CORE 1.1

WINTER 1999

Computer History Museum

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Core

Message from the President

November 24, 1999

Welcome to CORE,

We prepared this material to keep our many supporters and friends abreast of History Center developments, programs and activities. There are many exciting developments to report, among them: the 1999 Fellow Awards; a great photo essay about Computer History Museum in the November issue of "Wired"; a new 15,000 square-foot warehouse to house our ever-growing collection of artifacts; a January 2000 lecture about Superpaint (featuring its inventor Dick Shoup and Alvy Ray Smith, who received a Technical Academy Award for digital painting in 1998), and much, much more.

Through reading this material, I hope you will feel, as I do, the energy and excitement that our staff, board and volunteers bring to this important and challenging endeavor to preserve and present artifacts and stories of the information age.

My heartfelt thanks to all of you who contribute your time, money, artifacts and other resources to Computer History Museum. Together, we are working to preserve our computing heritage.

We hope you will include The Computer History Museum History Center in your year-end giving plans. Your support is what keeps us growing and vital.

Please let me hear from you. I look forward to your comments, suggestions, and participation.

Sincerely,

Karen Mathews

Upcoming Events

Thursday **January 13, 2000**	Computer History Lecture Series Dick Shoup & Alvy Ray Smith **Recollections of Early Paint Systems**
Time	6:00 p.m.
Location	Moffett Training/Conference Center (Bldg 3) NASA Ames Research Center Moffett Field, CA

Computer pioneers Dick Shoup and Alvy Ray Smith will be speaking on the evolution and development of Superpaint, the world's first computer painting program, developed at Xerox PARC in the early 1970s.

Alvy Ray Smith

Dick Shoup

Recent Events

1999 Fellows Dinner

Vintage Computer Festival 3.0

Zuse Colloquium

Gordon Moore Lecture

COMDEX 1999

Computer History Museum is a busy place! Thanks to a solid volunteer corps, the Center is able to mount a variety of events meant to promote our educational and preservation missions in the history of computing. The five events took place since September 30 and brought us to the attention of over 2,000 people directly and probably 10 times that indirectly.

1999 Fellows Dinner

Over 220 guests attended Computer History Museum's 1999 Fellow Awards Ceremony & Dinner. The event is Computer History Museum's annual tribute to those who have made fundamental contributions to computing. For more information on the event, including biographies of the 1999 Fellows, please visit http://www.computerhistory.org/fellowawards/.

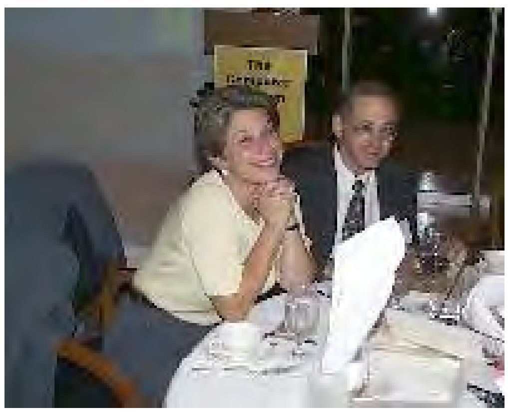
This annual fundraiser began with a cocktail reception during which guests had an opportunity to talk to History Center staff and volunteers, learn about Center projects and progress, and try out our new website (www.computerhistory.org).

President Karen Mathews with WIRED magazine contributing editor David Pescovitz.

Doug Engelbart speaks with Computer Museum Founding President Gwen Bell. Engelbart was the introducer for Alan Kay -- one of the three 1999 History Center Fellows.

Horst Zuse (left) accepting award on behalf of his father Konrad Zuse from Hermann Rampacher, Chief Executive of the German Konrad Zuse Society.

Alan Kay (left) receives a 1999 Fellow Award from presenter Doug Engelbart.



Event MC Donna Dubinsky and History Center Board Chairman Len Shustek

Presenter Ed Feigenbaum (left) and 1999 History Center Fellow John McCarthy

Information poster on the Zuse Z23 Mainframe computer donation. The 1960 transistor-based machine travelled 7,500 miles to reach Computer History Museum!

History Center volunteer Lee Courtney (left) discusses current projects with Stanford professor and History Center founding member Gio Wiederhold.

Vintage Computer Festival 3.0

The Vintage Computer Festival is the brainchild of Sam Ismail, a San Francisco Bay Area computer enthusiast, and takes place annually at the Santa Clara Convention Center over two days. VCF is a great way to meet fellow computer collectors in an informal and engaging atmosphere.

VCF puts the emphasis on fun and on building a community of mutually-supportive computer history supporters both locally and around the world (VCF Europe is in the planning stages!)

Aside from an exhibition space and flea market, it also hosts a mini lecture series each morning of the event.

Computer History Museum was delighted to participate again this year by setting up an exhibit showcasing our activities. As well, History Center curator Dag Spicer joined VCF and History Center volunteer Alex Bochannek and computer pioneer Lee Felsenstein as judges in the Exhibit competition. A truly diverse range of exhibits made the VCF a great learning experience for everyone!

Computer History Museum encourages computer history buffs everywhere to attend and support VCF 4.0 next year.

Zuse Colloquium

Konrad Zuse was honored by three significant events at Computer History Museum this year: he was made one of three History Center Fellows for 1999 (posthumously); and was the subject of a day-long colloquium on his work. Also, one of his mainframe computers was dedicated to the Center's permanent collection.

Zuse was a fascinating character in the history of computing because his inventions, which embodied great originality, went unnoticed for many years due to wartime conditions, even in his native Germany. Three distinguished Zuse scholars spoke at the colloquium about his work in the context of computing generally and as part of the German war effort.

A condition of Zuse's will (he died in 1995) was that one of his machines should be displayed in America so that people there might appreciate his contributions. Fortunately for the Computer History Museum, a group of high school students carefully restored one of his Z23 mainframe computers for this donation. In a touching ceremony featuring one of these students, several instructors from the school, representatives of the German Informatics Society, the Konrad Zuse Society, and the Deputy Consul General of Germany (San Francisco); the machine was formally donated to the Museum's permanent collection.

Zuse Z23 Mainframe in its permanent home at Computer History Museum.

German guests at the Z23 Dedication Ceremony.

As well as the machine, all system documents (on CD-ROM) were included in the donation, as were a painting by and portrait of Konrad Zuse--both of which now hang in the Center's administrative offices.

Finally, an exhibit display of the Zuse Z3 (relay computer) Adding Unit was donated by Professor Raul Rojas---a brilliantly conceived and meticulously executed instructional display the Museum will treasure for years to come.

Gordon Moore Lecture

Intel co-founder and Chairman Emeritus Gordon Moore gave a lecture at the NASA Ames Research Center, co-sponsored by Computer History Museum and the Churchill Club--a local Silicon Valley organization.

Dr. Moore spoke about the evolution of the semiconductor industry, a speech that was followed by tours of our exhibit area given by History Center staff and volunteers. Over 200 people got their first look at the collection highlights on display!

Moore's lecture covered the early days of Shockley Semiconductor, Fairchild, and Intel, including a discussion of his eponymous law--originally coined somewhat in jest by Caltech professor and friend Carver Mead.

From left, History Center Chairman Len Shustek, President Karen Mathews, and speaker Gordon Moore at Computer History Museum. Collections Coordinator Chris Garcia peeks from behind!

Moore with History Center board members Gordon Bell and Dave House.

COMDEX 1999

On November 15 in Las Vegas, Computer History Museum co-hosted, with Computer Reseller News, the third annual Industry Hall of Fame Awards. Twelve computer industry luminaries were inducted, including History Center Founding Members Donna Dubinsky, Charles Geschke, and Ray Ozzie.

History Center President Karen Mathews and Computer Museum Founding President Gwen Bell represented Computer History Museum at this exciting event.

Collection News

Exhibit Space Doubles!

Computer History Museum has added 10,000 square feet of storage space by leasing Building 45 at NASA Ames, just one block from our Visible Storage Area. This has allowed us to convert the middle bay of Bldg 126 from storage to exhibit space, effectively doubling the number of items we can now display.

The new space was urgently needed to accommodate the many artifacts Computer History Museum now receives daily as well as several very large institutional donations that threatened to take up every remaining square inch of warehouse space.

The Center will be mounting new and original exhibits in the former "middle bay" of Visible Storage--exhibits focused on mini and microcomputers as well as the Internet. We will also have room to re-institute our monthly Computer History Lectures surrounded by artifacts--a venerable tradition among regular History Center lecture goers!

The new exhibits are expected to be ready by January 1, 2000--a great way to start the millennium!

New Storage Area - Building 45 Visible Storage (Bldg 126) is across from the water tower

Cavernous interior of Building 45 (40 foot ceilings!)

IBM 1620 Up and Running

The IBM 1620 Project, an historical restoration undertaken by History Center volunteers, reached a critical milestone on October 23 at 10:55 a.m. when, for the first time in over 15 years, the machine successfully executed an instruction. The IBM 1620 was first introduced in 1960, sold for $74,500 dollars, and came with 20 to 60K (digits) of core memory. It was popular in educational and light engineering markets and IBM manufactured some 2,000 of the machines. Weighing 1,200 lbs and consuming approximately 2kW of power, the 1620 could also be ordered with paper tape, punch card, and disk I/O. It could perform 1,700 ADD instructions per second.

The restoration project was begun in January of this year under the leadership of volunteer Dave Babcock, a senior software developer with the compiler group at SGI (and now with HP). The purpose of the project was not only to restore machine hardware to working condition but also to learn general techniques of museologically-sound computer restoration; to act as a magnet for attracting historically-relevant materials about the 1620; and to advance the Center's understanding of what is important in preserving the history of computing machinery.

Joe Fredrick and Steve Casner debug 1620 power supply units.

Portland IBM 1620 owner and technical guru David Wise--instrumental in History Center 1620 Project success.

All three of these goals have already been met. The highly-talented volunteer restoration team, comprising both software and hardware engineers from across the country, are building a modern interface to simulate paper tape, punch card reader & punch, and console keyboard since these system elements are not available at this time. When it was determined that the 1620's core memory was irretrievably damaged through the ravages of time, the team designed and built a semiconductor replacement for the original core, carefully annotating their modifications for the benefit of future scholars.

As word spread about the project, documentation and software began arriving at Computer History Museum in large quantities. Manuals, schematics, reference cards, marketing literature and photographs--as well as over 300,000 punch cards, representing the largest single collection of 1620 software in the world--arrived within six months of project start. These cards are being read and a CD-ROM produced in order to preserve these hundreds of programs, compilers, games, and utilities. The project has thus greatly increased the Center's holdings, creating a wonderful legacy for future students of this machine.

Tim Coslet maps out entire circuit board complement of 1620.

Local 1620 Project Team--over 25 people around the world have contributed.

Finally, many important questions relating to what about computers is worth preserving were (in part) answered. While working hardware was the main goal, the project has preserved documents, ephemera, software, photographs, films, and oral histories about the 1620--allowing a highly-accurate historical context for the machine to be developed. The team also wrote a simulator (in Java) so that people on the web can learn from the machine. Similarly, it is anticipated that all project materials will eventually be digitized and placed on the web. Congratulations to all team members for their persistence, intelligence, and great care!

Recent Donations

Computer History Museum receives some 100 historical objects per week all year round. This makes us the single largest collector of computing history in the world!

Some highlights from items donated in the past several months:

Mechanical Calculators:
Monroe CST-8 (1949)
Monroe CSA-10
Monroe CAA-10
Friden SW10
VE-PO-AD (1930)

Microcomputers:
Apple Powerbook 100
Atari 2600 (1979)
Cromemco SCC
IBM PC Jr. (1983)
IMSAI 8080 (1976)
Otrona Attache (1987)
Tandy 600 (1985)
Xerox 860 (1981)

Mainframes:
Zuse Z23 (1960)
Honeywell DPS-8 (Multics)

Minicomputers:
DataPoint 2200 System
DEC PDP-11/70
HP1000 (1978)
HP2115A (1968)
HP3000 (1986)
Sun 960A System (1987)
TI 960A (1972)
TI 960B (1973)

Supercomputers:
ETA-10 Supercomputer (1988)
IBM Multi-RIOS Prototype (1991)
Intel iPSC2 (1987)
Intel iPSC 860 (1990)
Intel Paragon XP/S (1994)
Intel Touchstone Delta (1991)

Other / Special Purpose:
CDC 679 Magnetic Tape Unit (1988)
CDC 819 Disk Storage Unit (1988)
DEC Alpha Prototype System (1991)
DEC Alpha EV-5 Test Wafer
DEC MicroVAX Die Plot (1984)
DEC MicroVAX II Die Plot (1987)
Fujitsu VP2000 SIM CPU (1988)
GENIAC Kit (1958)
IBM 3151 ASCII Terminal (1987)
Iomega Bernoulli Box (1987)
ILLIAC IV PCB Test Core (1972)
InfoGear iPhone (1999)
Sega AI Computer (1986)
Spyrus FORTEZZA Crypto Card (1999)
U.S. Robotics 1200bps MODEM (1976)
Xerox Alto (1972)

Documentation:
Datapro Reports (Complete Run)
George Stibitz Personal Papers
Original SRI RFCs (#1-1000)
APL Collection (50 lin. ft.)
Zuse Z3 Adder Unit Display (1999)
UVC Video Collection (150 pioneers)

WIRED Magazine

IEEE Poster

Radio & Television

In The News

WIRED Magazine

Computer History Museum was featured in a 24 page article of WIRED magazine's November 1999 issue (See "The Computer Hall of Fame - Modern Art." pp. 276 - 299). This photo-essay by New York photographer Todd Eberle and WIRED contributing editor David Pescovitz was one of the largest articles ever published by the magazine according to WIRED staffers.

Some of the Center's most famous historical machines were highlighted in beauutiful color photographs, suggesting that quite apart from a machine's technical attributes, they may also be appreciated on an aesthetic level as embodiments of human creativity at its best.

WIRED also supported Computer History Museum by being a co-sponsor of this year's 1999 **History Center Fellow Awards**. The Center is grateful for this support and proud of its collaboration with WIRED on the article which brought it to the attention of several million WIRED subscribers and news-stand readers.

To read an on-line version of the article, visit:
http://www.wired.com/wired/archive/7.11/computer.html

"Mona by the Numbers," produced by H. P. Peterson in 1964 on a CDC 3200 computer. One of many images in the WIRED article mentioned above.

IEEE Poster

History Center Curator Dag Spicer and researcher Anna Gloukhov collaborated with the editors of Computing in Science & Engineering magazine, published by the IEEE, to produce "The Top Ten Algorithms of the 20th Century," a fold-out supplement to their November/December 1999 issue.

In addition to providing images for the poster, Computer History Museum assisted with research.

"Top Ten Algorithms Poster," produced in co-operation with the IEEE and Computer History Museum

Radio & Television

Computer History Museum receives approximately three to five media requests daily for information on the history of computing. Some recent projects the Center has collaborated on include:

1. PBS Special on Y2K with host Bob Cringely
2. NHK (Japan) Special on the History of Computing
3. San Francisco Chronicle, "Computer Valhalla," Stan Bunger, May 20, 1999, Business Section, page 1.
4. CLiCK Weekly, "Computer Museum Saves The Valley's Tech Relics," Steve Enders, Nov 2, 1999, pp. 1-2.
5. Computerworld, "Flashback," (Regular column), Consulting Historians, Jan, 1999 - Dec, 1999.
6. KRON's New Media News (Stan Bunger), Tech History Series , Monthly, 1997 - present.
7. Microsoft's "Is Your Computer Ready for Y2K?" co-marketed with Blockbuster Video.
8. Popular Mechanics, January 2000 issue.
9. Novatis Internet Timeline

Sightings

Many of the pioneers whose inventions the Center preserves have occasion to visit us. To the first three people who can identify the principal contributions of this issue's visitors listed, we will send a complimentary "Evolution of the Microprocessor" poster! Think you know the answer? E-Mail your responses to Chris Garcia at the Museum. (garcia@computerhistory.org)

1. Cliff Stoll
2. David Patterson
3. Randy Katz
4. Ike Nassi
5. Josh Fisher
6. Herb Grosch
7. Gordon Moore
8. Forrest Baskett.

Cliff Stoll with Museum curator Dag Spicer

Josh Fisher beside his MultiFlow Trace VLIW machine, on display at Computer History Museum.

June 2000

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www.computerhistory.org

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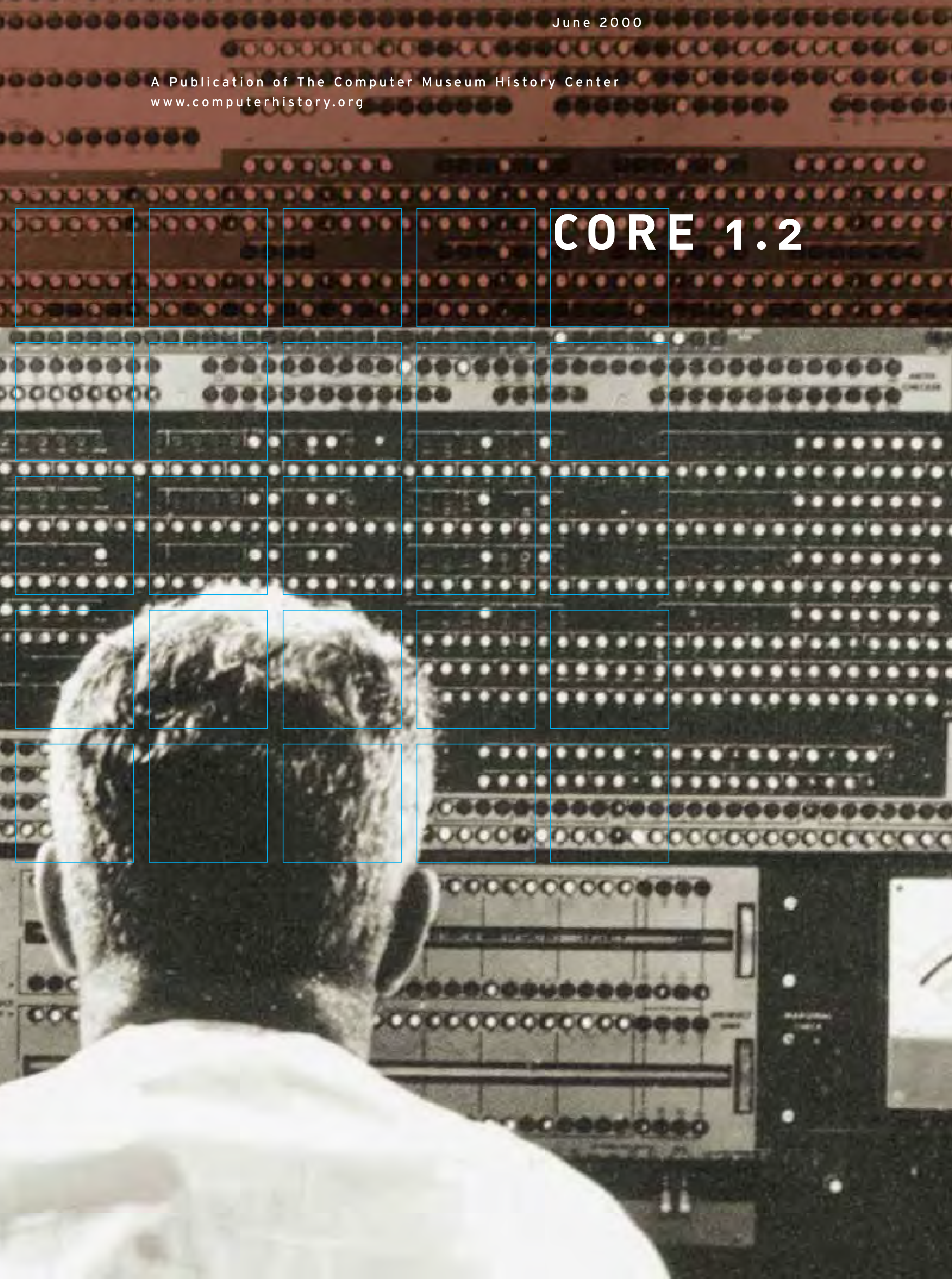

A NEW VISION

I'm extremely excited and grateful for this once-in-a-lifetime opportunity to serve as The Computer Museum History Center's new Executive Director and CEO. We have an important dream — to preserve and present the artifacts and stories of the information age — and a rapidly unfolding plan to make it a reality.

Our strategic advantages not only go beyond our growing, world-class collection of artifacts but also include people who make daily commitments of energy, time, and money. We have the best staff, volunteers, Board of Trustees, and donors of any organization I've ever seen!

We have made great strides in the last few months. Over 200 supporters attended our gathering on May 3rd at the Visible Storage Exhibit Area, and I hope you have seen the great press coverage we have been attracting (e.g., ***SF Examiner***, May 12, 2000, "Bits of History"). We are now an independent 501(c)(3) non-profit organization; the Board has added several dynamic new members (list on opposite page), and our staff is growing to meet your needs (page 13). Our Computer History Lecture Series attracts standing-room audiences and world-class speakers; our collection continues to grow exponentially (page 11); we have added some new exhibits to our Visible Storage Exhibit Area — such as the Meiko CS-2 supercomputer, the Pixar Image computer, and a Sun-1 workstation; we are evolving into a leading partner in the NASA Research Park; and we will soon unveil aggressive plans to develop a permanent home in three to five years! And, I must mention the GREAT team of people who have restored an IBM 1620 – it's a sight to behold, and the real lessons that we've learned from this "info-architectural" dig are being documented for the world.

I have developed a set of priorities and tasks all aimed at moving the Museum forward as the authoritative and world-recognized reference for computer history. These priorities include:

PEOPLE – the individuals who make the museum tick: Board, donors, staff, scientists, hobbyists, volunteers, and people interested in computing history.

INNOVATION – the technologies, ideas, and systems to make a revolutionary new class of museum that will capture computing's past, present, and implications for the future.

COMMUNITIES – the organizations, institutions, societies, and groups that will become our partners in building a persistent collaborative network for the longer term.

OPERATIONS – the principles, policies, technology, and people to operate a world-class museum ecosystem that will exceed all your expectations.

There's so much more to be done, but I know you can tell that we are swiftly moving the museum into its next phase! This translates into a call to help in various ways: 1) Take the time to get involved – as a volunteer, innovator, contributor, donor or lecturer – in capturing, preserving, and organizing history; 2) Help us spread the word about our mission, and encourage others to get involved; 3) Give us your ideas, concerns, and suggestions; 4) Carefully consider contributing to the strong financial base we need each year to operate, and to our capital and endowment opportunities that we will be announcing soon.

Again, thanks for your help – we will always need it! You'll hear from me often as we build this living legacy aimed at preserving the invention that has given each of us so much and has truly changed the world.

John C Toole
Executive Director & CEO

June 2000
A publication of The Computer Museum History Center

CORE 1.2

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

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

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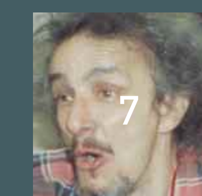
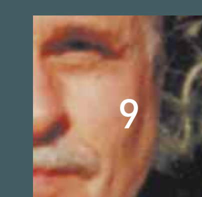
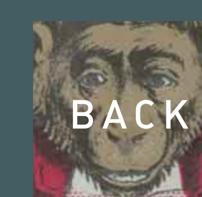
IN THIS ISSUE







Cover Photo
An operator sits at the IBM Stretch's impressive console (see pg 10).

OUR BEGINNINGS

THEN

by Eleanor Weber Dickman

The unloading crew smiled with relief as four 18-wheelers carrying 100,000 pounds of computing history rolled to a stop in front of Building 126 (a warehouse located at NASA's Moffett Field in Mountain View, California). The group was waiting to unload machines, artifacts, documents, photographs, journals and other memorabilia — all bearing witness to the extraordinary history of a most amazing intellectual revolution.

These were not ordinary workmen. In several cases, these very volunteers were developers and users of the mainframes, processors, operating systems, and languages that comprised the collection they were about to move into a Visible Storage Exhibit Area at Moffett Field. This was an important step forward for The Computer Museum History Center that had been established in 1996 in Silicon Valley as the West Coast branch of The Computer Museum in Boston, Massachusetts.

Gordon Bell, Gwen Bell, and Len Shustek stood at the forefront of this effort. Shustek, a staunch advocate for preserving computing history, currently serves as the chairman of the Board of Trustees. Gordon Bell, senior researcher at Microsoft, former VP at Digital Equipment Corporation, and recipient of the National Medal of Technology, and his wife, the visionary Gwen Bell, were the force and drive that had brought The Computer Museum into being over 15 years ago and helped guide it through its amazing development and growth.

IN THE BEGINNING

Gwen Bell remembers how it all began. The concept of a computer museum developed while Gordon Bell, then a professor at Carnegie Mellon University, wrote his classic ***Computer Structures*** with Allen Newell in Pittsburgh in the late 1960s. As Gordon researched diverse information processing systems, he "began bringing back artifacts. Soon, office and home were filled with modules [of early computers], memory devices that predated the core, and calculators that preceded computers."

When the Bells returned to the Boston area so Gordon could run engineering for Digital Equipment Corporation, they needed space for their collection. DEC bought a former RCA building with "a grand lobby and open balcony waiting to be used for exhibits," recalls Gwen. The Digital Computer Museum opened in September 1979.

Building 126 at Moffett Field, beside the world's largest dirigible hangar

Its first public event was a lecture on the EDSAC by Maurice Wilkes. At the time, Gwen noted, "the birth of The Museum was coincident with [Digital's] 25th anniversary and... was the Corporation's... present to the public." The Museum was supervised by a distinguished board of directors reflective of the diverse nature of the information industry. Exhibits were augmented with lectures by and about computer pioneers, and included historic and archival collections of machines displayed to show their "intrinsic beauty and functionality."

THE EARLY YEARS: PEOPLE AND PROGRAMS

As the Digital Computer Museum grew, its services expanded. The growth of the archives and library was spurred both by the ongoing collection of artifacts and the development of other programs. Archival documentation, reference materials, and audio-visual transcriptions of lectures extended the Museum's focus to an international scope. In the spring of 1982, the Museum received non-profit charitable foundation status from the Internal Revenue Service. Later that year, the Museum established a store that offered educational material such as books, posters, and slides on the history of computing.

In the fall of 1982, the Museum inaugurated a series of informal talks, known as "Bits and Bites," that included technical presentations as well as reminiscences about the everyday use and development of computers. These talks complemented the formal lectures that focused on significant events in the evolution of information processing, such as Tom West and Tracy Kidder's session on "Inside the Soul of a New Machine."

The Digital Computer Museum celebrates its opening

The Museum relocated to Museum Wharf in the heart of downtown Boston, where it lived for many years

In 1983, a major gallery exhibit devoted to "The Pioneer Computer Timeline" was created, based on a lecture series initiated by Gordon Bell. Speakers included Maurice Wilkes (EDSAC), George Stibitz (Bell Telephone Relay Computers), and John Vincent Atanasoff (breadboard Atanasoff-Berry Computer). A videotaped archive of the series, as well as artifacts such as the Whirlwind, contributed to the integrated exhibit. The Timeline described specifications and gave overview descriptions for each machine in the exhibit. It was Gordon's intent that "the timeline put the pioneer computers in their historic perspective."

A NEW HOME

In the fall of 1983, The Computer Museum finalized plans to relocate to Museum Wharf in the heart of downtown Boston, sharing space with the venerable and popular Children's Museum. The Computer Museum occupied the top two floors of a renovated wool warehouse with a view of the city. It offered greater visibility for the Museum's ambitious educational and preservation goals. An exciting 60,000 square feet of space would be available for exhibition and administration. The Museum, which had dropped "Digital" from its title, set May 1984 as the target date for the opening of its first public exhibition in its new home.

As the year turned, Museum volunteers devoted over 200 person-hours to a series of "packing parties" for the move to 300 Congress Street. And, as they would do 13 years later in California, volunteers helped unpack the collection at its new site.

On November 13, 1984, the Museum officially opened to the public. The initial exhibits included: the Whirlwind vacuum tube computer; the SAGE computer room; Gordon Bell's 20-year timeline of major inventions, software developments, and benchmark applications; and the story of Cray computers. Gwen described the exhibits as "the tip of the iceberg of our collection of artifacts, working machines, software, documentation, photographs and films." Gwen Bell had been at the helm of The Computer Museum since 1982, serving as Founding President, Treasurer, and Executive Director. Oliver Strimpel, the Museum's Associate Director and Curator, aided her from 1983 onward. Joseph F Cashen, a founder of Prime Computer, became the Museum's new executive director in 1987.

PRESTIGIOUS PARTNERSHIPS

In 1988, the Museum signed a collaborative agreement with the Smithsonian Institution's National Museum of American History. The joint arrangement was with the Division of Computers, Information and Society, whose scope encompassed historical research, preservation, and exhibition. The Computer Museum developed a common catalog and a database of both collections, with the goal of preserving all important artifacts.

The Digital Computer Museum's first public event was a lecture on the EDSAC by Maurice Wilkes

Gordon Moore, Len Shustek and Dave House admire the collection after Moore's recent lecture at the Visible Storage Exhibit Area

The museum boasts more than 3,000 computer artifacts, 1,000 films and videos, 5,000 photographs, as well as several thousand linear feet of catalogued documentation and gigabytes of software

The Museum also enjoyed other collaborative relationships with the Scientific Instrument Commission of the Union Internationale d'Histoire et de Philosophie des Sciences, the Science Museum in Kensington (United Kingdom), and the Deutsches Museum in Munich (Germany). According to Gwen, "One of the goals of The Computer Museum [was] to show that computer innovations are not unique to any one country, any one company, or any one institution."

A WORTHY INHERITANCE

Having established a landmark framework for the preservation of the history of computing, the Museum entered a new phase in 1996 with the establishment of The Computer Museum History Center in California. The Boston site continued to emphasize exhibitions while the Silicon Valley organization developed and maintained the archival collections.

A few years later, The Computer Museum in Boston relinquished its exhibition space on Museum Wharf, consolidating its displays under the roof of Boston's premiere Museum of Science. The remaining half of its collections traveled to Moffett Field in February 2000, adding significantly to the archives of the History Center. In 1999, The Computer Museum History Center became an independent entity and is now moving forward with its mission to "preserve and present for posterity the artifacts and stories of the information age."

The Computer Museum History Center currently features a "Visible Storage Exhibit Area," a warehouse space which houses artifacts and other pieces of the History Center's extensive collection. The Museum also conducts a well-respected lecture series and is developing a sophisticated restoration program. One of its first projects involves restoring an early IBM 1620 machine to full operation.

Today, the Museum boasts more than 3,000 computer artifacts, 1,000 films and videos, 5,000 photographs, as well as several thousand linear feet of catalogued documentation and gigabytes of software. All this material now awaits a new home in a multi-million-dollar museum, storage site, and research center that will be built within the next three to five years.

According to John Toole, newly appointed Executive Director and CEO of The Computer Museum History Center, "Our goal is to develop a world-class center where scholars, researchers, and hobbyists can explore, contribute to, and appreciate the important events and discoveries in the timeline of the information age. Our collection of the stories and artifacts of past innovators will become an outstanding showcase for the future."

As Boston Computer Museum's Executive Director Oliver Strimpel once wrote, "The perspective of history casts into sharp relief the astonishing technological changes over the past 50 years of computing. Thus, through preservation, the Museum gains an ability to inspire its visitors..."

In addition to the staff of the Silicon Valley site, the growth of The Computer Museum History Center is aided by a cadre of dedicated volunteers, including Dave Babcock, Lee Courtney, Charlie Pfefferkorn, Elizabeth (Jake) Feinler, and Ed Thelen. Courtney, CEO of Monterey Software Group in Mountain View, stands ready to unpack and set up the new displays. "What the Museum is doing is very important. We really are at the cusp of the information revolution, both with new computers and a history that goes back 50 years. The Museum is capturing this ongoing history and its impact on society."

And, concludes Trustee Chairman Len Shustek, "...we want to build the world's most comprehensive center for the study and research of computing history — creating the industry's center for the technical history of computers, and becoming a specialized and significant center for technical visitors from around the world." He further believes that we are "responsible to provide universal access, freedom from censorship, efficient searches, clever organization, fair intellectual and commercial property rights, and unlimited archival storage — all in a way that makes economic sense."

Fortunately, with its professional, lay, and volunteer leadership, The Computer Museum History Center stands poised to meet this challenge in an exciting and successful way. All who are interested are invited to join us as we implement our vision for the future. ■

NOW

Eleanor Weber Dickman is the Vice President of Development & Public Relations at The Computer Museum History Center

REPORT ON MUSEUM ACTIVITIES

by Karen Mathews

Karen Mathews is the Executive Vice President of The Computer Museum History Center

The year 2000 has been action-packed so far and I certainly believe that there is no stopping us now. Engaging the creative, competent, principled leadership of John Toole is a real coup, and the Museum is already benefiting from his presence. If the Museum offered stock I'd be buying it up, because this organization is a definite winner. Board, staff and volunteers continue to pull together here to create wonders — the drive, stamina and collective abilities are phenomenal. Numerous developments of late have furthered the Museum's mission to preserve and present the artifacts and stories of the information age. Here are just a few:

Gordon Bell with Ned Chapin at a private reception for Core Supporters

Gray-Bell Archive

A central part of the Museum's mission is to present personal stories and perspectives behind important computing developments. In pursuit of this goal, the Museum recently instituted the Gray-Bell Archive, supported by computing industry pioneers Jim Gray and Gordon Bell. "What we have in mind with this archive is to capture views of the pioneers and various aspects of computing," says Bell, a Museum trustee.

As part of the Gray Bell Archive, the Museum was able to acquire the extensive University Video Communications (UVC) collection, containing nearly 200 video presentations by computing legends such as Seymour Cray, Gordon Moore, Bjarne Stroustrup, Alan Kay, Donald Knuth, John Backus, Carver Mead, and many others. Many contain information not recorded elsewhere.

With the addition of the UVC collection, the Museum's video and film archive now includes 1,000 titles. Some of these are both viewable online and available on videotape at a nominal charge for classroom, professional or personal use. Visit our website for details, or call Karyn Wolfe at +1 650 604 2570.

Donor Notes

Last December, Trustee John Shoch challenged donors to join him in becoming a Core Supporter. He asked donors and friends to show their continued commitment to the Museum by making gifts between 1K ($1,024) and 64K ($65,536). During the challenge period, more than 60 supporters made contributions totaling $510,000. On February 10, Gordon and Gwen Bell opened their home in a private reception for these Core Supporters, including Gordon & Betty Moore, Gene & Marian Amdahl, and Arthur & Toni Rock (page 12). We thank everyone who contributed to this appeal.

The Museum is now completing its drive for the fiscal year ending June 30, 2000. Please join us and support our mission to preserve the artifacts and stories of the information age by becoming a Core Supporter today!

Since many supporters pay their annual memberships and make donations through gifts of appreciated stock, we have made it even easier to give. Morgan Stanley Dean Witter is now handling the Museum's stock transfer plan. Here is the account information:

FBO: The Computer History Museum Center, DWR Account # 112-014033-072, 245 Lytton Avenue, Suite 200, Palo Alto, CA 94301-1963, DTC #015. Simply contact Matthew Ives at Morgan Stanley Dean Witter, +1 650 853 4072 or Eleanor Dickman at the Museum, +1 650 604 2575.

Beowulf innovator Thomas Sterling with a Beowulf cluster: off-the-shelf commodity PCs that provide low-cost, high-performance computing

A crowded Visible Storage Exhibit Area and an air of excitement as Shustek introduces Toole

Cliff Stoll fascinates attendees at the reception following the Early Computer Crime lecture

Chairman of the Board Len Shustek (left) and new Executive Director and CEO John C Toole engage the crowd on May 3

The original SuperPaint hardware, the first paint program, forms part of the Museum's permanent collection

Special Event

A special announcement reception, **REFLECTIONS OF THE PAST, NEW VISION FOR THE FUTURE**, was held May 3rd in the Visible Storage Exhibit Area. Over 200 supporters and friends attended to celebrate the arrival of the Museum's new Executive Director & CEO, John C Toole. Museum Board Chairman Len Shustek, John Toole, and NASA's Nancy Bingham entertained and informed attendees with information about our new leadership, vision, and plans.

Many thanks for the stellar volunteer services of Mary Artibee, Dave Babcock, Peggy Burke and the creative team at 1185 Design, Lee Courtney, Eleanor Dickman, John Francis, Barbara French, Eli Goldberg, Milt Mallory, John Mashey, Charlie Pfefferkorn, Bill Pitts, Aimee Quemuel, LaFarr Stuart, Ed Thelen, Betsy Toole, Mike Zahares, and other giving and talented people who helped with this event.

Old friends Dave Patterson (left), Bernard Peuto (Museum Trustee), and Forest Baskett

Computing pioneer Donald Knuth admires the Jonniac on May 3 at the New Vision event

Computer History Lectures

Over 100 people came to hear **BEOWULF-CLASS PC CLUSTERS: AN HISTORICAL PERSPECTIVE** featuring Thomas Sterling of NASA JPL and the California Institute of Technology on April 13. Prof. Sterling revealed the motivation and importance of Beowulf-class computing, its hardware and software elements, and its history - from inception of 16-processor systems, to present day systems of up to 1,000 processors and more.

EARLY COMPUTER CRIME on March 23rd attracted over 300 people who experienced the rare opportunity to hear inside stories from those who have been at the heart of identifying, reporting on and protecting against computer crime. Presented in the wake of the "denial of service" attacks this past spring, panelists — including Whitfield Diffie, distinguished engineer at Sun Microsystems; John Markoff, technology writer for ***The New York Times***; Peter Neumann, principal scientist at SRI International; and Cliff Stoll, astronomer and story-teller — reminisced and discussed the nature of computer crime with an energetic audience. SRI alumnus Donn Parker of Adario provided the introduction. A reception gave attendees a chance to interact with the speakers and explore the Museum's artifacts.

RECOLLECTIONS OF EARLY PAINT SYSTEMS, presented on January 13, featured Dick Shoup and Alvy Ray Smith relating stories of their early adventures in pixel graphics and the development and use of SuperPaint, the world's first paint program. Over 100 people attended the lecture and were entertained by stories and re-creations of some of the earliest computer graphics.

Dedicated volunteer Ed Thelen and Museum Curator (and forklift operator) Dag Spicer unload one of many artifacts from a recent shipment

IBM 1620 Restoration Project

Now in its second year, this volunteer project with team leader Dave Babcock is making great progress. The team is reading and cataloging the 1620 software collection (over 300,000 punch cards) acquired last year, thanks to a hardware loan from Melbourne Technical Services. The project's significant milestones include:

- Completing a semiconductor replacement for the machine's defective core memory unit
- Successfully executing the main IBM CPU diagnostic
- Building, debugging, and running both the console and paper tape emulators
- Sorting and cataloguing 10 boxes of 1620, IBM System/360, and unit record equipment documentation

Through the team's hard work, the Museum now has a running 1620! As the project continues, we will post updates to our website.

Volunteer Notes

The Computer Museum History Center relies on a unique set of dedicated volunteers — and we have some of the best. From college students to CEOs, our volunteers donate their time and talents to preserve computing history. Recently, Museum volunteers have:

- Prepared our newly added 13,000 sq. ft. auxiliary warehouse to safely store more artifacts
- Unloaded four tractor-trailer loads of artifacts from the DEC historical collection donated by Compaq and two loads of artifacts from The Computer Museum at the Museum of Science in Boston
- Prepared 5,000 sq. ft. of additional exhibit space
- Created exhibit displays
- Catalogued hundreds of artifacts
- Donated countless hours and expertise

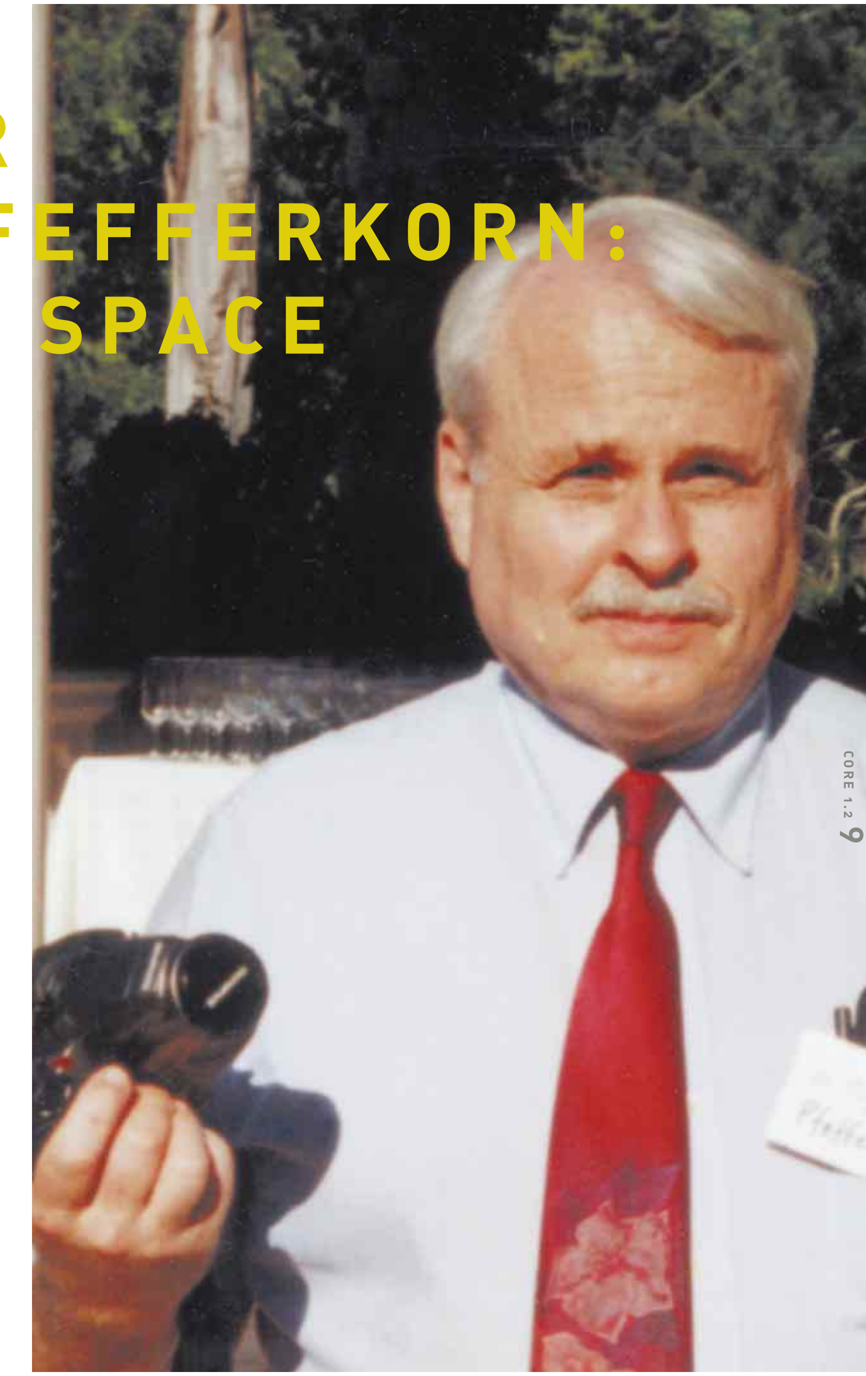
There are a number of volunteer opportunities and countless ways to get involved:

- Helping arrange, catalogue, clean, and photograph artifacts
- Preparing for and staffing lectures and other events
- Assisting with projects in our administrative offices
- Engaging in specific projects geared to individual expertise and talent, including a current need for sheet metal fabrication for the IBM 1620 Restoration Project

We are defining a number of exciting new volunteer projects that require help. If you would like to volunteer to make a difference, contact our volunteer coordinator Lee Courtney (courtney@computerhistory.org). He is a volunteer himself and can help you get involved.

VOLUNTEER CHARLIE PFEFFERKORN: MASTER OF SPACE AND TIME

by Lee Courtney



As with most non-profit organizations, a group of dedicated volunteers helps leverage the work of the staff. The contributions of our volunteers include physical plant improvement, curatorial assistance, exhibit construction, restoration, and research. One of these great volunteers is **CHARLIE PFEFFERKORN.**

Working with Dag Spicer, the Museum's Curator, Charlie is responsible for planning and organizing the Museum's complicated storage needs. He analyzes the requirements, creates detailed diagrams, and then helps supervise the placement of the artifacts. He volunteers on a weekly basis.

Charlie helped to mastermind the effort to absorb the recent tidal wave of donated artifacts at the Museum. He planned and helped execute critically important projects, such as relocating a large part of the collection and receiving the Digital Historic Collection, a massive donation by Compaq of 1000+ artifacts transported in four tractor trailers. We're very lucky to have someone as talented and dedicated as Charlie Pfefferkorn, who has rightly earned the title, **MASTER OF SPACE AND TIME** at the Museum!

As a volunteer, Charlie appreciates the chance "to see and work with the various artifacts that define the history of computing." He meets people who have participated in the development of computing and gets to know volunteers with "interesting backgrounds and lots of neat stories" who are making a "significant contribution" to bringing "computer history alive."

Charlie earned a PhD in computer science from Carnegie-Mellon University and was a faculty member at Purdue University. Interestingly, his PhD thesis was in artificial intelligence, focusing on using the computer to design room layouts containing equipment or furniture. His interest in space and storage has thus persevered over the years and now benefits the Museum.

Since arriving in the Silicon Valley over 25 years ago, Charlie has worked for several companies in various technical, managerial, and consulting roles, including working with the ILLIAC IV and other computing projects at NASA Ames. He is also actively involved in the Software Development Forum in San Jose, where he serves as a member of the Executive Council and as co-chair/founder of the International Software SIG. He is also a Visiting Fellow and "Pubmeister" for the Silicon Valley World Internet Center.

Lee Courtney is also a volunteer and the volunteer coordinator at The Computer Museum History Center

THE IBM STRETCH SYSTEM

by Dag Spicer

In the early to mid 1950s, IBM and UNIVAC, the only two large companies building computers, were considering the use of transistors in their products. Though the transistor effect had been discovered in 1947 at Bell Labs, vacuum tubes remained commonplace in computer hardware, while American manufacturers struggled to make a reliable, mass-producible transistor.

Today it may seem surprising that IBM was undergoing tremendous turmoil about its role in the new field of computers. However, the public had begun to associate the UNIVAC name (not IBM) with computers. CBS's 1952 election coverage included a UNIVAC machine that correctly predicted Eisenhower's victory. And, when former IBM customers started assigning key contracts to UNIVAC, IBM executives took notice.

Steve "Red" Dunwell and Werner Buchholz, two senior IBM engineers, proposed a new machine, code-named "Datatron." Based on transistors, the machine would enable IBM to leap ahead of UNIVAC and would embody many new architectural concepts.

100 TIMES FASTER

In a famous memo dated October 25, 1954, Dunwell wrote: "The Datatron program is intended to assure IBM a preeminent position in the field..." and will "take a giant step and make substantial advances on all fronts." A team of senior IBM technical and management staff met to consider building what John von Neumann had earlier exhorted them to create: "the most advanced machine... possible in the present state of the art." Besides allowing IBM to leapfrog its main competitor, Dunwell argued that the machine would allow IBM to unify its various computer products — roughly divided along scientific and business lines — thus greatly reducing manufacturing costs and simplifying IBM's engineering and production processes.

After great internal debate and a contract from Los Alamos Scientific Laboratory, the project went ahead. Now code-named "Stretch," the machine was to be "100 times faster than the most advanced computer working today," and President Tom Watson proudly noted that the new machine could complete "100 billion computations in a day."

THE NEWS SPREADS

The first machine (officially named the IBM 7030) was delivered to Los Alamos on April 16, 1961. Although far short of being 100 times faster than competing machines, it was accepted and ran for the next 10 years, with the then-astonishing average reliability of 17 hours before failure.

While customers were generally happy with the machine's performance, internally, Stretch was considered a failure for not meeting its speed benchmark. IBM reduced the price from $13.5 million to $7.78 million, thus guaranteeing that every machine was built at a loss. Dunwell's star within IBM fell dramatically, and he was given fewer responsibilities.

As time went on, however, attitudes within IBM changed. From a lagging position in industry, IBM had moved into the forefront through the manufacturing, packaging, and architectural innovations Stretch had fostered. Dunwell's exile ended in 1966, when the contributions Stretch had made to the development of other IBM machines — including the monumentally successful System/360 product line — became evident. Dunwell was made an IBM Fellow that year, the company's highest honor.

A SUCCESSFUL FAILURE

The Stretch story is only one of many in the history of computing that shows how triumphs are built upon the ashes of "failures." Stretch is one of the hallmark machines — despite its near invisibility to history — that defined the limits of the possible for later generations of computer designers and users. You may recognize many Stretch innovations in present-day products:

- Multiprogramming
- Memory protection
- Generalized interrupt system
- Pipelining
- Memory interleaving
- Speculative execution
- Lookahead (overlap of memory and arithmetic ops)
- Concept of a memory bus
- Coupling two computers to a single memory
- Large core memory (1MB)
- The eight-bit character (the "byte")
- Variable word length
- Standard I/O interface

"THE FASTEST WAY TO SUCCEED IS TO DOUBLE YOUR FAILURE RATE."

Thomas J Watson Sr. founder of IBM

Ironically, microprocessor companies 20 or 30 years later "re-invented" most of these innovations. The Computer Museum History Center has parts of the original Stretch machine (serial number 1) from Los Alamos and a complete Stretch (minus core memory unit) from the Lawrence Livermore National Laboratory. ■

STRETCH SPECS

The Stretch covered 2,500 square feet, the size of the average American home, and weighed approximately 40,000 lbs. The CPU alone was 900 square feet (30' x 6' x 5'). Nine machines were ultimately produced and sold for $7.78 million each (1961 dollars). The processing units alone used 21kW.

Stretch employed aggressive uniprocessor parallelism; had an instruction set of 735 instructions (including modes) of variable field length; used magnetic core memory (6 x 16KW, 2.1us cycle time); and had 169,200 transistors. The basic machine cycle was 300ns (3.3 MHz), and it performed at approximately 500 KIPS (code dependent). Stretch accommodated word lengths of 64 + 8 check bits (SECDED), had a disk of 2MW and 8Mbps, and used magnetic tape in its 12 x IBM 729 IV tape drives. The machine had a 1,000 cpm (card per minute) card reader; a 600 lpm printer; and a 250 cpm card punch.

FURTHER READING

Bashe, Charles, et al. ***IBM's Early Computers.*** Cambridge: MIT Press, 1986, pp. 416-468.

Blaauw, Gerritt, & Brooks, Frederick. ***Computer Architecture: Concepts and Evolution.*** New York: Addison Wesley, 1997.

Buchholz, Werner. ***Planning a Computer System: Project Stretch.*** New York: McGraw-Hill Book Company, 1962. Out of print.

Dunwell, S. W. "Design Objectives for the IBM Stretch Computer." ***Proc. Eastern Joint Computer Conference.*** December 1956, pp. 20-22.

Dag Spicer is Curator & Manager of Historical Collections at The Computer Museum History Center

A version of this article first appeared in ***Dr. Dobbs Journal*** online.

RECENT DONATIONS

to The Computer Museum History Center

MECHANICAL CALCULATORS

Friden SRQ 10 Calculator (1964), X1781.2000, Gift of Andrew Egendorf

Friden STW 10 Calculator (1950), X1782.2000, Gift of Andrew Egendorf

Friden ST 10 Calculator (1945), X1783.2000, Gift of Andrew Egendorf

Monroe LA7-160 Adding Machine (1945), X1805.2000, Gift of Andrew Egendorf

NCR 31A Accounting Machine (1940s), X1821.2000, Gift of Dale Takeda

UNIT RECORD EQUIPMENT

IBM Type 3741 Dual Data Station (1984), X1806.2000, Gift of Bill Richardson

IBM Type 3742 Dual Data Station (1984), X1803.2000, Gift of Bill Richardson

IBM Type 5225 Printer (1984), X1804.2000, Gift of Bill Richardson

IBM Type 557 Alphabetic Interpreter (1948), X1802.2000, Gift of Bill Richardson

MICROCOMPUTERS

IBM 5110 Personal Portable Computer System (1978), X1780.2000, Gift of Carol Tomlinson

MITS Altair 8800 (1975), X1827.2000, Gift of Craig Payne

Morrow Designs MD-2 (1983), X1800.2000 A, Gift of Joe Pryluck

Commodore 128 System (1984), X1775.2000, Gift of Robert and Mary Ward

Mac Portable (1989), X1894.2000, Gift of Randy Katz

MINICOMPUTERS

HP 3000/52 (1980), X1880.2000, Gift of Advant Corporation

HP 3000/I (1974), X1881.2000, Gift of Advant Corporation

HP 3000/III (1978), X1882.2000, Gift of Advant Corporation

HP Micro 3000 (1986), X1883.2000, Gift of Advant Corporation

SUPERCOMPUTERS

Meiko CS-2 Supercomputer (1994), X1860.2000, Gift of UCSB and Alpha Processor

MIT J-Machine Supercomputer Prototype (1988), X1858.2000, Gift of MIT

IBM MRCS - Multi-RIOS Computer Server Prototype (1991), X1776.2000, Gift of IBM Research

WORKSTATIONS

PIXAR Image Computer (1985), X1823.2000, Gift of Loren Carpenter

Sun 4/260 System (1988), X1801.2000, Gift of William King

Sun-1 Workstation (1982), X1825.2000, Gift of Caltech

Sun-1 Workstation (1982), X1826.2000, Gift of Caltech

OTHER/SPECIAL PURPOSE

Heath EC-1 Electronic Analog Computer (1960), X1827.2000, Gift of Paul Kostka

Sony SOBAX Electronic Calculator (1978), X1887.2000, Gift of Eric Barbour

Lynn Conway's personal papers on IBM ACS Project (1965+), Gift of Lynn Conway

Ford/Visteon Engine Computer Collection (1978-1999), X1835.2000 - X1840.2000, Gift of Ford/Visteon

IBM Floppy Disk Drive (Project Minnow) Prototype (1970), X1841.2000, Gift of David Noble

The Computer Museum History Center seeks and accepts computing-related artifacts from hardware and software to memorabilia, video footage, and documentation. If you would like to make a donation to the museum, please visit our website for details at: http://www.computerhistory.org/donor or contact Dag Spicer by phone at +1 650 604-2578. All donations must be approved in advance by our collections committee. Thank you.

For previous recent acquisitions, see Core 1.1, available at http://www.computerhistory.org/event/core/1.1/collections_news/

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Please notify us of any changes to your listing: wolfe@computerhistory.org. Thank you!

YOU ARE INVITED TO JOIN

The Computer Museum History Center. Your donation will help preserve the artifacts and stories of the Information Age for future generations.

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___ 8K ($8192)
___ 4K ($4096)
___ 2K ($2048)
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GENERAL SUPPORTER

___ $500
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___ other $ __________

Please return this form (or facsimile) with your remittance to:

The Computer Museum History Center
PO Box 367, Moffett Field, CA 94035
+1 650 604 2579
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www.computerhistory.org

YES, I want to help save computing history. Please process my donation at the level indicated below. I look forward to learning more about the programs and activities of The Computer Museum History Center, especially its plans for growth in the coming years.

___ Enclosed is my check payable to: The Computer Museum History Center

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THANK YOU

for joining our network of supporters.
We look forward to getting to know you!

A future lecture will feature Dave Ditzel talking about his experiences with the Fairchild Symbol, a one-of-a-kind machine he was delighted to re-discover at a recent visit to the Museum

UPCOMING EVENTS

JUNE 22
COMPUTER BOWL KICK-OFF EVENT
www.computerbowl.org

THE FAIRCHILD SYMBOL MACHINE
David Ditzel, Transmeta
Computer History Lecture

EARLY TRANSISTORIZED COMPUTERS
Richard L Grimsdale, University of Sussex
Computer History Lecture

NOVEMBER 9
Annual Fellow Awards

Check our website regularly for updates and details: www.computerhistory.org.

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www.computerhistory.org

ATTENDING EVENTS AND TOURING THE COLLECTION

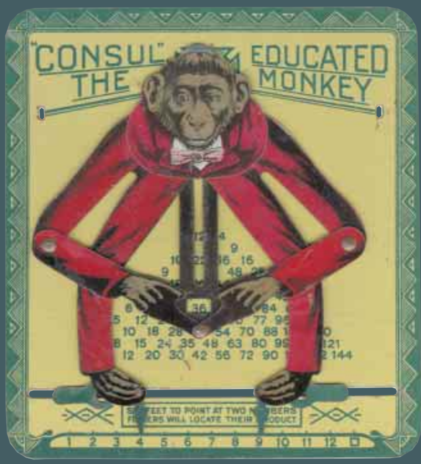
The Computer Museum History Center is housed at NASA Ames Research Center, Moffett Field, California. To attend an event or to tour the collection, please call Wendy-Ann Francis +1 650 604 2579 a minimum of 24 hours in advance. The collection is open to the general public by appointment on Wednesdays at 1:00 pm. Members may also request private tours.

Design + Layout = Skout

MYSTERY ITEMS

from the Collection of
The Computer Museum History Center

"CONSUL," THE EDUCATED MONKEY is a simple mechanical calculator made of movable sheet metal parts and a multiplication table insert. When pointing the monkey's feet at a pair of numbers, Consul points to the result in the pyramid of numbers between his hands. By sliding in an "addition table," Consul can also be made to add by the same principle. The calculator was patented on June 27, 1916, by William Robertson, of Belmont, Ohio, and the invention assigned to the Educational Novelty Company of Dayton, Ohio. Consul's packaging states: "It makes no difference to the monkey whether children are bright or stupid. He never loses patience at having to answer their questions."



From the permanent collection of
The Computer Museum History Center.
"Consul," The Educated Monkey (1916), XB302.84,
Gift of Gwen and Gordon Bell

WHAT IS THIS?

This item will be explained in the next issue of CORE.

Please send your best guess to mystery@computerhistory.org before 7/15/00 along with your name and shipping address. The first three correct entries will receive a free poster:
25 YEARS OF MICROPROCESSOR EVOLUTION

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SEPTEMBER 2000

CORE 1.3

A PUBLICATION OF THE COMPUTER MUSEUM HISTORY CENTER
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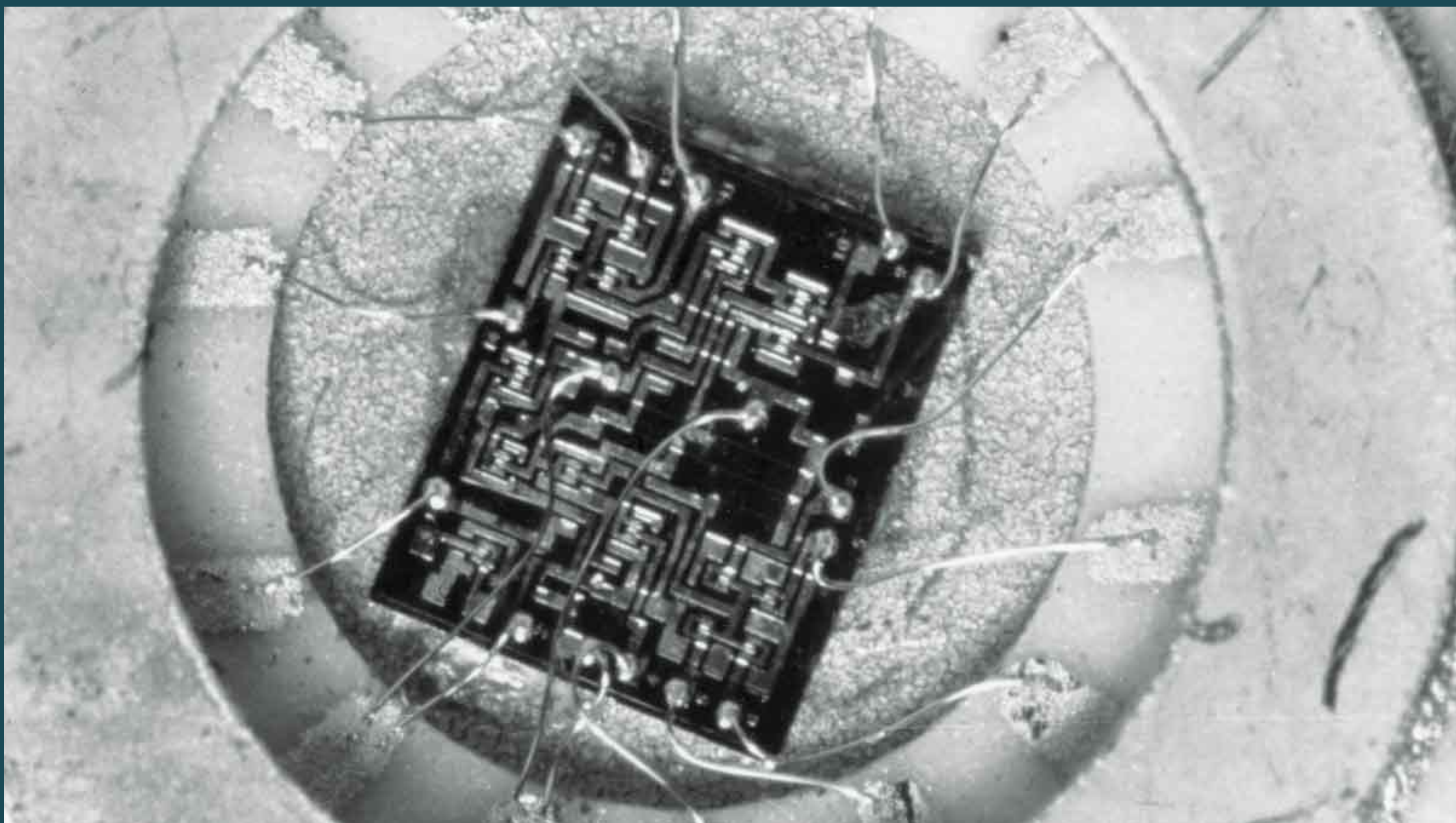


The Museum plans to build a permanent facility in front of historic Hangar One at Moffett Field

MAKING IT HAPPEN

Our dream of moving the Museum forward is stronger than ever. It has been a very busy quarter. We held our annual Board retreat in June, and in September we elected two new Trustees: Donna Dubinsky of Handspring and John Mashey of Silicon Graphics. We finished our fiscal year with over $100,000 in the black; and enjoyed welcoming a significant number of new Core Supporters. Meanwhile, we grew our artifact collection; watched our volunteer IBM 1620 restoration team move closer to finishing the project; refined our "new building" concept; and worked closely with NASA as part of their proposed research park. In addition, we had a wonderful volunteer appreciation party at Len Shustek's home; an elegant donor appreciation party at the home of Dave House and Karla Malechek; participated in the Computer Bowl 2000 preview with the Museum of Science in Boston; and welcomed a constant stream of visitors each week.

I want to thank everyone again–Board, staff, volunteers, supporters–for their enthusiastic efforts in helping to define and evolve our strategies to build a lasting legacy of the information age.

The more we talk to groups and to individuals, the more we affirm the very serious need that our mission fulfills! Over the next six to nine months, you will see a number of visible efforts to integrate our strategy, development, building, collection, exhibit, and volunteer activities.

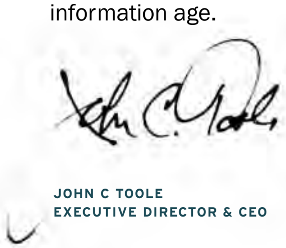
I hope you are also hearing more about us in the public sector as well. NASA held its first round of public information meetings in July for local communities, and presented options for the proposed NASA Research Park. This is a very exciting project, and we are positioned as a prime partner with building space just in front of historic Hangar One. We will be reporting to you in the future as we progress in building our permanent home. Of course, keep your eye on our website as well—our presence in cyberspace is going to grow rapidly well before the Museum opens its new building. Our unique combination of content, collection, people, and enthusiasm differentiates us from many organizations on the web.

Development activities, now staffed under the direction of Eleanor Weber Dickman, are moving aggressively to define, organize and streamline the fund-raising process. You should already sense a new responsiveness from the staff. All of us welcome your input, suggestions, and comments.

Whether you've visited the Museum recently or not at all, we hope to see you visit very soon. Some of the new interesting artifacts on display include an original UNIVAC I mercury delay line and some vintage IBM unit record equipment (1930s).

Finally, we are planning a festive and grand occasion for our annual Fellow Awards banquet on November 9. Make your plans now—it's a great opportunity to sponsor a table and invite some new people to become part of the Museum community. In the meantime, Karen Mathews, with all your help, is putting together a terrific lecture series program that starts this month—see her column for the specifics.

Again, thanks so much for your help! Please send us your ideas and suggestions, and bring others along to help us build a living legacy of the information age.



JOHN C TOOLE
EXECUTIVE DIRECTOR & CEO

September 2000
A publication of The Computer Museum History Center
CORE 1.3

MISSION
TO PRESERVE AND PRESENT FOR POSTERITY THE ARTIFACTS AND STORIES OF THE INFORMATION AGE

VISION
TO EXPLORE THE COMPUTING REVOLUTION AND ITS IMPACT ON THE HUMAN EXPERIENCE

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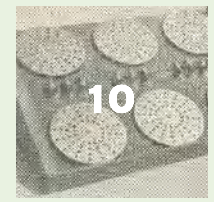
Cover: An early integrated circuit (IC)



IN THIS ISSUE

(opposite)
The Northrop brochure introducing Maddida

Another NORTHROP DEVELOPMENT

MADDIDA:

BRIDGE BETWEEN WORLDS

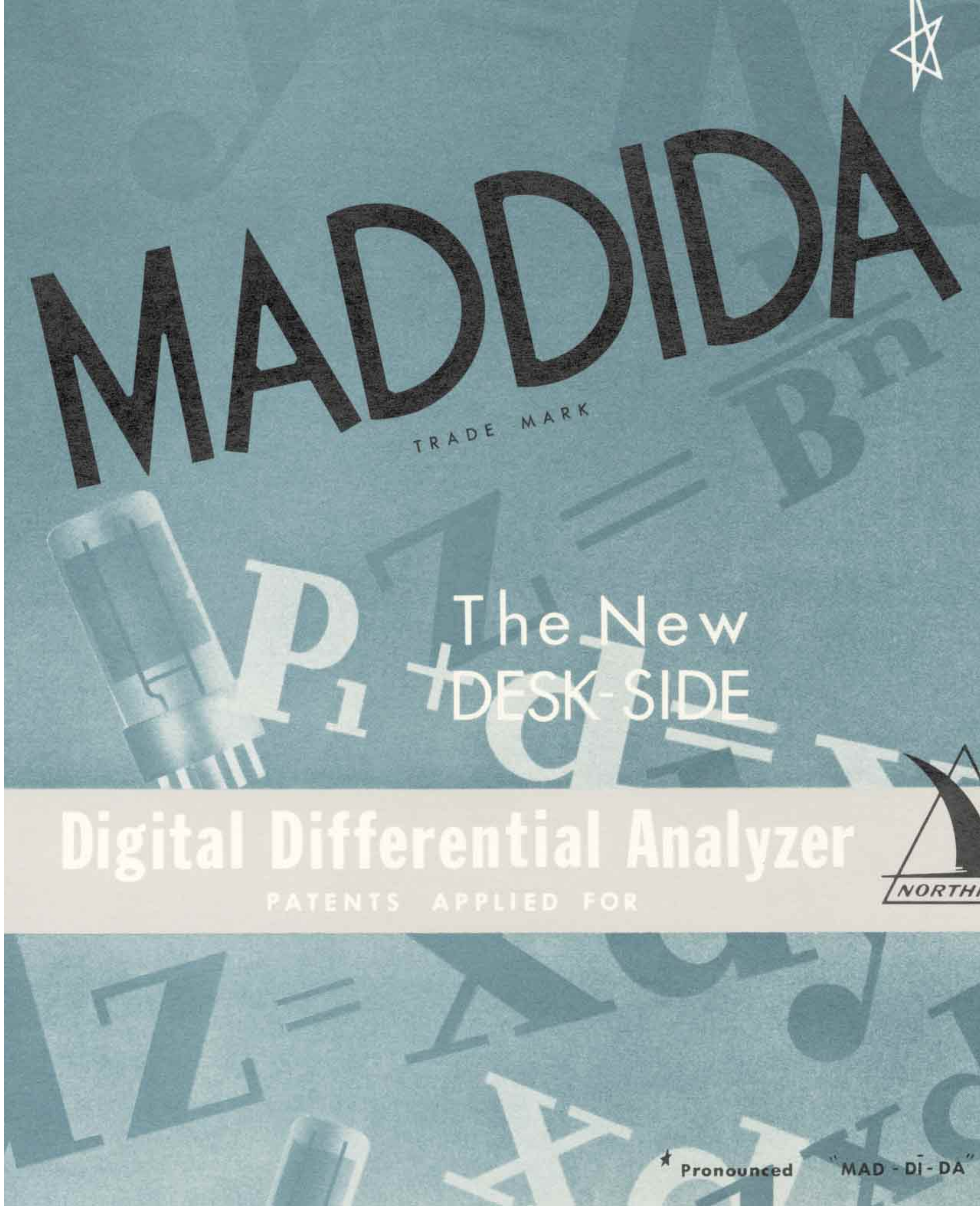
DAG SPICER

Aside from the Yankees beating the Dodgers in the World Series four games to one, 1949 was not a peaceful year for most of America and the world in general. The Berlin Airlift and its attendant tensions simmered on, Communist forces had invaded the Chinese mainland, and the first Soviet atomic bomb test had taken place that August. Pulled in the wake of this political tide were enormous military expenditures in armaments and weapon systems, as well as in basic aeronautical, jet aircraft, and rocket research.

Some of the most advanced of such research was taking place at Northrop Aircraft near Los Angeles. In a delightful turn of phrase, Paul Ceruzzi of the Smithsonian Institution calls Northrop the "midwife of the computer industry," alluding to the importance of that company's computational demands in driving computer development, both at Northrop, and at IBM and UNIVAC, the two major producers of computational devices at the time. Late that year, a small group of Northrop engineers completed a unique computing machine that showcased Northrop's skill in addressing its most important problem—demanding numerical calculation. This machine was a pit stop on the road from mechanical to electronic methods of calculation that combined old concepts with new technology.

Called MADDIDA (**MA**gnetic **D**rum **D**ifferential **A**nalyzer), and pronounced "MAD-DI-DA," this device of about 900 diodes and 50 vacuum tubes started out as a project supporting Northrop's SNARK missile program—essentially an intercontinental cruise missile. Northrop had hired ENIAC co-designer John Mauchly two years earlier to provide an on-board guidance computer for SNARK. The result was BINAC, a room-sized behemoth that never worked reliably. BINAC's failure prompted the MADDIDA project, with Hewlett-Packard building an initial prototype for Northrop under contract.

Although it was still too large to fit inside a missile, being about the size of a refrigerator turned on its side, MADDIDA was robust, reliable, and relatively inexpensive to produce. Due to this size limitation, it did not meet the project objectives of a guidance system for SNARK. However, given that in-house engineering teams had great difficulty in obtaining access to larger mainframe-type machines, MADDIDA was immediately put to use for engineering work. Northrop staff, like that of every other aircraft company, typically used what can only be described as "stockyards" of human "computers" who sat at desks and used mechanical calculators like the popular Friden or Marchant models of the day. The scene was right out of Dickens: rows of crewcut young men as far as the eye could see in shirtsleeves and skinny ties filling in calculation sheets month after month, year after year. Most of these calculations, as Stanford professor and aviation pioneer Walter Vincenti notes, were for "data reduction," that is, the aggregation of flight test and structural analysis data. This data came in great quantity and at great speed—a single aircraft of the



Pronounced "MAD-DI-DA"

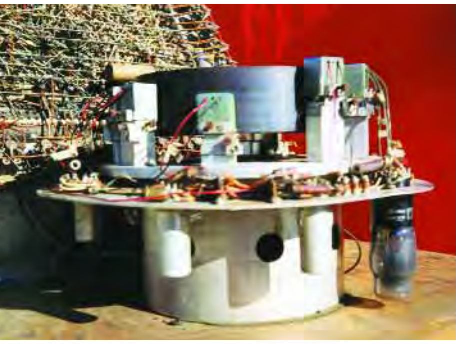
1 The storage drum from the MADDIDA prototype

2 Side view of head and drum assembly

3 Front view of Northop's MADDIDA prototype, showing diode matrix

4 Rear view of the MADDIDA prototype

PHOTOS BY DAG SPICER



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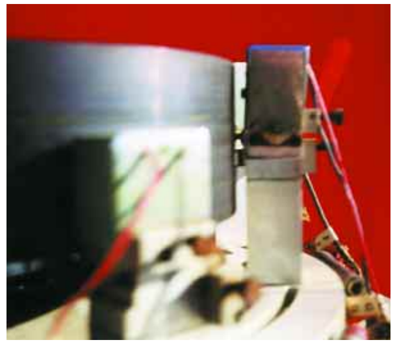

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advanced type that Northrop was developing could require millions of discrete calculations. Although not a general-purpose machine, MADDIDA was ideally suited to a broad range of Northrop's in-house engineering work.

One of the most important milestones in the development program occurred when MADDIDA was flown across the U.S. from it's Hawthorne, California home to the Institute of Advanced Study (IAS) at Princeton, New Jersey. There, project engineers demonstrated MADDIDA to John von Neumann. Don Eckdahl, an original MADDIDA designer, visited The Computer Museum History Center in March of 1998 and remarked that what had impressed von Neumann most was that MADDIDA arrived in Princeton, was plugged in, and almost immediately began performing useful work. von Neumann, with his characteristic aplomb, saw even more applications than the original designers and wrote a paper on the machine's possible new uses.

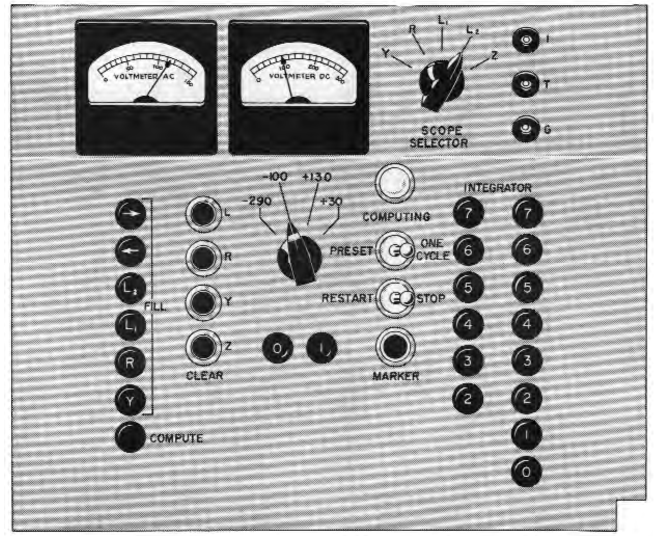
The MADDIDA prototype became a commercial product and was marketed to industry, research labs, and universities. Recapitulating what computer users knew of the larger "giant brains" produced by IBM, UNIVAC, and research institutions, the company brochure proudly stated that MADDIDA would "...operate for months at a time without error or breakdown. This type of performance has been hitherto unheard of for large scale automatic computers."

Interestingly, MADDIDA's architecture was basically that of a mechanical analyzer implemented with electronics. That is, the machine replicated the analog functional blocks of a mechanical device with vacuum tubes and diodes; mechanical analogies used throughout promotional and training literature made the transition straightforward for people trained on the previous generation of mechanical analyzers. As the brochure notes further on, "There are no plugboards, nor are there any physical interconnections to make in setting up a problem on MADDIDA. The desired connections between integrators are easily expressed as a binary code, and this code is typed into the computer along with initial conditions."

As Ceruzzi noted, Northrop engineers contributed in many fundamental ways to the booming post-WWII aircraft and defense industry in southern California. MADDIDA, for example, was not the only machine invented there to solve computing problems. That same year, for example, William Woodbury and Greg Toben, a pair of young Northrop engineers, had "lashed up" two IBM accounting machines into a programmable (via plugboard) machine, one they whimsically called "the poor man's ENIAC." It is a poignant fact, certainly for Northrop engineers, that the accounting department held most of the computing power in the company—in fact, Toben and Woodbury borrowed one of their machines from Accounting.

IBM did not initially warm to the *fait accompli* of their machines being opened, modified, and operated, but Toben and Woodbury's prototype metamorphosed into IBM's Card Programmed Calculator (CPC), becoming one of the company's most successful machines at the time. With nearly 700 CPCs in the field, IBM management quickly saw a pent-up demand for computing cycles among aircraft manufacturers and others, and thus began a reluctant transition by the company into electronic computers.

MADDIDA 44A (the commercial version of MADDIDA) Control Panel drawing from the Northrop MADDIDA brochure



As with MADDIDA, the technological advances of so many computing projects are often equaled or surpassed by the formation of computer experts trained by the project themselves, experts who then go on to propagate into and define the industry. When Northrop decided not to pursue the commercial computer business, about a dozen of the MADDIDA project team left to form their own company, CRC. Woodbury and Toben soon joined IBM where they became major contributors to the Model 650 computer design, another highly-successful IBM product. In fact, a 1984 study by the Babbage Institute determined that some 14 companies can be traced back to people in the original MADDIDA group.

Like the changes of 1949 that were redefining many of the basic relationships between peoples and nations, MADDIDA represents a transitional period between two key technologies. While remaining faithful to its roots in the analog analyzers with which its inventors were comfortable, MADDIDA took a bold, bright step forward into the then-new and computationally-driven world of jet aircraft, missiles and rockets. It was such advanced computation, provided economically and reliably by machines like MADDIDA, that enabled both the computing and aerospace industries to move forward. ■

The original MADDIDA prototype forms part of the permanent collection of The Computer Museum History Center.

MADDIDA prototype (1949), X1050.91, Gift of the LA County Museum

Dag Spicer is Curator & Manager of Historical Collections at The Computer Museum History Center

References

Ceruzzi, P. *Beyond the Limits: Flight Enters the Computer Age*. Cambridge: MIT Press, 1989.

Donan, J., Taylor, P. H., Weaver, S. E., Northrop Aircraft, Inc. *MADDIDA Preliminary Report*. Project MX-775, Report No. GM-545, May 26, 1950, 20 pp. TCMHC # 102626166.

"F.P." *Logical Equations for MADDIDA 44A*. Revised Sep 21, 1950, 12 pp. TCMHC # 102626265.

Northrop Aircraft, Inc. *MADDIDA: The New DESK-SIDE Digital Differential Analyzer*. Hawthorne: Northrop Aircraft, Inc., Brochure No. 38, December 1950, 19 pp. TCMHC # 102626167.

Bashe, C. J., Johnson, L. R., et al. *IBM's Early Computers*. Cambridge: MIT Press, see pp. 34-72 and p. 168ff.

von Neumann, J. *An Adaptation of the MADDIDA, A Digital Differential Analyzer of Northrop Aircraft, Inc.* 30 pp.

National Museum of American History website, Computer Oral History Collection: http://www.si.edu/lemelson/dig/computeroralhistory5.html.

Specifications

Machine Type: Electronic Digital Differential Analyzer

Architecture: Integrator functional blocks (22); 44 on commercial version

Word size: 22 bit (6 decimal places)

Memory: Magnetic drum (8" diameter, 2 ½" height), Approx 1.5 Kbits x 4 channels

Logic: vacuum tube (53), germanium diode (904)

I/O: 12 input and 12 output channels; printer, Teletype, unit record equipment

Power consumption: Approx. 750W

Weight: Approx. 400 lbs

Size: 40" x 30" x 50" (HWD)

Applications: Solution of ordinary differential equations (linear and non-linear, any order or degree), aviation industry, engineering, industrial control, education

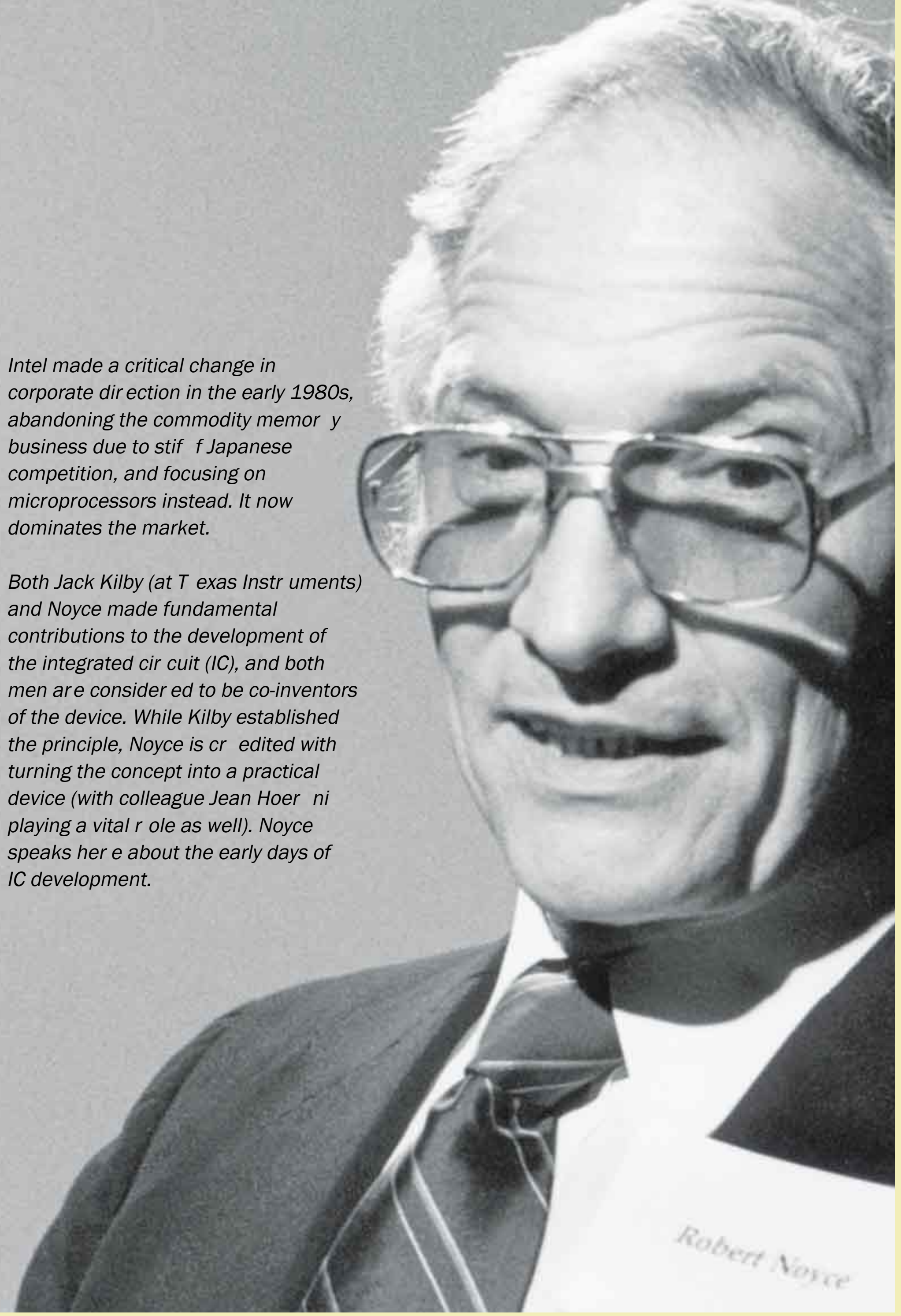
Cost: $500,000 (USD in 1949)

Robert Noyce was born on December 12, 1927 in Burlington, Iowa, and died on June 3, 1990. The son of a Congregationalist minister, Noyce earned his PhD in physics at the Massachusetts Institute of Technology in 1953 and became a research engineer for Philco Corporation, one of only a handful of companies in the world manufacturing transistors at the time. In 1956, lured by the weather and the opportunity to pursue technical challenges at the highest level, Noyce joined transistor co-inventor and Nobel laureate William Shockley at the Shockley Semiconductor Laboratory in Mountain View, California.

Due to management differences and disagreements about product development, Noyce and seven others left Shockley to co-found Fairchild Semiconductor Corporation in 1959. Noyce served as director of research and then as vice president and general manager. After more management problems, this time at Fairchild, Noyce, Gordon Moore, and Andrew Grove left in 1968 to found Intel Corporation, with Noyce serving as chairman until 1975 and vice chairman from 1979 to 1983.

Intel made a critical change in corporate direction in the early 1980s, abandoning the commodity memory business due to stiff Japanese competition, and focusing on microprocessors instead. It now dominates the market.

Both Jack Kilby (at Texas Instruments) and Noyce made fundamental contributions to the development of the integrated circuit (IC), and both men are considered to be co-inventors of the device. While Kilby established the principle, Noyce is credited with turning the concept into a practical device (with colleague Jean Hoerni playing a vital role as well). Noyce speaks here about the early days of IC development.



THE INTEGRATED CIRCUIT: ORIGINS AND IMPACTS

ROBERT N NOYCE

As I was driving in tonight, I was listening to a Chrysler ad pointing out that the company was 60 years old. I think of Chrysler and the auto industry as old. Then, I thought, the semiconductor business must be reaching middle age, since it is now over 30.

In 1954, the semiconductor business amounted to 25 million dollars: the growth sequence then was 35, 80, 140, 210, 360, and then 550 million [dollars] by 1960. Half the business was in transistors; silicon accounted for a relatively small share.

In the 1950s, everyone was trying to figure out new and better ways of making transistors. At one of the solid state circuits conferences, an explorer's kit, designed to keep you from getting lost in the woods, was displayed. It consisted of a box with a small cube of germanium and three pieces of wire. If you got lost, you were to start making a point contact transistor. Whereupon ten people would lean over your shoulder and say, "That's not the way to do it." Then, you would turn around and ask, "Where am I?"

At the time, germanium alloy transistors were made by putting indium on top of semiconductor germanium and melting it just enough to dissolve some of the germanium and then recrystalizing it on both sides to make a PNP transistor.

One baffling research question was why germanium, when it was heated and then cooled in the laboratory, changed from N- to P-type. Simultaneously transistors were being manufactured with N-type germanium on the factory because the indium acted as a "getter" to pick up all the impurities instead of converting the germanium.

In the mid-fifties, the thinnest possible transistor was a fraction of a mil [one mil = 0.001 inch] and a mil was a megacycle so these weren't very useful for anything except for hearing aids.

Between '54 and '55, we started worrying about diffusion as a way of getting impurities into the semiconductors, giving good control of the depth dimension. The problem was to get control of the other dimensions. Some of the first work was done at Philco because the semiconductor group worked right across the hall from the laboratory that was working on etching shadow mask tubes for color television. They were experienced with photo engraving, which turned out to work a lot better.

The invention of the planar transistor by Jean Hoerni further set the stage for the birth of the integrated circuit. Planar transistors solved the problem of impurities on the surface of the transistors and at their junctions that had been lousing up the specified characteristics. Hoerni's idea was to leave the silicon dioxide, a very good insulator, on top of the transistor when it was being diffused, thus forming a protective cover.

The government gave further impetus by their interest in getting things into smaller packages. The Air Force project Tinker Toy and the concept of molecular engineering didn't really work very well, but it did let everyone know that there was an interest in getting things small. A square inch chip with ten thousand transistors was very labor intensive: each transistor had to be attached by a couple of wires and soldered down. There had to be a smarter way.

I remembered that when I was in college, I could slave over something, finally get the right answer, hand in my paper and it would come back with big red markings on it. My physics professor would say I did it the hard way. Then he'd jot down a couple of sentences which clearly made it much easier for me by using some other method. I guess that is what stuck with me because one of the characteristics of an inventor is that he is lazy and doesn't like to do it the hard way. Putting those 20,000 wires on 10,000 chips of silicon seemed like the hard way to me.

Although the printed circuit board was starting to be used, the thought of printing a circuit on top of the transistors had not occurred. It was the genesis of the idea of the integrated circuit. All the elements were converging: photo engraving enabled reproduction and the planar transistor allowed conductors directly on top of it. Three ideas popped up at that time. One was junction isolation, which I patented, even though it turned out that Kurt Lehovic had thought of it years before at Sprague. At Fairchild, J. Last thought of the idea to etch the transistors apart, glue them down to something and if you still knew where they were you hopefully put them together. This idea had been previously patented at Bell Labs. The one I did get a patent on used intrinsic isolation, that is to use the silicon as an insulator. It didn't work well at first because by bombarding it with neutrons or doping it, leakage occurred and the life was too short. Junction isolation is now being broadly used.

After the original concept was developed, things moved very slowly. One reason was the low yield on transistors: with 50% yield and ten transistors together, the final yield of one over two to the tenth is a small number. We didn't even consider putting a thousand transistors together. Another problem was that the early integrated circuits were very slow. And, of course, the market was opposed to this innovation.

Progress followed the classic Moore's curve. Every year you could get something twice as complex as the year before. That extrapolates to a million elements in 1980. We didn't quite make that unless you allow for the introduction of new things like magnetic bubbles. The technology also changed from bi-polar to MOS.

Costs are determined by complexity and the number of leads per square inch of silicon with problems setting to 20,000. Starting with a ⅝th inch wafer in 1963, costs were reduced by increasing the

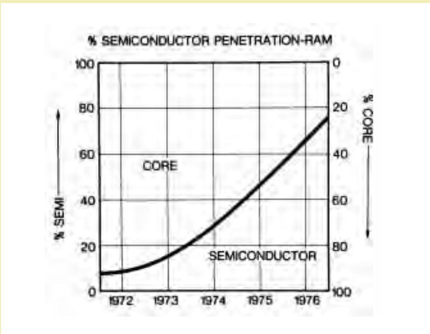
1 Graph of semiconductor penetration through 1976

2 Comparative costs of various memories through 1978

3 Photomicrograph of the Intel 4004, the first commercial microprocessor

4 Original Intel ad announcing the 4004-family of microprocessors

5 Worldwide semiconductor shipments went from $.005 billion in 1954 to $149.4 billion (USD) in 1999



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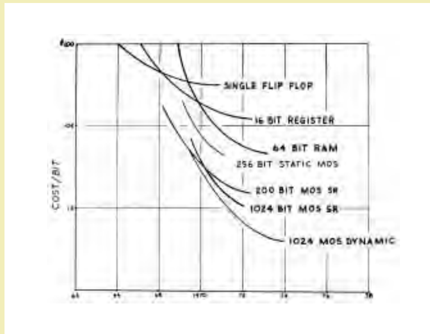

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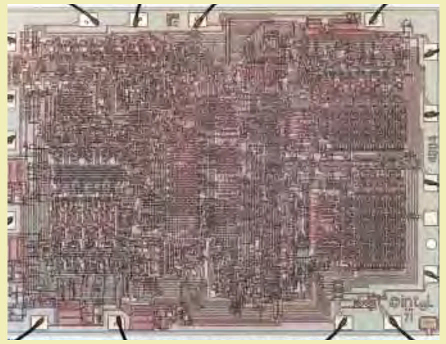
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size to 1 ½ inch in '65 and two inches in 1970. The die size and area were also increased to reduce the density of defects that would kill the surface. It became possible to use an ever-increasing area to put a circuit on and have it work. Circuit dimensions themselves have been reduced below the size of neurons, 10 microns, and these are being used for speech synthesizers and other products. Today we have two micron circuits and are talking about .7 microns, so we indeed are getting down to biological dimensions and it is conceivable to talk about things the brain can do.

Other new ideas were important. One was MOS and the second was epitaxy. Prior to the use of epitaxy, only the surface could be more impure than the underlying material. This was another bag of tricks.

The first set of integrated circuits had straight Boolean functions. With progress the designers wanted complexity with lots of leads out of a circuit and the semiconductor manufacturers just didn't like that at all. In addition, the more complex products had a lower demand, and as manufacturers we were thinking of making millions of items. Simultaneously, the computer companies in the early seventies were talking about tens of thousands per year. One kind of chip, however, was like heroin to the computer designers and that was memory. Give them a little bit and they want more. Thus, memory chips became a major standard product.

WHAT HAS THE CHIP WROUGHT?

The chip has been one of the main elements allowing the ubiquity of computers. Computers, as tools and devices to help train people to think logically and work precisely, have caused a major revolution in education, business, government, and all aspects of society. The telecommunications manufacturers would have us believe that every telephone in the world will be a computer terminal.

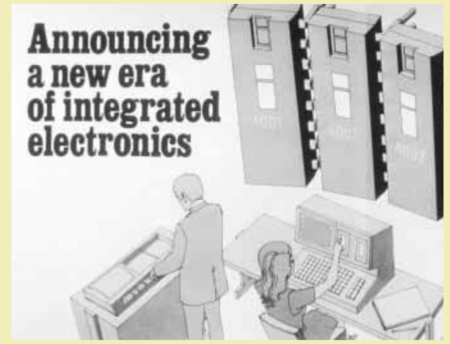
Some people fear this idea, just as I feared the telephone. One day, when I was quite young, my folks were out and left me alone. The telephone rang. I panicked, picked it up, and said, "Hello, nobody's home," then hung it up. Today I can't imagine living without a telephone.

Let me point out a couple of other changes that I've observed. The first computer in an automobile only controlled the non-skid brake and exhaust and it cost twice as much as the car and filled the whole trunk. In fact, the rear seat had to be used as well in order to install the computer. Today computers in cars do ten times more work and cost about $30. They are less expensive than a mechanical carburetor and will pay for themselves in the first year in gas savings.

Jobs in the future are not going to require the skills of the past. One hundred-and-fifty years ago, 50% of the American labor force was employed on the farm. Fifty years ago the greatest proportion was in manufacturing. Today that is about 20%. These latest statistics are inaccurate because the categories have not changed with the economy. Intel is included in the manufacturing sector, even though only 30% of our people actually touch any products that are shipped. Most of our employees sell, keep books, or even do such useful work as design the next generation of products. Today, more than 50% of the labor force is working with information.

The computer is the major tool that can help information workers. It's a productivity enhancer for people who work with ideas as well as for people who work with things. It will allow more human use of human beings. Dull

"This year, the industry will produce at least 100 quadrillion transistors. This is more than Professor E.O. Wilson of Harvard estimates for the number of ants on earth."
Gordon Moore, 1999



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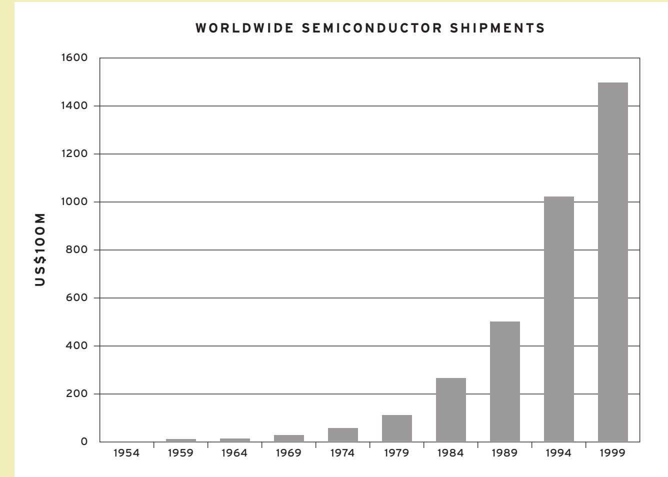

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repetitive tasks are the first to go. For example, retyping a letter for one mistake, or reformatting a marketing forecast.

The tradition of liberal arts education was designed to allow people to understand and communicate in society. Grammar, rhetoric and logic came first, and then the quantitative studies of arithmetic, music with its geometrical relationships, geometry and astronomy followed. The same task is essential today. The student has new tools to help understand the continuing accelerating advances in technology. Most students will be working with a computer in some way.

It's not necessary for society to break down into C. P Snow's two cultures in which those who do not work with technology are left behind those who have the modern tools to become productive. Despite the advances in technology, math, science and engineering are not attracting enough people in the US. The power of our computers that can help people as tools is growing beyond common imagination.

The Computer Museum has the CDC 6600, the first production supercomputer from 1963. It cost more than $3 million and only had 500,000 transistors. That will be available on a single chip within a couple of years and everyone can have a super computer. All the educational institutions have a challenge to make this work for the science and liberal arts.

POSTSCRIPT BY DAG SPICER

In the 15 years since Robert Noyce gave this lecture at The Computer Museum, much has changed in the world of semiconductors. Noyce speaks of 2 micron circuits; production devices are now made at 0.18 microns (and experimentally even smaller). In 1985, Intel's 386 CPU had 275,000 transistors; the latest Pentium III contains nearly 30,000,000. The value of semiconductor shipments worldwide went from $5 million in 1954 to $149.4 billion (USD) in 1999.[1]

One of the most remarkable constants of this period, which Noyce pointed out, has been the continuing applicability of Moore's Law in terms of transistor counts as well as the resiliency of optical lithography over alternative technologies. Another constant is that IC-making technologies use many similar processes—albeit vastly refined—to those that Noyce started himself some 40 years ago by buying projector lenses from a San Francisco camera store and building his first contact printer. While the technical advances have continued relentlessly, mere quantitative measures do not tell the whole story. Computers changed qualitatively, not just quantitatively, in about the mid-1970s, moving from "number crunchers" to platforms for visualization, entertainment, and communication. And, as Noyce noted, perhaps a bit skeptically, telephones have indeed become computer terminals.

As Noyce's friend and colleague Gordon Moore recently noted in a lecture here at the Museum last October, the industry annually produces more transistors than there are ants on earth. In spite of this astounding rate of diffusion, ensuring the continued miniaturization and proliferation of transistor technology until at least the next decade, the fundamentals of IC design and manufacture are much the same as those Noyce and his colleagues pioneered some four decades ago.

[1] Semiconductor Industry Association

Dag Spicer is Curator & Manager of Historical Collections at The Computer Museum History Center

FROM THE COLLECTION

THE GENIUS ALMOST AUTOMATIC COMPUTER

DAG SPICER

Developed by the legendary Edmund Berkeley (founder of the ACM and author of *Giant Brains or Machines That Can Think*), GENIAC was a very Spartan arrangement of masonite wheels with metal contacts and flashlight bulbs out of which some 30 "small electric brain machines" could be built. Basically, GENIAC provided N-pole by N-throw rotary switches that could be wired in series to perform logical operations.

Berkeley had designed and marketed a previous machine, known as "Simon," that had appeared as a series of 13 articles in *Radio Electronics* from 1950-51. GENIAC stood for "Genius Almost Automatic Computer" and sold for "under $20" in 1955, when first introduced. In addition to the musical and computational uses advertised above in *Astounding Science Fiction* in 1957, a *Popular Science* advertisement listed some of the projects: computer circuits for binary and decimal adding, subtracting, dividing, and multiplying; the solution of problems in symbolic logic, reasoning, and comparing; "psychological testing;" experimental game-playing circuits for tic-tac-toe and nim; as well as "actuarial analysis."

GENIAC is important as both a cultural and technological artifact, one whose pedagogical purpose embedded cultural and political assumptions relating to the cold war that most of GENIAC's young users probably never thought or cared about: GENIAC was fun!

Several GENIACs form part of The Computer Museum History Center's permanent collection. ■

Dag Spicer is Curator & Manager of Historical Collections at The Computer Museum History Center

GENIAC (Genius Almost Automatic Computer) (1955), X877.88, Gift of William R Simpson

GENIAC (Genius Almost Automatic Computer) (1955), X836.87, Gift of Elliot Linger

GENIAC (Genius Almost Automatic Computer) (1955), X734.86, Gift of Thadeus M Hershey

References

Oliver Garfield Company. Geniacs: *Simple Electric Brain Machines and How To Make Them*. New Haven: Oliver Garfield Company, 1955, 64 pp. TCMHC # 102626164.

Leslie, S. *The Cold War and American Science*. New York: Columbia University Press, c.1994.

GEORGE STIBITZ COMPLEX NUMBER CALCULATOR DESIGN DRAWINGS (1940), X2010.2001, GIFT OF GEORGE ROBERT STIBITZ

CHRIS GARCIA

While working for Bell Telephone Labs, George Robert Stibitz (1904-1995) created the Complex Number Calculator, an electromagnetic relay system used to solve complex calculations. In 1940, Stibitz demonstrated the machine—by then renamed the Bell Labs Model 1—at a meeting in Hanover, New Hampshire, with an operator accessing the machine in New York City via telephone lines. Stibitz allowed the astounded attendees to pose questions while a Teleprinter printed the answers. This may have been the earliest example of a remote job and foreshadowed the later link between communications and computing. Stibitz was born in York, Pennsylvania, and graduated from Denison University in 1926 with a PhD in applied mathematics. He received a second PhD in physics from Cornell in 1930 and joined Bell Telephone Laboratories as a mathematical consultant. In 1964, Stibitz joined the Department of Physiology at Dartmouth Medical School as a research associate. He became a professor in 1966 and professor emeritus in 1970.

In 1986, Stibitz donated to the Museum his collection of design diagrams of the Complex Number Calculator as well as photographs of the original machine in operation. He also presented a lecture for The Computer Museum on the Model 1 and advances at Bell Telephone Labs. ■

An operator at the remote console for the Bell Labs Model 1, 1940

COMPUTER SPACE (1970), X1025.90, GIFT OF ALAN RIFKIN

CHRIS GARCIA

While Pong (1972) is often called the "First Arcade Video Game," the title rightfully belongs to Computer Space, developed a year earlier in 1971 by Nolan Bushnell for Nutting Associates of Mountain View, California. The game closely resembled Steven "Slug" Russell's SpaceWar!, developed at MIT in the early 1960s for play on the DEC PDP-1. Computer Space featured two ships gliding through star-filled space trying to shoot down opponents with missiles. The black and white monitor and console speakers seem quite primitive by today's game standards, but in the 1970s, these were far more sophisticated than anything else that was being played in pinball-dominated arcades.

Perhaps the best reason Pong gets all the attention is the fact that not many people played Computer Space with its complex controls. Pong, possibly the easiest of the early video games, sold more than 100,000 units, while Computer Space sold less than 3,000 units. Realizing that the game itself may have been too complex for most users of the day, Nutting Associates then tried unsuccessfully to market the game in a "Beautiful Space-Age Cabinet" with attendant scantily-dressed model.

After the failure of Computer Space, Bushnell formed Atari (originally called Syzygy), and released the wildly popular Pong game in 1972. Atari went on to become the dominant video game company through the early 1980s. After selling Atari to Warner Brothers, Bushnell later founded Pizza Time Theatres and Sendai Electronic Games. ■

Chris Garcia is Historical Collections Coordinator at The Computer Museum History Center

Computer Space, the first commercial coin-operated video game

MUSEUM VIDEOTAPES MAY NOW BE ORDERED ONLINE

One of the ways The Computer Museum History Center preserves the personalities, stories, and visions of the information age is through its extensive archive of videotapes—now 2,000 titles and growing. These recordings are valuable, not only for historical inquiry, but for contemporary understanding as well. The Museum is proud to offer a wide selection of its video holdings for classroom and personal use. Please visit **WWW.COMPUTERHISTORY.ORG/STORE** for a complete list of titles and prices.

The collection contains a variety of material, including:

MUSEUM "COMPUTER HISTORY" LECTURES by leading computing innovators. Often these videos are the only permanent record of important talks and favorite ideas of people who have influenced the technology revolution.

MUSEUM "HISTORY IN THE MAKING" LECTURES, meant to capture the present vision, technology, and process of people who may one day be important parts of computing history.

RECORDINGS IN THE GRAY-BELL ARCHIVE, including presentations by computing legends and innovators derived from more than a decade of work by University Video Communications (UVC).

The Museum distributes thousands of videos per year and many titles are also available for viewing on the web. Visit our website for more information. Stay tuned, since we update the site and add to the archive regularly.

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RECENT DONATIONS

TO THE COMPUTER MUSEUM HISTORY CENTER COLLECTION

MICROCOMPUTERS

Wang 53-2 Personal Computer (1984), X1817.2000, Gift of Harry Brooks

Tandy TRS-80 Model 4 (1982), X1930.2000, Gift of Bob Morgan

Tandy TRS-80 Model 4 (1982), X1931.2000, Gift of Bob Morgan

Apple Powerbook Duo with DuoDock (1990), X1926.2000, Gift of Leslie Lindsay

IBM 5271 Computing System (1983), X1923.2000, Gift of Bill Spangler

Mindset Video Production System (1983), X1921.2000, Gift of Molly Hogan

Mindset Personal Computing System (1983), X1922.2000, Gift of Molly Hogan

Digital Equipment Corporation Hi-Note Laptop (1994), X1938.2000, Gift of Bonnie Sontag

COMPONENTS

NexGen Nx586-60 VLB Motherboard (1995), X1945.2001, Gift of Norbert Juffa

NexGen Nx586 PF110 PCI Motherboard (1995), X1946.2001, Gift of Norbert Juffa

Integrated Information Technologies XC87DLX2/50 Math Coprocessor (1994), X1947.2001, Gift of Norbert Juffa

OTHER / SPECIAL PURPOSE

Lexitron VT 202 Word Processor (1979), X1920.2000, Gift of Holvick Construction

US Robotics Palm Pilot Professional (1995), X1935.2000A-C, Gift of Tuck Takagawa

Matsucom OnHand Wearable PC (1997), X1936.2000, Gift of Tuck Takagawa

Silicon Valleyopoly Board Game (1989), X1937.2000, Gift of Tuck Takagawa

Advanced Concepts Ltd. Crayola Crayon Box Calculator (1994), X1944.2000, Gift of Joseph Camp

Tubular Audion Vacuum Tube (ca 1912), X1943.2000, Gift of Eric Barbour

Kendall Square Research KSR 1 Promotional Model (1992), X1948.2001, Gift of Norbert Juffa

Pre-Production Apple Duo External Floppy Drive (1990), X1928.2000, Gift of Leslie Lindsay

Apple Newton with Fax Modem (1990), X1927.2000, Gift of Leslie Lindsay

IBM UPAC Coupler (1983), X1924.2000, Gift of Bill Spangler

Burroughs 1C Dish Platter (1971), X1977.2001, Gift of William Klehm

FOCUS ON PEOPLE

ELEANOR DICKMAN

DAVE ANDERSON, DAVE HOUSE, AND GRANT SAVIERS: THE RACER'S EDGE

When Trustees Dave Anderson, Dave House and Grant Saviers walk into an Executive Committee meeting at The Computer Museum History Center, the room fairly crackles with their intensity and drive. Their mission is to help preserve the history of computing. Their focus is how this history will be important for future generations. And it is clear that these three engineering executives[1] want to get things done!

Their love for things mechanical, their intellectual energy, and their competitive spirits have made them successful contributors and corporate executives in today's high-tech world. These same traits make them enthusiastic amateur race car drivers.

Anderson is the veteran speedster of the group, having raced for the past eight years. Saviers joined the circuit a year-and-a-half ago, and House will celebrate his first anniversary on the track in November. House has been in love with cars since his childhood "in the automotive state of Michigan." He characterizes himself as "an adrenaline junkie," observing that racing is a "chance to drive fast legally." Speed also motivates Anderson: "It's a natural fit between my heavy foot and my [sense of] competitiveness, an opportunity to provide an outlet for both." For Saviers, the thrill is to "push myself... the adrenaline rush of racing is unbelievable!"

All, however, have approached the fast track with the same methodical preparation required by an engineering or management challenge. Certified by the Skip Barber Racing School, they compete in events sponsored by the Sports Car Club of America (SCCA). Anderson is proudest of his performance in the SCCA Spec Racer Class, in which he won the Pacific Coast championship. House hasn't won any records as of yet, but believes that "racing is more of the challenge than the winning; there is always somebody to compete with." He says that the object of racing is to "keep the car right on the very edge of control but never getting out of control or making a mistake." Saviers agrees, and cites one particularly exhilarating episode, when he managed to regain control of his car as it was spinning at 115 mph, "with only minor damage to the car and nothing to me."

Many of the qualities that make Anderson, House and Saviers good racers also make them outstanding Trustees. House says, "Clearly the parts of our personalities that make us want to race are also the things that make us want to make things happen." Competitive and inventive, Anderson likes using his leadership skills "to help create and build an effective organization." Saviers, who describes himself as "a builder of things," wants to build the Museum "in different dimensions."

All three have been long-time supporters of The Computer Museum History Center. A DEC employee for 25 years, Saviers has been affiliated with the Museum since he worked for Gordon Bell, who, with his wife Gwen, founded the original Computer Museum. House was introduced to the Museum by fellow Trustee Gardner Hendrie (House's mentor years ago at Honeywell), and later became involved with the Computer Bowl. Participating in the Computer Bowl as a contestant five years ago also connected Anderson to the Museum.

The Trustees agree that the Museum's most important mission is preservation. Notes House: "I'm interested in celebrating the history and the stories

Grant Saviers, Dave Anderson, and Dave House share a passion for fast cars and cutting-edge leadership

PHOTO BY ELEANOR DICKMAN

of the computer industry, an industry that has changed our world. It is still new, and many of its pioneers are still with us." Saviers describes computing as "a very creative learn-while-doing technology," and wants to ensure that the milestones in computer history are preserved and explained. "It's marvelous," he says, "to celebrate what the best and brightest have done in the past." Anderson fears that "our technology industry has been particularly poor at [preserving its history] and The Computer Museum History Center is absolutely needed to "maintain our valuable artifacts and stories."

With Anderson, House, and Saviers on the "track," the race to build a strong organization and a new facility is one The Computer Museum History Center is sure to win!

[1] Dave Anderson: CEO, Sendmail; Chairman of GeoFin Corp; former Chief Technical Officer, Amdahl. Dave House: 22-year veteran of Intel; former CEO, Bay Networks; former President, Nortel. Grant Saviers: former Chairman & CEO, Adaptec; former Vice President, Storage Systems, DEC.

Eleanor Dickman is Vice President of Development & Public Relations at The Computer Museum History Center

REPORT ON MUSEUM ACTIVITIES

KAREN MATHEWS

An unbeatable partnership between you—our supporters—and a committed group of talented, hard-working Trustees, staff, and volunteers has put us squarely on track to continue increasing the scope and breadth of the Museum's operations throughout this fiscal year. Thanks to your generosity and commitment, the Museum has exceeded its projections for fiscal year 2000 by over $100,000. It is exciting to be part of this successful effort to build a community resource that will serve as a world center for computing history.

As always, I welcome the chance to answer your questions or discuss any of the information that follows. All contact information can be found on page 17.

Karen Mathews is Executive Vice President at The Computer Museum History Center

Chris Garcia teaches a group of children about core memory in the Visible Storage Exhibit Area

MUSEUM VISITORS

Our Visible Storage Exhibit Area includes many unique and rare objects from the collection such as the Honeywell Kitchen Computer, the Apollo Guidance Computer, two Apple I boards, and pieces of the ENIAC, ILLIAC IV, and SAGE. We are always thrilled to host tours for both individuals and groups. Our many visitors this quarter included Mary Wasik and 25 students from Blach Intermediate School in Los Altos, California. Here are some of the students' written responses:

> "Excellent tour! Extremely old computers with mere K's of memory!"
>
> "My impression... was that the computers were really cool and that technology has changed a lot in a few years."
>
> "I... learned that there are computers in the world worse than ours."

What past or present technology innovations were you marveling at when you were 13?

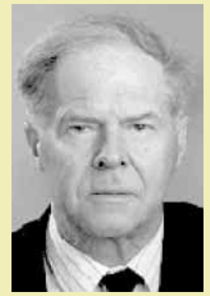
1999 Fellow Award presentations (from top): Horst Zuse (left) accepted posthumously on behalf of his father, **Konrad Zuse** (presented by Hermann Rampacher), **John McCarthy (left)** (presented by Ed Feigenbaum), and **Alan Kay (left)** (presented by Doug Engelbart)

JAN LUNDBERG PHOTOGRAPHY

2000 FELLOW AWARDS BANQUET

Each year the Museum presents Fellow Awards to people who have made significant contributions to computing. To date, we have recognized 14 Fellows, all of whom are featured on our website at www.computerhistory.org/exhibits/hall_of_fellows. We will announce three more honorees at our annual dinner and Fellow Awards Banquet on **THURSDAY, NOVEMBER 9, 2000,** at the Hotel Sofitel in Redwood Shores, California. Please save the date for a magical evening with the pioneers, and movers and shakers of the IT world. The Museum is looking for additional corporate partners to join Citigate Cunningham and Greater Bay Bancorp-Mid Peninsula Bank in sponsoring this memorable event. If you can help or have any ideas, please let me hear from you! We look forward to sharing the experience with you. To reserve your place or arrange for a table, please contact Wendy-Ann Francis.

In a lecture on September 28, Richard Grimsdale will discuss 1950s-era computing in the UK



LECTURE PROGRAM

On Thursday, September 28, the Museum will present Richard Grimsdale lecturing on "The Manchester University Transistor Computer." As a research student at the University of Manchester in 1950, Grimsdale wrote test and diagnostic programs for the Ferranti Mark 1—no small feat, due to the almost total lack of circuit diagrams. From programming the EDSAC in 1950 to his recent work in VLSI accelerator chips for 3-D image generation, Grimsdale has many fascinating stories to relate.

Grimsdale is one of many speakers in our terrific lecture program for 2000. Stay tuned for upcoming announcements. In addition to our popular History Lecture Series, we will be adding "History in the Making" presentations featuring people who are "potentially making history today." To receive lecture announcements, please contact info@computerhistory.org.

Lecture sponsorship opportunities are available. Sponsors ensure their own place in history with permanent recognition in the Museum's video archive as supporters of this important effort to preserve the stories of the information age. You and your company can make a highly-visible, long-lasting contribution to this effort through your participation. Please contact me if you can help or would like to know more.

Trustees and donors relax at the donor appreciation party in July: (left to right) Christine Hughes, Andy Cunningham, Gordon Bell, Donna Dubinsky, and Peggy Burke

PHOTO BY ELEANOR DICKMAN

DONOR NOTES

On July 27, 2000, donors, Trustees and staff celebrated the successful end of our fiscal year with a recognition party for Core Supporters (those who make annual donations of $1,000 or more). The event was graciously hosted by Dave House and Karla Malechek at their lovely hilltop home in Saratoga, California. For those of you who were unable to attend, please know that you were missed and that we plan to hold other such events in the future.

As you know, The Computer Museum History Center welcomes donations to help preserve computing history through collecting, educating, and public communications efforts. The Museum recognizes all of you as very special people and organizations. You loyal, consistent supporters with an abiding interest in preserving the history of computing truly set an example for others to emulate.

In June, volunteers received thanks and awards for the help they gave over the previous year at the Volunteer Appreciation Event 2000. Staff members also shared plans for the upcoming year at the Museum.

PHOTO BY WENDY-ANN FRANCIS

VOLUNTEER APPRECIATION EVENT

Over 50 people gathered at Museum Chairman Len Shustek's home on a sunny afternoon in June to honor the many and varied contributions of Museum volunteers. In addition to enjoying a relaxing picnic on the lawn and lots of socializing, volunteers received personalized certificates and Superman T-shirts! Special thanks to Len Shustek, Lee Courtney, Karyn Wolfe, Wendy-Ann Francis, Betsy Toole, John Francis, and John Toole for helping out! There are many rewarding opportunities to get involved at the Museum as a volunteer. Please contact our Volunteer Coordinator, Lee Courtney.

CURATOR LECTURES IN FINLAND

Last March, Curator Dag Spicer travelled to the Kiasma Museum of Contemporary Art in Helsinki, Finland, where he spoke to an international audience of 300 on the "Archaeology of Computer Culture." Dag was invited to lecture as part of a major exhibition and symposium called "Alien Intelligence" (http://www.kiasma.fi/outoaly/en/cont_outo.htm) that focused on the past, present, and future of computer-mediated interactions. The exhibition featured a "media-archeological" gallery, with historical artifacts from 19th century automata to 20th century autonomous robots and digital pets, including what is likely the world's first artificial life form, Grey Walter's turtle, *Machina speculatrix* (http://www.plazaearth.com/usr/gasperi/walter.htm).

THANKS TO OUR ANNUAL FUND DONERS

We acknowledge with deep appreciation those individuals and organizations that have given generously to the Annual Fund of The Computer Museum History Center.

CORE BENEFACTORS
16K+ ($16,384+)

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This list is current as of September 20, 2000. Please notify us of any changes to your listing (wolfe@computerhistory.org). Thank you.

YOUR ANNUAL DONATION to The Computer Museum History Center will help preserve the artifacts and stories of the Information Age for future generations. Please help us fulfill this important mission.

CORE BENEFACTOR

___ other $ ____________
___ 16K ($16,384)

MAJOR CORE SUPPORTER

___ 8K ($8,192)

CORE SUPPORTER

___ 4K ($4,096)
___ 2K ($2,048)
___ 1K ($1,024)

GENERAL SUPPORTER

___ $500
___ $250
___ $100
___ $35 (student)
___ other $ ____________

Please return this form (or facsimile) with your remittance to:

The Computer Museum History Center
P.O. Box 367 Moffett Field, CA 94035
+1 650 604 2575 (tel)
+1 650 604 2594 (fax)
www.computerhistory.org

YES, I want to help save computing history. Please process my donation at the level indicated. I look forward to learning more about the programs and activities of The Computer Museum History Center, especially its plans for growth in the coming years.

___ Enclosed is my check payable to: The Computer Museum History Center
___ I prefer to donate stock and will notify you when the transfer is made
___ Charge my Visa ____ Mastercard ____

Visa/Mastercard number ____________________
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WELCOME to our network of supporters. We look forward to getting to know you!

TRIBUTE DONATIONS

What do you give the entrepreneur who has everything? To commemorate a birthday, anniversary, job promotion or successful IPO venture, or to honor the memory of a colleague or loved one—consider making a donation to the Museum on their behalf. We'll be happy to send an acknowledgement to the recipient or family. Your thoughtfulness will be appreciated by those you have remembered, and by the Museum as well.

STOCK DONATIONS

We gratefully accept direct transfers of securities to our account. Appreciated securities forwarded to our broker should be designated as follows:

FBO: The Computer Museum History Center; DWR Account # 112-014033-072; DTC #015; and sent to Matthew Ives at Morgan Stanley Dean Witter, 245 Lytton Avenue, Suite 200, Palo Alto, CA 94301-1963.

In order to be properly credited for your gift, you must notify us directly when you make the transfer. If you have any questions regarding a transfer of securities, please contact Eleanor Dickman.

DONOR SPOTLIGHT

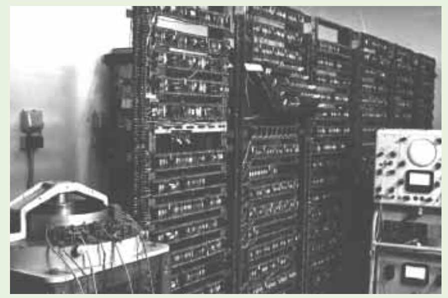
DEL THORNDIKE & STEVE TEICHER

DEC alums Steve Teicher and spouse Del Thorndike have supported the Museum since its inception. Steve was a senior group engineering manager at DEC, and Del was the head of technical education for the semiconductor group. Steve has always endorsed the idea of preserving the inventions and biographies of pioneers of the information age, and praises Gordon and Gwen Bell, founders of the original Digital Computer Museum, "for their good sense of keeping bits of history."

Now pursuing an MBA at Rollins College (FL), Steven indicates that The Computer Museum History Center has "a unique opportunity to preserve artifacts, photographs, and videotaped lectures of industry titans" that might otherwise have been lost. "If you were an archeologist a few hundred years from now, these are the types of things you would want to have preserved." Del sees The Computer Museum History Center as contributing "a new form of art," by highlighting the beauty of machines that "somebody worked hard to put together" in aesthetic as well as functional ways. "We tend to be interested only in the new," she says, "but it's the old that we learn from."

UPCOMING EVENTS

SEPTEMBER 28, 6 PM



THE MANCHESTER UNIVERSITY TRANSISTOR COMPUTER
Richard Grimsdale
University of Sussex, UK
Computer History Lecture
Moffett Field, California

OCTOBER 11, 6 PM
A CARTOONIST'S LOOK AT COMPUTER HISTORY
Richard Tennant, 5th Wave Cartoonist
Special Presentation
Moffett Field, California

OCTOBER 14, 9 AM - 5 PM
VOLUNTEER WORK PARTY
Bldg 126, Moffett Field, California

OCTOBER 21, 4 PM (TENTATIVE)
TONY SALE
Computer History Lecture
Location TBD

NOVEMBER 8, 6 PM
THE STRETCH-HARVEST COMPILER
Fran Allen, IBM Fellow
Computer History Lecture
Location TBD

NOVEMBER 9, 6 PM
FELLOW AWARDS BANQUET 2000 INDUCTEES: FRAN ALLEN, VINTON CERF, AND TOM KILBURN
Hotel Sofitel at San Francisco Bay
Redwood Shores, California

NOVEMBER 18, 9 AM - 5 PM
VOLUNTEER WORK PARTY
Bldg 126, Moffett Field, California

DECEMBER 9, 9 AM - 5 PM
VOLUNTEER WORK PARTY
Bldg 126, Moffett Field, California

ATTENDING EVENTS AND TOURING THE COLLECTION

The Museum is housed at NASA Ames Research Center, Moffett Field, California. The collection is open to the general public by appointment on Wednesdays at 1:00 pm. To attend an event or to tour the collection, please call Wendy-Ann Francis at least 24 hours in advance. Donors may also request private tours.

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+1 650 604 2594 (fax)

or
THE COMPUTER MUSEUM HISTORY CENTER
PO Box 367, Moffett Field, CA 94035

WWW.COMPUTERHISTORY.ORG

VOLUNTEER OPPORTUNITIES

The Museum tries to match its needs with the skills and interests of its volunteers. Monthly volunteer work parties are listed in the calendar to the left. For more information, please contact Betsy Toole or visit our volunteer web page at www.computerhistory.org/volunteers.

MYSTERY ITEMS

FROM THE COLLECTION OF THE COMPUTER MUSEUM HISTORY CENTER

Explained from CORE 1.2

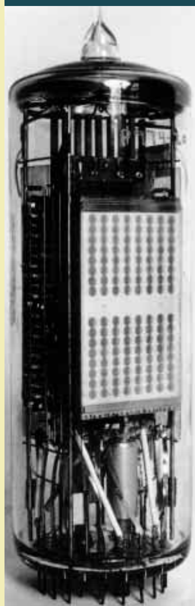
The MIT RDA Differential Analyzer Component was part of an enormous mechanical "computer" built at MIT in late 1941 under the direction of U.S. wartime research head Vannevar Bush. The RDA, or "Rockefeller Differential Analyzer" (funding came in part from the Rockefeller Foundation), weighed 200,000 lbs (100 tons), had 2,000 vacuum tubes, 200 miles of wiring, and 150 motors. Legendary mathematician and electrical engineer Richard Hamming donated this particular component to the Museum in May of 1987. At the time of his donation, Hamming wrote, "I had used it for important work in guided missiles in 1946-47 and later, when I heard it was being torn down, I asked, politely, for a piece. They sent the differential gears that were the form of addition on the machine. I have dropped it numerous times so that the gears are not as backlash free as they were originally on the machine, which was perhaps the most accurate analog computer of its size yet built."

MIT RDA DIFFERENTIAL ANALYZER COMPONENT (1941), X838.87, GIFT OF RICHARD HAMMING

The RDA operated 24 hours per day and solved many critical problems in atomic physics, acoustics, ballistics, and other fields during WWII. By 1949, a digital version of the differential analyzer called MADDIDA (see page 2) was constructed by the Northrop Corporation. The RDA ran its last calculation in 1950, when it was finally dismantled, bringing to a close the era of large mechanical differential analyzers.

WHAT IS THIS?

THIS ITEM WILL BE EXPLAINED IN THE NEXT ISSUE OF CORE.



Please send your best guess to mystery@computerhistory.org before 10/15/00 along with your name and shipping address. The first three correct entries will receive free posters: 25 YEARS OF MICROPROCESSOR EVOLUTION.

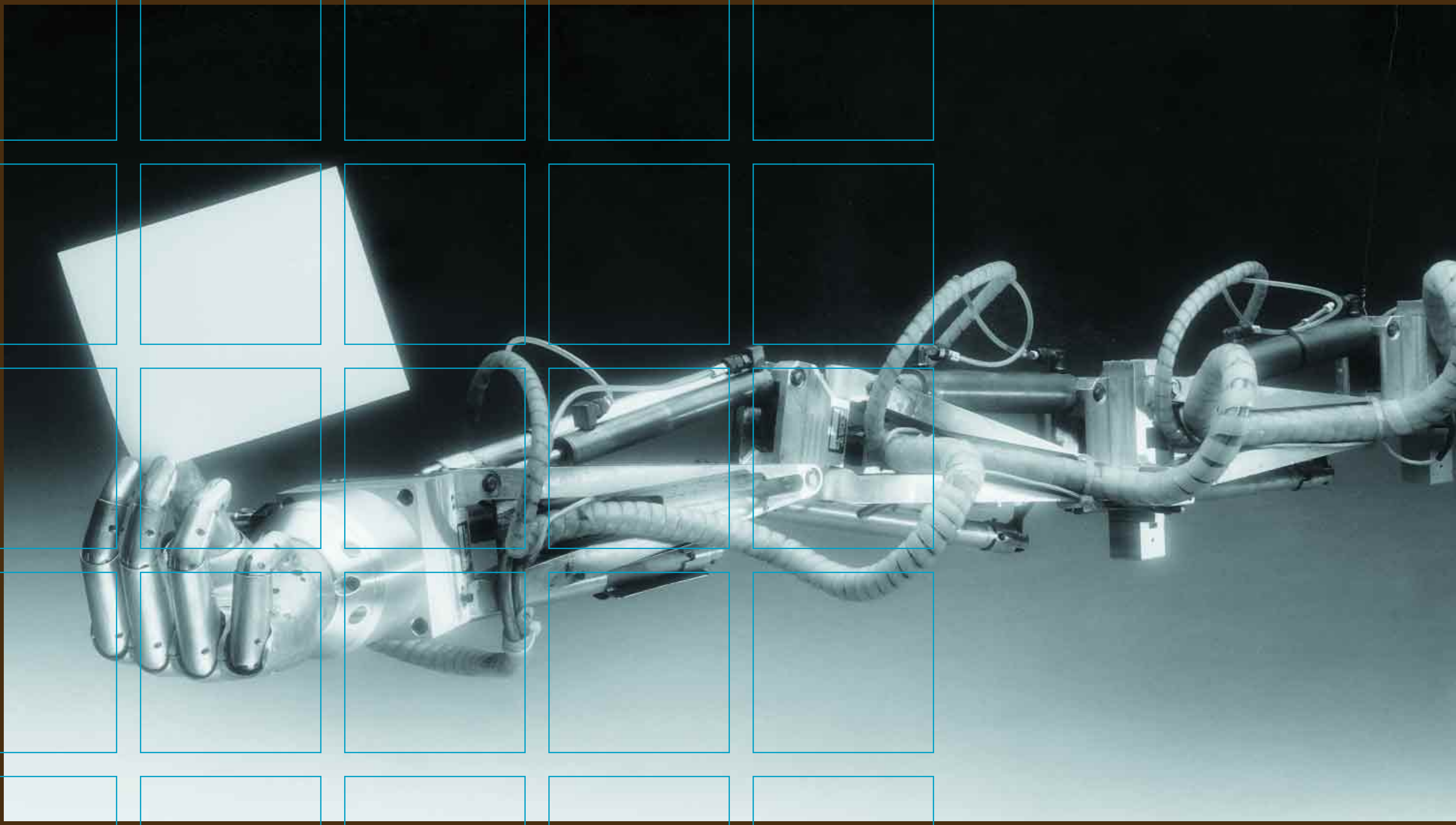
The Computer Museum History Center
PO Box 367, Moffett Field, CA 94035

Address Service Requested

NOVEMBER 2000

CORE 1.4

A PUBLICATION OF THE COMPUTER MUSEUM HISTOR Y CENTER
WWW.COMPUTERHISTOR Y.ORG



THE NEXT LEVEL

I am pleased to report that we have reached a new level of professional organization at the Museum. We now need your help to "blast through" the next plateau on our way to our permanent home. After you see what we are accomplishing, please help us exceed our expectations in our annual financial campaign, which is the lifeblood needed to bring lectures, preservation activities, detailed planning, and energy to everyone engaged in our mission.

It's also the right time to invite everyone to help expand our Museum community, which is so important for our long-term growth. But please don't forget to ENJOY our evolving Museum culture—you made it all happen, so I hope you are taking advantage of our lectures, events, and Fellows Awards... just as you might enjoy fine wine with friends.

As many of you know, I've personally immersed myself in our people and events, concluding (again) that we have the most amazing group of supporters—from the best dreamers to the best "doers" I have ever seen. If we share the excitement and turn it into action, we cannot fail!

The past quarter has been extremely active. Remember those priorities I established in the June issue of CORE? Let's see what's been happening—you can read more details in other articles—but here are some snippets and highlights:

People – Please welcome Kirsten Tashev and Julie Stein as new employees. Kirsten is our new building and exhibits project manager. She comes to us with a solid background in both areas, and has worked for both commercial firms and museums. Julie is an executive assistant, so you'll be seeing her in many roles, including working projects at many functions.

Our volunteers have been extraordinary—on volunteer days, on regular days, and for major events. Our "volunteer steering committee" has begun to organize, brainstorm, and improve communications. They are surveying other museum volunteer programs, planting the seeds for our own docent program, and developing signage for our Visible Storage Exhibit Area.

Innovation – We're starting to discuss and collect a large number of ideas about our future building as well as our web presence—including creative ways to exhibit our collection. You are going to be hearing lots more on this in the next six months and we welcome your thoughts.

Communities – We have spent many productive hours with different groups—gathering feedback and ideas, and planning collaborations. For instance, we presented at the Vintage Computer Festival; spent quality time at the Charles Babbage Institute's conference on "Unbundling History: the Emergence of the Software Product;" and met with several CEO's, curators, professors, and executive directors of places such as the Oakland Museum of California, Heinz Nixdorf Museum, and the University of Sussex, to name just a few.

Operations – I hope you have seen many of the new items in our Visible Storage Exhibit Area, and you will see even more changes in the future. In addition to the new sample display of our robotics collection, we hope to put more networking and software artifacts out for you very soon. Our collection continues to grow—see page 17 for examples. I've received many positive compliments about our recent lectures and hope to see you at our future ones. We are also getting our message out in exciting and creative ways such as hosting executive receptions (for example, the TTI Vanguard group in September), doing interviews, and accommodating film crews.

I also want to emphasize how important and helpful NASA has been to us. Plans for the NASA Research Park at Moffett Field, the site of our future building, are moving ahead rapidly. We are attending monthly partner meetings among all participating organizations, and developing a cooperative view of our future home. You will be seeing a great deal of publicity as we move through the Environmental Impact Statement submissions. As you can see, the dream you have begun to dream with us is on the way to becoming a reality!

I hope you can feel the positive movement. Yet, we are also limited in resources by what we can do, and I want to begin a new phase of growth next year. So please help us in every way possible in our annual campaign—not just in dollars donated but also in the number of people we are able to reach. Both metrics are very important as we build an institution that you'll be proud of over the next 3, 5, 10, 25, and 50 years.

Thanks again for all your help. We've got an exciting year ahead!

JOHN C TOOLE
EXECUTIVE DIRECTOR & CEO

November 2000
A publication of The Computer Museum History Center

CORE 1.4

MISSION
TO PRESERVE AND PRESENT FOR POSTERITY THE ARTIFACTS AND STORIES OF THE INFORMATION AGE

VISION
TO EXPLORE THE COMPUTING REVOLUTION AND ITS IMPACT ON THE HUMAN EXPERIENCE

The Computer Museum History Center
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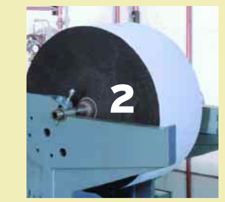
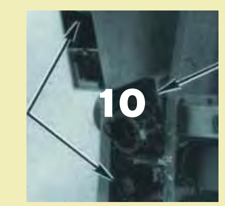
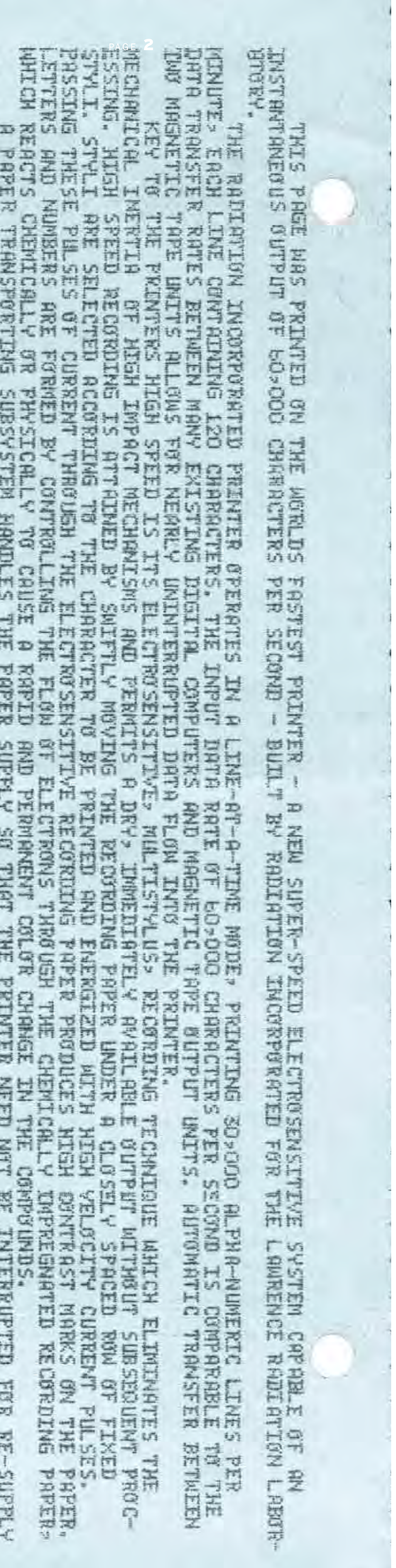
Cover: The Minsky Tentacle Arm. In 1968, Marvin Minsky developed the Tentacle Arm which moved like an octopus. It had twelve joints designed to reach around obstacles. A PDP-6 computer controlled the arm, powered by hydraulic fluids. Mounted on a wall, it could lift the weight of a person. See story on robots in the Museum's collection, page 10.

IN THIS ISSUE






THIS PAGE WAS PRINTED ON THE WORLDS FASTEST PRINTER - A NEW SUPER-SPEED ELECTROSENSITIVE SYSTEM CAPABLE OF AN INSTANTANEOUS OUTPUT OF 60,000 CHARACTERS PER SECOND - BUILT BY RADIATION INCORPORATED FOR THE LAWRENCE RADIATION LABORATORY.

THE RADIATION INCORPORATED PRINTER OPERATES IN A LINE-AT-A-TIME MODE, PRINTING 30,000 ALPHA-NUMERIC LINES PER MINUTE, EACH LINE CONTAINING 120 CHARACTERS. THE INPUT DATA RATE OF 60,000 CHARACTERS PER SECOND IS COMPARABLE TO THE DATA TRANSFER RATES BETWEEN MANY EXISTING DIGITAL COMPUTERS AND MAGNETIC TAPE OUTPUT UNITS. AUTOMATIC TRANSFER BETWEEN TWO MAGNETIC TAPE UNITS ALLOWS FOR NEARLY UNINTERRUPTED DATA FLOW INTO THE PRINTER.

KEY TO THE PRINTERS HIGH SPEED IS ITS ELECTROSENSITIVE, MULTISTYLUS, RECORDING TECHNIQUE WHICH ELIMINATES THE MECHANICAL INERTIA OF HIGH IMPACT MECHANISMS AND PERMITS A DRY, IMMEDIATELY AVAILABLE OUTPUT WITHOUT SUBSEQUENT PROCESSING. HIGH SPEED RECORDING IS ATTAINED BY SWIFTLY MOVING THE RECORDING PAPER UNDER A CLOSELY SPACED ROW OF FIXED STYLI. STYLI ARE SELECTED ACCORDING TO THE CHARACTER TO BE PRINTED AND ENERGIZED WITH HIGH VELOCITY CURRENT PULSES. PASSING THESE PULSES OF CURRENT THROUGH THE ELECTROSENSITIVE RECORDING PAPER PRODUCES HIGH CONTRAST MARKS ON THE PAPER. LETTERS AND NUMBERS ARE FORMED BY CONTROLLING THE FLOW OF ELECTRONS THROUGH THE CHEMICALLY IMPREGNATED RECORDING PAPER, WHICH REACTS CHEMICALLY OR PHYSICALLY TO CAUSE A RAPID AND PERMANENT COLOR CHANGE IN THE COMPOUNDS.

A PAPER TRANSPORTING SUBSYSTEM HANDLES THE PAPER SUPPLY SO THAT THE PRINTER NEED NOT BE INTERRUPTED FOR RE-SUPPLY

The paper required for the Radiation printer was a sandwich of a black conductive layer coated with a white top layer. The overall appearance was bluish-gray. Printing was accomplished by an electric arc burning a hole in the white coating to reveal the black layer underneath. Too bad we can't produce the odor here!

THE RADIATION PRINTER

GEORGE MICHAEL

There are very few computer users who still can recall the frustration of having to wait for a printout. For instance, around 1953-1954, at the Lawrence Livermore National Laboratory (LLNL), the first printers used in conjunction with the UNIVAC I—our first computer—were nothing more than typewriters with print rates of perhaps 6 characters per second (cps). Since the typical output from a design calculation involved between 50,000-100,000 characters, printing would take an inordinately long time. The quest for speedy printing at LLNL led us through a succession of interesting machines, one of which we relied on for about 10 years, starting in 1964. This was the so-called "Radiation Printer," an eccentric and demanding invention that met our needs for speed despite its own oddities.

