

## V. Resources for Instructors

### 26. Key Resources in the History of Computing

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#### **Abstract**

*This guide provides an annotated and highly selective list of specific online, published, and institutional resources for the history of computing. It focuses on English-language secondary sources. Online resources include institutional sites and a smattering of sample sites presenting virtual exhibitions or primary sources. The guide to published books and articles on the history of computing includes sections on overall and reference works, as well as the history of: computer hardware and the computer industry; programming languages and software; communication and control systems; business and administrative applications; scientific computing; and computer science. The guide also lists home pages and journals with history of computing content.*

This paper provides a kind of annotated bibliography of resources for the history of computing. When preparing my introduction to the history of computing for the computer scientist, I soon found that while there are many, many Internet pages full of links to history of computing websites there is no one-stop place where an interested reader could learn about the main electronic, institutional, and printed resources in the field. In particular, very few of the Internet sites refer readers to printed books and papers (still the best sources of information on most areas of computing history) or exercise much quality control. So while this resource list makes no attempt to be exhaustive, it has the advantage of covering journals, museums, professional associations, books, and journal articles as well as the key websites.

There are, however, some definite limitations of scope to this guide. Most importantly, the list is biased toward secondary sources (basically books and articles written after the events concerned, usually by historians rather than the people involved) rather than primary ones (the original documents and records). It is also biased toward work produced by professional historians rather than journalists, and toward analytical work rather than personal memoirs. The Internet is full of websites produced by fans, hobbyists, and collectors and almost none of these are referenced here. So far, such sites are the best sources of factual information on the history of microcomputers and videogames, both topics I have almost ignored here. Emulators for mini- and microcomputers are readily available, and these can be excellent teaching aids. Unfortunately, emulation and retro computing sites tend to appear and disappear too rapidly to track. Because I read only one language, I also confined this to sources written in English, which in turn are mainly confined to the United States, Britain, and occasionally Canada.

There is also almost nothing here on useful sources for other kinds of social investigation of computing, such as computer ethics, courses on “cyber culture” and the sociology of the Internet, or books on the way computers have changed work life or society. Many of the most important sources for the professional historian of computing do not directly relate to computers at all, but are to be found in social history, business history, labor history, organizational sociology, and so on. I kept the brief simple: to identify the essential secondary information sources concerned directly with the history of computing.

To help those with little knowledge of the field, I have marked a small number of particularly important institutions and unusually accessible and broadly relevant books with the phrase “(Start here).”

### **On-Line Resources: Institutions**

*alt.folklore.computers* (newsgroup)

(<http://groups.google.com/groups?q=alt.folklore.computers&hl=en&safe=off&meta=site%3Dgroups>)

In the absence of any computer history newsgroups, active listservs or web forums, the next best thing is this long-running and much-trafficked newsgroup where old-timers hang out and remember the good old days. Passionate discussions, hacker culture, reminiscences, and historical trivia. The Google news archive listed above is a great resource.

*ASIS Special Interest Group on the History and Foundations of Information Science*

(<http://www.personal.kent.edu/~tfroehli/sighfis/sighfis.html>)

ASIS (or ASIS&T as it now is; they haven't updated this site to reflect that) is the scholarly/professional society for information scientists, which is what technically and scientifically oriented library-type people call themselves. There are no comparable interest groups active within ACM, IEEE CS, or any historical societies.

*Charles Babbage Institute (Start here)*

(<http://www.cbi.umn.edu/>)

There are two main reasons to visit the Babbage website. The first is to access its collection of oral history interviews, now numbering several hundred. Almost all of these have been transcribed, and the transcripts can be downloaded. A simple Web interface lets you search the abstracts and keywords for names or phrases of interest. The other main reason is to browse the finding aids for its archival collections. A finding aid is basically a catalog listing the contents of each folder stored within the archives. While almost none of the archival material is available online (the exception being a selection of photos from the Burroughs collection), having access to the finding aids lets you see what relevant materials CBI holds, request materials in advance of a visit, or even purchase copies of particular documents without visiting. The site also holds the full run of the institute's newsletter, covering the history of computing since the late 1970s.

*Computer History Museum (Start here)*

(<http://www.computerhistory.org/>)

Although the museum is now settling into its new home, it will be some time until its exhibits are finished. For this reason, it has relied on its website in recent years, creating a number of on-line exhibitions based around timelines and photographs, and covering topics such as the Internet and the microprocessor. It also documents the museum's busy schedule of talks by computer celebrities, and hosts its glossy newsletter CORE.

*IEEE Annals of the History of Computing (Start here)*

(<http://www.computer.org/annals/>)

Few libraries have a full run of this journal. Fortunately, the IEEE Computer Society Digital Library now covers all 25 volumes in .pdf form, though the earlier issues seem to have been scanned without compression, resulting in some very bulky files. For recent volumes, there is a convenient feature to download the whole issue in a single file. Even if you do not have a personal subscription, your institution may have one.

