
John Warnock was born in Salt Lake City, Utah, in 1940. He holds a B.S. in mathematics and philosophy (1961), an M.S. in mathematics (1964), and a Ph.D. in electrical engineering (1969), all from the University of Utah.

Warnock joined Xerox's Palo Alto Research Center (PARC) in 1978, where he was a principal scientist in their computer sciences laboratory working on interactive graphics. As part of his responsibilities, Warnock, along with colleague Chuck Geschke and others, developed a printer protocol called Interpress.

When Xerox declined to pursue the Interpress idea further, Warnock and Geschke started their own company, Adobe. Their work evolved into the PostScript page description language, which, when combined in 1985 with hardware from Apple Computer, formed the first "desktop publishing" (DTP) system. DTP systems allowed nearly anyone to electronically compose documents and print them as they appeared on the screen. This new approach to electronic printing allowed business users to greatly improve the quality and efficiency of their document production.

Since the invention of PostScript, Adobe has become the leader in electronic imaging and publishing and is the industry leader in graphical arts software.

Warnock is a member of the National Academy of Engineering (1996) and an ACM Fellow.

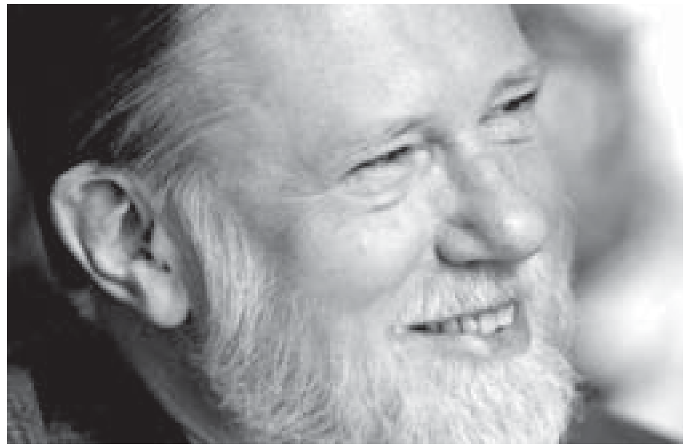


Aldus PageMaker, 1987

2002

CHARLES GESCHKE

For his accomplishments in the commercialization of desktop publishing with John Warnock and for innovations in scalable type, computer graphics, and printing.



Charles Geschke was born in Cleveland, Ohio, in 1939 and holds an A.B. in classics (1962), and an M.S. in mathematics (1963), both from Xavier University, and a Ph.D. in computer science (1972) from Carnegie Mellon University.

In 1978, Geschke formed the Imaging Sciences Laboratory at Xerox PARC, where he directed research in computer science, graphics, image processing, and optics. He hired his long-term research partner, John Warnock, and the two invented a page description language—a means of describing complex forms like typefaces electronically—called Interpress. When Xerox decided not to commercialize this invention, Geschke and Warnock left PARC and co-founded Adobe Systems.

Interpress evolved into Adobe's PostScript which, when combined in 1985 with hardware from Apple Computer (including Apple's new LaserWriter printer), formed the first "desktop publishing" (DTP) system, one in which anyone could set type, compose documents, and print them as they appeared on the screen—all electronically. This new approach allowed business users to greatly improve the quality and efficiency of their document production, spawning an entire industry.

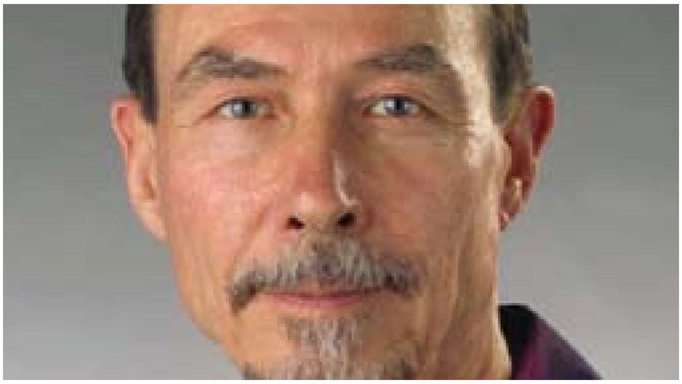
Geschke is a member of the National Academy of Engineering and an ACM Fellow. He retired as president of Adobe in 2000.

Adobe Illustrator, first version, 1987

CARVER MEAD

2002

For his contributions in pioneering the automation, methodology, and teaching of integrated circuit design.



Carver Mead was born in Bakersfield, California, in 1934 and holds B.S. (1956), M.S. (1957), and Ph.D. (1959) degrees in electrical engineering, all from Caltech.

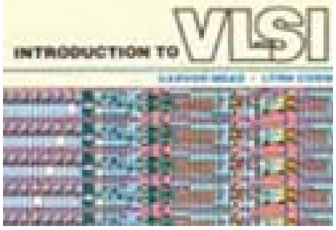
Mead has made many pioneering contributions to solid-state electronics and was one of the leading forces in Very Large Scale Integration (VLSI) design methodology.

His major innovations include the GaAs MESFET, a key amplifying device used in microwave communication systems from radio telescopes to home satellite dishes and cellular phones. Mead is also well-known for pioneering computer-aided design of VLSI circuitry through his methodology of "structured custom design," an approach now used by all semiconductor companies.

Mead's work with VLSI design also included co-authoring, with Lynn Conway, *Introduction to VLSI Systems*, a book that became the standard reference text for a generation of IC designers.

Mead's other work involves experimenting with "neuromorphic electronic systems" —circuits modeled on living nervous systems.

Mead is the recipient of many awards, including the Lemelson-MIT Prize (1999). He holds over 50 U.S. patents and fellowships or distinguished memberships in seven different scientific and professional societies. Until recently, he was the Gordon and Betty Moore professor at Caltech, having taught there for more than 40 years.



Cover, *Introduction to VLSI Systems*, 1980

JOHN COCKE

2002

For his development and implementation of reduced instruction set computer architecture and program optimization technology.

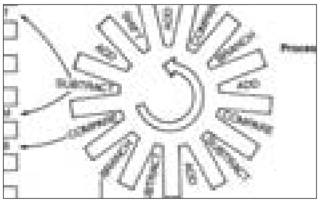
John Cocke was born in Charlotte, North Carolina, in 1925. He received a B.S. in mechanical engineering (1946) and a Ph.D. in mathematics (1956), both from Duke University.

An IBM employee for 37 years (1956–1993), Cocke made major contributions to compiler optimization and devised the concept of the reduced instruction set computer (RISC).

Cocke recognized that powerful special-purpose compilers could compensate for the simplicity of RISC hardware, resulting in high-performance computers. While the instruction sets of most computers were becoming ever more complex, Cocke's philosophy went against the prevailing wisdom, but has proven to be very successful.

The breakthrough project came in 1974, when Cocke and his team started to design a telecom computer which became known as the "801" minicomputer, named after the building in which his team worked. The project fell through, but the 801 led eventually to the RISC-based IBM PC RT introduced in 1985. The RISC design philosophy is now used in nearly every computational device made, especially mobile devices.

Among his many achievements, Cocke was made an IBM Fellow in 1972, and was awarded the National Medal of Technology (1991), the ACM Turing Award (1987), and the National Medal of Science (1994). He passed away in 2002.



IBM RISC Technology diagram, ca. 1982

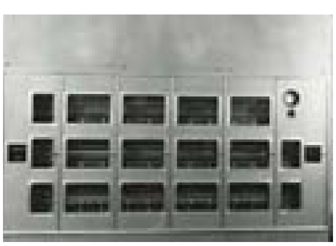
2003

DAVID WHEELER

For his invention of the closed subroutine, his architectural contributions to the ILLIAC, the Cambridge Ring, and computer testing.

David Wheeler was born in Birmingham, England, in 1927. He was awarded a scholarship to Trinity College, Cambridge, in 1945 and studied mathematics, taking his B.A. in 1948.

Wheeler started computer work as an undergraduate in 1947, and was granted a Ph.D. in 1951; his dissertation was titled "Automatic computing with the EDSAC." His wired-in EDSAC assembler of 1942, creating a simple system for users, led to a fellowship at Trinity College. He is generally credited as the first programmer to formally define and make use of the program subroutine, then known as a "Wheeler jump." He spent the next two years at the University of Illinois, helping design the programming system for the ORDVAC and ILLIAC machines, two important first-generation (vacuum tube) computer systems.



ILLIAC I computer at UIUC, ca. 1952

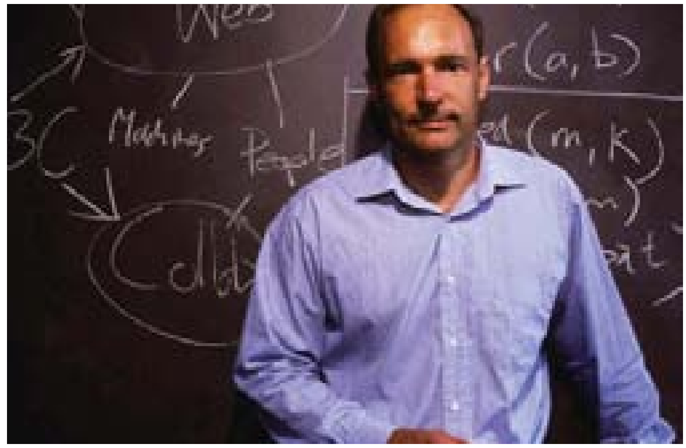
Wheeler spent time at the Universities of Illinois; Sydney, Australia; and California. He acted as a consultant to various organizations, including Bell Laboratories and Digital Equipment Corporation's Western Research Laboratory.

Wheeler was emeritus professor of computer science at the University of Cambridge, where he spent most of his career. He was elected a Fellow of the British Computing Society (1970) and of the Royal Society (1983), and was awarded a Pioneer Medal of the IEEE (1985). He passed away in 2004.

2003

TIM BERNERS-LEE

For his seminal contributions to the development of the World Wide Web.

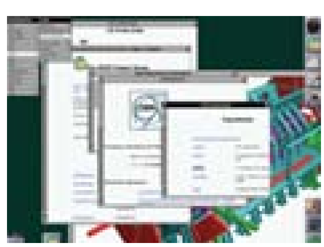


Tim Berners-Lee was born in London, England, in 1955. He holds a B.A. in physics from Oxford University (1976).

While working as an independent contractor at the European high-energy physics laboratory (CERN) in 1980, Berners-Lee built a prototype system for document sharing among researchers based on hypertext called ENQUIRE. In 1989, he had a new proposal, written with the help of Robert Cailliau, based on combining hypertext with the Internet, which he called the "World Wide Web." The world's first website, at CERN, went online August 6, 1991.