ON-THE-JOB HEARING LOSS

One of the first attempts to get something faster than the 6cps "typewriter" arrived from Remington Rand about 1957. This was a 600-line-per-minute impact printer, where a line included any number of characters from 0 to 120; each page held about 50 lines. As fast as this was, it was still too slow to serve the needs of dozens of people who spent too much of their valuable time waiting for results Also, when these so-called impact printers ran, the noise level was dangerously high. A few intense users lost some of their hearing from standing in front of this printer, anxiously trying to read their output as it was being printed. In addition to being very noisy, impact printers were not sufficiently reliable, so we sought other solutions.

THE GIRL WITH A CURL

We tried a marriage of cathode ray tubes and xerography: the SC5000 built by Stromberg Carlson in 1959. This device formed characters by projecting an electron beam through a character mask, creating a spatial distribution of electrons that formed the selected character when plotted on the screen of a CRT. The SC5000 further selected where to position the character along the print line. The light thus generated was projected onto a selenium-coated drum that is fundamental in the xerographic printing procedure. In this process, after the image was formed on the selenium drum, it was dusted with xerographic powder ("toner"), which adhered only where the light had suitably charged the surface. By bringing paper into contact with the drum, the image was transferred. The paper then moved through an oven where the powder was fused to the paper, fixing the powder in place. Input to the printing system was via magnetic tape.

The SC5000s were modified so that they printed at an impressive rate of about one page per second. This required expanding the fusing oven and adding a Rube Goldberg device to z-fold the printed output. Quite often, the paper would catch fire as it moved through the fusing oven. The printer kept running, but now acted more like an automatic stoking device, feeding fresh paper into the fire! The SC5000 was very much like the angelic little girl with a curl right in the middle of her forehead: "when she was good, she was very, very good, but when she was bad, she was horrid."

THE RADIATION PRINTER

Even when printouts were produced at the one-page-per-second rate, the total time was just too long to meet the aggregate needs of all users. The search for faster printing continued, so everyone was primed to welcome a new printing technology, ultimately embodied in the so-called "Radiation Printer."

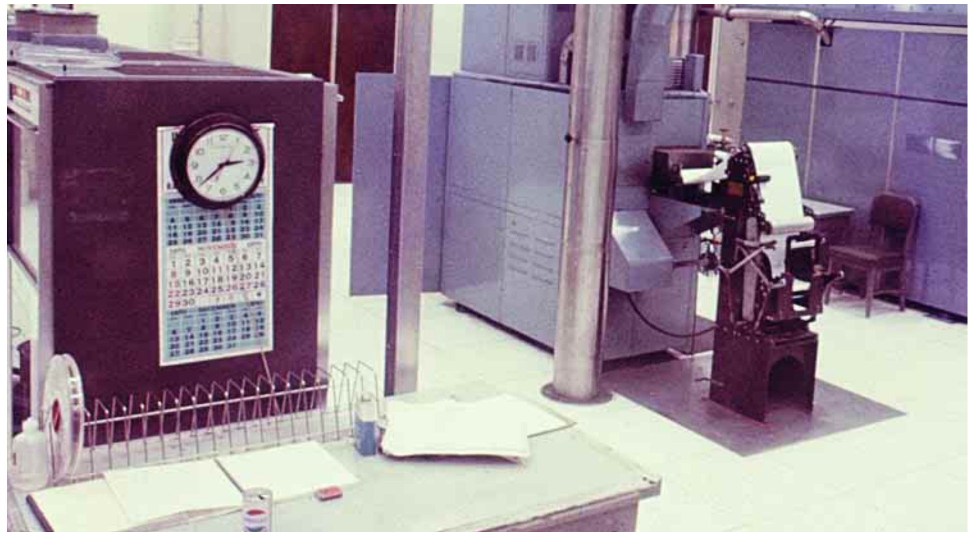
Two technologies came together in the Radiation Printer. First, the actual print process was based on an electrographic printing technology, and second, the process was wedded to a standard printing press that far predated the advent of computers, but was rugged and reliable. Before the arrival of computers, most printing presses were designed to produce many copies of the same page. For LLNL applications on computers, the problem is to produce just one copy for each of thousands of output files. The electrographic technique, which is both fast and clean, uses light to carry information to an electrically charged material where a toner is used to make the image visible. The image is then transferred to paper where it is fixed by chemistry or heat. Xerography is a good example of this technology. Even though further discussion of the process is beyond the scope of this article, some basic differences as used in the Radiation Printer are important to note.

Instead of light, electronic charge was used to carry the information. The charge was made to produce an electric arc from a selected stylus to a black electrographic web through a whitened paint-like material that coated the web. The arc burned a tiny hole in the coating thereby revealing the blackness of the web. This made toning and fixing steps unnecessary. One saw a black dot, and enough black dots produced a simulacrum of the image sent by the computer.

This type of printing process was normally used for the production of mailing labels for magazines like Time and Newsweek. Although no actual printer existed, everyone felt confident that a printer could be scaled up from a mailing label size to a larger page format, and it seemed it could be made to go quite fast and it promised to be economical. We solicited bids for a high-speed printer, and what became known as the Radiation Printer was chosen.

Some salesman got the Radiation Printer to brag about itself. Here are quotes from the literature (I have focused on the portions that appear to be accurate):

"The Radiation Incorporated...Printer operates in a line-at-a-time mode, providing 30,000 alpha-numeric lines per minute, each line containing 120 characters. The input data rate of 60,000 characters per second is compatible to [sic] the data transfer rates between many existing digital computers and magnetic tape output units. Automatic transfer between the magnetic tape units allows for nearly uninterrupted data flow into the printer....Key to the printer's high speed is its Electrosensitive, Multistylus Recording Technique which eliminates the mechanical inertia of high impact mechanisms and permits a dry, immediately available output without subsequent processing. High-speed recording is attained by swiftly moving the recording paper under a closely-



One of the cabinets shown here is the SC5000, circa 1960, that was prone to catching the paper on fire. The print rate was one page per second, with input via magnetic tape. One can also see a homemade device for Z-folding the paper.

spaced row of fixed styli. Styli are selected according to the character to be printed and energized with high velocity current pulses. Passing these pulses of current through the electrosensitive recording paper exposes high contrast marks on the paper. A paper transporting system handles the paper so that the printer need not be interrupted to add paper."

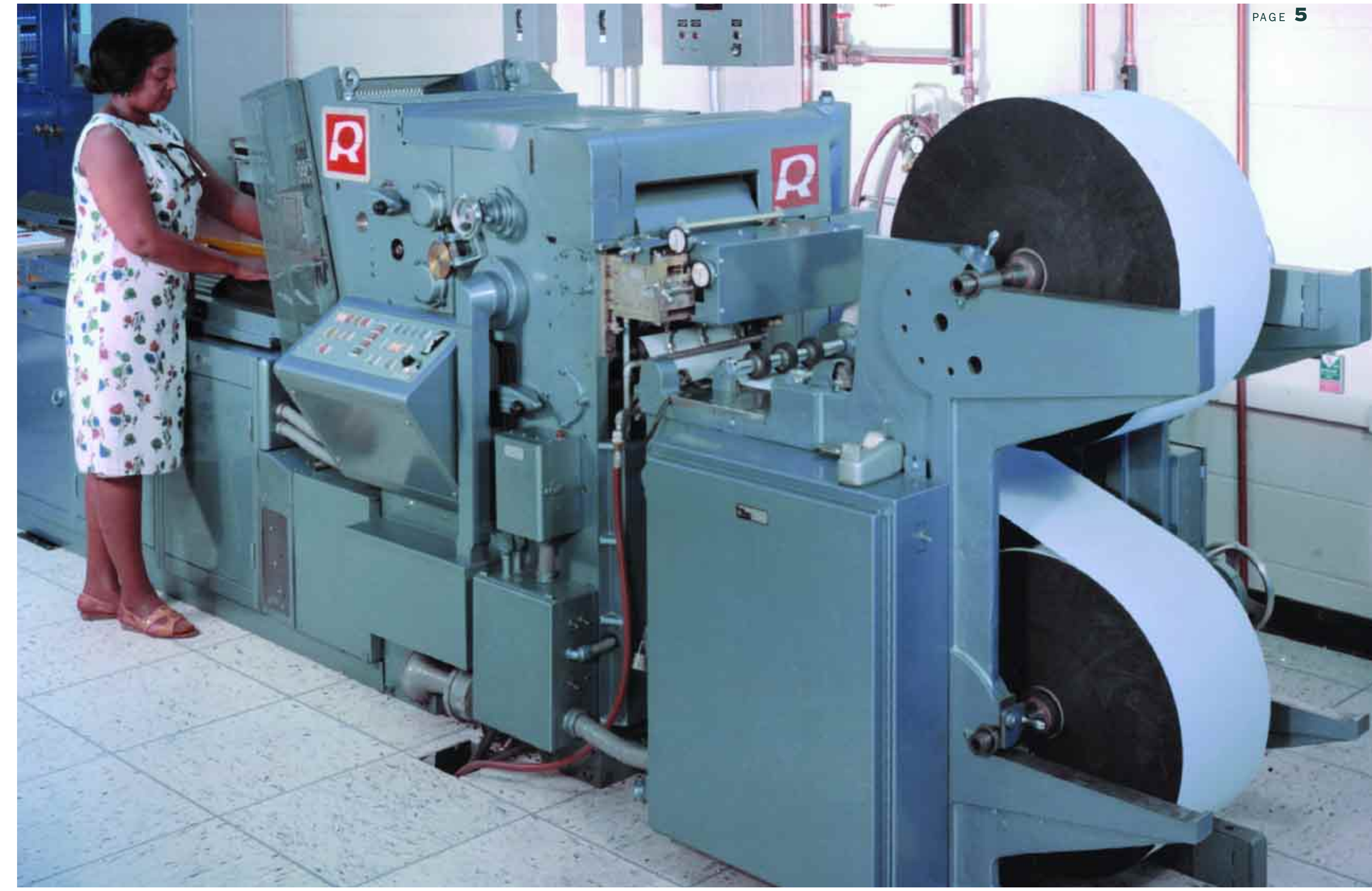
The printer had 600 styli arranged in 100 styli modules. The print area was about eleven inches in width, the page was 11 inches tall, and the images were not considered to be very high resolution. A traditional printing press was used to move the web past the styli. The procedure was dubbed "Revelation Printing," because the coating was burned away by the charge coming from the styli, thus revealing the black paper underneath. During operation, the styli tended to get contaminated with burnt paint debris and the printer would stop functioning. The solution had nothing to do with modern technology: cleanliness was achieved by blowing pulverized walnut shells against the styli. It was claimed that other nuts would not work.

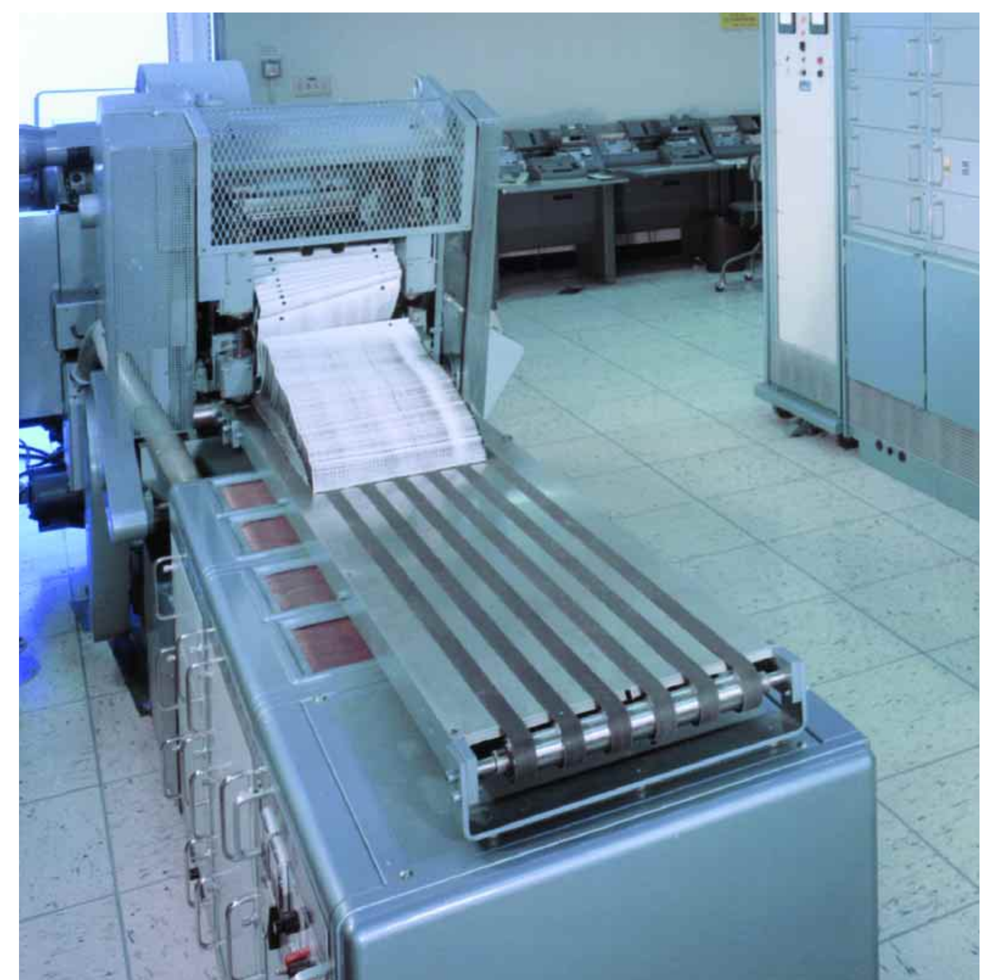
A few additional remarks seem to be in order. First, the Radiation Printer had nothing to do with radiation, but simply was named for the company that built the printer: Radiation, Inc., of Melbourne, Florida. The company modified a real (Hamilton) printing press and added the needed electronics and controls to produce a printer that ran at seven pages per second (for Indy drivers, this turns out to be about 4.3 mph). Printers in the newspaper business run even faster although they don't seem as versatile. In addition to printing at that speed, it punched binding holes at the top and bottom of each page, perforated each page so jobs could be separated, fan-folded the output, and separated the jobs one from another. The various performance numbers for the printer are summarized in the tables on page six.

There were enough styli to allow up to 120 character positions per print line, and each character was formed within a 7 x 9 dot matrix. Suitable spacing between characters and between lines of characters was thereby provided, so that in practice a page could contain up to 10 columns of numbers each up to 12 decimal digits, each column containing 55 to 60 numbers. The capacity of a page was thus about 5,000 characters. It was also possible (but not easy) to address any point in a line, so that with some special programming tricks, graphs could be produced. Printing was thus accomplished exactly as a video-scanned raster is produced. Something in the print process gave the output a disagreeable odor. Some of the users actually complained of headaches. An investigation of the odor failed to expose any serious health hazards, so the simplest response to this was to authorize the issue of fans that could keep the odor away from those sensitive noses.

THE IMPLICATIONS OF SPEED

So what does seven pages per second mean to the users? Each page was approximately 11 inches square. This implies the speed of the paper through the printer is about 77 inches per second. The print data was supplied from any magnetic tape able to provide a nominal 60,000 characters per second—we used IBM 729 tape handlers written at 800 characters per inch. Such tapes had a nominal rate of transfer of up to 62,500 characters per second, more than adequate for printing, so the extra time available allowed for the filling and emptying of buffers, and for the movement of the paper past areas at the top and bottom where no printing was done. On balance then, of the seven pages per second, about 1.3 pages-worth of that time was not used for printing, but for the extra movement of paper required to get from one page to the next, as well as time for hole punching and page scoring.





(above) Operator Mona Millings stands at the table where the separated output was delivered from the printer, and at the other end, the large rolls of paper used by the machine. Paper from the rolls could be spliced head to tail so there was no ordinary need for rethreading through the press. A roll lasted about 45 minutes and a special dolly was needed to move the rolls, since at over 200 pounds, they were far too heavy to be moved by hand.

(left) The machine perforated, folded, and hole-punched the printouts.

TABLE 1. APPROXIMATE PAGES OF COMPUTER PRINTOUTS PER MONTH IN 1978

TELETYPES	200,000
35 MM FILM	600,000
ON LINE PRINTERS	830,000
RADIATION PRINTER	3,400,000
6 MICROFICHE RECORDERS	9,800,000

TABLE 2. EARLY COMPUTER PRINTING TO 1974 (APPROXIMATE SPEEDS)

TYPEWRITERS	1/20 LINES/SEC	1953
LINE PRINTERS (IBM 406)	2.5 LINES/SEC	1954
HIGH SPEED PRINTER (REMINGTON RAND)	10 LINES/SEC	1958
SC5000	60 LINES/SEC	1959
RADIATION PRINTER	420 LINES/SEC	1964

TABLE 3. A SUMMARY OF RADIATION PRINTER PERFORMANCE NUMBERS

PRINT TECHNOLOGY	ELECTROGRAPHIC, REVELA TION
DATA SOURCE	MAGNETIC T APE, UP TO 800 BPI; 75 IPS
CHARACTER RA TE	UP TO 62.5 KCPS
PRINT RATE	7 PAGES/SEC; 4.3 MPH
PRINT SIZE	5000CH/PG

Table contents ar e par tially extracted fr om several unpublished inter nal reports. The values ar e for comparison only .

Thus the rated speed of seven pages per second meant that the user was getting about six completed pages per second within the seven-page time. As you might expect, the users became more sophisticated at doing other things while waiting for their printouts. In total, then, the thr oughput speed of this printer was generally adequate to meet the needs of the gr owing user community, and it did so for a bit over ten years.

The Radiation Printer was integrated into the nor mal operations of the computation depar tment, and ver y quickly was pr oducing ar ound 40,000,000 pages per year . This was only about one-fifth to one-thir d of its capacity, which was a good thing. The machine could be taken down for emergency maintenance, and still ver y quickly clean out the entir e print backlog when it was br ought back on line. Later on during its tenur e, some micr ofiche recorders wer e added. Their annual output quickly gr ew to about 130,000,000 pages distributed over about 1,000,000 pieces of fiche. The effect on the Radiation Printer was less than expected however: the annual output dr opped to ar ound 30,000,000 pages per year and stayed ther e. For most users, the fiche was used for long-term storage of the pr oblem r esults, and output fr om the Radiation Printer was used mostly for day-to-day checking. When a pr oject was finished, the paper was generally discar ded.

CONCLUSION

The output fr om the Radiation Printer was not pr etty. It was har d to r ead; the gray-on-black paper was heavier than ordinary paper; it had, for some, an undesirable odor; and it took up too much storage space. The users often referred to the output as "scunge," but it met their needs, pr oducing at the rate of seven pages per second. None of the printers that wer e brought in to replace it ever came close to this speed. However , as ef fective as the printer was, no one shed a tear when it was r emoved sometime during the late 1970s.

AFTERWORD

It's always humbling and sometimes instr uctive to ask if anything was learned. Ther e ar e several lessons available, though who lear ned them is not clear, nor is the question of whether the lessons have had any long-ter m positive ef fects. Somewhat in the spirit of a post mor tem, her e ar e some things that wer e lear nable:

Simple works best soonest;
Speed wins—most of the time;
True zealots will put up with practically anything to get the job done;
On the matter of print tradeof fs, most users pr efer quality mor e than they prefer quantity.

In the course of dealing with users of all sor ts, we evolved an additional r ule to help get thr ough the day: Generally , if somebody doesn' t know what to do, don't ask him.

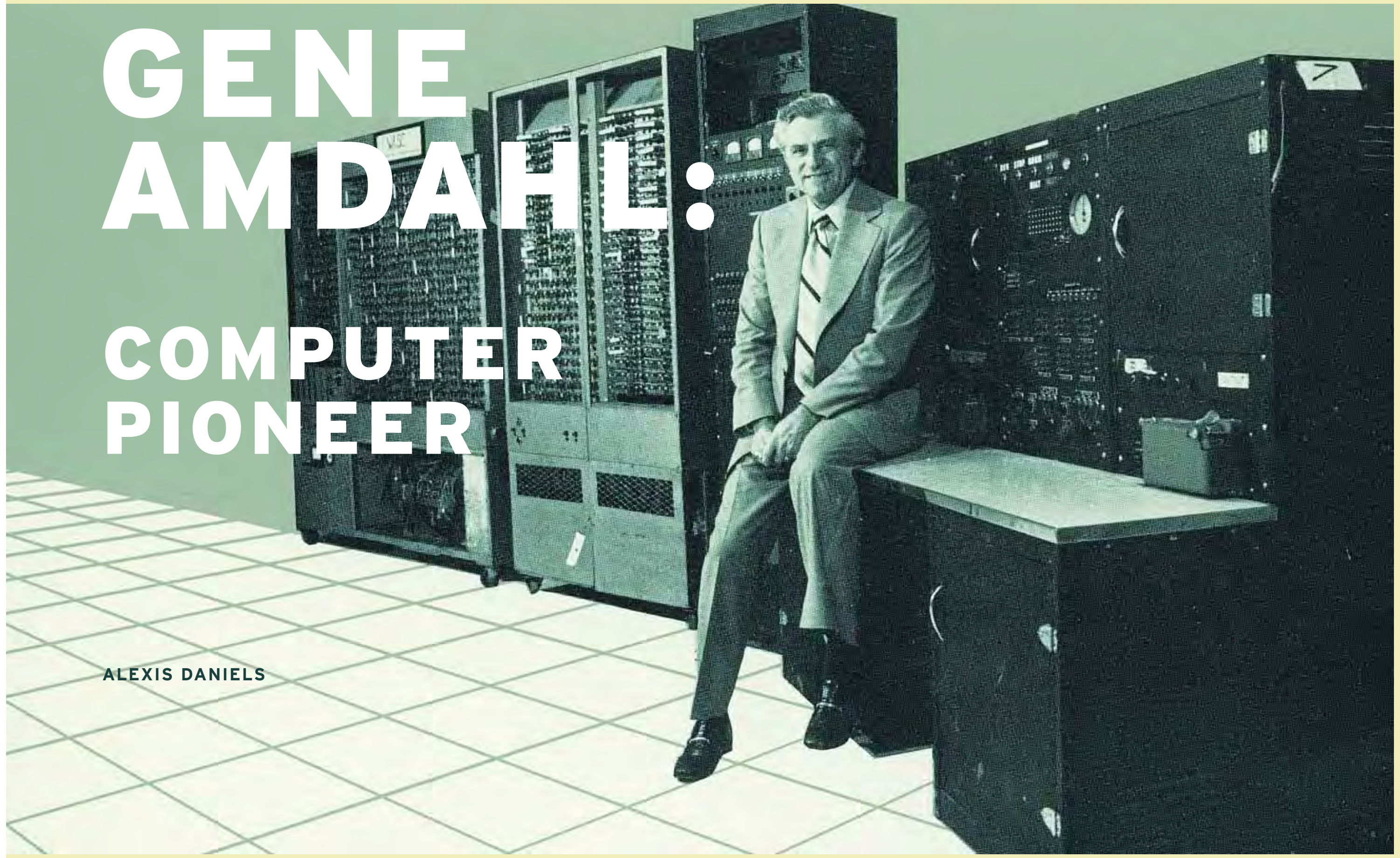
A NOTE ABOUT DA TES: more precise dates may exist, but most of ficial r ecords appear to be in a state of flux. The dates used her e ar e my best approximations.

George Michael began working as a physicist in 1953 at Lawr ence Liver more National Laborator y (LLNL). Michael' s inter est in computing and the physics of what you could do with a computer began with the ar rival, one week later , of their first computer—a UNIV AC 1—and has continued ever since. He has been r etired for seven years and is cur rently inter viewing the people who built the original computing systems at LLNL (then called the University of Califor nia Radiation Laborator y—UCRL).

GENE AMDAHL:

COMPUTER PIONEER

ALEXIS DANIELS



Gene Amdahl' s WISC is cur rently on display at the The Computer Museum Histor y Center' s V isible Storage Exhibit Ar ea.

Recently, over several hours of videotaped inter views conducted by William Aspray , Executive Dir ector of Computing Resear ch Association, Gene Amdahl r eflected on his pr ofessional experiences and documented the course of his amazing technical life. The following material condenses some of the stor y that was gather ed.

Gene Myr on Amdahl was bor n in Flandreau, South Dakota in 1922. Even though his father had only thr ee years of schooling, the elder Amdahl knew the impor tance of education. When Gene declared his intention to go to South Dakota State to study engineering, his father encouraged him to get a liberal arts education instead, emphasizing that lear ning how to make a living was not as impor tant as lear ning how to get the most out of life. Never theless, Amdahl went on to South Dakota State and accomplished both goals. Although he began as an average student, his per formance changed dramatically when he took a physics course during the summer of his fr eshman year . He became consumed by a passion that not only alter ed the course of his life, but which later had a pr ofound impact on the entir e computer industr y.

Although his under graduate work was interrupted during W orld War II by a two-year stint in the U.S. Navy , Amdahl returned to South Dakota State and received his bachelor' s degr ee in engineering physics in 1948. He then began his graduate work at the University of W isconsin with a thesis on "The Contributions to the Magnetic Moments of Heavy Nuclei Due to Spin Anti-Symmetr y and V elocity-Dependent Forces."

Meanwhile, he began designing computers on his own time. When the Electrical Engineering depar tment hear d about this "other" work, Amdahl was encouraged to build a computer that could be used to train graduate students in the emer ging field of digital computing. The r esulting computer , known as the W isconsin Integrally Synchronized Computer (WISC), was designed in the summer of 1950, and submitted as Amdahl' s doctoral thesis in June 1951. His ideas wer e so innovative that the Physics Depar tment felt unqualified to evaluate it and sent it to others for r eview and acceptance. His thesis passed the test, and Amdahl received his doctorate in theor etical physics in 1952.

After graduate school, Amdahl wanted to star t a company building computers but he lacked suf ficient financing. He inter viewed with Inter national Business Machines (IBM) and was hir ed, in par t, because IBM was impr essed with the quality of the writing in his doctoral thesis. Rather than the dr y, technical style of most theses, Amdahl' s writing had a missionar y's zeal that engaged his r eaders. He accepted a position with IBM in 1952 and was the most highly-paid person in the histor y of IBM to be hired dir ectly out of school.

In the fifties, the envir onment at IBM was one of innovation and excitement when new technologies emer ging from

Gene Amdahl was the chief architect of the IBM 360 family of computers, the first instruction-set compatible machines.

CRA's William Aspray, Gene Amdahl, and The Computer Museum History Center's John Toole at the taping of the Amdahl interview in September, 2000.

The IBM 7030, also known as the STRETCH project, was begun in 1956. It used the then-new transistor technology and introduced many novel architectural concepts such as pipelining, multiprogramming, memory protection, a generalized interrupt system, memory interleaving, speculative execution, lookahead (overlap of memory and arithmetic ops), the concept of a memory bus, the coupling of two computers to a single memory, large core memory (1MB), the eight-bit character (the "byte"), variable word length, and a standard I/O interface

Amdahl was the chief design engineer of the IBM 704, the first commercial machine with floating-point hardware. Unlike the 701A, the 704 was not compatible with the 701.

The Amdahl 470 V/6 was the first product of Amdahl Corporation. It was introduced to the marketplace in 1975, to compete with IBM's mainframe computers. These computer clones were known as "plug-to-plug compatibles."

the war effort were beginning to be applied in industry. Amdahl initially worked on machine designs for character recognition and simulation studies to determine if a machine could be made to behave like a human brain. He was the chief architect for the IBM 704 computer, IBM's first commercial machine with floating-point hardware and the first widely-used machine to use indexing and a high-level programming language (FORTRAN). While the marketing department at IBM predicted a market of only six machines, Amdahl himself predicted a market for 32 machines, and the price of the 704 was based on that projection. Since 140 machines were sold, the 704 proved to be highly profitable to IBM and secured Amdahl's place within IBM as a bold, innovative thinker and manager.

In 1955, Amdahl, John Backus and others at IBM began work on the 7030 project, also known as "STRETCH." The goal of the STRETCH project was to build a super computer for the Los Alamos National Laboratory with 100 times the performance of anything else available at that time and to "stretch" IBM internally in terms of design, manufacturing, and device technologies. Frustrated with management's directions, Amdahl left IBM in 1956. He worked for other computer companies on a variety of projects that included designing airborne computers for fighter planes to maximize the plane's capabilities in a dogfight, as well as creating a data entry system for FAA flight planning. Back at IBM, the first of nine STRETCH computers was delivered in 1959 and, although each was sold at a loss, the intellectual debt IBM's later System 7000 and System/360 family of computers owed to STRETCH was to be enormous.

Despite his earlier disenchantment with IBM, Amdahl agreed to return to the company in 1960. He was named Manager of Architecture for the IBM System/360 family of mainframe computers. The System/360, announced in April of 1964, was a series of instruction-set compatible machines covering a 400:1 performance range. It became the greatest success story in the history of computing and IBM's most profitable product line ever—in fact, the basic System/360 architecture is still embedded in many current IBM products today.

By 1969, Amdahl had been named an IBM Fellow, that company's highest honor, and was made director of IBM's Advanced Computing Systems Laboratory in Menlo Park, California. After a time, Amdahl again became disenchanted with IBM's bureaucracy and the internal barriers he felt were hampering the company's growth and ACS product development. Even though many company executives believed his ideas had merit, they refused to change direction, and so, once again, Amdahl left IBM.

When Amdahl resigned from IBM for the second time, he decided to pursue the dream he had held since completing graduate school: to start a company that would build computers. In order to circumvent future legal problems, he fully disclosed his plans to senior management at IBM who cautioned him that there was no money to be made in large computers.

In 1970, Amdahl Corporation was formed in Sunnyvale, California, with the mission to build more innovative mainframe computers (called PCMs—Plug Compatible Mainframes) and to compete head-to-head with IBM. Most industry analysts thought Amdahl was foolish to take on IBM and he experienced problems raising the capital he needed. Despite the difficulties, Amdahl was able to simplify design, improve technology, and build discounted computers that could be substituted for the more costly IBM models. The company's first computer, the Amdahl 470 V/6, shipped in 1975 and sold briskly, being a direct, drop-in replacement for IBM's System 360/165 but one-quarter the size and four times as fast (the price was the same at $3.5 million).

Although IBM had not originally considered Amdahl Corporation as a potential competitor, the company soon learned that it had underestimated its former employee's determination. At its peak, Amdahl Corporation captured 22% of the large systems market and had a pre-tax profit of 30%. Amdahl Corporation became the biggest threat to IBM's domination of the mainframe market and forced IBM to re-align its marketing strategies to take PCM manufacturers into account.

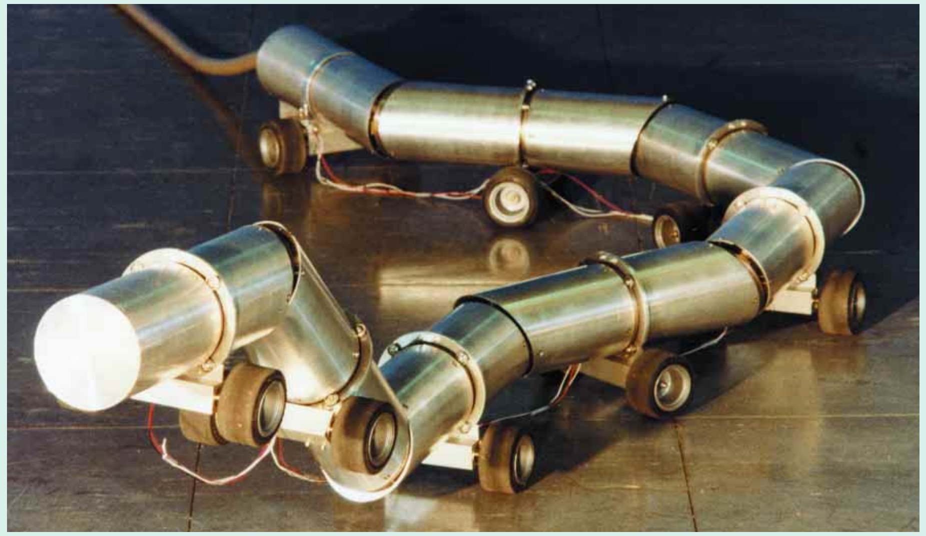
Ever in search of new challenges, Amdahl left Amdahl Corporation in 1980 and went on to establish three other companies: Trilogy Systems (now part of Elxsi Corporation), Andor Systems, and Commercial Data Servers (CDS). In 1991, The Times of London named him one of the "1,000 Makers of the 20th Century," and Computerworld called him one of the 25 people that "changed the world."

Gene Amdahl not only followed his father's advice to learn to make a living and to get the most out of life, but he also left a lasting mark on the computer industry with his well-known law on the theory of computer architecture itself. [1] His innovative and pioneering spirit showed the world that it was possible to compete with IBM on its own terms. Yet perhaps most notable and memorable are his sustained records of accomplishment and energy over a lifetime. ■

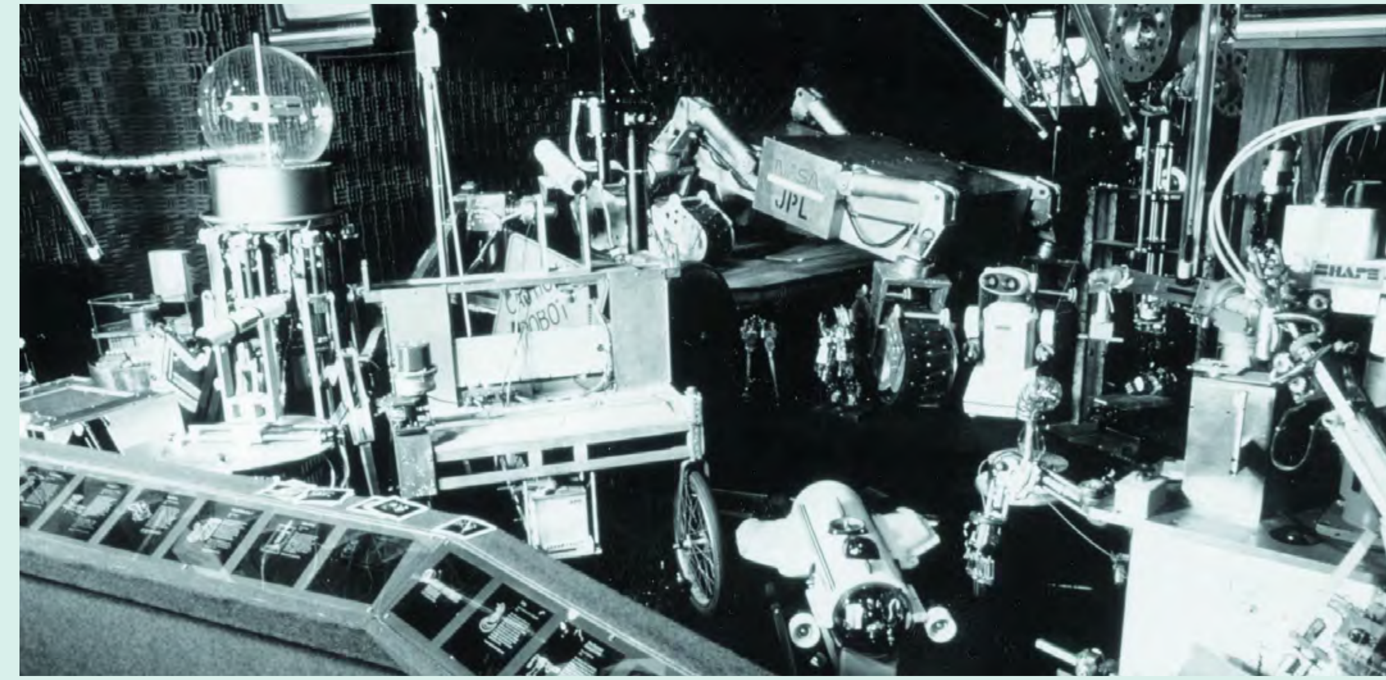
[1] Amdahl's Law states: "If x of a program is inherently sequential, the maximum attainable speedup is 1/x." Experience has shown this law to be fundamental to computer designs which incorporate multi-threaded kernels and parallelism.

FROM THE COLLECTION

Oblex, a snake-like rover, is currently on display in the new robot exhibit



The Robot Theatre as it appeared on display at the Computer Museum, Boston



ROBOTS ENTER VISIBLE STORAGE

CHRIS GARCIA

The final pieces of The Computer Museum collection arrived in California in 1999. Along with most of the earliest PCs (a result of our "Earliest PC Contest" in the 1980s), parts of the UNIVAC 1, rare punch card equipment from the 1920s, and 200 other artifacts rejoined the main collection. Some of the more interesting of these artifacts are machines from the "Robot Theatre," a Boston exhibit highlighting some of the world's earliest and most influential robots.

Recently, many of these robots were put on display in the Museum's Visible Storage Exhibit Area. The massive Mars Rover Hardware Prototype (Jet Propulsion Labs, 1977) dominates the 15-robot display. Designed to explore and map the rugged Martian terrain, the Rover used caterpillar tracks on flexible legs, which allowed the Rover to remain level as it moved over the uneven surface. The first Mars Rover project was abandoned in 1978 when manned space flight became NASA's priority.

Shakey (Stanford Research Institute, 1970) also features prominently in the display. The first mobile robot to use artificial intelligence to control its actions, Shakey employed sensing devices such as a laser rangefinder, bump sensors, and a TV camera, and transmitted data to DEC PDP-10 and PDP-15 computers. The computers radioed back commands, allowing Shakey to plan its directions. The process was slow—it could take up to 30 minutes for Shakey to move one meter.

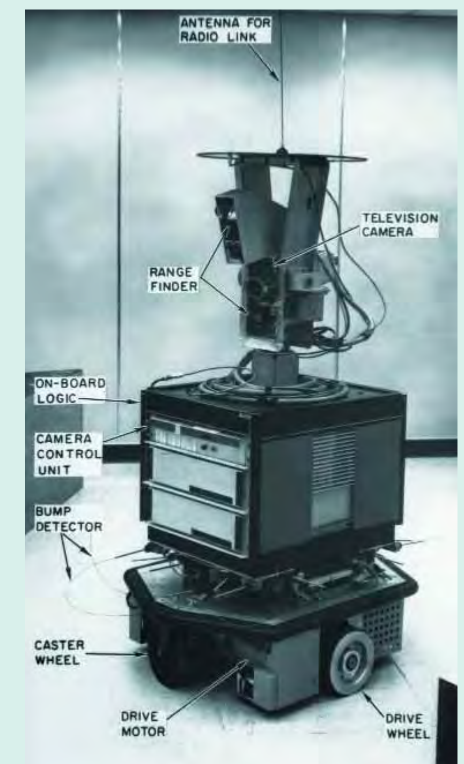
The collection also includes several important robot arms. The ORM (Victor Scheinman and Larry Leifer, 1965) was the first attempt at a computer-controlled arm. The ORM, whose name means "snake" in Norwegian, features seven metal disks sandwiching 28 inflatable air sacks. The method used to create movement—inflating different combinations of sacks—proved to be the arm's undoing, as it was not easy to repeat movements accurately.

The Stanford Arm (Victor Scheinman, 1969) was the first successful electrically powered, computer-controlled robot arm. Built to help develop industrial assembly techniques for commercial robots, the Stanford Arm design eventually led to the Vicarm, a robot arm used in research.

The display also features commercial robots used for household and entertainment purposes. The mobile Hubot (Hubotics Corporation, 1981) was designed for home use and was advertised as "the first home robot that's a personal companion, educator, entertainer and sentry...and he can talk!" The ads for Hubot also pointed out that he could function as a personal computer, with 128k memory, disk drive, and keyboard. The Hero Jr. (Heath/Zenith, 1980) was also designed for home use, and came as a kit. The Hero Jr. could roam hallways, play games, and even act as an alarm clock. The OMNIBOT 2000 (Tomy Kyogo Company, 1985) was a complex robot toy that could be programmed to move, talk and carry objects. The first US ads for OMNIBOT pictured it as a butler serving drinks and making jokes with partygoers.

Due to space limitations, not all of our robots are currently on display. Some of the machines that are not yet being shown include Takeo Kanade's Direct Drive Arm (1981), the Mars Rover Software (testbed) Prototype (1977), and Hans Moravec's Stanford Cart (1965). ■

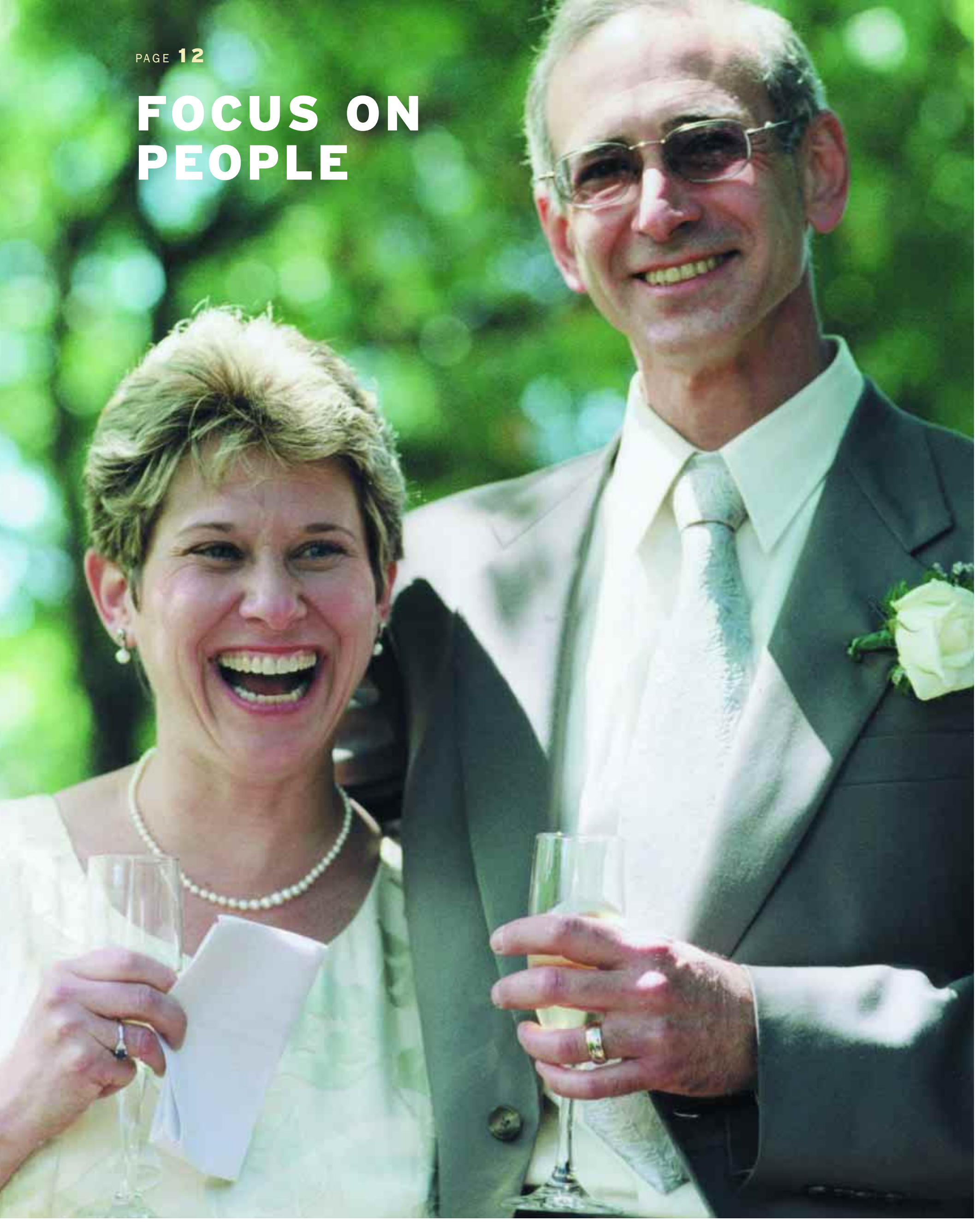
Chris Garcia is Historical Collections Coordinator at The Computer Museum History Center



SRI's Shakey, with labels on the various instruments used to allow Shakey to manuever

The Denning Mobile Robot, used to guard hallways in areas such as prisons and warehouses, was equipped with sonar and microwave beacons to guide it along

FOCUS ON PEOPLE



LEN AND DONNA:

PARTNERS IN PHILANTHROPY AND LIFE

ELEANOR DICKMAN

Note: We invite you to meet recently married **Len Shustek** (co-founder of Network General, occasional professor at Stanford University, and current Chairman of the Board of Trustees of The Computer Museum History Center) and **Donna Dubinsky** (former president of Palm Computing, co-founder and CEO of Handspring, and new member of the Board of Trustees of the Museum). Here, in their own words, are their reasons for supporting the Museum. We hope you will enjoy, as we so often do, their enthusiasm, insight, and commitment to a good cause.

Len, you've been involved in The Computer Museum History Center for a long time. Please comment on the continuing fascination you have for this institution and articulate why.

The computing revolution is not just a phenomenon of interest to the computer industry; it is reshaping our civilization. Most people would agree that the computer is one of the half-dozen most significant inventions ever, and its ultimate effect on our lives is impossible to predict.

The astounding thing is that most of its history has unfolded within the last 50 years. Many of the pioneers are still living. Yet viewed from 500 years from now, this will seem like a point event: "suddenly, computers appeared."

We owe it to ourselves, and our descendents, to tell the story of how it happened. And it's only incidentally a story of machines; it's more richly a story of successes and failures, of company founders and investors, of evangelists and charlatans, of visionaries and beneficiaries of that vision. It is, in other words, a story of people.

Len, you've often expressed concerns that the "legacy of the information age is [in danger of] being lost." Why do you feel that The Computer Museum History Center is the "right" place to see that legacy is preserved?

There are very few organizations in the world whose primary focus is preserving the history of the information revolution. The Museum has that as its sole mission and it is, as investment bankers like to say, a "pure play." It has no internal competing interests. It has amassed what is probably the best collection of computer history artifacts in the world, which was seeded by the collection from The Computer Museum in Boston and has been aggressively expanded since.

More importantly, The Computer Museum History Center has an involved community of people who are passionate about the mission. That includes our hard-working staff as well as volunteers of all kinds: board members, advisors, financial supporters, computer devotees, students, industry professionals, retirees, and others. With the new additions to senior management in place, we are equipped to move to the next level and achieve the goal of a permanent and sustainable institution.

Donna, as an entrepreneur in the world of wireless handheld computing, what appeals to you about the old, and very large computers, and the way in which size and power have changed ratios over the years?

We view handheld computing as the next generation of computing. Just as minis were radically different from mainframes, and PCs were radically different from minis, handhelds will be that much different from PCs. Yet, at the same time, there are certain elements of logical progression regarding systems architecture that are compelling. I love seeing our tiny products in the context of the historical giants.

Donna, when you tell your colleagues about The Computer Museum History Center, you convey an enthusiasm for and excellent understanding of the special niche the Museum holds in the high-tech culture of Silicon Valley and in the world of museums in general. Please expand upon this concept for our readers.

I believe that in order to build the future one needs to understand the past. We each stand on the shoulders of those before us, and there is so much work we do that would not have been possible without those pioneers of prior days, whether they were successful or not. I think the Museum will play an important role in understanding the past and in honoring the people who created it. I also think that it is important that this museum be located in Silicon Valley, which has been such an epicenter for the industry, particularly in the most recent 20 years.

Donna, given your extraordinarily busy life, why did you decide to take on the extra mantle of "Trustee" for The Computer Museum History Center?

I'm very excited about being able to contribute. I just want to see it happen, and I want it to be great, so I'm willing to invest some of my own time and effort to help make that happen. I think it is important to donate to causes that you relate to at a personal level. I'd rather focus on a few things that I care about than give to everything—although I certainly get called by everybody! I don't really expect anything explicit back from people to whom I donate other than living up to whatever commitment they have made in their own projects.

Len, you've often told the story of how The Computer Museum helped you find and marry Donna. Tell our readers, too!

I always enjoy telling this story. In 1997, The Computer Museum in Boston did a special issue of the newsletter highlighting our establishment of the History Center as a west-coast subsidiary, and it included a page-long profile of me. To my surprise, a long-time supporter read it and became interested in me! She mentioned it to a friend who, not seeing any reference to a wife or family, tracked me down, qualified me as available, and set up a blind date. Thence followed Phase One, wherein I was pursued, and Phase Two, wherein I was smitten, and we are now in Phase Three, wherein Donna Dubinsky and I are very happily married. I don't necessarily recommend the Museum network as a dating service for everyone, but it worked for me!

And Donna, what's your perspective on this story?

I think Lenny described it well. I read the article in the Boston Computer Museum newsletter. Since I have always loved history, and I have been involved in the computer business for 20 years, it seemed like a true intersection of my interests. The interview with Lenny intrigued me because of his sense of humor and his passion for the project, so I decided to check him out! My favorite line was that his best advice was to "always initialize your variables."

Donna, what are your dreams and goals for the Museum and how will you work in your role as Trustee to achieve them?

I look forward to helping build a center for excellence in understanding the history of computers. I think there will be many challenges, such as cataloging the history of software, or the web, or understanding and explaining the Silicon Valley ecosystem. It seems to me that the easiest task is to display the hardware. The harder task will be to build a coherent historical record that includes the bigger picture. I am also anxious to see the Museum capture history today, whether using videotape or other media, such that we preserve for future generations the spark and dynamism that is happening here and now.

Len, what do you think are the greatest contributions The Computer Museum History Center can make to the culture of Silicon Valley in the next 10 years?

The Museum is international in scope and not bounded by geography, but we are physically based in Silicon Valley because it is the current center of the world for the computer industry. We intend to become one of the landmark institutions here. We will be one of the "things to see" for the high-school and above crowd. We will be one of the regular tourist attractions to which visitors at Silicon Valley companies and conventions go—they will go to The Tech to learn about the latest in science and technology, and to our Museum to see how computers happened and who did it. Our location is an extraordinary site next to the dirigible hangar at Moffett Field, and our building will be architecturally significant and not just another concrete tilt-up. More than that, our goal is to become the center for activities and events that are infused with computer history, to be the place to take pride in our accomplishments. From live lectures by pioneers to private company events in "The Hall of Supercomputers," from seminars on history to company press parties among the exhibits, the Museum will be a destination.

Eleanor Dickman is Vice President of Development & Public Relations at The Computer Museum History Center

REPORT ON MUSEUM ACTIVITIES

KAREN MATHEWS

Steve Roberts takes a final spin on his computerized and networked recumbent bicycle, the BEHEMOTH (Big Electronic Human-Engineered Machine... Only Too Heavy.) The BEHEMOTH is now on an open-ended loan to the Museum and can be seen in the Visible Storage Exhibit Area.

A guest at the Steve Roberts lecture examines the user interface that connected Steve to his bike. One of Steve's goals was to continue his writing while mobile. This helmet allowed him to do that. It has a heads-up display unit with a 720 x 280 screen, a cursor controlled by ultrasonic sensors activated by head movement, and a keyboard in the handlebars. To combat the problem of overheating in the Styrofoam-lined helmet, Steve recirculated ice water through the helmet liner from a seven liter tank.

Steve Roberts explains his latest project, the Microship. He is building a pair of canoe-based amphibian pedal/solar/sail Linux-powered trimarans. This Fall, Roberts, his partner, Natasha, and their cat, Java, will set sail on a multi-year expedition thoughout the US.

Volunteer docent Ed Thelen conducts a tour of the Visible Storage Exhibit Area for TTI Vanguard conference attendees during a reception hosted by the Museum

Executive Director & CEO John Toole welcomes guests to Professor Richard Grimsdale's lecture on The Manchester University Transistor Computer

September and October were especially busy months here at The Computer Museum History Center with both staff and volunteers participating in a number of events. We presented two lectures that were part of our on-going lecture series, hosted an event for TTI Vanguard, and participated in the Vintage Computer Festival. The Museum's volunteer corps provided a tremendous amount of help and support for all of these events. Very special thanks go out to Dave Babcock, Lee Courtney, Sue Cox, Pat Elson, Jake Feinler, John C. Green, Tracy King, Ron Mak, Eugene Miya, Charlie Pfefferkorn, Bill Scofield, Ed Thelen, and Betsy Toole.

The lecture series plays a special role at the Museum by giving us opportunities to deliver on our commitment to preserve and present the stories of the information age. These are the stories that inspire us and amplify the importance of the human experience that is such a critical part of technological achievement.

On September 6, a diverse audience of more than 100 people from children to old-timers attended a lecture by high-tech nomad, Steve Roberts. A pioneer in integrating mobile computing and communications, Roberts has pedaled over 17,000 miles around the US on a computerized and networked recumbent bicycle that allowed him to remain connected and productive while wandering freely. During his presentation, Roberts demonstrated his bicycle, the BEHEMOTH. Later, during a reception at the Museum's Visible Storage Exhibit Area, attendees were able to examine the bike up close, as well as check out Steve's latest work in progress, a solar/sail-powered satellite-networked computerized folding trimaran called the Microship. Again, the entire staff, and many volunteers assisted with this event.

On September 7, the Museum hosted a reception and tour for 130 people who were attending "The Future of Systems" conference presented by TTI Vanguard. Executive Director & CEO John Toole welcomed the group on behalf of the Museum, and was followed by NASA speakers Bill Berry, Lynn Rothschild, and Peter Norvig, who discussed NASA's latest research projects.

About 75 people attended a lecture on September 28 by Professor Richard Grimsdale of the University of Sussex. A computer pioneer who got hardware working in 1947, Professor Grimsdale talked about his work on industrial applications of process control computers including the Ferranti Mark 1. He designed what is considered one of the earliest transistor computers—the Manchester University Transistor Computer. Professor Grimsdale showed the audience the Williams Tube from the Ferranti Mark 1 and a drum from the Atlas, a computer that had a 100-nanosecond read-only memory.

The Computer Museum History Center was a large presence at this year's Vintage Computer Festival (September 30 and October 1). An estimated 400 people visited our booth where we were showed them the Apollo Guidance Computer, the Apple 1, a working Kenbak-1, a Scelbi, and Ivan Sutherland's VR glasses prototype, among other artifacts. John Toole and Dag Spicer presented a seminar, and Dag was an exhibit judge. Additional Museum staff (Betsy Toole and Chris Garcia) also participated in this event and were supported by volunteers John Francis, Lee Courtney, Alex Bochannek, Ed Thelen, Mike Walton, Mike Albaugh, and Eli Goldberg.

The rest of the year looks as if it is going to continue at a hectic pace with three lectures and the Fellow Awards Banquet already scheduled. Be sure to check the calendar of events on page 17 to see what's ahead. We are also mounting a vigorous year-end fund raising campaign and continuing to develop plans for the construction of our permanent home. Many thanks to the donors, volunteers, and staff who continue to provide the support we need to make The Computer Museum History Center the preeminent resource of its kind in the world. ■

(from left) Eleanor Dickman, VP of Development & PR; Dag Spicer, Curator and Manager of Historical Collections; Professor Richard Grimsdale; Betsy Toole; Executive Director John Toole; and Chris Garcia, Historical Collections Coordinator, enjoying the Grimsdale lecture reception

Chairman of the Board Len Shustek shows lecture attendees how the Cray 2 kept its components cool by immersing its entire CPU in inert fluorocarbon, the substance used for artificial blood

VIDEO COLLECTION EXPANDS WITH NEW RECORDINGS

The Computer Museum History Center preserves the personalities, stories, and visions of the information age through its extensive archive of videotapes—now 2,000 titles and growing. The Museum is proud to offer a wide selection of its video holdings for classroom and personal use. Available soon through our website:

Thomas Sterling on **BEOWULF**

Cliff Stoll, Whit Diffie, Peter Neumann, and John Markoff on **COMPUTER CRIME**

Stuart Feldman on the **OBJECTS OF E-COMMERCE (OOPSLA 1999)**

Several more new titles will be announced soon as the Museum continues to record its lecture series and collect other interesting and important presentations. Our archives include:

MUSEUM "COMPUTER HISTORY" LECTURES by leading computing innovators. Often these videos are the only permanent record of important talks and favorite ideas of people who have influenced the technology revolution.

MUSEUM "HISTORY IN THE MAKING" LECTURES, meant to capture the present vision, technology, and process of people who may one day be important parts of computing history.

RECORDINGS IN THE GRAY-BELL ARCHIVE, including presentations by computing legends and innovators derived from more than a decade of work by University Video Communications (UVC).

WWW.COMPUTERHISTORY.ORG/STORE

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We acknowledge with deep appreciation the individuals and organizations that have given generously to the Annual Fund.

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Is your name on our list of Annual Fund donors? If so, you are one of a select group of people who appreciates the impact of the computing revolution on our lives today. You also take pride in your own role in ensuring that this history of innovation is preserved for posterity. We are grateful for your generosity and support. And if your name is not on this list, we welcome your contribution and will be delighted to add your name to our roster. You may use the form on this page to join our family of donors. Thank you!

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FBO: The Computer Museum History Center; DWR Account # 112-014033-072; DTC #015; and sent to Matthew Ives at Morgan Stanley Dean Witter, 245 Lytton Avenue, Suite 200, Palo Alto, CA 94301-1963.

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TO THE COMPUTER MUSEUM HISTORY CENTER COLLECTION

BEHEMOTH (Big Electronic Human-Engineered Machine... Only Too Heavy) (1983-1991), L2003.2001, Loan from Steven K. Roberts

IBM Type 85 Electrostatic Storage Tube (from IBM 701) (1952), L2062.2001, Loan from Bob Brubaker

Gavilan Mobile Computer (1981), X2001.2001, Gift of David Fylstra

Apple Newton Message Pad (1993), X2002.2001, Gift of David Fylstra

Palm Pilot Prototype (1995), X1980.2001, Gift of Robert Marinetti

TI SR-56 Programmable Calculator (1976), X2013.2001, Gift of James Tomayko

Halicrafters Super Defiant Radio (ca 1940), X2003.2001, Gift of Harvey Ulijohn

Varityper (1980), X2043.2001, Gift of Tom Kleinschmidt

Heathkit H-89 (1980), X2052.2001, Gift of Paul Edwards

Hayes 300 bps MODEM (1978), X2053.2001, Gift of Paul Edwards

Cray Y-M/P 8I (1988), X2044.2001, Gift of NASA Ames Research Center

UPCOMING EVENTS

NOVEMBER 8, 6 PM
THE STRETCH-HARVEST COMPILER
Fran Allen, IBM Fellow
Computer History Lecture
Pake Auditorium, Xerox PARC

NOVEMBER 9, 6 PM
2000 FELLOW AWARDS BANQUET INDUCTEES: FRAN ALLEN, VINTON CERF, AND TOM KILBURN
Hotel Sofitel at San Francisco Bay
Redwood Shores, California

NOVEMBER 18, 9 AM - 5 PM
VOLUNTEER WORK PARTY
Bldg 126, Moffett Field, California

DECEMBER 9, 9 AM - 5 PM
VOLUNTEER WORK PARTY
Bldg 126, Moffett Field, California

FEBRUARY 6, 6 PM
IT'S 2001: WHERE'S HAL?
David G Stork
Ricoh California Research Center & Stanford University
Location TBD

ATTENDING EVENTS AND TOURING THE COLLECTION

The Museum is housed at NASA Ames Research Center, Moffett Field, California. The collection is open to the general public by appointment on Wednesdays at 1:00 pm. To attend an event or to tour the collection, please call Wendy-Ann Francis at least 24 hours in advance. Donors may also request private tours.

VOLUNTEER OPPORTUNITIES

The Museum tries to match its needs with the skills and interests of its volunteers. Monthly volunteer work parties are listed in the calenda. For more information, please visit our volunteer web page at www.computerhistory.org/volunteers.

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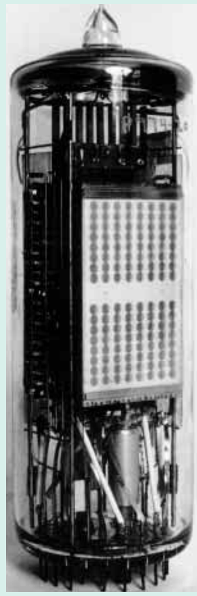
MYSTERY ITEMS

FROM THE COLLECTION OF THE COMPUTER MUSEUM HISTORY CENTER

Explained from CORE 1.3

40 RCA Selectron tubes on Rand Corporation's JOHNNIAC Computer constituted the 256 word 40-bit memory of the machine. A Selectron tube consists of a large cylindrical vacuum tube with a thermionic cathode down the axis and a dielectric forming the curved surface; bits are written and read by a complex series of "holding beams" and a very precise mechanical alignment of internal circuit elements. The Selectron was designed by RCA's Jan Rachman in the early 1950s and saw limited use in the first generation of custom built computing machines such as the RAND JOHNNIAC. JOHNNIAC went operational for the first time in the first half of 1953 with 256 40-bit words of RCA Selectron Tube storage. The plans for the tube itself were scaled down



RCA Selectron Tube from JOHNNIAC, RCA (1953), XD215.80, Gift of John Postley

from providing 4,096 bits per tube to 256, largely due to the device's inherent complexity and poor manufacturability. Nonetheless, Selectron memory was very reliable, once tubes were qualified and "burned-in." Later that year, RAND contracted with Telemeter Magnetics for the first commercially built core storage for the JOHNNIAC. The Selectron tubes were removed in 1954 in anticipation of the coming core storage replacement. In March 1955, the machine was back on-line with 4,096 40-bit words of magnetic core storage. This became the dominant form of computer memory for nearly the next thirty years, and the Selectron's brief lifetime as a memory technology came to an end.

Prior to core storage's availability, however, ENIAC co-designer Presper Eckert commented favorably on the Selectron as a viable memory system, stating: "Except for its complex constructional details and its cost, there is much to recommend the Selectron as a memory system: it does not require regeneration; the access time is reasonable; there is no destruction on readout; the locating system does not drift since it is mechanical in character and fixed in relation to the storage element; and there is no resolution problem since the storage elements are isolated one from another. Somewhat like other electrostatic systems, the Selectron is not subject to loss of memory in the event of a short power failure."

WHAT IS THIS?

THIS ITEM WILL BE EXPLAINED IN THE NEXT ISSUE OF CORE.

Please send your best guess to mystery@computerhistory.org before 12/15/00 along with your name and shipping address. The first three correct entries will each receive a free poster: 25 YEARS OF MICROPROCESSOR EVOLUTION.

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MAY 2001

CORE 2.2

A PUBLICATION OF THE COMPUTER MUSEUM HISTORY CENTER
WWW.COMPUTERHISTORY.ORG

A TRIBUTE TO MUSEUM FELLOW

TOM KILBURN

A FISCAL YEAR OF CHANGE

At the end of June, the Museum will end another fiscal year. Time has flown as we've grown and changed in so many ways. I hope that each of you have already become strong supporters in every aspect of our growth, including our annual campaign–it's so critical to our operation. And there's still time to help us meet the financial demands of this year's programs!

Let's take a short walk together around the Museum, and see what's been happening. With a goal of becoming operational in 2005, getting the programs, organization, and most importantly, the people in place is essential.

The architectural and exhibit design teams have begun the schematic design phase of our new building. This is a particularly exciting time to be engaged as we seriously think through the relationships of architecture, event space, exhibits, storage, and visitor experience. And speaking of related plans, have you seen some of the "facelift" changes in the Visible Storage Exhibit Area, or the plans for the interim office and storage space we'll be using until the new building opens?

People make the Museum succeed—Board, staff, volunteers, and the public. Please welcome to our Board of Trustees Sally Abel (Fenwick and West LLP) and David Emerson (Cooley Godward LLP). The legal expertise of these two new members is truly welcome in our fast-paced organization and is already being put to good use.

At the staff level, Curator Dag Spicer left in March after five years of service with the Museum. He's taking a well deserved rest before deciding what to do next. His dedication, expertise, and smiling face will be sorely missed, although I feel he will be part of our future in some way. We have focused key recruiting efforts on building a new curatorial staff for the years ahead. Charlie Pfefferkorn—a great resource and long-time volunteer—has been contracted to help during this transition.

In other departments, Camilla Neve joined as a development associate to support the growing expectations of our fundraising team. We also have two NASA interns working on staff: Amy Bodine is finishing her internship as a collections and web services intern, and Jessica Huynh is the new web services intern. For current staff openings, see www.computerhistory.org/jobs.

The number of volunteers has been growing, and they participate in every way imaginable. If you've been by recently, you may have noticed that the great docents we have are much more visible. Ed Thelen does many of our regular public tours on Wednesdays and Fridays, and the entire group has won the hearts of groups like the Stanford Alumni that recently visited. This is just a hint of our future docent program that will be evolving over the next several months.

You can probably tell that we're very proud of where we are at the close of this fiscal year. In addition to the above:

Events—Two exciting events, the Xerox Alto retrospective and DECWORLD 2001, cap off our wonderful spring lecture series. Karen Mathews gives an account on page 11 of current Museum operations and events.

Visible Storage Exhibit Area—The staff and volunteers have worked hard to give the middle bay a new "look and feel." For example, if you haven't seen the new exhibit "Innovation 101," you are in for a treat.

Collections—As word spreads, our collection grows, which emphasizes our need for space and staff to take care of the new items.

Interim plans—In order to grow and operate until the opening of our permanent home, we must accommodate increasing warehouse and people space. We are moving forward with a temporary structure that will allow us to build our operation and manage a dynamic collection process.

This is a particularly important time for the Museum. We are growing in programs, people, and facilities, but we are also vulnerable to the economic downturn and changes that result. We could not have achieved what we have already without the generous support of so many Museum friends. But to grow, we've got to expand and mature in so many ways. Fortunately, your support makes all the difference, and I encourage you to contribute to our annual campaign as generously as you can. You'll hear more about our capital campaign in the future.

Finally, I hope you are enjoying the diverse and important programs that are available. We are on the steep slope of growth to build a new cultural institution that celebrates computing history, and many of you have been part of that rise. Help bring others into the circle of Museum friends.

JOHN C TOOLE
EXECUTIVE DIRECTOR & CEO

May 2001
A publication of The Computer Museum History Center

CORE 2.2

MISSION
TO PRESERVE AND PRESENT FOR POSTERITY THE ARTIFACTS AND STORIES OF THE INFORMATION AGE

VISION
TO EXPLORE THE COMPUTING REVOLUTION AND ITS IMPACT ON THE HUMAN EXPERIENCE

The Computer Museum History Center
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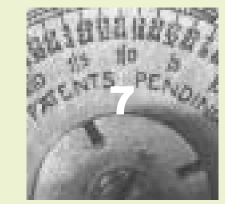
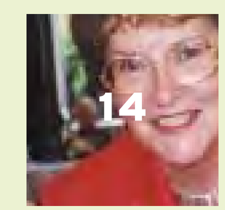
The Museum seeks technical articles from our readers. Article submission guidelines can be located at www.computerhistory.org/core, or contact Editor Karyn Wolfe at core@computerhistory.org.





IN THIS ISSUE

A TRIBUTE TO

TOM KILBURN

1921-2001

BRIAN NAPPER AND HILARY KAHN

Tom Kilburn *TCMHC photo #102621798*

Tom Kilburn, who died on January 17, 2001 at the age of 79, spent his lifetime at the forefront of the computing revolution that he himself helped to start. By co-inventing the first effective electronic storage (memory), and then leading the design and development of five major computer systems, he kept England's University of Manchester at the center of the "second industrial revolution" for a 25-year period.

The UK's University of Manchester, which Tom Kilburn helped keep at the center of the computing revolution for 25 years

Freddie Williams led the effort to use cathode ray tubes (CRTs) in the 40s to solve the need for memory.

Geoff Tootill in front of the rebuilt Baby machine at the Museum of Science and Industry in Manchester

Freddie Williams (right) and Tom Kilburn in front of the Mark 1 console in 1949

While working for Williams, Kilburn and Tootill built the Baby to demonstrate the viability of CRTs for storage (memory). It worked successfully for the first time on June 21, 1948, becoming the world's first functioning stored program electronic computer.

Kilburn was born in 1921 and educated in Dewsbury, Yorkshire, England. In 1940 he went to Cambridge University to read Mathematics. Upon graduating with first-class honors in 1942, he chose to enlist in the military for unspecified key war work. He was sent on a six-week intensive electronics course and then to the Telecommunications Research Establishment (TRE), where he joined a group led by F. C. (Freddie) Williams. This group concentrated on troubleshooting problems in radar and other electronic circuitry for groups both inside and outside TRE.

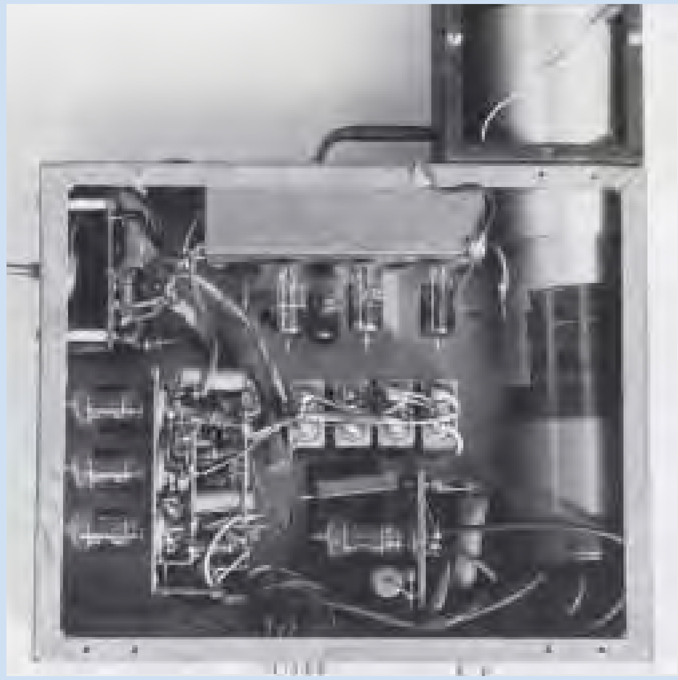
By the end of the war, Williams had an international reputation and Kilburn had become an accomplished electronics engineer. In the summer of 1946, having seen ENIAC, Williams became aware that the lack of a suitable storage mechanism was holding up the development of electronic computers, and decided to investigate the possibility of using cathode ray tubes (CRTs) to solve the problem. Work elsewhere in the world at that time was investigating the use of mercury delay lines to solve the storage problem, and RCA was working on yet another device, the Selectron tube, for the US flagship IAS machine being developed under John von Neumann.

Williams returned to the University of Manchester in December 1946 as Professor of Electro-technics (soon renamed Electrical Engineering). He chose Kilburn to come with him on secondment (loan) from TRE to work full time on the CRT project. Kilburn spent 1947 tackling the problem and building prototypes to prove the viability of CRT storage, ending up with a 2048 bit store on a standard radar CRT. In December 1947, he wrote a definitive report on the mechanism. However, he knew that the most effective proof of the mechanism would be to use CRTs in a computer. So, with the help of G. C. (Geoff) Tootill, he designed and built a small computer incorporating the CRT store. This computer—the Baby—had a store size of 32 words, consisted of some 650 valves (vacuum tubes), was 16 feet long, and weighed half a ton. It worked successfully for the first time on June 21, 1948 and so became the world's first functioning stored program electronic computer.

A program was loaded into the Baby's memory using hand keys and then the stored program was executed. This program, which calculated the highest factor of a number—and which Kilburn admitted was probably the only complete program he ever wrote—was an early example of computer software. The CRT storage system pioneered by Kilburn and Williams was used around the world by computer systems as an alternative to mercury delay line stores until the mid 1950s, when both were supplanted by core memory. The Selectron design of RCA could not be made to work, and the IAS machine and its clones resorted to "Williams Tube" storage, as it became known, until the JOHNNIAC was able to use a much-modified design in 1953.

TCMHC photo #102621797 (P1746)

The Williams Tube cathode ray tube memory system pioneered by Kilburn and Williams was used around the world by computer systems as an alternative to mercury delay line stores until the mid 1950s, when both were supplanted by core memory.



TCMHC photo #102621810

Inside the Williams Tube

At the University of Manchester, Tom Kilburn led further developments based on the Baby. By October 1949, a full-sized machine (the Manchester Mark 1) was operating. This machine was the prototype of the Ferranti Mark 1 that Ferranti Ltd. released in February 1951 as the world's first commercial computer. The machine had a fast random access magnetic drum and instruction modification registers added to it. So by 1949, the Manchester team had effectively added two more "primitives" [basic capabilities] to the five of the classic von Neumann computer model: the two-level store (memory) and the index register. The two-level store used CRTs as the main store (nowadays RAM) and the drum as the secondary store (nowadays the hard disc). In other early machines that did not have index registers, every instruction that referred to an address not known before the program was loaded–for example to access an array element–had to be physically altered in store each time before it was obeyed.

© Computer Science Department, University of Manchester. Used by permission.

Tom Kilburn (right) at the console of the Ferranti Mark 1

In 1951 Kilburn took over the active management of the computer group within Williams' department at the University of Manchester. Work started on two new pioneering computers, the Transistor Computer (that first worked in 1953) to experiment with using transistors instead of vacuum tubes, and MEG (1954), which provided floating-point arithmetic. These were amongst the very earliest, if not the earliest, machines of their class. The more experimental Transistor Computer was manufactured by Metropolitan Vickers as the MV950 (first delivered 1956), and MEG, now with core memory, was manufactured as the Ferranti Mercury (1957). Nineteen Mercurys were sold, providing a major computing resource for the UK scientific community. Meanwhile the software wing of the computer group set up a large computing service on the department's Ferranti Mark 1. This service was used by many other universities, industrial firms, and government organizations. R.A. (Tony) Brooker ably led the software side starting in 1951 and in 1954 produced his first high-level language, the Mark 1 Autocode.

TCMHC photo #102621827

The Ferranti Mercury (MEG)

TONY BROOKER'S MARK 1 AUTOCODE

A suitable instruction sequence for evaluating the sum of squares of v1, v2, . . . v100.

```
      n1 = 1
      v101 = 0
2     v102 = vn1 x vn1
      v101 = v101 + v102
      n1 = n1 + 1
j2,   100 >= n1
```

© Computer Science Department, University of Manchester. Used by permission.

An emotional moment on the day the Manchester Atlas was finally switched off. Tom Kilburn is seated at the machine and (we believe) the people behind him are singing Auld Lang Syne!

In 1956 Tom Kilburn and his team started to look at the design of a machine that would be far larger and, with transistors and core memory now available, much faster. It was called MUSE (for micrOSEcond) and aimed at a speed of 1 million instructions per second. This was 1,000 times faster than the Mark 1 that was still running the computer service. The innovation required to achieve this speed, and then to deal effectively with the implications of it, was massive. This included a long list of new features that made the jump from the basic designs of the early 1950s to the sophisticated mainframes of the middle 1960s, including the key advance of multiprogramming. Although two similar projects in the US with a similar timescale (LARC and the IBM STRETCH) were proceeding, little practical help was to be gained from their progress. And of course the massive improvement in power necessitated an explosion in software requirements as well—a large operating system and (given the number of languages appearing by the early sixties) a large coordinated compiler suite.

Ferranti formally joined the MUSE project in 1959 and the machine was renamed Atlas. The first Atlas started working (at the University) in late 1962. During the 1960s Atlas was the jewel of the UK and European computer industries, and was for a short time arguably the most powerful machine in the world, and (for a longer time) the most sophisticated. Perhaps the most important features of Atlas that were unique to Manchester were virtual memory and Brooker's Compiler Compiler.

Atlas innovations included:

- interrupts, pipelining, interleaved storage, autonomous transfers
- extracodes, read-only memory (for key supervisor routines and extracodes)
- virtual memory (one-level store, paging, associative store)
- virtual computer for user program, (pseudo) parallel processes within a program
- large operating system (distributed over ROM, RAM, drums, tape)
- multiprogramming, spooling, job scheduling, simple file store
- interface between user, computing service and operating system (O/S)
- provision of a homogeneous set of compilers (using the Compiler Compiler), and their integration with the O/S
- new languages Atlas Autocode and the Compiler Compiler

Photo by John Francis 1969, used by permission

This Atlas, "Titan" was situated in the mathematical laboratory and was the main Cambridge University computer during the late 60s.

The final machine built under Kilburn's active leadership was MU5 (1972). The main focus of MU5 was to provide an architecture geared to the efficient coding and running of programs written in high-level languages. Unlike all the previous Manchester machines, MU5 was not turned directly into a manufactured computer, but the architecture of the successful ICL 2900 series incorporated many features developed for MU5.

Obviously Tom Kilburn did not do all this work on his own! In the later years the university-based team that he led with focus and vision contributed greatly. Ferranti personnel also contributed in important ways to the production of the machines. In the early years Kilburn leaned a lot on Williams' experience, enterprise, and leadership, but from the spring of 1947 and on, Kilburn himself provided the main technical and innovative driving force and, together with Tootill, physically built the CRT store and the Baby. He also did the bulk of the design of the Manchester Mark 1. By 1951, Kilburn was actively leading the computer group and continued to maintain a firm grip on the details of central computer design for the next 20 years. He was much less active on the software side, but he still had to manage both the software development and the continuous development of the computer service, which made a significant contribution to the funding of new research, as indeed did the 80 or so patents to which he was party.

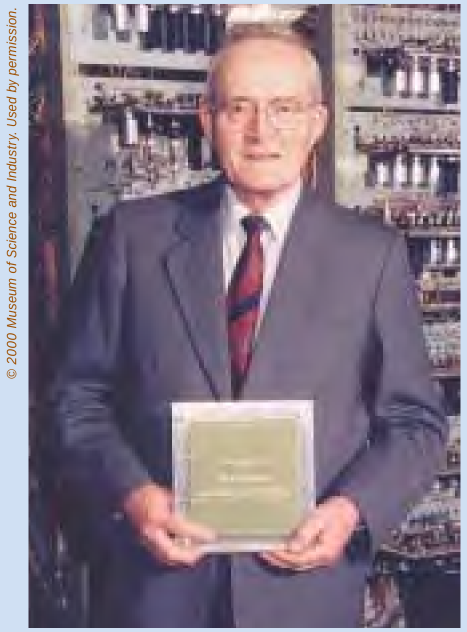
In 1964 Kilburn made a major contribution to the academic life of the UK by founding the first Computer Science department, sizeable from the start, and distinguished from other departments that followed by its high hardware content.

In general, Kilburn's computers were great technical rather than commercial successes. Like STRETCH—of which only a dozen systems were sold—Kilburn's contributions to ideas and techniques advanced the computer industry toward more commercially successful machines. Tom was quite happy about this. He was a modest man and a true gentleman, for whom technical achievement meant far more than financial gain. He was, however, a very firm believer in his own work, and aware of the relevance of money to help fund further research. Importantly, he was also aware of the value of his contributions to the British economy by fending off US dominance in the UK computer industry.

Kilburn was appointed professor of computer engineering in 1960 and in 1964 became professor of computer science. He was elected a Fellow of the Royal Society (FRS) in 1965 and appointed as a Commander of the British Empire (CBE) in 1973. Honors from around the world recognized his pioneering work. These included the first ever John Player Award of the BCS (1973), the Computer Pioneer Award from the IEEE (1982), and the Eckert-Mauchly award from ACM-IEEE (1984).

Tom Kilburn started a quiet retirement in 1981, but in 1998 was persuaded to play a major role in the celebration of the 50th anniversary of the birth of the Baby. This included advising the British Computer Society (BCS) Computer Conservation Society on the building of a working replica of the Baby, now installed in the Museum of Science and Industry in Manchester. His final honor was to be made a Fellow of The Computer Museum History Center and his last professional act, in November 2000, the week before going into hospital, was recording an acceptance speech in front of the working replica.

Tom Kilburn is survived by a son and a daughter. ■



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Tom Kilburn accepting the award designating him a Fellow of The Computer Museum History Center in November 2000

Dr Brian Napper was a lecturer in the Department of Computer Science, University of Manchester for over 30 years. His research interests were in the area of compiler technology, including in particular, the Revised Compiler-Compiler. After retiring in 1997, he took over the development of the web site http://www.computer50.org, devoted to the history of early computer development at Manchester. His e-mail address is brian.napper@cs.man.ac.uk.

Professor Hilary Kahn has also been on the academic staff of the Department of Computer Science, University of Manchester for over 30 years. Her research interests include the application of modeling in engineering and in large system integration, and the use of advanced software engineering techniques to support hardware and system design. She planned the 50th Anniversary celebrations that took place in June 1998 to commemorate the first successful operation of the Baby machine, and acts as curator for the historical collection held in the Department. Her e-mail address is hilary.kahn@cs.man.ac.uk.

FROM THE PHOTO COLLECTION: CAPTURING HISTORY

CHRIS GARCIA

To photograph truthfully and effectively is to see beneath the surfaces and record the qualities of nature and humanity that live or are latent in all things.

-Ansel Adams

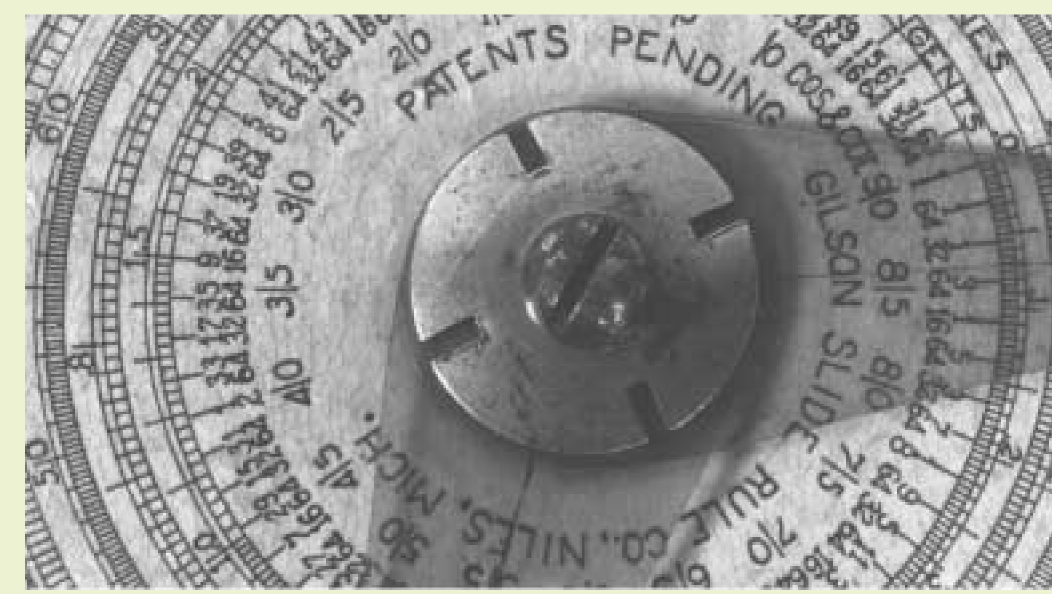
As Ansel Adams suggested, photographs are unique tools. Photos capture moments in time, unusual perspectives, human reactions, as well as facts and details. They not only explore the subject, but also portray context. Because of this, the Museum actively collects and uses photographs in fulfilling its mission of preserving and presenting the artifacts and stories of the information age.

The 10 photos shown here are drawn from the Museum's collection of over 5,000 images. They illustrate the complexity of computing history and show how an object and its context can be appreciated through different lenses. We hope you will find these photos interesting and informative.

Individuals and companies, as well as professional and amateur photographers, have donated much of the material in the archive. This variety of sources and reasons for photographing brings to mind another of Adams' observations that "there are always two people in every picture: the photographer and the viewer." Why a photo was taken can often be as revealing as what the photo shows and how it was taken. Thus, the images in our archive not only document the content of the information age, they also document the cultural assumptions, aspirations, and motives of those who have been watching it and remarking upon it. Even today, our reactions to these photos reveal the assumptions that we make about the past.

If you have photos that document computing history, please contact media@computerhistory.org or call me, Chris Garcia, at +1 650 604 2572. I would be delighted to speak with you about making a donation of your personal photos to our permanent photographic archive.

Exploring the details of artifacts communicates a better understanding of items. This image of a late 19th century circular slide rule gives an excellent view of the merits and failings of contemporary slide rules. The slide shown is designed to be used for geometric calculations, and from this close-up view, we can see the numbers clearly, but users at the time would have had trouble making accurate calculations because the numbers were uncomfortably close and difficult to distinguish.



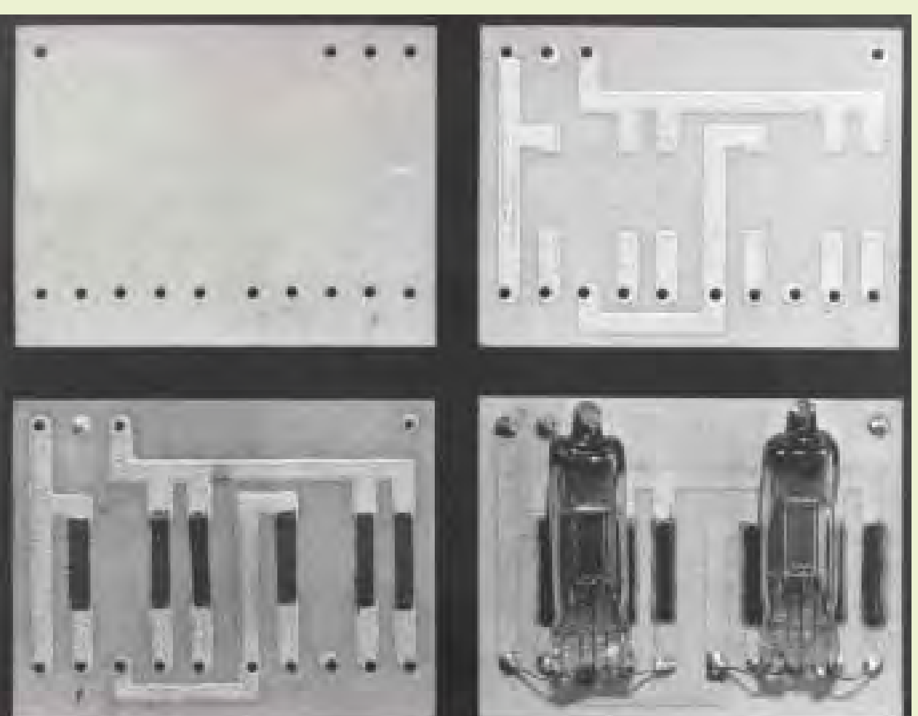
Gilson Circular Slide Rule (c. 1900),
photo by D. Bromfield, TCMHC photo #102624000 (P4455)

Museums often excel at **recreating atmospheres that existed in earlier times** for exhibits. Here, we see an insurance office at the turn of the 20th century. On the right, Walter Wright, the first actuary in New England, uses the Arithmeter, a cylindrical slide rule employed frequently by the insurance industry to compute life expectancy. The second gentleman appears to be working with a book of tables, and we can also see an early typewriter as well as a planimeter, used for measuring distances on maps, on the back wall.

Insurance Office (c. 1890),
TCMHC photo #102621823 (P4445)

Although few people have the privilege of **being present when history is made**, photographers have recorded moments such as the completion of the trans-continental railroad, the Hindenburg explosion, or outstanding portraiture such as produced by master photographer Yousf Karsh. This photo shows the UNIVAC 1 computer predicting that Eisenhower would win the 1952 presidential election, and portrays subtle clues to the atmosphere of the moment. A young Walter Cronkite examines a printout by UNIVAC 1 while J. Presper Eckert interprets the results. This photo captures a major milestone in the shifting public perception of computers. For a few years before IBM became synonymous with computers, UNIVAC was a generic term for a computer, just as Kleenex is for tissue or Band-Aid for a wound dressing.

UNIVAC 1 predicts Eisenhower Election Victory (1952), *TCMHC photo #102621909 (P2000)*

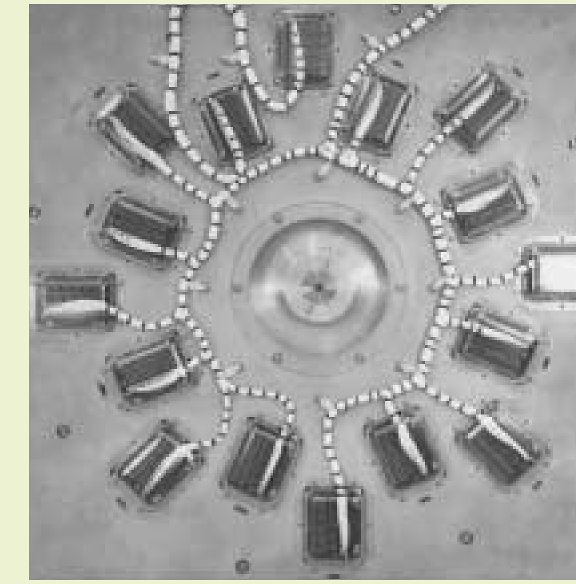


Photos can help to **document manufacturing processes**. This photo demonstrates the four successive steps in making a printed circuit board during the1950s: cutting, firing, and shrinking the boards; applying circuit wiring; adding resistors; and finally, completing the package by applying the miniature tubes. Taken by the National Bureau of Standards, this photo gives us a visual account of the techniques used in this historical process.

Making a printed circuit element (c. 1950s), National Bureau of Standards
TCMHC photo #102622814 (P1893)

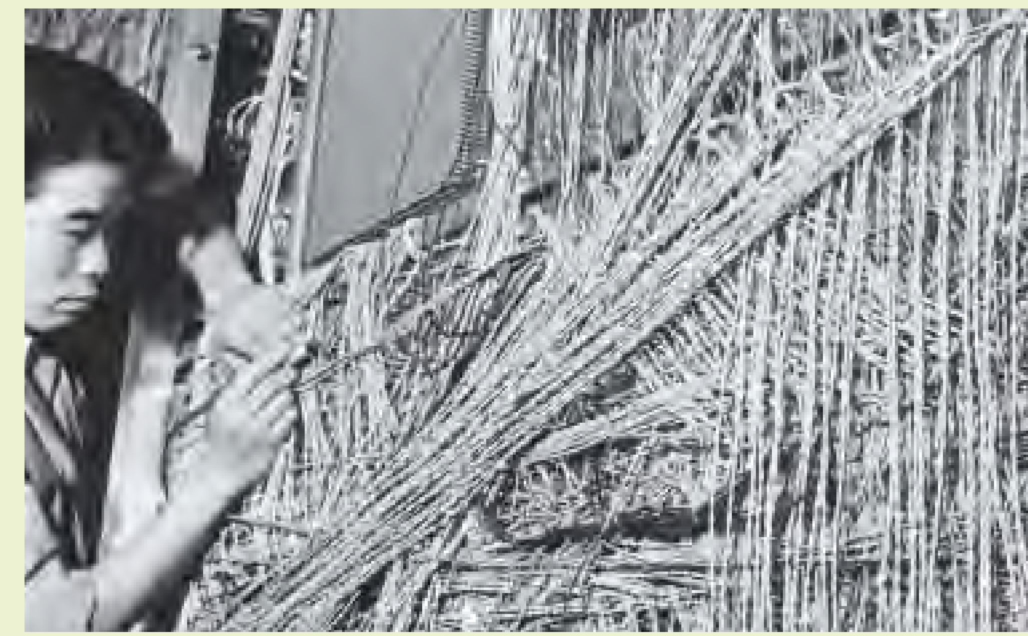
Capturing the beauty of historic artifacts has been a favorite activity of photographers. For instance, renowned New York City fashion photographer Todd Eberle created an XX-page photo art essay for WIRED magazine drawing primarily from items in the Museum collection. In this picture, an unknown photographer chose the arrangement of the wiring connecting to heads on the drum memory unit of the Librascope General Precision Model 30 (LGP-30) as a point of focus because of its aesthetic qualities. The machine, often seen in early years at universities and smaller companies, used a magnetic drum with a capacity of 4096 thirty-two-bit words.

Librascope General Precision Model 30 (LGP-30) Drum Memory Unit (c. 1960)
TCMHC photo #102621820 (P1631)



The people and the tasks they performed are windows to the inside stories of what it meant to live and work in the technological past. The ETL Mark IV-A was Japan's first transistorized computer and here we see a young man wiring the backplane by hand, a laborious task required for most early machines. Note the tunnel diode memory (left) and the plated-wire memory (upper right) as well as the miles of wiring.

Backplane wiring of the ETL Mark IV-A (1959),
TCMHC photo #102623913 (P1195)



Photographs help us to **remember machines that no longer physically exist**. This photo of an artist's rendering of the ERA 1103A, an early commercially successful scientific computer, is a good record of the size and scope of the system. Images of complete systems such as this were used by companies in deciding which systems to purchase and now for exhibit design and by prop makers as a way to produce good replicas for film and television.

Remington Rand Engineering Research Associates 1103A (1954)
© The Charles Babbage Institute, Used by Permission

Recording institutional history is important. Many institutions were critical to the development of computer technology, and the Museum itself is also an institution whose history needs to be recorded. Here is a photo of a Museum anniversary dinner that includes key developers of critical technology who were also contributors to the creation and growth of the Museum. The conversation includes DEC founder and CEO Ken Olsen (center), who, along with Robert Everett, helped ensure the Museum's acquisition of MIT's Whirlwind; Gwen Bell (left), founding president of the Museum; and George Michael (right), a physicist at Lawrence Livermore National Labs dating back to the days of the UNIVAC I. George has helped the Museum collect several supercomputers and also served on the Museum board for several years.

The Computer Museum Anniversary Dinner conversation between Ken Olsen, Gwen Bell, and George Michael (May 11, 1983)
photo by Carolyn Sweeney, © 1983 TCMHC photo #102621821 (P5010)

Depictions of people using computers are less abundant than photos of the machines themselves. The language BASIC (Beginners All-Purpose Symbolic Instruction Code) was developed as a way to allow Dartmouth students to use the GE 235 based time-sharing system. The BASIC language proved to be easy enough to allow elementary school students the opportunity to learn it, like the one shown here struggling with his program. BASIC proved a versatile language, migrating from mainframes to the PDP-11 based time-sharing systems to early personal computers.

Student using Teletype to code in BASIC (c. 1970),
TCMHC photo #102627494 (P1036)

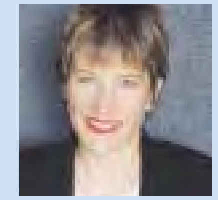
Photos can **demonstrate various technologies that developed concurrently with computing**. For instance, many devices were developed to allow users to communicate with computers. This Computek graphics tablet allowed a user to use a stylus to draw pictures that were presented on a CRT display. The technology allowed for the development of new applications in medicine and the arts. ■

Computek Graphics Tablet (1968),
TCMHC photo #102627488 (P4522)

Chris Garcia is Historical Collections Coordinator at The Computer Museum History Center

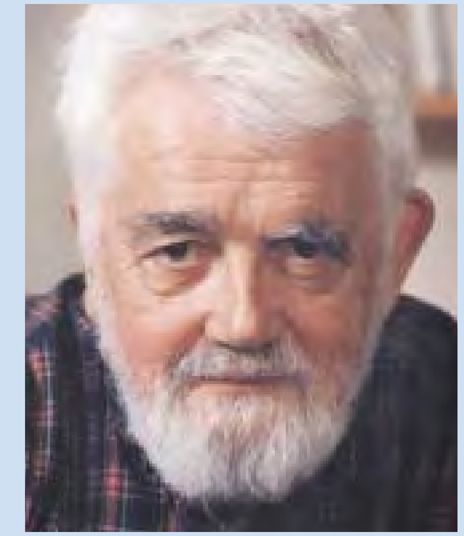
REPORT ON MUSEUM ACTIVITIES

KAREN MATHEWS



Karen Mathews is Executive Vice President at The Computer Museum History Center

The Computer Museum History Center has begun taking dramatic steps forward to ensure the success of our long-range plan to open a landmark museum facility by the year 2005. We are supporting an increased level of outreach and activity with new staff; we are creating more events (lectures and other celebrations); and we are developing informational materials to tell our changing story in an effective and meaningful way–from publications to exhibits and even building design. Here are some specific activities and happenings since the last issue of CORE. I hope you can see how much progress we are making and why we are very excited.



Museum Fellow John McCarthy reminisced about the origins of artificial intelligence in a lecture on March 8.

Museum Fellow Vint Cerf discussed the past and future Internet in a lecture on April 18.

Len Shustek, John Toole, Vint Cerf, Dave House, and Karen Mathews (left to right) after Cerf's lecture at a reception in the Visible Storage Exhibit Area

The Xerox Alto will be the subject of a lecture by Butler Lampson and Chuck Thacker on June 4.

LECTURES PRESENT THE INVENTORS' PERSPECTIVES ON IMPORTANT INNOVATIONS

John McCarthy, Museum Fellow and Professor Emeritus, Stanford University, entertained about 180 people on March 8, 2001 with the "Origins of Artificial Intelligence," a personal retrospective from a founder of the field. McCarthy told the story of how a proposal—by Marvin Minsky, Nathaniel Rochester, Claude Shannon, and John McCarthy—was made for a Dartmouth working group on artificial intelligence to be held in the summer of 1956. It was hoped that the workshop would bring in new ideas and make substantial progress on the AI problem. The proposal to the Rockefeller Foundation, available as http://www.formal.stanford.edu/jmc/history/dartmouth.html, was apparently the first appearance of the phrase "artificial intelligence."

On April 18, Museum Fellow and Internet pioneer Vint Cerf lectured to an audience of over 300 people about "The Internet: 21st Century Tidal Wave." Cerf presented fascinating insights into the Internet's current scale and growth rates, new applications that the Internet is being adapted to support, the appearance of Internet-enabled appliances, and the need for a new version of Internet Protocol to allow the Net to grow well beyond its current size. He also outlined the Interplanetary Internet effort now under way at the Jet Propulsion Laboratory in Pasadena, California.

Our next lecture presentation, "Xerox Alto: A Personal Retrospective," by two of the Alto designers, Butler Lampson and Chuck Thacker, takes place at Moffett Field on June 4 at 6:00 PM. The revolutionary Xerox Alto was an important attempt in the early 1970s to create a "personal-sized" device that was powerful enough to handle serious applications. Further details can be found on our website.

As always, Museum lectures are captured on videotape for the permanent archives, and we are moving to make transcripts and videotape copies of these lectures available to those who can't attend in person. In order to create videos for outside distribution, the Museum seeks a sponsor/partner for the post-production process. If you can help either with services or with sponsorship, please write to me at mathews@computerhistory.org or call +1 650 604 2568.

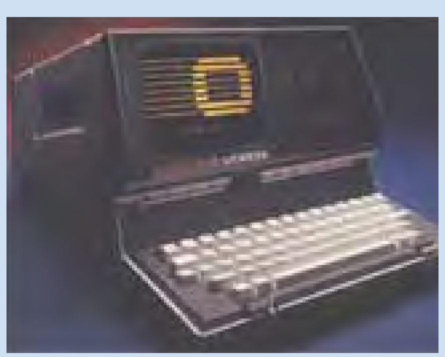
REPORT ON MUSEUM ACTIVITIES

CONTINUED

APPRECIATION FOR OUR SUPPORTERS

Ike Nassi and Ronee Nassi invited Core Supporters (annual supporters at the $1,000 level and higher) into their home for a special party on April 22. Everyone enjoyed hearing inside stories about the Museum's progress, including updates on the selection process for the architect being chosen to design the Museum's new building and preliminary information on plans for the Museum's new identity.

As our fiscal year draws to a close, the Development team is working day and night in an effort to reach our goals for the Annual Fund—the support that makes our innovative programs possible. Although donations to the Annual Fund are higher than last year, we also have a much more challenging goal. A fiscal year-end campaign is now underway to raise the needed funds that are so important to preserve our past, celebrate our present, and plan for the future. Please know that we treasure your participation and support—we are building this Museum together.



Michael Plitkins recently donated the Vixen Osborne and many other items from his personal collection to TCMHC.

COLLECTION CONTINUES TO GROW

Recent donations to the collection include an Encore Multimax and a Cray Y-MP EL (1992) from the Naval Postgraduate school; an 8080-based Homebrew PC (1980), from Robert Belleville; and the personal collection of Michael Plitkins of Tellme, which includes an IBM Tube Logic Trainer, early Apple products (such as a Lisa 1 prototype and the GLM or "Great Little Machine"), a Pixar Image Computer, a Symbolics machine, an Osborne Vixen, various English 8-bit micros, two Mindset computers, a Canon cat and many more items.

When asked how he began collecting, Michael replied, "I started collecting when I was a kid and didn't know it. I was using Apple and Commodore machines, and pretty much anything else I could get my hands on, and decided that there was a lot of really neat equipment out there with some very unique designs. Many years later I discovered that people were just relegating much of this old technology to trash heaps and that seemed wrong. So I started buying equipment when interesting things became available." Michael got most things working whenever he could, but eventually ran out of space and time. "It all comes down to preservation and passing along old knowledge," he said. "Acorn machines, Transputers... many people have never even heard of these wonderful things, and they deserve to be preserved so people can see how they worked."

Visit the Visible Storage Exhibit Area soon to see some of these new acquisitions on display!

VOLUNTEERS AND STAFF TRANSFORM MUSEUM EXHIBIT SPACE

It took an amazing amount of focus and energy over the course of five Saturday work parties, but volunteers and staff have succeeded in replacing the ceiling tile throughout the entire Visible Storage Exhibit Area—no small feat.

In addition, a large portion of the PC collection on display has now been placed on shelves, and plans are underway to significantly upgrade the exhibits in the rest of the "middle bay."

These projects are just some of several site improvements planned to enhance the Museum's main exhibit space.

Progress is visible in the Museum's second warehouse building also, with major consolidation, racking and document processing improvements in recent weeks.

Everyone here is excited to see these changes in the main buildings housing our collections especially in the areas where tours and most Museum receptions take place. It's thrilling to work together with you, our volunteers, to accomplish so much together.

NEW EXHIBITS MAKING GREAT STRIDES

One of the behind-the-scenes committees working toward the Museum's future world-class building and exhibit space is the Exhibit Committee, headed by Trustee Gardner Hendrie. Calling upon the talents of volunteers, trustees and staff, this committee has researched, debated, and explored many ideas on how best to portray aspects of computing history. Discussions have centered around the inventors' stories, personal computers, networking, software, processing technology, storage and super-computing, as well as analyses of the effects of computers on society, the industry's grand failures, and more. The work of this committee is essential to the Museum's architecture and exhibit design firms as we go through the new building design process.

MUSEUM COLLABORATES WITH INTEL'S SCIENCE & ENGINEERING FAIR

Each year, Intel Corporation sponsors a science fair to honor the achievements of secondary students from around the world. More than 1,200 students from over 40 countries participate in the International Science and Engineering Fair (ISEF). This year, Intel ISEF took place at San Jose's Convention Center from May 6-11, and featured a special lobby exhibit entitled "Innovation 101," developed in collaboration with The Computer Museum History Center. The exhibit highlighted Silicon Valley computing industry pioneers, and the Museum provided photographs of the innovators and artifacts that demonstrate their accomplishments. Staff members Kirsten Tashev, Dag Spicer, Chris Garcia, and Eleanor Dickman coordinated the content research, acquisition of display items, and text development for the multi-dimensional exhibit panels. After ISEF, "Innovation 101" will be relocated to Museum's Visible Storage Exhibit Area. In addition to the pleasure of productive collaboration, the experience was a good exercise for Museum staff as the process of exhibit development is explored and prototyped.

COME TO DECWORLD 2001!

WHAT MADE DIGITAL GREAT

Saturday, June 16, 2001

9:30am - 10:00pm

DAY
The Computer Museum History Center
Mountain View, California, USA

EVENING
Santa Clara Marriott
Santa Clara, California, USA

$125 per person
(to cover lunch, dinner, and snacks)

Space is limited and reservations are required.

For conference information and to register, contact:

DECWORLD 2001
The Computer Museum History Center
Building T12-A
Moffett Field, CA 94035, USA
+1 650 604 2579
decworld@computerhistory.org
www.computerhistory.org/decworld

The purposes of this special one-day conference are:

1) to have fun

2) to bring together people who took part in the rise of Digital Equipment Corporation in order to hear and contribute stories that will become part of the Museum's permanent archive of the history of computing, and

3) to share Digital's greatness with non-Digital people who would like to understand the unique social phenomenon that was Digital Equipment Corporation.

90-minute audience-interactive panels will cover three "eras:" from start-up, to product lines, to Fortune 1000 presence and taking on IBM. Leading the panel sessions will be Digital alumni with Gordon Bell, Len Bosack, Ed Kramer, Jack Smith, Richie Lary, Grant Saviers, Julius Marcus, Bob Supnik, and YOU (see the website for an updated list of panelists).

Memorabilia contributed by attendees will be on display, and roving recorders will document stories for Museum archives. A reception will be held in the Museum's exhibit area where many DEC artifacts will be on display among hundreds of other computing artifacts. An evening banquet and keynote with Ed Schein and Win Hindle will wrap up the event.

INTERNET HISTORY BUFF: JAKE FEINLER

ELEANOR DICKMAN

Jake was convinced of the importance of preserving the history of the Internet and salvaged anything that could describe how the Internet had evolved. In one case, she remembers literally scooping a huge pile of "trash" off the floor at midnight to keep the janitors from hauling it away.

An avowed Internet enthusiast and early participant, Elizabeth "Jake" Feinler came to The Computer Museum History Center (TCMHC) with two garages full of Internet documents collected over the years and encouraged Founding President Gwen Bell and Curator Dag Spicer to expand the Museum's horizons to include Internet history. Then she volunteered to help develop a system for organizing the Museum's document collection and has been donating her time ever since!

Jake tells her story with a wicked sense of humor. Take, for example, how she got her nickname: "When I was born, double names were popular. My real name is Elizabeth Jocelyn Feinler, and my family was going to call me Betty Jo to match my sister's name, Mary Lou. Only two at the time, my sister's version of Betty Jo sounded like *Baby Jake*. I always say, *Thank goodness they dropped the 'Baby.'*"

A West Virginia native with an academic background in biochemistry (an undergraduate degree from West Liberty State College, and graduate study at Purdue University), Jake has honed her skills as an information scientist on a variety of projects over the years. Early on at Chemical Abstracts Service in Columbus, Ohio, she served as assistant editor on one of the biggest information projects in the world at the time: indexing the world's chemical compounds back almost 100 years. Then she came to California where she headed up the Information Research Department at SRI International. "There were no big computerized search services at that time, so one had to search the big abstract services for information, and run down the articles the hard way." She assisted with such projects as the Handbook of Psychopharmacology and the Chemical Process Economics Handbook. Once, she even "helped save some baby walruses by finding the composition of walrus milk!"

Jake was working on a large handbook project for the NASA Skylabs program when she decided she needed computer power to do the job. "It was then," she recalls, "that I discovered a group of people (mostly with beards and wild hair, wearing Birkenstocks, and looking like unmade beds) up on the second floor of SRI, totally engrossed in staring at television sets and rolling little devices around on a table." This was Douglas Engelbart's Augmentation Research Center (ARC) group, and the "little device" was his invention, the mouse.

Jake joined ARC in 1972, and in 1973 became principal investigator for the Network Information Center under contract to the Defense Advanced Research Projects Agency (DARPA), and the Defense Communications Agency (DCA). Her group managed the Internet Naming Registry, and was responsible for coming up with the current Internet host-naming scheme of dot com, dot org, dot edu, and dot gov. Jake then went on to become center director for the Network Information Systems Center at SRI. After she left SRI, in 1989, she worked as a network requirements manager and helped develop guidelines for managing the NASA web for NASA Ames Research Center.

Over the years, Jake was convinced of the importance of preserving the history of the Internet and salvaged anything that could describe how the Internet had evolved. In one case, she remembers literally scooping a huge pile of "trash" off the floor at midnight to keep the janitors from hauling it away. To Jake, "the evolution of the Internet and of computers are intertwined and cannot be separated, and the story of how they both evolved is one well worth preserving." While at NASA, she learned that a computer history museum was being established, and was delighted to find in TCMHC a "match" for all the material she had collected.

Now a volunteer and a member of the TCMHC Volunteer Steering Committee, Jake considers the Museum to be similar to a Silicon Valley start-up. She likes being involved with the "exciting challenges of any start-up, and it is fun to be included in the excitement and enthusiasm of the staff, board, and donors as they try to pull off this gigantic undertaking." She also "enjoys the social aspects of helping to host events, meeting old friends, and hearing computer giants tell tales of how it was. And, of course, the camaraderie with the other volunteers and staff."

Jake feels that The Computer Museum History Center has an important educational and cultural contribution to make. She remembers reading many years ago the book, The Soul of a New Machine, and being thrilled by the Who, What, Where, When, and Why of it. She says, "The Computer Museum History Center will preserve the core of Silicon Valley history and will thrill countless 'newbies' with the story of computers and the Internet and their impact on society."

Even though she insists she is "a perennial beginner at most hobbies," Jake pursues a variety of interests in addition to volunteering at the Museum. She says, "I dabble at watercolors (badly), help a friend write books on Celtic quilting (I've never made a quilt), and collect pincushions" (a collection her friends started for her when she said she was tired of sticking pins into a tomato.) She recently adopted a Siberian Husky who likes to retreat with her to her cabin in the woods. She's an opera "ring head" about to experience her fourth full production of Wagner's Der Ring des Nibelungen when the new production opens in Seattle. She likes nature travel to places like Australia and Antarctica, and her ultimate goal is to "free my right brain before it atrophies." Meanwhile, The Computer Museum History Center is delighted to be the beneficiary of Jake's love of information about the Internet and the creativity she brings to her work at the Museum!

Eleanor Dickman is Vice President of Development & Public Relations at The Computer Museum History Center

CURRENT STAFF AND VOLUNTEER OPENINGS

The Computer Museum History Center offers a unique chance to help build a world-class Museum that will preserve and present information age artifacts and stories for generations to come.

We are actively seeking qualified, motivated, and talented people for the following positions:

STAFF

- Curator of Exhibits
- Curator of Collections
- Director of Development
- Administrative Assistant
- Vice President of Facilities & Logistics
- Director of Cyber museum Exhibits

For detailed information about these job opportunities and how to apply, please visit our website at www.computerhistory.org/jobs

VOLUNTEER

- Research & Reference team member
- Office organization & systems support
- Visible Storage Exhibit Area renovation team member
- Website projects including CGI scripting
- DECWORLD 2001 event team
- Fellow Awards 2001 event team

For detailed information about these and other volunteer opportunities, please visit our website at www.computerhistory.org/volunteers or call Karyn Wolfe.

THANKS TO OUR ANNUAL DONORS

We acknowledge with deep appreciation the individuals and organizations that have given generously to the Annual Fund.

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___ 1K ($1,024)

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___ $500

___ $250

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Please return this form (or facsimile) with your remittance to:

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Is your name on our list of Annual donors? If so, you are one of a select group of people who appreciates the impact of the computing revolution on our lives today. You also take pride in your own role in ensuring that this history of innovation is preserved for posterity. We are grateful for your generosity and support. And if your name is not on this list, we welcome your contribution and will be delighted to add your name to our roster. You may use the form on this page to join our family of donors. Thank you!

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We gratefully accept direct transfers of securities to our account. Appreciated securities forwarded to our broker should be designated as follows:

FBO: The Computer Museum History Center; DWR Account # 112-014033-072; DTC #015; and sent to Matthew Ives at Morgan Stanley Dean Witter, 245 Lytton Avenue, Suite 200, Palo Alto, CA 94301-1963.

In order to be properly credited for your gift, you must notify us directly when you make the transfer. If you have any questions regarding a transfer of securities, please contact Eleanor Dickman at +1 650 604 2575.

UPCOMING EVENTS

PLEASE RSVP FOR ALL EVENTS AND ACTIVITIES

MON, JUNE 4, 6 PM
XEROX ALTO: A PERSONAL RETROSPECTIVE
Chuck Thacker & Butler Lampson, Microsoft
LOCATION: *NASA Ames Main Auditorium Moffett Field, CA*

SAT, JUNE 16, 9:30 AM – 10:00 PM
DECWORLD 2001
WHAT MADE DIGITAL GREAT
See page 13 for more information.
LOCATION: *Moffett Field & Santa Clara, CA*

MON, SEPTEMBER 17, 6 PM
ORIGINS OF LINUX
Linus Torvalds, Transmeta Corporation
LOCATION AND DATE TO BE CONFIRMED

TUES, OCTOBER 23
FELLOW AWARDS BANQUET
LOCATION: *Fairmont Hotel, San Jose, CA*

THURS, NOVEMBER 8, 6 PM
QUESTIONS ANSWERED
Donald Knuth, Stanford University
LOCATION: *NASA Ames Main Auditorium Moffett Field, CA*

VOLUNTEER OPPORTUNITIES
The Museum tries to match its needs with the skills and interests of its volunteers. See page 15 for current special project openings. Monthly work parties generally occur on the 2nd Saturday of each month (below). For more information, please visit our volunteer web page at www.computerhistory.org/volunteers.

WORK PARTIES
Please RSVP at least 48 hours in advance to Betsy Toole.

Sat, June 9, 9am
Sat, July 14, 9am
Sat, Aug 11, 9am
Sat, Sept 8, 9am

EVENT SUPPORT
The Museum relies on regular volunteer support for events (listed at left). Contact us if you are interested in lending a hand!

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Current staff openings are listed on page 15.

MYSTERY ITEMS

FROM THE COLLECTION OF THE COMPUTER MUSEUM HISTORY CENTER

Telefunken Diode Matrix (1965)

Explained from CORE 2.1

TELEFUNKEN DIODE MATRIX (1965)

This is a Telefunken microcode diode matrix board. Telefunken was a German firm that began as "Gesellschaft fur drahtlose Telegraphie m.b.h." (Usually known as "System Telephunken") in 1903 as a subsidiary of Allgemeine Elektricitats-Gesellschaft (AEG) and Siemens and Halske AG to do work in radio. Among other companies in West Germany (Siemens, Zuse, SEL), Telefunken entered the computer business in the 1950s.

The use of diode matrices for decoding instructions and generating microcode was very common in the pre-IC era and was relatively flexible in that microcode could even be modified in the field by simply adding or subtracting diodes from the matrix.

The use of diode matrices for decoding instruction sets was used as early as 1950 in the MIT Whirlwind computer. Also, the 1956 Royal McBee LGP-30 (Librascope General Precision) computer used 1450 diodes to decode its full instruction set (16). Both the diode matrix and the independent concept of using microcode (Maurice Wilkes) were later used together to produce diode microcode boards like this Telefunken board in 1965.

The use of a diode array to generate microcode would have been very efficient in terms of cost, power, and space. The diodes could perform both AND functions to decode the instruction and OR functions to combine all instructions that gated particular data paths at particular times. The same technique, but using transistors instead of diodes, was used later in microprocessors, including the Data General MicroNova.

Prior to using diode matrixes, instructions were usually implemented in separate sets of electronic circuits.

WHAT IS THIS?

THIS ITEM WILL BE EXPLAINED IN THE NEXT ISSUE OF CORE.

Please send your best guess to mystery@computerhistory.org before 07/15/01 along with your name and shipping address. The first three correct entries will each receive a free poster: **COMPUTER CHRONOLOGY - THE EMERGENCE OF THE INFORMATION AGE**

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CORE 2.3

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SHAPING UP FOR SUCCESS

Our vision of a computer history museum is taking shape. It includes 1) a permanent home with unique artifacts and exhibits, 2) a Cyber-Museum of virtual displays and digital information, and 3) communities of people across the world linked by a variety of Museum programs. Our goal is to build a single organization that combines these three vital resources into a lasting institution.

I am happy to report that we ended the last fiscal year in the black–a critically important accomplishment in a down economy–and our growth is almost doubling every year! Congratulations to all involved for helping to create tangible progress out of great ideas. As you can guess, we are vigilant about the economy and its financial impact on us this year, but are doing everything we can to minimize our risks.

I'd like to welcome Lori Crawford as the most recent addition to our Board of Trustees. Lori comes to us from Infinity Capital with a wealth (!) of non-profit experience and will be chairing the Finance Committee.

We have also made some significant staff changes in the last several months that are very important to our future. Mike Williams, Professor Emeritus of Computer Science at the University of Calgary, has joined us as head curator. Known worldwide as a computer historian, Mike has published extensively, served as editor of the IEEE *Annals of the History of Computing*, curated exhibits for other museums, and fallen in love with our collection and plans. I hope you have already met him and share our excitement about welcoming him to the Museum. In addition, Dag Spicer, after a leave of absence, has rejoined us for several months as exhibit curator to formulate plans for the permanent building.

David Miller came on board with great energy and experience as the vice president of development. He has taken the reigns from Eleanor Dickman, who had a wonderful year with us. Both Board and staff are working to strengthen and expand our already successful development organization to insure future growth.

Mike Walton joined us in June as the director of cyber exhibits. Some of you may know Mike from his work at ConXion, which hosts our web site, or his previous volunteer work at the Museum. The CyberMuseum team has already begun a series of experiments and explorations to help formulate our long-term technical strategies and to add real value to the current organization. This includes, among other things, experimenting with video from DECWORLD 2001 and looking at long-term "cyber exhibits."

Pam Cleveland has joined us as events manager and her expertise has been so important with the frequent, spectacular, and unique events the Museum is hosting.

Finally, we welcomed the arrival of three new NASA interns in June: Jennifer Cheng brings experience and energy to our event planning and development teams, Kathy Vo Jozefowicz is defining and implementing our e-store, and Robert Yeh provides financial and administrative support. We are very happy to have such professional and dedicated people working with us and have wondered how we would have survived our summer of growth without their help.

Our interim building is well under way. At press time, we are moving forward with a temporary steel structure–including 22.5K square feet for the warehouse, 9K square feet for exhibits/meetings, and 9.5K square feet of office space–that we expect to complete by April 2002. It will allow us to build our operation and manage a dynamic collection process for several years. In addition, we intend to keep buildings 126 and 45 until they are demolished for the proposed NASA Research Park. I think we will all see an exciting physical presence very soon.

Meanwhile, the architecture and exhibit design teams for our permanent home are moving rapidly ahead. As of August/September we are finishing the "programming" phase and will be moving into the "schematic design" phase of the project. Please review the materials on our website–we want your feedback and ideas.

Inside this issue, you'll see more about our volunteers and the great role they play in so many ways. Our Volunteer Appreciation Day in August was only a very small token of our appreciation for each and every one of them.

I can't close without acknowledging the great programs we've recently had and reminding you that the 2001 Fellow Awards Banquet is coming up on October 23rd. This year, we have put together an incredible program to honor Fred Brooks, Jean Sammet, and Maurice Wilkes. In addition to the Fellow Awards, we will update you on our exciting progress and celebrate our international outreach with a unique series of events in cooperation with the offices of the Consulate General of Switzerland. Artifact donations, a distinguished lecture panel, and a special reception will make that week very wonderful indeed.

Finally, we continue to need your support in so many ways, but hope you are also enjoying the multitude of experiences through which computing history can be preserved. The next six months are shaping up to be very important, and opportunities abound to engage in the organization–just ask! It is exciting to turn dreams into reality and to have so many people everywhere be part of it.

JOHN C TOOLE
EXECUTIVE DIRECTOR & CEO

October 2001
A publication of The Computer Museum Histor y Center

CORE 2.3

MISSION
TO PRESER VE AND PRESENT FOR POSTERITY THE ARTIFACTS AND STORIES OF THE INFORMA TION AGE

VISION
TO EXPLORE THE COMPUTING REVOLUTION AND ITS IMPACT ON THE HUMAN EXPERIENCE

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The Museum seeks technical ar ticles fr om our r eaders. Article submission guidelines can be located at www.computer histor y.org/cor e, or contact Editor Kar yn Wolfe at cor e@computer histor y.org.

IN THIS ISSUE

NEW WAYS TO EXPLORE COMPUTING HISTORY:
PROTOTYPING THE PROCESS AT DECWORLD 2001

BY KARYN WOLFE

None of these stories are the truth; these are all of our recollections after the fact. *–Gordon Bell*

All the stories I'm going to tell you are true; some of the details have been revised to enhance the audience experience. *–Joe DiNucci*

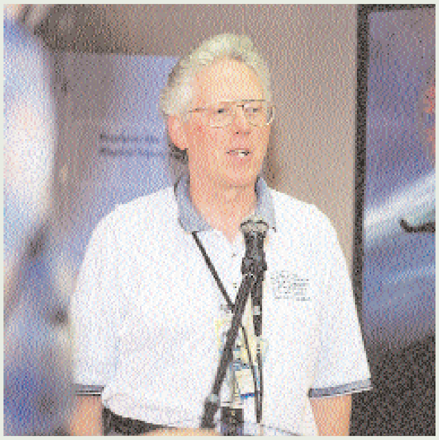
The DECWORLD 2001 experiment included videotaped interviews with many ex-DEC employees.

In June 2001, The Computer Museum History Center sponsored an unusual event: DECWORLD 2001, a retro-spective conference focused on the stories and recollections of the people who helped create and develop the now-defunct Digital Equipment Corporation (DEC). Approximately 200 people attended the weekend, which included informal get-togethers, a DEC artifact exhibit, show-and-tell, panel and open mike sessions, video presentations, a speaker banquet, video interviews, and lots of time to talk and get reacquainted.

The Museum created DECWORLD 2001 in order to gather stories and information that might otherwise be widely dispersed or even lost. The event was very successful in helping the Museum to fulfill its mission "to preserve and present for posterity the artifacts and stories of the information age." We collected hundreds of quotes and comments, received donations of new DEC hardware, and captured hours of presentations, stories, and interviews. As we synthesize these new materials into our archives, we are learning how to best make them usable and available for research and display both in our physical Museum and in our CyberMuseum that is under development. Our experiences with video, digital formatting, transcribing, web posting, interviewing, etc., are an experiment that will inform upcoming collection efforts.

We thought that the best way to convey the results of our efforts was to show you just a portion of the material that we collected while documenting the unique culture and technical contributions of Digital Equipment Corporation. For a longer version of this article, for more information about the program and attendees, and for pictures and detailed reports about the event, please visit our website at www.computerhistory.org/decworld.

Gordon Bell examines an artifact at the "show and tell."



Grant Saviers sported multiple badges from his years at DEC.

DIGITAL "RULES" AND CULTURE

Attendees described the unique culture and "rules of the game" found at DEC, particularly in the early days when the company was small and literally defining much of the market. Here are some of their thoughts.

***I never, in my life, spent a period of time with so many truly brilliant people as I did at DEC.* –Jeff Kalb**

"He Who Proposes, Does"

Everyone was encouraged to accept responsibility for programs. The expression 'He who proposes, does' was very common and the idea that someone like myself, for instance, in 1981, having been with the company only six to eight months, could take a proposal all the way to the Board of Directors was something very foreign to me. –Jeff Kalb

"Do The Right Thing" Drove the Organization

It seems that the most empowering value of the company was to 'Do the Right Thing.' That gave people a tremendous sense of personal responsibility and support for the things that they did. So many were able to get positions of responsibility much greater than they ever would have expected to. –Ted Johnson

DEC was Training Ground for Many Entrepreneurs

Probably the huge legacy of Digital was the incredible training ground that we provided. A vast number of people went on to become CEOs, to found new companies, to do things as entrepreneurs. I'm really proud to be associated with those that have gone on to do great things. Periodically somebody will say, 'Yeah, I was at DEC and started this company...' and they transported the DEC environment to create good cultures and essentially great designs. –Gordon Bell

A Company of Techies

Field sales had a test for who the customers were. If the customer couldn't program the machine and fix it from one of the handbooks, they didn't pass the test as a customer and we bypassed them. That's the kind of company it was. –Julius Marcus

Group Process Really Works

As a young consultant, one of the most unusual things about Ken Olsen's approach was that he did not set me up to make presentations or to give lectures. He said: 'Come to the meetings and see what you can do.' What I saw was people interrupting, people shouting at each other. 'What's this all about?' I thought, and began to realize it was about finding truth. No one person was smart enough. But, when we got into a group and debated the issue, we would get smart very fast. That was a very important philosophical principle for how DEC worked. The reason you don't make arbitrary decisions from a position of authority is because you're probably not that smart. –Ed Schein

A Boundary-less Organization

Digital was a place without laws. I read General Electric's annual reports and Jack Welch talks about trying to be a 'boundary-less' organization. Well, in a very natural way, that was Digital during the early days and quite far into the company's history. We were boundary-less because people were empowered to get the job done by using the resources of the company in whatever way was possible. And that meant going directly—not up through the hierarchy and down again—to the place from where you needed the help. And, by and large, that help was always given in the spirit in which it was requested. –Win Hindle

Evening speaker Win Hindle described DEC's internal culture as "merit-based, yet competitive; contentious, but fair; critical and open-minded."

Evening speaker Ed Schein asserted that DEC was "based on very strong individuals, which is the quintessential American, individualistic, competitive company."

TECHNICAL CONTRIBUTIONS

In addition to the atmosphere of working at DEC, attendees expressed admiration for the contributions they saw the company had made to the development of the computing industry... from the idea of interactive computing, to the concept of OEMs and VARs as channels of distribution for complete products, to the precocity and longevity of concepts such as VMS.

Panel Two included Grant Saviers, Dick Clayton, Julius "Mark" Marcus, Len Bosack, and Rich Lary presenting thoughts about 1970-1980, when "product lines were in full force."

Digital's Role in Interactive Computing
Digital had a unique role in computer history. The industry was comprised of companies that took punched cards, sorted them, and did a little bit of arithmetic with them. From the very beginning we started with computers controlling things. So we built interactive computers, which was almost beyond the understanding of most people. We had this new concept—like with the SAGE system—that computers had the ability to do something, to interact with something. It was a paradigm shift.
–Stan Olsen

The Invention of the OEM and VAR Approaches
In my role in commercial OEM at DEC, we revolutionized the sale of commercial computers into the industry. We invented the VAR [Value Added Reseller] program and we really got minicomputers established in the commercial marketplace in a wide variety of applications, spurring a huge growth within the industry. Almost all the computer companies now use the VAR approach to selling those kind of systems. –Jim Willis

VMS Safe and Secure
I want to draw your attention to just how good VMS is. It's actually the 25th anniversary of the first boot up of VMS Starlet on June 14, 1976. So VMS is 25 years old, and it's still 25 years ahead of the SQLs and the NTs. And to this day, if you want to make a safe web site, you put it up on VMS with freeware, and it's so secure that no one can hack it, and the only VMS people that could hack it are too ethical to do so, thank you very much! –Max Burnet

Timesharing
Digital anticipated personal computing. Even in the early days with PDP-6 and DEC-10, timesharing made it possible for people to do computations individually, in real time, and let the pace of thought control what happened as opposed to the pace of the computer and the operations. So I think Digital's contribution, in the large, was to enable individual use of computing and then the company embodied that by allowing individuals to do their very best.
–David Rodgers

By 1980, finally people knew that "Digital" didn't mean watches.
–Grant Saviers

CONCLUSION

As you can hopefully see, the day resulted in wonderful reminiscences and rich contributions to the Museum's archival coffers. Thanks to all who participated. Attendee and Museum volunteer Mike Baxter made the following comments a few days after the event:

I'm still in awe at what I experienced at DECWORLD 2001. It was mind-bogglingly important, a successful experiment, and a most mature retrospective...I was very impressed to see mistakes discussed openly and without recrimination. This is really important learning, know-how that can be reused. "Museum" does not adequately describe what The Computer Museum History Center has done: The artifacts are by no means idle museum pieces, there are layers of stories hidden within them waiting to get out. ■

We hope you visit **www.computerhistory.org/decworld** for a more complete picture and to discover more anecdotes and quotes, including:

Cats in the Cabinet by Marcia Russell

How VAX Got Started by Rich Lary

The Loading Dock Problem by Len Bosack

The Story of Mullen Blue by Pat Mullen

700 Pounds of Lead by Pat Mullen

UNIX for Sale – ouch! By Bob Glorioso

The Origin of "PDP" by Stan Olsen

Problem Solving for the Imp-11 by Jim Leve

The Story of the Digital Handbook Concept by Stan Olsen

Marketing Starts Writing Code by Bud Hyler

Giving Up "Frenchness" by Ed Schein

DEC Takes over Rhode Island by Marcia Russell

My Job Description (memo) by Ken Olsen

A WALK THROUGH "VISIBLE STORAGE"

BY LEN SHUSTEK

Like all serious collecting museums, The Computer Museum History Center can only display a small part of the collected artifacts at any one time. In our current temporary facilities at the NASA Ames Research Center at Moffett Field in Mountain View, California, we have configured one of the warehouses into a "Visible Storage Exhibit Area" where you can see, smell, and even (curators should stop reading here!) touch about two hundred of the thousands of items in our collection. And this is only the "iron;" we also have software, documents, photos, posters, audiotapes, videos, films, t-shirts, and coffee cups—everything you need to document the history of a revolution, which this is.

Every Museum docent gives a different tour, stopping at certain items, telling unique stories—each weaving different threads of computing history's story. Here is one virtual and very personal tour, and I ask forgiveness if I've omitted any of your favorites. Every item shown here—with the exception of the people pictured!—is currently on display at The Computer Museum History Center.

EARLY COMPUTING

Once upon a time, "computers" were people that computed, not computing machines. Mechanical devices helped make the people more reliable and faster than a reckoner who had only pencil and paper. For instance, the 1895 Swiss **"Millionaire"** was one of

Photo by Jessica Huynh

the first affordable mass-produced machines that could multiply and divide as well as add and subtract. About 5,000 were produced, and this, one of several in our collection, still works as well as it did the day it was made.

The Comptometer was used, mostly

Photo by Jessica Huynh

by businesses, only for adding and subtracting, but trained operators could tally a column of numbers blazingly fast because all the digits of a single number could be pushed at the same time. If you don't believe this, I'll get my mother, who was a Comptometer operator in the early 1940s, to give you a demonstration. But mechanical calculators were not the genesis of modern electronic computers, they were instead one of many dead ends.

Once upon a time, "computers" were people that computed, not computing machines.

ANCESTRAL BEGINNINGS

One of the direct ancestors of the computer was the handsome **Hollerith census machine**, which was designed

to solve a new kind of problem. In 1880, the U.S. census had taken seven years to produce 21,000 pages of data. There was a real danger that the 1890 census might take more than 10 years to count, which would trigger a constitutional crisis because that document requires an "actual enumeration" every decade for allocating seats in the House of Representatives. A young New York engineer named Herman Hollerith won a three-way competition for technology to save the day by using "punched cards" to record and then tabulate the data. It was a great success, and 26,000 pages of data were compiled in only 2 ½ years.

But as a business, Hollerith's "Tabulating Machine Corporation" had a less than stellar business plan: they had only one product, and one major customer that bought every 10 years. Hollerith gradually made the transition to supplying general office machines based on the same technology, and diversified the product line by merging with a computing scale company and a time clock company, calling the result CTR ("Computing-Tabulating-Recording") Company. Hollerith's health was failing and he retired in 1911 with about a million dollars, which was serious money in those days.

It took a consummate salesman fired from National Cash Register in 1911 to rename the company "IBM" in 1924 and create the dominant force in computers for many decades. That salesman was **T.J. Watson**, and he and

his son Tom Watson, Jr. ran the company for an astounding 60 years between them.

IBM started before the invention of the electronic computer. Its products were electro-mechanical machines designed primarily for office automation, based on Hollerith's punched card. Here are **machines used for punching, copying, and sorting** the cards.

Photo by Michael Dubinsky

Photo by Michael Dubinsky

IBM's business model was brilliant: instead of selling machines, they leased them and so created a recurring revenue stream. And, they sold the "razor" for your "shaver" as well: in 1930 IBM sold 3 billion of those punched paper cards, accounting for 10% of their revenue and 35% of their profit.

…as a business, Hollerith's "Tabulating Machine Corporation" had a less than stellar business plan: they had only one product, and one major customer that bought every 10 years.

The drive toward fast electronic computers with no moving parts was natural and unstoppable, but some people still enjoyed tinkering with homebuilt computers made out of more unusual technology. Here are three examples, constructed as early as 1932, by Prof. Derrick Lehmer at the University of California at Berkeley. One is built from bicycle chains and screws, one from industrial gears and toothpicks, and one from 16mm film strips and wooden bobbins.

Lehmer's Sieves, three very different

Photo by Jessica Huynh

"computers," solve the same problem—finding prime numbers using the Sieve of Erastasthones—and dramatically demonstrate that an algorithm and the device that executes it are very different indeed.

in those days the notion of computers sharing program "software" (a term not yet invented) was not an issue—if you had a computer, you wrote programs specifically for it and no other machine used them.

ELECTRONIC BEGINNINGS

It wasn't until the 1940s that electronic devices we recognize as being similar to modern computers began to appear. Here is a small part of one of the first, the **ENIAC** ("Electronic Numerical Integrator and Calculator"), designed

Photo by Michael Dubinsky

during WWII at the University of Pennsylvania to compute ballistics tables for the Army. Unfortunately ENIAC, a room-sized monstrosity with 18,000 vacuum tubes, was finished too late to help with the war effort. And, it wasn't really a computer in the modern sense, because it didn't have a program stored in memory that could be easily changed.

The "stored program" breakthrough occurred June 21, 1948 at the University of Manchester on a test computer called "The Baby" that at the time wasn't considered important enough to preserve so it no longer exists. But starting in 1949 and based on that idea, true computers as we know them today began to appear. **The Johnniac** was one of the first generation

Photo by Michael Dubinsky

of computers in that modern design, and the only one ever named for John Von Neumann, the brilliant Hungarian-born mathematician who played an important role in the invention of the modern "stored program" computer. The Johnniac was built by the Rand Corporation of Santa Monica, California, and was an approximate copy of the machine built under Von Neumann's supervision at Princeton's Institute for Advanced Studies. It wasn't exactly the same, but that was ok because in those days the notion of computers sharing program "software" (a term not yet invented) was not an issue—if you had a computer, you wrote programs specifically for it and no other machine used them.

These new contraptions were clearly going to be useful for many different things. But in the early 1950s if you wanted a computer for, say, calculating some physics equations for your PhD dissertation, you had a problem. Computers had been invented, but you couldn't buy one. If you were determined enough, like Gene Amdahl at the University of Wisconsin, you simply built one for yourself. This is his **WISC** from 1952, the "Wisconsin Integrally Synchronized Computer." In

Photo by Jessica Huynh

the process Amdahl decided that building the computer was more fun than doing the physics, and he went on to design many important computers that were manufactured first by IBM and later by his own eponymous company. But this early handcrafted WISC, like many of the objects in our collection, is a one-of-a-kind item. If you look closely you can also see that it is the only object in our collection that is perforated with bullet holes, a punishment many of us have wished but not dared to inflict on our own computers. For the real story on the bullet holes, visit the Museum and ask a docent.

MEMORY MAKES IT WORK

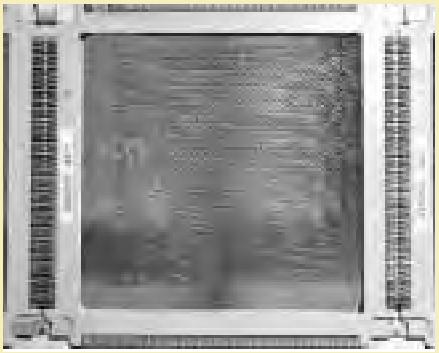
The biggest impediment to building computers in the early 1950s was the lack of a good way to store data—which was now both numbers and programs. Early machines experimented with a wide variety of bizarre schemes, from vacuum tubes that conducted a current or not, to CRT screens with spots of light and dark, to this strange-looking **delay line from the UNIVAC I** that

Photo by Jessica Huynh

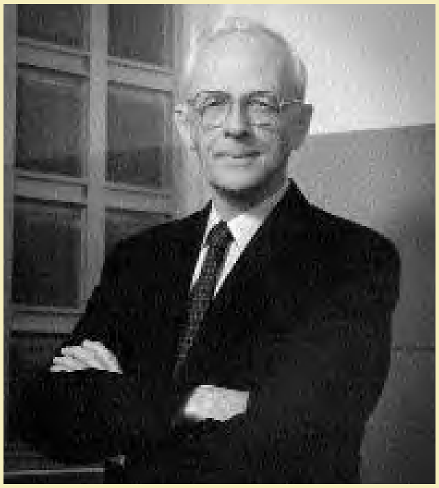
stored information as sound waves traveling through metal tubes filled with liquid mercury.

The biggest impediment to building computers in the early 1950s was the lack of a good way to store data—which was now both numbers and programs.

The 1953 breakthrough that caused computers to flourish was the **magnetic core**: a small ferrite doughnut that could



be magnetized either clockwise ("zero") or counter-clockwise ("one"). An Wang at Harvard pioneered the use of core, and **Jay Forrester** at MIT made it



practical by inventing a matrix scheme using two wires at right angles to read and write individual cores without having a separate wire for each one.

Magnetic core became the dominant computer memory for 25 years until semiconductor memories were invented. Forrester, who was inducted as a Museum Fellow in 1995, decided shortly after his invention that all the really interesting problems in computer hardware had been solved, and he moved on to other fields where he made equally brilliant and seminal contributions.

One of the first large computers that core memory made possible was a huge system for the military with the combat-speak name of "Semi-Automatic Ground Environment" or **SAGE**. This photo

Photo by Michael Dubinsky

shows only a few of SAGE's 51,000 vacuum tubes, every one of which had to be working simultaneously in order for the computer to work.

There were 46 **SAGE** computers built, one plus a second hot-standby backup

Photo by Michael Dubinsky

Photo by Michael Dubinsky

in each of 23 underground bunkers located in the northern U.S. and Canada. Their purpose was to process radar data and detect Russian piloted bombers coming over the north pole toward the U.S. Despite all the tubes, these machines were incredibly reliable and were operated until the early 1980s. The fact that by then Russia had long since developed Inter-Continental Ballistic Missiles (ICBMs) and SAGE was not fast enough to track them usefully didn't put them out of business. Perhaps the Russians didn't know SAGE's limitations.

BUILDING SUPERCOMPUTERS

Many of the artifacts in the collection demonstrate technological or commercial failures, and studying these is one of the best ways to learn from history. The **"STRETCH,"** IBM's attempt

Photo by Michael Dubinsky

in the late 1950s to build a supercomputer dramatically better than anything that had come before, was a commercial failure because it was too expensive and not fast enough. But it pioneered amazing technology that later surfaced in other computers over the next 20 years. Due to its commercial failure project engineer Red Dunwell was considered a persona non grata by T.J. Watson for many years, but later was lauded by Watson when STRETCH's numerous innovations had become apparent.