*National Archive for the History of Computing*

(<http://www.chstm.man.ac.uk/nahc/>)

Similar to the Charles Babbage Institute, but for the UK. Its main content is catalogs of archival holdings stored at the University of Manchester.

*Resource Center in Cyberculture Studies*

(<http://www.otal.umd.edu/~rccs/>)

has an excellent collection of links, book reviews, and literally hundreds of syllabi concerned with cultural and sociological aspects of the Internet. Courses with historical content make up an appreciable minority of the online syllabi.

*Software History Center*

(<http://www.softwarehistory.org/>)

On-line resource, including a list of early mainframe software figures and a number of short anecdotes.

*Virtual Museum of Computing*

(<http://vmoc.museophile.org/>)

This used to be the most complete collection of links to pages on specific topics such as computer science pioneers and corporate histories. Unfortunately this site is getting progressively less useful because updates have been very scarce in recent years, many of the links have expired, and a number of mirrors (to which you may find yourself automatically redirected) have vanished.

**Online Resources: Virtual Exhibitions and other Primary Sources**

*Classic Computer Magazine Archive*

(<http://www.atarimagazines.com>)

This volunteer site holds the digital full text of a growing number of computer hobbyist magazines from the late 1970s and 1980s, including *Antic* and *Creative Computing*.

*DigiBarn Computer Museum*

(<http://www.digibarn.com/>)

One of those sites full of disorganized material, some of which scrolls down for page after page. It documents a physical homebrew museum which, like several such establishments across the US, seems to take a nineteenth century, "cabinet of curiosities" approach, cramming a lot of stuff into limited space. As well as pictures of rare and not-so-rare personal computers and peripherals, it hosts some interesting stories, some digitized documents and memorabilia, and lots of photographs of old software. There are huge numbers of sites around the net aimed at collectors, reproducing old documentation, photographing obscure prototype, and celebrating beloved machines.

*Ed Thelen's Antique Computer Site*

(<http://www.ed-thelen.org/comp-hist/index.html>)

Holds an unmatched trove of vintage computer documentation in its "on-line documents" section, including original manuals for several key computers and IBM punched card machines and a series of reports from the 1950s and 1960s surveying the early computer industry. This is a personal home site, hard to navigate but full of interesting nuggets.

### *Historic Documents in Computer Science*

(<http://www.fh-jena.de/~kleine/history/>)

Someone called Karl Kleine has scanned a set of early manuals for programming languages, from FORTRAN to C++.

### *IBM Archives*

(<http://www.ibm.com/history>)

Includes a catalog of their main archives. While most of the actual content is not on-line, they do appear to be working to add material –including a useful A-Z glossary and some materials concerning the PC and the 701, IBM's first big computer.

### *Smithsonian Computer History Collection*

(<http://americanhistory.si.edu/csr/comphist/>)

Includes a guide to its Information Age exhibition on display in Washington, D.C., as well as on-line resources and oral histories.

### *The Mouse Site*

(<http://sloan.stanford.edu/MouseSite/>)

Produced by historian Alex Pang, then working at Stanford library, this site includes a mass of information about the history of the mouse, from Doug Englebart's original designs to its commercialization and simplification for the Apple Macintosh. It includes a selection of Englebart documents on-line, interviews with key participants and rare video footage.

### *The NATO Software Engineering Conferences*

(<http://www.cs.ncl.ac.uk/people/brian.randell/home.formal/NATO/index.html>)

Brian Randell, one of the editors of the proceedings of the celebrated Garmisch and Rome conferences at which the idea of Software Engineering was given its first serious discussion, has placed the original reports on-line together with some photographs and reminiscences.

### *UVA Computer Science: Computer Museum*

(<http://www.cs.virginia.edu/brochure/museum.html>)

Apparently based on a physical collection of machines and memorabilia. Doesn't give much context, but does include a whole lot of nice scans of important computers, components, manuals and specification sheets (click on images from the main page for more or bigger ones).

### *World of Spectrum*

(<http://www.worldofspectrum.org>)

I'll pick just one of the sea of retro computing, nostalgia and emulation sites. This one covers the much loved Sinclair Spectrum from the early 1980s, and links to dozens of emulators, an archive of thousands of programs, documentation and, most remarkably, a searchable database covering thousands of pages from old computer magazines. No professionally trained historians have focused yet on this era, but there is certainly a mass of source material out there.

## **Key Books and Articles on the History of Computing**

The main unit of scholarly production in history is the book. Here is a selection from the enormous number now produced. Emphasis is on scholarly rather than journalistic work. Everything included here is either excellent or the best work in an important subject area. For topics where no good book is yet available, and to interesting work not yet available in book form, a few papers have also been included.

