

Fact sheet

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Boston Opening November 14, 1984

Background In 1974, Ken Olsen and Bob Everett saved the MIT Whirlwind computer from the scrapheap. They determined a need to preserve the history of computers and in 1982 founded The Computer Museum as a public, non-profit organization with a board that included 16 other industry leaders. It is the world's only museum devoted solely to computers and their impact on society. The Museum has the most comprehensive collection of historical computers and robots in the world.

Facilities 53,000 square feet; 6 exhibition galleries; 275-person auditorium (3,200 square feet); Museum Store.

Annual Operating Budget \$1.5 million. Income sources: donations-45%; memberships-18%; admissions-16%; Museum Store-11%; functions-8%; other-2%.

Audience 100,000 visitors/year (40% students); over 1 million served through traveling exhibits.

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Members 2600 individual from 45 states and 13 countries; 142 corporate members worldwide.

Museum Hours Winter: Tuesday through Sunday, 10am to 5pm, Fridays until 9pm; Summer: daily, 10am to 6pm, Fridays until 9pm.

Admission \$6.00 for adults; \$5.00 for students and seniors; free for Museum members. Half price Friday 5-9pm. Group rates by arrangement.

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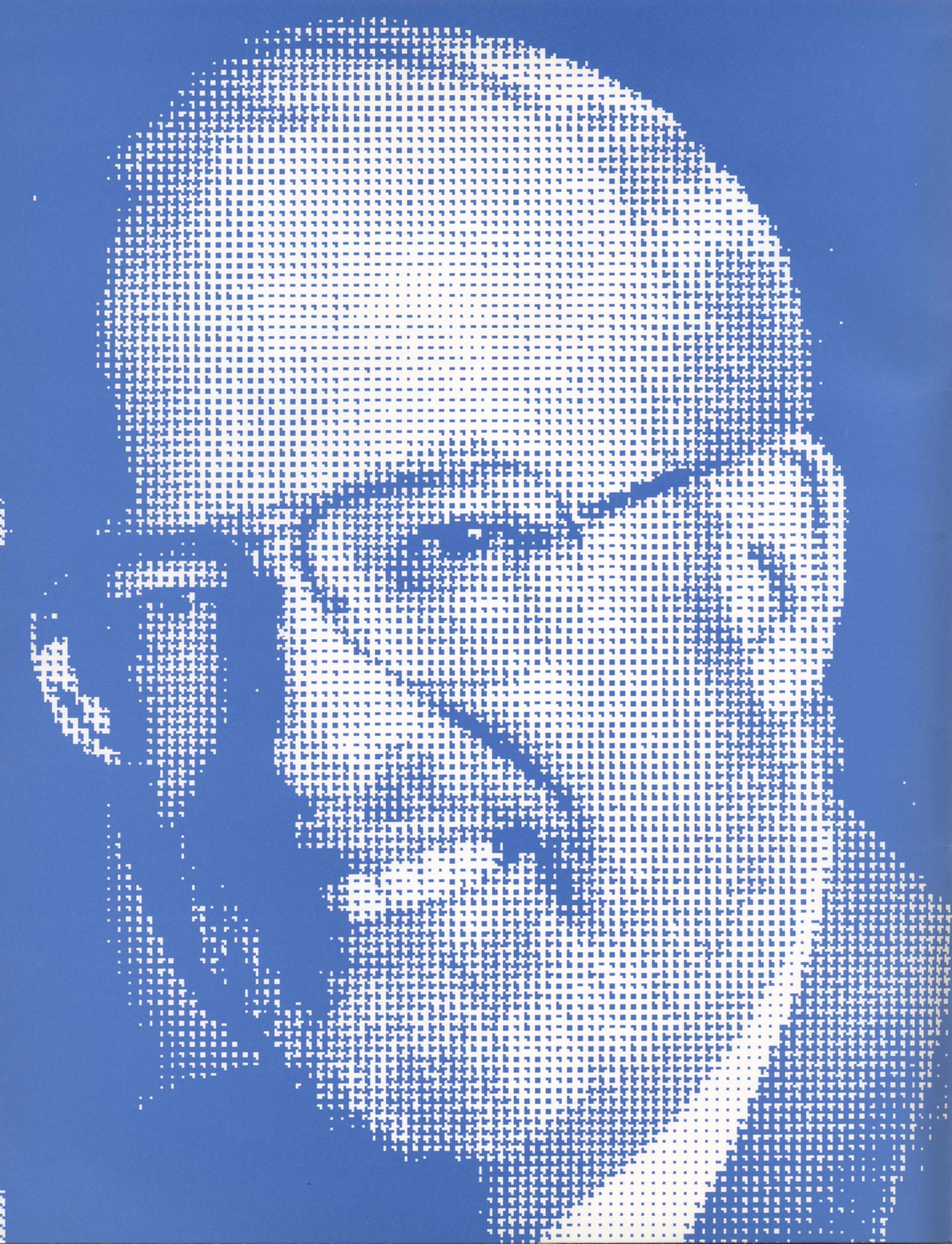
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The Museum's mission is threefold:

- To educate and inspire all ages and levels of the public through dynamic exhibitions and programs on the technology, application, and impact of computers;
- To preserve and celebrate the history and promote the understanding of computers worldwide;
- To be an international resource for research into the history of computing.



from the Chairman

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The 1989 fiscal year ended just after our Annual Meeting in June. It was a year marked by a significant strengthening of the Museum's management and governance. At the beginning of the fiscal year, Adeline Naiman, a well known figure in computer education, joined the Museum as Director of Education. In March, Janice Del Sesto was named Director of Development and Public Relations.

In addition, a number of new Board Members were added which broadened our representation in both the business community and the computer industry. C. Gordon Bell of Stardent Computer, Lawrence S. Brewster of Aspen Technology, Richard Case of IBM, Seymour Papert of MIT, Anthony Pell of Pell, Rudman, Robert Shafto of The New England, and Casimir Skrzypczak of NYNEX all joined the Board. August Klein and Carver Mead moved on to become Trustees.

Unfortunately for the Museum, Joe Cashen, our Executive Director, informed us in March that he wished to leave to pursue other interests. A committee was

formed to search for a successor.

The Exhibit Planning Committee completed its recommendations for the development of the remaining space in the Museum. It settled on four major exhibits to be developed over the next few years. The first, The Walk-Through Computer, will help provide insight into how computers work. Milestones of a Revolution will offer a coherent history of the development of computers by focusing on nine major steps in their development. A Computer Discovery Center will attempt to demystify personal computers for the general public and show what they can do and how they do it. The Networked Society will focus on the behind-the-scenes ways in which computers impact our daily lives.

In the area of collections, our biggest successes include the rescue of the Johnniac from its outdoor storage location in Los Angeles and acquisition of the 1970s operational Superpaint computer built at Xerox PARC.

Probably the most exciting event of the year was the first Computer Bowl which pitted

celebrity teams from the East and West against each other in a test of knowledge about computer trivia. Led by a remarkably quick-witted Mitch Kapur, the East won the contest. However, the West vowed to recoup their honor in the Second Bowl in April 1990. In addition to being fun for all who participated, both contestants and audience, it raised over \$450,000 in cash, products and services for the Museum.