Although IBM was very successful in providing computers for the military and for ordinary businesses, from STRETCH onward, and for the next several decades, it struggled with building the very fastest scientific computers. In 1965, a small company in Minnesota introduced the **CDC 6600**, which

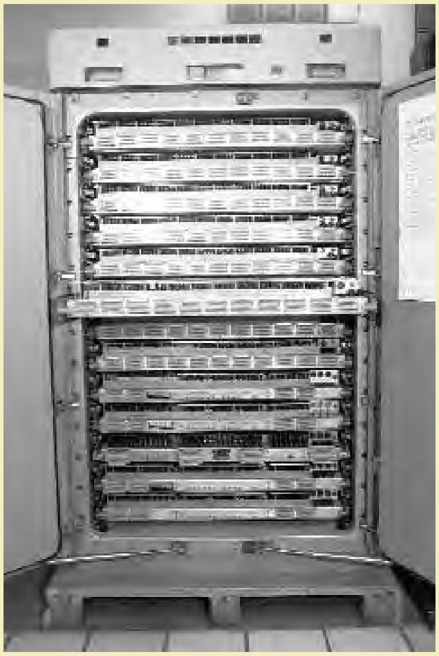
Photo by Jessica Huynh

tweaked IBM's nose by being the fastest computer in the world for many years. An angry T.J. Watson blasted his staff with this memo: "Last week, Control Data...announced the 6600 system. I understand that in the laboratory...there are only 34 people including the janitor. Of these, 14 are engineers and 4 are programmers.... Contrasting this modest effort with our vast development activities, I fail to understand why we have lost our industry leadership position by letting someone else offer the world's most powerful computer."

Sometimes, Mr. Watson, bigger isn't better.

Part of CDC's advantage over IBM was its smallness, but part was the remarkable genius of its principal designer, Seymour Cray. He got his start designing computers for the military, like this **Univac NTDS** computer used on

Photo by Jessica Huynh



board a battleship and built like a tank. In general, the military's influence in the early development of computers was huge and the industry would not have developed as quickly without it.

Seymour Cray had a long and

distinguished career based on repeatedly designing the world's fastest computers until his untimely death in a car accident in 1997. This **Cray-1** from

Photo by Jessica Huynh

1975, sometimes called the "world's most expensive loveseat," is perhaps the most famous example.

The physical design of fast supercomputers presents two important problems: keeping the circuitry close together so that delays caused by wiring are minimized, and getting the heat out so that circuits don't overheat. In speaking about this machine at the time, Cray was as proud of the plumbing that kept it cool as the electronics that did the computing, and would talk at length about his patents for copper tube extrusions into the aluminum cooling columns.

Cray's next machine, uncreatively called the **"Cray-2,"** solved the cooling/

Photo by Michael Dubinsky

plumbing problem another way: the boards themselves were swimming in a non-conducting liquid called "Fluorinert," an artificial blood plasma that just happens to have the right thermal, mechanical, and electrical properties. Changing out a defective board within the 30-minute "mean time to repair" requirement was a challenge, though, since all the Fluorinert had to first be pumped into a holding tank, the board replaced, and the liquid pumped back.

Other people solved the cooling problem for supercomputers in other ways. The **"ETA-10,"** created by engineers who,

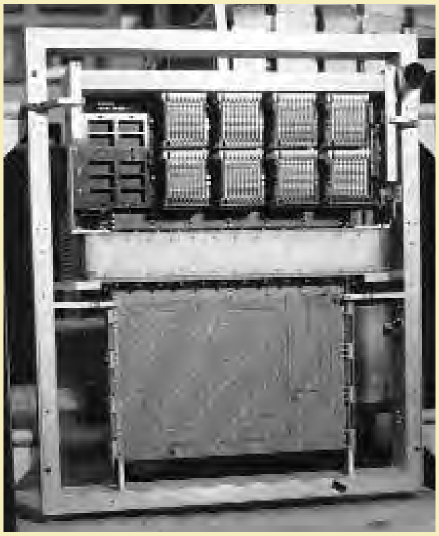


Photo by Jessica Huynh

like Cray, had left CDC, contained circuit boards that were immersed in a vat of liquid nitrogen.

MAKING MAINFRAMES

In the meantime, IBM was doing a booming business selling mid-sized computers for both business and scientific purposes. But by the early 1960s it had a looming crisis: it was building too many different kinds of computers. Each used different technology, software, engineers, salesmen, and support technicians. To consolidate behind a single uniform product line that could do both scientific and business computing at both small and large scale, Watson put a 28-year-old untested manager by the name of Fred Brooks in charge of a "you bet your company" project that would obsolete their entire product line. It was a remarkably bold move for a 60-year-old prosperous company and it could have been a colossal disaster, but the result was wild success: IBM dominated the mainframe computer industry for 20 years with the **System/360** that was introduced in 1964.

Photo by Jessica Huynh

Within the 360 family, IBM did finally manage to build a supercomputer that could compete with the CDC 6600. And this **IBM 360/91** was perhaps the

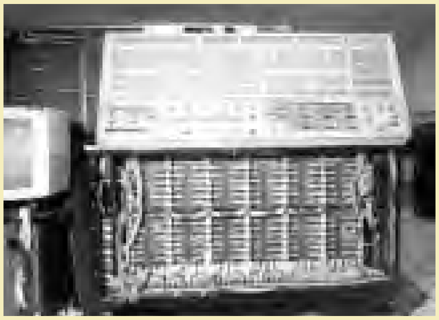


Photo by Jessica Huynh

pinnacle of the "lights and switches" front console design, although even by then most of the operation and fault diagnosis of computers was being done electronically. The end of the flashing lights and whirring tape drives since then has made computers more efficient but much less photogenic.

MINI COMPUTERS FOR THE MASSES

While Seymour Cray's companies were building massive supercomputers, Digital Equipment Corporation (DEC) was a pioneer in "mini-computers" for the masses. This **PDP-8** from 1965 was a

Photo by Jessica Huynh

huge success; for about $17,000 anyone could own a serious professional computer. You could even argue that it was the first "personal" computer, if that means a computer small enough for one (strong) person to pick up and put in his car!

By that definition, DEC had started by making decidedly non-personal computers like this **PDP-1**, which had

Photo by Jessica Huynh

only 8K of memory, weighed a ton, and could fit in no one's car. But DEC's machines were always approachable and touchable, and this one was the inspiration for one of the first computer games, SpaceWar!, which simulated dueling rockets ships on the screen of the circular display tube.

DEC went on to make many other medium-sized computers. One that set a standard was the 1978 VAX, of which we have several in the collection. For years rumors were floating around that certain eastern European countries had built clones of U.S. computers because they could build the machine and then steal the programs; software had as much value as hardware. After the fall of the Berlin wall and the collapse of the Soviet Union we were able to get this **clone of a DEC VAX**, made from

Photo by Jessica Huynh

U.S. and British integrated circuits and Bulgarian (?) circuit boards, all running purloined DEC software.

The computer revolution has been a worldwide activity, and our collection is appropriately international in scope. This **Z-23** medium-sized computer was

Photo by Jessica Huynh

built by the German Zuse Computer Company in the early 1960s. Its designer, Konrad Zuse, a formerly under-recognized genius of computer design, independently invented many concepts before WWII that were subsequently reinvented by others in different countries. But he lost that advantage to engineers from Great Britain and the U.S. because of Germany's war activities. His son, Horst Zuse, a computer scientist himself, has worked to restore his father's proper place in history and facilitated the donation of this machine to us.

BUT DO THEY STILL WORK?

Many people touring the Visible Storage Exhibit Area ask how many of our machines still work. The answer, unfortunately, is "very few." Even if we have complete hardware and documentation and the necessary software, it takes a huge effort to restore and keep the older machines running. But it can be done, and this **IBM 1620**, designed in 1959, is an example.

Photo by David Pace

A dedicated team of Museum volunteers led by the indefatigable Dave Babcock worked for over a year to get this early transistorized machine back in working condition. As part of the project, they also created an exquisitely detailed cycle-by-cycle simulator that runs on the web. They collected a huge library of 1620 software on original punched cards, which were converted to modern storage and can now run on both the real machine and on the simulator. In the long term—think 100 or 500 years—the only consistent way to keep these old machines running and to preserve the accomplishments they represent will be to do it in "virtual space" through simulations.

The end of the flashing lights and whirring tape drives since then has made computers more efficient but much less photogenic.

PERSONAL COMPUTING POWER

By the mid-1970s, computers became really personal and started showing up in homes. The do-it-yourself computer kit that started this revolution was the **Altair 8800**, which appeared on the

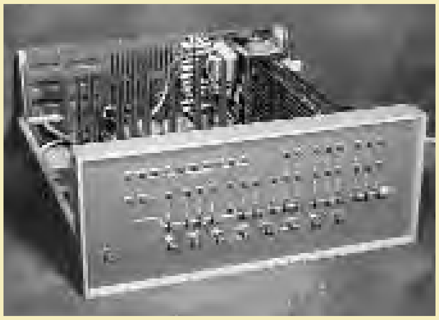


Photo by Jessica Huynh

cover of Popular Electronics in January

1975 and had thousands of propeller-head hobbyists dreaming of owning their own.

None of the companies that built "real" computers took this kind of computer seriously. But new companies started in the most unassuming ways and surprised the establishment. The two scruffy-bearded Steves (Jobs and Wozniak) who showed off this **Apple I** at a Homebrew Computer

Photo by Jessica Huynh

Club meeting in 1977 were not obvious candidates for creating Apple Computer, a hugely important computer company that would still be an major force 25 years later.

Only a few hundred of the Apple I's were built. The company's first big success was the **Apple II**, which was wildly

Photo by Jessica Huynh

popular in schools and even made a foray into businesses because of VisiCalc, the world's first interactive spreadsheet. Apple kept moving quickly: their first big failure was the **Apple III**,

Photo by Jessica Huynh

their first non-product was the **Lisa**, and

Photo by Jessica Huynh

the world's first mass-market high-resolution graphical computer was the justifiably famous **Macintosh**.

Photo by Jessica Huynh

Eventually large companies recognized that personal computers were becoming a serious force, and even IBM produced one that subsequently set the standard for 90% of the desktop computers. In retrospect, that was a most unusual turn of events: the "open standard" computer was produced by the starched shirts at "Big Blue" whereas the hippies at Apple kept their design to themselves. The interpretations and lessons of this bit of history will be debated for years.

But the 1982 IBM PC, of which we have many examples in the collection, was not IBM's first personal computer. Back in 1975 they had produced this **"IBM 5100"** to run the BASIC and APL

Photo by Michael Dubinsky

languages. The remarkable thing, besides the high price tag, was that it was actually a shrunken mainframe on a desktop running an emulation of the big 360 systems and their software. Fred Brooks' idea of "one computer for everything" had perhaps gone a bit too far.

INNOVATION AND FIRSTS

Where were the big companies when the innovative products were first coming out of the young upstarts? Well, in some cases, they were creating innovations and failing to make products out of them. Xerox, in their Palo Alto Research Center (PARC), created the **Alto**, a high-resolution

Photo by Kevin Powerx

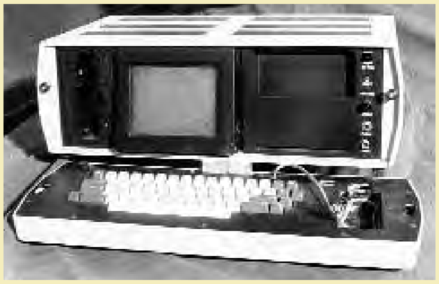
graphic computer that was intended to be what the Macintosh became. Xerox PARC also created the world's first **prototype laser printer**, based on a

Photo by Kevin Powerx

standard office copier. But even with that head start they did not come to dominate the early laser printer market.

PARC also prototyped portable computers, like the **NoteTaker**,

Photo by Kevin Powerx



which was never produced but looks remarkably similar to the later **Osborne 1**. How Xerox repeatedly

Photo by Kevin Powerx

managed to invent the future but failed to build it has been chronicled in several books like the aptly titled *Fumbling the Future* by Douglas Smith and Robert Alexander and the more recent *Dealers of Lightning* by Michael Hiltzik.

One of the minefields in the technological history business is the election of "firsts." It depends on pedantically precise definitions, requires meticulous and detailed records, is almost always controversial, is often historically meaningless, and engenders emotional responses that can sometimes lead to fisticuffs. But it's fun! So in that spirit, The Boston Computer Museum, our ancestor whose collection is the core of ours, ran a contest in 1985 to discover the real first personal computer. The winner, as the "first advertised commercially-available non-kit computer under $1000," was a computer you have never heard of: the **Kenbak-1**, designed

by John V. Blankenbaker and advertised in Scientific American in 1971. "Firsts," when you find them, may not be what you expect.

The Museum's award for the first microprocessor-based computer was given to an almost equally obscure French computer, the Micral, designed by Vietnamese immigrant Thi Truong around an Intel 8008 and programmed by Philippe Kahn.

The election of "firsts" depends on pedantically precise definitions, requires meticulous and detailed records, is almost always controversial, is often historically meaningless, and engenders emotional responses that can sometimes lead to fisticuffs. But it's fun!

Speaking of microprocessors and firsts, what was the first microprocessor-based device? It was this **calculator from Busicom**, a Japanese company that hired Intel in 1971 to create the world's first microprocessor, the 4004. This

Photo by Kevin Powerx

prototype, from Federico Faggin's desk, has one of the world's first working microprocessor chips plugged into it.

ALTERNATE ROUTES AND DEAD ENDS

Although the digital electronic computer now dominates, it wasn't always clear that binary was the best way to compute. From the 1920s to the 1960s "analog computers" represented numbers in a much more direct way than an abstract string of bits: a signal of 5.2 volts could be the number 5.2. You could add, subtract, multiply, and divide at blazingly fast electronic speeds. But the accuracy of the results and the complexity of the computational sequences was limited, so stand-alone analog computers, like these made by **EAI** and **Heathkit**, became dinosaurs that only survive in textbooks and computer history museums.

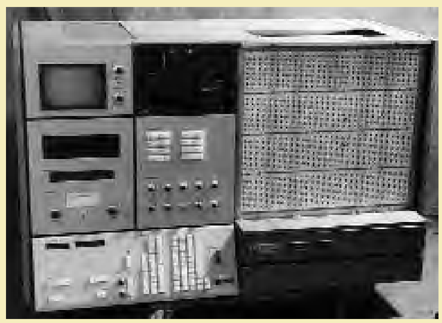


Photo by Kevin Powerx

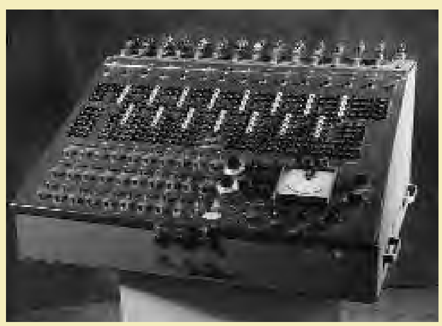


Photo by Kevin Powerx

The Museum collection contains many other instructive dead-ends, although not all of them were failures. The **Illiac IV** from 1970 was an experiment

Photo by Kevin Powerx

in making one fast computer out of a bunch of slower ones that all execute the same program in lock-step on different data. It worked, but it turns out not to be a great way to build fast computers. Note the coffee-table-sized hard disks, that hold about as much as yesterday's floppy disk.

Stand-alone analog computers became dinosaurs that only survive in textbooks and computer history museums.

Some computers in the collection always bring a smile to visitor's faces. This **"kitchen computer"** was the fantasy item in the Neiman-Marcus

catalog in 1965, and was an attempt to answer the persistent and puzzling question: Why would anyone want a computer in their home? The standard answer for years had been "for storing recipes," and this computer had a built-in chopping board to facilitate following its recipe instructions. Of course, the input was in binary and the output was in octal, so the user interface left something to be desired! For about $10,000, you could get the computer, an apron, a set of cookbooks, and a two-week programming course. As a measure of the social sensibility of the time, the advertising tag line for this Honeywell-built computer was "If only she could cook as well as Honeywell can compute." We have no indication that even one of these wonderful home appliances was actually sold, but many home computers still come with recipe software.

UBIQUITOUS NETWORKING

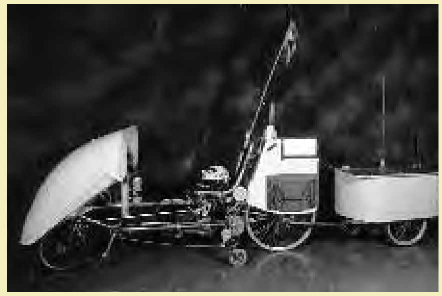
The most dramatic change in computing in the last five years has been the astounding growth of the Internet and the World Wide Web. This interconnection of millions of computers started modestly in the late 1960s by a government-funded project called ARPANET. This refrigerator-sized computer was the "Interface Message Processor" **("IMP")** manufactured by

Photo by Jessica Huynh

Bolt Beranek and Newman of Cambridge, Mass., as the communications pipe for the ARPANET, which started with only four nodes: mainframe computers at Stanford, UCLA, UC Santa Barbara, and the University of Utah. Thirty years later, even cell phones can be nodes on the network.

At the dawn of the era of ubiquitous mobile computing, this virtual tour appropriately ends with an early ungainly example of mobile personal computing: Steve Roberts' computerized recumbent bicycle **BEHEMOTH** (Big Electronic Human-Energized Machine ...Only Too Heavy). In the 1980s, Steve logged

Photo by David Pace



about 17,000 pedal-powered miles while sending email from a chorded keyboard built into the handlebars and reading responses on the heads-up display attached to his helmet. If it sounds like Steve was pedaling to the beat of a different drummer, think about him in a few years when every device you own is seamlessly connected to the Internet and you do email while in the shower.

If you have enjoyed this virtual tour of our Visible Storage Exhibit Area, I encourage you to visit in person and see the other 2/3 of it, which altogether is still only 10% of our hardware collection. And if you think it is important to preserve these items and stories as a record of one of most remarkable technological achievements of our civilization, please support The Computer Museum History Center.

Leonard J. Shustek is the chairman of the Board of Trustees of The Computer Museum History Center. Len Shustek's educational background is in computer science (MS, PhD, Stanford University) by way of physics (BS, MS, Polytechnic University in Brooklyn NY). After graduation he joined the faculty at Carnegie Mellon University as an assistant professor of Computer Science.

In 1979 he co-founded Nestar Systems Inc., an early producer of networked client-server computer systems. In 1986 he was co-founder of Network General Corporation, a manufacturer of network analysis tools, notably "The Sniffer(tm)". The company became Network Associates Inc. after merging with McAfee Associates and PGP. Shustek is now semi-retired and serves on the boards of several high-tech startups and three non-profit organizations.

He teaches occasionally as a consulting professor at Stanford University, and is a partner at VenCraft, a small "angel financing" venture capital fund. He is also a trustee of Polytechnic University. Write to him at shustek@computerhistory.org.

RECENT DONATIONS

TO THE COMPUTER MUSEUM HISTORY CENTER COLLECTION

Apple IIe, Amdek data display, Daisywheel Printer, and sheet feeder (1985), X2164.2001, Gift of C. T. Kennedy

Assorted early PDAs including a Grid Pad, a Toshiba T100X, an NCR System 3130, and a GO G400 PDA with external disk drives (c. 1992), X2165.2001 - X2168.2001, Gift of Ed Devinney

IBM 1130 computer system with extensive software and documentation (1964), X2180.2001, Gift of Robert Garner

Three-and-a-half linear feet of assorted documents, many dealing with early IBM and CDC computers, X2191.2002, Gift of Douglas Albert

"The Bus Probe" Curcuit Board (1981), X2192.2002, Gift of Peter Ingerman

Cromemco System 3, LSI Information Terminal, Prism printer, disk drives, and a complete library of associated software and documentation (c. 1980s), X2217.2002, X2256.2002, X2190.2002, Gift of Peter Ingerman

Onyx C8002, Zephyr Console Terminal, and extensive documentation and operating manuals (c. 1981), X2218.2002, Gift of Douglas Broyles

Two "Cedar" circuit boards (c. 1995), X2219.2002, Gift of Dr. Allan Malony

IBM Selectric (1963), X2221.2002, Gift of Donald Knuth

Twelve books on programming and personal computing topics (c. 1982-1992), X2223.2002, Gift of Mark Possoff

Six linear feet of assorted rare publications, documents, and personal papers (c. 1950-1980s), X2224.2002, Gift of George Michael

HP65 and HP67 User's Library (c. 1975-1977), X2233.2002, Gift of George Michael

Hitachi TFT display and accessories, core memory module, and IBM data cartridges, X2235.2002, Gift of Joshua Shapiro

Olivetti PR-2300 printer (JP 101) (c. 1985), X2238.2002, Gift of Mark Possoff

Interact Model 1 Home Computer System with a complete library of software and documentation (c. 1982), X2239.2002, Gift of Lawrence Ching

Aaron Paint System (c. 1990), X2240.2002, Gift of Harold Cohen

PT-396/AS plotter (c. 1950s), X2241.2002, Gift of Douglas Brentlinger

Assorted ephemera including UNIVAC and other early flow chart templates, core memory, UNIVAC publications, and computer textbooks (c. 1966-1970s), X2242.2002, Gift of Richard and Jean Lehman

DEC baseball cap, X2243.2002, Gift of Gordon Bell

PDP-6 backplane and a group of PDP-6 system modules (c. 1963), X2244.2002, Gift of Robert Garner

PDP-10 disk (c. 1967), X2245.2002, Gift of Elizabeth Feinler

Assorted DEC t-shirts and software, X2247.2002, Gift of Pierre Hahn

"Alpha Implementations and Architecture" signed and donated by the author (1996), X2248.2002, Gift of Dileep P. Bhandarkar

AI textbook collection (c. 1980s), X2251.2002, Gift of Arthur Iadonisi

Replicas of the Genaille-Lucas Arithmetique, "Napier's Bones," Napier's Calculating Box, and Schickard's Clock, X2252.2002 - X2256.2002, Gift of Gordon Bell

VT 180 "Robin" computer system complete with disk drives and modems (1982), X2262.2002, Gift of H. Michael Boyd

RX180 AB Disk Drive (1982), X2263.2002, Gift of H. Michael Boyd

RISC II Chip (c. 1985), X2265.2002, Gift of David Patterson

Macintosh Portable Computer, Apple Desktop Bus Mouse, power adapter, and case (1989), X2266.2002, Gift of Randy Katz

TI programmable 59 calculator with a PC100C printer/docking port, including cover, full program library, complete manuals, and clippings (c. 1977), X2267.2002, Gift of Bruce Watts

HP 9810A calculator (Model 10), program library and associated documents, X2269.2002, Gift of Robert Schapp, Jr.

Osborne 1 portable computer, Trantor external hard drive, and extensive associated Osborne software and documentation (1981), X2271.2002, Gift of Ann Hyde

Millenium Information Systems Programming Panel, CPU, 2 2-Slot 8" disk drives, an Atari 1200 XL, and five boxes of associated software and documentation (c. 1978-1982), X2272.2002, Gift of Harry Stewart

Four linear feet of assorted computing documents including networking and Stanford AI Lab documents, X2273.2002, Gift of Mark Kahrs

Metaphor digital workstation unit with infrared keyboard, numeric keypad, special purpose keypad, and mouse (c. 1997), X2274.2002, Gift of Tim VanRoekel

IBM Personal System portable computer, Model 8573-401 (1991), X2276.2002, Gift of Dana Herbert

Visual Technology, Inc., Notebook portable computer with original instruction manual and two OS manuals, X2277.2002, Gift of Sylvio Demers

Extensive donation of Lotus software, ephemera, and publications as well as industry literature (1980-2000), X2278.2002, Gift of the Lotus Division of IBM

Assorted UNIVAC I and UNIVAC II equipment (c. 1953-1958), X2279.2002, Gift of Mac Maginty

REPORT ON MUSEUM ACTIVITIES

KAREN MATHEWS

Karen Mathews is Executive Vice President at The Computer Museum History Center

In July of 2001, The Computer Museum History Center celebrated its second anniversary as an independent non-profit institution, with the exciting and important mission to preserve and present early information age developments. In two short years we have tripled our staff, volunteer base, events, and annual budget. We have significantly increased our world-class collection and the number of tours we offer. All the while, we have worked behind the scenes planning a premier Museum building, complete with innovative and inspiring exhibits, scheduled to open in 2005. In short, we have made amazing progress across all areas of the Museum. Here are some highlights.

MAKE HISTORY ON OCTOBER 23: DON'T MISS THE ANNUAL FELLOW AWARDS

Each year, on one brilliant evening, hundreds of industry luminaries come together to applaud the achievements of three outstanding people in the computer technology world. This year that evening is Tuesday, October 23 at the San Jose Fairmont Hotel.

Honorees are: **Frederick P. Brooks** for his contributions to computer architecture, operating systems, and software engineering; **Jean E. Sammet**, for her contributions to the field of programming languages and its history; and **Maurice Wilkes**, for his life-long contributions to computer technology, including early machine design, microprogramming, and the Cambridge ring network.

The 2000 Fellow Awards Banquet brought together more than 300 industry luminaries and enthusiasts to celebrate three new Fellows: Fran Allen, Vint Cerf, and Tom Kilburn.

Hosts for the evening are Donna Dubinsky, Len Shustek, Suhas Patil, Jayashree Patil, Elaine Hahn, Eric Hahn, Karla House, Dave House, Angela Hey, John Mashey, and Peter Hirshberg. The master of ceremonies is Internet luminary and 2000 Fellow Vinton Cerf.

To further enhance the magical evening, a reception prior to the banquet and ceremony will feature an impressive exhibit of artifacts recently donated to the Museum by various Swiss individuals and organizations, initiated and coordinated by the Swiss Science and Technology Office in San Francisco and shipped courtesy of PRS Presence Switzerland. A number of dignitaries and pioneers from Switzerland will be in attendance.

Don't miss this marquis event! Call or visit www.computerhistory.org for details and registration.

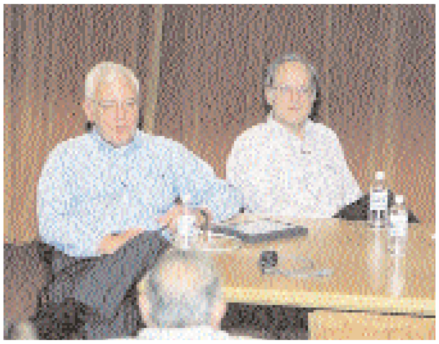
Banquet emcee Peter Hirshberg, 2000 Fellow Vint Cerf, Museum CEO John Toole, and Museum Trustee Chairman Len Shustek celebrated with Cerf at his induction as a Fellow.

DECWORLD 2001

Museum-sponsored DECWORLD 2001 represented another benchmark in the Museum's quest to gather and preserve personal stories of the computing revolution. Nearly 200 people from 16 states and two countries—many who had not seen each other for years—gathered to present the inside stories of Digital Equipment Corporation, a company whose achievements notably influenced the technology boom. Twenty-seven people donated items to the Museum's collection. Over 60 DEC alumni were interviewed, recording stories for posterity, and approximately 10 hours of video recorded the entire proceedings. Museum staff is busy converting videos, transcripts, and other images of the event for posting to the web. For details, see Karyn Wolfe's article in this issue and visit http://www.computerhistory.org/decworld.

PERSONAL RETROSPECTIVES ON THE XEROX ALTO

On June 4, Butler Lampson and Chuck Thacker closed the Spring Lecture Program with an entertaining talk given to over 300 people that included personal stories from time spent at Xerox PARC developing the Xerox Alto. Attendance, by a show of hands at the lecture, included a high percentage of

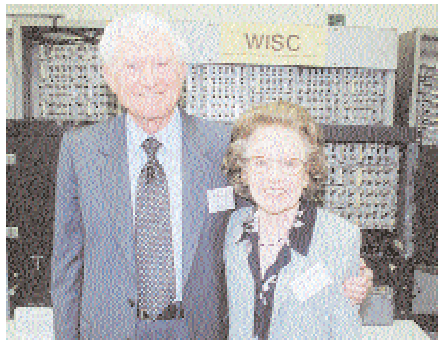


Chuck Thacker and Butler Lampson discussed the Alto and other advances made during their time at Xerox PARC in the final lecture of the Spring program.

people who had been in the development group itself. The Alto demonstrated many new concepts in computing, and the same design team invented so many, many things whose impacts are still with us: for example, LANs, Ethernet, bit-mapped displays, graphical user interfaces, laser printing, and object oriented programming. Lecturers discussed how Xerox did better capitalizing on ancillary investments at PARC (e.g. Ethernet, physics) than it did on the Alto.

GENE AMDAHL LAUNCHES FALL LECTURE LINEUP

The first of our fall lecturers, Gene Amdahl spoke on September 5 to an appreciative crowd of 200. He told the story of how, through a series of events at IBM, he was able to identify a business opportunity for a theoretical competitor to create a lower-priced machine at the high end of IBM's line. IBM would likely have had to lower the price of its own high-end machine, impacting the prices of the entire line. Thus, they could not lower prices, even at the high end, giving a theoretical competitor the edge.



Gene and Marian Amdahl stand in front of Gene's PhD thesis—the WISC computer—after his Fall lecture that opened the 2001 lecture program.

After leaving IBM, Amdahl set out to deliver on this idea under the auspices of Amdahl Corporation. He relayed some of the difficulties and opportunities along the path and how eventually, through sheer tenacity, Amdahl Corp. was funded by the Heiser Corporation and later, Fujitsu, and Nixdorf, who made it possible to fulfill his vision. The company grew exponentially: it went from $50 million in sales in its first year, to $100 million, $200 million, and $400 million by the fourth year. Amdahl left the company after five years, and subsequently founded three other companies.

COLLECTION HIGHLIGHTS

Here are some of our recent acquisitions:

The IBM 1130. Purchased and donated by Robert Garner, this small computer designed for both scientific and business applications became popular with universities. Machines like this occasionally appear on Internet auction sites and with help from people like Robert, the Museum is able to acquire them for the permanent collection. Says Garner, "It's a thrill to discover and then donate workhorse computers of bygone eras to the Museum. The mid-west owners of this operational IBM 1130, selling it on eBay, were delighted that it found a suitable home. I myself have pleasant memories playing Star Trek on the 1130 late in the evenings while an undergraduate!"

RISC II Chip. Donated by UC Berkeley Professor David Patterson, the RISC II contained 40,760 transistors and ran at 3 MHz. Designed by Bob Sherburne and Manolis Katevenis, students of Professors David Patterson and Carlo Sequin, this is the second in a revolutionary line of Reduced Instruction Set Computers.

Aaron Paint System. Donated by artist and inventor Harold Cohen. Aaron, an artificial intelligence-based system for drawing, has changed over the years. The version donated used a small robotic arm with a built-in paint delivery system. The association between Cohen and the Museum dates back to the late 1970s when Cohen and an earlier system painted a mural for the Museum's original site in Marlborough.

EXHIBITING AT HOT CHIPS

Museum staff created an exhibit for the recent Hot Chips and Hot Interconnect Conferences at Stanford University. The exhibit featured highlights from various areas of the collection, including Don Lancaster's TV Typewriter Prototype, an early RISC wafer, and the "canonical teapot" used in many early computer graphics tests.

Hot Chips organizing committee member Allen Baum said, "Listening to presentations about the latest cutting edge technology is great, but it really hits home when you can see what used to be the latest and greatest, and how little time it took to advance from there. An exhibit like this gives perspective on what we can look forward to, and just how fast it is likely to come."

CYBERMUSEUM ACTIVITIES

As more physical artifacts make their way into the digital realm, we will need great ways to represent the complex relationship of ideas, people, companies, and computing machines that comprise computing history. An enthusiastic new addition to the staff, Mike Walton, has joined us as director of cyber exhibits to help tackle these problems. Backed by an impressive CyberMuseum Committee led by Gordon

Bell, the group is exploring methodologies for collecting and presenting stories and oral histories online, capturing visitor submissions about the artifacts in discussion forums, and taking in digital artifact donations such as pictures, media, or software.

As the CyberMuseum grows, you will see it start to manifest in parts of our current website. Each new experiment completed by the staff will add a new feature or exhibit to the site. As the process is refined, the CyberMuseum will extend the real-world Museum into cyberspace. In the future, it may also give depth to the exhibits in the real-world, physical Museum.

PUBLIC RELATIONS UPDATE

Media attention has stepped up in recent months. Articles about the Museum have appeared in the New York Times, International Herald, and the San Francisco Chronicle among others. Associated Press and Newhouse News Wire released articles that were picked up by several publications across the country. CNN.com taped a show in the Visible Storage Exhibit Area featuring an interview with John Toole, KICU Channel 36 ran an interview with Toole, and NPR featured an interview with Museum Board of Trustees Chairman Len Shustek.

APPRECIATION FOR OUR VOLUNTEERS

Volunteers have given their all at a number of work parties, receptions, and events over the past four months. Museum staff had the happy occasion to honor and thank these wonderful volunteers at an Appreciation Party on August 18. A picnic at Chase Park, Moffett Field, featured horseshoes, volleyball, Texas barbecue, and "Carniac the Magnificent," a computer history trivia buff wearing a turban and cape–aka John Toole!

John "Carniac" Toole illuminated and entertained volunteers and staff with some amazing facts about computing history at the annual appreciation event.

Volunteers who attended the Museum's annual appreciation event received a t-shirt, a certificate of appreciation from the staff and Trustees, a great barbeque, and heartfelt thanks from Museum staff.

VISIT THE MUSEUM'S ON-LINE STORE

We are proud to make Museum souvenirs and items from our archives available to you, including:

VIDEOS

200+ UVC videos from the Gray-Bell archive include presentations by computing legends and innovators. See and hear Seymour Cray, Danny Hillis, John Hennessy, Alan Kay, James Gosling and others talk about their work and visions.

POSTERS

Some of our most popular items. Our posters depict the stories of the Internet, microprocessor evolution, memory, and the chronology of computers. The posters are both beautiful and educational.

DECWORLD 2001 ITEMS

Tote bags and polo shirts are of very high quality and celebrate a company that impacted computing history (see article on page 2).

HATS

Our staff and volunteers wear these baseball caps proudly (yes, in the Museum) and we hope you will too. Here's an easy way to spread the word about the Museum.

POSTCARDS

These collectible postcards are printed on high-quality paper, and each one pictures and describes a one-of-a-kind artifact from our collection.

COMING SOON

We will soon be making videos available from the Museum's lecture series. Visit our website to be put on the mailing list:

www.computerhistory.org/store
+1 650 604 2577

www.computerhistory.org/store
+1 650 604 2577

THANKS TO OUR ANNUAL DONORS

We acknowledge with deep appr eciation the individuals and or ganizations that have given gener ously to the Annual Fund.

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THU, OCTOBER 11, 6:30 PM
FROM SMALLTALK TO SQUEAK
Dan Ingalls
LOCATION: *Xerox PARC, Pake Auditorium*

WED, OCTOBER 17, 6PM
EARLY COMPUTER MOUSE ENCOUNTERS
Panel Presentation: Daniel Borel, Stuart Card, Bill English, Jean-Daniel Nicoud, and Niklaus Wirth
LOCATION: *Xerox PARC, Pake Auditorium*

TUE, OCTOBER 23, 6 PM
ANNUAL FELLOW AWARDS BANQUET & SWISS TECHNOLOGY RECEPTION
LOCATION: *Fairmont Hotel, San Jose, California, USA*
www.computerhistory.org/fellows

MON, OCTOBER 24, 6 PM
LECTURE TITLE TO BE ANNOUNCED
Fred Brooks, University of North Carolina Chapel Hill

THU, NOVEMBER 8, 6 PM
QUESTIONS ANSWERED
Donald Knuth, Stanford University

THU, DECEMBER 6, 6 PM
LECTURE TITLE TO BE ANNOUNCED
Eric Schmidt

POSTPONED.
DORON SWADE, AUTHOR
THE DIFFERENCE ENGINE
Please check our website for new date and time

VOLUNTEER OPPORTUNITIES
The Museum tries to match its needs with the skills and interests of its volunteers and relies on regular volunteer support for events and projects. Monthly work parties generally occur on the 2nd Saturday of each month, including:

NOVEMBER 10, DECEMBER 8, JANUARY 12

Please RSVP at least 48 hours in advance to Betsy Toole for work parties, and contact us if you are interested in lending a hand in other ways! For more information, please visit our volunteer web page at www.computerhistory.org/volunteers

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MYSTERY ITEMS

FROM THE COLLECTION OF

THE COMPUTER MUSEUM HISTORY CENTER

Explained from CORE 2.2

THE COMPTOMETER

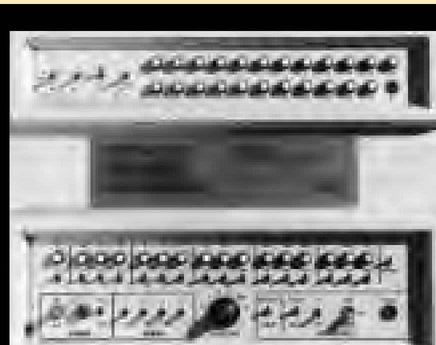
The early, wooden-cased Comptometer mechanical calculator was invented in 1886 by Dorr E Felt of Chicago, who claimed that it was the first successful key-driven adding and calculating machine. For each digit to add, a pushbutton numbered from 1 to 9 is selected, thereby rotating a Pascal-type wheel with the corresponding number of increments. The carrying of tens is accomplished by power generated by the action of the keys stored in a helical spring, which is automatically released at the proper instant to perform the carry. Numbers are subtracted by adding the complement (shown on the keys in smaller numbers).

Through effective marketing and training (at Comptometer Schools) of skilled operators versed in complement arithmetic, these machines became the workhorses of the accounting profession in the first part of the century. They never successfully advanced into the electromechanical era, but remained purely mechanical, two-function adding and subtracting machines.

For further information:
http://members.cruzio.com/~vagabond/ComptHome.html#Intro

WHAT IS THIS?

THIS ITEM WILL BE EXPLAINED IN THE NEXT ISSUE OF CORE.



Please send your best guess to mystery@computerhistory.org before 11/15/01 along with your name and shipping address. The first three correct entries will each receive a free poster: **COMPUTER CHRONOLOGY – THE EMERGENCE OF THE INFORMATION AGE**

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CORE 3.1

A PUBLICATION OF THE COMPUTER HISTOR Y MUSEUM
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OUR ACTIONS TODAY

The achievements of tomorrow must be rooted in the actions we take today. Many exciting and important events have happened since our last *CORE* publication, and they have been carefully chosen to strategically shape where we will be in five years.

First, let me officially introduce our new name and logo to everyone who has not seen them before. The Computer Museum History Center has become the Computer History Museum (CHM). We have adopted the wonderful new logo that you see here and will use it everywhere in our institutional communications and designs. It symbolizes the strengths we have in an artifact-rich collection, the digital age of the Museum's present and future, and people and communities worldwide—those who build our organization, the public we serve, and the lessons of history we pass on to future generations. We are very grateful to Museum Trustee Peggy Burke and her team at 1185 Design who worked so enthusiastically to help us create our new look.

A huge thank you to everyone who contributed generously and early to our Annual Fund campaign. In today's environment of public benefit corporations, annual fundraising is perhaps the most difficult task, yet one of the most important to sustained success. Our growth path is steep, and we need everyone to help make our organization successful. If you forgot to renew by calendar year-end, please do so right now as you read this. It makes a big difference.

In early December, we held a press conference to announce many exciting things—our growing relationship with NASA, construction of the "Beta Building" scheduled to open in early fall, our new name and logo, appointment of our new Head Curator Mike Williams, and our future plans. In my opinion, it was an outstanding success, and I hope you caught the impact of these announcements that have heightened awareness of our enterprise in the community. I'm very grateful to Harry McDonald (director of NASA Ames), Len Shustek (chairman of our Board of Trustees), Donna Dubinsky (Museum Trustee and CEO of Handspring), and Bill Campbell (chairman of Intuit) who participated as panelists. We were fortunate to receive good media coverage and were honored with special guests that included Dan Goldin, former NASA administrator; Zoe Lofgren, US Congresswoman for the Santa Clara Valley; Don Knuth; Gene Amdahl; Randy Katz; and Jeff Hawkins; among others.

COMPUTER HISTORY MUSEUM

Our announcements, taken together, created much more than just a "typical" press event. It was also the "virtual groundbreaking" of a new organization ready to meet the challenges of its future. With pride, I looked at about 100 people attending from all over Silicon Valley; viewed the great artifact display symbolic of one of the world's finest collections; listened to Mike Williams' passion and excitement while giving his tour; smiled at the awe and interest of people who met us for the first time; and saw the work of a dedicated staff who created a highly professional event.

We are building a community with passion, enthusiasm, and the commitment to build something that simply doesn't exist anywhere else in the world. With your sustained help, our actions have been able to speak much louder than words, and it is my goal to see that we are able to follow through on our dreams!

This issue of *CORE* is loaded with technical content and information about our organization—from a wonderful perspective on the first mobile experiments in the SRI van and an assessment of computing in Switzerland, to our new buildings and our emerging CyberMuseum project. Our international presence is growing with real content. I hope you see all of these elements as actions we are taking to meet the challenges of our future plans.

Because NASA's gates are moving back, making us accessible by all, a sustained public presence will now be possible for us. You also should have heard about us at the public environmental impact hearings for the NASA Research Park. They are now completed, and have also raised our visibility in the community. Finally, our programs continue to grow—we've got a great series of lectures and events for this year. Enjoy the Museum in every way you can.

There are still many incredible challenges ahead, and it will take lots of hard work and support. Our new Beta Building, being constructed next to our proposed permanent location, will grow to be a Silicon Valley icon, and is symbolic of lots more to come for the entire community. Help us build a great institution and enjoy the steps along the way to celebrating computing history.

JOHN C TOOLE
EXECUTIVE DIRECTOR & CEO

CORE 3.1
February 2002
A publication of the Computer History Museum

MISSION
TO PRESERVE AND PRESENT FOR POSTERITY THE ARTIFACTS AND STORIES OF THE INFORMATION AGE

VISION
TO EXPLORE THE COMPUTING REVOLUTION AND ITS IMPACT ON THE HUMAN EXPERIENCE

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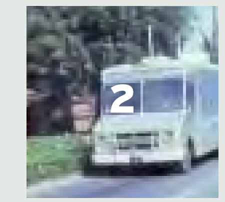

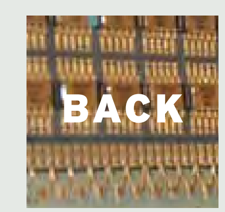

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Cover: Stanford Research Institute (SRI) Van, X1590.99, Gift of SRI International (see page 2)

THE SRI VAN
AND COMPUTER INTERNETWORKING

BY DON NIELSON

Stanford Research Institute (SRI) Van, X1590.99, Gift of SRI International

Since the days when it was a stagecoach stop between San Francisco and Monterey, Rossotti's was a well-known San Francisco mid-peninsula "watering hole" nestled in the second bank of foothills west of San Francisco Bay. In the 1970s, it had a casual atmosphere and some outdoor seating—a good location for the small ceremony about to take place. No one would mind if we parked SRI's "bread truck" van alongside the courtyard and ran a few wires to one of the tables. It was far enough from SRI (Stanford Research Institute) to qualify as "remote," but close enough to have good radio contact with them through a repeater station atop a hill above Stanford.

So it was that this venue was chosen to mark the occasion of the first internet transmission on August 27, 1976. [1] The van was an SRI-outfitted mobile radio lab that contained the equipment needed to make it a portable node on the emerging Packet Radio Network (PRNET). PRNET was sponsored at SRI by ARPA (Advanced Research Projects Agency) and started in 1973 or so. Placing a terminal on one of the wooden courtyard tables and connecting it to the van, a number of SRI people who had gathered for the celebration filed a normal weekly Packet Radio Program report—representing the work of all the Program's contractors—to ARPA. While the testing of such a connection had been going on for several months, this long e-mail report was, in a ceremonial sense, the first internet transmission; that is, the first formal use of the internet protocol known as "TCP." [2]

TCP was designed to carry information over dissimilar networks, in this case the PRNET, through a gateway at SRI, then across the ARPANET to a set of hosts distributed around the United States. This small, virtually unknown, but deliberate episode became a milestone in mobile digital radio and the flexible integration of digital communications networks. But let's back up a bit and review in more detail the emergence of internetworking and the role the SRI van played in it.

In the early 1970s, the ARPANET was growing rapidly. Universities, or their close affiliates, were the main players connecting to the network. Under inducement from the sponsors at ARPA, and through their own inventions of new and useful network services such as electronic mail, network traffic began to grow. In the meantime, the notion of a radio version of the wired ARPANET had come to Larry Roberts at ARPA. When Roberts left, first Bob Kahn and then Vint Cerf pursued that same idea at ARPA. Both Roberts and Kahn had seen the military need for a mobile, wireless version of the embryonic ARPANET. SRI and ARPA had also discussed the possibility of a transportable, possibly handheld, terminal or switching node for such a network rather than the massive, seemingly nuclear-hardened early IMPs (see back cover for more on the IMP) of the fixed network. Following that instinct, ARPA formed a team of contractors in what came to be called the Packet Radio Program. The team's mission was to create a wireless adjunct to the evolving ARPANET. Members of the new Packet Radio Program were Bolt Beranek and Newman (BBN) in Boston, Collins Radio in Dallas, Network Analysis on Long Island, University of California Los Angeles, and SRI. Because it had a good understanding of radio and systems integration, SRI was chosen as system engineer and technical director (SETD) of the program as well as integrator for ARPA's packet radio effort, a position it maintained for over a decade.

(left) Packet Radio van with antennas atop. Deliberately left unmarked over its years of service, the van was often full of expensive equipment and in some cases also full of Army generals. SRI was trying to not attract attention...and, except for one curious San Francisco police officer, it didn't.

(right) The inside of the van with a DEC LSI-11 running TCP at the top of the rack and two packet radios lower down. A Datamedia terminal sits to the right of the rack on the workbench.

It should be pointed out that the introduction of a radio segment to supplement the ARPANET came from simply following the military context in which this and a great deal of research in the United States is done. If the military were to ultimately employ this new interactive digital technology, there would have to be allowances for the military's inherent mobility and possible deployment to any point on earth. So a radio network, particularly one that served a mobile population, was needed. It turned out to be intrinsically different from the existing fixed, wired one. This clear difference, along with the need for the two networks to work well in tandem, led to the notion of a communication software structure that would effectively bind these disparate networks together as though they were one.

One technical insight needs to be inserted here to understand how disparate packet networks can easily function together. In most communications networks it is only the source and destination terminals that are visible to network users. The resources that lie in between are normally of little interest to them as long as they fulfill their role. In circuit switching, once chosen, the same physical pathway is maintained for the whole session. When circuits are leased, the connection may even be "hardwired."

In packet switching, where sub-units of a single message may travel entirely different routes from source to destination, the exact role of intervening resources would not even normally be known. Thus, there arose the concept of a "virtual circuit," where the only defining network nodes lay at the ends and in which the intervening nodes are neither specified nor known by either network users or providers. This switching concept had been part of the basic ARPANET design and was now to be extended to this amalgam of wire and radio networks and thus to the world of internets.

It was the clear differences between the wire-based ARPANET and the radio-based packet radio (and eventually satellite networks) that led Kahn, then heading the networking efforts at ARPA, and Cerf at Stanford University, to design the first end-to-end protocol that could span dissimilar packet networks. The essence of such a construct began to emerge when Kahn addressed the problem posed by these dissimilar networks at a seminar held by Cerf in the summer of 1973. [3] After some airing in the internet community, the rudimentary elements of such a protocol came together for them on an October 1973 weekend at the Palo Alto Rickey's Hotel. [4] They published the design in May 1974, [5] and named it the TCP, or Transmission Control Protocol. With some modifications, it is still in use as the basis for transport in the worldwide Internet.

Following the introduction of TCP, ARPA contracted for three separate implementations: Stanford University, BBN, and University College in London. The first, clearly "buggy" specification to appear was in December of 1974 when Stanford produced RFC 675. BBN had an in-house version working reliably about a year later and began exchanging TCP traffic with Stanford on an intranet basis. Jim Mathis, a student of Cerf's at Stanford, started to implement their protocol in 1975. He came to SRI in the summer of 1976, where he completed a version that would run on the much more modest hosts of the packet radio network (Digital Equipment Corporation LSI-11 microcomputers). In the meantime, Cerf, now a program

(top) The site of the first two-network internet transmission on August 27, 1976 (from the left: Don Cone, (unknown), Nicki Geannacopulos, Dave Retz, Ron Kunzelman, Jim McClurg, and Jim Mathis).

(bottom) Nicki Geannacopulos compiles and sends online the packet radio weekly report.

manager at ARPA, was trying his best to inculcate the Department of Defense with the virtues of packet switching and TCP for their future data networks.

As a part of this emerging digital radio network, SRI foresaw the need for a mobile laboratory. A lot of design work lay ahead regarding the notions of nodal power and reach, the size of packets and the functions they were to perform, and the routing and reliability strategies in a network characterized by packet loss rates much higher than that seen on wire-based networks. Then there were the critical choices of radio frequencies and the signal processing strategies for the propagation and noise environments in which such a packet-switched radio network would operate. Since computers are notoriously intolerant of errors, how could a vulnerable radio environment be made to transport perfect data?

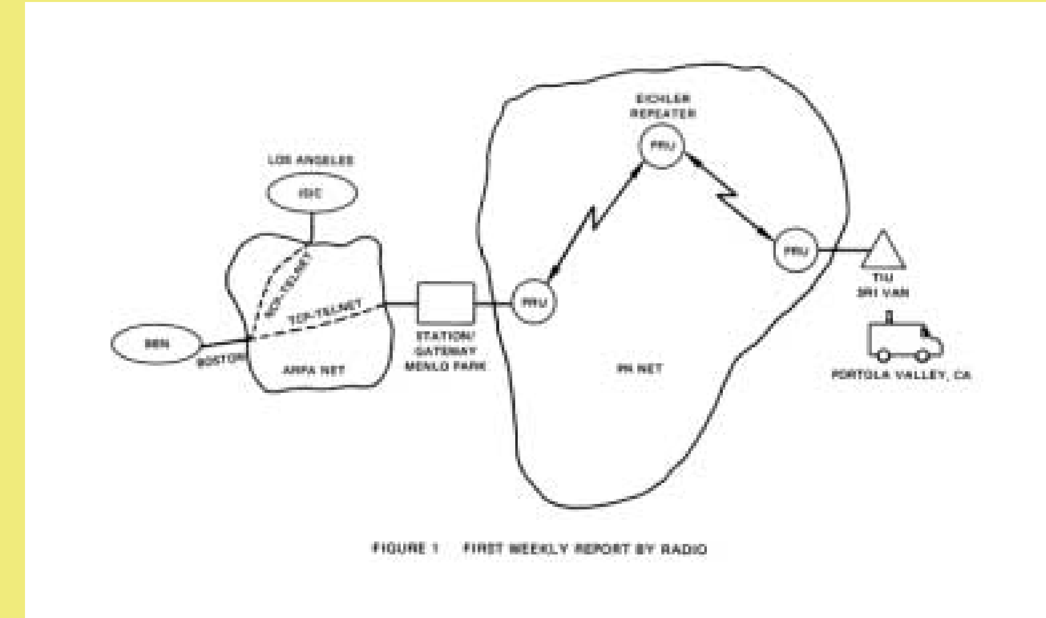
The SRI van was first used to characterize the radio frequency channel on which a packet radio system would be expected to operate. This was to be a fault-tolerant, dynamically-adaptable network. And so, a tough urban setting, with its shielding, reflective buildings, and electrical noise, was chosen. Radio modulation was designed that was tolerant of multipath distortion and noise. Packets were encoded for error detection and re-transmission when received inaccurately. Noise and the propagation patterns were characterized. When it came time to transport information across the packet radio network, a subnet was installed in the Bay Area and the van became a mobile node in that network. The PRNET became a self-organizing network, with addressing and routing, capable of accommodating the transmission challenges imposed by mobile users. It was the first mobile packet network.

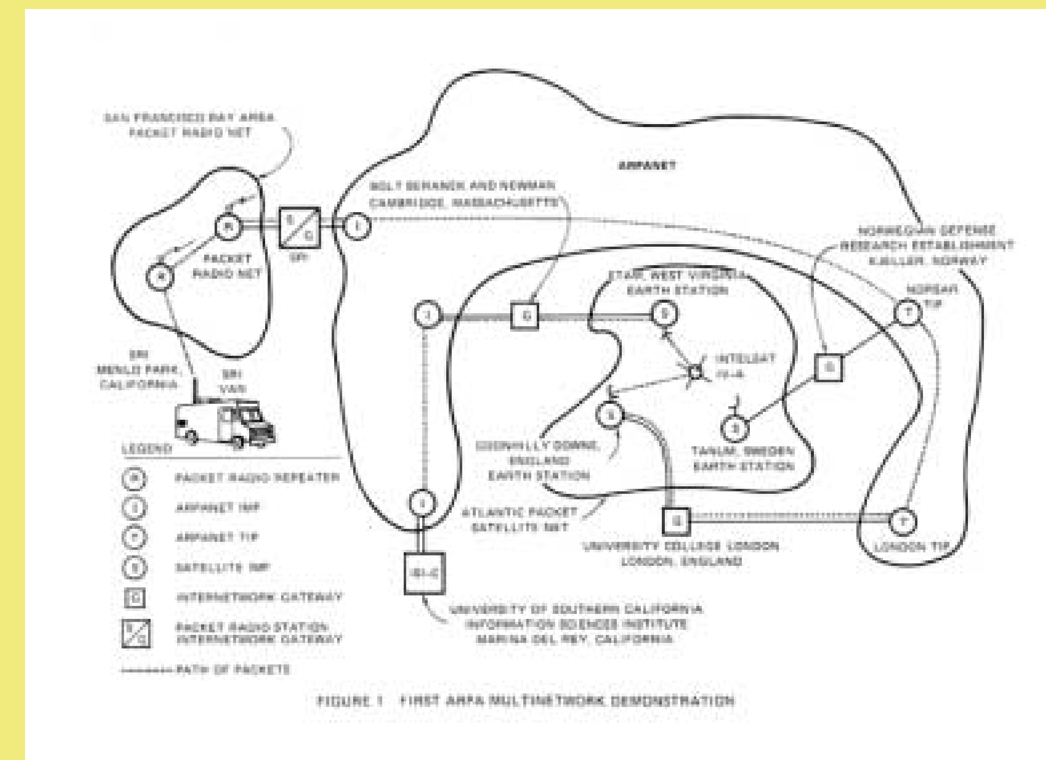
Given the difficulty of the radio environment, a couple of interesting demonstrations were often used at the time to illustrate the robustness of this new concept of networking. To illustrate the flow of traffic between a terminal in the mobile van and some distant network host, a character generator would grind out continuous alphanumeric sequences that formed patterns on a CRT in which errors would be obvious. While moving at high speed in the SRI van, the signal would sometimes be interrupted due to shielding of the radio signal (as when going beneath an underpass). The flow would stop momentarily but no errors were observed. Error-detecting cyclic redundancy checks, applied at the end of each transmitted packet, were used to verify reception accuracy. These checks plus the end-to-end ordering and re-transmission properties of TCP would not permit delivery of altered packets even though packets were frequently lost! Another similar procedure was to withdraw the synthesizer card from the packet radio. This would terminate the character flow, but re-inserting it would start it again. Thus, traffic would stop, then resume, but no errors were ever observed. Those demonstrations were splendid evidence that each packet could have sanctity, even in a tough environment of intermittent propagation and noise. This was an exciting consequence and certainly foreign to those circuit-oriented engineers who saw mobile digital radio systems as some sort of oxymoron.

The first testing of TCP across dissimilar networks started in the summer of 1976. The first trials stayed one radio hop from the Packet Radio station (the PRNET's controlling node) where the bidirectional ARPANET gateway software, built by Ginny Strazisar at BBN, was located. During July and August the SRI team tested and tuned Mathis' version of TCP for better accuracy and speed. It was in August of 1976 that a terminal, attached to an LSI-11 "host" running TCP that was in turn attached to the PRNET, proceeded through a gateway to first access an ARPANET host. For the first time, at least in a ceremonial sense, dissimilar networks were bridged by TCP, thus clearly creating a two-network internet connection. That specific network configuration is shown in the figure at the top right, which is copied from a packet radio progress report written at that time.[6] The occasion was the aforementioned distribution via TCP of the normal, long weekly Packet Radio Program report. (Those SRI people present are also shown in the pictures on the left page.) Other two-network TCP connections would soon follow.[7]

Within a year, and fulfilling the assumed need for a network of global reach, ARPA moved to include its third packet network, one that was satellite-based. It was then time to demonstrate all three networks together. On November 22, 1977, what has come to be more generally regarded as the first internet transmission occurred between the SRI mobile packet radio van and a host computer at USC by way of London! The route is shown on the bottom right.[8]

So internetworking was born of necessity, to demonstrate at ARPA that the innovations of packet switching were indeed relevant to the military's mode of operation. No matter where deployed, they could move about as needed and still be tethered to the powerful computing hosts kept safely away from the fighting. The robustness of the networks, be they fixed or mobile, was, of course, not just a military feature. Packet switching was sensible from the point of view of high network utilization and for offering a soft failure in the presence of moderate network congestion or even limited node failure. To be sure, the PRNET was a collective effort of many people, just as were the first workings of the internet. But the SRI van, purchased by SRI as a piece of capital equipment and designed to be used in a wide variety of experimental roles, found its major role in these first internetworking experiments.





(top) Diagram of the first two-network internet transmission on August 27, 1976. (Original illustration from an SRI technical report "Progress Report on Packet Radio Experimental Network" published in September 1977.)

(bottom) Diagram of the first three-network internet transmission on November 27, 1977, comprised of three physical and four logical networks, the ARPANET being used twice. (Original illustration from an SRI technical report "Progress Report on Packet Radio Experimental Network" published in February 1978.)

AFTERWORD

The possible importance of "the van" began to surface sometime in 1996 when an *IEEE Spectrum* editor called and mentioned that Vint Cerf had said in an interview that "SRI was the site of the first internet transmission." I said I would look into it and began digging through old PRNET documentation to verify a couple of events that I vaguely remembered.

After the November 1977 date was confirmed and defined accurately and had been promulgated a bit, the next call came from The Computer Museum History Center (now the Computer History Museum) about celebrating the 20th anniversary of the Internet at the Supercomputer Conference in San Jose in 1997. I offered that the van was still at SRI but had languished unused for perhaps 10 years on the back lot. When it was clear there was interest in putting it on the convention floor, Don Alves of SRI and I began the job of getting it running, dressing it up as best we could, trying to replenish the almost non-existent radio and internet equipment that had been in it, getting it re-licensed, and coaxing it to San Jose. While not beautiful, it did seem to carry some symbolism for many who saw it. So, rather than returning it to certain deterioration and scrap, SRI offered it to the Museum, where it lives today.

Don Nielson has been at Stanford Research Institute, now SRI International, for 40 of its 55-year history. During the events associated with the internet transmissions mentioned above, he was the SRI principal investigator for ARPA in the early stages of the packet radio program. While that program was unfolding, he became director of SRI's Telecommunication Sciences Center (1975), the center at SRI for computer networking. To better align its work with the future of computing, this group was permitted by SRI to join the Computer Science Division, which Don came to head from 1983 until his retirement as an SRI vice president in 1998. Since then he has been writing a book on SRI's major innovations, from which this segment about the SRI van was drawn.

1 Identifying the first of anything that is created in a collaborative way is somewhat arbitrary. Certainly, experimental trials had been conducted prior to this time. Then there is the question of how many networks it takes to qualify as an "internet." In this case we have chosen first the minimum number—two—and then about a year later—three. In all this we are of course referring to just the transport aspects of internetworking. The terminology of "packets" arises from how message traffic is packaged in modern digital networks. A packet is a fixed-length, individually-addressed subunit of a message. Its fixed length simplifies buffering hardware at all the intermediate nodes and its addressing permits both packet accountability and diffusion across unused portions of a network.

2 TCP is the acronym for Transmission Control Protocol, network software that establishes, operates, and closes a reliable virtual circuit across dissimilar networks. While still in use today, the overhead for this type of connection was deemed excessive for some types of traffic. This soon led to a companion transaction protocol called the Internet Protocol (IP). Together they comprise the transport system of today's Internet.

3 Abbate, Janet. *Inventing the Internet*, MIT Press, 1999, page 127.

4 Communication with Vinton Cerf, January 15, 2002.

5 Cerf, Vinton G, and Robert E. Kahn. "A Protocol for Packet Network Interconnection," *IEEE Transactions on Communications*, Vol. Comm-22, No. 5, May 1974.

6 From "Progress Report on Packet Radio Experimental Network," by R.C. Kunzelman, M.A. Placko, and R.T. Wolfram. Quarterly Technical Report 5, SRI Project 2325, Contract DAHC15-73-C-0187, ARPA Order 2302, September 1977.

7 An expected part of the ARPA work was to demonstrate progress and give evidence of this new networking capability. So TCP, spanning the PRNET and the ARPANET, would be demonstrated in May 1977 between the SRI van and hosts at ISIC and SRIKL. On August 11, 1977, a TELNET connection was demonstrated between the van and the Naval Ocean Systems Center in San Diego for Admiral Stansfield Turner (Dir. CIA) and William Perry (DDR&E). On September 19, 1977, a single LSI-11 microcomputer, running a multi-connection TCP, multiplexed four terminals through a packet radio to four different ARPANET hosts, essentially all of the ones running TCP servers at the time.

8 From "Progress Report on Packet Radio Experimental Network," by R.C. Kunzelman, V.D. Cone, K.S. Klemba, J.E. Mathis, J.L. McClurg, and D.L. Nielson. Contract MDA903-78-C-0126, ARPA Order 2302, February 1978.

THE SRI VAN AND EARLY PACKET SPEECH

When the ARPANET was perhaps five years old and before the development of internet protocols, Bob Kahn at ARPA set a group of contractors exploring how the new network could handle normal telephone traffic. Given the initial focus on reliable data transmission, it was not clear whether the variability in interpacket delay would permit the smooth flow required by a voice call. In 1974, Kahn initiated the Network Speech Compression Program because of the narrow bandwidth of the initial circuits comprising the net. This program resulted in the choice of some compression algorithms and these were first tried over the ARPANET. In 1976, SRI's Earl Craighill and Tom Magill, both of whom had been working on the speech program, convinced ARPA to let them try speech on the Bay Area PRNET. By this time the internet protocol, TCP, was also being tested and so speech experiments began also on an internet basis.

Because the SRI van was an easily outfitted facility and already had packet radio and internet equipment installed, it became the first mobile node for packet speech experiments. In addition to the challenges of mobile data transport, transporting natural-sounding speech focused on the importance of delay variance. Innovations were needed in variable rate encoding, new buffering strategies, and rapid rerouting of packets whenever the route in use failed. All these were to help smooth the flow of speech. Importantly, these requirements for packet speech influenced the decomposition of the protocol into reliable or guaranteed (TCP) and non-guaranteed (IP) services.

Thus, internet speech connections were being conducted as early as 1977-1978, about the same time as the Internet itself was becoming a reality.

(top) SRI's Speech Packet Project Leader Earl Craighill in the SRI van, which housed the speech encoding and packetizing equipment.

(bottom) SRI's Jan Edl demonstrating speech transmission over the Internet. The Mickey Mouse phone was deliberately used to illustrate that the speech equipment hardware and software was designed to accommodate a standard, off-the-shelf telephone.

COMPUTERS MADE IN SWITZERLAND

BY DOMINIK LANDWEHR

1 The Swiss Federal Insitute of Technology (ETHZ) in Zurich opened the first Swiss computing department (called the Institute for Applied Mathematics) in January, 1948, where the earliest Swiss computer, the ERMETH, was developed under the direction of Eduard Stiefel.

2 After an extensive survey of (primarily U.S.) computers existing at the time, Stiefel and his team developed the ERMETH—Elektronische Rechenmaschine der Eidgenössischen Technischen Hochschule (ETH)—which was of simple design, built to perform reliable scientific calculations, and which ran for the first time in July 1956.

3 In the late 1970s, Zurich computer specialist Niklaus Wirth was inspired by the "workstation" concept he discovered at Xerox PARC. He returned to Switzerland to build the Lilith machine, which had a screen of higher resolution than the contemporary Apple II, and made use of a mouse.

4 Wirth built the Lilith computer between 1977 and 1980. The powerful workstation was one of the first to have a mouse, a high-resolution monitor, and a graphical user interface—well configured for graphics creation. By comparison, at this time, the Apple II was equipped with just a keyboard for input.

5 The Dépraz mouse, the first computer mouse "made in Switzerland," was manufactured by precision engineering expert André Guignard for Wirth's Lilith workstation.

6 A bottom view of the Dépraz mouse.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INTRODUCTION

Over the past 150 years, products such as instant coffee and soups, precision tools and machinery, pharmaceuticals, and medicines have elevated Switzerland to a leading position among the world's industrialized nations. One might therefore expect Switzerland to have equally made a name for itself in the development and marketing of computers. Despite some brilliant computer pioneers, such is not the case, however, and Swiss products don't hold as prominent positions in the world computer market as they do in textile machinery and gas turbines. But who knows what will happen in the future?

EARLY COMPUTING AND THE LILITH COMPUTER

The best place to begin our search for innovative computer products is at the Swiss Federal Institute of Technology in Zurich (ETHZ), one of the few universities in Europe that could stand comparison with the elite universities of the United States. Between 1954 and 1959, electrical engineer and Professor Eduard Stiefel and two of his assistants (later professors themselves), Heinz Rutishauser and Ambros Speiser, developed a science-oriented computer, the ERMETH. This early computer has indeed been seen as a significant advancement, but it was rapidly overtaken by other computing developments. In particular, as noted by Ambros Speiser: "The real importance of data processing in the commercial field was not recognized until these applications began to overtake those of a scientific nature."

In 1976, Niklaus Wirth, a Zurich computer specialist who at the time regarded himself as an electrical engineer, traveled to the Xerox Palo Alto Research Center (PARC) in California. There he saw a "workstation" for the first time: a machine capable of dialogue with the user that would make possible an entirely new approach to computing. At the end of a year in California, Wirth made the return journey to Switzerland with a computer mouse in his suitcase and an improved workstation design in his head. Developed under the name Lilith, the workstation had a high-resolution graphical screen (592 x 768 pixels, compared to the alphanumeric display of 24 lines of 40 characters of the contemporary Apple II) and made use of a mouse as well as rudimentary windowing technology. This computer was nevertheless not yet based on a microprocessor but rather on relatively low-integration level circuits.

When its commercialization started in 1982, the Lilith machine was sold as a pure research computer. A first batch of 10 was built in the USA at a unit price of 20,000 Swiss Francs. The first "outsider" to discover this Swiss machine was Heinz Waldburger who, as head of computer services at Nestlé, was looking for a high-performance solution for his corporation. Waldburger was already looking ahead to the concept of a multimedia computer capable of processing not just data but also images and sounds. His specifications helped provide a name for the new company that would market the Lilith: DISER (Data-Image-Sound-Processor and Emitter-Receiver system). The line included two "Modula Computers"—an MC 1 and an MC 2. DISER had ambitious objectives and it opened sales offices in Zurich, Lausanne, Orem, Atlanta, Chicago, Dallas, and Paris. But a total of only 140 machines were manufactured, of which 120 were sold. The company misjudged its market and after six months it was already at the end of the road. Cheap memory chips and high performance microprocessors had ushered in a new era.

LOGITECH–KING OF THE COMPUTER MOUSE

When Wirth set out to build his Lilith workstation in 1978 he found himself in need of a computer mouse. His colleague, Jean-Daniel Nicoud of the Swiss Federal Institute of Technology in Lausanne, managed to get the precision engineering expert André Guignard interested in the project. The result was the first computer mouse "made in Switzerland," which was built by the Dépraz company and used for the Lilith workstation.

Roughly at the same time another Swiss, Daniel Borel, a physicist and graduate student at Stanford, discovered the Alto workstation, the new interface technologies—mice, menus, and windows—as well as America's entrepreneurial spirit. That provided him with inspiration to found his own company. He began thinking hard about exciting products on which to base a new company. In 1981, Daniel Borel, Pierluigi Zappacosta, and Giacomo Marini founded Logitech.

Logitech eventually took over the mouse concepts and products from Nicoud and Dépraz, developed prototypes suitable for mass production and showed these to potential clients in the computer industry. "Various companies including Hewlett-Packard immediately showed an interest. But they told us our products were too costly," remembers Borel. The next step was decisive for the ultimate survival of the company: they managed to create a subsidiary in Taiwan and to transfer production there. Because dozens of Taiwanese competitors soon arose, Logitech had to react quickly and always work hard to undercut them. This was only made possible because the subsidiary was managed locally from Taiwan, whereas business could not have been conducted out of Switzerland or California. Today Logitech is a leader not only in the computer mouse field but more generally in computer-human interfaces (touchpads, keyboards, trackballs, joysticks, webcams, etc.).


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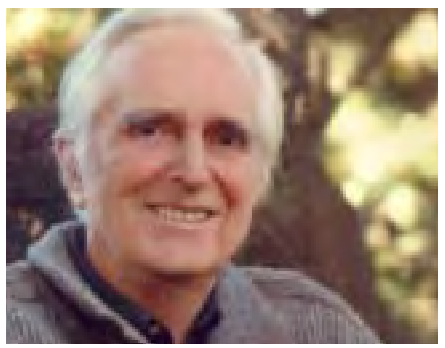
7 Daniel Borel was inspired by "new" interface technologies—mice, menus, and windows—and ultimately co-founded Logitech in 1981. He is now president of this successful company.

8 Doug Engelbart pioneered the mouse in the 1960s at SRI.

9 In 1994, Supercomputing Systems (SCS) founder Anton Gunzinger was highlighted in a *Time* magazine special issue as one of 100 figures who will influence events in the 21st century. SCS then delivered the promising, but commercially unsuccessful, GigaBooster supercomputer to the market.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While the Logitech head office remains in Switzerland, the company's operational headquarters are in Fremont, not far from Stanford University. It is no coincidence that the same building also houses an organization by the name of Bootstrap, the consulting firm of the inventor of the mouse, Doug Engelbart. Engelbart pioneered the mouse and a number of other developments at the Stanford Research Institute (SRI) in the 1960s. Engelbart did not become rich from his inventions, and indeed the recognition of his achievements was late in coming. But as a guest of Logitech, Bootstrap pays no rent. It is Borel's way of saying thank you to the researcher who made it all possible.

BYE-BYE SUPERCOMPUTER

It was not that long ago that the name of Anton Gunzinger, a Zurich computer specialist, was very popular. In a 1994 *Time* magazine special issue, Gunzinger was named one of 100 people who will inluence events in the 21st century. Gunzinger had succeeded in developing a very promising new computer that not only improved performance significantly while consuming less energy, but more importantly, cost a mere fraction of the "supercomputers" then on the market. Gunzinger and his team created a design based on 170 processors, all working in parallel, which in practice achieved a speed of 10 gigaflops, i.e., 10,000 million floating-point operations per second, with the maximum possible speed at that time being between 100-200 gigaflops. Encouraged by his achievements, Gunzinger founded the company Supercomputing Systems (SCS) in 1993. The new start-up was built on a dream: "We shall make supercomputers in Switzerland and earn a living at it." The company's presentation included the trendy tag line: "because it's fun."

Switzerland's first commercial supercomputer hit the market in 1995 with the combative name "GigaBooster." But just 10 units were sold. Today Gunzinger coolly analyzes the flop in the following terms: "At a time when PCs were becoming more powerful with each passing year, we were competing in the wrong market and research funds from the state and other sources simply dried up." There was another problem too: the software had to be frequently updated and the costs soon exceeded the capabilities of such a small firm, which brought production to a halt.

Gunzinger's SCS did, however, overcome this hardship and is still going strong today, employing some 60 people. As Gunzinger says, "We have learned from our mistakes and we now stick to what we are good at, namely developing computer systems." SCS is now active in a wide variety of fields, and has developed, for instance, a digital sound mixer based on up to 126 processors, making use of Gigabooster technology, as well as a

10 SupercomputingSystems' GigaBooster hit the market in 1995 as a promising super computer that greatly increased performance for a fraction of the cost. Yet only 10 units were sold.

11 Jean-Daniel Nicoud facilitated the donation of a significant portion of the items listed on page 13. A foremost developer of microprocessor-based computers in Switzerland, Nicoud spent hours documenting the donation for the Museum.

12 This logic module from the ERMETH computer now resides in the collection of the Computer History Museum. The first computer ever built in Switzerland, the ERMETH is currently on display at the Technorama in Winterthur, Switzerland.


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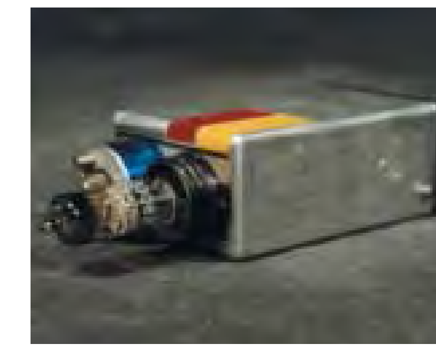
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new encryption system that is able to encode and decode at a rate of 155 megabits per second.

CONCLUSION

One out of these three ventures became a worldwide and widely-respected player in the computer business. Not a bad percentage overall, although one could have dreamed of a more prominent role for Switzerland in the hardware field. On the other hand, in niches like knowledge management, secure banking transactions, cryptography, etc., many Swiss pioneers and companies are key players, and venues like biocomputing are just beginning to be explored.

The discovery of this mostly unknown role in computer history has also paved the way for various conservation initiatives. The Museum of Communication in Bern displays the most important milestones of the PC's history worldwide in its temporary exhibition, "Control-Alt-Collect: Computers in Retirement," which will last until Spring 2003. Various private collections have been made accessible to the public. A private initiative led by the Association of Friends of the Swiss Computer Museum, which aims at better understanding the increasing influence of information and communication technologies on society, plans to create a museum which will gather large Swiss collections of calculating and typing machines as well as computers. Finally, in October 2001, the enthusiastic donation of more than 3.5 tons of computers from Switzerland to the Computer History Museum is yet another sign of the increased interest in this global technology revolution. ■

Dominik Landwehr is the head of the Science and Future Department at the Migros Culture Percentage, a private Swiss benefactor that is designed to give the general public access to cultural and social events. Landwehr is running a number of educational and artistic programs in the field of technology. He regularly contributes articles to a number of publications, including the renowned *Neue Zürcher Zeitung,* which covers a wide array of topics about technology and society. At present he is doing research into the use of the German cipher machine Enigma, which was widely used in Switzerland during World War II. Landwehr graduated from Zurich University and has worked for various Swiss newspaper, radio, and television agencies. A number of missions for the International Committee of the Red Cross (ICRC) brought him to Thailand, Romania, and the Afghan border in Pakistan.

RECENT DONATIONS

TO THE COMPUTER HISTORY MUSEUM COLLECTION

ARTIFACTS AND SOFTWARE

Computer Displays, Inc., Mechanical Mouse (c. 1970), X2322.2002, Gift of Richard Fryer

Data General/One Notebook computer, printer, software, documentation, and carrying case (c. 1983), X2297.2002, Gift of William Geiger

DEC VLSI VAX microcode and documentation CD-ROM archive, X2350.2002, Gift of Bob Supnik

ETH Zurich Switcherland (1993-98), X2323.2002, Gift of Hans Eberle

Fairchild Semiconductor 1/2-inch wafer of planar transistors (1958), X2351.2002, Gift of Art Zafiropoulo

Fairchild Semiconductor first working planar transistor (1957), X2352.2002, Gift of Art Zafiropoulo

Hewlett-Packard HP110 portable computer (1984), X2338.2002, Gift of Allen Chalmers

IBM 026 keypunch print wheel (c. 1960), X2243.2002, Gift of Lee Schur

IBM 10SR MODII 14-inch hard drive assembly (HDA), X2344.2002, Gift of Will Galloway

IBM Model 604 Electronic Calculating Punch (1948), X2294.2002, Gift of Robert Garner

Marchant Calculating Machine Company "Figurematic" calculator (1948), X2320.2002, Gift of George William Bolton

Non-Linear Systems Kaypro 4 portable computer, documentation, and software collection (1984), X2333.2002, Gift of Ronnie Sue Helzner

Punch card equipment and book collection (c. 1958), X2281.2002, Gift of Alfred C Hexter

DOCUMENTATION

Applied Computer Techniques Apricot Software collection (1985), X2332.2002, Gift of Michael Kimball

Automatic Digital Calculators (1965), X2324.2002, Gift of Allen Baum

Basic Programming Concepts and the IBM 1620 Computer (1962), X2282.2002, Gift of Derek Peschel

Computer book collection (various dates), X2299.2002, Gift of Harry Stewart

Early computing texts collection (various dates), X2354.2002, Gift of L Peter Deutsch

Operating Principle of the Belgrade Hand Prosthesis Mechanism, X2293.2002, Gift of Tom Callahan

Preliminary description of the UNIVAC (1950), X2292.2002 A, Gift of Robert Garner

RCA 301 documentation collection (c. 1965), X2339.2002, Gift of Allen Chalmers

RCA 301 salesmen's model (c. 1960s), X2337.2002, Gift of Allen Chalmers

Texas Instruments Advanced Scientific Computer internal memo collection and machine descriptions (c. 1968), X2347.2002, Gift of William Kastner

Two early programming texts by Kristen Nygaard (c. 1965), X2336.2002, Gift of Kristen Nygaard

UNIVAC Maintenance Manual (1958), X2292.2002 B, Gift of Robert Garner

UNIVAC Solid-State 90 bound manual set (1959), X2292.2002 C, Gift of Robert Garner

Xerox PARC technical report collection (70 publications) (1970s-1980s), X2353.2002, Gift of James Mitchell

Xerox PARC technical report collection (c. 1970s-1980s), X2295.2002, Gift of Mike Rutenberg

GIFTS OF MICHAEL PLITKINS

Apple Computer, Inc., Apple II GS Woz Edition personal computer system (c. 1989), X2415.2002

Apple Computer, Inc., Lisa II System including four profile external hard drives, an AppleWriter printer, an ImageWriter II printer, an Apple Modem 1200, and assorted PCBs (c. 1990), X2431.2002

Apple Computer, Inc., Lisa/Mac XL personal computer system (1984), X2410.2002

Apple Computer, Inc., Newton Message Pad 100 (1993), X2405.2002

Atari Computer Corporation Atari 400 home computer (c. 1980), X2422.2002

Atari Computer Corporation Atari 400 home computer (c. 1980), X2423.2002

Atari Computer Corporation Atari 800 home computer (c. 1982), X2424.2002

Atari Computer Corporation Atari 800 home computer (c. 1982), X2427.2002

Atari Computer Corporation Atari 810 home computer disk drive (c. 1982), X2425.2002

Atari Computer Corporation Atari 810 home computer disk drive (c. 1982), X2426.2002

Atari Computer Corporation Portfolio 16-bit personal computer (1989), X2407.2002

Canon Cat V777 Work Processor (1987), X2402.2002

Commodore Business Machines Amiga 1060 personal computer (c. 1985), X2419.2002

Commodore Business Machines Commodore 16 (c. 1983), X2417.2002

Commodore Business Machines Commodore 64 (c. 1978), X2418.2002

Commodore Business Machines PET 2001 Personal Computer (1977), X2400.2002

Commodore Business Machines plus/4 Personal Computer (c. 1983), X2416.2002

Convergent Technologies, Inc., Workslate (1983), X2406.2002

Convergent Technologies, Inc., Workslate microprinter (c. 1985), X2428.2002

Hewlett-Packard Integral Personal Computer (1985), X2412.2002

IBM Vacuum Tube Logic Trainer (c. 1955), X2411.2002

Mindset Corporation MINDSET personal computer system (1983), X2408.2002

Mindset Corporation MINDSET personal computer system (1983), X2409.2002

Motorola, Inc., Envoy Personal Wireless Communicator (c. 1994), X2405.2002

Osborne Computer Corporation Executive Portable Computer (1982), X2401.2002

Osborne Computer Corporation Vixen portable computer (1987), X2403.2002

Radio Shack TRS-80 64K Color Computer 2 (c. 1985), X2414.2002

Radio Shack TRS-80 Micro Color Computer (c. 1984), X2413.2002

Sinclair Research Ltd. QL microcomputer (c. 1984), X2429.2002

Sony Corporation Hit Bit HB-75AS home computer (c. 1983), X2428.2002

Sun Microsystems Sun-3/80 workstation system (1990), X2420.2002

Symbolics, Inc., 3620 LISP workstation system (c. 1990), X2430.2002

Texas Instruments Homecomputer 99/4A (c. 1979), X2421.2002

If you would like to update the Museum regarding your artifact donation, please contact Registrar Jeremy Clark at +1 650 604 1524 or clark@computerhistory.org.

COMPUTING IN SWITZERLAND ITEMS

Bobst Graphic Lausanne Scrib portable computer (1977), X2310.2002, Gift of Bobst Group SA

Convex Computer Corporation, C3820 Gallium Arsenide Supercomputer System (1994), X2301.2002, Gift of the Swiss Center for Scientific Computing

Convex Computer Corporation, C3820 manual collection (c. 1991), X2327.2002, Gift of the Swiss Center for Scientific Computing

Crocus manual collection (c. 1976), X2328.2002, Gift of Jean-Daniel Nicoud

Epsilon-System, SA, Crocus microcomputer system kit (1977), X2313.2002, Gift of André Thalmann

Epsitec Smaky manual collection (1986-1994), X2325.2002, Gift of Jean-Daniel Nicoud

Epsitec Systems Belmont/Lausanne Smaky 324 single board computer (1987), X2302.2002, Gift of Epsitec SA

Epsitec Systems Smaky 100 personal computer (1984), X2307.2002, Gift of Jean-Daniel Nicoud

Epsitec Systems Smaky 130 personal computer system (1990), X2308.2002, Gift of Jean-Daniel Nicoud

Epsitec Systems Smaky 300 personal computer (1990), X2311.2002, Gift of Epsitec Systems SA

Epsitec Systems Smaky 400 single board computer (1996), X2312.2002, Gift of Epsitec Systems SA

Epsitec Systems Smaky 6 Microcomputer and Stoppani Electronic SA MICROLERU Smaky 6 microcomputer paper tape reader (1978), X2309.2002, Gift of Jean-Daniel Nicoud

ETH Zurich Ceres-1 (1987), X2321.2002, Gift of Hans Eberle

ETH Zurich Ceres-3 personal computer system (1990), X2318.2002, Gift of Nicklaus Wirth and ETH Zurich

ETH Zurich ERMETH logic module (c. 1956), X2314.2002, Gift of Ambros Speiser

LCD-EPFL Novasim Virtual Data General NOVA peripheral (1972), X2306.2002, Gift of Jean-Daniel Nicoud

LCD-EPFL Stoppani, Ltd. Travers Dolphin (Dauphin) System "Club" development system (1977-1980), X2304.2002, Gift of Jean-Daniel Nicoud

LCD-EPFL Stoppani, Ltd. Travers Dolphin (Dauphin) System "Industry" development system (1977-1980), X2305.2002, Gift of Jean-Daniel Nicoud

LCD-LAMI-EPFL OMS Data Aquisition System (1972), X2303.2002, Gift of Jean-Daniel Nicoud

Microscope journal collection (1975-1980), X2326.2002, Gift of Jean-Daniel Nicoud

Supercomputing Systems GigaBooster (1992), X2316.2002, Gift of Supercomputing Systems

Supercomputing Systems MUSIC (Multiprocessor System with Intelligent Communication) (1994), X2317.2002, Gift of Supercomputing Systems

Supercomputing Systems Swiss TNet crossbar switch and connectors (1999), X2315.2002, Gift of Supercomputing Systems

Swisscom AG Swiss public telephone booth containing a working Teleguide electronic telephone directory (c. 1997), X2319.2002, Gift of Swisscom AG

EXPANDING THE COLLECTION

The Computer History Museum often receives support from friends of computing history who work with our collections team to expand the collection in important ways. Individual donors may contribute their own collections, as with the items listed on the opposite page that were donated by **Michael Plitkins**, a senior staff engineer in advanced telephony at TellMe. A quick scan through the list reveals Plitkins to be a collector of both popular and obscure computing artifacts—including rare prototypes—with a real nose for the important details of computing history as well. It is an honor that he chose the Museum to be the recipient of his devoted and personal collecting efforts.

The items listed on this page reflect another such effort, when several people and organizations made a group donation this past fall of artifacts related to computing in Switzerland. Over the course of many months, the Swiss Science and Technology Office at the Swiss Consulate in San Francisco helped pull together a donation of computers, peripherals, documentation, and stories by several key players. The items were then shipped (courtesy of PRS Presence Switzerland) to the Museum (most were shipped from Switzerland), and were exhibited at a reception prior to the Fellow Awards Banquet on October 23, 2001. This exhibit of a truly "international" flavor was much appreciated by donors and friends of the Museum, since many of them had never had the opportunity to see Swiss-made computing innovations, except Logitech mice, of course!

One of the "key players" in this particular donation was **Jean-Daniel Nicoud**, a leader in Swiss microprocessor-based computing and micro-robotics and professor emeritus at the Swiss Federal Institute of Technology in Lausanne. Not just a prolific inventor, Nicoud was also a favorite with students because of his interactive and creative teaching style, as well as the variety of robot-building contests he set up over time. In 1974, he organized the first International Conference on Microprocessors and coordinated 10 other conferences over the years. Nicoud indicates that miniaturization and human interaction have always held an attraction for him, and he continues to develop small mobile robots, with particular interest in defusing landmines and in the development of autonomous flying robots. As a co-developer of the first Swiss mouse and of several subsequent Logitech mice, Nicoud also developed the Scrib, the first portable computer for journalists, and built the line of Smaky personal computers, which were the only Swiss-made computers that sold in significant numbers. In the course of this "Swiss" donation, Nicoud spent hours religiously documenting the machines and their development processes so that the Museum could have appropriate materials through which to understand and exhibit the items.

As an institution, the Museum is grateful for the time and dedication of people like Plitkins and Nicoud who truly value preserving the stories and artifacts of the information age. Indeed, it is only because of people like these that the Museum exists and will continue to grow.

BEYOND VIRTUAL

BY MIKE WALTON

HOW BIG A BOX DO YOU NEED?

What would you do if you wanted to present the entire history of computing and had limited square footage in which to put it? This is the challenge that the Computer History Museum faces, and for us the answer is clear: We need to present online the wealth of knowledge contained in our Museum.

You have probably heard of the great progress toward our permanent home in 2005, but another important innovation has been developing in our back rooms. As part of our critical mission, we are going to preserve much of computing history using today's computers and present it across the networks of tomorrow. While the physical Museum is being carefully crafted and planned to inhabit 120,000 square feet in the future, the Museum online is free to expand beyond the space restrictions of the "real" world.

We are calling this project the **CyberMuseum**. The name is derived from the term "Cyberspace," first coined by science-fiction author William Gibson in 1984 in his book *Neuromancer*:

> Cyberspace. A consensual hallucination experienced daily by billions of legitimate operators in every nation, by children being taught mathematical concepts....A graphical representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the non-space of the mind, clusters and constellations of data. Like city lights, receding...

Cyberspace was thus defined as a place where the world's information could be visualized. In the CyberMuseum, our goal over time is to visualize and access the entirety of computing history, making the institution an exciting place for the novice and serious researcher alike, enabling the gathering of authentic information at all levels of interest. This vision becomes powerful and challenging when coupled with the magnitude and quality of artifacts in our collection.

"GOING" ONLINE

An enterprising company today would probably never consider whether or not to have a website. The Internet has arrived, and if you're not there, it's like being cut out of the phone book. In many cases, "going" online usually means representing the physical institution with a phone number, address or driving directions—information that ties the website to the physical.

Our CyberMuseum will most certainly do this, but this "virtual" facsimile of the real world will inhabit only a portion of the overall CyberMuseum. Both the physical Museum and the CyberMuseum will benefit from shared research, overlapping exhibit design, and ever-increasing data about the collection. CyberMuseum projects can build tools to help manage our Museum data internally. Such tools can help the Museum develop, use, modify, and expand data in a centralized manner.

The CyberMuseum can go beyond the normal "virtual" museum, allowing our collection, media library, and other resources to be accessed through one easy-to-navigate portal. Exhibits online can provide multiple levels of experience, allowing any depth of research. The challenges of this vision, of course, are also great—to rapidly adapt and present consistent data in different views to a world-wide audience while keeping it simple enough to navigate by novice users, all on a small budget!

PRESERVING BITS AND PIECES

Experiments currently under way are exploring the possibilities outside the "virtual museum" box. The initial approach is to systematically convert the wealth of knowledge in our library, collections, and media stores into digital format while indexing what we have to increase depth and completeness of our data. By digitizing our collection, we are fulfilling multiple purposes: we preserve the information, and at the same time we make it usable for the web and other projects such as physical exhibit design.

Meanwhile, we are trying various ways to display, exhibit, and update this information. We are investigating ways to enrich video with other content, such as running transcripts or closed captioning. It is possible to create hyperlinks within the media to access material outside of the video presentation and thus enrich the experience.

To get through just a portion of the large collection we have acquired at the Computer History Museum would take years. So to begin, we identified some of the most significant subjects and objects, and are working with them in limited digital conversion exhibit experiments. Together with the exhibit design teams for the physical building, we are streamlining the process. By getting the "recipe" right for the many types of materials, we can begin the task of automating the lengthy process of working through the rest of the collection.

Some of the issues that arise as these experiments are carried out are: What formats will have longevity? How can the complex hyperlinks of interrelated information be managed? How detailed do these records actually need to be? How do you reconcile conflicting and missing information in such a complex environment? How do you best instill the "human factor" into digital reporting?

Chair of the CyberMuseum Committee Gordon Bell (right) and Director of Cyber Exhibits Mike Walton discuss the next set of project goals. The CyberMuseum will not only communicate the physical Museum to web visitors but will also present computing history in a dynamic and inventive way.

CYBERMUSEUM CHAMPIONS

The CyberMuseum project is not just about web objects, but is also about people and communities. Gordon Bell, an original founder and current Trustee of the Museum and a senior researcher at Microsoft, is a major champion of the CyberMuseum. He has dedicated a lot of personal time and resources to help bring the Computer History Museum's mission and vision to Cyberspace.

Bell has been performing a number of interesting personal explorations over the last few years in a project he calls MyMainBrain. Partly experiment in data representation, partly personal librarian, and right now, all about Gordon, MyMainBrain contains digitized documentation, images, media, and minutiae from his long career. He hopes to make the process available as a software tool for others to organize and catalog their own lifetime achievements or as a memory assistant and productivity aid.

The experiments and experience from MyMainBrain have already helped the CyberMuseum project by laying some of the groundwork for storage methods and data acquisition.

Bell also was a pioneer earlier in his career, among other places, as vice president of research and development at Digital Equipment Corporation. Digital led the revolution that empowered end users to interact directly with computers, for ever abolishing the idea of computers as untouchable by inexperienced hands. Cyberspace is advancing in this same spirit, and a CyberMuseum goal is to put the history of computing directly into the hands of the public.

CAPTURING ORAL HISTORIES

A picture and list of specifications might be an adequate display for a specific computer, but presenting personal histories with stories and media is a much more complex endeavor. The CyberMuseum is conducting experiments in capturing stories on video in a number of oral history projects. One of the fortunate facts about computing history today is that many of the early pioneers are alive to tell their stories. Some of the best information comes from the individuals who were on the front lines of computing history. Recording a story "straight from the horse's mouth" can capture not just basic statistics of the era but also a sense of the participant's world view, interpretation of events, and the emotions of actually being there.

Oral histories are often done by interviewers who are experts in the field and with highest production values wherever possible. The Computer History Museum is treating oral histories with the great care expected of a historical collecting museum, yet is also experimenting with new methods. We are also moving forward in our "pro-casual" video collection. By creating a portable recording studio, we can be on the spot for impromptu interviews.

The CyberMuseum plans to organize the oral histories online, posting past and present interviews along with statistics, artifact information, and materials from other sources to create an information-rich environment. Our monthly lectures are also videotaped and can be added to our permanent display on the web. Soon you might be able to watch our lectures streamed live from location.

At this stage, the role of the CyberMuseum project is to experiment, evaluate the technologies, provide recipes, and ensure the preservation of materials in formats that can be used online.

FOSTERING AN INTERNATIONAL COMMUNITY

Perhaps the greatest potential for the CyberMuseum project lies in reaching a much larger audience than the physical Museum could expect to reach. People who may never see us in person will be able to get much of the experience and information online. While nothing can replace the visceral experience of seeing the collection first-hand, the CyberMuseum will bring as much of it to life as possible.

We hope our efforts will bring together many outside sources of research in a multilateral preservation effort. A fortune in data and research is already at risk of disappearing for lack of funding or interest. The CyberMuseum can link researchers, user communities, universities, and collectors, while enrolling them whenever possible to participate in the common mission of presenting and preserving the stories of computing history.

If you would like to get involved with the project or contribute your stories or insights to the Museum, please contact us and become a part of our community.

Mike Walton is the Director of Cyber Exhibits at the Computer History Museum.

REAL DESIGN, REAL BUILDINGS

BY KIRSTEN TASHEV

SELECTING OUR TEAM

The Museum's building plans have passed some key milestones in the last several months, including our plans for both the permanent building and an exciting temporary facility. Last spring, after completing a five-month "ideas competition" with three outstanding architectural firms, the Museum selected Esherick Homsey Dodge & Davis (EHDD) of San Francisco, California, to design the new building. Museum Trustee and Building Committee Chairman Grant Saviers explained, "the purpose of the competition was not to choose a design for the new building, but to select the best architect for the project going forward." (Excerpts of the competition can be seen on our website). With the competition behind us, we are very pleased to be collaborating with the EHDD team on the design of the Museum's permanent facility.

"We are thrilled to work with the Computer History Museum board and staff to design one of the first Silicon Valley landmarks of the 21st Century," said Chuck Davis, senior design principal, EHDD. "Our goal is to capture the unique character of the Computer History Museum and to create an inspiring environment where people can learn and study computing history and innovation." Founded in 1946 by legendary architect Joseph Esherick, EHDD has become a leader in the architecture field, with a wide breadth of cultural institution experience including aquariums, museums, zoos, and libraries. EHDD has designed recognized facilities such as the Monterey Bay Aquarium in Monterey, California; the National Museum of Marine Biology/Aquarium near Kaohsiung, Taiwan; the Exploris interactive museum in Raleigh, North Carolina; and the east wing of the New England Aquarium in Boston, Massachusetts.

The Museum selected another first-class firm to develop the exhibitions for the new building. After an intensive interview process with eight qualified firms from across the United States as well as visits to the finalists' recent projects, we selected Van Sickle & Rolleri (VSR) of Medford, New Jersey. VSR is recognized for its work on the Experience Music Project in Seattle, Washington; the Gerald R. Ford Museum in Grand Rapids, Michigan; and the Intrepid Sea-Air-Space Museum in New York, New York. VSR has also received several awards including the Southeastern Museum Conference Curator's Committee Exhibition Competition Award and The American Association for State and Local History Award of Merit in 2000. Dennis Van Sickle, VSR principal, said, "We look forward to working on this most prestigious project and believe the time has come to create a museum that captures the rich stories of an industry that has truly changed the world."

CREATING COLLABORATION

From the beginning, the Computer History Museum purposefully set out to create a collaborative team relationship between architecture and exhibits in order to foster a process by which each discipline would inform the other. The goal is to create a building that seamlessly integrates the architecture and exhibits, so that they support and enhance each other. Towards this end, over the past summer, EHDD and VSR worked very closely with Museum representatives in the "programming" phase of the new building.

The purpose of the programming phase has been to clearly identify the scope of the building and to systematically refine the needs of the new facility in order to meet the Museum's mission, budget, and programs. Discussions have focused on the overall visitor experience as well as defining specific requirements including size, function, character, adjacency, and quality of each space (see chart on opposite page), while allowing enough flexibility in the design to accommodate future growth and change. As you read this article, the team is well into the next phase—"schematic design"—that will result in a more refined building program in terms of architectural amenities and exhibit spaces, as well as a signature building design.

PHASING THE APPROACH

In the "programming" phase, the team developed a strategy to build the new facility in two phases: Phase I, scheduled to open in late 2005, will initially include 32,000 sf (square feet) of gallery space with 23,000 sf of exhibits fully installed. Phase I also includes administrative offices, a retail store, a small café cart, a research reference library, a multi-purpose room for events, and other spaces for a total of 72,000 sf. The remaining 9,000 sf of exhibits within Phase I are scheduled to open in 2007.

In Phase II, an auditorium will be added as well as a larger restaurant. The exhibits will be expanded, as will the administration, library, and multi-purpose events spaces. Phase II will add approximately 48,000 sf and is slated to open in 2010. This strategy gives us flexibility with our program and budget and brings us remarkably close to our first estimates and goals made before the programming phase began. Together, Phases I and II equal approximately 120,000 sf.

BENCHMARKS

During the programming phase, Museum representatives and the design team conducted various information-gathering tours of local museums, including the San Francisco Museum of Modern Art, the San Jose Museum of Art, the Tech Museum of Innovation in San Jose, and the Children's Discovery Museum of San Jose. In the fall, the team was also fortunate to visit some outstanding international museums that display computer history exhibits, including the Science Museum in London, England; the Deutsches Museum in Munich, Germany; and the Heinz Nixdorf MuseumsForum in Paderborn, Germany. These are fantastic institutions and we are honored to be building strong relationships with them. Their hospitality was wonderful and greatly contributed to making the trip an overwhelming success.

BETA BUILDING UNDERWAY

Other exciting news currently in the works is our plan to construct a temporary building to be located less than 500 feet south of Moffett Field's landmark Hangar One, and adjacent to our future permanent building site. Scheduled to open in the fall of 2002, the temporary space is being dubbed the "Beta Building," both a nod to the computer industry's term for a product in testing phase and an indication that more is on the way with the Museum's permanent home opening in 2005. When the temporary space is completed, it will contain 41,000 sf of usable space, including 22,500 sf for artifacts storage; 9,000 sf for exhibits and event space for more than 200 people; and 9,500 sf for office space and a catering prep kitchen. It will be used for Museum functions, additional artifact storage, and will bring together staff now housed in three separate buildings at Moffett Field. The Beta Building will provide the Museum with the necessary space to grow, hold events, and stage and organize our artifact collection, and will allow us to explore new ideas as we plan our permanent facility.

The Beta Building will be located at Moffett Field, just south of the historic Hangar One and will provide the Museum with much-needed space for operations and exhibits during the process of building the new Museum building, scheduled to be completed in the fall of 2005.

The Beta Building is being designed by Daniel, Mann, Johnson and Mendenhall Holmes & Narver (DMJMH+N), an architecture, engineering, and construction services firm with offices in San Francisco and around the world. DMJMH+N's other recent public projects include the United States Botanic Garden Conservatory in Washington, DC; the School of Social and Behavioral Sciences at California State University in San Bernardino, California; and the Performing Arts Center at California State Polytechnic University in San Louis Obispo, California.

As you can see, we are moving forward rapidly to create critically important facilities necessary for us to achieve our goals and become the great institution we are striving to be. Our building plans—coupled with our CyberMuseum (see article on page 14), our active programs, and the communities of people who are helping us—will allow us to evolve and serve the public for many years to come. ■

Kirsten Tashev is the Building and Exhibits Project Manager at the Computer History Museum.

NEW BUILDING—AMENITY BREAKDOWN / PHASING PLANS (NET SF)

AMENITY	PHASE I (2005)	PHASE II (2010)	TOTALS
EXHIBITS (INCLUDES CIRC.)	32,500 sf	20,000 sf	52,500 sf
VISITORS SERVICES	7,230	0	7,230
CAFÉ (IN LOBBY AREA)	0	1,700	1,700
RETAIL 1,600		0	1,600
MULTIPURPOSE 1,600		9,000	10,600
ADMINISTRATION 6,560		5,000	11,560
LIBRARY 1,500		3,000	4,500
LOADING/SERVICES 4,200		0	4,200
BUILDING SERVICES	1,750	0	1,750

REPORT ON MUSEUM ACTIVITIES

BY KAREN MATHEWS

Karen Mathews is Executive Vice President at the Computer History Museum

Revolutionary Linus Torvalds spoke on September 18th about the extraordinary and accidental Linux phenomenon.

In his lecture last fall, Dan Ingalls discussed Smalltalk, the software environment meant to support the Dynabook computer, and which evolved into the current-day object-oriented Squeak.

An October panel called "Early Mouse Encounters" featured (left to right) Doug Engelbart, Bill English, Jean-Daniel Nicoud, Stuart Card, Niklaus Wirth, and Daniel Borel (not shown) on the earliest developments of the mouse user interface.

Fred Brooks addressed an audience the day after his induction as a Fellow of the Museum (see page 20).

A crowd of 250 people heard Fred Brooks explore "What is the Real Virtue in Virtual Reality?"

Each new issue of *CORE* serves as a marker of our steady progress in building a solid institution "to preserve and present for posterity the artifacts and stories of the information age." I am always amazed and gratified to see how much there is to relay to you. Among many other topics throughout this issue, we can tell you about our successful year-end solicitation effort, seven recent lectures, further collections activities including a large donation and exhibit of computing artifacts from Switzerland, the 2001 Fellow Awards event, Museum participation in the CRN Industry Hall of Fame event, and a major press announcement with NASA.

YEAR-END CONTRIBUTORS ENABLE MUSEUM GROWTH

Thanks to the generosity of so many of you who responded to our year-end fund-raising appeal, we are well on our way to meeting the ambitious financial goals set forth at the beginning of the fiscal year. We are grateful for the many people who, in spite of recent financial and political challenges in our country and world, have demonstrated their commitment to our mission. Heartfelt thanks to all of you.

We still have $359,000 to raise by the end of our fiscal year on June 30, and we hope that those of you who have not yet given will make a pledge or a gift as soon as possible before we close the year. Your support will make a real difference!

PUBLIC PROGRAMS AT THE MUSEUM

We were proud to offer a rich set of lectures and events last fall. The average attendance for Museum lectures was 250 people, which speaks volumes about the intellectual curiosity and vigor of our community. I encourage you to attend these wonderful events and to get the word out to others who would enjoy hearing the inside stories from the innovators of the information technology revolution. Feel free to make suggestions for speakers and topics you would like us to include. And please talk to us about sponsorship of the lecture program—a terrific opportunity to show your support of our growing public presence. Among other things, this would accelerate our ability to offer videos of these lectures to our public. Stay tuned for Charlie Sporck on semiconductor industry history; Jeff Hawkins, Donna Dubinsky, and Ed Colligan on the creation of the handheld computer; Charlie Bachman on the origins of the database; and Al Shugart on early storage developments.

LINUS TORVALDS
THE ORIGINS OF LINUX

To an audience of 350 on September 18th at Space Camp, Linus Torvalds, creator of the operating system phenomenon Linux, provided an inside look at how he went from writing code as a graduate student in Helsinki in the early 1990s to becoming an icon for open source software by the end of the decade. At the age of 11, Torvalds started using a Vic-20 computer as a "classic geek with BASIC." Early on, he believed that UNIX was better than everything else; however, in Finland it was difficult to find UNIX for the hobbyist. Why did he write his own operating system? He said, "Because, hey, that was what you did." He added, "When you don't have anything to start with, you can't see the progress you are making—it's just one instruction set at a time." Twice he had been about to give up, but persevered just the same. Currently, Torvalds is a working member of the software team developing Transmeta's Code Morphing™ chip software and Mobile Linux.

DAN INGALLS
FROM SMALLTALK TO SQUEAK

Smalltalk-80, the language from which the Squeak programming environment is derived, traces its roots to the famous beanbag chair culture of Xerox PARC (Palo Alto Research Center) in the 1970s. Developed by a team headed by Dan Ingalls, Smalltalk was to be the supporting software environment for Alan Kay's visionary portable and networked Dynabook computer—a concept that remains compelling today. Though the original Dynabook never came into being, Smalltalk took root and continued on. Ingalls told the story at Xerox PARC on October 11th to an audience of over 200 Museum guests of how the forward-looking Smalltalk concepts and capabilities have evolved into a modern environment called Squeak. Ted Kaehler (who worked with Dan at Xerox PARC, Apple, Apple again, Disney, and Viewpoints Research Institute) attended the talk and said, "There are many attitudes and stances in object-oriented software that are completely accepted now. Dan reminded us of how hard they were to think of and defend 30 years ago."

EARLY COMPUTER MOUSE ENCOUNTERS

The Museum, together with the San Francisco Swiss Science & Technology Office, hosted a panel discussion on October 17th at Xerox PARC with Daniel Borel, Stuart Card, Doug Engelbart, Bill English, Jean-Daniel Nicoud, and Niklaus Wirth. These early developers and proponents of the computer mouse relayed insider stories of how the concepts came about and were implemented. This event was made possible with the support of PRS Presence Switzerland. Zurich Network sponsored the reception and Spotlife is providing web streaming.

Throughout the 1960s and 1970s, Doug Engelbart and his lab at SRI pioneered an elaborate hypermedia-groupware system called NLS (oNLine System), most of whose now-common features were conceived of, fully integrated, and in everyday operational use by the early 1970s. NLS was first demonstrated in public at the 1968 Fall Joint Computer Conference in a remarkable 90-minute multimedia presentation, in which Engelbart used NLS to outline and illustrate his points, while others of his staff linked in from his lab at SRI to demonstrate key features of the system. This was the world debut of the mouse, hypermedia, and on-screen video teleconferencing. Engelbart said, "It isn't the human-computer interface I was looking at, it's the... human's interfacing with [an] augmentation system." He explained that "humans have certain basic sensory, perceptual, mental, and motor capabilities, and we get approached with various challenges such as language and social issues. We have to adapt and learn, and things [like the mouse] essentially augment us so that we can be capable within that environment."

Stuart Card is a Xerox research fellow and manager of the User Interface Research group at Xerox PARC. His study of input devices led to the Fitts's Law characterization of the mouse and was a major factor leading to the mouse's commercial introduction by Xerox. Daniel Borel co-founded Logitech, whose first commercially-available product was the computer mouse in 1982. Bill English was the first person to ever use a mouse. In 1963, while he was chief engineer for Engelbart's Augmented Human Intellect Research Center, English built the first mouse based on an idea in Engelbart's early notes. He later developed the "Hawley" mouse that was used with the Xerox PARC Video Terminal System and early Alto computers.

ETH Zurich Professor Emeritus Niklaus Wirth spent two years on sabbatical at Xerox PARC, where he became an enthusiastic user of the workstation Alto, which heralded a new era of computing with its high-resolution display and the mouse. Back in

Museum Fellow Don Knuth calls on an inquirer in his lecture, "Questions Answered," that drew almost 300 attendees.

Audience members pose questions in an "ask the professor" style lecture by Don Knuth.

David Stork addressed friends of the Museum before previewing "HAL's Legacy," his documentary film that investigates similarities and differences between the 1968 vision of technology in the year 2001, and technology as it actually evolved.

In December, Google, Inc. Chairman and CEO Eric Schmidt discussed lessons learned from his experience in the technology trenches.

Museum volunteer and donor Robert Garner acquired and donated a 1948 IBM 604—a punched card calculator whose speed performance was due to its implementation with electronics (vacuum tubes), rather than IBM's traditional relay technology.

Museum supporter Ned Chapin examines the Switcherland and MUSIC artifacts at the "Computing in Switzerland" exhibit reception prior to the Fellow Awards Banquet on October 23rd.

Switzerland, he used the mouse for the workstations Lilith and Ceres, which he designed in conjunction with the programming languages Modula-2 and Oberon. Jean-Daniel Nicoud is professor emeritus of ETH Zurich in Lausanne, Switzerland. Among many other inventions, he developed the Dépraz Mouse, initially sold by Logitech.

FRED BROOKS
WHAT IS THE REAL VIRTUE IN VIRTUAL REALITY?

Hewlett-Packard Company, with the help of its Chief Science Officer Stephen Squires, generously hosted this October 24 event, which included a lovely reception. Fred Brooks addressed an enthusiastic crowd of 250 people about work since 1990 in virtual reality at the University of North Carolina, Chapel Hill. In that year, virtual reality was hyped by the press and by a professional association conference panel, unfortunately designed to "wow" people rather than inform them. Brooks reminded us that "a lily needs no gilding—the plain truth is exciting enough." He posited that the research challenge of virtual reality is to make it "look real, sound real, feel real, and interact realistically." Even in today's world, Brooks said, "virtual reality barely works." Advancement in virtual reality technology consists of making strides in four dimensions: fast, pretty, handy, and real. Brooks said, "We figure out which one hurts worse, work on it, then move on to the next loudest problem." Currently, the greatest inhibitor is "swimming" due to lag (latency). Other problems include poor registration with the real world, ergonomics, cables (and wireless), and the tedium of building models. Brooks assured us that virtual reality technology will one day fulfill its promise as a useful tool in areas such as vehicle simulation, molecular medicine and structure, and more. "Computer scientists are toolsmiths," he said. "Is this tool dangerous?" he asked. "Sure! All tools are dangerous. The danger lies not in our tools, but in ourselves."

DONALD KNUTH
QUESTIONS ANSWERED

Nearly 300 people gathered at Xerox PARC on November 8th to try to "stump the professor," a rare opportunity to ask *The Art of Computer Programming* author Don Knuth anything and everything about computer programming. Knuth is professor emeritus of The Art of Computer Programming at Stanford University where, since 1968, he supervised the Ph.D. dissertations of 28 students. The author of numerous books, Knuth's software systems, TeX and MF, are used extensively for book publishing throughout the world. His numerous awards include the Turing Award, the National Medal of Science, the Steele Prize, the Adelsköld Medal, the Harvey Prize, the John von Neumann Medal, and the Kyoto Prize. He holds honorary doctorates from Oxford University, the University of Paris, the Royal Institute of Technology in Stockholm, the University of St. Petersburg, the University of Marne-la-Vallee, Masaryk University, St. Andrews University, Athens University of Economics and Business, the University of Tübingen, and 16 colleges and universities in the USA.

Attendee Bob Zeidman said, "It was great to be able to hear Don Knuth, one of the many pioneers that the Computer History Museum is able to bring in each month. Professor Knuth is a living legend for his developments in computer science. He is also, I found out, a quiet guy of towering height with a good sense of humor who is quick to point out his own shortcomings. I particularly agreed with his call for better communication skills among programmers, and I'm looking forward to examining his CWEB language for 'literate progamming.'"

2001: HAL'S LEGACY DOCUMENTARY

Museum members and guests enjoyed a pre-broadcast preview on November 20th of the 90-minute version of a PBS documentary by David Stork comparing state-of-the-art technology today with the computer capabilities depicted in the 1968 epic film, "2001: A Space Odyssey." Now that 2001 has come and gone, we can compare the film's computer science "visions" with current technological fact—in particular those related to its central character, the HAL 9000 computer, which could speak, reason, see, play chess, plan, and express emotions. In some domains, reality has surpassed the vision in the film. In numerous others, reality has fallen far short. In the documentary, Stork navigates between scenes from the film and interviews with Arthur C. Clarke, Marvin Minsky, Gordon Moore, Rodney Brooks, Larry Smarr, Daniel Dennett, Raymond Kurzweil, Doug Lenat, and others. These contributors to "HAL's Legacy" have given us more than a scorecard for the film and novel. They have shown the reasons for the way things developed—and may continue to develop—to 2001 and beyond. The film was produced by David Kennard and InCA and funded by the Alfred P. Sloan Foundation.

Event attendee Ellen Spertus, assistant professor of computer science at Mills College, Oakland, commented, "Even people who say they don't like computers are fascinated by robots, real or imaginary, making them a great way to draw people into computer science. HAL's Legacy, which I plan to show my students, uses people's fascination with HAL, an imaginary artificial intelligence, to introduce them to the even more fascinating real world of artificial intelligence."

ERIC SCHMIDT
UNWINNABLE WARS: PERSONAL PERSPECTIVES ON TECHNOLOGY LEADERSHIP

On December 6th at Xerox PARC, Eric Schmidt, chairman and CEO of Google Inc., examined unwinnable battles he was involved with or witnessed during his rich and varied 20-year career in the computer industry. He recollected trying experiences at Sun Microsystems attempting to replicate its initial standardization victory with NFS (Network File System) in the company's long-standing battle to prevail over other UNIX companies and later, over Microsoft itself. He looked at the futile UNIX user-interface wars (such as Open Look vs. XOpen), the calamitous merging of Sun's UNIX (SunOS) and AT&T's UNIX (System V), and the failure of UNIX to unify behind a single version.

He observed the importance of understanding history, and that, "each and every generation makes the same mistakes." An example that surfaced during the talk was that some of the old battles found during the UNIX wars might be reemerging on today's Linux stage. Lively discussion followed in the question-and-answer period on topics such as competing against a behemoth (such as Microsoft), and why cooperative consortia don't work. Schmidt made the point that the best progress is often made when academia or egos not interested in monetary profit are able to form useful standards (such as the Internet standards created by Vint Cerf and the IETF).

Prior to his post at Google, Schmidt was chairman and CEO of Novell, chief technology officer and corporate executive officer at Sun Microsystems, a member of the research staff at Xerox PARC, and held positions at Bell Laboratories and Zilog.

COLLECTIONS HIGHLIGHTS

The report of items acquired in recent months is on page 12. Here are a few highlights: Richard Fryer donated an early CDI mouse, circa 1970, an excellent example of an early commercial mouse intended for use with minicomputers and larger mainframes. Former Marchant employee George William Bolton donated a "Figuremaster" mechanical calculator and allowed the Museum to record his thoughts on his years working with Marchant. And, longtime Museum supporter and friend, Robert Garner

The "Computing in Switzerland" exhibit showed artifacts related to computing in Switzerland, including much of the line of Smaky personal computers.

Banquet attendees enjoy the Fellow Awards program.

Museum Trustees Len Shustek and Donna Dubinsky relax after the Fellows banquet.

acquired an IBM 604 Electronic Calculating Punch for the Museum. The 604, a vacuum tube-based machine, was announced by IBM in 1948 and was probably the company's first attempt at a wholly electronic machine targeted at the emerging commercial computing market.

SPECIAL EXHIBIT OF COMPUTING ARTIFACTS FROM SWITZERLAND

A reception prior to the Fellow Awards banquet and ceremony on October 23rd featured an impressive exhibit of artifacts donated to the Museum by various Swiss individuals and organizations. The exhibit displayed a series of artifacts related to computing in Switzerland, including: a 1956 ERMETH pluggable unit, 1972 Novasim, 1976 Crocus, 1977 Dauphin, 1978 Scrib, 1978 Smacky 6, 1986 Ceres-1, 1990 Ceres-3, 1991 MUSIC microcomputer, 1993 Convex C3820, 1994 GigaBooster supercomputer, and the 1999 TNet switch. Additionally, a Swiss public telephone booth equipped with a functioning Teleguide electronic phone directory (donated by Swisscom AG) demonstrated how intertwined computers have become with our daily lives.

Donors Hans Eberle, Jean-Daniel Nicoud, and Niklaus Wirth were present and spoke to the audience. Other donors include Ambros Speiser and André Thalmann, The Bobst Group, Epsitec SA, ETH Zürich, Supercomputing Systems AG, Swisscom AG, and the Swiss Center for Scientific Computing.

Swiss chocolatiers Albert Uster Imports, Nestlé Switzerland, Lindt, and others donated delicious chocolates for exhibit viewers. The artifact donation was initiated and coordinated by Christian Simm and his staff at the Swiss Science and Technology Office in San Francisco, and shipped courtesy of PRS Presence Switzerland.

THE 2001 FELLOW AWARDS–A SUCCESS BY ANY MEASURE

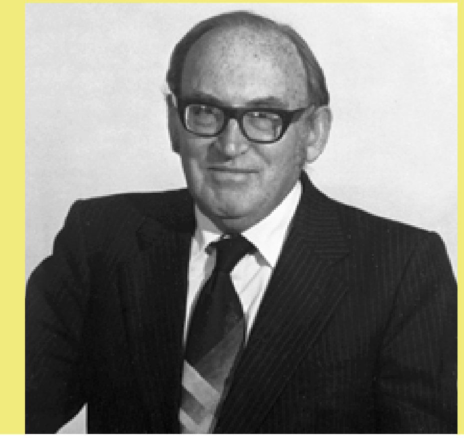
Over 400 Silicon Valley entrepreneurs, computer scientists, business leaders, academics, and other friends of computing history supported the Museum at this year's Fellow Awards Banquet at the San Jose Fairmont Hotel on October 23rd. Master of Ceremonies and 2000 Museum Fellow Vint Cerf led the evening to celebrate the achievements of honorees Frederick P. Brooks, Jean E. Sammet, and Maurice Wilkes.

Hewlett-Packard Company was the Lead Sponsor for the event. Patron Sponsors were 1185 Design, Allegro Networks, Citigate Cunningham, eBay, Intel, and Mid-Peninsula Bank. Hosts for the evening were Donna Dubinsky, Len Shustek, Suhas Patil, Jayashree Patil, Elaine Hahn, Eric Hahn, Peter Hirshberg, Angela Hey, and John Mashey. Following are a few highlights from the evening.

Len Shustek cited John Brockman's work with a group of experts from various fields to identify the most important inventions of the past 2000 years. Only three inventions got more than five votes each. Second on the list was the invention of the computer (to find out the other two you can buy Brockman's book!). Shustek pointed out that for 5,000 years of recorded civilization, there were no computers, and suddenly computers appeared. Now and forevermore, computers will be everywhere, affecting what we do, how we live, how we work, how we play. He said, "We need to preserve the structure of how that happened, so that looking back from 500 years from now, it doesn't look like a point event—that computers suddenly arose, with no recognition of who did it, and why they did it, and how they did it, and how it came to be. That's what the Museum is here to preserve."

Maurice Wilkes (via videotape) told us that it took around three years before the first computers were working, and how, while development was going on, it seemed interminable. "When pressed, I used to tell people that I hoped to have a machine working in the summer. But I did not say *which* summer," he said, and added, "No doubt as time goes on we will see many more changes. And this is where the Museum comes in. As I see it, an important function of the Museum is to record changes as they occur, and to collect artifacts that will illustrate those changes for the benefits of posterity."

New Fellow Jean Sammet enjoys a moment at the banquet table during the award ceremony.



New Fellow Maurice Wilkes, who resides in the UK, delivered an acceptance speech by videotape.

The 2001 Fellow Awards went to: **Frederick P. Brooks**, for his contributions to computer architecture, operating systems, and software engineering; **Jean E. Sammet**, for her contributions to the field of programming languages and its history; and **Maurice Wilkes**, for his lifelong contributions to computer technology, including early machine design, microprogramming, and the Cambridge Ring network.

Fred Brooks said, "I remember at age 13 reading *Time* magazine; it had a cartoon on the front of the Harvard Mark I [computer] looking like a kind of a beast. The article described this computer. I knew at age 13 that that was what I wanted to do."

Vint Cerf pointed out after hearing our 2001 Fellows speak, "It illustrates how their insights and their perspectives are still incredibly valuable to every one of us today. It is by knowing and understanding the past that we can shape and guarantee the future."

CRN INDUSTRY HALL OF FAME

The Computer History Museum participated as a co-host of the CRN Industry Hall of Fame event on November 12 in Las Vegas. Honorees were Doug Engelbart, Judy Estrin, Mort Rosenthal, Phil Zimmerman, the late Robert Noyce, and the late Grace Hopper. Thanks to CRN for recognizing the accomplishments and determination of such wonderful people in computing. John Toole spoke at the event about the Museum and its plans. I was pleased and honored to accept the award for Grace Hopper on behalf of the Museum and to give a short tribute to her memorable contributions, which include the time- and error-saving compiler.

JOINT NASA/COMPUTER HISTORY MUSEUM PRESS ANNOUNCEMENT

On Friday, December 7th, the Museum and NASA co-hosted a press tour and special announcement for nearly 100 people who gathered to hear about the Museum's partnership with NASA for a presence in the NASA Research Park, the Beta Building (see page 16), the appointment of Head Curator Michael R. Williams, and the Museum's new name and logo. Panelists included NASA Ames Research Center Director Henry McDonald; Museum Executive Director & CEO John Toole; Chairman of the Museum's Board of Trustees Len Shustek; Museum Trustee and CEO of Handspring Donna Dubinsky; and Intuit's Chairman of the Board Bill Campbell. The press responded with great enthusiasm and coverage included KLIV, KGO, KTVU, KICU, the *San Jose Mercury News*, and the *San Jose Business Journal*.

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We acknowledge with deep appreciation the individuals and organizations that have given generously to the Annual Fund.

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YES! I/We want to become an Investor in Preservation! I/We choose to make a donation to the Annual Fund at the following level:

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___ I want to increase my support to the Computer History Museum with a matching gift. My company form is enclosed (retirees and board members may also be eligible).
___ Please send information on investing in your building/endowment fund.

WHAT IS NEEDED TO REALIZE THE DREAM IS YOU!

THE ELEMENTS ARE HERE: artifacts, photographs, videos and audiotapes, marketing materials, documentation, and gigabytes of historic software.

THE VISION IS HERE: knowledgeable and dedicated Trustees, Advisors, and staff members are implementing the dream: to build, endow, and operate a landmark facility where the Museum's collection can be adequately displayed and researched.

THE OPPORTUNITY IS HERE: the Museum is part of the proposed NASA Research Park at Moffett Field, California, destined to become a world-class, shared-use education and R&D campus, partnering with local communities, academia, industry, nonprofits, and government agencies.

BECOME AN INVESTOR IN THE MUSEUM
Join this eminent community of people—including collectors and historians, software and hardware engineers, computer scientists and theorists, entrepreneurs and investors, visionaries and inventors, and the general public—who share a passion for preserving computing history for generations to come.

For pioneers at the forefront of the computing industry, supporting the Museum preserves the contributions that you made.

For industry professionals, researchers, and scholars, supporting the Museum ensures access to unique and valuable resources that shed light on the evolution and significance of computing history.

For those simply curious, interested, or excited by computing history, supporting the Computer History Museum will allow everyone a better understanding of the impact of the information age.

UPCOMING EVENTS

Please RSVP for all events and activities by calling +1 650 604 2714 or visiting www.computerhistory.org/events. Thank you!

TUE, FEBRUARY 26
THE PALMPILOT STORY
Donna Dubinsky, Jeff Hawkins, and Ed Colligan of Handspring, Inc. along with Andrea Butter, co-author of *Piloting Palm*
MEMBER RECEPTION: 6:00 PM
Bldg 126, Moffett Field
LECTURE: 7:00 PM
Moffett Training & Conference Center, Bldg. 3

TUE, APRIL 16
THE INTEGRATED DATA STORE (IDS)—THE PROBLEMS AND THEIR SOLUTIONS
Charlie Bachman
MEMBER RECEPTION: 6:00 PM
Bldg 126, Moffett Field
LECTURE: 7:00 PM
Moffett Training & Conference Center, Bldg. 3

TUE, MAY 21
THE HISTORY AND FUTURE OF ELECTRONIC PHOTOGRAPHY
Carver Mead, Foveon, Inc.
Please check our website for location and time

THU, SEPTEMBER 5
HALF A CENTURY OF DISK DRIVES AND PHILOSOPHY: FROM IBM TO SEAGATE
Al Shugart, Al Shugart International
Please check our website for location and time

THU, SEPTEMBER 26
VON NEUMANN: FROM STORED PROGRAM CONCEPT TO THEORY OF COMPUTING
Bill Aspray, Computing Research Association
Please check our website for location and time

VOLUNTEER OPPORTUNITIES
The Museum tries to match its needs with the skills and interests of its volunteers and relies on regular volunteer support for events and projects. Monthly work parties generally occur on the 2nd Saturday of each month, including:

MARCH 9, APRIL 13, MAY 11, JUNE 8, JULY 13, AUGUST 10

Please RSVP at least 48 hours in advance to Betsy Toole for work parties, and contact us if you are interested in lending a hand in other ways! For more information, please visit our volunteer web page at www.computerhistory.org/volunteers

MUSEUM ARTIFACTS
ON LOAN AT THE FOLLOWING EXHIBITS

FEB 8–MAY 27, 2002
BRAINS TO BYTES—THE EVOLUTION OF INFORMATION STORAGE
The Museum of American Heritage (MOAH)
Palo Alto, California
www.moah.org

APRIL–SEPT 2002
WORLD'S FAIRS
San Francisco International Airport Terminal C3
San Francisco, California
www.sfoarts.org

MAY–SEPT 2002
GAME ON! (THE WORLDWIDE CULTURE AND HISTORY OF VIDEO GAMES)
Barbican Gallery, London, United Kingdom
www.barbican.org.uk

SEPT 2002
THE COMPUTING REVOLUTION
Museum of Science
Boston, Massachusetts
www.mos.org

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Current staff openings can be found at www.computerhistory.org/jobs.

MYSTERY ITEMS

FROM THE COLLECTION OF
THE COMPUTER HISTORY MUSEUM

Explained from CORE 2.3

The Interface Message Processor (IMP) was the packet switching node of the ARPANET, which connected computer systems, beginning in the early 1970s, into a nationwide research network for computer resource sharing. This ARPANET originally consisted of only four nodes (UCLA, SRI, UCSB, and the University of Utah) and eventually grew to over 100 nodes. It was connected via "gateways" (now called routers) to two other networks (packet radio and SATNET) that were also supported by DARPA (Defense Advanced Research Projects Agency). These three interconnected networks ultimately evolved into today's Internet with its tens of millions of nodes.

The IMP (Interface Message Processor), X105.82, Gift of Bolt Beranek and Newman, Inc.

During an early ARPANET planning session, engineer Wesley Clark suggested developing a standard minicomputer interface in order to avoid creating separate hardware and software for every different time-sharing system that would be connected. The IMP was thus a communications "switch" accepting packets and relaying them to other IMPs or locally-connected host computers. In December 1968, DARPA selected Bolt Beranek and Newman (BBN) to develop the IMP. Frank Heart led the team, with Severo Ornstein as lead hardware developer and Bill Crowther as lead programmer. MIT professor Bob Kahn, who had taken a leave of absence in 1966 to join BBN, was responsible for the system design.

Shortly before the planned delivery date of September 1, 1969, the first IMP arrived at the laboratory of Professor Len Kleinrock at UCLA. A month later, the second IMP arrived at SRI and, soon thereafter, the first characters were transmitted between SRI and UCLA. In November and December, IMPs number three and four were installed at University of California Santa Barbara and the University of Utah. The network quietly expanded to 13 sites by January 1971 and 23 by April 1972.

WHAT IS THIS?

THIS ITEM WILL BE EXPLAINED IN THE NEXT ISSUE OF CORE.

Please send your best guess to mystery@computerhistory.org before 04/15/02 along with your name, shipping address, and t-shirt size. The first three correct entries will each receive a free t-shirt with the new Museum logo and name.

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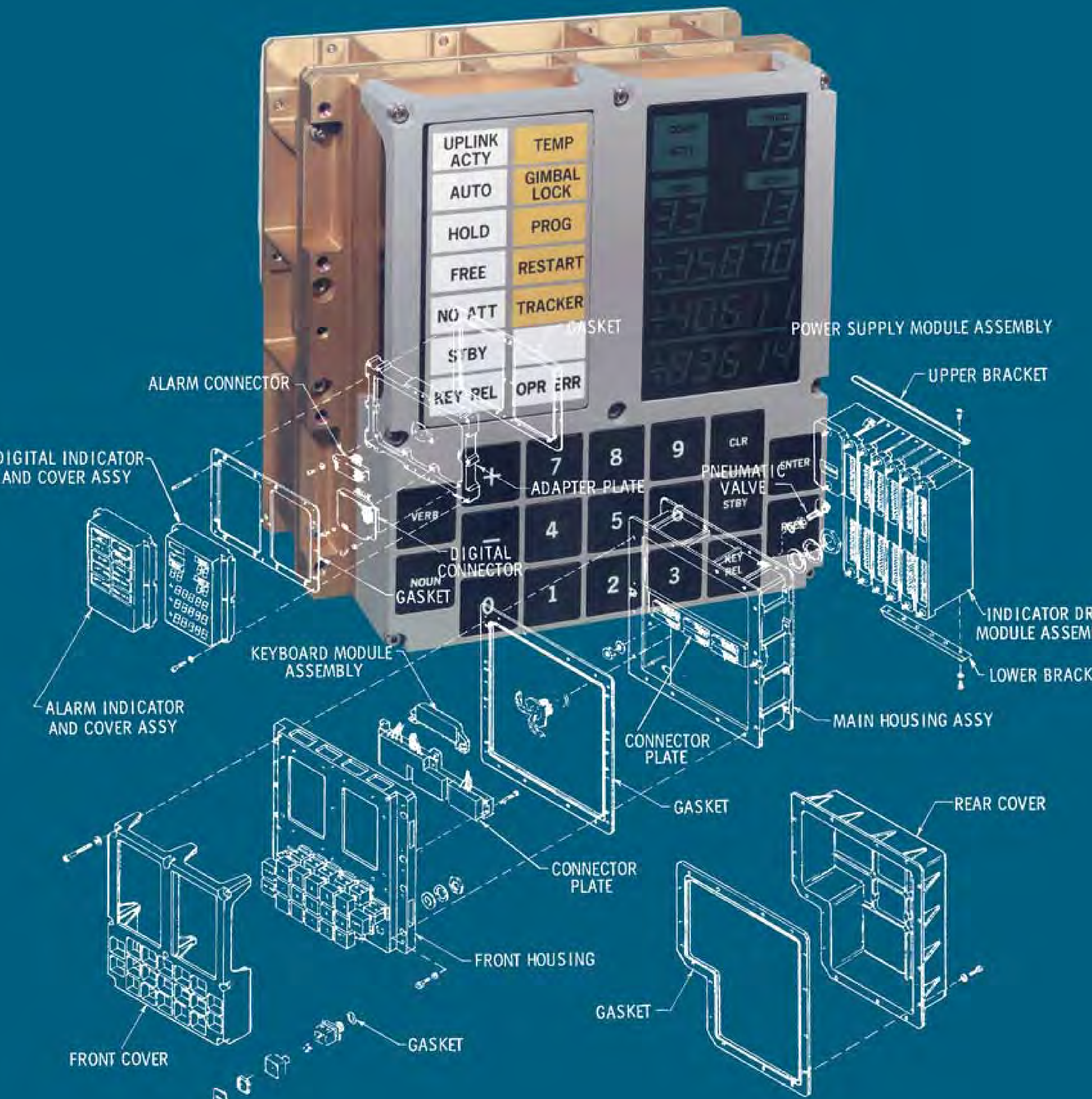


FUNDAMENTALS IN CHANGING TIMES

As our fiscal year ends in June, it's natural to look at the Museum's accomplishments and future plans. It is also a time to reflect on how amazing our annual fundraising support has been during a difficult year in the U.S. and around the world. Thank you to everyone who has contributed to our expanding programs and enabled us to grow in stature, capability, and professionalism! It is critically important to operate in the black, and I am happy to report that our audited 2001 financial statements show exactly that. With your continued support, we expect to do the same this year and in the upcoming fiscal year that starts on July 1.

The economy, the war on terrorism, and the corresponding impacts on local climates have been extraordinary challenges for all non-profits, but the Museum has remained strong with your help. This is an important testament to our base of support, which has helped this organization through good times and bad. The mission of preserving the stories and artifacts of the information age strikes a fundamental note in many people's minds, which makes our organization solid even in challenging times. If you have not already donated to our annual campaign, please consider this mission and what we are trying to accomplish, and become a contributor—we have included an insert in this issue to make it as easy as possible.

Look carefully at all the activities reported in this issue, and you will see how our organization is growing. The free lecture series has been a tremendous success. Our curatorial staff is doing an outstanding job in organizing the collections, focusing on future exhibits, and working with an impressive list of volunteers who are helping as docents, greeters, and enthusiastic helpers. We are also finding ourselves much more prominent in the press. Tours of our Visible Storage Exhibit Area (with expanded Saturday hours twice a month) provide visitor access to our collection and demonstrate our emphasis on content in the fulfillment of our mission. Finally, the new building architecture team, led by EHDD, completed their schematic design phase, and delivered an amazing set of great ideas for our permanent home. The schematic design phase of exhibit design will continue through early fall.

While our public presence has continued to increase during this economic downturn, the Trustees and staff have also considered the challenges, opportunities, and risks at every stage. In fact, we have been constantly evaluating our long-term plans, and have developed new insights into the future. Although it's too early to publicly address any emerging options, we are continually challenging our assumptions as we search for the best investments of our resources. The changing economy poses some unique opportunities today, but also challenges us to project our next 10 years very carefully. We also are getting much more information on the costs and timelines for our plan of record with NASA, which becomes important to our analysis. The "Beta Building" that will provide additional room for us to grow is still a major priority, but will be delayed several months in this calendar year as we refine our plans. Stay tuned for more information.

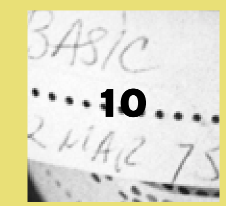
Although, over time, plans and details may evolve to meet opportunities and to address challenges, the building blocks of our organization—the people, the collection, and the mission—are fundamentally strong and the basis of a great institution. Help us make this year the best ever!

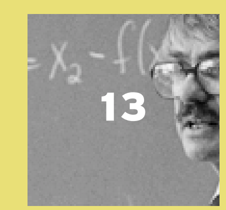
JOHN C TOOLE
EXECUTIVE DIRECTOR & CEO

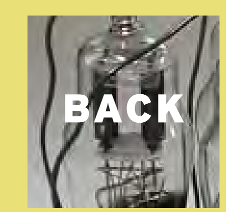
May 2002
A publication of the Computer History Museum
CORE 3.2

MISSION
TO PRESERVE AND PRESENT FOR POSTERITY THE ARTIFACTS AND STORIES OF THE INFORMATION AGE

VISION
TO EXPLORE THE COMPUTING REVOLUTION AND ITS IMPACT ON THE HUMAN EXPERIENCE







IN THIS ISSUE

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Cover: Photo and exploded-view diagram of the Apollo Guidance Computer Display Keyboard (DSKY)

THE APOLLO GUIDANCE COMPUTER

BY ELDON HALL AND DAVID SCOTT

INTRODUCTION

The following article is drawn from a lecture given by Apollo Guidance Computer (AGC) lead designer Eldon Hall on June 10, 1982 at The Computer Museum in Boston. It was first printed in *The Computer Museum Report* in Fall, 1982 and provides some insight into the development of a major component that allowed "a giant leap for mankind."

The Computer History Museum collection contains several items and prototypes comprising the AGC, including logic modules, a DSKY, and rope memory; as well as lecture videotape; photos of the units in use and under test; and various paper documents that provide us with further details.

Eldon Hall led the hardware design effort throughout the development of the AGC and pioneered the use of integrated circuits in this design. His group at the MIT Instrumentation Laboratory (MIT/IL) was awarded the contract in 1961 to begin work on the Apollo Guidance Computer after their successful work on the Polaris missile project, in which Hall was responsible for encouraging the Navy to use digital guidance computers. Hall received his AB in Mathematics at Eastern Nazarene College, his AM in Physics at Boston University, and had completed much of a PhD in Physics from Harvard when he took a position at MIT/IL in 1952.

DESIGNING THE AGC

BY ELDON HALL

In the early sixties the so-called mini-computer had not emerged and there was no commercial computer suitable for use in the Apollo mission. Most of the technologies that were eventually used in the Apollo computer were ones just emerging from research and development efforts. The "design" was mainly a task of fitting the components together in order to meet the mission requirements for computational capacity and miniaturization.

FROM POLARIS TO APOLLO

Previous aerospace computers greatly influenced the development of the Apollo Guidance Computer. The demands placed on these computers provided the motivation to miniaturize and develop semiconductors. The MIT Instrumentation Lab, now called Charles Stark Draper Laboratory, had responsibility for the design of the computers used in the Polaris, Poseidon, and Apollo programs.

The lab's first significant venture into the field of digital computing was, for the Polaris program, a very small ballistic missile launched from a submarine. A special-purpose digital computer was designed to solve the specific equations required for the guidance and control system based on analog techniques originally developed by the Navy. With a need for increased accuracy, the Navy decided to use digital techniques for the Polaris program, resulting in the construction of a wired-program, special-purpose computer to solve the guidance and control equations. In 1959 the first version of this system, called the Mark 1, flew in a Polaris missile. It was the first ballistic missile flown with an on-board digital computer providing the guidance and control computations. The computer occupied about four-tenths of a cubic foot, weighed 26 pounds, and consumed 80 watts. Even before this first guided flight succeeded, designs were already being explored that would reduce the size and improve the maintainability of the system. The new design, eventually designated Mark 2, repeated the architecture and logic design with improvements in circuits and packaging.

In August 1961, when NASA contracted the laboratory to develop the Apollo guidance, navigation, and control system, the mission and its hardware were defined in only very broad terms. A general-purpose digital computer would be required to handle the data and computational needs of the spacecraft. Therefore a special arrangement of display and controls would be necessary for in-flight operation. The boost phase of the mission, which was the Saturn system, had its own internal guidance system to put the command and service module in translunar trajectory. Then the Apollo system took over to guide the mission to the moon.

In effect, navigating in space is the same as navigating on Earth. One might take a star sighting with a sextant. That information is put into the computer and from it the state vector, i.e. the position and velocity of the missile at any point of time, is computed. The computer orients the missile such that the change in velocity will cause the state vector to be updated so the missile will free-fall into the targeted point. While it is thrusting, the guidance system must control the attitude of the vehicle, the magnitude of the thrust in the case of the Lunar Excursion Module (LEM), and the direction of the thrust in the case of the command and service module.

