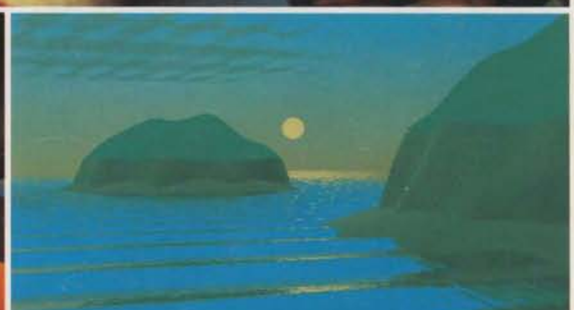
# THE COMPUTER MUSEUM REPORT

VOLUME 13

SUMMER 1985



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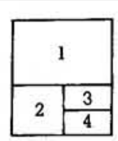


The cover photographs are still frames from the following computer animated films (see article on page 4):

1. The adventures of Andre & Wally B. Lucasfilm Ltd.
2. Snoot and Muttly, Susan Van Baerle and Douglas Kingsbury
3. Carla's Island, Nelson Max
4. Vol Libre, Loren Carpenter

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The Computer Museum

The Computer Museum is a non-profit 501(c)3 foundation that chronicles the evolution of information processing through exhibitions, archives, publications, research, and programs.

**Museum Hours:** The Museum hours are 10 AM–6 PM, Tuesday, Wednesday, Saturday, and Sunday and 10 AM–9 PM, Thursday and Friday. It is closed Mondays, Christmas, New Years, and Thanksgiving.

**Membership:** All members receive a membership card, free subscription to The Computer Museum Report, a 10% discount on merchandise from The Computer Museum Store, free admission and invitations to Museum previews. For more information, contact Membership Coordinator at The Computer Museum, 300 Congress Street, Boston, MA 02210, (617) 426-2800.

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# The President's Letter

When I wrote the first letter in the first *The Computer Museum Report* in May 1982, I was the President, Treasurer, and Executive Director of the Museum. The whole staff consisted of three other people plus some summer students, and there were about 100 members. After a year, the Board of Directors decided that I shouldn't create, write, and sign the checks and Professor James McKenney became Treasurer.

Then this year, the Museum had its first assessment on the way to accreditation by the Association of American Museums. It became equally clear to me that the role of President and Executive Director of an ongoing public museum were indeed different. There was no way for me to do all that I have been doing as President—maintaining a close, ongoing relation with the computer industry—and also be a director of this major museum that is making a significant footprint in the Museum community.

It is with great pleasure that I introduce Michael Templeton as the new Executive Director. Michael was actually the first museum professional to visit the museum! In the fall of 1980, when he was the Executive Director of the Association of Science and Technology Centers, ASTC, he scheduled a meeting at the Museum in Marlboro of their advisory board for the travelling exhibit, Chips and Changes. At the time, he encouraged me to push ahead and develop the Museum.

My next visit with Michael was in Portland, Oregon, where he had become the Director of OMSI, the Oregon Museum of Science and Industry, a Museum that I had long admired. Why? First, Oregon Software originated there. This company was formed by a group of students and their physics teacher, Rusty Whitney, who wrote a Pascal compiler on the PDP-11 in the basement of OMSI. Ten years later the company is alive and thriving. Second, OMSI pioneered in computer-based exhibits and had a very good working relationship with the electronics firms in the Northwest.

At the time of the Museum assessment, I thought that one of the few people in the world who could come in and be in synch with the Museum was Michael Templeton. When I called his home in Portland, I learned that he was consulting at the National Science Foundation. He changed his plans and travelled back to Portland via Boston, walking into the middle of an exhibit planning meeting. Everyone felt that this was a match that was meant to be. I will stay on as President and CEO (in the jargon of industry) and he will be the Executive Director and COO.

## The New Trustees

Each year, a class of the Board of Directors retires to become Trustees of the Museum. This year, Gordon Bell, Harvey Cragon, Robert Everett, George Michael, Ken Olsen, Kitty Selfridge, and Erwin Tomash made this step. Gordon Bell and Bob Everett will continue to work on the development committee to ensure that the capital campaign will reach its goal by 1988. Harvey Cragon, George Michael and Edwin Tomash will remain involved with the Collection and Exhibition Committee. Kitty Selfridge, who started the member volunteer organization, will remain an active member of the Museum. And finally, Ken Olsen, who was the first Chairman of the Board, will remain a vital force behind the scenes.

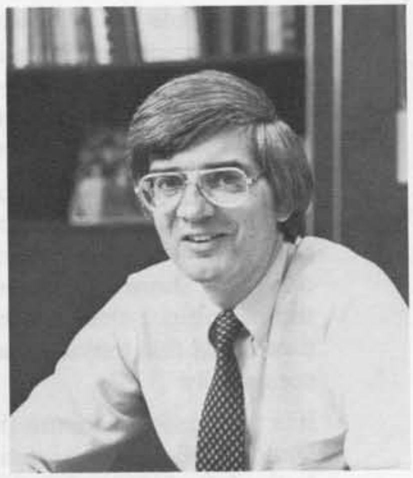
## The New Board Members

Seven people were elected to the Board of Directors, each bringing special talents and perspectives to the table.

Sir Arthur Humphreys, retired Chqirman of ICL Ltd., renews the Museum's connection with The Charles Babbage Institute, of which he is a trustee, and strengthens our international ties.

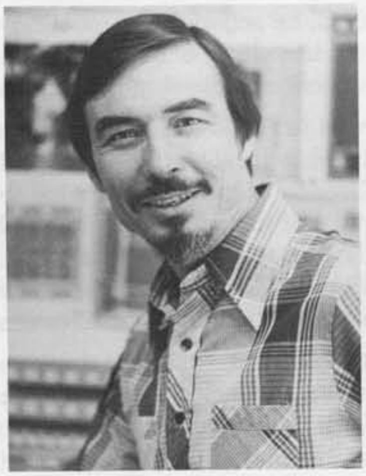
August Klein, President of MASSCOMP, has come on board as the Chairman of the Museum's capital campaign. In Gus's words, "I don't just join an organization, I

Robert Lucky



August Klein

Michael Templeton



William Millard

Jonathan Rotenberg

Carver Mead

Maurice Wilkes

invest in it." His experience comes from both business and philanthropy: he was a 25 year employee of IBM and served as a director of United Way in Greenwich, Connecticut, Denver, Colorado, and Jacksonville, Florida. Gus is establishing a committee to meet our March, 1988, deadline of $10,000,000. He also says, "Hey, I'm delighted to start with one-third of the goal in our pocket."

Robert Lucky, Executive Director of the Research, Communications Sciences Division at AT&T, is a Fellow of the IEEE, a member of the National Academy of Engineering, and a member of the Advisory Committee of the National Science Foundation. He will help the Museum develop its collections, exhibitions, and publications on the subject of communications and computers.

Carver Mead, Gordon and Betty Moore Professor of Computer Science at Cal Tech, views the microprocessor as computer. He is spearheading our efforts to "get the semiconductor story right." This leads the Museum in the direction of collecting and exhibiting the evolution of chips and how they are made.

William Millard, Chairman of ComputerLand, was part of the firm that developed the groundbreaking IMSAI-8080 microcomputer. Watching the early growth of the IMSAI dealer network, Bill Millard established ComputerLand in 1976, a franchise network that provided financial and business experience to computer retailers. He is personally interested in both history and the future. Reflecting these interests, he has established a ComputerLand competition for the earliest microcomputer artifacts donated to the Museum. He will also spearhead a long range planning committee for the Museum.

Jonathan Rotenberg is President and Founder of the Boston Computer Society, the largest one of its kind in the United States. His longtime dream has been to establish a computer discovery center—an idea that extends the museum exhibit plans. He will work with us to build the computer discovery center into the Museum.

Maurice Wilkes built the first, operational, full-scale stored program computer, the EDSAC, and gave the very first Computer Museum Lecture, making him a bona fide pioneer not only in computers but in the establishment of this Museum. Maurice, a senior engineer at Digital Equipment Corporation, is extraordinarily interested in the preservation of both the software and hardware that laid the foundations for the industry. Parts of the EDSAC, languishing in the basement of the Science Museum in London, were sent to us for exhibiting. His contributions will help us develop historical exhibitions planned for next year.

The new Board members have a diversity that reflects that of the Museum. Our exhibits contrast state of art with historic firsts, include the stories of individuals and corporations, and encompass all the levels of integration from silicon to software.

The future of the Museum will continue to evolve. The new executive director and new class of directors renew our activities. Personally, my role will again change as the Museum becomes broader and deeper. And I'll be around and willing to do what is needed to make the Museum great.

