NOVEMBER 2000

CORE 1.4

A PUBLICATION OF THE COMPUTER MUSEUM HISTORY CENTER
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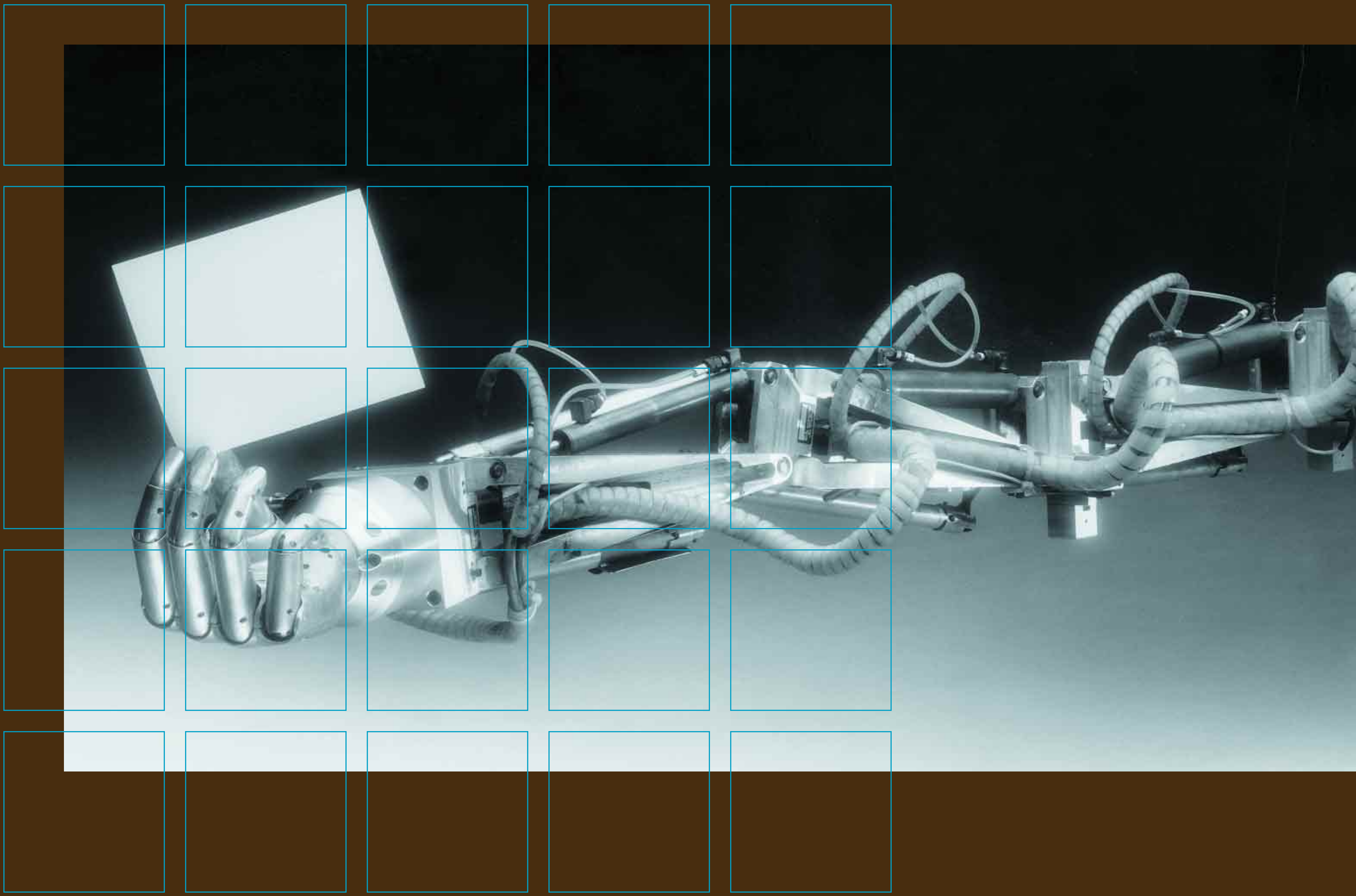


THE NEXT LEVEL

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

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

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

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

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

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

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

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

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

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

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

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

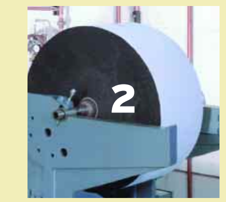
JOHN C TOOLE
EXECUTIVE DIRECTOR & CEO

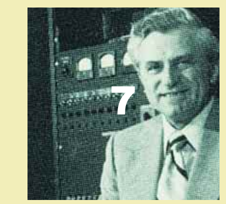
November 2000
A publication of The Computer Museum History Center

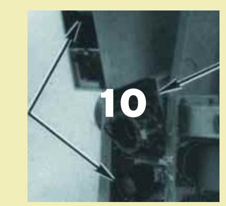
CORE 1.4

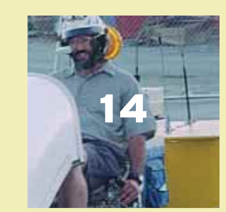
MISSION
TO PRESERVE AND PRESENT FOR POSTERITY THE ARTIFACTS AND STORIES OF THE INFORMATION AGE