DESIGN CONSTRAINTS

Initially the need for a very reliable computer with significant computational capacity and speed was clear. The design constraints included very limited size, weight, and power consumption. If the designers had known then what they learned later, or had a complete set of specifications been available as might be expected in today's environment, they would probably have concluded that there was no solution with the technology of the early sixties.

Establishing interface requirements was a monumental task. The astronaut interface was one of these. In 1962, computers were not considered user-friendly. Heated debates arose over the nature of the computer displays. One faction, which usually included the astronauts, argued that meters and dials were necessary. Logically, the pressure for digital displays won most of the arguments because of their greater flexibility in the limited area allowed for a control panel. In late 1963, as the requirements for the LEM were being firmed up, NASA decided to use identical guidance computers in both the command module and the LEM.

In the early manned orbital missions before Apollo, NASA learned that the human animal, confined in a spacecraft for a week or so, was not as clean as might be expected from observations on Earth. This additional constraint had

Inside the Apollo capsule

Assemblers at Raytheon testing and building AGC modules

Lead designer Eldon Hall testing the Apollo Guidance Computer

The interface with the astronauts was the DSKY (for display keyboard). It used digital displays and communicated with the astronauts using verb and noun patterns and two-digit operation and operand codes. A set of status and caution lights is shown in the top left corner.

a rather interesting and far-reaching impact on the mechanical design of the computers and other hardware. All electrical connections and metallic surfaces had to be corrosion resistant and even though the computer was designed to have pluggable modules, everything had to be hermetically sealed.

THE SUPPLIERS

By the end of 1962, NASA selected contractors: General Motors' AC Sparkplug Division for the inertial systems and system integration; Raytheon, Sudbury Division, for the computer and computer testing equipment; Kollsman Instrument for the optical systems; North American Aviation for the command and service module; and Grumman Aircraft for the Lunar Excursion Module.

In late 1959 and 1960 the lab began evaluating semiconductors, purchased at $1,000 each from Texas Instruments. Reliability, power consumption, noise generation, and noise susceptibility were the prime subjects of concern in the use of integrated circuits in the AGC. The performance of these units under evaluation was sufficient to justify their exclusive use in place of the core transistor logic proposed initially for the Apollo project design. The micrologic version of the Apollo computer was constructed and tested in mid-1962 to discover the problems that the circuits might exhibit when used in large numbers. Finally, in 1964, Philco-Ford was chosen to supply the integrated circuits used in the prototype computer that operated in February 1965. These cost approximately $25 each.

SPECIFICATIONS

Approximately one cubic foot had been allocated in the command module for the computer. The first prototype was operating in the spring of 1964 and utilized the wire wrap and modular welded cordwood construction that had been produced for the Polaris program. It was designed to have pluggable trays with room for spare trays.

Since the clock in the computer was the prime source of time, it had to be accurate to within a few parts per million. The data and instruction words in the memory were 15 bits plus parity. Data was represented as 14-bit binary words plus the sign bit. Double-precision operations were provided to supply 28-bit computations. The instruction word contained the address and operation codes for the computer operation. The memory address field was extended by organizing the memory in banks.

The AGC had 2,000 15-bit words of erasable core memory and started with 12,000 words of read-only memory, called rope memory. It was quickly upgraded to 24,000 words. Then by mid-1964, when the first mission program requirements had been conceived and documented, there was increasing concern about the possible insufficiency of the memory. This prompted a further expansion to 36,000 words.

DESIGN AND USE OF THE CONSOLE

A display and keyboard was developed for the astronauts and had the designation DSKY (pronounced "Diskey"). Functionally, the DSKY was an integral part of the computer, and two were mounted remotely and operated through the discrete interface circuits. One was for a sitting position and another one near the entry to the LEM, convenient for a reclining position.

The principle part of the DSKY display was a set of three numeric light registers. Each register contained five decimal digits consisting of segmented electro-luminescent lights. Five decimal digits were used so that a computer word of 15 bits could be displayed in either decimal or octal. In addition, three two-digit numeric displays indicated the major program in progress, the verb code, and the noun code. The verb/noun format permitted communication in a language whose syntax was similar to that of spoken language. Examples of verbs were display, monitor, load, and proceed. Examples of nouns were time, gimbal angles, error indications, and star identifications. Commands and requests were made in a form of sentences, each with a noun and a verb, such as "display velocity" or "load desired angle." To command the computer, the operator pressed the Verb key followed by a two-digit code. This entered the desired verb into the computer. The operator then pressed the Noun key and a corresponding code. When the enter key was pressed, the computer carried out the operation that had been commanded. The computer requested action from the operator by displaying a verb and noun in flashing lights to attract the astronauts' attention.

IN-FLIGHT USE

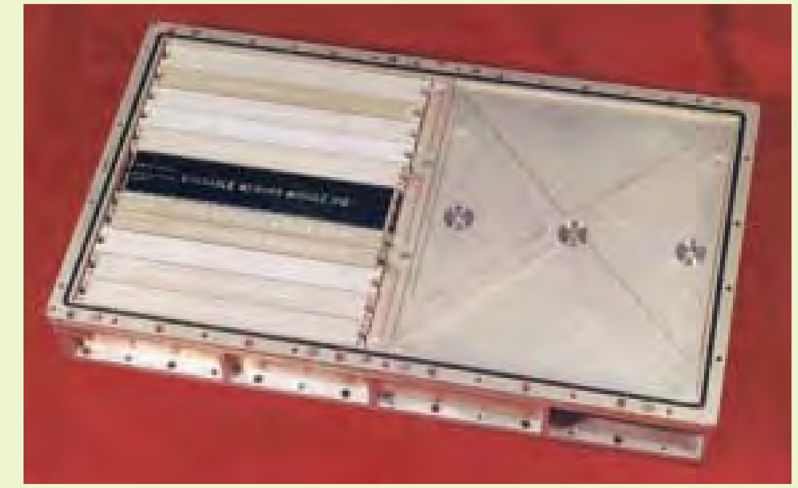
Shortly after the lift-off of Apollo 12, two lightning bolts struck the spacecraft. The current passed through the command module and induced temporary power failure in the fuel cells supplying power to the AGC. During the incident, the voltage fail circuits in the computer detected a series of power trenches and triggered several restarts. The computer withstood these without interruption of the mission programs or loss of data.

The read-only memory of the computer consisted of six rope memory modules, each containing 6,000 words of memory. This special type of core memory depended on the patterns set at the time of manufacture. Its sensing wires were woven into a set pattern. It had five times the density and was far more reliable than the coincident current core memory used for erasable storage in the computer. Being unalterable, it also provided a greater incentive for error-free software development.

The Apollo 11 lunar landing had an anomaly that attracted public attention. The computer in the LEM signaled a restart alarm condition several times during a very critical period prior to touchdown. This fact was broadcast to the public and those who knew its significance were close to a state of panic.

After analysis, it was determined that the alarms were an indication to the astronauts that the computer was overloaded and was eliminating low priority tasks from the waitlist. The overload resulted from the rendezvous radar being set in the wrong mode during the lunar landing phase, wasting computer memory cycles. The computer software was responding to overloads as designed.

This incident triggered a news brief in Datamation in October, 1969, faulting the computer design for being too slow. It rightfully claimed that there were a number of minicomputers, including the PDP-11, that were at least an order of magnitude faster. In the eight years since the initiation of the Apollo program, commercial technology had far surpassed that of the Apollo design and capacity. However, no commercial computer could claim to match the power consumption and space characteristics of the AGC.



The Apollo Guidance Computer was responsible for the guidance, navigation, and control computations in the Apollo space capsule. The AGC was the first computer to use integrated circuit logic and occupied less than one cubic foot of the spacecraft. It stored data in 15-bit words plus a parity bit and had a memory cycle time of 11.7 microseconds, utilizing 2,000 words of erasable core memory and 36,000 words of read-only memory. The frame is made of magnesium for lightness and designed to hermetically seal the components.

The read-only memory of the computer consisted of six rope memory modules, each containing 6,000 words of memory. This unique type of core memory treated each core as a transformer within a matrix of discrete "rope-like" wires and depended on the patterns set at the time of manufacture. Wires running through the core stored a "1," and those bypassing the core represented a "0." It had five times the density and was far more reliable than the coincident current core memory used for erasable storage in the computer. Being unalterable, it also provided a greater incentive for error-free software development.

The module in the collection has been used only on Earth. The Museum's prototype computer ran at Draper Labs and was used to test the routines for in-flight machines. However, in space, all of the components had to be completely "potted" to insure that all the parts would stay firmly in place and remain uncontaminated.

Photo courtesy of NASA.

The Apollo 9 prime crew from left to right: Commander James A McDivitt, Command Module Pilot David R Scott, and Lunar Module Pilot Russell L Schweickart. The Apollo 9 mission was designed to test the Apollo Command/Service Module (CSM) and Lunar Module (LM) in Earth orbit to verify that the CSM could successfully dock with the LM, and to test the LM systems in a "free flying" attitude to ensure that it performed as per specifications.

MISSIONS WITH THE AGC

BY DAVID SCOTT

In 1963, when NASA was conducting the selection of the third group of astronauts for the U.S. space program, I had just received a graduate degree at MIT and finished test pilots school. My interests and the program's need for a user to interact with the design of the guidance computer at the MIT Instrumentation Lab were a good fit. I was part of the discussions whether to use analog or digital controls.

THE MIT INTERFACE

When I was studying at MIT, the ability to rendezvous in space was an issue for debate. It wasn't clear whether it was possible to develop the mathematics and speed of computation necessary to bring two vehicles together at a precise point in space and time—a critical issue for the Apollo mission's successful landing on the moon and return to Earth. Between 1963 and 1969, with the flight of Apollo 9, this was accomplished. I stayed in the spacecraft while Rusty Schweickart and Jim McDivitt got in the lunar module and went out about 60 miles away. The computer behaved flawlessly during our first successful rendezvous in space.

Another assignment for Apollo 9 was to take the first infrared photographs of the Earth from space. To do this, a large rack of four cameras was mounted on the spacecraft. Since they were fixed to the spacecraft, the vehicle itself had to track a perfect orbit such that the cameras were precisely vertical with respect to the surface that they were photographing. During simulations it was determined that manual orbit procedures would be inaccurate. We were at a loss.

About two weeks before the flight, I called up MIT and asked if they could program the computer to give the vehicle a satisfactory orbit rate. They answered, "Of course. Which way do you want to go and how fast?" In a matter of a couple of days we had a program and a simulator that automatically drove a spacecraft at perfect orbit rate. We got into flight with very little chance to practice or verify, but we put on the cameras and the results were perfect.

POTENTIAL COMPUTER FAILURE

During the development process we ran many simulations of in-flight computer operations with particular concern for in-flight failure. But in the 10 years that I spent in the program there was never a real computer failure. Yet people often wonder what a computer failure would have meant on a mission. It would have depended on the situation and the manner in which the computer failed.

We probably would not have expired, but there were some parts of the mission in which a computer failure would have been especially compromising. Navigation was not necessarily time critical but the lunar landing was very time critical. You could have a situation during a lunar landing in which, if the computer failed, the engine would be driven into the ground. Unless the astronaut could react quickly enough to stop it, the Lunar Module could have been flung on its side. Chances are that the astronaut could prevent such an event by switching to manual control of the vehicle. It must be remembered that the computer had been designed to be as reliable as possible and the astronauts had a great amount of confidence in the machine.

PROBLEMS OF SUCCESS

We had a backup called the entry monitor system, which had a graphic display based on the accelerometers in the spacecraft. With this display the vehicle could be flown manually using pre-drawn curves to be followed for attitude, g-loading, and velocity. It was reassuring to know that we were still able to return to Earth even if the Apollo Guidance Computer failed. During re-entry there was a scroll in the entry monitor system and we could see the computer tracking the predetermined curves all the way to the landing site. As our skills and the computer programs improved over the years of the Apollo program, we came down closer and closer to the carrier waiting to meet us. Finally, by the last Apollo mission, they didn't park the carrier directly on the landing point. ■

Excerpted by Ben Goldberg from remarks made by David Scott on June 10, 1982 at The Computer Museum in Boston. Reprinted from *The Computer Museum Report*, Fall 1982.

USAF Colonel David Scott flew on the Gemini 8, Apollo 9, and was spacecraft commander on Apollo 15. On the Gemini 8 mission in 1966, Scott and Command Pilot Neil Armstrong performed the first successful docking of two vehicles in space. As Command Module Pilot for Apollo 9 in 1969, Scott helped complete the first comprehensive Earth orbital qualification and verification test of a fully configured Apollo spacecraft. In 1971 Scott commanded Apollo 15, the first extended scientific exploration of the Moon, doubling the lunar stay time of previous flights and using the first Lunar Roving Vehicle to explore the Hadley Rille and the Apennine Mountains. Scott received an MS and an Engineer's Degree in Aeronautics and Astronautics from MIT in 1962.

AGC SPECIFICATIONS

Instruction Set
Approximately 20 instructions; 100 noun-verb pairs, data up to triple-precision

Word Length
16 bits (14 bits + sign + parity)

Memory
ROM (rope core) 36K words; RAM (core) 2K words

Disk
None

I/O
DSKY (two per spacecraft)

Performance
Approx. Add time: 20μs

Basic machine cycle
2.048 MHz

Technology
RTL bipolar logic (flat pack)

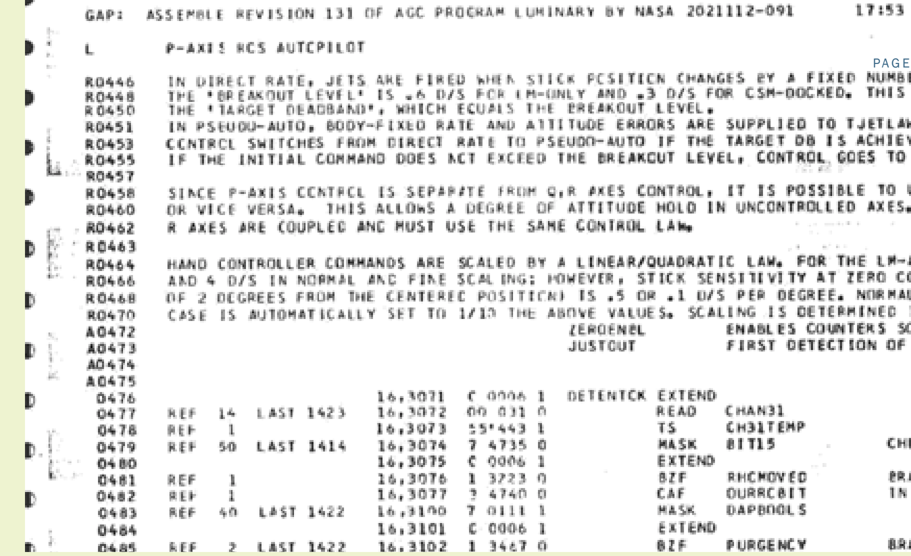
Size
AGC: 24" x 12.5" x 6" (HWD)
DSKY: 8" x 8" x 7" (HWD)