Gwen Bell
President

Gwen Bell

# Computer Animation in the Museum

by Oliver Strimpel

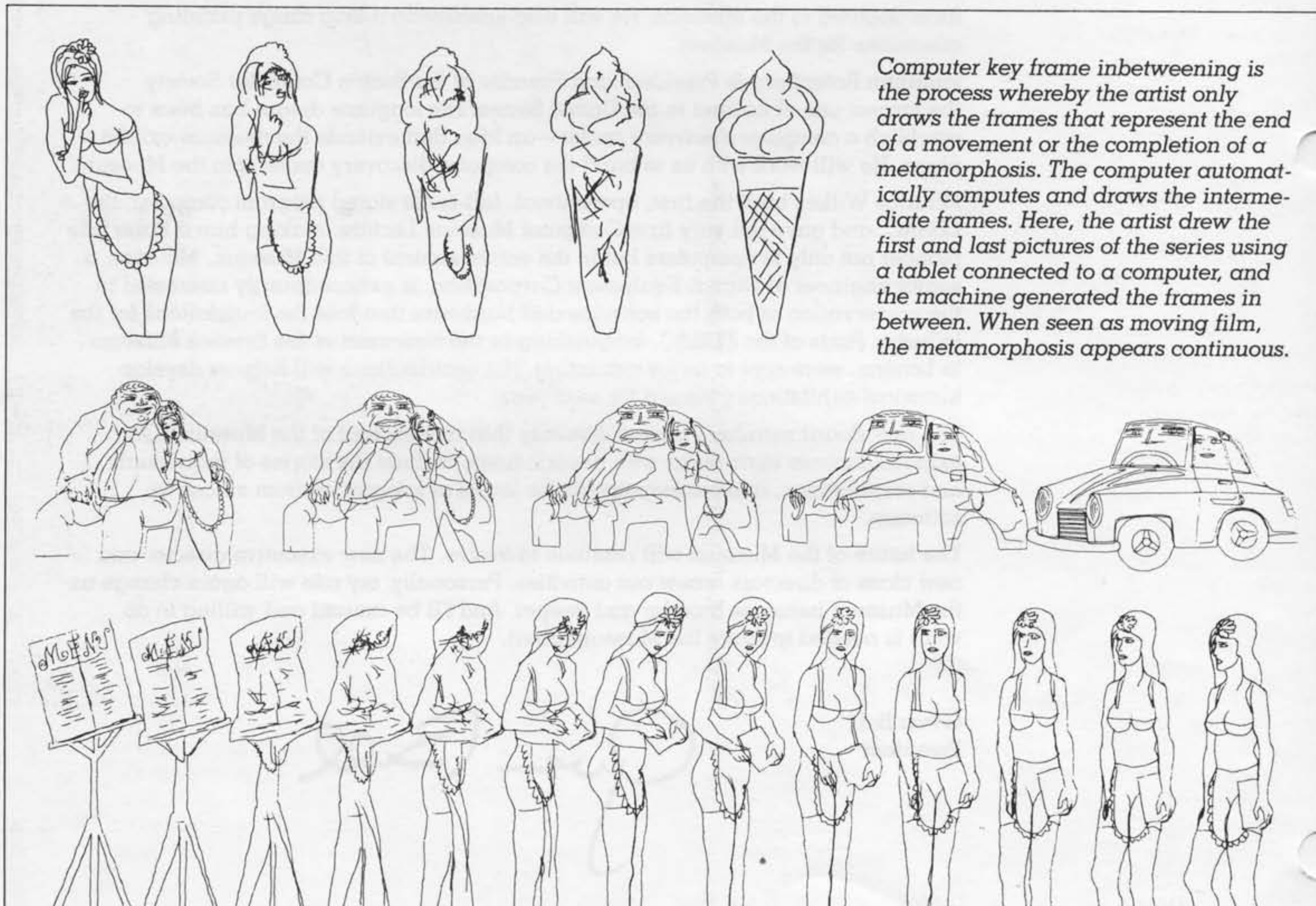
Film and video animated by computer are an important record of hardware and software development. The need to produce large numbers of images and to animate them smoothly absorbs a large amount of computer time and fully exploits all the available spatial and color resolution of computer graphic systems. Makers of film and video have consistently stretched their resources to the limit.

The Museum is building up a collection of computer-animated film and video. An important recent acquisition is a set 12 films donated by Ken Knowlton made at AT&T Bell Laboratories between 1963 and 1976. The computer (an IBM 7094) was used both to draft the images on a microfilm recorder (a Stromberg–Carlson 4020), as well as to calculate what should be drawn. A short piece by Ed Zajac that simulates the oscillations of a communications satellite in the Earth's gravitational field was completed in 1963, making it the earliest computer generated film known to the Museum. Several of the films are educational, visually explaining subjects such as Bell Labs' own movie-making system, programming languages, and Newton's laws of motion and gravitation. Others explore human visual perception using images with random noise, and still others use the medium for its aesthetic possibilities.

Another significant set of computer-animated films were donated by F R A Hopgood. He led a group who used the Atlas computer at the Rutherford Laboratory in England to develop a convenient high-level computer animation system from 1968 to 1973. The Museum's films explain concepts in computing and physics, but non-technical entertaining films were also made. The system w later developed into a package called ANTICS which continues to be used today, particularly in Japan.

Also in the collection is a record of the first real time animation, a simulated flight of the Apollo LEM. This was filmed from the screen of an Adage Graphics Terminal in 1967.

The Museum has created a mini-theater in "The Computer and the Image" gallery to screen some of the more recent pieces in the computer animation collection for the public. Five pieces spanning the development of the art were selected for a 20 minute program which shows continuously. Each piece demonstrates creative and original use of the techniques of computer animation.



*Computer key frame inbetweening is the process whereby the artist only draws the frames that represent the end of a movement or the completion of a metamorphosis. The computer automatically computes and draws the intermediate frames. Here, the artist drew the first and last pictures of the series using a tablet connected to a computer, and the machine generated the frames in between. When seen as moving film, the metamorphosis appears continuous.*

**Hunger** (1975)
by Peter Foldes
National Research Council, Ottawa, Canada and National Film Board of Canada

*Hunger* is the first film to use the computer to animate hand-drawn images. It shows a man with an insatiable appetite devouring a huge quantity of food. He is then tormented by nightmares in which hordes of starving people devour his own body. The freedom offered by computer animation is used to its fullest extent to convey the film's disturbing message. For example, as he eats, the man's body steadily becomes more inflated and numerous mouths appear to help him eat faster. His visions are graphically portrayed, as in the woman metamorphosing into an ice cream cone.

The technique used is known as "key frame inbetweening." In traditional animation, the animator draws key frames while assistants laboriously draw intervening frames to make motion appear smooth. But in this film, the 'tweens' were drawn by computer. The machine works out the intermediate frames by taking averages of the initial key frame and the final one. In *Hunger* the interpolation is linear, which means that the motion starts off jerkily and progresses smoothly till the end-point is reached. Naturally, animators wish to control motion. Contemporary 'tweening systems now allow many types of movement to be simulated. The most common requirement is to start off slowly, accelerating gradually, and then slow down to a stop. Real living characters generally follow this type of motion.

**Vol Libre** (1980)
by Loren Carpenter

In *Hunger*, all the key frames are line drawings created by the artist. The computer smooths the passage between these frames. In *Vol Libre*, the computer is used to generate all the images—indeed the images are so complex that they could not be drawn by hand. The film shows a flight through an imaginary landscape of mountains, valleys and lakes. As the landscape is synthetic, the viewpoint can be moved freely, simulating truly free flight.

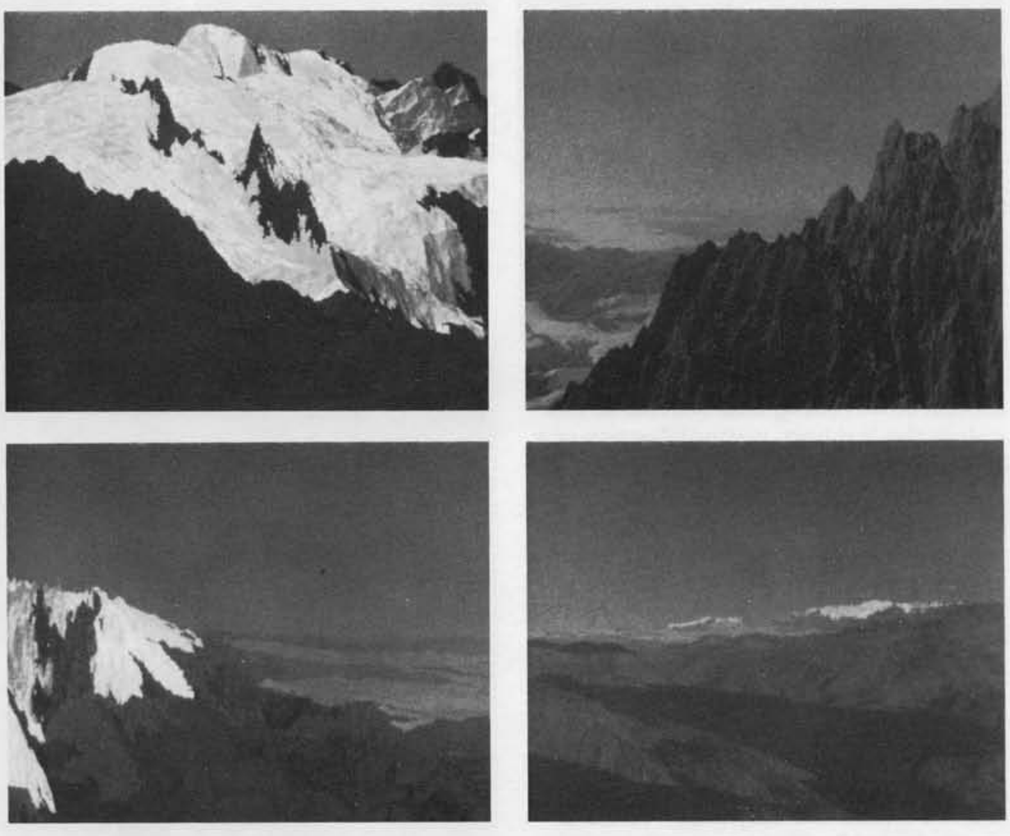
The landscapes were simulated using a class of mathematical objects termed fractals by their discoverer, Benoit Mandelbrot. Many natural phenomena, such as clouds, rivers, coastlines, turbulent flow, and capillary networks can be modelled as fractals. *Vol Libre* is the first film that used fractals to simulate a landscape. It also showed that such an artificial landscape could be viewed from several angles and still appear self-consistent. This is not obvious, as the landscape surface is not a real entity, and only the visible portion in the 'camera' is calculated for each frame.

The film received a standing ovation when it was first shown at the ACM SIGGRAPH conference in 1980. Despite images that are crude in comparison to today's, the film is true to its name, conveying an exhilating sense of liberation from the shackles of gravity and inertia.

**Carla's Island** (1980)
by Nelson Max,
Lawrence Livermore National Laboratory

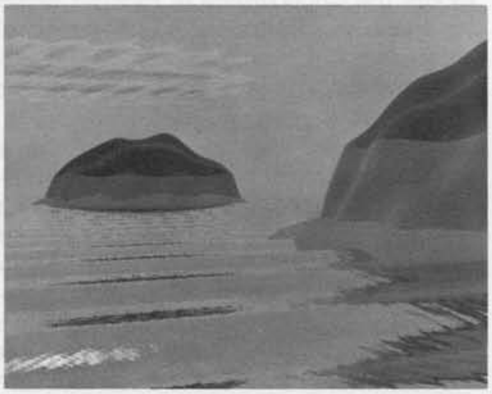
Nelson Max made the first attempt to model the appearance of moving water for the film *Carla's Island*. A range of simulated lighting is shown on the water surface, from broad daylight to moonlight.

Ray-tracing, modified by some time-saving short cuts, was used to render the play of light on the rippling water surface. During the sunset and rising and setting of the moon, a single cycle of water wave motion was repeated many times, but the colors were changed by altering the color table. This meant that there was no need to recalculate all the reflections. The results worked out for one set of colors were



*View of mountains in a fractal landscape. To create the landscape, Loren Carpenter started off by entering 180 altitude points. These points were connected, giving an initial database of 300 triangles to represent the landscape. The computer then used a random process to assign a midpoint for each triangle, either above or below the plane of the triangle, and connected the edges with the new midpoint to make three new, smaller triangles. The process was repeated until the triangles were only a couple of pixels across. The splitting was carried out afresh for each viewpoint.*

reused for a different set, chosen to shift towards the colors of sunset and then moonlight. The effect is convincing, and only required a very small amount of extra computer time for a considerable extension in the length of film.