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









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

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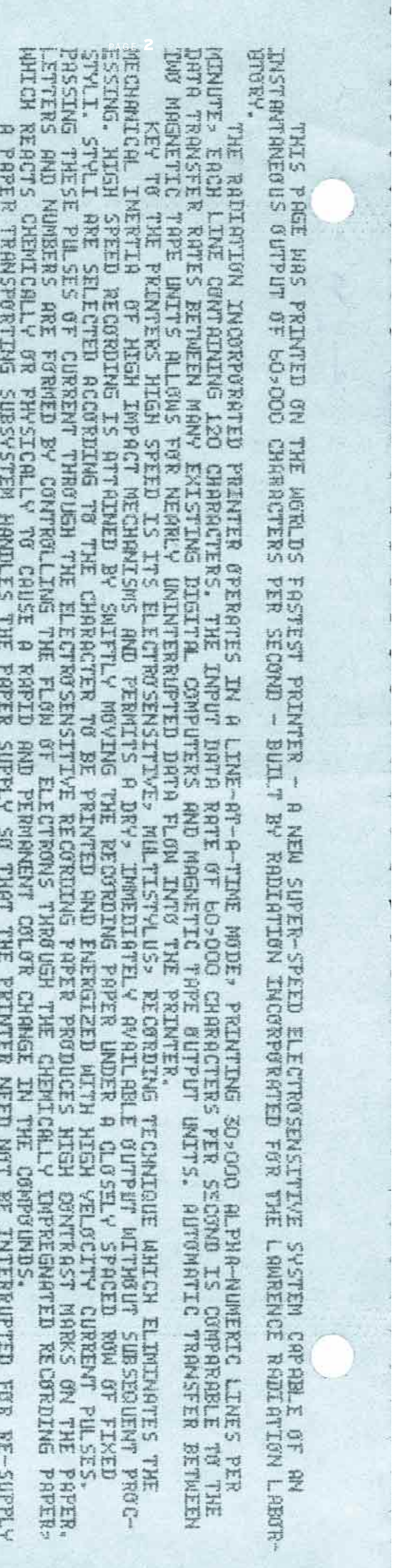

THIS PAGE WAS PRINTED ON THE WORLDS FASTEST PRINTER - A NEW SUPER-SPEED ELECTROSENSITIVE SYSTEM CAPABLE OF AN INSTANTANEOUS OUTPUT OF 60,000 CHARACTERS PER SECOND - BUILT BY RADIATION INCORPORATED FOR THE LAWRENCE RADIATION LABORATORY.

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

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

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

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

THE RADIATION PRINTER

GEORGE MICHAEL

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

ON-THE-JOB HEARING LOSS

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

THE GIRL WITH A CURL

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

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

THE RADIATION PRINTER

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

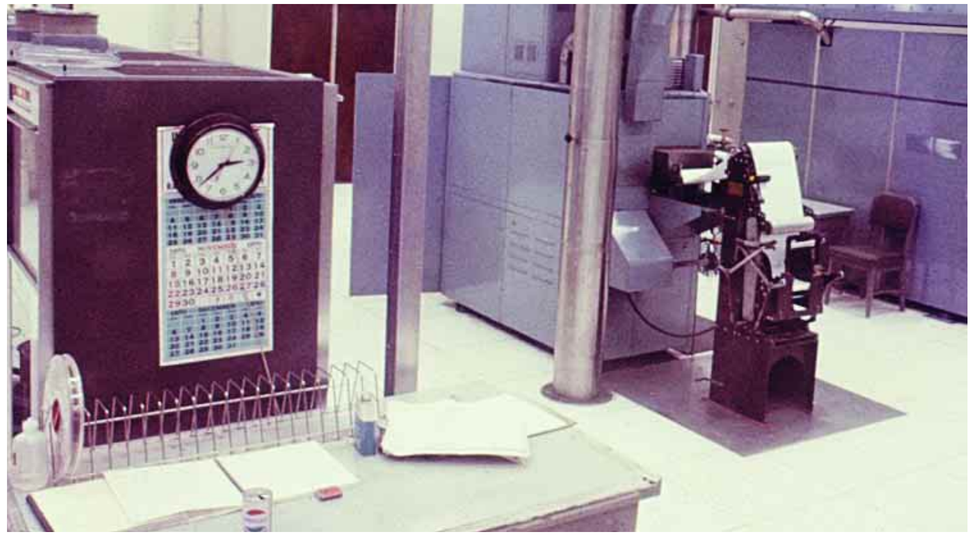
Two technologies came together in the Radiation Printer. First, the actual print process was based on an electrographic printing technology, and second, the process was wedded to a standard printing press that far predated the advent of computers, but was rugged and reliable. Before the arrival of computers,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

