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William Aspray

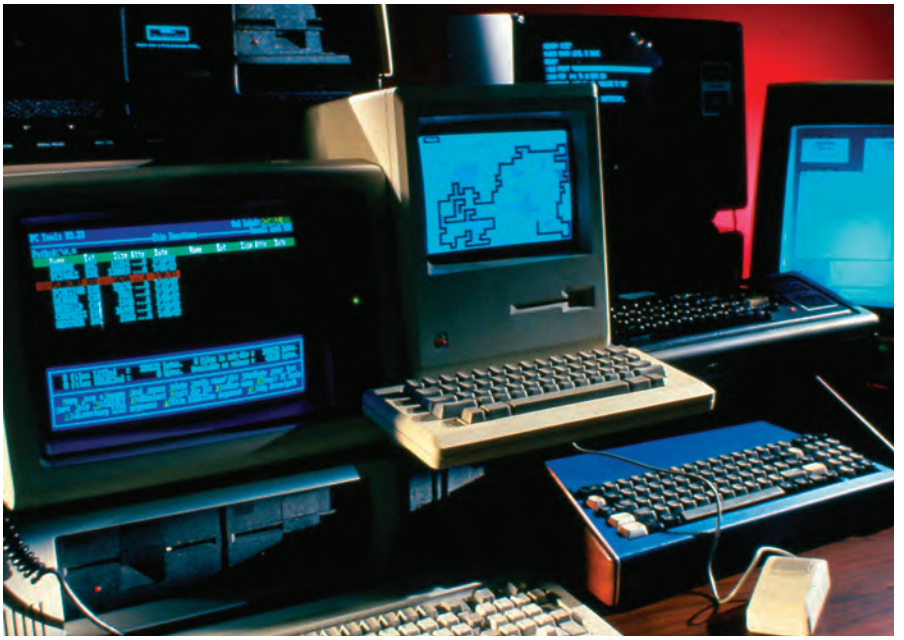
Computer Museum Series
Great Computing Museums of the World, Part Two

The second of a two-part series highlighting several of the world's museums dedicated to preserving, exhibiting, and elucidating computing history.

Some of the science and technology museums around the world are devoted to science discovery—to teaching their visitors, especially children, about the principles of science and technology. Other science and technology museums are more focused on the history and cultural significance of particular scientific discoveries and technological inventions. Some museums include a blend of the two functions.

This is the second installment of a two-part *Communications* series featuring five of world's greatest computing museums. These museums have been chosen for their contributions to the history and culture mission, though most of them have some elements of the science discovery mission as well. There are perhaps hundreds of small and not-so-small museums around the world either devoted entirely to computing or at least having significant computing exhibits. The museums highlighted in this series have been selected because of the large size of their exhibits, the importance and quality of the artifacts shown, and the quality of their interpretations.

An exhibit is not simply a collection of artifacts; it includes signage and other accompanying information (films, lectures, guided tours) that help to interpret the artifacts and set them in context. Each of the exhibits described in this series is the result of years of human labor in preparation: designing the exhibit, selecting and securing the artifacts, and giving them the right interpretation. This work has been carried out by some of the best historians of science and technology, who work in these museums collecting artifacts and the associated information and documentation about them, answering queries from all kinds of people about their collections and about the science and its history, undertaking scholarly research, preparing educational materials, and doing much more. The exhibits are only one facet of what these museums do.



A selection of the U.S. National Museum of American History PC collection.

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The museums featured in this column are the Science Museum in London, the Deutches Museum in Munich, and the U.S. National Museum of American History in Washington, D.C. (The first part of series appeared in the January 2010 issue.) We hope you enjoy the accounts of these museums and that these stories will whet your appetite to explore the museums' Web sites and to visit the museums in person.