This is the Museum's fifth year at its downtown location as a public institution. I think we have made significant progress in our goal to expand both the audience the Museum serves and the base of support locally and nationally which makes such an institution possible. However, much remains to be done if we are to achieve our ambitious exhibit, collecting, and educational program goals. We thank the many individuals, corporations, foundations and government agencies who have supported us and look forward to adding new friends in the future.

Gardner Hendrie

the Year in review

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A dominant focus this year was computer-generated art and graphics. Six interactive graphics stations joined the Image Gallery. Fall brought a dazzling exhibit of SPOT satellite imagery.

During school vacation weeks, local artists demonstrated their original techniques, and some participated in our annual Kids Computer Fair. A high point was the SIGGRAPH '89 Art Show, now traveling to other museums.

A new Resource Center provided state-of-the-art educational materials for visitors to try. Build Your Own Robot workshops brought in adult-child teams and many volunteers for a shared experience. These are only a few of the ways in which The Computer Museum fulfilled its mission of reaching out to visitors far and near.



JULY 1988

July 2-4 - The Computer Animation VideoFest

July 13-August 31 - Pilot PC Resource Center

AUGUST 1988

August 15-November 15 - Imagine: Art With the Macintosh



JANUARY 1989

January 14-16 - SIGGRAPH Festival
The public premiere of the 1988 SIGGRAPH film show

FEBRUARY 1989

February - New exhibit software shows visitors how core memory works

February 20-23 - Second Build Your Own Robot, Logo, Computer Playspace, and Dancing Trees workshops

February 25-26 - Fourth Annual Kids Computer Fair introduces entertaining educational software via special interactive exhibits, demonstrations, resource table, and Robot Playpen

SEPTEMBER 1988

OCTOBER 1988

October 7, 1988 - The East Coast wins the First Computer Bowl

October 30 - Robert Abel, Odyssey Filmmakers: **The New Age of Computers: Life in the Hypermedia Fast Lane**



NOVEMBER 1988

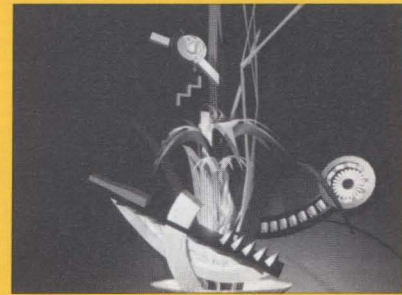
November 6 - Thomas A. DeFanti, Electronic Visualization Laboratory, University of Illinois: **Computer Graphics And Beyond: The Viewer As Participant.** The opening of The Interactive Image adds six state of the art graphics workstations to the Image Gallery

November 29 - Terra Firma in Focus: The Art and Science of Digital Satellite Imagery opens

DECEMBER 1988

December 26 - First Build Your Own Robot workshop

December 26-31 - The Computer as an Artist's Tool educational program features Boston artists working in their media to create dramatic new images



© 1988 Hiroshi Kamoi

MARCH 1989

March 5 - Jean-Claude Risset, Directeur de Recherche, Centre National de la Recherche Scientifique: **Computer Sound Illusions: A Musical Resource For Now and the Future**



APRIL 1989

April 1-30 - Treasures Within Your Reach introduces visitors to online services from Prodigy Services Company, CitiNet, and CompuServe

April 16 - Third Robot-Building workshop

April 27 - During National Science & Technology Week, Museum joins all-day "hands-on science museum" for Congress on Capitol Hill, sponsored by the Association of Science-Technology Centers (ASTC)

April 29-30 - John Lasseter's 1989 Academy Award winner "Tin Toy" highlights SIGGRAPH Festival

MAY 1989

May 14 - With the New England Computer Arts Association, the Museum sponsors Creativity in the Computer Arts: A NEWCOMP Symposium, funded in part by the Mass. Cultural Council and the National Endowment for the Humanities

JUNE 1989

June 16 - New Resource Center opens in time for National Educational Computing Conference and features computer-based instructional software and hardware for teachers, students, and parents

June 30 - Computer Art in Context: SIGGRAPH '89 Art Show opens, setting visitor record for July and August and featuring over 50 2-dimensional works, installation pieces, animation, and moving sculpture from around the world, sponsored by the Association for Computing Machinery's Special Interest Group for Graphics and Interactive Techniques (ACM SIGGRAPH)



The Computer Museum is in an exciting but critical stage in its development. In 1988-89, we worked hard on two fronts—to raise money for new exhibits and to place the funding of the Museum's day-to-day operations on a more secure footing. We have made great strides, and as we move into the 1990s, we face the challenge of building an endowment and purchasing the space in which we are housed.

Support from more than a hundred corporations and over a thousand individuals financed the "contributions" portion of the Museum's revenues. We are working to expand our circle of supporters, especially into the growing community of computer users.

The Museum Store and functions business grew significantly. For the first time in several years, our store has made a profit, owing to improvements by its able new manager, Christina O'Sullivan. Functions, the rental of our space for luncheons, dinners, receptions, and press conferences, continues to grow under Kathy Keough. Over 75 events, including several with more than a thousand people, brought an additional 12,000 visitors into the Museum.

In March, Janice Del Sesto joined our staff as Director of Development and Public Relations. With over a decade of fundraising and public relations experience, including our own Computer Bowl, Janice brings a great deal of wisdom and focused energy to the Museum. With the Board and newly formed volunteer committees, she has greatly accelerated our fundraising and increased international media coverage of the Museum.

The five-year plan created in 1988 for the refurbishment of Museum galleries with dramatic new exhibits has been converted into a master plan for implementation from 1989 through 1993 by Richard Fowler. Fowler, a designer on sabbatical from Britain's National Museum of Film, Photography and Television, will also design The Walk-Through Computer in the first phase of implementation.

A desire by other museums to develop computer-based displays led us to formalize a program for the distribution of our exhibits as "kits" under the direction of Dan Griscom, our able Exhibits Engineer. Contracts were signed with two Museums for five different exhibits. In addition, we prepared a proposal for seed money to fund this program.

Adeline Naiman, who joined us in August 1988, organized a first-rate education advisory committee. Individuals not only participate on overall educational planning but on the task forces for the planned exhibitions and programs.

Some highly significant artifacts were added to the collection, including Superpaint, the innovative graphics computer built at Xerox PARC in the early 1970s, and Johnniac, one of the pioneering computers from the 1950s.

The Computer Museum is the first, and remains the only, museum of its kind in the world. It attracts visitors from all over the country and abroad and reaches distant populations with traveling exhibits and exhibit kits. This year's *Annual* is testimony to a strong, devoted staff and an incredible cadre of volunteers committed to serving our diverse public. With your ideas and support, the Museum can bring exciting new exhibits and special programs to local, national, and international audiences and inspire millions of people with the extraordinary potential of computer technology.

Oliver Strimpel

computer **A**rt in context

The Computer Museum opened "Computer Art in Context: SIGGRAPH '89 Art Show" on June 30th for a six-month stay. This show was a juried exhibition featuring more than 50 computer art works from around the world. It represented some of the finest work being done in computer art today and offered a new perspective on art-making,

involving exciting new applications of computer technology.