The Web proposal was based on a system of globally unique identifiers for resources, the HTML publishing language, and the use of HTTP. The turning point came in 1993 with the introduction of the free Mosaic web browser, which allowed images to be displayed alongside text, unlike the other hypertext systems then in existence. That same year, CERN announced that the World Wide Web would be free to everyone.

In 1994, Berners-Lee left CERN and founded the World Wide Web Consortium at MIT, a group of member organizations, including vendors, willing to create standards for the Web. In 2004, he was knighted for his pioneering work.



World Wide Web browser-editor, 1993

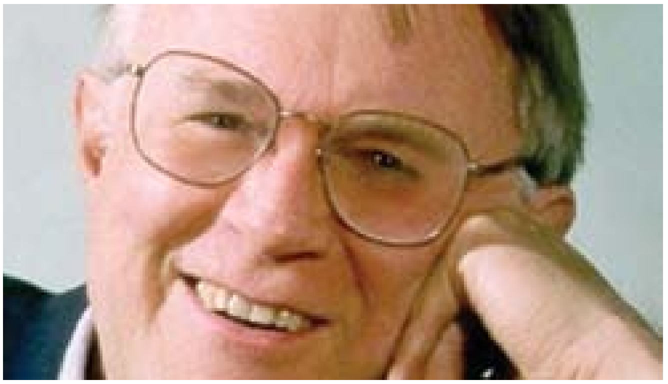
"THE WEB SHOULD BE A UNIVERSAL INFORMATION SPACE: INDEPENDENT OF HARDWARE OR SOFTWARE CHOICE, NETWORK ACCESS, OF LANGUAGE, CULTURE, OR PER-SONAL DISABILITY... A CREATIVE SPACE, LIKE A BLANK SHEET OF PAPER."

TIM BERNERS-LEE

2003

GORDON BELL

For his key role in the minicomputer revolution and for contributions as a computer architect and entrepreneur.



Gordon Bell was born in Kirksville, Missouri, in 1934. He received B.S. (1956) and M.S. (1957) degrees in electrical engineering from MIT.

In 1960, Bell was hired by the founders of Digital Equipment Corporation (DEC) to design circuits and systems for their new PDP-1 computer. He became the architect of several other important computers at DEC and was considered a brilliant designer. In 1966, Bell left to teach computer science at Carnegie Mellon University but returned to DEC in 1972 as vice president of engineering. He then led the company in a bold direction based on his vision for a new family of computers called the VAX, which would become the most successful product in company history.

Bell retired from DEC in 1983 but later launched several companies to design and build high-performance computer systems using new technologies. In 1987, he established the ACM Gordon Bell Prize to reward original research in parallel processing.

Since 1995, he has worked at Microsoft as a researcher and is also an angel investor and entrepreneur.

Bell is a member of the U.S. National Academy of Engineering and received the U.S. National Medal of Technology in 1991. With Gwen Bell and Ken Olsen, he was a founder of The Computer Museum.

Gordon Bell (standing) and Alan Kotok at a DEC PDP-6 computer, ca. 1963

2004

NIKLAUS WIRTH

For seminal work in programming languages and algorithms including Euler, Algol-W, Pascal, Modula-2, and Oberon.

Niklaus Wirth was born in Winterthur, Switzerland, in 1934. He received the degree of electronics engineer from the Swiss Federal Institute of Technology (ETH-Zurich) (1959), an M.Sc. from Laval University (1960), and a Ph.D. in electrical engineering and computer science from UC Berkeley (1963).

Upon graduation, Wirth became an assistant professor at the newly created computer science department at Stanford University. From 1968 until his retirement in 1999, he was a professor at ETH in Zurich. There, he developed the programming languages Pascal (1970), Modula-2 (1979), and Oberon (1988). Pascal, in particular, became a widely used programming language in computer-science education and influenced a generation of students and professional programmers.

Following two separate sabbatical leaves at the Xerox Palo Alto Research Center (PARC) in California, Wirth became an enthusiastic adopter of the groundbreaking workstations he saw there, and returned home inspired to build similar systems. While doing so, he simultaneously created several elegant and useful programming languages and environments that had profound research implications.

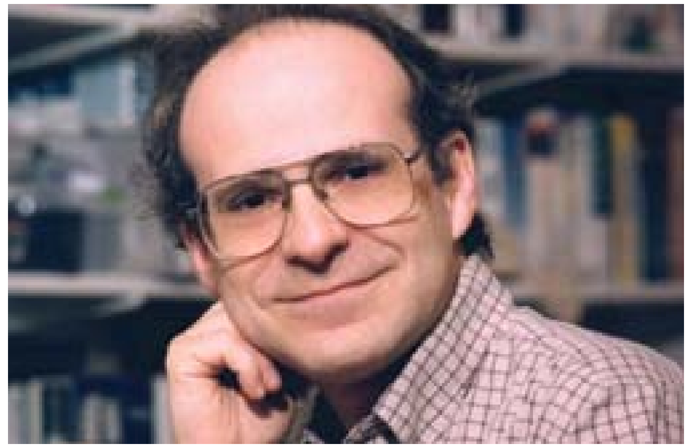
Wirth has contributed to both hardware and software aspects of computer design and has written influential books on software engineering and structured programming. Among other recognitions, he holds the ACM Turing Award (1984).

Sample Pascal program listing, ca. 1970

2004

BOB FRANKSTON

For advancing the usefulness of personal computers by developing the VisiCalc electronic spreadsheet.



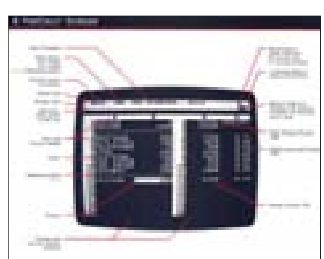
Bob Frankston was born in Brooklyn, New York, in 1949. He received S.B. degrees in both computer science and mathematics (1970) and master's and engineers degrees in computer science (1974), all from MIT.

In 1979, Frankston founded Software Arts with friend and Harvard MBA student Dan Bricklin to develop and sell VisiCalc, the first electronic spreadsheet program for personal computers. VisiCalc was first available for the Apple II personal computer, which significantly drove Apple II sales. It became a blockbuster product and remained a widely used program for personal computers for many years. After VisiCalc was purchased by Lotus Development, it evolved into Lotus 1-2-3.

From 1985 to 1990, Frankston worked at Lotus Development, where he created the Lotus Express product and a fax facility for Lotus Notes. At Slate Corporation, (1990 to 1992), Frankston worked on mobile and pen-based systems. At Microsoft (1993 to 1998), he focused on the consumer use of computers, in particular, home networking, and the idea of wireless networking.

Since 1988, he has been an angel investor providing early-stage financing for technology start-ups.

Frankston is a Fellow of the IEEE and ACM and holds the ACM Software System Award (1985).



VisiCalc screen diagram, 1979

FRANKSTON ARTIFACT: COURTESY OF DAN BRICKLIN

2004

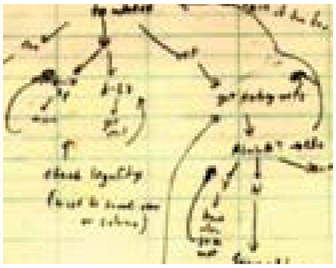
DAN BRICKLIN

For advancing the utility of personal computers by developing the VisiCalc electronic spreadsheet.

Dan Bricklin was born in Philadelphia, Pennsylvania, in 1951. He holds a B.S. in electrical engineering and computer science from MIT and an M.B.A. from the Harvard Graduate School of Business Administration. He also holds an honorary Doctor of Humane Letters from Newbury College.

In 1979, he founded Software Arts, where he served as chairman of the board and executive vice president until 1985. Their flagship product, VisiCalc, transformed the personal computer industry by providing an electronic spreadsheet for business users. For many such users, VisiCalc was the program that convinced them to purchase a PC. Prior to forming Software Arts, Bricklin was a market researcher for Prime Computer Inc., a senior systems programmer for FasFax Corporation, and a senior software engineer for Digital Equipment Corporation, where he was project leader of the WPS-8 word processing software.

In 1990, Bricklin co-founded Slate Corporation to develop application software for pen computers. In 1994, he was elected a Fellow of the ACM and is a member of the National Academy of Engineering. In late 1995, Bricklin founded Trellix Corporation, a provider of website publishing technology.



Detail of Bricklin's Slate diagram for a spreadsheet, 1978-79

BRICKLIN ARTIFACT: COURTESY OF DAN BRICKLIN / EVANS ARTIFACT & PORTRAIT: ©IBM CORPORATION / BRICKLIN PORTRAIT: ©LOUIS FABIAN BACHRACH

2004

BOB EVANS

For excellence in management of computer systems, hardware, and software development projects, including the IBM System/360, which revolutionized the computer industry.

Bob Evans was born in Grand Island, Nebraska, in 1927. He received a B.S. in engineering from Iowa State University (1951).

Bob Evans started his 33-year career at IBM in 1951 as a junior engineer, supporting IBM's electronic (vacuum tube) computers. He rose quickly through the organization and became vice president of IBM's data systems division in 1962. In this position, he was placed in charge of all development for a daring new family of computers IBM was planning. This family, known as the System/360, was the largest single change of direction in the company's history and Evans was given overall responsibility for all hardware and software of the new machines.

The System/360 was a major win for IBM and remains one of the most successful computer products of all time. It was through Evans' leadership that the project was completed.

In his last seven years at IBM, Evans was corporate vice president, Engineering, Programming and Technology. In 1984 he retired from IBM to join Hambrecht and Quist as a venture partner.

In 1988, he moved to a spin-off from H&Q, Technology Strategies and Alliances, where he served as a managing partner. He passed away in 2004.

IBM System/360 Computer, 1965

2004

ERICH BLOCH

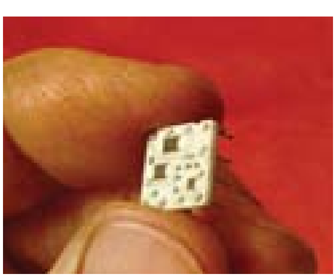
For engineering management of the IBM Stretch supercomputer and the Solid Logic Technology used in the IBM System/360, which revolutionized the computer industry.

Erich Bloch was born in Sulzburg, Germany, in 1925 and holds a B.S. in electrical engineering from the University of Buffalo (1952). He also studied at the Swiss Federal Institute of Technology (ETH-Zurich).