Weight
AGC: 70 lbs; DSKY: 17.5 lbs

Number produced
AGC: 75; DSKY: 138

Cost
Unknown

Power consumption
Operating: 70W @ 28VDC
Standby 15.0 watts



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GAP:   ASSEMBLE REVISION 131 OF AGC PROGRAM LUMINARY BY NASA 2021112-091       17:53 DE
       L        P-AXIS RCS AUTOPILOT
       R0446    IN DIRECT RATE, JETS ARE FIRED WHEN STICK POSITION CHANGES BY A FIXED NUMBER
       R0448    THE 'BREAKOUT LEVEL' IS .6 D/S FOR LM-ONLY AND .3 D/S FOR CSM-DOCKED. THIS LA
       R0450    THE 'TARGET DEADBAND', WHICH EQUALS THE BREAKOUT LEVEL.
       R0451    IN PSEUDO-AUTO, BODY-FIXED RATE AND ATTITUDE ERRORS ARE SUPPLIED TO TJETLAW,
       R0453    CONTROL SWITCHES FROM DIRECT RATE TO PSEUDO-AUTO IF THE TARGET DB IS ACHIEVED
       R0455    IF THE INITIAL COMMAND DOES NOT EXCEED THE BREAKOUT LEVEL, CONTROL GOES TO PS
       R0457
       R0458    SINCE P-AXIS CONTROL IS SEPARATE FROM Q,R AXES CONTROL, IT IS POSSIBLE TO USE
       R0460    OR VICE VERSA.  THIS ALLOWS A DEGREE OF ATTITUDE HOLD IN UNCONTROLLED AXES.
       R0462    R AXES ARE COUPLED AND MUST USE THE SAME CONTROL LAW.
       R0463
       R0464    HAND CONTROLLER COMMANDS ARE SCALED BY A LINEAR/QUADRATIC LAW. FOR THE LM-ALO
       R0466    AND 4 D/S IN NORMAL AND FINE SCALING; HOWEVER, STICK SENSITIVITY AT ZERO COLN
       R0468    OF 2 DEGREES FROM THE CENTERED POSITION IS .5 OR .1 D/S PER DEGREE. NORMAL A
       R0470    CASE IS AUTOMATICALLY SET TO 1/10 THE ABOVE VALUES. SCALING IS DETERMINED IN
       A0472                                                  ZEROENBL      ENABLES COUNTERS SO T
       A0473                                                  JUSTOUT       FIRST DETECTION OF OU
       A0474
       A0475
        0476                              16,3071  C 0006 1  DETENTCK EXTEND
        0477    REF  14  LAST 1423        16,3072  00 031 0           READ   CHAN31
        0478    REF   1                   16,3073  55*443 1           TS     CH31TEMP
        0479    REF  50  LAST 1414        16,3074  7 4735 0           MASK   BIT15           CHECK
        0480                              16,3075  C 0006 1           EXTEND
        0481    REF   1                   16,3076  1 3723 0           BZF    RHCMOVED        BRANC
        0482    REF   1                   16,3077  3 4740 0           CAF    OURRCBIT        IN DE
        0483    REF  40  LAST 1422        16,3100  7 0111 1           MASK   DAPBOOLS
        0484                              16,3101  C 0006 1           EXTEND
        0485    REF   2  LAST 1422        16,3102  1 3467 0           BZF    PURGENCY        BRANC
```

Even as the Apollo 11 crew—Armstrong, Aldrin, and Collins—were sitting on the launch pad, the only "documentation" on the AGC program was the listing itself, part of which is shown here.

IN THE COLLECTION

Burroughs Corporation Apollo Guidance Computer read only rope memory (1963), XD115.76, Gift of Charles Stark Draper Laboratory

Draper Laboratories Apollo Guidance Computer block 1 components: 3 logic prototypes, 1 finished logic module (1962), X1067.91, Gift of Eldon Hall

Draper Laboratories Apollo Guidance Computer block 2 prototype components: 1 sense amplifier, 2 logic modules (year unknown), X1068.91, Gift of Eldon Hall

MIT Instrumentation Laboratory Apollo memory stack module (1962), X186.83, Gift of Boguslaw Frankiewicz

MIT Instrumentation Laboratory, Raytheon Company, Charles Stark Draper Laboratory Apollo Guidance Computer Prototype Processor-Logic-Interface-Memory modules (1962), X37.81B, Gift of Charles Stark Draper Laboratory

MIT Instrumentation Laboratory, Raytheon Company, Charles Stark Draper Laboratory Apollo Guidance Computer Prototype Universal DSKY Input/Output array (1962), X37.81A, Gift of Charles Stark Draper Laboratory

FURTHER READING

Apollo Operations Handbook, GUIDANCE AND NAVIGATION SYSTEM (G&N), Basic Date: 12 November 1966, http://users.primary.net/~pebecker/apollogc.htm

For a summary of NASA flight computers and software reliability, see: http://www.dfrc.nasa.gov/History/Publications/f8ctf/chap3.html

Hall, Eldon. *Journey to the Moon: The History of the Apollo Guidance Computer*, Washington: American Institute of Aeronautics, 1996.

For an Apollo 8 mission journal, see: http://history.nasa.gov/ap08fj/index.htm

An online version of *Chariots for Apollo: A History of Manned Lunar Spacecraft*, by Courtney G Brooks, James M Grimwood, Loyd S Swenson, published as NASA Special Publication-4205 in the NASA History Series, 1979 can be found at: http://www.hq.nasa.gov/office/pao/History/SP-4205/contents.html

A thorough history of the Apollo Guidance Computer is located at: http://hrst.mit.edu/hrs/apollo/public/

HISTORY MATTERS

BY MICHAEL R WILLIAMS

Michael R Williams is Head Curator at the Computer History Museum.

BUILDING A COLLECTION IN A COMPUTER MUSEUM

The challenges encountered in creating a computer history collection are often different from those found in creating, say, a collection of rare historical science books. For the latter, wide agreement exists as to what constitutes an historic breakthrough and which authors are the fundamental authorities. Computers are, of course, a modern invention and we often do not have the insight to say, with any real confidence, what are the real advances and what are simply derivative embellishments. Additionally, many of the people who worked in the early days of computing are still alive, which makes documenting history both easier and harder. It is only human nature to consider one's own accomplishments to be fundamentally important, which may or may not be the case.

When it comes to creating a collection of relatively modern artifacts, a museum has two basic choices, both of which have advantages. The first is to simply collect everything possible (within certain parameters) and hope that another 15 or 20 years will bring some perspective, allowing curators to weed out unimportant items over time. However, unless the subject is something the size of a postage stamp, storage space simply runs out too soon. The second methodology is to use the best knowledge and intuition in deciding what is or will be important in the future and from the start to limit the items brought into the collection. In this case, some important items will undoubtedly be rejected and impossible to obtain at a later date.

At the Computer History Museum, we have striven over the past twenty years to collect items according to a process of curatorial review centered around the Museum's Collections Committee. We have been fortunate to have generous storage space during this time. However, since the institution's move West, the collection has doubled in size, thanks to an aggressive policy of rescuing important artifacts. Coupled with the storage requirements demanded by the Museum's preservation mission, space is becoming an increasing challenge and will continue to be so, even with a new facility.

When we accept a donation and properly "accession" it through documents that transfer ownership rights to us, we are legally obligated to keep it for a specified period of time. Legislation in this regard was enacted to prevent various unethical groups from accepting potentially valuable donations and selling them on the open market. Here at the CHM we have an additional policy that requires us to keep each item in our collection until the Board of Trustees specifically authorizes the Museum to "de-accession" it, preventing staff members from simply cleaning house on a whim.

Many other considerations arise when evaluating a potential donation. The question of whether an item looks good and would make an interesting exhibit must be balanced against its usefulness in illustrating a particular technology or its status as something of such importance that it must be obtained regardless of its exhibiting potential. One such item would be the Apollo spacecraft guidance computer (see page two), which may not much to look at. But, who wouldn't agree that a device that helped humans get to the moon deserves a place in the Museum?

Another approach can be to compromise—perhaps "hedge our bet" is a better term—by accepting illustrative pieces of something big. For example, we recently decided that we could not accept an entire Fujitsu/Amdahl 5995A (a system 390 class of computer). Instead, we arranged for the donation of sample boards from the CPU and memory sections as well as the fundamental design documentation. This gives us visually and technically interesting items to exhibit as well as information that future historians might want. Additionally, the donor is now investigating the possibility of producing a family tree of all 390 systems—something historians will certainly find interesting.

What the Museum has attempted to do is to develop a philosophy to guide our decision on any particular donation. In essence it states, "we want to have as many of the home runs as possible, and a representative sample of the doubles, base hits, and strike-outs." To accomplish this, the collections department meets once a week to discuss items offered for donation. If the decision is obvious, we make it there and then; for further advice, we consult the Collections Committee, which is composed of members of our Board of Trustees and other experts in the field.

Everyone has a favorite machine and sometimes we must be very diplomatic in declining an offer. However, if anyone knows of an IBM 650 or one of their 700 series of machines we will be happy to consider it at our next weekly collections meeting!

To find out how to donate an item, please visit our web page at http://www.computerhistory.org/collections/donateArtifact/ or call Chris Garcia at +1 650 604 2572 for more information.

RECENT DONATIONS

TO THE COMPUTER HISTORY MUSEUM COLLECTION

1940s-era slide rule documentation collection (various dates) X2389.2002, Gift of Herbert F. Spirer

A Computer Perspective (1973), *The Personal Computer Lilith* (1981), X2386.2002, Gift of Ron Mak

APL documentation and ephemera collection (1963-1995), X2393.2002, Gift of Curtis Jones

Apple Macintosh PowerBook 165c and Color StyleWriter 2200 (1993), X2384.2002, Gift of Lynne Engelbert

Atanasoff-Berry Add-Shift Module replica (c. 1995), X2446.2002, Gift of John Gustafson

Bound firing tables for a 155mm M1/M1A1 gun (1942), X2395.2002, Gift of the United States Department of the Army, Aberdeen Proving Ground

Commodore SX-64 Executive portable computer (1985), X2367.2002, Gift of Lee and Mary Long

"Compu-mug" coffee mug (c. 1980), X2364.2002, Gift of Jim Gross

Computer Logic (1964) and Charting Courses (1931), X2392.2002, Gift of Steven Golson

Computer Simulation Applications (1971), X2397.2002, Gift of Julian Reitman

Digital Equipment Corporation document collection, including many *Pocket Service Guide* handbooks (1964-1983), X2394.2002, Gift of Petar Sredojevic

Early computing manuals collection (c. 1960-1980), X2381.2002, Gift of Charles Jortberg

Epson PX-8 laptop computer (1983), X2451.2002, Gift of Chris Illes

Guide to the IBM pavilion, 1964 World's Fair, X2382.2002, Gift of Dag Spicer

Hewlett-Packard Integral Personal Computer (1985), X2369.2002, Gift of Peter Gulotta

IBM 1403 printer music audio tape (1970), X2386.2002, Gift of Ron Mak

IBM advertisements (c. 1950), X2450.2002, Gift of Robert Garner

IBM manual collection (c. 1964-1969), X2398.2002, Gift of Donald Keegan

IBM Models 3494 and 3590 Tape Library Subsystems and Drives (c. 1998), X2399.2002, Gift of University of California, Berkeley, Computer Science Division

IBM software and documentation (various dates), X2391.2002, Gift of Richardson Data Services

Illiac I drum image (CD-ROM) (1952), X2447.2002, Gift of Al Kossow

Inside NETBIOS (1986), X2383.2002, Gift of NASA Ames Library

Laser Computer Inc. pc3 portable computer, software, and manuals (1989), X2390.2002, Gift of Bobby Greenberg

"Laws of Computer Programming" coffee mug (1982), X2365.2002, Gift of Jim Gross

MACTEP (MASTER) personal computer, documentation, and software (c. 1993), X2452.2002, Gift of Serguei Nikolaev

Manual and documentation collection (various dates), X2388.2002, Anonymous Donor

Palm Pilot VII (c. 1998), X2385.2002, Gift of Andrea Butter

Promotional button collection (1970s-1980s), X2451.2002, Gift of Chris Illes

Ricochet Model 21062 wireless modem (1992), X2448.2002, Gift of Karen Mathews

Tano AVT2 Personal/Business Computer, manuals, and software (c. 1985), X2396.2002, Gift of Mark Possof

The Portable Companion collection and related Osborne documentation (1982-1984), X2445.2002, Gift of Leslie Blackwell

Two TRS-80 computer cassettes (c. 1982), X2366.2002, Gift of Jim Gross

Tutorial Description of the Hewlett-Packard Interface Bus (1980), X2387.2002, Gift of T J Forsyth

Various computer science manuals and supercomputer documentation collection (various dates), X2449.2002, Gift of Eugene Miya

Xerox 860 Information Processing System printer wheels and ribbons, documentation, and software library (c. 1980), X2453.20002, Gift of Kenneth G Lehmann

GIFTS OF DAVID BELKNAP

Apple Newton Message Pad (1993), X2357.2002

Apple Newton Message Pad 110 with GPS docking port (1994), X2358.2002

Casio Z-7000 personal digital assistant (1993), X2355.2002

GRiD System Corporation 2260 "Convertible" personal digital assistant (c. 1992), X2359.2002

GRiD System Corporation 2260 "Convertible" personal digital assistant (c. 1992), X2360.2002

GRiD System Corporation Model 2352 PalmPad (1992), X2361.2002

GRiD System Corporation Model 2352 PalmPad (1992), X2362.2002

MicroSlate Datellite 300L personal digital assistant (1991), X2356.2002

NCR Safari 3115 CommStation docking port (c. 1992), X2363.2002

NCR Safari 3115 portable computer (c. 1992), X2363.2002

GIFTS OF MICHAEL PLITKINS

Apple GLM computer system (c. 1984), X2435.2002

Apple IIc Plus computer system (1988), X2433.2002

Apple III computer system (1980), X2437.2002

Apple LISA I prototype computer system (1983), X2436.2002

Apple LISA II personal computer (c. 1984), X2442.2002

Apple Lisa NOS cathode ray tube (c. 1983), X2438.2002

Apple/Franklin floppy disk drive (c. 1978), X2441.2002

Atari 520 ST personal computer system (c. 1985), X2439.2002

Atari 520 ST personal computer system (c. 1985), X2440.2002

Atari 520 STFM personal computer (c. 1985), X2443.2002

IBM 320 POWERserver (c. 1996), X2444.2002

Pixar Image computer in Symbolics SCOPE cabinet (c. 1987), X2434.2002

Sony HB-75AS Hit Bit Home Computer (c. 1985), X2432.2002

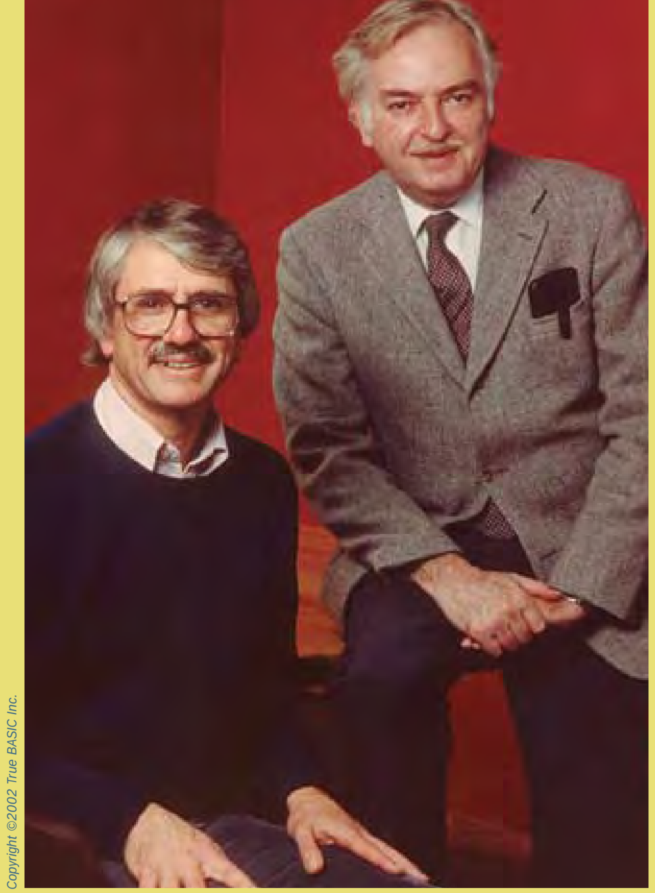
(Dates represent dates of introduction and not necessarily dates of manufacture.)

If you would like to update the Museum regarding your artifact donation, please contact Registrar Jeremy Clark at +1 650 604 1524 or clark@computerhistory.org.

BASIC

BY CHRISTOPHER GARCIA

BASIC paper tape. Written by Bill Gates for the Altair 8800, BASIC quickly became the language of choice among hobbyists, and was the first piece of software to be heavily pirated.



Thomas Kurtz and John Kemeny, co-inventors of BASIC

Students using a PDP-8 based timesharing system

Batch processing dominated the earliest days of computing. A programmer would take a deck of cards he or she had punched of f-line, give them to a system operator, and wait, sometimes days, for the results. Obviously, this meant large delays in analyzing and adjusting code, since iterations could not be tested immediately.

The need for systems where multiple users could function as individual operators helped bring about the BASIC language. BASIC, the "Beginners All-Purpose Symbolic Instruction Code," was invented in the early 1960s by two Dartmouth mathematics professors, Thomas Kurtz and John Kemeny, and various Dartmouth students. They wanted to create an easy-to-learn language that could be used on the GE225 timesharing system that Dartmouth was about to launch. This time-sharing system would allow many users to log in at the same time, running programs remotely via terminals in the mathematics and science departments.

Kurtz and Kemeny thought that the most popular languages of the day, including Fortran and ALGOL, were too complex for non-technical users. Using elements from several languages, and adding features such as line numbering that made troubleshooting easier, the two developed BASIC. With just 14 commands in the beginning—including the famous "GOTO"—BASIC could be learned in as little as two learning sessions, creating a tremendous advantage over other languages that could take months to learn.
BASIC may have been the first programming language written for use by non-computer professionals. Many early timesharing systems used BASIC, including those powered by GE machines and DEC PDP-11 systems. BASIC began to show up in many elementary schools around the country, particularly in cities where school districts could use teletypes to get at university mainframe timesharing systems. Children as young as seven years old learned BASIC as part of their curriculum. This early introduction made sure that BASIC would continue to evolve.

When the microprocessor was introduced in the early 1970s, some of the young people introduced to BASIC in elementary schools started building computers from kits and went on to start companies. It should be no surprise that many early microcomputing systems chose BASIC, especially since Kemeny and Kurtz never patented or copyrighted the language. The first BASIC considered to be a full language implemented on a microprocessor was Li Chen Wang's Tiny Basic, which appeared in *Dr Dobbs* magazine in early 1975.

Bill Gates, then a student at Harvard, wrote a BASIC interpreter for the Altair in March, 1975. Microsoft (then Micro-Soft) released their own version on paper tape later in the year, once delivery of Altairs had started. A paper tape was easy to pirate, because it could be run into the computer and a copy could then be punched out.

After this had been occurring for awhile, Bill Gates wrote an open letter to hobbyists (see page 12) claiming that software copying was theft. He stated that this theft had resulted in an income of two US dollars per hour for all the work he and his team had put into BASIC for the Altair. The letter was published in many computer hobby magazines and was the first time people began to contemplate the idea that software sharing was piracy. Some hobbyists believed passionately in free sharing of software, and Gates' letter began to turn some of them against Gates and Microsoft—an attitude that persists even today.

In 1983, BASIC designers Kemeny and Kurtz released their own polished version of BASIC called True BASIC. The two originators claimed that the variants of BASIC released by multiple companies were altering the premises of BASIC, and the "true" BASIC was to be the definitive version. However, it did not sell as well as the other versions on the market, especially those made by Microsoft.

Many new systems used BASIC to introduce people to computing. In the 1980s, the British Broadcasting Corporation (BBC) used a version of BASIC called BBCBASIC (occasionally called BBasiC by the few Americans who knew anything about it) to be used on the BBCMicro, later the Archimedes, and many other British micros. The BBC Micro had been designed as part of a BBC plan to introduce computers to the general population (since to a degree Britain had been lagging behind the US in the percentage of homes and classrooms with computers). The machine and the variant of BASIC are almost unknown in America, though some believe that it could have caught on in the US with a proper introduction. There continues to be a strong group of users who proclaim BBCBASIC to be "the best, most powerful BASIC ever written."

BASIC began to fade from the limelight when languages like C and Pascal were implemented for small machines. The beginning of object-oriented programming and languages like C++ brought a close to BASIC's glory days. The language still exists today in Microsoft's QBASIC and a few other products, and also as Visual BASIC, an object-oriented language developed by Microsoft, though it is less popular than many of the other object-orientated programming languages.

Some people point to BASIC as the "gateway" programming language: it was the first real language to enable the common person to program computers and it ultimately helped to make computer science a discipline of its own. Kemeny passed away in the early 1990s, but Kurtz continues to speak and write about the early days of BASIC. Recently, Kurtz denied the claim that BASIC was the single-most important advancement in the history of programming, commenting, "I'm sorry to say, but I don't think we had much effect..."

Christopher Garcia is Historical Collections Coordinator at the Computer History Museum.

FURTHER READING

Wexelblat, Richard L. *History of Programming Languages*, Academic Press, New York, 1981.

William Henry Gates III

February 3, 1976

An Open Letter to Hobbyists

To me, the most critical thing in the hobby market right now is the lack of good software courses, books and software itself. Without good software and an owner who understands programming, a hobby computer is wasted. Will quality software be written for the hobby market?

Almost a year ago, Paul Allen and myself, expecting the hobby market to expand, hired Monte Davidoff and developed Altair BASIC. Though the initial work took only two months, the three of us have spent most of the last year documenting, improving and adding features to BASIC. Now we have 4K, 8K, EXTENDED, ROM and DISK BASIC. The value of the computer time we have used exceeds $40,000.

The feedback we have gotten from the hundreds of people who say they are using BASIC has all been positive. Two surprising things are apparent, however, 1) Most of these "users" never bought BASIC (less than 10% of all Altair owners have bought BASIC), and 2) The amount of royalties we have received from sales to hobbyists makes the time spent on Altair BASIC worth less than $2 an hour.

Why is this? As the majority of hobbyists must be aware, most of you steal your software. Hardware must be paid for, but software is something to share. Who cares if the people who worked on it get paid?

Is this fair? One thing you don't do by stealing software is get back at MITS for some problem you may have had. MITS doesn't make money selling software. The royalty paid to us, the manual, the tape and the overhead make it a break-even operation. One thing you do do is prevent good software from being written. Who can afford to do professional work for nothing? What hobbyist can put 3-man years into programming, finding all bugs, documenting his product and distribute for free? The fact is, no one besides us has invested a lot of money in hobby software. We have written 6800 BASIC, and are writing 8080 APL and 6800 APL, but there is very little incentive to make this software available to hobbyists. Most directly, the thing you do is theft.

What about the guys who re-sell Altair BASIC, aren't they making money on hobby software? Yes, but those who have been reported to us may lose in the end. They are the ones who give hobbyists a bad name, and should be kicked out of any club meeting they show up at.

I would appreciate letters from any one who wants to pay up, or has a suggestion or comment. Just write to me at 1180 Alvarado SE, #114, Albuquerque, New Mexico, 87108. Nothing would please me more than being able to hire ten programmers and deluge the hobby market with good software.

Bill Gates

Representation of Bill Gates' open letter to hobbyists claiming that software copy was theft

THOMAS KURTZ ON BASIC

INTRODUCTION

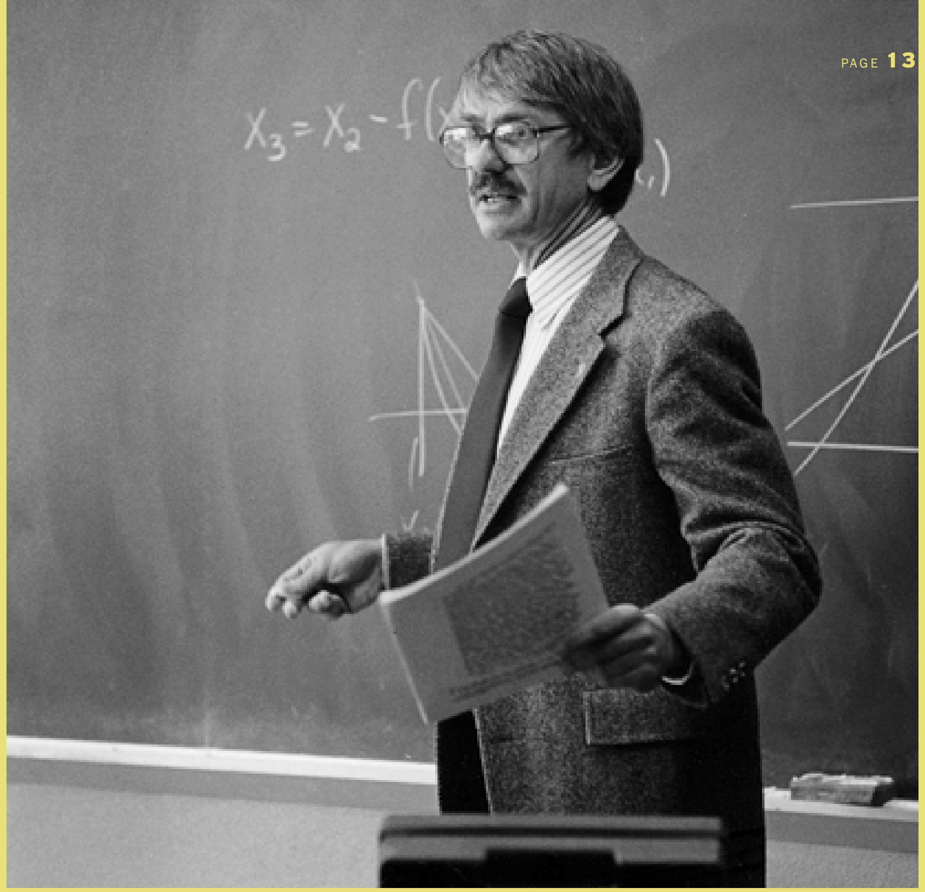
In an email exchange with Computer History Museum Curator of Exhibits Dag Spicer, Thomas Kurtz graciously responded to several questions regarding his experiences with BASIC. Thomas Kurtz and John Kemeny, along with many students at Dartmouth, invented BASIC in the 1960s. Kurtz and Kemeny later wrote a version called True BASIC.

Dag Spicer: In your opinion, what was required to transition from a single-user paradigm to a timeshared paradigm in computing? How did you observe this happen and what, in retrospect, is striking about how it occurred?

Thomas Kurtz: Timesharing was a way to provide many persons with a small amount of computing resources from a single, expensive main frame, each user having the impression that he/she "owned" the whole computer. Remember, 1964 was long before personal computers or microcomputers, and there were only mainframes. Timesharing was a fantastic improvement over punched cards! In other words, there was no paradigm; it was a matter of economics, plus wanting to allow thousands of students at the computer.

DS: Before the arrival of the GE225/235 BASIC timesharing system in 1964, Dartmouth students had access to the school's LGP-30 machine. In your Wexelblat paper you observe that by using this machine, "a good undergraduate could achieve what at that time was a professional-level accomplishment, namely, the design and writing of a compiler." What was Dartmouth's policy regarding getting machine time on the LGP-30? Did these high-level accomplishments surprise you? Why?

TK: Remember that what arrived in 1964 were two machines, the GE-225 (later the 235) and the Datanet-30. Dartmouth undergraduate students built the entire timesharing system with their



Professor Thomas Kurtz lectures to his class.

bare hands! Regarding the LGP-30, at the time we acquired the machine in 1959, there was a crude interpreter called "24.1." What our students did over the next few years was: build a genuine algebraic language processor (in one summer); build a compiler for Algol-60 (actually, a subset of Algol-60); build a load-and-go Algol-like processor for student use (we called it SCALP for Self Contained ALgol Processor); prove a number theory result about the tenth Fermat number; construct a concordance of the works of Wallace Stevens; and on and on. All this was done by undergraduate students in their spare time. I observed that the work done by our students was superior in sophistication and quality to the work done by the industrial users of the same LGP-30.

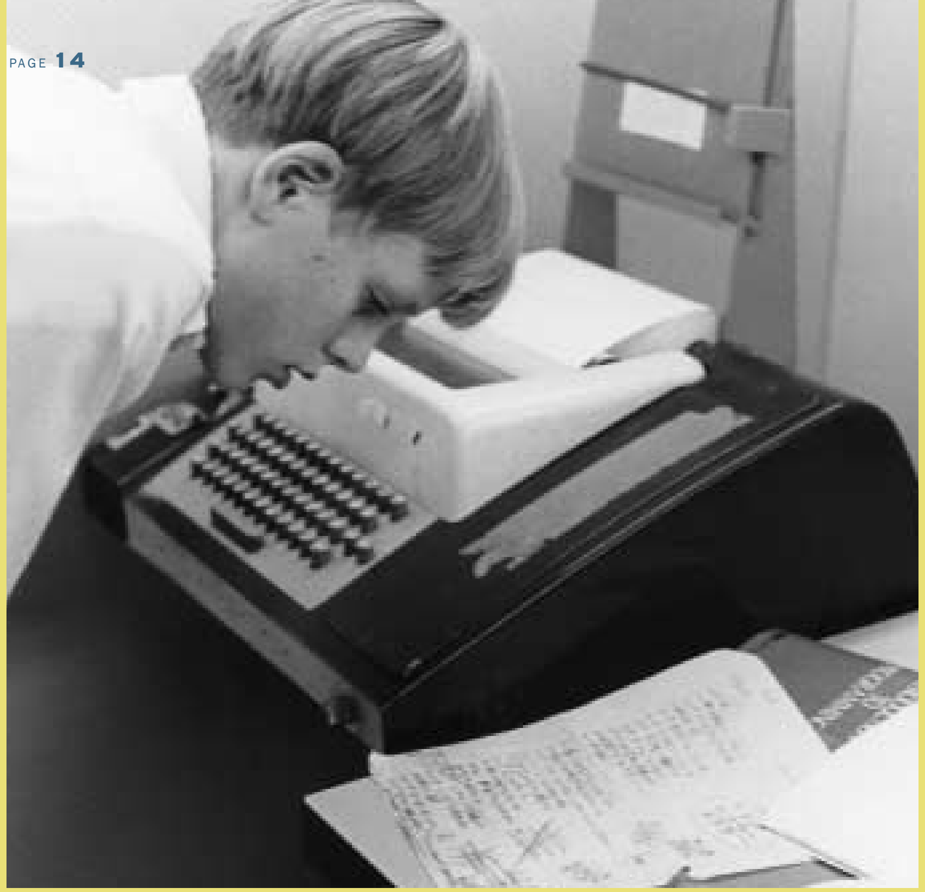
DS: You once said that, "Lecturing about computing doesn't make any sense, any more than lecturing on how to drive a car makes sense." How important was the timesharing metaphor (in contradistinction to batch punch card processing) to your goals for BASIC as a language "for the rest of us?"

TK: Punched cards could not do the job. They were okay for professionals working full time on huge projects, but students (with few exceptions) wouldn't stand for the messing around with keypunches, waiting in line for their job to run, and grappling with the completely unintelligible error messages that came back. They just wouldn't do it. And recall, we were trying to educate ALL Dartmouth students, especially those having major interests in the humanities and social sciences.

Therefore, at the time, timesharing was the only way. BASIC was a part of the solution, being far simpler to understand and use than Fortran or Algol.

DS: Can you explain the relationship between BASIC and GE's Mark I timesharing system and how the relationship helped promulgate BASIC as a standard?

TK: In the fall of 1964 or thereabouts, the GE Service Bureau decided to add Dartmouth timesharing to their existing offerings, which were restricted to punched-card type services. So they hired the two students who wrote the



A student goes over his program in the mid-1970s

One of millions of young students who learned BASIC at an early age

Early users of the Dartmouth timesharing system on the GE-225

timesharing executive to go to Phoenix to install the Dartmouth timesharing system on similar hardware at the service bureau. Of course, they renamed it the GE timesharing system, Mark I. It was with our blessing, as (1) they had provided a slight bit more than their usual educational discount plus several other non-monetary benefits, and (2) we had no interest in marketing what we had built through a commercial operation. The timesharing system, also called the GE-265, was the basis of the GE service bureau operation for the next ten or so years, and eventually provided them with $100,000,000 in annual revenue. I seem to recall that the GE-265 was replicated in over 50 locations, some of them in the GE Service Bureau, the others in various corporations and in a few school districts.

Thus, BASIC became the most widely used language in the timesharing world, as other vendors "copied" the GE approach on different computers. At one time, there were over 100 companies in the world offering timesharing services, and the vast majority offered some form of BASIC. Thus, when (finally) microcomputers began to appear, the vendors adopted BASIC as being (a) simple, (b) easy to learn, and (c) able to fit in the teeny memories at the time. This then motivated an effort to standardize BASIC in 1974. (It failed, as coming too little, too late.) Gates and Allen wrote one of the first (not the first) BASIC interpreters in 1975. In short, the GE connection was the vehicle that popularized BASIC, which was then picked up by the emerging personal computer industry.

DS: What principles of BASIC do you believe still remain fundamentally important or true? What ideas are so ubiquitous today they no longer feel like BASIC, but nevertheless are/were?

TK: Since most of the users would be casual and occasional users, the language had to be simple and easy to remember. Error messages should be in English and also be suggestive. Beginners should not have to learn fancy stuff of use mainly to experts. These aspects are not present today in most computer applications. The majority of applications are so huge that a casual user must take a course to figure out how to use them. Their desktops are cluttered with so much junk that it is almost impossible to figure things out without studying the manual. And most manuals are atrocious. The computer industry is out for the quick buck, and puts little effort into creating reliable and safe products with readable and useful manuals. The whole strategy is to bring out upgrades on a regular basis in order to establish a revenue stream, each upgrade making the product ever more complicated. The whole virtue of simplicity has been lost!

DS: Why do you think there has been such a proliferation of programming languages since the invention of the stored-program computer some 50 years ago?

TK: My opinion is that all (well, almost all) programming languages are the same, differing only in the spelling of the words, and the clientele for which they are intended. Each new systems programmer that comes along feels he can improve things by inventing a new language. In some cases, a new language was needed because it was intended for a different environment. For example, C was invented as a higher-level improvement for assembly language on Unix machines.

DS: How did RAND's JOSS (Johnniac Open Shop System) influence you?

TK: John Kemeny had used JOSS at the Rand Corporation, and so had experience with timesharing systems. But we did not adopt JOSS as there were details that we preferred not to use. For example, each JOSS statement ended with a period. Well, periods are the way most folks represent decimal numbers. Also, we wanted to make all internal calculations in double-precision floating point to (a) provide enough accuracy for serious computations, and (b) isolate our users from having to learn about the internal number formats. Other than that, I cannot recall our discussions about JOSS.

DS: You are part of a project to reconstruct the Dartmouth timesharing system. Can you say more about that?

TK: Oddly enough, I didn't write any of the code. John Kemeny had written a BASIC compiler for the GE-225 using punched cards during the summer of 1963, but didn't do any coding once the hardware arrived in 1964. (I had written much code for the LGP-30, as he did as well.) It was clear that our students were better at coding than we were. All we did was to supervise the project. Kemeny was 1/12 time as the supervisor of the programming group, but interfered little in their work, except to maintain the main goals, such as simplicity. I was the director of the "center." We collaborated on the original design of BASIC, and on the additions and improvements that were subsequently made.

DS: You and Dr. Kemeny are heroes to many for your invention of BASIC. Do you have any heroes?

TK: Anyone who makes significant progress toward world peace.

DS: Is there anything you'd like to say about the role of BASIC in the history of computing?

TK: Dartmouth BASIC will be celebrating its fortieth birthday in 2004. It is still around; its current incarnation is True BASIC, which is used in schools and some colleges. While we have used True BASIC to build many serious applications, its chief appeal is that it is simple and easy to use. Plus, there have been no major language changes in the last decades; teachers much prefer continuity, as they don't want to have to change their teaching materials every year.

We are hot on this project of recreating the Dartmouth timesharing system, circa 1965. One of the then student programmers, Steve Hobbs (formerly of DEC and Compaq, now of Intel), has located assembly language listings of the BASIC compiler and runtime, the Algol compiler and runtime, the 235 exec, and the D-30 exec. We are now in the process of hand transcribing these listings into a machine-readable form. (We tried scanning but that didn't work. Plus, we have to proofread very carefully anyhow.) As of the moment, the D-30 exec has been transcribed and proofread. The Algol compiler and runtime has been transcribed, but not proofread. Once the code is thus finished, someone will write emulators for the 235 and D-30. When completed, we will actually have a working model of the original (well, one year later) system.

Others who are directly involved in the project are: John McGeachie, who wrote the original GE-235 exec to DTSS and Ron Martin, who took over the code for the D-30 exec (which had been originally written by Mike Busch.) As we progress, I am sure more people will become involved. A start of a website for this project can be found at: http://www.dtss.org. ■

For more information about True BASIC, visit the company website at www.truebasic.com.

REPORT ON MUSEUM ACTIVITIES

BY KAREN MATHEWS

Karen Mathews is Executive Vice President at the Computer History Museum

It is clear—when we think about it—that computer history is created every day. The challenge of preserving and presenting important artifacts and stories of that history is our abiding passion at the Computer History Museum. Much of what we do on a daily basis relates to education and serving the public; researching and planning for the future building and the physical and CyberMuseum exhibits; processing artifact donations; cataloguing and caring for the existing collection; planning and holding programs and events; and of course, raising the funds to continue and advance this important work. In my opinion, it is our great privilege to both facilitate and observe the process of preservation in action.

CHARLIE SPORCK

PUTTING THE SILICON IN SILICON VALLEY

With SEMI (www.semi.org) as our co-host, Charlie Sporck kicked off the Museum's Spring 2002 lecture series on January 16 with his talk, "Putting the Silicon in Silicon Valley: The Birth of the Semiconductor Industry in Silicon Valley," where he relayed fascinating and sometimes surprising personal observations and stories about the people and personalities who brought the semiconductor industry in Silicon Valley into being. Recruited by Fairchild Semiconductor in Mountain View, Calif., Sporck began as a production manager and rose to vice president and general manager. It was during this period at Fairchild that Jean Hoerni developed the planar process and Bob Noyce, the integrated circuit. These innovations, together with the manufacturing equipment and organization, became

Charlie Sporck (left) autographs his book, *Spinoff: A Personal History of the Industry that Changed the World*, after his Museum lecture on January 16.

After leaving Fairchild in the late 1960s, Sporck distinguished himself as CEO of National Semiconductor, where, under his leadership, the company became a multi-billion-dollar giant. With Richard L Molay, Sporck recently co-authored *Spinoff: A Personal History of the Industry that Changed the World*, a book about the Silicon Valley semiconductor industry. Lecture attendee Mike Cheponis remarked, "I really appreciated Charlie Sporck's talk and book. I wish more computer old-timers would do what he's done! It is very nice to see someone like him 'giving back' to the community of preserved history."

JEFF HAWKINS, DONNA DUBINSKY, AND ED COLLIGAN

THE PALMPILOT STORY

The late 1980s and early 1990s buzzed with corporations and startups trying to develop portable computers that used pens as the means of interaction. By late 1993, every one of these efforts had failed. Though running out of funding, one of these startups, Palm Computing, introduced the Pilot organizer and Palm operating system, which, in turn, launched the handheld computing industry. Last February 26, to an audience of 250, Jeff Hawkins, Donna Dubinsky, and Ed Colligan discussed the roots of handheld computing, how Palm learned from failure, and the challenges of battling conventional technology wisdom. Andrea Butter, former Palm marketing executive

Pioneers (left to right) Jeff Hawkins, Donna Dubinsky, and Ed Colligan discuss the roots and challenges of the handheld computing industry.

Andrea Butter, former Palm Computing marketing executive, facilitated a panel discussion with Hawkins, Dubinsky, and Colligan on February 26.

and co-author of *Piloting Palm: The Inside Story of Palm, Handspring, and the Birth of the Billion Dollar Handheld Industry*, facilitated the discussion.

In 1994, Hawkins invented the original PalmPilot products and founded Palm Computing. He is often credited as the designer who reinvented the handheld market. As president and CEO of Palm Computing, Dubinsky helped make the PalmPilot the best-selling handheld computer and the most rapidly adopted new computing product ever produced.

Handspring President and CEO Donna Dubinsky autographs Butter's book, *Piloting Palm*, before the panel discussion with colleagues Hawkins and Colligan.

Handspring Chairman and Chief Product Officer Jeff Hawkins (right) shows off the Treo.

Doug Engelbart (left) and Pierluigi Zappacosta prepare for Engelbart's talk in which he reminisced about his lifetime of invention and research.

Attendees record their thoughts during Engelbart's lecture.

It is incredible how much tenacity and determination it took to make this happen. As the vice president of marketing for Palm Computing, Colligan worked with Hawkins and Dubinsky to lead the product marketing and communications efforts for Palm. After their successful run together at Palm Computing, Hawkins and Dubinsky co-founded Handspring in July of 1998 to create a new breed of handheld computers for consumers. Colligan joined Handspring to lead the development and marketing efforts.

Be sure to visit our Visible Storage Exhibit Area and view the PalmPilot prototype on display.

DOUG ENGELBART

OUTRACING THE FIRE: 50 YEARS (AND COUNTING) OF TECHNOLOGY AND CHANGE

Hosted at Microsoft's Silicon Valley Campus on March 26, Doug Engelbart—thinker, inventor, and humanitarian—shared with an audience of 250 some of the influences and struggles behind his life of research. Pierluigi Zappacosta, founder of Logitech and chairman of Digital Persona, facilitated the dialogue.

Although he may be best known for his tangible evidence of productivity—the computer mouse, display editing, outline processing, multiple remote online users of a networked processor, hyperlinking and in-file object processing, multiple windows, hypermedia, context-sensitive help—Engelbart's drive has been to maximize his professional contributions toward helping humankind cope with complex and urgent problems.

Since 1989, he has become the recipient of an extraordinarily long string of awards, including the Lemelson-MIT Prize of $500,000, and the National Medal of Technology in 2000. Still to be recognized is that Engelbart's technological accomplishments are but part of his humanitarian career. Said lecture attendee Susan Nycum, "My impressions are that Doug is, as always, looking ahead and impatient with looking behind—even at his own accomplishments. [This is] something he shares with all the 'young for their age' senior superstars I know."

250 people attended the Engelbart event.

Our host and Microsoft's general manager of cable services, Colin Dixon, said, "I think the most magical moment for me... was when Doug mentioned, almost offhandedly, an invention he made during the war. He described how he held a tube of electro-luminescent gas up against an antenna he was trying to tune. When he had the power set just right, the gas in the tube glowed most intensely. It was a fascinating glimpse into the mind of a consummate inventor." Engelbart continues to propagate his ideas through his Bootstrap Institute. Additional background information is available at www.bootstrap.org.

CHARLIE BACHMAN

ASSEMBLING THE INTEGRATED DATA STORE (IDS)

On April 16, Charlie Bachman, winner of the ACM Turing Award and Distinguished Fellow of the British Computer Society, described the circumstances under which the first database management system (DBMS) came into being. In 1960, General Electric was desperate to computerize their manufacturing systems, without each of 100 departments inventing their own solution. Bachman and others at GE set out to solve the problem. By 1964 they had created and put into production a generic manufacturing system (MIACS), a transaction-oriented operating system, and the first database management system (Integrated Data Store, or IDS), all running on an 8K GE 225 computer. IDS was a unique combination of existing software technologies: virtual

Charlie Bachman discussed his experiences in developing the first database management system, the Integrated Data Store.

memory, blocked records, list processing, data descriptions, self identifying records, data manipulation language, recovery and restart, etc., and was the first disk-based database management system used in everyday production. Among other things, Bachman was also responsible for developing data structure diagrams (ER diagrams), commonly known as Bachman diagrams, as graphical representations of semantic structures within the data.

In April 1983, Bachman Information Systems, Inc. was created to commercialize Computer Aided Software Engineering (CASE) concepts, which he developed while at Honeywell and Cullinet. In 1991 the company went public, and in 1996, merged with Cadre Technology, Inc., to form Cayenne Software, Inc. Bachman's IDS and CASE products are still alive under the CA banner. Today, Bachman is a consultant and is currently working on a book about the story of the development of IDS.

STEVE RUSSELL AND NOLAN BUSHNELL

SHALL WE PLAY A GAME? THE EARLY YEARS OF COMPUTER GAMING

From their humble beginnings in the 1960s as demonstrations of computer interactivity, computer video games have become a major part of popular culture in America, Japan, Europe, and elsewhere. On May 7, Stephen "Slug" Russell, inventor of the early computer game SpaceWar!, and Nolan Bushnell, designer of Computer Space and founder of Atari, shared their personal stories, starting from the days when computer games were played on mainframes. Stewart Brand, publisher of the original *Whole Earth Catalog* and president of The Long Now Foundation, moderated this fascinating discussion about the advent of the modern gaming age.

Video game fans gathered to celebrate the 40th birthday of Spacewar! and the 30th birthday of PONG.

Slug Russell, Bill Pitts, Steve Golson, and Nolan Bushnell (left to right) enjoyed the rare opportunity to play the Galaxy game, which was developed by Pitts and based on Spacewar! Find Spacewar! online at: http://agents.www.media.mit.edu/groups/el/projects/spacewar/

Hanging out together at the model railroad club and inspired by the writings of sci-fi author E.E. "Doc" Smith, Russell and his team of programmers at MIT worked to create SpaceWar! in 1962. "The space program was peaking at the time and people didn't have much sense of what it might be like to steer the spacecraft," said Russell. "I was into realism and really trying to teach people what flying in space was all about."

SpaceWar! was created on a Digital Equipment Corporation (DEC) PDP-1, an early "interactive" mini-computer that used a cathode-ray tube display and keyboard input. The computer was a donation to MIT from DEC, which hoped MIT's think tank would be able to do something remarkable with its product. A game was possibly the last thing the company expected. But Russell's SpaceWar! showed that fun could be a driving force in the advancement of computer technology. It influenced companies like Atari and others in creating a powerful new entertainment medium.

Delighted fans Cassidy Nolen and Nicole Servais with Nolan Bushnell's autograph.

As a youth in Salt Lake City, Bushnell worked in the games department of an arcade. He first encountered SpaceWar! on an IBM machine in the mid 1960s and describes himself at the time as "truly obsessed with the game." Bushnell co-founded Atari in 1972 and after four years of financial struggles, the company was purchased by Warner Communications. It had become "part of the Atari culture to get to the bank first with your paycheck," Bushnell admitted. Having brought PONG to the masses, Bushnell is justifiably revered as the "Father of the Video Game Industry."

TOURS AT THE MUSEUM BRING PEOPLE TOGETHER

You never know whom you will run into at the Museum's Visible Storage Exhibit area—nor what you will learn about them. For example, Jamis MacNiven, owner of the famed Buck's Restaurant of Woodside, California (where hundreds of businesses have been founded over breakfast), recently organized a tour for some of his friends. His guests included: Brian Carlisle, founder of the robotics firm, Adept Technology, where the Milano Cookies are assembled; venture capitalist Paul Dali; Reid Dennis, founder of Institutional Venture Partners and pilot of a 50-year-old airplane that he restored and flew around the world; Kevin Kelly, co-founder of *WIRED* Magazine and outspoken optimist for the coming new age of interconnectivity; Jacques Littlefield, who has an impressive operation in Woodside to collect and restore army

(left to right) Jacques Littlefield, Brian Carlisle, Steve Zelencik, Reid Dennis, Meihong Xu, Bill Peacock (behind), Len Shustek (behind), Kevin Kelly, and Larry Roberts converse in the Museum's Visible Storage Exhibit Area.

Bill Peacock, Jacques Littlefield, and Jamis MacNiven with Museum Curator of Exhibits Dag Spicer at a special tour arranged by Buck's Restaurant owner MacNiven.

tanks from around the world; Bill Peacock, venture capitalist and former assistant secretary of the United States Army; networking pioneer and entrepreneur Larry Roberts; Dennis Taylor, managing editor of *Silicon Valley Biz Ink*; Meihong Xu, venture capitalist with Möbius and formerly an intelligence officer in China; and Steve Zelencik, senior vice president at Advanced Micro Devices and a great finder of computer artifacts himself.

Why not organize a tour for your friends? Contact Kelly Geiger at +1 650 604 0345 to make arrangements.

COLLECTION CONTINUES TO GROW

Among the many items recently donated to the Museum's collection (see page nine), the following are particularly noteworthy. A replica of an add-shift module from the Atanasoff-Berry Computer (ABC) replicates in exact detail the circuitry and components used in the original ABC from 1937. While the machine was not a direct progenitor of the modern stored program digital computer, it played a key role in a decades-long lawsuit over the official "inventor" of the digital computer, a legal battle that Atanasoff eventually won.

Secondly, the U.S. Army's Aberdeen Proving Ground donated an original World War II Artillery Firing Table, precisely the type of table the production of which was the impetus for the design and construction of the ENIAC, the United States' first electronic computer. Gunners used the 1942 booklet of tables to properly guide their artillery shells to their targets. It was the long process of calculating these tables by rooms full of human "computers" that led the Army to consider an automated method of production. ENIAC, though completed after the war, was still used to calculate firing tables but also played a major role in the development of the hydrogen bomb.

Finally, Al Kossow donated an ILLIAC I drum image: a snapshot of the actual bit patterns stored on the computer's drum memory (delivered on paper tape). The ILLIAC I, a vacuum tube machine completed in about 1952, was a direct descendant of the famous IAS (Institute for Advanced Study) machine designed by John von Neumann—the prototype of the modern stored-program, binary, parallel, digital computer. This acquisition helps the Museum fulfill its mission of preserving not just hardware, but software as well, and is an exciting find from the "prehistoric" era of the modern computer.

A paper tape of the ILLIAC I drum memory was recently donated to the Museum by Al Kossow.

On March 30, Museum volunteers and staff visited Jacques Littlefield's Tank Farm in Portola Valley.

VOLUNTEERS VISIT TANK FARM

About 30 Museum volunteers and staff went on a field trip on March 30 to Pony Tracks Ranch in Portola Valley to see Jacques Littlefield's tanks and the Military Vehicle Technology Foundation organization. Curator Roy Robertson showed us 150 of the nearly 200 tanks held on the site. Most of them are operable and many have been restored to combat-ready appearance and operating condition. We are always interested in seeing how other organizations collect, restore, preserve and present their collections. The foundation is doing an impressive job.

THANKS TO OUR ANNUAL DONORS

We acknowledge with deep appreciation the individuals and organizations that have given to the Annual Fund.

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This information is current as of May 1, 2002. Please notify us of any changes to your listing (liska@computerhistory.org). Thank you.

COMPANIES PLAY CRITICAL ROLE IN PRESERVATION

Your company has played a critical role in the computer industry; you spent nights sleeping underneath your desk and an 80-hour work week was average. Now it's time for you to help preserve the history you created by becoming a corporate member of the Computer History Museum.

Corporate members join the Museum on an annual basis, and enjoy many advantages and exclusive privileges for the critical support they provide.

Through this program, your company will be associated with the Museum's most visible and significant activities.

Contributions play an essential role in guaranteeing the future success of the Computer History Museum, and helping us to continue our work collecting the artifacts and human stories of computing history.

The items we seek and the pioneers of the industry are disappearing; we need your help to preserve this piece of history now.

For further information please contact David Miller, vice president of development, at 650.604.2575 or miller@computerhistory.org.

MUSEUM SEEKS DIRECTOR OF INDIVIDUAL GIVING AND MAJOR GIFTS

The Computer History Museum has an immediate opening for a director of individual giving and major gifts. As a member of the development team, the director is responsible for the Museum's annual fund program and goals and serves as major gifts officer for the Museum's capital campaign.

For more information please visit www.computerhistory.org/jobs.

UPCOMING EVENTS

Please RSVP for all events and activities by calling +1 650 604 2714 or visiting www.computerhistory.org/events. Thank you!

TUE, MAY 21
THE HISTORY AND FUTURE OF ELECTRONIC PHOTOGRAPHY
Carver Mead, Foveon, Inc.
MEMBER RECEPTION: 6:00 PM
LECTURE: 7:00 PM
AMD, Commons Building
Sunnyvale, California

TUE, JUNE 4
EARLY TECHNOLOGY MARKETING EFFORTS: AN EVENING WITH REGIS MCKENNA
Regis McKenna, The McKenna Group
MEMBER RECEPTION: 6:00 PM
LECTURE: 7:00 PM
Xerox PARC Auditorium
Palo Alto, California

THU, SEPTEMBER 5
HALF A CENTURY OF DISK DRIVES AND PHILOSOPHY: FROM IBM TO SEAGATE
Al Shugart, Al Shugart International
MEMBER RECEPTION: 6:00 PM
LECTURE: 7:00 PM
Xerox PARC Auditorium
Palo Alto, California

TUE, OCTOBER 22
FELLOW AWARDS BANQUET
Fairmont Hotel, Imperial Ballroom
San Jose, California

TUE, NOVEMBER 12
JOHN WARNOCK AND CHUCK GESHKE
Adobe Systems, Inc.
MEMBER RECEPTION: 6:00 PM
Building 126
LECTURE: 7:00 PM
Moffett Training and Conference Center
Building 3
Moffett Field, California

TUE, DECEMBER 10
STEVE WOZNIAK
MEMBER RECEPTION: 6:00 PM
Building 126
LECTURE: 7:00 PM
Moffett Training and Conference Center
Building 3
Moffett Field, California

TOUR THE MUSEUM

Tours of the Museum's Visible Storage Exhibit Area are normally held on Wednesdays and Fridays at 1:00 p.m. and the first and third Saturdays of each month at 1:00 p.m. and 2:00 p.m. For tour registration call +1 650 604 2579.

VOLUNTEER OPPORTUNITIES

The Museum tries to match its needs with the skill and interests of its volunteers and relies on regular volunteer support for events and projects. In addition to special projects, monthly work parties generally occur on the second Saturday of each month, including:

JUNE 8, JULY 13, AUGUST 10, SEPTEMBER 14, OCTOBER 12

Please RSVP at least 48 hours in advance to Betsy Toole for work parties, and contact us if you are interested in lending a hand in other ways!

For more information, please visit our volunteer web page at www.computerhistory.org/volunteers

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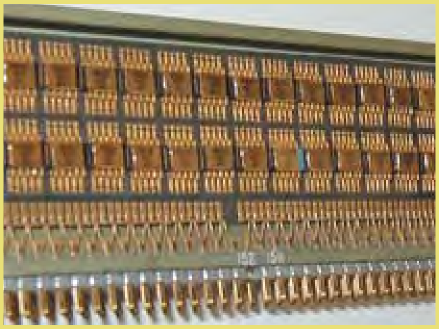
Current staff openings can be found at www.computerhistory.org/jobs.

MYSTERY ITEMS

FROM THE COLLECTION OF THE COMPUTER HISTORY MUSEUM



MIT Instrumentation Laboratory, Raytheon Company, Charles Stark Draper Laboratory
Apollo Guidance Computer Prototype Processor-Logic-Interface-Memory modules (1962),
X37.81B, Gift of Charles Stark Draper Laboratory

Explained from CORE 3.1

APOLLO GUIDANCE COMPUTER LOGIC MODULE PROTOTYPE

Shown here is a prototype logic module from the Apollo Guidance Computer (AGC) currently on display at the Computer History Museum. The AGC was a 70 lb. box of integrated circuitry (with attached control panel) that performed real-time guidance and control and served as a lifeline to American astronauts descending to the lunar surface in 1969.

Spanning nearly a decade of development, the AGC began in about 1961 as a research project at the MIT Instrumentation Lab in Cambridge, Massachusetts. It was built by Raytheon and used approximately 4,000 discrete integrated circuits from Fairchild Semiconductor.

The Apollo Guidance Computer program was a landmark both in terms of hardware design and software management and laid the foundation for SpaceLab and shuttle computer systems development. The speed, power, and size requirements for the AGC pushed along an entire industry that was just taking its first steps along the breathtaking curve of Moore's Law.

See page two for more information about the AGC.

WHAT IS THIS?

THIS ITEM WILL BE EXPLAINED IN THE NEXT ISSUE OF CORE.

Please send your best guess to mystery@computerhistory.org before 07/15/02 along with your name, shipping address, and t-shirt size. The first three correct entries will each receive a free t-shirt with the new Museum logo and name.

COMPUTER HISTORY MUSEUM

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NOVEMBER 2002

CORE 3.3

A PUBLICATION OF THE COMPUTER HISTORY MUSEUM
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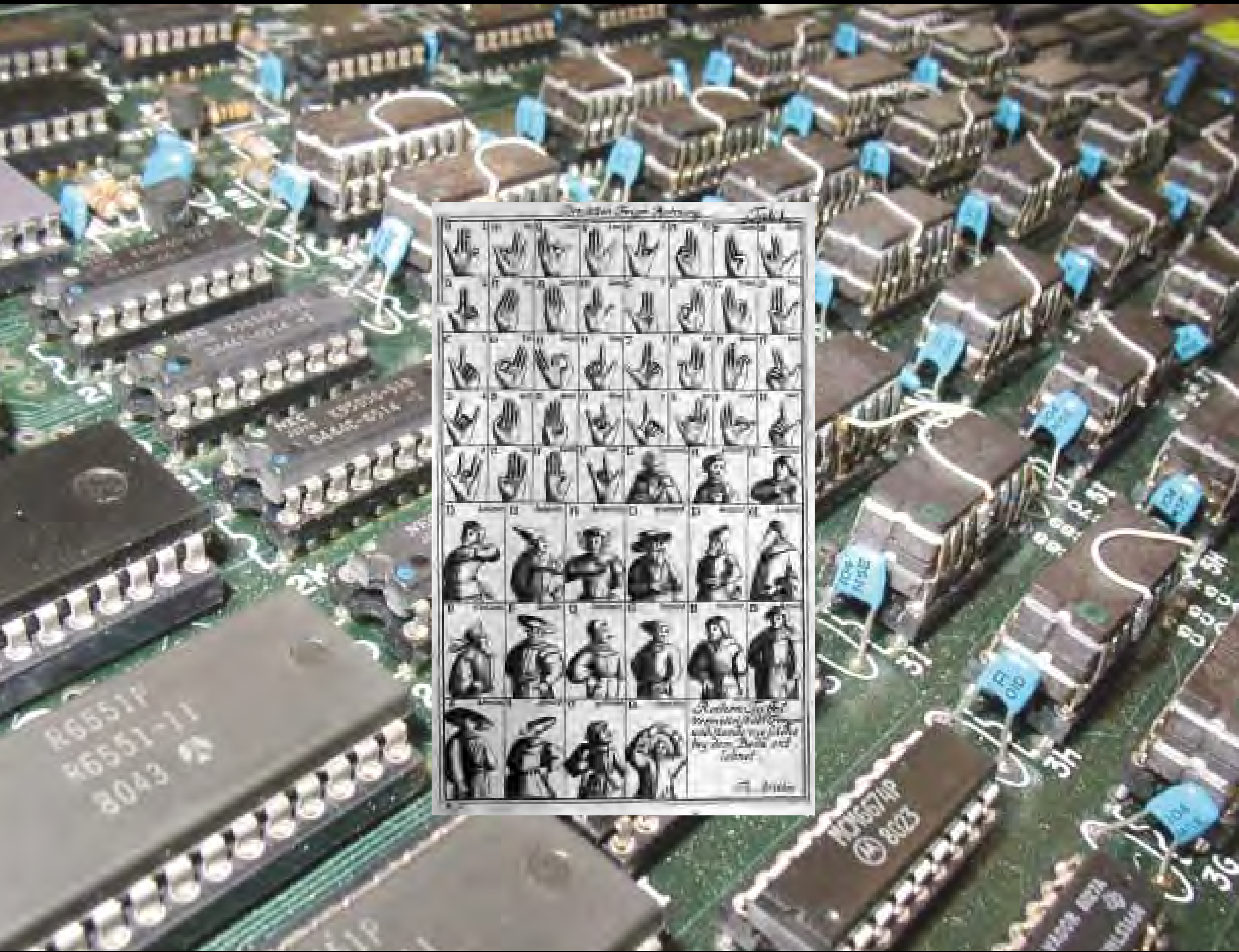


WE HAVE PURCHASED A GREAT BUILDING!

The year 2002 will forever be very special for the Computer History Museum. I am proud to announce that we have acquired a spectacular 119,000 square-foot building on 7.5 acres of land at 1401 N. Shoreline Blvd. in Mountain View, California. With this purchase, we are taking a major step toward realizing our dreams of having a permanent home, owning our own land, directing our future, focusing on programs, and building new relationships with the communities we serve.

The transformation won't happen overnight because we will open this new space in several phases. We plan to move our staff into the building by the end of the year and unveil the first phase of our public presence on Shoreline Blvd. in May 2003 after a few renovations are completed. Read more about our exhibit planning process in Kirsten Tashev's article on page two.

It is awesome to see how we have grown, wrestled with major decisions, and emerged even stronger in commitment, passion, and action—all in the past year or so. In that time, our strategies have definitely changed, but the goal remains the same: to build a major institution that preserves and presents the artifacts and stories of the information age. I'm convinced more than ever that we are setting the course for an innovative future—our mission is unique and focused, and we have one of the best collections of computing artifacts in the world.

We owe much to the people at NASA for their support and help in our own recent history. We will continue to use buildings 126 and 45 at Moffett Field for critical storage for as long as possible. We intend to foster great relationships with partners in the NASA Research Park over time; after all, our building on Shoreline is just one freeway exit north of our current offices! We are neighbors in Mountain View now, with federal and local governments connected to a community of "can-do" people.

We are watchful in this economic climate and mindful of our duty to faithfully fulfill our responsibilities to our supporters. For the important cause we represent, I'm proud to ask you to please consider an increased or new contribution to our annual fund, a donation to our capital campaign, and to help spread the news about the Museum to others. Look carefully at this issue of *CORE* to see what we have accomplished, and remember that you are always a welcome part of our institution.

With the excitement of the new building, don't overlook the simultaneous extensive growth in our public programs, which include world-class lectures that contribute to our historical archive, oral histories, participation in special events to collect computing histories (such as an IBM Stretch reunion, DECWORLD 2001, and upcoming Apple retrospective and database panel events), and numerous exhibitions that bring artifacts and history alive.

It is motivating to meet people everywhere who share our dreams, including early supporters of the Computer History Museum. Although some of you are geographically distant from California, people everywhere want to be part of the Museum. With this encouragement, we are increasingly offering special events and programs targeted to the needs of our "remote" community. It was a pleasure, for example, to be at the Museum of Science in Boston this fall to celebrate the opening of the "Computing Revolution" exhibit, which features many of our artifacts. I hope those on the East Coast will visit that exhibit and experience something of the Computer History Museum 3,000 miles away from California.

Lastly, I want to thank everyone involved for their personal sacrifices, the long hours, and the spectacular execution this summer and fall in acquiring the new building. The passion, persistence, and generosity of our Trustees, staff, volunteers, and supporters has enabled our bold move—I could tell story after story of how each person really made a difference.

It's a wonderful but awesome responsibility to preserve a heritage. I'm proud to report that we have been taking some giant steps forward. Help us continue to grow—the best is yet to come!

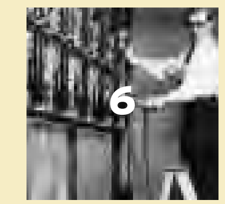
JOHN C TOOLE
EXECUTIVE DIRECTOR & CEO

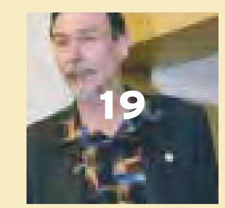
November 2002
A publication of the Computer History Museum
CORE 3.3

MISSION
TO PRESERVE AND PRESENT FOR POSTERITY THE ARTIFACTS AND STORIES OF THE INFORMATION AGE

VISION
TO EXPLORE THE COMPUTING REVOLUTION AND ITS IMPACT ON THE HUMAN EXPERIENCE

IN THIS ISSUE





Computer History Museum
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Mountain View, CA 94043-1311, USA
+1 650 810 1010
+1 650 810 1055 (fax)
(effective December 15, 2002)

WWW.COMPUTERHISTORY.ORG

Submission guidelines: www.computerhistory.org/core or write core@computerhistory.org.

Cover: Humans have relied on calculation for over 2,000 years. Foreground: an early method known since Roman times of storing numbers on the fingers—first described by The Venerable Bede—and here shown in a woodcut from Jacob Leopold's 1727 *Theatrum Arithmetico-Geometricum*. Background: typical Integrated Circuit Dynamic Random Access Memory (DRAM) circuit board used in modern-day digital computers. Photo: Dag Spicer.

EXHIBITING
COMPUTING HISTORY

BY KIRSTEN TASHEV

INTRODUCTION

Currently the Museum is working on the Schematic Designs—the rough layout and look of the exhibitions—for our permanent home. This process is now underway for our Timeline exhibit, which will cover approximately 15,000 square feet (s.f.) and focus on the milestones of computing history. We are finding that while it is easy to select artifacts for the Timeline, it is very hard to determine what to leave out, a problem commonly faced by museums. We struggle to tell the story of computer history even in 15,000 s.f. Fortunately, we are also exploring ways to complement the exhibits with online exhibitions so that the World Wide Web becomes one of our "natural resources" as we build our permanent home.

Another challenge we face is that the story we are trying to tell is unique. There are relatively few computer history museums—let alone computer exhibits—in the world. On the one hand, this gives us a lot of freedom; on the other hand, we have few opportunities to learn from the successes and failures of others. We also face the expectations of our future visitors who have their own views on what a computer history museum should be. As Ed Rodley (see page 6) discovered in his audience research for the MOS exhibit, ironically, many visitors expect a computer history exhibit to be about new stuff. The word "computer," being synonymous in our modern culture with "cutting-edge," seems to neutralize the other word in the sentence, namely "history." Even in working with museum designers and other outside consultants, we've found that people imagine a "tech" museum featuring exhibits full of the latest gadgets. In many ways, our Museum is "the history of the latest gadget," beginning, however, with the abacus! Our challenge is to harness this fascination for the "next new thing" and to find ways to motivate our visitors to appreciate the achievements of the past as the gadgets of *their* day.

MUSEUM STEPS

We are developing the curatorial outline for the Museum's future Timeline exhibit. The Timeline will be divided into four eras, starting with pre-computing and ending with the Internet. For each era, we have developed key messages that we want to convey and corresponding lists of potential artifacts, images, diagrams, audio-visuals, and computer "interactives" that can help to communicate the key messages. One of the challenges that we found in developing the Timeline is an inherent tension between showing advances chronologically versus grouping them according to genre or type. For example, a chronological layout allows visitors to see developments occurring around the same time in various fields of computing and their impact on each other, while a thematic-based layout allows the visitor to see developments in a specific area, such as memory or software, in a linear and comparative way.

In developing the exhibit in our prescribed 15,000 s.f., we constantly have to ask ourselves whether an artifact or story is a "headline" and thus deserving of a place on the Timeline. In other words, is an achievement *revolutionary* or *evolutionary*? Fortunately, the new Museum will have five Theme Rooms (1,000 to 1,500 s.f. each), which will allow us to explore specific topics in more detail and show developments in sub-fields of computing side by side.

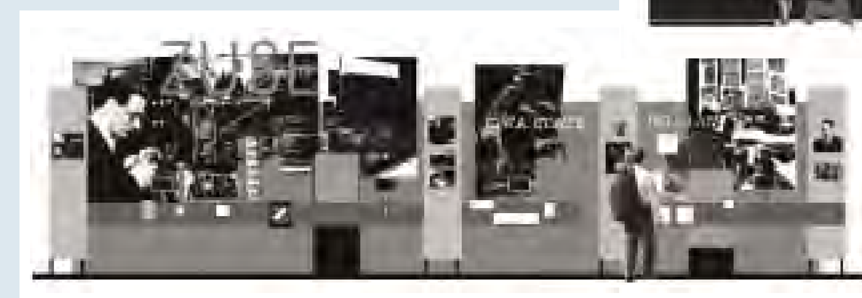
Schematic Design is not just about content, but also about design; we begin to think about how the exhibits will look. The Museum is working with exhibit designers Van Sickle & Rolleri, Ltd. (VSR) to develop conceptual exhibit floorplans and elevations. From our curatorial outlines, VSR begins creating "elevations," or wall views, of each exhibit area. (See elevations on next page.) They also create conceptual floor plans to determine adjacencies of exhibit areas and potential traffic flow. When we saw VSR's visual interpretation of our curatorial outlines for the first time, we were surprised by the sheer scale required to accommodate text, photos, and audio-visuals in creating an exhibition rich in content. It looked nothing like our current Visible Storage Exhibit Area, with one machine lined up next to another. The transformative power of context on an artifact is truly amazing.

Our next steps are to develop Schematic Designs for the rest of our exhibits, including the Theme Rooms. Then we will begin the Design Development phase, in which each discrete exhibit component is selected and when draft text, photo research, and audio-visual design begin. In this phase, we will more fully flesh out how we will capture different points of view and incorporate multiple layers of content for our diverse audiences.

We still have a lot of work to do to open the new Museum, and many issues to resolve. Some of the challenges that we face in developing the exhibits range from the practical—such as whether the Cray-1 is too heavy for a second floor—to the conceptual, including who our audience is and finding the right balance between technical content, people stories, and societal impacts. I would like to share with you some of our thoughts about these issues.

MEMORY VS. HISTORY

Museums that seek to display contemporary history have a unique challenge: they are about both history and living memory. History is a discipline in which we try to take a distant and critical view of the past, while memory is personal and involves



The Museum is working with exhibit designers to determine how our exhibits will look and how best to use photographs and other supporting materials to communicate key messages. Shown here are several "elevations" from our future Timeline exhibit.

individual connections with the past. The Computer History Museum, which centers around a relatively contemporary topic, is faced with the challenge of balancing memory and history. While exhibits indeed serve a function of commemoration, the Museum must be careful to consider the bias of its sources and obtain information from a variety of places. Exhibits must balance the need for critical distance and objectivity with the evocative power of personal stories. For example, telling the story of the first personal computer inevitably brings together people who reminisce about the Altair 8800 (1975), while the historical record shows that several others preceded it, such as the Kenbak-1 (1971), the Micral (1973), and even the lesser known 008A Microcomputer Kit by RGS Electronics (1974). As English historian Eric Hobsbawm wrote, "Historians are the professional remembrancers of what their fellow citizens wish to forget."

Our curatorial team is conducting research by speaking to both the pioneers of computing history and to the many professionals who contributed to the development of the industry. First-hand knowledge is balanced with information from primary source materials, the input of our historian advisors, and the views of subject-matter experts. We are exploring ways to create exhibits that will capture multiple points of view and we also want visitors to share their stories on the exhibit floor through both low- and high-tech tools.

CONTENT VS. ENTERTAINMENT

Museums have undergone a major transformation over the last 50 years. The days of the "cabinets of curiosities" or the phylogenetic displays of the traditional natural history museums are a thing of the past. In the 1960s and 1970s, museums underwent a renaissance, primarily influenced by developments in the fields of communication, education, sociology, and psychology that had fundamentally re-shaped our understanding of how people learn. These findings forced museums to rethink how they exhibited items. Concurrently, museums faced reduced government funding and therefore had to attract more visitors and increase gate receipts in order to supplement their income. This new focus on attendance pushed museums to be more visitor-focused and to provide more intellectually-accessible exhibits. In order to attract visitors, exhibits had to be not only academically correct but also interesting and even

To understand how much space will be required for an exhibition and determine the best adjacencies of exhibit areas, exhibit designers create space study models such as the one shown here.

entertaining. A new type of museum emerged, namely the science center, which took a hands-on approach to learning. Many world-class science centers were developed, including the groundbreaking Exploratorium in San Francisco, California.

As government funding decreased again in the 1980s, the need to maximize gate receipts increased and the era of the blockbuster exhibit emerged, with a clear emphasis on entertainment over content—or "edutainment," as it was called. More recently, however, the pendulum has swung somewhat in a reaction to "dumbed-down" exhibits. Museums now realize that they can not hope to compete with theme parks and that they shouldn't try. Instead, their unique products are content and access to the real thing. Furthermore, as museums build endowments and use special events to help cover operating costs, they are able to enjoy more freedom and can develop unique, content-rich programs.

The Computer History Museum will most certainly focus on content, and our goal is to make our exhibits intellectually accessible to both people who have significant knowledge of computers as well as those who do not. The primary target audience of the Museum is adults and the content will be geared for high school age and above. In order to address this diverse audience, we are working on exhibits that tell stories about technological achievement as well as people. For example, in telling the story of Konrad Zuse, you can focus on the fact that in 1941 he began building a machine called the Z3 in 1941, widely considered the first fully functional, program-controlled electromechanical digital computer in the world. You can also mention the fact that it was controlled by punched paper tape and that it could calculate with floating point numbers years before any other machine. On the other hand, there is a great personal story to be told. Konrad Zuse, born in Berlin in 1910, was a young man uncertain about whether to be an engineer or an artist. Choosing engineering, he soon grew tired of the tedious manual calculations required to do his work at Henschel Aviation Company. Zuse quit his job and began experimenting with some early prototypes in his parents' living room. His work was cut short during the war since Berlin was under constant Allied bombardment. Zuse and his pregnant wife, Gisela, fled the city and his Z4 was transported to the countryside under cover of night. Desperate to resume work on the Z4, he survived the difficult years after the war by making woodcuts and selling them. Eventually, Zuse went on to found the first computer company in Germany, Zuse KG, and built 250 computers. He continued to paint throughout his life.

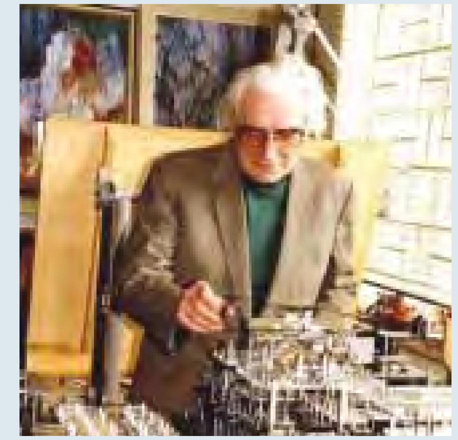
Given that we are working with contemporary history, we are fortunate to have a rich collection of film footage of pioneers telling their stories as well as the opportunity to collect oral histories from the innovators of the recent past and today. Exhibits can provide visitors with the unique opportunity to view this rich archival footage in the context of the artifacts and other supporting documentation. Of course, this is not to say that we won't have the specifications of every machine. We know that our "other" audience—the most astute, detail-oriented, skilled, and knowledgeable "geeks"—will be very disappointed if we don't tell them what the Z4 could do. We are exploring ways to communicate multiple perspectives, including technical data. We have talked about everything from flip panels that reveal a machine's specs to handheld devices that allow the visitor to get the hardware perspective, the software view, and so on. We also recognize that it will be impossible to appreciate the importance of an artifact or story without some understanding of the technological breakthroughs it represents, and for that reason we will provide clear explanations on the fundamentals of how something works for our non-technical visitors where necessary.

HANDS-ON VS. MINDS-ON

"I hear and I forget. I see and I remember. I do and I understand."
– Confucius

While most people associate hands-on exhibits with science centers and children's museums, interactivity also has its place in the history museum. The process of developing exhibitions has been influenced greatly by the work of Dr. Howard Gardner at the Harvard School of Education over the past 30 years. Prior to Gardner's groundbreaking findings, educators had focused on developmental learning stages, where children share similar abilities according to their age group. What Gardner found was that while children did go through developmental stages, they also had different learning styles. These individual learning styles continue into adulthood, making his discoveries applicable to exhibit planning. Gardner outlined several fundamentally different learning styles, including:

1) Narrational: people who learn best by hearing a story or a narrative when presented with a concept;
2) Logical-Quantitative: people who approach a concept by using numerical or deductive reasoning processes;
3) Foundational: people who examine a concept from a philosophical point of view;
4) Esthetic: people who respond to sensory stimuli, and learn through images, sounds, etc.; and
5) Experiential: people who learn best with a hands-on approach, dealing directly with the materials that convey the concept.



Konrad Zuse in his workshop (1986).

Fortunately, museums are ideal settings for people to acquire new information using various learning styles. Exhibits can be rich with text, data, sensory stimuli, and hands-on experiences. Although our audience is primarily adults who tend to be "minds-on," many of them will be attracted to experiential hands-on activities as well. I can't count how many times I have been asked by members and visitors, "will the machines be operational and will visitors be able to play with them?" Of course, for reasons of preservation, it is not possible to allow visitors to "play" with the machines, and it is very expensive to keep them operational. However, we are thinking about software simulation, hands-on models of machines, and, not to fear, select machines restored and operational for visitors to enjoy with the help of a trained docent. For example, the recently-restored IBM 1620 might be fired up once a week. Exhibit cabinetry might have special discovery drawers that hold demonstration pieces for docents to use to explain a concept or to simply allow visitors to feel how light a silicon wafer is.

CYBER VS. ACTUAL REALITY

"Cannot find REALITY.SYS...Universe Halted." –Anonymous

In developing the Museum's physical exhibits, we are exploring how they will interact and complement the CyberMuseum. Many museums have Web sites, some have cyber exhibits, and even fewer have cyber archives that allow direct access to collection information over the Web. We are striving to develop our physical and CyberMuseum concurrently so that each can inform the other. We see the CyberMuseum as the digital hub of the Museum's exhibit halls, where many of the learning experiences will take place either on the exhibit floor at the Museum or in the homes of our virtual visitors. The CyberMuseum will also allow us to exhibit much more content than we could display in the context of a physical exhibition. We are also thinking about creating study areas within the galleries so that visitors can delve more deeply or, more likely, settle a dispute!

Ask your friends what they expect to see in a computer history museum; you might be surprised by what they say. And next time you are in the Visible Storage Exhibit Area, picture the artifacts in content-rich exhibitions and, if you can, try to see if you can decide what artifact to leave out. It's not easy! ■

Kirsten Tashev is Building and Exhibits Project Manager at the Computer History Museum

SUMMARY OF EXHIBIT TECHNIQUES

1. Artifact displays with some "touchability" through a "study collection" (artifacts with multiple copies in the collection) and hands-on explanatory models
2. Docent-led tours that are enhanced by live demonstrations of running machines or hands-on viewing of the "study collection" materials
3. Graphic and text enrichment of displays using diagrams, specs, photos, vintage advertisements, excerpts from technical documents, and visual/numerical metrics for comparisons
4. Recreated environments that achieve a sense of "being there," e.g. an 1890s punch-card office or a 1950s mainframe installation
5. Audio-video stations or mini-theaters that highlight people stories or promotional films from the period
6. Computer interactives that explain concepts, simulate software, or offer access to the Museum's rich cyber archive
7. Hand-held devices that allow visitors to drill down into information with increasing granularity

SUMMARY OF ORGANIZATIONAL EXHIBIT LAYOUT

1. Timeline Exhibit: major headlines in computing history, multi-layered with a rich variety of both people stories and technological achievements
2. Theme areas: chronological focus on developments within key areas of computing history: networking, I/O, software, storage, and processors
3. Topical exhibits: changing exhibits on special topics such as privacy and computers, AI, robotics, computer advertising, computers and medicine, games, etc.
4. Visible storage: access to sections of the Museum's rich collection of artifacts in a densely-displayed area with minimal interpretation (including artifact labels, hand-held audio guides, or docent led tours)

BRINGING COMPUTING HISTORY TO THE PUBLIC

BY ED RODLEY MUSEUM OF SCIENCE, BOSTON, MASSACHUSETTS

Editor's Note: As the Computer History Museum plans and designs its future exhibits, we will share many "inside looks" into our progress, including the update on page two by Building and Exhibits Program Manager Kirsten Tashev. Meanwhile, we have many important collaborations with peer institutions that both educate and highlight the artifacts and stories of the information age. See page 25 for a list of current exhibits that feature Museum artifacts.

One important collaboration is with the Museum of Science (MOS) in Boston, Massachusetts. Over the past year, Museum staff have worked closely with Ed Rodley, an exhibit planner at MOS, in creating an exhibit called "The Computing Revolution," which opened this fall. We have provided artifacts, video footage, and research to support the design process (see sidebar on page ten). This collaboration highlights the shared history between the Museum and MOS and is a mutual opportunity to exhibit important computing history information. Read the details on the Museum's history in *CORE* 1.2 at www.computerhistory.org/core.

In his article, Rodley describes the "behind the scenes" process of exhibit creation, particularly where computing history is being presented at a hands-on science museum. Two machines will be discussed in detail: the MIT Whirlwind, which belongs and will return to the Museum's collection, and a model of Schickard's *Rechenmaschine*, created by master fabricators at MOS.

INTRODUCTION

The opening of "The Computing Revolution," a new exhibit at MOS on computing history, highlights the 1999 merger of The Computer Museum in Boston and the Museum of Science. This exhibition, developed in consultation with the Computer History Museum, will be the first of many anticipated collaborations.

What does a computing history exhibit at a science museum look like? "The Computing Revolution" is not the typical kind of exhibition done at MOS. For the past decade, the museum has focused on developing interactive exhibitions that help visitors develop science thinking skills. Creating a small, artifact-based historical exhibition has been a real change of pace and quite a challenge.

When The Computer Museum in Boston originally opened its "People and Computers" exhibit, it used almost 6,000 square feet (s.f.) to tell the story of computing history. Our gallery for this exhibit is a bit over 1,200 s.f., so clearly it would be impossible to do an encyclopedic exhibition. We chose instead to display even fewer objects than possible but to interpret those objects in greater depth.

Our exhibit follows a chronological order, starting with the development of mechanical calculators and following computing up to the present. The exhibit will have six theme areas, corresponding not to decades, but to eras, based on society's perceptions of computers. The eras are: Computer Pre-History, World War II, Big Machines, Personal Computers, The Internet, and the 21st Century.

Rather than create a typical museum display of objects with small descriptive labels of 50 words each, we selected a dozen "highlight" objects to stand in for entire generations of computers. These items provide focus for conveying layers of historical, social, and technological information. The circumstances that gave birth to the machines will be explored and the items compared to a personal computer of about the year 2000, in terms of power consumption, physical size, memory, processing speed, etc. Since the machines are non-functional, we will bring them to life using media-rich experiences. Visitors will be able to explore how they worked; listen to inventors and users; and take in the sights and sounds of the era, from newsreels to TV ads. This inevitably excludes a tremendous amount of information, but it allows us to do justice to a few objects, and to tell some good stories.

EVALUATION (OR PLANNING FOR SURPRISES)

The longest part of the exhibit development process here at MOS is the formative evaluation phase. Since exhibitions, especially interactive ones, are so expensive to design, we spend as much time as possible testing concepts in prototype, creating a rough approximation that does what we want it to do. Once we've determined that the basic concept works, we'll build a slightly more polished version and test that. This process continues until we are confident that the exhibit will be successful.

For this project, I wanted to know what attitudes visitors would have about a computer history exhibit at the museum. We administered a very brief

Whirlwind control room, 1954, from the film *Making Electrons Count*. Courtesy of MIT Museum.

survey that probed their level of knowledge and interest in computers. It became clear that the artifact exhibit I had envisioned would need some rethinking. When we asked visitors, "What would you *expect* to see in an exhibit called 'The Computing Revolution?'" over half indicated historical objects. In second place, however, came "new stuff." When we asked the similar question, "What would you *like* to see in such an exhibit?" the results were enlightening. Almost half the visitors said they'd like to see "new stuff" and another quarter wanted to know how computers worked. History, even though the visitors knew it was a history exhibit, came in a distant third.

Based on this feedback, we tried to identify ways to make the exhibit more appealing to the museum's traditional visitors who are accustomed to interactive exhibits. I decided to add a number of exhibits that had nothing to do with the chronology of computing. These would address some basic aspects of computing—like how a hard drive works, what's inside a mouse, and what "hacking" means—and would be placed throughout the gallery, so that each section would appeal to many people.

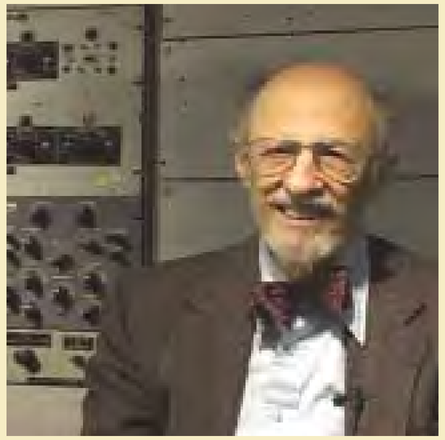
We brainstormed a number of possible interactive ideas and went back out onto the exhibit halls to talk to visitors with our top dozen ideas. We asked them to rate their interest in each idea on a simple four-point scale and to tell us their age and gender. We collected 101 surveys and sat down to the much longer process of interpreting the results.

There were some interesting differences between groups. Women tended to like components that explained how computers worked. Hacking seemed to interest adults in the 19–34 age range. Overall, the most popular exhibit ideas were on WWII code machines, when computers go wrong, and hacking. We liked all these components ourselves, so it was good to get confirmation that the ideas were appealing. The least popular ideas were mechanical calculators and the binary number system. Both of these were important to us, so we knew we had our work cut out for us.

Most troubling was finding that the least popular ideas were all slated for the very beginning of the exhibit. So, we dropped a couple of these ideas and altered the layout to make the initial experience more dynamic and hopefully tempt visitors into the gallery. We moved the 21st Century into the entry opposite Prehistory and moved The Whirlwind so it could be seen as soon as one walked through the door.

WHIRLWIND

A good example of our approach to artifact interpretation is the Whirlwind computer. It is difficult to imagine a more exciting piece of computing history. The first electronic digital



Courtesy of the Museum of Science.

Whirlwind alumnus and ACM Turing Award winner Fernando Corbató went on to pioneer timesharing at MIT with CTSS and later Multics.

MITRE Corporation Archives.

Whirlwind was the first real-time, parallel-processing computer with core memory. At left are the marginal checking and toggle-switch test control panels. From left to right: Stephen H. Dodd, Jay W. Forrester, Robert R. Everett, and Ramona Ferenz, 1951.

computer built at MIT, Whirlwind was a pioneer first-generation computer. It was also the prototype for the United States' first air defense system, known as SAGE. The Whirlwind team, led by Jay Forrester and Bob Everett, invented magnetic core memory to replace the notoriously unreliable electrostatic memory systems then in use. By doing so, they created the dominant form of computer memory for the next 25 years. Throughout the 1950s, Whirlwind was the machine on which a generation of MIT scientists and engineers learned computing and developed a style of human-computer interaction very different from that being promoted by commercial computer manufacturers such as IBM, Remington Rand, and others. Computer hacking (in the non-pejorative sense still used at MIT) started with Whirlwind.

Whirlwind originally occupied an entire floor of the Barta Building (N42) at MIT. The Computer History Museum owns the bulk of the surviving pieces of Whirlwind. For this exhibit, MOS is displaying six racks from the Whirlwind control room, along with one of its core memory stacks and a "Flexowriter," a typewriter-like device used to communicate with the great machine. Thus, we have a non-functional fragment of a machine that doesn't even resemble a computer to a large percentage of our visitors. Our challenge from the outset was, therefore, how to convey that importance and excitement

MITRE Corporation Archives.

The internal workings of Whirlwind. Here, the machine's size dwarfs three technicians (John A. O'Brien, Charles L. Corderman, and Norman H. Daggett) working on the Electrostatic Storage Rack. At left, Jay Forrester and Norman H. Taylor inspect the Arithmetic Element Rack, 1952.

to a lay audience. The most straightforward way to do that was to have Whirlwind users tell their stories. We interviewed a number of Whirlwind alumni, many of whom are still active in computing. Their first-hand accounts of using Whirlwind provided not only technical insights, but also personal views of the project and its people. We will supply the larger context through the use of contemporary film and television footage.

We also decided to add a simple interactive display of the basic concept behind magnetic core memory. Early on, we discussed the merit of spending time (and money) developing interactive material on an obsolete technology. In the end, though, we agreed to make a simple core memory array that visitors could operate. The reasons were two-fold: first, I felt it would be very difficult to interpret the artifact unless visitors could see what it did; and second, core memory was also the last storage

Courtesy of the Museum of Science.

Magnetic core memory, first exhibit prototype at the Museum of Science.

Courtesy of the Museum of Science.

First prototype Schickard *Rechenmaschine* in the workshop at the Museum of Science.

technology in which it was possible to detect what was going on without the aid of complicated sensors. Our test array of eight cores has compasses sitting next to each core. When a core is magnetized, you can see the compass needle move and read the array to determine the value (a "0" or a "1") of each core.

The prototype had several shortcomings that became apparent during testing. Hard ferrite cores aren't easy to come by anymore, so we made do with dirty steel, which required quite a bit of current. When a core was magnetized, the compass needle would gyrate wildly for several seconds before settling down. The cores would stay magnetized for some time, so if the visitor didn't clear the array before writing a number to it, he or she might get an unexpected answer. This "non-volatility" was the major selling feature of core memory, but it proved to be a problem for us. Some of the Whirlwind programmers we interviewed mentioned having had the same problem when core memory was first installed in Whirlwind. The final version of the exhibit will have a better ferrite material for the cores and compasses that are a bit more stable.

SCHICKARD'S RECHENMASCHINE OF 1623

To provide a sense of the deep history of computing and to counter the notion that the only kind of computer is what we see on our desks, we have built a reconstruction of the world's first mechanical calculator, invented in 1623 by a German scientist named Wilhelm Schickard (1592-1635). His *Rechenmaschine* (calculating or "reckoning" machine) combined a version of Napier's bones with two discrete gear mechanisms that allowed the user to perform basic arithmetic operations on numbers up to six digits long. Only two examples of Schickard's machine were ever built during his lifetime, and after his death all knowledge of it was seemingly lost. Records of the machine resurfaced in the 1930s among the papers of the astronomer Johannes Kepler, a friend of Schickard's. These notes were again lost during World War II, only to reappear again in the 1950s.

They came to the attention of Baron Bruno von Freytag Löringhoff, an historian from Schickard's hometown of Tübingen, Germany. Using Schickard's notes and sketches, the Baron spent years piecing together how the machine worked and eventually built a working model. From the 1970s on, he commissioned numerous copies that can now be found throughout Germany. I had been looking for a mechanical calculator to include in the exhibition, so pursuing the *Rechenmaschine* seemed like an easy decision. There must be plans with modern measurements, albeit in German, and it should just be a matter of getting a copy of the plans and building our own. Or so it seemed.

After a year of e-mails and phone calls, I had learned a great deal about Schickard and the circle of scholars studying him, but had nothing concrete on the *Rechenmaschine*. The Baron had died some years ago and there were no plans among his papers. I finally located the company that had built the Baron's reconstructions in the 1970s, only to find that they had destroyed all their plans after his death. But then another hope appeared. A high school in Bautzen, Germany had built a

Rechenmaschine, based on one of the Baron's copies. After several e-mails and more weeks, a reply. They had built a machine and had plans they would let us use. They would even machine the gears if we wanted!

More months passed until we received blueprints for the cabinet of the machine. We looked for the plans for the gear mechanisms, but to no avail. More months, and more e-mails passed as we tried to ascertain whether plans for the gears existed. In the meantime, we built a cabinet and rotating drum assembly so that we could at least test that much of the machine with the public.

Once you learn how to use the machine, you can do multiplications on it faster than you can on paper, but we weren't at all confident that we could get visitors to successfully use the machine. However, after only three days of user testing, it became clear that the machine was very popular. This may have something to do with its appearance. It is the only wooden object in a room full of metal and plastic. Or it may have been labeling the item as "a calculator from 1623." What was clear was that adults and children would spend several minutes calculating with the machine. Completing the machine took on a new urgency.

Finally, out of the blue, an extremely heavy package arrived from Germany. It was full of gears… and nothing else—no plans, no assembly instructions. One of our technical designers sat down with the pile and some photographs of the mechanism and managed to put all the pieces together.

AN EXHIBIT READY FOR VISITORS

Over the summer, we entered the main production phase of the exhibition. By the opening in September, we had prepared the gallery, finalized designs for components, evaluated our remaining prototypes, and installed the artifacts. If you happen to be in Boston this fall, I encourage you to see how it all turned out. ■

Ed Rodley is an Exhibit Planner at the Museum of Science, Boston. In his 15 years there, he has developed exhibitions on topics ranging from the Soviet space program to Leonardo da Vinci. His current research interests involve using handheld computers in a museum setting.

ITEMS ON LOAN TO MOS BY FOR "THE COMPUTING REVOLUTION" EXHIBIT

- Anderson-Jacobson acoustically-coupled modem
- Apollo Guidance Computer logic module
- Apollo memory stack module
- Apple II, Drive II
- Apple Macintosh CPU, keyboard, and mouse
- Assorted punch cards (077 plugboard, 96 col S/3)
- Bell Telephone Labs transistor
- Control Data Corporation memory disk
- Data General core planes (2)
- Digital Equipment Corporation core plane PCB
- Digital Equipment Corporation PDP-8e from the Massachusetts General brain surgery station
- Early IBM brochure
- First black-and-white TV used with an Apple on the East Coast
- Friden Flexowriter
- Hollerith Census Machine model
- Hollerith Electric Tabulation System Pantograph (reproduction)
- Hollerith punch card
- IBM "THINK" sign
- IBM Model 016 keypunch
- IBM PC CPU, keyboard, and monitor
- Internet Worm Source Code
- Marchant adding machine
- MITS Altair 8800
- MITS Altair BASIC source tape
- MS-6502 BASIC, data cassettes (22)
- Paper tapes
- Remington-Rand 1958 UNIVAC brochure
- SpaceWar! source tape
- SWAC Williams tube
- UNIVAC I supervisory control console
- UNIVAC instructional manual
- UNIVAC products St. Paul (1959)
- UNIVAC system routines (1958)
- UNIVAC Uniservo
- UNIVAC Unityper
- US Army firing tables gun, 155-MM, M1 and M1A1 firing shell, H.E., M101
- USAF SAGE background material, photos, press kit, and red book
- USAF SAGE exhibit background references
- USAF SAGE lightgun
- Visicalc for Apple V1.0 (1979)
- Whirlwind core memory stack A 69
- Whirlwind filament transformer panel including table
- Whirlwind indicator panel (s/n 18)
- Whirlwind indicator panel (s/n 78)
- Whirlwind operations matrix driver mating panel #1
- Whirlwind operations matrix driver mating panel #3
- Xerox PARC Ethernet transceiver

HISTORY MATTERS

BY MICHAEL R WILLIAMS

A PERSONAL PERSPECTIVE ON KONRAD ZUSE

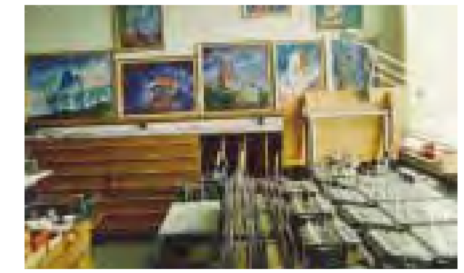
I am privileged to have met many of the great pioneers in computing. Some of them were aloof, some unpleasant, some remarkably friendly, but all were interesting. Of course, many of the earliest pioneers (Schickard, Pascal, Leibniz, etc.) didn't live during my lifespan, and I couldn't meet others such as Russian pioneer Sergey Lebedev due to political considerations. It is possible to research these people's lives, but still, nothing matches the chance to meet someone in person.

Artifacts tell the story of the development of computing, but it is the people behind these devices that I find most fascinating, and among them, I have a great fondness for Konrad Zuse. I first met Konrad in the late 1970s and was immediately struck by his friendly, open ways. We had supper together one night and I spent additional time with him over a one-week period.

He is best known for his early creation of automatic mechanical and relay-based calculating machines: the Z1 through the Z4 and several special-purpose machines that were used on the assembly line of the Henschel Aircraft factory where he worked. He was also instrumental in devising the first high-level language, the Plankalkül, for describing the actions of a computer program. These technical achievements are noteworthy, but he also had other accomplishments that shaped his life.

Zuse was a painter of note. He gave up early ambitions of becoming an architect to pursue air craft engineering. His interest in cityscapes is clearly evident in his paintings, many of which have abstract futuristic city themes (see photo on this page and on page five).

While at the university, he and a group of friends put on a weekly cabaret. Like many such performances in pre-war (WWII) Berlin, they were satirical and



Konrad Zuse's workshop was filled with paintings made by the pioneer himself.

drew large crowds. One in particular aimed directly at political figures of the day; Hitler's police raided the theater and shut them down, while more severe sanctions were taken against several Jewish performers. This impacted Zuse deeply and although, like many Germans, he worked in the war effort and was intensely proud of his German roots, he remained distrustful of political parties and their leaders for the rest of his life. I well remember that when asked publicly how his machines had contributed to the Holocaust, he was particularly incensed. He quietly explained that such an inquiry only showed a lack of knowledge about his life and views; and, he remained visibly upset for the rest of the day.

In the last days of the war, with Russian troops on the outskirts of Berlin, Zuse and Werner von Braun, the famous rocket scientist, spirited the unfinished Z4 into a farmhouse basement for safekeeping. Later, proud of their accomplishments and hoping to continue their work, the men willingly surrendered to American troops and explained what they had been doing during the war. Of course, the rocket expert was immediately shown off to the press, while Zuse was almost completely ignored. A man from Hollerith, the British tabulating machine company, interrogated him. Although the representative didn't seem to either appreciate or understand the concepts behind Zuse's automatic computing machines, probably only a handful of people in the world at the time could have. He was released to go back to his family.

The next time you tune into a documentary about the end of the war, watch von Braun's surrender closely. Emerging from a DC3, he appears to be raising his arm in a Nazi-style salute. In actuality, he was wearing a body cast from neck to waist, his arm in a raised position. In the effort to squirrel away the Z4, the massive machine had tipped over on von Braun, badly injuring him.

Post-war Germany was not an easy place to start a computer firm. Initially, in genuine hardship, Zuse found himself looking through farmers' fields for the occasional forgotten turnip in order to feed his family. Even when basic food and shelter became more available, it was still surprising to find someone refurbishing a computer—the Z4—and gathering engineers together to create computing machines.

Konrad Zuse was a visionary who always managed to find a way through difficult situations and rightly deserves a place in our memories as both a fascinating person and a pioneer of computing history. ■

Michael R Williams is Head Curator at the Computer History Museum.

Overleaf: A typical IBM System 360 installation. Introduced in April of 1964, the System 360 was a family of software-compatible mainframe computers spanning a 40:1 performance range. The Model 40, one of the smaller models, is shown here. With IBM's legendary sales and customer support, as well as a complete line of new peripherals, the announcement allowed IBM to consolidate its divergent product lines into one unified architecture. The result was near total dominance of the computing market by IBM for the next decade, with half a dozen other companies fighting over only 20% of the market.


IBM
SYSTEM

UNIVAC

THE FIRST AMERICAN COMMERCIAL COMPUTER

BY CHRIS CARCIA

Operator (front) at the UNIVAC console while colleague mounts a new data tape on a UNISERVO tape drive.

While an operator looks on, Presper Eckert (standing, left) and a young Walter Cronkite (right) examine UNIVAC's 1952 election prediction results.

When you think of 1950s computers, does the "UNIVAC" come to mind? Besides being the first commercial computer in the United States, the UNIVAC became synonymous with "computer," due in part to the power of a single event: the CBS television coverage of the 1952 election. Now, during the 2002 election season, it seems appropriate to remember that event 50 years ago.

FOUNDATIONS IN THE CITY OF BROTHERLY LOVE

The UNIVAC was the second commercially sold electronic computer in the world, beaten by one month by the Ferranti's Mark I in Manchester, England. A 30,000-pound, room-sized computer with 5,400 vacuum tubes that consumed 125,000 watts of power, the UNIVAC had origins in the "ENIAC," built by Presper Eckert and John Mauchly for the U.S. Army at the University of Pennsylvania's Moore School of Electrical Engineering. The ENIAC was completed by 1946, and design of the follow-on "EDVAC" machine had begun by the time the pair left the school over patent issues in March of that year. Eckert and Mauchly stayed in Philadelphia and founded a partnership, the Electronic Control Company (ECC), to produce computers for both scientific and business use. The company received a National Bureau of Standards grant of $75,000 to study mercury delay line memory systems and tape I/O ("input/output") devices. ECC hired employees and took out space on Walnut Street in Philadelphia. The two soon came to realize that the study could be turned into a complete computer system and changed the name of the company to Eckert-Mauchly Computer Corporation (EMCC). The EDVAC was never formally completed but formed a test bed for the pair's next machine, the "UNIVAC."

Originally referred to as an "EDVAC-type machine," and renamed UNIVAC (for "**Univ**ersal **A**utomatic **C**omputer") in 1947, the research project led to a design contract for $169,000 in June 1948. These amounts did not cover actual costs, but Eckert and Mauchly hoped to recover the difference in sales. They applied for additional government grants and pursued private investors but met with little success. In the climate of the Cold War in the United States, "security issues" were raised about Mauchly and several other employees and the company lost sales to the Navy as well as a nuclear project at the Oak Ridge National Laboratory.

THE BINAC

In the interim, Eckert and Mauchly agreed to build a machine for Northrop Aircraft called the BINAC ("**BIN**ary **A**utomatic **C**omputer"). EMCC accepted the contract in October of 1947, with the ambitious—some would say unattainable—goal of completing the machine by the next May. The BINAC was a dual-CPU system, which used mercury delay lines and a magnetic tape unit for I/O. In August of 1949, EMCC delivered the BINAC to Northrop after several months of operation in Philadelphia. The BINAC cost almost three times as much to build as Eckert and Mauchly had estimated and was of marginal reliability, leading some key members of EMCC staff to leave for firmer ground with companies such as Burroughs and GE that were just entering the business.

BECOMING UNIVAC

After the completion of the BINAC, EMCC contracted with the U.S. government to build three computers, one for the Census Bureau, and one each for the Air Force and the Army Map Service, with contracts of $150,000 for the first machine and $250,000 for the other two. EMCC had also signed deals with the Prudential Insurance Company and A.C. Nielsen—contracts that made IBM stand up and take notice that a new business might be forming. By the time these contracts were signed, EMCC was running out of money, putting the future of the company in jeopardy. Fortunately, a new investor, the American Totalisator Company (ATC), the makers of Tote® boards for posting racetrack odds, saw promise in the UNIVAC for racetrack use, and gave EMCC $500,000 to keep the company afloat. Even with the infusion of cash, EMCC could not cover the development costs of the UNIVAC, and so, on February 1, 1950, Remington Rand Corporation purchased the company, paying stockholders $100,000 plus 49% of profits over the first eight years.

The UNIVAC had one thousand words of mercury delay line memory and a basic clock rate of 2.25 MHz. The machine came with eight "UNISERVO" tape drives, using 1,500-foot reels of metal tape. No punched card equipment was available at first, so the UNITYPER was developed to enter information directly from keyboard to tape. The inability to use punched card equipment with the UNIVAC led many companies to go to IBM for computers that could be used with the IBM accounting machines they already owned. Eckert and Mauchly recognized this weakness and offered a 100-card-per-minute card-to-tape option. Originally designed for 80-column IBM cards, the system was redesigned after the buyout to use Remington Rand's 90-column cards, a system that employed round holes instead of rectangular ones as IBM's did.

THE ELECTION OF 1952

In August of 1952, CBS' director of News and Public Affairs, Sig Mickleson, met with a Remington Rand public relations representative who indicated that they could provide a machine that would help predict the election returns of that year. While Mickleson knew enough about computers to see the fault in this proposition, he thought that the machine could speed up the processing and analysis of the returns, giving CBS an edge over the other networks. Mickelson arranged for several CBS staff members, including anchor Walter Cronkite and reporter Charles Collingwood, to visit the UNIVAC that would be used in Philadelphia. Collingwood arrived late for the meeting, which allowed a mischievous coder to program a Teletype to print, "Collingwood, you're late. Where have you been?" This simple event completely astonished Collingwood, making him the perfect person to sell the UNIVAC to television viewers.

With only three months until the debut, the UNIVAC team went about designing a way to interpret the results. Max Woodbury, a mathematician at the University of Pennsylvania, wrote a program that would make a prediction based on returns from precincts CBS had decided were most significant. He devised an "if X, then Y" program that would bring the results into focus. It turned out to be a bigger task than expected, and the team had to be expanded to six people in order to complete it in time for election night.

The program completed, the election coverage was set, with Woodbury, Mauchly, and stationed at the Philadelphia site with the UNIVAC serial number 5, and Collingwood and Cronkite at the CBS studio in New York. A Teletype allowed communications between the various teams and a console with blinking lights was set up in New York, with the teletype relaying the output from the UNIVAC in Philadelphia. The election night coverage began at 8 p.m. EST and the first round of results was run at about that time, before the polls had closed in the western states.

NOT THE ANSWER WE'RE LOOKING FOR

The first run of all the returns from the CBS "key precincts" returned an unexpected result: odds of 100–1 in favor of an Eisenhower victory. Pre-election poll results had indicated a very close election with Adlai Stevenson as the front-runner. The word of the prediction sent the crew into hurried debates over whether or not to announce the numbers. Mickleson eventually made the call not to go on air

(above and right) With its "UNISERVO" tape drives, the UNIVAC was probably the first commercial machine to use magnetic tape as a storage medium. Customers initially resisted this technology since they could no longer "see" their data as they could with punch cards. IBM salesmen played up this fear, "hinting" that the UNIVAC, if it went out of control, could project shards of metal tape, potentially injuring or even killing customers.

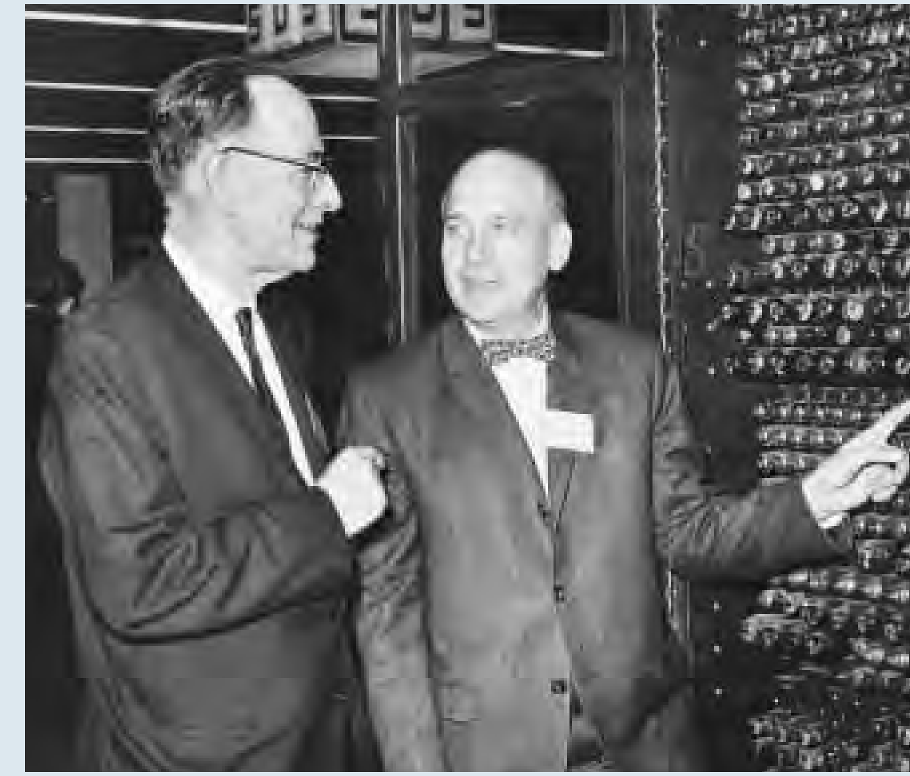
with them and to have the numbers rerun. Woodbury ran another set of information, with the UNIVAC coming up with odds of 8–7 in favor of Eisenhower, which Collingwood announced about 9 p.m. While reviewing the results, Woodbury detected an error in the data: he had added a zero to Stevenson's totals from New York State. He reran the correct set of numbers, and Eisenhower's odds were back up to 100–1. At that point, there was no interpreting the results in any other way and CBS became the first network to call the election. As it turned out, the UNIVAC's calculations were remarkably accurate, with predicted totals for Eisenhower being 32,915,000 votes, while the actual total was 33,936,252—a difference of less than 3%.

ELECTIONS HAVE NEVER BEEN THE SAME

The effects of CBS's use of the UNIVAC became clear during the next election when every major network began using a computer to predict the results. As computer speeds increased, so did the ability of news organizations to call elections quickly. As early as 1972, elections were thought to be over as soon as a computer gave an early prediction based on as little as 3% of the total vote. Many have said that the availability of such early computer predictions, often before the polls are closed on the West Coast, have changed the course of elections, giving early front-runners a large advantage with the weight of these computer predictions and discouraging voters in western states from going to the polls.

Significant parts of the UNIVAC I form part of the Computer History Museum's permanent collection and may be seen, on temporary exhibit, at the Museum of Science in Boston, until 2005. A UNIVAC I mercury delay line is on display at the Museum's Visible Storage Exhibit Area in Mountain View, California. ■

Christopher Garcia is Historical Collections Coordinator at the Computer History Museum.



John Mauchly (left) and Presper Eckert with a piece of the ENIAC machine at a 1966 conference in San Francisco.

UNIVAC I SPECIFICATIONS

Architecture: serial, decimal, stored program

Word length: 11 digits + sign

Memory size: 1,000 words (Mercury acoustic delay line) + 100,000-word magnetic tape (metal substrate)

Speed: Mercury delay line: 400μs; 12, 800 characters per second

Clock rate: 2.25 MHz

Arithmetic element: fixed-point (software floating point)

Instruction format: 2 instructions per word; 45 instructions

I/O: magnetic tape ("UNISERVO"), 80- or 90-column punch cards, printer ("UNIPRINTER"), paper tape

Technology: vacuum tube (5,800) + diode (18,000)

Power consumption: 124.5 KVA + 35-ton air conditioning unit

Size: 1,000 square feet

Purchase price: $950,000 [1953 dollars] for CPU + 10 UNIVSERVOs

Rental cost: $16,200 per month for a 1 shift, 5 days per week

Weight: 29,853 lbs

First shipment: March 1951, U.S. Bureau of the Census

Number built: 46

Typical customers: U.S. Census, USAF, GE, Metropolitan Life, U.S. Steel, AEC, Westinghouse, Consolidated Edison, Dupont, Chesapeake, and Ohio Railway

FURTHER READING

Bell, C. G., and Newell, A. *Computer Structures: Readings and Examples*, New York: McGraw-Hill (c) 1971.

Lundstrom, D. E., *A Few Good Men from UNIVAC*, Cambridge: MIT Press, (c) 1987.

McCartney, S., *ENIAC: The Triumphs and Tragedies of the World's First Computer*, New York: Walker and Company, (c) 1999. [Note: this is a popular account; ENIAC was not the "world's first computer." –Ed.]

Ralston, A., Reilly, E.D., Hemmendinger, D., *Encyclopedia of Computer Science, 4th Edition*, London: Nature Publishing Group, 2000.

Stern, N.B., *From ENIAC to UNIVAC: An Appraisal of the Eckert-Mauchly Computers*, Bedford (Mass.): Digital Equipment Corporation, 1981.

Weik, M.H., *A Survey of Domestic Electronic Digital Computing Systems*, Report # 971 (December 1955), Ballistic Research Laboratories, Aberdeen Proving Ground, U.S. Department of the Army, Maryland, U.S.A.

Wilkes, M., *Automatic Digital Computers*, New York: John Wiley and Sons, 1956.

RECENT ADDITIONS

TO THE COMPUTER HISTORY MUSEUM COLLECTION

Assorted documentation, including several early Texas Instruments calculator manuals (1972–1980), X2466.2002, Gift of David G. Pitts

Carterphone, Inc., original Carterfone (c. 1959), X2468.2002, Gift of Scott Brear

COBOL document collection (1965–1986), X2461.2002, Gift of Jitze Couperus

Collection of Don Hoefler's *Micro Electronic News* (1979-1984), X2464.2002, Gift of Thomas S Knight

Collection of historic computing printed circuit boards, documents, books, and magnetic media (various dates), X2487.2002, Gift of Shushan Teager

Collection of 19 antique vacuum tubes (c. 1940–1960), X2455.2002, Gift of Martin B Cowan

Collection of UNIVAC manuals and documentation (c. 1955), X2480.2002, Gift of Robert Garner

The *Community Computerist's Directory*, two issues (1981), X2470.2002, Gift of Stephen Pizzo

CompuPro, microcomputer system and software collection (c. 1978), X2472.2002, Gift of NASA Ames Research Center

Digital Convergence Corporation, CueCat barcode scanner (c. 1998), X2460.2002, Gift of John Levy

E.S.R., Inc., DIGI-COMP I (1963), X2463.2002, Gift of Peter Schwarz

Fujitsu Technology Solutions, Inc., 5990 document and photograph collection (c. 1988–1992), X2458.2002, Gift of Fujitsu Technology Solutions, Inc.

IBM, commemorative reproductions of the FORTRAN language manual and programming guide for the 704 (1982), X2477.2002, Gift of Don Ewart

IBM, complete English language documentation for the first office software suite for the IBM PC (1984), X2478.2002, Gift of Paul F May

IBM, FORTRAN 25th Anniversary videotape (1983), X2477.2002, Gift of Don Ewart

IBM, mainframe subroutines from a Russian library (1984), X2475.2002, Gift of Michael Lehner

IBM, PC Technical Reference Manual (1981), X2456.2002, Gift of Laurel V Kaleda

IBM, ThinkPad Trans Note (1999), X2465.2002, Gift of Steve Wildstrom

IBM, two Japanese language software and documentation packages applications for the IBM PC (1984), X2478.2002, Gift of Paul F May

Lotus, Lotus 1-2-3 documentation (1983), X2456.2002, Gift of Laurel V Kaleda

Marchant, ACRM adding machine (c. 1932), X2482.2002, Gift of Mike Smolin

Maxis, SimCity V1.0 for Windows (1989), X2486.2002, Gift of Lisa Pegg

Metaphor, 1200 ML5 workstation (1988), X2479.2002, Gift of Charles Irby

NEC, SX-4 promotional video collection (c. 1996), X2457.2002, Gift of Philip Tannenbaum

NLS chord set keyboard (c. 1972), X2481.2002, Gift of Douglas Gage

Persci, dual-floppy 8" disk drive (c. 1977), X2483.2002, Gift of Ira D Baxter

Quantum Corporation, hard disk drives collection (1985–1995), X2460.2002, Gift of John Levy

Russian "Felix" arithmometer (c. 1932), X2480.2002, Gift of Robert Garner

Scientific Data Systems, Sigma-5 computer system (1965), X2473.2002, Gift of Carnegie Mellon University's NMR Center for Biomedical Studies

SCOPUS, disk pack (c. 1975), X2461.2002, Gift of Jitze Couperus

Softbook Press, Softbook Model SB-200 e-book (1998), X2484.2002, Gift of Gordon Bell

Sony, Magic Link Personal Intelligent Communicator and keyboard (c. 1994), X2465.2002, Gift of Steve Wildstrom

Summagraphics, MM1201 tablet with light pen (c. 1985), X2474.2002, Gift of NASA Ames Research Center

Synertek, KTM-3 user's manual (1979), X2482.2002, Gift of Mike Smolin

Synertek, MOS data catalog (1979), X2482.2002, Gift of Mike Smolin

System Integrators, Inc., Coyote workstation (c. 1985), X2467.2002, Gift of Paul Saffo

Teletype Corporation, ASR-33 Teletype (1971), X2485.2002, Gift of Tom Kochender fer

Texas Instruments, Inc., PASS (Portable Analysis Synthesis System) device and microphone (1985), X2472.2002, Gift of NASA Ames Research Center

Texas Instruments, Inc., TM 990/189 microprocessor trainer (1979), X2471.2002, Gift of Christopher Garcia

U.S. Census Bureau, UNIVAC I serial number plate (S/N 1) replica (1963), X2459.2002, Gift of F Grant Saviers

University of Texas at Austin, computer-generated bronze casting of an earless monitor lizard, X2488.2002, Gift of Tim Rowe

WaveMate, Jupiter Processor and associated manuals (c. 1975), X2483.2002, Gift of Ira D Baxter

6 books (various dates), X2474.2002, Gift of Gary Bronstein

10 linear feet of early computing documents and manuals, including an IBM 701 Manual of Operations (1951), X2454.2002, Gift of Gloria M Bauer

GIFTS OF THE MUSEUM OF AMERICAN HERITAGE, PALO ALTO

Abacus (c. 1980), X2469.2002

Assorted flexible disk drives and media, X2469.2002

Assorted optical media and drives (1990–1999), X2469.2002

Dataplay disks (c. 2000), X2469.2002

IBM, Foxtail diskette (c. 1983), X2469.2002

SmartMedia and Compact Flash card assortment (c. 1998), X2469.2002

(Dates represent dates of introduction and not necessarily dates of manufacture.)

REPORT ON MUSEUM ACTIVITIES

BY KAREN MATHEWS

Karen Mathews is Executive Vice President at the Computer History Museum

A wise person once said, "If you want to predict the future, go to history for advice." In the world of information technology, we seek to provide access to the wisdom of history, every day. Here are some highlights of our activities since the last *CORE* publication.

CARVER MEAD ON ELECTRONIC PHOTOGRAPHY—HISTORY IN THE MAKING

On May 21, AMD graciously hosted 300 attendees for a reception and lecture by Carver Mead, Foveon chairman and Caltech Gordon and Betty Moore professor emeritus. Mead pointed out that the pioneers of photography, like those of computing, have repeatedly stumbled through an array of steps before they were able to arrive at new solutions.

Although the first photographic images were obtained in 1727, it was not until 1837 that a repeatable and useable photographic process was developed. Various schemes were tried over the ensuing century for enabling

Carver Mead explains in a lecture on May 21 how the electronic full-color imaging technology developed by Foveon, a company he co-founded, addresses a long-standing vision for color-image sensing.

monochrome silver-halide technology to produce color images, culminating in the introduction of Kodachrome in 1935.

The first electronic images were captured by vacuum tubes, and more recently by solid-state sensors. Once again, the underlying photosensitive process was basically monochrome, and the efforts to convert it to a color technology showed striking parallels with the earlier silver-halide approaches. In 2002, Foveon introduced X3, the first electronic full-color technology, thereby completing the evolution of color-image-sensing and, in fact, challenging the definition of "pixel" to include red, green and blue in one complete picture element.

Attendee Baldwin Cheng, of McCann Erickson, said, "Carver Mead is a fascinating innovator and a true character. His talk was not only an educational review of the history of photographic technology but also an exciting look at its future. Now my 1.3 'megapixel' Olympus seems as advanced as a Kodak Brownie."

REGIS MCKENNA ON EARLY TECHNOLOGY MARKETING IN SILICON VALLEY

Together with the Silicon Valley American Marketing Association, the Museum hosted a lecture by Regis McKenna on June 4 to an audience of 250 at PARC in Palo Alto. McKenna, who has worked with some of the most recognizable companies in Silicon Valley and helped launch many important technological innovations, discussed his personal experiences and observations from 30 years in the marketing trenches. He recalled that, in the 1970s, only science writers were covering technology and prior to 1983, the *Wall Street Journal* would not publish an article about any company not already on the New York Stock Exchange.

One of McKenna's main messages was that Silicon Valley is missing a dialogue with the past. He said, "It's not just re-investing money, it's re-investing knowledge." In this regard, he advised

Regis McKenna reminisced about technology marketing in the Silicon Valley over the past 30 years, and made a few recommendations to current entrepreneurs.

today's entrepreneurs and business people to concentrate on building infrastructure and standards rather than brands. "Marketing is going to follow quality," he said, "and if you are successful it almost doesn't matter what you call the effort."

John Wharton and a crowd of 250 people assembled on June 4 at PARC to hear a lecture by Silicon Valley marketing legend Regis McKenna.

Museum volunteer and lecture attendee Tim Boyd remarked, "I most enjoyed his story of his grandkids. His grand-daughter's [remark] that, 'we don't need software—we just go on the Internet and get what we want' was very on-point, and fun to hear the telling of it. Like other nerds...I've been caught in the middle of the religious argument about whether my friends or family should buy Macs or PCs. Like Regis, I'd concluded that for most people the larger number of software titles gives the PC the nod. About three years back I had the epiphany ...that for many people browsing was the thing, along with e-mail, and it mattered not which hardware you choose."

AL SHUGART: HALF A CENTURY OF DISK DRIVES AND PHILOSOPHY: FROM IBM TO SEAGATE

Al Shugart spoke on September 5 to an audience of 250 at Xerox PARC about five decades of rich experience in the disk drive industry. Shugart joined IBM as a customer engineer in 1951 and later participated in the development of IBM's 305 RAMAC, the precursor to today's hard drives. He pioneered the floppy disk at Shugart Associates, and later co-founded Seagate in 1979 (with an eight-page business plan and $500,000 in funding on a handshake) to develop small hard drives for personal computers.

Disk drive legend Al Shugart spoke on September 5 at PARC's Pake Auditorium about 50 years of experience in the industry.

Said Shugart, "One of my earlier recollections of [the] IBM lab at 99 Notre Dame Street in San Jose was watching Don Johnson, one of the pioneers of this development, pouring iron oxide paint onto a rotating 24-inch disk from a Dixie cup. No cleaner, no equipment. The equipment was so crude the Dixie cup didn't look out of place. And I certainly had no idea I was walking into the beginning of a technology and a product development program that would have such a profound impact upon the entire computer industry."

Attendee Pete Delisi said, "It's always awe-inspiring to hear first person from the people who created these industries. I remember very well the disk drive products that Al was describing and remember them as significant shifts every time a new product came out. Now we're dwarfed by progress in every segment of the computer industry and it's easy to lose sight of the tremendous contributions that guys like Shugart made. We 'old-timers' will never forget where we have been."

MITCH WALDROP: THE REVOLUTION THAT MADE COMPUTING PERSONAL

In a lecture on September 19 co-hosted by Hewlett-Packard, author Mitch Waldrop brought us the fascinating story of JCR Licklider and the personal computing revolution. Licklider may well have been one of the most influential—and east known—people in the history of computer science. As a division director in the Pentagon's Advanced Research Projects Agency (ARPA) in the early 1960s, Licklider put in place the funding priorities which led to the Internet and the inventions of the "mouse," "windows," and "hypertext."

Mitch Waldrop spoke at Hewlett-Packard Labs on September 19 about the life and accomplishments of JCR Licklider, further detailed in his book *The Dream Machine*.

Attendee Todd Anderson remarked, "Another great piece of the puzzle... Waldrop showed how quickly a good piece of history and perspective [almost!] slipped past us without anybody capturing it. At least we know we are missing parts."

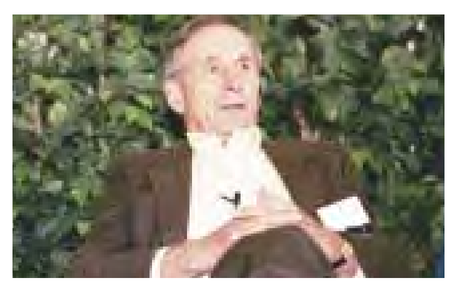
PIONEERS OF VENTURE CAPITAL

Legendary venture capitalists Bill Draper, Pitch Johnson, Burt McMurtry, Tom Perkins, Arthur Rock, and Don Valentine gathered at Moffett Field on September 30 to participate in a panel moderated by Fenwick & West's Gordy Davidson. To a standing-room-only audience of over 300 people, these founders and pioneers of the field told fascinating tales of how they got their start, their "aha" moments, their biggest hits, what they learned, and the ones that got away.

A reception in the Museum's Visible Storage Exhibit Area before the "Pioneers of Venture Capital" lecture enabled many local VIPs to see the Museum's collection for the first time.

Bill Draper (Draper Richards) and Pitch Johnson (Asset Management Company)

Burt McMurtry (Technology Venture Investors) and moderator Gordon Davidson (Fenwick & West LLP)



Arthur Rock (Arthur Rock & Co.)

Tom Perkins (Iolon, News Corporation, and the Hewlett-Packard Company) and Don Valentine (Network Appliance)

The panel was arranged by Museum Trustee Donna Dubinsky, who remarked, "I was most struck by the notion of these pioneers as 'company builders' rather than 'promoters.' I think that concept got lost a bit in the bubble, so it was nice to hear it reiterated."

Museum Trustee Ike Nassi noted, "At the Computer History Museum we often have the opportunity to interact with pioneers, to hear their thoughts. At the VC panel, we had an opportunity to not only see some of the unquestioned pioneers of this revolution comment on what it was like...but to hear them interacting with each other, trading stories..."

Generous funding for the presentation was provided by Allegis Capital and an anonymous donor. Sponsorships like these allow the Museum to fulfill its mission and to produce high-quality programming.

A videotape of this presentation may be obtained through the Museum's website at www.computerhistory.org/store.

DONOR APPRECIATION PARTY

The Museum held a special donor appreciation party on June 8 to celebrate and thank our valued supporters. More than 100 current members—including pioneers, engineers, industry fans, executives, computer users, and VCs—assembled at the home of Alexia Gilmore and Colin Hunter in Atherton, California. Some traveled from as far away as Massachusetts for great food, entertainment, and conversation.

More than 100 Museum members gathered at the home of Alexia Gilmore and Colin Hunter for a donor appreciation party on June 8.

The performance group Teatro Zinzanni delivered a Computer History Museum rendition of The 12 Days of Christmas and a fortuneteller provided readings. Some of the lucky attendees received autographed lecture posters and Museum logo merchandise. Thanks to our hosts, Alexia, Colin, Sheila and John Banning, and everyone who came and made the event such fun.

Members of the performing group Teatro Zinzanni kicked off the donor appreciation party with a lighthearted song and dance about the Museum.

This year's party recognizing annual donors was hosted by John and Sheila Banning, Colin Hunter, and Alexia Gilmore (left to right).

EXECUTIVE DIRECTOR HELPS LAUNCH LLNL MUSEUM

On July 11, 2002, Lawrence Livermore National Laboratory opened the LLNL Computer History Museum exhibit in conjunction with its 50th anniversary. After a brief talk by LLNL Director Emeritus Edward Teller, our own Executive Director and CEO John Toole participated in the event with a presentation, "Preserving Computing History: From Teller to Teraflops." The visit by Teller was a surprise to many, including Toole, who had named his talk after Teller. Toole was privileged to enjoy a photo shoot and conversation afterwards with the pioneer. "Even the 'youngsters' in the audience could appreciate our computer history, though they didn't live through it like some of the rest of the audience," said LLNL Associate Director of Computation, Dona Crawford. The LLNL exhibit features dozens of artifacts it has donated to CHM over the years, and which the Museum lent back to LLNL for the exhibit.

Museum Executive Director and CEO John Toole with LLNL Director Emeritus Edward Teller and LLNL Associate Director for Computation Dona Crawford (left to right).

COLLECTION HIGHLIGHTS

An original Carterfone Communications Corporation "Carterphone" was recently donated by Scott Brear. Manufactured by Carter Electronics in 1959, the telephone allowed mobile radio users

An original Carterfone, which sparked a debate that eventually led to the FCC's landmark "Carterphone decision," allowing third-party companies to manufacture and connect equipment to the public-switched telephone network (PSTN).

to connect with the public telephone network. In 1966, telephone companies challenged its legality, and a lengthy struggle began. Eventually, the Federal Communications Commission handed down the landmark "Carterphone Decision," which allowed an open, competitive market to exist for communications equipment and facilities. This Carterphone is one of a few remaining such devices in existence.

Thomas S. Knight donated a collection (1979-1984) of Don Hoefler's *Micro Electronic News*. Hoefler was a Silicon Valley icon who reported on the semiconductor industry for many years. He is widely accepted as the person who, in 1972, first put into print the term "Silicon Valley."

DOCENT TRAINING

The Museum has a small cadre of dedicated volunteers who have provided docent services at the Visible Storage Exhibit Area over the past few years. Now, our exposure is increasing and we have a need for more trained docents to lead visitors through the collection. Head Curator Mike Williams has created a new docent training program and classes are available. If you are interested in becoming a docent, please contact Betsy Toole for information on upcoming training sessions.

Head Curator Mike Williams leads a group of docents in training through the items in the Visible Storage Exhibit Area.

VOLUNTEERS IN MOTION

Over the past months, our volunteers have contributed a tremendous amount of help to the Museum. This help is vital to our operation and growth. Thank you for everything you do.

Once every month, volunteers gather on a Saturday to assist Museum staff with a variety of tasks. In June, volunteers helped build pallet racks in one of our warehouses. It took about 12 hours to move artifacts out of the warehouse, build the racks, then reorganize the items in a much more accessible arrangement. What a difference to the collections and warehouse staff!

Another group of volunteers helped receive and organize a delivery of almost 200 boxes from the Digital Equipment Corporation archive recently donated by HP/Compaq.

Slava Mach assists with the installation of artifact shelving during a volunteer work party.

Volunteers also participated as part of our annual Fellow Awards event team, many and varied fundraising efforts, volunteer planning, and various office duties. Others provided graphic design, web design, and scanning services.

If you are interested in helping the Museum in any of its tasks to preserve and present computing history, please contact Betsy Toole for more information.

ANNUAL FELLOW AWARDS BANQUET

This year, the Museum once again celebrated the inventors and visionaries of the information technology revolution at our Fellow Awards Banquet. About 400 people gathered to honor four new Fellows: John Cocke, Charles Geschke, Carver Mead, and John Warnock. 2000 Museum Fellow Fran Allen delivered an acceptance speech on behalf of John Cocke, who passed away earlier this year.

Master of Ceremonies and Trustee John Shoch, new Fellow Carver Mead, and Executive Director and CEO John Toole (left to right) after the ceremonies at the Fellow Awards Banquet in October

The theme of the evening was "Architects of Change" and attendees were treated to a reception exhibit featuring the stories and artifacts of all 24 past and present Museum Fellows. It was a wonderful opportunity to reflect on the stunning intellect, creativity, and vision that these innovators have brought to our world.

Alloy Ventures general partner and Museum Trustee John Shoch entertained the audience and led the evening as Master of Ceremonies. Board of Trustees Chairman Len Shustek addressed the group about the importance of preserving the artifacts and stories from this incredible time we are experiencing—an information revolution that is creating tools to amplify the human mind. John Toole, Executive Director and CEO, announced the purchase of our new building at 1401 N Shoreline and presented a retrospective multi-media presentation

(left to right): 2002 Museum Fellows John Warnock, Charles Geschke, Carver Mead, and Fran Allen (who accepted the award on behalf of John Cocke)

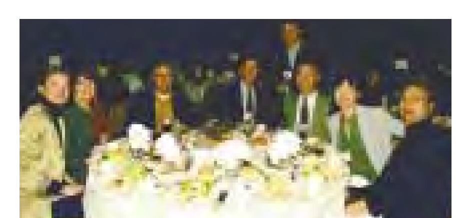
Barbara Warnock, Peggy Asprey, and Marva Warnock

Museum Trustee Eric Hahn and volunteer Angela Hey

on the Museum's history, from some of the earliest lectures and advertisements, to the move west, through current visions for the building and exhibits.

For those of you who missed this gala event, here are highlights of the contributions for which our new Fellows were honored.

At IBM, **John Cocke** developed the concept of reduced instruction set computer (RISC) technology, a cornerstone of high-speed computer design, relying on a minimal instruction set and highly efficient compiler design. He was a multifaceted talent at IBM, working in compilers and inventing the concept of "lookahead" for the IBM STRETCH computer. He inspired generations of engineers and won the National Medal of Technology (1991), the National Medal of Science (1994), and the ACM Turing Award (1985) for



Trustee Peggy Burke and the 1185 Design table

his lifelong achievements in computer science. Cocke graduated in 1956 from Duke University with a Ph.D. in mathematics. He passed away on July 16 of this year.

A reception prior to the Fellow Awards Banquet featured a walk through the accomplishments of all 24 Museum Fellows

Visionary and inventor **Carver Mead** has spearheaded major innovations across many disciplines and made many contributions to the field of microelectronics. He created what is now called HEMT, the standard amplifying device used in communications. He pioneered the design concept for VLSI (very-large-scale integrated) circuits, which is now ubiquitous in the semiconductor industry. Mead has also experimented with neuromorphic electronic systems, which imitate functions of living nervous systems.

A professor for over 40 years at Caltech, Mead also contributed to an explosion of new chips on the market through his mentoring of students. He holds over 50 US patents, has written and contributed to more than 100 scientific publications, and has received numerous awards.

Like many pioneers, **Charles Geschke** and **John Warnock** left the structure of a large corporation to move the industry forward on their own as entrepreneurs. In the early 1980s, Geschke and Warnock were working at Xerox's Palo Alto Research Center to develop a page-description language (PDL) called Interpress. When Xerox did not introduce it, Geschke and Warnock started Adobe Systems, Inc. in 1982 and began to work on solving some of the long-standing problems that plagued the relationship between PCs and printers.

Together, John Warnock and Charles Geschke created PostScript, the PDL that revolutionized the creation and printing of documents and introduced a new computer-based industry—desktop publishing. Over the years, the two men have worked closely together and greatly influenced the development of the industry over time. PostScript was selected by the International Standards Organization (ISO) as the standard PDL.

Said attendee Alex Osadzinski, "I found the Fellows banquet very moving. The montage playing on the screens...reminded me of how this industry is built on the achievements of just a few talented and visionary people. The humility exhibited by the newly-elected Fellows was very inspiring....These folks are such tremendous role models; we can all learn something from them."

Sincere thanks go to the many people who supported the banquet. Hewlett-Packard Company was our Lead Sponsor, and 1185 Design and Adobe Systems were Patron Sponsors. The Wizard circle of tables included Warburg Pincus, *WIRED* magazine, Garner Hendrie and Karen Johansen, and Len Shustek and Donna Dubinsky. The Guru circle of tables included Alloy Ventures, Gwen Bell, Paul Borrill, Goldman Sachs, John Mashey, and Bernard Peuto. Our gratitude also to the evening's hosts: Robin and David Anderson, Donna Dubinsky and Len Shustek, Elaine and Eric Hahn, and Karla and Dave House.

1401 N SHORELINE BLVD., MOUNTAIN VIEW, CALIFORNIA—THE MUSEUM'S NEW HOME

We hope you are as excited as we are about our new building. Staff, volunteers, and Trustees have been working hard behind the scenes to prepare for operations in the new space. Be sure to check out John Toole's letter on the inside front cover of this issue of *CORE* to learn more about our plans. Stay tuned for details as they develop! And please feel free to contact us if you would like to have more information.

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"Pioneers of Venture Capital" featuring Bill Draper, Pitch Johnson, Burt McMurtry, Tom Perkins, Arthur Rock, and Don Valentine.

"The PalmPilot Story" with Jeff Hawkins, Donna Dubinsky, and Ed Colligan

2003 CALENDAR

This beautiful calendar features "Computing Pioneers and Their Inventions" on simulated blue bar tractor-feed printer paper.

UPCOMING EVENTS

Please RSVP for all events. Register by phone: +1 650 810 1027. Register online: www.computerhistory.org

TUE, NOVEMBER 12
ADOBE SYSTEMS— THE FOUNDERS' PERSPECTIVE
John Warnock and Chuck Geschke
Member and VIP Reception—6:00 pm
Computer History Museum, Bldg 126
Lecture—7:00 pm
Moffett Training and Conference Center, Bldg 3
Moffett Field, California

TUE, DECEMBER 10
AN EVENING WITH STEVE WOZNIAK
Steve Wozniak
Member and VIP Reception—6:00 pm
Computer History Museum, Bldg 126
Lecture—7:00 pm
Moffett Training and Conference Center, Bldg 3
Moffett Field, California

MON, FEBRUARY 10
DATABASE PANEL DISCUSSION
Chris Date, Herb Edelstein, Bob Epstein, Ken Jacobs, Pat Selinger, Roger Sippl, and Michael Stonebraker with George Schussel
Lecture—7:00 pm
Moffett Training and Conference Center, Bldg 3
Moffett Field, California

MUSEUM ARTIFACTS ON LOAN

JULY 30–AUG 2, 2002
"TRANSFORMING FANTASY"
DARPATech 2002
Anaheim, California
www.darpa.mil/DARPATech2002/

APRIL–SEPTEMBER 2002
"WORLD'S FAIRS"
San Francisco International Airport
Terminal C3
San Francisco, California
www.sfoarts.org

OCTOBER 19, 2002–FEBRUARY 2, 2003
"GAME ON! THE WORLDWIDE CULTURE AND HISTORY OF VIDEO GAMES"
National Museums of Scotland
Edinburgh, Scotland
www.nms.ac.uk

MARCH 6, 2002–MARCH 6, 2003
"CENSUS CENTENNIAL CELEBRATION"
U.S. Department of Commerce,
Bureau of the Census
On-line exhibit
www.census.gov/mso/www/centennial/

JULY 11–OCTOBER 15, 2002
"50 YEARS OF COMPUTING AT LAWRENCE LIVERMORE NATIONAL LABORATORY"
Livermore, California
Tours must be reserved in advance.
Call +1 925 424 6575 or visit www.llnl.gov/PAO

SEPT 2002 (ONGOING)
"THE COMPUTING REVOLUTION"
Museum of Science
Boston, Massachusetts
www.mos.org

TOUR THE MUSEUM

Tours of the Museum's Visible Storage Exhibit Area are held on Wednesdays and Fridays at 1:00 p.m. and on the 1st and 3rd Saturdays of each month at 1:00 p.m. and 2:00 p.m. Please make a reservation at +1 650 810 1010.

VOLUNTEER OPPORTUNITIES

The Museum tries to match its needs with the skills and interests of its volunteers and relies on regular volunteer support for events and projects. In addition to special projects, monthly work parties generally occur on the 2nd Saturday of each month, including:

NOVEMBER 9, DECEMBER 14
JANUARY 11, FEBRUARY 8

Please RSVP at least 48 hours in advance to Betsy Toole for work parties, and contact us if you are interested in lending a hand in other ways! For more information, visit our web page at www.computerhistory.org/volunteers.

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Current staff openings can be found at www.computerhistory.org/jobs.

MYSTERY ITEMS

FROM THE COLLECTION OF THE COMPUTER HISTORY MUSEUM

Explained from CORE 3.2

ATANASOFF-BERRY COMPUTER (ABC)

Atanasoff-Berry Computer (ABC), Add-shift module replica (c. 1995), X2446.2002, Gift of John Gustafson.

This modern-day recreation of a critical module in the ABC machine consists of seven vacuum tubes mounted on a sheet-metal chassis wired identically to the original 1942 prototype, and hand-assembled by engineers at Iowa State University's Ames Laboratory in the mid-1990s using authentic antique components. Approximate size: 8" x 5" x 4."

John Vincent Atanasoff (1903-1995) and graduate student Clifford Berry (1918-1963) started on the ABC design in 1937 (completing it in 1942) as a means of solving the thorny mathematical problems they faced on a daily basis. The machine was built into a desk-sized cart and cost about $5,000 (1940 dollars) to develop and build. Using a form of capacitor memory of Atanasoffís own design, the ABC could solve up to 29 simultaneous linear equations in 29 unknowns. While the machine was somewhat unreliable (some question it ever having worked at all), it was involved in one of the most protracted patent disputes in U.S. history (Honeywell vs. Sperry-Rand), centering on the "invention" of the digital computer. Though Atanasoff was legally credited with this invention at the trial's conclusion in 1973, most historians feel this strict legal interpretation to be inaccurate and that credit properly goes the team at Manchester University in Britain for their "Baby" machine (1948).

Whatever one's position on this issue, the recreation is an impressive accomplishment in itself. Costing $350,000 (1997 dollars) to complete, a team of devoted faculty, students, and interested individuals invested thousands of person-hours into research, fabrication, and testing to bring back to life a machine from the prehistoric era of computing. This module is a spare from that reconstruction effort. For more information, see: http://www.cs.iastate.edu/jva/jva-articles.shtml.

WHAT IS THIS?

THIS ITEM WILL BE EXPLAINED IN THE NEXT ISSUE OF CORE.

Please send your best guess to mystery@computerhistory.org before 12/31/02 along with your name, shipping address, and t-shirt size. The first three correct entries will each receive a free t-shirt with the new Museum logo and name.

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SEPTEMBER 2003

CORE 4.1

A PUBLICATION OF THE COMPUTER HISTOR Y MUSEUM
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ANNOUNCING OUR ALPHA PHASE!

With the extraordinary efforts and support of so many people this year, we have reached another major milestone. The Museum initiated its Alpha Phase on June 2 at 1401 N Shoreline Blvd! This marks the official opening of a new Visible Storage display area, the dedication of the Hahn Auditorium, and the beginning of our public presence in our new home. Yet there's much more ahead to realize our dream—plans are already under way for the Museum's Beta Phase, and Releases 1.0 and 2.0 over the next several years.

It's exciting to see the opportunities our new home has given us. In the new Visible Storage, for example, you will still find many favorite artifacts from the display at Moffett Field. However, we now have an entirely new look, labels for all of the items, and about double the number of artifacts in a larger gallery for a more complete representation of computing history. A great online virtual visible storage can be found at www.computerhistory.org. I know you will be pleased to see how we are bringing that story to the world.

We also opened our new Hahn Auditorium and multi-purpose room, named in honor of the Hahn family, our largest donor to date. Eric Hahn is also a trustee who has helped us grow dramatically and who served as the first chair of the Development Committee in California. This space will become a community gathering place for computing history enthusiasts, host everything from history lectures to major events, and allow us to record important events for posterity.

Our new building has been drawing the interest of corporations, attracting many new volunteers, and allowing trustees, staff, and volunteers to productively work together in one environment. Since June, we have moved most of our collection from offsite storage into unused portions of the Museum building, and we may soon be offering special member tours to explore the deep recesses of our great collection.

Although accomplishments have been great, the economic climate has been extremely challenging. We need your help in finding people and organizations to support us as we grow, and are looking for volunteers to help in many areas, including development. We also reorganized early this year in anticipation of next year's economic situation, and have consolidated some functions. The staff has been tremendous during this difficult time of change, and you will see some of their titles have changed.

With our new presence in Mountain View, you can tangibly see how we are able to grow into a great museum. Yet our programs take support and dedicated people. Please consider increasing your annual campaign support and making a capital campaign gift. In addition, we have just kicked off a great corporate membership program and have created recognition walls for all to see. For information on the member programs and naming opportunities please contact Karen Tucker.

Be sure to read the report on Museum activities. While we've been preparing to open our great building, our public programs have been spectacular. The awesome lectures and events we plan and support have truly brought to life the meaning of preserving the stories of the information age.

The launch of our Alpha Phase is a giant step forward for the Museum. We now have an unparalleled public presence that will be built in phases over time along with great programs and access to the largest collection in the world. Help us to grow and let us know how you enjoy your Museum!

JOHN C TOOLE
EXECUTIVE DIRECTOR & CEO

September 2003
A publication of the Computer History Museum

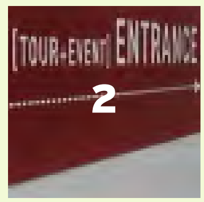
CORE 4.1

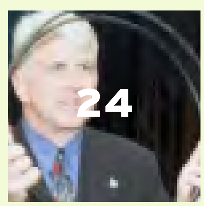
VISION
TO EXPLORE THE COMPUTING REVOLUTION AND ITS IMPACT ON THE HUMAN EXPERIENCE

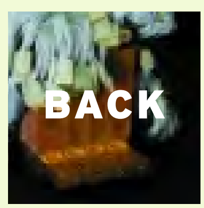
MISSION
TO PRESERVE AND PRESENT FOR POSTERITY THE ARTIFACTS AND STORIES OF THE INFORMATION AGE

PUBLICATION STAFF

Karyn Wolfe
EDITOR







IN THIS ISSUE

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Cover: Celebrating the opening of the Alpha Phase of the Computer History Museum at 1401 N. Shoreline Boulevard in Mountain View, California! See article on page 2.

Kirsten Tashev is Director of Collections and Exhibitions at the Computer History Museum

COMPUTER HISTORY MUSEUM: ALPHA PHASE

BY KIRSTEN TASHEV

The Museum's entrance at 1401 N. Shoreline in Mountain View, Calif.

The Museum reached a key milestone with the opening of its Alpha Phase on June 2, 2003. At an open house celebration held at the new building, the Museum unveiled a 400-person Hahn Auditorium and meeting space, donor acknowledgment walls, and a 9,000-square-foot Visible Storage exhibit area. The opening was a great success and was attended by about 600 people, including city officials, Museum members, trustees, staff, contractors, and guests. The celebration began with a ribbon cutting ceremony and presentations by Executive Director & CEO John C. Toole and Museum trustees, and was followed by tours of the new Visible Storage exhibit area and a reception.

Photo by Earnest J. Ray

After a ribbon cutting ceremony, over 600 guests celebrated the opening of the Museum's Alpha Phase.

Photo by Earnest J. Ray

The open house included tours of Visible Storage and a reception.

In October 2002, the Museum purchased its landmark building at 1401 N. Shoreline Boulevard in Mountain View, Calif. Built in 1994, the building was state-of-the-art for its time and its open concept design lends itself well to the Museum's future plans. But, several key upgrades were necessary to transform the building from office to museum in compliance with public assembly building codes. Renovations were begun shortly after purchasing the building and included such requirements as fire walls, mechanical and safety upgrades to accommodate a larger occupancy capacity, and structural upgrades to support both the increased occupancy of potential visitors as well as the significant weight of some of the Museum's most historic artifacts.

THE HAHN AUDITORIUM

The renovations also allowed the Museum to significantly improve its facilities for ongoing public programs. The Museum's popular speaker series will now be held in the new 400-seat auditorium. The Hahn Auditorium, named after major benefactors Elaine Hahn and Museum Trustee Eric Hahn, is equipped with a high quality sound and recording system that will allow

Photo by Earnest J. Ray

The new Hahn Auditorium was named after Eric and Elaine Hahn, has a 400-seat capacity, and will serve as a multi-purpose space for banquets, receptions, and other events.