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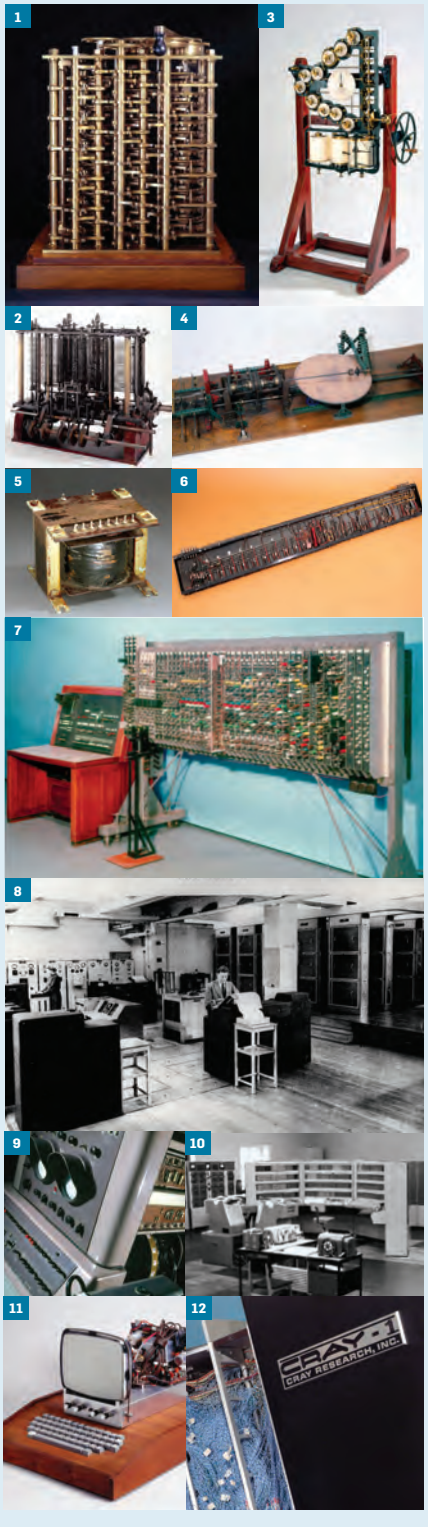
Highlights of the London Science Museum's Computing Collection



1. Difference Engine No. 1: This trial portion of the Difference Engine was used by Babbage as a demonstration machine.

2. Analytical Engine Mill, 1834–1871: Babbage's design possessed all the essential logical features of the modern general-purpose computer.

3. Lord Kelvin's tide predicting machine, 1876: By cranking the handle, the machine calculates the harbor's tide patterns for up to a year in only four hours.

4. Hartree and Porter differential analyzer, 1934: Built using Meccano at a cost of just £20, the model was based on the differential analyzer built by Vannevar Bush at MIT, 1930.

5. Parts of Colossus, 1943: From the code-breaking machine used during the Second World War at Bletchley Park.

6. Unit from ENIAC, 1946: Developed at the University of Pennsylvania, the machine laid the foundations for high-speed digital computing.

7. Pilot ACE, 1950: The first machine to embody the theoretical ideas of a general-purpose computer by mathematician Alan Turing.

8. Unit from LEO 1, 1951: The first business computer used by the Lyons teashops.

9. Ferranti Pegasus Computer, 1959: Currently the oldest working electronic computer in the world.

10. BESM-6 supercomputer, 1966: The only known example of a Russian supercomputer in the West.

11. Apple I, 1976: This first Apple computer was a kit machine for home assembly.

12. Cray I-A, 1976: The last operating Cray 1-A in the world, the machine employed a cylindrical design to reduce the need for wiring.

The Science Museum in London

Tilly Blyth

The Science Museum's collections in London form an enduring record of scientific, technological, and medical change since the 18th century. The Science Museum has its origins in the Great Exhibition of 1851. Initially part of the South Kensington Museum, the impetus was to promote the new "industrial arts" (what we might now call art, craft, science, design, and engineering).

The museum's science collections were enriched in 1876 with the acquisition of a large number of scientific instruments, and the engineering collections grew through the absorption of the Patent Office Museum in 1883. The museum attracts over 2.6 million visitors a year, and is world renowned for its historic collections, awe-inspiring galleries, and inspirational exhibitions.