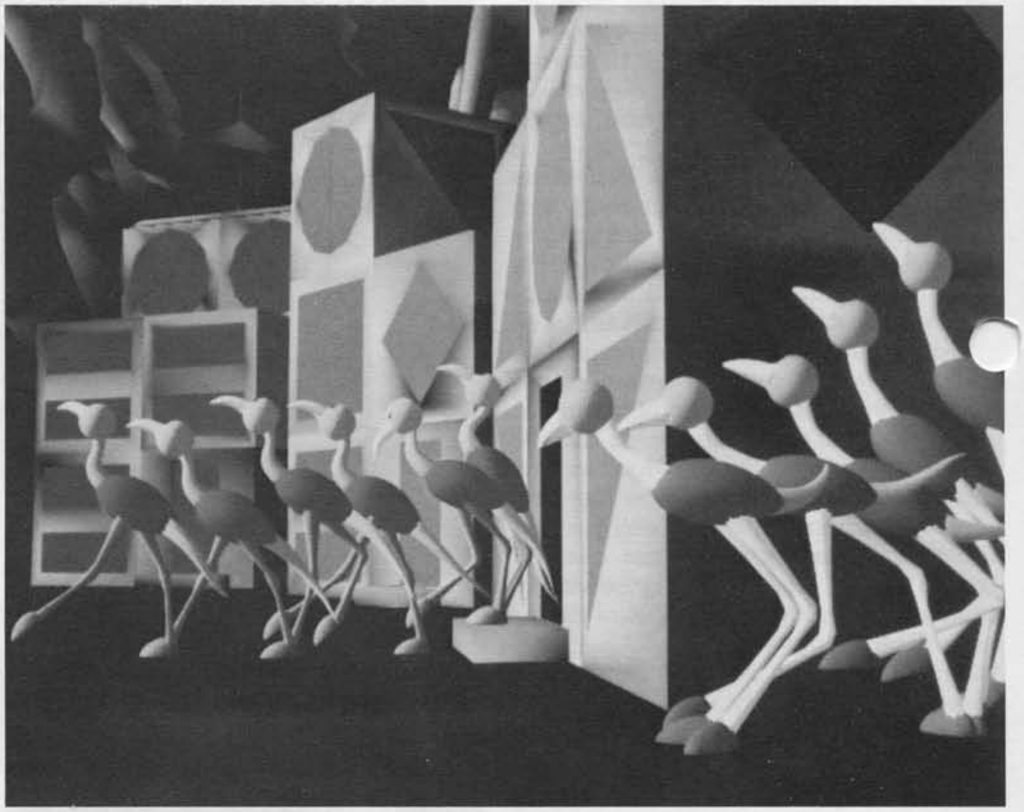
*The water surface is modelled by a collection of travelling sine waves. To calculate the lighting, a simplification of a rendering technique known as ray-tracing is used. In ray tracing, the computer follows individual light rays backwards from the viewpoint, reflecting or refracting them off objects in the artificial scene until they hit a light source, matte surface or fade. The destination of the ray is used to work out the ray's contribution to the image. As a ray has to be followed for each pixel of the image, ray tracing is very demanding of computer time. As a short cut, the rays in Carla's Island are only followed for a maximum of 2 reflections on the water, and then assumed to originate from whatever they point to. It still took a Cray-1 supercomputer 7 seconds to compute each 512 by 384 frame.*

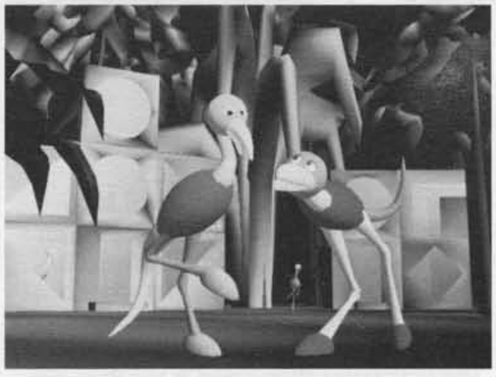
**Snoot and Muttly** (1984)
by Susan Van Baerle and
Douglas Kingsbury,
Ohio State University

Snoot and Muttly are two bird-like creatures who play together in a rainbow colored world under trees and floating bubbles. Three types of animation are used. The tails, necks and legs of the animals not only move but change shape as they walk. Taking the legs, for example, the animator input the positions of the hip, knee and ankle for five key positions during a step. The computer then interpolated between the positions.

The heads, feet, eyes and beaks are animated by normal key frame animation, following a smooth rotation without changing shape between the key positions. Finally, the bubbles were placed randomly on a grid and were then moved both systematically to simulate a wind or natural buoyancy, as well randomly between themselves. The computer smoothed the movement between the grid points.

Snoot, Muttly, the bubbles and the trees are rendered with a smooth-shading model simulating sunlight.





*Snoot and Muttly are constructed using simple shapes: the bodies are ellipsoids, the necks, tails and legs are tubes, and the head and eyes are spheres. Despite this crudeness, the creatures are convincing and full of character owing to their movement. Successive key frames are shown in these pictures.*

**André & Wally B.** (1984)
by Steven Baraniuk, Loren Carpenter, Ed Catmull, Rob Cook, Tom Duff, Craig Good, John Lasseter, Sam Leffler, Eben Ostby, Tom Porter, William Reeves, David Salesin and Alvy Ray Smith of the Computer Graphics Project, Lucasfilm Limited

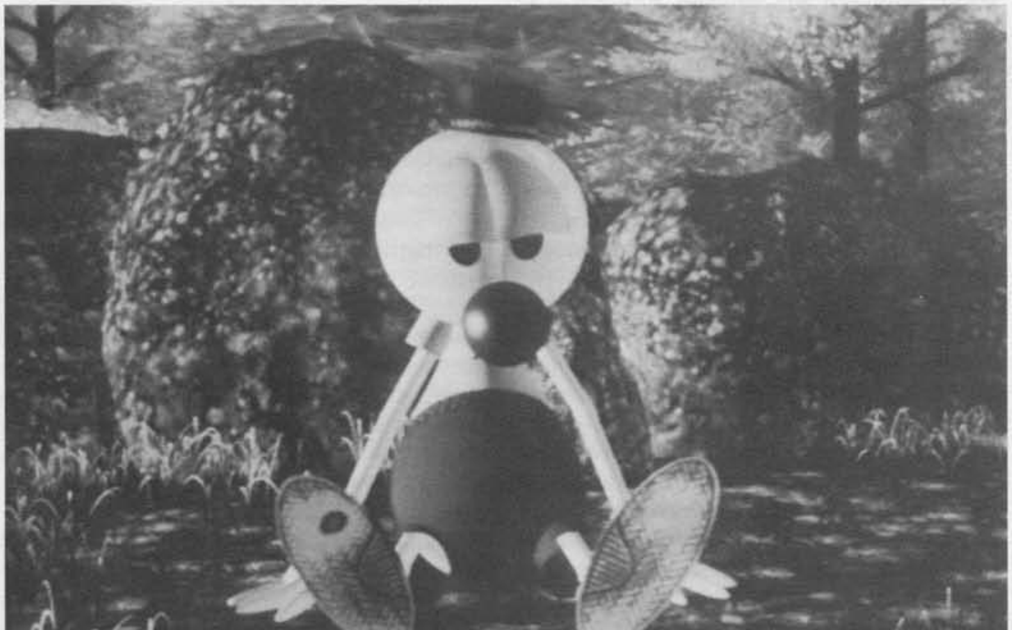
This 1.8 minute film is presently the most sophisticated piece of computer animation. It opens with a sunrise shot of a magnificent forest, zooming in to reveal an android, André, waking up and stretching. Soon he is confronted with an aggressive-looking bee, Wally B. In classic Disney cartoon style, André momentarily diverts the bee's attention and then flees with Wally in hot pursuit.

André and Wally B. were created on a computer by a Disney-trained animator. Using a tablet and a vector display, he input the characters by hand and then used the computer to animate them. In order to give him the necessary freedom, 547 independent controls were needed for the model of André, 252 for Wally B. Careful attention was given to the interface so that the animator could make use of the available flexibility without becoming aware of the complexity of the computing task.

Once the vector version was complete, the characters were rendered with color and texture and added to the forest backgrounds. For the first time in computer animation, motion blur was added. Without motion blur, sharp edges of animated characters tend to 'strobe', or double up. By deliberately blurring moving objects as if they were moving with the camera shutter open, the strobing disappears and the motion looks more realistic.

To create even this short clip occupied many months of the entire computer graphics research team at Lucasfilm. The huge computer processing needs were met by 10 VAX 11/750's, including those of Project Athena at MIT, and Cray XMP-2 and XMP-4 supercomputers of Cray Research.

The Museum is continually collecting computer animation. The Computer Animation Theater is a showcase of the collection, changing each year to display new pieces. Acquisitions include early work going back to the 1960's, as well as very recent material selected from the film show at each year's ACM SIGGRAPH conference, the prime forum for this medium. This year's selection will be on show at the Museum by this fall.



*André waking up in the forest. André is a full three-dimensional model. He and Wally B. move in a forest background generated from a 3-dimensional database of 46,254 trees. These were made using particle systems which, rather like fractals, have the property that with a simple starting set of data, complex natural-looking shapes can be generated by repeatedly applying a simple set of rules.*

# The Story of the COBOL Tombstone

*The following is a transcript of COBOL's 25th Anniversary Celebration at The Computer Museum on May 16, 1985.*

**John L. Jones**, Chairman of the CODASYL Committee: The fact is that no one has ever admitted any involvement in the Tombstone. Furthermore, no one has ever explained the meaning, intent, and thought behind the Tombstone.

Let me explain that COBOL and the CODASYL Committee are alive and well and have never had to make use of this tombstone. Both are strictly voluntary committees; in fact all of the work is done by volunteers and always has been done that way. We work on actual language development, refinement and clarification.

One of the key concepts of COBOL was Flowmatic, an idea that was developed by Commodore Grace Hopper. Flowmatic had one other derivative from an Air Force Project, the Air Material Command Compiler, "AIMACO," that was, as far as I'm aware, the first effort to take one language and apply it to efforts on two very different machines, the IBM 705 and the UNIVAC 1105. The compiler ran on the UNIVAC 1 and developed programs for the binary 1105 and the decimal 705. That was another inspiration to begin COBOL.