the Museum to produce well-engineered events and to support its archival efforts. The Hahn Auditorium also serves as a multi-purpose space, allowing the Museum to hold any number of institutional and potential rental events, including banquets, receptions, meetings, etc. This year the Museum plans to hold the annual Fellow Awards Celebration in the new facility on October 21, 2003.

UNVEILING OF DONOR WALLS

Also at the opening, the Museum unveiled a series of donor walls, including plaques that recognize the early Boston and Silicon Valley founders, as well as the current annual donors, corporate members, and capital campaign donors. The new donor walls are prominently displayed in the lobby reception area and will continue to recognize the financial support of the many individuals and companies who enable the future growth of the Museum.

A series of new donor walls in the lobby reception area acknowledge current annual donors, corporate members, capital campaign donors as well as early Boston and Silicon Valley founders.

A REVITALIZED VISIBLE STORAGE

Key to the Alpha Phase opening was the reincarnation of the Museum's Visible Storage exhibit area. Formerly housed in a World War II-era warehouse at Moffett Field, the original Visible Storage suffered from cramped quarters, poor lighting and climate control, and little to no interpretation in the form of labels or other self-guided explanatory information. Although docent-led tours greatly enhanced the Visible Storage at Moffett Field, docents were often required to double back and point over and between objects in order to provide adequate tours of the history of computing.

As soon as it was clear that the Museum would likely purchase the building at 1401 N. Shoreline Blvd., the Museum's collections and exhibitions staff, along with the exhibit design firm, Van Sickle & Rolleri Ltd., with the input of trustees and other subject specialists, began the work of designing the new Visible Storage. From the outset, the design embraced the concept of a Visible Storage rather than a full-fledged museum exhibit. Visible Storage—sometimes known in the museum field as Open Storage—has become quite popular in the last decade as a legitimate display technique. Unlike a Museum exhibit that attempts to explain more complex information through extensive graphics, audio-visuals, and computer interactives, a Visible Storage relies mainly on artifacts or objects as the primary means of communication along with a limited number of explanatory labels. Since the majority of museums have limited space and can only exhibit between 10 and 20 percent of their collections at any one time, the low-cost method of Open Storage allows them to provide public access to "back end" collections that they otherwise would not be able to display. In the case of the Computer History Museum, this approach allows us to make our collection available to the public while we fundraise to build more content- and multimedia-rich exhibitions.

Visible Storage has been moved from a warehouse at Moffett Field (above) to the new building (below). Many enhancements have been made, including improvements in look and feel, expanded labels, and an organized layout displaying 50% more artifacts.

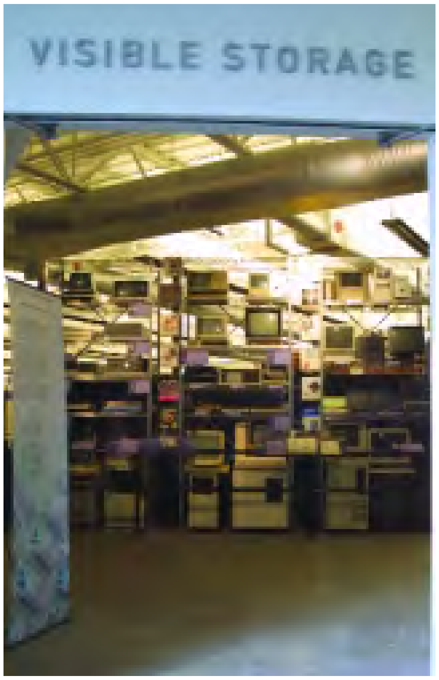
Having worked for a little over a year on the future 15,000 square-foot Timeline of Computing History exhibition scheduled to open in two to four years, the team had a solid outline of the major highlights of computing history fresh in their minds. Although restricted to using the artifacts themselves and to limited explanatory techniques, the team wanted to create a new and improved Visible Storage that would attempt to touch on all aspects of computing, including software, hardware and underlying technology, graphics systems, networking, Internet, and computing precursor systems.

In developing the new Visible Storage, a tension between presenting information chronologically versus thematically presented itself. The end resulted in a compromise, so that the artifacts are laid out in a loose chronological order, yet the plan allows for diversion here and there to show developments by theme in a specific area such as storage or peripheral devices, or supercomputers, etc.

The experience is greatly enhanced by explanatory labels for each artifact. Expanded labels explain more complex or less object-based information, such as computing concepts or developments in the field of software. Although the new Visible Storage is not a full-scale exhibition, nor by any means a comprehensive presentation of computing history, with approximately 600 artifacts, 150 historic photos, and a computer restoration workshop featuring the IBM Model 1620, it offers much greater access to the Museum's rich collection.

FUTURE EXHIBITIONS

While the Alpha Phase opening is no doubt a significant achievement for the Museum, there still remains much to be done in order to preserve and present the amazing story of the computing revolution. The Museum is currently raising funds to expand its offerings through world-class exhibitions in future phases or releases. The Museum plans to create exhibitions that are rich in contextual media and interpretive content, covering all aspects of computing history. These will include a



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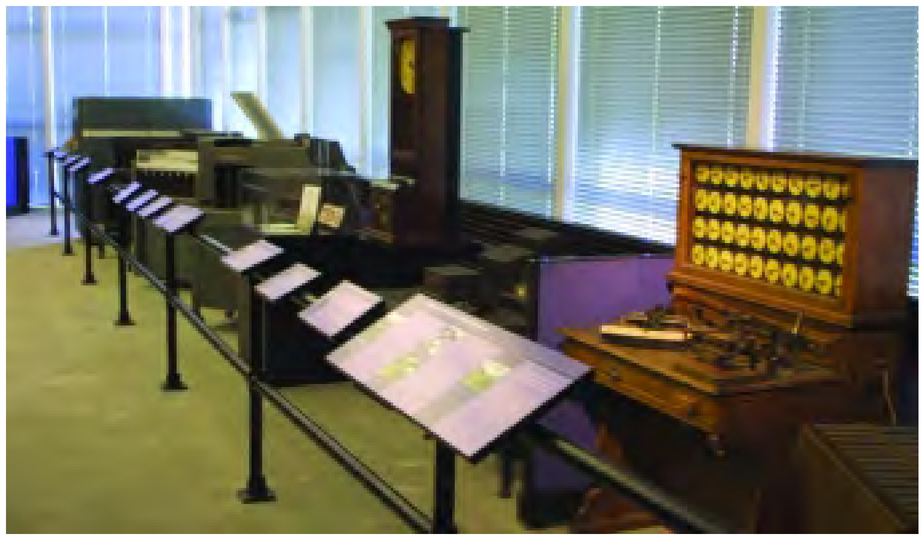

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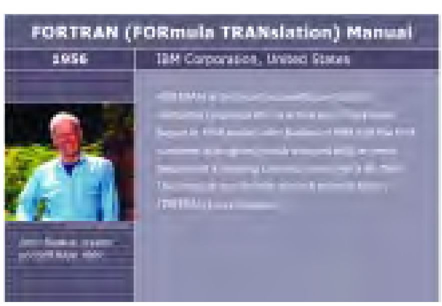
1) Enter our new Visible Storage exhibit area, displaying approximately 600 artifacts, 150 historic photos, and a computer restoration workshop featuring the IBM 1620.

2) An organized layout, expanded labels, and protective stanchions are helping to improve visitor experience.

3) An office area of the building was converted for Visible Storage. The carpeting was removed and the cement flooring was re-finished, blinds in the floor-to-ceiling windows are kept shut to protect the artifacts from light, and cubicle walls were re-purposed as dividers between sections.

4) Even though the new Visible Storage has more space and more artifacts, the displays are still fairly dense with a lot of items located closely together. To the interested, the experience can be one of great depth.

5) Just one of the new item labels found throughout Visible Storage.



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The Museum is developing a Timeline Exhibit that will be media-rich and highly interpretive. These artists renderings explore ideas for how this Timeline Exhibit could be configured.

The Museum is planning additional building renovations for two upcoming phases, Release 1.0 and Release 2.0. In addition to the Timeline Exhibit and Theme Galleries, plans call for a reference library, gift shop, café, and multipurpose event and classroom spaces.

Timeline of Computing History that will focus on headline stories in a chronological format, five Theme Room galleries that will explore specific topics in more detail and show developments in sub-fields of computing side by side, and a large gallery for changing topical exhibits, the possibilities of which are endless.

Plans also include a rich online CyberMuseum experience to include access to the Museum's collections, and a variety of interpreted Cyber Exhibits. In addition, the Museum plans to offer a reference library, gift shop, café, and multipurpose event and classroom spaces. These amenities will enable us to expand our community and will support the Museum's educational programs, including a speaker series, seminars, workshops, artifact restorations, and other volunteer-led projects.

As I hope you can see, the Museum has a solid base upon which to achieve its objectives, with its deep collection, enthusiastic supporters, promising facility, and public mission. To reach our goals, however, we need your help as a supporter, donor, and volunteer. Please stop by, see our Alpha Phase, and help us achieve our future plans through your support and participation.

Tours of the new Visible Storage are now given on a regular basis, and a Virtual Visible Storage is also now available. For more information, please visit the Museum's Web site at www.computerhistory.org.

THE MCM/70 MICROCOMPUTER

BY ZBIGNIEW STACHNIAK

INTRODUCTION

In early 1972, a small group of computing professionals came together in Kingston, Canada, to design a novel computer system based on emerging microprocessor technology. The result of their work at Micro Computer Machines Inc. (MCM) was the MCM/70 personal computer. The following article details the early stages in the development of the MCM/70 microcomputer. The article is based primarily on development notes authored by Mers Kutt, the first president of MCM. These notes, most likely written between February and May of 1972, are among the oldest records chronicling the coming of the personal microcomputer. Quotations by Kutt, Gordon Ramer, José Laraya, and Morgan Smyth were obtained through interviews by the author between March, 2001, and December, 2002. Kutt's notes and recordings of the interviews currently reside at the York University Computer Museum in Toronto, Canada.

MCM/70 UNVEILED

The MCM/70 computer, designed by MCM between 1972 and 1973, is possibly the earliest example of a microcomputer manufactured specifically for personal use. From the hardware and software engineering points of view it does not have much in common with early hobby computers, such as the MITS Altair 8800 or Apple I, except that these computers were microprocessor-based. By the time the Altair 8800 kit was offered to hobbyists in early 1975, with its 256 bytes of RAM memory and no high-level programming language capability, the MCM microcomputers were providing in-house APL (A Programming Language) support for applications ranging from engineering design, modeling and simulation, to investment analysis and education. By the time the Apple I board was offered for sale in 1976, the MCM machines were being used by Chevron Oil Research Company, Firestone, Toronto Hospital for Sick Children, Mutual Life Insurance Company of New York, Ontario Hydro-Electric Power Commission, NASA Goddard Space Flight Center, and the U.S. Army, to name just a few MCM customers.

The official announcement of the MCM/70 came on September 25, 1973, in Toronto. Two days later, it was unveiled in New York and the following day in Boston. An early prototype had been demonstrated to the APL community in May of 1973 during the Fifth International APL Users' Conference in Toronto. Another prototype was touring Europe in August and September of that year and was showcased by the MCM team in Holland, Germany, Switzerland, France, Italy, and the U.K. Other prototypes of the machine included an early refinement of the Intel SIM8-01 development board, a rack-based wire-wrapped system, a desktop bare-bones system, and even a cardboard mockup.

Announcement of the MCM/70 during the press conference at the Royal York Hotel in Toronto, September 25, 1973. From left: Mers Kutt, Gordon Ramer, Ted Edwards, and Reg Rea. Source: *Canadian Datasystems*, October 1973, p. 49.

The MCM/70 desktop bare-bones system. 3D model created by André Arpin.

Photograph by Z. Stachniak

Mers Kutt speaking at York University, Toronto, October 2001

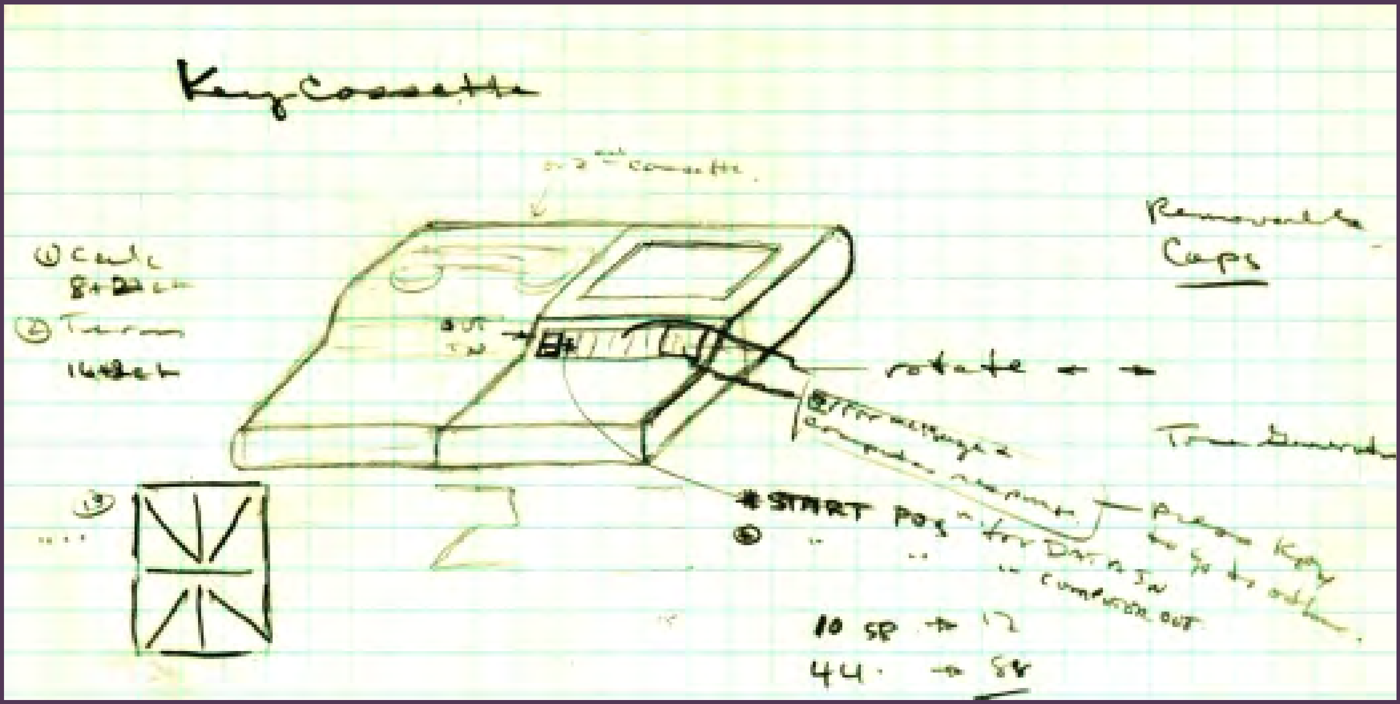
KUTT SYSTEMS INC.

In the fall of 1971, just after he left his first company, Consolidated Computer Inc., Canadian inventor and entrepreneur Mers Kutt decided to develop a small desktop personal computer that could be programmed in APL. Kutt followed technological developments and market trends in the semiconductor industry closely. He personally knew Bob Noyce, then the CEO of Intel Corporation, and was meeting with Intel marketing staff and participating in Intel promotional seminars. He had a good knowledge of the technical specifications and of the developmental progress of Intel's first 8-bit microprocessor—the 1201, later renamed the 8008. For Kutt, the near completion of the 8008 chip in late 1971 was a technological trigger point urging him to move ahead with his personal microcomputer project.

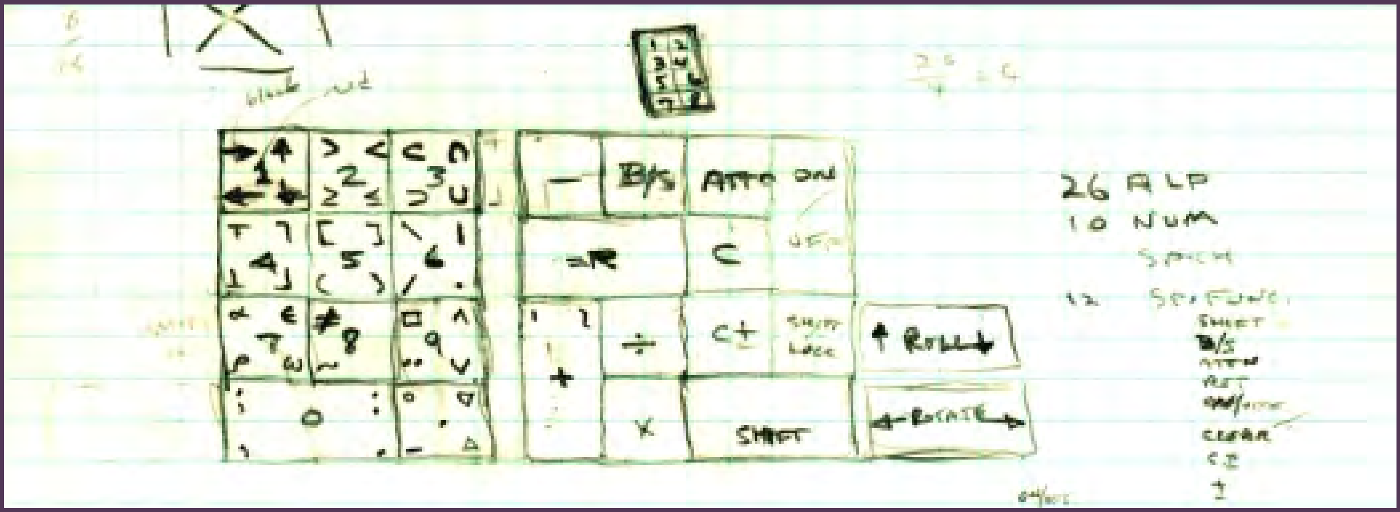
In the beginning, there were just two: Mers Kutt and Gord Ramer, whom Kutt recruited to work on the software aspect of the project. Before joining forces with Kutt, Ramer was the director of the Computing Center at St. Lawrence College in Kingston. Before that Ramer had worked at York University, then on the outskirts of Toronto, and developed the York APL dialect of Iverson's APL language. His experience with space-efficient York APL was critical for the writing of the MCM/APL interpreter, which Ramer initiated even before the 8008 chip was available in quantity from Intel.

The small company was incorporated on December 28, 1971, under the name Kutt Systems Inc. On the same day, Hank Smith, who was in charge of Intel's Micro Computer Systems Group, signed a shipment invoice for a SIM4-01 development system, an MCS-4 chip set, and an MP7-01 EPROM programmer, together valued at $1,231, to be delivered to Kutt at no charge. The second shipment from Intel, on May 23, 1972, delivered a SIM8-01 development board and an MP7-02 programmer. By that time, the company had hired, among other people, a hardware engineer by the name of José Laraya, APL programmers Don Genner and Morgan Smyth, and software engineer André Arpin, whose main job would be to develop the virtual memory system for the MCM/70 computer.

MCM was aiming at a small, microprocessor-based desktop computer that would be affordable, as easy to use as a hand-held calculator, and functionally as powerful as a mainframe computer running APL. Nothing similar had ever been built before. At the time, in December 1971, the news of a CPU on a single chip was only about one month old. Furthermore, APL interpreters were not even available for minicomputers.



The Key-Cassette drawing. Source: M. Kutt's notes



A fragment of the Key-Cassette's keyboard. Source: M. Kutt's notes

Page two of the MCM/70 User's Guide introduces the keyboard layout.

THE KEY-CASSETTE CONCEPT

The company was aiming at a small, microprocessor-based desktop computer that would be affordable, as easy to use as a hand-held calculator, and functionally as powerful as a mainframe computer running APL. Nothing similar had ever been built before. At the time, in December 1971, the news of a CPU on a single chip was only about one month old. Furthermore, APL interpreters were not even available for minicomputers.

The size, price, and usability targets set by Kutt Systems for its microcomputer focused the attention of the company on the calculator market. "The world was full of calculators," recollects Kutt. "They made a real Big Bang." In his notes, Kutt entered, "Try and use existing calculator cover, display, modify power supply, and replace keyboard." Indeed, off-the-shelf calculator components could save the company money. For instance, to package the computer into a case that would match the design elegance of a calculator cover, the case would have to be manufactured using the injection molding technique. But that was expensive: a good quality mold with sharp corners would cost around $25,000.

Kutt's notes provide an early glimpse of the "computer of the future." His drawing, entitled Key-Cassette, is among the oldest preserved sketches of a microcomputer to be manufactured for the consumer market. The name "Key-Cassette" most likely derives from "Key-Edit," the name of the data entry system manufactured by Kutt's former company, Consolidated Computer Inc. The drawing depicts a case in the style of a typical desktop calculator of that time. The lower part of the front panel hosts a built-in keyboard and the top part depicts a single cassette drive on the right and either an acoustic coupler or the second cassette drive on the left. A small display and some switches are placed in the middle of the panel.

The annotated drawing provides enough information to grasp the basic operations of the Key-Cassette. The small 32-key keyboard of the Key-Cassette would allow the user to enter all the alphanumeric characters as well as the APL and special function symbols. To achieve such a degree of compactness, each key was designed to enter up to 5 symbols (using a combination of key strokes). The symbols on the keys would be color coded to distinguish between the symbols that can be entered directly (red symbols in the center of the keys) and those that could be entered via a combination of key strokes (black symbols placed in the corners of the keys).

The one-line display of the Key-Cassette would allow the user to view a single line of APL code, a computer output, or an error message. Using the rotate keys "→" and "←", the displayed information could be scrolled left and right to fully reveal its contents. Using the roll keys "↓" and "↑", one would scroll through the lines of APL code. The sketch of the Key-Cassette is augmented with two drawings of possible segmented display elements: one comprised of 13 display segments and the other of 15 segments. Finally, the tape cassette drives were to provide external storage.

The production model of the MCM/70 would be equipped with a more "user-friendly" APL keyboard (layout modeled after the keyboard of the IBM 2741 terminal), with a one-line plasma display and up to two digital cassette drives providing over 100KB of storage each. Only the sides of the case would be injection molded, while the rest of the case would be made of cheaper aluminum.

FROM THE KEY-CASSETTE TO THE M/C PROTOTYPE

Kutt's notes contain a detailed analysis of Intel's MCS-4 chip set, the 8008 processor, the SIM8-01 development system, and the MP7-02 programmer. Kutt looks at the technical specifications, pricing, and second sourcing for electronic components. He looks at Intel itself, its marketing activities.

In April of 1972, Kutt paid Intel a visit and learned from Bob Noyce and Hank Smith about the status of the 8008 chip, the availability of the SIM8-01 development board, and its supporting software. He inquired about the possibility of Intel manufacturing custom CPU boards for the MCM computer. In his notes, Kutt entered that standard 8008 prototyping boards, ones that could be used to prototype and test an MCS-8 based system without building his own board, would have a "tremendous impact."

A month later, Kutt received the SIM8-01 board from Intel and gave it to José Laraya for the evaluation and the estimation of its potential for growing an APL machine out of it. Laraya recalls: "Mers brought it [the SIM8-01] in and said, 'Here, see what it does.' It was really computing, it really did things, one little chip." The experimentation with the SIM8 board concentrated on interfacing with various devices (such as the teletype) and on the use of the MP7-02 programmer for the purpose of burning Ramer's APL interpreter into the EPROM chips.

But this early attempt at building a microcomputer, now called the M/C prototype in the notes, was a disappointment. Kutt wrote that the machine "is useless as is," and has to be "drawn up, rewired, and debugged." In the end, Laraya decided to abandon the SIM8 approach and, instead, was determined to build his own hardware from the ground up. He remembers thinking, "OK, this [SIM8-01] is fine, great, interesting, works with teletype...But now, let's build something serious.' ' Laraya adds, "Mers got the chips and on the basis of that I developed the rack version....It was very fast from the time we had the [SIM8-01] development board."

Laraya modularized the design of the M/C prototype. One card included the 8008-based CPU as well as the display and the keyboard interfaces. Another card contained memory. There was a specially designed APL keyboard, with the soft character generator, and a small plasma display (Burroughs Self-Scan 32-character display). The production model would have one more board with the cassette controller and the Omniport interface on it (to connect a variety of peripherals via the Omniport connector at the back of the machine).

The rack prototype of the microcomputer was good enough for Ramer and Genner to start porting their APL interpreter into it. On November 11, 1972, the prototype was demonstrated to shareholders during the Special General Meeting of the Shareholders of Kutt Systems in Kingston, Ontario. During that meeting a motion was passed to change the name of the company to Micro Computer Machines.

THE MCM/APL

In the early 1970s, APL was only available on mainframe computers. The development of an APL interpreter and the memory management system for an 8008-platform characterized by low speed, restricted instruction set, and small memory addressing space was the most challenging aspect of the personal computer project at MCM.

Photograph by Z. Stachniak

Morgan Smyth (left), Don Genner, and Gord Ramer (right) at York University, Toronto, October 2001

The team that developed the interpreter had worked together before. In late 1960s, Gord Ramer designed a dialect of the APL/360 language that he named York APL. He implemented the language with the assistance of Don Genner while both Ramer and Genner held positions in the Computing Center at York University. J. Morgan Smyth was among the first users of the York APL and he was frequently commuting between his work place—Ryerson Polytechnic Institute in Toronto—and York University to discuss the implementation issues of York APL with Ramer and Genner. At MCM, the trio would develop one of the first high-level language interpreters for a microprocessor: Ramer would design the language, Genner would implement it, and Smyth would document it in an excellent *MCM/70 User's Guide* published by MCM in 1974.

The work on the interpreter started in early 1972 even before MCM built any hardware that could be used by the software engineering group. Having only the specifications of the 8008 chip, Ramer and Genner used the IBM System/360 assembler to emulate the 8008. "The 360 assembler was written in such a way that you could use macros to generate code for any hardware," says Ramer. "Thus [we] generated macros for each 8008 instruction and *voila*!" A similar emulator, the INTERP/8 (written in Fortran IV), was later available from Intel. It provided a software emulation of the 8008 chip along with some execution monitoring commands.

When the rack prototype of the microcomputer was finally working at MCM's manufacturing facility in Kingston, the development of the APL interpreter could be done directly on the 8008-based hardware and the interpreter's code could be burned into EPROMs using the Intel MP7-02 programmer. Programming "was really slow," says Laraya, "and you had to program it by hand using switches....We had to put the code and set the switches and the addresses and hit 'program' [the EPROM]. Every time we programmed, Don [Genner] used to smoke one cigarette and say, 'That's how long it takes to program a chip.' He smoked one cigarette, and when he finished, [the chip] was programmed."

In his notes, Kutt sketches the directions for the development of the APL interpreter for the microcomputer. First, the basic, stripped-down version of APL/360 would be implemented. The description of an APL fragment that comprises single dimension vectors, some defined and some system functions, spans two pages in the notes. Then the interpreter would be extended in two directions to support the scientific and business utilization of APL. "When we came up with the APL [interpreter] for our PC," says Kutt, "our prime target was to make it simple to use...so [the user] wouldn't have to become embroiled in the little nitty-gritty things you have to look after in APL."

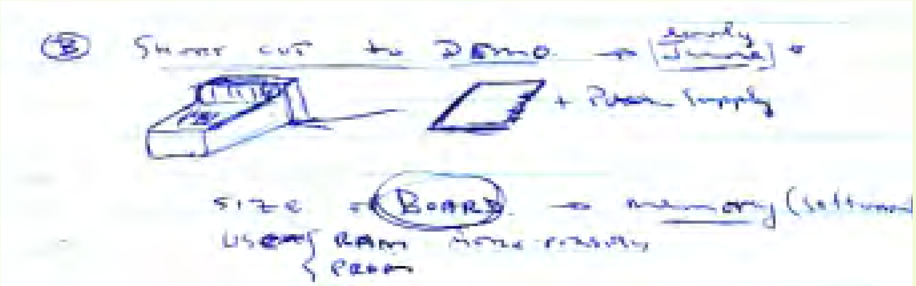
> *Programming "was really slow and....every time we programmed, Don [Genner] used to smoke one cigarette and say, 'That's how long it takes to program a chip.' He smoked one cigarette, and when he finished, [the chip] was programmed."*
>
> *—José Laraya, MCM Engineer*

The full description of the MCM/APL interpreter for the MCM/70 computer appeared in the *MCM/70 User's Guide*.

SELLING THE FUTURE

The notes disclose some urgency to prepare a viable demonstration of the M/C computer. Early demonstrations were vital to attract venture capital and finance the operations of the young company. Kutt sketches a "short-cut to demo" in his notes and estimates its completion at the early June of 1972.

The M/C demonstrator was to consist of a single CPU and memory board and a power supply packed into a desktop calculator-like case that featured a built-in keyboard and a small display. It was to be basic hardware with just enough



The Short-cut to demo drawing. Source: M. Kutt's notes

software stored in ROM to demonstrate the way the 8008 could handle a subset of APL. It is unclear whether such a machine was ever constructed. However, a more refined portable prototype of the MCM/70 was built and shown during the Fifth International APL Users' Conference in Toronto, in May of 1973. "I remember we had the fiberglass model there," says Laraya. "It was heating up." Ramer, too, remembers the event vividly: "The demo had to be interspersed with short talks to allow José [Laraya] to exchange the heat-sensitive parts and then restart the system for the next segment of the demo."

With limited RAM and no external storage, that prototype was nothing but an advanced APL-based scientific calculator. However rudimentary, it did attract attention of the APL community and made it evident that in the near future high-level programming languages, such as APL, would be readily available on small desk-top machines. Other prototypes of the MCM/70, including one mounted in an attaché case and powered by batteries, were showcased throughout Europe and North America in the second half of 1973, attracting the attention of daily and technical press.

One of the most successful demonstrators that the company put together had, in fact, no hardware at all. "We had a cardboard mockup of the computer," says Smyth. "It...was a small, slick little box...it was just cardboard. And we went around to a law firm in downtown Toronto and met with the bunch of senior lawyers there....Mers was gonna try to get some venture capital....These guys were quite old and, at one point [during Kutt's presentation], actually the secretary came in with a can of candies....to perk 'em up. And I thought, 'man, we are wasting our time here.'"

Smyth continues, "And near the tail of our presentation, which went on for over two hours, ...one of these guys said, 'Now, just a minute. This contradicts what you said at the very beginning.' I'm thinking, 'What?' They were paying attention and I was very impressed... We walked out of there with half a million dollars....It was...just cardboard....He [Kutt] is waving this around: 'This is what it's going to look like!' You are talking about selling the future!"

GOOD LUCK, AND WELCOME TO THE COMPUTER AGE!

The production model of the MCM/70 shared many technical features with the Key-Cassette and the M/C concepts. From its prototypes, the MCM/70 inherited a desktop design with built-in APL keyboard, a one-line plasma display, and cassette drives mounted on the front panel. The computer was powered by the Intel 8008 microprocessor and its ROM chips contained the MCM/APL interpreter.

But other features, not discussed in Kutt's notes, also make the MCM/70 a truly unique piece of microcomputer engineering. The MCM/70's 14KB of ROM contained not only the MCM/APL interpreter but also the cassette and virtual memory operating systems (called EASY and AVS, respectively). AVS, designed by André Arpin, used one of the cassette drives to provide virtual memory by swapping programs and data between the cassette and RAM. With virtual memory, the MCM/70 offered an excess of 100KB of memory. A power failure protection system built into the power supply of the computer allowed continuous operation by battery in the event of power failure. For extended power loss, the computer initiated an orderly shutdown: it automatically provided system back-up by copying the content of RAM to a cassette before shutdown. The system was automatically reinstated when power was restored and batteries were recharged.

Kutt made some market analysis notes looking primarily at the IBM System/360 users who might benefit from a smaller and much less expensive system. He calculated APL university prospects at around 15 in Canada and 75 in the U.S. And indeed, following the announcement of the MCM/70, many academics expressed interest in the MCM hardware: "APL is currently used in all of our introductory courses so that

Photograph by Z. Stachniak

The MCM/70. Courtesy of Harley Courtney

"The complexity of the large computer machines and the complexity of the special computer languages...has till now prevented the general public from using computers directly themselves. But the simplicity of the MCM/70 and its associated computer language...make personal computer use and ownership a reality....Enjoy the privilege of having your own personal computer."

—The MCM/70 Introductory Manual, 1973

the potential for systems like yours at Yale is very high," wrote Martin H. Schultz, Professor of Computer Science at Yale University, to MCM in November 1973. By 1976, an estimated 27.5% of the MCM systems sold in North America went to educational institutions.

The notes, however, do not make any reference to "personal computing" nor to possible marketing strategies aimed at promoting the personal utilization of MCM's microcomputers. This is hardly a surprise as the notes were made in the very early stages of the development of the MCM/70. That situation would change with the publication of the first promotional documents by MCM in 1973. "It has been a combination of the complexity of the large computer machines and the complexity of the special computer languages," reads the *MCM/70 Introductory Manual* published by MCM in 1973, "that has till now prevented the general public from using computers directly themselves. But the simplicity of the MCM/70 and its associated computer language (known as APL) make personal computer use and ownership a reality....Enjoy the privilege of having your own personal computer—It's a privilege no computer user has ever had before the MCM/70....Good luck, and welcome to the computer age!"

It is difficult to explain unequivocally why the MCM/70 was not the commercial breakthrough to launch the personal computing industry. It is also difficult to estimate the number of MCM/70 computers sold worldwide or the scope of impact it had on the APL community and on the rise of personal computing. Even so, it was MCM's historical role to show that with the advent of microprocessor technology, affordable personal computing was at our fingertips. It was not too far fetched to imagine that, "in the coming years the computer field is going to be made of millions of small computers and a limited number of large computers" (Mers Kutt, Boston, September 28, 1973). ■

Zbigniew Stachniak is an associate professor of computer science at York University in Toronto, Canada. His research concentrates on formal methods in artificial intelligence (automated reasoning, knowledge representation), on symbolic logic in computer science, history of computing, and history of logic.

The author extends his gratitude to the National Science and Engineering Research Council of Canada for supporting his research on MCM.

FURTHER READING

Chevreau, J. "The Third Coming of Mers Kutt." *Report on Business Magazine*, November 1985, pp. 110-115.

Stachniak, Z. "The Making of the MCM/70 Microcomputer." *IEEE Annals of the History of Computing*, May/June, 2003.

The MCM Collection at York University Computer Museum: http://www.cs.yorku.ca/~zbigniew/MCM_col.html

RECENT ADDITIONS

TO THE COMPUTER HISTORY MUSEUM COLLECTION

Two (2) Core Memory Plane Assemblies (1973), X2523.2003, gift of Richard Walters

Two (2) microchip portfolio sets (1976 – 1989), X2497.2003, gift of Hewlett-Packard Company

Three (3) publications relating to early computers (c. 1950-1955), X2529.2003, gift of Gordon Uber

Four (4) original photographs of Steve Wozniak and Steve Jobs (1976), X2554.2003, gift of Joe Melena

Amdahl 470/V6 MCC (Multi Chip Carrier) (c. 1985), X2576.2003, gift of Mr Naoya Ukai

Ampro Computers, Inc., Series 100 "Bookshelf" CP/M Computer, operating software, and documentation, (c. 1982), X2535.2003, gift of Steve Brugler

Anderson Jacobson Model ADC 260 Acoustic Coupler (c. 1975), X2523.2003, gift of Richard Walters

Anderson Jacobson Model ADC 300 Acoustic Coupler (c. 1975), X2523.2003, gift of Richard Walters

Apollo Computer, Inc., "Network Outlet" connection (1983), X2573.2003, gift of Jonathan Gross

Apple Macintosh (1984), X2523.2003, gift of Richard Walters

Apple Macintosh Laptop with Duo Dock (c. 1994), X2523.2003, gift of Richard Walters

Bell Laboratories Picturephone (1964), X2560.2003, gift of Les Earnest

"The Binary Slide Rule" (c. 1940), X2551.2003, gift of Wolfgang Schaechter

Bowmar Instrument Company, MX55 Personal Calculator ("Bowmar Brain") (1970), X2510.2003, gift of Michael Percy

Bowmar Model 901B Calculator (c. 1973), X2577.2003, gift of Mary M Mourkas

Burroughs Adding Machines (two) (c. 1935 and c. 1945), X2525.2003, gift of Chuck Kaekel

Burroughs B1900 Mainframe Computer System (including peripherals) (c. 1985), X2550.2003, gift of the Pennyroyal Center

Canon Cat V777 Work Processor, associated software and documentation (1987), X2538.2003, gift of Paul Cubbage

Canon Cat180 Daisy Wheel Printer with Canon Cat40 Cut Sheet Feeder Option (c. 1987), X2538.2003, gift of Paul Cubbage

Check Point Software Technologies, Inc., FireWall-1 Ver. 2.0 Media Pack (1994), X2513.2003, gift of Check Point Software Technologies, Inc.

Check Point Software Technologies, Inc., SofaWare S-box Internet Security Appliance (2002), X2513.2003, gift of Check Point Software Technologies, Inc.

Check Point Software Technologies, Inc., VPN-1 & FireWall-1 Media Pack (2002), X2513.2003, gift of Check Point Software Technologies, Inc.

Collection of early IBM ephemera, software, and documentation (c. 1950-1970), X2517.2003, gift of Bob Brubaker

Collection of Apple Developer Group CD Series compact discs (c. 1988-1993), X2531.2003, gift of Lars Borresen

Collection of Apple marketing materials on compact disc (1990-1993), X2546.2003, gift of Terry L Kristensen

Collection of artifacts, documents and media related to the WEIZAC and GOLEM computers (various dates), X2556.2003, gift of Gerald Estrin

Collection of computer industry business cards (1982-2003), X2561.2003, gift of Tom Halfhill

Collection of Cray software documentation (various dates), X2514.2003, gift of Warren Yogi

Collection of Digital Equipment Corporation ephemera (various dates), X2524.2003, gift of Judith Burgess

Collection of documents, photographs and slides related to the history of super computing, mass storage systems and networking at the National Center for Atmospheric Research (c. 1979-2000), X2548.2003, gift of Basil L Irwin

Collection of early timesharing manuals by Tymshare, Inc., (1974-1984), X2547.2003, gift of Joe Smith

Collection of early Xerox Corporation computer manuals, newsletters and reports (various dates), X2542.2003, gift of Mike Rutenberg

Collection of ephemera related to the development of computer memory (various dates), X2537.2003, gift of William F Jordan

Collection of ephemera, documents and slides related to the history of microelectronics (various dates), X2549.2003, gift of Olive Thompson

Collection of fourteen (14) advertisements for Honeywell computers (c. 1965), X2539.2003, gift of Mark Barnett

Collection of IBM ephemera, documents and media (c. 1955-1967), X2558.2003, gift of Neil Lewis

Collection of machine and program manuals and brochures (c. 1950-1969), X2564.2003, gift of Chuck Baker

Collection of photographs and ephemera related to the IBM Model 1360 "Cypress" Photo-Digital Storage Systems (c. 1967), X2509.2003, gift of Jack Harker

Collection of photographs of the UNIVAC Incremental Computer (1956), X2529.2003, gift of Gordon Uber

Collection of reference manuals, flowcharting template, pocket guides, and programmer reference cards (1964-1985), X2553.2003, gift of Ken North

Collection of selected materials from the Tandem Archival Collection (various dates), X2528.2003, gift of Hewlett-Packard Company

Collection of seven (7) boxes of assorted software and related documentation (1980-1990), X2502.2003, gift of Arel Lucas

Collection of software and documentation related to personal computing (c. 1980-1995), X2557.2003, gift of George Glaser

Collection of the first one hundred Sun Microsystems Laboratories technical reports (1991-2002), X2544.2003, gift of Sun Microsystems, Inc.

Collection of UNIVAC materials (various dates), X2562.2003, gift of Carol Canzano-Zito

Collection of various materials relating to the industrial design of the Xerox Alto (1973), X2536.2002, gift of Terry West

Commodore "SuperPET" SP9000 personal computers (two), dual disk drive, hard drive, software and documentation (c. 1981), X2494.2003, gift of Vladimir Steffel

"Computer Music from the University of Illinois" record album (c. 1963), X2552.2003, gift of Richard Ellis

Computers (Boy Scouts of America Merit Badge Series) (1968), X2493.2003, gift of Dag Spicer

Computran Model AN 7 Computer Trainer (c. 1965), X2514.2003, gift of Warren Yogi

Control Data Corporation Removable Disk Pack (c. 1970), X2523.2003, gift of Richard Walters

Core Memory Plane Assembly (1960), X2523.2003, gift of Richard Walters

"CRAM-80" homebrew computer (c. 1975), X2566.2003, gift of Steven E Young

DEC software and manual collection (various dates), X2571.2003, gift of Kenneth L Voss

Designing with FPGAs & CPLDs (2002) and *Verilog Designer's Library* (1999), X2506.2003, gift of Bob Zeidman

Digital Equipment Corporation "Computer Lab" Digital Logic Trainer (c. 1962), X2518.2003, gift of Rob Keeney

DOS 3.30 for the Dynabyte 5200 Computer Unit (1982), X2535.2003, gift of Steve Brugler

Dynabyte Business Computers, Technical Manual for the Dynabyte 5200 Computer Unit (c.1982), X2535.2003, gift of Steve Brugler

DYSEAC components and documents (1954), X2489.2003, gift of David E Hartsig

E & L Instruments Mini-Micro Designer (MMD) 1 8080 trainer board (c. 1976), X2534.2003, gift of Phil Keller

Electronics Australia EDUC-8 microcomputer (1975), X2520.2003, gift of John Whitehouse

Franklin ACE 1000 with documentation and software (c. 1983), X2523.2003, gift of Richard Walters

Friden Flexowriter (c. 1961), X2515.2003, gift of Richard Leamer

Fujitsu Stylistic ST4100 (2003), X2575.2003, gift of Mr Toshio Morohoshi

Gavilan Mobile Computer, software, and documentation (1984), X2505.2003, gift of Angelina M Jimenez

Gear and arm from Science Museum, London, Babbage Engine construction (2003), X2563.2003, gift Dr Thomas Bergin

RECENT ADDITIONS, CONT'D

Handspring, Inc., Treo 180 Communicator (2002), X2503.2003, gift of Donna Dubinsky

Hewlett-Packard HP-85 Personal Computer (c. 1983), X2523.2003, gift of Richard Walters

Hewlett-Packard HP-97 Programmable Calculator (c. 1979), X2523.2003, gift of Richard Walters

Hewlett-Packard Model 200C Oscillator (c. 1940), X2526.2003, gift of George Durfey

Hewlett-Packard Model 200C Oscillator (c. 1940), X2565.2003, gift of SRI International

Hewlett-Packard production prototype DDS-1 tape drive and data cartridge (c. 1987), X2512.2003, gift of Dominic McCarthy

IBM "Reflexione" ("THINK") Sign (c. 1970), X2545.2003, gift of Tom Reif

IBM 360/30 CCROS card (c. 1965), X2578.2004, gift of Brian Knittel

IBM 5110 minicomputer system, with original CPU, monitor, disk drive, tape unit, printer, documentation, and software library (c. 1978), X2511.2003, gift of Jan Engel

IBM 700-series pluggable unit (1952), X2491.2003, gift of Gwen Bell

IBM AN/FSQ-7 (SAGE) Theory of Programming Manual (1957), X2527.2003, gift of Robert F Martina

IBM core plane (c. 1960), X2499.2003, gift of Art Siegel

IBM Hard Drive Assembly (c. 1970), X2523.2003, gift of Richard Walters

IBM Hexadecimal Adder (1957), X2545.2003, gift of Tom Reif

IBM *Manual of Instruction Customer Engineering* (1946), X2568.2003, gift of Warren Yogi

IBM Model 10 Card Punch (c. 1940), X2523.2003, gift of Richard Walters

IBM Model 5151 Personal Computer Display (c. 1981), X2523.2003, gift of Richard Walters

IBM Time Clock (c. 1913), X2569.2003, gift of Len Shustek

IMSAI 8080 Microcomputers with documentation libraries (two) (c. 1976), X2523.2003, gift of Richard Walters

IMSAI Dual 8" Floppy Disk Drive (c. 1976), X2523.2003, gift of Richard Walters

International Correspondence Schools Computer Code Translator Slide-Chart (1983), X2519.2003, gift of Bill Kochanczyk

Kaypro 2000 Personal Computer and Docking Port (c. 1987), X2523.2003, gift of Richard Walters

Keuffel & Esser Company, Beginner Slide Rule (c. 1954), X2553.2003, gift of Ken North

Let ERMA Do It (1956), X2507.2003, gift of George Durfey

Livermore Data Systems Model B Acoustic Coupler (c. 1965), X2523.2003, gift of Richard Walters

M & R Enterprises Pennywhistle 103 modem, X2559.2003, gift of Bill Hill

Mechanical Analog Computer (c. 1965), X2523.2003, gift of Richard Walters

Monroe Epic 2000 Electronic Printing Calculator (c. 1955), X2530.2003, gift of Dorothy Burkhart

Netronics Research and Development, Ltd., COSMAC ELF microcomputer (1976), X2532.2003, gift of Bill Buzbee

Okimate 10 Personal Color Printer (c. 1984), X2523.2003, gift of Richard Walters

Olympia magnetic dictation machine (c. 1970), X2521.2003, gift of Bob Fernetich

Original Homebrew Computer Club T-shirt (c. 1986), X2579.2004, gift of Carrie Karnos

"The Orm" robotic arm (1965), X2574.2003, gift of Stanford University

Packard Bell PB 250 minicomputer and collection of associated software and documentation (1961), X2515.2003, gift of Richard Leamer

PCD Maltron Ergonomic Keyboard (c. 1990), X2523.2003, gift of Richard Walters

Philips Nino 300 Personal Data Assistant (c. 1998) and Nino T-Shirt, X2555.2003, gift of Kevin Turner

Processor Technology Corporation SOL Terminal Computers (two) (c. 1978), X2523.2003, gift of Richard Walters

Programming Systems & Languages (1967), *A SNOBOL4 Primer* (1973), and *Computers and Society* (1972), X2567.2003, gift of Jim Gross

Punch card carrying case (c. 1960), X2504.2003, gift of Herman Griffin

Quantum Computer Services, Inc., America Online Ver. 1.0 (1989), X2508.2003, gift of Adam Gross

Radio Shack (TRS-80) 64K Color Computer 2 (c. 1985), X2523.2003, gift of Richard Walters

Radio Shack (TRS-80) Model 4 Micro Computer (c. 1985), X2523.2003, gift of Richard Walters

"Rancho Arm" robotic arm (1963), X2574.2003, gift of Stanford University

Remington Rand Corporation magnetic tape (c. 1966), X2573.2003, gift of Jonathan Gross

Rockwell International R6500 Advanced Interactive Microcomputer (c. 1979), X2522.2003, gift of Bob Bynum

Russian "Microcalculator Electronica B3-36" calculator (1983), X2514.2003, gift of Warren Yogi

Russian "Olimpik-C" personal computer (c. 1993), X2514.2003, gift of Warren Yogi

Russian abacus (*stchoty*) (c. 1963), X2514.2003, gift of Warren Yogi

Sama & Etami, Inc., "The Concise Conversion Tables and Circular Slide Rule" (c. 1960), X2551.2003, gift of Wolfgang Schaechter

Seagate ST-225 hard disk drive (1984), X2572.2003, gift of Henry Plummer and Robert Lewis

Sharp Corporation Model OZ-7000 "Wizard" Electronic Organizer and Interface Software (date unknown), X2543.2003, gift of Eugene Miya

Signed promotional poster: "Intel Delivers Solutions" (c. 1982), X2533.2003, gift of Stephen Casner

Silicon wafer collection (c. 1965-1995), X2495.2003, gift of Mark Noreng

Smithsonian Institution Annual Report 1874, X2563.2003, gift of Dr Thomas Bergin

Tadpole Technology SPARC-book 2 (1993), X2500.2003, gift of Bill McKie

Tandy 1400 FD Personal Computer with associated cables, manuals and software (c. 1989), X2540.2003, gift of Mark Gilkey

Tandy Acoustic Coupler 2 (c. 1989), X2540.2003, gift of Mark Gilkey

Tandy Corporation TRS-80 III (1981), X2501.2003, gift of Bob Zeidman

Tandy Radio Shack Model 200 Portable Computer (1985), X2523.2003, gift of Richard Walters

Technical Design Labs Xitan microcomputer (c. 1977), X2516.2003, gift of Cappy Jack

TeleSensory Systems, Inc., Speech+ Calculator (English language model) (1975), X2535.2003, gift of Steve Brugler

TeleSensory Systems, Inc., Speech+ Calculator (German language model) (1976), X2535.2003, gift of Steve Brugler

Unisys historic videotape collection (various dates), X2492.2003, gift of Unisys Corporation

UNIVAC Products Handbook (copy) (1959), X2570.2003, gift of Unisys Corporation

Vacuum Tube Flip Flop Module (c. 1975), X2523.2003, gift of

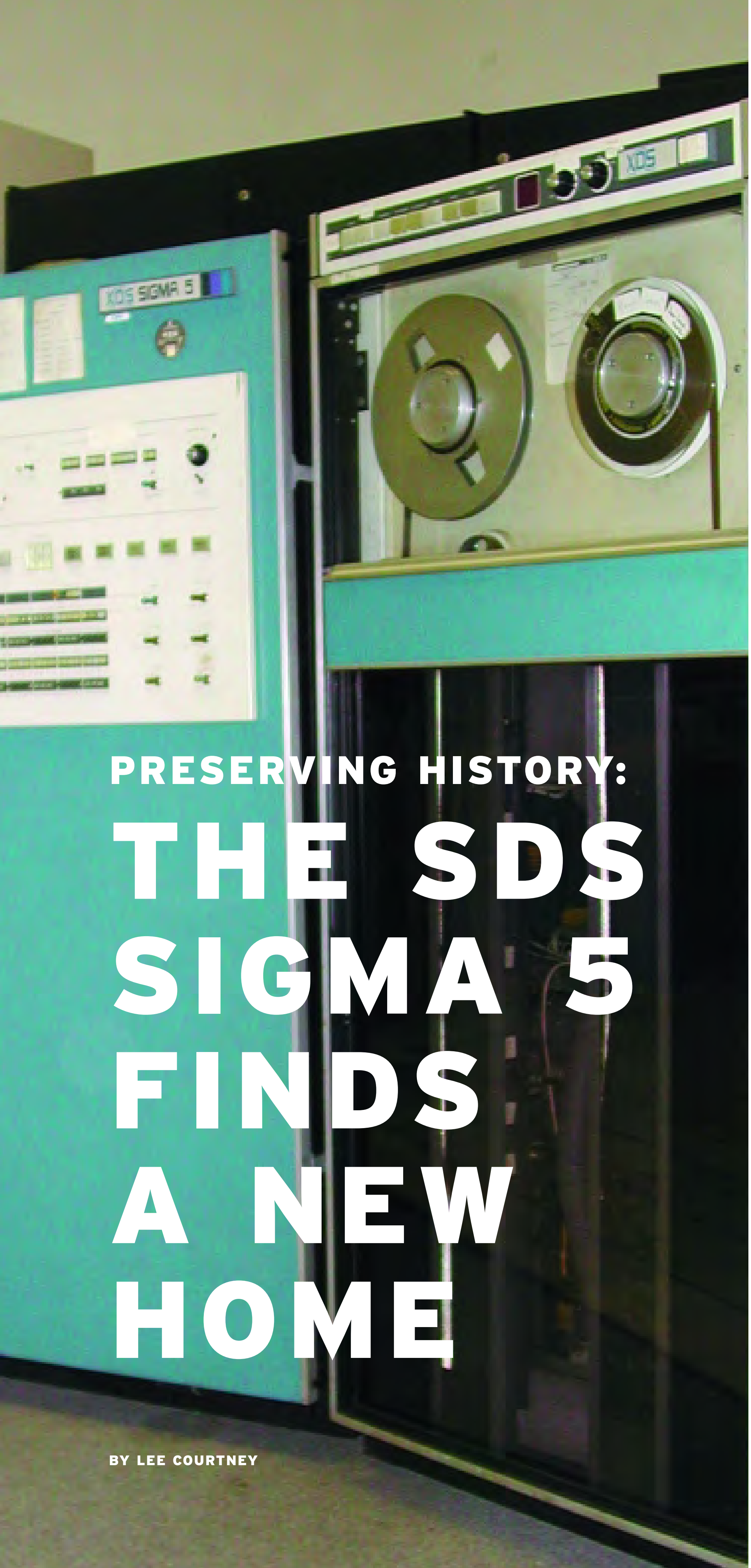
VISICALC 1.0 software (1982), X2490.2003, gift of Mary Cooper

Wozniak "Blue Box" (c. 1972), X2541.2003, gift of Allen Baum

Wyse Technology, Inc., Series 7000i Model 760 MP computer (c. 1994), X2498.2003, gift of Barbara Gasman

Xerox 860 information processing system (1980), X2496.2003, gift of Ken Lehmann

(Dates represent dates of introduction and not necessarily dates of manufacture.)



PRESERVING HISTORY:

THE SDS SIGMA 5 FINDS A NEW HOME

BY LEE COURTNEY

CPU and tape drive cabinets

One never knows where one will find hidden treasure. In this case, a photo posted on Usenet contained a serendipitous glimpse of hidden treasure, and this is the story of how an operational 35-year-old mainframe computer system was discovered, donated, and moved to the Computer History Museum.

FINDING A PIECE OF MAINFRAME HISTORY

In August 2000, while perusing the PDP-8 newsgroup, I ran across a query about an old computer (see www.computerhistory.org/projects/pdp8_restoration/). Pittsburgh graduate student Raymond Jensen was asking for information on an old system—the PDP-8 made by the now-defunct Digital Equipment Corporation—he had discovered in a basement laboratory along with several other large unknown computers. He subsequently provided a Web page with photos of the equipment, which indeed depicted a PDP-8 minicomputer. However, one picture also showed a portion of a large tape drive, which I immediately recognized as a Scientific Data Systems (SDS) reel-to-reel tape drive like the one I had used on an SDS Sigma 7 mainframe computer in the early 1970s. Was it possible that a Sigma-series mainframe was attached to that tape drive? By chance had I stumbled across what was perhaps a 1960s-era mainframe still persisting "in the wild?"

I immediately contacted Jensen and told him the machine just outside the picture could be an older SDS mainframe, and might be of interest to the Computer History Museum. A few days later I received an email from him indicating that it was indeed a Sigma 5 mainframe and that it was located at Carnegie-Mellon University (CMU) in the chemistry department's NMR (Nuclear Magnetic Resonance) Facility for Biomedical Studies. Jensen knew nothing more about the system, its origin, or even its manufacturer, except that it was really big and was comprised of several cabinets. He provided the CMU email addresses of Dr. Aksel Bothner-By and Dr. Joseph Dadok, both of whom were retired from the chemistry department.

Lee Courney inventories the Sigma 5 shipment after arrival at the Museum.

Console teletype. Through the mid-1970s, most mainframe computer systems used hardcopy terminal as consoles to aid in resource accounting, operator tasks, and general system debugging. The Sigma 5 was unusual in that it employed a TTY utilizing EBCDIC rather than the more common ASCII character encoding.

My immediate thought was that this would make an excellent addition to the collection at the Computer History Museum. I wrote both Bothner-By and Dadok, along with the current Chemistry Department Chairman Richard McCullough, asking for more information on the Sigma 5, its current status, and their interest in donating the system to the Computer History Museum.

Bothner-By and Dadok relayed that the system was indeed an SDS Sigma 5 mainframe first installed at CMU around 1968 and was still operational although no longer used. And the chemistry department was interested in seeing the system preserved at the Computer History Museum. Since the system was still operational, it would be important to make sure it arrived at the Museum in the same condition. This would require careful de-installation, documentation, and packing of the system. Unfortunately, CMU would not be able to provide resources to perform these tasks.

DONATION RECONNAISSANCE AND AGREEMENT

It turned out I was taking a business trip to the east coast in November 2001 and was able to make a side trip to meet with both Dadok and Bothner-By. The purpose of the trip was to examine the system in person, determine a rough inventory of what items would be part of the donation, assess the scope of the necessary shipping preparation, and learn more about the machine's history and possibilities it might have for future use.

I anxiously arrived at CMU and met Bothner-By in his office at the Mellon Institute. The Sigma 5 resided in a sub-basement laboratory in part of the building that has not been renovated since original construction in the 1940s.

We went downstairs through the basement to the sub-basement, with pipes overhead and long corridors stretching into the distance. We passed many offices and labs as we descended deeper and deeper into the building. I felt like I was walking into an episode of the X-Files. Bothner-By explained that the Sigma 5 resided in a part of the building that had housed a small-scale prototype chemical plant during World War II. At the end of one long corridor, we reached the NMR Lab with the magnet and control rooms on the right side of the hallway and a computer room with the Sigma 5 on the left. Dadok, who had emigrated from Czechoslovakia in 1968, soon joined us after an event honoring a visit by the new president of that country.

Entering the Sigma 5 computer room was a step back in time to the days when mammoth computers were isolated in large rooms with raised floors for snaking cables between cabinets and for hiding large power conduits, while air-conditioning units constantly blew cold air to cool the systems. The Sigma 5 sat in the center of the room, as it had for the last 33 years. At opposite ends of the computer room were a 1960s-era PDP-8 system, a 1970s-era Harris minicomputer, and a late-1980s VAX. Racks holding 1/2-inch magnetic tapes used with the Sigma 5 stood along one wall. Various storage cabinets and bookshelves with printouts and systems' documentation covered the other walls. We had to talk loudly over the low rumble of a large air-conditioning unit.

The atmosphere took me vividly back to the early 1970s when I used an SDS Sigma 7 in high school and later worked as the console operator for my university's IBM mainframe. That one moment standing in the computer room with the Sigma 5 made the trip worthwhile.

We talked briefly about the current state of the Sigma 5. One important task I wanted to accomplish on that visit was to capture Bothner-By and Dadok's experiences with the system and stories of its use. I videotaped Bothner-By discussing the work done in his lab and Dadok discussing his careful maintenance of the machine and associated instrumentation during all the years of use. We spent several hours videotaping the machine in operation, with Dadok powering on the system and going through the different components, how the machine operated, and quirks of the Sigma 5. Unfortunately, a hardware error prevented us from booting up the system.

In addition to videotaping the Sigma 5, we also discussed the instrumentation attached to the Sigma 5 and its function and contributions to science over the years. The attached equipment included the original NMR spectrometer, more recent NMR instrumentation, and a custom-built system for controlling the instrument that interfaced to the Sigma 5. The control system was composed of two 19-inch racks containing various consoles and

The card reader, the primary input device for programming the Sigma 5

Button detail

electronic equipment including an SDS A-D (Analog-to-Digital) converter, which converted signals from the instrument and sensors to digital form that could then be stored and processed by the Sigma 5.

Bothner-By and Dadok provided a wealth of information on how the Sigma 5 was used at CMU. Originally the Sigma 5 was purchased by the NIH (National Institute of Health) and installed at the University of Indiana. After a year it became available and Bothner-By wrote a proposal for its installation in his lab at CMU. In 1968 the system was moved to CMU and installed as part of the NIH-sponsored National NMR Facility for Biomedical Studies in the chemistry department. This facility provided access to an extremely powerful nuclear magnetic resonance spectrometer that allowed biologists, biochemists, and other scientists to analyze the chemical makeup and structure of organic compounds.

When introduced, the Sigma 5 was marketed as a real-time and process-control system, as well as a small mainframe for business or scientific computing. True to its real-time nature, the Sigma 5 was the primary control, data collection, and analysis tool used for the spectrometer. Since the Lab was a national facility sponsored by the NIH, users came from all over the United States as well as other countries. For many years, the magnet used in the NMR spectrometer controlled by the Sigma 5 was one of the most powerful of its type.

When a sample was being analyzed, the Sigma 5 was connected to various sensors that collected data that was recorded on a reel-to-reel magnetic tape or a high-speed fixed-head single-platter disc called a RAD. Once collected, the Sigma 5 could reduce, analyze, or display the data. Originally the system was outfitted with a plotter and could produce graphical representations of data. A FORTRAN compiler was also available for creation of programs to perform analysis. However, many scientists using the instrument wrote their data to magnetic tape for later analysis at their home institution.

An artifact of 1960s computing that benefited the lab was that complete hardware documentation and system software source code were provided with the Sigma 5. In addition to I/O designed to facilitate "custom" hardware and interfaces, the complete documentation allowed Dadok to design and interface scientific instruments unanticipated by the original designers and to apply the system to new problems.

Today we would refer to these attributes as open standards, design, and source. By studying the Sigma 5 and its contemporaries, we can see that the concept of "open source" was already a well-established practice even by the time the Sigma 5 came into being in the mid-1960s.

After capturing about four hours of video of the system along with Bothner-By and Dadok describing the lab, instruments, Sigma 5 system, and how all were used in the scientific community, it was time to head to the airport. I had taken this trip to learn what I could about the system in order to prepare a proposal to the Museum for acquiring it. It was apparent that this could be a significant addition to the Museum's collection and could help to document computing history, especially 1960s-era mainframe technology.

APPROVING THE DONATION

Once back in California, it was time to work on the Museum end of things. Each week the Museum receives multiple inquiries about potential donations. Unfortunately, it cannot automatically accept all of them. Currently, the collection occupies over 35,000-square-feet of horizontal storage space, so obvious practical constraints affect the acceptance of new items. Because the Museum must carefully consider the historical value of an artifact before accepting it, a Collections Committee—a group of staff and volunteers chaired by Museum Trustee John Mashey—meets regularly to consider, accept, and decline donations.

Using collective experience as well as formal evaluative criteria, the Collections Committee looks for donations that are relevant to the mission of the Museum—to preserve and present for posterity the artifacts and stories of the information age—and that add to our understanding of computing history.

These items generally fall into one of five categories: hardware, software, documentation and printed matter, films/video/photos, and ephemera. Items currently in the collection range from individual hardware components such as vacuum tubes from early computers to software such as Bill

The cables were hard-wired into the cabinets and had circuit boards attached at various points.

The weave of cables from cabinet to cabinet to power source were like a Gordian knot—almost impossible to untangle without a sword.

Gates and Paul Allen's original BASIC paper tape, to complete mainframe/supercomputer systems such as the Cray-1, and include films and videos of important lectures given by pioneers in the field of computing.

In preparing a proposal for the Collections Committee, I considered how the Sigma 5 would contribute to the collection, its value in establishing an historical record for its era, and how it could provide insight into the evolution of computing. The donation met the Museum's desire to collect items greater than 10 years old, having been installed at CMU in 1968. In addition, I considered the role SDS played as a company in the mid-1960s, the Museum's need for a representative sample of 1960s-era mainframe computing technology, and how a well-documented and operational mid-1960s mainframe would contribute to the understanding of computing. While the SDS Sigma series was not the most prevalent system of its time, it was an excellent touchstone and example of 1960s computing.

This donation would provide the Museum with a rare and very desirable opportunity: to approach an artifact acquisition from a systems perspective. Often items, especially larger ones such as the Sigma 5, arrive at the Museum in partial condition, lacking essential peripherals, software, and/or documentation, or they are too fragile or damaged to be handled or used. Collecting a piece of a system such as part of a CPU or even a set of individual components does not allow the entire system to be studied, understood, or experienced. In this instance, CMU was offering to donate all hardware, spare parts, software, and documentation for a system that was in running condition.[1] The Sigma 5 could perfectly meet the Museum's desire to collect and preserve artifacts that would provide an accurate and complete picture of computing technology.

I proposed to the Collections Committee that we accept the donation of the Sigma 5 and all related pieces that would provide a complete picture of the Sigma 5 system and 1960s mainframe computing, including items such as the metal file cabinet used to store punched cards. The committee saw the Sigma 5 as a valuable addition to the collection and agreed that we should accept the system as a whole. Now all that was left was to arrange de-installation of the system and shipment to the Museum in California.

TRANSPORTATION AND LOGISTICS

Initial conversations with Bothner-By and Dadok indicated there was no rush to move the system. CMU would wait until adequate space became available at the Museum. I began researching the logistics of actually getting the donation to California.

Then one day I received an urgent email from Bothner-By: the system must be moved as soon as possible. The machine room housing the Sigma 5 had been transferred from the chemistry to a different department and was scheduled to be demolished and remodeled. The Sigma 5, along with all other contents of the NMR Lab, needed to be removed immediately!

This put the transportation planning process into hyper-drive. Two significant challenges had to be faced: transportation costs and preparing the system for pickup. Based on our history of transporting similar systems, we estimated that it would cost about $7,500 to prepare and ship the Sigma 5. Unfortunately, the Museum budget did not have an allocation for this. However, I knew that Max Palevsky, one of the founders of Scientific Data Systems, had generously contributed to the initial founding of the Museum. I wrote asking if he would sponsor the move and soon received a phone call indicating he would be happy to. With funds in hand, we began the task of planning the actual move.

For transportation of high-value artifacts that are fragile, heavy, and bulky, the Museum uses a carrier with experience in transporting computers, electronics, and similar equipment. Usually the Museum receives donations of large systems that have been de-installed without planning for future use or study. Cables are often cut instead of being unplugged and carefully packed; software and documentation are missing; and integral pieces of the system have been abandoned or disposed. Even when an item is donated "intact," it is often removed or packed with an eye towards expediency rather than preservation. For example, packing tape may be directly applied to surfaces, leaving damaging residue or pulling off paint and surface material when removed.

Given the excellent condition and completeness of the Sigma 5, avoiding these mistakes was a very high priority. Having facilitated several system moves, I knew that a Museum representative needed to do the actual preparation of the system for shipping to California. We worked out a date and logistics for pick-up and began to plan the de-installation process.

THE DE-INSTALLATION

Again my travel plans coincided with Museum needs and I made a trip to Pittsburgh in June 2002. To help the de-install of the Sigma 5 proceed smoothly, a preliminary written plan was created to document the process with both photographs and a log kept in my notebook computer.

I planned to spend the day documenting the system configuration, uncabling, packing, and staging the donation for pick-up. Consulting with staff at the Museum and others who had direct experience with SDS and XDS—Xerox purchased SDS in 1969 and named the company XDS, or Xerox Data Systems—machines, I learned how to best prepare the system, i.e., what to do or not, what was important, and what could be left behind. For example, a former SDS hardware engineer told me that connectors on peripheral cables were very fragile and would often break when being removed. He provided advice on how to remove a cable and avoid strain that could damage it. This advice proved to be invaluable and insured that many fragile items were handled correctly and without damage.

I met Bothner-By in Pittsburgh on Thursday morning, May 17, about 8:30am. I found the computer room in the same condition as the year before. The NMR Spectrometer had already been disassembled, so the control room equipment and Sigma 5 were left. The plan called to first map the system *in situ*, take photographs, and inventory all the cabinets, spare parts, software, documentation, and other donated items. I inventoried the major pieces that would need to be handled by movers: hardware cabinets, peripherals, and several cabinets holding punched cards and spare parts. We also did a quick inventory of software stored on magnetic tape. Tools for disassembly were located in a helium generation room down the hall, along with some system documentation.

The next step was to pull floor tiles and do a quick assessment of which cabinets to uncable first. Yikes! Removing more and more floor tiles revealed an ever-more complicated Gordian Knot[2] of data and power cables snaking all over the machine room. Usually when de-installing, one would take Alexander the Great's approach to loosen the original Gordian Knot, but because we wanted to preserve the Sigma 5 intact, that approach was avoided. I had an inkling this might take a little longer than I initially thought.

Uncabling the CPU presented several problems. I had hoped to just unplug the power cables and keep them with the system. However, after tracing the paths of the primary and peripheral power cables, I found them running through a hole in the wall into the next room that was (of course) locked and inaccessible. If I couldn't unplug from the building power, I'd just disconnect the hard-wired cables. Although the power was hard-wired into the main CPU cabinet, it fed power to other cabinets in the system, which simplified that part of the disassembly.

Fortunately, the breaker box was located in the computer room. Before disconnecting power, I double-checked that the three-phase 408V power to the system was turned off at the breaker box. Then I checked again.

Separating the cabinets from each other was even more complicated. Unlike modern systems where elements such as disc, memory, tape, and CPU are physically present in a single cabinet, the Sigma 5 CPU was composed of three large interconnected cabinets housing the CPU, floating point unit, and core memory. Tens of cables were laced between, through, and under these cabinets. In addition, cables connected the CPU and peripherals, some of which were physically next to the CPU, and some of which were located at a distance across the room.

Today's cables have connectors on each end that allow them to be disconnected quickly and easily. On the Sigma 5, in addition to the mass of tangled cables snaking between cabinets, each cable had a 4x4-inch printed circuit board hardwired to each end. I soon discovered it got worse. Some cables had not just two, but up to five cards hardwired at various points in-between the ends and were 20 or more feet long. These cards enabled the cables to plug into backplanes or card cages in one or more cabinets.

I saw why most systems of this type are removed from service by cutting the cables. Finding, untangling, and removing what looked to be several hundred cables seemed an impossible task. It made sense to start where the peripherals attached to the CPU. With a lot of patience and gently working with cables that had not been moved in over 30 years, I was provided a detailed lesson in 1960s-era mainframe packaging and interconnect technology.

In addition to untangling the cables between the cabinets, it was important to record exactly where each cable was plugged, in order to facilitate the eventual reconstruction of the Sigma 5. I defined a labeling protocol based on designations present in each hardware cabinet. Each card plugged into a socket and was tagged with a code that indicated 1) cabinet, 2) frame, 3) row, and 4) slot.

By the end of the day on Thursday, I had removed only about a third of the cables, no software or spare parts had been packed, and I was beginning to worry about completing the task by the end of Friday. By working until 3am, I finally disconnected and packed most data cables. The next day, Bothner-By and I started working at 9am with a goal to finish preparing the system by 1pm so I could catch my plane that afternoon. Hope springs eternal. About 3pm, it was obvious that there were several more hours of work and I changed my departure to Saturday morning.

The Computer History Gods must have been smiling on us because the process of separating the system in an orderly fashion became easier and easier with each cable. The core memory cabinet was the first to be completely decabled. Once several bolts holding the cabinets together were removed, it was moved aside for the first time in 30 years. I made a mental note that rubber wheels sitting in one position for that period of time also tend to flatten, so it was as much pushed as it was rolled.

While I concentrated on physically separating the cabinets, Bothner-By was packing away documentation and spare parts. Since the lab closure called for removing all furniture and systems, he just packed all the spares in place in their storage cabinets to be shipped to California. Cabinets of punched cards were likewise secured and locked. The system documentation was packed into six large boxes. I looked through a tape library of about 200 half-inch magnetic tapes, picked those that appeared to contain system software, and packed them into another four or five boxes. In the late afternoon, all cables were disconnected except those in the CPU cabinet with the operator front panel. In the interest of time, these were simply rolled up and packed in a large box on top of the cabinet, leaving one end still connected. This was OK for transport, and the cables would be removed on arrival at the Museum. When this was completed, all cabinets had been separated, positioned, and labeled for pick-up the following week. An inventory was created for the shippers. The de-installation and preparation of the Sigma 5 was complete by about 5pm on Friday.

It looked like there would be some unused room in the shipment. In addition to the Sigma 5, the machine room contained a PDP-8 with two seven-track 1/2-inch tape drives. While the Museum has several PDP-8 systems, I knew of no operational 7-track tape drives. Since these are extremely rare, they would be very useful for reading and converting the Museum's collection of 7-track tape media. Bothner-By and I tracked down Professor Mort Kaplan who owned the PDP-8. He confirmed it was no longer being used and agreed to donate it to the Museum. After a phone check with the Collections Staff to confirm we would accept donation of the PDP-8, it was quickly prepped and moved into place to piggy-back on the shipment.

At 9pm Friday, I left the Mellon Institute at CMU, my original eight-hour de-install task completed after almost 31 hours of work in a 48-hour time period. I was exhausted as I drove to the Pittsburgh airport, but still very excited thinking that soon the Museum would be in possession of an almost mint-condition artifact for the collection.

LESSONS LEARNED

What was learned from this de-install? In addition to learning about interconnect technology on the Sigma 5 and navigating the inner sub-basement sanctum of the Mellon Institute, I also learned that assumptions based on experience with a contemporary system are not always applicable to older mainframe technology. I was reminded how important it is to plan your work and work your plan. A standard set of tools can make the job go much faster.

Sigma advertisements promoted the machine's ability to handle real-time applications while running background processes (far left) and their ability to handle more input and output than existing technologies required. "Anything you deliver we can handle," the ad concludes (immediate left).

Talking with subject matter experts for the Sigma hardware, scoping out the donation and logistics ahead of time, and lots of patience paid off in spades when it came time to actually de-install, prepare, and move the system. Taking notes in real-time on a laptop and annotating with photos from a digital camera was a big help in gauging my progress and should greatly facilitate reconstruction of the system in the future and with other SDS/XDS hardware donated to the Museum. I also learned a lot of dust and debris can accumulate under a computer room false floor over a 30-year period.

THE SIGMA 5 AT THE COMPUTER HISTORY MUSEUM

The Sigma 5 was delivered to the Museum in California about a month after I completed the de-installation. It was initially stored in the Museum's warehouse at Moffett Field. Upon arrival, the different pieces in the shipment were entered into the Museum's collection database. This process records a description of each artifact, physical characteristics, and assigns it a permanent, unique accession number for future reference.

On April 4, 2003, the CPU cabinet with operator panel, card reader, teletype console, and tape drive were moved to the Museum's new building in Mountain View California. A display area was prepared for the Sigma 5 describing the system and its capabilities. The Sigma 5 is on display for visitors in the new Visible Storage eshibit area along with the CDC 6600, IBM System 360, SAGE, and 600 other artifacts from the collection.

WHAT'S NEXT FOR THE SIGMA 5, AND HOW CAN YOU HELP?

With the Sigma 5 acquisition safely in California, many possible projects are envisioned for it. Immediate projects include photographing and making a more detailed catalog of the Sigma 5 artifacts. This will allow the Sigma 5 to be displayed via the CyberMuseum at the component and system level. A more detailed catalog needs to be completed of the Sigma 5 documentation, software, and spare parts.

Longer term projects might include reconstituting the Sigma 5 as a running system, incorporating the system as part of a larger exhibit, scanning the SDS/XDS documentation and ephemera and making them available via the Web, or creating a working Sigma simulator which could run the software donated with the Sigma 5. Completing an oral history project of Scientific Data Systems would provide significant insight into the state of the computer industry in the 1960s when many business and technology innovations were realized.

A more formal set of de-installation guidelines for artifacts based on the notes and log from the Sigma 5 and other artifact donations need to be created and adopted for future acquisitions.

As with other Museum projects, the likelihood of these projects being implemented relies on knowledgeable, reliable, and motivated volunteers. If you have an idea for or would like to participate in a project involving the Sigma 5, or other facet of the Museum, as the volunteer coordinator, I will be very happy to hear from you. Please feel free to send me an email at courtney@computerhistory.org.

And as always, the Collections Committee is interested in considering additional SDS and XDS artifact donations that complement the Sigma 5, from components to software to ephemera to other SDS/XDS systems.

The Computer History Museum is entering a new and exciting phase of its life. Many pieces are coming together to allow the Museum to build a world-class institution documenting the history of the information age. Now the Sigma 5, and other artifacts like it, can be properly preserved for study and enjoyment for past, present, and future generations.

AFTERWARD

Many expectations and goals for this acquisition were exceeded because of advanced planning, foresight of donors, generous contributions, and hard work on the part of volunteers and others interested in seeing computing history recognized and preserved. This acquisition was the result of the efforts of many people.

Thanks go to: Drs. Aksel Bothner-By and Joseph Dadok of the CMU Chemistry Department for their time and effort to keep the system running, recognizing the value of the system to documenting the history of computing, and working to facilitate its contribution to the Museum; numerous volunteers on the Web who provided invaluable information allowing me to successfully complete this project—in particular Keith Calkins, George Plue, and Ed Bryan; and Max Palevsky for his generous support of this project and the Museum in general. Special thanks to the staff in the Collections Department and Collections Committee who approved the donation and helped with arrangements for its safe transport to California. ■

When not serving as the Chair of the Museum's Volunteer Steering Committee, participating in numerous Museum initiatives and projects, and pestering the staff about SDS/XDS items, Lee Courtney is an Engineering Manager at MontaVista Software and harried father of a very energetic three-year-old boy, who also happens to be the Museum's youngest volunteer.

[1]When the Chemistry Department acquired the Sigma 5 in the late 1960s, SDS, and subsequently Xerox Data Systems (XDS), were contracted to perform periodic maintenance on the system. In 1975, Xerox exited the mainframe computer business and sold their customer base to Honeywell. After some false starts, CMU, like many other Sigma sites, opted for self-maintenance. This meant accumulating a supply of spare parts and collecting the documentation needed to maintain the system. In addition to self-maintenance of hardware, CMU opted to maintain its own system software. This was fortuitous for the Museum because it provided a treasure trove of information to accompany the Sigma 5. Additionally, because Bothner-By and Dadok took such care in maintaining and documenting the system, the Museum and its visitors will benefit from a breadth and depth of equipment and information rarely available for this class and age of system.

[2]The Gordian knot has come to represent a most difficult puzzle. According to Greek legend, an oracle prophesied that the future king of Phrygia would come into town riding in a wagon. When the peasant Gordius and his wife did just that, the elders made Gordius king. He dedicated his wagon to Zeus, tying it in front of his palace with an intricate "Gordian" knot as a reminder of his humble beginnings. Decades later, an oracle foretold that the person who finally unraveled the Gordian knot would rule all of Asia. Many, many men tried to untie the famous Gordian knot until Alexander the Great drew his sword, slicing the knot in half.

SIGMA 5 SPECIFICATIONS

Instruction set:	90 instructions
Word length:	32 bits plus parity, EBCDIC character encoding
Memory:	Up to 512K bytes multiport core memory with 2- or 4-way interleaving and 950 nsec cycle time
I/O:	Multiplexed IO processor: 8 to 24 channels each with bandwidth of 450 or 900KB/sec and supporting up to 32 standard speed devices each
Optional selector IO processor:	8 to 32 channels each with bandwidth of 3.3MB/sec
Performance	**Min – Max (all times in usec)**
AW **Add Word:**	2.0 – 3.36
LW **Load Word:**	2.0 – 3.36
STW **Store Word:**	2.5 – 3.94
AWM **Add Word to Memory:**	3.3 – 5.0
BAL **Branch and Link:**	1.3 – 3.22
Technology:	Discrete transistors
Number customer installations:	Approximately 250 as of 1972
Purchase price:	$90-500K
Installed base markets:	Defense, scientific/engineering R&D, space, universities
Primary competitive systems:	IBM 360/40, /44, /50, 370/135, /145; DECSystem 1040, 1050, 1055; CDC 3300, 1700; Univac 418-III
System software:	Basic Control Monitor, Batch Processing Monitor, and Batch Timesharing Monitor; FORTRAN IV; Assembler; COBOL; scientific libraries
Peripherals:	RAD files (fixed head disk), disk, 7- and 9-track magnetic tape, hardcopy TTY and CRT terminals, unit record equipment, paper tape, plotters, datacomm, and A/D & D/A converters

Sources: *Sigma 5/8 Sales Guide*, Xerox Data Systems, January 20, 1972, and the *SDS Sigma 5 Computer Reference Manual*, September 1968

THE SDS SIGMA 5 IN CONTEXT

BY PETE ENGLAND

WITH ED BRYAN AND WENDELL SHULTZ

In 1961, Scientific Data Systems (SDS) started with an objective of providing computers for the scientific, engineering, and education markets. Many of the founders of SDS had pioneered this market while at the original Packard Bell Computer Corp. By using solid-state but serial logic and an innovative memory technology cheaper than core, Packard Bell was able to offer a machine starting at $40,000. Until then, a price below about $100,000 was difficult for manufacturers to offer so a computer priced at less than half that opened up new markets. Crossing a lower price threshold—thus attracting new customers—has happened several times in the history of computers. Once hooked, their demand for capability increases, and prices rise once again.

SDS participated in this trend and provided more capabilities to that same market. The Series 9 machines used core memory with serial solid-state logic for an initial price of $54,000 for the SDS 910 in 1962. However, when the customer finished acquiring necessary peripherals and additional memory, the price would often be two to four times that amount. The Series 9 machines were successfully used in a variety of “embedded” applications where they provided control and captured data from systems, experimental environments, and other real-time situations.

A desire for computers that could combine these tasks with business applications led SDS, with its Sigma line, to focus on multi-use and timesharing capabilities. To meet these requirements, SDS invented a memory map to allow dynamic relocation of programs that were being run at the same time. A fixed-head Rapid Access Disk with storage of up to 3MB supported the high-speed swapping of programs in and out of memory. Reading or writing up to eight heads in parallel on some models gave a transfer rate of 3MB/sec.

In April 1964, IBM announced the System/360, which provided many new characteristics but not capability for timesharing or any significant real-time applications. The 360 incorporated base registers to make programs less sensitive to their location in memory but did not provide a means to relocate programs dynamically. These shortcomings gave SDS an opportunity that it exploited well.

After Sigma architecture was set and the Sigma 7 announced, other timesharing endeavors came to light. IBM started a project working with universities (Michigan, Carnegie Mellon) to modify a 360/65. UC Berkeley modified an SDS-930 to provide a memory map and larger memory. SDS productized and sold that modification as the 940 to the growing timesharing service bureau market until the software for the Sigma 7 could be finished.

The Sigma 7 was first delivered in December 1966, and the Sigma 5 was delivered in August 1967. These machines still used core memory but more of it, up to 512K bytes. The logic was now bit parallel for more speed and early integrated circuits were used for implementing the working registers. The goal of the Sigma 5 was to provide real-time and batch simultaneously, allowing batch capability to be used for software development, data processing from real-time capture, business applications, or processing student jobs—all while the machine remained responsive to real-time needs. The Sigma 5 had the same processing capability as the Sigma 7 although some of it was optional. It had the same interrupt system, flexible I/O, and RAD, but it did not have the memory map. And it found its way into applications similar to many of the original 9 series machines but with the benefit of multi-use.

After a few years of trying to support the minimally-configured Sigma 5 at its starting price of $90-100,000, basic requirements were increased and the base price was more like $160,000. But, still, a typical configuration could get to $500,000. The Sigma 7, fully configured, could be well over $1,000,000.

This particular cycle started with computers that cost only $40,000. Another cycle started when DEC introduced the PDP-8s for $10,000. Even with limited capability, they enabled a new set of customers to obtain computers for the first time. As time passed, customer demands increased and the Minicomputer’s capabilities and cost grew until it too passed $1,000,000 for some configurations. And then came the Microcomputer or PC...

Pete England was the architect of the SDS Sigma series of machines. Ed Bryan and Wendell Shultz developed the operating systems for the series.

REPORT ON MUSEUM ACTIVITIES

BY KAREN TUCKER

Karen Tucker is Vice President of Development, Marketing, and PR at the Computer History Museum

WE HAVE MADE GREAT STRIDES

With the purchase of our new building in October 2002 came an exciting change of direction from the Museum's previous plan to build at NASA Ames, a change that enabled us to "step up the pace" and offer more to our members and to the public than ever before.

And step up the pace we did. In December 2002, less than two months after the completed purchase, with help from volunteers and many others, the Museum relocated to the new building. Construction on a Visible Storage exhibit area and a new auditorium began the following month and was completed in May 2003. On June 2, over 600 people gathered to celebrate the opening of the Alpha Phase. See the article on page two for more details. It was a wonderful evening and gave us all a chance to celebrate how far we have come in so short a time.

Museum lectures and events continue to feature innovators and champions of computing history. Here are just some of our recent offerings.

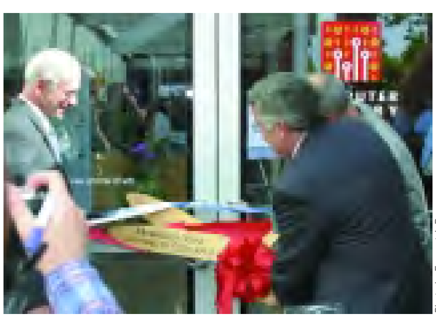


Photo by Earnest J. Ray

Board Chairman Len Shustek (left) and Executive Director and CEO John Toole officially ushered in the Museum's Alpha Phase in a ribbon cutting ceremony with the city of Mountain View at the new building.

Adobe co-founder John Warnock expressed the importance of "shooting ahead of the duck" when introducing new technology.

Adobe co-founder Charles Geschke described his and Warnock's efforts to create a company culture that was positive and respectful of employees, customers, shareholders, and the community alike.

ADOBE SYSTEMS–THE FOUNDERS' PERSPECTIVE

On November 22, 2002, the 20th anniversary year of Adobe Systems, more than 300 people gathered at Moffett Field to hear Adobe founders John Warnock and Charles Geschke in a talk facilitated by Bernard Peuto. The two spoke about the company's success throughout the years and shared key philosophies and strategies that enabled the company to revolutionize desktop publishing.

From PostScript to Illustrator to Photoshop to Acrobat, Adobe repeatedly introduced products for which there was no market. Warnock said that, "it's really important...not to try essentially for today's market, but to look a couple years out and shoot ahead of the duck." Geschke explained policies and culture that they believe helped the company to experience success and longevity. He said, "We wanted to build...a place that, frankly, we would like to work...And we felt if we did that, we could attract...the great engineers, the insightful marketing people, the dedicated sales people." Over the years, when asked to delineate the "Adobe way," he would reply, "There's really only one rule: if you are confused about how to deal with [someone]...just treat that individual the way you'd like to be treated...and that will be the 'Adobe way.'"

AN EVENING WITH STEVE WOZNIAK

Apple co-founder Steve "Woz" Wozniak engaged an audience of 300 people at Moffett Field on December 10, 2002 with personal stories about his childhood—including pranks he used to play. He recalled his interest in electronics, the inspiration of Tom Swift books, his success in science fairs, and positive feedback he received from his teachers and his parents. He relayed how he became a licensed ham radio operator in 6th grade. He said he "went all the way through high school thinking, 'I'm designing computers right and left, but I don't think they ever have jobs designing computers. I mean engineers, which I want to be, you know, they design TVs and radios and things.'" He described how early on he "measured himself by how few chips" he used and discussed the sequence of break-throughs and events that eventually led to early Apple designs. To learn more, check out the events section of the Museum Web site.

Steve Wozniak told stories about a childhood full of pranks and programming and discussed early innovations at Apple.

Steve Wozniak autographs a *BYTE* magazine.

25 YEARS OF HENNESSY AND PATTERSON

On January 7, the Museum opened the new year with a lecture at PARC with John Hennessy and David Patterson and facilitated by John Mashey. More than 200 people heard these legendary men speak about early RISC development and their work since that time. As assistant professors, both men taught "brainstorming" classes to explore new technology directions. Hennessy recalled the class goal of designing a processor where they "almost naively" assumed, "given that VLSI is going to become the implementation technology, we need to re-look at the question of how processors should be architected when they're not being built from gate arrays or bits-wise kinds of technology." He added, "the fact that we had a limited number of transistors forced us to think really hard about what belonged in hardware and what belonged in software."

Patterson recalled being visited early on by John Cocke, who encouraged both him and Hennessy in their respective work. Patterson surmised that, although Cocke never said it, he visited the west coast to "communicate ideas so they could figure out how" to create the

John Hennessy recollected how he got into computers in the first place, how RISC developed, and how the technology evolved over time.

Dave Patterson was first introduced to computers one semester in college when he took a programming class because all of the math sections were full.

chips IBM was somehow not managing to create. "IBM was super-secretive with ideas, except Cocke would just go talk with a bunch of faculty and grad students...and get us excited...." "This was very controversial stuff. We did this as assistant professors....It was heresy. It got emotional reactions."

Together the two authored *Computer Architecture: A Quantitative Approach*, considered for over a decade to be essential reading for every serious student and practitioner of computer design.

HOW DATABASES CHANGED THE WORLD

Chris Date, Herb Edelstein, Bob Epstein, Ken Jacobs, Pat Selinger, Roger Sippl and Michael Stonebraker, with moderator George Schussel gathered on February 10 to share database stories and lessons learned.

After introductions, Date started the panel with a memorable acknowledgment of relational database pioneer Edgar "Ted" Codd, who was unable to attend (and sadly, passed away just two months later on April 18). Date said, "We are all here...in this room because of what Ted Codd did back in the 70s" at IBM when he proposed the relational database model that "basically put the whole field of database management onto a solid scientific footing."

The panel noted the paradigm shift of relational databases and told stories of the companies and people that developed, used, and marketed database technologies over the past three decades. Marketing was noted as of primary importance to successful products and Selinger discussed some of the user testing that IBM underwent in its decision to stick with SQL, a powerful language criticized as problematic and sometimes cumbersome. Epstein predicted that databases will be used more and more as monitoring systems to process streaming data, where companies will be "passing data through queries instead of passing queries through data." Sippl said, "There is a new revolution coming, not of the algebra of how to deal with tables of data, but how

Photo by Earnest J. Ray

The database panel discussed the paradigm shift of relational databases, the incredible growth of the database industry, and ideas about the future of data management.

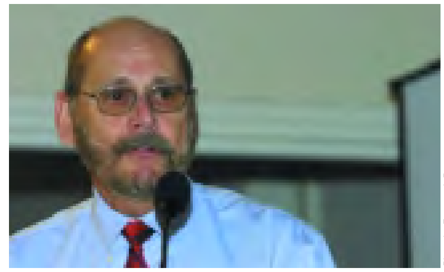


Photo by Earnest J. Ray

George Schussel moderated the database panel.

to deal with combinations of business processes....There's going to be a simple, powerful model for doing that...that will have as big an impact as the relational database did. It's dealing with our processes, not just our data." Edelstein concluded that there is and will continue to be a "vast increase in the scale of information" being processed, where great "complexities come from the nature of data and the rules associated with data." We are going to "need a way to deal with these complexities....Someone [will surface who will] abstract these new complexities into a new paradigm."

NATURE OR NURTURE: ESTRIN'S LIFE IN TECHNOLOGY, SO FAR

Judy Estrin, second-generation computer scientist thrice named to *Fortune* magazine's list of the 50 most powerful women in American business, spoke at a Museum event hosted by Microsoft on March 5. Long-time friend and venture capitalist Yogen Dalal masterfully facilitated the conversation. Estrin described her "rich beginnings" and the "incredible role models in terms of values, ethics, and love of learning" she found in her parents, Thelma and Gerald Estrin, who worked together to build Israel's first mainframe computer, the Weizac. She said, "most of the people who grew up with me knew me as a people person and maybe a facilitator, but not necessarily a leader....I'm not sure that anybody would have guessed that I would have ended up being an entrepreneur. On the other hand," she countered, "I think that I perhaps was destined to be a technologist" because of her family environment, among other things.

Estrin, who has co-founded multiple startup companies and become an expert in organizational management, described her experiences at several companies over the years. She remembers writing her first business plan on a TRS-80 with cassette tape storage. At Zilog, she "learned that marketing matters." She had been quoted from those days as saying that "marketing is an unnecessary evil," but came to believe that "technology for technology's sake doesn't solve anybody's problems because it never gets to the customer." Estrin co-founded her first startup at age 26, her third startup was acquired by Cisco Systems, and she is presently CEO of Packet Design, her fourth startup company.

Photo by Robert Hull

Venture capitalist Yogen Dalal facilitated a conversation with Judy Estrin. The first time he met her, he was "struck by her incredible amount of energy...and adventuresome spirit."

Photo by Robert Hull

Judy Estrin has been a role model for women in business, and always just "assumed" she would succeed in her efforts. She gives credit to her "rich beginnings" within a creative technology family.

Photo by Michael Baxter

Dan Bricklin (left) and Bob Frankston (right) created VisiCalc, the first electronic spreadsheet program.

THE ORIGINS AND IMPACT OF VISICALC

On April 8, Dan Bricklin, Bob Frankston, and Mitch Kapor along with Charles Simonyi discussed the invention of VisiCalc, the first electronic spreadsheet program. Bricklin and Frankston created VisiCalc and Kapor followed their innovation with Lotus 1-2-3.

Bricklin came to understand the need for changeable content and prototyping through observing his dad's printing business. In college, he daydreamed about a "magic, typeable blackboard that would do what I couldn't, which is, when I made a mistake...in my [spreadsheet] homework, I could erase one number and have [the blackboard] change all the numbers."

Frankston reminisced about programming much of the software, creating final code that was just 20KB, including operating system, screen buffer, and disk utilities. Simonyi pointed out that today's Microsoft Excel requires 8.7MB for the software alone.

Kapor admitted that when Frankston gave him the first demo of VisiCalc, he said, "huh?" Then added, "Fortunately that was not the last demo I got!" In creating Lotus 1-2-3, Kapor wanted to "design something that could just stand next to VisiCalc without embarrass-ment." Bricklin observed that in Lotus 1-2-3, Kapor kept "all the things [from VisiCalc] that ended up being the right things, as opposed to making it different for the sake of different, and then added new features" and changed things that were worth changing.

The lecture was co-hosted and held at Microsoft in Mountain View. Visit www.bricklin.com for a personal history of VisiCalc.

Photo by Michael Baxter

Mitch Kapor followed on VisiCalc with Lotus 1-2-3, wanting to do something that "took it to the next level."

CELEBRATING THE ETHERNET'S 30TH ANNIVERSARY

On May 22, the Museum and PARC co-hosted a special celebration of "Ethernet at 30." The event was sponsored by 3Com, Cisco, HP, and Intel, and held at PARC in Palo Alto, Calif. The first panel of speakers included inventor Bob Metcalfe and early Ethernet pioneers Gordon Bell, Judy Estrin, and David Liddle.

Metcalfe remembered that, in 1982, he thought with amazement, "there are people buying Ethernet whom I have *never* met." He remembers thinking just four years later that "there are people *inventing* Ethernet whom I have never met!" He went on to define several elements that made Ethernet successful, including packets, layering, distribution, the ether itself, and the Ethernet "business model," which consists of *de jure* standards, proprietary implementations, fierce competition moderated by a market committed to interoperability, and an evolution over time that preserves the same base technology. Estrin pointed out the commitment to being a "best" technology, instead of a deterministic one limited by the lowest common denominator. Liddle gave an interesting history of competing standards that enabled Ethernet, although barely at times, to continue to succeed. Bell, who was instrumental in developing corporate alliances, told stories of his advocacy for the technology.

Ann Winblad moderated the second panel discussion on the future of networking with industry thought-leaders Andy Bechtolsheim, Eric Benhamou, W. Eric Mentzer, and Stephen Squires. Bechtolsheim expressed his belief that the hardware and technology evolution

Bob Metcalfe celebrated the 30th anniversary of Ethernet on May 22. Other presenters included Gordon Bell, Judy Estrin, David Liddle, Andy Bechtolsheim, Eric Benhamou, W. Eric Mentzer, and Stephen Squires.

Cake to celebrate the anniversary of this long-lived and successful technology

will continue, but that "the challenge before us is in software, at the intersection of computing and connectivity." Benhamou reminded us that Aristotle defined ether as the substance that surrounded the earth. This vision of "pervasive connectivity will be ever more relevant as we head into the 21st century," he said. Squires characterized Ethernet as an "enduring and multidimensional invention" and envisioned the next 30 years supporting the successful implementation of nano-technology in every aspect of our lives. It "won't be just a little more of the same," he said, "but a leveraging" of current advances—molecular electronics, scalable modules, new abstractions and visualizations to hide the details, systems growth, and applications development—to create comprehensive change.

Mentzer reflected on the continuing "convergence of the digital and real worlds" and concluded the program with high praise for Ethernet, asking, "How many technologies do you know that are 30 years old that you still want to be working on?"

FIST LECTURE EVENT IN THE MUSEUM'S NEW BUILDING

On June 10, the Museum christened the Hahn Auditorium with its first panel event in the new building: "Jurassic Software: A Look Back at The Beginnings of Consumer Software." On the panel, Intuit co-founder Scott Cook; Broderbund Software co-founder Doug Carlston; and Electronic Arts and 3DO founder Trip Hawkins reminisced about the early days and recalled lessons learned in the founding of a new industry. Stewart Alsop, venture capitalist, former *P.C. Letter* publisher, and Demo and Agenda conference founder, moderated the lively discussion.

Attendee Bob Glass remarked, "It was exciting to hear the 'grand masters' talk about the anecdotes that formed the beginning of personal computing! It put a human touch to my knowledge of the evolution of consumer software."

John Wharton said, "What fascinated me at the Consumer Software panel was hearing the inventors themselves describe the context of their work—what they'd been doing when inspiration hit, how they fleshed out their basic concepts, and who helped them hone their ideas to create a successful product. You can't get stuff like that from books"

VOLUNTEERS AND THE MUSEUM: CAN'T HAVE ONE WITHOUT THE OTHER

The Computer History Museum's volunteers are the lifeblood of the organization! Behind-the-scenes volunteers contribute many hours of their time helping with a diverse array of projects. Some help plan new displays,

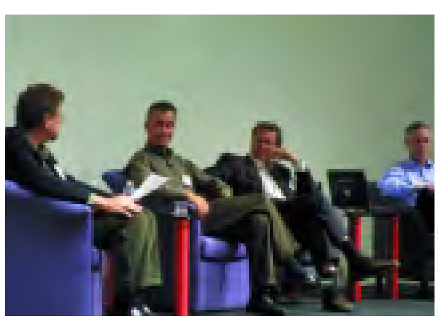


Photo by Michael Baxter

The Museum held its first lecture in the Hahn Auditorium on June 10, 2003. A panel on early software included Scott Cook, Doug Carlston, and Trip Hawkins, with moderator Stewart Alsop.

assist with the Web site, or arrange for future exhibits. Some help with administration at the Museum's office. Still others open the Museum to six public tours each week as well as many special tours and scheduled events. Since moving to the new Shoreline location and opening the Alpha Phase, more than 50 dedicated volunteers have been involved with the staff and their projects.

Also since our move to the new building, 20 new docents have enabled us to increase the number of tours from two to six per week. Tours are now available Wednesday, Friday, and Saturday afternoons. Thanks to Museum volunteers who have taken the training to become docents and greeters—they independently run public tours, welcome visitors, handle sales in our Museum store, and make the collection come alive.

The Volunteer Steering Committee, a representative group that meets with staff regularly, is the voice of the volunteers. The group is headed by Lee Courtney, who serves as chairman. Send requests for information or comments on the volunteer program to Lee Courtney or to Volunteer Program Manager Betsy Toole. For those interested in helping, please visit www.computerhistory.org/volunteer and click on "Become a Volunteer."

YOUR SUPPORT COUNTS

Our members and supporters are providing faithful and generous support for the Museum in spite of the challenges of the current economy. See the list of people on page 28 who are current members at the $100 and above level.

If you have been contemplating joining or lending your financial support to the Museum, we encourage you to "take the plunge!" Not only can you enjoy the benefits of being associated with this great institution, you can take pleasure in your support of important work to preserve and present key objects and stories of this amazing time in history. Please contact me if I can help you in any way. Thank you!!

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Please make your reservation by calling +1 650 810 1013 or emailing: tours@computerhistory.org.

VOLUNTEER OPPORTUNITIES

The Museum tries to match its needs with the skills and interests of its volunteers and relies on regular volunteer support for events and projects. In addition to special projects, monthly work parties generally occur on the 2nd Saturday of each month, including:

OCTOBER 11, NOVEMBER 8, DECEMBER 13

Please RSVP at least 48 hours in advance to Betsy Toole for work parties, and contact us if you are interested in lending a hand in other ways! For more information, visit our web page at www.computerhistory.org/volunteers.

MYSTERY ITEMS

FROM THE COLLECTION OF THE COMPUTER HISTORY MUSEUM

Explained from CORE 3.3

English Electric, DEUCE Mercury Delay Line Amplifier Circuit (1955), XD 4.75, Gift of Murray Allen.

This small section of the British DEUCE (Digital Electronic Universal Computing Engine) computer constructed at the English Electric Company is approximately 2 lbs. and 4 1/8" x 8" x 2 15/16" (HWD). This three-vacuum-tube module formed part of the machine's mercury delay line memory, which translated a digital pulse train into sound waves, sent these waves down a tube, then recirculated the waves back through the tube.

The English Electric Deuce was a general-purpose vacuum tube digital computer, with a serial organization and a 1 MHz clock rate. It was a re-engineered Pilot ACE (Automatic Computing Engine), a landmark machine conceived but unrealized by Alan Turing and developed by the UK National Physical Laboratory. The ACE can be seen today at the Science Museum, London. The DEUCE contained 1,450 vacuum tubes and was nearly twice the size of the ACE prototype.

The DEUCE's word length was 32 bits, and its arithmetic units were capable of performing single, double, and mixed precision binary integer arithmetic. The fast main memory was comprised of 12 mercury delay lines. Eight delay lines held executable instructions, and four delay lines comprised auxiliary storage. The magnetic recording drum (an example of which resides at the Computer History Museum) contained one block of 16 read heads and a separate block of 16 write heads. Each head provided access to a track of 32 words and both blocks could be moved independently to any of 16 positions.

The DEUCE used standard Hollerith (IBM) 80-column punched card machines. Reading and punching transferred one binary word per row of a card and conversion to and from decimal was performed by software.

The first machine was delivered in the spring of 1955. From late 1955 onwards, English Electric began selling the DEUCE 2, followed in 1957 by a DEUCE 2A; these featured, among other things, re-engineered input/output systems. The company sold about 31 DEUCE 1 and 2 machines between 1955 and 1964, priced at around 50,000 UK Pounds in 1958.

WHAT IS THIS?

THIS ITEM WILL BE EXPLAINED IN THE NEXT ISSUE OF CORE.

Please send your best guess to mystery@computerhistory.org before 12/15/03 along with your name, and shipping address. The first three correct entries will each receive a free travel mug with the Museum's logo.

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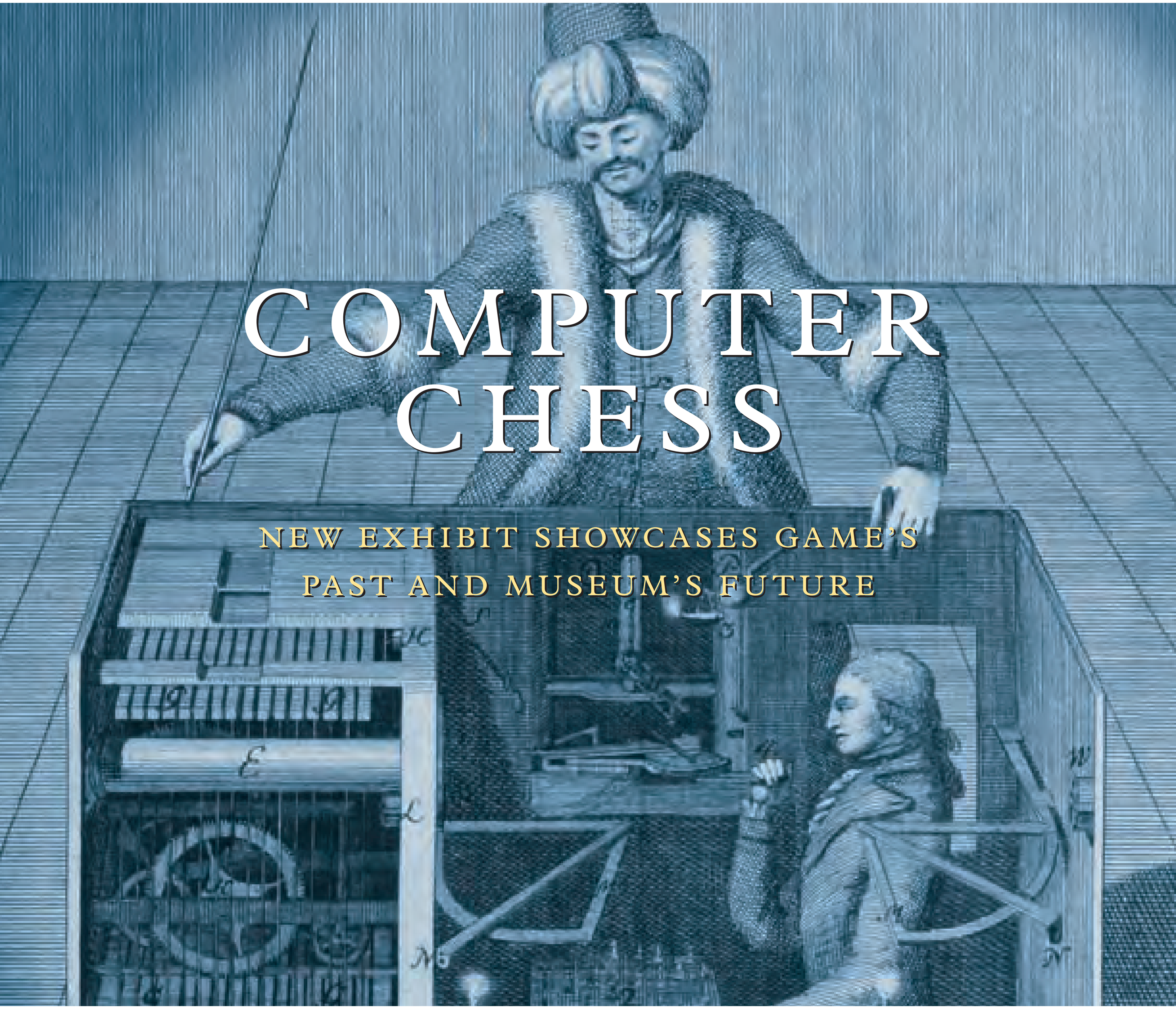

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Cover artwork: *Engraving of The Turk, 1789.* In 1770, Hungarian inventor Wolfgang von Kempelen created a chess-playing automaton called The Turk whose human-like playing qualities amazed audiences across Europe and America. Some observers guessed the secret that was a mystery for most of its career: the source of its playing strength was a human chess player hidden inside. Courtesy of the Library Company of Philadelphia, CHM# L062302012.

Photo this page: In 1968, David Levy played a friendly game of chess with Stanford professor John McCarthy. After the match McCarthy remarked that within ten years a computer program would defeat Levy. Levy bet McCarthy 500 pounds that this would not be the case. In August 1978, Levy (shown here) won the bet when he defeated Chess 4.6, the strongest chess playing computer of the day. Gift of David Levy, CHM# 102634530

Core 5.1

A PUBLICATION OF THE COMPUTER HISTORY MUSEUM // MAY 2006

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EDITOR'S NOTE

This issue of *Core* is a wonderful demonstration that being a computer museum is about more than just collecting old computers.

It is about designing physical and web-based exhibits to explain the excitement of trying to build smart machines. It is about telling hitherto unknown spy stories leading to the development of Russian computers during the Cold War. It is about bringing classic machines from 40 years ago back to life. It is about the changing fashion in how computers are promoted and sold. It is about building a comprehensive and eclectic collection that includes makeshift hardware, legendary software source code, historic t-shirts, computer-generated 45 RPM records, and news releases about attempted espionage of computer technology.

All these efforts represent different aspects of the same mission: the information revolution is having a profound effect on our civilization, and we owe it to future generations to preserve, understand, and explain how it came to be. To do so, we collect objects of all types as the raw material, we recreate historical conditions for study, and we describe what we know to others. These goals are lofty and important.

But we also do it because it's fun! Would we have restored the PDP-1 if it wasn't the "Spacewar! Machine?" Maybe, but maybe not. The man-machine conflict in the computer chess exhibit is the essence of science fiction. The Zelenograd story is in the best tradition of dramatic spy thrillers, except that it's true. The story of the computer is just not the facts of technological development: it is a rich human story.

What of the chapters that are being written now? The pace of development in computers blurs the distinction between past and future. The British psychiatrist R. D. Laing said, "We live in a moment of history where change is so speeded up that we begin to see the present only when it is already disappearing." Unlike those who study the history of the printing press or the Crusades, we are both burdened and privileged by having the object of our study evolving in our lifetimes. What an experience that is!

I hope you enjoy this and future issues of *Core,* and get involved in the effort to preserve computing history. We live in a remarkable time of technological change and should celebrate it joyously.

Len Shustek

Len Shustek is the Chairman of the Computer History Museum. He has been the co-founder of two high-tech companies, a trustee of various non-profits, a director of several corporations, and on the faculty of Carnegie Mellon and Stanford Universities.

COMPUTER HISTORY MUSEUM

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

VISION
To explore the computing revolution and its impact on the human experience

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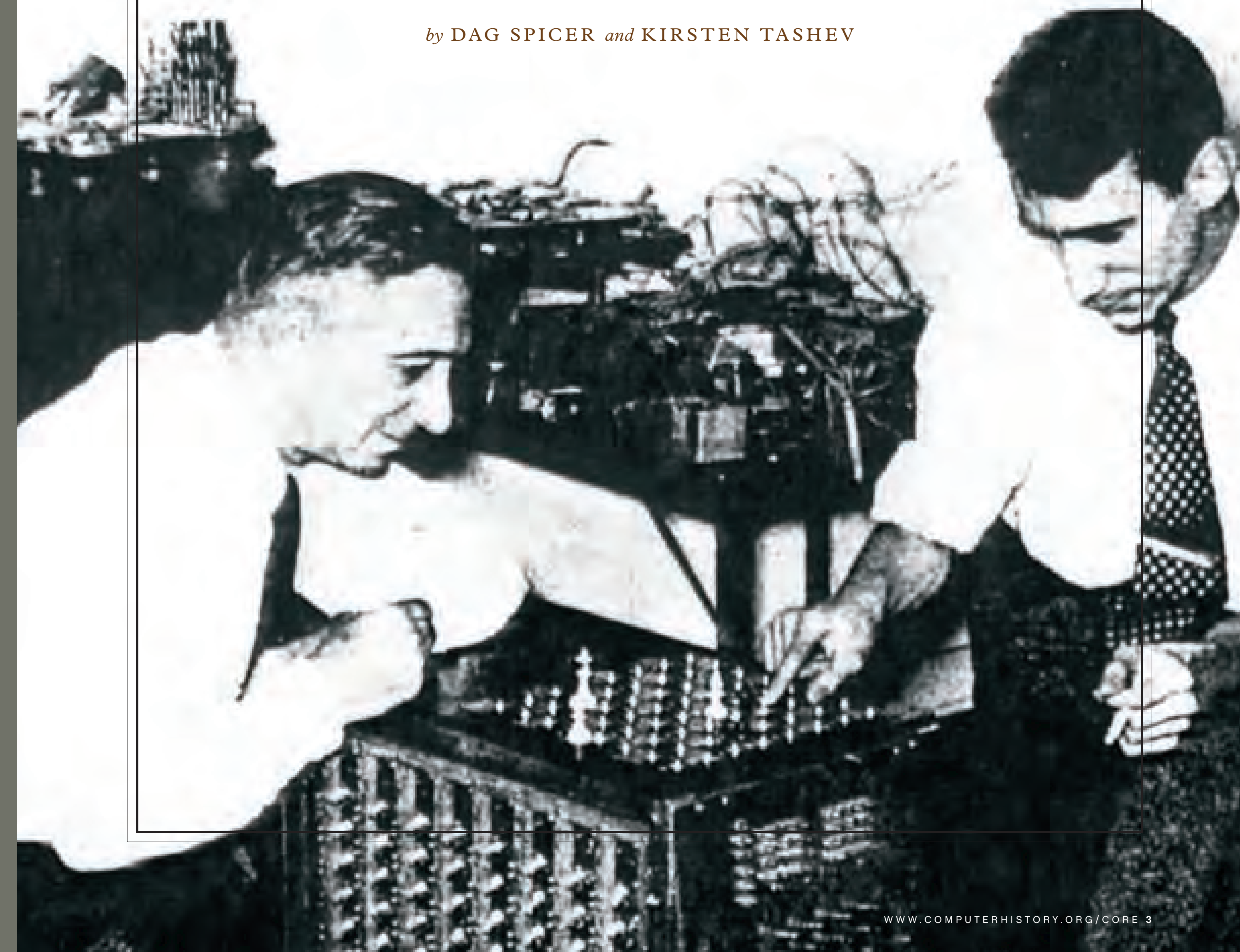
THE QUEST TO BUILD A THINKING MACHINE

A HISTORY OF COMPUTER CHESS

by DAG SPICER *and* KIRSTEN TASHEV



WHY COMPUTER CHESS?

In September 2005, the Computer History Museum opened "Mastering the Game: A History of Computer Chess," a dynamic new exhibit that chronicles the story of how computer science explored the bounds of machine thinking through the design of a computer to play chess.

This exhibit represented a two-year project to examine how to teach visitors about software—an abstract and traditionally challenging topic to display. In fall 2003, the museum formed a Software Exhibits Committee and the team explored conceptually a variety of "software" topics, including the history of text processing, programming languages, and game software. Within a year, the team decided to prototype an exhibit in order to fully understand the challenges.

The history of computer chess as an exhibit topic was proposed when discussing game software. The topic immediately resonated with the team. A five-decade-long story with a distinguished cast of characters, the history of computer chess also mirrored the larger story of computer history, providing visitors with an overview of general technological developments over time.

Computer chess also represented an accessible way for visitors to learn about software. Even if they don't play, most people know that chess is a difficult problem to solve for people and machines alike. With this familiar jumping off point, visitors could begin to explore some important computing software concepts such as algorithms, upon which all computer chess programs are built.

Additionally, as part of its international mission, the museum is committed to providing online visitors with access to exhibits and source material from the collection. To that end, delving into the topic of computer chess through exhibit development has unearthed broad and deep source material such as research papers, tournament brochures and photographs, source code as well as oral histories conducted by the museum during the research phase of the exhibition. This rich content makes the topic well-suited for more exploration in cyberspace and the museum has created an online exhibit to parallel the physical exhibit at its headquarters.

Finally, the history of computer chess also has drama; it is a story, ostensibly about man vs. machine, and the dream to build a thinking machine, a topic that continues to fascinate.

You are invited to visit the "Mastering the Game: A History of Computer Chess" exhibit at the museum or online. Here is an overview of the topic to whet your appetite!

from previous page:
Computer pioneer Claude Shannon developed the foundations of computer search strategies for how a machine might place chess. Shannon (right) and chess champion Edward Lasker play with Shannon's early relay-based endgame machine, c. 1940. Gift of Monroe Newborn, CHM# 102645398

Chess is

a very ancient game. It probably came to the west from Persia (Iran) via India during the reign of the Persian king Chosroes (d. 576 A.D.). For much of the last fifteen hundred years, chess has been popular with the ruling classes as a test of tactical and strategic acumen, a test whose lessons could possibly be applied to the world stage itself. Indeed, in the Middle East, chess is known as "the game of the king," and the word "Schach mat" ("Shah mat" in Persian) signifies "the king is dead," thus "Checkmate."

Although it had royal origins, chess was also popular with the less privileged, since it is inexpensive to play, requiring nothing more than a board with 64 black and white squares and some game pieces. Chess boards themselves could be status symbols but the game itself, of course, was no respector of persons. While it is easy to learn—even children can attain remarkable proficiency—chess has been associated with intellectual pursuits since its earliest beginnings. Since the rules were easy to program into a computer and it had nearly infinite (10 to the 120th power) possible games, chess was interesting to early computer pioneers as a test bed for ideas about computer reasoning. As pioneers in the 1940s sought ways to understand and apply computers to real-world problems, they began almost immediately to use chess.

THE TURK

But the story begins not with the birth of the computer in the 1940s, but 170 years earlier in 1770, when diplomat and inventor Wolfgang von Kempelen built a mechanical chess player called "The Turk." As part of his desire to rise in social position, Von Kempelen created The Turk as an entertainment and presented it to the Empress Maria Theresa of Austria-Hungary. The Empress and her court were stunned by The Turk's strong play as well as by its mysterious movements which seemed to indicate it was "thinking."

Word of The Turk spread quickly throughout Europe and it became a sensation. It would travel to public fairs and royal courts for the next 85 years, amazing audiences and playing such well-known figures as Napoleon Bonaparte, Benjamin Franklin, and even Charles Babbage (who would later design and build one of the earliest mechanical calculating machines). Although some of The Turk's observers guessed its secret, most had no idea that the source of its playing strength was a human chess player carefully hidden inside.

Although The Turk was eventually revealed to be a magic trick, the drive to build a machine that appeared to think or mimic human abilities continued throughout the 18th and 19th centuries. Indeed, European craftsmen built automata (literally: self-guided machines) that appeared to write, sing, and even play musical instruments. These automata grew out of the Enlightenment concept of humans as machines that could be understood through rational principles. The movements of automata were usually guided by clockwork mechanisms, which were becoming a mature technology by the mid-19th century.

Such creations were illusion, of course, no more intelligent than the mute wood and metal parts out of which they were constructed. The era of automata ended about 1900 at a time when the world's scientific knowledge was evolving into a system based on mathematically-understood principles supplemented by profound distaste for "metaphysics" or references to mystical (i.e. non-rational) forces as a means of explaining nature. This knowledge was extended dramatically in the first third of the 20th century on both theoretical and experimental planes and resulted in the invention of such things as widespread electrification, the light bulb, the automobile, the airplane, motion pictures, radio, sound recording, television, and air conditioning, to name but a few practical inventions; on the theoretical level, some of the key developments were quantum theory, organic chemistry, discovery of the electron, and Einstein's three earth-shattering papers of 1905 that would re-write physics forever. The world was transitioning from mysticism to science.

Concurrently, as companies and governments sought to automate the processing of information that was generated by modern-day life, initially mechanical solutions (like the Hollerith census machine of 1890) were proposed. These were followed in the 1910s and '20s by electrical machines, then, during WWII, by electronic solutions. In particular, the modern "statistical society," with its government-driven desire to acquire quantitative justifications for its policy decisions, was, and remains, a major driving force behind the development of computers. No one considered these early mechanical or electrical machines "thinking" in any way.

GIANT BRAINS

However, the emergence of the *electronic* computer in the late 1940s led to much speculation about "thinking" machines. In light of all the scientific accomplishments at the time, there seemed to be no limit to what science could achieve, including, perhaps, building a machine that could think. If a computer could play chess, so went the reasoning, then perhaps other problems that seemed to require human intelligence might also be solved. For example, in a 1949 paper, Claude Shannon, a researcher at MIT and Bell Laboratories, said of programming a computer to play chess that, "Although of no practical importance, the question is of theoretical interest, and it is hoped that...this problem will act as a wedge in attacking other problems...of greater significance."

Another computer pioneer, the Englishman Alan Turing, one of the most brilliant mathematical minds of the 20th century, studied the idea of "building a brain" and developed a theoretical computer chess program as an example of machine intelligence. Working at a time before he had access to a computer, in 1947 Turing designed the first program to play chess, testing it with paper and pencil and using himself as the "computer."

Commercial computers arrived in the early to mid-1950s as companies applied knowledge gained through WWII technological developments to new products. "Electronic" computers at this stage meant that such machines were based on vacuum tubes. These tubes could switch hundreds, even thousands, of times faster than the previous relay or mechanical systems of just five years earlier, resulting in computing machines that could accomplish in seconds what would previously have taken a human months or years to calculate.

OPENING MOVES

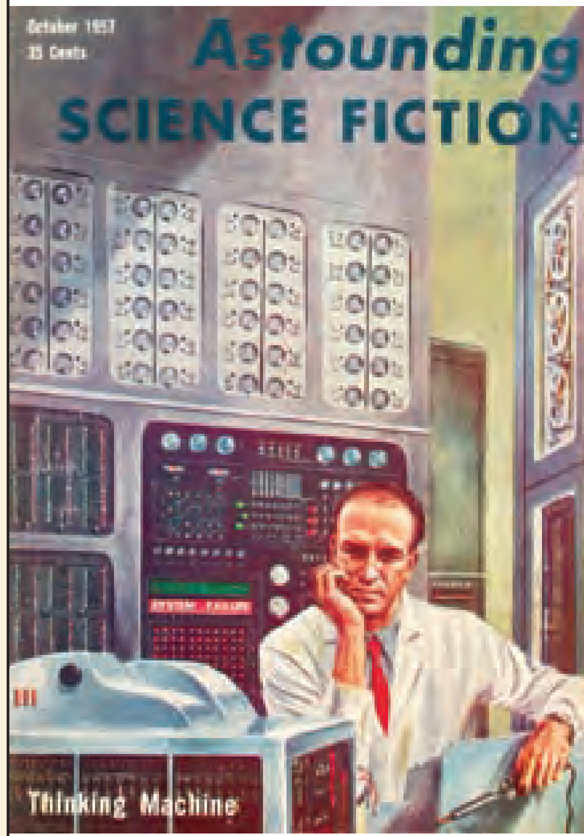
A colleague of Turing's, Dr. Dietrich Prinz, a research scientist on one of these new electronic machines (the Ferranti Mark I computer at Manchester University), continued the quest to create a chess-playing computer program. Prinz wrote the first limited program in 1951. Although the computer was not powerful enough to play a full game, it could find the best move if it was only two moves away from checkmate, known as the "mate-in-two" problem.

In the United States, Alex Bernstein, an experienced chess player and a programmer at IBM, wrote a program in 1958 that could play a full chess game on an IBM 704 mainframe computer. The program could be defeated by a novice player and each move took eight minutes. The interface—front panel switches for input and a printer for output—was not easy to use either.

While Prinz, Bernstein, and others wrote rudimentary programs, it was in this environment that scientists developed and extended the fundamental theoretical techniques for evaluating chess positions and for searching possible moves and counter-moves.

For example, early artificial intelligence pioneers Allen Newell and Herbert Simon from Carnegie Mellon University together with Cliff Shaw at the Rand Corporation, developed some of the fundamental programming ideas behind all computer chess programs in the mid-to-late 1950s. Their NSS (Newell, Simon, Shaw) program combined "algorithms" (step-by-step procedures) that searched for good moves with "heuristics" (rules of thumb) that captured well-known chess strategies to reduce the number of possible moves to explore. Specifically, the program used the "minimax" algorithm with the "alpha-beta pruning" technique.

King Otto IV of Brandenburg playing chess with woman, illumination from Heidelberg Lieder manuscript, 14th century. © Archivo Iconografico, S.A./CORBIS



Thinking Machine, *Astounding Science Fiction* cover, Oct. 1957-10. Used with permission of Dell Magazines. CHM# L062302011

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IBM programmer Alex Bernstein wrote a chess program for the IBM 704 mainframe computer in 1958. Bernstein told the computer what move to make by flipping the switches on the front panel. Courtesy of the IBM Archives, CHM# L02645391

Minimax allowed the computer to search a game tree of possible moves and counter-moves, evaluating the best move on its turn and the worst move on its opponent’s turn. The “alpha-beta pruning” technique ignored or “pruned” branches of the search tree that would yield less favorable results, thus saving time. Today most two-person game-playing computer programs use the minimax algorithm with the alpha-beta pruning technique.

The NSS chess program ran on the Johnniac computer, which is on display in the Computer History Museum’s Visible Storage area.

By the early 1960s, students at almost every major university had access to computers, which inevitably led to more research on computer chess. It was in 1959 that MIT freshmen Alan Kotok, Elwyn R. Berlekamp, Michael Lieberman, Charles Niessen, and Robert A. Wagner started working on a chess-playing program for the IBM 7090 mainframe computer. Their program was based on research by artificial intelligence pioneer John McCarthy. By the time they had graduated in 1962, the program could beat amateurs.

Richard Greenblatt, an MIT programmer and accomplished chess player, looked at this earlier MIT program and decided he could do better. He added 50 heuristics that captured his in-depth knowledge of chess. His MacHack VI program for the DEC PDP-6 computer played at a level far above its predecessors. In 1967, it was the first computer to play against a person in a chess tournament and earned a rating of 1400, the level of a good high school player.

This early success led to giddy predictions about the promise of computers. In fact, psychologist and artificial intelligence pioneer Herbert Simon claimed in 1965 that, “machines will be capable, within 20 years, of doing any work that a man can do.”

BRUTE FORCE

Work on computer chess continued, mainly in universities. By the 1970s, a community of researchers emerged and began to share new techniques and programs. The introduction of annual computer chess tournaments, hosted by the Association for Computing Machinery (ACM), also created a friendly but competitive atmosphere for programmers to demonstrate and test their programs. Tournament organizer Monty Newborn said of these tournaments: “Play was often interrupted to resuscitate an ailing computer or terminal. The audience howled with laughter. For the participants, however, it was a learning experience.”

At the same time, computers were doubling in speed about every two years. Early computer pioneers tried to make their programs play like people do by relying on knowledge-based searches (or heuristics) to choose the best moves. A new generation of researchers included heuristics, but also relied on increasingly fast hardware to conduct “brute force” searches of game trees, allowing the evaluation of millions of chess positions—something no human could do.

In fact, it was in 1977 at Bell Laboratories, when researchers Ken Thompson and Joe Condon took the brute force approach one step further by developing a custom chess-playing computer called Belle. Connected to a minicomputer, by 1980 Belle included highly specialized circuitry that contained a “move generator” and “board evaluator,” allowing the computer to examine 160,000 positions per second. This custom hardware revolutionized computer chess and was so effective that in 1982 at the North American Computer Chess Championships (NACCC), this $17,000 chess machine beat the Cray Blitz program running on a $10 million supercomputer. It was a harbinger of how more nimble systems would meet, and ultimately bypass, the performance of much larger machines.

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1 In the late 1950s, Carnegie Mellon University researchers Allen Newell (right) and Herbert Simon (left), along with Cliff Shaw (not shown) at the Rand Corporation, were early pioneers in the field of artificial intelligence and chess software, c. 1958. Courtesy of Carnegie Mellon University, CHM# L062302007

2 John McCarthy, artificial intelligence pioneer (shown here, c. 1967) used an improved version of a program developed by Alan Kotok at MIT to play correspondence chess against a Soviet program at the Moscow Institute for Theoretical and Experimental Physics (ITEP) created by George Adelson-Velsky and others. In 1967, the four-game match played over nine months was won 3-1 by the Soviet program. Courtesy of Stanford University, CHM# L062302006

3 Mikhail Donskoy (shown here in 1974) developed the Kaissa chess program along with Soviet scientists Vladimir Aralzarov and Alexander Ushkov at Moscow’s Institute for Control Science. In 1974, Kaissa won all four games at the first World Computer Chess Championship in Stockholm. Gift of Monroe Newborn, CHM# 102645348

4 In 1977, Ken Thompson (right), best known as the co-creator of the Unix operating system, and Joe Condon (left) designed and built Belle, a dedicated chess-playing machine connected to a minicomputer. Belle’s custom hardware and endgame database revolutionized computer chess. Courtesy of Bell Laboratories, CHM# L062302004

Larry Atkin (front) and David Slate's chess program dominated computer chess tournaments for nearly a decade, winning every championship except two in the 1980s. At the 10th Annual ACM Computer Chess Championship supercomputer-based Chess 4.9 won the tournament, followed closely by custom chess machine Belle. Sargon 2.5 the only microprocessor-based chess program in the tournament, came in an impressive seventh place. Gift of Monroe Newborn, CHM# 102645350

In 1968, David Levy played a friendly game of chess with Stanford professor John McCarthy. After the match McCarthy remarked that within ten years there would be a computer program that would defeat Levy. Levy bet McCarthy 500 pounds that this would not be the case. In August 1978, Levy (shown here) won the bet when he defeated Chess 4.6, the strongest chess playing computer of the day. Gift of David Levy, CHM# 102634530

In this period, chess software also made dramatic progress. The programs CHESS (developed at Northwestern University), the Russian KAISSA, and Thompson and Condon's Belle introduced several novel features, many of which are still used today. One of most powerful techniques was "iterative deepening," a technique that gradually increased the depth of the search tree that a computer could examine, rather than searching to a fixed depth. This allowed the most efficient use of the limited time each player was given to choose a move.

Although computer chess programs had improved significantly, they were still not a match for the top human players. In fact, in 1968 International Master David Levy made a famous bet against John McCarthy that no chess program would beat him for the next 10 years. The Canadian National Exhibition in Toronto in 1978 presented Levy with an opportunity to defend his bet. The top program, CHESS 4.7, would be participating in the tournament. "Until 1977," said Levy, "there seemed to be no point in my playing a formal challenge match against any chess program because none of them were good enough, but when CHESS 4.5 began doing well… it was time for me…to defend the human race against the coming invasion." Levy won his bet.

> Organizer Monty Newborn said of these tournaments: "Play was often interrupted to resuscitate an ailing computer or terminal. The audience howled with laughter. For the participants, however, it was a learning experience."

MIGHTY MICROS

Just as Levy was winning his bet, home computers, such as the Apple II, TRS-80 and Commodore PET, were introduced. It wasn't long after their introduction that programmers began writing chess programs for these machines so that anyone with a microcomputer could play chess against a computer.

Before these commercially available machines, the first microprocessor-based chess programs were produced by hobbyists who shared information openly through computer clubs and magazines. One of the first such programs was Microchess, written in 1976 by Peter Jennings. Microchess sold several million copies and demonstrated that there was an audience for early computer games. Interestingly, some of the early profits from Microchess were used by the company Personal Software, (which had purchased Microchess from Jennings), to help finance the marketing of one of the first spreadsheet programs, VisiCalc.

By the early 1980s, computer software companies and others began selling dedicated chess computers and boards. One of the most successful chess boards was the Chess Challenger, sold by Fidelity Electronics. Even though Chess Challenger played below amateur-level chess, the novelty of the product made it an instant success. Other consumer chess boards included interesting features such as feedback and evaluation, which allowed beginners to improve their game. Boris, a Chess Challenger rival, displayed messages in response to the player's moves such as: "I expected that."

Annual computer-to-computer competitions also stimulated improvements. The World Microcomputer Chess Championships (WMCCC) started in 1980. Funding came from chess software manufacturers, who hoped that placing well in the competition would lead to increased sales. Each year the top programmers refined their code in an effort to win the next World Championship title. Although this competitive atmosphere spurred the development of high-quality chess programs, many early participants lamented the loss of collegiality and openness. Some microprocessor-based programs began challenging mainframe and supercomputer-based programs. For example, in 1989, Sargon, running on a personal computer, defeated the chess program AWIT running on a six-million dollar mainframe computer.

CHALLENGING THE MASTERS

As computers steadily played better chess, some developers began to turn their attention to the ultimate challenge: defeating the best human player in the world. The Fredkin Prize, established by Ed Fredkin at Carnegie Mellon University in 1980, offered three prizes for achievement in computer chess. The top prize of $100,000 was for the first program to defeat a reigning World Chess Champion.

One of the major centers of such development was Carnegie Mellon University. In the mid-1980s, two competing research groups developed separate chess computers, one named Hitech and the

1 Microchess (shown here on the Radio Shack TRS-80, 1976), created by Peter Jennings, was the first commercially-available microcomputer-based chess program. It was first introduced in a small advertisement in the KIM-1 user magazine, known as KIM-1 User Notes. Courtesy of Peter Jennings and Digibarn, CHM# L062302022

2 By the early 1980s, computer software companies and others began selling dedicated chess computers and boards. Some consumer chess boards included interesting features, such as the Novag Robot Adversary (shown here) which used a robotic arm to move the chess pieces of the computer. It was programmed by David Kittinger in 1982 and used a Z-80 processor. Gift of Monroe Newborn, CHM# 102645420

3 The Sargon III (shown here running on an Apple II microcomputer) computer chess program was developed in 1984 by Kathe and Dan Spracklen, a husband and wife team. CHM# L062302024

Deep Thought I circuit board, 1988 ca., 102645419, Gift of Feng-Hsiung Hsu. Carnegie Mellon University students Murray Campbell, Feng-Hsiung Hsu, Thomas Anantharaman, Mike Browne and Andreas Nowatzyk developed custom chess machine Deep Thought I in 1988.

other ChipTest. While both machines took different programming approaches, they shared advances in custom chip technology, allowing them to further implement brute force search strategies in hardware that had previously been performed by software. This allowed faster and thus deeper searching.

Building on the initial ChipTest machine, the team developed a second machine, called Deep Thought, after the fictional computer in *The Hitchhiker's Guide to the Galaxy*. This machine won the Fredkin Intermediate Prize in 1989 for the first system to play at the Grandmaster level (above 2400). Both Hitech and Deep Thought won many computer-to-computer chess tournaments. More importantly, they stunned the chess community in 1988 by defeating human opponents, Grandmasters Arnold Denker (Hitech) and Bent Larsen (Deep Thought). Concurrently, microcomputers were steadily advancing, leading to David Kittinger's microprocessor-based program, WChess, which in 1994 achieved worldwide acclaim when it won against American Grandmasters at the Intel-Harvard Cup "Man vs. Machine" tournament.

> In 1982 at the North American Computer Chess Championships (NACCC), the $17,000 chess machine, Belle, beat the Cray Blitz program running on a $10 million supercomputer. It was a harbinger of how more nimble systems would meet, and ultimately bypass, the performance of much larger machines.

DEEP BLUE

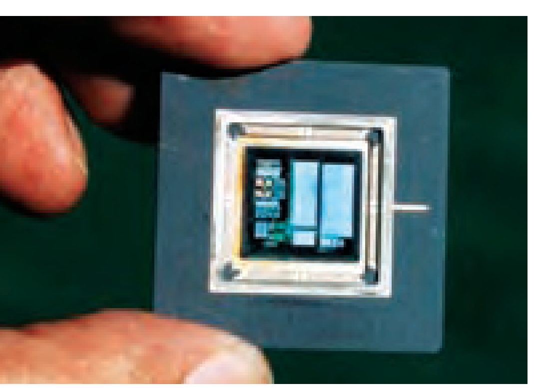
The goal to defeat the top human player seemed within reach and the recognition that would come to whoever built a system to do so got one company interested in the challenge: IBM. In 1989, key members of the Deep Thought team graduated and were hired by IBM to develop a computer to explicitly defeat reigning World Chess Champion Garry Kasparov. The first match took place at the New York Academy of Science in 1989. Kasparov's win was swift but the team learned many valuable lessons and spent the next seven years refining the machine's software and adding more custom processors.

In 1996, Deep Thought was renamed Deep Blue. By now it could examine 100 million chess positions per second (or about nine to 11 moves ahead). The team felt that Deep Blue was ready to face Kasparov again. At that year's ACM annual conference in Philadelphia, Deep Blue and Kasparov played a best-of-six game match. In the first game, Deep Blue made history by defeating Kasparov, marking the first time a current World Chess Champion had ever lost a game to a computer in a tournament. Kasparov bounced back, however, to win the match with a score of 4-2. At the end of the match, to the delight of the IBM team, Kasparov remarked, "In certain kinds of positions it sees so deeply that it plays like God."

Kasparov quickly agreed to a re-match challenge for the following year. To prepare, the team tested the machine against several Grandmasters, and doubled the performance of the hardware. A six-game rematch took place in Manhattan in May 1997. Kasparov won the first game but missed an opportunity in the second game and lost. He never recovered his composure and played defensively for the remainder of the match. In the last game, he made a simple mistake and lost, marking May 11, 1997, the day on which a World Chess Champion lost a match to a computer.

In spite of his loss, it is remarkable that a human could hold his own against a machine that could evaluate 200 million positions per second. For Kasparov, it was a novel forum: his typical psychological strategy of intimidation had no effect on Deep Blue, nor did the machine ever tire or get frustrated, factors which began to affect Kasparov's play as the match progressed. In fact, most observers felt that Kasparov beat himself by not playing his best during the match, though this should not detract from the achievement of the Deep Blue team.

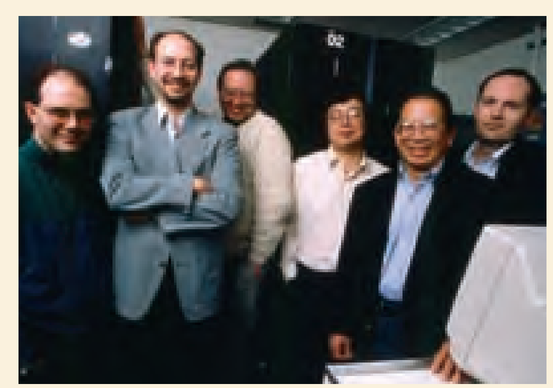
The popular media had portrayed the 1997 re-match as a battle between "man and machine." Kasparov also played along, proclaiming "playing such a match is like defending humanity." In fact, it was not a battle of man vs. machine at all. As philosopher John Searle suggests, the match was really about man vs. man, that is, Kasparov vs. Deep Blue's programmers, a view shared by most of them as well. Much like The Turk before it, Deep Blue's "magic" relied on human abilities hidden within a box, and on publicity and ballyhoo about the machine.



Deep Blue custom chess chip, version 2, 1997, 102645415, Gift of Feng-Hsiung Hsu. IBM's Deep Blue relied on custom chess chips designed by Feng-Hsiung Hsu. The chips, one of which is shown here, contained 1.5 million transistors and ran at 24 MHz. Although this chip contained only one quarter the number of transistors of a Pentium 2—the top microprocessor at the time—it was immensely powerful as a specialized chess processor.

Deep Blue (1997) was based on IBM's RS/6000 SP2 supercomputer, consisting of 30 processors in two towers (shown). The 480 identical custom chess chips (integrated circuits) were key to the system's performance as a chess playing machine. It calculated 200 million positions per second, at times up to thirty moves ahead. Courtesy of IBM Archives, CHM# L062302016

World Chess Champion chess player Garry Kasparov (shown right) was defeated by IBM's Deep Blue chess-playing computer in a six-game match in May, 1997. The match received enormous media coverage, much of which emphasized the notion that Kasparov was defending humanity's honor. Courtesy of Najlah Feanny/CORBIS SABA, CHM# NF1108205



To promote its image as a leader in computer technology, IBM supported the development of a computer that could beat the World Chess Champion. The Deep Blue team included (left-right) Joe Hoane, Joel Benjamin, Jerry Brody, Feng-Hsiung Hsu, C.J. Tan and Murray Campbell. IBM also hoped that this research might have applications to complex problems in business and science. Courtesy of IBM Archives, CHM# L062302000

WHAT'S NEXT?

Today, computer chess programs that play as powerfully as Deep Blue run on personal computers as well as portable chess machines that fit in a pocket. This shrinking has interesting effects on observers: Deep Blue, made up of two imposing seven foot tall cabinets with blinking lights is much more impressive than its rough equivalent today, something the size of a cellular phone. While many might have thought Deep Blue was intelligent, it is much harder to consider something that fits in one's pocket as being so. Nonetheless, the quality of these programs is remarkable: they can defeat over 99% of all human players and cost well under $100. Grandmasters and World Champions alike use them to train for play, both against machines and other humans. The way the game is taught and played is different: a 16-year-old novice, for example, with access to all of a Grandmaster's games on the Internet, could conceivably defeat him by exploiting a weakness revealed during a computer simulation of such games.

In spite of the millions of positions per second being evaluated, computers and humans (at the highest level) are still very closely matched. To date, for example, there have been only two other matches between a computer and a World Chess Champion and both have ended in ties.

Deep Blue defeated the best human chess player using large amounts of calculation. But was it a thinking machine? As Murray Campbell, Deep Blue team member, pointed out, "I never considered Deep Blue intelligent in any way. It's just an excellent problem solver in this very specific domain." Campbell's remarks bring to mind Alan Turing's observation that to determine whether a machine is intelligent requires only that it fool a human into believing so. In other words, there is no objective test for intelligence that lies outside of human perception. Though some argue that human thinking is simply a form of calculation and therefore amenable to computer simulation, many disagree. Beyond extremely impressive achievements in specific domains—which will have far-reaching effects on our lives—a machine that can reason in general terms is still quite a few years and many startling breakthroughs away.

Dag Spicer is senior curator at the Computer History Museum and Kirsten Tashev is vice president of collections and exhibitions.

THE HISTORY OF COMPUTER CHESS:

AN AI PERSPECTIVE

CAMPBELL FEIGENBAUM LEVY MCCARTHY

Presented September 8, 2005 • Computer History Museum, Hahn Auditorium

PERSONAL STORIES, CONTROVERSIAL OPINIONS, FRESH CHALLENGES

Murray Campbell, Deep Blue Project, IBM Corporation
Edward Feigenbaum, Stanford University
David Levy, Int'l. Computer Games Assoc., International Master in Chess
John McCarthy, Stanford University
Monty Newborn, Moderator, McGill University

COMPUTER HISTORY MUSEUM

Find the video files at: **www.computerhistory.org/core**

THE INNOVATORS HAVE SOMETHING TO SAY ABOUT COMPUTER CHESS

JOE CONDON KEN THOMPSON

PERSONAL INTERVIEWS NOW ONLINE
(audio files and written transcripts):

Hans Berliner // Feng Hsuing Hsu // Richard Greenblatt // David Levy // Peter Jennings // Alan Kotok // Harry Nelson // Monroe Newborn // Kathe and Danny Spracklen // Ken Thompson

COMPUTER HISTORY MUSEUM

www.computerhistory.org/chess

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EXPLORE THE COLLECTION

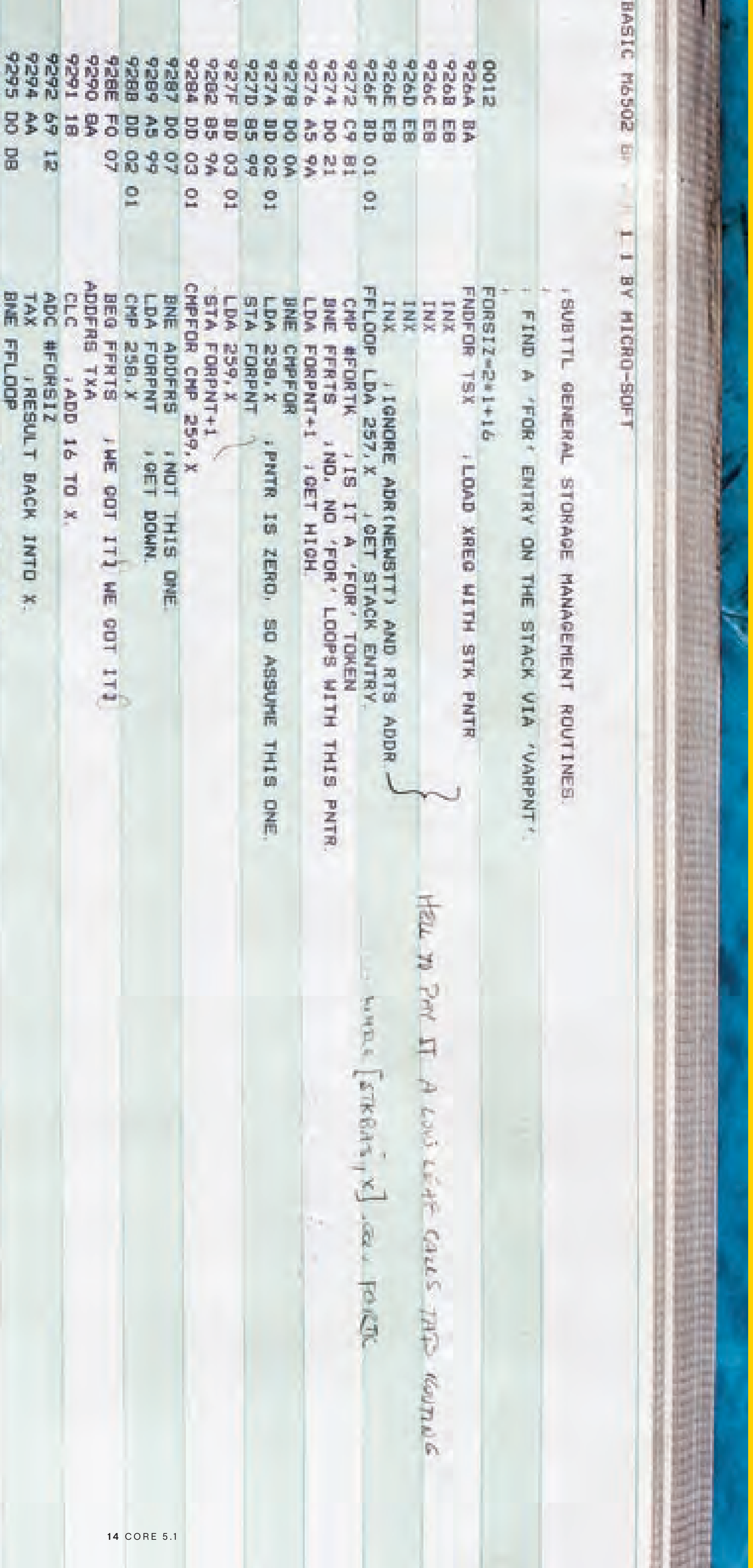
OBJECT

Google corkboard server rack
Date: 1999
Collection: Object
Donor: Gift of Google
CHM#: X2839.2005

Google's use of inexpensive personal computers as the backbone of its search engine was born of necessity since founders Larry Page and Sergey Brin did not have much money for equipment. By building a system based on commodity PCs, Google's aim was to maximize the amount of computational horsepower per square foot at low cost.

This do-it-yourself rack was one of about 30 that Google strung together in its first data center. Even though several of the installed PCs typically failed over time and could not be repaired easily, these "corkboard" server racks—so-called because the four PC system boards on each of its trays are insulated from each other by sheets of cork—launched Google as a company.

—Chris Garcia



EXPLORE THE COLLECTION
SOFTWARE

Listing of Micro-Soft BASIC source code with handwritten notations
Date: 1976
Collection: Software
Donor: Gift of David Gjerdrum
CHM#: X2977.2005

Few pieces of software were more important to the early history of personal computing than Micro-Soft BASIC. Initially developed at Dartmouth in the early 1960s, Micro-Soft's BASIC was one of the first languages converted for use on microcomputers. This made BASIC the most shared and copied program over the first years of homebrew computing. The fact that everyone shared (copied) the program led to the famous "open letter" from Micro-Soft head Bill Gates, who denounced the practice and brought the concept of software piracy to light.

This listing shows source code for the 8K version of BASIC 1.1 (for the 6502 microprocessor) that Micro-Soft released in 1976. The donor made several hand-written notes in the margins. This sort of documentation, complete with notation, is rare and helps researchers understand the methods of use, the roads not taken, and the ways in which software evolves.

The museum's collection includes several versions of Micro-Soft BASIC in various formats, including paper tape and cassette as well as early hobbyist magazines that discuss both the advantages and disadvantages of Micro-Soft's version of the language.

—Chris Garcia

EXPLORE THE COLLECTION
DOCUMENT

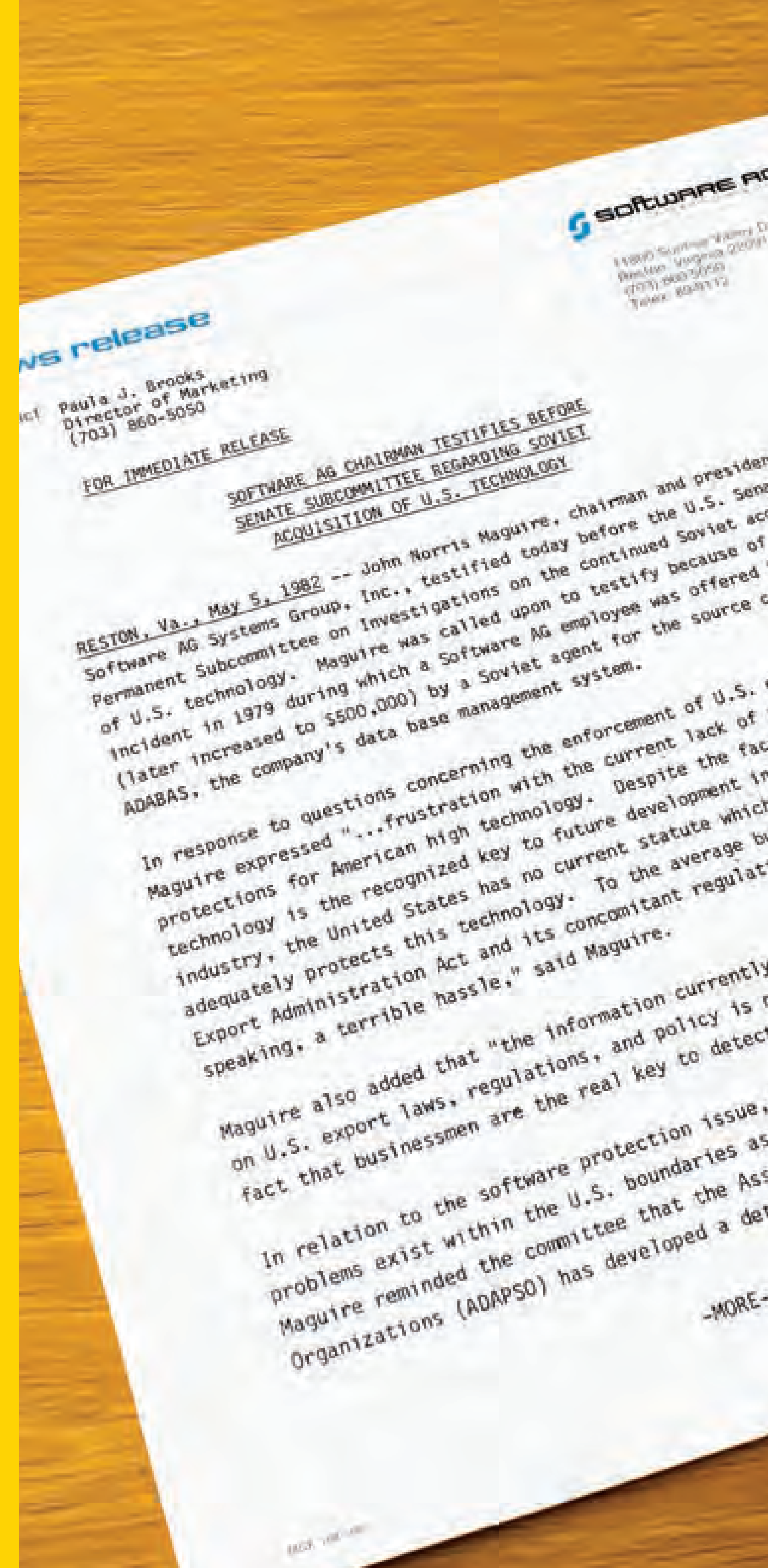
News release, Software AG of North America
Date: May 5, 1982
Collection: Document-text
Donor: Gift of John Maguire
CHM#: 102641740

Espionage and senate hearings: it's all in a day's work for the museum's Information Technology Corporate Histories Project (ITCHP). This May 5, 1982 news release from Software AG of North America announces that company president John Maguire gave testimony before the U.S. Senate Permanent Subcommittee on Investigations regarding the continued Soviet acquisition of U.S. technology. Maguire provided a first-hand account of the personal interactions that he and other Software AG employees had with Soviet agents over several years, beginning in 1979. That year, Maguire was contacted by a Soviet agent who sought to purchase the source code for Software AG's database management system, ADABAS. Without the agent's knowledge, Maguire notified the FBI of the agent's attempt to obtain the technology. Maguire then cooperated with the FBI by tape-recording conversations with the agent regarding a possible transaction. Thanks to Maguire's cooperation, the agent was eventually charged and sentenced for his efforts to obtain the source code.

The complete document and many others related to the case, including Maguire's full statement are available on the museum's website.

Supported by a grant from the Alfred P. Sloan Foundation, the ITCHP's objective is to construct and preserve a database of historical source materials for approximately thirty information technology companies using the Internet to both collect the materials and to provide access to them. Materials being collected are personal recollections contributed in various forms (key entry, documents, photos, personal stories, etc.) by people currently or formerly affiliated with selected companies. The web site allows people to add stories to the database, comment on stories submitted by others, and engage in discussions with other contributors.

—Sarah Wilson



COMPUTER MARKETING TODAY DIRECTS THE WEB SURFER TO A GLEAMING ARRAY OF PRODUCTS JUST A MOUSE CLICK AWAY. BUT HOW HAVE THE WAYS COMPUTERS HAVE BEEN SOLD CHANGED OVER TIME TO REFLECT THE LARGER PUBLIC PERCEPTIONS OF WHAT COMPUTERS ARE AND WHAT THEY MEAN TO US?

SELLING THE COMPUTER REVOLUTION

BY PAULA JABLONER

A 39" x 12" poster depicts marketing brochure covers from the museum's collection of historical marketing materials (1948-1988). Learn more at the museum's latest online exhibit at **www.computerhistory.org/brochures.**

The posters are on sale at the museum's gift shop. (1185 Design, Palo Alto, California)

THE HISTORY OF COMPUTER MARKETING provides a fascinating window into how popular perceptions and the common understanding of computers have changed. The omnipresent nature of computers in 21st century everyday life, where a new tech gizmo is announced daily, begs the question of how computers were first sold and to whom? The Computer History Museum's new online exhibit *Selling the Computer Revolution: Marketing Brochures in the Collection* provides materials that can help answer this question by providing a view into the evolving world of computer sales over four decades.

The exhibit presents 261 brochures, just a small sampling of the Computer History Museum document collection, estimated at 12 million pages or 4,000 linear feet. The curatorial staff selected materials that were eye-catching and reflected a diversity of decades, companies (both well-known & short lived), applications (i.e. personal, business, scientific etc.) and categories (i.e. mainframes, input-output, software etc.). Additional effort was made to include brochures that sold software or were directed toward the technologically-savvy individuals of the time.

THE FIRST MARKETING BROCHURE // In the earliest years of electronic computers, the first customers were large: typically government agencies, such as the American Census Bureau, or insurance companies. The Eckert-Mauchly Computer Corporation, produced a brochure in 1948 (see pg. 18, item A) for their new UNIVAC computer that made interesting claims, either visionary or foolish, depending on your point of view:

> WHAT'S YOUR PROBLEM? Is it the tedious record-keeping and the arduous figure-work of commerce and industry? Or is it the intricate mathematics of science? Perhaps your problem is now considered impossible because of prohibitive costs associated with conventional methods of solution. The UNIVAC* SYSTEM has been developed by the Eckert-Mauchly Computer Corporation to solve such problems. Within its scope come applications as diverse as air traffic control, census tabulations, market research studies, insurance records, aerodynamic design, oil prospecting, searching chemical literature and economic planning.

In 1951, the first UNIVAC was delivered to the U.S. Census Bureau. Remington Rand, which had bought out the two inventors the year before, created a "UNIVAC Division," and eventually delivered 46 machines at prices of over $1 million each.

1950s: TRADITION DOMINATES IN THE FACE OF INNOVATION // The UNIVAC brochure (possibly the first computer marketing brochure) does not accurately represent the marketing strategies typically developed in the 1950s when computers were usually marketed as "super-calculators," not general-purpose machines. Marketing materials were usually narrowly targeted to either business or scientific users, rather than both, as UNIVAC attempted.

Underwood was one of about 30 firms entering the computer business by the early 1950s. In 1956, their *Elecom "50," The First Electronic Accounting Machine,* was deliberately not marketed to businesses as a "computer," but rather for its "accurate-low cost accounting," which positioned it as an advanced calculator (see pg. 18, item B). Marketing that emphasized similarity to earlier products promoted acceptance of a new product by making it seem to be an extension of existing equipment and techniques.

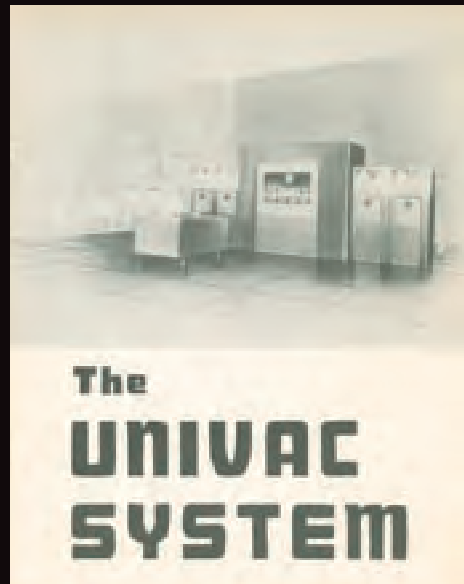
Yet Elecom is a word created from the first three letters of electronic computer. The brochure iconography uses the canonical stylized Bohr model of the atom so effectively used throughout the 1950s as shorthand for "modern," "space-age," and "advanced."

BUTTONED-UP COMPUTING // As is typical of the computer industry "life-cycle," by the early 1960s, many of the office products vendors had already left the business, including Underwood. The Control Data 160-A Computer brochure from 1962 markets the same computer for commercial and scientific uses while squarely selling the machine as an electronic computer— not an advanced calculator (see pg. 18, item C).

Fourteen years after the first UNIVAC brochure, Control Data makes many similar claims, advertising the 160-A for "general data processing...data acquisition and reduction...peripheral processing...scientific computing with FORTRAN...civil engineering problems...biomedical experimentation and analysis." The 160-A is a "low cost" scientific wonder. The technologically savvy person and/or the businessman could read more than five pages of specifications, including that of a magnetic core memory "consist[ing] of 8,192 words...divided into two banks of storage—each with a capacity of 4,096 12-bit words and a storage cycle time of 6.4 microseconds." The 160-A was sold as a serious business or scientific tool, with men in suits operating the machine that retailed for $60,000.