### *Reference Works and Overall Histories*

Martin Campbell-Kelly and William Aspray, *Computer: A History of the Information Machine* (New York, NY, 1996). **(Start here)**

The best overall history of the computer. It examines at the computer primarily as an extension of other business tools, focuses on business history of the firms producing computers. Summarizes a lot of earlier work while weaving it into a story. Good treatment of ENIAC and its commercialization as Univac, IBM's mainframes of the 50s and 60s and the first big on-line applications. A second edition is due in 2004.

Paul E. Ceruzzi, *A History of Modern Computing* (Cambridge, MA, 1998).

This is the other main history of the computer. More technical in its approach than Campbell-Kelly & Aspray, with less emphasis on business application and continuities with pre-computer technologies. However, it does feature good treatment of computer architecture and DEC – makes a strong case for the minicomputer as the precursor of modern personal computing. A second edition recently appeared, strengthening coverage of the 1990s.

Software History Bibliography (Charles Babbage Institute).

<http://www.cbi.umn.edu/shp/bibliography.htm>.

The online CBI software history bibliography includes references to monographs, journal articles, reports, oral histories, and archival collections relating to the history of software.

J.A.N. Lee, *Computer Pioneers* (Los Alamitos, CA, 1995).

Biographies and obituaries of leading figures. Currently out of print and almost impossible to find second hand, though a library near you probably has a copy.

Michael R. Williams, *A History of Computing Technology* (Englewood Cliffs, NJ, 1985).

Well produced, technical history of computation from scientific perspective. There is now a second edition.

### *Computer Hardware and the Computer Industry*

Charles J. Bashe, et al. *IBM's Early Computers* (Cambridge, MA, 1986).

Written by a team of IBM insiders, this history is exhaustively researched, detailed and clearly written. There is no better guide to the computers of the 1950s. Currently out of print. A companion book, *IBM's 360 and Early 370 Systems*, by several of the same authors, covers similar ground for the 1960s.

Ross Knox Bassett, *To the Digital Age* (Baltimore, 2002).

Most books about the personal computer era have tended to take the underlying hardware technologies for granted. This book describes the development of MOS transistors, their integration onto silicon chips, and the creation of the microprocessor. It uses interviews and archival documents to discuss the contributions of Fairchild, IBM, and Intel. Bassett makes a particular effort to trace the transfer of ideas between firms, and to tie the dramatically different fortunes of IBM and Intel in turning research into products to their different cultures and internal organizations.

David Caminer, John Aris, Peter Hermon, and Frank Land (eds.), *User Driven Innovation: The World's First Business Computer*. (London, 1996).

A collection of articles, written by the participants, on the origins of the world's first administrative computer (a London tea shop company), its commercialization as a spin-off company (LEO Computers) and its fate.

Martin Campbell-Kelly, *ICL: A Technical and Business History* (New York, 1989).

Covers more than the title suggests, because ICL's origins lay in the punched card era and it represented the merger of almost the entire UK hardware industry. Currently out of print.

James Cortada, *Before the Computer: IBM, Burroughs and Remington Rand and the Industry they Created, 1865-1956* (Princeton, NJ, 1993).

The main history of the pre-computer office machine industry. Charts the shifting fortune of adding machine, typewriter, and bookkeeping machine companies – full of facts and figures. Argument is that computer business evolved out of existing office machine industry.

Robert X. Cringley, *Accidental Empires* (New York, 1996).

A history of microcomputer industry from the mid-1970s to the very early 1990s. Far from academic in its methodology and writing style, but probably more fun to read than any other book ever written on computing. Beneath the folksy exterior and focus on personalities are some vital questions about architecture and technological evolution that historians and economists are yet to really address. And he actually relates the quirks of his subjects to the strategies and fortunes of the businesses they shape.

Michael Hiltzik, *Dealers of Lightning: Xerox PARC and the Dawn of the Computer Age* (New York, 1999).

The story of Xerox's Palo Alto Research Center is one of the most famous in the history of computing. During the mid-1970s a fairly small team invented Ethernet and the laser printer, while building the first modern windowing system (inventing icons and greatly improving mouse control and windows) and making huge strides in object oriented programming. Having been handed the key ingredients of a late-1980s workstation about a decade early, Xerox then conspicuously failed to dominate the computer industry, though it did make some money on laser printers. This book is the most thorough account of the PARC story, and while neither exceptionally readable nor exceptionally insightful, it still tells a fascinating tale.

Tracy Kidder, *The Soul of a New Machine* (Boston, MA, 1981). **(Start here)**

Only history because it's old, but still impossible to overlook. This Pulitzer Prize winner is the inside story of the development of a late-1970s minicomputer. Kidder captures the excitement of technological creation, the culture of computer hackers and the gulf between corporate politics and technical striving better than anyone since. It's also a primer on mini-computer design and the computer industry of the era.

