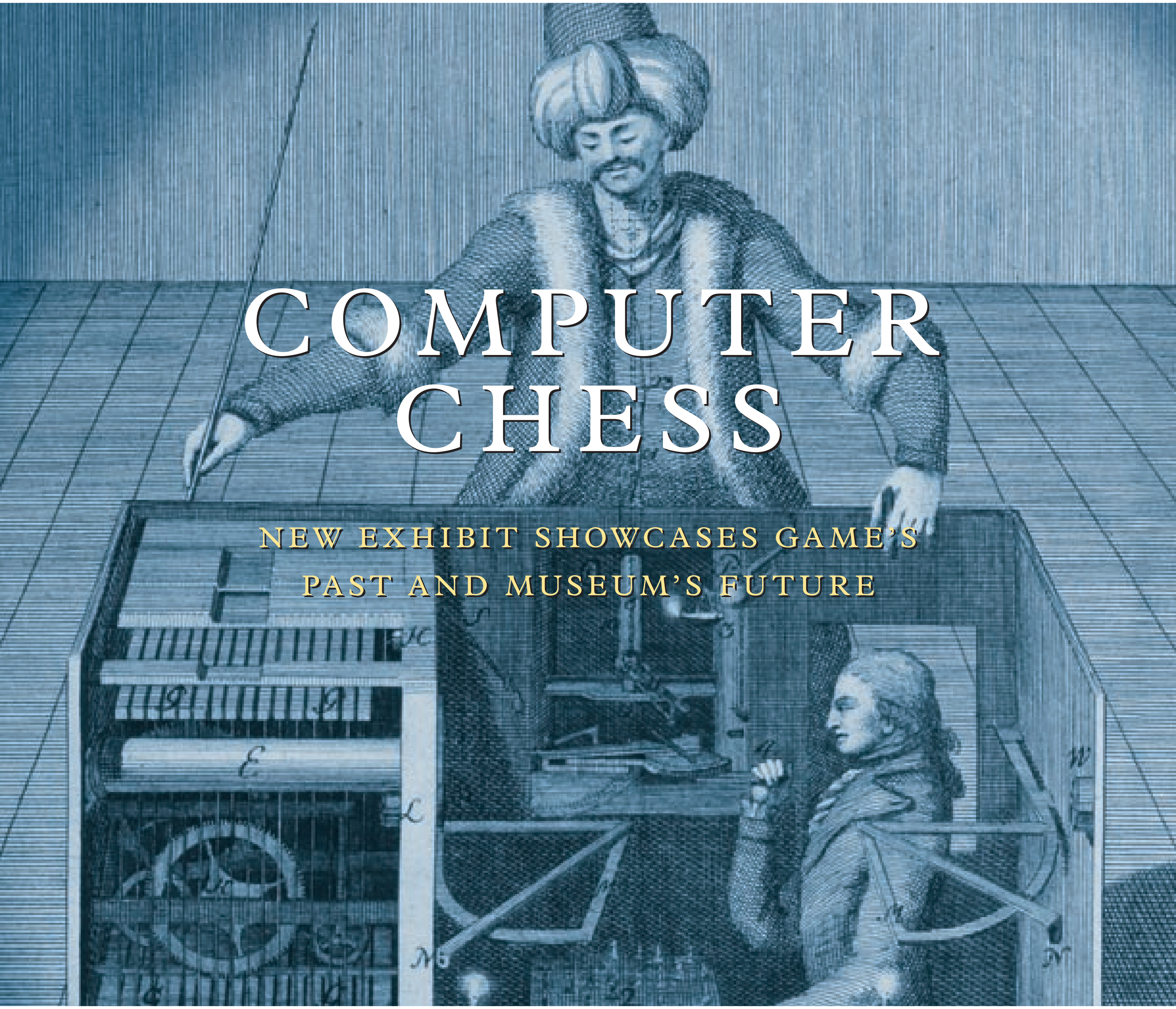
Core 5.1

A PUBLICATION OF THE COMPUTER HISTORY MUSEUM // MAY 2006



COMPUTER CHESS

NEW EXHIBIT SHOWCASES GAME'S PAST AND MUSEUM'S FUTURE

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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

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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 make-shift 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.