Bloch worked at IBM from 1952 to 1981 in a variety of critical technology management roles, including overseeing the difficult manufacturing challenges of IBM's groundbreaking System/360 family of mainframe computers in the 1960s. Bloch's other positions at IBM included engineering manager of the Stretch supercomputer system, head of the Solid Logic Technology (System/360) program, vice president of the Data Systems Division, and general manager of the East Fishkill development and manufacturing facility—critical components of IBM's global mainframe business strategy for over two decades.

As director of the U.S. National Science Foundation from 1984 to 1990, Bloch oversaw the foundation's $3 billion annual budget and the award of more than 10,000 research grants in the natural and social sciences and engineering.

He was awarded the U.S. National Medal of Technology for developments that revolutionized the computer industry and is a member of the U.S. National Academy of Engineering, the Swedish Academy of Engineering Sciences, a Fellow of IEEE, and a foreign member of the Engineering Academy of Japan.



IBM 360 SLT module, 1965

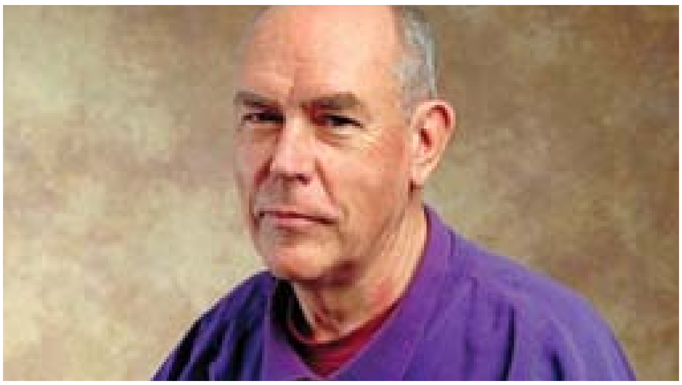
"IF YOU WANT TO KNOW ABOUT THE FUTURE, ASK THE YOUNG PEOPLE WHO WILL MAKE IT HAPPEN. THE OLDER GENERATION MAY HAVE USED UP ITS VISION GETTING US WHERE WE ARE."

IVAN E. SUTHERLAND

2005

IVAN E. SUTHERLAND

For the Sketchpad computer-aided design system and for lifelong contributions to computer graphics and education.



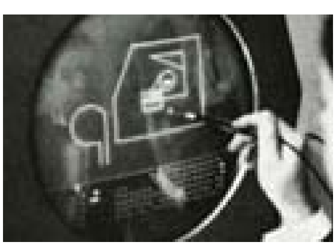
Ivan E. Sutherland was born in Hastings, Nebraska, in 1938. He received a B.S. from the Carnegie Institute of Technology (1959) in electrical engineering, an M.S. from Caltech (1960) and a PH.D. in electrical engineering from MIT (1963).

Sutherland's dissertation, *Sketchpad: A Man Machine Graphical Communication System*, described a groundbreaking interactive computer-aided design system, one whose graceful interaction and functionality inspire admiration among computer graphics professionals even today.

From 1964 to 1966, Sutherland was director of the Information Processing Techniques Office of the Advanced Research Projects Agency (ARPA), where he guided computer research across the United States. In 1968, he joined colleague David Evans to build a center of computer graphics research at the University of Utah and to found with him the Evans and Sutherland Computer Corporation.

From 1976 to 1980, Sutherland served as chairman of computer science at Caltech, and from 1980 onwards, was a vice president of the consulting firm Sutherland, Sproull and Associates, acquired by Sun Microsystems in 1990 to form the basis of its corporate research laboratory.

Sutherland has won many awards for his work, including the ACM Turing Award (1988) and the IEEE John von Neumann Medal (1998).



MIT Sketchpad program, ca. 1965

2005

ALAN F. SHUGART

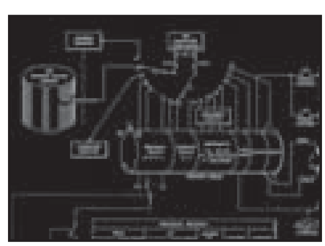
For his lifelong contributions to the creation of the modern disk drive industry.

Alan F. Shugart was born in Los Angeles, California, in 1930. He received a B.S. in engineering physics from the University of Redlands (1951).

In 1951, Shugart began his career at IBM as a field engineer, solving customer problems at their offices. He rose quickly through the organization as an effective leader who inspired great loyalty in team members. Over his 18-year career at IBM, Shugart contributed to or managed a number of difficult disk drive development programs, including the groundbreaking RAMAC—IBM's (and the world's) first disk drive.

Shugart left for Memorex in 1969. He stayed until 1972, then launched Shugart Associates, where he led efforts to perfect the eight-inch floppy disk drive as a mass-produced device. After a dispute over company direction with his board, Shugart left in 1974.

In 1979, he and Finis Conner founded Seagate Technology with the mission of producing hard disk drives for the new personal computer market. Their first commercial product was a 5 1/4", 5 MB hard disk drive that sold for $1,500 and became a major enabling technology for the PC industry. Within a decade, Seagate had become the world's largest producer of disk drives. Shugart passed away in 2006.



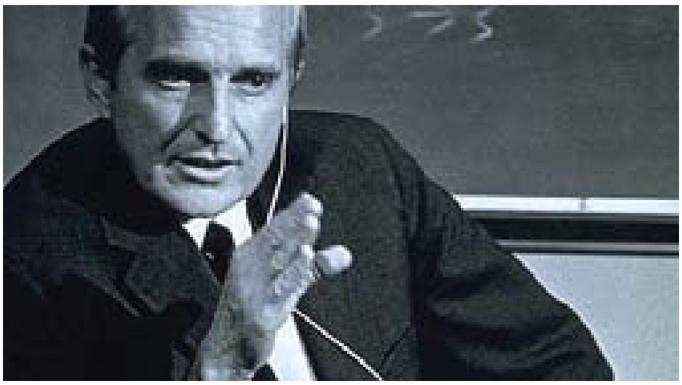
IBM 305 RAMAC system diagram, ca.1956

SHUGART ARTIFACT: ©IBM

2005

DOUGLAS ENGELBART

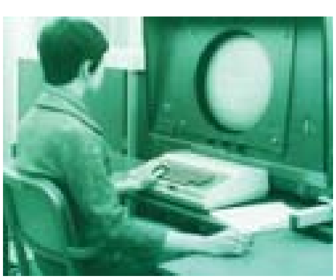
For advancing the study of human-computer interaction and developing the mouse input device, and for the application of computers to improving organizational efficiency.



Douglas Engelbart was born in Portland, Oregon, in 1925 and holds a B.S. in electrical engineering from Oregon State University (1948) and an M.S. (1953) and Ph.D. (1955), also in electrical engineering, from UC Berkeley. After a stint as an assistant professor at Berkeley, he left for the Stanford Research Institute (SRI) in Menlo Park, California, where he stayed for two decades.

While at SRI, Engelbart's most important work began with his 1959 founding of the Augmentation Research Center, where he developed some of the key technologies used in computing today. Engelbart brought the various strands of his research together for his "mother of all demos" in San Francisco on December 8, 1968, an event that presaged many of the technologies and computer-usage paradigms we would use decades later. His system, called NLS, showed actual instances of, or precursors to, hypertext, shared screen collaboration, multiple windows, on-screen video teleconferencing, and the mouse as an input device. This demo embodied Engelbart's lifelong commitment to solving humanity's urgent problems by using computers as tools to improve communication and collaboration between people.

Engelbart has authored over 25 publications, holds more than 20 patents, and has received many honors, including the National Medal of Technology (2000).



NLS workstation, ca. 1968

2005

PAUL BARAN

For fundamental contributions to the architecture of the Internet and for a lifetime of entrepreneurial activity.

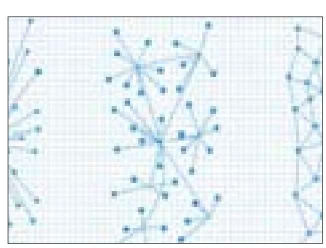
Paul Baran was born in Grodno, Poland, in 1926. He received a B.S. in electrical engineering from Drexel Institute of Technology (1949) and an M.S. in electrical engineering from UCLA (1959).

Baran began working with computers as a technician on the groundbreaking UNIVAC I (1951) computer system, the first commercially available computer in the United States. After working at Hughes Aircraft on radar systems for several years, he then joined the Rand Corporation in 1959, where he developed the concept of packet switching to make distributed networks survivable in the event of nuclear attack. While at Rand, he also wrote a 13-volume set of reports defining in detail an all-digital nationally distributed network for digital voice and data.

Baran's packet switching ideas served as a foundation upon which others later built the ARPANET, which, over time, evolved into the Internet.

In 1968, Baran left Rand to co-found the Institute for the Future, a not-for-profit research group specializing in long-range forecasting. In 1972, he started a number of for-profit companies based on technologies he developed, and continued founding companies until 2003.

Baran won the U.S. National Medal of Technology in 2007. He passed away in 2011.



Early packet network diagram showing centralized, decentralized, and distributed network topologies, ca. 1965

2006

MARVIN MINSKY

For co-founding of the field of artificial intelligence, building the first artificial neural networks, and creating early robotics systems.

"NO COMPUTER HAS EVER BEEN DESIGNED THAT IS EVER AWARE OF WHAT IT'S DOING; BUT MOST OF THE TIME, WE AREN'T EITHER."

MARVIN MINSKY

Marvin Minsky was born in New York, New York, in 1927. He holds a B.A. from Harvard University (1949) and a Ph.D. from Princeton University (1954), both in mathematics.

Minsky has been a leading figure in computer science since the 1950s. He is one of the founders of the field of artificial intelligence (AI), and, with John McCarthy, established the MIT AI Lab in 1959 as a world center for research.

Throughout a career that has mirrored AI's general developments and posed some of its most difficult research questions, Minsky has left his imprint on generations of students and colleagues. His work has straddled computer science and psychology by applying computational concepts to the understanding of human psychological processes. This work has been widely influential, as have his parallel efforts in endowing machines with intelligence.

Minsky, who pioneered intelligence-based mechanical robotics and telepresence, designed some of the first mechanical hands with tactile sensors as well as visual scanners and their software and computer interfaces. He also is the inventor of the widely used confocal scanning microscope.

Among the honors he has received are the ACM Turing Award (1969), the Japan Prize (1990), and the Benjamin Franklin Medal (2001).

Cover of *The Society of Mind*, 1986

MINSKY PORTRAIT: ©MIT

2006

BUTLER LAMPSON

For fundamental contributions to computer science, including networked personal workstations, operating systems, computer security, and document publishing.