The Science Museum's collections celebrate computing as one of the most important technologies of our time, both in its own right, but also as an underpinning and enabling technology for so many other industries (see http://www.sciencemuseum.org.uk/).

The museum's computing collections are perhaps most well known for containing the seminal objects and material legacy of the mathematician and inventor Charles Babbage (1791–1871). In Victorian Britain printed mathematical tables were used by navigators, architects, engineers, mathematicians and bankers, but these tables were calculated by human clerks (literally called calculators) and they were quite often riddled with errors. Charles Babbage became interested in mechanizing the production of these tables and he developed a series of diagrams and prototypes to enable him to explore his ideas.

Babbage designed two types of engine, Difference Engines and Analytical Engines. The Difference Engines are calculators that work on a mathematical principle of "a method of finite differences," which allow polynomial equations to be calculated using pure addition. In contrast, The Analytical Engines mark a progression toward a general-purpose machine. They are one of the startling intellectual feats of the 19th century

and tangibly support Babbage's reputation as a computing pioneer.

Examples of both types of machine are on display, including Babbage's original trial piece for the Difference Engine No. 1, a portion of the mill of the Analytical Engine, and the first completed engine, the Difference Engine No. 2, built by the museum in 1991 for the 200 centenary of Babbage's birth. With over 4,000 parts, and weighing five tons, the machine can calculate numbers up to 31 digits long.

The Science Museum's displays also reflect Britain's role at the forefront of computing research in the 1940s and as central to the creation of a new global computing industry in the 1950s. During this period, Britain created the digital, electronic computer, the code-breaking Colossus machine (1943), the first stored-program computer, the Manchester Baby (1948), and the first business computer, the Lyons LEO (1951). Artifacts from all of these machines are on display in the Computing Gallery.

The Science Museum's galleries also showcase three important complete computers from this pioneering industry: the Pilot ACE computer (1950), embodying the original ideas of the mathematician Alan Turing and his conceptual discovery of the general-purpose machine; the Ferranti Pegasus (1959), which was fast and reliable and is now the oldest working electronic computer in the world; and ERNIE (1957), the first random-number generator for the national Premium Bonds that used a hybrid of valves and transistors and generated physical random events through a series of neon gas diodes.

Contemporary machines on display in our *Making the Modern World* gallery include the Cray 1-A supercomputer (circa 1976) and an Apple 1 (1976). Displayed side by side, the research machine (the Cray was installed at Aldermaston Atomic Weapons Establishment in England) and the Apple kit home computer built by enthusiasts provide a strong message about the shift to personal computing during the late 1970s.

Since its founding, the museum has always had a remit to display contemporary science and technology alongside its historical collections. In doing so it has presented new computing technologies using art and interactive elements, through a computer arts booth (1975) and exhibitions like *The Challenge of the Chip* (1980). Today, visitors flock to view *Listening Post* by Ben Rubin and Mark Hassan, an art installation that presents a dynamic and visually enticing portrait of Internet communication.

The Science Museum's collections celebrate computing as one of the most important technologies of our time.

In addition to the public galleries, the Science Museum Library and Archives in London (see http://www.sciencemuseum.org.uk/about_us/about_the_museum/science_library.aspx) offers a world-class collection on the history, biography, and social context of science and technology.

The collections in Swindon offer original scientific and technical books and journals, alongside computing archives of important historical interest. These include the personal papers and technical drawings of Charles Babbage, Mike Woodger from the National Physical Laboratory, and Stanley Gill, who was significant in early U.K. computing policy.

The Archives Collection holds a range of computer literature, most notably through the ICL archive that contains significant information about the products and history of the merged companies that became ICL, including British Tabulating Machine, Powers-Samas, ICT, and English Electric.

The Science Museum Library collection also holds trade literature specific to a particular machine, installation, or company.