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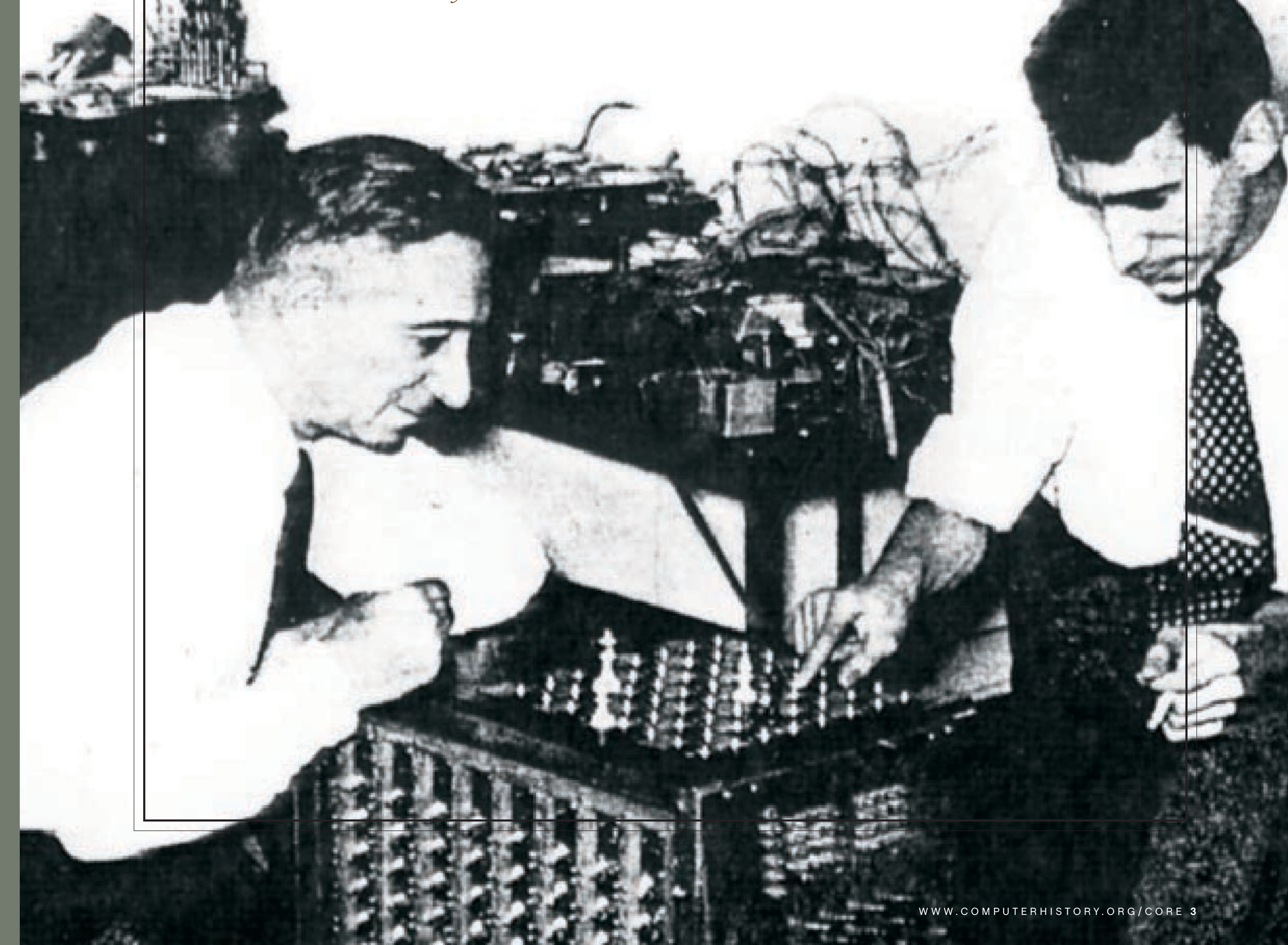
THE QUEST TO BUILD A

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

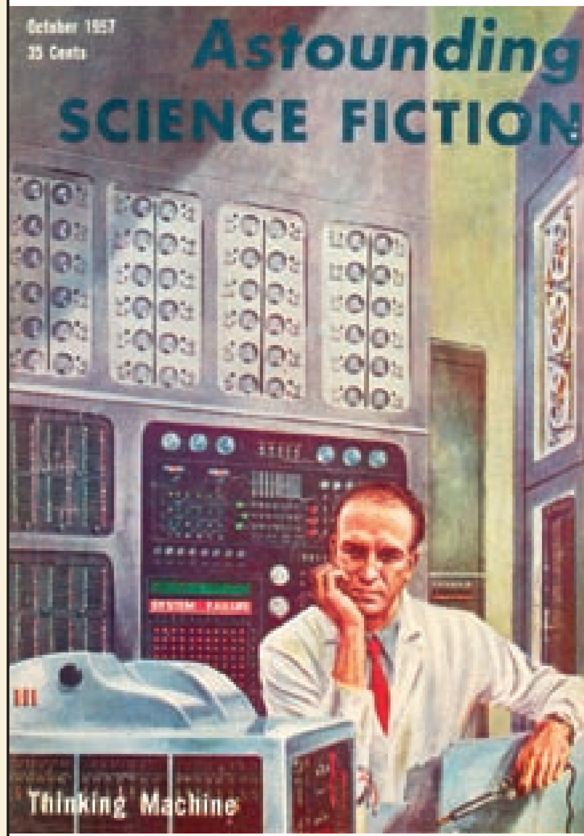
A colleague of Turing's, Dr. Dietrich Prinz, a research scientist on one of these new electronic machines (the Ferranti Mark I computer at Manchester University), continued the quest to create a chess-playing computer program. Prinz wrote the first limited program in 1951. Although the computer was not 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 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."

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

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.

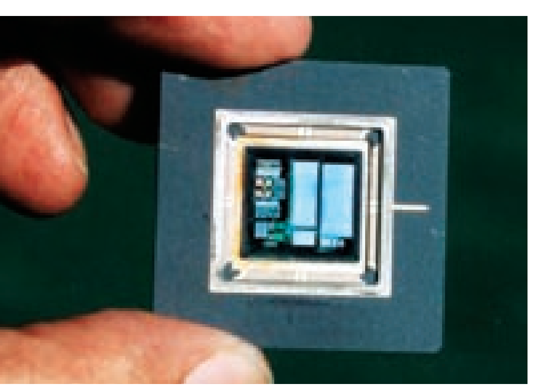
One of the major centers of such development was Carnegie Mellon University. In the mid-1980s, two competing research groups developed separate chess computers, one named Hitech and the

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.