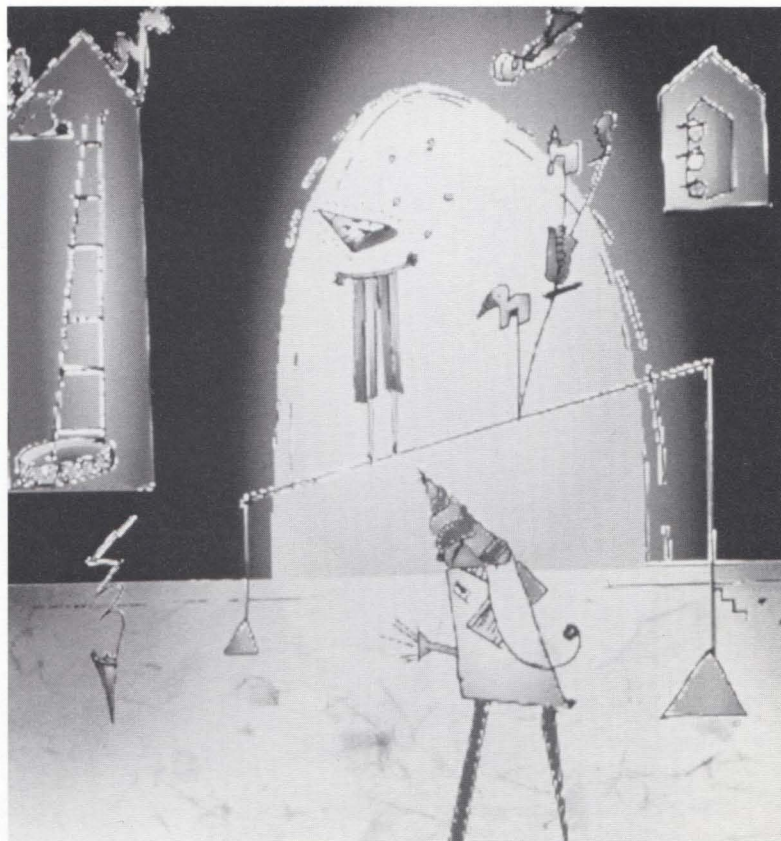
The work varied in approach, method, concept, and format, but the computer was used as a creative tool in every case. Unlike some of the previous shows, the art (rather than the tool) was the focal point. The work ranged from the traditional computer tool, pen-plotter output, to the traditional art forms,

such as a sculptured bronze whose shape was formulated by mathematical computation.

"Computer Art in Context" was the occasion for a unique collaboration among The Computer Museum, which offered a public venue for the art show, the professional meeting of the Association for Computing Machinery's Special Interest Group on

Nancy Freeman

All Sisters, Small Change © 1989



Barbara Joffe

Circus

cibachrome print 30" x 70", © 1989

collaborator: Computer Arts Institute,

Scans

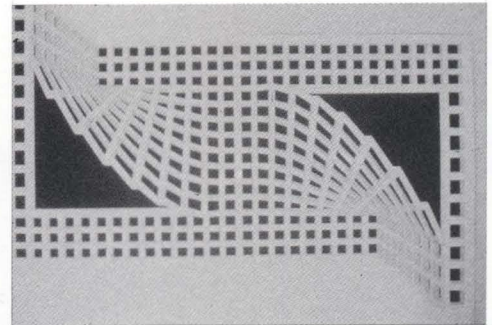
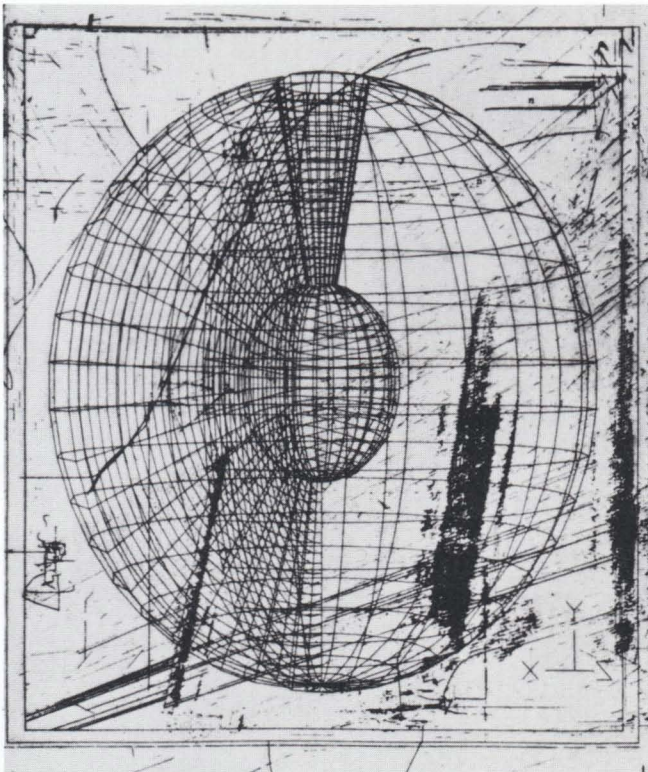
Computer Graphics (ACM SIGGRAPH), and *Leonardo*, the Journal of the International Society for the Arts, Sciences and Technology, that produced the catalog.

The SIGGRAPH conference, held in Boston in 1989, is a professional conference that supports an art show for its attendees. In addition, traveling exhibits derived from the show were created in 1983, 1985, and 1987. Last summer's opening at The Computer Museum was the first

opening of the SIGGRAPH Art Show to the public and to the critics.

The catalog of "Computer Art in Context," published by *Leonardo*, includes full-color reproductions of all the work in the show and fourteen articles that provide the intellectual environment for the pieces. Roger F. Malina, *Leonardo* Executive Editor, prepared an article that traces the debate over the significance of art using computers through twenty-two years of the publication of the

magazine. He concludes: "There is also a need for a new generation of art theorists and art historians to develop the critical and historical context within which the significance of individual computer artworks can be assessed. These theorists and historians should pay particular attention to art that could not have been made without the use of a computer and that exploits the unique capabilities of computers, electronics and telecommunications systems."