Emerson W. Pugh, *Building IBM: Shaping an Industry and its Technologies* (Cambridge, MA, 1994).

A less technical, more general history of IBM and its computers from the creation of the tabulating machine to the crisis of the early 1990s. Based on the IBM archives.

James S. Small, *The Analogue Alternative: The Electronic Analogue Computer in Britain and the USA, 1930-1975* (New York, 2001).

The first comprehensive history of analog computers and computing, an important electronic precursor to modern programmable digital computers. Small shows that the analog computer

industry developed alongside the early digital computer industry and remained vibrant well into the 1960s for scientific, technical and control purposes.

Steven Usselman, "IBM and its Imitators: Organizational Capabilities and the Emergence of the International Computer Industry." *Business History Review* 22/1 (Spring 1993): 1-35. An interesting, analytical article about the institutional development of IBM, its relationship to the broader environment, and a comparison with its competitors in other countries.

John Vardalas, *The Computer Revolution in Canada: Building National Technological Competence* (Cambridge, MA, 2001).

A history of computing in Canada, from the Second World War though to the 1980s. One major theme is the role of military policy in shaping the development of Canadian computing, another is the related push to nurture a self-sufficient computer industry. Essential readings for Canadians, but also of more general interest as a contrast with the US story, particularly because important influences that are often overlooked in the US context become much more apparent here.

Thomas Watson, Jr. and Peter Petre, *Father, Son & Co: My Life at IBM and Beyond* (New York, 1990). **(Start here)**

Watson led IBM to dominance of the computer business during the 1960s, succeeding his father who created the firm. This fascinating biography, produced with a skilled ghostwriter, provides perhaps the most readable introduction to the punched card and mainframe business and provides an insider viewpoint of key moments in its development.

#### *Programming Languages, Software, and the Software Industry*

Atsushi Akera, "Voluntarism and the Fruits of Collaboration," *Technology and Culture* 42/4 (October 2001): 710-36.

SHARE was a voluntary organization of large IBM scientific computing installations. It set up a shared library of systems and utility software, and attempted to coordinate the production of the first standard operating system for IBM machines. This has interesting parallels (and differences) with today's open source software movement.

Manfred Broy, and Ernst Denert (eds.), *Software Pioneers: Contributions to Software Engineering*. Berlin: (Berlin, 2002).

Another book based on a conference. This one even includes DVDs of the speeches. In an unusual format, the book is split between often interesting speeches made during the conferences by the pioneers themselves, giving a retrospective view of their accomplishments, and reprints of their crucial original papers. "Software Engineering" is very broadly defined, so as well as the obvious suspects such as Tom DeMarco, Michael Jackson, Fred Brooks and Barry Boehm, the conference included the likes of Peter Chen, David L. Parnas, Niklaus Wirth, Friedrich L. Bauer, and Alan Kay.

Martin Campbell-Kelly. *From Airline Reservations to Sonic the Hedgehog: A History of the Software Industry* (Cambridge, MA, 2003). **(Start here)**

The first overall history of the software industry, and a very good one too. Software is given a suitably broad interpretation here, to include computer services and timesharing firms in the 1960s and 1970s (though not more recently), as well as packaged applications and systems software. Mainframe and microcomputer software (including games and personal titles) are all covered. However, this is a history of the software *industry* and not of software itself, or for the most part of its usage.

Ulf Hashagen, Reinhard Keil-Slawik, and Arthur L. Norberg, eds. *Mapping the History of Computing: Software Issues*. (New York, 2002).

The proceedings of a workshop at which an eminent group of historians and computer scientists got together to examine different ways of thinking about the history of software (“as science”, “as engineering,” etc.) and to try and come up with a research agenda for the future. Lengthy comments and discussion summaries are included as well as the papers themselves. Many of the papers related to software engineering, in one way or another.

Steven Levy, *Hackers: The Heroes of the Digital Revolution* (Garden City, NY, 1984). **(Start here)**

Levy, a journalist, tells the story of three crucial chapters in the evolution of interactive computing: the obsessive MIT hacker programmers of the 1960s, the personal computer hardware enthusiasts of the 1970s, and the videogame developers of the 1980s. The final section now seems only mildly consequential, but remains quite interesting. The first two sections are extraordinarily vivid and insightful accounts, doing a great job of getting at the motivations and cultures of these influential enthusiasts. His codification of “hacker culture” has been a major influence on today’s free software movement (hacker in this sense comes from MIT traditions, and has little to do with breaking into computers).