Butler Lampson was born in Washington, DC, in 1943. He holds an A.B. degree in physics from Harvard (1964) and a Ph.D. in electrical engineering and computer science from UC Berkeley (1967).

Lampson's long career covers a remarkable range of topics, including computer architecture, local area networks, raster printers, page description languages, operating systems, programming languages and their semantics, fault-tolerant computing, transaction processing, computer security, and WYSIWIG editors. He is also widely admired as a technical leader.

While at the Xerox Palo Alto Research Center (PARC), he made major contributions to the Alto personal workstation, an encryption system for Ethernet, the Bravo text editor, the Interpress page description language, and several of groundbreaking computer architectures and systems including the SDS 940 timesharing system and the Xerox PARC "Dorado" computer.

Lampson has taught at UC Berkeley and was a major contributor at the Computer Science Laboratory at Xerox PARC and Digital Equipment Corporation's Systems Research Center.

He holds, individually or with others, 23 patents relating to networks, security, raster printing, and transaction processing.

He has received many honors, including the ACM's Software Systems Award for his work on the Alto and the IEEE Computer Pioneer Award. He was awarded the von Neumann Medal and, in 1992, the ACM Turing Award.

Xerox Alto, 1977

"NEW CAPABILITIES EMERGE JUST BY VIRTUE OF HAVING SMART PEOPLE WITH ACCESS TO STATE-OF-THE-ART TECHNOLOGY."

ROBERT KAHN

LAMPSON ARTIFACT: ©PARC

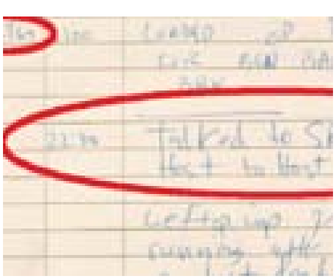
2006

ROBERT KAHN

For pioneering technical contributions to internetworking and for leadership in the application of networks to scientific research.

Robert Kahn was born in New York, New York, in 1938. He holds a B.E.E. from the City College of New York (1960), and M.A. and Ph.D. degrees from Princeton (1962, 1964).

Together with Vint Cerf, Kahn is known as "the father of the Internet." Shortly after graduating, Kahn joined the research firm BBN, where he was responsible for system design of the ARPANET, the first wide-area packet-switched network. He was also a part of the BBN team that developed the Interface Message Processor (IMP), a small computer that served as the ARPANET packet switch and which standardized the network interface to all attached host computers.



UCLA IMP logbook entry showing first connection between two host computers over the ARPANET, October 1969

KAHN ARTIFACT: UCLA

In October 1972, he demonstrated multiple computers exchanging information across different networks. Soon thereafter, he became director of the U.S. Defense Advanced Research Projects Agency (DARPA)'s Information Processing Techniques Office, where he initiated the Internetting project to develop an open architecture for networking.

While devising methods of ensuring reliable communications between such networks, he and Vint Cerf developed the architecture for the TCP/IP protocol suite, the fundamental communications protocol of the Internet.

Kahn has received dozens of awards, including the U.S. National Medal of Technology (1997) and the ACM Turing Award (2004).

2006

SIR ANTONY HOARE

For development of the Quicksort algorithm and for lifelong contributions to the theory of programming languages.

Antony Hoare was born in Colombo, Sri Lanka, in 1934. He received a B.A. in classics from Oxford University (1956).

Hoare's interest in computing was awakened in the early 1950s when he became fascinated by the power of logic and mathematics. In 1959, while studying machine translation of languages in Moscow, he invented the now well-known sorting algorithm, "Quicksort."

Hoare returned to England the following year and worked as a programmer for Elliott Brothers, a small British computer manufacturer, designing the first commercial Algol 60 compiler. He continued until 1968, when he became professor of computing science at Queen's University, Belfast.

Elliot 803 digital computer, ca. 1960

Hoare moved to Oxford University in 1977 and devised a system of logical rules that any programmer could follow, in the process helping to move the writing of software from a somewhat mystical discipline into a field with solid foundations.

Other results of his research include the Z specification language, the CSP concurrent programming model, and a method of analyzing the performance of parallel computing systems.

He is a fellow of the Royal Society, holds the ACM Turing Award (1980) and the Kyoto Prize (2000), and was knighted in 2000.

2007

JOHN L. HENNESSY

For fundamental contributions to engineering education, advances in computer architecture, and the integration of leading-edge research with education.

John L. Hennessy was born in 1953 and grew up in Long Island, New York. He earned his bachelor's degree in electrical engineering from Villanova University (1973) and his master's (1975) and Ph.D. (1977) in computer science from SUNY Stony Brook.

Hennessy joined Stanford University's faculty in 1977 as an assistant professor of electrical engineering. In 1981, he drew together researchers to focus on a computer architecture known as RISC (Reduced Instruction Set Computing), a technology that would revolutionize the computer industry by increasing performance while reducing cost. During his sabbatical year in 1984, he co-founded MIPS Computer Systems to produce commercial RISC microprocessors. It was a risky concept at the time, but RISC technology now appears in devices as varied as supercomputers and smartphones.

John Hennessy (center) inspects MIPS chip layout, 1984

Hennessy, who has lectured and published widely, is the co-author (with David Patterson) of two well known textbooks on computer architecture and design.

In October 2000, he was inaugurated as Stanford University's 10th president.

Hennessy is a member of the National Academy of Engineering and the National Academy of Sciences, and a fellow of the American Academy of Arts and Sciences, the ACM, and the IEEE.

2007

DAVE PATTERSON

For fundamental contributions to engineering education, advances in computer architecture, and the integration of leading-edge research with education.

Dave Patterson was born in Evergreen Park, Illinois, in 1947 and holds an A.B. in mathematics (1969), and M.S. and Ph.D. degrees in computer science (1970, 1976) all from UCLA. He holds the Pardee Chair of Computer Science at UC Berkeley, where he has taught computer architecture since 1977. Over the course of his career, he has emphasized the integration of teaching with research and the fostering of ties between industry and academia. These ties have proven critical to the rapid adoption of many of his innovations.

From 1982 to 1983, Patterson led the RISC project, a collaboration between UC Berkeley and the ARPA VLSI program. This project became the foundation of the highly influential SPARC micro-architecture from Sun Microsystems and has had wide influence across the field of computer design.

Berkeley RISC-II CPU die shot, 1984

Between 1989 and 1993, Patterson and Berkeley colleague Randy Katz led the Redundant Arrays of Inexpensive Disks (RAID) project, which resulted in vast improvements in disk system speed and reliability. Nearly every web server in the world now uses some form of RAID.

Patterson was made an ACM Fellow in 1994 and served as its president from 2004 to 2006. He is also a fellow of the IEEE Computer Society, and a member of the National Academy of Engineering, the National Academy of Sciences, and the American Academy of Arts and Sciences.

2007

CHUCK THACKER

For leading development of the Xerox PARC Alto, and for innovations in networked personal computer systems and laser printing technologies.

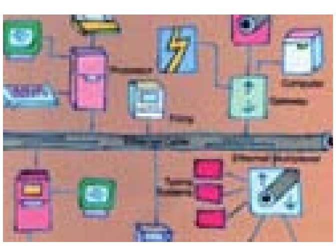
Chuck Thacker was born in Pasadena, California, in 1943 and holds a B.S. in physics from UC Berkeley (1967) and an honorary doctorate from the Swiss Federal Institute of Technology (ETH-Zurich).

Soon after graduation, Thacker joined Berkeley Computer Corporation, where he led the design of their new computer's processor and memory subsystem. After BCC failed commercially, Thacker joined the Computer Science Laboratory at the Xerox Palo Alto Research Center (PARC), where he led the hardware development of many innovative systems, including the design and engineering of the groundbreaking Alto computer hardware and much of its microcode.

At PARC, Thacker contributed to the Ethernet local area networking system and the world's first laser printer.

In 1983, Thacker was a founder of DEC's Systems Research Center (SRC) in Palo Alto, California, working on multiprocessor systems.

In 1997, he joined Microsoft to help establish the company's Cambridge, U.K., Research Laboratory. After returning to the U.S. in 1999, he joined the newly formed Tablet PC group and managed the design of the first prototypes of this new device. He now works on alternative and reconfigurable computer architectures. Thacker received the ACM Turing Award in 2009.



Ethernet concept sketch, 1979

2007

MORRIS CHANG

For dramatically accelerating the rate at which semiconductor-based devices and systems can be produced by developing the concept of an independent semiconductor manufacturing foundry.

Morris Chang was born in Ningbo, China, in 1931. He holds B.S. (1952) and M.S. (1953) degrees in mechanical engineering from MIT and a Ph.D. in electrical engineering from Stanford University (1964).

From 1958 to 1983, Chang worked at Texas Instruments (TI), rising to group vice president for its worldwide semiconductor business. Under his leadership, TI emerged as the world's leading producer of integrated circuits.

In 1983, Chang left TI to become president and chief operating officer of General Instrument Corporation. A year later, Chang was recruited by the Taiwanese government to spearhead that country's industrial research organization, the Industrial Technology Research Institute (ITRI). While there, he focused on using technology to advance Taiwan's larger social and economic goals. In this capacity, Chang founded Taiwan Semiconductor Manufacturing Company, Ltd (TSMC) in 1987.

TSMC is a "dedicated silicon foundry," an independent factory available to anyone for producing integrated circuits. Using this approach, both entrepreneurs and established semiconductor companies could avoid having to build their own very expensive semiconductor factories and focus instead on circuit features and system-level product design as ways of being unique in the marketplace.

Chang is a member of the U.S. National Academy of Engineering.

Morris Chang (left), ca. 1965

2008

LINUS TORVALDS

For the creation of the Linux kernel and management of open-source development of the Linux operating system.

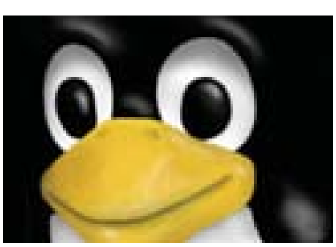
Linus Torvalds was born in Helsinki, Finland, in 1969. He holds an M.Sc. in computer science from the University of Helsinki (1997). He also holds an honorary doctorate from Stockholm University (1999) and from the University of Helsinki (2000).

Torvalds created the Linux kernel and oversaw open-source development of the widely used Linux operating system. Linux is used in devices ranging from supercomputers to smartphones and has transformed computing by being low cost, stable, secure, and open source.