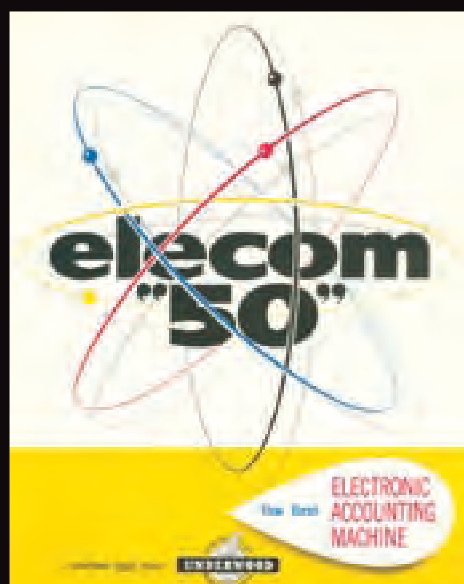
FASHION COMPUTING // In sharp contrast to the brush cut and slide-rule culture of the scientific user, the 1966 Electronic Associates, Inc. brochure for their *640 Digital Computing System* represents an unusual front cover and perhaps the first computer photo shoot that acts in imitation of fashion photography (see pg. 18, item D). Though not Miami Beach, the computer is fully accessorized with peripherals, posing in an outdoor courtyard replete with a model lounging by the fountain. For the bargain minded, the 640 was available at prices starting below $30,000.

> Most important, the EAI 640 strikes a balance between the work it can do and the cost to do it. Simply stated, balance means value. The EAI 640 Digital Computing System offers the best value available in small scale computer systems.



Item A
Eckert Mauchley Computer Corporation Univac System, 1948 (front cover) CHM # 102646308

Item D
EAI 640 Digital Computing System, 1966 (front cover) CHM# 102646101



Item B
Underwood Elecom "50" the First Electronic Accounting Machine, 1956 (front cover) CHM# 102646271

Item E
Digital Equipment Corporation PDP-11 time sharing, 1970 (front cover) CHM# 102646128

Item C
Control Data Corporation 160-A Computer, 1962 (front cover) CHM# 102646114

Item F
Leeco Inc., Is Software Development Getting You Down?, 1981 (front cover) CHM# 102646182

By the mid-1960s, advertisers were stressing the flexibility, versatility, expandability, and capacity of the computer to make logical decisions. The computer had come a long way, from being an "advanced calculator" to part of a complete information management system.

MINIS EVERYWHERE // By 1970, the tenor of computer marketing had changed again due to the expanding markets achieved with lower cost minicomputers and timesharing services. The DEC PDP-11 brochure shows the joint evolution of the minicomputer and mini skirt (item E). It is one of the first brochures with women appearing in non-traditional roles. On page five, two women are shown in white lab coats while pursuing research. Possibly this is why the brochure emphasized hard-to-find clerical workers.

> One of the most difficult problems facing business today is increasing the productivity of costly, hard-to-find clerks and secretaries. RSTS-11's power and flexibility offer the benefits of reduced costs, increased customer satisfaction, and increased job satisfaction for clerical workers.

Many advertising campaigns of the 1970s focused on revolutionizing the office through the promise of office automation with a PDP-11, starting at just $20,000.

COMPUTING FOR THE MASSES // Is Software Development Getting You Down? Some brochures were just too eye-catching to pass-up, such as Leeco's 1981 Dimension software (item F), which assisted programmers in writing software. Like so many other marketing materials, the brochure's pitch centered on taking "advantage of state-of-the-art technology while slashing costs."

Twenty-five years after the Elecom "50," technology professionals are starting to forego business attire. Any brochure before the 1970s would have shunned the rolled up sleeves, off kilter ties and chaos depicted in this front cover image. The brochure also illustrates another persistent aspect of the computer industry–short-lived companies. Just as Underwood stopped producing computers by 1960, we are so far unable to locate any information about Leeco.

The 1980s and onward saw the mass marketing of computers as they started becoming ubiquitous in everyday life. But the industry first had to convince people that they needed a computer in their home by encouraging the belief that innovations in the computer industry would make life better. For popular appeal, computer companies made use of well-known celebrity spokespersons such as William Shatner for Commodore or Jack Nicklaus for Atari, along with the use of popular media (TV and mass market periodicals for the first time) and imagery.

One of the most famous TV ads of all time may still be Apple's "1984" Super bowl commercial. Playing on Orwellian themes of centralized, bureaucratic control–a reference to IBM's perceived dominance of the computer market–Apple introduced their new personal computer with, "On January 24 Apple Computer will introduce Macintosh. And you'll see why 1984 won't be like 1984."

The personal computer industry has been spectacularly successful. In 1984, as the first Mac was being marketed, 8% of American households owned computers. Almost 20 years later in 2003, 62% of American households (70 million), had one or more computers (55% with Internet access). What a dramatic change from the 1950s, when marketing consisted of extremely targeted mailings to a very small group of interested professionals.

It is 2030 and the Computer History Museum's "Selling the Computer Revolution"–version 10 has just been announced. What will bring smiles from 2006? The 2006 Consumer Electronics Show, just might provide some intriguing possibilities. Many of the pitches revolve around celebrity, fashion, and size. Will the descendents of the iPod be just as fashionable in 2030?

> Our Smallest iPod Yet
> The size of a pack of gum, iPod shuffle weighs less than a car key. Which means there's nowhere your skip-free iPod shuffle can't go. And it makes a tuneful fashion statement. Just throw the included lanyard around your neck and take a walk." [emphasis added]

Appearances by actors Robin Williams and Tom Cruise make it apparent that celebrity marketing is here to stay in the electronics industry. Unlike William Shatner hawking Commodores over 20 years ago, now many technologists have become superstars in their own right–think "Steve, Bill, Larry and Sergey!"

The staff, volunteers and interns working on the project had a great time reflecting upon the technological advances, marketing strategies, and iconographic changes in the world of tech marketing while creating the website. We hope you'll enjoy the exhibit just as much. Though not celebrities, we hope you've read our marketing pitch–so go turn on that computer, type in www.computerhistory.org/brochures and explore the 261 brochures through curated topics–decades, categories and applications–or a keyword search.

Paula Jabloner is archivist at the Computer History Museum.

SELLING THE COMPUTER REVOLUTION: ONLINE EXHIBIT BY THE NUMBERS

COMPANIES

- 91: Represented in website exhibit
- 20: Brochures for IBM (largest representation)
- 12: Brochures for Hewlett-Packard (2nd largest representation)
- 17: Brochures with UNIVAC in the title
- 49: Companies with just one representative brochure

PROJECT

- 261: Brochures included in website
- 2871: Pages scanned
- 17: People helped create the site
- 455: Intern hours
- 39: Minutes—average time to catalog one brochure
- 1: Website created

DATES

- 1948-1978: Date range of UNIVAC brochures
- 1948-1988: Years covered in collection (40)

EXPLORE THE COLLECTION
MEDIA

He Saw the Cat: Computer Speech, 45 RPM record
Date: 1963
Collection: Media
Donor: Gift of Warren Yogi
CHM#: X3119.2005

Bell Labs was one of the earliest research groups to explore computer speech. During the late 1950s and early 1960s, various scientists there undertook research in computer voice synthesis for possible application to the telephone system.

While they sound primitive today, these early experiments reflected one of the most important research programs in the world attempting to place computer speech on a firm scientific foundation.

The highlight of this recording is the song "Daisy," performed on an IBM 7094 computer in 1961 with special speech hardware. When film director Stanley Kubrick heard this recording some time later, he decided to use a version of it to form the "dying" words of the ethically-ambiguous HAL 9000 computer in Kubrick's masterpiece, "2001: A Space Odyssey."

—Chris Garcia

Restoring the DEC PDP-1 Computer

Mike Cheponis

In the early 1960s, Bob Savelle used a light pen on the screen of the DEC Type 30 display, which was the display for the PDP-1. The power supplies in the Type 30 took many, many months to fix. This was, in large measure, because the restoration team didn't want to summarily replace the originals with modern units and because they had no schematics or other documentation of the supplies, which therefore required reverse engineering. CHM#: 102618913

Over the past two years, I've had the privilege of working with a dedicated, brilliant bunch of guys to bring one of the museum's PDP-1 minicomputers (first shipped in 1961) back to an operational state. The machine is currently restored, and will soon be moving from the restoration lab into the museum's demonstration area where it can be seen by all.

TIMELINE

The original proposal for restoration was written in 2001 when the museum was based at Moffett Field. Joe Fredrick, Eric Smith, and I produced our final proposal on November 4, 2003. The PDP-1 itself was running on May 18, 2004, and the complete machine was fully restored as of November 1, 2005, almost two years to the day since beginning of the project.

Team members have now begun working on the "maintenance phase" and will continue as long as we wish to keep the machine running.

GETTING STARTED

The team was comprised mostly of alumni of Dave Babcock's IBM 1620 restoration team, which pioneered the restoration program at the CHM, so we had a good idea of how to go about the project. We had the three of us (Joe as the hardware lead, Eric the software lead, and me), the machine, and a task.

We did no "recruiting" of restoration team members; we figured that if people wanted to help, they would hear about the new effort by the osmosis of being associated with the museum! In fact, that turned out to be a very good way to acquire team members, and our initial expanded team thus included: Bob Lash, Peter Jennings, Rafael Skodlar, and Al Kossow. Each member came with an impressive array of experience and passion.

Bob Lash had used a PDP-1 at Stanford; Peter Jennings brought a wealth of experience in electronics and old electronic equipment restoration; Rafael Skodlar used to be a DEC service technician on later DEC gear; and Al Kossow is a document scanning and software archiving wizard extraordinaire. Without Al's ceaseless efforts to acquire and scan in PDP-1 documentation and software, we would still be toggling in programs via the panel switches!

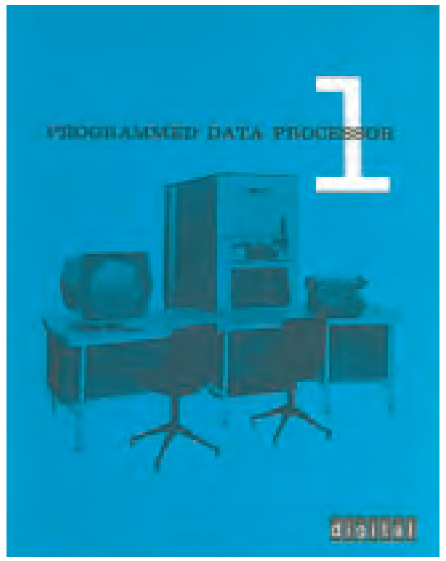
We decided to hold our restoration meetings on Tuesday evenings from 6-9 pm. We promised all that no matter how interesting or hopeful an effort might be, we would always be out of the lab by 10 pm. This scheduling and rule worked out quite well for this project.

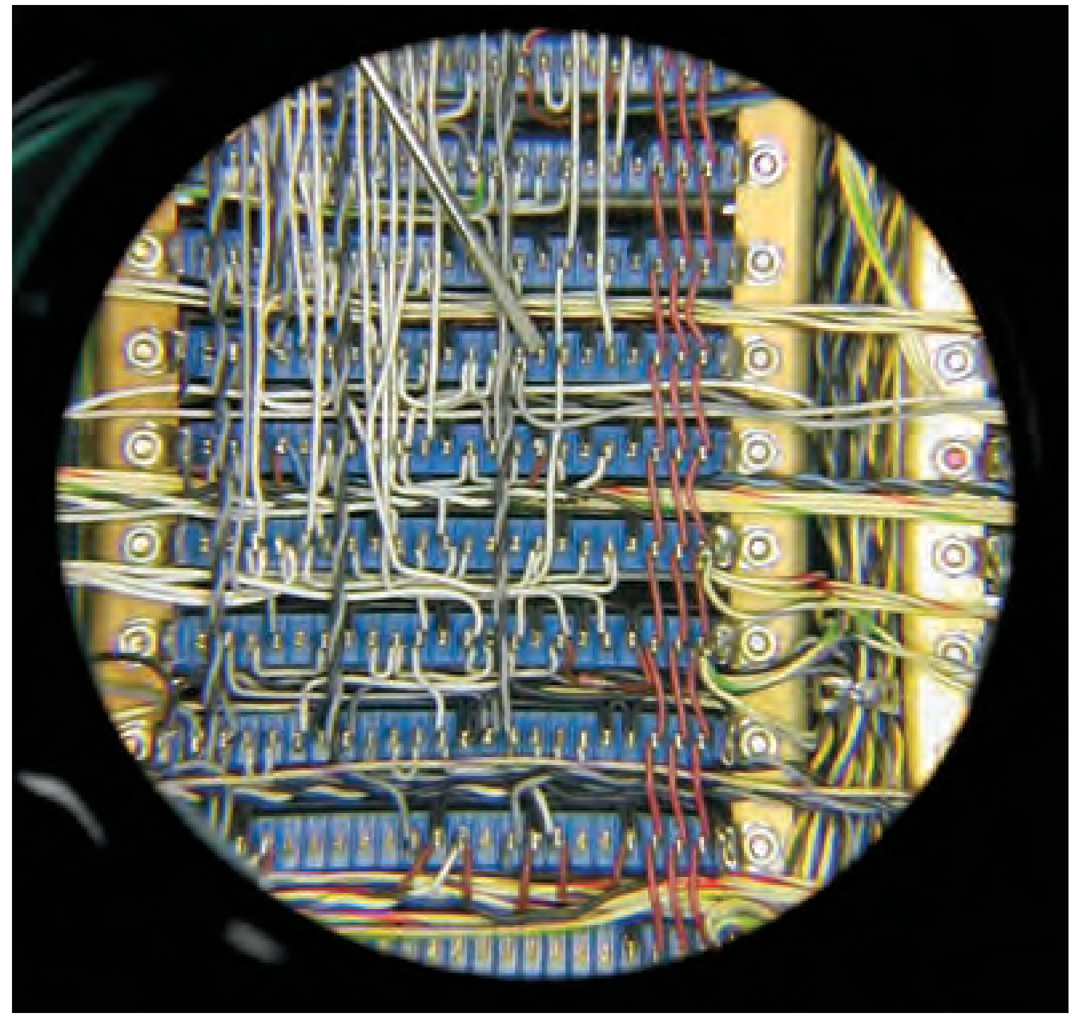
The team proceeded to do the things all restorations must do: Check and revivify the power supplies, inspect for missing or broken parts, replace dangerously frayed power cables, etc. In these early stages,

this page, left to right

Cover of 1963 Programmed Data Processor 1 (PDP-1) brochure. Read more about the museum's extensive documentation of marketing brochures on page 16. © Digital Equipment Corporation (DEC). CHM#: 102646296

Closeup of the PDP-1 backplane. During the restoration, the team was pleasantly surprised at how well the PDP-1's circuits had fared over the years.





Eric wrote a program to allow power supply capacitor "reforming" to the specs that Bob and Joe had prepared. This phase took about three months, consistent with the power supply timeline that had been required for the IBM1620 restoration.

ONGOING OPERATIONS

One of our buddies from the 1620 Restoration Project, electronics genius R. Tim Coslet, decided to join our group, and it took barely a nanosecond to have him welcomed to the team. You see, we had a few "ground rules" and one of them was that existing team members voted on whether a prospective member should join the team. Everybody got one vote, and it had to be unanimous.

This kept our team cohesive. Shortly afterward, Lyle Bickley, a well-known long-time restorer of vintage computers with a wealth of experience also joined the team.

One advantage of having more members on the team was the ability to attack several problems during the same work session. So, for example, while Joe and Bob were reforming capacitors, Rafael and Peter could be inspecting and repairing cooling fans, and Eric and Al could be reading in more PDP-1 software paper tapes.

In fact, the entire project was driven by a "checklist" that was written on the whiteboard. Checkmarks showed up as tasks were completed.

One "big" checkmark appeared on May 18th, 2004. On that day we got our first "toggled-in" program to run; it incremented the accumulator and then jumped back to the increment instruction, a two-word program. If you go to the website at www.computerhistory.org/pdp-1, you can click on a link that will show you the short movie we made that day. Incidentally, the reason we were so careful to use just a few words of main memory, which is good old 18-bit-word core memory, was so that we could read the contents of core and preserve it, as it is part of the artifact. Eric whipped up a USB interface to Linux, and a small amount of electronics allowed a bit-serial-type interface to dump the whole 12K (three 4K banks) of memory. We haven't tried to figure out what was there, but at least we can restore it bit-for-bit if we need to.

Naturally, the main reason for restoring the PDP-1 was to run the original computer game Spacewar!, which was written in 1962 in PDP-1 assembly language. We knew that having this program running and available to Museum visitors would bring back memories to old timers but would also help build a bridge between today's "MTV generation" and people who were their own age in the early 1960s.

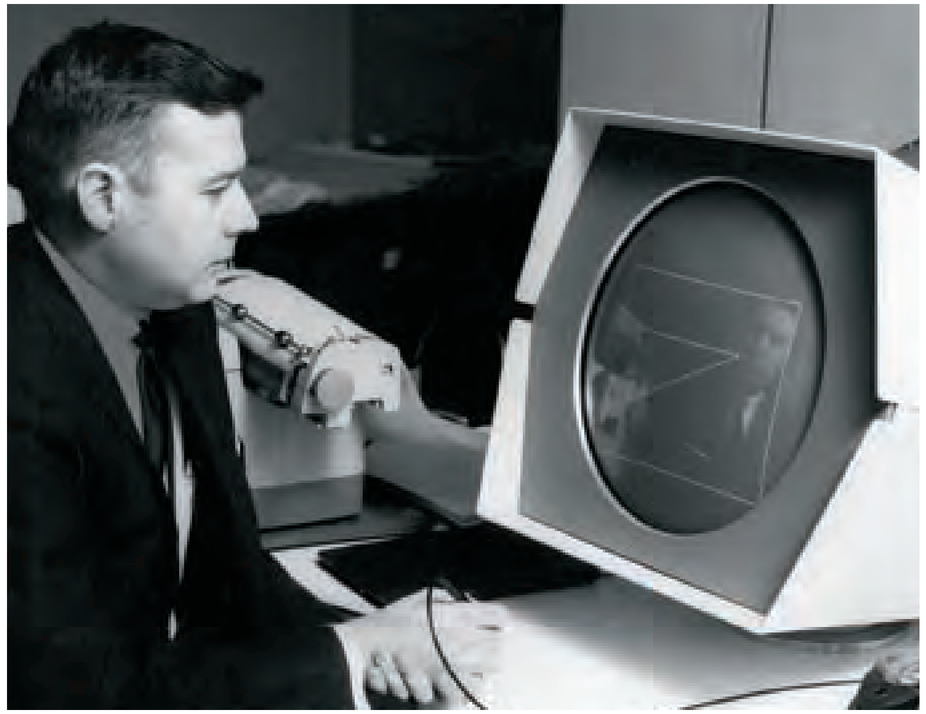
Right about this time, Peter Samson joined our group. Peter, you see, was one of the original contributors to Spacewar! (Steve Russell, who helped the team at our kickoff meeting, and who has all along helped via email, was the main Spacewar! creator, and he had help from Peter Samson, Martin Graetz, Wayne Witanen, Alan Kotok, and Dan Edwards.)

Peter also had a trick or two up his sleeve. It turned out that he had written a four-part, music-playing program "in the

right, top to bottom

In the restoration room, team members worked on various projects, from examining the PDP-1 backplane with a high intensity lamp to analyzing and repairing the paper tape punch in documented step-by-step methods. Then there's always the power supply to ponder!

It takes three to tangle with an old piece of hardware. The restoration team worked on every aspect of the PDP-1. Here they examine the front panel. Note the famous whiteboard in the background!



top to bottom

Around 1960, this man used a light pen on the screen to maniupulate a drawing on the PDP-1 display. CHM# 102652246

This photograph from about 1960 was most likely a promotional shot. Note the wooden floors, a legacy of the woolen mill that preceded DEC in this building. CHM# 102652245

day." And, thankfully, the museum had the various music data sets on paper tape. There was just one problem: Peter was unable to find his original source code. Well, for an ordinary mortal, this would have been a problem, but for Peter, well, obviously, the thing to do was to reverse-engineer the music data format, and then to re-write the program from scratch to play the music!

But, that wouldn't be enough. No, he would then proceed to use Bob Supnik's PDP-1 simulator to assemble and test his code (on a modern PC), and that turned out to be good. But a modern PC doesn't have four bits coming out of a register attached to speakers to make sound. And yet, when Peter's program was first run on the restored PDP-1, it played the music correctly and at the right pitch! So four-part music is also an important part of the upcoming PDP-1 display, thanks to Peter's efforts!

IT'S NOT REALLY THE PDP-1 PROJECT ANYMORE...

While it was a great feeling to have the main PDP-1 running again, the peripherals were not working except for the paper tape reader. It wasn't for lack of trying, it's just that mechanical monsters tend to be less reliable than the transistorized electronics in the PDP-1, and also tend to be more finicky.

But, just as the teacher arrives when the student is ready, Ken Sumrall arrived when the Soroban mechanical typewriter was ready. In fact, we had invited Ken, a well-known restoration enthusiast and museum volunteer, to view our first try at getting Spacewar! to work. Of course, it didn't work that night, but Ken was still hooked, and joined up to do mechanical work, mainly, at first with superman Rafael.

For the longest time, we all joked that this was no longer the PDP-1 restoration: it had become the "Type 30 Restoration Project"—the Type 30 being the model number of the DEC display. That peripheral has not a lot of electronics, but does have a lot of power supplies and of course a light-pen input device. The power supplies in the Type 30 took many, many months to fix, in large measure because we wanted to preserve the artifact as completely as possible (meaning we didn't want to just replace the original power supplies with modern units), and because we had no schematics or other documentation on most of these supplies, and therefore required reverse engineering. Eventually, the "50 Volt" adjustable power supply started to work after we fixed a cold solder joint, and the Type 30 has been reliable ever since. Ken and Joe worked on the light pen, which did require a modern 1 KV power supply because the original was potted shut and suffered a failed transformer (no replacement was available.)

Then there was the Soroban console typewriter. An early IBM electric typewriter with a modification unit attached to the bottom by the Soroban Company, it allowed the computer to actuate the printing mechanism, and also typing on the keyboard to be captured by the PDP-1.

Although we did have some documentation on the Soroban's operation, including a complete adjustment manual that Al Kossow found, it was still quite a task to get it working again. Ken wondered if it would ever work! And of course by that time, the project was being called "The Soroban Restoration Project"—not because everybody was working on the Soroban, but because it took months and months to finally "checkmark" on the whiteboard.

AND SO, IT WORKS!

You might ask, "Why did it take so long to restore this machine? After all, during its service lifetime, it darn well had better be put back into working order in a matter of days at most!" Well, yes.

We carried over Dave Babcock's "Principles of Restoration" from the IBM 1620 restoration project. We were always mindful that we were working on an artifact—that we were to "do no harm." Any decisions on this point were made as a group, and, even then, if we thought we needed further clarification or assistance, we didn't hesitate to contact Dag Spicer, the museum's senior curator, for advice.

Whenever a component was replaced, it was "tagged and bagged" and its replacement was marked with red nail polish or red tape. Removed old parts had recorded the date of their removal, the location from which they were removed, and the reason for their removal. Hundreds of components have been replaced, from the line cords on the cooling fans, to the bearings in the paper tape reader, to germanium transistors on logic boards.

We only worked on the machine about three hours per week. This was a volunteer effort, where the volunteers also paid for most of the replacement parts and tools out of their own pockets. Sometimes we were able to get manufacturers to send us free or low-cost samples, and a few times we did ask the museum for help.

Also, none of us was ever a PDP-1 repairman. We're electrical engineers and software engineers by training, so a lot of what we did was to study schematics, principles of operation manuals, and observe behavior to figure out what we should fix. Having had no history with fixing the machine previously, we also didn't know what the frequent failure modes were.

Lastly, we tended to be very conservative with our repairs. If we could test the problem on the bench and prove that we had a solution, then we'd proceed. Making test jigs, test procedures, and running them takes longer than swapping a few circuit cards and watching what happens.

But, after all, we have a working PDP-1 that has been carefully brought back to functioning. And we believe this is the only functioning PDP-1 in the world!

ETERNAL GRATITUDE

Besides the tremendous support given to the team by the museum when required, Robert Garner stands out as a major contributor to the project's success. Early on, he took an interest in the project and has donated boxes and boxes of spare PDP-1 modules that he was able to acquire.

PARADE OF VISITORS

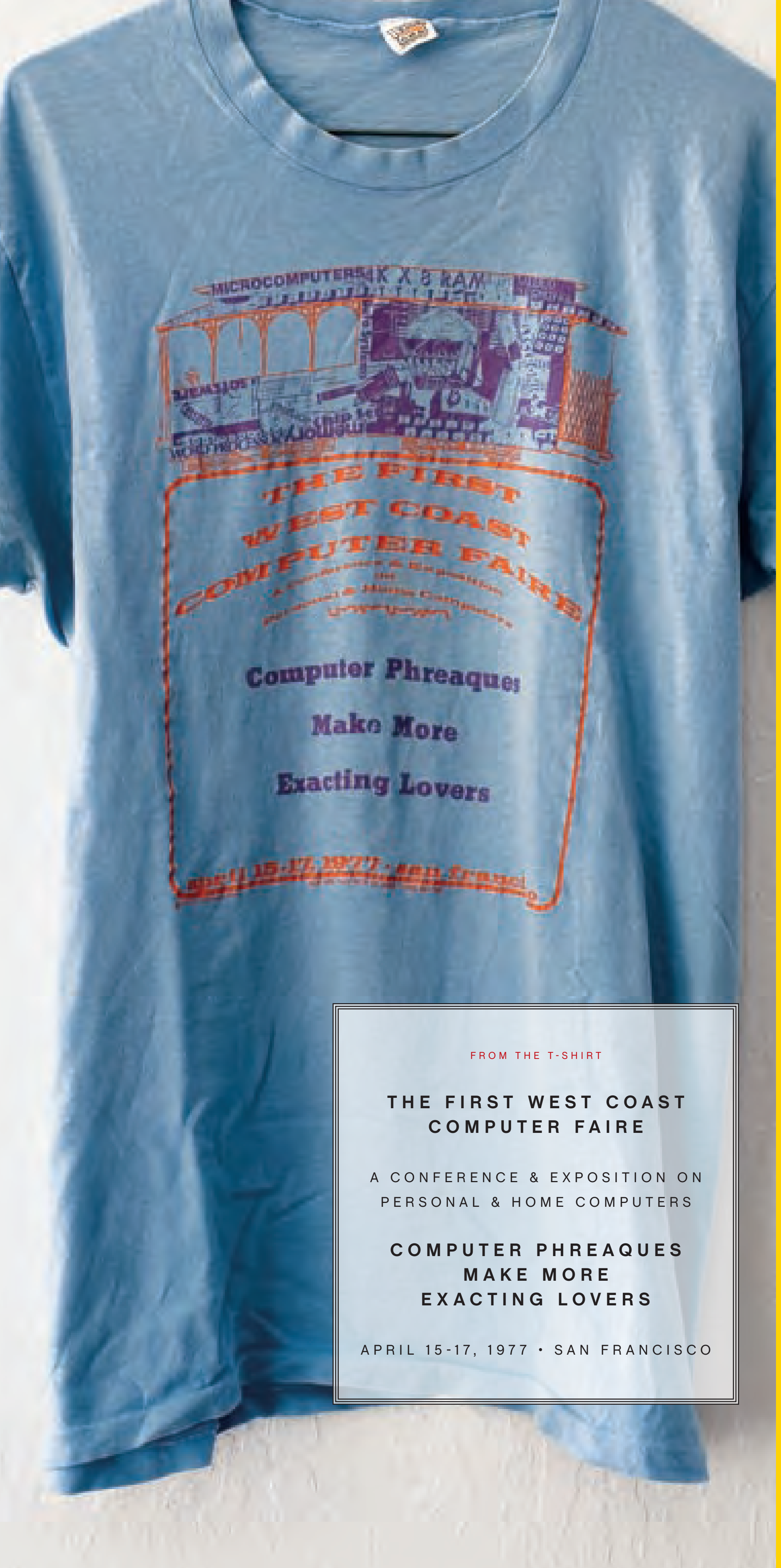
This story wouldn't be complete without mentioning some of the VIPs who have graced our PDP-1 since it became at least partially functional.

In November 2004, Lyle and I had gone to the lab to take some measurements for a replacement part on the paper tape punch. While we were minding our business, in trooped a cadre of folks, including museum CEO John Toole, board members Dave House and Len Shustek, and some guy who had just given a lecture upstairs... I think I got his name right, yes, it was Bill Gates! We demo'd Spacewar! and Bill told us about a baseball game he had written while at Harvard that used a PDP-1 display for output.

And there have been many other wonderful folk who've seen the machine working, usually playing Spacewar!, including Gordon Bell, Alan Kotok, Carver Mead, George Gilder, Bert Sutherland, Bob Sproull, Paul Baran, and many others.

I hope you will visit the restored PDP-1 at the Computer History Museum and experience a piece of living history!

Mike Cheponis first worked on the PDP-1 at MIT (located in 26-256, which also housed the TX-0) in 1972 when he was an undergrad. His love of all machines DEC continued and he was selected to be a co-op student at DEC Marlborough, employee ID 26571, working on DECsystem-10 OS software. Mike owns and operates California Wireless, Inc., a Silicon Valley consulting firm specializing in hardware and software for communications systems. He has a working DEC PDP-11/45 in his living room, and still remains married!



FROM THE T-SHIRT

THE FIRST WEST COAST COMPUTER FAIRE

A CONFERENCE & EXPOSITION ON PERSONAL & HOME COMPUTERS

COMPUTER PHREAQUES MAKE MORE EXACTING LOVERS

APRIL 15-17, 1977 • SAN FRANCISCO

EXPLORE THE COLLECTION

EPHEMERA

First West Coast Computer Faire T-shirt
Date: April 15-17, 1977
Collection: Ephemera
Donor: Gift of Richard Delp
CHM#: X3288.2006

Computer users have been meeting since the days of the first commercial computers, beginning in about the mid-1950s. These groups (such as SHARE for mainframes and later DECUS for minis) began as informal meetings for sharing ideas (and software) but quickly became regular, well-planned, elaborate forums for the exchange of scientific and professional information as well as the creation and renewal of personal contacts.

In 1977, as microprocessor-based computers began to be sold, Jim Warren and Bob Reiling organized the West Coast Computer Faire, which took place on April 15-17 at the Brooks Civic Auditorium in San Francisco, California. Exhibitors included the major computer kit companies like MITS and Digital Research, as well as computer and chip makers such as Intel and Commodore.

As had happened with their mainframe and minicomputer forebears, this annual conference became critically important to the success of both customers and computer makers. In fact, many historians consider this first Faire as the beginning of the microcomputer revolution.

It was at the first West Coast Computer Faire, for example, that two of the three most successful microcomputers were introduced: The Apple I (demonstrated by 21-year old Steve Jobs and Steve Wozniak) and the Commodore Pet. The success of the Faire led to the creation of other trade shows, including the hugely popular COMDEX.

—Chris Garcia

Joel Barr (left) and Alfred Sarant in 1944 in front of the apartment at 65 Morton Street in Greenwich Village, New York, where they microfilmed American military secrets for Soviet intelligence.

HOW TWO AMERICAN SPIES HELPED BUILD THE SOVIET SILICON VALLEY

BY STEVEN T. USDIN

In early 1973 an American spy operating under the cover name Philip Staros overcame his claustrophobia and squeezed into the crowded control room of a brand new Soviet Tango-class submarine as it plunged under the icy waters of the Baltic Sea. The largest diesel-powered submarine ever built, the Tango was created to elude and destroy American nuclear submarines.

Speaking confidently in flawless Russian, Staros was demonstrating to a group of Soviet admirals how the Uzel, the first digital computer used in a Soviet sub, could track several targets simultaneously and calculate how the torpedoes should be aimed and fired. He and another American, Joel Barr, known in Russia by the KGB-supplied alias Joseph Berg, had led the team that designed the Uzel.

The story of how Staros—whose real name was Alfred Sarant—came to be onboard that submarine, and of how he and Barr created the Uzel and many other advanced Soviet military technologies, begins in New York in the 1930s. It is a Cold War drama combining espionage, high technology, romance, and betrayal. And it hinges on a question that is as relevant today as it was seven decades ago: Why do intelligent young people dedicate their lives to ideological fantasies?

Six decades later, Barr vividly remembered the personal circumstances that led him to embrace communism as a teenager during the Depression. First there was a "tremendously harrowing scene" when marshals evicted his family from their Brooklyn apartment, then their shame at relying on charity for groceries, and finally the miserable tenement "with no toilet in the apartment, no hot water, only a coal stove for heat," and elevated trains roaring by twice per minute just feet from the windows.

The Communists' analysis, that the nation was run by and for a tiny, greedy elite that oppressed the workers, seemed plausible to Barr, as it did to thousands of other young people who grew up in the 1930s in New York's Jewish ghetto.

Barr enrolled in City College of New York (CCNY), the most radical campus in America, to study electrical engineering. Like other colleges it had two main political groupings; instead of identifying themselves as Democrats or Republicans, however, CCNY students' allegiance was divided between Stalin and Trotsky. The faculty published an underground Communist publication, *Teacher and Worker*, that echoed the *Daily Worker*.

Barr quickly associated himself with the Stalinists and joined a Young Communist League chapter headed by Julius Rosenberg.

After graduating, Barr, Rosenberg and many of their CCNY friends joined the Communist Party. Their world was turned upside down on August 21, 1939, by news of the Nazi-Soviet Pact. Barr's friends remained in the Party and, as Jews who understood Hitler's intentions, in doing so they crossed the line from the left edge of the political spectrum into the territory of the zealot.

After a decade of economic depression, Barr and his comrades considered themselves fortunate to find any work, so they took jobs with virtually the only employer that was hiring, the military.

When Barr started at the U.S. Army Signal Corps Laboratory in the summer of 1940, everything about the technology he worked on, even the word "radar," was a military secret. Although the job was intellectually stimulating, contributing to the war effort was troubling to Barr and his comrades. The Communist Party of the U.S., following the line dictated by the Kremlin, was stridently opposed to American preparation for war or assistance to Great Britain.

Rosenberg conceived of a way out of the dilemma, a solution that would allow dedicated communists to work for the military while remaining true to their ideals. The answer was staring them in the face every day: the blueprints and manuals they worked with could be of great value to the Soviet Union.

Rosenberg started down the road to becoming a spy before German troops crossed into Russia—that is, at a time when Stalin was allied with Hitler and there was every reason to expect that information given to Moscow would be sent on to Berlin. He and Barr volunteered their services as Soviet patriots.

Members of the Rosenberg ring were optimally placed to obtain valuable technical information. While senior scientists were subject to strict security measures, including compartmentalization, the CCNY graduates designed manufacturing processes and performed quality-control inspections at factories. They needed to know how weapons were built and were encouraged both to study related weapons and to bring their work home.

SECRET DOCUMENTS THAT BARR AND HIS COLLEAGUES SLIPPED TO SOVIET INTELLIGENCE HASTENED THE RED ARMY'S MARCH TO BERLIN, JUMP-STARTED ITS POST-WAR DEVELOPMENT OF NUCLEAR WEAPONS AND DELIVERY SYSTEMS, AND LATER HELPED COMMUNIST TROOPS IN NORTH KOREA FIGHT THE AMERICAN MILITARY TO A STAND-OFF.

The Russians merely had to supply Leica cameras for microfilming and provide their agents with rudimentary training in spy craft to minimize the chances that their activities would be detected. The amateur spies were more talented at stealing and copying classified information than at covering their tracks. But, their astounding successes were made possible by U.S. counterintelligence, which was fixated on Nazi espionage and viewed domestic communists as potential subversives, not industrial spies.

The FBI aggressively searched for communists in sensitive government jobs, but it took half-hearted actions when it found them. When the Bureau alerted Army counterintelligence that Barr was a secret member of the Communist Party, he was quickly fired, an act which should have been the end of his career in military electronics and thus as a Soviet spy.

Barr wasn't out of work long, however. Within three weeks he was working for Western Electric Corp. and had access to some of the most sensitive defense-electronics secrets in the American arsenal. Rosenberg and other members of their espionage ring had similar experiences.

Barr recruited Sarant to assist with extracting and microfilming classified documents. Together Barr and Sarant gave the USSR over 9,000 pages of documents detailing over 100 weapons systems, including not only the most advanced land- and air-based radar systems used to track aircraft, guide bombs and locate enemy submarines, but also analog computers and insights on manufacturing techniques. Other members of the Rosenberg ring provided Russia with the proximity fuse and 12,000 pages of blueprints for the first American jet fighter.

Secret documents that Barr and his colleagues slipped to Soviet intelligence hastened the Red Army's march to Berlin, jump-started its post-war development of nuclear weapons and delivery systems, and later helped Communist troops in North Korea fight the American military to a stand-off.

By June 1947 security procedures at defense contractors had tightened up a bit and Barr's employer, Sperry Gyroscope, contacted the FBI to ask about his reliability. A quick inspection of the Bureau's files revealed that he'd been fired as a communist five years previously. The FBI interviewed two of three references Barr had provided Sperry, but they provided no useful information. Inexplicably, the third reference was never contacted; his name was Julius Rosenberg.

When Sperry fired Barr in October 1947, he figured that his career was over at a minimum, and that he might be in danger. He sold all of his belongings, collected some cash from his KGB contacts, and made plans to travel. Barr told his girlfriend that he planned to try to visit the Soviet Union to get a first-hand look at communism.

Barr remained in covert contact with the KGB as he traveled in Europe, enjoying a bohemian life. He arrived in Paris on July 4, 1949, and convinced Olivier Messiaen, a world famous avant-garde composer, to accept him as a student.

Events at home, especially newspaper stories about the arrests of Soviet spies, troubled Barr. Worry turned to panic in June 1950, when the arrest of Ethel Rosenberg's brother, David Greenglass, was announced. It was clear that the cloak of secrecy around his espionage was unraveling.

The morning after newspapers reported Greenglass's arrest, Barr walked out of his Paris apartment carrying a single bag, with a viola slung over his shoulder. As far as subsequent FBI and CIA investigations launched about a month later could determine, he vanished at this moment. For more than three decades, no one in the West knew where Barr was, or even whether he was alive or dead.

In fact, the KGB helped Barr escape to Prague, where they gave him a new identity. For the rest of his life, Barr told friends, family and colleagues that he was born in Johannesburg, South Africa. His new name, Joseph Berg, was a KGB joke: he was Joe Berg from Jo'burg.

Barr's former partners in espionage weren't as well placed to disappear. In addition to the Rosenbergs, other members of the ring were tracked down and arrested.

The FBI knocked on Sarant's door in July 1950. Rather than immediately arrest him, the Bureau interrogated Sarant intensively for a week, hoping that he would crack. Sarant kept his cool, however, and managed to give the FBI the slip. Accompanied by Carol Dayton, a neighbor with whom he'd been having an affair, Sarant escaped to Mexico. Each left a spouse and two young children behind.

Sarant and Dayton contacted Polish intelligence officers in Mexico City. Their escape was straight out of a spy novel, including hiding in safe houses for months, wearing disguises, carrying false passports, waiting for a moonless night to wade across a river

Two pages from Joel Barr's address book. On the left, his KGB-supplied "legend," with imaginary birth and death dates for his parents and details of his putative South African education. On the right, reminders of logistics for clandestine meetings in Prague (Staro is an abbreviation for Staromestske, the Old Town Square in the heart of Prague). Barr could arrange a meeting with his KGB contact by telephoning a certain number and introducing himself in German; a paper slid under his door would summon him to a meeting.

The Scientific Center at Zelenograd, headquarters for the Soviet Union's version of Silicon Valley.

into Guatemala, and sailing to Casablanca in the hold of a Polish cargo ship.

The American couple were stashed in Warsaw for half a year and then sent to Moscow. Barr, who had been working as an engineer in Prague, was brought to the Soviet capital for a dramatic reunion with his old friend.

Sarant, who was given the name Philip Staros, presented himself to the Russians as a brilliant engineer who had been thwarted because of his communist beliefs. The KGB believed him, or at any rate was willing to let him prove himself.

The trio was sent to Prague, where Sarant and Barr were put in charge of a team of engineers and tasked with creating a computerized anti-aircraft weapon. They succeeded, building an analog computer that received input from radar, predicted a plane's future path, and controlled artillery. The first computerized anti-aircraft weapon built in the Soviet bloc, it was still in use with minor modifications at least into the late 1980s.

Eagerly accepting a subsequent invitation to put their skills to work in the Soviet Union, Sarant and Barr, Dayton, and Barr's Czech wife, moved to Leningrad in January 1956. Sarant and Barr's first project was to design a component for the equipment that tracked the Sputnik.

In July 1959, a team led by Sarant and Barr created a prototype of a new computer, which they dubbed the UM-1. The UM-1 achieved a number of Soviet firsts; among them, it was the first Soviet computer to use transistors. In contrast to the room-sized monsters produced by other Soviet computer designers, the UM-1 was small enough to fit on a kitchen table and light enough for one person to lift, and it required about the same power as a light bulb.

This success led to an expansion of their team to about 2,000 people over the next two years. They designed another computer, a civilian version of the UM-1 called the UM-1NKh, which was eventually put into production and was widely used in applications such as steel plants and nuclear power stations.

Barr and Sarant then went to work on a much more advanced computer, an all-purpose computer for use in airplanes, in space and for missile control. The team also developed components that would be needed to create new generations of computers, including a novel ferrite core computer memory that was likely more advanced than anything in the U.S. at the time.

In 1962 Staros and Berg received a visit from a young engineer who was looking for help with some components of a cruise missile guidance system. He was quite impressed by their achievements and reported on them to his father. The engineer's name was Sergei Khrushchev, and his father was Nikita Khrushchev. Sergei's comments, and strong support from top Soviet military defense officials, prompted Nikita Khrushchev to arrange a visit to meet the two foreigners.

On May 4, 1962, Khrushchev toured Sarant and Barr's laboratories, accompanied by a delegation that included the chief of the Communist Party in Leningrad, the head of the Soviet Navy and other senior defense industry officials. Sarant told Khrushchev that the future of Soviet power lay not in its capacity to roll tons

Nikita Khrushchev's visit to Alfred Sarant and Joel Barr's enterprise, Design Bureau Number 2 (KB-2), May 4, 1962. Left to right: Admiral Sergei Gorshkov, commander-in-chief of the Soviet Navy and deputy minister of defense; Dmitri Ustinov, deputy chief of the Soviet Council of Ministers; Alexander Shokin, chairman of the State Committee of Electronic Technology (GKET) and minister of the USSR; Alfred Sarant (aka Philip Staros), director and chief designer, KB-2; Nikita Khrushchev; Joel Barr (aka Joseph Berg) (standing to Khrushchev's right, wearing glasses), chief engineer and principal scientist, KB-2; Yevgeny Zhukov, senior engineer, KB-2; Nikolai Averin, director, Special Design Bureau 998.

of steel or make enormous dams, but in its ability to manipulate atoms and molecules. The key to catching up with and surpassing the West, he said, would be microelectronics, a word Sarant had introduced into the Russian language.

Sarant proposed the creation of a secret city dedicated to microelectronics. To his and Barr's astonishment, Khrushchev agreed on the spot. Within months an official decree establishing a new city on the outskirts of Moscow was formally promulgated. The Soviet leader personally signed the papers inducting Sarant into the Communist Party of the Soviet Union and making him a citizen. In August 1962 Sarant drove the first stake into the ground marking the beginning of construction of Zelenograd.

Although it was widely known that they were not Russians, Sarant and Barr's origins were kept secret: Barr's wife didn't learn his real name or that he was American until 20 years after they'd married. There was more than a little opposition to foreigners getting the top positions at a high prestige operation like Zelenograd. In the end, Sarant was denied the top job and very reluctantly had to settle for number two, scientific director. Still, he had over 20,000 people with advanced degrees reporting to him and more authority than any other American had ever wielded in Soviet military industry.

Sarant and Barr's meteoric rise was largely due to Khrushchev's patronage, and when he was deposed in the winter of 1964 they were forced out of Zelenograd. In typical Soviet fashion, Sarant's role in conceiving and designing Zelenograd, which rapidly became the Soviet version of Silicon Valley, became a non-event.

The two Americans retreated to Leningrad where they were commissioned to build computers and microelectronic components for the Soviet space program, the Red Air Force, and civilian industry. The CIA and American technical journals learned about some of Sarant and Barr's computers and, without having any idea that they were designed by Americans, rated them as among the best ever produced in the USSR.

A Rand Corporation journal suggested in 1972 that one of their computers, the Electronica K-200, signaled "some fundamental shifts and improvements in Soviet design policies." The authors had no idea how correct they were when they wrote that "everything we know about [the Electronica K-200] suggests technological transfer: transfer of technology from a qualified, capable (by Soviet standards) design and production environment to an application environment long thwarted by unreliable, inappropriate, and scarce computational equipment. The K-200 is the first Soviet production computer that can be fairly characterized as well-engineered. It may not be up to Western standards, but it easily surpasses anything else known to be currently available in the Soviet Union for process control automation."

Barr and Sarant's most lasting physical legacy, beyond Zelenograd, is the Uzel. The Soviet military liked to reuse hardware whenever possible to keep development costs down and to enhance reliability. When another generation of diesel subs was designed, which NATO calls Kilo class, it retained the Uzel; there is still a team of programmers in St. Petersburg working on Uzel software upgrades.

Joel Barr in 1995.

Among the quietest and most deadly submarines in the world, Kilo subs equipped with Uzels are operating today in the fleets of China, Iran, and India. If the Chinese launch an attack on Taiwan, the Iranians decide to scuttle tankers in the Persian Gulf, or India attacks Pakistan's sea lanes, the torpedoes will be aimed and the craft will be navigated with the assistance of a computer designed by two American Soviet engineers.

About the time the Uzel was completed, Barr and Sarant's fortunes took turns for the worse. One of their leading antagonists, the head of the Leningrad Party branch, was promoted to a candidate member of the Politburo. Through a series of maneuvers, their autonomy was reduced and finally eliminated. Sarant found himself a position as the director of a new artificial-intelligence institute in Vladivostok, as far away from Leningrad as a person could get and still remain in the Soviet Union. Barr stayed behind, retained a super-sized salary, but had few or no official responsibilities.

Sarant died from a heart attack in 1979 and was eulogized in Izvestia as "a tireless scientist, a talented organizer who for many years gave all his strength and bright talent to the development of Soviet science and technology." There wasn't a mention of his foreign origins.

Traveling on a Soviet passport as Joseph Berg, Barr returned the United States in October 1990 to address an international semiconductor technology conference in San Francisco. He was astounded that his arrival was apparently unnoticed by the FBI and the press.

Barr visited the U.S. a second time in early 1991 to speak at another conference, where he met Gordon Moore and told the Intel Corp. founder that he and Staros had often cited "Moore's Law" (that the number of transistors per square inch of integrated circuit would double roughly every year) to the Soviet leadership.

On his second trip the United States Barr applied for a U.S. passport, writing on the form that he'd lost his old one in Prague in 1950. A few weeks later a shiny new American passport bearing his picture and the name Joel Barr arrived. Barr split the remaining years of his life between Russia and the U.S., maintaining dual lives. He received a Russian pension and Supplemental Security Income as well as Medicaid in the U.S., voting in the 1992 New York presidential primary for Jerry Brown and in 1996 in Russia for the communist presidential candidate.

Barr died in a Moscow hospital in August 1998.

BEHIND THE STORY

INTERVIEW WITH STEVE USDIN

EDITOR: Your book, *Engineering Communism: How Two Americans Spied for Stalin and Founded the Soviet Silicon Valley* was published in 2005. How did you come to research and write about this particular subject?

STEVE: As a journalist, I have reported on the intersection of technology, science and public policy for over twenty years. I met Joel Barr in Moscow in 1990. I was researching an article about opportunities for American companies to acquire the rights to Soviet technology. He was introduced to me as a Russian named Joseph Berg. It was clear within seconds that he wasn't Russian; he sounded like a grown up Bugs Bunny, and had an accent like that could only come from New York. The afternoon that we met he took me to Zelenograd, the Soviet Silicon Valley, although he didn't mention his role in creating it.

We developed a close friendship, I visited him in St. Petersburg several times and he lived at my home in Washington for weeks and months at a time. We started to work on his autobiography, but the project never got far because Barr was more interested in talking about what could have or should have been than what really happened.

After Barr died I started to put together the picture from other sources—declassified American, Soviet and Czech intelligence files, interviews with friends, colleagues and relatives—and it quickly became clear that his life and the life of his friend, Alfred Sarant, were far more interesting than I'd realized. Not only were they fascinating individuals, but they had played significant roles both as spies for the Soviet Union during World War II and as pioneers of Soviet high technology.

EDITOR: Tell us what you know about the personal lives of Barr and Sarant and their families.

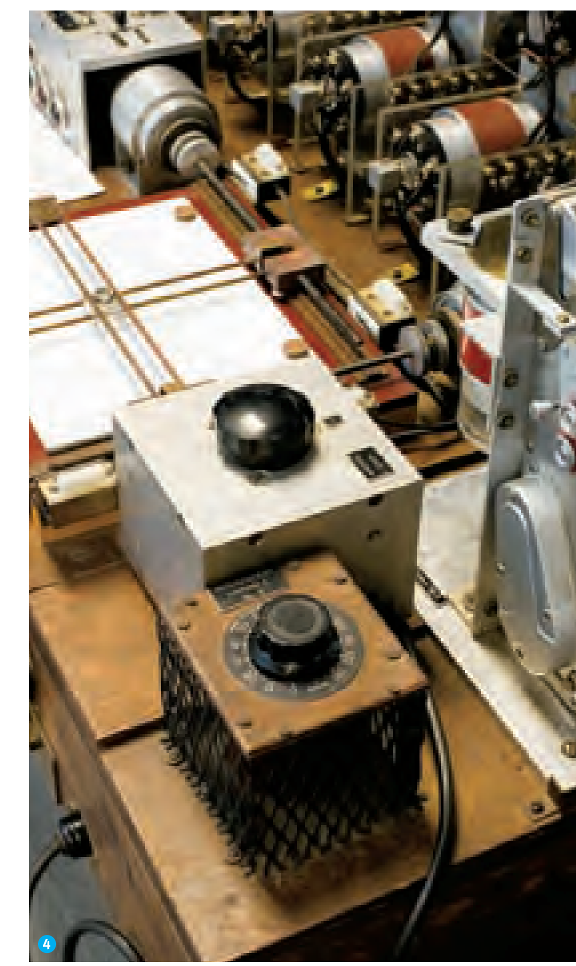
STEVE: From the moment Barr joined the Communist Party in 1939—and especially after he started spying for the KGB—he led parallel lives. The habit of secrecy and duplicity spilled over into his personal life. The starkest example of this was his family life. He was a genuinely devoted family man, with a wife and four children. But at the same time, he had a passionate relationship with a married mistress who raised two of his children. Barr's wife didn't learn about the affair for almost two decades.

Sarant's life, and especially the story of Carol Dayton, the woman who ran away with him, is even more fantastic. She had four children in Russia but was haunted by thoughts of the two children she'd left behind in the United States. Incredibly, after Sarant died the KGB arranged for a reunion, secretly bringing Dayton's children to Prague in 1981. Dayton returned to the United States in 1991 and reconciled with the husband she'd abandoned in 1950.

Steve Usdin is senior editor at BioCentury Publications.

ARTIFACT DONATIONS

The following artifacts demonstrate the variety of donations the museum receives to its collection. To view a complete list of items received since spring 2003, visit the Core website.



1 Source Code Listing for Adventure Game
Date: 1977
Collection: DOCUMENT
Donor: Gift of Mark G. Leonard
CHM#: X3230.2006

In the minicomputer era, games became very popular, especially in college computer centers. One of the most popular, Colossal Cave Adventure, (also simply known as Adventure) was designed by Will Crowther and written in the FORTRAN programming language.

2 iPod Prototypes
Date: 2001-present
Collection: OBJECT
Donor: Gift of Jon Rubinstein
CHM#: X2943.2005

Apple Computer introduced the iPod music player in October 2001. The computer-based device gained a global following due to its capacity and its special iTunes software that made sharing music simple.

3 Screen Shots from Video Games
Date: 1980s-90s
Collection: MEDIA
Donor: Gift of Arnie Katz and Joyce Worley-Katz
CHM#: X3286.2006

In 1981, Arnie and Joyce Worley-Katz started one of the earliest video game magazines, *Electronic Games*. This donation comprises thousands of screenshots and publicity stills for new videogames that they were sent by developers.

4 NORDSIECK Differential Analyzer
Date: 1950
Collection: OBJECT
Donor: Gift of Dick Norberg
CHM#: X2933.2005

Hand-made in 1950 at Washington University by Professor Richard Norberg using war surplus components, the Nordsieck is a mathematical equation solver capable of solving sophisticated equations for relatively low cost. Differential analyzers represent a technology between hand or mechanical adding machine methods of calculation and digital computers. This model was used to verify problems in nuclear science and astrophysics and as a teaching aid.

5 Collection of Mugs
Date: 1980s-2000s
Collection: EPHEMERA
Donor: Gift of Howard, Louise, Cynthia, and Liz Karr
CHM#: X2672.2004

This collection comprises over 300 mugs assembled over 20 years by Howard, Cynthia, and Liz Karr, principals of the finance executive recruiting firm, Karr and Associates. The mugs represent a broad spectrum of computer companies—many of which no longer exist.

EXPLORE THE COLLECTION

MYSTERY ITEM

Cray-3 Supercomputer, 2 CPU Octant
Date: 1993
Collection: Object
Donor: Len Shustek
CHM Accession #: 102631029

This is part of a Cray-3 supercomputer, a liquid-cooled machine that had a theoretical performance of 15 GFLOPS (billion floating point operations per second) and that used exotic gallium arsenide (GaAs), instead of silicon, for its circuitry. The Cray-3 was designed to be the fastest machine in the world: a computation that took the fabled 1946 ENIAC machine 67 years, for example, could be completed by the Cray-3 in just one second.

The 366 modules in the "octant" shown here comprise a multi-layer sandwich of printed circuit boards that contain 69 electrical layers and four layers of GaAs circuitry. Cray's skillful use of packaging is truly awe-inspiring: in each module, three-dimensional package design required drilling 350,000 precision holes, mounting up to 1,024 integrated circuits into 64 boards, and making 120,000 connections with 240 feet of stranded wire.

A 2-octant (four-processor) machine consumed 90,000 watts of power (enough to power 35 average U.S homes) and, like the Cray-2, was cooled by immersion in Fluorinert, a liquid, non-conducting fluorocarbon also used as a blood plasma substitute. One observer of a running Cray-3 described peering at the liquid cooled machine's interconnect wires through the top cover and seeing them "...waving like kelp in a sea current."

As the computing world moved to massively parallel computer architectures, machines like the C-3 ceased being attractive. Although Cray Computer Corporation (CCC) shipped one complete 2 octant (4-processor) Cray-3 to NCAR, another to a U.S. intelligence agency on a trial basis, and had a third 4 octant (8-procesor) machine in-house, the market failure of the machine forced CCC into bankruptcy. Estimated cost of a full system was $30,000,000.

WHAT IS THIS?

Take your best guess! The first three correct submissions are eligible to receive museum posters. View a close-up photo and make your guess at **www.computerhistory.org/core** or email **editor@computerhistory.org.**

COMPUTER HISTORY MUSEUM
1401 N Shoreline Blvd
Mountain View, CA 94043-1311 USA

Address Service Requested

Artifact donations (alphabetical by donor's last name)

IBM Model K Head Disk Assembly (HDA), X3425.2006, Gift of Carmin Adams

Shugart Associates Model SA400 5 1/4" floppy disk drive, X3186.2005, Gift of James Adkisson

Assorted electronic games (1970s), X3448.2006, Gift of Dwain Aidala

Assorted IBM software, X3144.2005, Gift of Mike Albaugh

Computer-related books (1987-1996), X2756.2004, Gift of Diane Alexander

Intel 80960 and i486 microprocessor databooks (c. 1988), X3197.2006, Gift of Diane Alexander

Assorted Turbo Pascal software & manuals, X3389.2006, Gift of Jonathan Allan

Modula-2 software development system, X2765.2004, Gift of Jonathan Allen

Collection of 435 computer buttons, X2832.2005, Gift of Dorothy Allen

AltaVista promotional items, documents, X2654.2004, Gift of AltaVista

Assorted awards and documents (1970s-2000s), X3242.2006, Gift of Gene M. Amdahl

Apple Pippin game system (S/N 1) and others, X2769.2004, Gift of Dr. Gilbert Amelio

Assorted Honeywell manuals, X3264.2006, Gift of Donald R. Ames

Radio Shack Catalogs (1979-1987), X2636.2004, Gift of John Amos

Assorted programming and engineering texts (1970-1990), X3292.2006, Gift of Karl W. Anderson

Trial software assortment, X3066.2005, Gift of Karl W. Anderson

Apple Macintosh software, X2594.2004, Gift of Rick Andrews

Three Rivers PERQ 1 computer (c. 1983), X2778.2004, Gift of a anonymous donor

"NETSCAPE All Hands Meeting" (May 28, 1998) videotape, X2859.2005, Gift of a anonymous donor

“Only the Paranoid Survive ...," book by Andy Grove, X2989.2005, Gift of a anonymous donor

“Paradiso” Philippe Kahn CD recording, X2973.2005, Gift of a anonymous donor

Appletalk and Resedit reference books, X2836.2005, Gift of a anonymous donor

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Assorted calculation aids, assorted IBM mainframe documents (c. 1960-70), X3183.2005, Gift of Chuck Baker

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Early Apple Computer publications, documents, X2617.2004, Gift of Lilyann Brannon

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Microsoft OS/2 Software Developers Conference VHS tapes (8), X3287.2006, Gift of Dave Briccetti

USE compiler manual for UNIVAC 1103A and 1105 computers (c. 1958), X2624.2004, Gift of Frederick P. Brooks Jr.

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Scientific American, "Machines That Think" article (April, 1933), X3285.2006, Gift of Bob Brubaker

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Manuals & personal documents relating to Illiac I & II supercomputers, X3492.2006, Gift of John Ehrman

IBM Microfiche cards on mainframe troubleshooting, X2879.2005, Gift of John R. Ehrman

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Sun Microsystems, Inc., Sparcstation 10 & 20 motherboard prototypes (1992), X3314.2006, Gift of David Emberson

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IBM Type 85 Electrostatic Storage Tube (1953), X3064.2005, Gift of Bob Erickson

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Intel 8008 photo and original specification document, X2817.2005, Gift of Hal Feeney

Classic computer science texts, X3251.2006, Gift of Edward Feigenbaum

ILLIAC-IV supercomputer mylar data strip (c. 1974), X3472.2006, Gift of Elizabeth Feinler

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Community Memory Project documents and terminals (1972-1974), X3090.2005, Gift of Lee Felsenstein

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DEC PDP-6 circuit modules (c. 1963), X3103.2005, Gift of Robert Garner

IBM 1401 RPG & SPS source listings, X3508.2006, Gift of Robert Garner

IBM unit record machines videotapes, X2936.2005, Gift of Robert Garner

Power Computing, Inc., PowerBase 240 Macintosh clone, X3346.2006, Gift of Ronald Garner

Microsoft Windows/286 Presentation Manager v. 2.1, X2893.2005, Gift of Terrall R. Garrison

Early Intel development system hardware & documents, X2826.2005, Gift of Robert Garrow

Collection of IBM manuals, X2787.2004, Gift of Mark Geary

Epson PX-8 portable computer (1982), X3134.2005, Courtesy of Michael J. Howe

Intel commemorative belt buckle & wine bottle (1977), X2813.2005, Gift of Edward Gelbach

Modular Programming Symposium Preprint (1968), X2604.2004, Gift of Dennis P. Geller

Assorted Slate materials (1989-1993), X3337.2006, Gift of Mark Gerrior

Digital Research manuals, guides and software (1979-1981), X3533.2006, Gift of Curt Geske

IBM Oral Histories, X2965.2005, Gift of IBM

Supercomputing Research Center Splash-2 printed circuit board (1995), X3162.2005, Gift of the Supercomputing Research Center

Tektronix 909 desktop scientific programmable calculator & peripherals, X2900.2005, Gift of Kenneth P. Gilliland

Printout of MS-BASIC source code (1976), X2977.2005, Gift of David Gjerdrum

Borland, HP, IBM, Microsoft, Qualcomm, US Robotics literature, X2638.2004, Gift of George Glaser

Documents on BEA Systems, voice recognition, Y2K and semiconductor industry (1970-2000), X2717.2004, Gift of George Glaser

Mainframe-era business computing documents, X2902.2005, Gift of George Glaser

Assorted humorous books on computing by Robert Glass, X3160.2005, Gift of Robert L. Glass

EMIDEC 2400 Computer Training Manual (1962), X2712.2004, Gift of John Gleeson

Apple-related ephemera, text, videocassettes, software, hardware and images, X2870.2005, Gift of AppleLore

Easel, Inc. t-shirt, X2640.2004|102626789, Gift of Eli Goldberg

Apple Lisa release poster, X2582.2004|102630214, Gift of William Goldberg

Apple Macintosh 512 EPROM Adapter Board, X2619.2004|102626827, Gift of William Goldberg

IBM Selectric type typeballs, English and Hebrew, X2805.2004, Gift of William Goldberg

Assorted personal computing magazines (1975-1990), X3451.2006, Gift of Mark Goldstein

GCC Maria 1702B Graphics Processor poster, X2841.2005, Gift of Steve Golson

OS-9 documentation, X2980.2005, Gift of Dave Good

MSA Coaster caddy with coasters, X3363.2006, Gift of Bill Goodhew

Early books on computers and society (1950s), X3187.2005, Gift of Jessica Gordon

Heath H89 computer (1979), manuals & software, X3099.2005, Gift of Carl A. Goy

Heath H8 microcomputer (1977), X3177.2005, Gift of Carl Goy

Royal-McBee edge puncher, X2928.2005, Gift of JM Graetz

Apple Computer MessagePad 120 and promotional buttons, X2610.2004, Gift of Maxine Graham

"Lotus Selects" catalog (1991), X2669.2004 , Gift of Bea Gramann

ConSeal Personal Firewall demoware for Windows95, X3249.2006, Gift of James Grant

Data General manuals & arithmetic test program paper tape, X2831.2005, Gift of David Graybeal

Mountain Computer 1100A Intelligent Card Reader & manuals, X2913.2005, Gift of Michael E. Green

Intel ephemera, X2822.2005, Gift of Robert Greene

Microsoft Access version 1.1 (1993), X3184.2005, Gift of Gabe Groner

ADAPSO Brochure on disk copying, X2625.2004, Gift of Jim Gross

Documents relating to 1970s printers and processors, X2877.2005, Gift of Jim Gross, University of Wisconsin Sheboygen

Apollo Computer network outlet, Univac magnetic tape, X2573.2003|102630212, Gift of Jonathan Gross

CMU iWarp and TI GaAs microprocessor documents, X3145.2005, Gift of Thomas Gross

Assorted software on cassette (c. 1978), X3071.2005, Gift of Kathy Groves

"WYLBUR Overview" manual, X2960.2005, Gift of Dick Guertin

PL360 code on CD-ROM, X2974.2005, Gift of Dick Guertin

"Introduction to PL360 Programming" book, X2620.2004, Gift of Richard L. Guertin

Opus Systems 32/30 add-on processor board (c. 1988), X2690.2004, Gift of Ronald F. Guilmette

HP 2648 software, X2795.2004, Gift of Peter Gulotta

Code for SQLBase and SQLWindows (1988), X2688.2004, Gift of Umang Gupta

Leisure Suit Larry Collection of computer games, X2730.2004, Gift of Edward Haas Jr.

Catalog of digital computer specifications and companies, X3460.2006, Gift of Richard Haines

Documents related to computer history (1981-1989), X3308.2006, Gift of Jan Half

Compute! magazine (1981-1990), X3018.2005, Gift of Tom Halfhill

Software Digest Ratings Newsletter (1984-1997), X3020.2005, Gift of the San Francisco Public Library

Harvard Graphics 3.0 and design team photographs, X3526.2006, Gift of Buck Hallen

Wylbur, Milten, Orvyl - Stanford University mainframe software, X2796.2004, Gift of Stanford University

Transcript "Management Systems for the Space Generation" - Plaintiffs v. IBM 1976, X3412.2006, Gift of Larry Hanson

Jepperson Sanderson aviation calculator, X2857.2005, Gift of Mrs. Raymond O. Hargis

Orange Micro, Inc., Apple II microcomputer clone (1982), X3283.2006, Gift of Zvi Harrel

Early Apple Macintosh software, X2737.2004, Gift of Gary Harris

"Harvard Project Manager 3.0" cover signed by team members, X3505.2006, Gift of Lee Harris

Assorted photographs relating to computer service companies, X3284.2006, Gift of Peter Harris

DYSEAC-related artifacts (c. 1954), X2647.2004, Gift of David Hartsig

PFS software and manuals, X3528.2006, Gift of Barbara Harvie

"The Transistor: Dawn of a New Era" book (1997), X3326.2006, Gift of Charles C. Harwood

Assorted documents relating to floppy disk technology (1980s), X3223.2006, Gift of Marilyn Hasler

Ashton-Tate dBase II software package with disks and documentation, X3527.2006, Gift of John M. Hedblom

Rolodex REX cards, X3476.2006, Gift of David Henkel-Wallace

Manuals on IBM CPC, IBM 650, X3101.2005, Gift of Sarah T. Herriot

Data sheets on Honeywell instruments, X2994.2005, Gift of The Museum of American Heritage

Metal skip bar for the IBM 010, IBM Stick Printer Head, IBM 407 Print Wheel, IBM Key Punch Programmable, Two IBM components encased in Lucite, X2602.2004, Gift of Warren Higgins

Prolog development kit for Intel 4004, X2889.2005, Gift of Rhodes Hileman

Expander microcomputer, documentation (1981), X2626.2004, Gift of Bill Hill

Intel Mug (1985), X2812.2005, Gift of David House

Design specifications & documentation for Context MBA (1981) software, X2996.2005, Gift of Gilbert Hoxie

Deep Blue v.2 custom VLSI processor (1997), X3095.2005, Gift of Feng-Hsiung Hsu

Photographs (scans) relating to Deep Thought (I & II), Deep Blue, & HiTech computer chess machines (c. 1988-1997), X3306.2006, Gift of Feng-Hsiung Hsu

Osborne manuals and newsletters, X3229.2006, Gift of Merrill Hulse

Electronic Parts Catalogs and Data books from Fairchild, Motorola, National, General Electric, RCA, IBM & others, X3401.2006, Gift of Leslie Hurwitz

Assorted photos and documents relating to the SWAC, EDVAC, Pilot Ace, & G-15 computers (c. 1947-1965), X3247.2006, Gift of Harry Huskey

Harry Huskey personal papers related to the SWAC computer (1948-1982), X3462.2006, Gift of Harry Huskey

DEC VAX 8600, X2733.2004, Gift of Sellam Ismail

Philco Electronics All-in-One Experimenter's Kit (1961), X3042.2005, Gift of Pearl S. Jackson

Assorted DEC photgraphs and ephemera, X3227.2006, Gift of Joanne and Irwin"Jake" Jacobs

Assorted blank punched cards & documents (ca. 1967-1980), X3494.2006, Gift of David L. Jaffe

Manuals for dBase III, GemDraw, & Wordstar (c. 1982), X3398.2006, Gift of David L. Jaffe

Manuals on Compuserve Information Service and DEC VT-100 terminal, X3317.2006, Gift of David L. Jaffe

Aldus PageMaker Version 5.0 software, X2853.2005, Gift of Dr. James M. Janky

Apple Computer, PowerPC prototype card (c. 1993), X2665.2004, Gift of Steve Jasik

U. S. Air Defense Command "AN/FSQ-7/8 (SAGE) Digital Displays, X3405.2006, Gift of Alan Jeddloh

"Microchess" source code, program & documents (c. 1977), X3305.2006, Gift of Peter Jennings.

Luxor ABC 80 micrcomputer systgems, X3345.2006, Gift of IT-ceum, the Swedish Computer Museum

Assorted COMDEX buttons, X3113.2005, Gift of Allyson Johnson

"Computer development (SEAC and DYSEAC) at the National Bureau of Standards" book (1955), X2700.2004, Gift of Bruce G. Johnson

Early IBM San Jose ephemera relating to Rey Johnson (1951-1991), X3312.2006, Gift of David R. Johnson

IBM Model 85 punched card collator & manuals, X3421.2006, Gift of Joel Jones

IBM optical scanning device, X2614.2004|102626822, Gift of Dr. Stephen A. Jove

"The World of Objects" DVD, X3520.2006, Gift of Philippe Kahn

IBM manuals, brochures, films and books, X2725.2004, Gift of Ray and Laurel Kaleda

PAM Medac 310 (medical accounting) system, X2967.2005, Gift of Roger Kammeier

Scan of Eckert and Mauchly Computer Corporation business plan (1946), X3232.2006, Gift of Mitch Kapor

"Handbook of Mathematical Functions With Formulas, Graphs, and Mathematical Tables", X3522.2006, Gift of Carrie Karnos

"The Engineer's Manual" (1917) & "C.R.C. Standard Mathematical Tables" (1956), X3282.2006, Gift of Carrie Karnos

HP Stat/Math Calculator (c. 1990), X2660.2004, Gift of Carrie Karnos

Assorted Burroughs manuals, X2618.2004, Gift of Daniel Karpen

Cray Research, Inc. documents, X2599.2004, Gift of Daniel Karpen

275 Silicon Valley company coffee mugs, X2672.2004, Gift of Howard, Louise, Cynthia and Liz Karr

Caltech Hypercube Mark III supercomputer (1988), X3053.2005, Gift of Daniel S. Katz

Enigma booklets, X2942.2005, Gift of Jeff Katz

Univac 1107 Reference Manuals, &c., X3083.2005, Gift of Jeff Katz

Xerox PARC Alto II computer, X2932.2005, Gift of Dr. Alan Kay

DEC-11 Portable prototype, X3385.2006, Gift of Benjamin Kennedy

Assorted Apple ephemera, X3336.2006, Gift of Mariou Kenworthy

"Linux Journal" collection (1994-1999), X2644.2004, Gift of David Keppel

Linux Jounral magazine, X3303.2006, Gift of David Keppel

IBM 5140 &original carrying case, X2931.2005, Gift of James C. King

Esther Dyson and Release 1.0 papers, X2780.2004, Gift of Esther Dyson

IBM 360/30 CCROS card, X2578.2004|102630209, Gift of Brian Knittel

Artwork consisting of a drawing on printed paper, X2920.2005, Gift of Donald E. Knuth

“VISICALC Instant Calculating Electronic Worksheet” software (1979), X3104.2005, Gift of Richard A. Koenen

IBM 7030 ("Stretch") simulation results and early computer generated films (1958-1970), X3023.2005, Gift of Harwood G. Kolsky

Personal papers of Harwood G. Kolsky, X3021.2005, Gift of Harwood G. Kolsky

Assorted Prime and DEC manuals, X3392.2006, Gift of Pam Kompany

Optotech drive & manuals and software, X3506.2006, Gift of Mike Konshak

Collection of ACM publications, X2894.2005, Gift of Roger Kovach

Philco flow chart template, X2788.2004, Gift of Roger Kovach

CMG Conference proceedings (1980s), X2898.2005, Gift of Roger P. Kovach

Collection of computer journals, X2904.2005, Gift of Philip and Holly Kramer

Books on Russian BESM computer (1955-1966), X2673.2004, Gift of Herman Krieger

Apple Mani stone (c. 1997), X2628.2004, Gift of Ken and Chris Krugler

"The Origins of MATLAB" DVD, X3334.2006, Gift of The MathWorks, Inc.

IBM 1800 application brief for CYAC Haddam Neck Plant document, X2947.2005, Gift of Peter Kushkowski

DEC DECPro 350, RT-11 and 1984 VENIX software & manuals, X3051.2005, Gift of Gail LaForge

Lecture transcript on the SDS 940 (1966), X2793.2004, Gift of Butler Lampson

Momenta, GRiD and Dauphin pen computers (c. 1991-1995), X2651.2004, Gift of Sam Lanahan

Soviet adding and subtracting device, X3088.2005, Gift of Henry (Genrykh) Landa

Vercon Kyivverst documents, X3354.2006, Gift of Henry (Genrykh) Landa

Advertising documents from DEC, Byte, &c., X3429.2006, Gift of Willem Langeveld

Ephemera: Harvard Graphics mug; PFS pin; SPC Advanced Technology Group T-shirt, Still image: Harvard Graphics Roadrunner Team photograph", X3521.2006, Gift of Barbara Langworthy

Bernoulli Box A220H, manuals, software (1983), X3390.2006, Gift of John Larribeau

IBM SAGE – A/N FSQ-7 manuals, X2951.2005, Gift of Ken Larsen

"IBM Poughkeepsie News", X2682.2004, Gift of Chris Larson

IBM Historical Disk Drive Collection (1964-2000), X3372.2006, Gift of the IBM Corporation

Assorted circuit cards for the Apple II computer (1970s-1980s), X3426.2006, Gift of Robert Lashley

Assorted coffee mugs, X3347.2006, Gift of Jan Laskowski

Frox computer system, X2930.2005, Gift of Sheldon Laube

"Electronic Data Processing at the Bureau of the Census" booklet, X3163.2005, Gift of Kathryn Lauricella

Octopus 6600, LRLTRAN, CDC 3600 manuals, X2840.2005, Gift of Lawrence Livermore National Laboratory

AMD AM29116 16-bit bipolar microprocessor, X2955.2005, Gift of David Laws

AMD posters, X2940.2005, Gift of David Laws

MacConnection Advertising Cards, X2650.2004, Gift of Ken Laws

Collection of videotext-related documents (1982-1990), X2643.2004, Gift of Harold A. Layer

Cray Research Inc. manuals, X2934.2005, Gift of Art Lazanoff

"Inside Windows NT Workstation 4: Certified Administrator’s Resource Edition" book, X3214.2006, Gift of Glenn Lea

Assorted Control Data Corporation manuals, X3152.2005, Gift of Glenn Lea

Lotus Notes developer documents, X3360.2006, Gift of Glenn Lea

Commodore 128 and software (1985), X2713.2004, Gift of Homer W. Ledford

"2005 Computerworld Honors Program" DVD (2005), X3374.2006, Gift of Deborah Lee

Miscellaneous educational artifacts, still images & videotapes, X2677.2004, Gift of J.A.N. Lee

Photos from the "Annals of the History of Computing" (c. 1980-95), X3191.2005, Gift of J.A.N. Lee

Various calculation games/educational toys & photographs related to the "Annals of the History of Computing", X3341.2006, Gift of J.A.N. Lee

Quantum Hardcard EZ (c. 1993), X3073.2005, Gift of Joe Lee

SDS manuals (4); various other scanned manuals, X2848.2005 , Gift of Tim Lee

Early IBM promotional & instructional films (1950s), X2843.2005, Gift of Dan Leeson

Photographs of Herman Hollerith and family & tabulating devices, X3510.2006, Gift of Lucia B. Lefferts

"Computer development (SEAC and DYSEAC) at the National Bureau of Standards" (1955), X2699.2004, Gift of Alan and Henrietta Leiner

Booklet: “A new tool for the mind: The National Bureau of Standards Eastern Automatic Computer (SEAC)” (1950), X2728.2004, Gift of Alan and Henrietta Leiner

PILOT and DYSEAC documents (c. 1940), X2803.2004, Gift of Alan L. Leiner

Assorted IBM and Cray manuals, X2714.2004, Gift of Gary C. Lelvis

"Computer Tree" geneology poster, X2884.2005, Gift of Gary Lelvis

Panasonic RL-H1400 Hand Held Computer (c. 1982), X2758.2004, Gift of Gary Lelvis

Intel 3000 series manual (1976), MCS-40 manual (1974), X2819.2005, Gift of Dan Lenehan

Intel 80186 "One Million Shipped" key chain (1984), X2827.2005, Gift of Mary Lenehan

FORTRAN Source code for "Adventure", X3230.2006, Gift of Mark G. Leonard

Apple Macintosh 10th anniversary press packet (1994), X2710.2004, Gift of Marianne L. Lettieri

Eagle Computer PC & manual (1982), X3410.2006, Gift of Gary leung

Photographs of David Levy playing chess, X2905.2005, Gift of David Levy

Seagate ST-225 Hard Disk Drive (1984), X2572.2003|102630205, Gift of Henry Plummer and Robert Lewis

Practice Keyboard for the Apple IIe, X2601.2004|102630239, Gift of Neil Lewis

Databooks from National Semiconductor, Texas Instruments, Intel, Fairchild, GE, Signetics, DEC, RCA & others (1980s), X3423.2006, Gift of Michael J. Licata

Assorted ephemera from Symantec, McAfee, Microsoft, Aldus, Microsoft, &c., X3477.2006, Gift of Ruthann Quindlen

Apple II Video Overlay Card Protoype, X2596.2004|102630237, Gift of Mike Liebhold

Infineon Technologies, Wearable Cyberjacket (2004), X3386.2005, Gift of Christoph Liedtke

Books, MS-Excel for Windows (1985), X3161.2005, Gift of Bob and Sharon Lindsay

IBM basic computer functions manual (1967), X2708.2004, Gift of Bob and Sharon Lindsay

Digital Research, Inc. Concurrent DOS (1986) manual, X2658.2004, Gift of Bob Lindsay

NT Displayphone NT6K00, X2874.2005, Gift of Donald C. Lindsay

Apple Computer-related books, manuals and papers, X2697.2004, Gift of Mike Miley

Apple Macintosh software, X2964.2005, Gift of Owen W. Linzmayer

WAP-enabled cellular telephone assortment, X2801.2004, Gift of Openwave Systems Inc.

"Tom Thumb" Adding Machine, X3358.2006, Gift of Marc L'Italien

Caltech Mk III Hypercube supercomputer circuit board prototype, X2611.2004, Gift of Ruby Loch

Dragon Systems, Inc., Dragon Dictate software (1982), X3381.2006, Gift of Paul N. Loewenstein

Assorted computer books, X3403.2006, Gift of Esfandiar Lohrasbpour

Bendix G-15 computer manual (c. 1958), X3179.2005, Gift of Esfandiar Lohrasbpour

Computer-related books, X3077.2005, Gift of Esfandiar Lohrasbpour

Documents relating to computer architecture (ca. 1964-1984), X3488.2006, Gift of Esfandiar Lohrasbpour

Quantel "Picture Box" graphics subsystem, X3371.2006, Gift of Liza Loop

Computer-related buttons, X2881.2005, Gift of Linda Lorenzetti

Computer-related buttons, X2847.2005, Gift of Lorenzetti

“D: All Things Digital” conference videotapes, X3027.2005, Gift of the Wall Street Journal

Cray 1 supercomputer (1976), X2966.2005, Gift of Los Alamos National Laboratory

Borland Delphi version 1.0 (c. 1995), X3049.2005, Gift of Lisa Loud

IBM model 360 documents, X2875.2005, Gift of Donald Luke

USE compiler manual for UNIVAC 1103A and 1105 computers (c. 1958), X2623.2004, Gift of Terry Lydon

Burroughs computer manuals, X2909.2005, Gift of Brian Lyles

"The Lengthening Shadow" internal IBM book on T. J. Watson, Sr. (1962), X3262.2006, Gift of John H. MacFarlane

The Digital Group computer system, manuals & software System 3 (1980), X3370.2006, Gift of Charles H. Mackey

“The First Computers: History and Architectures" (2000) book, X3253.2006, Gift of William Maddox

SGI personal workstations (1990-1997), X3089.2005, Gift of SGI

"The Personal Computer Lilith" (April 1981), X3529.2006, Gift of Ronald Mak

IBM 1401 software, X3133.2005, Gift of Ronald Mak

"Amazing Amiga" and "Amazing Computer" magazines (1989-1997), X3393.2006, Gift of Carl Malberg

SRI International Magnetic Logic computer, X2915.2005, Gift of SRI International

Original SRI International mouse prototype, X3016.2005, Gift of SRI International

DEC corporate archives, X2675.2004, Gift of Hewlett-Packard Company

DEC KL-10 computer system design documents, X3149.2005, Gift of Hewlett-Packard Company

Exemplar supercomputer (1997), X3034.2005, Gift of Hewlett-Packard Company

"History of Control Data Corporation (CDC)" slide presentation, X3467.2006, Gift of Liz Manly

Teletype Corporation Model 19 teletypewriter (1942), X3420.2006, Gift of Lorna Mansfield

Early I/O equipment, X3142.2005, Gift of Armon Markarian

Various Datapro magazines, X2616.2004, Gift of Intel Corporation

Fidelity Electronics Chess Voice Sensory Challenger game & documents (1981), X3165.2005, Gift of Tony Marsland

Manuals from Scientific Data Systems (SDS) and Digital Equipment Corporation (DEC), X3316.2006, Gift of David W. Masters

Control Data Corporation (CDC) CDC 3000 core stack & CDC 6000 60-pin cable terminator, X3480.2006, Gift of David McCall

"The Last of the First: CSIRAC: Australia’s First Computer" book, X2919.2005, Gift of John McCarthy

Indecks Research, punch card data-processing system (c. 1966), X3070.2005, Gift of Jim McClure

OS/2 and Windows Magazine journals, X3114.2005, Gift of Steve McGinnis

Regis McKenna personal papers & videotapes, X2903.2005, Gift of Regis McKenna

Intel SDK-80 (1976) & Intel MCS-86 kit (1978) development systems, X2823.2005, Gift of Ken McKenzie

DEC "Introduction to Minicomputers" series -12 books, X3226.2006, Gift of Margery Meadow

Items relating to A Programing Language (APL), X3489.2006, Gift of George Mendonsa

Digital Research, Inc. software, documents & ephemera, X3514.2006, Gift of Marcel Mendoza

Ardent/Stardent 500 Stiletto computer prototype (1989), X3014.2005, Gift of Douglas Merrell

"Silicon Valley Bank: Reinventing an industry, financing the future" video (2003), X2736.2004, Gift of Silicon Valley Bank

Janus II timesharing system manual (c. 1969), X2789.2004, Gift of Bill Merritt

HP Pascal 3.0, HP Basic 3.0 software & manuals (1984), X3293.2006, Gift of Delta Electronics Mfg. Corp., Beverly MA

"What To Do After You Hit Return", X3365.2006, Gift of George Michael

Early microcomputer manuals & "A Programmer's Palimpsest"notes, X3465.2006, Gift of George Michael

Vector routines for the Cray-1 manual (1981), X2946.2005, Gift of George Michaels

"The Art of Computer Programming: Sorting & Searching" book (1998), X3195.2005, Gift of Margaret (Micki) Miller

Assorted catalogs, X2917.2005, Gift of Michael G. Miller

IBM Personal Computer Seminar Proceedings (1980s), X2910.2005, Gift of Michael G. Miller

"The Art of Computer Programming," first edition (1968), X2666.2004, Gift of Micki Miller

DEC-related ephemera, documents, X2642.2004, Gift of Sandy Mangia

Documents relating to Digital Research and Gary Kildall, X3516.2006, Gift of Maureen Minnes

Illiac IV and PDP-10 related documents (c. 1975), X3444.2006, Gift of Greg Minshall

Cray Research, Inc. documents, X2589.2004|102630231, Courtesy of Eugene Miya

"AI" journal (late 1980s to mid-1990s), X3224.2006, Gift of Eugene Miya

Assorted Cray documents & ephemera, X3367.2006, Gift of Eugene Miya

Cray manuals, X2753.2004, Gift of Eugene Miya

Cray-2 ECL logic board in lucite (1985), EFF materials, X2633.2004, Gift of Eugene Miya

Documents related to Supercomputing 2003 conference (2003), X3335.2006, Gift of Eugene Miya

Electronic Freedom Foundation (EFF) t-shirt, poster, document, X3294.2006, Gift of Eugene Miya

Ephemera, X3030.2005, Gift of Eugene Miya

Gary Kasparov at Salishan (19, X2962.2005, Gift of Eugene Miya

Supercomputing documents, X3267.2006, Gift of Eugene Miya

Supercomputing ephemera, X2842.2005, Gift of Eugene Miya

USENIX and Cray conference proceedings, X2747.2004, Gift of Eugene Miya

Recorder wire (c. 1956-1965), X2668.2004, Gift of NASA Dryden Flight Research Center

Macintosh PowerBook 170 used on Space Shuttle, X3028.2005, Gift of Silvano P. Colombano

IBM 5161 PC Expansion Chassis, X3072.2005, Gift of Roy Mize

IBM coffee mug, X3040.2005, Gift of Roy Mize

IBM punched card manuals, X3220.2006, Gift of Shel Molter

Complete set of IBM TSS S/370 manuals, X3216.2006, Gift of Robert Monnette

Datapoint Corporation ARCNET hub (c. 1984), X3085.2005, Gift of David A. Monroe

Dynamac in original carrying case, X2981.2005, Gift of Mike Moore

Intel Data Catalog (1975), X2816.2005, Gift of David Mooring

Microsoft Windows Operating Environment version 1.0, X3449.2006, Gift of Tom Moran

Intuit “MacInTax 1984 Version 1.0” (1984), X3102.2005, Gift of Michael Morgan

Fujitsu Stylistic ST4100 Tablet PC (2003), X2575.2003, Gift of Mr. Toshio Morohoshi

The Laureate Journal of The Computerworld Honors Program (2003), Computerworld Honors Program Archive 2003 CD-ROM (2003), X2605.2004, Gift of Computerworld

Bowmar 901B calculator, X2577.2003|102630208, Gift of Mary M. Mourkas

Early credit card verification machine, X2770.2004, Gift of Robert and Stephanie Munoz

Hyperion computer systems, peripherals, manuals & software (1982-1984), X3377.2006, Gift of R.A. Murch

“ARCNET” license plate, X2969.2005, Gift of John A. Murphy

Digi-Comp 1 educational computer kit (1963), X2691.2004, Gift of Paul Nahay

Google Corkboard Server Rack (1999), X2839.2005, Gift of Google, Inc.

Commemorative coffee mugs, X2588.2004, Gift of Randy Neff

HP 95LX calculator with manuals, X2914.2005, Gift of Keith D. Neilson

IBM Skip Bar Punch for the 010 and 031 Key Punches, IBM Relay Tester, Small collection of IBM spare parts, Various IBM customer engineering manuals and aids, Papers and documents related to and/or published by IBM, X2608.2004, Gift of Carl R. Nelson

CDC 7600 printed circuit board & manuals, X2935.2005, Gift of Terry Nelson

Board Game: “In The Chips: Silicon Valley" (1980), X3081.2005, Gift of Dave Nettleman

Training program for dBASE III/III Plus”, X2878.2005, Gift of Laura Neuman

Mark-8 microcomputer (Radio-Electronics magazine, 1974) & manuals, X2918.2005, Gift of Harley Newsom

SAMS Computerfacts (1985-1995), X2648.2004, Gift of East Meadow Public Library

SRI Internet Van (1973), X3258.2006, Gift of Don Nielson

Fujitsu VX supercomputer (1996), X2671.2004, Gift of Fujitsu America, Inc.

Documents relating to computer art and 3-D animation, X3155.2005, Gift of A. Michael Noll

IBM MagCard II Selectric Typewriter with reader & manuals, X3206.2006, Gift of Pam Nollkamper

NORDSIECK Differential Analyzer & documents (1948), X2933.2005, Gift of Dick Norberg

"The Origins of Cyberspace" book (2005), X3388.2006, Gift of Jeremy Norman

Items related to Presper Eckert personal papers, X3400.2006, Gift of Jeremy Norman

IBM 632 Electronic Typing Calculator Models 5,6 and 7 manual (1961), X3041.2005, Gift of Robert Northrop

Lotus 123 Release 1A, Grateful Med (1984, 1993), X3222.2006, Gift of Dr. Toni Novick

Peronal papers of Cuthbert Hurd, X2772.2004, Gift of Elizabeth R. Nowicki and William Nowicki

Assorted IBM and Intel ephemera, X2818.2005, Gift of Harry Nystrom

Intel Commemorative Wine Bottle (1977), X2811.2005, Gift of Hank O'Hara

Books on programming and database management, X2892.2005, Gift of Bruce Olsen

Documents & ephemera relating to GE and Tymshare, X3105.2005 , Gift of Tim O'Rourke

Digital Research CP/M manuals, X2945.2005, Gift of Steve O'Toole

Mitsubishi Amity-SP tablet computer (1996), X2693.2004, Gift of Akira Otsuka

Apple Macintosh IIci-based laserdisc system (1989), X3399.2006, Gift of Scott Palamar

Intel 486 and Pentium die shots, X2834.2005, Gift of Max Palevsky

Univac 1004 plugboard & misc. items, X2978.2005, Gift of Enrico Palumbo

Autographed print of supercomputing pioneers & Ergo computer, X3039.2005, Gift of Greg Papadopoulus

DEC manuals for VAX/VMS, PDP-11, X2686.2004, Gift of Nick Pappas

DEC software and manuals, X2868.2005, Gift of Nick Pappas

DEC word processing software and manuals, X2867.2005, Gift of Nick Pappas

IBM PC software (1990s), X2907.2005, Gift of Richard Pasco

Early IBM 700-series manuals, modules, X3139.2005, Gift of Robert L. Patrick

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On the cover: The eight founders of Fairchild Semiconductor in the company's production area. Back row, left to right: Victor Grinich, Gordon Moore, Julius Blank, and Eugene Kleiner. Middle: Jean Hoerni. Front: Jay Last and C. Sheldon Roberts. Facing the group: Bob Noyce. *Photo courtesy of Stanford University Libraries, Department of Special Collections.*

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Leslie Berlin is project historian for the Silicon Valley Archives at Stanford University. Her first book, *The Man Behind the Microchip: Robert Noyce and the Invention of Silicon Valley* (themanbehindthemicrochip.com), won the 2006 Book Award from the American Association for History and Computing. Leslie holds a PhD in history from Stanford.

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Leonard J. Shustek is chairman of the CHM Board of Trustees and a partner in the investment firm VenCraft. The retired cofounder of Network General Corporation (now Network Associates), Len is an occasional consulting professor at Stanford University, where he earned an MS and a PhD in computer science. He is also a trustee of Polytechnic University in Brooklyn, New York, where he earned his BS and MS in physics.

Dag Spicer is senior curator of the Computer History Museum, where he has been since 1996. A former electrical engineer, Dag also holds advanced degrees in the history of science and technology from the University of Toronto and Stanford University.

IN THIS ISSUE

When I was a child, I hated history. It was boring, the teachers made me memorize irrelevant facts, and those facts bore no detectable relationship to my life. If "there is a history in all men's lives," as Shakespeare's Warwick tells King Henry IV, then what's so special about it?

The answer is that some history has impact. It changes lives. It inspires. It teaches. That is the history we must collect, and we must find exciting ways to present it.

This issue of *Core* has multiple examples of collecting and presenting history that has impact. It starts with the remarkable story of discovering a previously unknown treasure trove of the raw material of history, in the form of hundreds of important artifacts hidden away in a warehouse in industrial Germany and destined for the scrap heap. They were rescued, thanks to the generosity of SAP AG, in a mission worthy of *Raiders of the Lost Ark*.

Then on to another form of rescuing history: gathering the stories of pioneers while they are still available to be told. The Sloan Foundation–sponsored IT Corporate Histories Project used equal measures of web-based high technology and old-fashioned human outreach to accumulate valuable materials for historians and researchers to use.

The excerpts from our oral history of Bill Atkinson and Andy Hertzfeld about their experiences at Apple give us insight into a remarkable company culture at a time when established companies were threatened by young upstarts. There is good advice here, too, from how programmers can be great to how everyone should live life.

We have many remarkable heroes in the computer industry. Here Leslie Berlin presents anecdotes about Bob Noyce from her recent biography. Leslie not only shows us various sides of the Intel cofounder's personality, but also helps us find the lessons we can learn from his successes and failures.

Finally, we pause in the center section to appreciate the visual beauty of the computer and its component parts. There are many ways that computers are used to create art, but photographer Mark Richards shows us that, when looked at through the right lens, computers are art.

We hope you enjoy this issue of *Core* and, as always, we welcome your comments.

Len Shustek
Chairman

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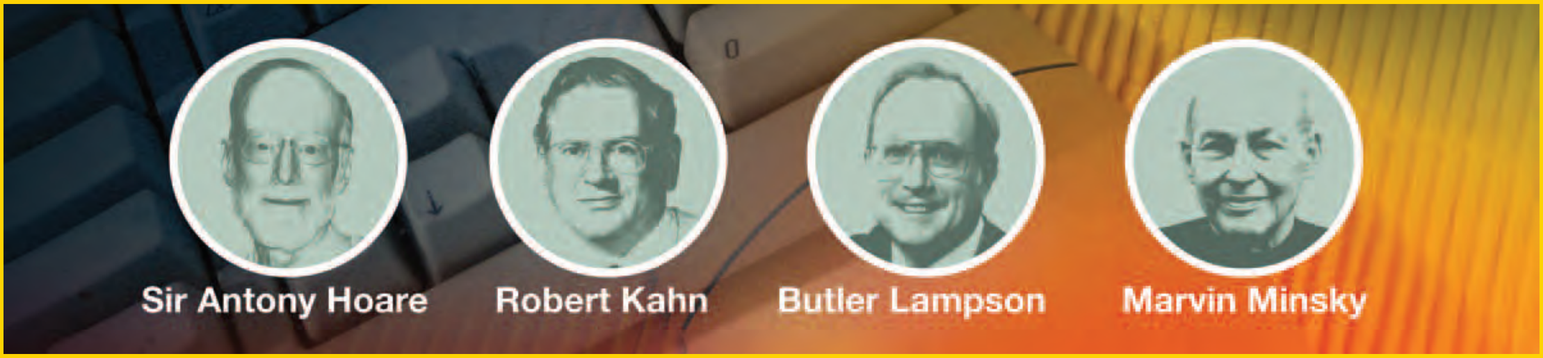
Sammy Yip

LAST YEAR'S FELLOWS



Rescued treasures: A curator's personal account

On December 8, 2006, the CMA CGM Hugo, three football fields long and one of the world's largest deep ocean container ships, slipped into its berth at the sunny Port of Oakland.

Among its precious cargo of more than 8,200 forty-foot containers were six holding rare computer artifacts from a warehouse in northwestern Germany on their way to the Computer History Museum in Mountain View, their journey sponsored by software leader SAP AG. These artifacts were rescued only weeks earlier by a "rapid-response team" composed of Museum volunteer (and native German speaker) Alex Bochannek and me, the Museum's senior curator.

How did these rare objects make their multi-thousand-mile journey to the Museum and why?

ABOVE | CHM's Dag Spicer holding an IBM System/370 CPU sign.

LEFT | Phillips P 2934 dot matrix printer (ca. 1985) *in situ* in the German warehouse. That plants could grow vigorously shows the weak boundary between the inside and outside of the warehouse.

TRACES OF THE PAST

This story begins in August 2006, when Siegfried M., a computer programmer and consultant from Dortmund, Germany, notified the Museum about a collection of rare computing objects in a warehouse near him. (For privacy reasons, I use only the initial of Siegfried's surname.) The warehouse was on the outskirts of Castrop-Rauxel, a small town in an industrial area once rich in coal. The town was bombed with particular vigor by the Allies during World War II as it also had large chemical and explosives complexes—a "double score" for Allied bombers.

History is always present in Europe . . . and even during this mission, sixty or more years after the conflagration, traces of the past were all around us.

We determined that the Castrop-Rauxel warehouse was being used as an informal storage area by Gustav T., who apparently had hoped to establish a German computer museum of his own. Gustav appeared to have acquired a collection of items belonging to a professor at the University of Aachen and combined it with small computer collections from other sources. After some time, Gustav was faced with personal bankruptcy. As a creditor, it was now Siegfried's intent to have a court-appointed administrator seize the collection and dispose of Gustav's obligations to him through its sale.

It was at this point that Siegfried contacted the Museum as a possible buyer. We were certainly interested!

Being sensitive to issues of national pride, we ensured that other German museums had had a chance to look over the collection and potentially acquire items for themselves. This "ecosystem" approach is used by most museums to make optimum use of scarce resources. As long as something is preserved in a professionally managed and stable institution, CHM is agnostic about where items ultimately rest.

Siegfried and volunteer Alex Bochannek spoke on the telephone at length about the collection coming to CHM. Siegfried agreed to travel to the warehouse that weekend and take pictures of the collection *in situ*.

When we received the pictures, we were quite taken aback by the size of the warehouse and the scope of its contents. The warehouse was being shared with a construction equipment operator, and while it did have doors, they were left open all day and the warehouse contents were covered in dust . . . and, in places, bird droppings.

RIGHT | **Exterior view of the warehouse.**

FAR RIGHT | **Initial aerial view of the warehouse.**

BELOW | **Map of western Germany. The warehouse was located in the village of Castrop-Rauxel.**

It's a good thing Alex and I did not understand the scope of

A quick meeting was convened with CHM board chairman Len Shustek, CEO John Toole, and vice president of operations David Dial to discuss next steps, if any. In a letter to the Acquisitions Committee of the Museum, I expressed my optimism at the opportunity:

> Alex and I believe this to be an opportunity of enormous scale, diversity, and significance. The Museum has never had such an opportunity in its over three-decade existence to fill existing gaps in the collection, provide spares for possible restorations, obtain duplicate objects for loans or trades, and dramatically enhance the international scope of its collection.

We all agreed this collection had enormous potential and was at least worth a visit to assess it more closely. This was August 4. By noon on August 6, Alex and I were landing in Frankfurt—an airport of jaw-dropping scale—where we rented a car and then headed out onto the autobahn toward Dortmund. We arrived at our hotel in Castrop-Rauxel nearly twenty-four hours after leaving Mountain View.

THE WAREHOUSE

The next morning, Alex and I were to briefly meet Siegfried at the warehouse, which turned out to be a storage building of the German national power company, RWE. We were very excited, not knowing in what condition to expect the building or its contents. Once on site, we checked in with the locals who brought us into the building.

What met us was so overwhelming—so broad, so high, so deep—that Alex and I exchanged incredulous smiles, probably half out of fear, half out of joy. At the warehouse we briefly met Siegfried, a personable man who spoke superb English (like most Germans today), and then returned to the hotel to prepare for the first working day of the visit.

Considerable preparation had been made in advance at the Museum in Mountain View to identify as many items as possible from Siegfried's initial photographs. Once on site in Germany, Alex and I worked to a 2m-by-2m grid system in which the entire collection (more than 14,000 square feet in area) was divided. The contents of each 2m-by-2m square were recorded in a notebook and included (where possible) manufacturer, model, and any other relevant information. About 20 percent of the collection contained pallets of documents and media (magnetic and otherwise) containing historical software. Some of these documents were unique—site planning documents and sales "requests for proposals" from universities and businesses wishing to bring computers into their organizations. These are rare and offer a great deal of information about business processes and their automation at a time when many organizations were making their first foray into computing.

the collection beforehand or we may have become discouraged.

Most of the collection, however, was hardware—it took Alex and me ten days to survey it—ranging from Depression-era mechanical punch card office machines to mainframes and minicomputers.

While we worked away, after a few days Alex asked what the backhoe operator, who had been working just outside the building near us since we arrived, was doing. He was, to my chagrin but Alex's bemusement (bravado?), looking for unexploded World War II ordnance. An unexploded 500-lb. bomb had been located only a week before we arrived, about 1,000 feet away from where we were working. As I noted, history in Europe is everywhere, and even here—more than sixty years later near a warehouse in a small town—Allied bombs were still being found.

On Day 5, representatives from the German moving company Hasenkamp visited us to discuss how to ship whatever items we decided ought to be sent on to Mountain View (later indicated by a yellow sticker as Alex and I walked around the collection one final time). When they arrived, they had the same smile Alex and I had had on our first arrival: Was it fear? Disbelief? Amazement? They were to return twice more before we left.

WHAT TO SAVE, WHAT TO LEAVE

We now began the most difficult part of the adventure: deciding which items to save and which to leave behind. With a budget already stretched, we had the task of taking "only" seven ocean containers' worth of cargo. Alex and I had a great deal of support from CHM software curator Al Kossow, who put his research skills to great effect, whether it was looking up obscure German data processing equipment or commenting on the desirability of obtaining particular software. Vice president of operations David Dial was also critical in navigating the intricacies of international freight forwarding. Due to the span of computer history represented by the collection, the thousands of individual objects, the distances, and possible customs issues involved, this team approach was absolutely mandatory for success.

Alex and I displayed Marine-like discipline in not opening boxes at random and exploring their contents—much as we would have liked to! Sadly, on a project of this scale, one must make instant decisions or end up saving nothing. We *did* allow ourselves fifteen minutes of "unstructured playtime" each day, which we spent opening random boxes as fast as we could in hopes of finding some highly interesting object. We were usually not disappointed. A 1950s Anker-Werke accounting machine (shown on page 8) and a 1960s AEG-Telefunken computer system (pictured on page 9) were just two objects from the rescue mission.

I think it's a good thing Alex and I did not understand the scope of the collection beforehand or we may have become discouraged. Now, we not only had to arrange for shipping the items we wanted halfway across the world, we had to arrange for proper recycling of the electronic waste from the items we did not retain (mostly common microcomputers). Europe has very strict recycling regulations but, thanks again to Alex, we were able to navigate the shipping and recycling

Missions like this one are central to the Museum's purpose of being home to the world's

smoothly. Prior to final recycling, CHM also invited several German computer clubs to look at the items we did not take and to consider bringing them into their own collections.

As Alex and I finished tagging all the items coming to Mountain View on Day 9, we were glad to be leaving the respiratory problems, bird droppings, mold, rat poison, and occasional dead bird behind. We left early the next morning for the return flight to San Francisco.

When the Hugo finally pulled into the Port of Oakland, we were reminded of those days in the warehouse. Now we begin the multiyear process of inventorying and creating catalog records for each of the many thousands of objects in the donation. CHM also moved ahead by a year its planned purchase of off-site warehouse space to accommodate the German donation.

WORKING AGAINST TIME

Every day, year after year, the Computer History Museum works against time. Every year many thousands of tons of computer equipment are disposed of in the world's landfills—a problem unforeseen in the utopian days of early computing. Many of these items are rather uninteresting, mass-produced IBM-compatible machines of which the Museum has sufficient exemplars.

But others are truly worthy of being saved. Although we cannot know absolutely, it seems certain that extremely rare (in some cases unique) items from computing's early days are in this same waste stream. I say it "seems certain" because the few rescue missions with which CHM has been involved have had outstanding results—but have also left all involved with a feeling of "Wow, that was close!"

This incredible fragility of our world's material traces—hardware, software, the ideas behind them, the marketing materials, the people involved who can (for a while) be interviewed for an oral history—makes the window for preserving computing history especially narrow. While the delicate nature of artifact discovery and preservation is well known to archaeologists (from whom all museum curators draw some of their DNA), computers present unique challenges—first of which is a form of consciousness raising, so that old computers are not automatically considered to have no value.

Missions like this one are central to the Museum's purpose of being home to the world's largest and most important collection of computers and computing-related objects. While some may say CHM was lucky, it has always been my view that luck is merely the intersection of preparation and opportunity. As this German adventure shows, CHM remains prepared to preserve computer history at a moment's notice.

I would like to dedicate this article to Alex Bochannek, who has volunteered at CHM for ten years and without whose generosity of spirit and language skills this acquisition simply could not have taken place. Alex is also a patient and fun travel companion. The entire Museum also thanks software industry leader SAP AG of Walldorf, Germany, which made an outstandingly big-hearted gift of $250,000 to CHM for the shipping and logistical support of this collection. Thank you both. _Dag Spicer

FAR LEFT | **Anker-Werke AG accounting machine (ca. 1955). This transitional technology, between punch card and electronic accounting methods, was used by the German banking industry for decades.**

LEFT | **The "guano sorter" found in the warehouse. Wintering birds were responsible. Fortunately, this level of contamination was found only beneath warm warehouse lights, which were sparsely situated. For occupational health reasons, this item was not retained.**

BELOW LEFT | **AEG-Telefunken TR 440 computer system (1969). This now rare German mainframe formed part of Germany's national industrial strategy to develop expertise in computer design systems.**

largest and most important collection of computers and computing-related objects.

THIS COLLECTION BROUGHT TO YOU BY SAP

Opportunities to obtain a large collection of museum artifacts are rare, and the financial and preservation responsibilities that go with such initiatives are significant. A most generous gift of $250,000 from global software leader SAP AG helped to provide the required logistical support—as well as to cover shipping and storage costs—for the successful rescue of thousands of artifacts from more than 112 European and international manufacturers, including Telefunken, Siemens, Zuse, Olivetti, and Groupe Bull.

Several of the artifacts will be used to populate the Computer History Museum's 14,000-square-foot "Timeline of Computing History" exhibit, to be launched in 2009, as well as other future physical and virtual exhibits. The new collection greatly enhances the Museum's ability to undertake major exhibits, and will provide researchers access to unique technical information unavailable anywhere else.

Steve Maysonave's videotaped story describes the agreement between Digital Research, Inc., and IBM for distribution of DRI's CP/M operating system with the IBM PC.

COLLECTING THE STORIES OF **COMPANIES THAT CREATED THE INFORMATION AGE**

By Luanne Johnson

One summer Sunday in 1973, on David del Rio's first day of work at Software AG, the phone rang. A client in Los Angeles was having problems with a trial of Adabas, a database management system developed in Germany and distributed by David's new employer.

Within twenty-four hours, David was on a plane from Virginia to Los Angeles with Dick McGann, an "experienced" Adabas programmer who had been with the company two whole months. David's promised four to six weeks of training were compressed into an eight-hour flight to California, during which he frantically reviewed documentation—all in German—and asked questions of Dick—usually, "What is this in English?" That night he fell asleep over the manuals, and the next morning he was on site assisting the client.

A COLLECTION OF STORIES

If this story brings a smile to your face, it's probably because you, too, have a fly-by-the-seat-of-your-pants, scramble-to-deliver-the-goods story to tell. The information technology industry was built by people who hustled to get the job done despite ever-changing requirements, impossible deadlines, and slim lines of support all around. It was hectic; it was exhilarating; it was crazy. You either loved it or you got out.

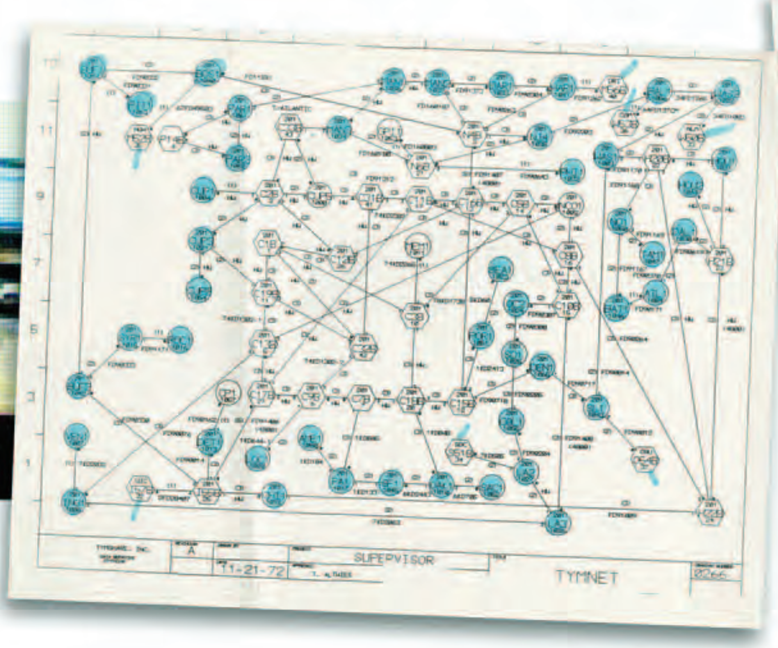
The IT Corporate Histories Collection (computerhistory.org/corphist) is a repository for these stories and many more materials that preserve the history of information technology companies. The collection was developed by a partnership of the Computer History Museum, the Charles Babbage Foundation, and the Software History Center (subsequently acquired by the Computer History Museum) and funded by a grant from the Alfred P. Sloan Foundation.

Through an initiative to use the Internet to preserve the recent history of science and technology, the Sloan Foundation encourages people to record history by telling their personal stories about working on technology projects. The IT Corporate Histories Collection focuses on stories told by people who worked for companies that developed and marketed information technology in all its permutations. The stories range from pithy anecdotes to in-depth descriptions of a company start-up or new product development. While most are memoirs written by the participants, the collection also includes a number of videotaped interviews.

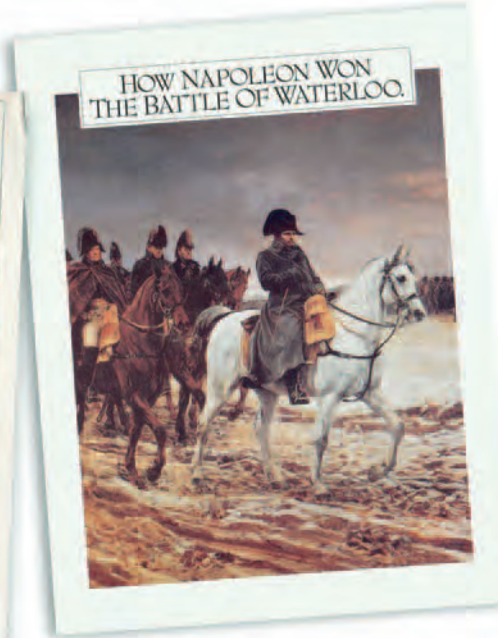
EXPLODING MYTHS

These stories provide great insights into the history of IT companies. Sometimes they serve to explode long-standing industry myths. For example, many in the IT industry have heard the story that Gary Kildall, the founder of Digital Research, Inc., blew off a meeting with "the suits" from IBM regarding licensing the CP/M operating system to go gallivanting in his private airplane. Supposedly the frustrated IBM folks turned to Microsoft's MS-DOS operating system for their PC, and DRI missed out on the greatest opportunity in the software industry.

Claims and counter-claims about this story have floated about for years. But Curt Geske was there. In his story "DRI and IBM—First Meeting," Geske tells us the meeting was a rather mundane affair between Dorothy Kildall, who ran the business end of things, and IBM lawyers over the wording of a nondisclosure agreement. IBM made it known that Microsoft already had a contract to do the work and expected DRI



A 1972 schematic of the Tymnet network. The Tymshare collection also includes schematics from 1974, 1975, and 1977, illustrating the dramatic growth of Tymnet.



From the Informix collection: A 1990s marketing brochure tells a fanciful tale of how Napoleon used the Informix On-Line database management system to manage his logistics and win the battle of Waterloo.

to supply them with the full source code for CP/M, which DRI was understandably reluctant to do. DRI and IBM did eventually reach an agreement for IBM to distribute CP/M, but as recounted in Steve Maysonave's videotaped story, the agreement was structured in a way that gave all the advantage to Microsoft. The outcome was consistent with the legend, but it hinged on the intricacies of contract negotiations rather than on Gary's preference for flying over attending meetings.

REVEALING INSIGHTS

Other stories in the collection support long-held beliefs. In the 1960s and 1970s, entrepreneurs had many war stories about how IBM—the "evil empire" of the time—was out to crush them. This was a persistent legend that was difficult to authenticate because IBM never had an official objective to crush competition. But stories from those who were there reveal how hard it could be to compete against a company that had such strong market dominance and controlled its customer accounts so effectively.

In "Day One at SAGNA," Michael Jakes recounts how a client refused to allow him to make copies of a report from a database selection committee that chose Software AG's Adabas over IBM's product. The client was so fearful of reprisals from IBM if the results of an analysis unfavorable to IBM leaked out that he allowed Michael, hidden in a conference room, only an hour to make as many handwritten notes as he could.

In another story, "MRX 1270 Terminal Control Unit," Robert DiMenna describes how IBM engineers provided incomplete interface specifications for their System 360/370 computers, and how the IBM salesmen exaggerated the risks of attaching non-IBM equipment to their computers, thereby retarding sales of the Memorex 1270. Clearly the competitive obstacles were real, whether they were the result of official IBM policies or simply the fallout of IBM's very focused marketing strategy.

REACHING OUT FOR MEMORIES

Because collecting personal stories was a key objective of the Sloan initiative, developing this collection required extensive outreach to find people who worked for these companies. The stories resulting from this effort are valuable historical source materials. Moreover, the outreach effort resulted in the collection of a large number of documents and other artifacts related to these companies—more than 1,500 documents in the online collection plus hundreds more donated to the Museum archives. The vast majority of these materials came from the personal files of individuals, not from corporate files. Because most of the companies covered by the project are defunct—long since acquired or otherwise out of business—the materials collected from the basements and attics of the participants represent historical information that was at risk of being lost forever.

More than 250 people have contributed everything from handwritten notes to organization charts to marketing brochures to network schematics—the whole hodgepodge of materials that employees of these companies saved for whatever reasons were important to them at the time. The Cincom collection includes marketing materials from the late 1960s that explain to potential customers what a database is and why you need one. Compare that to the Informix marketing brochure from the mid-1990s, which tells a fanciful tale of how Napoleon used the Informix OnLine DBMS to win the battle of Waterloo. In the intervening decades, database marketing materials had shifted from explanations of what the product was to attention-getting tactics.

The materials collected are critical to documenting the history of the industry that began to transform the world in the last half of the twentieth century. Thanks to the IT Corporate Histories Collection, they are being preserved to enlighten and inspire many generations to come.

CONVERSATIONS from the ORAL HISTORY COLLECTION

By Len Shustek

For many years the Computer History Museum has had an active program to gather videotaped histories from people who have done pioneering work in this first century of the information age. These recordings are a rich aggregation of stories that are preserved in the collection, transcribed, and made available on the web to researchers, students, and anyone curious about how invention happens.

The oral histories the Museum collects are conversations about people's lives. We want to know about their upbringing, their families, their education, and their jobs. But above all, we want to know how they came to the passion and creativity that leads to innovation.

Here, as an example, are excerpts from an interview conducted by Grady Booch on June 8, 2004, of Bill Atkinson and Andy Hertzfeld, who were major contributors to the creation of the Apple Macintosh.[1]

Bill Atkinson and Andy Hertzfeld.

The early 1980s were the Gold Rush days for the personal computer. We want to learn about the atmosphere of the time. There was, everyone says, something different about Apple.

HERTZFELD: The first computer I owned was an Apple II, serial number 1708, which I bought in January 1978. I wanted my own computer and checked out the Altairs and the IMSAIs, but I wasn't handy enough with a soldering iron. When the Apple II happened, I knew it was for me. I was a grad student at UC Berkeley, but it quickly just took over my life.

I wasn't an Apple employee then. I was one of those people who were led to Apple like a moth to the flame; the Apple II attracted me to Apple. I started at Apple in August of '79.

ATKINSON: The thing that drew me to Apple was this notion that you can do something with your life. Making a dent in the world is what Steve Jobs used to call it. You can have an impact for the positive if you are where things are being created.

I came to Apple in 1978. I was hired as the application software department, because there wasn't one. Actually, at the time I was a little better at pushing chips than software, but that's what they needed. So, okay, I can do that.

There is a famous legend that the Apple team visited Xerox PARC (Palo Alto Research Center) and carried away the user-interface ideas. What really happened?

ATKINSON: In 1979, when the Lisa team went to visit, we got to see the Alto and the Smalltalk System and I think the Bravo text editor. What people misunderstand is that we didn't just copy what we saw. It gave us great inspiration and gave us great confidence that, yes, we did want to do windowing, but then we had to go incrementally, evolutionary-wise, and develop this user interface a piece at a time by a lot of trial and error and a lot of stupid mistakes.

What really helped us was user testing. Larry Tesler was big on this. We wanted a beginning person to walk up and be able to figure it out. We'd give them tasks and say, "Here, edit this document and save it," and asked them to mutter a stream of consciousness. What are they thinking about? That was very important because *why* they do something is just as important as *what* they do. Thousands of these kinds of tests where you find that people made mistakes are what led us to the user interface.

The Mac project was run very differently from—and almost in competition with—the Lisa that had been started years earlier.

HERTZFELD: The Mac design did not flow out of the Lisa hardware. It was more like the Apple II, where you had a crazy genius coming up with very unorthodox techniques not used anywhere else. Burrell Smith, who designed the Macintosh digital board, really learned from Woz. The Apple II

1. Oral histories are not scripted, and a transcript of casual speech is very different from what one would write. I have taken the liberty of editing and reordering freely for presentation. For the original transcript, see: archive.computerhistory.org/search/oh.


Apple's Lisa II and Macintosh.

was the immediate predecessor of the Macintosh hardware, not the Lisa.

Lisa had seven different applications all developed by Apple, which was another way the Lisa team diverged from the Apple II. One of the characteristics of the Apple II was the third-party market. With Lisa the idea was that all the applications would be written by Apple. But you get a different spirit. The Mac brought it back home. It combined the Apple II spirit and a thriving third-party community. And Burrell and Woz are similar-type designers: the crazy genius instead of the conservative committee.

ATKINSON: The goals of the two were very different. We were designing the Lisa for an office worker, and since we weren't office workers ourselves, it was kind of hard to know exactly what they wanted. When the Mac was designed, I think we had a pretty clear picture of a fourteen-year-old boy using this thing, and we knew what they were like.

Every company has a unique culture for writing software. What was the Mac culture?

HERTZFELD: Freewheeling. Bill was really the center of coming up with the user interface, but he worked at home so he would come in maybe two or three times a week, usually when he had discovered something new. We would all gather around and talk about it and give him feedback.

ATKINSON: I'd get good suggestions from other people and say, "Oh, that's a good idea."

HERTZFELD: It was very loose. In the Lisa group there were a lot more philosophical arguments about what is the best way to do it in the abstract. With the Mac, it was much more, "Try it out and see how it feels," every step of the way.

PROFILE OF AN INVOLVED BOARD MEMBER

Gardner Hendrie

The founder and chair of the Oral History Committee at the Museum is Gardner Hendrie, who tackled that project like everything he does: comprehensively and in depth. He bought multiple sets of equipment, funded the necessary staff position, took a course in how to do oral histories, and for the last five years has been either videographer or interviewer (or both!) for at least a third of the more than 120 oral histories the Museum has done in locations all over the country.

Amazing as it sounds, this is only a small part of Gardner's contributions to the Museum. Gardner has been a trustee for more than twenty years, starting back when CHM was The Computer Museum in Boston. He is on the Executive and Finance Committees, for which he flies out from Boston every month. He is chairman of both the Exhibits and Investment Committees and has recently reinvigorated the Major Gifts committee. He personally gives at the highest level each year to the Annual Campaign and has made a multimillion-dollar contribution to the Museum Campaign. He funds special projects whenever he sees the need.

Gardner is a computer pioneer himself. He was the designer of several early minicomputers and was one of the founders of Stratus Computer Inc. Since 1985 he has been with Sigma Partners, a venture capital firm, and has served on many of their portfolio companies' boards.

For the last ten years Gardner has been my mentor and role model for energetic involvement. One of the great pleasures in being chairman of the Museum is the opportunity it provides to work with Gardner, and I thank him profoundly for that. _*Len Shustek*

Photo courtesy of Louis Fabian Bachrach.

But creating software is about more than writing programs that work.

ATKINSON: It's an art form. It's not just practical: "Does it do the job?" But is it clean inside? I would spend time rewriting whole sections of code just to make them more cleanly organized, more clear. I'm a firm believer that the best way to prevent bugs is to make it so that you can read the code and understand exactly what it's doing.

That was a little bit counter to what I ran into when I first came to Apple. There were a lot of people who prided themselves on how this little piece of code does something magic. I found that if I spent time going over the code, cleaning it up, making it sometimes tighter, but also making it so that it was straightforward for another person to follow in my footsteps, then I would feel proud of it.

Just as famous as the Apple visit to Xerox was Bill Gates's visit to Apple. Did Bill get it?

HERTZFELD: Well, he didn't get every detail, but definitely when he saw the Mac and the graphical user interface, he believed in it. He put a lot of resources on it, and Microsoft was really helpful in tweaking some of our rough edges. For a while they had almost as many people on the Mac as Apple did.

We always end by asking for advice for the next generation of innovators, in this case for software developers.

ATKINSON: If you want to get it smooth, you've got to rewrite it from scratch at least five times. Do a lot of user testing, because you can't see the things that you can't see. Don't try to ship that first prototype; hold off, and let it incubate in privacy. Don't tell the marketing people you're done when you've got the first fifth of it done! The thing that makes software smooth and useable is user testing, user testing, and user testing.

HERTZFELD: Pick things to work on that you really, really want to use yourself. You can close the loop with the user testing, but if you are one of the users, you can just iterate in your head.

Of all the things you can work on, work on the thing that isn't in the world that you want to make be in the world. Then you can be both user and creator. There is real power in that. To some extent, that's the secret of the Mac's success. We all wanted the Mac more than anyone else. So much so, that we had to make it.

Follow your heart. You have to do work each day that you believe in.

And that, my friends, is advice that applies to more than just writing software.

MY FIRST COMPUTER(S)

My first desktop computer (1982) was put together by San Francisco engineer and philanthropist Henry Dakin, who has helped many people in the nonprofit sector become computer functional. It consisted of a custom DOS-based computer, two eight-inch Shugart floppy drives, a big black-and-white CRT, and a dot-matrix printer. My first husband was an editor at the *San Jose Mercury News*, and the Merc outfitted its staff with TRS-80 laptops to cover the 1984 Democratic National Convention in San Francisco. I looked at his TRS-80 and said, "That's neat!" And got one for myself.

Dr. Gloria C. Duffy
President and CEO
The Commonwealth Club of California

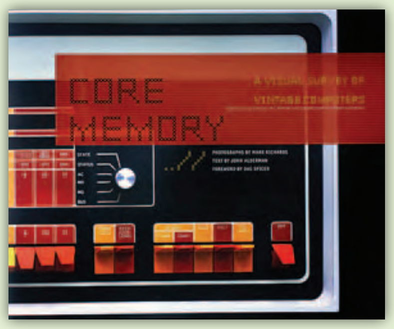
Why take pictures of computers?

Cray-3 "brick" module.
Cray Computer Corporation, 1993. ***Photo © Mark Richards.***

Imagine we could be around during the time of the first printing press. What would you want to keep for civilization to see in the future? This is one of the questions I asked myself as I photographed these computers. I set out to document what I saw as the visual elements of the beginning of a new era, the age of the computer, a time as significant as the age of the early printing press.

I wanted my photography to express the kind of passion that men and women felt when they were inventing these machines. More than just taking pictures, I wanted both the layperson and the computer professional to feel what I felt. To see these machines as more than steel and wire and plastic. To see that these are ideas and dreams and lives.

As a still photographer I can use only two dimensions, color, form, context, and a few other tricks. I must use them with my enthusiasm and my imagination, while staying true to the machines. My hope is that my photographs will allow people to see these machines in a new way. _Mark Richards



Mark Richards has photographed diverse human subjects, from combat in Afghanistan for *Time* to street gangs in Los Angeles for *Newsweek*. A California native, Mark has covered Silicon Valley since the early 1990s. His images have earned numerous awards from *Communications Arts* magazine, and his work has appeared in publications such as the *New York Times Sunday Magazine*, *Fortune*, *Smithsonian*, *Life*, and *BusinessWeek*.

These pictures are from *Core Memory: A Visual Survey of Vintage Computers* (Chronicle Books, 2007), which features Mark's photographs of machines from the collection of the Computer History Museum with text by John Alderman. *Core Memory* presents "a guided tour through some of the most notable and curious devices in the history of computing." The book is available in the Museum gift shop or by contacting Jim Somers at somers@computerhistory.org. The price for Museum members is $30, including tax. The book's list price is $35.

THIS PAGE | **Univac I mercury delay line memory tank. Remington Rand, 1951**.

OPPOSITE PAGE, TOP | **Close-up of ENIAC (Electronic Numerical Integrator and Computer) Function Table. U.S. Army, 1946.**

OPPOSITE PAGE, BOTTOM | **CDC 6600. Control Data Corporation, 1964.**

All photos © Mark Richards.

"Go off and do something wonderful"

FOUR STORIES FROM THE LIFE OF ROBERT NOYCE // BY LESLIE BERLIN

Bob Noyce (left) and his older brother Gaylord proudly display the glider they built in the summer of 1945.

Image courtesy of Stanford University Libraries, Department of Special Collections.

Robert Noyce was called the Thomas Edison and the Henry Ford of Silicon Valley: Edison for his coinvention of the integrated circuit, a device that lies at the heart of modern electronics; Ford for his work as a cofounder of two companies—Fairchild Semiconductor, the first successful silicon firm in Silicon Valley, and Intel, today the largest semiconductor company in the world. Noyce also mentored dozens of entrepreneurs, an effort he loved and called "restocking the stream I fished from."

Right up until his death in 1990 at the age of sixty-two, Noyce was a daredevil. His jacket bore a patch that read, "No guts, no glory." It was a fitting motto for a man who flew his own jets and took time off every year to go helicopter skiing. It is no wonder, then, that for many his life encapsulated the high-flying, high-risk, high-reward world of high technology.

It is impossible to do justice to Noyce in a brief article. Instead, I offer four stories that provide glimpses into what made him one of the twentieth century's most important inventors and entrepreneurs. And in the spirit of Noyce's belief that the best knowledge is knowledge that can be used, each story includes a "take-away" for readers.

For Bobby Noyce, the real test of success would be if he could, as he put it, "jump off the roof of a barn and live."

BOYHOOD ADVENTURER

When Noyce was twelve, he and his fourteen-year-old brother Gaylord decided to build a boy-sized glider. They used no blueprints, only the knowledge they had gained from years of constructing model airplanes.

Building the glider was the highlight of the summer of 1940 for many of the seventeen children Bobby Noyce convinced to help in the effort. A boy whose father's furniture store received rugs on long bamboo spindles donated the rods for the glider's frame. A girl sewed the cheesecloth that stretched over the wings. And the boy with the newly minted driver's license was charged with hitching the glider to the back of his father's car to see if the plane could be flown like a kite.

But for Bobby Noyce, the real test of success would be if he could, as he put it, "jump off the roof of a barn and live."

That's what he resolved to do. He climbed up on top of the barn near his house, had someone hand him the glider, took a deep breath, and then ran right off the edge of that roof into the unknown.

He was only aloft for a few seconds, but he landed without crushing the machine and declared the experiment a success.

TAKE-AWAY. Noyce, at age twelve, already possessed three attributes that would define his future success as a technical entrepreneur. First, his technical ability with his hands is evident. Throughout his life, Noyce was respected by engineers as well as scientists because he was not simply a thinker; he was also a builder. Second, the adolescent Noyce pulled together a diverse team, each member of which he tapped for his or her ability to contribute something unique to the project. Finally, in the boy who reached the edge of the roof and kept on running, we see the soul of the man who lived without limits, a man who believed that every idea could be taken further. These three attributes—technical credibility, the ability to assemble and motivate a diverse team, and a "no limits" mindset when it came to goal-setting—underpinned Noyce's technical and business success.

SCIENTIST TO MANAGER

In September 1957, Noyce, then thirty years old, joined a rebellion led by seven of his coworkers. Julius Blank, Vic Grinich, Jean Hoerni, Eugene Kleiner, Jay Last, Gordon Moore, and Sheldon Roberts had met more than a year earlier when they were hired by William Shockley, coinventor of the transistor, to work at his new company in Mountain View.

In short order, Shockley proved an unpredictable micromanager. Even worse, he wrenched the company's focus away from silicon transistors, the broad market for which was apparent even at that time, to four-layer diodes that were difficult to build and served a limited market. The group of seven, soon joined by Noyce, decided to leave.

It was not easy to find someone willing to fund a start-up company managed by young technologists in 1957, but with the help of two New York bankers (one of whom was Arthur Rock), the group did so. Fairchild Camera and Instrument agreed to back the fledgling operation, Fairchild Semiconductor, and soon acquired it outright.

Noyce headed research and development at Fairchild Semiconductor. He adopted a hands-off management style that encouraged outside-the-box thinking, creative freedom, and collaboration. He was an excellent supervisor of technical work.

In January 1959, Noyce became general manager of Fairchild Semiconductor. A PhD physicist with no formal business training, Noyce taught himself business skills over the next eight years. Within a decade of the company's founding, Fairchild Semiconductor had 11,000 employees and $12 million in profits. For a while, its parent company (essentially all of whose profit came from the semiconductor division) was the best-performing stock on Wall Street.

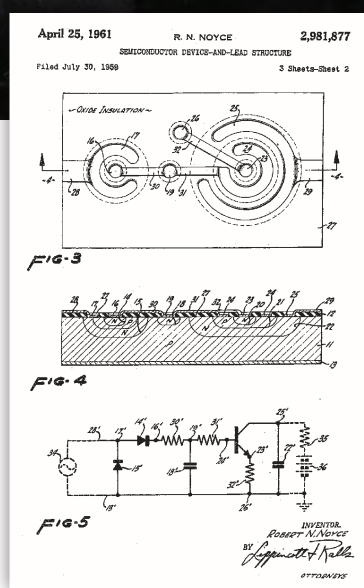
The eight founders of Fairchild Semiconductor in the company's production area.

BACK ROW, LEFT TO RIGHT: Victor Grinich, Gordon Moore, Julius Blank, and Eugene Kleiner.

MIDDLE: Jean Hoerni.

FRONT: Jay Last and C. Sheldon Roberts.

FACING THE GROUP: Bob Noyce.



At left, several key illustrations from Noyce's integrated circuit patent.

Then everything fell apart. Fairchild began missing scheduled deliveries. Products in the development stage could not be successfully transferred to manufacturing. The trickle of employees leaving Fairchild in recent years became a flood. In the third quarter of 1967, profits were 95.5 percent lower than a year before.

Fairchild Semiconductor declined for many reasons, but Noyce himself must bear some responsibility. His laissez-faire management approach—offering general directives rather than following up on specific process details—was ideal for inspiring and supervising highly creative technical work, but this management style did not translate well to large, multifaceted organizations.

TAKE-AWAY. Inspirational leadership alone is not effective management. At times, the same person can be both an excellent big-picture, rally-the-troops leader and an outstanding detail-oriented manager, but this was not the case with Noyce, who was the former but not the latter.

Noyce's experiences at Fairchild forced him to recognize his own shortcomings. "One thing I learned at Fairchild," he later admitted, "is that I don't run large organizations well. I don't have the discipline to do that, have the follow through."

When Noyce and his Fairchild cofounder Gordon Moore left the company in July of 1968 to start a small memory operation that today is called Intel, they deliberately split power evenly between them. This decision, which came directly from Noyce's having confronted his own managerial limitations at Fairchild, offers yet another take-away: Noyce was willing to act on the knowledge of his own professional limits.

INVENTOR

Of the seven patents Noyce filed in his first eighteen months at Fairchild, the best known is #2,981,877 for "Semiconductor Device-and-Lead Structure." Fairchild called the product developed on the basis of this patent—a complete electronic circuit built on a chip of silicon small enough to be carried off by an ant—a "monolithic integrated circuit." Nearly every electronic device today contains descendants of the integrated circuit in Noyce's patent application.

By the time Noyce's patent application was submitted, however, Noyce himself had left the lab—and research science—for good. As general manager of Fairchild Semiconductor, his primary contribution to integrated circuit development came through his funding relevant research and encouraging gifted researchers. It was not Noyce but a team led by his cofounder Jay Last and anchored by men such as Isy Haas, Bob Norman, Lionel Kattner, and Jim Nall that transitioned Noyce's notebook entry from good idea to real product. And in truth, Noyce's patent did not provide much guidance. It said that it ought to be possible to build integrated circuits using isolation techniques as well as the breakthrough planar process invented by Noyce's Fairchild cofounder Jean Hoerni. The patent did not, however, say how to make this possibility a reality. That was what Last's group figured out through their own remarkably innovative work, some of which earned team members patents on their own key ideas and processes.

TAKE-AWAY. Innovation is rarely the product of a single mind. Invention is best understood as a team effort, with the person ultimately called "inventor" occupying much the same space as the pitcher who has just had a perfect game. The outfielders might have caught a dozen fly balls, the first baseman might have nearly broken his neck to step on the bag an instant before the runner, the catcher might have called for pitches perfectly calibrated to each batter's weakness, but the record books note only that the pitcher threw a perfect game.

Noyce never hesitated to admit that his ideas about integrated circuits relied heavily on ideas that were "in the air" in 1958 and 1959. Without Hoerni, without Moore, without the work of Kurt Lehovec at Sprague, Noyce never would have imagined the integrated circuit in the way he did. Without Last, the microcircuits group at Fairchild, and other people around the world working in the field, Noyce's ideas would never have become marketable products.

MENTOR

After Noyce retired as Intel board chair in 1979—he remained a board member until his death—he enjoyed mentoring young entrepreneurs. Noyce worked with dozens of youthful technologists and funded many small companies. The best known of the entrepreneurs he encouraged was Steve Jobs, cofounder and CEO of Apple and cofounder of Pixar, Inc.

The two met in 1977, when Apple was a year old. Noyce's wife, Ann Bowers, headed human resources at Apple, and through her, Jobs deliberately sought out Noyce as a mentor. "Steve would regularly appear at our house on his motorcycle," Bowers recalls. "Soon he and Bob were disappearing into the basement, talking about projects."

Noyce answered Jobs's phone calls—which invariably began with, "I've been thinking about what you said" or "I have an idea"—even when they came at midnight. At some point he confided to Bowers, "If he calls late again, I'm going to kill him" . . . but still he answered the phone.

"He was very interested in—fascinated by—the personal computer, and we talked a lot about that," Jobs recalls of Noyce.

"Optimism is an essential ingredient for innovation."

BELOW | Bob Noyce and Steve Jobs in the mid-1980s. Jobs is one of many entrepreneurs who count Noyce among their major influences.

For his part, Jobs believed that "you cannot understand what is happening today without understanding what came before," and Noyce gave him a way to experience what Jobs called "that second wonderful era of the valley, the semiconductor companies leading into the computer."

TAKE-AWAY. There is an informal sort of generational succession in Silicon Valley that places Noyce near the top of the family tree. A few years ago, for example, the founders of Google asked Steve Jobs for advice and mentorship in the same way Jobs had come to Noyce when Apple was young.

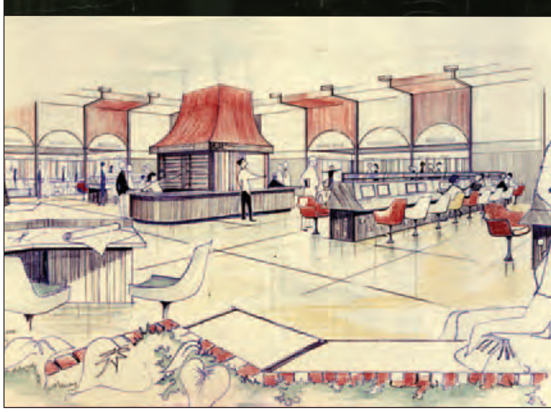
Noyce believed that would-be entrepreneurs needed successful role models (though he never would have put it that way). His financial success directly benefited the entrepreneurs whose companies he funded as an informal angel investor, but the stories about his success indirectly inspired many more who thought, "If he can do it, I can, too." This belief is an essential aspect of any innovative culture because it encourages new ideas and risk-taking—and with it engenders a self-perpetuating cycle of entrepreneurship. "Optimism is an essential ingredient for innovation," Noyce—who often advised people to "go off and do something wonderful"—once said. "How else can the individual welcome change over security, adventure over staying in a safe place?"

All images courtesy of Stanford University Libraries, Department of Special Collections.

EXPLORE THE COLLECTION A sampling of objects from across the Museum's five collections

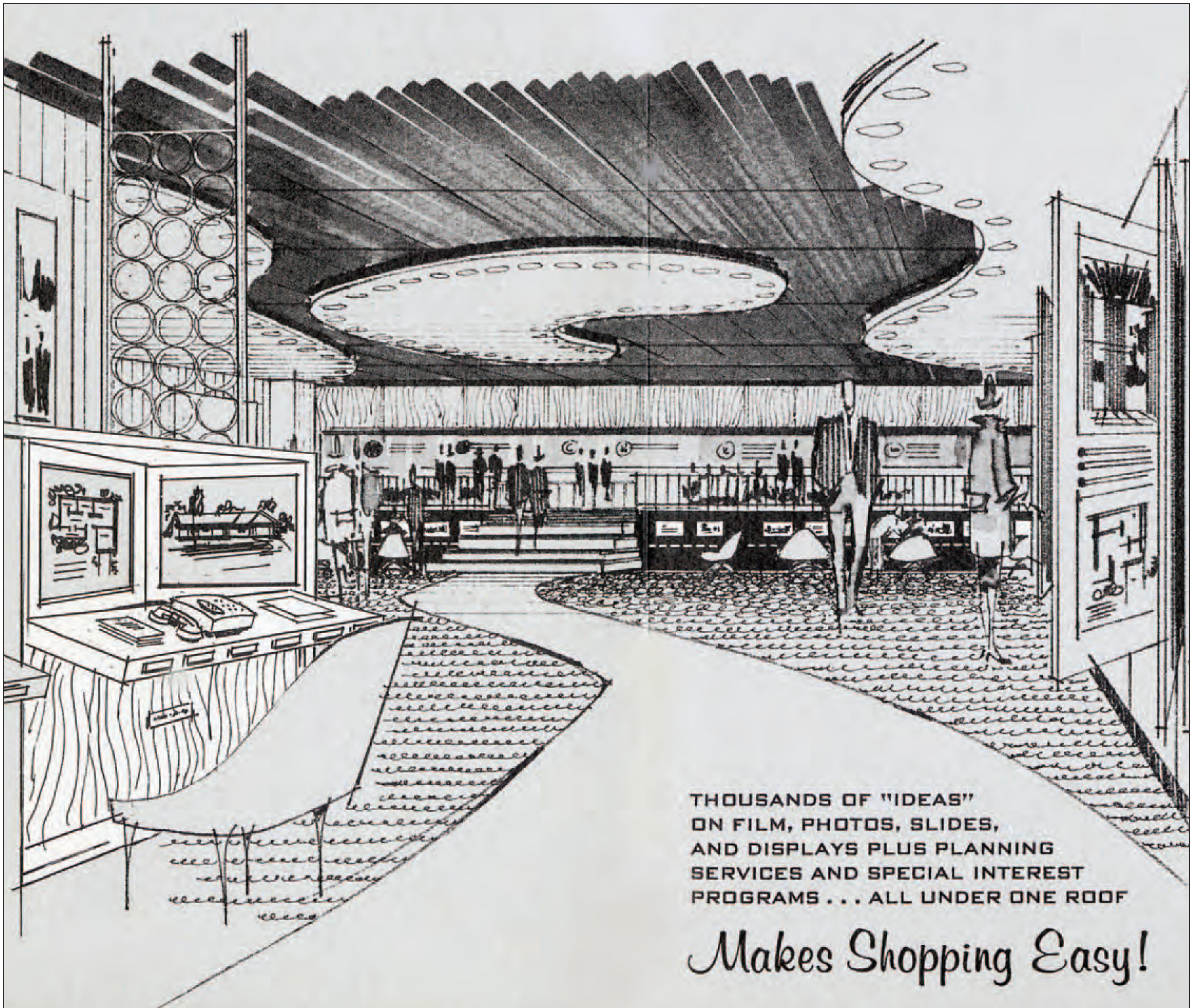
SLIDE-A-MAT RETAILING SYSTEM PROTOTYPE | CHM#: X3598.2006

DATE: 1965 | COLLECTION: OBJECTS | SOURCE: GIFT OF BRIAN KELLY CAROLAN



This 1965 prototype is early evidence of a novel concept in retailing that looks very familiar from our 2007 perspective. Want to bring your merchandise to potential ready-to-buy customers? Allow customers to compare products and services among vendors? Save them time? Allow them to shop from an armchair? Eliminate traffic congestion? These are not web-based ideas. They are just some of the advantages the Slide-a-Mat Retailing System offered—thirty years before the World Wide Web.

The Slide-a-Mat consisted of a custom desk with two rear-projection screens (with slide projectors inside), one of which showed a product or service and the other of which showed additional information such as specifications. If customers wanted to buy, they pushed one of the buttons running along the edge of the desk to specify the product, color, size, and other features.



LEFT | **Shoppers demonstrating the Slide-a-Mat.**

BOTTOM LEFT AND THIS PAGE | **Slide-a-Mat concept drawings and promotional materials.**

To enable customers to place orders, the Slide-a-Mat included a telephone with an optical sense card reader and a set of cards. When ready, the customer slid a vendor-specific plastic card into the telephone, which then dialed the vendor and connected the customer to a salesperson.

The Slide-a-Mat was patented, but internal problems led the company to go under. This prototype is the only physical trace of the system in existence. _*Dag Spicer*

MAN & COMPUTER, 16-MM FILM | CHM#: X3604.2006

DATE: 1965 | COLLECTION: MEDIA | SOURCE: GIFT OF HOWARD CHANG

Screenshots from *Man & Computer*.

Starting in the 1940s, IBM became a major producer of films used for training, documenting business processes, entertaining at company functions, and educating the public. Several IBM films were made by respected filmmakers and sometimes featured well-known actors such as Bob Newhart.

The film *Man & Computer*, made by IBM's UK branch in 1965, provides a basic understanding of computer operations. A large portion of the film shows the ways in which a computer can be simulated by five people using the standard office equipment of the day. The film employs a number of different techniques, including animations, and features a few brief scenes of an IBM System/360 in use—just months after the first machines were delivered.

_*Chris Garcia*

IBM SYSTEM/360 SALES MODELS | CHM#: X3749.2007

DATE: 1965 | COLLECTION: EPHEMERA | SOURCE: GIFT OF AL BURSTINER

On April 7, 1964, IBM made the most dramatic announcement in computer history. After investing nearly $5 billion in research and development, IBM had created a family of computer models that spanned a 40:1 performance range—and could all run the same software. This family of machines was known as the "System/360," an allusion to the system covering all points of the customer compass, from a small business doing payroll to a university undertaking scientific research to government agencies processing millions of checks per month.

Even though it was already the market leader in punch card equipment and "electronic data processing machines," this was a remarkable gamble by IBM.

After supporting seven mutually incompatible computer lines for years, IBM developed the System/360 as a means of simplifying their computer offerings for salespeople and customers alike. The System/360 was supremely successful. Its architecture dominated the mainframe computer industry for more than three decades and can still be seen in various IBM mainframes. IBM sold more than $100 billion worth of System/360 installations over the life of the family—a remarkable milestone, even by today's standards.

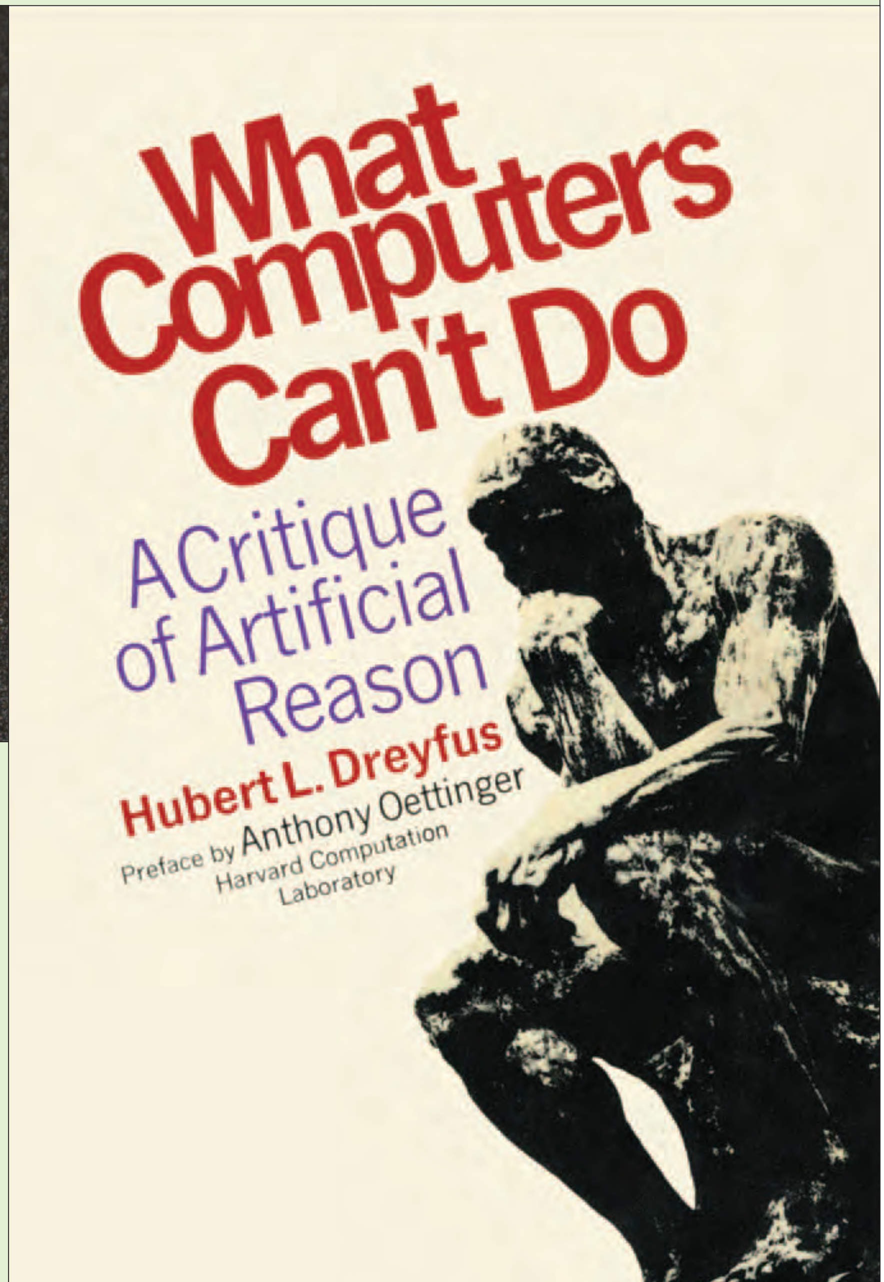
These sales models were used in two ways: first, as part of the presentation made by an IBM salesperson to potential customers; second, as a tool for planning computer installation and layout of the room where the computer would eventually reside. _*Dag Spicer*

TOP | **IBM System/360 sales models, 1965.**

BELOW | **IBM System/360 installation, 1965.**
Image courtesy of IBM Archives.

MACHACK VI VS. HUBERT DREYFUS, PAPER TAPE | CHM#: X3278.2006

DATE: 1967 | COLLECTION: SOFTWARE | SOURCE: GIFT OF BRUCE BUCHANAN



Hubert Dreyfus, a professor of philosophy at MIT in the 1960s, found that many of his students thought artificial intelligence (AI) was an already accomplished fact. This misplaced faith helped shape Dreyfus into an early critic of AI's claims, and in 1965 he was hired by the think tank the RAND Corporation to explore the issue. The result was a ninety-page paper questioning the computer's ability to serve as a model for the human brain and asserting, for example, that no computer program could defeat even a ten-year-old child at chess.

Two years later Richard Greenblatt, formerly an undergraduate at MIT, wrote a chess program using only 16K of memory for the DEC PDP-6 computer. The program, MacHack VI, played chess at a level far above its predecessors, a factor that would surprise Dreyfus (and the AI community) when demonstrated.

With some confidence, students at MIT challenged Dreyfus to play a game against MacHack VI. Dreyfus lost and the game became a milestone moment in AI—at least for AI proponents.

In fairness to Dreyfus, 1960s computers were primitive ancestors of today's machines, so to claim computers could think does indeed seem grandiose, even from today's perspective. After fifty years of research, one of the key conclusions of AI is that, for machines, simple things (e.g., tying a shoe) are difficult and difficult things (e.g., playing chess) are simple. _*Kirsten Tashev*

Can the machine, the robot, the computer replace man? Can man's behavior be formalized, his brain and body bypassed, to arrive at the essence of rationality? Is artificial intelligence possible? _*Hubert Dreyfus, 1972*

ABOVE LEFT | **Original paper tape from the chess match.**

ABOVE RIGHT | **Cover of Dreyfus's 1972 book, *What Computers Can't Do*, based on his RAND Corporation report of 1967.**

TYPED RESIGNATION LETTER FROM J. PRESPER ECKERT, JR., TO DR. PENDER | CHM#: X3278.2006

DATE: MARCH 25, 1946 | COLLECTION: DOCUMENTS | SOURCE: PURCHASE OF CHM

The transition of an invention from the laboratory to the marketplace, often difficult, is a process nearly every technology-based company must go through at some stage. In 1946, Presper ("Pres") Eckert and John Mauchly, inventors of the ENIAC computer at the University of Pennsylvania's Moore School of Engineering, wanted to form their own company but were constrained by their agreement with the university over patent rights to the EDVAC, ENIAC's successor.

In his resignation letter, Eckert writes:

> I have felt that the patent rights which have been assured me in connection with my work up to this time were an important part of my remuneration...it seems sensible at this time to resign, since...our commercial ideas for computing machines are incompatible with the Moore School's development program.

Eckert and Mauchly founded the Electronic Control Company (ECC), which became the Eckert-Mauchly Computer Corporation (EMCC) in 1947. With the death of their main financial backer only two years later, Eckert and Mauchly sold their business to the Remington Rand Corporation. For this they received $200,000 and a guarantee of eight years of employment. Their first commercial computer, the UNIVAC I, was delivered to the United States Census Bureau on March 31, 1951.

Although their own business failed, leaving an opening for Remington Rand, Eckert and Mauchly remained pioneers in the development of large-scale electronic computing systems.
_*Paula Jabloner*

RIGHT | **Typed resignation letter from J. Presper Eckert, Jr., to the University of Pennsylvania's Dr. Pender, March 25, 1946.**

March 25
1 9 4 6

Dear Dr. Pender:

It is with regret that I find it necessary at this time to resign from the Army Ordnance project for the design and construction of the EDVAC at the Moore School.

I have felt that the patent rights which have been assured me in connection with my work up to this time were an important part of my remuneration. My understanding was that such rights were to be given me for the duration of my employment on Army Ordnance work, after which my services would not be required by the Moore School, and I would be free to enter into commercial developments based on these rights.

When Commander Travis returned to the Moore School in the capacity of managing all such projects, he finally made it clear that the aforesaid agreement would cease to be in effect under the PY project. I believe that it is not difficult for you to understand that such an agreement would be of little value to me from the viewpoint of the patent situation, for by building a more efficient and faster computing machine, it would be necessary that we invent devices which would make our previous inventions, and consequently our rights on the devices contained in the ENIAC and EDVAC, of little or no value.

If we had decided to stay at the Moore School under the terms that are now presented, we would have to abandon our former plans. I do not feel that the alternative offered is sufficiently well planned, nor presented in sufficient detail to offer a satisfactory future to computing machines or to ourselves. In view of the conflict between Travis' plans and our plans, it seems sensible at this time to resign, since he feels our commercial ideas for computing machines are incompatible with the Moore School's development program. Travis seemed to feel that our methods of approaching the present development were unsound and that our aims were essentially disloyal to the Moore School. Our method is the same as the one used in approaching the design of the ENIAC at which time none of the stated reasons for our disloyalty existed. Since the method seemed to prove successful, I have been following the same procedure except for certain improvements. In contrast to the policy of some, I have always believed that a mad dash for an immediate working device did not give, even in the time of war, as satisfactory, nor in the final analysis, as quick a solution as that given by a careful analysis and the detailed

Dr. Harold Pender - 2 - March 25, 1946

comparison of all reasonable arrangements that presented themselves.

Both Dr. Travis and Dr. Warren seem to be pushing for a more rapid development -- a development which I felt would not give a reliable machine. Since, as an engineer, I am interested in seeing the wide-spread use of our work, I was not willing to jump into a poorly planned experimental program which would lead to a make-shift machine.

If at any future time I can be of any service to the Moore School, do not hesitate to contact me. I would hope that our difference of opinion in this matter does not leave the impression that I have any unpleasant feeling towards you, since our personal relation has been friendly and since I know you are only trying to leave the Moore School in the best possible condition when you retire. I am sorry to leave the many people at school with whom I have had pleasant relations, and I have a feeling of loyalty towards the institution as a whole.

Sincerely,

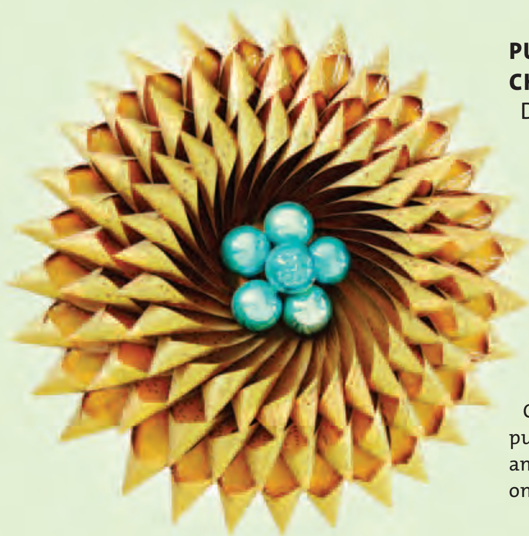
J. Presper Eckert, Jr.

JPE/fmm

RECENT DONATIONS Objects selected for their rarity, importance, or whimsy

TELEBIT MODEM PROTOTYPE
DATE: 1980
COLLECTION: OBJECTS
SOURCE: GIFT OF ERIC SMITH
CHM#: X3570.2006

Prototypes fulfill an important part of the Museum's mission to explore the deeper forces underlying technological innovation. Often a prototype can show the genesis of an important idea or a "road not taken" before the object stabilized and came to market. This modem prototype represents the beginning of the company Telebit, which offered modems based on a new approach to data transmission over noisy lines. Telebit was founded by Paul Baran, a CHM Fellow (2005), and was later acquired by Cisco.



ITR TIME CLOCK
DATE: 1916
COLLECTION: OBJECTS
SOURCE: GIFT OF LEN SHUSTEK
CHM#: X3854.2007

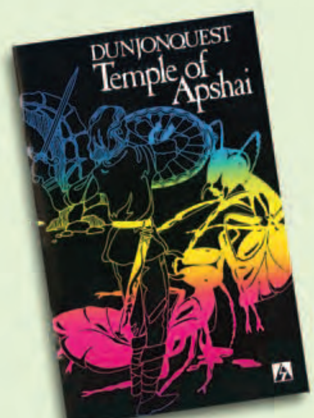
International Time Recording Company (ITR) was founded in Endicott, New York, in 1889. It sold time clocks based on the 1888 patents of Willard Bundy. According to an original sticker located inside this particular unit, the time clock was shipped to R. Wallace & Sons Manufacturing Company of Wallingford, Connecticut, in 1916.

PUNCH CARD CHRISTMAS WREATH
DATE: 1962
COLLECTION: EPHEMERA
SOURCE: GIFT OF CAMILLE BOUNDS
CHM#: X3612.2007

Among the rarest things in the Museum's collection are "unofficial" objects created by computer users. This wreath, for example, was made over the Christmas holidays in 1962 using IBM punch cards. Its maker, a CalTech student, sold such wreaths to put himself through school. Due to its age and fragility, this wreath may be the only one of its kind.

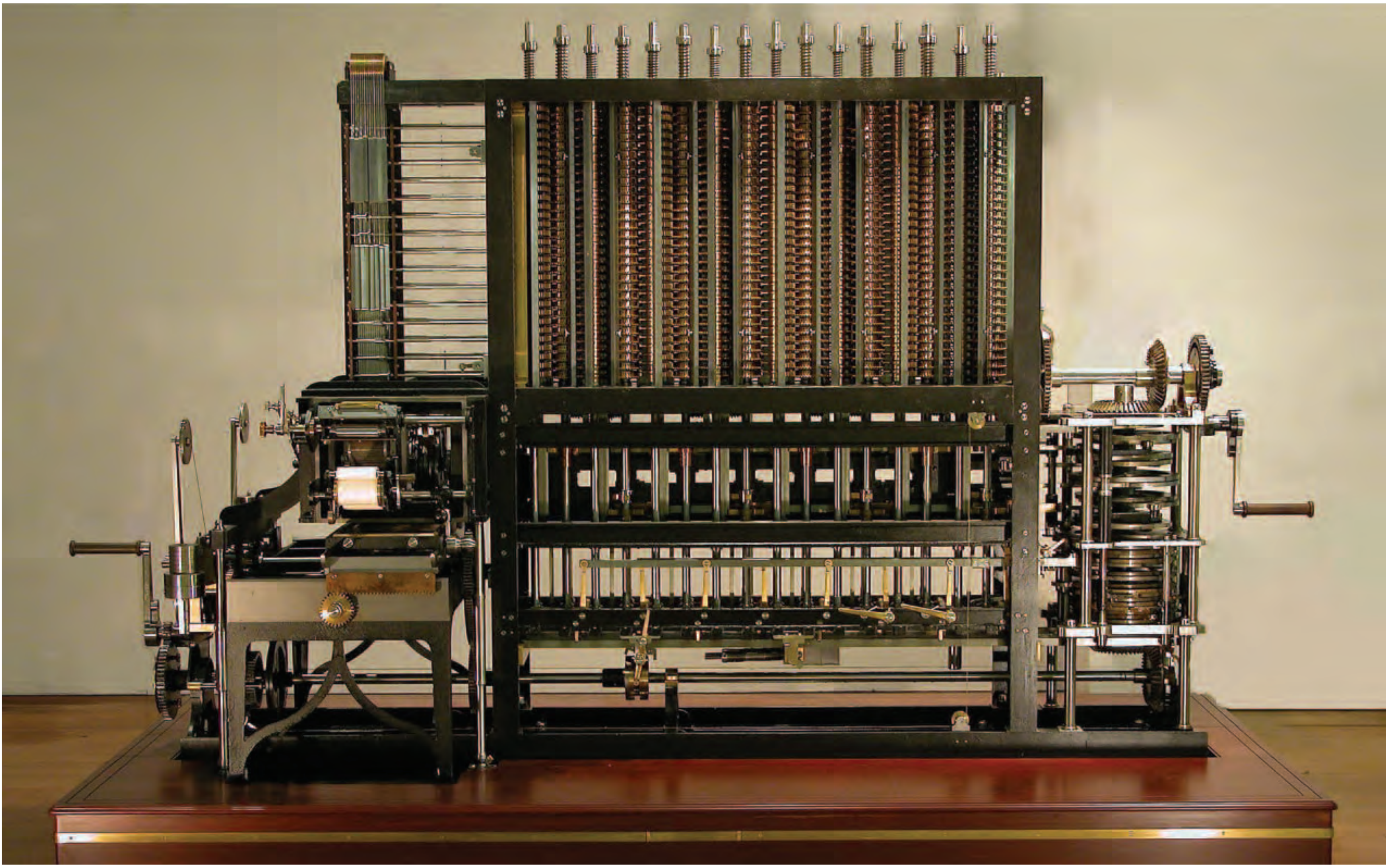
ROBOTS
DATE: 1970s–1980s
COLLECTION: OBJECTS
SOURCE: GIFT OF MONROE H. POSTMAN
CHM#: X3806.2007

By the mid-1970s, the microprocessor was inexpensive enough to place into toy and educational robots, which soon proliferated as often-whimsical links between the fearful imaginings of Shelley's Frankenstein and more sedate versions of robots as helpers. Often these robots simply integrated technologies into an android shell: many had cassette or eight-track tape players as well as home console video games built into them.



***TEMPLE OF APSHAI*, AUTOMATED SIMULATIONS, INC.**
DATE: 1981
COLLECTION: SOFTWARE
SOURCE: GIFT OF PHIL ROOT
CHM#: X3671.2007

Temple of Apshai was a computer role-playing game released for many platforms, including the IBM PC (the PC version is shown here). The game was inspired by role-playing board games of the 1970s such as Dungeons & Dragons. *Temple of Apshai* was followed by two sequels: *Gateway to Apshai* and *Hellfire Warrior*.



THE VICTORIAN COMPUTER: CHARLES BABBAGE'S DIFFERENCE ENGINE

In 1821, inventor and mathematician Charles Babbage was poring over a set of mathematical tables. Finding error after error, Babbage exclaimed, "I wish to God these calculations had been executed by steam." His frustration was not simply at the grindingly tedious labor of checking manually evaluated tables, but at the daunting unreliability of those tables. Science, engineering, construction, banking, and insurance depended on tables for calculation. Ships navigating by the stars relied on them to find their position at sea.

THE BABBAGE ENGINE WEIGHS FIVE TONS AND CONSISTS OF 8,000 PARTS. IT IS AN ARRESTING SPECTACLE IN OPERATION.

Babbage launched himself on a grand venture to design and build mechanical calculating engines that would eliminate errors. His bid to build infallible machines is a saga of ingenuity and will, which led beyond mechanized arithmetic into the entirely new realm of computing.

Though Babbage was not able to realize his dream of building a mechanical calculating machine, his vision was finally achieved in 2002 when the Science Museum of London completed the first full-sized Babbage Difference Engine. Over the past three years a duplicate engine, along with a printing apparatus, was built. The Babbage engine weighs five tons and consists of 8,000 parts. It is an arresting spectacle in operation.

This machine will be on display at the Computer History Museum for one year, beginning in September 2007. Guest curator Doron Swade, formerly of London's Science Museum, will be scheduling lectures both about Charles Babbage and about the Science Museum's task of building the Difference Engine. Throughout the year, CHM staff and volunteers will be demonstrating the machine, and an online exhibit will provide more information about Babbage and the Difference Engine.

For more information about lectures, demonstration schedules, and other events, call +1 650 810 1010 or visit: computerhistory.org.

Image courtesy of the Science Museum of London.

DONOR APPRECIATION *As of March 2007*

MUSEUM CAMPAIGN

EXA: $10M+

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Bill & Melinda Gates Foundation

PETA: $5M–$9.99M

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Intuit, in honor of founder Scott Cook

TERA: $1M–$4.99M

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KILO: <$100K

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Microsoft Corporation

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SVB Financial Group

SUPPORTING: $10K+

Broadcom Corporation

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Imation

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Madison Tyler Technology

nVidia Corporation

SanDisk Corporation

Sigma Partners

CONTRIBUTING: $5K+

Fairchild Semiconductor

Liquid Computing

Mid-Peninsula Bank

Network Appliance

SDF Public Access

Six Apart

SRI International

IN-KIND CONTRIBUTIONS

1185 Design

Ardehali Consulting

Four Seasons Hotel Silicon Valley

HeartStrings Music, LLC Studio

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Intuit

Krause Taylor Associates

Myers Sound Tech

San Jose Mercury News

SwiftPartners, LLC

Tekrati

Upright Marketing

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THE CORE CIRCLE

CORE BENEFACTOR: 64K ($65,536+)

Paul G. Allen Family Foundation

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Gardner Hendrie and Karen Johansen

Dave House

CORE PATRON: 32K ($32,768+)

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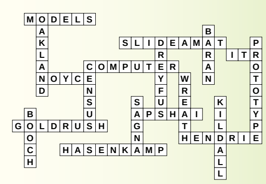
SOLUTION TO PAGE 32 CROSSWORD PUZZLE



PASSAGES

We are saddened to report on the passing of these computer pioneers since January 1, 2006.

Alan Kotok—May 26, 2006
Computer pioneer, architect, programmer

Bernard Galler—September 4, 2006
Computer pioneer, educator, founding editor, Annals of the History of Computing

Ray Noorda—October 9, 2006
Businessman, CEO of Novell (1982–1994)

Donald Wilson—November 25, 2006
LexisNexis developer

Al Shugart—December 12, 2006
Disk drive industry pioneer

Richard Newton—January 2, 2007
Electronic design automation and integrated circuit design pioneer

Jean Ichbiah—January 26, 2007
Principal designer of Ada programming language

Neil Lincoln—January 26, 2007
Supercomputing architect and pioneer