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The Deutches Museum

Hartmut Petzold

The Deutsches Museum is one of the world's biggest and oldest museums for science and technology, today with approximately 1.3 million visitors a year. Founded in 1903 as a "Museum of Masterpieces of Science and Technology," in 1906 Kaiser Wilhelm II placed the foundation stone for the new museum building on an island in the Isar river in the Bavarian capital Munich; the museum was completed and opened in 1925. The fundamental idea, which continues influencing the museum, involves presenting the newest "masterpieces" as a logical and historical extension of their precursors. From the very beginning this conception has been both criticized and also copied in many ways.

Planning the exhibition "Informatik" (English translation: computer science) began in 1983. At that time, there were only some experts knowing the Internet, and the personal computer was an expensive and special device. The "Informatik" exhibit opened in 1988; the initiator of the exhibition project was Professor Friedrich L. Bauer, who involved many university- and academic-based experts and collaborators. Bauer, as a mathematician and co-founder of computer science as a new academic discipline, had no difficulties presenting the historical instruments and machines as ancestors of the computer.

The museum's exhibition room borders on the exhibitions on microelectronics, telecommunication, and geodetics. It is subdivided into cabinet-like thematic units by numerous walls providing explanatory text. Therefore visitors do not typically initially notice that the middle of the hall is marked by Konrad Zuse's early program controlled calculators Z3 and Z4. The Z4's original parts are presented in the same condition as they were in 1955, when they were used at the ETH Zurich. The Z3, representing Zuse's priority as the inventor and builder of the first free programmable automatic calculator, working in 1941, and anticipating an essential part of John von Neumann's classical computer concept from 1945, is a reconstruction, built by Zuse himself from 1961–1962 (the original

machine had been destroyed by the bombs of World War II). Representing one of the highlights of the Deutsches Museum, the Z3 is still demonstrated to visitors. Located near the Dehomag/IBM plugboard programmed punched card tabulating machine D11, the pioneer machines of Konrad Zuse also mark the middle of the exhibition in a technohistorical sense. Zuses's machines separate the historical mathematical instruments, the mechanical calculators, and sequence controlled historical automatons in the first part of the exhibit from the spectrum of the big, middle, and small real computers in the second part of the exhibit.

One main issue is the separation of analog and digital calculating instruments and machines. The contrast is highlighted by red text tables for all explanations on analog technology, and by blue tables for all texts on digital technology. One of the outstanding early analog calculating instruments is the exceptionally big astrolabium, made by Erasmus Habermel in 1588. A showcase with different modern slide rulers, mainly used by engineers until the 1970s, is a logical follow-on. This part of the exhibition also includes a big and unique collection of mechanical planimeters, and some components of several big mechanical and electronic analog computers.

The blue-marked part with digital instruments and calculators begins with a small collection of different abaci. A historical sequence of selected mechanical digital desk calculators starts with Wilhelm Schickard's reconstructed machine, and is continued by replicas of the machines of Blaise Pascal and Gottfried Wilhelm Leibniz, all designed during the 17th century. Particularly valuable is an original calculator, made by Anton Braun and Philippe Vayringe and presumably completed around 1735. Beside these historical unique specimens one can view the broad spectrum of the mechanical calculators, industrially produced in series, beginning with C.X Thomas and ending with the sophisticated Friden-Model SRW 10. Many of the mechanical calculators were still used in the 1970s. A special cabinet on the cryptology is presented as a part of the digital calculating exhibit—here not with digits but with letters. Visitors find several coding machines, including two Enigmas. Some historical sequence controlled automatons are also shown as a part of the prehistory of the computer, one of them the famous mechanical trumpeter, made by Friedrich Kaufmann in 1810.

The fundamental idea involves presenting the newest "masterpieces" as a logical and historical extension of their precursors.