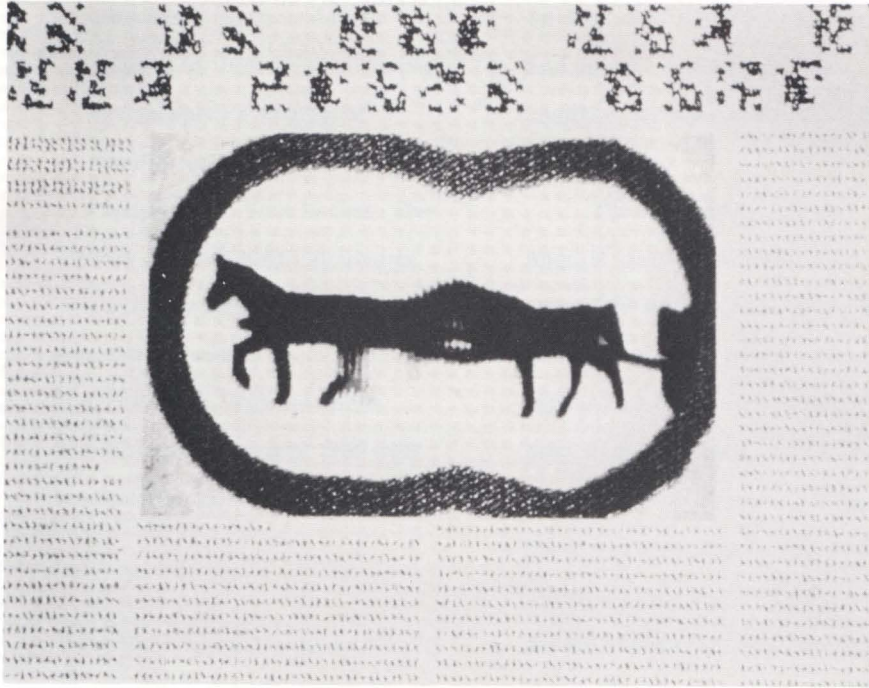


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Daniela Bertol

Bending and Twisting; Hypothesis #3,
© 1988

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Steven Herrstadt

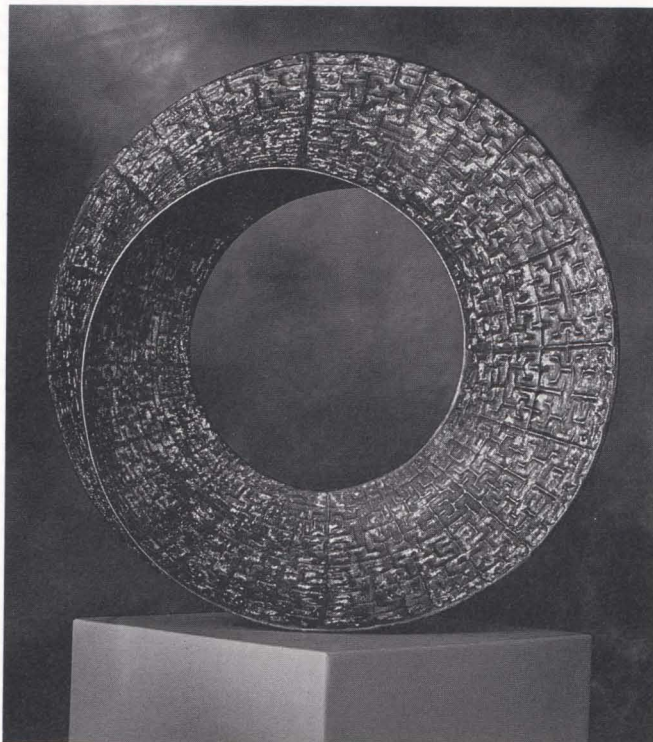
Global Pillage
© 1989



Brian Reffin Smith

Horse Text Piece

©1988



Helaman Ferguson

Umbilic Torus NC,

Silicon bronze, 27 x 27 x 9 in, ©1988

Collaborators: Paul Oliphant-programmer,

Kent Kokohnen-Manufacturing engineer.

Computer Aided Manufacturing Lab.,

Brigham Young University. Casting by

Wasatch Bronze works, Lehi, Utah.



In keeping with its worldwide mission, in 1988 the Museum began to implement a program of traveling exhibits. The first one, **Computers in Your Pocket: The History of Hand-held Calculators**, will travel through 1990. The second one, **Terra Firma in Focus**, opened at the Museum in 1988 and began traveling in the spring of 1989 with continuation through 1991.

COMPUTERS IN YOUR POCKET

This exhibit has not stopped traveling since its August 1988 debut at The Science Museum of Virginia in Richmond. Circulated by the Smithsonian Institution Traveling Exhibition Service (SITES), its itinerary includes 13 museums and science centers across the United States and Canada.

The exhibition, funded by Hewlett-Packard, has been "very popular," according to Betsy Hennings, SITES Project Director. It is a "wonder-

ful demonstration of how real artifacts and interactive displays can be combined so that people can do and learn."

The collection of rare and unusual calculating devices from around the world chronicles the basic human need to count and remember with tools one can carry. It includes more than 60 artifacts, eight interactive elements, and one video. Among them: the oldest mechanical pocket calculator, designed by Englishman Samuel Morland in 1666, Napier's Bones (1617), and the first scientific hand-held calculator, the HP35 (1972).

TERRA FIRMA IN FOCUS

This exhibit opened on November 29, 1988, at The Computer Museum, with the sponsorship of the SPOT Image Corporation, The Analytical Science Corporation, and Digital Equipment Corporation. The exhibit highlighted scientific applications of remote

sensing with large-scale black-and-white and color images taken by the SPOT satellite.

Based on the organization of the Museum exhibition, a 63-image set was selected to travel under the auspices of the Association of Science-Technology Centers (ASTC), Washington, D.C.

The traveling exhibit was booked to open at the Space Coast Science Center, Melbourne, Florida, and travel through 1991.

For information about either exhibit, call Gail Jennes, The Computer Museum, 617-426-2800.

enhancing the **G**raphics gallery

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In 1984, "The Computer and the Image" was opened as a gallery to show how computers are used to manipulate images (image processing) and create synthetic images (computer graphics).

The arrival in Boston of the prestigious computer graphics conference of the ACM SIGGRAPH in the summer of 1989 provided the impetus to enhance this gallery. Three exhibits, running since 1984, and the film show were retired. Ten new hands-on interactive stations, a giant plot of a silicon chip, and a new show in the Animation Theater were installed.

The addition of the giant plot of a silicon chip realized a part of the original gallery plan never before implemented. Advanced Micro Devices specially produced a full-color 11-by-11-foot plot of their 29000, a highly sophisticated microprocessor.

"The Interactive Image" is a set of hands-on exhibits developed by the Electronic Visualization Lab at the University of Illinois, Chicago. Using an artistically designed video game-style interface with buttons and a joystick, visitors learn how to create computer-animated movies, generate kaleidoscopic patterns, process images of their own faces, and discover the

beauty of the Mandelbrot Set and plant-like forms called graftals.

A highly informative new program on the rendering of three-dimensional objects was developed to our specifications by Hewlett-Packard. Visitors use knobs (with instant response) to swivel, zoom into, and illuminate the classic test object — a teapot — rendered by progressively more realistic methods, from wire-frame to smooth shading and ray-tracing.

Real-time realistic images can also be explored on a Titan computer from Stardent Computer. In one example, visitors control the speed and direction of simulated wind. They see, in real time, how a simulated flag responds to the effect of the wind on the flag as it flaps in the breeze. Such computer analysis would have been unthinkable on anything less than a supercomputer when the gallery opened in 1984!

New exhibits on flight and driving simulation offer exhilarating experiences for visitors. On an IRIS workstation donated by Silicon Graphics, visitors pilot a 747 over a synthetic mountainous terrain. And the Atari Games' "Hard Drivin'" simulator (on loan until spring 1990)

actually mimics the force of the road on the steering wheel as the driver rounds a curve. The coupling of 3-D computer graphics (the view looking through the windshield) with mechanical feedback adds a compelling new dimension of realism to the simulation.

Perhaps the most practical new exhibit is "Design a Deck" from Innovis Interactive Technologies. Visitors use a computer and trackball to design a house deck complete with steps, railings, and flooring. The exhibit is a customized version of a system that is in widespread use in home-improvement centers.

The enhancement of "The Computer and the Image" was made possible, in part, by grants from the Association of Computing Machinery's Special Interest Group on Graphics and Interactive Techniques (ACM SIGGRAPH) and the National Computer Graphics Foundation.

Oliver Strimpel

Exhibit planning

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The Museum has embarked on a major phase of new exhibit development. When our plans come to fruition, the Museum will be radically enhanced, with four major new exhibits covering almost half an acre.