Steve Lohr, *Go To: The Story of the Math Majors, Bridge Players, Engineers, Chess Wizards, Maverick Scientists and Iconoclasts—The Programmers Who Created the Software Revolution* (New York, 2001). **(Start here)**

Much better than the cheesy title suggests, this book relies heavily on interviews (Lohr’s and existing oral histories) to retell the origins of the most famous programming systems, from FORTRAN to GNU. Some of these stories have been done to death already (Xerox PARC) but many remain fresh (credit goes for including Visual Basic along with the more theoretically respectable developments). Does a good job of explaining why each one was important and what was novel about it, but doesn’t tell you much about what people actually did with these systems once they were released—in terms of either applications or experiences.

Richard L Wexelblat (ed.), *History of Programming Languages*. New York: (New York, 1981); and

Thomas J Bergin, and Rick G Gibson (eds.), *History of Programming Languages II*. (New York, 1996).

Based on the proceedings of a seminar bringing together the creators of languages such as FORTRAN and BASIC to tell stories about the creation and subsequent evolution of these languages. Each session was devoted to a single language. The strength of this kind of thing is in presenting a fairly polished set of memoirs, and sometimes capturing discussion and disagreement. The second volume, and corresponding seminar, covers newer languages such as C++, LISP, ADA, SMALLTALK and PASCAL. Table of contents available at: <http://www.csis.american.edu/tbergin/pubs/programming.html>.



## *Communication and Control Systems*

Janet Abbate, *Inventing the Internet* (Cambridge, MA, 1999). **(Start here)**

Still the only full-length scholarly history of the emergence of the Internet. Reliable, concise and clearly written. Looks at the origins of packet-switching technology, the creation of ARPANET, the transition to TCP/IP, and the uses made of the system by academic researchers. Although there is a brief discussion of the Web and the commercialization of the Internet, it is something of an afterthought to the focus on the Internet as a scientific network.

Paul Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, MA, 1996). **(Start here)**

Very readable. Includes history of SAGE air defense network, draws parallels with SDI. Shows military origins of real-time computing, networks and other technologies. Edwards looks at broader cultural and political issues, and adopts a cultural studies sensibility in including discussion of science fiction films as well as military systems.

David A. Mindell, *Between Human and Machine: Feedback, Control, and Computing Before Cybernetics* (Baltimore, 2002).

Excellent and complicated treatment of the prehistory of computing, focusing on real-time control and communication technologies during WWII and the preceding couple of decades. These include feedback and communications engineering, naval fire control, guidance technologies, differential analyzers and anti-aircraft systems. Each is situated within a specific tradition of engineering practice, but collectively they lay the groundwork for many of the better known post-1945 developments in computing. More details in my review, at: <http://www.tomandmaria.com/Tom/Writing/MindellReview.pdf>.

## *Business and Administrative Applications*

Atsushi Akera, "Engineers or Managers? The Systems Analysis of Electronic Data Processing in the Federal Bureaucracy." In *Systems, Experts, and Computers: The Systems Approach in Management and Engineering, World War II and After*, ed. Agatha C. Hughes and Thomas P. Hughes, 191-220. (Cambridge, MA, 2000).

A nice case study of early attempts by members of the National Bureau of Standards to use expertise in computer technology and knowledge of the techniques of "systems analysis" to assert broader control over administrative computing across the Federal government.

Jon Agar, *The Government Machine* (Cambridge, MA, 2003).

This history is the first to really explore the use made of the computer and other information technologies by government. The book surveys a very broad range of developments in British government, from Babbage and his famously unbuilt machines, through the much less well known stories of government statistical work, punched card machine use, operations and methods experts, information handling during the World War II, and computerization during the 1950s and 1960s.

Martin Campbell-Kelly, *The Railway Clearing House and Victorian Data Processing* (London, 1994).

A nice case study of how a large scale administrative system functioned long before the introduction of the computer.

Alfred D. Chandler and James W. Cortada, *A Nation Transformed by Information: How Information Has Shaped the United States from Colonial Times to the Present* (New York, 2000).

This hefty anthology is an attempt to explore information as a theme in US History. The focus is on information considered broadly, rather than just the computer, and so the book includes discussion of the U.S. Post Office, radio, telegraphy, and so on. The treatment of computer and precursor technologies is the context of business applications, with Yates and Cortada providing chapters summarizing their main ideas.

Thomas Haigh, "The Chromium-Plated Tabulator: Institutionalizing an Electronic Revolution, 1954-1958," *IEEE Annals of the History of Computing* 23/4 (October-December 2001): 75-104;

and

Thomas Haigh, "Inventing Information Systems: The Systems Men and the Computer, 1950-1968," *Business History Review* 75/1 (Spring 2001): 15-61.