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.

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."

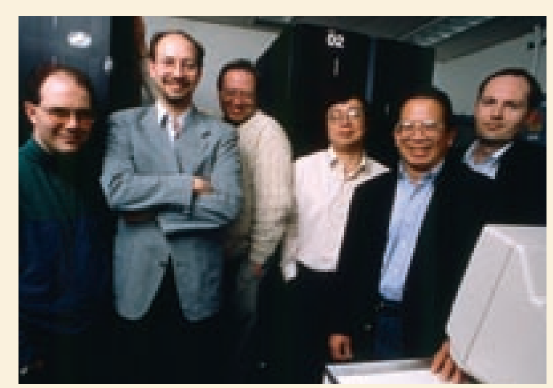
Kasparov quickly agreed to a re-match challenge for the following year. To prepare, the team tested the machine against several Grandmasters, and doubled the performance of the hardware. A six-game rematch took place in Manhattan in May 1997. Kasparov won the first game but missed an opportunity in the 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 (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

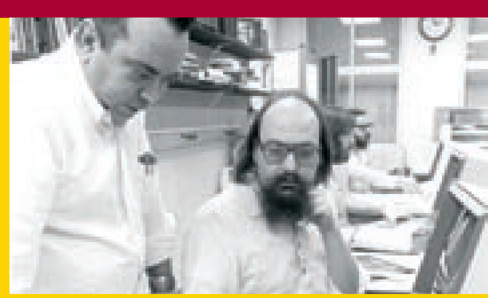
PERSONAL STORIES, CONTROVERSIAL OPINIONS, FRESH CHALLENGES

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

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(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