In 1988, the Museum adopted a five-year exhibit plan calling for exhibits that treat four general themes: how computers work, the evolution of computing, the applications and impact of computing, and people in computing. New exhibits will be developed for each of the first three themes. The last theme will be addressed by weaving stories about people in computing into all exhibits, thereby imparting an engaging human element throughout.

During 1989, the thematic guidelines solidified into specific exhibit gallery plans. As visitors enter the Museum, they will be greeted by innovative and definitive exhibits on how computers work and on computer evolution. These will serve as introductions to the entire visit. Visitors will then encounter exhibits on computer applications and impact, an area which holds the greatest public appeal because it underscores the unprecedented value of these tools and shows

how computers increasingly touch everyone's life.

The theme—how a computer works—will be addressed by a unique exhibit, "The Walk-Through Computer." Visitors will actually interact with it, walking into a giant working replica of a desktop computer. Development of this million-dollar project is in full swing. The exhibit opens in June of 1990.

The evolution of computing will be addressed in a 5,000-square-foot exhibit entitled "Milestones of a Revolution." The goal is to present a few key developments in computing within their proper historical context, together with a critical examination of the ways computers have affected people's lives. The preliminary exhibit plan has nine selected milestones, each with a recreated environment through which visitors will walk. Artifacts and period ephemera will be backed up by interactive video and graphics. This one-million-dollar exhibit is planned to open in the summer of 1991.

The third theme—computer applications and impact—is already featured in "The Computer and the Image" and in "Smart Machines." These address computer graphics, image-processing, artificial intelligence,

and robotics. These galleries will be retained and two new ones will be added.

The "Computer Discovery Center" will address the applications of the personal computer to people's everyday work and play. Many hands-on exhibits will give visitors an opportunity to discover new ways of benefiting from using a personal computer. This is a joint project with The Boston Computer Society and is expected to provide many exhibits that can be sold to science and technology centers around the world.

"The Networked Society" will feature large-scale computer-based systems that underlie modern society. Examples are telephone networks and systems for online banking, international finance, airline reservations, news services, manufacturing, and retail inventory control. This final phase should be complete by 1993.

Oliver Strimpel

The first part of the paper discusses the importance of the study and the objectives of the research. The second part describes the methodology used in the study, including the data collection and analysis techniques. The third part presents the results of the study, and the fourth part discusses the conclusions and implications of the findings.

The study was conducted in a laboratory setting, and the data were collected over a period of six months. The results show that there is a significant difference between the two groups, and this difference is statistically significant.

The findings of this study have important implications for the field of research, and they provide valuable insights into the underlying mechanisms of the phenomenon being studied.

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The Museum is for everyone. People of all ages come here to find out about computers. Many are curious about how computers came about, what they used to look like, and who was involved in their development. Some want to get their hands on a computer and feel how it operates and how they can control it. Others want to see how the insides of their computer really work and what more they might accomplish. Old hands often want to reach out and touch an old friend. All visitors come to participate in the excitement that hums around the brave new computer-driven world.

How can the exhibits and educational programs meet the expectations of such diverse audiences? Certainly not by reducing information to the lowest common denominator but through a diversity of programs and a layering of information from simple to complex. Many exhibits are transparent to five-year-olds, who are growing up fearless in the electronic universe. Other exhibits offer new challenges and insights to experts, who may know some of the particulars but are enchanted

to discover depths they never had occasion or time to plumb.

Our new educational Resource Center opened in time for the National Educational Computing Conference's June 1989 tenth-anniversary gathering in Boston. The Center affords parents, children, educators, and the general public opportunities to try out innovative software and hardware that schools can use to enhance learning. One of these is a set of multimedia materials for a dozen subject areas that offers film, photographs, and documents on laserdisk. Sensitive probes enable students to use the computer as a real-time scientific lab instrument. Young visitors take pleasure in operating our LEGO/Logo circus. *LogoWriter* allows beginning authors to enter and print out their creations. *MathCad* is a powerful algebra tool. *Puppeteers* gives visitors a chance to write a script, create their own characters, and see and hear their play acted out.

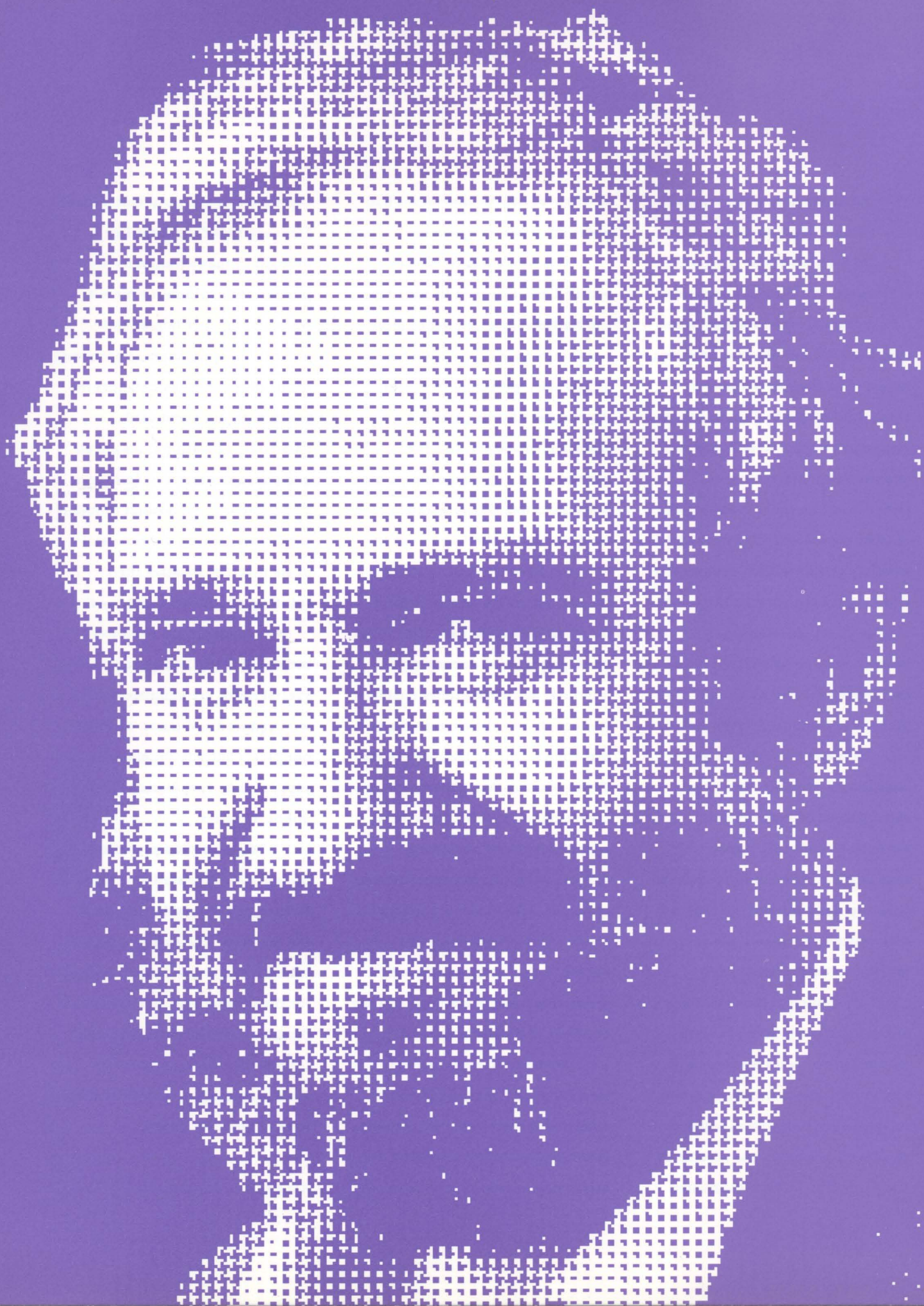
School holidays featured workshops in which adult-child teams built their very own moving robot. In December, professional artists demonstrated how they use

computers as art tools. Our annual February Kids Computer Fair brought in many hundreds of parents and children to try out software for their homes and schools. In April, three telecommunications exhibits put visitors in touch with bulletin boards, databases, educational resources, and consumer services. In May, a computer-arts symposium brought composers, artists, dancers, and poets together to share their thinking and display their work.