In 1953–54, most people wanted to program in machine language. The idea of compilers, like the first idea of power steering in automobiles, was intensely resisted: you lost the "feel" of the machine just as you might loose the "feel" of the road. I worked quite a bit with Grace at that time, talking about a compiler "A0" that she had written. In my 1954 Master's thesis I quoted her about using networks of small computers to perform functions that at that time were limited to big computers. Then, this quote about what we now call "distributed processing and micros" was used in the IBM anti-trust case around 1980.

**Grace Hopper:** When I started, I just went ahead with the idea. I have later learned that it is much easier to apologize than to get permission. In the case of Flowmatic, we discovered that a lot of people hated symbols, even though the mathematicians and engineers loved them. These people used words. We proposed that we should write programs in English statements providing a compiler that would translate to machine code. I was told that this couldn't happen because computers don't understand words. I said that they didn't have to; they just had to compare bit patterns. "Add" has just as many bit patterns as a plus sign does. But I was getting nowhere. So we acted on the motto: Just go ahead and do it. The lesson that we learned from COBOL is that you must go ahead and do it and make it work, and then get out and sell it.

**Donald Nelson**, Chairman of the COBOL Committee: The size of specifications of COBOL has grown from a stack of pages three-quarters of an inch high to a stack four inches in thickness. About 60 percent of the programs that exist are written in COBOL, and on mainframes its about 70 percent. The language has evolved over the years to meet many of the criticisms about it. Suggestions and revisions can be made by any group and are then reviewed by the committee.

**Jack Jones:** Howard Bromberg was very involved in COBOL from the beginning. The first demonstration that Grace's COBOL compiler worked on different machines was done on a UNIVAC 1 and then Howard's on an RCA 501.

We are missing Charlie Phillips, who recognized the idea of COBOL when he was in the Defense Department, and put his energy behind it to make it happen. In 1959, his efforts made COBOL come to life. His untimely recent death was very unfortunate and we sincerely miss him on this occasion that he was looking forward to.

**Howard Bromberg:** I thought a long time about the Tombstone and whether tonight was the appropriate forum to come clean. Let me set the background.

During the formative days, the COBOL activities represented the primary computer manufacturers of the time. A handful—8 manufacturers—and a double handful of computer users were represented. At that time we were attempting to create a specification for a language that would be understandable by users, translatable by machines and easy to learn. We were also concerned that the language would be acceptable on all computers, even though there weren't that many back then.

Having worked with Grace Hopper, I subsequently worked for RCA carrying her banner and using the techniques that she taught me. I was the corporate representative to the COBOL committee and the manager of the Automatic Programming Group. This group at RC[illegible] was creating an embodiment of the COBOL language specifications in our hardware. We kept about one week behind the COBOL language committee. When we moved a week ahead of the committee, I got nervous. RCA wanted to commercialize COBOL as a product, to have a marketing edge. The other manufacturers were seeking the same goal. As a result we sometimes became testy with one another, and with the organization running the activity. The Committee would meet every six weeks, with each member having very specific technical assignments. The meetings would last three to four days and then we would return to our companies to scheme and work.

One Friday afternoon about 3 o'clock I had an opportunity to discuss my frustration with the chairman of the CODASYL committee, Charlie Phillips. He was the coordinator of everything, good and bad. As such, he was the recipient of a lot of verbal abuse and, later on, a lot of praise. I discussed with Charlie the speed of specification of COBOL. After I described, in colorf[illegible] language, how I felt and the problem[illegible] that this was causing me and my company, suggesting that he do something "with it," I hung up and left work in a fit of pique.

As I drove down the freeway, I saw, to my surprise, a monument company next to an exit. Easy off. Easy on. So I did the easy off.

I went in and said, "I'd like to buy a monument."

The salesman said, "You've come to the right place. What did you have in mind?"

"A serious monument that would show my appropriate respect. Since I have to send it, I would like it to be compact." He stepped back and let me wander around. I chose that tombstone because I liked the sacrificed lamb effect.

Mind you, when you buy a monument, it is blank. So the clerk asked, "And what name do you want inscribed?"

I said, "I'll write it for you." I wrote the name down: COBOL.

"What kind of name is that?"

"Well it's a Polish name. We sho[illegible]ened it and got rid of a lot of unnecessary notation."

"Fine. Give me the money and come back in two weeks."

In two weeks I returned, still in a fit


*Howard Bromberg and Commodore Grace Hopper share a gleeful moment by the infamous COBOL Tombstone. (Photo: Lilian Kemp)*

of pique, mind you. To my surprise, he had gold leafed the name. Today is the first day that I have seen it in twenty-five years and I am still very pleased. Back then, I took it home, not to my office, which is probably the smartest thing that I've ever done. My neighbors helped me build a crate for it out on the sidewalk because they wanted to get that thing out of the neighborhood. I put my name and home address on it and sent it to Charlie Phillips at the Pentagon and felt better.

Grace wanted me to remind you that I sent it collect.

Now, I have denied this story for years. People would call up and ask me, "Hey, did you send that tombstone?" And I would always respond, "What tombstone?" It appeared in a drawing on the cover of the ACM Communicatons. More phone calls. I would say, "I don't know anything about it." Grace in her travels used to tell the anecdote. And even more phone calls. But still denial, until tonight.

Back to that time. Two weeks thereafter I had still not heard from Charlie. The fit of pique returned. And I said, "He's doing this to me on purpose." So I called him. We chatted about the weather and other nice things. And I thought, he's got me. Finally I said, "By the way, did you receive something in the mail?"

Charlie Phillips said, "I did indeed. I wonder what you meant by that?"

I said, "Thank you, Charlie." And I hung up.

I was then called to the Vice Presidential suite of RCA where I worked. The suite was interesting because all of the doors were eight feet tall and the ceilings of the room were twelve feet. I always thought that it was to make the vice presidents feel important and it made me feel very unimportant. After waiting the requisite amount of time, I was ushered into the boss's office. He said, "People at the headquarters in Rockefeller Center have heard that you sent a tombstone to somebody at the Department of Defense. They think this may hamper our ability to bid successfully on defense contracts. Did you do that?"

I said, "Yes."

He said, "Would you like to explain to me why?"

How are you going to explain this to a marketing vice president? So I said, "No."

He said, "Thank you." I went back to my office and sort of organized things, just in case. To their great credit I never heard a word about it again. That also helped my denial to this time. It's here. I did it and I'm glad.

I wondered on the flight out here, whether it really means anything—this hunk of marble. Why are we all here? I guess that it means different things to different people. From my standpoint it shows me the humor that we are able to associate with the work that we were and are doing. . . . the ability to make fun of oneself personally and professionally makes us noble.

COBOL was so different. There were no individuals; they were sublimated to the group. The accomplishment was incredible because we flew in the face of tradition not knowing any better. COBOL "created" a standard. Standards are usually not created; they are recognized and they evolve. In the next twenty-five years I believe that we will continue to profit from the lesson we learned from COBOL: that a language has to help people talk to people. People do not talk to machines. This is the whole assumption on which COBOL has been built.

*Participants in COBOL's 25th Anniversary Celebration at The Computer Museum on May 16, 1985, surround the COBOL Tombstone. Left to right: Ron Hamm, current CODASYL Committee Chairman John L. Jones, Dr. Jan Prokop, Oliver Smoot, CODASYL Secretary Thomas Rice, current COBOL Committee Chairman Donald Nelson, Commodore Grace M. Hopper, Michael O'Connell and Howard Bromberg. Also present were Connie Phillips and Nan Wilson, the daughters of Charles A. Phillips. (Photo: Lilian Kemp)*

# Recollections of Memories from RCA in the Fifties

by Jan Rajchman

*The following is a transcript of Jan Rajchman's talk at The Computer Museum on March 7, 1985, on The Computer Museum Program Series. Mr. Rajchman is the retired Vice President of Research Information Sciences at RCA.*

**Maurice Wilkes** (builder of Cambridge University's EDSAC): I first heard Jan Rajchman lecture at a course at the Moore School in Philadephia in the summer of 1946. He spoke about the selectron, which was a vacuum tube for storing information, and I admired his ingenuity at the time. Some may think that the pin limitation began with semiconductors, but I can assure you that it started with vacuum tubes.

In the early fifties, I visited Jan at the RCA Laboratories in Princeton where he was working on core memories. I can remember him asking me if I thought that programmers would ever want as much memory as 10,000 words. There was a view then, held by von Neumann, among others, that you didn't need much core memory provided that you had a magnetic drum to back it up.

At that time as today, Jan carried out pioneering work on memory technology and it is with pleasure that I am introducing him tonight.

**Jan Rajchman:** In 1939, a U.S. Army Colonel visited RCA and spoke of the German superiority in the air and the lack of controllers for U.S. anti-aircraft guns. The mechanical directors for the guns, which had been designed for use on ships and tanks, were utterly too slow for aircraft. The Colonel said, "I don't know anything about electronics except that it's fast, so why don't you look at the problem." The job was assigned to me.

My natural inclination was to look at how the problem was solved mechanically and to do it electronically the same way. After a few months, I discovered that doing anything analog at high speed was very difficult. Very soon I switched to the digital approach with a binary base and the laboratory developed various arithmetical units including shift registers, adders, multipliers, and an arbitrary function generator, now called a read only memory. It also became evident that the digital technique with many tubes would be very bulky and it would take a long time to develop an anti-aircraft fire control device. At that time, the printing of ballistic tables fell behind the invention of new gun types needing new tables. The idea of one central machine for generating ballistic tables was the origin of what became the ENIAC.

There was some question as to whether the ENIAC could be built at RCA, where we had already done more work, or at the Moore School of the University of Pennsylvania. Frankly, RCA had cold feet. The RCA hierarchy felt that any machine with 30–40,000 tubes would be a monster and would never work. In effect, RCA turned down the job of building the ENIAC. However, we were asked to cooperate, and I went to consult many times. They adapted the read only memory and a decimal rate counter.

While the ENIAC was first tested to make ballistic tables, it quickly became apparent that other problems had higher priority, including some for the atomic bomb. A major issue was how to change the design of the machine from one problem to another. The original ENIAC was designed for a specific problem and then patch cords allowed it to be set up for a different problem. Then people said, "Well, why not relays instead of patch cords?" And from that they said, "Well, why not vacuum tubes? There are vacuum tubes everywhere else." Very, very slowly the idea for the stored program evolved. That is to say, the idea that you could build a machine for any problem without having to know the problem in advance. You could program the machine later to solve the problem. The evolution of this idea took a surprisingly long time. What was missing, of course, was the memory. Obviously the stored program computer has to have a memory for the program and the data.