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

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

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

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



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

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

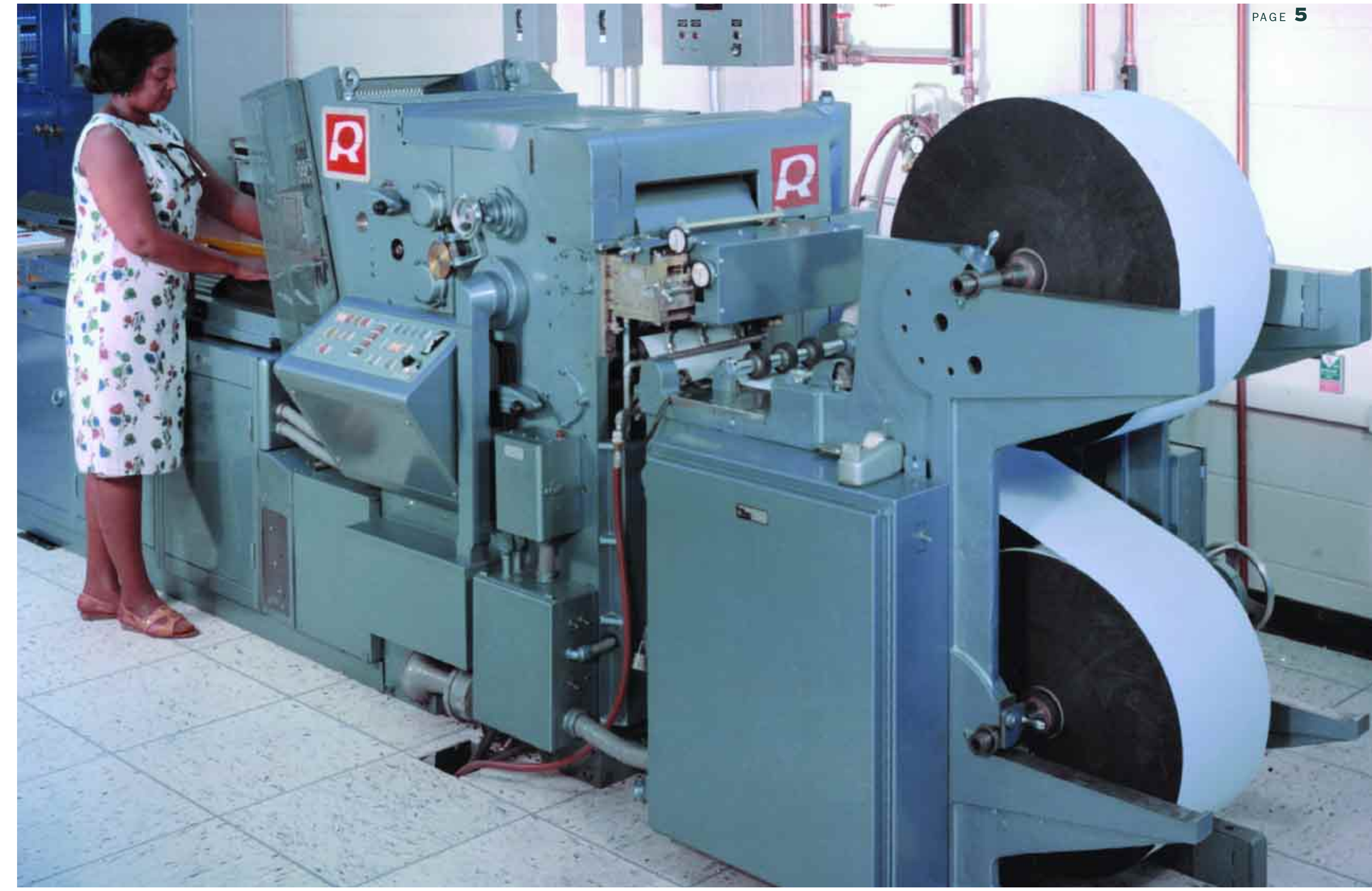
The printer had 600 styli arranged in 100 styli modules. The print area was about eleven inches in width, the page was 11 inches tall, and the images were not considered to be very high resolution. A traditional printing press was used to move the web past the styli. The procedure was dubbed "Revelation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