In the fall of 1991, after purchasing a personal computer, Torvalds began using Minix, an UNIX-inspired operating system, as a self-teaching tool. He started work on his own kernel, later to be named "Linux," and, after forming a team of volunteers to work on this new kernel, released version 1.0 in the spring of 1994. Linux quickly proliferated and engaged a wide community of grassroots support.

In 1996, Torvalds accepted a position at Transmeta in San José, California. Along with his regular work duties, he continued to oversee kernel development for Linux.

In 2003, Torvalds left Transmeta to focus exclusively on Linux, and he continues to be the ultimate authority on which new code is incorporated into the standard Linux kernel.



Linux penguin mascot

2008

BOB METCALFE

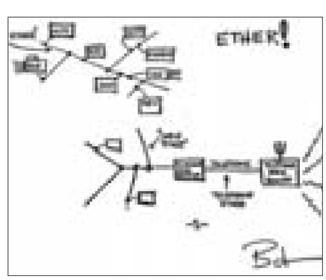
For fundamental contributions to the invention, standardization, and commercialization of Ethernet.

Bob Metcalfe was born in 1946, in Brooklyn, New York. He graduated from MIT in 1969 with bachelor's degrees in electrical engineering and industrial management. He also completed a master's in applied mathematics (1970) and a Ph.D. in computer science (1973) at Harvard.

A year earlier, Metcalfe had joined the Xerox Palo Alto Research Center (PARC), working in the Computer Science Laboratory. While there, and in collaboration with David Boggs, he invented and developed the Ethernet local-area network (LAN) technology and its system of packet protocols. This allowed personal computers to share files and printers, a major advancement.

In 1979, Metcalfe founded 3Com Corporation to build on this work and promote "computer communication compatibility." 3Com initially developed PC LAN products based on emerging UNIX, TCP/IP, and Ethernet standards. It went public in 1984 and grew into a billion-dollar networking company.

From 1990 to 2000, Metcalfe wrote weekly Internet columns for *InfoWorld*, later collected in his book, *Internet Collapses*. In 2001, Metcalfe joined Polaris Venture Partners. His contributions have been widely recognized, including the ACM Grace Murray Hopper Award, the IEEE Medal of Honor, and the National Medal of Technology. He is a member of the National Inventors Hall of Fame.



Ethernet sketch by Bob Metcalfe, 1972

“IT’S THE HIGHEST CALLING, TO BE IN TECHNOLOGICAL INNOVATION. DEMOCRACY, FREEDOM, PROSPERITY—THEY ALL STEM FROM TECHNOLOGICAL INNOVATION.”

BOB METCALFE

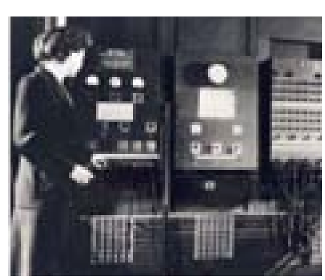
2008

JEAN BARTIK

For contributions as one of the first programmers of the ENIAC computing system in 1945 and for further assistance in converting the ENIAC system into one of the first stored-program computers.

Jean Bartik was born in Gentry County, Missouri, in 1924. She attended Northwest Missouri State Teachers College, receiving a B.S. in mathematics (1945), a GED (master’s) in English from the University of Pennsylvania (1967), and an honorary D. Sc. from Northwest Missouri State University (2002).

Upon graduating in 1945, she was hired to compute ballistic (gun) firing tables for the U.S. Army. She was one of hundreds of human “computers,” usually women, who calculated these tables by hand using mechanical desktop calculators. That same year, a novel electronic device to compute firing tables automatically was completed at the University of Pennsylvania.



ENIAC, ca. 1946

Bartik was one of six human computers chosen to work on the new machine, called ENIAC. She and the team taught themselves ENIAC’s operation and became its (and, arguably, the world’s) first programmers.

In 1947, Bartik became part of a group that converted ENIAC into a stored-program computer, a major milestone that improved its efficiency and usefulness. She also made contributions to the early BINAC and UNIVAC I computers.

Bartik, who was recognized late in life, became a strong advocate for increased participation by women in science and technology. She passed away in 2011.

2009

FEDERICO FAGGIN INTEL 4004 TEAM

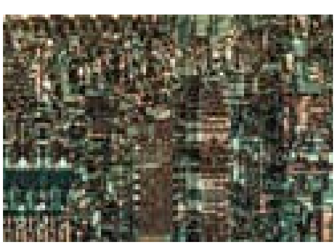
For his contributions to the development of the world's first commercial microprocessor.

Federico Faggin was born in Vicenza, Italy, in 1941. He received his doctorate (Laurea) in physics from the University of Padua (1965). He began working at SGS Fairchild in Italy, where he developed their first MOS process technology and their first integrated circuits (ICs). In 1968, he moved to Palo Alto, California, to work at Fairchild Semiconductor, where he created MOS silicon gate technology, the basis of all modern CMOS integrated circuits.

In 1970, he joined Intel, where he led implementation of a new method for random logic chip design using silicon gate technology. With help from Masatoshi Shima, he designed and developed all four ICs in Intel's groundbreaking MCS-4 microprocessor family, the world's first commercial microprocessor.

Faggin left Intel at the end of 1974 to found Zilog with Ralph Ungermann. At Zilog, he conceived and architected the Z80 microprocessor and directed its development. He was Zilog's president and CEO until 1980. In 1986, he co-founded and was CEO of Synaptics, a company pioneering in touchpads and touchscreens. He later became president and CEO of Foveon Inc., a company making image sensors, from 2003 until the company was acquired in 2008.

Faggin shares the Kyoto Prize (1997) and the National Medal of Technology (2009) with Mazor, Hoff, and Shima.



Intel 4004 die shot, 1971

2009

MARCIAN "TED" HOFF INTEL 4004 TEAM

For his contributions to the development of the world's first commercial microprocessor.

Marcian "Ted" Hoff was born in Rochester, New York, in 1937. He received his B.S. in electrical engineering from Rensselaer Polytechnic Institute (1958) and an M.S. (1959) and Ph.D. (1962) from Stanford University.

Hoff joined Intel in 1968 and is credited with the idea of using a universal processor to replace custom-designed circuits. This arose from a contract Intel had with Japanese company Busicom to build a set of integrated circuits for their new electronic calculator. Working with Stan Mazor, Hoff defined the instruction set and architectural specifications of the new chip, known as the Intel 4004. Fellow team members Masatoshi Shima and Federico Faggin implemented the design in silicon, creating the world's first commercial microprocessor. The microprocessor is now the core technology of all modern electronics systems.

In 1980, Hoff was named the first Intel Fellow and stayed in that position until 1983, when he went to Atari as vice president of technology. Hoff was most recently chief technologist at Teklicon, an intellectual property consulting firm, at which he served from 1990 to 2007.

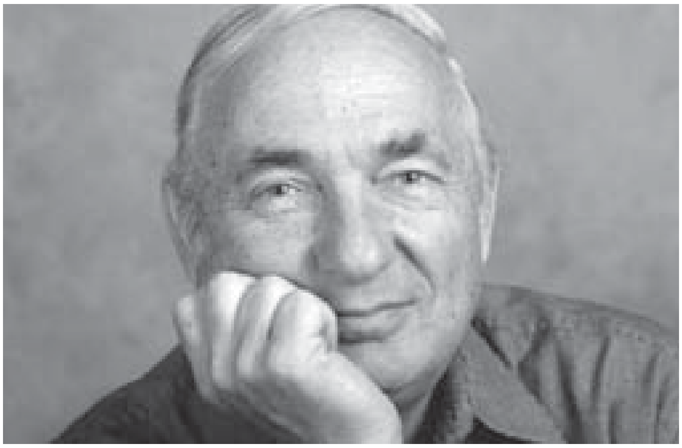
Hoff shares the U.S. National Medal of Technology (2009) with Faggin and Mazor and the Kyoto Prize (1997) with Faggin, Mazor, and Shima.

Intel's first microprocessor advertisement, ca. 1971

2009

STAN MAZOR INTEL 4004 TEAM

For his contributions to the development of the world's first commercial microprocessor.



Stan Mazor was born in Chicago, Illinois, in 1941. He studied mathematics at San Francisco State University.

In 1964, Mazor joined Fairchild Semiconductor in Mountain View, California, first as a programmer, then as a computer designer in the digital research department. While there, he helped specify and implement the Symbol high-level language computer, for which he received a patent.

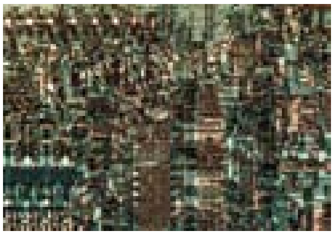
In 1969, he left Fairchild for Intel, where he worked under Marcian "Ted" Hoff on the Busicom calculator's instruction set and architectural specifications. In 1971, as part of a team that included Federico Faggin and Masatoshi Shima, he developed the Intel 4004 microprocessor, or "computer-on-a-chip," the world's first commercially available microprocessor.

Mazor wrote software for the revolutionary new chip and also proposed the first 8-bit microprocessor (the 8008) and was co-developer of Intel's popular 8080 microprocessor.

In 1974, Mazor moved to Intel's Brussels office as a field applications engineer helping customers to use Intel products.

During the 1980s, he worked at Silicon Compiler Systems and Synopsys. He has lectured at universities around the world, including Stanford University and the University of Santa Clara.

Mazor shares the Kyoto Prize (1997) with Shima, Hoff, and Faggin and the U.S. National Medal of Technology (2009) with Hoff and Faggin.



Intel 4004 die shot, 1971

MAZOR, SHIMA ARTIFACTS: ©INTEL CORPORATION

2009

MASATOSHI SHIMA INTEL 4004 TEAM

For his contributions to the development of the world's first commercial microprocessor.

Masatoshi Shima was born in Shizuoka, Japan, in 1943. He holds a B.S. in chemistry from Tohoku University (1967) and a DR. ENG. from Tsukuba University (1991).

In 1969, Shima worked at Japanese calculator manufacturer Busicom when it accepted a proposal by Intel to implement the logic for their new calculator in large-scale integration (LSI) logic. Following Marcian "Ted" Hoff's initial concept, Shima, Hoff, and Mazor jointly defined the functional specifications of the new chip, called the Intel 4004, and now known as a microprocessor.

Busicom calculator, 1971

Shima worked on the 4004's logic design, logic simulation, and test program generation. In 1971, the completed Busicom calculator was shipped and Intel began developing microprocessors on its own as a viable business, one with world-changing consequences.