Jim Gray—January 29, 2007
(missing at sea)
Database pioneer

Doug Ross—January 31, 2007
CAD and software methodology pioneer

Ken Kennedy—February 7, 2007
High-performance computing pioneer

John Backus—March 21, 2007
FORTRAN team leader

Karen Spärck Jones—April 4, 2007
Pioneer in AI and natural language processing

CHM BY THE NUMBERS

$77,346,995 donated to the Museum Campaign. Only $47,653,005 to go!

IN THE COLLECTION

4,000 linear feet of documents (or **12 million** pages)
5,000 videos and films
5,000 software titles
20,000 photographs
20,000 objects and ephemera

SINCE MOVING TO OUR PERMANENT BUILDING IN 2003

4 million visitors to the Museum's website
29,692 tour attendees
2,263 Museum members
671 people who have volunteered
473 events held with 69,955 attendees
123 oral histories recorded
53 lectures held with 15,038 attendees
27 staff additions
16 new Fellows

It's your museum. Customize it.

My CHM is a personalized interface that lets you track the Museum news and information that's most important to you. Through a personal login at **computerhistory.org**, you can stay informed about coming events, keep track of the gifts you've made, and more. Visit us online and sign up today!

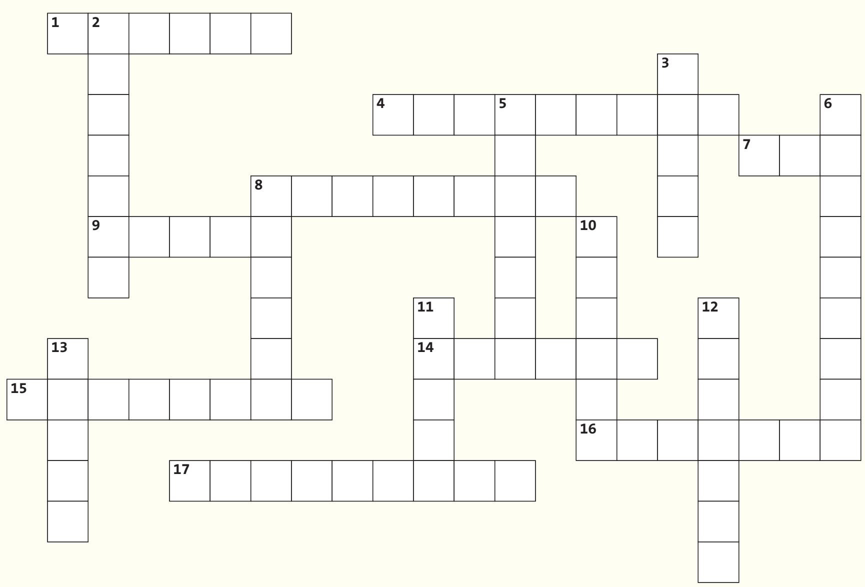
CROSSWORD PUZZLE

ACROSS

1 IBM System/360 artifacts used as sales and planning tools.
4 Slide-based browsing system.
7 Initials of the company that made the recently donated time clock.
8 IBM UK's film "Man & _____."
9 Chairman of Intel until his retirement in 1979.
14 Temple of _____.
15 "The early 1980s were the _____ days for the personal computer" *(two words)*.
16 Board member profiled in this issue.
17 German moving company that assisted with the SAP collection.

DOWN

2 California port city where the SAP collection arrived.
3 Telebit was founded by CHM Fellow Paul _____.
5 MIT professor defeated by MacHack VI.
6 "Often a _____ can show the genesis of an important idea or a 'road not taken.'"
8 The first UNIVAC was sold to the United States _____ Bureau.
10 A CalTech student sold a punch card _____.
11 "Day One at _____."
12 Cofounder of Digital Research, Inc.
13 The Atkinson and Hertzfeld Oral History was conducted by Grady _____.



ALL ANSWERS CAN BE FOUND IN THIS ISSUE OF *CORE*. SOLUTION TO PUZZLE ON PAGE 31.

HELP US PRESERVE THE INFORMATION AGE BEFORE ANYBODY FORGETS IT.

BECOME A MEMBER

Today, people take technology as much for granted as the air they breathe. It's the mission of the Museum to preserve the remarkable history of technology and to celebrate the accomplishments of the extraordinary people who have done so much. As a member, you'll help us preserve our heritage. And you'll enjoy a number of benefits, including:

- Complimentary admission to the Museum's speaker series and speaker receptions
- Discount admission to special Museum activities
- Member email announcements
- Subscription to *Core* magazine
- Museum memento
- And more

Call **+1 650 810 1883** or join online at:
computerhistory.org

VOLUNTEER

Help us explain technology to the outside world. This is a perfect opportunity to share your knowledge and your enthusiasm for computers. As a Museum volunteer, you can help in building the collection and restoring computing artifacts. You can assist with lectures, receptions, tours, and special events, or help us with administration and operations. In the process, you'll also interact with industry leaders, expand your knowledge of computer history, and enjoy the satisfaction of helping us build a world-class museum and research institution.

To learn more, call **+1 650 810 1027**
or visit us online at:
computerhistory.org/volunteers

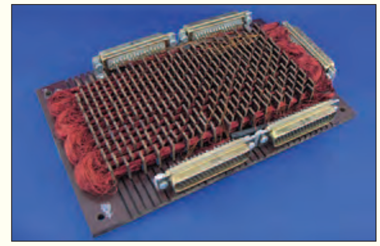
MYSTERY ITEM

Who are these people and what computer is that?

Photo courtesy of Regency Pictorials, Inc.

Take your best guess! The first three *Core* readers who submit correct answers after July 1, 2007, will receive a free copy of *Core Memory: A Visual Survey of Vintage Computers.*

The fourth and fifth correct submissions will receive Computer History Museum posters. Email your guess to: **editor@computerhistory.org.** Good luck!



Last issue's mystery item was a rope memory unit from the Apollo Guidance Computer. Congratulations to Brian Knittel, Mike Albaugh, and Randy Neff for correctly identifying it. Each of these lucky people will receive a "25th Anniversary of the Microprocessor" poster.

Rope memory is a special form of magnetic core memory ("core"). While core is useful for storing temporary or changing results, rope memory is a form of read-only memory (ROM) that will keep its contents even in the absence of power. This quality made it particularly attractive as a means of storing the various control programs for the Apollo spaceflight. It was also a very dense form of memory, though brittle and extremely difficult to manufacture. This particular unit was made by Burroughs.

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2008

CORE

A Publication of
the Computer
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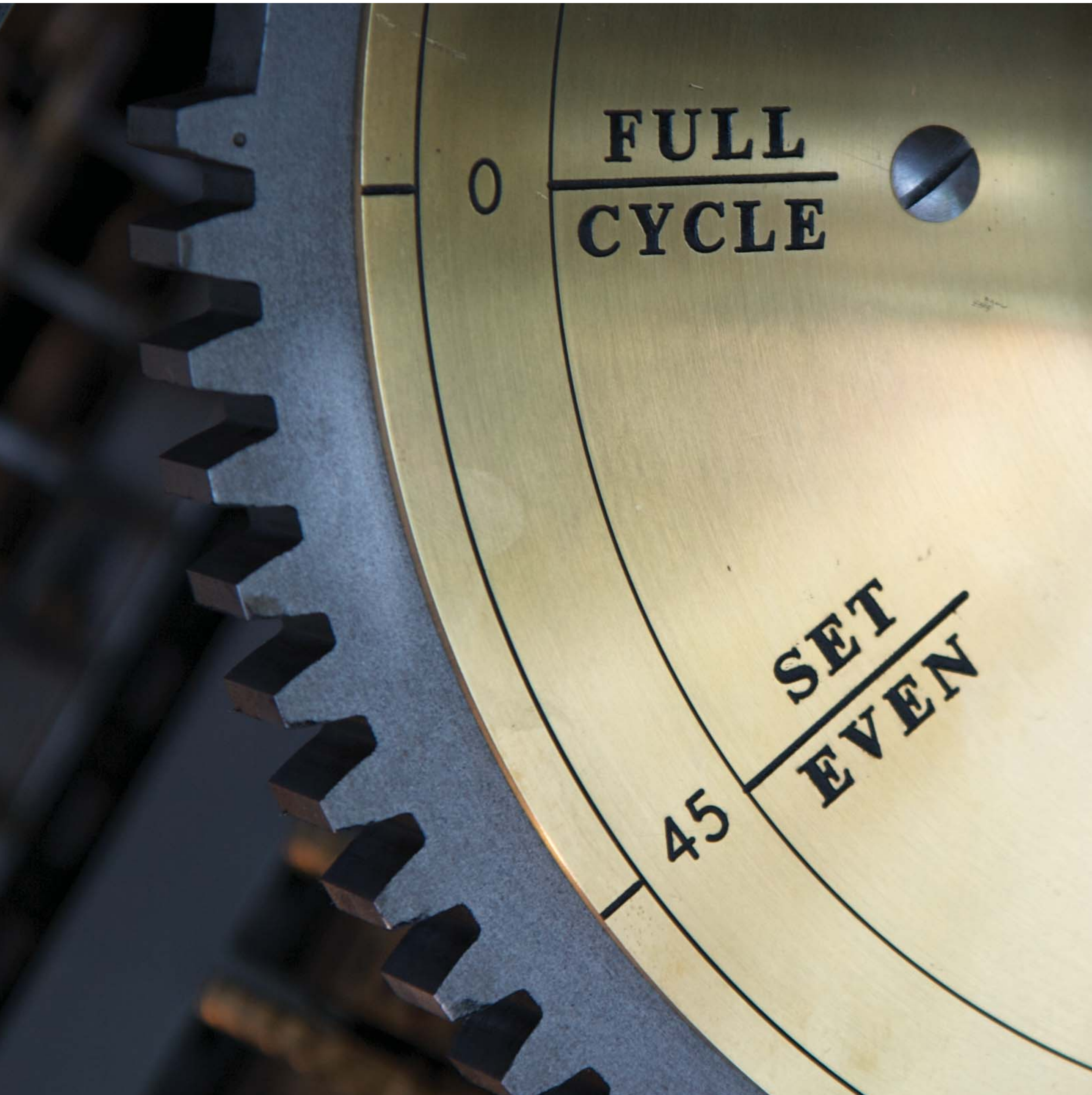
Industry Tales: Fairchild at 50
Charles Babbage: Legacy and Legend + Photo Gallery
Valley of Death: Excerpt of *The Life and Times of Andy Grove*

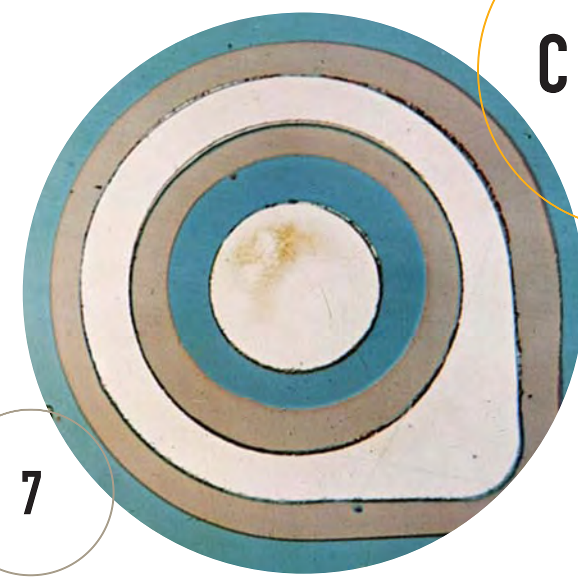


Cover: The Babbage Engine's chapter wheel indicates progress throughout the calculating cycle.

This page: Babbage Engine's bevel gears transmit power from the crank to the camstack.

Opposite: The distinct "teardrop" geometry of the first planar transistor invented by Jean Hoerni of Fairchild.

CORE
2008



7

CURATORS

CHM
Curators' favorite computer-related quotes

DAG SPICER
SENIOR CURATOR

"There's an old story about the person who wished his computer were as easy to use as his telephone. That wish has come true, since I no longer know how to use my telephone."

BJARNE STROUSTRUP

AL KOSSOW
SOFTWARE CURATOR

"If builders built houses the way programmers built programs, the first woodpecker to come along would destroy civilization."

GERALD P. WEINBERG, AUTHOR OF *THE PSYCHOLOGY OF COMPUTER PROGRAMMING*

ALEX BOCHANNEK
CURATOR

"Man is still the most extraordinary computer of all."

JOHN F. KENNEDY

CHRIS GARCIA
CURATOR

"I do not fear computers. I fear the lack of them."

ISAAC ASIMOV

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CHAIRMAN'S LETTER

OUR NEW CEO

Welcome to John Hollar, our new President and CEO:
Most of you already know the wonderful news about our new President and CEO: after months of looking for a great person to lead our institution, we were able to convince John Hollar to take that role and help move CHM to the next level in our growth.

The diverse worldwide experience and business insights John brings from his major roles at the FCC, at PBS, and at Pearson in London are extremely valuable to the Museum. He combines enthusiasm for the evolution of technology with relevant experience in creating and distributing media and web-based content. His professional leadership and fresh approach have already injected a new palpable excitement. For more information about John Hollar's background, see the press release at: computerhistory.org/press.

John's priority will be to continue our momentum toward becoming a full-time exhibiting institution and world-class destination. The next phase includes the development of a comprehensive plan for exhibits and programs, completing the $125 million fundraising campaign, and adding education and research components to the Museum. One of John's top goals is to drive the launch of a major exhibit on computer history, tentatively called "Computer History: The First 2,000 Years," which is scheduled to open both in the building and on the web in 2010. We are making great progress on developing this complex and comprehensive exhibit using a mix of staff curators, volunteers, and outside experts.

I hope you enjoy the changes you see in this issue of *Core*. We try to make it an entertaining mix of computer history and information about the Museum. Our field is a rich one, so read about colorful pioneering individuals like Charles Babbage, Andy Grove, and Gene Amdahl, and the remarkable story of Fairchild's role in developing the semiconductor industry. Learn how the CHM collection, the largest collection of computing artifacts in the world, is managed and how it continues to expand. And as always, give us your feedback and stay involved.

Regards,

Len Shustek

LEN SHUSTEK
CHAIRMAN, BOARD OF TRUSTEES, COMPUTER HISTORY MUSEUM

CONTRIBUTORS

Core 2008 Contributors give us their take on computer history

DAVID A. LAWS

Who has 'made it'?
Fairchild Semiconductor

What milestone contributed the most?
The conception and creation of the first monolithic integrated circuits (ICs). That itself involved three distinct milestones. (1) Jean Hoerni's invention of the planar transistor manufacturing process. (2) Bob Noyce's insight that the oxide insulation layer feature of the process would enable the interconnection of multiple transistors on a chip. And (3) Jay Last and his team's creative engineering efforts that turned these concepts into the reality of the modern integrated circuit. Fairchild called its first ICs "Micrologic."

Why should we celebrate it?
Fairchild's planar integrated circuit is the foundation of just about every computer chip that has been produced in the succeeding 50 years. Today the computer is the chip.

Why is CHM important?
CHM gives us the opportunity to celebrate these important milestones and the stories of the people who made them happen and to record them for posterity. Together with the Chemical Heritage Foundation and the IEEE, CHM will host events in Spring 2009 to celebrate the 50th anniversary of the events that led to the development of the IC.

DAG SPICER

Who has 'made it'?
IBM

What milestone contributed the most?
The IBM 7030 ("Stretch") project resulted in profound changes in the way IBM researched, developed, and manufactured electronic computers. It laid the blueprint for dozens of technical innovations in computing that are still in use today and it laid the foundation for IBM's groundbreaking System/360 mainframe computer system.

Why should we celebrate it?
We celebrate any event to reflect upon the past and to look to the future. We celebrate to see how companies succeed or fail due to any one of dozens of complex, interlocking reasons and to learn what factors contribute to success and which to failure. Finally, we celebrate for nostalgia—to satisfy the perpetual longing for an imagined "simpler time."

Why is CHM important?
CHM is home to the world's largest collection of computing artifacts, software, media, documents, and ephemera. Since it began collecting in the mid-1970s, it has acquired many of the most important machines and technologies in computing—works that are masterpieces of the machine age. CHM is the Louvre of computing.

DORON SWADE

Who has 'made it'?
Tim Berners-Lee. By foregoing patents, royalties and other commercial benefits from his work creating the Web, he succeeded in realising a network with access for all. He transcended the supposed imperatives of financial self-interest—a remarkable accomplishment —and created something bigger than a "commercially successful product." Well, so far anyway.

What milestone contributed the most?
The microprocessor.

Why should we celebrate it?
The cost-performance of large-scale integration was the engine of the computer's remarkable rise. I choose the microprocessor as a symbol of semiconductor integration.

Why is CHM Important?
The institutional mandate of museums of science and technology is to maintain a material record of technological change. Inseparable from this is historical interpretation of significance as this informs all their cultural outputs and informs acquisition of objects for their collections.

Computer-related devices are arguably the most successful new technology of the last half-century and the preservation of its history is therefore pre-eminently important. CHM is the largest single institution with this historic mission. It is important because the history of computing is important.

RICHARD S. TEDLOW

Who has 'made it'?
Intel

What milestone contributed the most?
Intel's decision to act as the sole source for its 386 microprocessor instead of licensing its technology to other companies.

Intel took a big gamble that IBM would buy its 386 even though there was no competing manufacturer. In fact, IBM was slow to accept Intel's 386. By 1986, however, the "clone" market had developed and Compaq had become a major player in the PC industry. Compaq used IBM's tardiness to establish a leadership position. That is why Compaq purchased Intel's 386 and incorporated it into its own next-generation PC—the Compaq DeskPro 386.

Why should we celebrate it?
This caused leadership in the PC industry to migrate from the assemblers (such as IBM) to the component suppliers (Intel and Microsoft). This was a change of historic importance. IBM, Intel, and Microsoft are all still very much alive but IBM no longer manufactures PCs.

There is often a battle in the value chain of an industry concerning leadership. In the automobile industry, the assembler is the most important player. But sole sourcing of the 386 made the suppliers more important than the assemblers in the computer industry.

Why is CHM important?
This industry, more than any other, perhaps, is about the future. It also wants to hang onto its heritage.

The last minutes of Electronic Arts' *EA-Land*, captured on August 1, 2008 by Stanford University's "How They Got Game Project" for its Archiving Virtual Worlds collection.

PRESERVING VIRTUAL WORLDS

MUSEUM UPDATES

> "Capturing oral histories now, is critical...wouldn't you love to be able to hear Michaelangelo talk about what it was like to paint the Sistine Chapel?"
>
> DONNA DUBINSKY
> CEO OF NUMENTA, AND MEMBER OF CHM'S BOARD OF TRUSTEES

Virtual worlds like *Second Life* have gotten a great deal of press attention in recent years. Few know they have a rich history stretching back to the 1976 computer game "Adventure." Multi-User Dungeons (MUDs), the invention of virtual reality, and full-blown simulated cities were some of the markers along the way. But most of this history is being lost because the complex interactive environments of virtual worlds are so challenging to archive.

In an effort to preserve records of these worlds, CHM curator Marc Weber, Bruce Damer of the Digibarn, and Kevin Hughes of CommerceNet are developing wiki timelines that Henry Lowood and the "How They Got Game" Project of the Stanford Humanities Lab will use as part of a new project, "Preserving Virtual Worlds," funded by the U.S. Library of Congress through the National Digital Information Infrastructure Preservation Program (NDIPP). Groups at the University of Illinois, University of Maryland, and Rochester Institute of Technology are also partners. Henry Lowood is a long-time friend of CHM's activities and is Curator for History of Science & Technology Collections at Stanford, which include the Silicon Valley Archives and Silicon Genesis oral history project.

Weber, who is founding curator of CHM's Internet History program and co-founder of the Web History Center and Project, is working with Damer, Hughes, and timeline company, Dipity.com to adapt a wiki-like timeline system that will let pioneers enter and edit recollections and materials at: nethistory.org/timelines/virtual_worlds. This effort is an evolution of digital library ideas Hughes and Weber first posted online in 1996, which are now greatly aided by the maturation of wiki-like systems.

Damer's 1997 *Avatars! Exploring and Building Virtual Worlds on the Internet* (Peachpit Press), was the first book about shared social Virtual Worlds. He is co-founder of the Digibarn Computer Museum, and has donated over 175 hours of unique historic video to the Virtual Worlds video archive, now hosted by the Internet Archive. He also engaged the community in pioneering experimentation that helped to define the medium, such as the first cyber-conference held in 1998.

In Spring 2009, CHM will collaborate with Damer, Lowood and Weber to produce a lecture program exploring the history of Virtual Worlds. ○

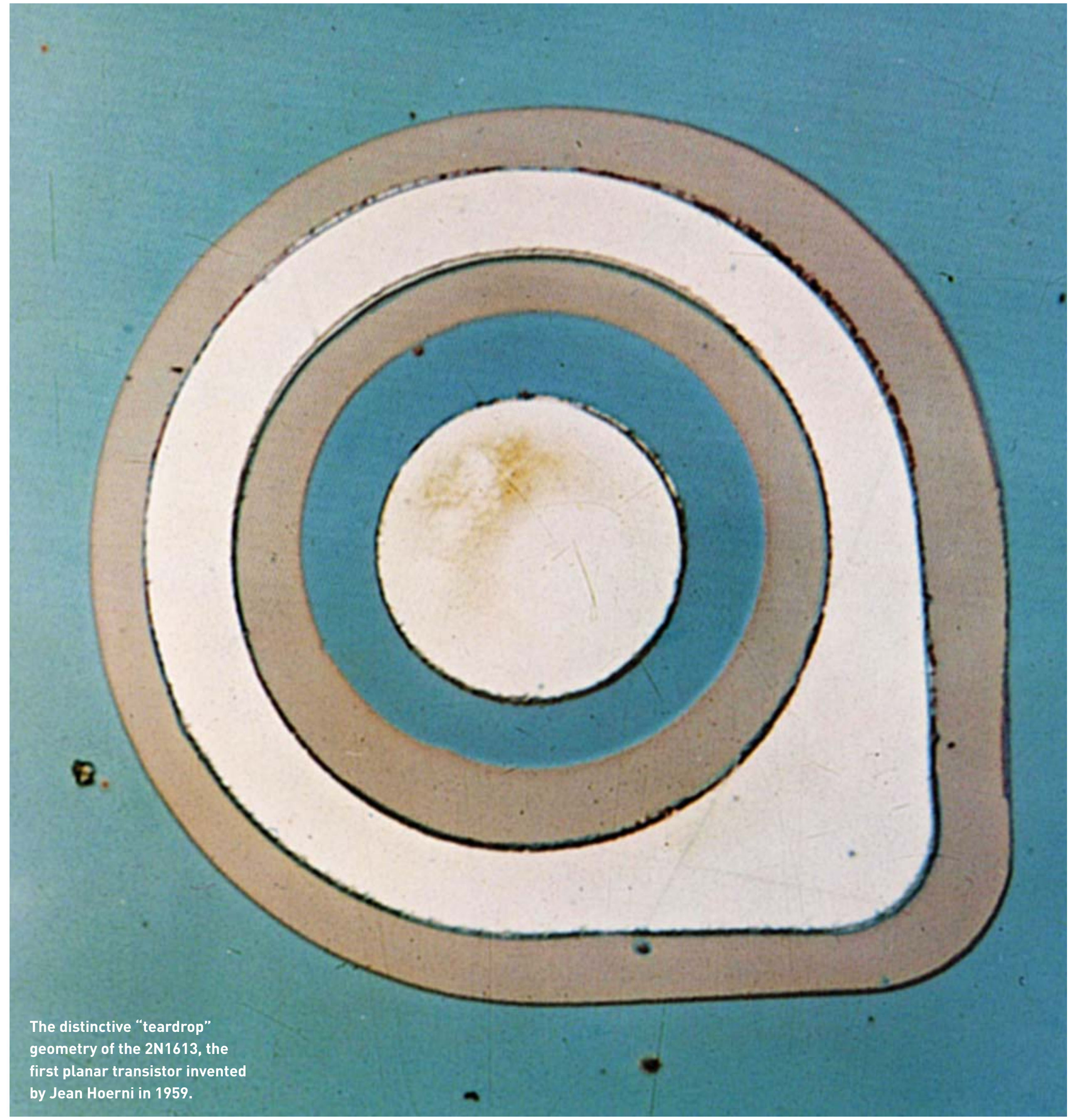
> **Virtual worlds like *Second Life* have...a rich history stretching back to...1976...**

THE SILICON ENGINE

Semiconductors are the silicon engines that have powered computers toward ever greater capabilities and speeds over the last 50 years. The Computer History Museum's new Silicon Engine web exhibit explores the history of semiconductors through a timeline of major development milestones, biographies, and snapshots of the companies responsible for them. It also includes a section on resources for students and teachers. The exhibit was created through a collaborative effort of the Museum's Semiconductor Special Interest Group and the Museum's Exhibit and Information Systems teams, and made possible by a grant from the Gordon and Betty Moore Foundation. The Silicon Engine online exhibit can be found on CHM's website at: computerhistory.org/semiconductor. ○

> "I think young people can come to the Museum and think, 'Wow, look how they started with such simple little things.'"
>
> STEVE WOZNIAK
> CO-FOUNDER OF APPLE AND CHM FELLOW

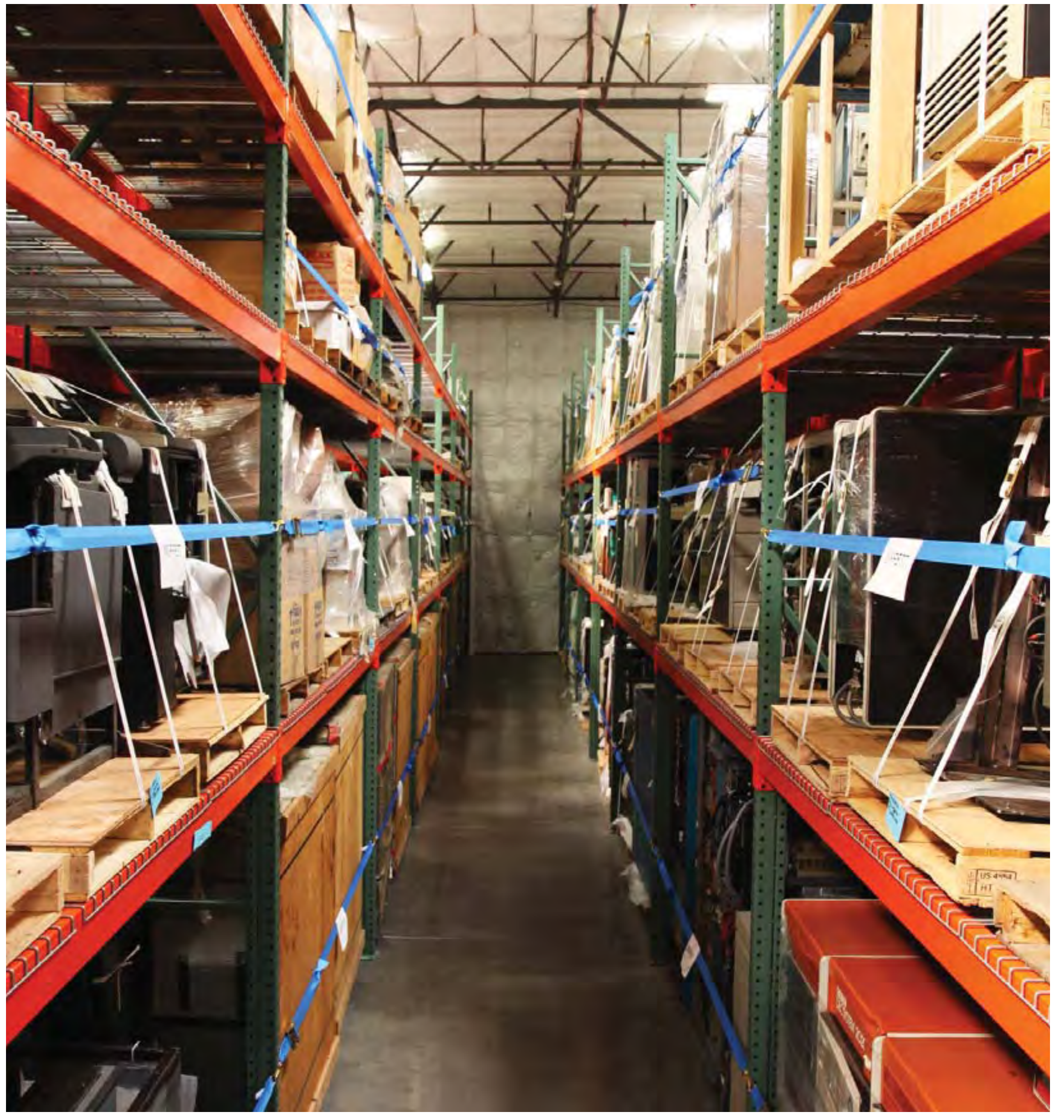
FAIRCHILD CAMERA & INSTRUMENT CORPORATION



The distinctive "teardrop" geometry of the 2N1613, the first planar transistor invented by Jean Hoerni in 1959.

"Computing technology is such a remarkable revolution that it would be tragic if we didn't record and save the information necessary for future generations to understand how it happened."

LEN SHUSTEK
CHAIRMAN OF CHM'S
BOARD OF TRUSTEES



After cataloging was completed at the Museum, objects larger than a miniature refrigerator have been palletized and carefully stowed, floor to ceiling, in offsite storage.

DOCUMENTING A WORLD-CLASS COLLECTION

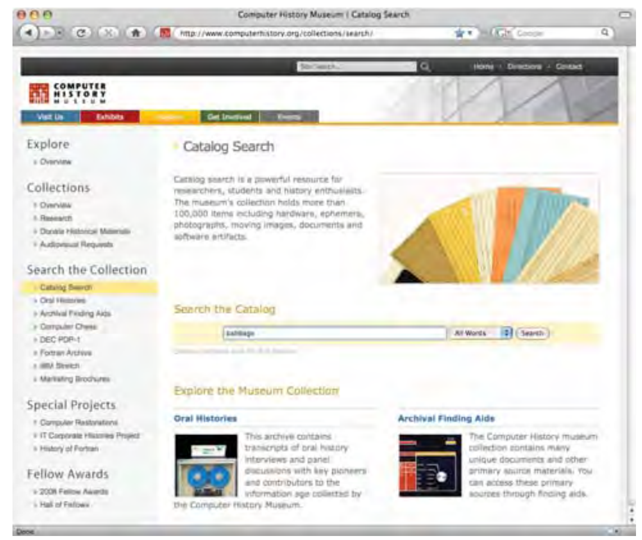
A museum ensures the safe-keeping of its collections, determines how to grow them, and decides which items to make publicly available through exhibits, programs and reference centers through the fundamental processes of inventorying, photographing and cataloging its artifacts. In July 2007, the Computer History Museum received a federal two-year grant of more than $144,000 from the prestigious Institute of Museum and Library Services (IMLS) to support CHM's Collection Cataloging and Reconciliation Project (CCARP).

The project's goals are to catalog and photograph 9,000 new physical objects and to attach an additional 11,000 digital photographs to pre-existing records within the artifact database. In early November, CHM happily reported that our staff and volunteer catalogers exceeded the two goals by achieving 9,222 new object records and attaching 14,264 digital images. The Museum's online Catalog Search now contains more than 61,000 artifact records. ○

400,000
CHM videos have been viewed on YouTube in just the past year

JUST A CLICK AWAY

The Computer History Museum's collection of artifacts including hardware, software, documents, ephemera, photographs and moving images is now available using the new online Catalog Search feature, which is a result of the Collection Cataloging and Reconciliation Project. More than 61,000 items from our enormous collection can now be viewed on CHM's website, using the Catalog Search. You will now find improved search tools and an integrated image viewer. Even the Museum's Special Collections can be searched and viewed online: Oral Histories, Computer Chess, DEC PDP-1, IBM Stretch, Fortran Archive and Marketing Brochures. Additionally, new artifacts are frequently cataloged and added to the vast collection. The new Catalog Search tool can be found on CHM's website at: computerhistory.org/collections/search. ○



CHM's Collection Catalog Search webpage—over 61,000 artifact records now available on the web.

The CHM YouTube channel—with more than 50 computing history lectures and historic videos, such as the video below of our legacy institution, The Computer Museum.

CHM'S YOUTUBE CHANNEL

Did you know you can drop in on CHM from anywhere in the world? Thanks to an in-kind donation from Google, CHM has created a fully branded YouTube channel that highlights the Museum and brings CHM's lectures and video collection to a huge worldwide audience. Since the channel opened in November 2007, the CHM YouTube channel has been visited by more than 325,000 people. And more than 2,000 people have subscribed to the channel so they can receive email updates about new videos.

Thousands more have clicked through from the YouTube channel to CHM's own website to explore the Museum's online exhibits. The Computer History Museum's YouTube channel can be found at: youtube.com/computerhistory. ○

"The computer is the single most important invention in the second half of the 20th century."

DAG SPICER
CHM'S SENIOR CURATOR

VOLUNTEER SPOTLIGHT: MARCIN WICHARY & HERB KANNER

Marcin Wichary (left) and Herb Kanner (right) in front of the Museum's Visible Storage exhibit.

Computing changes so much and it's likely that children can't imagine life without the Internet, computer graphics, or mice.

Volunteers continue to be the backbone of the Computer History Museum. *Core* talked to two of our valued volunteers, Marcin Wichary and Herb Kanner, who between them have provided over 2,000 volunteer hours.

Please tell us about your background.

Marcin: I got into computing at the early age of 8 with a cheap 8-bit machine. It didn't come with software so I was forced to learn to program it.

I finished my Master's in Computer Science in Poland, followed by a doctorate in human-computer interaction in the Netherlands. As I was wrapping up my thesis, I began thinking of my future career, and sent my resume to those dream companies that I was sure would never hire me. But I didn't have anything to lose. I sent my first resume to Google, and I was hired as a user experience designer, off that first resume, in 2005. After a stint in Switzerland, I moved to California in 2006, and have been volunteering at the Museum since 2007.

Herb: I actually started out studying music at the Music Conservatory of Oberlin College (Oberlin, Ohio). Because of insufficient interest in music, I eventually transferred to the University of Chicago to major in physics. When World War II intervened, I joined the army and the Metallurgical Laboratory, which was a code name for the Chicago part of the Manhattan Project, from 1942 to 1946. I entered graduate school at University of Chicago in 1946 and got a physics Ph.D. in 1951. I then worked at Shell Development Company in Houston, Texas, and while working there, I became fascinated with computers, playing with an IBM 650.

424

volunteers contributed 18,885 hours total in FY2008

Other jobs throughout my career included Assistant Professor of Applied Mathematics at the Institute for Computer Research at the University of Chicago, manager of what they called the Advanced Technology Department at Control Data Corporation, and stints at RCA, International Computers Limited in England (a subsidiary of NCR), Mohawk Data Systems, Tymnet, and the Development Systems Group at Apple Computer.

How did you both become interested in computing and computer history?

H: I was hired at Shell Development in 1952 as a physicist. In less than a year there, I started an operations research group. This led me to using computers for some of the group's problems. That early, I saw that computers would create a second industrial revolution and decided to switch to that field.

M: And I am a product of this revolution (laughs). As for computer history, there was no one single moment I can recall. While other people were moving on to newer and faster computers, I never did. With time, I actually started slowly going back in time. The more I learned, the more fascinated I was. After a while I realized this is was becoming a serious interest, and I decided to do something about it. Volunteering at CHM was one result of that. The other was creating guidebookgallery.org.

What draws you to the Computer History Museum?

M: The idea of preserving, exploring and demonstrating the ever-changing relationships between computers and people. The fact that many people volunteering or visiting the Museum actually shaped computing history themselves means I get to meet my demigods on seemingly a weekly basis! Also there are so many different opportunities for volunteers. I never operated a video camera nor cranked a Difference Engine before I came here!

H: It was former CHM CEO John Toole's introductory talks at several lectures I attended that drew me to the Museum. The first was at Moffett Field. He made me realize the importance of preserving the artifacts and the stories. And I decided to volunteer.

What thrills you about showing the Visible Storage exhibit to new visitors?

H: I think the biggest thrill is when I encounter a visitor who worked on one of the exhibited machines and I learn something significant and interesting about the machine that I did not know.

M: Agreed! And I love seeing kids in the Museum, especially as CHM is not otherwise terribly kid-friendly. Computing changes so much and it's likely that children can't imagine life without the Internet, or computer graphics, or mice. The micros from the 1980s are more ancient to them than vacuum tubes to me—it must be fascinating for them to be able to look back at computers this way. I'm hoping that, for some of those kids, seeing the Difference Engine No. 2 in action, or one of the first videogames, or realizing their cell phone has more computing power that the old refrigerator-sized machine they're looking at will be a transformative event—perhaps one that will make them want to join the computer industry themselves.

What advice do you have for people who want to become volunteers?

M: Don't be afraid! Even if you think you don't know anything about computer history, you'll have many opportunities to learn—and tons of fun while doing it. Plus, even people who've been doing this for decades are still learning!

H: Jump in. You'll have fun and meet some great people. ○

"We were great 'finishers'! We didn't just do the fun parts of a project and people always gave us jobs because of it."

JEAN BARTIK
ENIAC PROGRAMMER AND CHM FELLOW, ON WHY SHE WAS SO SUCCESSFUL


WAYNE MILLER/MAGNUM PHOTOS

The Fairchild Semiconductor founders, circa 1960. From left: Gordon Moore, Sheldon Roberts, Eugene Kleiner, Robert Noyce, Victor Grinich, Julius Blank, Jean Hoerni, and Jay Last.

INDUSTRY TALES

FAIRCHILD AT 50

BY DAVID A. LAWS

The Museum hosted a celebration for a pioneering company

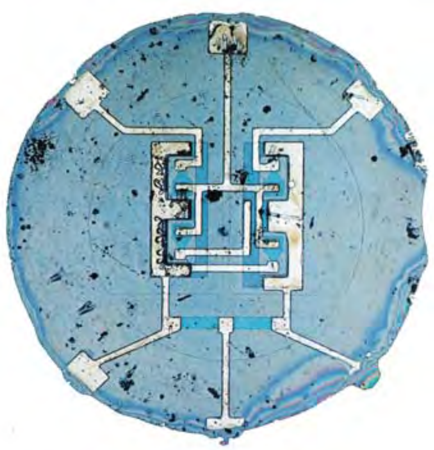
In October 2007, the Computer History Museum and Stanford University hosted a gala celebration of the 50th anniversary of the founding of Fairchild Semiconductor. According to Wyn Wachhorst, the founding of Fairchild "will be seen in centuries to come as an epochal turning point in human evolution."[1]

Alumni and friends of Fairchild traveled from around the world to remember the legendary company that delivered some of the most exciting, professionally rewarding, technologically challenging, and frustrating experiences of their careers. Fairchild and its technologies changed the world in ways its founders could never have imagined. And then it faded into obscurity in the 1970s.

In the Beginning

Fairchild Semiconductor was founded in 1957 by eight young engineers and scientists from co-inventor of the transistor William Shockley's Semiconductor Laboratory in Mountain View, California. Described by Michael Malone as "perhaps the most extraordinary collection of business talent ever assembled in a start-up company,"[2] Fairchild employees pioneered an entrepreneurial business culture; spawned manufacturing and marketing techniques that gave birth to the phenomenon later dubbed Silicon

Fairchild and its technologies changed the world in ways its founders could never have imagined. And then it faded into obscurity in the 1970s.



Die photograph of the first planar integrated circuit. The Fairchild type "F" flip-flop, comprising 4 transistors and 6 resistors, was introduced in March 1961.

Valley; and reshaped the worldwide semiconductor industry. Fairchild went on to develop some of the most important innovations in 20th century technology and sow the seeds of the microelectronics-driven computer industry and personal digital products of today.

The planar process, developed by co-founder Jean Hoerni in early 1959, is the jewel in the crown of Fairchild's technological achievements. Hoerni's approach revolutionized the production of semiconductor devices and enabled the development of monolithic integrated circuits (ICs). It allowed semiconductors to be manufactured in a high-volume production environment that was amenable to continuous reductions in cost at the same time that it delivered extraordinary increases in the number of transistors on a chip and improvements in their performance. Even today, his basic concept continues to inform the manufacture of billion-transistor microprocessor and memory chips. Historian Christophe Lécuyer ranks it as "the most important innovation in the history of the semiconductor industry."[3]

Fairchild Semiconductor was initially funded as a division of Fairchild Camera and Instrument Corporation of Syosset, New York. It grew rapidly and was highly profitable. At the peak of its influence, the division controlled over 30 percent of the market for integrated circuits. By the late 1960s, it reached $150 million in annual sales and employed some 30,000 people.

A Vital Diaspora

Despite—or perhaps because of—the rapid growth spurred by the division's extraordinary outpouring of ideas and innovation, the young company ran into difficulties meeting customer demands, retaining employees, and managing operations. Rather than invest in expanded semiconductor manufacturing capacity and personnel, though, the Syosset headquarters decided to drain its semiconductor profits to finance other ventures.

Even though Fairchild was an early leader when it came to granting stock to engineering employees, the number of shares it offered was extremely small. So the management team had a difficult time supporting and rewarding the many new ideas spawned by its engineers. Many of these entrepreneurial-minded engineers were spurred to leave Fairchild and form companies of their own. The results of this entrepreneurial outpouring include Advanced Micro Devices (AMD), Intel, and National

1 Wachorst, Wyn. "The Real Revolutionaries," *Gentry Magazine* (Menlo Park, California, February 2008)

2 Malone, Michael S. *Bill & Dave: How Hewlett and Packard Built the World's Greatest Company* (Portfolio, April 5, 2007)

3 Lécuyer, Christophe. *Making Silicon Valley* (MIT Press, 2006)

Semiconductor. This exodus of talent combined with a capacity shortage, an increase in competition, and a steep economic downturn brought about the end of Fairchild's glory days just ten years after it was founded.

Revival Efforts

In 1968, C. Lester Hogan (1920–2008), previously from Motorola, headed a new management team that attempted to revitalize the flagging company. He moved the corporate headquarters to Mountain View, expanded capacity, and invested in new technologies and products. Revenues grew substantially under this regime but the company didn't regain its former profitability and prominence.

Next, French oilfield services conglomerate, Schlumberger, purchased the company as a diversification move. But when it, too, was unable restore the company to its previous fortunes, Schlumberger sold the assets to National Semiconductor in 1987.

Finally in 1997, National Semiconductor divested a number of former Fairchild mature product lines in a leveraged buy-out to a group of executives based at Fairchild's former South Portland, Maine facility. And today, the reborn Fairchild Semiconductor is once again a public company with annual revenue of more than $1 billion.

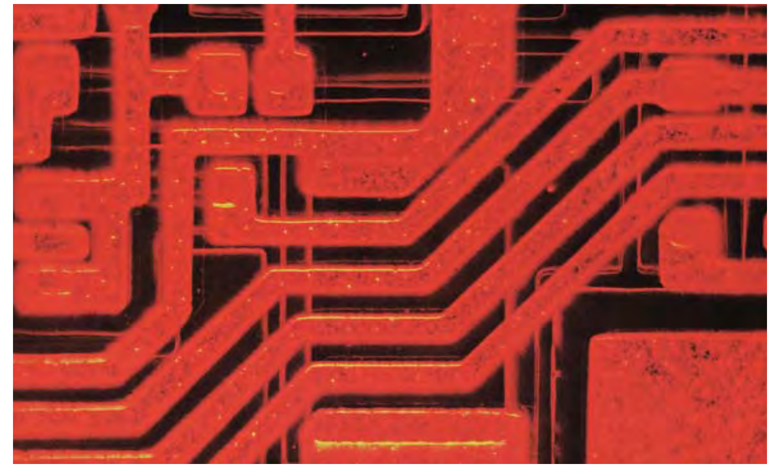
But the legacy of the original Fairchild also lives on through the worldwide diffusion of its technology and culture, which spread through the diaspora of former employees. There are hundreds of companies—among them systems, software, and service businesses—in the San Francisco Bay Area and beyond who can trace their roots back to Fairchild.

A Celebration of the Legacy

Fairchildren, as former employees of the company are often called, are famous for their affection for the company and their gratitude for the semiconductor industry training and ex-

THIS AND OPPOSITE PAGES: FAIRCHILD CAMERA & INSTRUMENT CORPORATION)

ACCOMPLISHMENTS



Metal interconnect lines on an integrated circuit. Photomicrograph by Richard Steinheimer of Fairchild Semiconductor, circa 1968–1969.

Other important contributions to computer history from the company's engineers:

The first high-speed silicon transistors, developed for the CDC 6600 supercomputer, on display in the Museum's Visible Storage exhibit.

"Micrologic," the first monolithic integrated circuit family. It powered the computer that guided the Apollo space missions.

The first commercially successful analog. also known as "linear," integrated circuits. Because of their role in interfacing real-world analog signals such as sound, temperature and speed to the language of the digital computer, these form one of the most important segments of the industry.

Early work in understanding and commercializing the MOS (Metal-Oxide-Semiconductor) technology, including the important silicon-gate process that is the basis of 99 percent of ICs produced today.

Invention of the CMOS (Complementary MOS) process that consumes the lowest possible power and permits battery operation of many of our most popular electronic devices.

The observation now known as Moore's Law, which stated that the number of transistors that can be placed inexpensively on an integrated circuit doubles approximately every two years. It has provided a yardstick against which technology progress has been measured for over 40 years.

The first commercial CCD (Charge Coupled Devices) optical imaging sensors used in digital cameras.

Some of the earliest dedicated semiconductor memory devices, including the first commercial shipments of all-semiconductor computer main memory systems; see the ILLIAC IV supercomputer, also in the Visible Storage exhibit.

Panel discussion: Julius Blank, Jay Last, Gordon Moore, and Arthur Rock, moderated by Leslie Berlin on October 4, 2007.

perience they gained there. This is an industry that has treated many of them very well. And although Fairchildrens' legendary capacity for "working long days and partying long nights" has no doubt been diminished by the passage of time, that didn't stop nearly 1,000 former employees and friends of the company from reuniting for three days in October 2007 to rekindle friendships, swap stories, and celebrate their heritage.

On Thursday, October 4, at the Stanford University campus, Julius Blank, Jay Last, Gordon Moore, and Arthur Rock—three Fairchild Semiconductor founders and the banker who helped them—discussed the firm's significance and its early years in a panel discussion. The panel was moderated by Leslie Berlin, biographer of Fairchild and Intel co-founder Robert Noyce. Stanford University President and CHM Fellow, John Hennessy introduced this panel of esteemed speakers.

Friday, October 5 began with a series of afternoon panels at the Computer History Museum. The panels surveyed eight aspects of the Fairchild experience. In order of presentation, the topics and session moderators comprised:

- The Founding Years & R&D - Harry Sello
- Bipolar Digital Products - Bill Welling
- Linear Products - Norman Doyle
- MOS Products - Gil Amelio
- Manufacturing and Support Services - C. E. "Ed" Pausa
- Discrete Products - George Wells
- International Sales & Marketing - Robert Blair
- North American Sales & Marketing - Bernie Marren

In all, more than 30 panelists recounted—and no doubt embellished—stories from their days at the company. These sessions were recorded on video and the content was transcribed and added to the Museum's oral history archives at: computerhistory.org/collections/oralhistories.

Before a packed house in the Museum's Hahn Auditorium, Fairchild alumnus and noted venture capitalist Floyd Kvamme led three distinguished industry leaders through the "Legacy of Fairchild." The noted speakers were all chairmen emeritus from industry giants: Wilfred Corrigan of LSI Logic, Gordon Moore of Intel and W.J. "Jerry" Sanders III of AMD. They gave a wide-ranging and entertaining discussion of their early careers at Fairchild. A video of this session is posted on the CHM YouTube Channel at: youtube.com/computerhistory. The transcript is available on the Museum's oral history page.

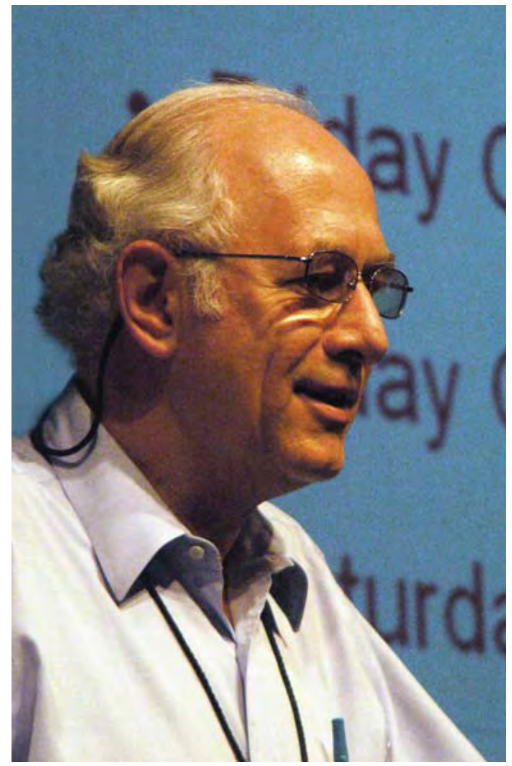
Saturday, October 6 concluded the celebration with a gala reunion party held at the Museum, which was decorated with photographs, posters, and banners of memorable people and products. Attendees circulated through an exhibit of Fairchild artifacts and documents donated by attendees. The celebration also featured a tour of objects associated with the company in Visible Storage, a video theater showed *The Fairchild Chronicles* movie, and multiple projectors displayed continuously changing still images of employees in various states of decency onto giant screens. There was also a room of Fairchild-produced consumer products and video games. The highlight of the décor was a re-creation of the popular company watering hole, "Walker's Wagon Wheel," which included wagon wheels from the Museum collection and a section of the original bar rescued from the demolition site. Founders Julius Blank, Jay Last and Gordon Moore ceremonially cut a "Happy 50th Birthday" cake.

There are hundreds of companies in...the San Francisco Bay Area and beyond who can trace their roots back to Fairchild.

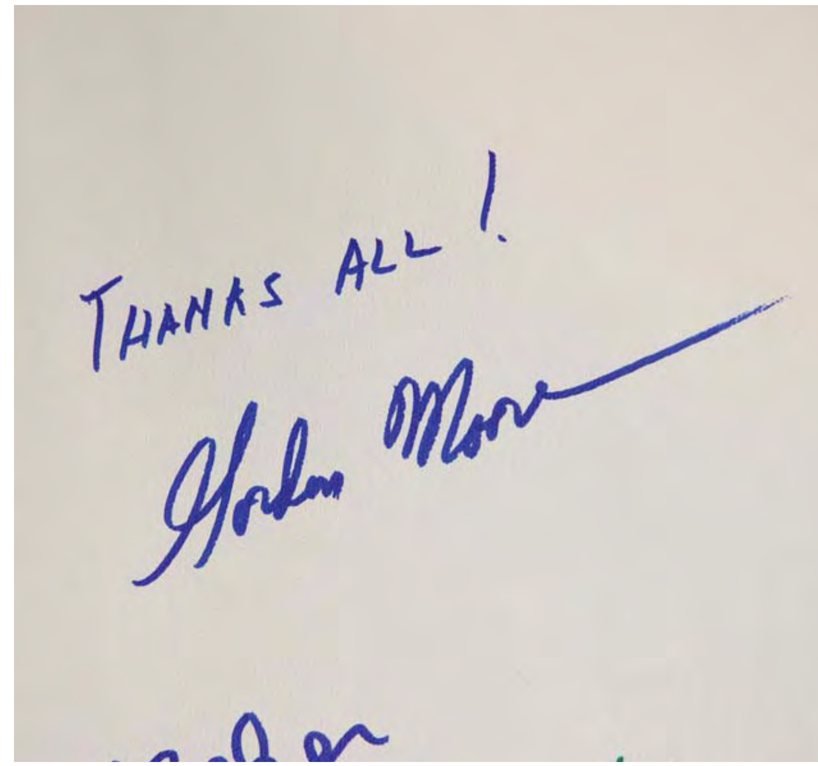
The events held at Stanford were co-sponsored by Stanford Libraries and the Bill Lane Center for the Study of the North American West. Celebrations that took place at the Museum were made possible through the generous donation of funds, materials and time by dozens of dedicated alumni volunteers, Fairchildren and family and friends, as well as the Computer History Museum. ○

David A. Laws joined Fairchild affiliate SGS-Fairchild in London, England in 1966. He moved to the Silicon Valley headquarters in 1968, where he later worked for Advanced Micro Devices, Altera and other companies in senior management positions.

Although Fairchildrens' legendary capacity for "working long days and partying long nights" has been diminished...that didn't stop nearly 1,000 former employees and friends from reuniting...



David A. Laws, Fairchild alumnus and former Director and a member of the CHM Semiconductor Special Interest Group, addresses the audience.



Signature of Fairchild co-founder Gordon Moore.

LEFT: MIKE DUBINSKY / RIGHT: JULIE HENDRIKS / OPPOSITE: MIKE DUBINSKY.

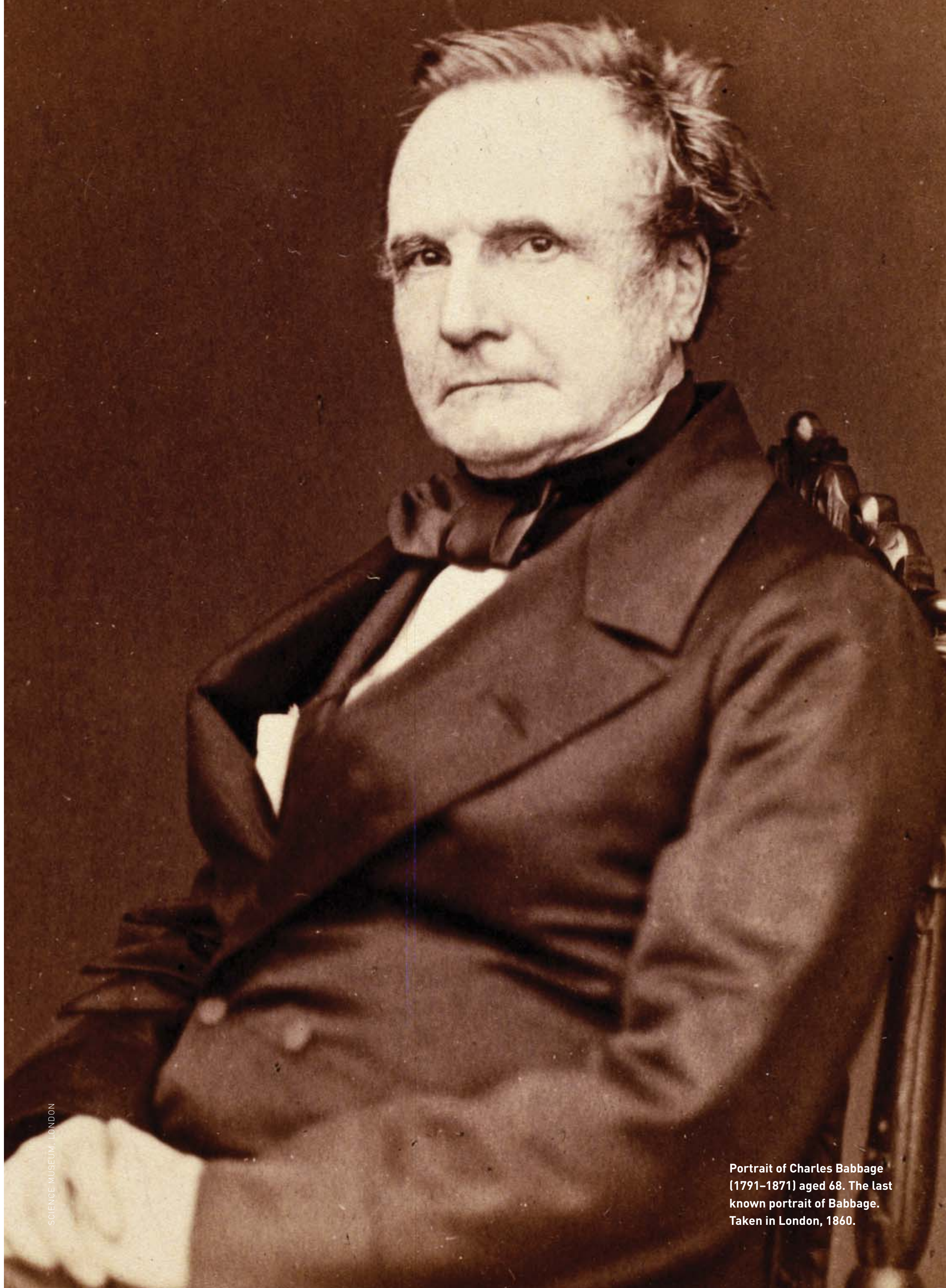
FEATURE

LEGACY AND LEGEND

Charles Babbage and modern computing

BY DORON SWADE

Charles Babbage (1791-1871) is routinely referred to as the father, grandfather or forefather of the modern computer. The language of fatherhood implies an unbroken line of descent to our own age with Babbage as the patrilinear source. His designs for vast but unbuilt mechanical calculating engines were the first to embody the essential principles of automatic general-purpose digital computation. Because he was the first it is often assumed that the modern computer has descended directly from his work. But the lineage of the modern computer is not as clear-cut as these genealogical tributes imply.

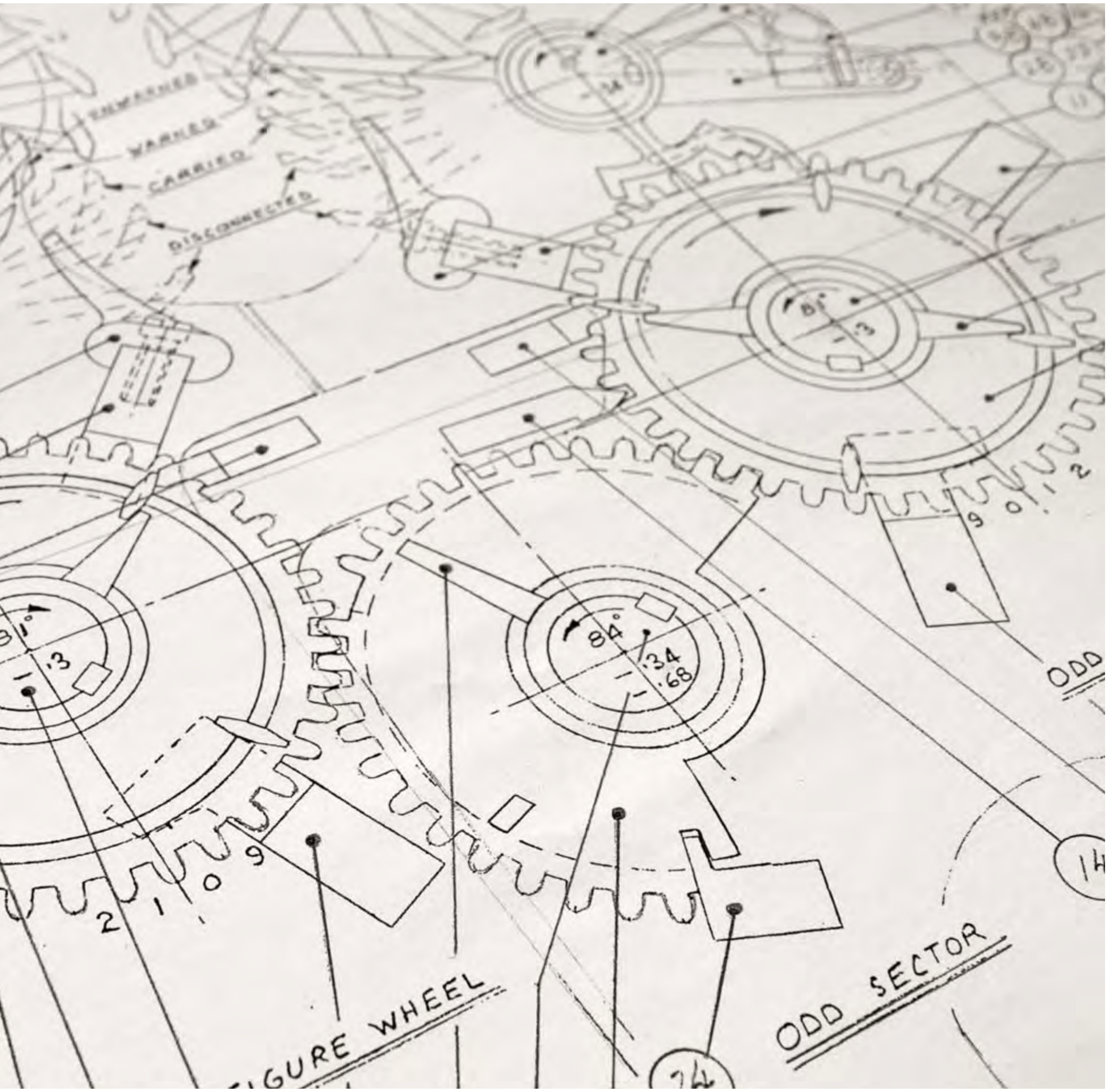


Portrait of Charles Babbage (1791–1871) aged 68. The last known portrait of Babbage. Taken in London, 1860.

In 1991, the bicentennial year of Babbage's birth, the cover of *New Scientist* declared Babbage the "architect of modern computing."[1] Two years later *Scientific American* carried a feature article in which the advertising abstract stated that "Charles Babbage's plans for mechanical calculators and computers paved the way for the modern computer revolution."[2] The perception of a direct debt to Babbage was reinforced when the Royal Mail launched, in 1991, special-issue postage stamps commemorating British scientific achievement. Babbage shared philatelic honours with Michael Faraday, Frank Whittle, and Robert Watson-Watt for their pioneering work on electricity, the jet engine, and radar respectively. The implication is clear—that Babbage contributed as much to modern computing as his compatriots did to their fields. Babbage's elevation from dismal failure to national hero was now official. But in the quartet of pioneers, Babbage is arguably the odd man out.

While the Royal Mail was minting a stamp in Babbage's honour, computer scientist and historian, Allan Bromley, who had studied Babbage's designs more closely than anyone, wrote that "Babbage had effectively no influence on the design of the modern digital computer."[3]

A detail from one of over 150 modern engineering drawings created by the London Science Museum. This one shows the essence of the calculating mechanism.



Maurice Wilkes, distinguished pioneer of post-WWII electronic computing at Cambridge, had come to the same conclusion. In 1971, the centenary of Babbage's death, Wilkes wrote that Babbage "however brilliant and original, was without influence on the modern development of computers."[4] Wilkes and Bromley are not alone. J. G. Brainerd, Director of the Moore School, wrote in 1965 that "Babbage's influence [on ENIAC] was nil."

It gets worse. In the same publication, Wilkes, who elsewhere describes Babbage as possessing "vision verging on genius," accuses Babbage not of pioneering the modern computer age, but of actually delaying it. Wilkes argues that Babbage's projected image became one of failure and that this discouraged others from thinking along similar lines.[5]

Wilkes...accuses Babbage not of pioneering the modern computer age, but of actually delaying it.

At first sight the allegation is shocking. But new evidence has come to light of at least one instance in which Wilkes's allegation, however originally intended, is specifically and historically vindicated.

Thomas Fowler, an impoverished self-taught Devonshire printer and bookseller, devised an original digital computing device based on ternary arithmetic. The machine, which was demonstrated in the 1840s, calculated logarithms to thirteen places "in a singularly beautiful and concise manner."[6] The calculator was a scientific novelty, and luminaries, Babbage included, flocked to view it. Fowler's son wrote, with unmistakeable bitterness, that the British government refused to fund Fowler's work on the grounds that it had already spent vast sums of public money on Babbage, with no obvious result. In retrospect, Fowler's machine was, in many respects, more promising than Babbage's. Fowler's work was not explored by his contemporaries, and this appears to have been directly a result of Babbage's failures.

Others in the 19th-century attempted automatic calculating engines—George and Edvard Scheutz, and later Martin Wiberg in Sweden, Alfred Deacon in London, and Barnard Grant in the United States. But these were isolated splutterings that failed to ignite a movement. There was a febrile twitch in the early 20th century. Percy Ludgate, an Irish auditor, designed an "analytical machine" in the first decade of the century. The design is original and Ludgate attests that he had no prior knowledge of Babbage's work.[7] The machine was a developmental *cul de sac*, with no discernable influence on what followed.

It seems then that there is no unbroken line of development from Babbage to the electronic era. But the gulf between the two is far from total. After Babbage, no one doubted that automatic machine computation was possible, and analysis, based on citation frequency from 1889 to 1948, shows that there are no large time gaps in awareness of Babbage amongst the

1 Swade, Doron. "Building Babbage's Dream Machine." *New Scientist* 1775.29 June (1991): 37-39.

2 Swade, Doron. "Redeeming Charles Babbage's Mechanical Computer." *Scientific American.* February (1993): 86-91.

3 Bromley, Allan G. *The Babbage Papers in the Science Museum: A Cross-Referenced List.* London: Science Museum, 1991, p. 9.

4 Wilkes, Maurice V. *Babbage as a Computer Pioneer*: British Computer Society and the Royal Statistical Society, 1971, p. 1. L.J Comrie, an acknowledged authority on the calculation and production of mathematical tables, is reported to have remarked that "this dark age in computing machinery, that lasted 100 years, was due to the colossal failure of Charles Babbage." See Cohen, I. B. "Babbage and Aiken." *Annals of the History of Computing* 10.3 (1988), p. 180.

5 Wilkes, 1971.

6 See Swade, Doron. *The Cogwheel Brain: Charles Babbage and the Quest to Build the First Computer.* London: Little, Brown, 2000, pp. 310-312. For an account of the reconstruction of Fowler's calculator see Glusker, Mark, David M Hogan, and Pamela Vass. "The Ternary Calculating Machine of Thomas Fowler." *IEEE Annals of the History of Computing* 27.3 (2005): 4-22.

7 For details of Ludgate's machine see Randell, B. "Ludgate's Analytical Machine of 1909." *Computer Journal* 14.3 (1971): 317-26. Also Randell, Brian. "From Analytical Engine to Electronic Digital Computer: The Contributions of Ludgate, Torres, and Bush." *Annals of the History of Computing* 4.4 October (1982): 327-41.

INFLUENCE

Small demonstration piece of Difference Engine No. 1. A similar piece was presented to Harvard in 1886 by Babbage's son and seen by Howard Aiken.

Modern recreation of Thomas Fowler's ternary calculating machine.

coteries of pioneers who carried the flag.[8] Some of the pioneers of the electrical and electronic eras were aware of Babbage. Others were not. But almost without exception all claim, with credible conviction, that their own efforts were uninfluenced by any detailed knowledge of Babbage's work.

One exception is Howard Aiken, one of two main bridging figures between Babbage and the modern age.[9] Aiken, who championed the construction of the Harvard Mark 1, completed in January 1943, claimed explicitly that he was directly influenced by Babbage's work. In the late 1930s Aiken came across a small demonstration piece that Babbage's son, Henry, had sent to Harvard to advertise his father's work. Aiken later claimed that he "felt that Babbage was addressing him personally from the past" and that "if Babbage had lived seventy five years later, I would have been out of a job."[10] Aiken repeatedly emphasised his indebtedness to Babbage, and his frequent tributes publicised Babbage's work in the post-war years.

Aiken styled himself as Babbage's modern-day heir. It is curious that the historian, I. B. Cohen, went out of his way to demonstrate not only that Aiken was largely ignorant of the detail of Babbage's work but that some of his perceptions were in fact wrong. Cohen in effect accuses Aiken of band-wagon fame—of attempting to stake a claim to his own place in history through a public affiliation with Babbage. It is an irony that the one pioneer to lay a strong claim to direct influence is accused of immodest self-promotion. History, it seems, is determined that Babbage shall have no intellectual heirs.

Babbage published practically nothing in the way of technical description of his engines, and his drawings, which remain largely unpublished in a manuscript archive, were not studied in any significant detail until the 1970s, notably by Allan Bromley. It is fairly conclusive therefore that Babbage's designs were not the blueprint for the modern computer and that the pioneers of the electronic age reinvented many of the principles explored by Babbage in almost complete ignorance of the detail of his work.

Such continuity as there is not in the technology nor in the designs, but in the legend. Babbage and his efforts were an inseparable part of the folklore shared by the small communities of scientists, mathematicians and engineers who throughout remained involved in calculation, tabulation and computation. Babbage's failures were failures of practical accomplishment, not of principle, and the legend of his extraordinary engines was the vehicle not only for the vision but also for the unquestioned trust that a universal automatic machine was possible. ○

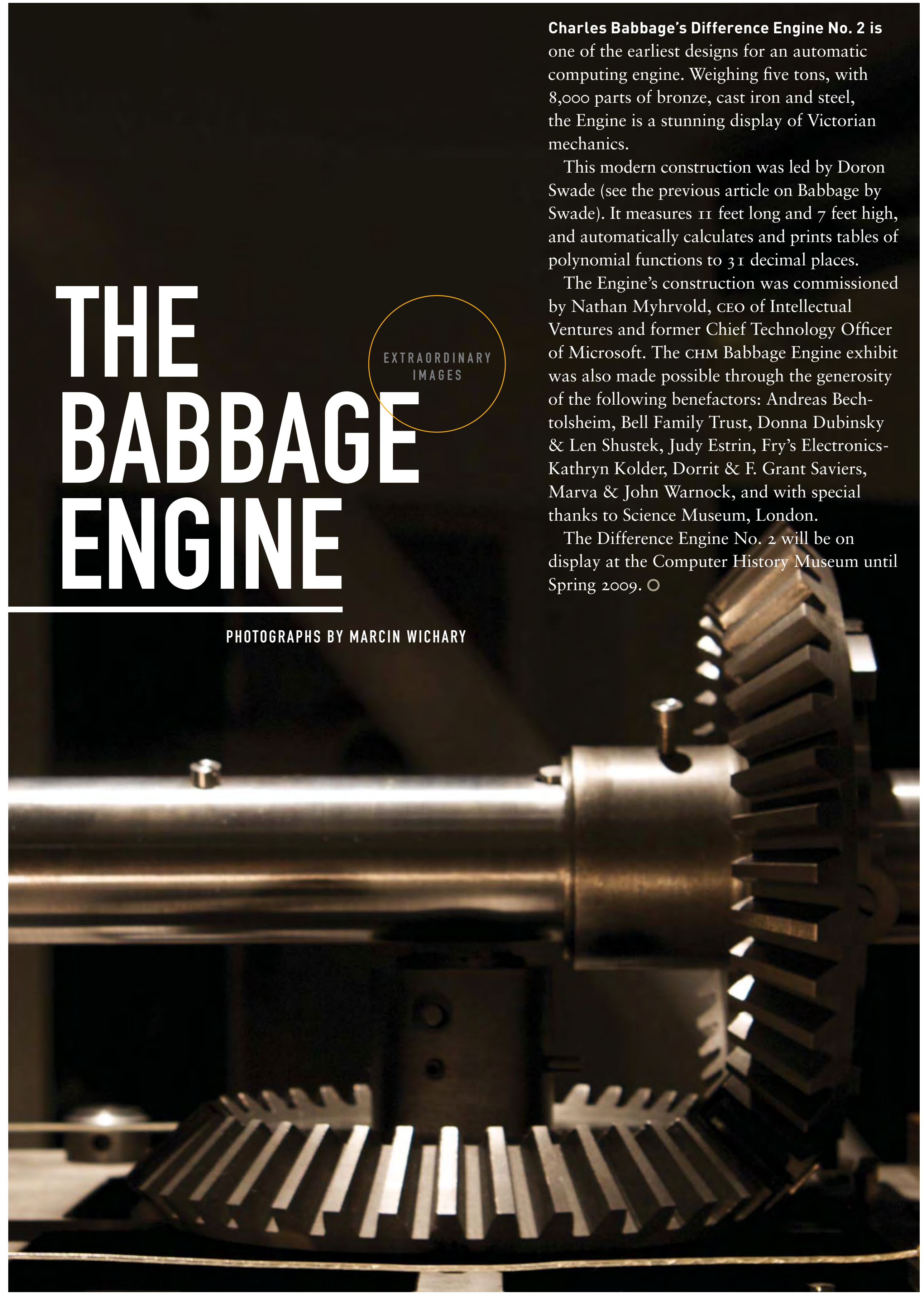
Doron Swade is a world-renowned expert on Charles Babbage and his Engines. Swade was Director of CHM's Babbage Project and curated the Museum's Babbage Engine Exhibit.

8 Metropolis, N., and J. Worlton. "A Trilogy of Errors in the History of Computing." *Annals of the History of Computing* 2.1 (1980): 49-59.

9 The other main bridging figure is Babbage's son, Henry Prevost, to whom Babbage bequeathed his workshop and drawings. Henry continued his father's work after Babbage's death, but without any startling outcome.

10 See Cohen, I. B. "Babbage and Aiken." *Annals of the History of Computing* 10.3 (1988): 171-91, and Cohen, I B. *Howard Aiken: Portrait of a Computer Pioneer*. Cambridge (Mass): MIT Press, 1999.

TOP: SCIENCE MUSEUM, LONDON / BOTTOM: BILL LEUNG, MATRIX PHOTOGRAPHY



EXTRAORDINARY IMAGES

THE BABBAGE ENGINE

PHOTOGRAPHS BY MARCIN WICHARY

Charles Babbage's Difference Engine No. 2 is one of the earliest designs for an automatic computing engine. Weighing five tons, with 8,000 parts of bronze, cast iron and steel, the Engine is a stunning display of Victorian mechanics.

This modern construction was led by Doron Swade (see the previous article on Babbage by Swade). It measures 11 feet long and 7 feet high, and automatically calculates and prints tables of polynomial functions to 31 decimal places.

The Engine's construction was commissioned by Nathan Myhrvold, CEO of Intellectual Ventures and former Chief Technology Officer of Microsoft. The CHM Babbage Engine exhibit was also made possible through the generosity of the following benefactors: Andreas Bechtolsheim, Bell Family Trust, Donna Dubinsky & Len Shustek, Judy Estrin, Fry's Electronics-Kathryn Kolder, Dorrit & F. Grant Saviers, Marva & John Warnock, and with special thanks to Science Museum, London.

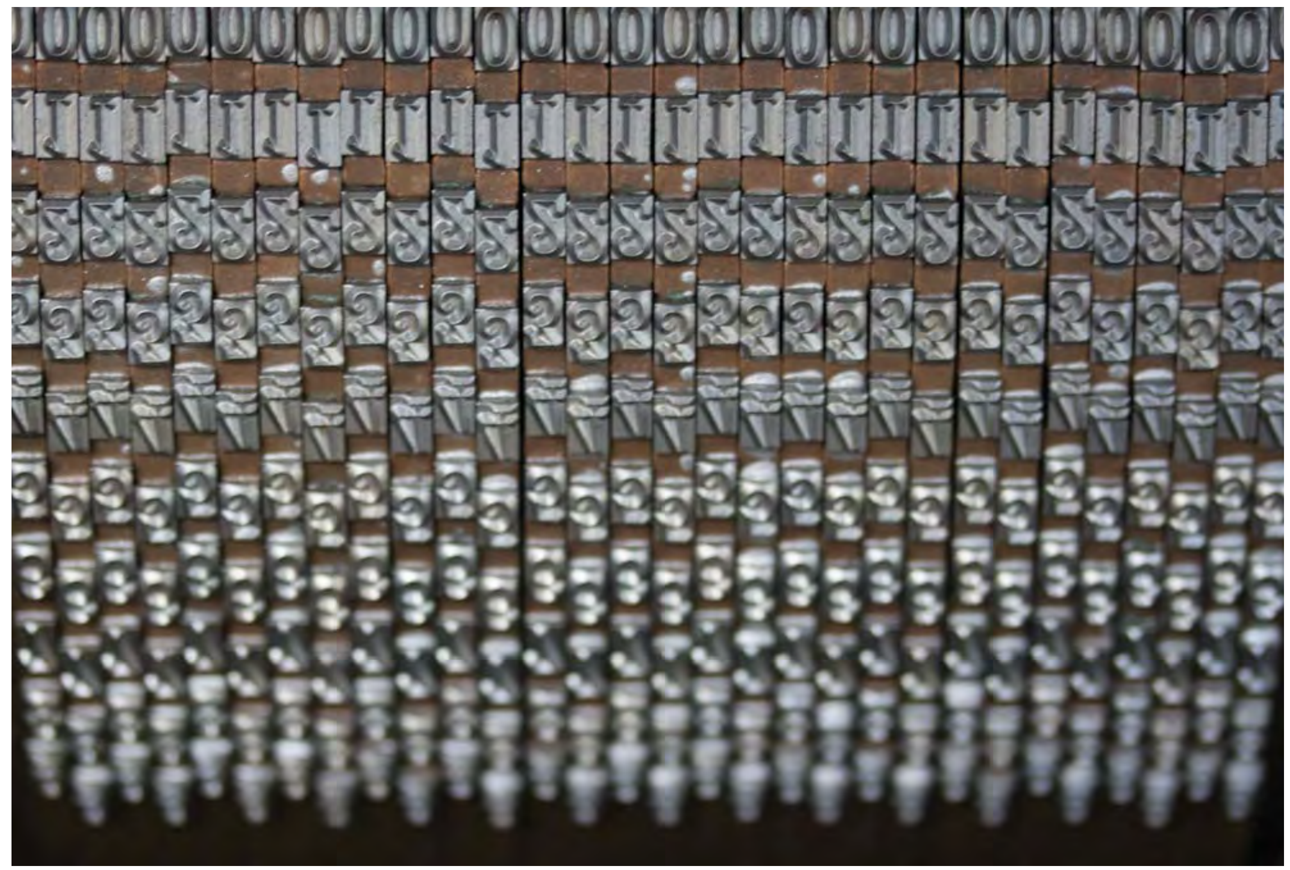
The Difference Engine No. 2 will be on display at the Computer History Museum until Spring 2009. ○

Note the thin line at the bottom - a catgut thread disconnects the main drive at the end of a page.

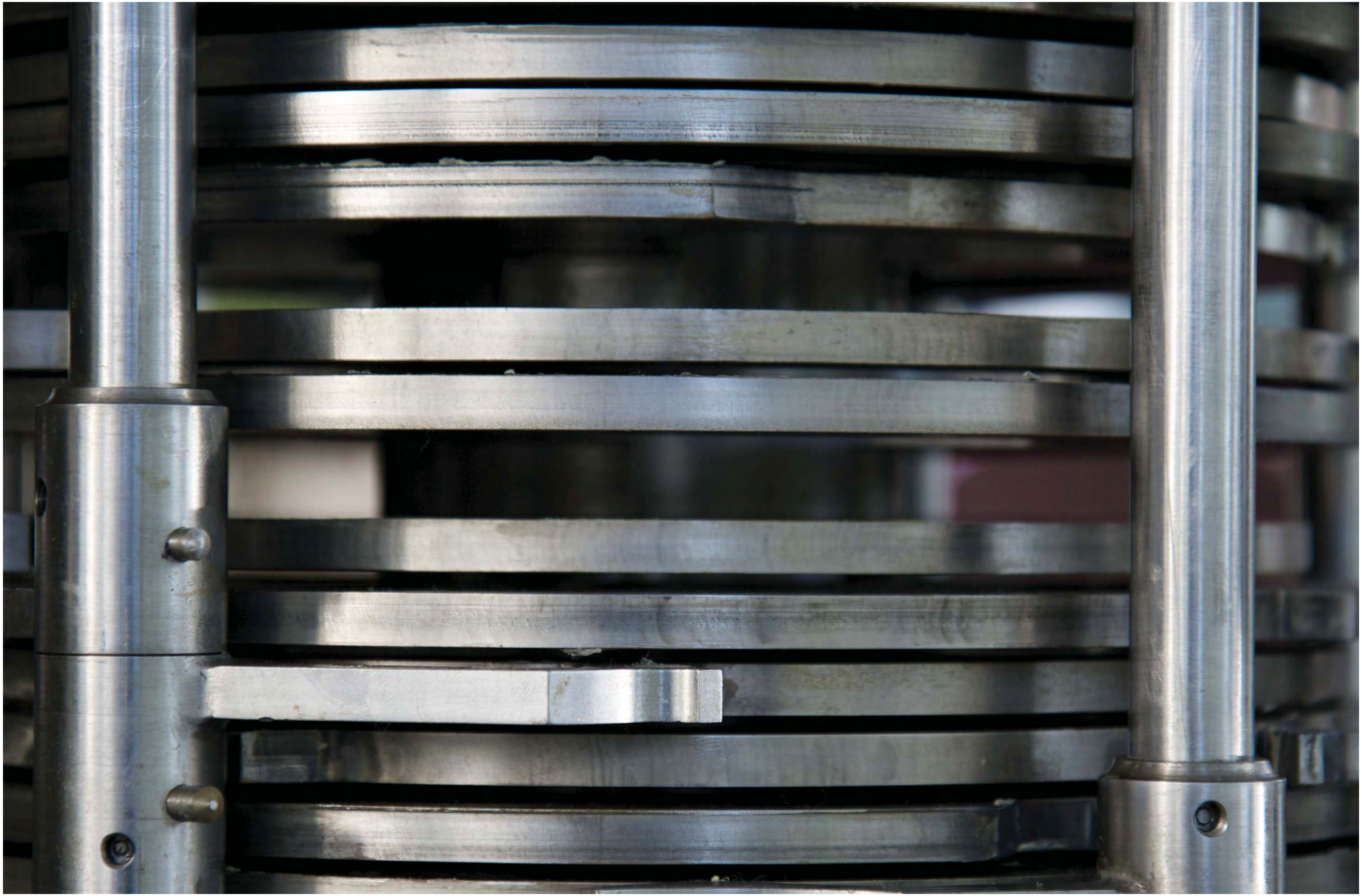
One of the 248 bronze figure wheels.

Figure wheels engaged with adjacent sector wheels during addition.

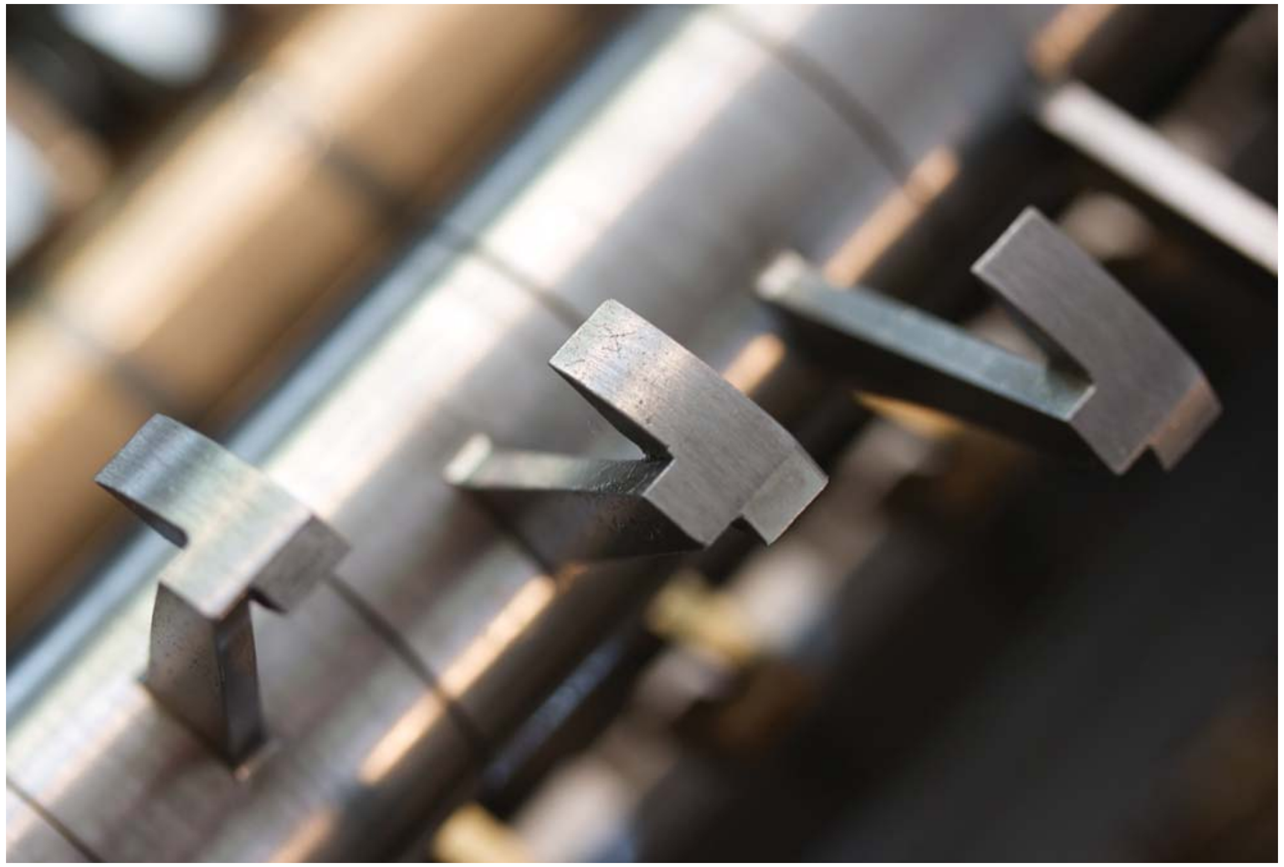
A page from Babbage's celebrated 1827 *Table of Logarithms.*



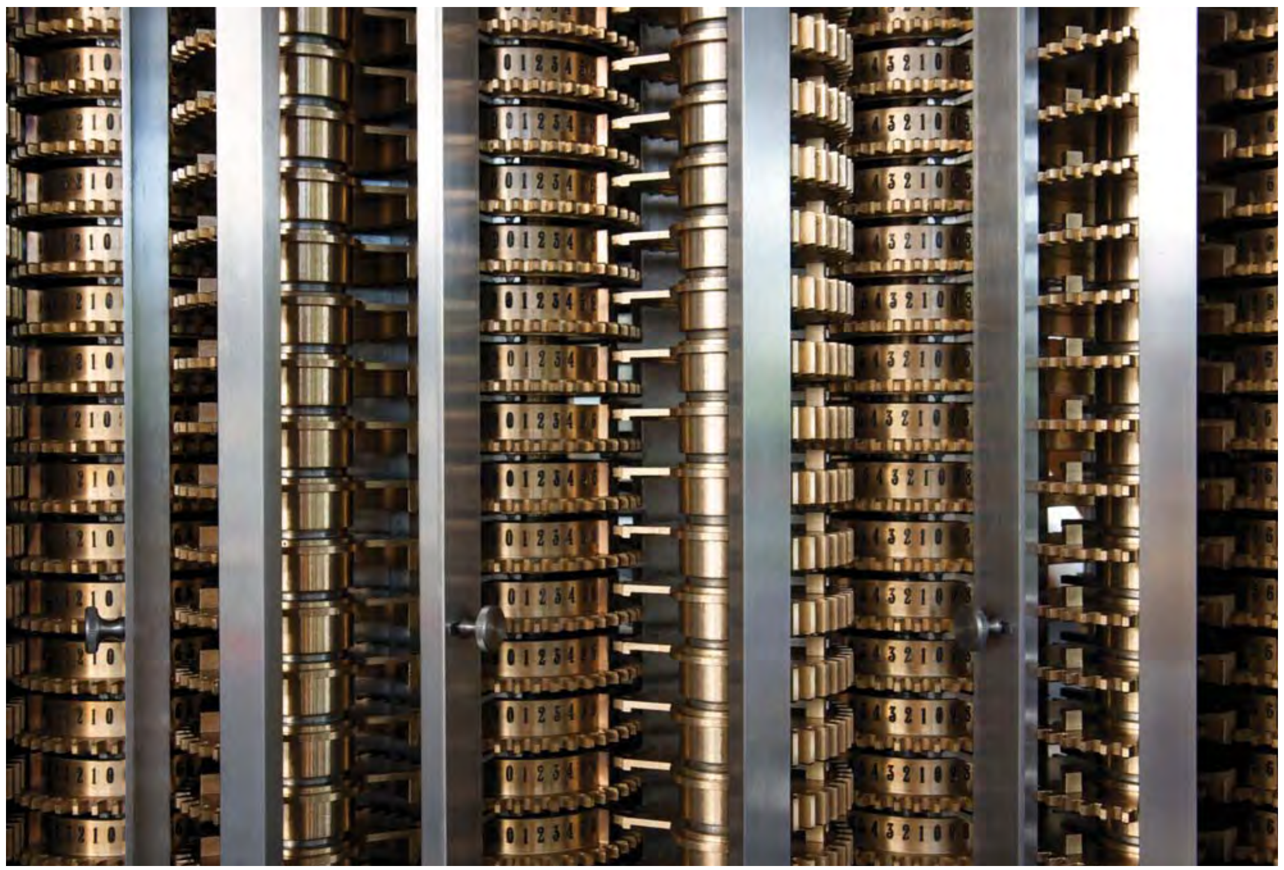
Closeup of type wheels in the printing section.



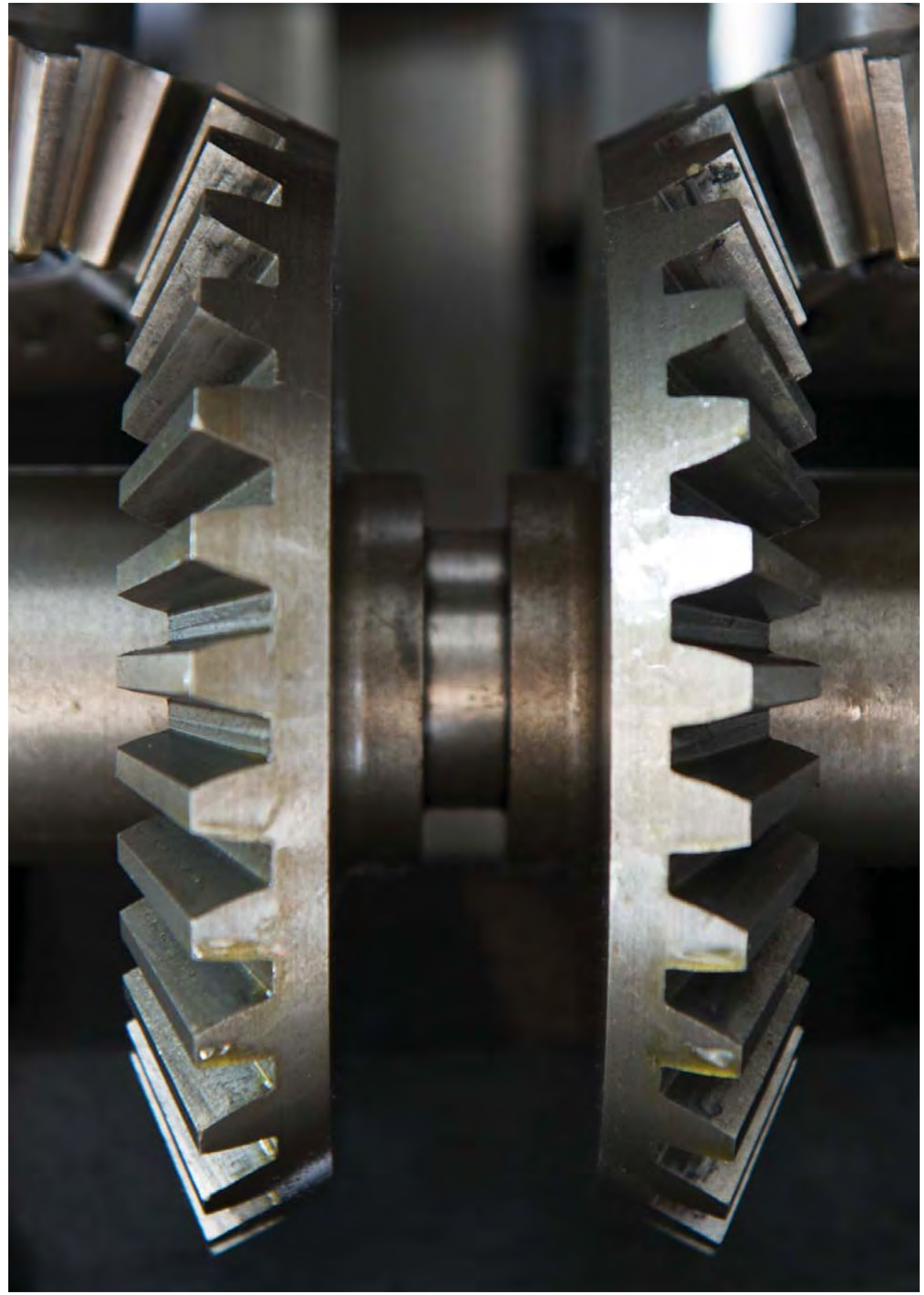
The subtle profiles of these cams encode the Engine's microprogram.



Helically arranged carry arms. As these columns rotate, carries are propagated sequentially from low to high digits.



Vertical columns of figure wheels store 31-digit decimal numbers.



Bevel gears drive a pair of vertical carry axes.

VALLEY OF DEATH

EXCERPT

Andrew S. Grove, born September 2, 1936, has been with Intel since the company was founded in 1968. Currently, his role is Senior Advisor to Intel's executive management.

MICHAEL PRINCE PHOTOGRAPHY

Excerpt of Richard S. Tedlow's *Andy Grove: The Life and Times of an American*—Chapter 10

Gordon Moore has a small wooden plaque that had etched on it: "This is a profit-making organization. That's the way we intended it… And that's the way it is!"

It certainly did not look that way in 1986 with the loss of $173 million. With the benefit of hindsight, we know that Intel pulled out of this dive dramatically in 1987. Sales soared 51 percent to $1.9 billion. The profit picture was equally exciting, hitting a record $248 million. Market capitalization increased by almost $2 billion to $3.328 billion. In 1987, Intel placed 200 on the Fortune 500, higher than ever before. We know today that Intel reached the precipice in 1986 but was able to leap it and continue its climb the following year. No one was arguing with Moore's sign displayed in 1987.

Life, however, is not lived in hindsight. What if the collapse of 1986 had continued into 1987? If the company experienced another 7.3 percent decline in sales, they would have dropped to $1.172 billion, well below the level of 1984. If the company's losses had continued at the 1986 rate, it would have been close to $350 million in the red, losing almost a million dollars a day. Its market capitalization would have fallen to $1.767 billion. Intel's situation would have been dire.

Grove has cautioned against drawing sharp distinctions between "management" and "leadership." One hears arguments in the academic world about management being "transactional." Management concerns itself with the myriad activities that, when undertaken effectively, keep the corporation running and increasing its profitability.

Leadership, one can argue, is "transformational." The leader drives the company in a whole new direction. The leader is charismatic and inspirational. His or her impact helps people exceed their own expectations of themselves.

The problem with these definitions is that, in Grove's words, "there is an implicit value judgment that suggests that leadership is better than management. In reality, you need both capabilities." Grove believes that "the same person should be able to do transactional jobs when those are needed and transformational jobs when those are needed… A tennis player has both a forehand and a backhand. Not all tennis players are equally good at both, but we don't talk about backhand players and forehand players."

True. Indeed, if anything, Grove's career indicates a bias toward management and a skepticism that borders on the acute when it comes to leadership, especially charismatic leadership. He and others in the company were proud when *Dun's Review* named Intel one of the "five best-managed" companies in the United States. There is no similar survey on the "five best-led" American companies.

Grove's efforts, more than anyone else's, put Intel deservedly on that list. John Doerr said that Grove made Intel the best-managed technology company in the world. The semiconductor industry had historically been plagued by poor management. Grove was determined to see Intel break that mold. Remember that Grove's first full-time experience in a corporation was at Fairchild Semiconductor from 1963 to 1968. If ever a company was "over-led" and "under-managed," it was Fairchild. Grove blamed Noyce, the perfect example of a charismatic leader, for that state of affairs.

If people were going to say nasty things about him because of his Late List and other such devices to instill discipline at Intel, Grove could not have cared less. He did not need the affection of Intel's workforce. What he needed, what he demanded, was that Intel's employees manage their work lives rigorously.

Grove's first book not on a technical topic, *High Output Management*, is all about management, not leadership. The book makes reference to "leadership" only in passing. The words, "charisma," "transformation," and even "strategy" do not appear in the index. The first two chapters concern themselves with running a restaurant called "Andy's Better Breakfasts." The chapter titles are "The Basics of Production: Delivering a Breakfast (or a College Graduate, or a Compiler, or a Convicted Criminal...)" and "Managing the Breakfast Factory." He did not have a chapter on "Leading the Breakfast Factory" or "Transforming Andy's Better Breakfasts into Chez Panisse."

Even conceding these points, the fact is that in 1986, Grove acted as a "leader," if that word has any meaning. What did Grove do? To make a long story short, he presided over the creation of a new product line for Intel. Under his leadership—his management also, but preeminently his leadership—Intel exited the memory business and became a microprocessor company. Or, as he put it, "The most significant thing was the transformation of the company from a broadly positioned, across-the-board semiconductor supplier that did OK to a highly focused, highly tuned producer of microprocessors, which did better than OK."

"There is an implicit value judgment that suggests that leadership is better than management. In reality, you need both capabilities."

Two beliefs that Grove said were "as strong as religious dogmas" made it more difficult than it otherwise would have been to get out of a product [memory] that any objective outsider could see was a loser for Intel. One of these "dogmas" was that memory was Intel's "technology driver." Because memory devices were easier to test than other Intel products, they were traditionally the products that were debugged first. The lessons learned could then be applied to other products. Intel's identity was rooted in its excellence in technology. In its industry, technology and testosterone were linked. Real men live on the technological edge.

The second dogma dealt with marketing. Intel owed it to its customers and therefore its salesforce to field a full line of products. The customers demanded one-stop shopping, and if Intel could not provide that service, its customers might defect to someone else who would.

At one point in mid-1985, after a year of "aimless wandering," Grove said to Moore, "If we got kicked out and the board brought in a new CEO, what do you think he would do?" Moore immediately replied, "He would get us out of memories." "I stared at him, numb, then said, 'Why shouldn't you and I walk out the door, come back, and do it ourselves?'"

This was a real moment of truth in the history of Intel, and it should be part of every management course at our business schools. Grove was able, by self-creating new management, to adopt a different frame for his decision making. He was no longer the actor. Now he was the audience. The audience was so displeased with the actor that it would give him the "hook" if it could. He was no longer the subject. He was the object. He got outside himself and looked at the situation as a fantasized, rational actor would.

This was a cognitive tour de force. It was made possible by Grove's capacity to frame issues differently from the way others do.

Grove said that even after this moment of clarity, effective action was inhibited by the intensity of emotion around this product and around the thought that Intel had been beaten at its own game. When he started talking about jettisoning memories, "I had a hard time getting the words out of my mouth without equivocation."

How do you get something like this done? Once you know that you have got to get rid of a product, how do you implement the decision? When I started teaching at the Harvard Business School more than a quarter of a century ago, a businessman said to me that if you are going to cut off a dog's tail, it is best to cut it right at the torso rather than half an inch at a time. The observation struck me as quite uncalled-for and even sadistic. We were talking about business, not mutilation of animals. The point he was dramatically making was that if you have a tough decision, you should implement it cleanly, completely, and without hesitation. The pain will only be greater if you move in stages.

Intel moved in stages, as if its executives were working their way through a trance. At one point, Grove, to his own amazement, allowed another executive to persuade him "to continue to do R&D for a [memory] product that he and I both knew we had no plans to sell."

At last, at long last, Intel got out of the memory business. It had taken three years. A decade later, Grove recalled that the mechanics of getting out of that business were "very hard." It was a "year-and-a-half-long process of shutting down factories, letting people go, telling customers we are no longer in the business, and facing the employees who all grew up in the memory business, who all prided themselves on their skills and those skills were no longer appropriate for the direction that we were going to take with microprocessors." The wounds remained always fresh for Grove. No matter what success Intel achieved, he never ceased to believe that what had happened before could happen again.

Lessons learned? For Grove, the whole memory episode reinforced in his mind the importance of middle management. "While [top] management was kept from responding by beliefs that were shaped by our earlier success, our production planners and financial analysts dealt with allocations and numbers in an objective world." So it was simply vital to have the ranks of middle management populated by top-flight executives and then to pay careful heed to what they say and do.

Second, in Grove's words, "It is always easier to start something than to kill something." Therefore, you better be careful about what you start. That is, however, another example of a lesson that may have been learned too well. With the triumphant exception of microprocessors in personal computers, Intel has not set the world on fire introducing new products into new markets.

Third, when your failure has been of the noble variety rather than the result of stupid mistakes, you as the top manager have to figure out a way to keep the talent that was involved in that unavoidable failure in the company. The DRAM technology development group was unquestionably highly talented. "The DRAM TD group led the company in linewidth reduction. They were already developing a 1-micron process while the logic group was still developing a 1.5-micron process. Sunlin Chou and his group were widely regarded as Intel's best resource for process development." Grove had hired Sunlin Chou at Fairchild in 1964 and always held him in particularly high regard.

What is called for in situations like this can legitimately be denominated as something more than management. What is called for is leadership. "So I went up to Oregon," Grove tells us. Oregon was the headquarters of the DRAM team. The team was worried about its future, not without reason.

Grove gathered them into an auditorium and delivered a speech whose theme was "Welcome to the mainstream." Intel was making the transition from a memory company to a microprocessor company. In fact, the transition had

In Intel's beginning, Gordon Moore and Robert Noyce used the name NM Electronics before deciding on the name Integrated Electronics or "Intel" for short.

already been made for Intel by marketplace realities. Although this group had not been involved in microprocessors, there was plenty of room for them, and the company would do what it could to help them make the contribution Grove knew they could.

The speech "actually went a lot better than I had expected." Grove's audience, knowledgeable people below the ranks of top management, had seen the handwriting on the wall and wanted some resolution of the situation. Thus Grove narrates this story as one in which "the CEO is the last to know" what others inside and outside the company had already figured out. Perhaps. However, that would not be the case as Intel moved self-consciously forward as a microprocessor company. ○

For Andy Grove's other valuable lessons learned, please refer to Richard S. Tedlow's book *Andy Grove: The Life and Times of an American.*

Richard S. Tedlow is a member of CHM's Board of Trustees and the Class of 1949 Professor at Harvard Business School, where he is a specialist in the history of business.

AN INTELLECTUAL BUSINESS LEADER

REMARKABLE PEOPLE

Gene Amdahl's thoughts on leadership

BY FIONA TANG

When asked to describe his success as an entrepreneur and business leader, Gene Myron Amdahl declared, "I did not view myself as a manager. I liked to work with things, not manage people. But I appreciate people and they knew that. So they would do their part because they were contributing to something valuable." This approach—one he calls intellectual leadership—served him well through a long and remarkable career but it required a subtle approach.

Amdahl, born November 16, 1922, is indeed a remarkable person. He received numerous prestigious awards within the technology industry, most notably the CHM 1998 Fellow Award, Harry H. Goode Memorial Award by the IEEE Computer Society, and the SIGDA Pioneering Achievement Award. He is an IBM Fellow, a member of the National Academy of Engineering and a Distinguished Centennial Alumnus of South Dakota State University.

Amdahl's career was highlighted by many years of project leadership within IBM and decades of entrepreneurship including the founding of Amdahl Corporation, Trilogy Systems, Andor International, and Commercial Data Servers.

Does he have advice for today's startups? Amdahl doesn't say people are doing things wrong but he notes a fundamental change in the business plan of today's startups: they don't often take a direct path toward a public offering these days and those that do take a long time to do it because the process is risky. "Today's new companies work on getting bought by bigger companies," he observes.

While Amdahl admits this may be the best way to attain financial success, he also advises that entrepreneurs pay attention to the design integrity of their technologies—hard though that may be. Given Amdahl's notable success as an intellectual business leader, professional project manager and entrepreneur, this advice is worth heeding.

Intellectual leadership—served him well through a long and remarkable career but it required a subtle approach.

A pencil drawing of Gene Amdahl, created in 1965. Donated to the Museum's collection by Amdahl.

MOVING IN

The Museum's collection settles into a new home

BY KAREN KROSLOWITZ

Anyone looking at the beige building that has become the Computer History Museum's new collections storage from the outside would never suspect that a world-class collection resides in such a non-descript industrial Bay Area neighborhood. Often, visitors and contractors who have toured the CHM's new building proclaim with surprise that it is "the cleanest warehouse" they've ever been in. In one sense, I deny that the Museum even has a warehouse because, as a collections management professional, I prefer to emphasize its status as a "museum artifact storage facility."

In need of space for the highly-anticipated "Computer History: The First 2,000 Years" exhibition, the Museum purchased and then relocated its collection just a few miles away from our Mountain View campus. Maintaining a separate and distinct building for collections storage offered numerous advantages. We gained the markedly improved ability to sustain consistent temperature and humidity levels; we can now more closely monitor collections-related activities and facilities issues, including heightening security and minimizing possible pest infestations.

So, in 2007, a never-before-occupied steel shell was converted into a modern artifact vault. Hired contractors wallpapered the walls and ceiling with insulation, boarded up the windows to reduce damaging UV rays, and installed enormous air-conditioning units to keep temperatures constant. All of these measures not only contribute to a longer life span for the artifacts the CHM will house there, but they save energy too.

> **"Boxes only come in two sizes—too big or too small."**

The move project was planned to occur over four phases. Phase 1 commenced in September 2007 when seven cargo container loads of the SAP-funded collection from Germany arrived at the new facility (Read "Rescued Treasures," *Core*, Spring/Summer 2007, pages 4–9). The curators, feverish with rediscovery, hastily opened crates and were followed by the registrars and archivists, who inspected the contents to assess condition and identify any unwanted pests. Volunteers arrived soon after to begin inventorying, cleaning, numbering and photographing the materials. Phase 2 followed a few months later with the transfer of objects from the aged storehouse at Moffett Federal Air Field. Spring 2008 brought the start of Phase 3: the relocation of all physical objects and about half the text collection from the Museum's main storage areas. Since the project began, CHM has relocated roughly 25,000 physical objects and 1,800 linear feet of text. We still have more to go with Phase 4, the temporary shift of 3-D objects currently on display in the Visible Storage exhibit, which will conclude the move project in the very near future.

For any museum or archive, a collection move is the right time to ensure its collections inventory is complete. For CHM, the move has been serendipitous. In August 2007, the Museum received a two-year cataloging grant to further document its physical objects (See "Documenting a World-class Collection" in this issue, page 8). With a collection estimated at about 100,000 artifacts, the Museum relies on an accurate database to locate exactly which artifacts researchers want to see and identify the ones the curators plan to exhibit in "Computer History: The First 2,000 Years." This move has also been the perfect time to procure specialty conservation supplies and time to assert extra effort in carefully packaging many artifacts into acid-free boxes for long-term storage.

Boxing and protecting the physical objects during the move has been challenging. As my predecessor, former Registrar Allison Akbay noted, "Boxes only come in two sizes—too big or too small." Our expert team of move specialists consists of museum professionals and computer industry retirees, whose expertise has been invaluable. They've pooled their collective knowledge and creativity when packing scores of circuit boards; a potentially explosive Stromberg-Carlson Charactron tube; commemorative champagne bottles; and the most fragile of core memory boards.

And what about all those big machines? It turns out pallet racks aren't useful solely to big lot wholesalers. Mainframe units, operator consoles, punched card sorters and more have been strapped to pallets and set aloft using a specialized forklift, whose forks can swivel 180 degrees and whose driver can ride with the pallet upwards to 20 feet. A scissor lift helps collections staff access the upper levels of 11-foot high shelving, where box after box of systems manuals, magnetic tapes, calculating machines, keyboards, and conference keepsakes now reside.

Exceptional organization and cleanliness are clear indicators of first-rate conservation practices in all museums and archives. So, when I hear the "cleanest warehouse" compliment, I feel quite proud because the praise truly belongs to the dozens of people who have contributed to cataloging the collection, to reorganizing the text archives, and to this move project overall. Our visitors' observations are evidence that we're managing our artifacts with care. During an open house event, long-time volunteer Dave Babcock exclaimed, "It's so wonderful to see all the artifacts being stored properly and getting the care they deserve. This new facility is like a dream come true!"

I couldn't agree more.

Karen Kroslowitz, the Museum's Registrar, has extensive experience in managing museum collections within institutions such as the William K. Vanderbilt Museum & Planetarium on Long Island and the Wing Luke Asian Museum, Seattle, WA.

The smallest of physical objects are securely nestled in a sea of white archival boxes.

EXPLORE THE COLLECTION

AMSLER INTEGRATOR MODEL 4282 & ASSOCIATED GUIDE RAIL

BY JIM MCCLURE

CHM#: B1506.01 and 102630325, respectively
DATE: c.1900
DONOR: Gwen and Gordon Bell

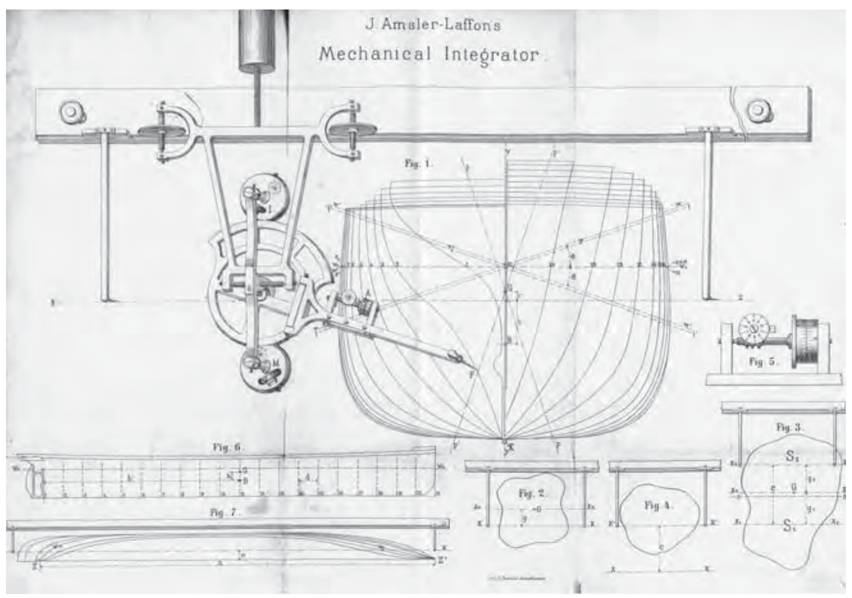
Ship stability was a great concern to shipbuilders in the 1870s and 1880s. Ships frequently capsized during initial sea trials or even upon an initial launch. This happened often with loss of life and goods, so Lloyd's of London insisted new ships be launched and rolled to see if they capsized before it would insure them.

In the 1700s, scientists such as Pierre Bouguer, Daniel Bernoulli and Leonhard Euler, began studying principles of stability—specifically ship stability—and publishing their research. But the calculations needed to assess stability were so complex that they could take years.

It wasn't until 1855 that Jakob Amsler, a Swiss mathematician, conceived of a device—the Amsler Integrator—that would solve exactly this sort of calculation. It looked deceptively simple yet Amsler worked for years to produce a commercial version of it in 1878.

The Integrator's popularity quickly grew. In 1880, shipbuilder William White declared, "This is a thing for which we have been longing for years because it will save us an immense amount of mere routine work."

The Integrator could determine the area, center of gravity, and static and inertial moments around any axes of the cross section of any ship almost as quickly as the Integrator's operator could trace its outline. A stability analysis that once took a year could now be performed in hours.



This training drawing illustrates the measurement of stiffness, displacement, and stability of a complex ship's hull design. A few measurements replaced weeks of hand calculations.

The Integrator quickly calculates the bending properties of any railroad rail design placed under it. The user need only trace the outline. This complex mechanism calculates static and inertial moments as a drawing is traced.

ASCI RED: THE WORLD'S FIRST TERAFLOP COMPUTER

BY DAG SPICER

CHM#: X4603.2008
DATE: 1997–2006
DONOR: Sandia National Laboratories

In the time it took you to read this sentence, ASCI Red could breeze through five trillion calculations. This pioneer of supercomputers may be retired—with portions resting in the Computer History Museum's permanent collection—but the breakthroughs it made will long be felt.

At ASCI Red's decommissioning ceremony, supercomputing pioneer Justin Rattner observed, "When Chuck Yeager cracked the sound barrier or Armstrong landed on the moon, I wonder if they had the same feeling. It is with great fondness that we say goodbye to ASCI Red. It's been a great run and we'll never forget it."

ASCI Red owes its creation—in December 1996—to a 1992 Federal policy directive to discontinue live nuclear weapons testing. In order to obey this directive, Intel and Sandia National Laboratories created ASCI Red to simulate those tests. While pursuing this goal, it became the first computer in the world to reach one trillion calculations per second (1 Teraflop or TF). A later CPU upgrade pushed ASCI Red's speed to a stunning 3TF. For much of its amazing run—between the years of 1997 and 2000—ASCI Red was the fastest computer in the world.

Remarkably, ASCI Red's service life was nearly 10 years, unheard of in the field of rapidly-obsolescent supercomputers. It owed both its speed and longevity to a "massively-parallel" processing system, using over 9,000 standard Intel CPUs (Pentium Pro). This allowed it to break large calculations down into smaller ones for each CPU to work on—resulting in enormous speed. ○

The ASCI Red supercomputer required 1,600 sq. ft. and was comprised of 85 cabinets, of which CHM has five in its permanent collection.

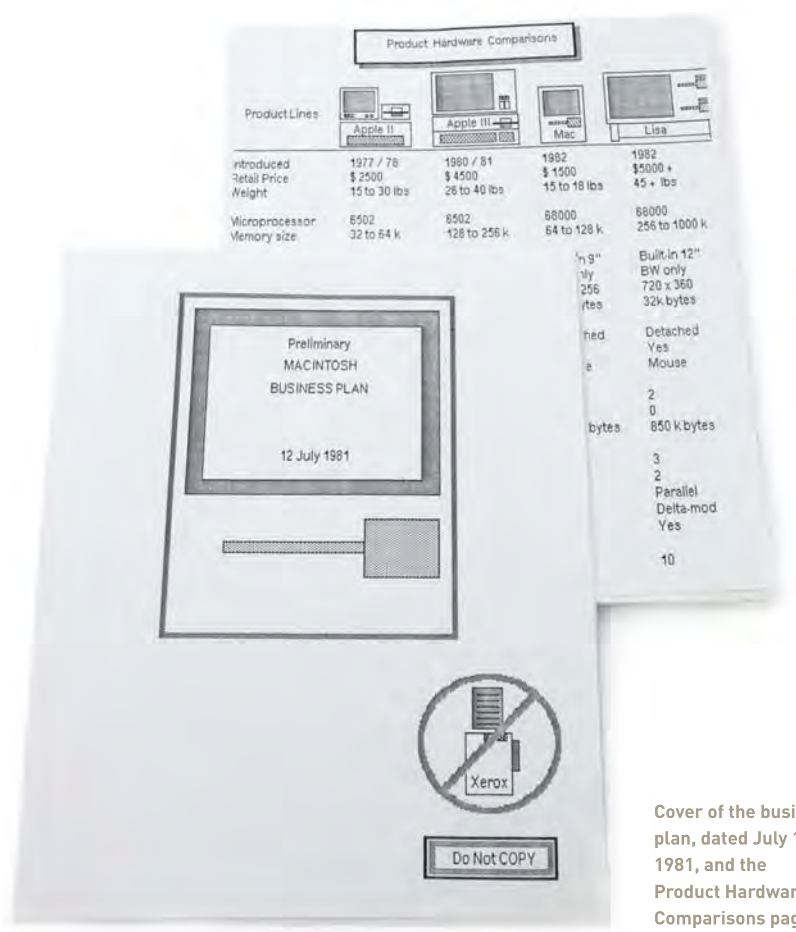
PRELIMINARY MACINTOSH BUSINESS PLAN

BY PAULA JABLONER

CHM#: X4554.2008
DATE: July 12, 1981
DONOR: Mike Markkula

Super Bowl XVIII was a turning point in the history of personal computers. During that game, the mass-marketing of personal computers kicked off with the phrase, "On January 24, Apple Computer will introduce Macintosh. And you'll see why 1984 won't be like *1984*." Not only was this Ridley Scott directed television ad ground-breaking, the Mac it promoted was itself revolutionary. The Mac offered a graphical user interface and mouse at a price that made the personal computer accessible to the novice computer user.

In July 1981, an internal Apple document outlined the Preliminary Macintosh Business Plan: "Jobs' Product Timeline" stated that Apple aimed to produce the Mac by mid-1982 at a price of $1,000 to $1,500 with no mouse. Eighteen months later, for $2,500, the Mac—with a mouse—launched. The strategy was to offer a computer to an audience of hobbyists (Band 1) who were already using Vic and TRS color computers and small businesses (Band 3) who had been buying the HP-85 or Xerox 820. Apple identified a market where no one else saw one and developed this computer to reach it: "... The job of Macintosh and VLC is to migrate the remaining Band 3 customers down to Band 2, leaving Band 3 manufacturers out in the cold!!" ○



Cover of the business plan, dated July 12, 1981, and the Product Hardware Comparisons page.

COLLECTION

RECENT ARTIFACT DONATIONS

BY DAG SPICER

IBM THINKPAD 701CS LAPTOP COMPUTER ("BUTTERFLY")

CHM#: 102707367
DATE: 1995
DONOR: Gregory Joseph Badros

IBM's ThinkPad 701CS was cutting edge in its day. It featured a large color display and keyboard packed into a "sub notebook" size that would still appeal today. It weighed only 4.5 lbs, ran for six hours on its battery, and had 16 MB of RAM and a 720-MB hard drive. A clever split keyboard expanded to a standard 85-key layout when you opened the lid. Because of the keyboard, the 701CS was dubbed the "Butterfly."

The 701 is also in the permanent collection of the Museum of Modern Art and was featured in the movies *Golden Eye*, *Mission Impossible*, and *Batman Forever*. ○

LIONS' COMMENTARY ON UNIX 6TH EDITION, 2 VOLS., WITH SOURCE CODE

CHM#: 102707366
DATE: 1976
DONOR: John Mashey

John Lions, professor of computer science at the University of New South Wales, wrote these two books as course notes on the UNIX operating system for his students in May of 1976.

When AT&T announced UNIX Version 7 in June 1979, its new academic and research license no longer permitted classroom use. Despite this, thousands of students made photocopies—and photocopies of those photocopies. Because of this, the popularity of the book spread quickly and widely.

In fact, for many years, the Lions' Book was the only UNIX kernel documentation available outside of Bell Labs. It is considered one of the classic works in computer science. ○

THE AMAZING DR. NIM BOARD GAME E.S.R. INC., U.S.A., CA.

CHM#: 102688881
DATE: 1965
DONOR: Warren Yogi

This deceptively simple plastic board game actually teaches binary arithmetic. It is a strategy game where one player (human versus Dr. Nim) takes turns removing marbles from a row. On each turn, this player must remove one, two, or three marbles. The player who gets stuck with the last marble loses.

The game's easy-to-read and entertaining manual includes philosophical speculations about whether computers can think. ○

SILICON RUN – 7 DVD SET

CHM#: 102707368 / X5022.2009
DATE: 1985–2004
DONOR: Ruth Carranza

Acclaimed as one of the world's best documentaries on the semiconductor manufacturing process, *Silicon Run* began in 1998 as an introduction to the design and assembly of Integrated Circuits (ICs). This newly-issued, 7-part series includes two introductory-level DVDs and four specialized programs on Etching, Lithography, Implantation, and Deposition—four key stages in how chips are made.

In time, even these advanced manufacturing techniques will appear dated. At which time, these DVDs will become a useful historical record of late 20th-century chip making. ○

ROCKET E-BOOK

CHM#: 102691369
DATE: 1998
DONOR: Donna Dubinsky

The Rocket e-Book was an early handheld book reader. It held about 4,000 pages of words and images—equal to about 10 novels—and weighed just 22 ounces. Users could connect to web-based retailers by connecting it to a PC. The battery lasted an average of 20 hours.

Several other companies also made (and still make) electronic book readers but none have sold all that well. Whether this technology will acquire mass appeal remains an open question. ○

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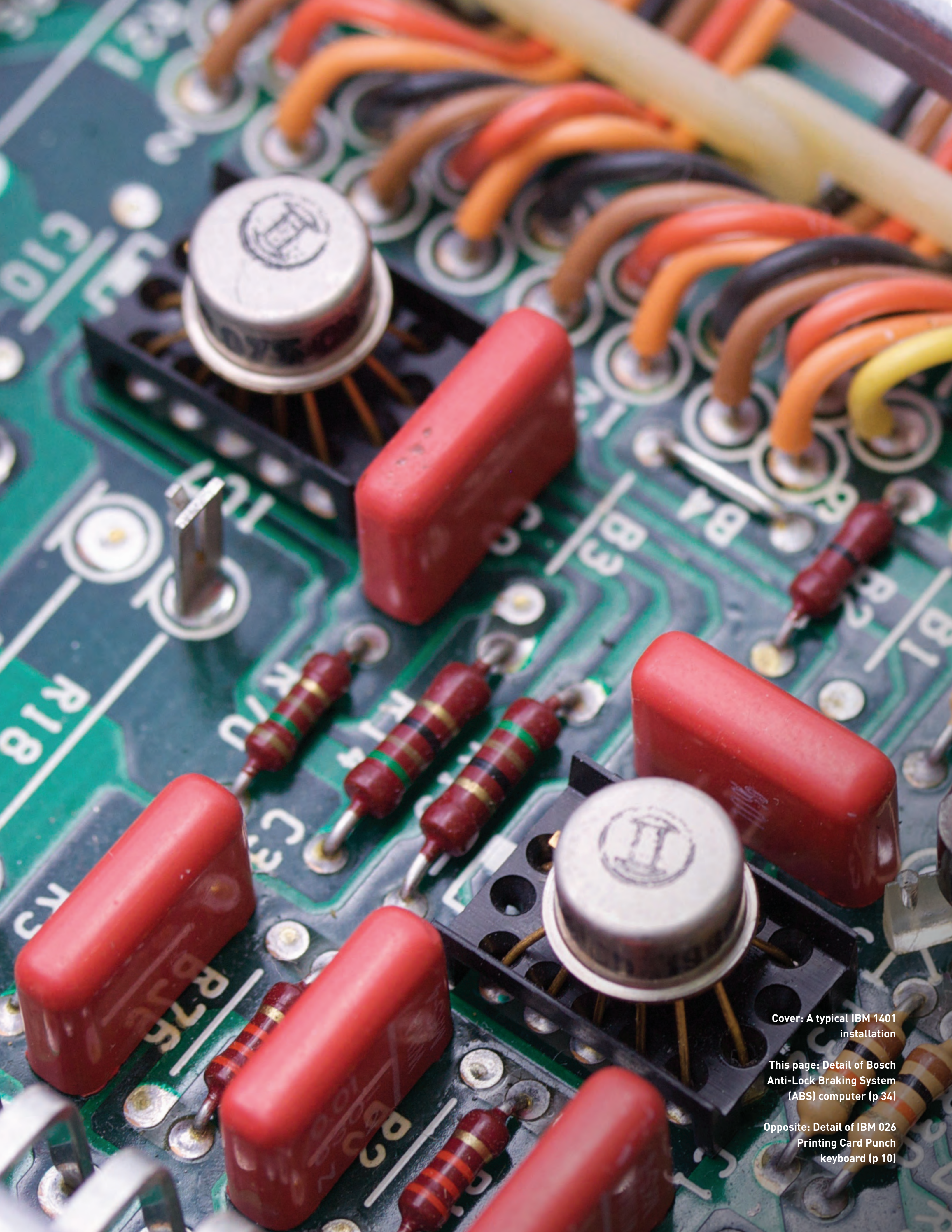
> "Having a place that will capture the history of the computing industry is phenomenal. This Museum is a remarkable institution with an important mission—I support the heck out of it!"
>
> BILL CAMPBELL
> INTUIT'S CHAIRMAN OF THE BOARD

2009

CORE

A Publication of
the Computer
History Museum

IBM 1401: A Legend Comes Back to Life
The Changing Face of the Mac
The Secret History of Silicon Valley

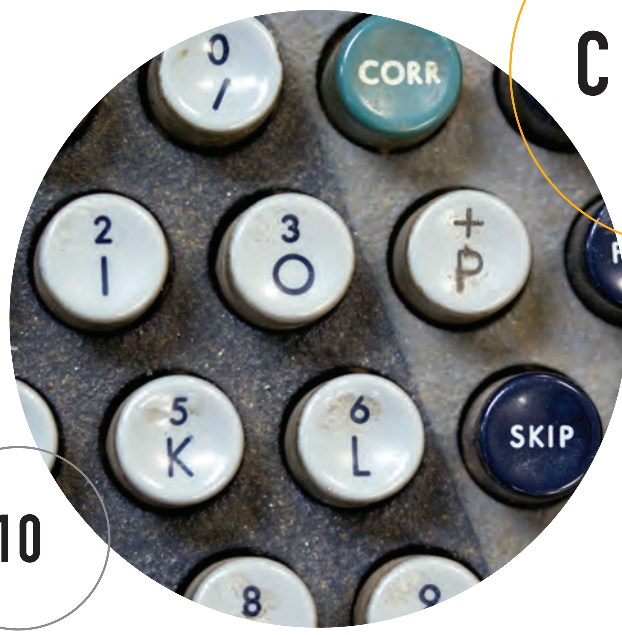


Cover: A typical IBM 1401 installation

This page: Detail of Bosch Anti-Lock Braking System (ABS) computer (p 34)

Opposite: Detail of IBM 026 Printing Card Punch keyboard (p 10)

CORE
2009



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COVER: IBM ARCHIVES

ARCHIVISTS

Archivists:
\ˈär-kə-vist, -ˌkī-\
A person in charge of archives, which is a place in which public records or historical documents are preserved (Merriam-Webster)

ELIZABETH BORCHARDT

DOCUMENTS ARCHIVIST

I enjoy providing access to the Museum's collection. People engaged in researching information from our collection make my work worth it. For example, a hospital was regularly using a 25 year-old IBM 4245 printer that had stopped working. Only the Computer History Museum had the maintenance manuals they needed to repair the printer. Access to our collection provides tremendous value to our community.

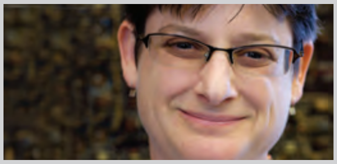
SARA CHABINO LOTT

SOFTWARE ARCHIVIST

Selecting records of historical value from this age of documentary overabundance is quite challenging, but it is also very rewarding. It is the Museum's responsibility to gather artifacts and stories to develop a historical collective memory, and to convey this information from generation to generation—a responsibility I take very seriously.

PAULA JABLONER

DIRECTOR OF COLLECTIONS



One of the joys of being an archivist is the excitement of consistently learning new things, from the historical tidbits gained while cataloging the background stories for new artifacts in our collection. I love passing this new knowledge on to our community as part of the Museum's mission to "preserve and present."

HEATHER YAGER

AUDIOVISUAL ARCHIVIST

My favorite aspect of film and video archival work is preservation. Most of our new video acquisitions are stored in digital formats, so often we are applying traditional archival preservation practices to modern formats. By exploring ways to expand preservation principles to encompass digital videos stored on servers, as well as videos tapes stored on shelves, the Museum can preserve historical content for posterity.

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CEO'S LETTER

A RECIPE FOR
CREATIVE ACCOMPLISHMENT

In his keynote address at the 2009 conference of the American Association of Museums, author Malcolm Gladwell described two essential qualities for what he called "creative accomplishment"—patience and persistence.

Citing his 2008 book, *Outliers: The Story of Success*, Gladwell defined patience in vivid terms: "the 10,000 hour rule." He contends that an individual masters a subject or skill only by patiently spending a minimum of 10,000 hours on it in focused practice. That's an average of 3 hours a day—every day—for 10 years.

Persistence is an equally important ingredient of "creative accomplishment," and it makes sense. Persistence simply means the ability to battle against, and ultimately overcome, the legion of obstacles that stand in the way of creating something worthwhile and enduring.

I am happy to report to you that 2009 has been a year of patience and persistence—and creative accomplishment—for the Museum as an institution. Thanks to your generous support, we patiently maintained our equilibrium in an incredibly turbulent economic storm. For the fiscal year ending June 30, we reported our 14th consecutive year of operating in the black. With our donors' help and commitment, moreover, we were able to do more than simply resist the financial storm. We expanded our public programs to celebrate the 50th anniversary of the integrated circuit, extended the Babbage Engine No. 2 exhibition, opened a new exhibit honoring the history of the semiconductor, and launched the pilot phase of our new education program.

All of this and more is described in our first-ever performance report, which is included with the members' issue of *Core*.

This issue of *Core* is also a tribute to other aspects of computer history that fit Gladwell's recipe. We tell stories celebrating the 25th anniversary of the Macintosh and the 50th anniversary of the IBM 1401, and we survey a small part of "the secret history of Silicon Valley" through a wonderful essay by Steve Blank.

Please accept my sincere thanks for enabling our own brand of creative accomplishment and for making these wonderful results possible this year. Together, we are building on an already great foundation to make the Museum a model for the 21st Century. When you visit, as I hope you will soon, you'll find an institution that is vibrant, growing and optimistic. You can understand why I'm especially excited to be working at the Museum with you in this endeavor.

Warm Regards,

JOHN C. HOLLAR
PRESIDENT & CHIEF EXECUTIVE OFFICER

CONTRIBUTORS

Core 2009 Contributors give us their take on computer history

STEVE BLANK

What is your favorite technology invention?
The Integrated Circuit—Kilby & Noyce

What is your favorite milestone in computer history?
A tie between:
1) William Shockley deciding to start his semiconductor company in Palo Alto.
2) The "Traitorous 8" leaving Shockley Semiconductor to start Fairchild

Why is CHM important?
Each generation assumes it is inventing the future, with no recollection that it's already been done.

Steve Blank is a lecturer at Stanford University's School of Engineering and Berkeley's Haas School of Business. He is a serial entrepreneur, having spent nearly 30 years as a founder and executive of high-tech companies in Silicon Valley.

DAG SPICER

Who is your favorite computer history unsung hero?
Gordon Bell. He had the vision early on that knowing about computers would be important and, with his wife Gwen, took on the arduous task of transforming the early Computer Museum in Boston from a dream into reality.

What is your favorite technology invention?
The 1961 IBM 7030 "Stretch" computer system had features that we still use today and which were absolutely groundbreaking for the time.

Why is CHM important?
We study history not to know dates, times and places but to know ourselves. The computer is now part of all our history and having a place that preserves and explains that history is vitally important to knowing who we are.

Dag Spicer is CHM's Senior Curator.

MARCIN WICHARY

Who is your favorite computer history unsung hero?
Adam Osborne. Just a glimpse of an alternative reality where Osborne Computer survived would make my day.

What is your favorite milestone in computer history?
The coming of micros—many companies jumped in, writing and rewriting the rules as they went along.

Why is CHM important?
Because an artifact doesn't mean much without the slice of history that surrounded its life.

Marcin Wichary is a Senior User Experience Designer at Google and has been a volunteer docent and a photographer at the Computer History Museum since 2007.

FELLOW AWARDS 2009

For more than 20 years, the Computer History Museum Fellow Awards have honored distinguished technology pioneers for their outstanding merits and significant contributions to both the advancement of the computer industry and to the evolution of the Information Age.

The Hall of Fellows is an extension of the Computer History Museum's overarching vision to explore the computing revolution and its worldwide impact on the human experience. The tradition began with our first Fellow, Grace Murray Hopper, inventor of the compiler, and has grown to a distinguished and select group of 47 members. This award represents the highest achievement in computing, honoring the innovators who have forever changed the world with their accomplishments.

In keeping with our mission "to preserve and present for posterity the artifacts and the stories of the Information Age," the Computer History Museum Fellow Awards publicly recognizes and honors these individuals and their accomplishments at an annual Gala Celebration, which was a well attended celebration this year.

We are pleased to honor the Fellow Awards Class of 2009:

Robert R. Everett for his work on the MIT Whirlwind and SAGE computer systems and a lifetime of directing advanced research and development projects.

Don Chamberlin for his fundamental work on Structured Query Language (SQL) and database architectures.

The Team of Federico Faggin, Marcian "Ted" Hoff, Stanley Mazor, Masatoshi Shima for their work on the Intel 4004, the world's first commercial microprocessor.

We thank the nominators of these special pioneers, and also thank Ike Nassi, CHM Trustee, for chairing the Fellows Selection Committee. ○

Nominations for the 2010 Fellows are underway. Visit computerhistory.org/fellowawards..

Gordon Moore at the Computer History Museum enjoying a conversation prior to his talk on the Integrated Circuit.

SYNCHRONIZED ELEGANCE IMAGING

2009 SALUTE TO THE SEMICONDUCTOR

> "Integrated circuits weren't enthusiastically embraced by the customer base in the beginning..."
>
> GORDON MOORE
> DURING MAY 8TH IC@50
> LECTURE EVENT AT CHM

More than 1,000 people attended programs during the week-long CHM IC@50 celebration, which marked the 50th birthday of the integrated circuit (IC).

The IC@50 events were the capstone of the Museum's year-long Salute to the Semiconductor program. This program integrates the Museum's core strengths: a special physical exhibit, "The Silicon Engine;" several CHM Presents evening lectures; a series of CHM Soundbytes lunchtime lectures, a commemorative booklet celebrating the 50th anniversary of the integrated circuit; and several new educational tours.

The IC@50 events included evening lectures by industry pioneers Gordon Moore, Jay Last, Jay Laythrop, Charles Phipps and historian Christophe Lécuyer. Joining the legends were industry executives including Brian Halla, CEO of National Semiconductor, who spoke at the original site of the Fairchild Semiconductor office for the IEEE Commemorative Plaque Unveiling

The IC@50 also provided the first public display of the original Fairchild Semiconductor patent notebooks of Hoerni, Last, Moore, and Noyce. These precious artifacts were on loan from National Semiconductor, the successor to Fairchild Camera and Instrument Corp.

Also on display was a replica of the original Kilby notebook. Texas Instruments created this replica especially for the IC@50 and later donated it to the Museum's collection.

CNET reported: "...As the week wore on at the Computer History Museum, it became clear that with a birthday of this magnitude, it was hard to overstate the impact of the integrated circuit, not just on the technology industry, but on modern society."

Other Salute to the Semiconductor program elements included Harvard Business School Professor Richard S. Tedlow, our first scholar in residence, presenting the Intel 386 business case. Tedlow also spoke to the Museum's student community about how Andy Grove spurred the company's growth during his tenure as Intel CEO. Both events generated stimulating question and answer sessions for our community.

550,000

Videos have been viewed on the CHM YouTube channel in just the past year

CHM launched the Silicon Engine exhibit in June with multimedia presentations examining the invention of the integrated circuit, the evolution of the semiconductor industry and the impact of these technologies on our lives. The exhibit draws on the Computer History Museum's collection of 300+ oral histories capturing the first-person stories from the technology giants. It features a multi-screen mini theater showing an 8-minute documentary on the invention of the transistor, the integrated circuit, the rapid growth of the semiconductor and the impact these technologies have made on the human experience.

Missed a Salute event? See the videos on CHM's YouTube channel: youtube.com/computerhistory ○

The IC@50 was co-produced by the Computer History Museum, the Chemical Heritage Foundation and the IEEE Santa Clara Valley Section.

Major funding for the Salute to the Semiconductor was generously provided by the Gordon and Betty Moore Foundation and Intel Corporation. Additional funding for IC@50 events was provided by National Semiconductor.

THE CREATION OF ALDUS

ORAL HISTORIES

INTERVIEWED BY SUZANNE CROCKER
EXCERPTED BY LEN SHUSTEK

The Computer History Museum has an active oral history program to gather videotaped histories from the pioneers of the information age. These interviews are a rich aggregation of personal stories that are preserved in the collection, transcribed, and made available on the web to researchers, students, and anyone curious about how invention and entrepreneurship happens.

Presented here are excerpts from an interview with Paul Brainerd, the founder of Aldus, whose flagship product PageMaker established the PC-based "desktop publishing" industry. The interview was conducted on May 16, 2006.

What was your early publishing experience?

In graduate school, I was the editor of the *University of Minnesota Daily*, a 35,000-circulation daily with a staff of over a hundred students. I learned a lot of valuable lessons there both on the editorial side as well as from a business perspective.

I then went to work for the *Minneapolis Star Tribune* for seven years as assistant to the operations director. We converted from "hot type" composition in the composing room to "cold type" using computer typesetting, and I developed the contracts and the specifications with the various companies. The most important was Atex, who made a text-editing system using computer terminals for reporters to write their stories.

It was an exciting time, getting grounded at a newspaper that had been there for a long time, and being mentored by some excellent people. But it would have been pretty hard to advance there unless I stayed for another 10 or 15 years.

So I joined their supplier, Atex, and moved from newspapers to high-tech. Things moved a lot faster! At the *Star Tribune*, everything required a proposal and two or three months to make a decision. At Atex, things were decided around the water cooler, sometimes in a matter of minutes. I stayed until Atex was purchased by Eastman Kodak in 1983.

Why did you start Aldus?

This whole idea of page layout was near and dear to my heart because I had done it the hard way with exacto knives and razor blades and wax on the back of cold type. Atex was a better but very costly system, mostly used for the larger metropolitan dailies and publications like *Newsweek*. It was fairly arcane, and it could take a month to learn the commands.

So I took the small nest egg from Atex stock plus all my savings—roughly $100,000—and gave myself six months to write a business plan and build a prototype. The engineers worked for half salary, and I worked for no salary. I wrote the business plan, and with the engineers developed the functional specifications for what became PageMaker.

During the summer of 1984, I tried to raise money and was told "no" 49 out of 50 times. The venture capitalists felt that a software company didn't have any long-term market

During the summer of 1984, I tried to raise money and was told "no" 49 out of 50 times. The venture capitalists felt that a software company didn't have any long-term market value.

value. Microsoft hadn't gone public yet! We got to our drop-dead date in September with less than $5,000 left.

Finally, we got a commitment from Vanguard in Palo Alto, who understood why software might have value. We raised $864,000 based on our business plan and a very rough prototype, and we shipped PageMaker 1.0 the following July.

Who was the customer?

When we formed the company in January of '84, it was the professional user. But I made one really smart move, which was we loaded everybody up in my Saab—myself and the three engineers—and took a trip to talk with potential customers about what we had in mind: a page-layout solution for small newspapers. We learned that all these newspapers were owned by chains or other corporate entities, and that their decision-making was typically a one-to-two-year process. That trip convinced us that we would be out of business by the time we sold anything.

That's why it's so important to talk to customers. They loved it, but I realized it wasn't the right market. So I totally revised the marketing section of the business plan to focus on small businesses, churches, schools, and small publishers.

We really underestimated how fundamental the value proposition was—what the "three-legged stool" of PageMaker, the Apple LaserWriter and the Macintosh could do. We were providing an order of magnitude gain compared to the frustrating and costly proofing cycle using a typesetter.

We showed it in January of 1985 when the LaserWriter came out, and people couldn't believe that we could do output of that quality.

> "Technology moves so fast that we often fail to remember the passion, drama and intensity of these moments in computer history. This museum does this for us."
>
> JAY ADELSON
> CEO OF DIGG

Who was the competition?

Our first competition, before we even released the product, was Microsoft, which we were very scared of even then. They had acquired a product from a third party, and put marketing materials together describing pretty much exactly what we were planning on doing. But the product never worked. The code was riddled with bugs and they had to withdraw it from market.

I'd say about half of our competition was like that, and simply dissolved over time. The other half stayed around but made other errors along the way.

> **When PageMaker was first released at a price of $495, that was almost unheard of. But (the gross margin) allowed us to reinvest in customer service, support, and product development.**

What was the association with Apple like?

The alliance was critical to both companies. For Apple, it was critical to the success of the Macintosh, and for Aldus, it was critical to our survival because we did not have the budget to bring PageMaker to the broader market.

We developed a whole desktop publishing marketing plan, which they funded a lot of, including full-page ads in *The Wall Street Journal*. Apple was putting a million dollars plus a month into it, and that gave us incredible momentum. We could never have done that without them.

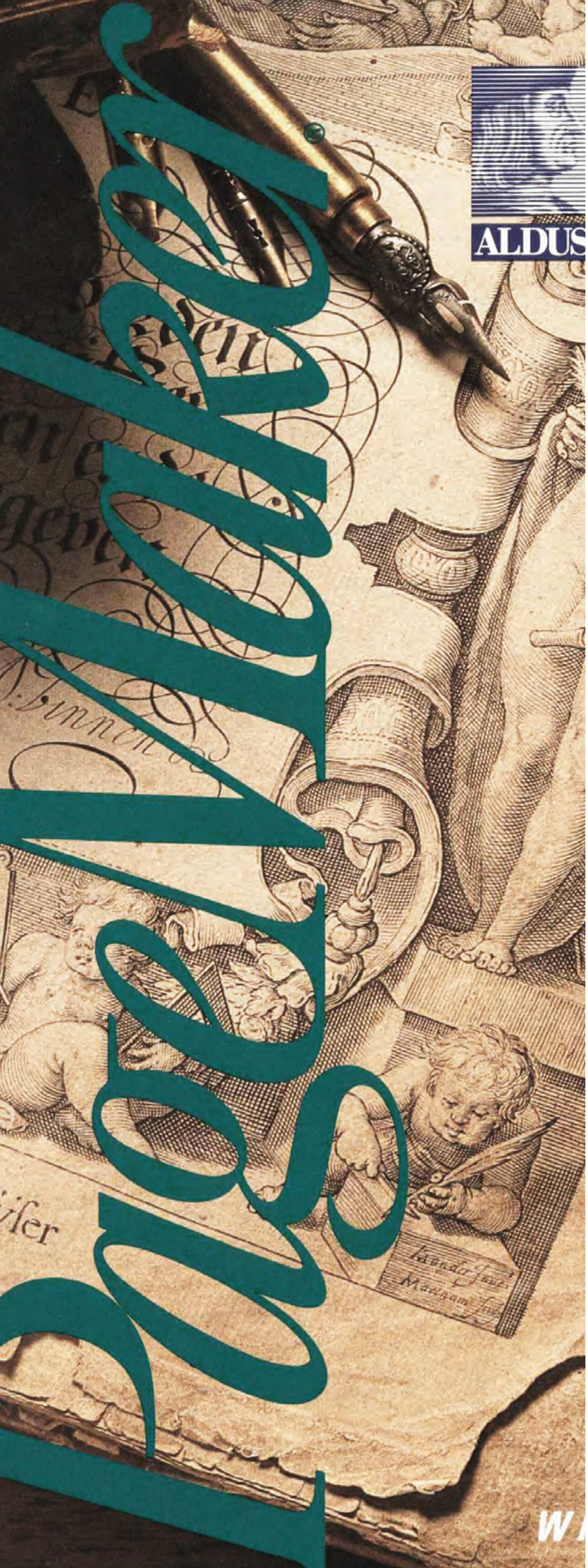
What challenges arose?

When PageMaker was first released at a price of $495, that was almost unheard of on the Macintosh. But it allowed us to have a gross margin of almost 90 percent and gave us all the money we needed to reinvest in customer service, support, and product development.

The problem was that as the industry started to mature in the early '90s, it became more about marketing and distribution. The margins started to go down, and you either had to acquire other companies or be acquired to continue to be successful.

We had become a public company in 1987, which fundamentally changes a company because suddenly you have public shareholders that are no longer interested in long-term product development. I ended up spending way too much of my time dealing with attorneys and shareholders, and less time doing the things I really enjoyed: talking to customers, understanding their needs, and working with the engineers to develop the products.

After seven or eight years, I went to the board and said, "I've really got to work out a transition plan here." The initial concept was to find a replacement, but we tried that two times and it didn't work.



Cover of the box of Pagemaker Version 1.0.

It's very hard, as you know, to replace a founder in this industry.

Instead, I actively solicited Adobe to acquire us. I felt that overall there was good synergy with our product lines, even though there was some overlap with FreeHand and Adobe Illustrator.

What made Aldus and Adobe compatible?

At a 30,000 foot level, we had similar approaches to running a company. But at a working level, there were some very definite philosophical differences.

There was a definite difference in the customer orientation. We spent a lot more time talking to customers. Adobe's philosophy was more of an engineering-based one: if we make a great product, like PostScript, sooner or later people will want it.

But the reason I even considered Adobe was their underlying ethical standard of running a high-quality company that was fair to their customers and their employees. Unfortunately, that couldn't be said of all the companies in the industry.

A lot of thought went into the merger, and I think it was one of the best. We were very honest with employees, and very clear about who would be staying and who would not. We gave a fair severance package, and a bonus to those who needed to stay through the transition. I think 99 percent of the employees felt that they were treated very fairly.

I then made a clean break with the business world and technology, and was off on my new career in the non-profit world. I endowed the Brainerd Foundation, which gives out about $3 million a year in support of environmental and social programs. It is very gratifying work because of the impact it has on people's lives.

And we are grateful for the impact that Aldus had. ○

CHM has conducted more than 300 oral histories since this initiative began in 2002. The online collection provides 150 transcribed interviews available to the public.

For pictures and full transcript of Brainerd's oral history, and the full 25-page transcript of Brainerd's oral history, visit: computerhistory.org/collections/oralhistories.
Title: Brainerd (Paul) Oral History
CHM#: 102657986

Oral history interviews are not scripted, and a transcript of casual speech is very different from what one would write. We have taken the liberty of editing and reordering freely for presentation.

IBM 1401 system.
Opposite: Detail of IBM 026 Printing Card Punch

FEATURE

BA

The story behind CHM's IBM 1401 restoration

BY DAG SPICER

CK TO LIFE

Amid the sound of cards being punched and the smell of hydraulic fluid from its printer, a team of Museum volunteers is restoring a classic computer system from the past in one of CHM's Restoration Laboratories. Known as the IBM 1401, this computer was released in 1959 and became one of the most successful in IBM's history—indeed in the history of computing itself. Never heard of it? That is perhaps not surprising since it's 50 years old. At a time when the world was just beginning to see the potential of computers in education, business and government, the 1401 was already a home run for IBM. With this computer, the company rode the wave of modernization, rapid growth, and optimism about the future that was so characteristic of the early 1960s.

For nearly the entire twentieth century, IBM was well known in the business world. And, thanks to a corporate outlook that was attuned to its own public image, it was known to many ordinary Americans as well. IBM was conservative and staid. It was a company that sold service—not just machines. In a rapidly changing business world, IBM stood for reliability and was known for solving customer problems, not just selling them equipment.

IBM based its business—from its origins at the start of the twentieth century until the start of the electronic computer era—on a piece of stiff paper stock known as a "punched card."

The punched card recorded information in the form of holes punched out of it according to a unique code. This information could be anything: someone's paycheck, a mathematical formula, a list of names, sales figures, or any information that could be contained in the punched card's 80-char-

IBM promotional photo showing typical 1401 system.

acter limit. The idea of a card holding one type of information—a "unit" of information, if you will—led to the card being known as a unit record and the machines that processed these cards were known as unit record (or punched card) equipment.

Such punched card machines performed basic but powerful business functions such as sorting, collating, reproducing (making a copy of the card), and so on. IBM (and its competitors) built machines that could process this information according to a pattern set by the user using wires plugged into a control panel. Panels thus represent a set of instructions or basic form of program.

Unit record equipment was used for nearly the entire twentieth century, albeit in greatly declining numbers after about 1970. IBM made billions of dollars leasing equipment while American (and international) business adopted the unit record approach to their business processes. By one estimate, in 1960 the sale of blank punched cards alone represented nearly 30 percent of IBM's revenue.

IBM Moves to Electronics

IBM began its electronic computer efforts around the end of WWII. Most of these early computers were gigantic, room-filling mainframe machines with a limited market. Typical clients were the military, government departments and well-heeled corporations, insurance companies and banks. By the late 1950s, IBM had produced several successful computers—still large, to be sure—but with increasing performance and relatively decreasing cost, a theme that has come to characterize the industry. There were many incompatible systems and virtually no software tools or languages. (FORTRAN, the popular scientific and engineering programming language, would come out of IBM in 1957; the business-oriented language COBOL was announced in the early 1960s). Users—even competitors—banded together to share information and control panel-wiring patterns.

IBM's unique problem at this time was how to move their lucrative punched card business into the electronic stored program era. The stored program was a feature of mainframes but had not trickled down to the level of the small to medium-sized business user. The stored program concept evolved from a need to replace the control panel wiring so typical of unit record equipment to the infinitely more flexible system of storing instructions inside the computer (as we do today), rather than on punched cards or wiring panels.

Known as the IBM 1401, this computer was released in 1959 and became one of the most successful in IBM's history—indeed in the history of computing itself.

The computer that allowed IBM to move its customers into the computer era was its Model 1401 Electronic Data Processing System. The 1401 is made up of three parts: a central processing unit (CPU), a card reader and punch (for reading and writing punched cards), and a high-speed printer. It also came with a magnetic tape drive—a feature that would revolutionize business.

separate unit record machines. But, it worked at electronic speeds and had no cumbersome control panel. In all, by the mid-1960s nearly half of all computer systems in the world were 1401-type systems.

IBM was pleasantly surprised (perhaps shocked) to receive 5,200 orders in just the first five weeks—more than predicted for the entire life of the machine!

The 1401 Arrives

The 1401 had a complex birth within IBM. One critical milestone in its creation was the decision to design a system that used magnetic core memory-like the RAM in today's computers—instead of the usual unit record equipment control panel that required laborious wiring. The result was a system that the user interacted with via a small number of special typed words. This was a big improvement in usability. In order to program a control panel, you needed considerable training and patience. While the 1401 did read and write punched cards, its optional magnetic tape system was a real breakthrough. Magnetic tape could store the equivalent of tens of thousands of punched cards on small, portable reels of tape. People began migrating their punched card information onto tape because it was not only more convenient, it saved space, time and, most of all, cost. IBM was pleasantly surprised (perhaps shocked) to receive 5,200 orders in just the first five weeks—more than predicted for the entire life of the machine! The 1401 hit a sweet spot in the market. In fact, it hit two:

1. For users who already had very large systems, the 1401 could be used to offload many minor or "housekeeping" tasks like printing; and
2. For small and medium-size businesses, the 1401 was a replacement—one that worked at electronic speeds—for half a dozen separate pieces of punched card equipment.

As the post-war economic boom continued in the '50s and '60s, business expanded alongside. Many new businesses were formed in industry, commerce, manufacturing, and many other fields. They all needed a way to manage their work. The 1401 was developed to cost about the same as an equivalent

Back to the CHM Restoration Lab

The Lab is a white room, about 40 feet by 30 feet simulating a data processing center from years past. An IBM clock hangs on the wall, a totem of IBM's varied manufacturing activities over the years and a tip of the hat to verisimilitude. You enter on a steep ramp built to accommodate a difference in floor height because the entire room is built on a raised floor beneath which snake the dozens of cables for the system. And there are cables! Each is the thickness of a junior-sized baseball bat, is thirty feet long, and weighs 20 lbs. or more. These information pipelines route the signals to and from the CPU to the card reader and punch, printer and tape drives. They have fearsome connectors at their ends that require real effort to plug in or disconnect. This is the *Era of Big Iron* and IBM was a giant in this industry. Its competitors were derisively known as "The Seven Dwarves."

In the Lab are two complete 1401 systems. The first is from Germany; the second—from Connecticut—operated as late as 1995. Each machine has distinctive features but the restoration team settled on the latter system as its restoration target. As a visitor, you'll be invited to sit at a keypunch machine—a typewriter-like device that punches what you type onto a card. (The bits that are punched out are called "chad.") Type your name and the keypunch whirs to life, clacking away as you type. It's an impressive feeling of power as your keystrokes are converted into punched cards.

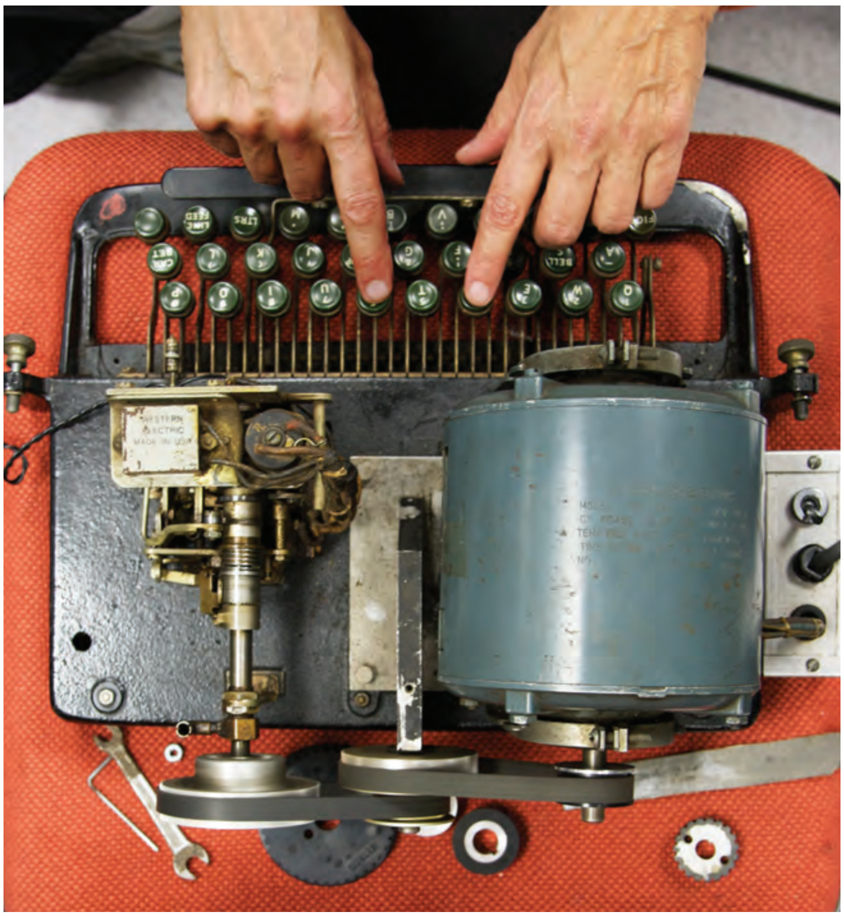
A kindly restoration team member—most likely a former IBM customer engineer as are most of the team—takes your card and adds it to several others. He will feed all these cards into the card reader, then move to the CPU—a cabinet the size of two refrigerators—and push several buttons. Suddenly your cards are pulled into the card reader with a whoosh and flap-flap-flap sound. After a few moments this stops and the printer, a mechanical beast that can move 75 inches of a paper in single second, springs to life, printing your name in giant letters. You have just used a computer, 1960s style!

Getting a printout of your name is cool but don't be misled. The 1401 was a serious business machine. It cranked out the payrolls and did the accounting for tens of thousands of businesses worldwide. The Museum is truly fortunate to have these machines. And getting one running was no small feat. It took a team of more than 30 active volunteers some 20,000 hours over five years and was truly a labor of love. Our 1401's each have over 500,000 separate parts, weigh four tons and—in their day—cost about $6,500 a month to lease (about $50,000 a month in today's dollars).

To Preserve and Present

Having an operating 1401 system is of great historical importance. It makes it possible to study these old applications and the way they were designed. A new generation can learn how people solved problems in the early days of computing and appreciate the creative solutions early computer pioneers found. Perhaps more importantly, in terms of IBM history and the industry as a whole, the 1401 was the product that gave IBM its first realistic glimpse of the size and importance of the market for computers. It caused a paradigm shift in how people worked with computers, whose capabilities (and limitations) would soon become the bedrock of our modern civilization. ○

Dag Spicer is CHM's Senior Curator.



Inside of IBM 026 Printing Card Punch keyboard and overview

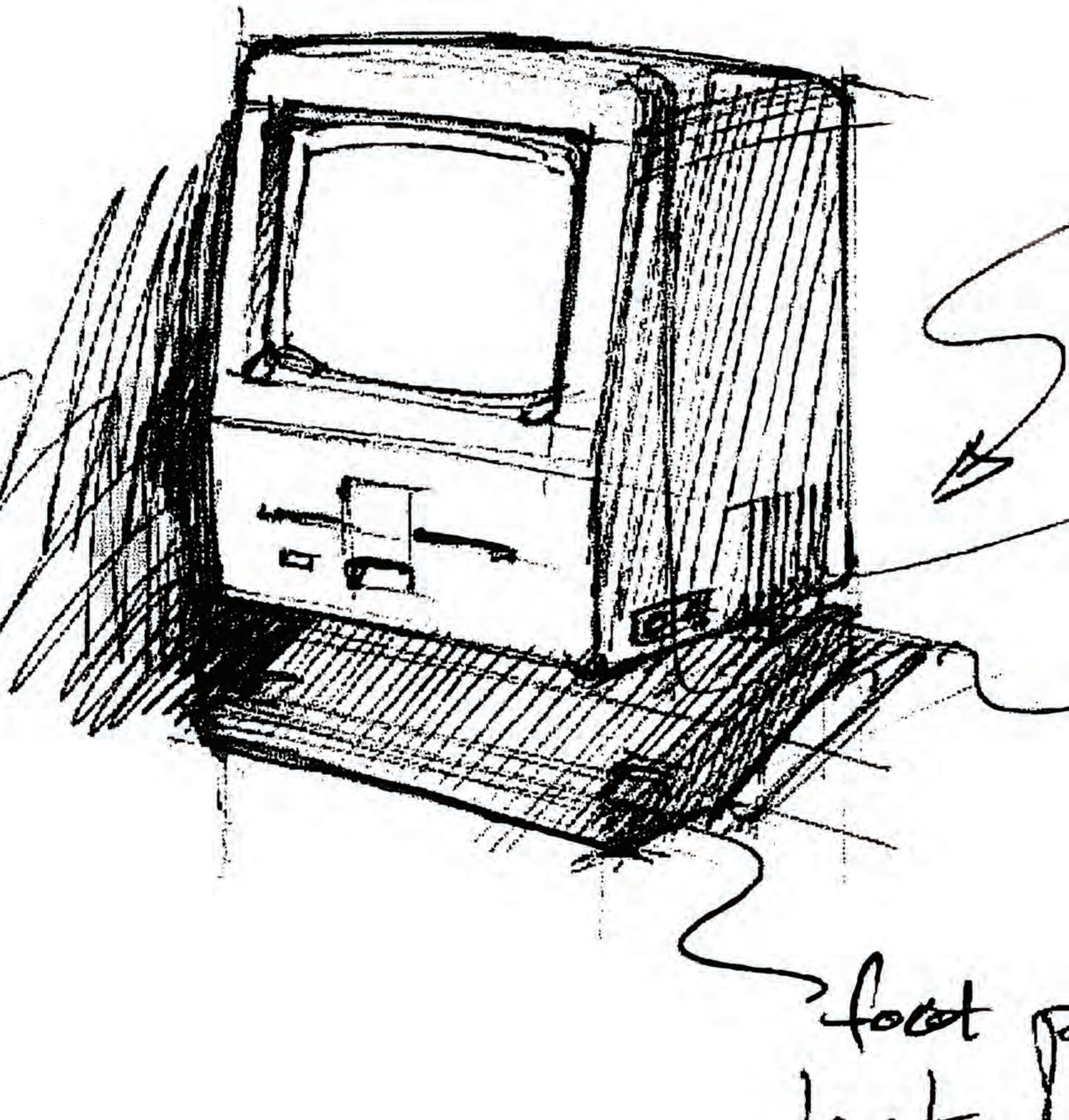
BY MARCIN WICHARY

Apple's Macintosh in its early years

THE CHANGING FACE OF THE MAC

FEATURE

Early sketch of a design for
the Macintosh, by frog design



The original Macintosh has been immortalized by history as nothing less than a silicon update to the myth of Prometheus—bringing enlightenment to a world overtaken by monotone, ugly, hard-to-use and harder-to-love IBM clones. Hailed by Apple and others as the last true computer revolution and a machine perfect in every way, it's easy to imagine it as a single, unified vision, brought to market with ruthless precision and efficiency. In reality, it was anything but.

The first incarnation of the Macintosh, as envisioned in early 1979 by Mike Markkula, Apple's chairman, was a sub-$500 game machine—the smallest sibling of a troika that also included Apple III and Lisa. Jef Raskin, chosen to lead the project, had enough prescience (the game-computer price wars of the early 1980s drove most of the manufacturers to extinction) to counter with something more ambitious: a friendly, general-purpose computer for the masses, available as soon as Christmas 1981. Raskin started by compiling "The Book of Macintosh"—a collection of articulate and influential documents filled with rallying cries such as, "Let's make some affordable computers!"[1] and pondering, "What will millions of people do with them?"[2]

The Mac's cornerstone was to be its friendly user interface. However, the familiar black-and-white reinterpretation of a desk top—developed in parallel between Lisa and Mac and much enhanced from its origins at Xerox PARC—was not the original choice. Raskin later built another computer as an example of the kind of interface he had in mind. Released in 1987, the Canon Cat did away with folders and files (replaced by one infinite document), and favored text and keyboard, over graphics and mouse.

But in Mac's case, the mouse wasn't a given either. Early memos mentioned a light pen, a trackball, and a joystick as the pointing devices of choice. But after being pushed by Steve Jobs toward Doug Engelbart's invention, the design team built and tested over 150 mouse prototypes (the earliest ones using a ball from a roll-on deodorant). Even the decision to remove all buttons but one—often presented as Exhibit A to confirm Apple's autocratic and arbitrary approach to interface design—was the product of many heated discussions.

The initial goal for the Mac's case was to make it highly transportable. Early prototypes resembled Osborne's later, popular portable, and even included provisions for batteries. As the project shifted from Raskin's purview to Jobs', however, this priority changed simply to something "different from everything else." That included the Apple Lisa, whose design was derided by Jobs as having a Cro-Magnon forehead above its screen.[3] But it might still have provided inspiration for the Mac's eventual anthropomorphic cues: The facade resembling a human face, a smirk of a floppy drive, and a chin leaving

The Macintosh as the world knows it, introduced on January 24, 1984, proved its success as a popular personal computer and one of the first to feature a mouse and a graphical user interface.

APPLE PRODUCT RELEASES

Technology and design evolution that has improved from generation to generation:

Apple I (1976)

Apple II (1977)

Lisa (1983)

Macintosh (1984)

Macintosh Portable (1989)

Macintosh PowerBook 100 (1991)

Newton MessagePad (1993)

iMac (1998)

iPod (2001)

OS X (2001)

iMac G4 (2002)

iMac G5 (2004)

iPhone (2007)

room to slide in the keyboard. The team endured a couple of distractions—the "Cuisinart Mac" being the most famous of them—but ultimately Jerry Manock's design remained the one chosen for the Mac's premiere.

That covers the three most essential components. But pick any other part—even those that seem to scream "Macintosh"—and you might be in for a surprise too. The processor? The 6809E was the team's first choice. The display? Initial plans called for a 4" or 5" screen, with a measly 256×256 resolution. Storage? The final product is credited with popularizing Sony's 3½" disks, but the Mac is happily seen sporting Lisa's five-inch Twiggy drive in its own user manual.

Even the name, chosen by Raskin as a tribute to his favorite variety of apple fruit, was in peril a couple of times. The advertisements proudly stated, "They didn't call it the QZ190, or the Zipchip 5000." Fortunately, they also didn't call it Annie, Apple V, or Bicycle—though at some point all of these names were attached to the project.

But, as exciting as it is, juggling all these alternatives is, ultimately, pointless. Sure, this might be a favorite pastime for anyone with an interest in computer history: Armed with a sometimes-too-intimate knowledge of business blunders, close encounters, and last-minute plan changes, we enjoy conjuring alternate realities. What if Gary Kildall stayed in his office to talk about the operating system for IBM's upcoming personal computer? What if HP decided to release Wozniak's first machine? What if today's most popular desktop computer was still Altair, and laptop—LisaBook Air? Finally, what if the Macintosh was indeed released as a cheap game console just in time to catch on to the runaway popularity of *Pac-Man*?

But this would be denying the Macintosh its true accomplishment. The first little beige box was finally announced in January 1984, with a $2,495 price tag. ("The design team was horrified," wrote Andy Hertzfeld years later. "[This price] felt like a betrayal of everything that we were trying to accomplish."[4]) The launch was a carefully choreographed marketing event that was as memorable as the product itself. But what turned out to be just as fascinating

1 Raskin, Jef, "Design Considerations for an Anthropophilic Computer" memorandum, May 28–29, 1979 http://library.stanford.edu/mac/primary/docs/bom/anthrophilic.html

2 "Computers by the Millions," internal Apple memorandum, March 18, 1980 http://library.stanford.edu/mac/primary/docs/cbm.html

3 Sculley, John, Odyssey: *Pepsi to Apple... Journey of adventure, ideas, and the future*, New York: Harper & Row, 1987, p. 160

4 Hertzfeld, Andy, *Revolution in the Valley: The insanely great story of how the Mac was made*, O'Reilly Media, 2004, p. 195 http://www.folklore.org/StoryView.py?project=Macintosh&story=Price_Fight.txt

Hailed by Apple as the last true revolution and a perfect machine, it's easy to imagine it as a single, unified vision brought to market with ruthless precision. In reality, it was anything but.

as the Mac's five-year crusade to establish its own identity was the apparent eagerness, in the decades since, to keep throwing it away.

The Mac's prototypical user, originally simply a "person in the street,"[1] was quickly narrowed down to the "knowledge worker."[5] But the progeny of the first Macintosh found a different purpose in life: the classroom companion; the pioneer of the desktop publishing revolution; the multimedia machine; the hub for your digital lifestyle; the mother ship for your collection of shiny iPods and iPhones.

The exterior evolved as well. Cuddly, humane design gave way to sterile principles of Hartmut Esslinger's corporate Snow White design language and the beige blandness of the Espresso style. The iMac era alone gave us translucent, colorful gumdrop curves and, later, foggy plastics—both admired and copied feverishly by competitors; and both incredibly dated next to today's dark glass and aluminum enclosures.

Throw in both of the architectural transitions—to PowerPC in the mid-1990s, and to Intel a decade later—and the well-publicized drama of finding a replacement for the aging operating system, and it's easy to see that the tumultuous five years it took to bring the Macintosh to market was only a foretaste of the Mac's complicated future and quite possibly the most troubled upbringing of any computer product in history. (Even its near deaths in 1985 and 1997 had a precedent; Apple cancelled the Macintosh project in its early stages on at least three different occasions.)

In some sense, however, all of these metamorphoses were entirely superficial. The principles that defined the Mac's essence reach much deeper. Those principles haven't buckled since Raskin and Markkula met in 1979 to talk about a "crankless computer" (in a nod to Ford's Model T) in one of the rooms of the then tiny Apple headquarters.

The continuing focus on the integrity of the user experience (Raskin in 1984: "You don't build a hardware box just to suit some hardware engineer and then try to cram software into it"[6]) makes the competition lose as much sleep today as ever, prompting nervous responses to the popular "I'm a Mac, I'm a PC" ads. And those ads have never really strayed too far from the first marketing campaign, with all its allusions to George Orwell's *1984*.

The message didn't need to change. Even though it celebrated its twenty-fifth birthday this year, and neither its enclosure nor the technology inside it would be recognizable to the original team, the Mac never sold its soul. It is designed better and easier to use than its competitors and, astonishingly, even with a market share again flirting with double digits, still feels like a "computer for the rest of us."[7]

And, in the end, this might turn out to be the Macintosh's most important legacy. ○

For more information on the Macintosh items mentioned in this article, visit CHM's Catalog Search: computerhistory.org/collections/search.

Marcin Wichary is a Senior User Experience Designer at Google and has been a volunteer docent and a photographer at the Computer History Museum since 2007.

5 Macintosh Selling Guide, Apple, 1984 http://archive.computerhistory.org/resources/text/Apple/Apple.Macintosh.1984.102646178.pdf

6 Markoff, John, and Shapiro, Ezra, "Macintosh's Other Designers," Byte, Issue#3 (August 1984, volume 9, number 8). p. 347 http://www.aresluna.org/attached/computerhistory/articles/macintoshsotherdesigners

7 The expression used in the Macintosh introductory brochure and other promotional materials http://www.macmothership.com/gallery/gallery3.html

8 Esslinger, Hartmut, *A fine line: how design strategies are shaping the future of business*, San Francisco: Jossey-Bass, 2009, pp. 7–9

COURTESY FROG DESIGN

EXTRAORDINARY IMAGES

WHEN ANYTHING WAS POSSIBLE

In what has now become the stuff of myth and legend, Apple's collaboration with Hartmut Esslinger and his firm, frog design, almost certainly defined what we now 'know' computers look like. Everyone today is familiar with the ubiquitous mouse and standard form of the desktop computer. But when Esslinger and Steve Jobs met, anything was still possible.

"When I started working for Apple in 1982," says Esslinger[8] "Steve Jobs' ambitious plan to make Apple into the greatest global consumer technology brand on the planet seemed crazy." At that time home computers were the dream of only a few nerds. What these computers would look like, how people would input information into them, even how they would look at the screen was still anyone's guess.

Esslinger and frog created several concepts out of foam and cardboard. They developed these ideas in white with spare lines and a clean look. This look came to be known as the "Snow White" design language and it quickly became part of Apple's Design DNA.

As is evident from the images that follow, generously provided to us by frog, anything was possible in 1982. Most of these images have never been seen anywhere else, and they represent a fascinating moment in history. They illustrate not only the solutions discovered but also the range of exploration it takes to develop an "iconic product with no historic precedent." ○


apple computer


mac







FEATURE

BY STEVE BLANK

THE SECRET HISTORY OF SILICON VALLEY

The role of World War II in the growth of Silicon Valley

For 20 years, Stanford University students knew Fred Terman as a kindly professor who helped William Hewlett and David Packard start a company, Hewlett-Packard. Fewer people knew Terman as the ultimate Cold War "warrior. He was, in fact, the father of electronic warfare and electronic and signals intelligence and a leader in partnering with the NSA and CIA to transform Stanford into an integral part of the U.S. intelligence community.

He also happened to invent the culture of entrepreneurship at Stanford and Silicon Valley.

It all started in World War II.

The Electronic Shield

The Allied bombing campaign of Occupied Europe was designed to destroy Nazi Germany's ability to wage war. But by 1942, Allied airmen were dying in droves. The German electronic air defense system was taking an increasing toll on bombers and crews. The Allies desperately needed to shut down the German Air Defense system.

So in 1942, the Allies set up the top secret Harvard Radio Research Lab with the goal of defeating the German Air Defense system. Its 800 staffers invented what would become the signals intelligence and electronic warfare industry. Directing this lab was an electrical engineering professor plucked from a school not yet known as an engineering powerhouse: Fred Terman from Stanford.

The Military/University Partnership

World War II forever changed the military's relationships with United States universities. Before World War II, the military did research and development in its own military labs. But Vannevar Bush, the head of the Office of Scientific Research and Development, enlisted universities into the war effort and funded them directly.

During WWII, MIT, Cal Tech, Harvard and Columbia received tens of millions of dollars for military R&D, money that forever changed their trajectory in technology. But Stanford, then considered a second-rate engineering school, got almost nothing. Terman, Vannevar Bush's first PhD student, had written a highly-regarded textbook on radio engineering, and so was recruited to run the Harvard Radio Research Lab.

ISTOCK PHOTO

The "Stanford Dish" radio-telescope in the foothills of the University.

In the mid-1950s, our strategic weapon of choice was the manned bomber. In order for the bombers to penetrate the Soviet air defense system, though, the Strategic Air Command and CIA needed details on Soviet radar so they could build jammers. To this end, Terman dedicated Stanford's engineering resources and made Stanford crucial to the National Security Agency and Central Intelligence Agency for electronics intelligence and signal intelligence. At this moment, the Cold War became an electronic war with the goal of uncovering what was going on inside this closed country.

Fred Terman in his Stanford University office, ca. 1938

COURTESY STANFORD NEWS SERVICE

But Terman returned after the war with the idea of turning Stanford into a center of excellence for microwaves and electronics. He started by recruiting 11 members from his Radio Research Lab. They set up the Electronics Research Lab for basic and unclassified research. In 1946, the Office of Naval Research gave them their first contract to fund Stanford's research into microwaves

By 1950, Terman had turned Stanford's engineering department into the MIT of the West.

Another War and a New Game

In 1949, the Soviet Union exploded its first nuclear weapon. In 1950, the Korean War turned the Cold War hot. And the newly formed National Security Agency asked Terman's team to work on classified intelligence and military programs. Engineering set up the Applied Electronics lab for classified programs. Stanford University was now a full, covert partner in government R&D.

From Cold War to Entrepreneurship

Yet Terman wanted Stanford to focus on advanced research, not the actual production of military systems. So he encouraged his engineering students to start companies that could supply microwave components and intelligence systems to the military. He encouraged professors to consult for those companies. Getting out in the real world is good for your academic career, he told them. And he made licensing Stanford's intellectual property possible. These were heretical concepts in the 1950s and '60s. And they fundamentally changed the Valley into something we recognize today. These ideas caused the Valley to blossom in the mid-1950s into Microwave Valley.

CIA/NSA Innovation

In the mid-1950s, the CIA launched Project Genetrix: They flew high altitude balloons—with 350lb cameras as their payloads—across the Soviet Union. They simply popped the balloons up into the jet stream and hoped the balloons would come out at the other end of the Soviet Union.

But as the CIA was tracking these balloons with radar, it was also picking up an unexpected Soviet radar signal. Eventually the CIA figured out that they were getting this signal because a piece of metal in the balloon was accidentally cut to the frequency of a Soviet height-finding radar and that signal was being picked up in our receiving radar.

This lucky accident spawned Project MELODY. Every time the Soviets launched an intercontinental ballistic missile (ICBM), the CIA sent up radar receivers in Iran. And we used the Soviets' own missile telemetry beacon to steer those radars. So every Soviet radar within a thousand miles bounced off the Soviet ICBM, and the CIA tracked their reflections. This bit of espionage provided intercepts of all Soviet missile tracking radars including all their anti-ballistic missile radars. These receivers were built and designed at Stanford.

In the late 1950s, the Soviets had upgraded their early warning radar to the Tall King. The CIA and Strategic Air Command wanted to know where these radars were and how many there were first.

Someone realized that like all radars, the Tall King radar signals continued traveling out into space. But with the right geometry they bounced off the moon when it was over the Soviet Union. The idea was to point radar dishes at the moon, and then use the moon as a bistatic reflector and listen for the Tall King signals. About once a month everything would line up.

But because this idea required very large dishes, the United States in the late 1950s became very interested in radio astronomy. Under cover of a civilian agency, the CIA funded the Stanford University dish, attached electronic intelligence receivers to it, and borrowed it to search for the Soviet Tall King (and later Hen House) radars.

It was the Cold War crisis and not profit that motivated Terman—and the newly-formed companies of Silicon Valley—in the 1950s and the 1960s. The motivation for entrepreneurship was crisis and it found funding from the military not from industry.

Why It's Called Silicon Valley

If it had been up to Terman, Silicon Valley would be known as Microwave Valley. But serendipity arrived in 1956. William Shockley started Shockley Semiconductor, Silicon Valley's first chip company.

Shockley had a WWII military background as extensive as Terman's. He had been director of operations research for anti-submarine warfare at Columbia, head of radar bombing training for the Air Force, and deputy director of all of weapons R&D in the Cold War. Shockley had a reputation for being a terrific researcher, an awesome talent spotter, and a terrible manager. One testament to his poor skills as a manager was the infamous "traitorous eight." In 1957, eight of his best researchers—including Gordon Moore and Robert Noyce—left Shockley Semiconductor and founded Fairchild Semiconductor.

In the next 20 years, 65 other chip companies start because this one ex-military guy—Shockley—who worked on air to ground radar in World War II, and who happened to manage the team that invented the transistor, started his company in Silicon Valley.

Why We Don't All Work for the Government?

Terman may have been motivated by the Cold War but the Valley, as we know it today, is driven by profit and venture finance. What happened? This started out as Microwave Valley. What changed? The money. Fundamentally, funding for startups in the Valley shifted from the military to venture capital.

Venture capital began simply as a way for rich families to invest. In the early 1940s, J.H. Whitney established a family office to make investments. Lawrence Rockefeller had the same idea and established his family office. So did other rich industrialists.

These family offices were all on the East Coast and tended to focus their investments there, in a wide variety of industries.

But in 1958, after the launch of Sputnik the year earlier, the U.S. government wanted to spur entrepreneurship. The Small Business Administration (SBA) announced it would match every dollar an individual put into a startup. By 1968, 75 percent of venture capital came from the SBA. And, in fact, the idea was so lucrative that corporations set up their own SBAs. And Bank of America, Fireman's Fund, and private companies did so as well.

But everyone was still trying to sort out the right model for investing.

Then in 1978 and 1979, life changed in Silicon Valley when the government made two simple changes: 1) It slashed capital gains tax—from 50 percent to 28 percent. 2) Pension funds were now allowed put up to 10 percent of their holdings into high-risk ventures—venture capital funds being one of them. And to manage that capital, VCs transitioned to limited partnerships. The amount of money directed into VCs jumped by a factor of 10 and Silicon Valley's second engine of entrepreneurship took off by 1979. It was, and still is, fueled by profit.

So in summary: Terman, Stanford, and our intelligence agencies spawned the entrepreneurial culture of Silicon Valley. The military primed the pump as an investor and customer for key technologies (semiconductors used in missile guidance systems, computers at NSA and Livermore, and of course, DARPA's interest in packet switching and the Internet.) But venture capital turned the Valley toward volume corporate and consumer applications. ○

Terman happened to invent the culture of entrepreneurship at Stanford and Silicon Valley. It all started in World War II.

To see Steve Blank's CHM lecture on our YouTube channel visit: youtube.com/computerhistory.

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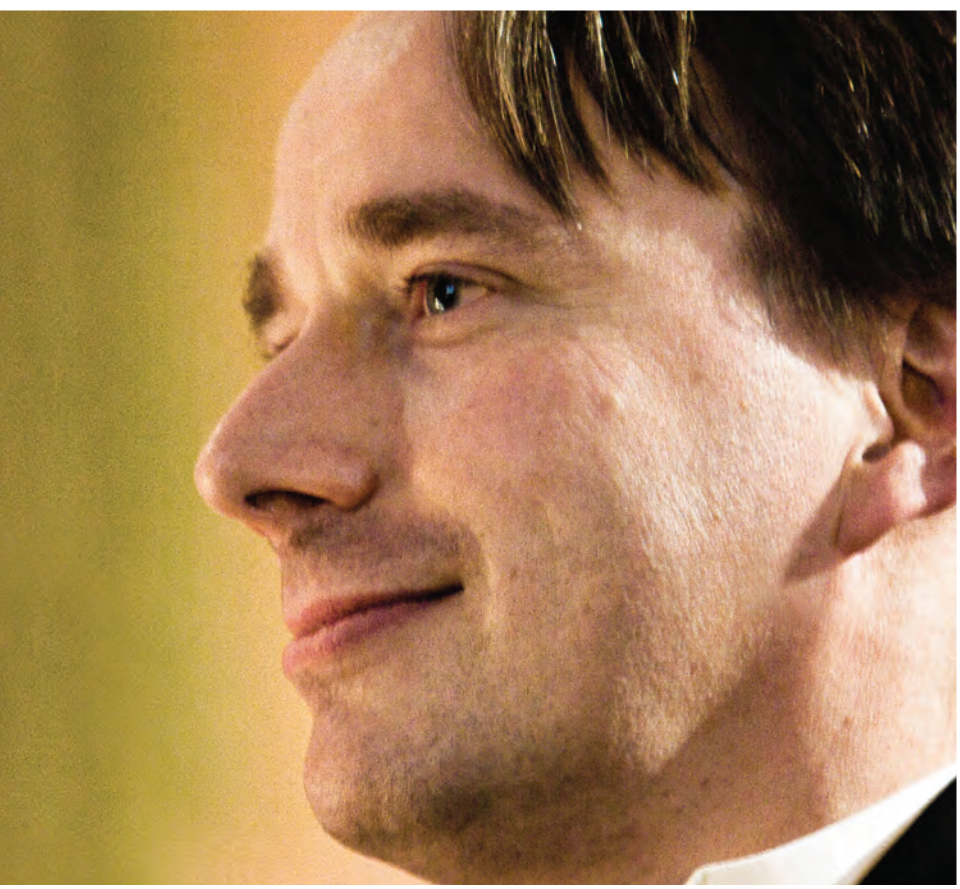
REMARKABLE PEOPLE

TECHNOLOGY ROCK STAR

BY FIONA TANG



Though it was created by a single individual named Linus Torvalds, Linux has truly become a world-changing software environment. An estimated 64 million people around the world use Linux, according to the Linux Counter. The Linux Foundation projects the Linux ecosystem will reach $50 billion in the next two years.

A self-professed geek, Torvalds hails from a family of journalists, where he is considered the black sheep. He was named after Linus Pauling, Nobel Prize-winning chemist, and Linus from the Peanuts cartoon. He attributes his "dualistic nature of serious and not-so-serious" to his name.

Torvalds was awarded one of the 2008 CHM Fellow Awards, for creating the Linux kernel and overseeing open source development of the widely used Linux operating system. Linux got its start as an operating system when Torvalds began playing around with MINIX, a UNIX-like operating system—short for Minimal UNIX. Torvalds had simply posted it to a MINIX forum to gather a little feedback. And feedback was what Torvalds got—in spades. Users have quickly become fanatical in their following of Linux.

In spite of the ingenuity of the original creation, Linux, as we now know it, is founded on a quiet spirit of collaboration. To Torvalds, collaboration came hand-in-hand with passion. How did Linux manage to pick up such a huge fan-base of users all working to continually improve on the product? Torvalds said, "They always volunteered. I wouldn't even want to work with people who don't feel passionately about what they do because searching for people to do something doesn't work… It started out slow and on a very small scale. But it was a natural progression." As a result, Linux, with the help of the Internet, has spurred the widespread, successful movement of what is now known as Open Source.

This August, Linux turned 18. It has grown from 10,000 lines of code to roughly 7 million. And even though Torvalds is one of the few scientists in a family of journalists, he's now likely to be the most widely published of his family—and have more fans than most rock stars.

"The impact that Linus has had on the software industry can't be overestimated. He sparked the world's largest technology project in the history of computing. And now, 18 years later, millions of people are contributing to the Linux kernel and the $50 billion ecosystem it supports," said Jim Zemlin, Executive Director at The Linux Foundation. ○

This article was based on Linus Torvalds' contribution to the Computer History Museum's oral history collection. Explore the oral history collection at: computerhistory.org/oralhistory.

Linus Torvalds at the Computer History Museum's 2008 Fellow Awards.

SYNCHRONIZED ELEGANCE IMAGING

CHM COLLECTION BY THE NUMBERS

69,500+
online collection records for search

300+
oral histories recorded since 2002

54
unique countries represented in the collection

5,000
linear feet of archival material

8,521
software titles in the collection

EXPLORE THE COLLECTION

COLLECTION

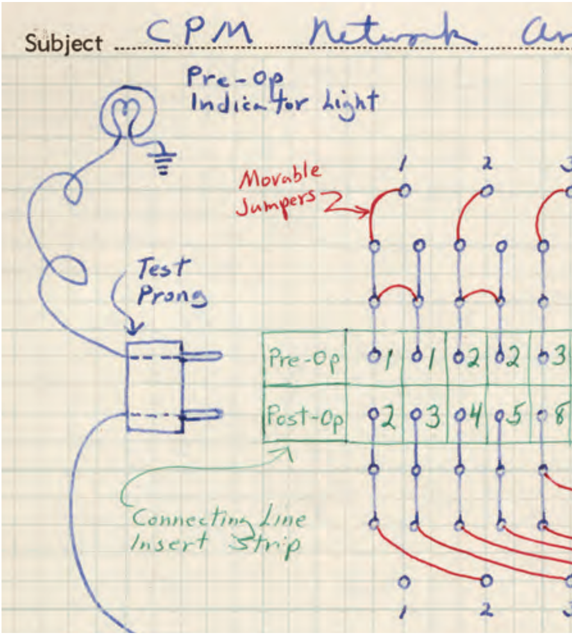
Top and Close-up: Project Network Analyzer (1964): This special purpose device uses a project-specific plugboard inside the unit. The pre-wired switches and lights replaced the external probe of the earlier design.

Bottom: Indicator Circuit (1962): When probing a plugboard set up for a project schedule, these lamps showed how the schedule was affected by changes in task durations.

CPM NETWORK ANALYZER INDICATOR CIRCUIT AND PROJECT NETWORK ANALYZER

BY ALEX BOCHANNEK

CHM#: X5248.2009
DATE: 1962, 1964-1966
DONOR: Doris-Jane Fondahl



Human civilizations have embarked on large-scale projects for thousands of years. But it wasn't until the 1950s that the scientifically founded discipline of project management emerged.

Beginning in 1956, the DuPont chemical company—with Remington Rand Univac—devised the Critical Path Method (CPM) to solve construction scheduling problems. CPM and related methods essentially represent project tasks and their relationships as a network. The extensive calculations necessary for the technique at DuPont were performed by their UNIVAC computer.

In 1958, the U.S. Navy awarded a contract to Stanford University civil engineering professor John Fondahl to investigate the feasibility of performing CPM calculations by hand instead of by expensive electronic computers. He published an influential book on the subject in 1961, which was widely read in the construction industry.

Realizing that some of the manual calculations were quite repetitive, Fondahl constructed a device to aid him in this task in 1962. He wired up an IBM accounting machine plugboard to create the electrical analogy of a project schedule. The Indicator Circuit was used to probe the plugboard, entries were made into a worksheet, and the schedule was then manually recalculated. With the help of Stanford's Electronics Lab, Fondahl constructed the more sophisticated Project Network Analyzer in 1964.

John Fondahl intended to commercialize his inventions but decided against it when smaller, cheaper computers arrived and his interests shifted toward more complex resource-scheduling problems. He continued to use the one-of-a-kind devices in his home and office, though, and preserved both units until his passing in 2008.

Left: Detail of Indicator lights on the Project Network Analyzer. Above: John Fondahl's laboratory notebook describing his CPM Network Analyzer (1962). The Indicator Circuit with its test prong is shown in the drawing.

ELLIS D. KROPOTECHEV AND ZEUS, A MARVELOUS TIME-SHARING DEVICE MOVIE

BY HEATHER YAGER

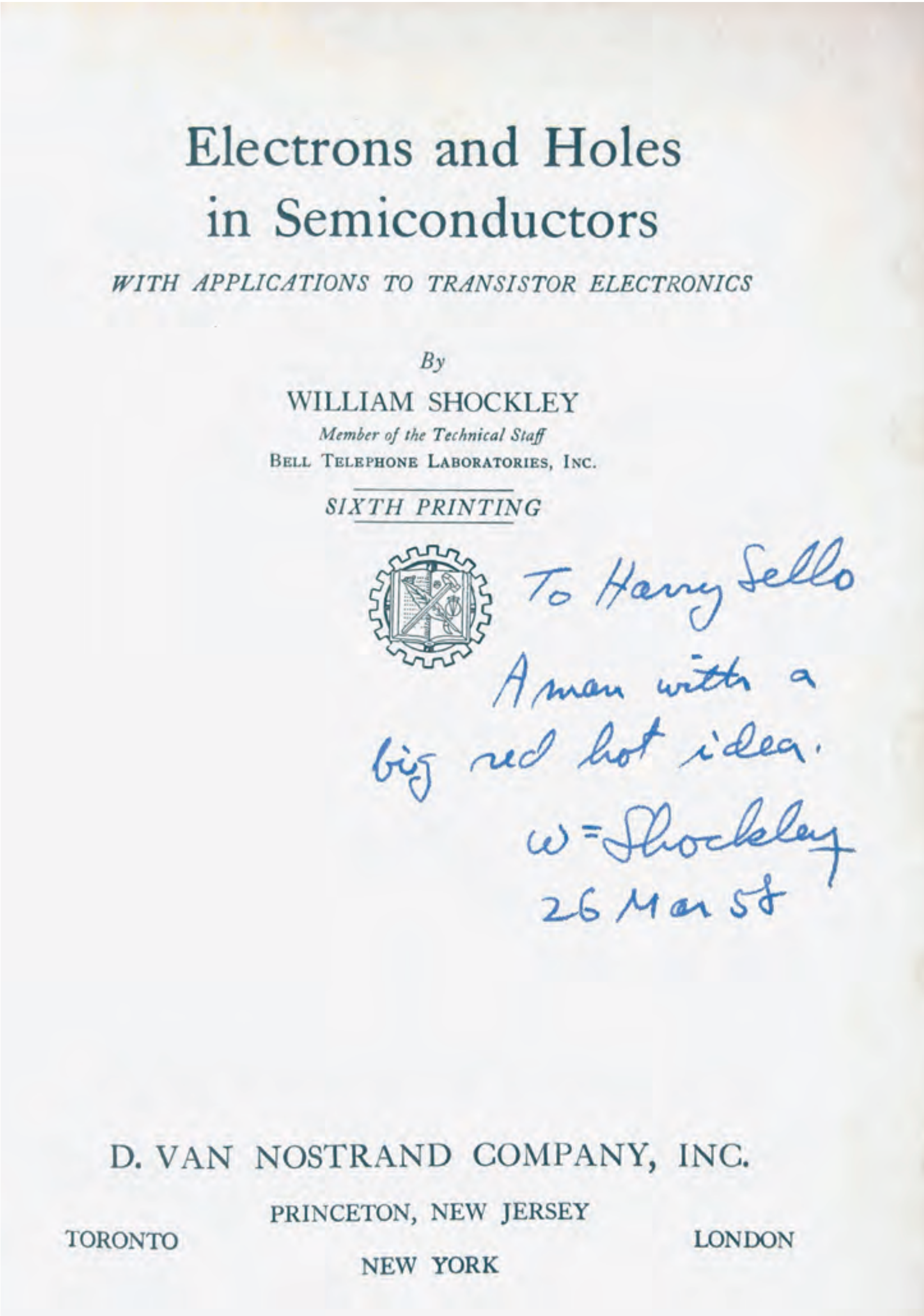
CHM#: 102651555
DATE: ca.1967
PRODUCER: Stanford University, Department of Computer Science

The film *Ellis D. Kropotechev and Zeus* features Zeus, a time-sharing system developed by the Department of Computer Science at Stanford University. Written and acted by programmers and faculty, the film mixes physical comedy with a touch of surrealism and a clever soundtrack featuring the Rolling Stones and Wagner's "Ride of the Valkyries," an engaging look at the culture of computer programming in the 1960s. The story is a race against time: Ellis D. Kropotechev is a computer scientist attempting to run and debug a program before departing to meet his girlfriend. The five hour wait time and error-riddled output of his program cause Kropotechev to lose hope, and he envisions his girlfriend leaving him. As he lights a cigarette and considers giving up, a nearby computer terminal speaks to him and invites him to try a time-sharing device instead. Using Zeus, Kropotechev is able to correct the errors in his program quickly, and the film ends with a shot of Kropotechev and his girlfriend walking arm-in-arm into the sunset.

From the start of the modern computer era in the mid-1950s, programming was a time-consuming process involving punching one's programs onto cards, submitting the cards to a computer operator, then waiting (sometimes a day or more) for results. This film captures the technical importance of the late 1960s transition from this so-called "batch" method to timesharing, an interactive method in which the programmer used a video display terminal to directly interact with the computer himself. Other users also shared part of the computer's time, giving each user the appearance that the computer was responding only to them.




Title page of Shockley's book, signed to Harry Sello by the reknowned author.


Electrons and Holes in Semiconductors

WITH APPLICATIONS TO TRANSISTOR ELECTRONICS

By

WILLIAM SHOCKLEY

Member of the Technical Staff

BELL TELEPHONE LABORATORIES, INC.

SIXTH PRINTING

To Harry Sello
A man with a
big red hot idea.
W=Shockley
26 Mar 58

D. VAN NOSTRAND COMPANY, INC.

PRINCETON, NEW JERSEY

TORONTO LONDON

NEW YORK

ELECTRONS AND HOLES IN SEMICONDUCTORS BOOK BY WILLIAM SHOCKLEY

BY DAVID LAWS

CHM#: 102704591
DATE: 1950
DONOR: Harry Sello

Harry Sello generously donated his copy of William Shockley's magnum opus "Electrons and Holes" to the Museum collection for exhibit in the Silicon Engine artifact display. Sello's copy of the book is unique in that when he was working at Shockley Semiconductor Labs in Mountain View he came up with an improved design for a diffusion furnace.

Shockley asked him what he was working on. Impressed with the approach, he asked Harry if he understood all the thermal and mechanical considerations involved. As Harry says, "When the boss asks you a question like that what else can you say but 'Yes.' Several minutes later Shockley returned with a copy of his book signed on the title page with the message, "To Harry Sello. A man with a big red hot idea. W=Shockley, 26 Mar 58."

Stills from the movie, *Ellis D. Kropotechev and Zeus.*

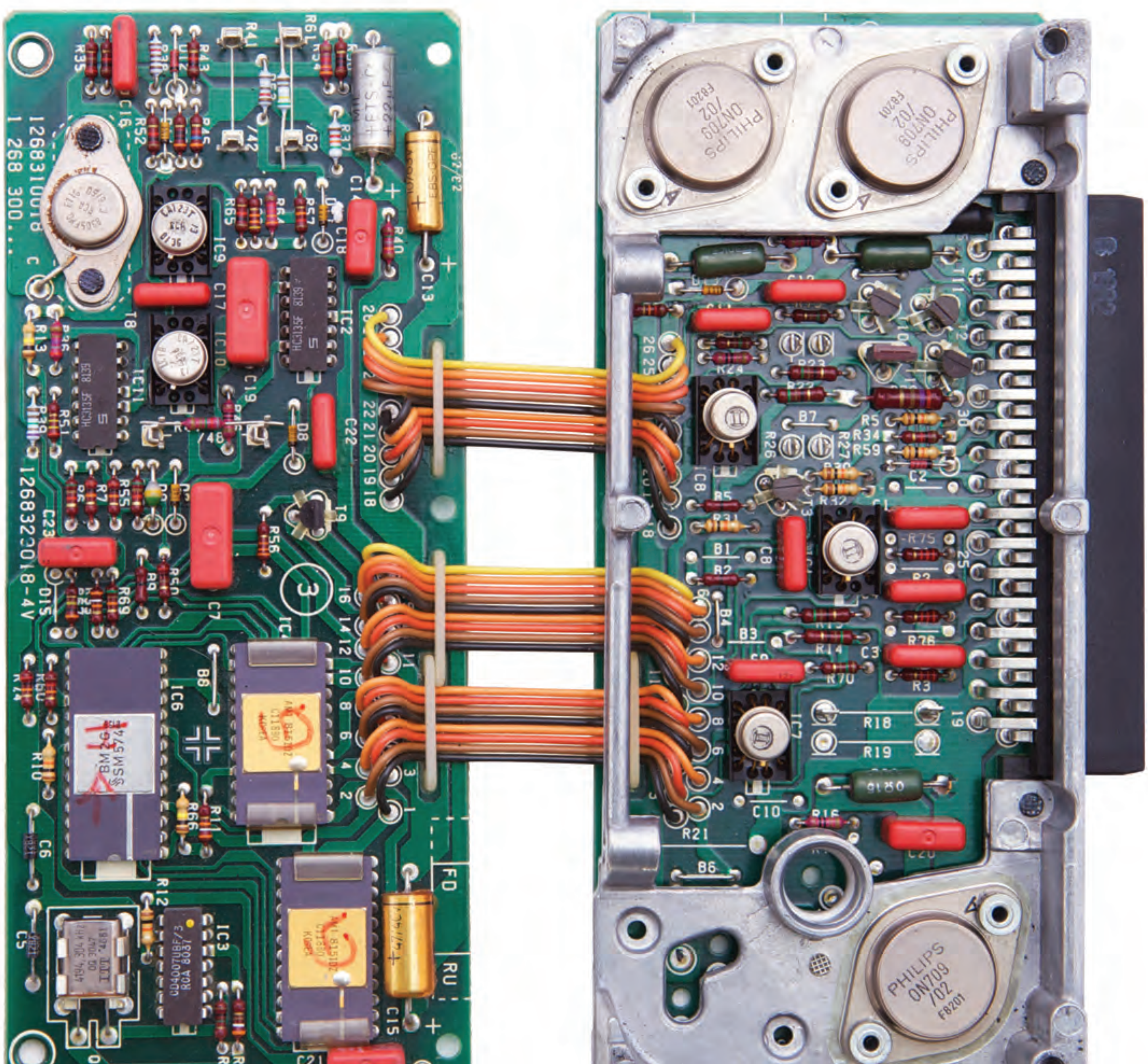
RECENT ARTIFACT DONATIONS

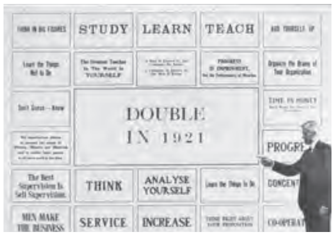
BY DAG SPICER

BOSCH ANTI-LOCK BRAKING SYSTEM (ABS) COMPUTER

CHM#: X5442.2009
DATE: 1978
DONOR: Robert Bosch GmbH

The Bosch ABS-2 system was introduced in 1978 as an option to the Mercedes-Benz S-class luxury car. It marks the beginning of general availability of fully-electronic ABS for passenger cars. By the 1990s, further developments incorporated ABS into more complex traction and stability control systems and ABS is now commonplace in new automobiles This device marks one of the earliest examples of the use of digital control for real-time automotive applications. ○





IBM SYSTEM 360 SLIDE SET

CHM#: X5321.2009
DATE: 1965
DONOR: Dan Leeson

These slides of IBM's very early products, history and key people were used as part of a lecture series given by IBM's Education Department to branch offices around the world. They include images of IBM President and CEO Thomas Watson Sr. ○

TANDEM "NON-STOP" COMPUTER SYSTEMS

CHM# 102711483 – 102711488
DATE: 1983-1997
DONOR: Hewlett-Packard

These five machines represent some of Tandem's "highly-available" computer systems. Such systems were popular with customers who demanded high reliability and quick performance, such as stock markets, telecom companies, banks and ATM networks. While conventional systems of the era, including mainframes, had a mean time between failures in the order of a few days, the Non-Stop system was designed with uptimes measured in years. In 1997, Tandem was acquired by Compaq, which was then acquired by HP in 2002. ○

MYSTERY ITEM

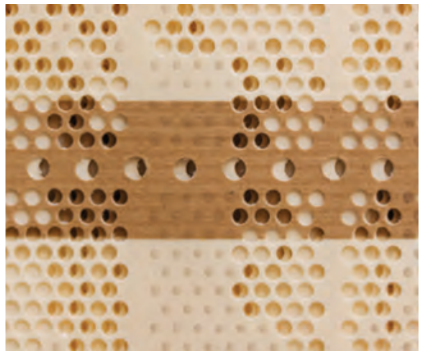
WHAT'S THIS?

Take your best guess!
The first two *Core* readers who submit the correct answers by March 1, 2009, will receive a free copy of *Core Memory: A Visual Survey of Vintage Computers*. Email your guess to: editor@computerhistory.org. Good luck!

Previous *Core* Mystery Item Description
This is a section from a long, interconnected, series of Jacquard loom cards, used to control the patterns made by a weaving machine. Jacquard cards were the inspiration for the punched card accounting systems and computers used during much of the twentieth century.

As these cards were initially used to control computers, it is ironic that the cards shown here were produced using a modern computer-controlled card-making system made by German company Grosse.

The 2008 winners: Gerald Steinback and Jason Walding



ABOUT CHM

The Computer History Museum is dedicated to the preservation and celebration of the computing revolution and its worldwide impact on the human experience. It is home to the largest international collection of computing artifacts in the world, encompassing computer hardware, software, documentation, ephemera, photographs and moving images. CHM brings computer history to life through an acclaimed speaker series, dynamic website, onsite tours, as well as physical and online exhibits.

CURRENT EXHIBITS

2010 will be an exciting year of progress toward completing our major, new exhibition, scheduled to launch in the fall. Please "pardon our dust" as you visit througout the year.

The Silicon Engine
This new exhibit celebrates the 50th anniversary of the integrated circuit (IC) and presents the history and innovations of the IC. The exhibit details the invention of the transistor, its role as a building block of the integrated circuit, the rapid growth of semiconductors and the profound effect these technologies have had on modern life.

Charles Babbage's Difference Engine No. 2
Designed in the 1840s, the Engine is a stunning display of Victorian mechanics and an arresting spectacle of automatic computing. It consists of 8,000 bronze, cast iron and steel parts, weighs 5 tons, and measures 11 ft. long and 7 ft. high. On display until early 2010.

Visible Storage
Closed to pack and move the specific artifacts into the major, new exhibition.

Mastering the Game: A History of Computer Chess
Our History of Chess exhibit examines computing's five-decade-long quest to build a computer to challenge the best chess players.

Innovation in the Valley
Learn about the innovators of computing technology in Silicon Valley who have changed the world, including local giants Apple, Cisco, HP, Intel and Sun.

ONLINE EXHIBITS

Eleven online exhibits at computerhistory.org/exhibits

COLLECTION

Collection:
More than 100,000 items
Catalog Search:
Search 68,000 artifacts online: computerhistory.org/collections/search
Oral Histories:
Search 150 transcribed interviews: computerhistory.org/collections/oralhistories/
YouTube Videos:
View 72 lecture videos: youtube.com/computerhistory

HOURS

WED • THU • FRI • SUN:
12 noon – 4 pm
SATURDAY:
11 am – 5 pm

TOURS

WED • THU • FRI:
1 pm & 2:30 pm
SATURDAY:
12 noon, 1:30 pm & 3:15 pm
SUNDAY:
Times vary, please call ahead

BABBAGE ENGINE DEMONSTRATIONS

WEEKDAYS:
2 pm
SAT • SUN:
1 pm & 2 pm

INFO

EVENTS:
computerhistory.org/events
GIVING:
computerhistory.org/giving
ARTIFACT DONATIONS:
computerhistory.org/collections/donateArtifact
VOLUNTEERING:
computerhistory.org/volunteers

CONTACT

1401 N. Shoreline Blvd,
Mountain View, CA 94043
(650) 810-1010
info@computerhistory.org
computerhistory.org

JOIN • DONATE • VOLUNTEER • CONTRIBUTE

COMPUTER HISTORY MUSEUM

ABOUT US

The Computer History Museum is dedicated to the preservation and celebration of the computing revolution and its worldwide impact on the human experience. It is home to the largest international collection of computer artifacts in the world, encompassing computer hardware, software, documentation, ephemera, photographs and moving images.

CHM brings computer history to life through an acclaimed speaker series, dynamic website, onsite tours, as well as physical and online exhibits. We have a wide variety of programs and participation opportunities.

Support computer history by becoming involved as a member, attendee, donor, corporate sponsor or volunteer.

HOURS

Wednesday, Thursday, Friday, and Sunday: 12 noon – 4 pm
Saturday: 11 am – 5 pm

BABBAGE ENGINE DEMONSTRATIONS

Weekdays: 2 pm
Saturday and Sunday: 1 pm and 2 pm

TOURS

Wednesday, Thursday, Friday: 1 pm and 2:30 pm
Saturday: 12 noon, 1:30 pm and 3:15 pm
Sunday: 12 noon, 1:30 pm and 2:30 pm

INFO

Events: computerhistory.org/events
Membership: computerhistory.org/giving
Artifact Donations: computerhistory.org/collections/donateArtifact
Volunteering: computerhistory.org/volunteers
Contact: core@computerhistory.org

"Men and women who innovate, who invent, who engineer and succeed—they're the heroes of our age. The Museum is a tribute to those innovators, and to their spirit."

JOHN HOLLAR
PRESIDENT AND CEO OF CHM

MYSTERY ITEM

WHAT'S THIS?

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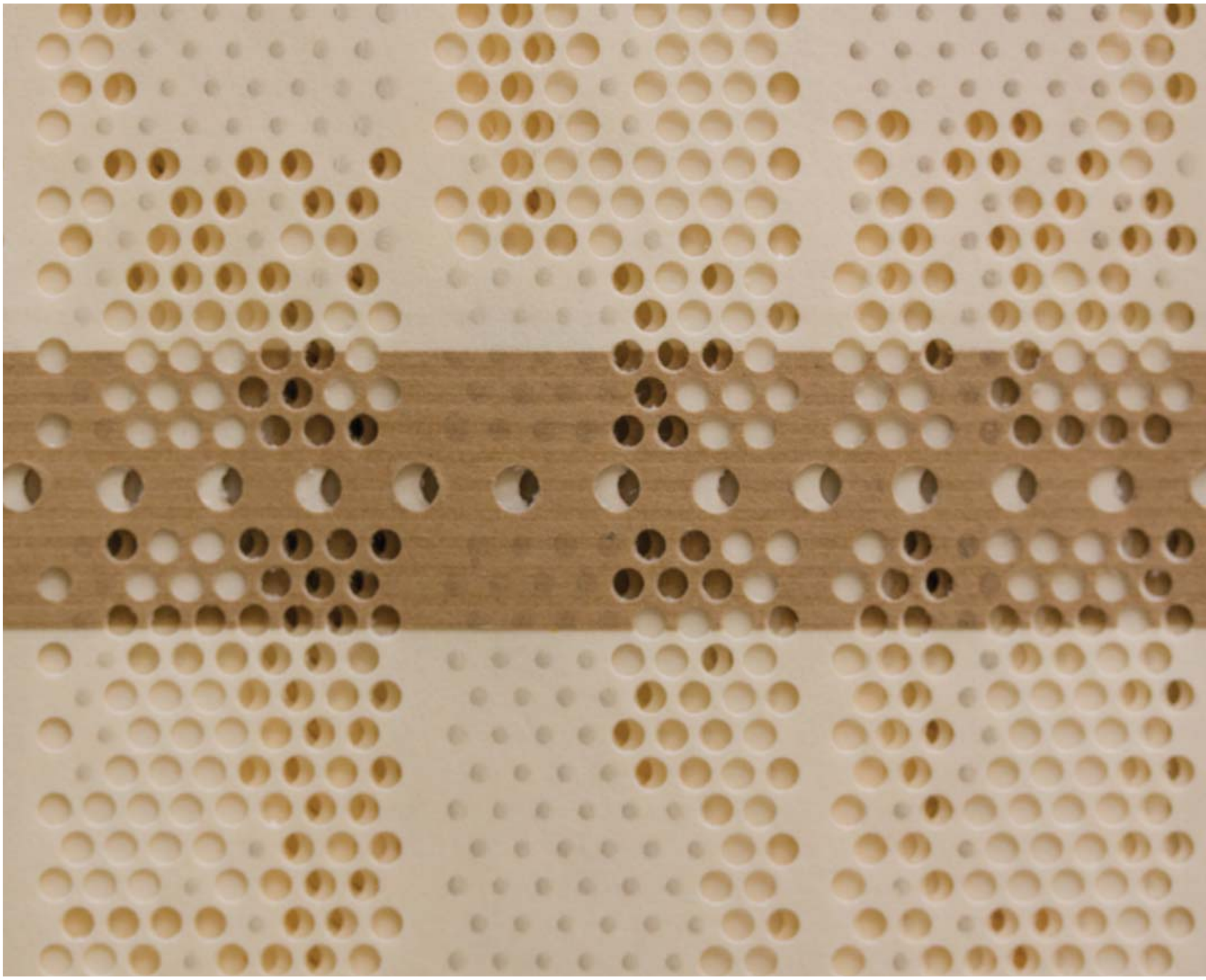

Previous *Core* Mystery Item Description

This is a black and white image of ENIAC co-designer Presper Eckert with guests of ABC's "Nightlife" television program. The episode aired March 24, 1965. From left to right: William Williams, Presper Eckert, Angie Dickinson, Pat Boone and Mort Sahl. The computer is a Univac 422, a medium-scale mainframe system that was sold to colleges and universities for educational purposes.

REGENCY PICTORIALS, INC.