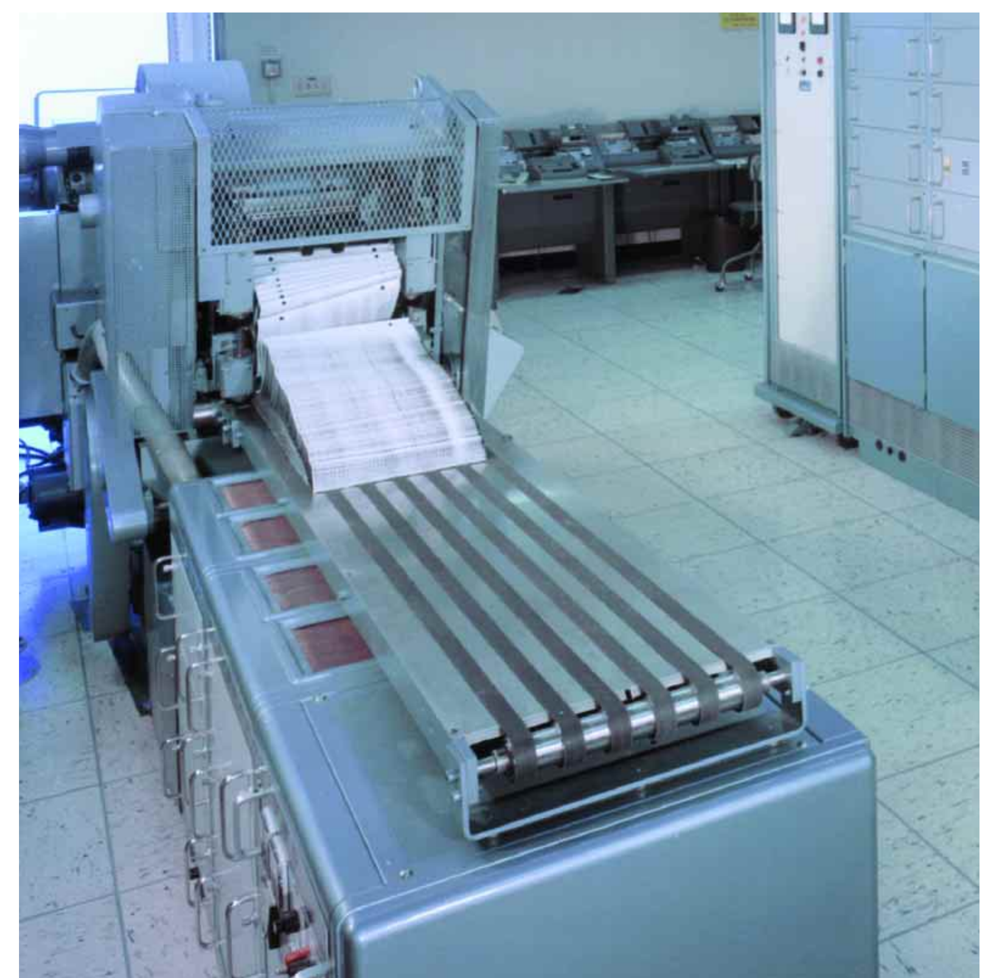
A few additional remarks seem to be in order. First, the Radiation Printer had nothing to do with radiation, but simply was named for the company that built the printer: Radiation, Inc., of Melbourne, Florida. The company modified a real (Hamilton) printing press and added the needed electronics and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

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

THE IMPLICATIONS OF SPEED

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





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

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

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

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

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

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

TABLE 3. A SUMMARY OF RADIATION PRINTER PERFORMANCE NUMBERS

PRINT TECHNOLOGY	ELECTROGRAPHIC, REVELATION
DATA SOURCE	MAGNETIC TAPE, UP TO 800 BPI; 75 IPS
CHARACTER RATE	UP TO 62.5 KCPS
PRINT RATE	7 PAGES/SEC; 4.3 MPH
PRINT SIZE	5000CH/PG

Table contents are partially extracted from several unpublished internal reports. The values are for comparison only.

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

The Radiation Printer was integrated into the normal operations of the computation department, and very quickly was producing around 40,000,000 pages per year. This was only about one-fifth to one-third of its capacity, which was a good thing. The machine could be taken down for emergency maintenance, and still very quickly clean out the entire print backlog when it was brought back on line. Later on during its tenure, some microfiche recorders were added. Their annual output quickly grew to about 130,000,000 pages distributed over about 1,000,000 pieces of fiche. The effect on the Radiation Printer was less than expected however: the annual output dropped to around 30,000,000 pages per year and stayed there. For most users, the fiche was used for long-term storage of the problem results, and output from the Radiation Printer was used mostly for day-to-day checking. When a project was finished, the paper was generally discarded.

CONCLUSION

The output from the Radiation Printer was not pretty. It was hard to read; the gray-on-black paper was heavier than ordinary paper; it had, for some, an undesirable odor; and it took up too much storage space. The users often referred to the output as “scunge,” but it met their needs, producing at the rate of seven pages per second. None of the printers that were brought in to replace it ever came close to this speed. However, as effective as the printer was, no one shed a tear when it was removed sometime during the late 1970s.

AFTERWORD

It’s always humbling and sometimes instructive to ask if anything was learned. There are several lessons available, though who learned them is not clear, nor is the question of whether the lessons have had any long-term positive effects. Somewhat in the spirit of a post mortem, here are some things that were learnable:

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

In the course of dealing with users of all sorts, we evolved an additional rule to help get through the day: Generally, if somebody doesn’t know what to do, don’t ask him.