One of the first ideas (due to Pres Eckert, I believe) was to use a delay line where pulses at one end are detected at the other end, and then are put back at the input. Of course, the more memory there is, the longer one has to wait for any desired bit. It was clear that a "random access" was desirable to avoid this dilemma. The term "random access" was born and I was very unhappy about it. There is nothing "random" about random access memory, because, in fact, the exact address is selected deterministically. I also didn't like the word memory. Memory in animals is more than storage. I like the way the British put it, an addressable store of information. But the term random access memory stuck.

After the war, von Neumann, who was the great proponent of the stored program computer, undertook to build a machine at The Institute for Advanced Study, and asked RCA Laboratories to provide the random access memory on which it was to be based. That task was assigned to me. In those days, with the triumph of the cathode ray tube in television and oscilloscopes, it was natural to think of using it for a random access memory. Charge is simply deposited on the screen by directing the beam to the selected address where it remains until again bombarded by the beam. Addressing involved analog deflection and storage depended on good insulation of the screen. Many groups (notably MIT) attempted to realize memories in this manner. Most found that structuring the target was necessary. Professor F. C. Williams at Manchester University succeeded in avoiding any such structuring by using a metallization on the outside of an ordinary cathode ray tube and an ingenious use of the naturally occurring redistribution of secondary electrons near the bombarded area. His scheme was a very inventive *tour de force* and provided early memories using commercially available tubes. However, the signals were very weak and the system of analog deflection very delicate. Extreme electromagnetic as well as mechanical insulation was necessary to protect the machine from vibrations such as those due to a passing truck. (By the way, F. C. Williams' ideas were subsequent to those of the Selectron Tube.)

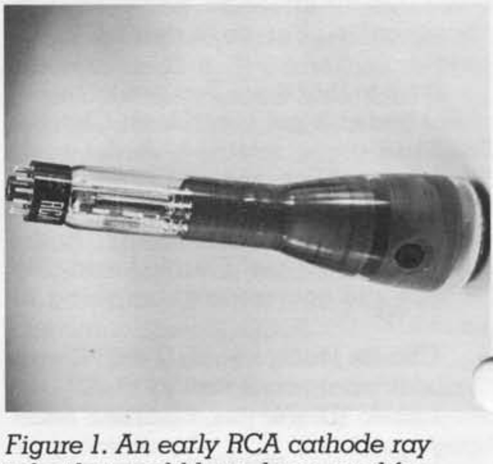
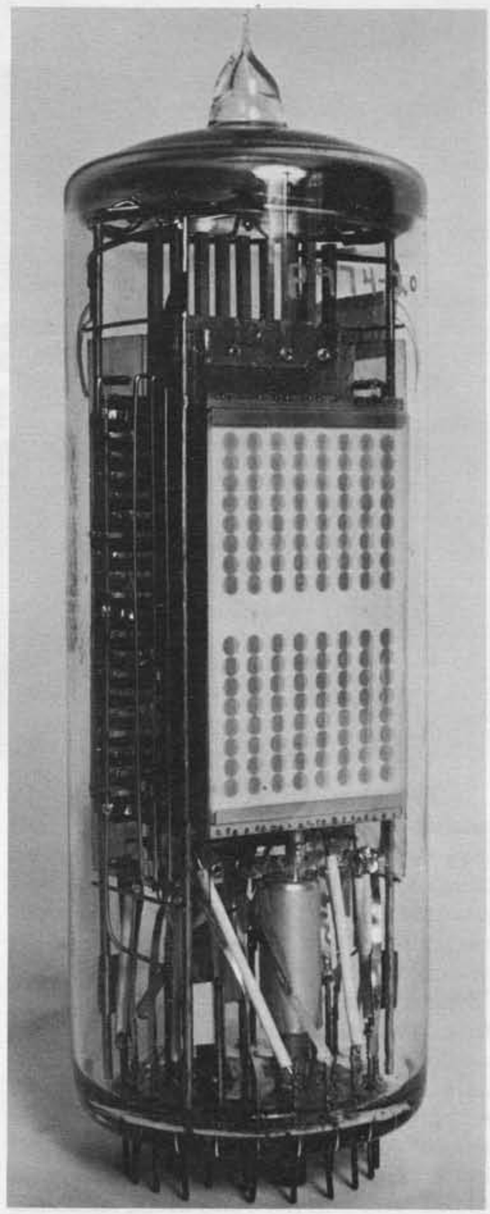


*Figure 1. An early RCA cathode ray tube that could have been used for storage.*

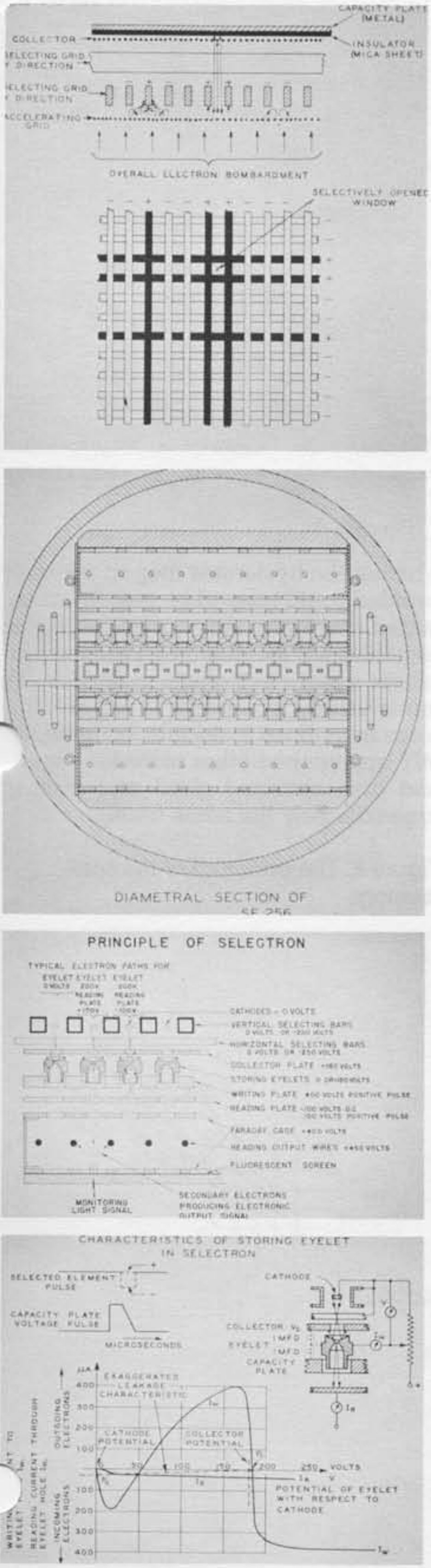
*Figure 6. A 256 digit selectron tube from the Johnniac at Rand. Gift of Keith Uncapher and Tom Ellis.*



Our approach, the Selectron Tube, was a radical departure from all the cathode ray tube attempts of the time. It utilized a purely digital selection system based on a uniform electron bombardment of "windows" created by two orthogonal sets of parallel bars. By applying appropriate voltages to the bars, the passage of electrons was stopped in all windows except a selected one. The onerous number of individual connections to each bar and its individual drive were avoided by connecting the bars inside of the tube into groups and making connections and drives only for the much smaller number of resulting groups. Such a reduction of addressing channels is possible since the passage of electrons between two bars depends on the potential of each bar. Both need to be relatively positive and equal to each other for the electrons to pass. Hence there is an "AND" gate. By appropriate connections between the bars, a row of bars, or a "picket-fence", controls N spaces by means of only 2 N at right angles to each other, e.g., an array of 1024 × 1024, or more than a million, could be controlled by only 20 channels. The principle of selection is illustrated by figures 2–5.

Moreover, the Selectron, in contrast to other memory tubes attempted at the time, used a radically different method for storage. It utilized discrete metal elements that were forcefully maintained at one or another of two stable potentials by a constant electron bombardment. Hence storage of information was not dependent on insulation and did not need any explicit refresh, as in other approaches. The overall electron bombardment of the matrix of bars was not stopped by the bars in the storing condition, thereby providing the "locking-in" current for every element. Only momentarily, during the selection, was that locking current interrupted. Read-out was obtained by using a part of the bombarding current of the element passing through a hole in the element, illustrated in figures 4 and 5.

The particular selectron tube design brought to practical realization had only 256 bits of storage, had a cycle time of 20 microseconds (very short in those days), and required rather extensive power-consuming circuits. (Plans made earlier for larger capacity tubes were not carried out, mostly due to the advent of core memory.)




*Figures 2–5. The principle of selection used in the Selectron tube.*

The Selectron can be viewed as "integrated vacuum technology." We thought of applying such a technology to binary adders and multipliers. These tubes were based on the concept of many internal electrically floating electrodes. Some research was funded by the government and several tubes were partially built. However, the general concept did not seem practical because it required an exact logic predesign that did not tolerate the changes and additions that are inevitable in real life. Incidentally, the early integration of transistor semi-conductor circuits suffered from the same rigidity of design.

During the development of the Selectron, I conceived what came to be known later as the core memory. About a year after we had started to work on it, we heard that at MIT Jay Forrester had independently had the same concept. MIT was working on it for the SAGE project. From that time on we helped each other with frequent mutual visits.