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EXPLORE THE COLLECTION

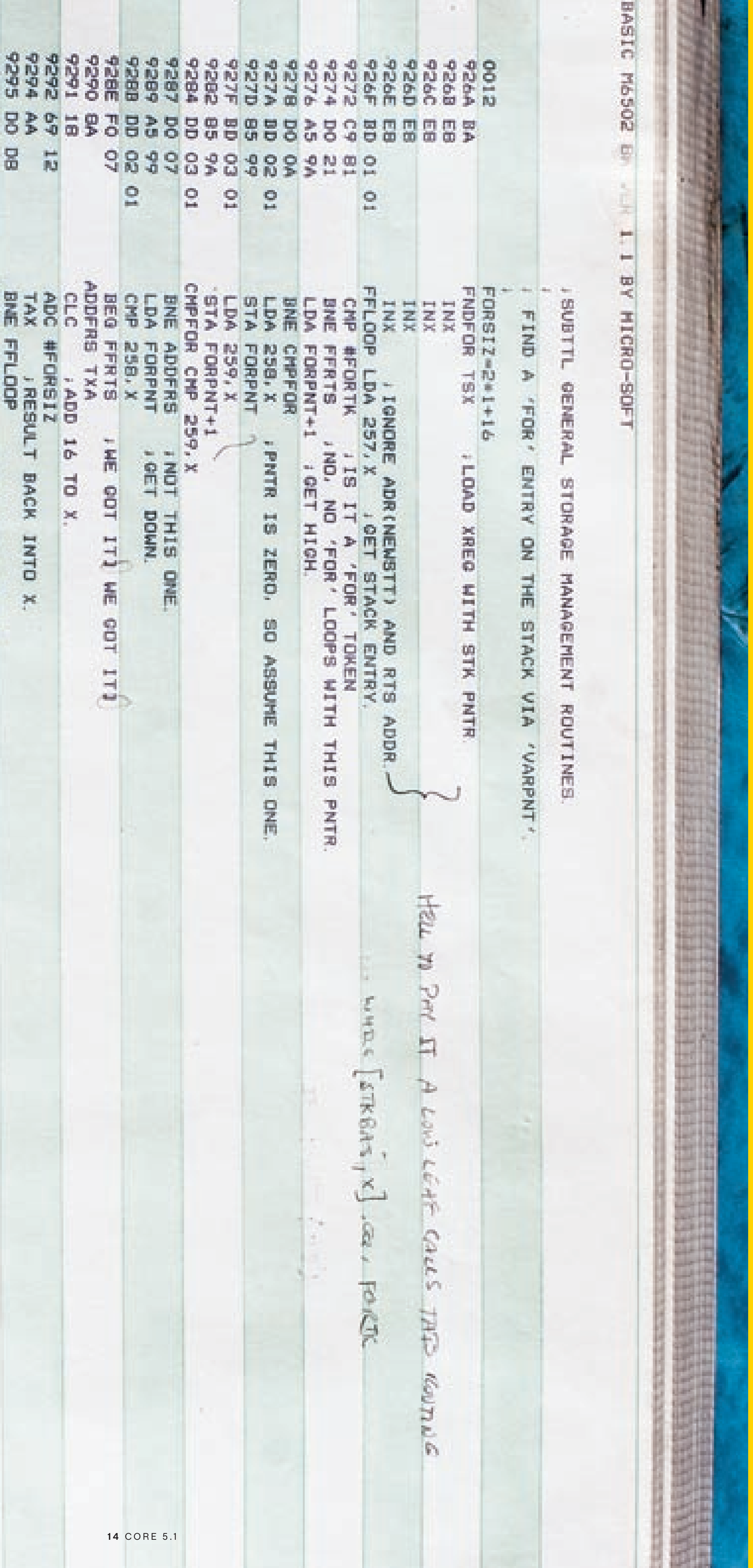
OBJECT

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

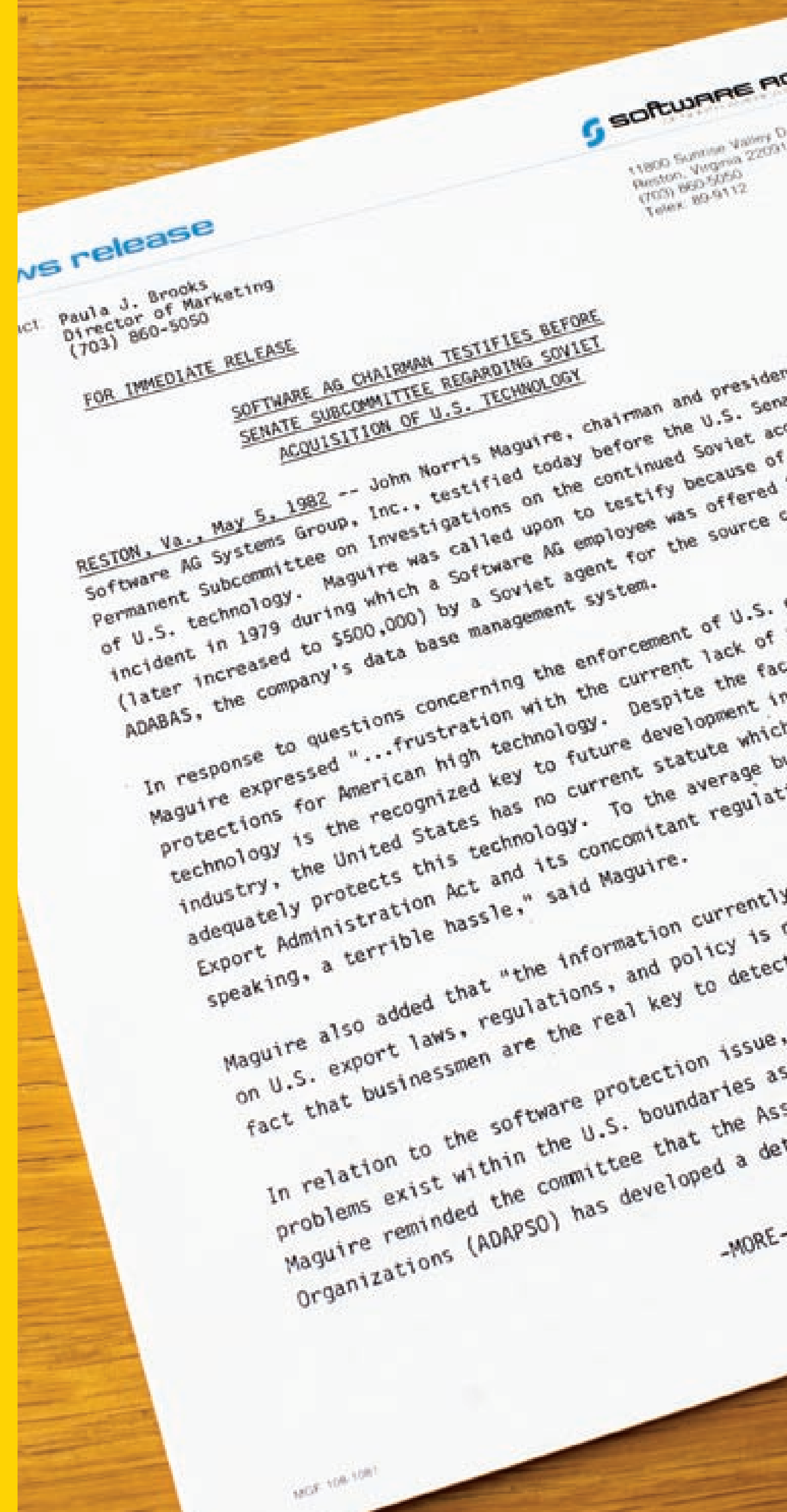
News release, Software AG of North America
Date: May 5, 1982
Collection: Document-text
Donor: Gift of John Maguire
CHM#: 102641740

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



SELLING THE COMPUTER REVOLUTION

BY PAULA JABLONER

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?

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."

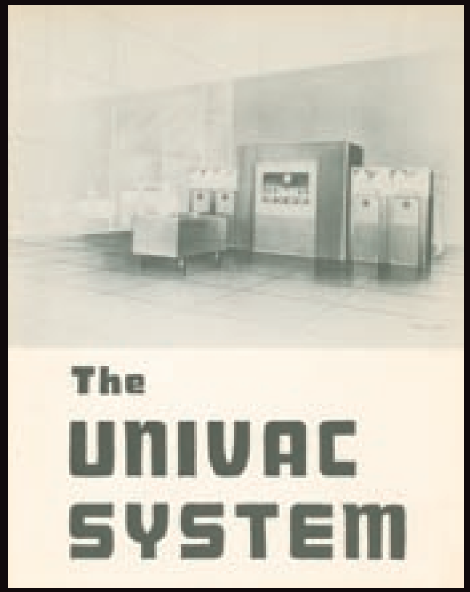
BUTTONED-UP COMPUTING // As is typical of the computer industry "life-cycle," by the early 1960s, many of the office products vendors had already left the business, including Underwood. The Control Data 160-A Computer brochure from 1962 markets the same computer for commercial and scientific uses while 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.