No book has yet been published to tell the overall story of computer use by American businesses, so I will shamelessly recommend two of my own papers. The former examines the first wave of computer use in business administration, including the processes by which the machines were brought and sold, continuities with earlier punched card applications, and the new jobs and departments created around them. It is available online at: <http://www.tomandmaria.com/Tom/Writing/Chromium-PlatedTabulator.pdf>. The latter examines the redefinition, during the 1960s, of the computer as a tool for "information systems" rather than "data processing," and the role of computer manufacturers and experts in administrative methods of popularizing a new ideal of management by computer. It is available online at: <http://www.tomandmaria.com/Tom/Writing/InventingInformationSystems.htm>.

JoAnne Yates, *Control Through Communication: The Rise of System in American Management* (Baltimore, MD, 1989).

This book deals with the late 19<sup>th</sup> century and the first few years of the 20<sup>th</sup>, so does not address the computer at all. It is, however, a well-researched and readable history of the introduction and use of earlier administrative technologies such as files, adding machines, typewriters, carbon paper and memoranda. These are the things that, one by one, the computer has replaced. The first part covers the technologies; the second part gives case studies.

JoAnne Yates, "Co-Evolution of Information-processing Technology and Use: Interaction Between the Life Insurance and Tabulating Industries." *Business History Review* 67, no. 1 (Spring 1993): 1-51;

and

JoAnne Yates, "The Structuring of Early Computer Use in Life Insurance." *Journal of Design History* 12:1 (1999): 5-24;

and

JoAnne Yates, "Application Software for Insurance in the 1960s and Early 1970s." *Business and Economic History* 24:1 (Fall 1995): 123-34.

Yates has been working for some time on a book providing a detailed case study of the use of computers and punched card machines in the insurance industry. These papers present parts of that broader project.

### *History of Scientific Computing*

William Aspray (ed.), *Computing Before Computers* (Ames, IA, 1990).

This collection provides a readable introduction to the various computer technologies used for scientific calculation before the spread of the digital electronic computer, including analog computers and punched card machines. It is now out of print, but the full text is online at <http://ed-thelen.org/comp-hist/CBC.html>.

William Aspray, *John von Neumann and the Origins of Modern Computing* (Cambridge, MA, 1990).

Rather than trying to cover the whole of von Neumann's life, Aspray uses an examination of his contributions during the 1940s and 1950s to computer design, numerical analysis, computing theory, and several other areas as a window into the broader history of computing and applied mathematics during this period.

Martin Campbell-Kelly, Mary Croarken, R. Flood, and E. Robson (ed.), *The History of Mathematical Tables: From Sumer to Spreadsheets* (New York, 2003).

Mathematical tables might not sound so thrilling, but they were one of the main items driving the development of scientific computing technology and techniques during the nineteenth and early twentieth centuries. This book, based on a conference but very nicely edited and produced, provides concise, readable and authoritative introductions to a number of topics, including Babbage and his engines, large scale table-making efforts in the UK and in the US, and the production of nautical and astronomical tables. Most of the authors are professionally trained historians.

Mary Croarken, *Early Scientific Computing in Britain* (Oxford, 1990).

A concise history of British computation, focusing on the development of different computing centers and their use of mechanical and electronic aids. It begins in the early twentieth century, moves through the introduction of differential analyzers, and finishes with the World War II and the electronic computers of the immediate post-War era. No such overall history has yet been published on the US story over the same period.

Paul N. Edwards. "The World in a Machine: Origins and Impacts of Early Computerized Global Systems Models." In *Systems, Experts, and Computers : The Systems Approach in Management and Engineering, World War II and After*, ed. Agatha C Hughes and Thomas P Hughes (Cambridge, MA, 2000), 221-53.

Edwards should soon be publishing a book on the use of computers to model the world's atmosphere, climate, and other "dynamics," something initially viewed as vital applications though it proved much harder to do and more limited than expected, eventually providing the big cliché of chaos theory (you know, the one about the butterfly flapping its wing and making a storm). Until the book arrives, you can read this early presentation of some of the material. Edwards has helpfully placed it online at <http://www.si.umich.edu/~pne/PDF/wiam.pdf>.

Herman H. Goldstine, *The Computer from Pascal to von Neumann* (Princeton, NJ, 1972).

Mixes the early history of calculating devices with an insider's perspective on the development of the computers of the 1940s and 1950s.

David Alan Grier, "The Math Tables Project of the Work Projects Administration: The Reluctant Start of the Computing Era." *IEEE Annals of the History of Computing* 20/3 (July-September 1998): 33-50;

and

David Alan Grier, "The Rise and Fall of the Committee on Mathematical Tables and Other Aids to Computation." *IEEE Annals of the History of Computing* 23/2 (April-June 2001): 38-49.

Grier will soon publish a book tracing scientific computing in the United States from the origins of numerical analysis to the beginnings of digital electronic computing. In the meantime, several articles from the same research have been published.