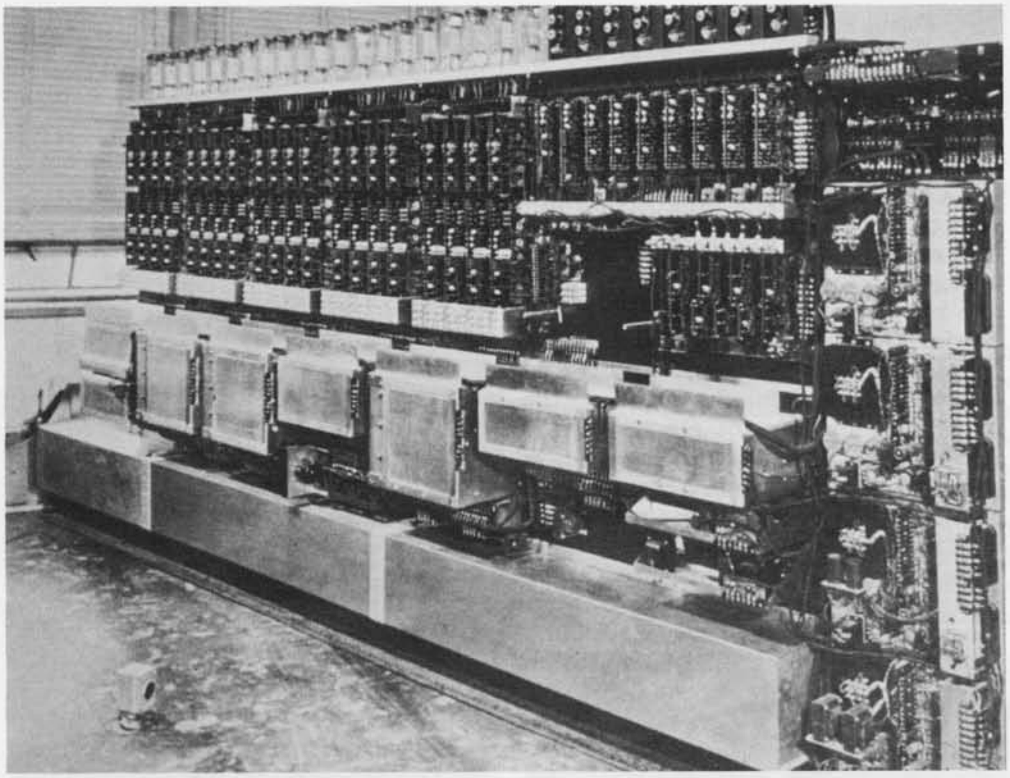
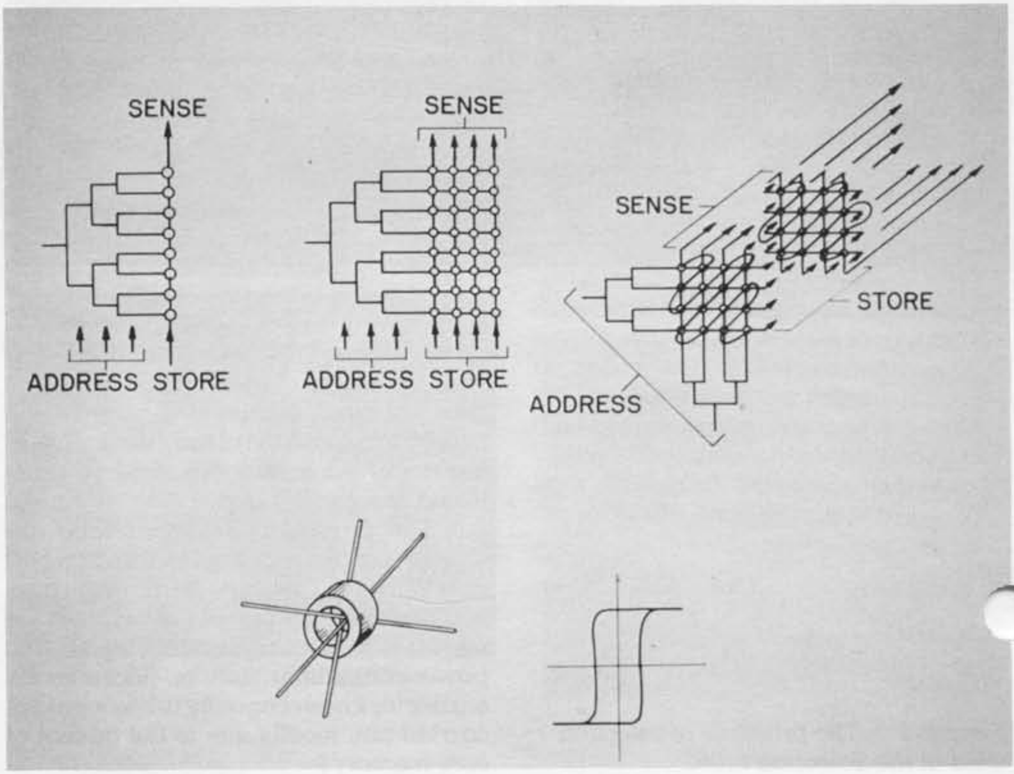


*Figure 7. The monster circuitry and power supplies needed to drive the selectron memory at RCA. This machine is similar to the Johnniac built at Rand.*

The idea of the core memory is very simple. A core is made of a material that has a square hysteresis loop. When magnetized by a current pulse, it will assume one or the other of its two magnetizations, and thereby "remembers" in which direction it was magnetized. This "memory" property is a free gift of nature. The main artifice that had to be devised was the magnetization of one core among many in an array in a desired direction, without disturbing the sate of any other core. This is achieved by the coincidence of two currents, one along rows and the other along columns, whose combined effect magnetizes the core at the intersection. The currents are too weak to singly change the magnetization of a core as their magnetomotive force is below the "knee" of the hysteresis loop. Of course the critical need is for a material with a square loop. Actually, I had thought of the concept long before; in fact, I cannot remember when it was not evident to me. However I did not know of any material with a "square loop."

To my great amazement one day, I was reading a technical journal and I found that the Germans had developed a square loop material that was used in magnetic amplifiers for submarines. ARMCO Corporation in Philadelphia acquired the patent rights and were manufacturing the material, which consisted of a very thin ribbon of permalloy. This very delicate ribbon was "wrapped" around a ceramic bobbin. Each such bobbin could serve as an element of the core memory. MIT had also discovered the ARMCO bobbins and we both used them in early experiments. They were about $10 each, relatively bulky and delicate. It seemed evident that ferrites would be preferable. Ferrites are made of metal oxides, are insulators, produce no eddy currents, and were and are widely used for high frequency transformers and television yokes. In these applications, any hysteresis produces great losses and is carefully avoided. I approached experts on ferrites at RCA and asked them whether the hysteresis they so carefully avoided could instead be greatly accentuated and I was very surprised that in less than six months they produced excellent square hysteresis materials. We immediately proceeded to model tiny cores from those materials. Incidentally MIT approached other material exper. and also obtained good materials at approximately the same time.

*Figure 8. The principal of the core memory.*



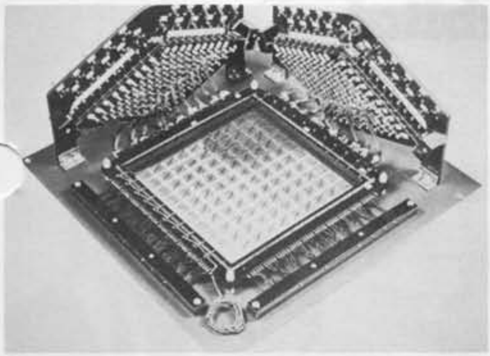


*Figure 9. One of RCA's first core memories.*

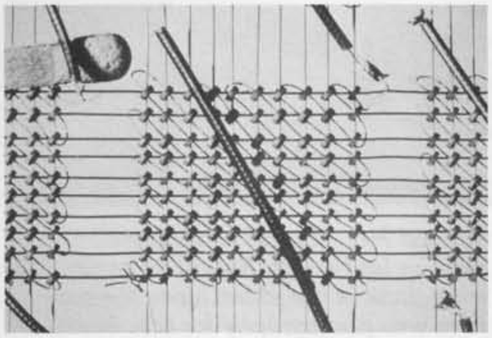


*Figure 10. Detail of an early RCA memory. Note the use of decimal numbers, chosen because of the craze for decimal machines prelevant at the time.*

As is well known, the core memory became the standard and was a key in the development of computers. It was surprising that the memory, which by its very operation requires many elements, should be made by discrete elements assembled into arrays. Why not an "integrated" fabrication of some sort whereby all magnetic elements and their linking conductors are made by some overall integrated technique that made the whole array at once. Thus, from the very beginning there was an issue of "integration" versus "automation" (as cores became gradually made by automated presses, were tested automatically and assembled semi-automatically). For example, RCA and Bell Labs made ferrite plates with an array of holes, each threaded by metalized coatings on the plates. Many groups worked on plated wires, which could be made by a continuous process. However, the cores continued to be made by improved methods and, by and large, provided better operation at lower cost, and thus prevailed against all other magnetic memory approaches. In a sense, automation won against integration.

All the efforts at integration were not lost, however. In experimenting with apertured ferrite plates, we invented the transfluxor, a core with two holes, i.e. a relay with no moving parts. The transfluxor was used in some of the early satellites and for foolproof controls in the New York subway. Ironically, the Russians read our papers and used these devices in many industrial controls as they were very slow in developing transistors. Such magnetic logic circuits might be the basis of computers (in fact Univac had a design) if the transistor had not been invented.

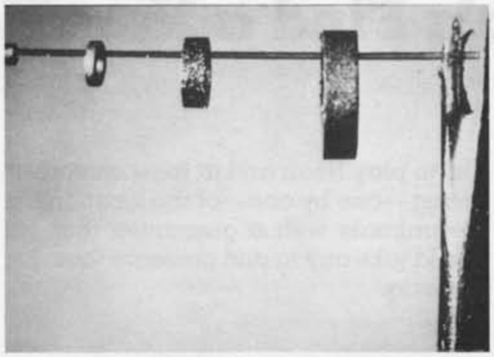


*Figure 11. Cores held on a strand of human hair.*

A brief mention should be made of our early attempts at integration on a grand scale: planes with half a million bits. These utilized the cryotron, a superconductive switch invented by Dudley Buck at MIT, and made by thin film evaporation techniques. Interestingly enough, our main problems turned out not to be with the indispensable operation at liquid helium temperature, but rather with the problems of imperfections that seem inevitable with such large and dense arrays. It is these imperfection problems that plague present day large capacity chips, and that are being solved by sophisticated error correcting methods and extreme care in fabrication.

The modern development of integrated circuits is of course one of the present day wonders. Memory chips with a million or more bits are being manufactured at very low cost. The integrated circuit memory chips have given us a solution to the memory that is better by orders of magnitude than any previous technology. In fact, it is very difficult to imagine a better technology. The chip is a triumph of fabrication of geometries at the micron, and soon submicron, scale. Operation is obtained by deliberate geometrical shaping and deliberate synthesis of materials, and is all human artifact, not based on some fortuitous natural property, as that of the square hysteresis of some magnetic material.