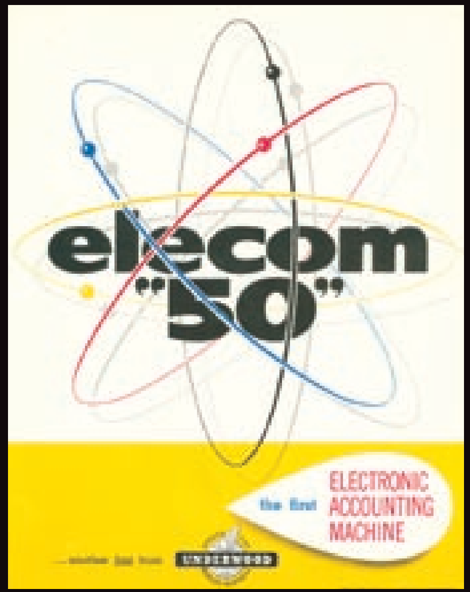
> Most important, the EAI 640 strikes a balance between the work it can do and the cost to do it. Simply stated, balance means value. The EAI 640 Digital Computing System offers the best value available in small scale computer systems.

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

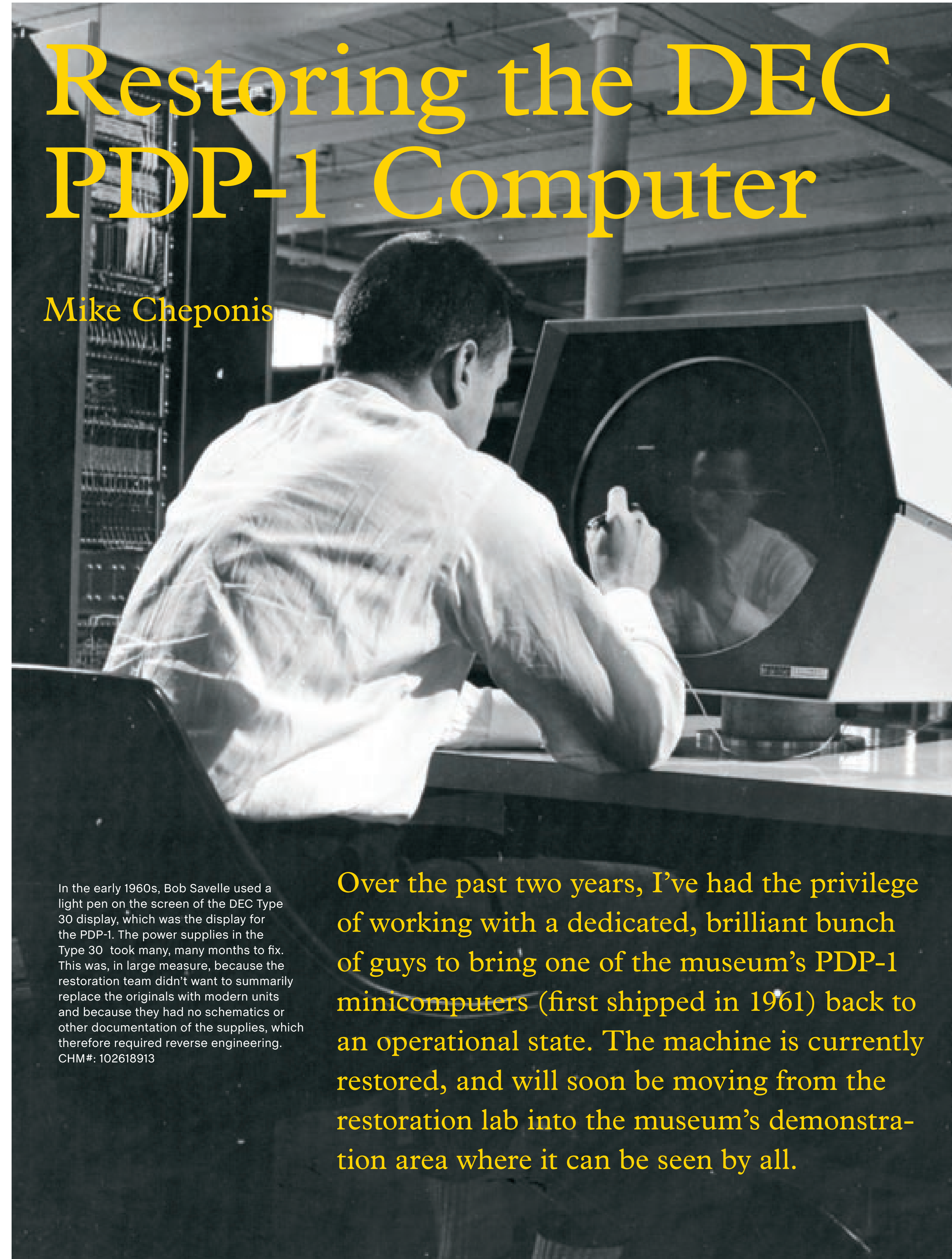
He Saw the Cat: Computer Speech, 45 RPM record
Date: 1963
Collection: Media
Donor: Gift of Warren Yogi
CHM#: X3119.2005

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!