In the second half of the exhibition with real computers, the gigantic central processing unit of the UNIVAC I Factronic with its mercury delay line memory is particularly representative. Visually it is overshadowed a bit the so-called PERM computer (Programmgesteuerte Elektronische Rechenanlage München) with its magnetic drum memory, which has been built at the Technical University Munich as a scientific project financed by the Deutsche Forschungsgemeinschaft (German Research Foundation) from 1950 until 1956. The UNIVAC computer, which was used at the Battelle-Institute at Frankfurt/Main between 1956 and 1963, represents the start of industrially produced computers in the U.S., whereas the PERM represents the beginning of research and development of electronic computers at German universities. Also interesting are some original parts of the U.S. pioneer computers ILLIAC and ORACLE. Several computers, developed and produced by the then West German industry are included in the gallery. With the exception of the vacuum tube machine Z22, produced by the Zuse KG in 1958, they all were designed on the base of discrete semiconductor elements.

Also presented is a Cray I from 1983, which until the end of Cold War in 1990 had its completeness checked for the COCOM-office (Coordinating Committee on Multilateral Export Controls) by an employee of the company. Several office computers produced by the companies Nixdorf, Kienzle, and Siemag/Philips, as well as several very early personal computers and electronic pocket computers are displayed at the end of the exhibition.

More artifacts of the collection of historical calculating instruments, machines, and computers are stored in the depositions of the museum, mostly in other buildings. Fundamental for research in the history of computers and computer science particularly in Germany, but not only, are the documents collected in the archive of the Deutsches Museum. In the estates of some German computer pioneers like Konrad Zuse, Heinz Billing, and Joachim N. Lehmann researchers can find many written and printed documents. In addition, the archive includes a large collection of historical printed materials like catalogues and advertising leaflets from many computer-producing companies.

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U.S. National Museum of American History

David K. Allison

The U.S. National Museum of American History has collected and preserves more than three million artifacts that document the history of the American people. These range from the original "Star-Spangled Banner" and Abraham Lincoln's top hat to Alexander Bell's telephone prototypes. The museum's collections form a mosaic of American life and comprise the nation's greatest single collection of historical objects.

The Division of Information Technology and Communications is one of eight curatorial divisions in the museum. Collections in the Division include computing, mathematics, electricity, printing, graphic arts, photography, and numismatics. The Computing Collection has approximately 2,000 objects in the following categories: supercomputers and components; mainframe computers and components; minicomputers and components; microcomputers and components; electronic calculators; analog computers; computer

games; documentation; computer paraphernalia; and related devices. The related Electricity Collection includes electronic components; microchips; cellular telephones; and personal digital assistants. Printers are distributed among the Computer Collection, the Photography Collection, and the Printing Collection. Indeed, the process of digital convergence increasingly links all the collecting units in the Division.

Further information about all of the components of the Division is available from the museum's Web site: http://americanhistory.si.edu. Among the materials there are transcripts of oral and video history interviews with leaders in American computing including J. Presper Eckert, Seymour Cray, Kenneth Olsen, Bill Gates, Steve Jobs, and Larry Ellison.

In addition to the holdings of the curatorial division, the museum's Archives Center has a number of computer-related collections (see http://americanhistory.si.edu/archives). Among its holdings are papers of Grace Murray Hopper, Ralph Baer, and Herb Grosch. Of particular interest are transcripts and other materials from a Computer Oral History project sponsored by the American Federation of Information Processing Societies in the 1960s and 1970s (see http://invention.smithsonian.org/resources/fa_comporalhist_index.aspx).

Although the computer collection is readily available to researchers, currently, little of it is on physical display at the museum. A major exhibition on the history of computing and communications, "Information Age: People, Information, and Technology" ran from 1990–2006, but has now closed. A new exhibition that will include coverage of digital computing is currently under development. Tentatively titled "American Enterprise," it is slated to be the Smithsonian's first comprehensive Smithsonian exhibition on the history of the American economy and to survey innovation in finance, manufacturing, agriculture, energy, information technology, and communications from the late 18th century to the present. C