Jennifer S. Light, "When Computers Were Women." *Technology and Culture* 40/3 (July 1999): 455-83.

The initial programmers and operators of the ENIAC, the first usable electronic digital computer, were largely women. In this paper, Light tells their story and examines their disappearance from the official record.

Stephen G. Nash, ed. *A History of Scientific Computing* (New York, 1990).

This edited publication based on a conference (the proceedings of which are available to members in the ACM Digital Library). The book is unobtainable at present (mid-2004), but should soon be appearing online, hosted by the Society for Industrial and Applied Mathematics. It consists mostly of first-person accounts by pioneers in scientific computing and numerical analysis.

Jeffrey R. Yost, *A Bibliographic Guide to Resources in Scientific Computing, 1945-1975* (Westport, CT, 2002).

An annotated list of more than a thousand primary and secondary sources (books, articles and archival papers) related to different kinds of scientific computing. These are grouped according to the main area of science (physical sciences, biological sciences, cognitive science, and medicine). As this is such a huge topic, and this is quite a slim book, it's inevitably far from complete, but it might point to some good first steps for student research projects.

### *History of Computer Science and Research*

William Aspray, and Bernard O. Williams, "Arming American Scientists: NSF and the Provision of Scientific Computing Facilities for Universities, 1950-73." *IEEE Annals of the History of Computing* 16/4 (Winter 1994): 60-74;

and

William Aspray, "Was Early Entry a Competitive Advantage? US Universities That Entered Computing in the 1940s." *IEEE Annals of the History of Computing* 22/3 (July-September 2000): 42-87.

Nobody has ever written a book giving the overall history of computer science as an academic discipline. One avenue would be to focus on the intellectual content of computer science, particularly theoretical computer science, and examine its connection with other disciplines such as mathematics and engineering. Another would be to look more sociologically at the institutional development of journals, departments, and funding sources in the new field. In these two articles, Aspray takes the latter approach and fills in important parts of this history.

Thierry Bardini, *Bootstrapping: Douglas Engelbart, Coevolution, and the Origins of Personal Computing* (Stanford, 2000). **(Start here)**

Despite the occasional theoretical flourish (Bardini teaches communications, not history) this is a clearly written, involving, and solidly researched look at a previously hazy chapter in computer history. It sets Doug Engelbart's invention of the mouse in the broader context of his '60s Californian philosophy, the institutional history of his research group, and the development of computer technology.

Alan Hodges, *Alan Turing: The Enigma of Intelligence* (New York, NY, 1983).

An excellent biography of the founding father of computer theory. Very long, but has drawn wide public interest, partly by making Turing a gay hero, and partly by documenting his wartime work cracking the German Enigma code, an inherently exciting chapter in the history of computing.

Arthur L. Norberg and Judy E. O'Neill. *Transforming Computer Technology: Information Processing for the Pentagon, 1962-1986* (Baltimore, 1996).

A history of ARPA's celebrated work in supporting the development of seminal computer science research during the 1960s and 1970s. The style is dry, but the material is fascinating. Different chapters explore work in computer graphics, artificial intelligence, and networking (ARPA was responsible for creating ARPANET, the precursor to the Internet).

Alex Roland and Philip Shiman, *Strategic Computing: DARPA and the Quest for Machine Intelligence* (Cambridge, MA, 2002).

This volume covers the efforts of DARPA leaders of the 1980s to shackle together an unrelated mass of apparently promising areas of basic research and sell them to Congress as an applied development effort in military applications. As well as being a fascinating case study in the interaction of computer science research with government agencies and military priorities, it also documents some important areas of recent history, particularly the push for a "fifth generation," and attempts to push technologies for natural language recognition, machine vision and expert systems into practical applications.

Donald MacKenzie, *Mechanizing Proof* (Cambridge, MA, 2001).

MacKenzie is an historically minded sociologist of science and technology, who likes to work by getting deep inside the technical discussions of the community he is studying. This book is a series of case studies, all exploring different aspects of the relationship between computer technology and mathematical proof. Some chapters explore use of computers to produce mathematical proofs, such as the Four Color Problem. Most of the book, however, examines attempts to formally prove the correctness of hardware and software, an important research area in theoretical computer science from the 1960s onward, and one attempted for some real-world military systems.

Mitch Waldrop, *The Dream Machine: JCR Licklider and the Revolution that Made Computing Personal* (New York, 2001). **(Start here)**

A big sprawling book. Waldrop uses Licklider, an experimental psychologist with a vision of man-machine interaction who controlled DARPA's computing research funding during the early 1960s, as a vehicle to structure a much broader story about the development of interactive computing. He starts with the World War II, and takes in cybernetics, artificial intelligence, timesharing operating systems, the Arpanet, and the famous research at Xerox PARC. The style is readable and journalistic, so this would be a nice introduction to the topic. The paperback version has a truly dreadful cover, but don't let that put you off.