Student groups from low-income districts and groups with special needs are admitted free or with reduced admission through our Ticket Subsidy Program supported by corporations and public agencies.

We have been preparing presentations for staff and volunteers to deliver inside and out of the Museum. The first two are on robotics and chips. A major effort for the coming year is outreach programs for The Walk-Through Computer, which promises to answer everyone's questions about how a computer works.

Adeline Naiman



computers in the *S*chools: momentum and inertia

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Like bread with butter, the word "computer" goes with the word "fast." Computers work fast—millions of operations a second. They evolve fast—what they do and what they look like has been transformed beyond recognition in each decade. And they've brought about astoundingly rapid change in the way many things get done—very many things but not everything.

One of the things computers have not changed, despite frequent utopian predictions that they would, is school. You can't altogether blame computers; nothing else has changed schools very much either. As the computer is associated with quick change, school is associated with change that is sluggish, slow, and even retrograde.

Is this a case of the proverbial irresistible force meeting the immovable object? Which will give?

I personally believe that school is going to change so much that people of a not-very-distant future might not even want to call their learning places school. But

when one looks at the computer presence in actual schools, one sees a mixed picture. There are wonderful signs of incipient real change. There are more prominent signs that "the system" is able to defend itself (like a living organism) against the foreign body; it is even able to use the computers to shore up its old structures. My optimistic belief that the forces of change will prevail is based on a theory of why school has resisted change. But first we must answer some questions.

Some school people will protest that it is unfair to represent school as something that does not change.

Of course, in one sense there is plenty of change. The buildings look different and many practices are more humane; dedicated teachers, administrators, and even parents work hard every day to make improvements. But it is interesting to establish a sense of degree of change by comparing schools with sectors of activity where change has been on another scale.

Imagine a party of time-travelers from the eighteenth

century—a surgeon, a watchmaker, a banker, and a teacher—who are visiting to see how members of their professions do things in our times. Imagine the bewildered surgeon trying to make sense of the procedures used in a modern operating room or the watchmaker trying to understand how a digital watch is made! The banker might have a slightly easier time of it, but the idea of electronic transfer of funds and instant verification of credit anywhere in the world would surely boggle his mind.

The teacher would be in a very different position. He (only a man would have been allowed on such a trip) would be a little puzzled by some of the activities in a modern classroom and astonished at some of the equipment. But on the whole he would immediately understand the point of everything he might see. He would even be sufficiently at home to take charge if his host, the modern teacher, were called away. (Imagine the surgeon taking over the operation!)

Whether someone from another century could step into the job offers a rough-and-ready test to

establish a difference between change and megachange. Let's use it to recast our question: Is megachange possible in education to a degree comparable with the revolutionary transformation of sectors of activity such as medicine, clockmaking, transportation, or communications? Is it desirable? Does the computer presence make it more feasible?

Now that they know what kind of change I have in mind, protesting educators might see me as wrong-headed, not for thinking that schools have not changed but for expecting them to do so. They might argue that surgery and clockmaking and the like are susceptible to technologically supported megachange just because they are intrinsically "technical" activities. But such things as loving and eating and learning are "natural" activities. They can be supported by technology but are not susceptible to radical transformation. Whether food is cooked on a wood fire or by microwaves or not at all, you still open your mouth and put it in.

I agree: learning is a natural

act. I am thinking of a baby learning to relate to its parents, to talk, to walk, and to manipulate things and people. Learning is natural—but school is not. School learning is an artificial creation, and its characteristic methods are intrinsically technical even when they do not use anything we would popularly call technology. Acquiring one's native language by immersion in a culture is natural learning in its purest form; teaching a language by the numbers, following a tightly laid-down curriculum, is about as technical as you can get. The difference between natural learning and technical teaching is even reflected in grammar: "the baby learns to talk"—"the teacher teaches children fractions." Who is the subject, who is the object, who is the agent, who is the patient?

Of course, what I am saying is a caricature. Many teachers work hard to encourage more natural learning in their classrooms, and some schools are committed to a policy of encouraging them to do so. Nevertheless, I maintain that the technical side of teaching is

inherent in the established model of school: it is inherent in the concept of a linear curriculum; it is inherent in the kind of testing used to measure success; it is inherent in the kind of work that children are expected to do in classrooms; indeed, it is inherent in the very idea of "class"—of children segregated according to age.

My view of how computers can contribute to megachange in learning has a touch of paradox: this most advanced of all technologies will contribute most powerfully to education by making it less technical!

Two examples of how computers are used in schools will begin to clarify what I mean. The first makes the technical side of school even more technical. Here the computer is used as an automated spelling and grammar teacher. Sentences appear on the screen. The student is invited to say which words are incorrectly spelled and which is a noun or a verb or whatever. The computer keeps track of everything the student has ever done and uses its more or less elaborate (or, as they

say, "intelligent") algorithm to decide on a suitable comment and to choose the next problem.... And so on; you get the idea—even the time traveler would quickly grasp it.

In this example, the computer is an active agent; it makes active interventions: it (pronoun, subject, agent) teaches (verb) the child (noun, object, patient). The example clearly shows how computers can strengthen the technical side of education. The second example takes a first step towards showing how computers can support natural learning. The computer is used as a word processor. Like pencil and paper, it serves as a medium for writing. Here the computer is not doing something to the child; the child is not the object of the transitive verb "teach." The student is the active agent, the subject of the sentence, "I am a writer!" The computer is used not to improve teaching but to improve writing and permit the child a stronger sense of being a writer.

Nothing in what I am saying is meant to devalue the importance

of teachers. Quite the contrary. The image of children using word processors provides a hint at richer opportunities for teachers to work as participants in a process of natural learning. For the fluidity of words electronically inscribed on screens allows the writer, even a young one for whom forming the letters by hand is still a chore and changing them a mess, to relate to text as something malleable. And this means that comments on the text are not judgments on a finished product but suggestions for improving it.