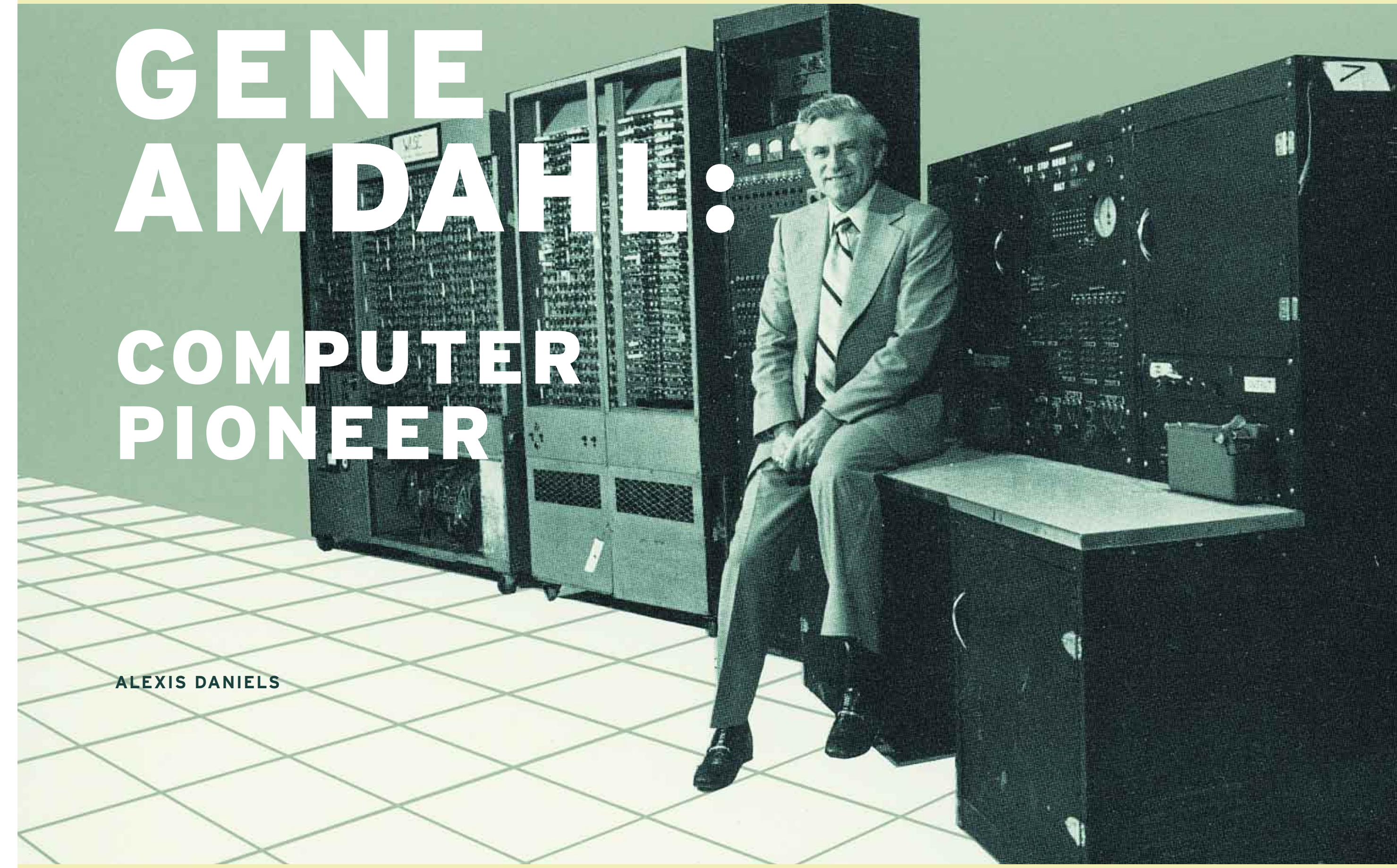
A NOTE ABOUT DATES: more precise dates may exist, but most official records appear to be in a state of flux. The dates used here are my best approximations.

George Michael began working as a physicist in 1953 at Lawrence Livermore National Laboratory (LLNL). Michael’s interest in computing and the physics of what you could do with a computer began with the arrival, one week later, of their first computer—a UNIVAC 1—and has continued ever since. He has been retired for seven years and is currently interviewing the people who built the original computing systems at LLNL (then called the University of California Radiation Laboratory—UCRL).

GENE AMDAHL:

COMPUTER PIONEER

ALEXIS DANIELS



Gene Amdahl’s WISC is currently on display at the The Computer Museum History Center’s Visible Storage Exhibit Area.

Recently, over several hours of videotaped interviews conducted by William Aspray, Executive Director of Computing Research Association, Gene Amdahl reflected on his professional experiences and documented the course of his amazing technical life. The following material condenses some of the story that was gathered.

Gene Myron Amdahl was born in Flandreau, South Dakota in 1922. Even though his father had only three years of schooling, the elder Amdahl knew the importance of education. When Gene declared his intention to go to South Dakota State to study engineering, his father encouraged him to get a liberal arts education instead, emphasizing that learning how to make a living was not as important as learning how to get the most out of life. Nevertheless, Amdahl went on to South Dakota State and accomplished both goals. Although he began as an average student, his performance changed dramatically when he took a physics course during the summer of his freshman year. He became consumed by a passion that not only altered the course of his life, but which later had a profound impact on the entire computer industry.

Although his undergraduate work was interrupted during World War II by a two-year stint in the U.S. Navy, Amdahl returned to South Dakota State and received his bachelor’s degree in engineering physics in 1948. He then began his graduate work at the University of Wisconsin with a thesis on “The Contributions to the Magnetic Moments of Heavy Nuclei Due to Spin Anti-Symmetry and Velocity-Dependent Forces.”