Shima was recruited by Intel to design the 8-bit 8080 microprocessor, and later moved to Zilog with Federico Faggin and Ralph Ungermann to develop the highly successful Z80.

In 1980, he returned to Japan as a director of the Intel Japan Design Center. In 2000, he became professor at Aizu University in Japan, and retired in 2004.

Shima shares the Kyoto Prize (1997) with Hoff, Faggin, and Mazor.

2009

DONALD CHAMBERLIN

For his fundamental work on Structured Query Language (SQL) and database architectures.

Donald Chamberlin was born in 1944 in San José, California, and holds a B.S. in engineering from Harvey Mudd College (1966) and an M.S. (1967) and Ph.D. (1971) in electrical engineering from Stanford University. Chamberlin is best known as co-inventor of SQL (Structured Query Language), the world's most widely used database language. Developed in the mid-1970s by Chamberlin and Raymond Boyce, SQL was the first commercially successful language for relational databases. Chamberlin was also one of the managers of IBM's "System R" project, which produced the first SQL implementation and developed much of IBM's relational database technology.

Chamberlin joined IBM Research at the T.J. Watson Research Center, Yorktown Heights, New York, in 1971. In 1973, he returned to San José, California, and continued his work at IBM's Almaden Research Center, where he was named an IBM Fellow in 2003. In 2009, he was appointed a Regents' Professor at UC Santa Cruz.

Chamberlin was named an ACM Fellow in 1994 and an IEEE Fellow in 2007. In 1997, he received the ACM SIGMOD Innovations Award and was elected to the National Academy of Engineering. In 2005, he was given an honorary doctorate by the University of Zurich.

Don Chamberlin with students

2009

ROBERT EVERETT

For his work on the MIT Whirlwind and SAGE computer systems and a lifetime of directing advanced research and development projects.

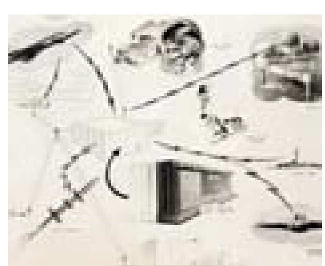
Robert Everett was born in Yonkers, New York, in 1921. He received a B.S from Duke University (1942) and an M.S. in electrical engineering (1943) from MIT.

Upon graduation, Everett joined the staff of MIT's Servomechanisms Laboratory, where he became associated with Jay W. Forrester in the development of the Whirlwind computer. Whirlwind's groundbreaking design laid the foundation for dozens of practical improvements in computer design, and formed the basis for the U.S. Air Force's Semi-Automatic Ground Environment (SAGE) air defense system.

In 1956, he was placed in charge of SAGE air defense system design and testing and also directed data processing research and development. This work led directly to the founding of the MITRE Corporation, a not-for-profit corporation formed to provide the U.S. Air Force with ongoing systems engineering support for North American air defense.

From 1956 to 1958, he was MITRE's technical director. In 1959, he was named vice president of technical operations and became executive vice president in 1969. From 1969 to 1986, Everett served as president of MITRE.

Everett is a Fellow of IEEE and a member of the U.S. National Academy of Engineering. In 1989, he received the U.S. National Medal of Technology.



SAGE Air Defense System diagram, ca. 1958

“THE BEST WAY TO DO RESEARCH IS TO MAKE A RADICAL ASSUMPTION AND THEN ASSUME IT’S TRUE.”

BILL JOY

2011

BILL JOY

For his work on the Berkeley Software Distribution (BSD) UNIX system and the co-founding of Sun Microsystems.

Bill Joy was born in Farming-ton Hills, Michigan, in 1954 and received his B.S. in electrical engineering from the University of Michigan and an M.S. in electrical engineering and computer science (EECS) from UC Berkeley (1979). As a Berkeley graduate student, Joy was a seminal figure in the creation, support, and rollout of BSD UNIX, an open-source operating system that was the first to have built-in TCP/IP networking.

With Vinod Khosla, Scott McNealy, and Andreas Bectholsheim, Joy co-founded Sun Microsystems, one of the leading workstation and server companies of the 1980s and 1990s, and a key player in the Internet boom and development of the Web. While at Sun, Joy was a key contributor to a number of Sun technologies, including the Solaris operating system, SPARC microprocessor architecture, and the Java programming language.

Joy left Sun Microsystems in 2003. Since 2005, he has been a partner at the Menlo Park, California-based venture capital firm Kleiner, Perkins, Caufield, where he participates in their green technology investment practice.

Joy is a member of the National Academy of Engineering and the American Academy of Arts and Sciences, and is a lifetime trustee of the Aspen Institute.

UNIX System Manager’s Manual, 1993

2011

RALPH MERKLE CRYPTOGRAPHY TEAM

For his work on public key cryptography.

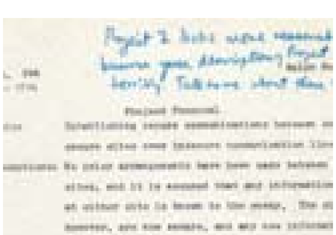
Ralph Merkle was born in Berkeley, California, in 1952. He received his B.S. in computer science (1974) from UC Berkeley and an M.S. (1977) and Ph.D. in electrical engineering from Stanford University (1979).

As an undergraduate in 1974, Merkle discovered a general method of securing electronic communications using a system of cryptographic key exchange now known as Merkle's Puzzles. Unfortunately, the idea was met with disinterest by his professors, and languished until Merkle learned about Martin Hellman and Whitfield Diffie at Stanford.

Merkle joined the team at Stanford for a summer in 1976 and became a doctoral candidate under Hellman the following fall. Working with Diffie and Hellman, Merkle developed the world's earliest public key cryptographic system. Their insight underpins secure transactions on the Internet, enabling e-commerce and a host of other interactions in which secure electronic communications are required.

On graduation, Merkle worked for Elxsi, a small computer company in Silicon Valley. Since 1988, Merkle has been researching nanotechnology and, in 2003, became a distinguished professor at Georgia Tech before returning to California in 2006.

He has been awarded the RSA Award in Mathematics (2000) and the IEEE Richard W. Hamming Medal (2010).



Undergraduate cryptography project proposal, 1974

2011

MARTIN HELLMAN CRYPTOGRAPHY TEAM

For his work on public key cryptography.

Martin Hellman was born in New York, New York, in 1945. He received a B.E. from New York University (1966), and an M.S. (1967) and Ph.D. (1969) from Stanford University, all in electrical engineering.

He is a cryptologist, professor, and computer privacy advocate. In 1976, he published, with Whitfield Diffie, *New Directions in Cryptography*, a groundbreaking paper that introduced a radically new method of distributing cryptographic keys. This method enabled secure communications over an insecure channel without prearrangement of a secret key. Their insight underpins secure transactions on the Internet, enabling e-commerce and a host of other interactions in which secure electronic communications are required.

In the 1980s, Hellman worked with scientists in the Soviet Union to establish more open ties and to foster dialogue to reduce the threat posed by nuclear weapons. He has also worked to develop environments in which students of diverse backgrounds can function to the best of their abilities within the university.

Hellman became professor emeritus of electrical engineering at Stanford University in 1996. Among many honors, he has won the IEEE Centennial Medal (1984) and the Electronic Frontier Foundation Pioneer Award (1994), and was elected to the National Academy of Engineering (2002).

Merkle, Hellman, and Diffie, 1977

HELLMAN ARTIFACT: STANFORD NEWS SERVICE

WHITFIELD DIFFIE CRYPTOGRAPHY TEAM

For his work on public key cryptography.

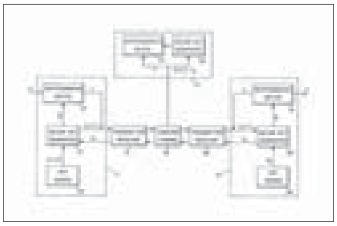
Whitfield Diffie was born in Washington, D.C., in 1944. He studied mathematics at MIT, receiving a B.S. in 1965.

On graduation, Diffie became an employee of the MITRE Corporation until 1969, when he joined the Stanford University AI lab to work with its director, John McCarthy, on proof of correctness of computer programs.

In the summer of 1972, Diffie's research interests changed to cryptography. In early 1973, he took a leave of absence to travel around the United States pursuing his new interest. He returned to Stanford with support from electrical engineering professor Martin Hellman, who was also pursuing research in cryptography.

Diffie and Hellman worked together throughout 1975 and were joined by Ralph Merkle in 1976. The results of their work appeared in Diffie and Hellman's paper, *New Directions in Cryptography*, in November 1976. The insights in this paper underpin secure transactions on the Internet, enabling e-commerce and a host of other interactions in which secure electronic communications are required.

In 1992, Diffie was awarded an honorary doctorate by the Swiss Federal Institute of Technology in Zurich, and in 2010, shared the IEEE Richard W. Hamming Medal with Ralph Merkle and Martin Hellman.



Public Key patent drawing, 1980

"WHEN A LOCK ICON APPEARS AT THE BOTTOM OF YOUR BROWSER, IT'S USING PUBLIC KEY CRYPTOGRAPHY."

MARTIN HELLMAN

2012

EDWARD FEIGENBAUM

For his pioneering work in artificial intelligence and expert systems.

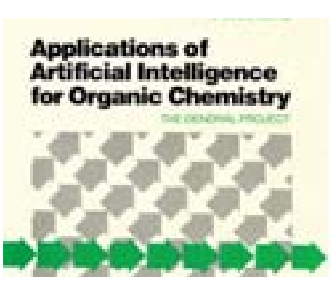
Edward Feigenbaum was born in Weehawken, New Jersey, in 1936. He holds a B.S. (1956) and Ph.D. (1960), both from Carnegie Mellon University. His dissertation was supervised by legendary computer pioneer Herb Simon and explored a pioneering computer simulation of human learning.

Feigenbaum is a pioneer in the field of artificial intelligence and is often known as "the father of expert systems." He founded the Knowledge Systems Laboratory at Stanford University and is currently a professor emeritus of computer science there.

Feigenbaum joined the Stanford computer science faculty in 1965 as one of its founding members. That same year, he and Nobel laureate Joshua Lederberg started the DENDRAL project. Later joined by eminent chemist Carl Djerassi and others, this project produced the world's first expert system (1965–1982). DENDRAL's groundbreaking accomplishments inspired an evolution of expert systems, moving artificial intelligence out of the laboratory and into the structure of countless software applications. As important, it changed the framework of AI science: the power of an AI program came to be seen as largely in its knowledge base, not in its inference processes.

Over a career spanning the history of artificial intelligence, he has written and spoken extensively on artificial intelligence topics.