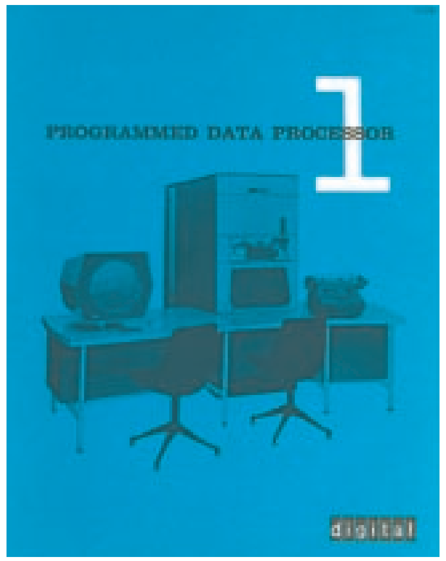
We decided to hold our restoration meetings on Tuesday evenings from 6-9 pm. We promised all that no matter how interesting or hopeful an effort might be, we would always be out of the lab by 10 pm. This scheduling and rule worked out quite well for this project.

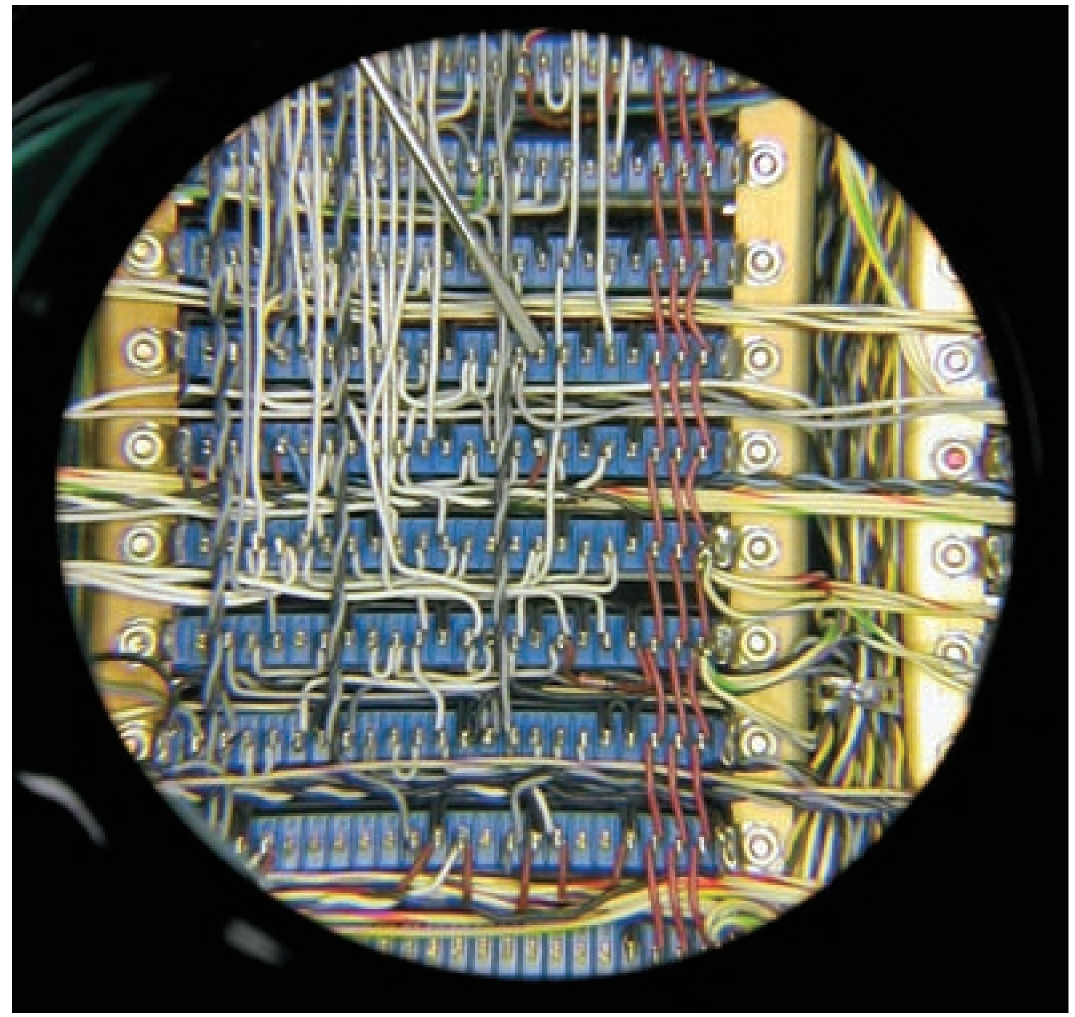
The team proceeded to do the things all restorations must do: Check and revivify the power supplies, inspect for missing or broken parts, replace dangerously frayed power cables, etc. In these early stages,

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.





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!

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.