Michael S. Mahoney. "Software as Science—Science as Software." In *Mapping the History of Computing: Software Issues*, ed. Ulf Hashagen, Reinhard Keil-Slawik and Arthur L. Norberg, 25-48 (New York, 2002).

Among other things, this complex paper is a discussion of the emergence of theoretical computer science from various obscure areas of mathematics. The text is available online at <http://www.princeton.edu/~mike/softsci.htm>.

National Research Council. *Funding A Revolution: Government Support for Computing Research* (Washington, DC, 1999).

A blue ribbon science panel produced a study showing the influence of government support on the development of computer science, hardware and software. The full text is on-line at <http://www.nap.edu/readingroom/books/far/contents.html>.

## Other Kinds of Resources

### *Articles about History of Computing*

Below is a sampling of provocative articles about the current state of the history of computing and its future. Most have been placed on-line by their authors. These all constitute thoughtful and fairly recent reviews of some important works in the field

Michael S. Mahoney, "The Histories of Computing(s)", a lecture in the series *Digital Scholarship, Digital Culture*, at the Centre for Computing in the Humanities, King's College, London, 18 March 2004 (to appear); and

Michael S. Mahoney, "Issues in the History of Computing," in Thomas J. Bergin and Rick G. Gibson ed., *History of Programming Languages II* (New York, 1996), 772-81; and

Michael S. Mahoney, "The History of Computing in the History of Technology", *Annals of the History of Computing* 10 (1988): 113-25.

At frequent intervals, Mahoney delivers a speech or writes an article directed at a different audience summing up his view of the current state of the history of computing and its possible avenues of development. These papers, among others, are available from <http://www.princeton.edu/~mike/computing.html>.

Nathan Ensmenger, "Power to the People: Toward a Social History of Computing." *IEEE Annals of the History of Computing* 25:1 (January-March 2004): 93-95; and

Paul N. Edwards, "Making History: New Directions in Computer Historiography." *IEEE Annals of the History of Computing* 23:1 (January-March 2001): 85-87.

Two short articles containing some thoughts on the future of the field. Edwards offers a number of ideas, while Ensmenger on the desirability of using the tools of social history to study the history of computing. Every issue of *Annals of the History of Computing* includes a "Think Piece" editorial at the back, where someone involved with the field contributes a short article presenting their suggestions on how to think about the field. Unfortunately you need a subscription to read these, though Edwards put his online at <http://www.si.umich.edu/~pne/PDF/makinghistory.pdf>.

### *Magazines and Journals with History of Computing Content*

*Technology and Culture*.

(<http://www.shot.jhu.edu>)

Produced by the Society for the History of Technology. (recent volumes on-line in Project Muse). SHOT is the leading organization for historians of technology.

*Business History Review*

(<http://www.hbs.edu/bhr/>)

Longest established journal of its kind, has published several articles on the history of computing over the past few years. Produced by the Harvard Business School (recent volumes in Proquest and Academic Index).

*Isis*

The leading history of science journal, produced by the History of Science Society. Hardly ever publishes computer-related articles, but we can hope.

*American Heritage of Invention and Technology*

([www.americanheritage.com/](http://www.americanheritage.com/))

Readable, often well researched, aimed at public, frequently includes articles on computer and electronic technologies.

In addition, there are many professional journals in related fields, including IEEE, SIAM and ACM publications, and the Journal of ASIS&T, that occasionally publish historical articles.

*Personal Home Pages of Historians of Computing*

These generally include links to the text of publications, syllabi, and other relevant material.

Jon Agar –[http://www.man.ac.uk/Science\\_Engineering/CHSTM/people/agar.htm](http://www.man.ac.uk/Science_Engineering/CHSTM/people/agar.htm)

Atsushi Akera –<http://www.rpi.edu/~akera/>

Thomas J. Bergin –<http://www.csis.american.edu/tbergin/>

Michael Buckland –<http://www.sims.berkeley.edu/~buckland/>

Martin Campbell-Kelly –<http://www.dcs.warwick.ac.uk/~mck/>

Greg Downey –<http://www.journalism.wisc.edu/~downey/>

Paul Edwards –<http://www.si.umich.edu/~pne/>

Nathan Ensmenger –<http://www.sas.upenn.edu/~nathanen>

Thomas Haigh (author) –<http://www.tomandmaria.com/tom>

John A.N. (JAN) Lee –<http://ei.cs.vt.edu/~janlee/Janlee.html>

Timothy Lenoir –<http://www.stanford.edu/dept/HPS/TimLenoir/>

Michael Mahoney –<http://www.princeton.edu/~mike/>

JoAnne Yates –<http://ccs.mit.edu/yates.html>

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