Meanwhile, he began designing computers on his own time. When the Electrical Engineering department heard about this “other” work, Amdahl was encouraged to build a computer that could be used to train graduate students in the emerging field of digital computing. The resulting computer, known as the Wisconsin Integrally Synchronized Computer (WISC), was designed in the summer of 1950, and submitted as Amdahl’s doctoral thesis in June 1951. His ideas were so innovative that the Physics Department felt unqualified to evaluate it and sent it to others for review and acceptance. His thesis passed the test, and Amdahl received his doctorate in theoretical physics in 1952.

After graduate school, Amdahl wanted to start a company building computers but he lacked sufficient financing. He interviewed with International Business Machines (IBM) and was hired, in part, because IBM was impressed with the quality of the writing in his doctoral thesis. Rather than the dry, technical style of most theses, Amdahl’s writing had a missionary’s zeal that engaged his readers. He accepted a position with IBM in 1952 and was the most highly-paid person in the history of IBM to be hired directly out of school.

In the fifties, the environment at IBM was one of innovation and excitement when new technologies emerging from

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

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

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

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

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

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

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

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

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

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

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

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

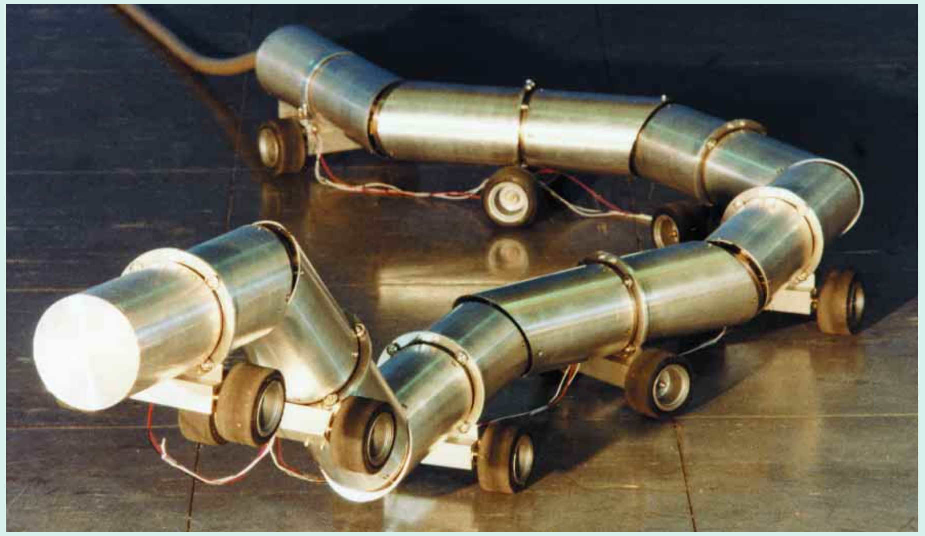
Ever in search of new challenges, Amdahl left Amdahl Corporation in 1980 and went on to establish three other companies: Trilogy Systems (now part of Elxsi Corporation), Andor Systems, and Commercial Data Servers (CDS). In 1991, The Times of London named him one of the "1,000 Makers of the 20th Century,"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

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

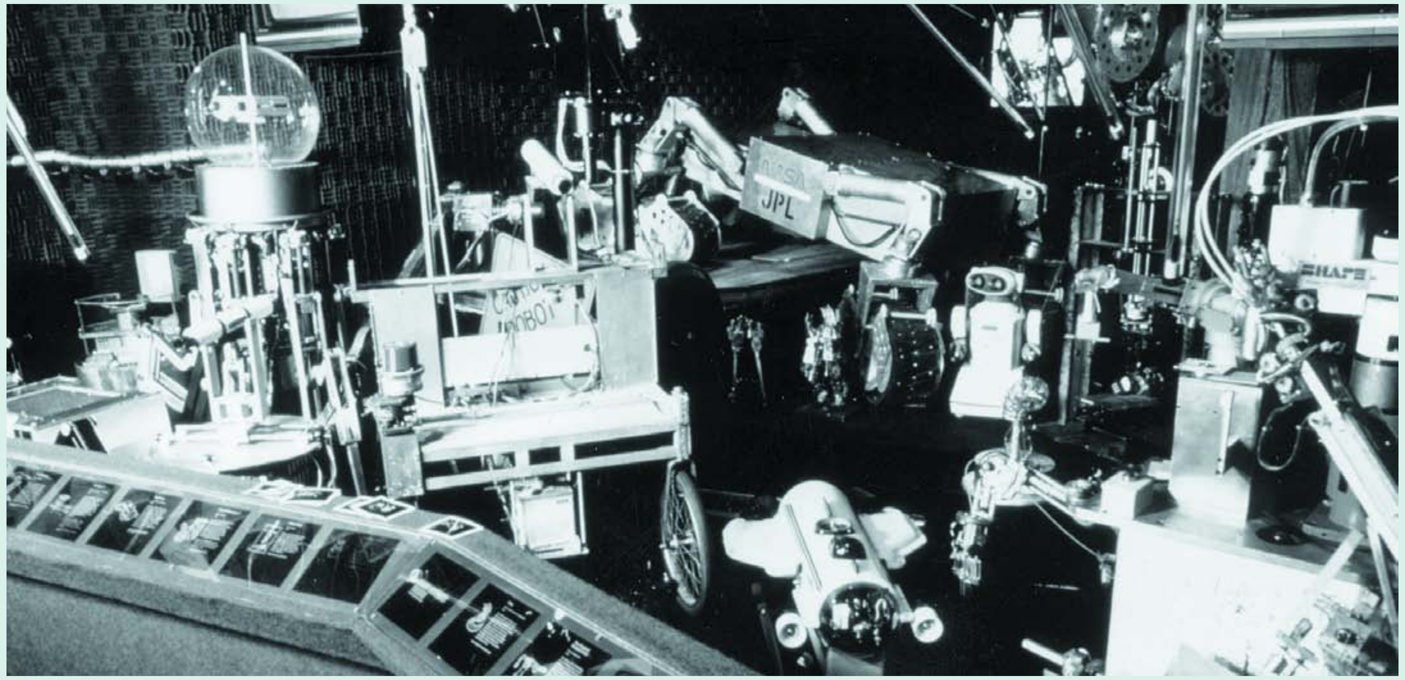
[1] Amdahl's Law states: "If x of a program is inherently sequential, the maximum attainable speedup is 1/x." Experience has shown this law to be fundamental to computer designs which incorporate multi-threaded kernels and parallelism.