In the early days, when any workable random access memory was a great achievement, von Neumann thought that a forty thousand bit capacity would be sufficient, provided there was a sufficiently large serial mechanical memory to back it, i.e., tape, drums and later discs. I was always convinced that there is essentially no limit to the need for capacity in the random access memory, and thought that there was no fundamental need for a hierarchy of memories but merely a practical recognition that such hierarchies provide indispensable storage capacity. Today, large capacity chips provide enough memory so that some personal computer systems need nothing additional (HP). This trend will continue into larger computers, particularly when non-volatile techniques are further developed. In the meantime, greater capacity in random access memories are being sought for image storage and manipulation, as well as for many, if not most, tasks sought by artificial intelligence. I believe that semi-conductor technology will provide ever greater, capacities for these uses. Though nature stores in DNA at densities orders of magnitude greater no reasonable proposal has yet been made to exploit such molecular storage for a random access memory or even for a memory that is accessed in some more sophisticated way, such as through the stored contents. Most inventions of men are imaginative intellectual constructs that more often try to defy nature rather than to imitate it.

# Honeywell Animals Find a New Habitat

Six of the famous computer component animals built by Honeywell are on display at the Museum. These six of the more than 100 animals made were "rounded up" by Morris Dettman, who sponsored these sculptures for a Honeywell advertising campaign that ran from 1964 to 1978. Honeywell put together the display of the animals along with an introductory case with illustrations of the ad campaign.

Each animal sculpture was produced from the contemporary computer components of the time. Since about half a dozen sculptors from the Boston area were used, several different types were produced. For the most part, the animals are either sculpted from styrofoam or formed from wire mesh and then the components put on the surface to form an appropriate mosiac.

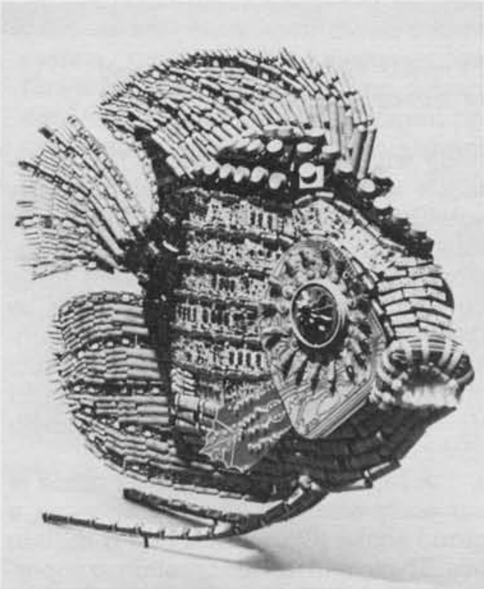
**The Story of the Animals**

The first sculpture was a fairly primitive, pterodactyl-looking bird escaping from a cage. The headline proclaimed, "You're free. Honeywell's 'Liberator' lets you switch to the H-200 without reprogramming."

The second sculpture was a racehorse. The headline was: "The Honeywell 200 is off and running."

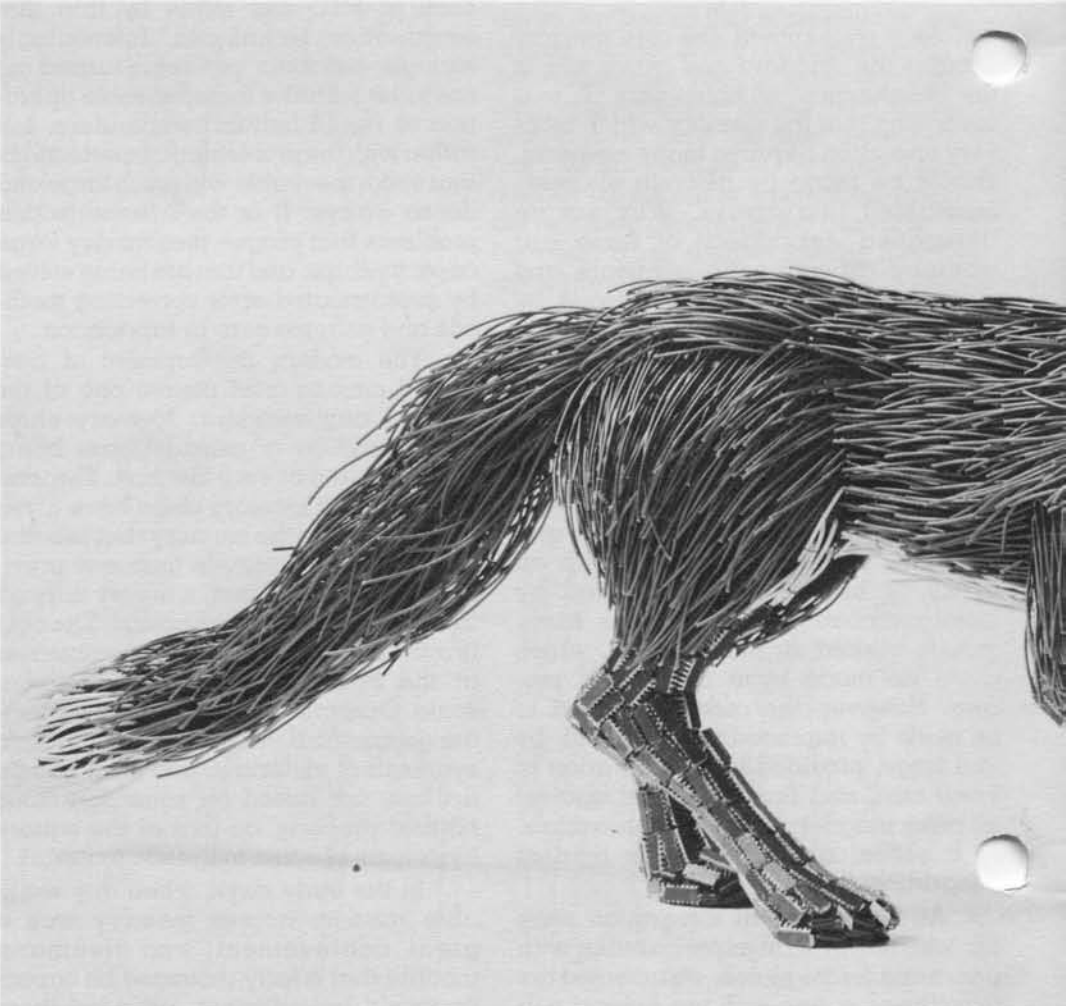
The dragon on display at the Museum was used with the slogan, "Honeywell's new computers introduce a little magic to banking." Walking around the case, the visitor can see how the components are attached to the wire mesh frame.

After use within the ads, the popular animals were often given as awards to employees and customers. We have heard that the pride of lions lie in rest in Phoenix and a six-foot span eagle is in Washington, D.C. The Museum would like to play Noah and at least compile a listing—one by one—of the locations of the animals with a guarantee that we would take any in and preserve them for posterity.

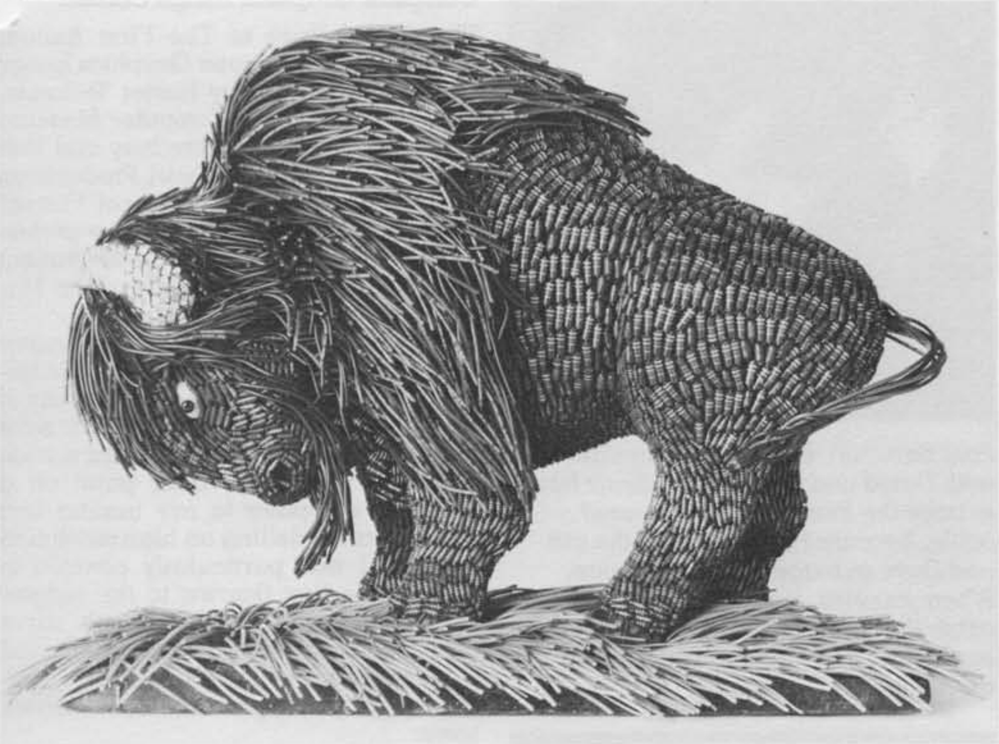


*Mr. and Mrs. Morris Dettman with a fish—or half a fish. Not all animals were done in the round since the purpose was photography for ads. Morry said, "The $1,500 to $5,000 price tags on any of the animals was quite cheap when you think of fees for models' time, props and so forth."*

*This early bird sculpture got the Honeywell ad campaign off the ground in 1964.*



# Wanted: Animals for the Permanent Collection.



### A Search for Lost Animals

The whereabouts of most of the one hundred animals, sculpted between 1964 and 1978 for one of the longest running ad campaigns, are unknown. If anyone knows the location of any of the other animals, the Museum would like to increase the flock for its collection, along with any of the other ephmeral material that was made to capitalize on their appeal. To date, the Museum has only a deck of cards and several posters, although calendars, small replicas and other items were made.

Honeywell's animals are an important part of the culture of computing and thus appropriate to be collected by the Museum. Anyone who saw the ads didn't forget them. The transistors, resistors, switches, cabling, diodes, and later integrated circuits from which they were made brought the "insides" of the computers to the forefront, demystifying and even making light of the magical equipment inside of the computer "black box."

Twenty-one years ago, Morris Dettman had the vision to create these animals and this year he saw to it that the display was made and loaned to the Museum for the enjoyment of the public.

*The fox has a styrofoam base and can be identified as one of the later sculptures because of the use of integrated circuits for the legs.*

# Questions About the New Exhibits

A number of new interactive exhibits were completed and new artifacts placed on display for the May 3rd annual meeting of the Board of Directors and our benefit party.

If you couldn't make the benefit, "The Magical Mystery Tour," you can still visit the Museum and take the trivia quiz on our new exhibits and win a prize. When you complete the quiz, give it to one of the interpreters and you will be rewarded with one of the Museum's special treasures.