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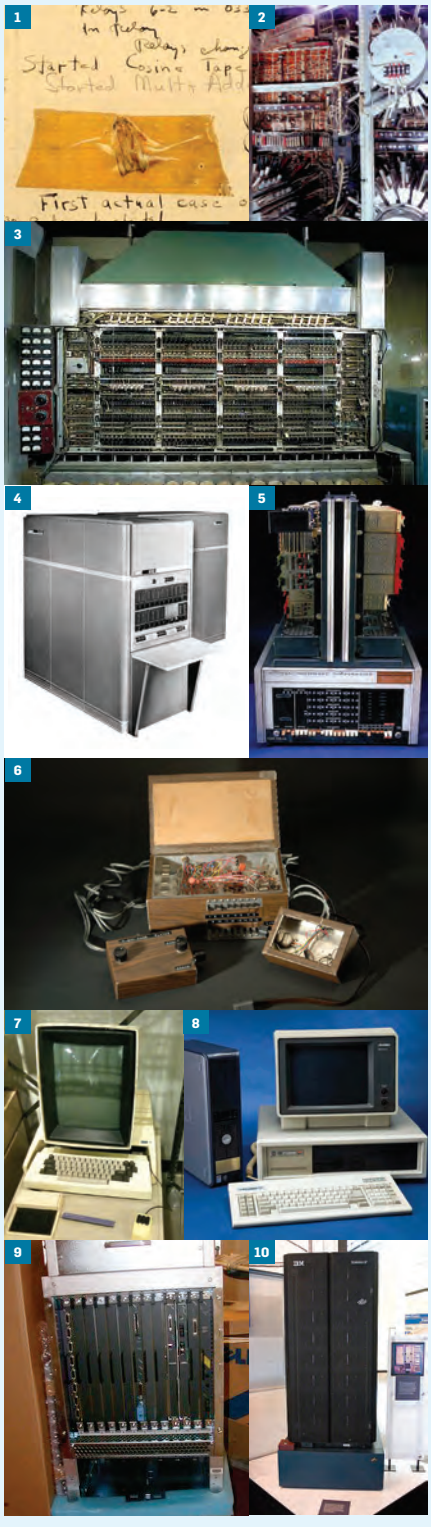
Highlights of the U.S. National Museum of American History



1. The "First Computer Bug," 1947: The Smithsonian has the research notebook with what is reputedly the "first computer bug," a moth taken from a register in the Mark II computer at Harvard and taped into the notebook with the note "first actual case of bug being found."

2. A UNIVAC I Console, 1951: In addition to the Console, the collection includes a mercury delay line memory unit and an arithmetic chassis unit.

3. The Institute for Advanced Study Computer, 1952: Developed at Princeton's Institute for Advanced Study in Princeton, NJ, the design for this computer was replicated in other early machines, such as MANIAC at Los Alamos and ILLIAC at the University of Illinois.

4. An IBM 650, 1954: This is an example of IBM's first mass-produced computer. The Smithsonian has a console unit and card reader/punch, plus documentation.

5. A Digital Equipment Corporation PDP-8 minicomputer, 1965: The collection includes both the processor and documentation.

6. The "Brown Box," 1967: A prototype for the first video game developed by inventor Ralph Baer.

7. A Xerox Alto, 1973: Developed at Xerox's Palo Alto Research Center, this device paved the way to graphical user interfaces and networked desktop computers.

8. Early personal computers, 1975–present: The Smithsonian collection includes a range of personal computers including several Altair 8800s, Apple IIs, Radio Shack TRS-80s, IBM PCs, an Apple Lisa, a Timex Sinclair, and one of Michael Dell's PC Limited computers, as well as more modern devices.

9. CIX Router, 1994: This Cisco Systems 7500 router was used between 1994 and 2001 as part of the first Commercial Internet Exchange. It was a private, membership organization that allowed networks to exchange Internet traffic directly, regardless of which network the customer obtained service from, at no additional charge for the traffic.

10. Deep Blue, 1997: The Smithsonian has one of the two towers of IBM's Deep Blue computer, which won the first regulation chess match against a world champion.