In 1994, Feigenbaum received the ACM Turing Award. From 1994 to 1997, he was Chief Scientist of the U.S. Air Force. He is a member of the National Academy of Engineering and the American Academy of Arts and Sciences.



Seminal book on the Dendral Project, 1980

2012

STEVE FURBER

For his work on the BBC Micro and design of the ARM processor architecture.

Steve Furber was born in Manchester, England, in 1953. He received a B.A. in mathematics in 1974 and a Ph.D. in aerodynamics in 1980, both from the University of Cambridge.

He is ICL Professor of Computer Engineering in the School of Computer Science at the University of Manchester.

From 1980 to 1990, he worked in the hardware development group at Acorn Computers Ltd and was a principal designer of the BBC Microcomputer (1982) and the ARM 32-bit RISC microprocessor.

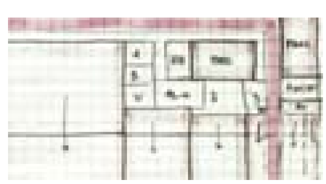
Designed with colleague Sophie Wilson as part of a national TV program on personal computing, well over a million BBC Micros were sold and used in more than 80 percent of all U.K. schools.

Furber and Wilson then co-designed the 32-bit RISC Machine processor (1985) to address a need at Acorn for a new microprocessor that outperformed any then commercially available.

The ARM processor core is now used in thousands of different products, from mobile phones and tablets to digital televisions and video games. It has enabled the mobile revolution in computing with its efficient power-sipping microprocessors. The number of ARM processor cores now shipped exceeds 30 billion, or more than four ARM microprocessors for every person on earth.

Furber's current research interests include the SpiNNaker project, which seeks to emulate a small portion of the human brain using one million ARM processor cores.

Furber lives in Wilmslow, England.



Original pencil sketch made for the first ARM chip floorplan, 1984

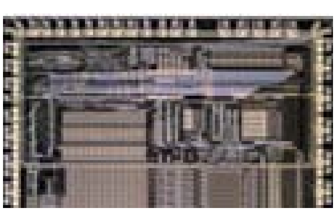
2012

SOPHIE WILSON

For her work on the BBC Micro and design of the ARM processor architecture.

Sophie Wilson was born in Leeds, England, in 1957. She began studying computer science at the University of Cambridge in 1975. In 1977, she developed an automated cow-feeder during her first summer vacation. She next designed the Acorn System 1, an early 8-bit microcomputer for hobbyists, which was produced commercially by the British company Acorn Computers beginning in 1979.

Now working at Acorn, she and colleague Steve Furber took less than a week to design and implement the prototype of what became the BBC Microcomputer. Furber and Wilson refined their design over the same summer, with Wilson designing the operating system and writing the BBC BASIC interpreter.



CORBATÓ ARTIFACT: MIT ARCHIVES

ARM 1 microprocessor, 1985

The BBC project succeeded beyond its creators' wildest dreams: in the ensuing decade, well over a million BBC Micros were sold and used in thousands of U.K. schools.

Wilson and Furber then co-designed the 32-bit RISC Machine processor (1985). This was used in the BBC Micro as a second processor (1986); Acorn's first general-purpose home computer based on their own ARM architecture, the Archimedes (1987); and Apple Computer's first personal digital assistant, the Newton (1993).

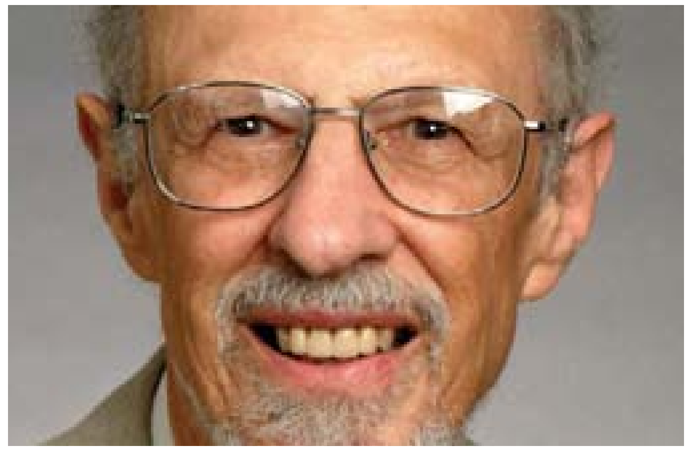
The ARM processor core is now used in thousands of different products, from mobile phones and tablets to digital televisions and video games. The number of ARM processor cores now shipped exceeds 30 billion, or more than four ARM microprocessors for every person on earth.

Wilson lives near Cambridge, England.

2012

FERNANDO CORBATÓ

For his pioneering work in timesharing and multi-access computer systems.



Fernando Corbató was born in Oakland, California, in 1926. He received his B.S. degree from Caltech (1950) and a Ph.D. from MIT (1956), both in physics.

Corbató is a professor emeritus in the department of electrical engineering and computer science at MIT and a pioneer in computer operating systems.

He achieved wide recognition for his work on the design and development of multiple-access and timesharing computer systems. These systems allow many users to share the resources of a single large computer, a dramatic advance in the 1960s when laborious batch processing methods—with their often days-long waits—were the norm. This new method, called timesharing, allowed for truly interactive computing in which near-instant response times dramatically increased productivity and user convenience.

In the late 1960s, Corbató led development of a groundbreaking new operating system, MULTICS (Multiplexed Information and Computing Service), which in 1973 became the basis of a commercial system offered by Honeywell Information Systems. MULTICS also had a major influence on the now-ubiquitous UNIX operating system.

In 1990, Corbató received the ACM Turing Award for his work on modern operating systems.

Corbató at MIT, ca. 1965

The Fellow Awards are one of the highlights of the year at the Computer History Museum. They represent an annual opportunity for us to salute and honor pioneers whose creativity, persistence, and vision have helped transform computing—and in turn, changed the world.

CELEBRATING FELLOWS

EVENTS

2000 Vint Cerf, former Museum CEO John Toole, and Board Chairman Len Shustek

2001 Jean Sammet holds up award alongside Vint Cerf and former Museum CEO John Toole

2002 John Warnock, Charles Geschke, Carver Mead, and Frances Allen

2003 Screen shot of Gordon Bell, Tim Berners-Lee, and David Wheeler during the ceremony

2004 Former Museum CEO John Toole and Niklaus Wirth

2005 Former Museum CEO John Toole, Al Shugart, and host Steve Westly

2007 John Hennessy during award acceptance speech

2008 Museum CEO John Hollar with Jean Bartik and her son, Tim Bartik

2009 The Intel 4004 Team on stage with The New York Times' David Pogue

2011 Cryptography Team with Museum CEO John Hollar and NPR's Laura Sydell

THE ORIGINS OF TIMESHARING

ORAL HISTORIES

INTERVIEW BY STEVEN WEBBER
EXCERPT BY ALEX BOCHANNEK

The Computer History Museum's Oral History Program seeks to record first-person accounts of momentous developments in computing history.

These recordings provide significant stories in the participant's own voice. At times, they also recover little-known anecdotes and folklore that offer a richer flavor of the working environment, the places, and people involved. Interviewees share reflections on a long career, lessons learned, and analysis of the arc of technological development.

In this 2006 interview, former MULTICS operating system programmer Steven Webber discusses the origins of timesharing and MIT's CTSS, Project MAC, and MULTICS with 2012 Fellow, Fernando Corbató.

Steven Webber: How did timesharing actually appear? What were some of the discussions?

Fernando Corbató: The [MIT Computation Center] got operating around 1957 and in just a few short years, we had developed an appetite for computing among the scientific and engineering community. [The demand] was pretty voracious and people were learning to program. My recollection is [that] Fortran hit the world around 1956 and had a huge impact because it suddenly opened the door for people to not be coders but to be real programmers in the sense that they could begin to deal in a semi-algebraic form with their programs. So the demand on the Computation Center was ever increasing and growing by leaps and bounds.

By 1958 and 1959, we were suffering from being overloaded. This was happening all across the country, of course. The state of the art for the IBM 704 [IBM's large-scale scientific computer at the time] was initially for it to be driven by a deck of punched cards, which you'd put in a punched-card reader with output printed out on the online printer. People had realized that this was terribly inefficient and so they had gone to pre-recording a batch of punched-card jobs on magnetic tape, and then, during the operation of a batch, the output stream would be recorded on magnetic tapes and subsequently printed off-line afterwards. This came to be called batch processing, and the obvious intent was to optimize and make the machine more efficient. But one of the consequences was that the individual programmer or user found himself with more and more frustrating access to the machine. It got to the point where, under the pressure of people queuing up, you would get maybe one shot a day at running your program. Typically, it might be just compiling it and trying to run it, but any error at all, a dropped comma, anything, would scrap the job. You would be left with a mound of paper, which was the dump of memory, and trying to figure out what had gone wrong. So one run a day to find a trivial mistake was terribly frustrating and counterproductive.

In retrospect, we came to recognize that what we'd done was we'd optimized the use of the machine but not the people. The first person to become really articulate about it that I heard was John McCarthy. McCarthy had joined the center when he joined MIT as a faculty member. John, in my mind, was probably the most influential person to articulate the vision of many people using a computer at once, with a computer multiplexing between individuals at multiple terminals and having high interaction.

Probably the most important thing that we didn't recognize and plan so much is [that MULTICS] was a training bed for an incredible number of professionals who went out to play roles all over the map…in advancing the computer world.

CTSS, Project MAC, and MULTICS

Webber: You have a computer system, a prototype, basically, for what actually was CTSS [MIT's Compatible Time-Sharing System]. When was this, and when did it actually start getting used at the Computation Center?

Corbató: We went from getting the [IBM] 7090 in the summer of 1962 to the late spring of 1963, when we were beginning to run CTSS with this new configuration involving the extra bank of memory, the 1301 disc drive, and the 7750 [communications] hardware. We were in place to be the workhorse for the Project MAC summer.

Webber: At the end of 1963, you now have two CTSS machines that are up and working, one at the computer center that's being used by people doing research in their work, and then the one with Project MAC.

Corbató: One piece of jargon was that the panels on the Project MAC machine were red and the panels on the Computation Center machine were blue, so people tended to refer to them as the blue machine or the red machine. And the interesting thing was that we could dial up our computer terminals to either machine depending on the number you picked because we were using a telephone switch and had a 7750 on both machines.

Webber: MIT is becoming at this point well known for their computer science, amongst just a few universities out there. Can you go a little bit more into what kind of specifications you were coming up with and why you didn't think certain machines would work and others would? It obviously had to do with what you thought the timesharing system was going to need.