FROM THE COLLECTION

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



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



ROBOTS ENTER VISIBLE STORAGE

CHRIS GARCIA

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

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

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

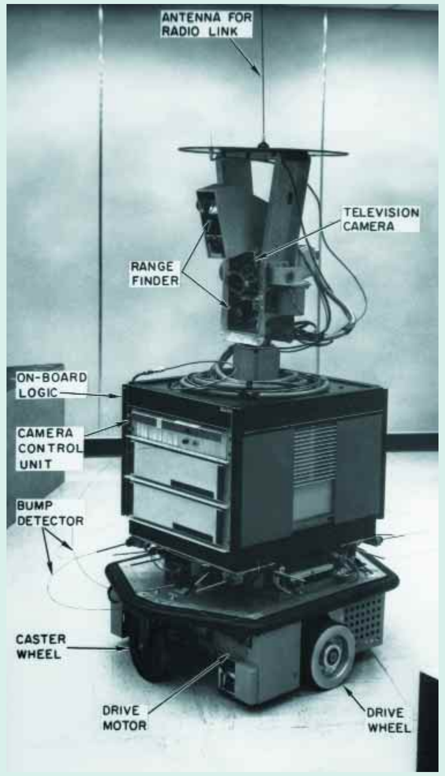
The collection also includes several important robot arms. The ORM (Victor Scheinman and Larry Leifer, 1965) was the first attempt at a computer-controlled arm. The ORM, whose name means "snake" in Norwegian, features seven metal disks sandwiching 28 inflatable air sacks. The method used to create movement—inflating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

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

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

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

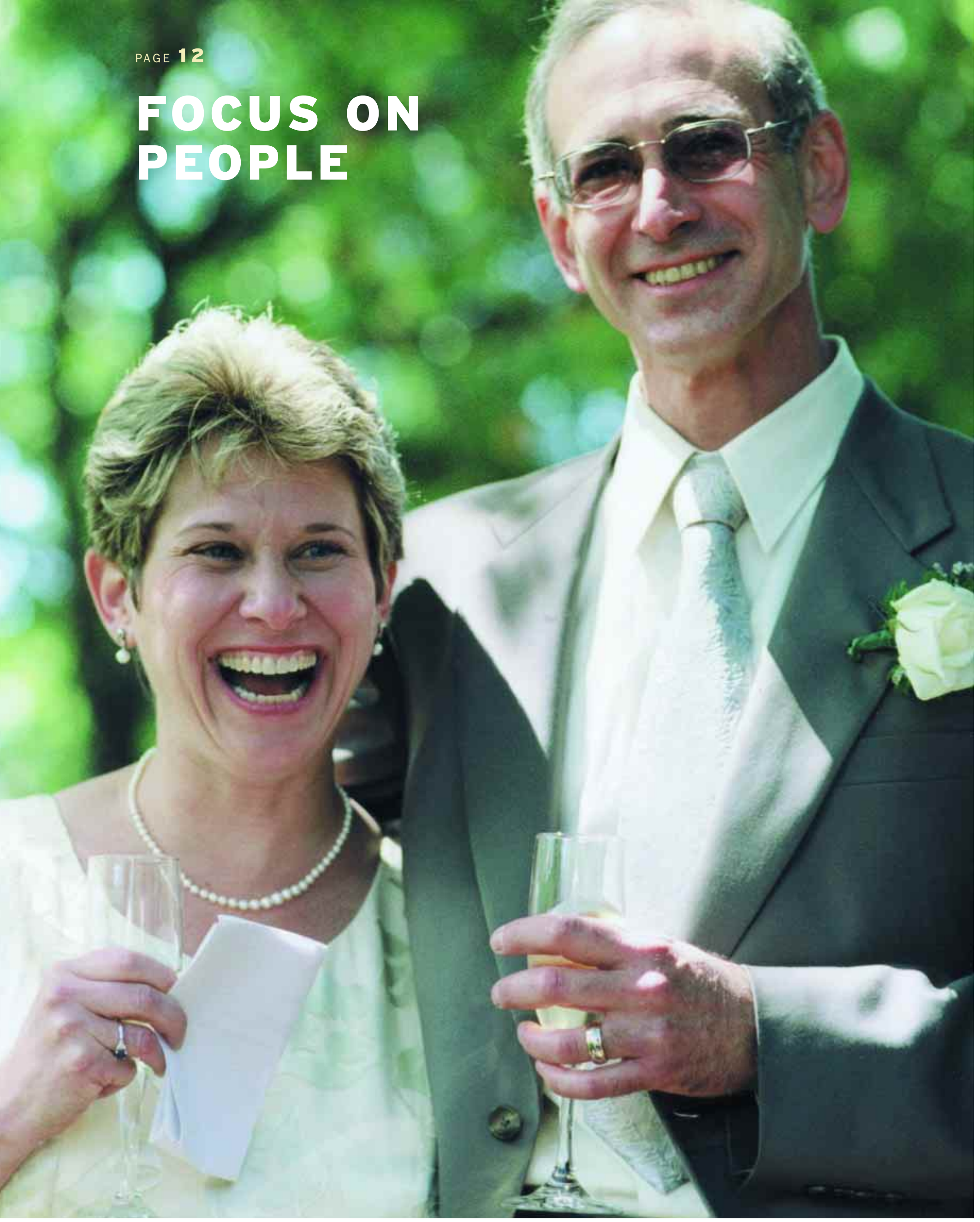
Chris Garcia is Historical Collections Coordinator at The Computer Museum History Center