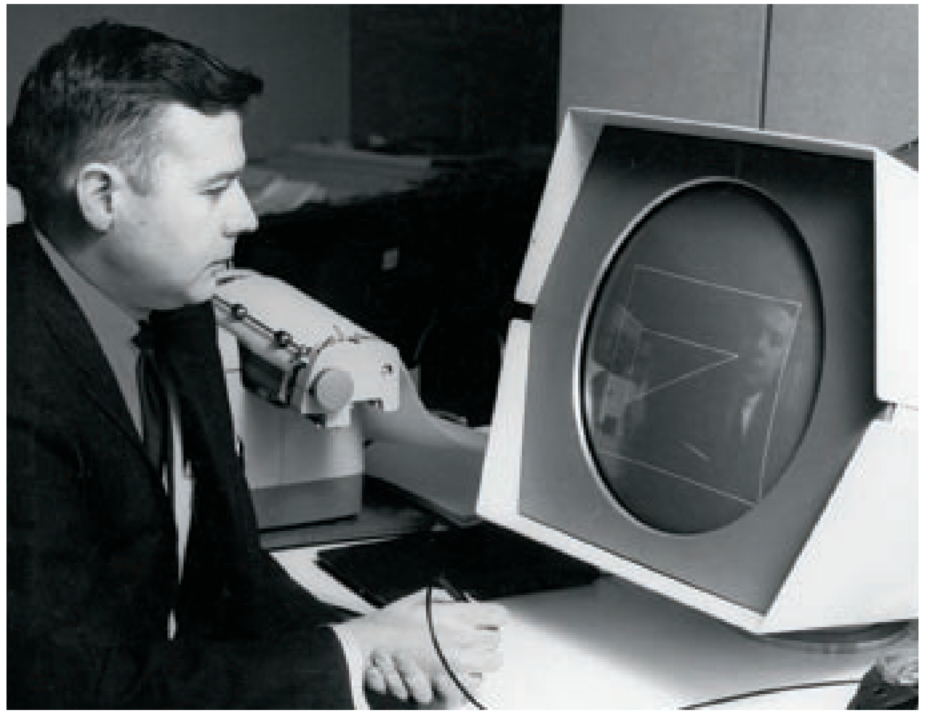
Naturally, the main reason for restoring the PDP-1 was to run the original computer game Spacewar!, which was written in 1962 in PDP-1 assembly language. We knew that having this program running and available to Museum visitors would bring back memories to old timers but would also help build a bridge 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 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

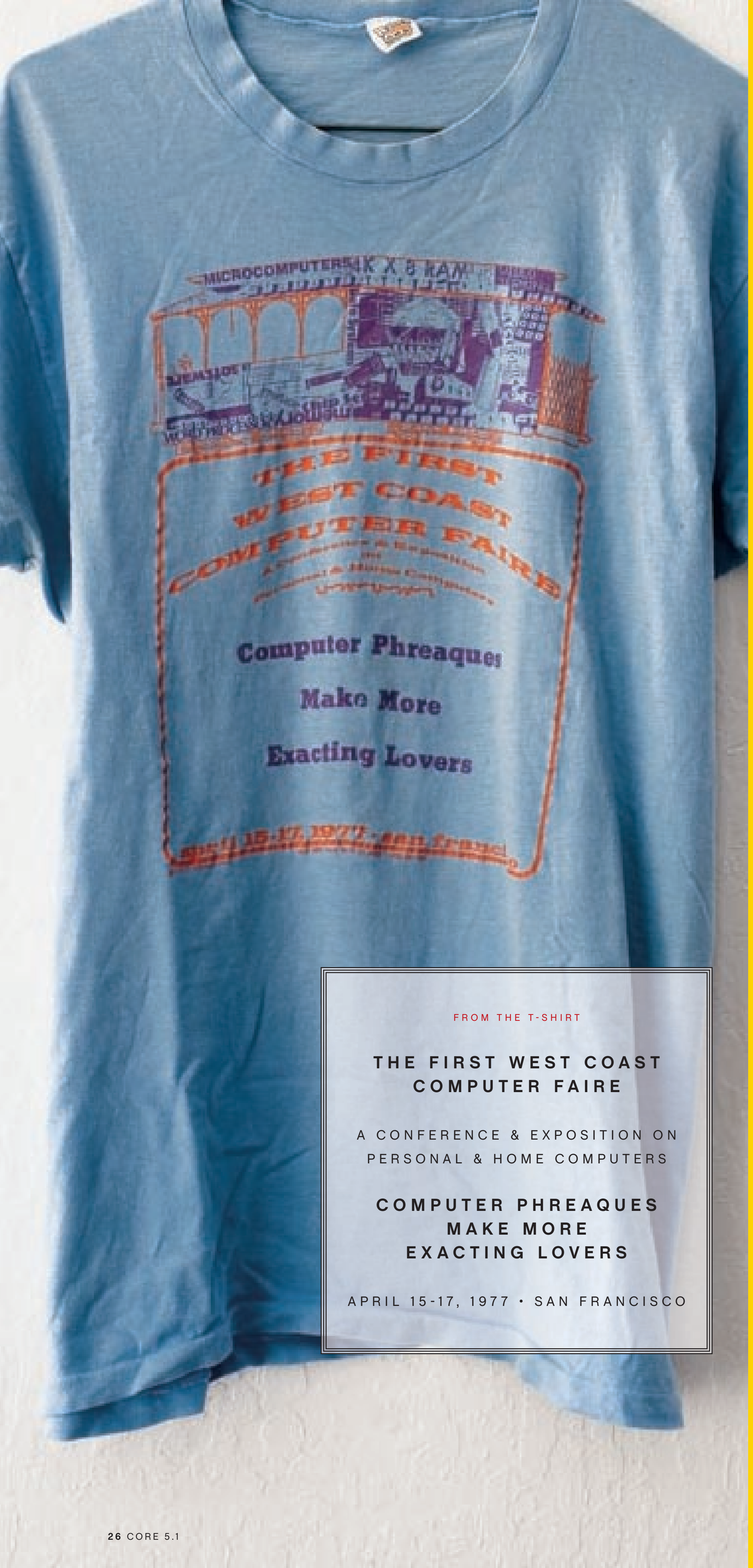
This story wouldn't be complete without mentioning some of the VIPs who have graced our PDP-1 since it became at least partially functional.