Corbató: We began to write some position papers. There, we spelled out what we expected MULTICS to be. Joe Weizenbaum suggested we might look at GE equipment. Indeed, we did look at GE equipment, and of all the vendors we looked at, they were the ones that seemed the most eager to please and [were] hungry. They had an architecture for the equipment which was more appropriate to being modified for a decent timesharing system.

The Project MAC and MULTICS Legacy

Corbató: The key goal of Project MAC was to influence the industry. I would say in retrospect we partly succeeded. We certainly got people to pay attention. We didn't get them to change their ways so quickly, but what was introduced was the notion of interactive computing. Nobody doubts that that's the way to use a computer today.

Webber: We never even mentioned what MULTICS stands for, and I think the last word is key there. What I was told was that it wanted to be as reliable as a dial tone on the telephone, and that's very difficult, of course. What does the acronym actually stand for?

Corbató: Multiplexed Information and Computing Service

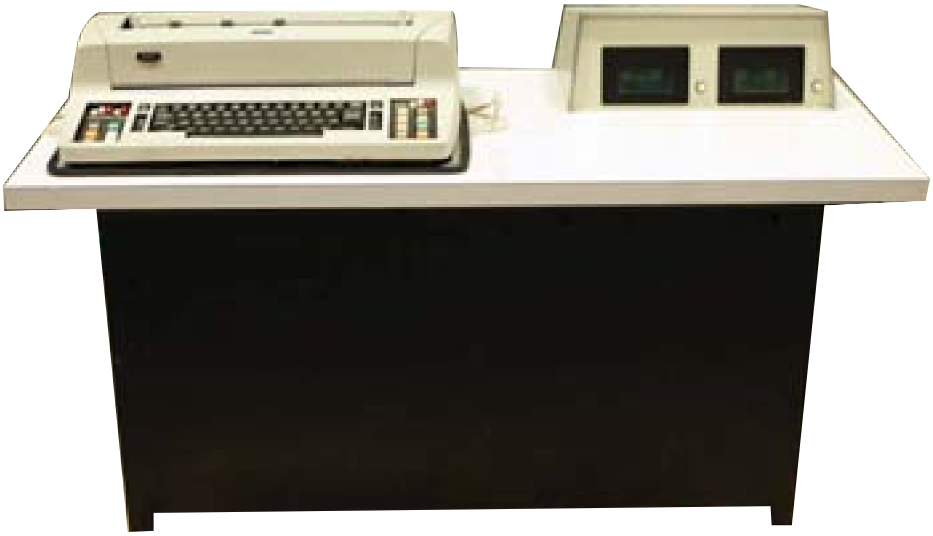
Webber: That was the key thing. We had to provide a service, and part of it is that you realize you have to provide something that's always there, like the electric light switch or the telephone. It means you have to look at things totally differently.

Corbató: I recognized fairly early in the game, as a programmer myself, that losing your programs because of a disc crash was a disaster, and you couldn't accept that. Hardware was so flaky in those days. People don't remember and don't realize how flaky things were. We used to crash all the time.

Webber: What do you think are some of the important legacies that came out of MULTICS?

Corbató: Probably the most important thing that we didn't recognize and plan so much is [that] it was a training bed for an incredible number of professionals who went out to play roles all over the map, yourself included, in advancing the computer world. In thinking about [it] I feel proud of the fact that Ken Thompson came in, learned, got a tremendous exposure to all the ideas, participated in some of them and when Bell [Labs] got jerked out of MULTICS, went on to do such a constructive thing as to build what's become UNIX. ○

Fernando Corbató at MIT's Computation Center upon arrival of the IBM 7090 mainframe, 1962



WANG 1200 WORD PROCESSOR

CHM#: 102746931
DATE: 1973
DONOR: James Battle

This Wang 1200 was Wang Labs' entry into the word processing market, based on an earlier-model calculator with modified software and an IBM Selectric typewriter. The cassette tapes held text during an editing session or form letters and templates for mail merge operations.

Wang became virtually synonymous with word processing in American offices in the late 1970s, when the more successful WPS system replaced the Wang 1200 series.

THE KERMIT PROJECT ARCHIVE

CHM#: X6335.2012
DATE: 1981–2011
DONOR: Frank da Cruz, Columbia University

In 1981, the Kermit protocol was developed at Columbia University for students to transfer files between central DECSYSTEM-20 systems and Intertec Superbrain CP/M computers. Subsequently, Kermit became one of the most widely implemented communication protocols; it was put to use in projects as diverse as U.S. Postal Service automation, International Space Station experiment support, and the 1994 Brazilian national election.

This collection includes a Superbrain computer, hundreds of versions of Kermit software, documentation, correspondence, newsletters, and ephemera.

SYNCHRONIZED ELEGANCE IMAGING

COLLECTION

RECENT ARTIFACT DONATIONS

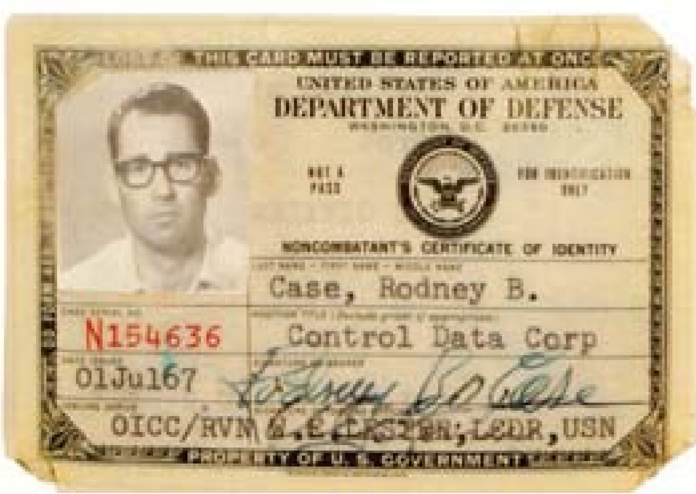
BY ALEX BOCHANNEK

CONTROL DATA CORPORATION SAIGON EPHEMERA

CHM#: X6309.2012
DATE: 1966/1967
DONOR: Rodney B. Case

The massive infrastructure required for the Vietnam War led to the hiring of construction consortium RMK-BRJ in Saigon, South Vietnam, by the U.S. Department of Defense. Control Data installed a CDC 3100 mainframe at that location in 1966.

Rodney Case worked as the Systems Administrator at the RMK-BRJ computer center. He was then promoted to manager of CDC's field operations in Southeast Asia. These identification cards and the office sign are from his work in Saigon.



DONOR PROFILE

SUPPORT

Mark and Debra Leslie of Portola Valley, California, are long-standing supporters of the Computer History Museum. In 2011, the Leslies pledged $1 million to support a new initiative in software history. The centerpiece of the initiative will be a physical and digital exhibition of software "game-changers." The working title of the project, scheduled to debut in 2013, is *Make Software, Change the World*.

Mark is retired after a 35-year career as a successful entrepreneur in Silicon Valley. He was most notably founding chairman and CEO of Veritas Software, which during his tenure grew from 12 employees in 1990 to 6,000, and from $95,000 in revenue to $1.5 billion annually. It was acquired in 2005 by Symantec Corporation.

Mark is now a lecturer in management at the Stanford Graduate School of Business, where he teaches courses in entrepreneurship and sales organization. He also serves on the boards of several private companies, a number of Silicon Valley nonprofits, and the New York University Board of Overseers.

Mark and Debra have established the Leslie Family Foundation and, through the foundation, generously support a number of nonprofit institutions that advance their vision of community service and education.

"When I saw the new Museum exhibition, *Revolution*, I immediately thought that the Museum had the opportunity to do for software what it has done with so many other areas of computing," Mark said. "I also thought that a focus on software would help the general public understand that the great breakthroughs of the most recent twenty years have largely been software-driven.

Because the Museum was already planning to make software an important part of its future strategy, we were able to help something strategic happen even faster than it might have. Debra and I are happy to support the work of the Museum, and to see it be front and center as a destination for history and understanding in Silicon Valley."

When I saw *Revolution*, I immediately thought that the Museum had the opportunity to do for software what it has done with so many other areas of computing.

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As of 12/31/2011

Vision
To explore the computing revolution and its worldwide impact on the human experience

Mission
To preserve and present for posterity the artifacts and stories of the information age

ABOUT THE MUSEUM

BACKGROUND

The Computer History Museum is the world's leading institution exploring the history of computing and its ongoing impact on society. It is home to the largest international collection of computing artifacts in the world, including computer hardware, software, documentation, ephemera, photographs, and moving images. The Museum brings computer history to life through an acclaimed speaker series, dynamic website, on-site tours, and exhibitions.

CURRENT EXHIBITS

Revolution: The First 2000 Years of Computing
Everyone uses computers. Few know the story of how they came to be. *Revolution* is the only historically authoritative exhibition exploring the explosive growth of computers, software, and networking. It chronicles the evolution and impact of modern computing from the abacus to the smartphone. This 25,000 sq. ft. multimedia experience is a technological wonderland that immerses visitors in the sights, sounds, and stories of the computer revolution.

Babbage Difference Engine No. 2: The Story of the First Computer Pioneer
Charles Babbage (1791-1871) designed the first modern programmable computer—complete with a printer—but he failed to build it. Engineers at the London Science Museum finally built the first working Babbage Engine in 2002. The Babbage Difference Engine No. 2 on display at the Museum has 8,000 parts, weighs five tons, and measures 11 feet in length. Learn more about this extraordinary object and the people who built it.

Mastering the Game: A History of Computer Chess
The history of computer chess is a five-decade-long quest, beginning in the earliest days of computing and reflecting ongoing advances in hardware and software. Chess presented the perfect computing challenge: a simple set of rules enabling games of stupefying complexity. Learn more about the journey to build a computer that challenged the world's best chess players.

PDP-1
Digital Equipment Corporation's (DEC) PDP-1 was the first commercial computer designed to interact with a single user. The Museum's restoration team brought the PDP-1 back to working condition. They retrieved data from its main memory, restored all the peripherals, and loaded the machine with vintage games, including *SpaceWar*!

HOURS

Wednesday–Sunday
10 am–5 pm

CONTACT

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1401 N. Shoreline Blvd
Mountain View, CA 94043
info@computerhistory.org
650.810.1010

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Generous contributions from individuals like you support our work in collections, exhibit development and educational programming. We strive to foster greater understanding of the computing revolution's worldwide impact on the human experience. Please help us tell the fascinating stories of the information age by making a gift today. Go to computerhistory.org/contribute/

Computer History Museum