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

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

FOCUS ON PEOPLE



LEN AND DONNA:

PARTNERS IN PHILANTHROPY AND LIFE

ELEANOR DICKMAN

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

REPORT ON MUSEUM ACTIVITIES

KAREN MATHEWS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

VIDEO COLLECTION EXPANDS WITH NEW RECORDINGS

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

Thomas Sterling on **BEOWULF**

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

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

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

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

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

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

WWW.COMPUTERHISTORY.ORG/STORE

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

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

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

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

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

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TO THE COMPUTER MUSEUM HISTORY CENTER COLLECTION

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

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

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

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

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

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

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

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

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

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

UPCOMING EVENTS

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

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

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

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

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

ATTENDING EVENTS AND TOURING THE COLLECTION

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

VOLUNTEER OPPORTUNITIES

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

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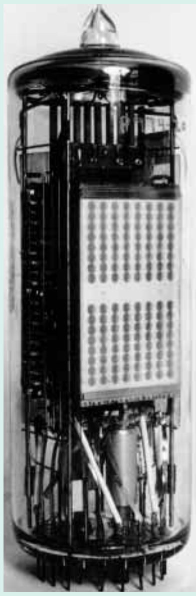
MYSTERY ITEMS

FROM THE COLLECTION OF THE COMPUTER MUSEUM HISTORY CENTER

Explained from CORE 1.3



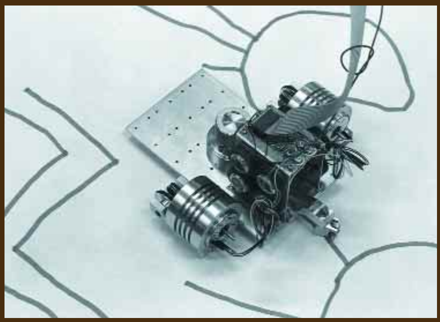
RCA Selectron Tube from JOHNNIAC, RCA (1953), XD215.80, Gift of John Postley

40 RCA Selectron tubes on Rand Corporation's JOHNNIAC Computer constituted the 256 word 40-bit memory of the machine. A Selectron tube consists of a large cylindrical vacuum tube with a thermionic cathode down the axis and a dielectric forming the curved surface; bits are written and read by a complex series of "holding beams" and a very precise mechanical alignment of internal circuit elements. The Selectron was designed by RCA's Jan Rachman in the early 1950s and saw limited use in the first generation of custom built computing machines such as the RAND JOHNNIAC. JOHNNIAC went operational for the first time in the first half of 1953 with 256 40-bit words of RCA Selectron Tube storage. The plans for the tube itself were scaled down from providing 4,096 bits per tube to 256, largely due to the device's inherent complexity and poor manufacturability. Nonetheless, Selectron memory was very reliable, once tubes were qualified and "burned-in." Later that year, RAND contracted with Telemeter Magnetics for the first commercially built core storage for the JOHNNIAC. The Selectron tubes were removed in 1954 in anticipation of the coming core storage replacement. In March 1955, the machine was back on-line with 4,096 40-bit words of magnetic core storage. This became the dominant form of computer memory for nearly the next thirty years, and the Selectron's brief lifetime as a memory technology came to an end.

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

WHAT IS THIS?

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



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

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