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.

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.

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.

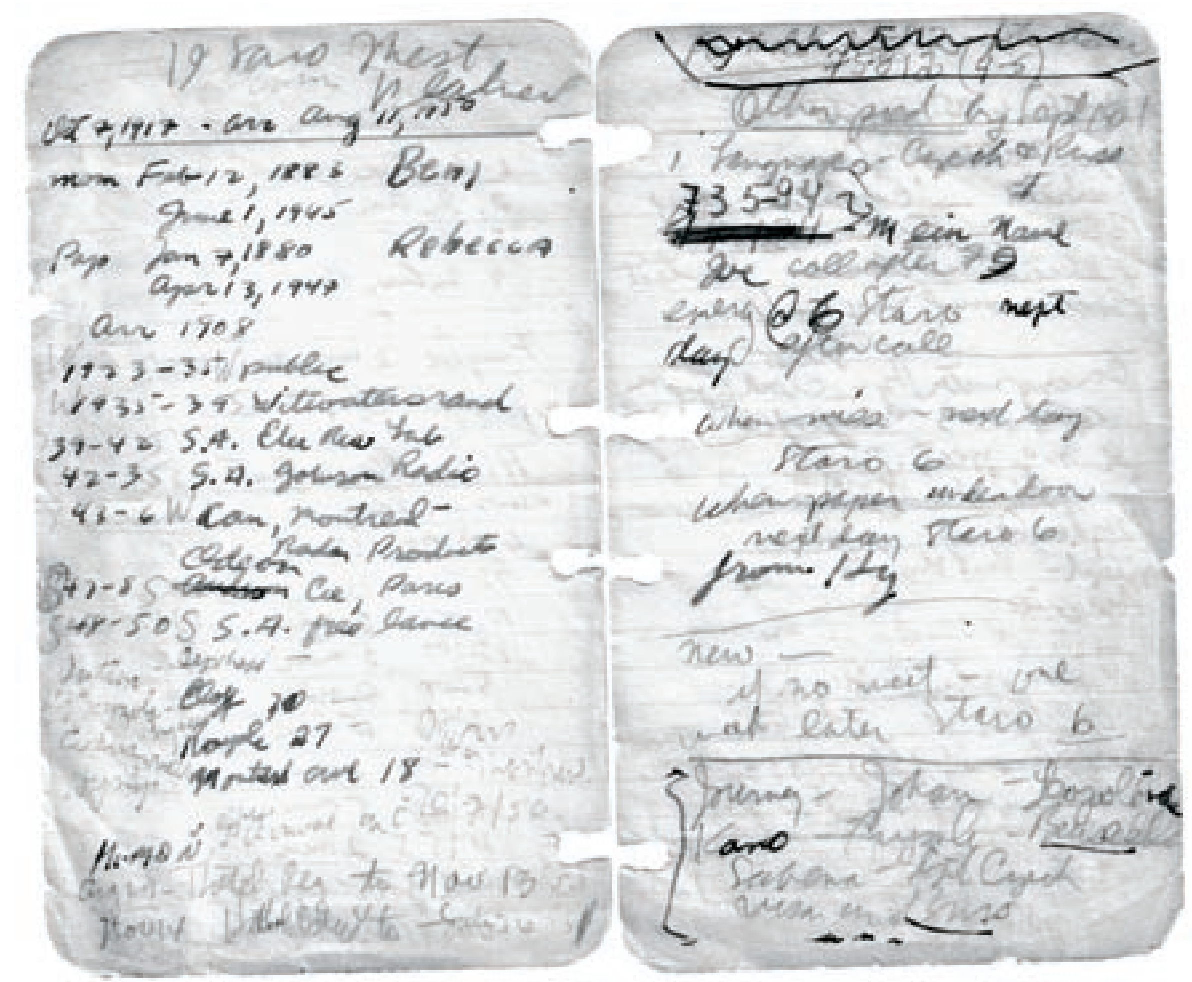
By June 1947 security procedures at defense contractors had tightened up a bit and Barr's employer, Sperry Gyroscope, contacted the FBI to ask about his reliability. A quick inspection of the Bureau's files revealed that he'd been fired as a communist five years previously. The FBI interviewed two of 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.



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.

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

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 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

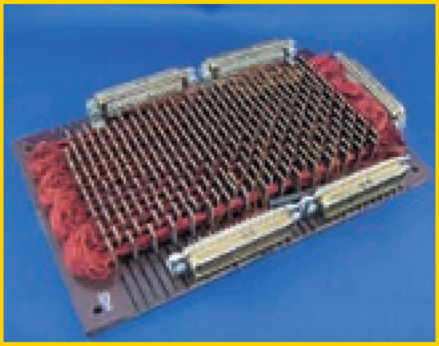
This is part of a Cray-3 supercomputer, a liquid-cooled machine that had a theoretical performance of 15 GFLOPS (billion floating point operations per second) and that used exotic gallium arsenide (GaAs), instead of silicon, for its circuitry. The Cray-3 was designed to be the fastest machine in the 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?



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Promotional materials and documentation for the IBM 705, 650, 702 and other IBM machines, X2609.2004, Gift of Martin M. Seldon

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PC software collection, X2783.2004, Gift of Dan M. Shaffer

Assorted books and journals on computing, X2584.2003, Gift of Joshua Shapiro

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