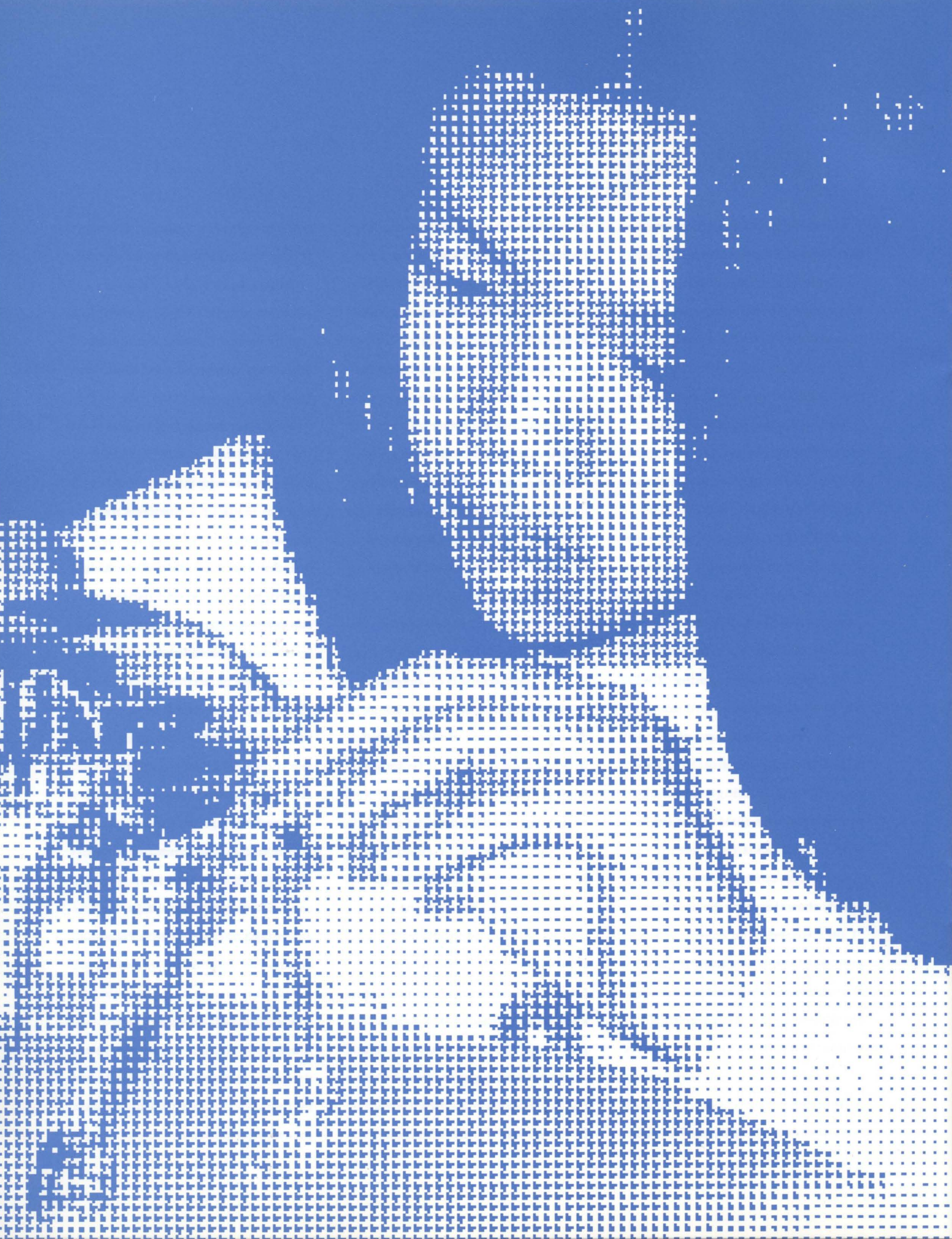
In my view this changed relationship of teacher to student contains the seeds of megachange in what school is about. To look at it more deeply we turn from writing to mathematics.

Indeed, thinking about teaching mathematics in grade school gives the best insight into why school has adopted its technical approach to teaching. Natural learning occurs best when knowledge is part of life. Babies learn to talk because they live in a world where language is used. But the mathematics taught at school does not play a significant role in

the lives of most children. And so school has been forced to adopt its technical strategies of breaking knowledge up into little, meaningless items and packing them into children's minds for use "when you grow up."

The situation is far worse than in the case of writing, for at least anyone who has seen a book and has made up a story has the elements needed to imagine the process of writing. And if would-be writers have pencil and paper they can try it for themselves. But where in life are there examples of creative use of mathematics that children can see and imitate? The blame for this shortage is not on the shoulders of schools or teachers. It is not their fault that our culture is so poor in interesting mathematics. We cannot expect them to change the culture. But we can hope that they will take advantage of changes that come about.

A walk through The Computer Museum is enough to show signs of dramatic change in the presence of mathematics in our culture. Think, for example about the implications



of computer art. In some cases, mathematical ideas are visible in the final product. Other works are opaque to the mathematics that might have been used in making them, just as one perceives an automobile functionally or aesthetically without awareness of the mathematics that went into designing it and making it. But there is a difference. The car does not incite you to imitate the mathematics.

The same walk through The Computer Museum shows examples of children engaged right there in creating computer art in ways that make mathematical knowledge very relevant to their personal projects.

What would the time-traveling teacher make of seeing these children programming computers to produce animations on their screens? Imagine him in a learning place for children (maybe it calls itself a school) toward the end of this century. Children of different ages are deeply engaged in personal creative projects, consulting one another and the adult who seems to be in charge.

These children are learning

about mathematics—and physics and control engineering, and about color and form and perception—by working on projects where they use the knowledge. They get it when they need it, not when the curriculum says so, and they get it sometimes from other kids, sometimes by just plain slugging it out, sometimes from books, and sometimes from the teacher. In a lot of ways, this is more like the child learning to walk and talk and argue in a family that does all those things than like following a curriculum in today's schools.

I must answer one last objection to my picture of how change can happen. "Anyone who is in touch with the reality of schools knows that you just can't do this. First, there aren't enough computers in schools. Second, those that are there are not powerful enough. Third, the software systems don't exist. The teachers don't know enough. These cultural trends are just beginning. And so on and so on."

Well, of course that is all obviously true. But so what? About a hundred years ago two bicycle

makers called Wright dreamed of a world of aviation. When their first flight hopped about as far as the wingspan of a modern big plane, they could have decided to go back to making bicycles. And people in schools can decide, and many do, to adapt their use of computers to present-day conditions in schools. Others dream and try to use what they have in hardware and knowledge to strive towards what they know the future will be like.

Seymour Papert

Dr. Papert, Professor of Media

Technology and Director of Epistemology and Research at Massachusetts Institute of Technology, joined The Computer Museum Board of Directors in June 1989 and serves on the Education Committee. He is the author of Mindstorms: Children, Computers and Powerful Ideas, which has been translated into 11 languages.



J o h n n i a c

Johnniac, constructed between 1950 and 1953, was built following the same design as the IAS (Institute for Advanced Study) computer at Princeton. The IAS project team was led by John von Neumann, Arthur Burks, and Herman Goldstine, who had all worked on the ENIAC and the EDVAC, and by Julian Bigelow. A condition of the funding by the Atomic Energy

Commission was that engineering plans be delivered to five other computer development centers: Los Alamos, where the MANIAC was built and still resides in the Museum there; the University of Illinois for the ILLIAC; Oak Ridge National Laboratory for the ORACLE; Argonne National Laboratory for the AVIDAC; and the Rand Corporation for Johnniac. The IAS machine is in the collection of the

National Museum of American History where it will be displayed in their new exhibit on The Information Age opening in May 1990.