In the 1950–70 timeline, the tombstone epitaph stands for ____________________.

A tin automatic reference guide was made for ____________.

The integrated circuit exhibit includes an evolving number of chips under the microscope. What are the colors of the IBM 64K chip? ____________

A number of additions have been made to the burial mound of single-user machines. The Honeywell Kitchen Komputer, an IMSAI, a Scelbi, and Apollo's first workstation with ____________ disk drives.

In the Image Gallery, there is a bar-relief image of the ____________, the S in typographics has ____________ lines of resolution, the teapot can be illuminated in ____________ different ways, the fourth order fractal is colored ____________, and, can the tree carry the girl over the house to the rabbit? ____________ (yes or no).

Six Honeywell animals show off the components of the era from 1964 to 1978. The blue stripes on the fish are made of ____________.

*Trying to get the EXTRA question: What is the resistance of the largest component of the owl's ear?* ____________

*Paul Severino, President of Interlan, with David and Chris Potter, didn't have to trace the location of the ethernet cable, because Paul arranged the gift and Dave managed the installation. When you visit, look for the yellow cable that starts in the computer room on the first floor and runs throughout the Museum.*

*Danny Hillis, the builder of the tinkertoy tic-tac-toe computer, making a point to Mitch Kapor. He's probably explaining the answer to the question: Where is the tinkertoy logic thinnest in the tic-tac-toe computer?* ____________

# Exhibits of the Best

**Computer Graphics Image Contest**

The Grand Prize of The First Annual International Computer Graphics Image Contest sponsored by Raster Technologies, Inc., and The Computer Museum was awarded to Don Stredney and Jose Garabis of Cranston/Csuri Productions for their rendering of "Medical Poster." Eight other winners, five in the professional category, and three in the student category, will be on display at the Museum through January 1.

Oliver Strimpel, the Museum's curator who sat on the judging panel, was impressed with the quality and diversity of content in the 300 images that were received. "The entrants spanned a wide range of technique, from paint on a personal computer to ray tracing and procedural modelling on high resolution devices. I was particularly pleased to receive the first (known to the judges) ray-traced rendering of a caustic curve and we awarded this image second prize in the professional category."

Winners in the professional category were:

**1st:** "Movie Package" by Maria Palazzi, Cranston/Csuri Productions.

**2nd:** Untitled by Michael Sciulli, J. Arvo and Melissa White, Apollo Computer Inc.

**3rd:** "Wood Duck" by Russell Brown, Adobe Systems.

**Honorable mentions:** "Under construction" by Patrick McCormack, U.S. Air Force, Scott AFB; "Knoll" by David Kamins, Boston University Computer Graphics Laboratory.

Winners in the student category were:

**1st:** "Space Tubes" by Anne Seidman, William Kolomyjec and John Donkin, Ohio State University.

**2nd:** "Study of Expression, No. 6" by Andrew Pearce and Milan Novacek, University of Calgary.

**3rd:** Untitled, by Hillary Kapan, University of Oregon.

**Original Artwork of BYTE Covers on Display Starting September 8**

In honor of BYTE's tenth anniversary, the Museum will display a retrospective of Robert Tinney's original artwork for BYTE covers. Since 1975, Robert Tinney has created more than 80 BYTE covers—from spoofs on the industry, the user and computer design to illustrations of highly technical subjects.

The Museum Store will also carry limited editions of prints and T-shirts from these covers.

# Fall 1985 Program Series

## Sundays at 4 p.m.

**September 8**
**Tony Hoare**, Oxford University
*The Mathematics of Programming*
BYTE's Tenth Anniversary Lecture

**September 15**
**Gardner Hendrie**
*From the First 16-bit Mini to Fault Tolerant Systems*

**September 22 1–4 p.m.**
**Stephen Ciarcia**, BYTE Columnist
*Ciarcia's Circuit Cellar Showcase*

**September 29**
**Walt Tetchner**, DEC, and **Dennis H. Klatt**, MIT
*DECTALK: History and Applications of a Talking Computer*

**October 6**
**Richard Greenblatt**, Vice President, Lisp Machines Inc.
*Artificial Intelligence at MIT: 1963–70*

**October 13**
**Alan Kay**, Fellow, Apple Computer
*Personal Computing before Micros*

**October 20**
**Siggraph Video Fest**
*The Best Computer Video of Siggraph 1985*

**October 27**
**Oliver Selfridge**, GTE Corporation
*Where do we want artificial intelligence to go?*

**November 3**
**Andries van Dam**, Brown University
*Computer Graphics: From Arcane Specialty to Anyone's Game*

**November 10**
**Otto Laske, Gregory Garrey, Peggy Brightman,**
New England Computer Arts Association, Inc.
*The Computer Arts in Perspective: Music, Graphics, Choreography.*

**November 17**
**Peter Rony**, IEEE Computer Society and
Japan Micro-Mouse Association
*Mappy, the Micro-mouse Inaugural Run of the Maze at the Museum*

**November 24**
**Tom Snyder**, Tom Snyder Productions
*Educational Software: A Satire of Itself?*

## Thursdays at 7 p.m.

**October 10**
**Barry Vercoe**, MIT Experimental Music Studio
*The Computer as Chamber Music Performer*

**October 24**
**Trip Hawkins**, President, Electronic Arts
*The Rebirth of the Home Computer*

**November 7**
**Joel Moses**, MIT Dept. of Electrical Engineering & Computer Science
*The Organization of Large Systems*
The Carl Engleman Memorial Lecture on Artificial Intelligence

**November 21**
**Philip J. Davis**, Brown University
*Millions of Digits of Pi: What's Behind It All?*

**December 5**
**Nelson Max**, Lawrence Livermore Laboratories
*Computer Animation in Mathematics, Molecular Biology and Art*

## The Computer Museum

All programs will take place in The Computer Museum Auditorium. Admission to the programs is free for Computer Museum members, and free to others with admission to the Museum: $4 for adults; $3 for students and senior citizens. Reserved seats are available to members by sending $2 per seat per program to Programs Coordinator, The Computer Musuem, 300 Congress Street, Boston, MA 02210. Please make checks payable to The Computer Museum and clearly indicate which program(s) you plan to attend. Seats may also be reserved by paying $2 at the door up to one half hour before the program begins.

Sponsored in part by grants from the Bank of Boston and Digital Equipment Corporation.

**For more information call 423-6758.**

**Sunday, September 22, 11:00–6:00**
**ATTIC SALE**

Get your hands on computer gadgetry, photos, graphics, books, manuals, and more at the Museum's "computer flea market"—a real hacker's dream.

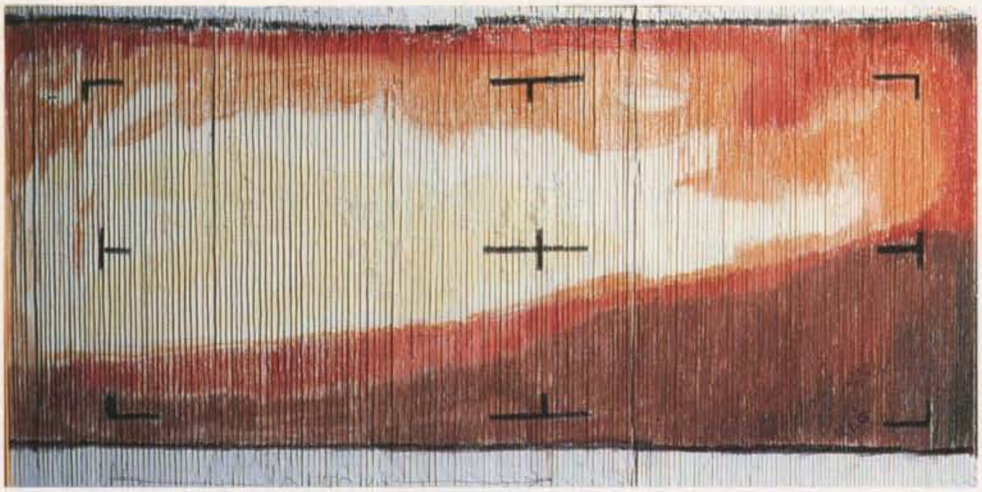
Clean out your attic with contributions to the Museum's sale—fully tax deductible. One hacker's throwaways are another's key parts! Items may also be sold on consignment, and vendor tables are available for rent. For more information about participating in the ATTIC SALE, contact Jessica Pollard at The Computer Museum (617) 426-2800.

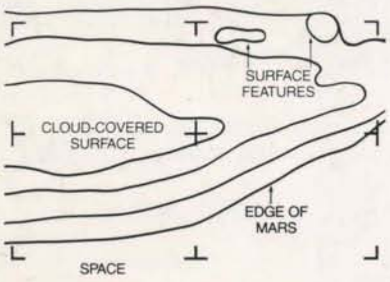
**Saturday and Sunday, October 27 and 28, 11:00–6:00**
**"A LOOK AT THE FIRSTS"**

As part of Museum Goers Month, we invite you "behind the scenes" to see some of the historic firsts in our stored collection. Meet *Shakey*, the first computer-controlled robot ever built, try out the first mechanical calculator, or play the world's first computer video game, *SpaceWars!*, running on the vintage PDP-1 computer. Some of the MIT hackers who created the *SpaceWars!* program in 1962 will be on hand to challenge those who dare. For nostalgia buffs we will power up the IBM 1401 and display the first digital computer—the ENIAC.

## THE END BIT

**0000000001**






The first view of another planet from a vantage point in space taken on July 15, 1965 when the space probe Mariner 4 flew by only 6,118 miles from the surface of Mars.

After the failure of Mariner 3 (whose camera shroud had jammed), NASA project scientists at The Jet Propulsion Laboratory anxiously awaited the signals from Mariner 4's cameras during the final approach to Mars. A picture was transmitted to Earth as a stream of eight bit numbers, each of which was coded for the brightness of a point in the picture. They were arranged column by column, starting at the top left hand corner.

When the data started to come in—at a rate of one eight bit number a second—the project scientists, eager to see the first closeup of the Martian surface, took turns to hand color-code the strips of data hot off the printer. Bob Nathan, one of the scientists, recalls that after approximately four hours about half the picture (100 columns) was in place, someone pointed to the wavy line near the bottom of the picture exclaiming "hey—could that be Mars?."

The information on the picture is minimal, owing to the uneven response of the Mariner's TV camera and the fact that the edge of Mars was cloud-covered.

On loan from NASA, Jet Propulsion Laboratory, Pasadena, California.

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