The commercialization of scientific computing did not occur until the mid-fifties, when IBM, UNIVAC, English Electric, and Ferranti put the laboratories out of the business of building computers. In 1950, when the IAS-type machines were funded,



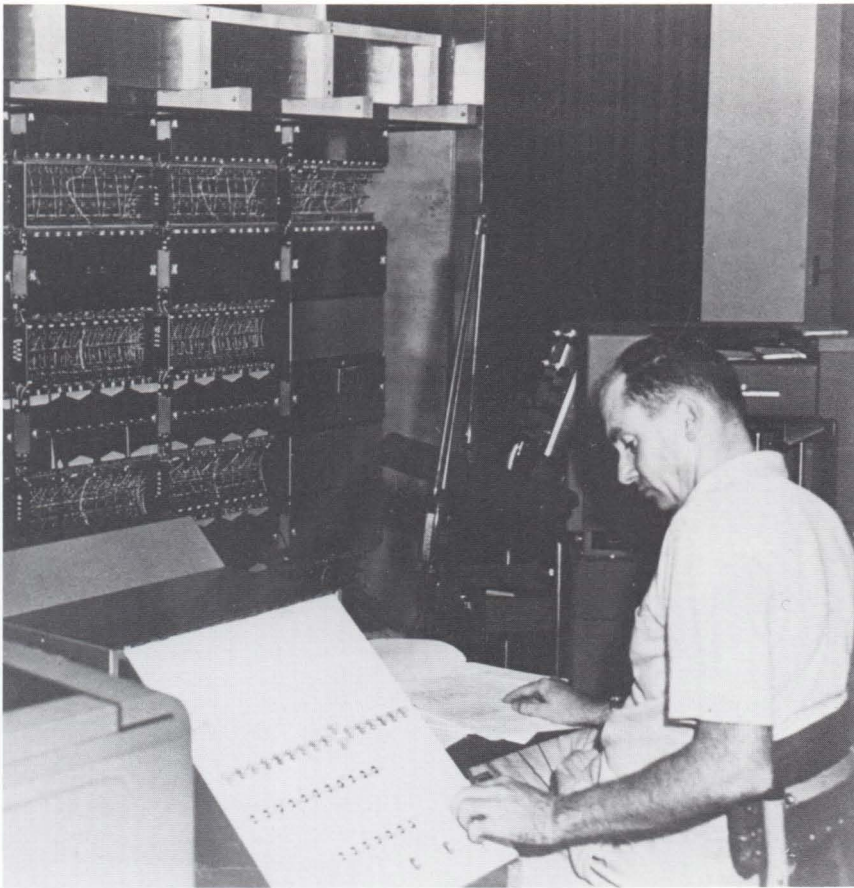
Facing Page
John von Neumann

Above
Keith Uncapher is at the Johnniac console.

most computers were built by small teams in laboratories for their own use. The Computer Museum holds three complete machines in this class: the Whirlwind built at MIT, the TX-0 built at Lincoln Laboratory, and now Johnniac.

With the support of the U. S. Air Force, The Rand Corporation project team of Cliff Shaw, John

Williams, George Brown, and Bill Gunning started the project in 1950 and had the machine running by April 1953. They decided to name it "Johnniac" in honor of the IAS machine's principal designer, mathematician John von Neumann (The last three letters of "Johnniac" stand for "integrated and automatic calculator.")



.....
Testing of the Johnniac involved programming the computer to work on an endless calculation while workers checked each connection. A memo from this time states, "Applications for wire-wrigglers now being accepted."

The overriding concerns in the design and construction of the five-ton Johnniac were reliability and ease of use. During the three years of development, the operational, as opposed to experimental, nature of the machine was continually borne in mind. The designers followed the plans for the IAS Computer with one exception: they decided to use the Selectron tube memory developed by Jan Rajchman at RCA. The Selectron had been developed under contract for the IAS machine but was delivered so late that the IAS machine and all of the other clones fell back on the memory device it was intended to replace, the Williams' tube memory developed by F.C. Williams at Manchester University in England. With the Selectron tube, Johnniac could access four times as much primary, random access memory, i.e, 4,096 40-bit words versus 1,024 40-bit words in the IAS. More important, by the time Johnniac was operational in 1953, core memory had been developed and tested for the WHIRLWIND at MIT, rapidly becoming the dominant form of random-access primary memory. Johnniac's Selectron-based architecture allowed for the replacement of Selectron tubes with the first commercial core memory

in 1955.

Power and refrigeration systems for Johnniac were heavily over-engineered: the original main power switch was so large the engineers were actually embarrassed enough to replace it with a smaller one. The air-conditioning machinery doubled the weight of Johnniac, bringing the total weight of the installed computer to ten tons. Equipment failure was dealt with automatically, with Johnniac initiating protective steps and recording the entire event. Occasionally human intervention was necessary, as co-designer Willis Ware related in 1965, at the ceremony marking Johnniac's decommissioning: "When it came time to service the machine, someone had to open a door. It was like standing in the deep freeze, and we quickly bought ski jackets — with hoods — for everyone. The machine also acquired one of its early names — the *Pneumoniac*."

The sheer size and complexity of Johnniac were invisible to its users, many of whom used JOSS (Johnniac Open Shop System), the first truly interactive language designed for time-sharing systems. JOSS was developed by J.C. Shaw, T.O. Ellis, I. Nehama, A. Newell, and K.W. Uncapher. While

JOSS itself is no longer in use, it influenced the style of interactive languages that followed it.

The limitations of punched card input and output frustrated both the developers and the users of Johnniac. Their scientific problems needed graphical interfaces, so Johnniac was used for the development of the Rand tablet, the first digitizing tablet, and the refinement of on line graphics printers and plotters.

Johnniac tended to run relatively simple programs during the day; nighttime use was reserved for solving of extended computations. This division of computing activity led to the rumor that Johnniac was afraid of the dark. Johnniac's average add time, including time needed to access the memory or storage, was 25 microseconds, and multiplications could take 400 microseconds each. With many scientific programs, Johnniac was set up to "crunch numbers" unattended for hours at a time. Astonishingly, Johnniac calculated with near-perfect accuracy only when the lights were on. It turned out that the neon tubes in the I/O section of the machine required ambient light in order to function properly.

Rand retired Johnniac after 13

years and 50,000 hours of operation — with only two transistor failures in over fourteen million transistor-hours, and a 0.92 good/attempted-to-run operating ratio. The occasion was marked by the brief ceremony referred to above. On 18 February, 1966, the original project leader Cliff Shaw programmed Johnniac to execute a sixty-second countdown and then shut itself off.

After display in the Los Angeles County Museum of Natural History, Johnniac was placed in storage for several years. With the assistance of the Los Angeles Museum, The Rand Corporation, and members of the original Johnniac team, The Computer Museum has arranged to obtain Johnniac for its permanent collection.

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Fifty artifacts were added to the collection this year, bringing the total number to 1025. One offer in ten was accepted. Donations often include documentation, photographs, and other materials related to the listed artifacts.

Some of these artifacts were saved thanks to friends' suggestions on which the Museum acted quickly. We depend on you to let us know when computers are being decommissioned, a pioneer is retiring and cleaning out his office, or where we might look for a buried computer treasure.

The Museum continues to upgrade management of the collection and optimize use of storage areas. Archival, photograph, film/video, and book collections complement the artifact collection, preserving a wide spectrum of materials significant to the history of computing.



.....
 La Radiotechnique terminal, one of many used with France's successful telecommunications network.

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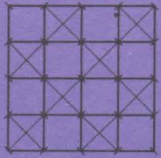
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